# 3.0 PLAN FORMULATION

## 3.1 PLANNING CONSTRAINTS

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

Another significant category of constraints is the scientific and technological uncertainties inherent in large-scale aquatic ecosystem restoration projects. While many of these were known as the plan formulation process began, others became more evident as the formulation process was completed. A summary of the key scientific uncertainties and technological challenges as they are currently understood, along with proposed strategies to address these uncertainties and challenges, is presented below.

### 3.1.1 Scientific and Technological Uncertainties

Scientists have documented the importance of the Louisiana coastal area for fish and wildlife habitat (Coalition to Restore Coastal Louisiana 1989; Keithly 1991; Herke 1993; Michot 1993; Olsen and Noble 1976), estuarine productivity (Morris et al., 1990), and ecological sensitivity to human activity (Templet and Meyer-Arendt 1988; McKee and Mendelssohn 1989; Reed 1989). This recognition has resulted in considerable efforts to investigate and understand the complex physical (Morris et al. 1990), chemical (Mendelssohn et al. 1981; Morris 1991), and ecological (Montague et al. 1987) processes that drive the system, providing Louisiana with a rich history of scientific studies. Studies on understanding relationships between different habitats and different aquatic species (Minello and Zimmerman1991) have been conducted due to the importance of the Louisiana coast's support to numerous estuarine dependent fish and its ability to provide important nursery habitat for diverse fish communities. The coastal areas have also been important for wintering waterfowl with several studies conducted to understand relationships between waterfowl use and habitat conditions. Oil and gas exploration and production have prompted numerous studies on subsurface geologic conditions. Additional geologic conditions have been investigated to aid in understanding deltaic processes that have shaped the Louisiana coast (Fisk 1944; Kolb and Van Lopik 1958; Frazier 1967; May 1984; Smith et al. 1986; Penland et al. 1988a, 1988b, 1988c; Dunbar et al. 1994; 1995). Studies on the Atchafalaya River and delta have also contributed to our understanding of deltaic processes (USACE 1951; Fisk 1952; Shlemon 1972). In addition, numerous studies performed in other ecosystems are applicable in understanding the ecology and function of the Louisiana coastal area. The results of these investigations provide considerable understanding of the physical, chemical, and biological processes that formed and sustain the Louisiana coast. The numerous state-sponsored studies generated from CWPPRA have developed basic trend information over the past 14 years. Studies funded by the National Science Foundation and others have aided in an understanding of impacts and have provided recommendations for improved operations for some existing diversion projects.

The LCA Study builds upon the best available science and engineering knowledge, which has resulted in part from the work described above. However, many of the studies conducted in the Louisiana coastal area have been limited in geographic extent or technical scope. Therefore, while previous research efforts have contributed to a strong understanding of the processes affecting the Louisiana coastal area, scientific and technical uncertainties still remain. Additional investigations to further reduce the scientific and technical uncertainties and to enhance the likelihood that restoration projects will successfully meet restoration goals would be necessary during LCA Plan implementation. The use of newer techniques like geospatial technology (e.g. GIS and remote sensing) should be investigated to determine their capabilities in answering areas of uncertainty. It is expected that geospatial technologies will be able to answer many of the uncertainties associated with the LCA Study. The LCA Project Delivery Team (PDT) reviewed annual Adaptive Management reports prepared to assess previously constructed CWPPRA projects. These efforts are an extension of the existing monitoring program used to identify "lessons learned" from the many CWPPRA projects, past and future, and will also serve as a valuable assessment of "what worked" and "why it worked" on projects that have been built long enough to provide useful data. Identification of the reasons why other projects did not meet initial project goals is also essential to reduce uncertainties.

This discussion on scientific and technological uncertainties is intended to illustrate that considerable information has been developed from prior studies, but that data gaps still exist and considerable scientific and engineering uncertainties remain. The PDT recognized the uncertainties and conducted plan formulation and evaluation with this recognition. The discussion that follows details the different broad types of uncertainties, with appropriate actions to resolve them during LCA Plan implementation.

### 3.1.2 Types of Uncertainty and Resolution Strategy Within the LCA Plan

There are numerous types of uncertainties that need to be addressed to support and improve Louisiana coastal area restoration efforts. Each uncertainty requires a different resolution strategy, based on the effects of the uncertainty on the program, degree of uncertainty, cost of addressing the uncertainty, and importance of reducing the uncertainty. Some of the known and most relevant uncertainties associated with the LCA Program are listed below, grouped by type of uncertainty. Many of these reflect uncertainties and engineering challenges inherent in all large-scale coastal restoration efforts. Most important in this discussion are the strategies presented to resolve the four uncertainty types presented.

#### 3.1.2.1 **Type 1 - Uncertainties about physical, chemical, geological, and biological baseline conditions**

The existing knowledge base regarding baseline conditions is sufficient (low uncertainty) to facilitate construction of many of the restoration features evaluated in the LCA Study. Continued improvement of tools, networks, and the acquisition of data to better establish these baseline conditions would allow for more detailed and coast wide monitoring and assessment, which would better support program level, as well as project level, Adaptive Management, described in appendix A SCIENCE AND TECHNOLOGY PROGRAM. Some specific examples of uncertainties and potential investigations designed to reduce the uncertainties are:

- *Determine quantity and quality of Mississippi River resources (sand, silt, clay, nutrients, water) available for restoration efforts.* Because the USACE and USGS have collected hydrologic stage, discharge, and water quality data for the Mississippi River and its distributaries for many years, there is a general understanding of flow volumes down the Mississippi and Atchafalaya channels. However, additional detailed analyses of the seasonal availability and qualities of the water/sediment stream would be necessary to make strategic decisions about resource allocation within the system.

- *Determine relative sea level change due to subsidence and the processes that contribute to the overall rate of change within the coastal region.* Accurate elevations across the coastal area are necessary for documenting and modeling subsidence and sea level change. Processes that contribute to subsidence include, but are not limited to, consolidation, faulting, fluid withdrawal, and regional tectonic movement. Considerable work to address these processes has been done for specific locations of the coast.

  In 1996, as part of the Morganza to the Gulf Feasibility Study, a contract report was prepared entitled "Datum Epochs, Subsidence and Relative Sea Level Rise for Southeastern and South-Central Coastal Louisiana." In 1995, BTNEP gathered elevation data in the Barataria Basin and Terrebonne Parish to evaluate subsidence rates. These data were compared to those in the feasibility report and a 1987 USACE funded report entitled "Terrebonne Marsh Subsidence Study." Subsidence is expected to magnify flooding problems for Terrebonne and Lafourche parishes in the future.

  Although these studies provide valuable insight to subsidence rates in selected portions of the coastal area, other portions of the coast are not as well characterized. Currently, local, state, and Federal agencies, as well as private industry, are working closely with the National Geodetic Survey (NGS) to establish a network of NGS High Accuracy Reference Network (HARN) monuments, NGS horizontal control monuments, and NGS vertical benchmarks using Global Positioning System (GPS) equipment to determine accurate horizontal and vertical positions relative to North American Vertical Datum of 1988 (NAVD 88) to meet the standards set forth by NOAA. Once the GPS data are adjusted, the benchmarks will be published by NGS.

This network of benchmarks will be used to help determine the processes contributing to subsidence at site-specific areas across the coast and the rates of subsidence. This information will be a critical component to future modeling efforts, which would influence future project design, cost, and success.

- *Collect detailed bathymetric data throughout the coast.* Information from the studies discussed above for subsidence also provides valuable insight into bathymetry of segments of the coastal area. Several of the LCA Study modeling tools and most future numerical models require detailed bathymetry to compute water depth and other wetland characteristics, but these data are currently not available throughout the coast. There is a need to rapidly and accurately depict coast wide bathymetry and regularly update the data to reflect changes due to sea level change, erosion, and sediment transport. The need is especially critical in the shallow, interior lakes and bays where data are difficult to collect.

- *Collect detailed topographic data throughout the coast.* Several of the LCA Study modeling tools relied on, and many future modeling efforts will require, detailed topography to compute water depth, duration and frequency of inundation and other wetland characteristics. However, these data are currently not available throughout the coast. Application of technological advances, such as light detection and ranging (LIDAR), would allow for rapid and accurate depiction of coastal topography. To be most useful, these data would need to be regularly updated to reflect changes caused by sea level change, subsidence, erosion, and sediment transport.

- *Determine sources of material (sand, silt, and clay) to meet needs of restoration efforts.* While much is known about the location, quantity, and quality of material available for use in restoration efforts, additional and unknown sources of material may be suitable and available. LDNR is currently working with Minerals Management Service (MMS) to develop a central database of known sand resources. Existing data are being used to develop a plan for additional data collection, including high resolution seismic, cores, and geologic mapping. These data would support modeling efforts to address sediment transport and linkages between nearshore and offshore environments.

- *Establish a coast wide network of monitoring stations to support understanding of natural variability, reference conditions, and performance measures, and provide a database, upon which future modeling efforts can be built.* Through CWPPRA, a Coastwide Reference Monitoring System (CRMS) for wetlands (Steyer et al. 2003) is being established to allow for more effective monitoring of the effectiveness of restoration features on reducing wetland loss along the Louisiana coast. Additionally, a CRMS Coastal Waters Monitoring program and a Barrier Island Coastwide Monitoring (BICM) program are also being developed. Networking the CRMS and BICM to function as one comprehensive monitoring program would help addresses network needs to focus on all major ecosystem components. A monitoring database and network that addresses physical, geological, biological, chemical and landscape components and/or processes of the ecosystem would be the most beneficial.

### 3.1.2.2 Type 2 - Uncertainties about engineering concepts and operational methods

There are several engineering techniques and operational approaches that could potentially improve the effectives of wetland restoration efforts, however, associated technological uncertainties with the techniques and approaches warrant further investigation. For example, there exists a capability with currently available dredging technologies to transport sediment long distances through pipeline conveyance. There is also a high degree of uncertainty about the availability of sufficient quantities of sediment resources and the sustainability of those resources.

In addition, uncertainties exist regarding the manner in which sediment materials can be properly discharged and dispersed to promote the establishment of new marsh vegetation while minimizing damage to existing marsh. Several of these uncertainties, and the potential investigations designed to reduce them, are:

- *Ability to use dredged material to restore coastal marshes using thin layer placement techniques.* "Thin layer placement" could provide the ability to distribute dredged material within interspersed marsh areas in order to increase substrate elevation to a level suitable for vegetation to spread into currently open water areas. However, the depth and impacts on existing vegetation need to be determined and techniques for proper dispersion to maximize plant growth and minimize suffocation of vegetation need to be refined. A reduced uncertainty about sources of sediment and appropriate particle size for enhancing productivity and maintenance of the marsh would also be beneficial. Prior to large-scale use of this restoration approach, different techniques for thin placement would need to be tested, including but not limited to, spray dredge and unconfined/semi-confined traditional hydraulic techniques. Additional information on plant mortality with different depths of fill would also reduce uncertainty associated with this restoration approach. In addition, impacts related to the acquisition of borrow material and its effect on the local ecosystem would need to be addressed.

- *Methods and outcomes from sediment delivery via pipeline.* Uncertainty about the cost-effectiveness of conventional dredging techniques to transport large quantities of sediment long distances from sediment sources would need to be addressed prior to its wide spread use in LCA restoration efforts. Conventional dredging equipment typically requires large pipelines for transport of sediment. However, there are uncertainties about how the material can be effectively transported efficiently over long distances and ultimately distributed within marsh habitats. Conventional sediment delivery equipment could result in large piles of sediment being deposited above tidal elevations, disrupting vegetative growth, and causing undesirable lateral water movements within the marsh. Therefore, new techniques should be developed and/or existing techniques refined to effectively transport large quantities of sediment to the marsh and to carefully redistribute those materials to appropriate elevations to promote marsh establishment. Additional tests should also be conducted to address uncertainties including final grade vs. design grade, dewatering periods, and potential water quality effects of transported materials. Tests should also be conducted to apply a two-tiered approach whereby large pipeline systems are used to convey high volumes of material and smaller dredges are used to then disperse the material into the marshes. Uncertainties regarding planting techniques on large scales should also be resolved. Addressing this uncertainty could be done in combination with addressing the thin layer disposal described previously.

When offshore sediment are used, the effects of using highly saline material as they relate to creating a healthy marsh environment should also be considered. In addition, impacts related to the acquisition of borrow material and its effect on the local ecosystem must be addressed.

- *Sources for marsh creation, restoration of maritime forests, and restoration of freshwater cheniers.* There is uncertainty regarding the efficacy of using saline mineral soils to support freshwater habitats. Uncertainties regarding the time required for soil to leach out salts and increase organic matter content in order to make the soils suitable for the establishment of freshwater vegetation would need to be resolved prior to using this technique on a large scale.

- *Combining techniques of marsh platform creation and freshwater/sediment diversion.* Individually, marsh creation and diversion techniques have been utilized successfully along the Louisiana coast. Combined, these two techniques may provide even greater results by creating land quickly while sustaining it in the face of relative sea level change. However, uncertainties should be resolved prior to utilizing this combination of restoration techniques on a large scale. When creating a marsh platform alone, the area is filled to a height that will settle to marsh elevation after dewatering and compaction have occurred. When combined with a diversion, however, it may be more effective to build the platform to a lower elevation and allow the diversion to build the platform to a more natural elevation for marsh establishment. The best combination of initial platform height and diversion operation that would minimize cost and maximize benefits would need to be determined.

- *Operational strategies for water diversions.* The LCA Study evaluates opportunities to reintroduce large quantities of river water into coastal marshes, but uncertainties exist about the most effective operational strategies to maximize restoration benefits. This operational uncertainty also limits the reliability of the size and design of the structures required for diversion. Several recent studies on the Caernarvon Freshwater Diversion have indicated that altering the operational strategy may increase marsh establishment or retention below the diversion. To optimize long-term sustainability of marsh landscapes, additional studies are needed to test different operational strategies, including pulsing methods and timing of the delivery of freshwater, sediment, and nutrients from diversions. In addition, there is uncertainty about potential water quality effects associated with diversions. Evaluation of potential water quality impacts could be done as part of project planning and NEPA compliance.

- *Sediment sources for reestablishment of barrier islands and land bridges.* Focused research and restoration projects already completed in the Louisiana coastal area have contributed to an understanding about the most effective and sustainable island geometry design. However, several issues remain regarding the potential sources of the large quantities of sediment that would be required to re-establish or restore coastal barrier islands. Two sand sources already identified are Ship Shoal and the Lower Mississippi River. Issues related to Ship Shoal are the quantity of available material and the cost-effectiveness of using this source relative to other sources. The sources of sands must be quantified and different transport mechanisms tested to determine a cost-effective approach to establishment. Studies to determine the type of sediment (percentage of sand/silt/clay) that may be used for barrier islands and back barrier marsh creation while facilitating vegetation growth and island stability would also be beneficial.

- *Remediation of canals for marsh restoration.* Canals cut throughout coastal marshes and their associated dredged material banks have resulted in fragmentation and accelerated loss of many coastal marshes. There has been considerable uncertainty and debate about the most effective approach for remediation of existing canals. Uncertainties about the viability of associated marsh restoration efforts and the timing of restoration also exist. Several different approaches to marsh restoration in existing pipeline canals could be examined and monitored, including: 1) backfill with small hydraulic dredge; 2) cross dikes to construct cells and improvements on effluent discharge location; 3) mechanical backfill; 4) gaps in the dredged material embankments to restore natural hydrology; and 5) test plugs as stand-alone features to reduce erosion within the canal. If backfill is used, impacts related to the acquisition of borrow material and its effect on the local ecosystem (e.g., neotropical migrants) may need to be addressed.

- *Erosion protection structures.* Erosion along open bays and channels has lead to wetland losses across the coast. Different approaches to reduce future erosion should be examined and effectiveness determined. Methods of construction and prediction of constructed structure sustainability should also be determined. It is necessary to construct and monitor a variety of erosion protection/foreshore protection features in a variety of foundation conditions. Improved designs and more accurate project cost projections would also benefit all future related restoration efforts.

#### 3.1.2.3 Type 3 - Uncertainties about ecological processes, analytical tools, and ecosystem response

Although numerous scientific studies have been conducted within the coastal environments, a considerable degree of uncertainty remains about ecological processes. Limitations in analytical tools to assess ecosystem responses also exist. Information obtained during baseline monitoring can be integrated into understanding of ecological processes. For example, processes that influence land-water exposure also have a significant influence on the ability to accurately compute land loss rates. Ecosystem models developed and calibrated with data collected for baseline conditions and from monitoring efforts can be used to refine model outputs. Some examples of potential studies to address these uncertainties include:

- *Develop a coast wide network of monitoring stations to support understanding of natural variability, establish reference conditions, assess performance measures, and provide a database upon which future modeling efforts can be built*. This effort can address Type 1 and Type 3 uncertainties.

- *Develop process-based models for prediction of land-building response to restoration features.* Models were developed to support LCA Plan formulation and evaluation, discussed in detail in appendix C HYDRODYNAMIC AND ECOLOGICAL MODELING. These models served as useful tools for evaluating restoration alternatives along with ecological benefits on a basin-level scale. While these tools were useful, refinement of the models and the incorporation of additional data, once it becomes available, would help reduce uncertainties. The incorporation of inorganic and organic components of the land building process would be an important aspect in the refinement of the models. Current modules have been based on natural analogs from the Atchafalaya and Wax Lake Outlet Delta that are of an inappropriate scale for application to many proposed restoration features. Incorporating organic production into a land building module would facilitate linkage with a habitat switching and production module.

#### 3.1.2.4 Type 4 - Uncertainties associated with socioeconomic/political conditions and responses

To date, the vast majority of modeling and assessment in support of the LCA Study has been derived from the natural sciences, geology, ecology, and engineering disciplines. Though most of these studies are predicated on National Ecosystem Restoration (NER)-based justifications and project costs, socioeconomic research is, by comparison, limited. Lack of economic linkages to biophysical processes limits the ability to assess direct risks of coastal land loss to dollars in market-based resources and infrastructure. As part of LCA Plan formulation, an economic linkage study and an economic impact assessment study were commissioned. While these studies developed estimates of economic impacts within the coastal area for future without-project conditions, more analysis would be required to detail National Economic Development (NED) costs and benefits at the project-specific level. To rectify this situation, socioeconomic modeling and assessment would be used to assist LCA Plan implementation.

Social sciences should be integrated with physical and ecological sciences in the planning and management processes, and by communicating with, considering, and including the public in the planning and implementation process. The following bullets are examples in the strategy to resolve the socio-political conditions and responses.

- *Develop behavioral analysis databases that utilize primary data collection techniques*. Uncertainty exists in how individuals and industries react to storms, hurricanes, and the future increasing vulnerability of the coastal area. This behavioral analysis could include investigations ranging from whether a Native American fisherman would relocate to follow the catch, to how a large industry would respond to increasing damages to pipelines. In-depth interviews and surveys would identify and quantify the risk and uncertainty related to human and industry behavior.

- *Develop spatial analysis tools in a Geographic Information System (GIS) environment that allows for project specific social and political impact assessment*. Modeling in a GIS environment would allow more refinement in identifying populations and sub-groups at risk from implementation of restoration projects. For example, issues such as environmental justice would benefit from this type of geographically refined analysis.

- *Economic Risk Assessment.* Stochastic modeling could be used to calculate the level of economic risk associated with landscape responses to various climatic probabilities (i.e. hurricanes, sea level change, and drought).

## 3.2 PLAN FORMULATION RATIONALE

In order to ensure that sound decisions are made with respect to development of alternatives and ultimately plan selection, the plan formulation process requires a systematic and repeatable approach. The Economic and Environmental Principles and Guidelines for Water and Related Land Implementation Studies (P&G) describes the USACE study process and requirements and provides guidance for the systematic development of alternative plans that contribute to the Federal objective. Alternatives should be formulated in consideration of four criteria: completeness, effectiveness, efficiency, and acceptability.

*Completeness* is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.

*Effectiveness* is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.

*Efficiency* is the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment.

*Acceptability* is the workability and viability of the alternative plan with respect to acceptance by state and local entities and the public and compatibility with existing laws, regulations, and public policies.

The first phase of the plan formulation process is the initial problem identification. The second phase is a thorough evaluation of the resources within the study area and an assessment of what currently exists within the area compared to estimates of the change in those resources over time. This evaluation, or inventorying phase, accounts for the level or amount of a particular resource that currently exists within the study, i.e. the "Existing Conditions." The phase also involves forecasting to predict what change(s) will occur to resources throughout the period of analysis, assuming no actions are taken to address the problems of marsh/land loss in Coastal Louisiana, i.e. the "Future Without-Project Conditions." Comparison of these two conditions of the study area measures the "Problems" resulting from the change in resources over time and identifies the "Needs" that must addressed as a result of the problems. Study area "Problems" and resulting "Needs" should be quantified based on this predicted change in resources. This second phase also results in the delineation of "Opportunities" that fully or partially address the "Problems and Needs" of the study area. An "Opportunity" is a resource, action, or policy that, if acted upon, may alter the conditions related to an identified problem. An example "Opportunity" is the utilization of the river for sediment delivery by diversion or dredge disposal.

The third phase is to then assess potential "Opportunities" to generate alternative solutions. Alternative plans are then formulated across a range of potential scales to demonstrate the relative effectiveness of various approaches at varying scales.

In the fourth phase, after alternative plans are developed, they must be "Evaluated" for their potential results in addressing the specific problems, needs, and objectives of the study. The measure of output is expressed by the difference in amount or effect of a resource between the "Future Without-Project" (No Action) conditions and those predicted to occur with each alternative in place (future with-project conditions). This difference is referred to as the benefits of the alternative. The LCA Study focus was on ecosystem restoration benefits, which are measured in metrics that reflect the area, productivity, and value of wetlands that are rehabilitated, restored, or maintained to the extent practicable.

The plan formulation process continues with the fifth phase, comparison of alternative plans to each other utilizing the benefit outputs and costs of the alternatives. A relationship between costs and varying levels of ecosystem restoration outputs across a full range of scales is compared.

The final phase in the process is selection of the plan that best meets the study objectives and the P&G's four criteria: completeness, effectiveness, efficiency, and acceptability.

Using the six-phase formulation process, the LCA Plan that best meets NER objectives was developed.

### 3.2.1 Objectives and Principles for Plan Formulation

In conjunction with the study constraints, two sets of strategic level principles guided the LCA Plan formulation process. The first was the USACE-adopted Environmental Operating Principles (EOPs). The second was the Study Guiding Principles for Plan Formulation (Guiding Principles). While the EOPs direct a general, strategic "way of doing business" for all USACE efforts, the Guiding Principles, developed during the first plan formulation scoping process, provide a "way of doing business" to address system-wide problems, needs, and opportunities associated with the Louisiana coastal area. At the tactical level, specific Planning Objectives were necessary to focus formulation of a plan intended to achieve specific outcomes contributing to the attainment of the overarching goal of reversing the current trend of ecosystem degradation and ultimate loss of function in the Louisiana coastal area (as indicated by points, A, B, and C in **figure MR 3-1)** . This graph demonstrates that multiple outcomes representing restoration of combined ecosystem functions are possible. The planning objectives further describe the elemental system functions that the PDT viewed as essential to reflecting successful restoration.

### 3.2.2 Planning objectives

In an effort to guide plan formulation, two tiers of tactical planning objectives were established - hydrogeomorphic and ecosystem. Concepts and features considered in this study, including freshwater diversions, sediment diversions, dedicated dredging/marsh creation, and barrier island protection, may effectively accomplish these planning objectives.

Hydrogeomorphic Objectives:

1. Establish dynamic salinity gradients that reflect natural cycles of freshwater availability and marine forcing (fluctuation related to normal daily and seasonal tidal action or exchange).
2. Increase sediment input from sources outside estuarine basins, and manage existing sediment resources within estuarine basins, to sustain and rejuvenate existing wetlands and rebuild marsh substrate.
3. Maintain or establish natural landscape features and hydrologic processes that are critical to sustainable ecosystem structure and function.

Ecosystem Objectives**:**

1. Sustain productive and diverse fish and wildlife habitats.
2. Reduce nutrient delivery to the Continental shelf by routing Mississippi River waters through estuarine basins while minimizing potential adverse effects.

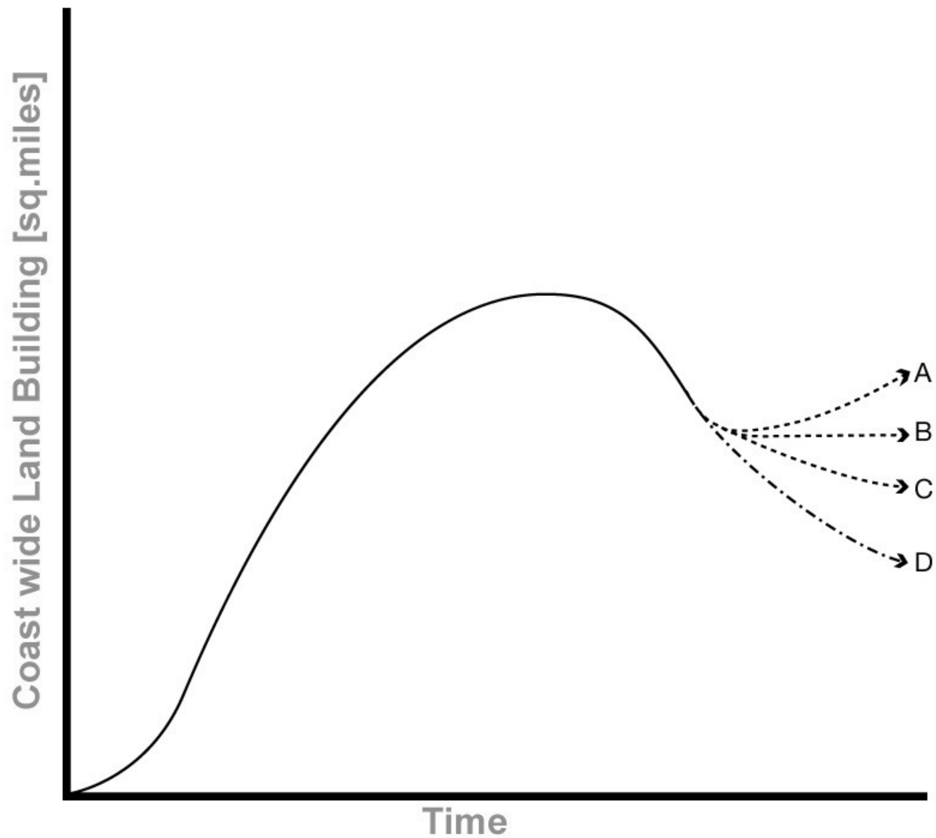


**Figure MR 3-1. Ecosystem Degradation Trend Over Time**. *The arrows represent conceptual outcomes for restoration (A, B, C) and the predicted future without-project (D).* ***(Not to scale.)***

### 3.2.2.1 Environmental operating principles

In 2002, the USACE reaffirmed its long-standing commitment to the environment by formalizing a set of EOPs applicable to decision-making in all programs. The principles are consistent with NEPA; the Department of the Army's Environmental Strategy with its four pillars of prevention, compliance, restoration, and conservation; and other environmental statutes and WRDAs that govern USACE activities. The EOPs have informed the plan formulation process and are integrated into all proposed program and project management processes. The EOPs are:

1. Strive to achieve environmental sustainability, and recognize that an environment maintained in a healthy, diverse, and sustainable condition is necessary to support life.
2. Recognize the interdependence of life and the physical environment, and proactively consider environmental consequences of USACE programs and act accordingly in all appropriate circumstances.

3. Seek balance and synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.
4. Continue to accept corporate responsibility and accountability under the law for activities and decisions under our control that impact human health and welfare and the continued viability of natural systems.
5. Seek ways and means to assess and mitigate cumulative impacts to the environment and bring systems approaches to the full life cycle of our processes and work.
6. Build and share an integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and impacts of our work.
7. Respect the views of individuals and groups interested in USACE activities, listen to them actively, and learn from their perspective in the search to find innovative win-win solutions to the Nation's problems that also protect and enhance the environment.

#### 3.2.2.2 Guiding principles

The PDT compiled the Guiding Principles for Plan Formulation in coordination with key stakeholder groups and with public comments provided during the scoping process.

1. It is evident that management of Louisiana's coast is at a point of decision. Only a concerted effort now will stem this on-going degradation, and thus alternatives must include features which can be implemented in the near-term and provide some immediate benefits to the ecosystem, as well as those which require further development and refinement of techniques and approaches.
2. Appreciation of the natural dynamism of the coastal system must be integral to planning and the selection of preferred alternatives. This should include assessing the risks associated with tropical storms, river floods, and droughts.
3. Alternatives that mimic natural processes and rely on natural cycles and processes for their operation and maintenance will be preferred.
4. Limited sediment availability is one of the constraints on system rehabilitation. Therefore, plan elements including 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, maximize use of sediment sources outside the coastal ecosystem (e.g., from the Mississippi River or the Gulf of Mexico).
5. Plans will seek to achieve ecosystem sustainability and diversity while providing interchange and linkages among habitats.
6. Future rising sea levels and other global changes must be acknowledged and incorporated into planning and the selection of preferred alternatives.
7. Displacement and dislocation of resources, infrastructure, and possibly communities may be unavoidable under some scenarios. In the course of restoring a sustainable balance to the coastal ecosystem, sensitivity and fairness must be shown to those whose homes, lands, livelihoods, and ways of life may be adversely affected by the implementation of any selected alternatives. Any restoration-induced impacts will be

consistent with NEPA in that actions will be taken to avoid, minimize, rectify, reduce, and then, only if necessary, compensate for project-induced impacts.

8. The rehabilitation of the Louisiana coastal ecosystem will be an ongoing and evolving process. The selected plan should include an effective monitoring and evaluation process that reduces scientific uncertainty, assesses the success of the plan, and supports adaptive management of plan implementation.
9. Recognizing that disturbed and degraded ecosystems can be vulnerable to invasive species, implementation needs to be coordinated with other state and Federal programs addressing such invasions, and project designs will promote conditions conducive to native species by incorporating features, where appropriate, to protect against invasion to the extent possible without diminishing project effectiveness.
10. Net nutrient uptake within the coastal ecosystem is maximized through increased residence time and the development of organic substrates, and thus project design should promote conditions that route riverine waters through estuarine basins and minimize nutrient export to shelf waters.

### 3.2.3 Coordination to Complete Plan Formulation

The plan formulation effort was conducted as a coordinated and collaborative effort involving a host of Federal and state agencies, the Louisiana academic community, and experts across the Nation. Multi-disciplinary teams have been convened to provide technical expertise and expedite review and decision-making within the plan formulation process based on the broad geographic scope of the coastal area and the complexity of aquatic ecosystem restoration efforts. The teams generally fell into one of three categories: coordination, project execution, and special. The role of each team is described in the following sections.

#### 3.2.3.1 <u>Coordination teams</u>

*Federal Principals Group* **-** A Federal Principals Group (FPG) was established to provide Washington, D.C. level collaboration among Federal agencies for the LCA Study. The FPG for the LCA Study includes regional representatives from the following:

- USEPA (Headquarters);
- Department of Interior - USFWS;
- Department of Interior - Mineral Management Service (MMS);
- Department of Commerce - NMFS;
- Department of Interior - USGS;
- Department of Agriculture - Natural Resources Conservation Service (NRCS);
- Department of Energy (DOE);
- Department of Transportation - Maritime Administration; and
- Department of Homeland Defense - Federal Emergency Management Agency (FEMA).

*Regional Working Group* **-** A Regional Working Group (RWG) was formed to support the Washington-level Federal Principal's Group and facilitate regional level collaboration and coordination on the LCA Study. The RWG membership mirrors the composition of the FPG.

*Executive Team* - An Executive Team was formed to provide executive-level guidance and support for the LCA Study. In addition, the Executive Team worked with the District Engineer on various issues throughout the LCA Study and plan formulation. The Executive Team consisted of the following members:

- District Engineer, New Orleans District, USACE
- Deputy District Engineer for Project management, New Orleans District, USCAE
- Secretary of the Louisiana DNR
- Deputy Secretary of the Louisiana DNR

*Governor's Advisory Commission on Coastal Restoration and Conservation* - By statute, the State of Louisiana recently established a Governor's Advisory Commission on Coastal Restoration and Conservation. The primary purpose of the Advisory Commission is to advise the governor and state legislature on the overall status and direction of the state's coastal restoration program.

*Framework Development Team* **-** A Framework Development Team (FDT) was formed to provide a forum for Federal interagency representatives, environmental non-governmental groups (NGOs), and State of Louisiana resource agencies to discuss LCA Study activities and technical issues.

#### 3.2.3.2 Project execution teams

*Vertical Team* - The Vertical Team (VT) was formed for the purpose of ensuring communication and coordinating activities within the USACE at the district, division, and headquarters levels. The VT has also provided guidance regarding the level of detail and overall approach for completing the LCA Study.

*Project Delivery Team (PDT)* - Execution of the LCA Study and PEIS rested primarily with the PDT. The PDT was comprised of professional personnel representing several Federal and state agencies, many of whom were "collocated" at the District office. Member agencies included the District, LDNR, USEPA, NRCS, USGS, USFWS, and NOAA.

The PDT also included researchers affiliated with Louisiana State University (LSU), the University of New Orleans (UNO), Southeastern Louisiana University (SLU), and the University of Louisiana at Lafayette (ULL), as well as various contractors.

The PDT was organized into various teams to support key elements of the planning process. The team organization was as follows:

- Public Outreach Work Group
- Goals and Objectives Work Group
- Numerical Modeling Work Group
- Desktop Modeling and Verification Work Group
- Benefits Protocol Work Group
- Environmental Impact Statement Work Group

- Institute of Water Resources (IWR) Plan Assessment Work Group
- Economics Work Group
- Real Estate Work Group
- Engineering Work Group
- Cultural/Recreational Work Group

#### 3.2.3.3 Special teams

*National Technical Review Committee* – The District formed a National Technical Review Committee (NTRC) to provide external, independent technical review of the LCA Study. The purpose of the NTRC was to ensure quality and credibility of the results of the planning process. The first seven meetings of the NTRC focused on ongoing review, comment study formulation, and plan development efforts. The NTRC held its eighth meeting to complete the review and provide comments on the LCA Study and plan development on 16–17 August 2004. Members of the NTRC included representatives from academia, the oil and gas industry, the Smithsonian Institution, and the USACE Institute for Water Resources. Each person was selected for their technical expertise in coastal geomorphology, river engineering, wetland ecology, socioeconomics, and planning.

*Independent Technical Review Team* - In coordination with the USACE Office of the Chief of Engineers Value Engineering Study Team (USACE-OVEST) and the Division, a Value Engineering/Independent Technical Review (VE/ITR) Team was established to perform an independent review of the plan formulation process and to perform an evaluation of the conclusions and recommendations of this report. Members of the VE/ITR included employees from the Jacksonville, Mobile, and Wilmington Districts.

*Office of the Chief of Engineers Value Engineering Study Team* – USACE-OVEST is a organization of the USACE that optimizes the value of programs/projects/processes by the employment of Value Engineering. The team consists of technically skilled people with a cross section of experience in construction, design, operations and maintenance (O&M), and project management. The team is also augmented with resources from throughout USACE. The VE methodology was applied at an early point in the LCA Study to assure the optimization of the scoping effort and subsequent study investigations. The VE study duration, team composition, and study outputs were adjusted to the LCA Study to produce optimum plan formulation results.

## 3.3 PLAN FORMULATION

This section summarizes the six phases of plan formulation. Each phase of the plan formulation process provided distinct results that were then used to initiate the next phase. A more detailed description of the entire plan formulation effort is available at the District upon request.

The LCA Study planning process used by the PDT evolved over two years, ultimately resulting in selection of a recommended near-term course of action. During this time, the PDT used an iterative planning process to identify and evaluate the merits of individual restoration features, the effects of combining these features into different coast wide frameworks, and ultimately the ability of these frameworks to address the most critical needs. **Table MR 3-1** highlights the purpose, decision criteria, and results of the major iterations.

Near the completion of the fifth phase of the plan formulation effort on going review of the study effort by the Vertical Team and PDT identified specific long-range uncertainties regarding the dynamic nature of the coastal ecosystem, science and technology (S&T) for implementation and model predictive capability. The Vertical Team and PDT, with guidance in the form of the Fiscal Year 2005 Federal budget, redirected the plan formulation effort towards the identification of a plan that focused on the critical restoration needs in the near-term, the next 5 to 10 years, along with investigative initiatives to provide better certainty on appropriate long-range restoration needs and activities. The PDT determined that an LCA Plan would best meet the overall study objectives through inclusion of several complementary plan components that differ in scale and time.

### 3.3.1 Phase I - Establish Planning Objectives and Planning Scales

In Phase I, the PDT developed the tactical Study Planning Objectives and planning scales for the study. The Planning Objectives were developed based on professional knowledge and extensive experience in coastal Louisiana restoration. The PDT also created planning scales to facilitate the development of different alternatives to meet the planning objectives. For the purposes of this report, the term “scale” does not refer to a specific state of the landscape. Rather, it reflects the degree to which fundamental environmental processes would be restored or reestablished, and the resulting ecosystem and landscape changes that would be expected over the next 50 years. The planning scales were developed in consideration of the tactical planning objectives and the strategic principles and established a minimum range of alternative restoration output necessary for plan formulation in each subprovince.

The PDT determined that the highest, most ambitious scale would be an annual net increase in ecosystem function. This uppermost scale, affecting an approximate 50 percent increase over no net loss, is referred to as “*Increase.*” The PDT determined that no net loss of ecosystem function would be an appropriate intermediate scale. This scale is referred to as “*Maintain.*” Reducing the projected rate of loss of function was judged to be another appropriate intermediate scale, as it is sufficiently different from the other scales and would offer an option that could provide substantial benefits over no action. This scale, achieving an approximate 50 percent reduction in the current loss rate, is referred to as “*Reduce.*” The lowest possible scale was no further action above and beyond existing projects and programs, such as CWPPRA. This scale was the basis for the No Action Alternative.

**Table MR 3-1. Major Iterations of Plan Formulation.**

| | **Iteration**<br>We started with: | **Purpose**<br>Our intent was to: | **Criteria**<br>We made decisions based on: | **Result**<br>The iteration ended with: |
|---|---|---|---|---|
| **Phase 1** | EOPs and Guiding Principles | Develop Planning Objectives and Planning Scales | • Professional judgment<br>• Extensive CWPPRA experience<br>• Scoping Comments | Planning Objectives<br>Planning Scales |
| **Phase 2** | Coast 2050 Plan<br>Section 905(b) Report | Assess broad scale strategies in 2050 Plan to identify Core Strategies for LCA Study effort | • Existing resources available in each of the four Subprovinces | LCA Core Strategies |
| **Phase 3** | LCA Core Strategies | Develop restoration features that would support LCA Core Strategies | • Planning Objectives<br>• Creating features that would meet various Planning Scales<br>• Developing features for all LCA Core Strategies | Restoration Features |
| **Phase 4** | Restoration Features | Combine Restoration Features into Subprovince Alternative Frameworks | • Need to combine Restoration Features into Alternative Frameworks that achieve different Planning Scales<br>• Need to develop significantly different Restoration Features for all LCA Core Strategies | Subprovince Frameworks |
| | Subprovince Frameworks | Create, assess, and select Coast Wide Restoration Frameworks | • Cost effectiveness (CE)<br>• Incremental Cost Analysis (ICA) | Tentative Final Array of Coast Wide Restoration Frameworks |
| **Phase 5** | Tentative Final Array of Coast Wide Restoration Frameworks | Address completeness of Coast Wide Restoration Frameworks in Tentative Final Array | • Public meeting and stakeholder comments<br>• Re-verification of CE/ICA | Final Array |
| **Phase 6** | Final Array | Identify highly cost-effective Restoration Features within the Final Array that address most critical needs | • Critical need sorting criteria<br>• Critical need assessment criteria | LCA Plan |

### 3.3.2 Phase II - Assess Restoration Strategies from the Coast 2050 Plan

The PDT, in conjunction with the Vertical Team and FDT, reviewed the Coast 2050 Plan and the LCA Section 905(b) reconnaissance report (for which the Coast 2050 Plan was the basis). These plans are described in Attachment 2, Prior Studies, Reports and Existing Water Projects. These reports identified problems in both the current and future coastal landscape and laid out 93 broad-scale strategies for addressing ecosystem restoration. Strategies in the context of the Coast 2050 and 905(b) reports often translate directly to restoration projects. However, since many of the 93 strategies in these documents represented common restoration methods, the strategies captured for incorporation in the LCA plan formulation effort represent those most common or "core" restoration methodologies identified both coast wide and in each subprovince.

Overall, the strategies would describe methods to accomplish:

- Creation and sustenance of wetlands through input and accumulation of sediment;
- Maintenance of estuarine and wetland salinity gradients for habitat diversity; and
- Maintenance of ecosystem linkages for the exchange of organisms and system energy.

Because these accomplishments were very similar to the tactical planning objectives developed in Phase I, the PDT assessed the 93 broad-scale strategies to determine common methodologies for effecting restoration of wetland and system functions. As part of this study, the PDT identified a smaller subset of core strategies for coastal restoration efforts in the four subprovinces.

For Subprovince 1, the core restoration strategies included basin-wide freshwater reintroduction and salinity control. Reintroductions were selected because of the readily available freshwater resource, the Mississippi River. Because of its function as a conveyance of saline water into the central portion of the subprovince, the closure or constriction of the existing MRGO navigation project was identified as a potentially significant component of the salinity control strategy.

For Subprovince 2, the core restoration strategies included: sustaining barrier islands, headlands, and shorelines; managing the available sediment of the Mississippi River; freshwater introduction; Mississippi River water and sediment introduction via the formation of a new delta; and preserving land bridges within the Barataria Basin.

For Subprovince 3, the core restoration strategies included: restoring Terrebonne / Timbalier barrier islands; rebuilding land in eastern Terrebonne Basin; modifying the Old River Control Complex operation scheme to increase sediment input to the Atchafalaya River; Mississippi River water and sediment introduction via the formation of a new delta; and management of Atchafalaya River freshwater, sediment, and nutrients.

In the Chenier Plain (Subprovince 4), there are no excess riverine resources available to promote land building and to control salinities in the estuarine system. As such, the core strategy for this subprovince is the control of estuarine salinities through the management of rainfall and runoff inputs to the system and the management of existing hydrologic structures and geomorphic features.

### 3.3.3 Phase III - Develop and Evaluate Restoration Features

In Phase III, the PDT developed 166 potential restoration features that would support the restoration strategies identified for each of the subprovinces in Phase II and that would achieve some level of the planning scales identified in Phase I. The term feature is used to describe any specific restoration project or defined collection of structural and non-structural elements combined to affect a wetland restoration action. Features represent the specific solutions for which costs were developed and from which restoration plans, or "frameworks", would be created. The term framework will be used to describe an assemblage of features developed to produce a discreet, cohesive, logical plan for achieving systemic restoration within a definable hydrologic or ecologic area.

The intent of this effort was to provide an initial identification of the most effective frameworks for meeting the overarching study objectives in concert with key strategies in each subprovince. Within this context, in addition to the programmatic nature of the NEPA documentation, the potential restoration features are intended to be representative of the most promising restoration actions and plan combinations for planning purposes. These features provide a basis for estimating costs and potential benefits and provide a starting point for identifying the most efficient framework combinations, most effective steps for addressing critical ecosystem needs, and estimating the overall cost of the ultimate implementation effort. The final refinement of feature scale and location is intended to be addressed in decision documents subsequent to the approval of this report. In developing the restoration features, the PDT took advantage of the extensive experience gained from other coastal restoration efforts, such as CWPPRA.

Preliminary costs and estimates regarding the potential for each feature to modify ecosystem functioning were based on experience and insight gained through the execution of the CWPPRA program, along with professional judgment and the best available information. The fourteen years of effort in project development and design under the CWPPRA program, along with design work completed under other Federal and state programs, provided an extensive base of design information to build on with basic component costs developed in the CWPPRA Engineer Work Group. Detailed documentation of the design assumptions, feature level of detail, and the development of the cost estimates are available at the District. The result of this phase was a "tool box" of restoration features for each subprovince, including features that addressed freshwater reintroduction (diversion), sediment diversion, hydrologic restoration, hydrologic modification, land acquisition, interior shoreline protection, barrier island and barrier headland restoration, and marsh creation and restoration. **Table MR 3-2** lists the number of features for each subprovince and categorizes them by feature type.

In addition, the PDT developed features whose implementation would result in varying levels of ecosystem function restoration. This exercise provided the PDT with similar features in some of the subprovinces, particularly in Subprovinces 1 and 2, that would address the reduce, maintain, and increase planning scales. For example, of the 21 freshwater reintroduction features identified for Subprovince 1, the PDT developed small, medium, and large freshwater diversion features to influence the same geographic area. Each of the diversions would result in a different level of ecosystem function restoration, and thus each would be more or less appropriate to satisfy a particular planning scale (i.e., a small freshwater diversion may or may not achieve the "increase" planning scale, whereas a large freshwater diversion in the same area would be more likely to achieve the "increase" scale).

The composition of restoration features (e.g., beneficial use of dredged materials, sediment diversion, etc.) developed for each subprovince was largely guided by the need to implement the restoration strategies previously identified in Phase II. For example, in Subprovinces 1 and 2, freshwater reintroduction was a restoration strategy. As such, the composition of restoration features for those subprovinces weighs heavily in favor of freshwater reintroductions because of the presence of an available resource, the Mississippi River. Careful examination of the distribution of restoration features developed in each subprovince can identify the nature of the ecosystem function in the area. Areas with or adjacent to abundant freshwater resources present ample diversion opportunities (i.e., Deltaic Plain) while areas with limited riverine resources (i.e., Chenier Plain) tend to provide more focus on preservation and management.

**Table MR 3-2. Types of Restoration Features by Subprovince.**

| Restoration Feature | Subprovince 1 | Subprovince 2 | Subprovince 3 | Subprovince 4 |
|---|---|---|---|---|
| Freshwater Reintroduction (Diversion) | 21 | 30 | 1 | |
| Sediment Diversion | 21 | 18 | 1 | |
| Dedicated Dredging and Beneficial Use / Marsh Creation and Restoration | 12 | 4 | 1 | 1 |
| Salinity Control | 1 | | 2 | 16 |
| Structure Modification (Hydrologic Restoration) | 4 | 1 | | |
| Hydrologic Modification (Hydrologic Restoration) | 1 | | 12 | 4 |
| Land Acquisition | 1 | | | |
| Barrier Island, Barrier Headland, and Interior Shoreline Protection and Restoration | 1 | 1 | 10 | 2 |
| Subprovince Totals | 62 | 54 | 27 | 23 |
| Total Number of Restoration Features for All Subprovinces | 166 | | | |

As a final step in Phase III, the PDT made initial assessments of the positive, negative, or neutral fit of the features to address the planning objectives established for the study. This positive, negative, or neutral assessment was also made for each feature against a broad range of resources. These assessments were used to identify strengths and weaknesses of features and as a basis for including them in appropriate subprovince frameworks in Phase IV.

### 3.3.4 Phase IV - Develop and Evaluate Subprovince Frameworks

#### 3.3.4.1 Development of subprovince frameworks

In Phase IV, the PDT created multiple frameworks, for each subprovince. It then evaluated the outputs and benefits of each subprovince framework using hydrodynamic and ecological models and benefit assessment protocols described in this section.

Since the resolution level and other capabilities of the available hydrodynamic and ecologic modeling system precluded adequate assessments of the effects of individual features in discreet increments, the analysis focused on combinations of features. This approach provided a basis for identifying the features that are the most likely to be effective and therefore should be included in the LCA ecosystem restoration plan. More detailed evaluations of individual features can be performed to support decisions to implement each of the features.

The combinations of restoration features in subprovince frameworks were guided by two requirements: 1) the need to combine restoration features to achieve various levels of planning scales in the subprovince, and 2) the need to develop appreciably different frameworks in each subprovince that would provide alternative planning approaches.

The PDT accomplished the second requirement with the use of restoration "approaches" that it created for each subprovince. By using different approaches to achieving restoration inside a subprovince, the PDT was able to develop appreciably different combinations of restoration features, and, in turn, an appreciably different set of frameworks. . For example, in Subprovince 1, the PDT identified "minimize salinity change" and "continuous [freshwater] reintroduction" as two different restoration approaches. The mix of restoration features in a framework to accomplish the "minimize salinity change" restoration approach would likely be one with few freshwater reintroduction features and/or where freshwater reintroduction features would be relatively small to medium. On the other hand, a mix of restoration features in a framework to accomplish the "continuous [freshwater] reintroduction" restoration approach would likely be one that relied heavily on freshwater reintroduction features, including features that would be relatively large. Restoration approaches for each subprovince are listed below:

Subprovinces 1 and 2

- Minimize Salinity Changes
- Continuous Reintroduction (w/Stage Variation)
- Mimic Historic Hydrology

Subprovince 3

- Rehabilitation/maintenance of geomorphic features
- Land Building by Delta Development
- Maximize Mississippi and Atchafalaya Flows

Subprovince 4

- Large-scale Salinity Control
- Perimeter Salinity Control
- Freshwater Introduction Salinity Control

To prevent the analysis of alternative frameworks from becoming overly complex, a maximum of nine frameworks were developed for each subprovince, with three frameworks for each planning scale (increase, maintain, and reduce). Around each planning scale a framework was developed based on the restoration approaches for that sub-province. . Subprovince 1, for example, contained 3 frameworks designed to increase ecosystem function based on minimizing salinity changes (E1), continuous reintroduction of freshwater (E2), and mimicking historic hydrology (E3). Of the 166 available restoration features in the toolbox, only 111 were found necessary to meet the criteria stated above in formulating the subprovince frameworks.

During Phase V of plan formulation, the PDT developed a reasonable, "supplemental" framework for each subprovince, the process and rationale of which is presented in the Phase V summary. To ensure that this Phase IV summary identifies all subprovince frameworks that were evaluated in this study, the supplemental framework for each subprovince is included in the total count of subprovince frameworks, described below. A total of 32 subprovince frameworks were developed and evaluated in this study in addition to the no-action alternative for each Subprovince. The individual features that make up each subprovince framework are identified in **tables MR 3-3** through **MR 3-6.** Full detailed descriptions of subprovince frameworks are available upon request through the New Orleans District office.

| **Subprovince Frameworks** |
| --- |
| Subprovince 1 = 10 Frameworks |
| Subprovince 2 = 10 Frameworks |
| Subprovince 3 = 5 Frameworks |
| Subprovince 4 = 7 Frameworks |

For Subprovince 1, there were a total of ten frameworks: three "reduce" (R); three "maintain" (M); and three "increase" (E); and the supplemental framework (N) (**table MR 3-3**). For Subprovince 2, there were a total of ten frameworks: three "reduce" (R); three "maintain" (M); three "increase" (E); and the supplemental framework (N) (**table MR 3-4**). For Subprovince 3, there were a total of five frameworks: three "reduce" (R); one "maintain" (M); and the supplemental framework (N) (**table MR 3-5**). For Subprovince 4, there were a total of seven frameworks: three "maintain" (M); three "increase" (E); and the supplemental framework (N) (**table MR 3-6**).

**Table MR 3-3. Subprovince 1 Frameworks.**

| Restoration Features | R1 | R2 | R3 | M1 | M2 | M3 | E1 | E2 | E3 | N1 |
|---|---|---|---|---|---|---|---|---|---|---|
| 15,000 cfs diversion at American/California Bay | | | | x | | | x | x | | |
| 110,000 cfs diversion (div.) at American/California Bay with sediment enrichment | | | x | | x | | | | | x |
| 250,000 cfs div. at American/California Bay with sediment enrichment | | | | | | x | | | x | |
| 12,000 cfs div. at Bayou Lamoque | | x | x | | x | x | | x | x | x |
| 5,000 cfs div. at Bonnet Carre Spillway | x | x | | x | | | | | | |
| 10,000 cfs div. at Bonnet Carre Spillway | | | | | | x | x | x | x | |
| 200,000 cfs div. at Caernarvon w/ sediment enrichment | | | | | | | | x | | |
| 1,000 cfs div. at Convent/Blind River | | | x | | | x | | | x | |
| 5,000 cfs div. at Convent/Blind River | | x | | | x | | x | | | x |
| 10,000 cfs div. at Convent/Blind River | | | | | | | | x | | |
| 15,000 cfs div. at Fort St. Philip | | | x | x | | | x | | | |
| 26,000 cfs div. at Fort St. Philip w/ sediment enrichment | | | | | | x | | | | |
| 52,000 cfs div. at Fort St. Philip w/ sediment enrichment | | | | | | | | | x | |
| 1,000 cfs div. at Hope Canal | x | x | x | x | x | x | | | x | x |
| 1,000 cfs div at Reserve Relief Canal | | | | | | | | | x | |
| 6,000 cfs div at White's Ditch | | | | | | | x | | | |
| 10,000 cfs div. at White's Ditch | | x | x | | x | x | | | x | x |
| Sediment delivery by pipeline at American/California Bays | | | | x | | | x | | x | |
| Sediment delivery via pipeline at Central Wetlands | x | | | x | | | x | | | |
| Sediment delivery via pipeline at Fort St. Philip | | | | x | | | x | | | |
| Sediment delivery via pipeline at Golden Triangle | | | | | | | x | | | |
| Sediment delivery via pipeline at La Branche | x | | | x | | | x | | | x |
| Sediment delivery via pipeline at Quarantine Bay | x | | | | | | x | | | |
| Authorized opportunistic use of the Bonnet Carre Spillway | | | | | | | | | | x |
| Increase Amite River Diversion Canal influence by gapping banks | | | | | | | | | | x |
| Marsh nourishment on the New Orleans East land bridge | | | | | | | | | | x |
| Mississippi River Delta Management Study | | | | | | | | | | x |
| Mississippi River Gulf Outlet Environmental Restoration Features | | | | | x | | x | | | x |
| Modification of operation of the Caernarvon freshwater diversion. (optimize for marsh creation) | | | | | | | | | | x |
| Rehabilitate Violet Siphon and post authorization for the diversion of water through Inner Harbor Navigation Canal for increased influence into Central Wetlands | | | | | | | | | | x |

*Note: R = Reduce; M = Maintain; E = Increase; N = Supplemental; Approaches: 1 = Minimize salinity change; 2 = Continuous reintroduction; 3 = Mimic historic hydrology.*

**Table MR 3-4. Subprovince 2 Frameworks.**

| Restoration Features | R1 | R2 | R3 | M1 | M2 | M3 | E1 | E2 | E3 | N1 |
|---|---|---|---|---|---|---|---|---|---|---|
| 5,000 cfs diversion (div.) at Bastian Bay/Buras | | | x | | | | | | | |
| 130,000 cfs div. at Bastian Bay/Buras | | x | | | | | | | | |
| 120,000 cfs div. near Bayou Lafourche | | | | | | | | | x | |
| 60,000 cfs div. at Boothville w/ sediment enrichment. | | | | | | | | | | x |
| 1,000 cfs div. at Donaldsonville | | x | x | | x | x | | | | x |
| 5,000 cfs div. at Donaldsonville w/ sediment enrichment | | | | | | | | x | | |
| 1,000 cfs div. at Edgard | | x | x | | x | x | | | | x |
| 5,000 cfs div. at Edgard w/ sediment enrichment | x | | | | | | | x | | |
| 5,000 cfs div. at Empire | | | x | | | | | | | |
| 90,000 cfs div. at Empire | | | | | | | | x | | |
| 5,000 cfs div. at Fort Jackson | | | x | | | | | | | |
| 60,000 cfs div. at Fort Jackson | x | | | x | | | | | | |
| 60,000 cfs div. at Fort Jackson w/ sediment enrichment | | | | | | x | x | x | | |
| 90,000 cfs div. at Fort Jackson w/ sediment enrichment | | | | | | | | | x | |
| 150,000 cfs div. at Fort Jackson w/ sediment enrichment | | | | | x | | | | | |
| 1,000 cfs div. at Lac Des Allemands | | x | | | x | x | | | | x |
| 5,000 cfs div. at Lac Des Allemands w/ sediment enrichment | | | | x | | | x | x | x | |
| 5,000 cfs div. at Myrtle Grove | x | | x | x | | | x | | | x |
| 15,000 cfs div. at Myrtle Grove | | x | | | | | | | | |
| 38,000 cfs div. at Myrtle Grove w/ sediment enrichment | | | | | x | | | | | |
| 75,000 cfs div. at Myrtle Grove w/ sediment enrichment | | | | | | x | | | | |
| 150,000 cfs div. at Myrtle Grove w/ sediment enrichment | | | | | | | | x | | |
| 5,000 cfs div at Oakville | | | x | | | | | | | |
| 1,000 cfs div. at Pikes Peak | | x | x | | x | x | | | | x |
| 5,000 cfs div. at Pikes Peak w/ sediment enrichment | | | | | | | | x | | |
| 5,000 cfs div. at Port Sulphur | | | x | | | | | | | |
| Barataria Basin barrier shoreline restoration | x | x | x | x | x | x | x | x | x | x |
| Implement the LCA Barataria Basin Wetland Creation and Restoration Study | x | | | x | | | x | | x | x |
| Mississippi River Delta Management Study | | | | | | | x | | x | x |
| Modification of operation of Davis Pond diversion | | | | | | | | | | x |
| Sediment delivery via pipeline at Bastian Bay | | | | x | | | x | | | |
| Sediment delivery via pipeline at Empire | | | x | x | | | x | | | |
| Sediment delivery via pipeline at Head of Passes | | | | x | | | x | | | |
| Sediment delivery via pipeline at Myrtle Grove | x | | | x | | | x | | | x |
| Third Delta (120,000 cfs diversion) | | | | | | | | | | x |

*Note: R = Reduce; M = Maintain; E = Increase; N = Supplemental; Approaches: 1 = Minimize salinity change; 2 = Continuous reintroduction; 3 = Mimic historic hydrology.*

**Table MR 3-5. Subprovince 3 Frameworks.**

| Restoration Features | R1 | R2 | R3 | M1 | | | | | | N1 |
|---|---|---|---|---|---|---|---|---|---|---|
| Backfill pipeline canals | | | x | x | | | | | | |
| Bayou Lafourche 1,000 cfs pump | x | x | | x | | | | | | x |
| Convey Atchafalaya River water to northern Terrebonne marshes | x | | x | x | | | | | | x |
| Freshwater introduction south of Lake De Cade | x | x | | x | | | | | | |
| Freshwater introduction via Blue Hammock Bayou | x | x | | x | | | | | | x |
| Increase sediment transport down Wax Lake Outlet | x | x | | x | | | | | | x |
| Maintain land bridge between Bayous du Large and Grand Caillou | x | | x | x | | | | | | x |
| Maintain land bridge between Caillou Lake and Gulf of Mexico. | | | x | x | | | | | | x |
| Maintain northern shore of East Cote Blanche Bay at Pt. Marone | | | x | x | | | | | | x |
| Maintain Timbalier land bridge | | | x | x | | | | | | |
| Multipurpose operation of the Houma Navigation Canal (HNC) Lock. | x | x | x | x | | | | | | x |
| Optimize flows and Atchafalaya River influence in Penchant Basin | x | x | x | x | | | | | | x |
| Rebuild historic reefs –Rebuild historic barrier between Point Au Fer and Eugene Island | x | x | x | x | | | | | | |
| Rebuild historic reefs – Construct segmented reef/breakwater/jetty along the historic Point Au Fer barrier reef from Eugene Island extending towards Marsh Island to the west | x | x | x | x | | | | | | |
| Acadiana Bays Estuarine Restoration | | | x | x | | | | | | x |
| Rehabilitate northern shorelines of Terrebonne/Timbalier Bays | | | x | x | | | | | | |
| Relocate the Atchafalaya navigation channel | x | x | | x | | | | | | x |
| Restore Terrebonne barrier islands. | | | x | x | | | | | | x |
| Stabilize banks of Southwest Pass | | | x | x | | | | | | |
| Stabilize gulf shoreline of Point Au Fer Island | | | x | x | | | | | | x |
| Alternative operational schemes of the Old River Control Structure (ORCS) operational scheme | x | x | | x | | | | | | x |
| Third Delta (120,000 cfs diversion) | | x | | x | | | | | | |

*Note: R = Reduce; M = Maintain; N = Supplemental; Approaches: 1 = Rehabilitation/maintenance of geomorphic features; 2 = Land-building by delta development; 3 = Maximize Mississippi and Atchafalaya flows.*

**Table MR 3-6. Subprovince 4 Frameworks.**

| Restoration Features | | | | M1 | M2 | M3 | E1 | E2 | E3 | N1 |
|---|---|---|---|---|---|---|---|---|---|---|
| Black Bayou bypass culverts | | | | | | | | | | x |
| Calcasieu Pass lock | | | | x | | | x | | | |
| Calcasieu Ship Channel beneficial use | | | | x | x | x | x | x | x | x |
| Chenier Plain freshwater and sediment management and allocation reassessment. | | | | | | | | | | x |
| Dedicated dredging for marsh restoration | | | | | x | x | | x | x | |
| East Sabine Lake hydrologic restoration | | | | | x | | | x | | x |
| Freshwater introduction at Highway 82 | | | | x | x | x | x | x | x | x |
| Freshwater introduction at Little Pecan Bayou | | | | x | x | x | x | x | x | x |
| Freshwater introduction at Pecan Island | | | | x | x | x | x | x | x | x |
| Freshwater introduction at Rollover Bayou | | | | x | x | x | x | x | x | x |
| Freshwater introduction at South Grand Chenier | | | | x | x | x | x | x | x | x |
| Freshwater introduction via Calcasieu lock and Black Bayou culverts | | | | | | x | | | x | |
| Gulf shoreline stabilization | | | | | x | | x | x | x | x |
| Modify existing Cameron-Creole watershed control structures | | | | | x | | | x | | x |
| New lock at the GIWW | | | | | x | | | x | | |
| Sabine Pass lock | | | | x | | | x | | | |
| Salinity control at Alkali Ditch | | | | | x | | | x | | x |
| Salinity control at Black Bayou | | | | | x | | | x | | x |
| Salinity control at Black Lake Bayou | | | | | x | | | x | | x |
| Salinity control at Highway 82 Causeway | | | | | x | x | | x | x | x |
| Salinity control at Long Point Bayou. | | | | | x | | | x | | x |
| Salinity control at Oyster Bayou | | | | | x | | | x | | x |

*Note: M = Maintain; E = Increase; N = Supplemental; Approaches: 1 = Large-scale salinity control; 2 = Perimeter salinity control; 3 = Freshwater introduction salinity control.*

### 3.3.4.2 Evaluation of subprovince frameworks

The four subprovinces in the LCA represent the appropriate area for evaluating and comparing specific hydrodynamic and ecologic functions. In order to evaluate the outputs and benefits of a particular subprovince framework, the PDT employed hydrodynamic and ecological models, benefit protocols, and agency and academic expertise to generate baseline information about the effects of the combinations of restoration features. Outputs and benefits evaluated by the PDT included measures of ecosystem function and response such as: land building, habitat switching, primary productivity of land and water, removal of nitrogen from Mississippi River water; and habitat use of wetlands by 12 coastal species. The outputs/benefits covered an array of ecosystem attributes and functions, and they provided a means of comparing complex patterns, both in space and time, of ecosystem change. All benefits were expressed relative to the No Action Alternative. A detailed description of the use of hydrodynamic and ecologic models, as well as the benefit protocols, to evaluate subprovince frameworks can be found in appendix C HYDRODYNAMIC AND ECOLOGICAL MODELING.

*Land Building* - This benefit assessment protocol measured the achievement of the subprovince framework in creating and preserving land (e.g., wetlands, barrier islands, and ridges) after 50 years. The measurement for land building was expressed in acres.

*Habitat Switching* - This benefit assessment protocol measured ecosystem response after 50 years by determining the conversion of wetland habitats from one type into another type, including open water. For example, freshwater reintroductions in a subprovince may result in the wetland habitat composition for the subprovince to switch to a composition where there was a greater percentage of freshwater marsh after 50 years. The measurement for habitat switching was expressed as change of habitat type in acres.

*Primary Productivity of Land and Water* - This benefit assessment protocol measured the change in primary productivity of land and water after 50 years. The PDT used the results from this benefit protocol and the Habitat Use benefit protocol, described below, to gauge the quality of the wetland habitats after 50 years. The measurement for primary productivity of land and water was expressed in terms of an index of composite plant productivity across the range of habitat types in the system.

*Removal of Nitrogen from the Mississippi River*_ - This benefit assessment protocol assessed the amount of nitrogen removed from the Mississippi River by the subprovince framework in tons per year. This assessment provided the PDT with information on how well a particular subprovince alternative would help address the hypoxia problem in the gulf. The measurement for removal of Nitrogen from the Mississippi River was expressed as a percentage of nutrients removed.

*Habitat Use* - This benefit assessment protocol measured the fish and wildlife habitat value for each marsh habitat type after 50 years. The PDT assessed habitat use for 12 coastal species, including: white shrimp, brown shrimp, oyster, gulf menhaden, spotted seatrout, Atlantic croaker, largemouth bass, American alligator, muskrat, mink, otter, and dabbling ducks. The 12 species were chosen because they provide the best representation of the ecologically diverse productivity of the coastal system. This assessment provided the PDT with information on the relative abundance of preferred habitats for the 12 coastal species in response to implementation of a subprovince framework. The measurement for habitat use was expressed in habitat units (HU).

The benefits were calculated for each of the subprovince frameworks and the end result was costs and benefits associated with each framework.

### 3.3.5 Phase V - Select a Final Array of Coast Wide Frameworks that Bests Meets the Planning Objectives

The subprovince frameworks developed by the PDT and evaluated through the ecologic models provided the basis for developing larger coast wide restoration frameworks. The creation of these coast wide frameworks was based on identifying the optimal combinations of the subprovince frameworks. Due to the fact that Subprovinces 1 through 3 share many of the same restoration resources, the PDT determined that these subprovince frameworks would need to be combined in a manner that determine the best allocation of resources while achieving the largest environmental benefits. Within the Deltaic Plain (Subprovinces 1 to 3), the availability of river water and sediment served to limit the number of possible combinations. There were no such limiting factors for the Chenier Plain, therefore any of the Subprovince 4 frameworks could be combined with any combination of the Subprovinces 1 to 3 frameworks. In addition a key difference in basic system function between the deltaic and Chenier Plains required that different benefit metrics be used. This allowed some simplification of the coast wide framework development process since the Subprovince 4 frameworks could be independently optimized. Therefore, combinations of frameworks in Subprovinces 1 to 3 were developed independently from the Chenier Plain frameworks.

The PDT used the IWR-Plan computer program (Version 3.3, USACE) to create and compare coast wide frameworks, which were composed of a framework from each subprovince. This automated program grouped the 32 subprovince frameworks and no-action alternatives into thousands of different combinations. The program then performed a cost effectiveness and incremental cost analysis (CE/ICA) using the outputs/benefits and the estimated costs that had been previously developed in the initial plan formulation phases.

#### 3.3.5.1 Cost effectiveness/incremental cost analysis

The Study developed and evaluated alternative coast wide frameworks formulated to preserve coastal habitat and functions. The benefits of the various frameworks were defined in non-monetary units, as previously described. Benefits for most of the study area were evaluated using a qualitative and quantitative metric that assessed each alternative's contribution to the stock of natural resources. In the Chenier Plain portion of the study area, benefits were measured more simply in acres of land preserved or restored. Since these feature outputs were not readily translatable to dollar terms, traditional monetary benefit-cost analysis could not be performed. Consequently, the use of the CE/ICA method was selected for the comparison of ecologic output benefits versus costs.

In the cost effective analysis, the combined weighted ecologic outputs, provided by the ecologic models and benefit assessment protocols described in the previous section, were documented for each coast wide framework. The combined weighted outputs and costs for each framework were also displayed and ordered by level of benefit. The primary factors of interest were ecological benefit versus cost. Detailed discussion of this portion of the analysis is available upon request through the New Orleans District office.

The coast wide frameworks were then assessed according to their ability to produce benefits for a given cost level. The result was a listing of coast wide frameworks that would achieve each benefit level at the lowest cost. A theoretical line, or an "efficient frontier", was developed to show those restoration frameworks with the lowest cost to benefit ratios. Restated, alternative frameworks screened in this manner met these two criteria: (1) no other solution produces the same level of benefit for less cost, and (2) no other framework provides more benefit for the same or less cost.

The cost-effectiveness assessment and identification of the efficient frontier was followed by an incremental cost analysis. Incremental cost is the additional cost for each increase in the level of output. Changes in incremental costs, combined with other selection criteria discussed below, facilitated a process of evaluating the desirability of implementing the remaining plans in the absence of a strict guideline for determining the best outcome (such as maximizing net benefits, as is done in NED analysis

#### 3.3.5.2 Development of the tentative final array for the Deltaic Plain

Following an initial CE/ICA analysis, the alternative framework selection process continued by applying three additional criteria to cost-effective coast wide frameworks. These criteria were developed to aid in identifying the point along the efficient frontier where coast wide frameworks could be anticipated to produce broad enough systemic benefits as to provide qualitative certainty of completeness. The three criteria were:

1. Alternative frameworks were limited to those that reduced land loss by at least one half of the current rate (based on 1990 to 2000 land loss data) of -24 $mi^2$/yr to -10 $mi^2$/yr. Reducing land loss by this amount would greatly contribute to the reduction of land loss as a result of ongoing restoration efforts.
2. Alternative frameworks were evaluated for their potential to provide storm surge protection across the coast (i.e., in all subprovinces), as well as for their potential to impact the navigation industry.
3. Alternative frameworks were assessed for their potential to add environmentally important features, such as barrier islands or a Third Delta feature, in subsequent implementation phases.

The first criteria simply assured that the frameworks identified would exceed the beneficial level that could be attained through current restoration programs. These programs have been identified as being capable of achieving only a fraction of the necessary restoration outputs. The second criteria sought to assure an adequate distribution of restoration measures by qualitatively identifying the relative damage risk to damage reduction potential. The comparison of spatially fixed investment versus potential wetland restoration effect allowed a qualified judgment of wetland restoration completeness versus relative use. The third criteria simply assessed and assured that important system needs or restoration opportunities were not being systematically overlooked as an artifact of the subprovince framework assemblages.

During this stage of the framework selection process, the PDT evaluated the frameworks that formed the cost-efficient frontier based on the above criteria and eliminated several of the frameworks from further consideration. Some cost-effective frameworks were eliminated because they did not provide comprehensive potential for coast wide restoration. Those cost-effective alternative frameworks that met the criteria occurred at approximately the point in the cost-effective curve at which the cost per unit benefit begins to rise rapidly. The CE/ICA software generates a numbered labeling to specifically identify the analyzed framework combinations these numbers will be used throughout the remainder of the report to refer to the cost effective or tentatively selected coast wide frameworks. Frameworks 5110, 7002, 7410, and 7610 represent those cost effective combinations that define the upper limit of the cost effective frontier. Framework 7002 represented the terminal point of the cost-efficient frontier shown in **figure MR 3-2**. However, upon review of these frameworks, the PDT identified several environmentally important features that were not included in or addressed by any of the cost-effective frameworks on the curve.

It was determined that additional frameworks near the cost-effective curve, particularly near the point of rapidly increasing unit cost, could fall within the limits of confidence, and as such could be considered in the final array. These additional frameworks would provide more completeness to a final array of restoration solutions. Beginning at the previously identified location on the cost-effective curve, the PDT began investigating other frameworks adjacent to the cost-efficient frontier that included important features not in the cost-effective framework combinations. A number of additional frameworks were identified that addressed the identified important features such as the barrier islands in Subprovince 3. These additional frameworks (5410 and 5610) were grouped with the remaining cost-effective frameworks to form a tentative final array. The six frameworks in the tentative final array for the Deltaic Plain were 5110, 5410, 5610, 7002, 7410, 7610 and 7002. As indicated above framework 7002 is the terminal, or maximum output framework. This framework has been included in the tentative final array as a representation of the required incremental level of investment necessary to achieve the maximum level of beneficial output. **Figure MR 3-3** graphically displays the Plan Formulation Process from Phase III through the initial CE/ICA analysis.

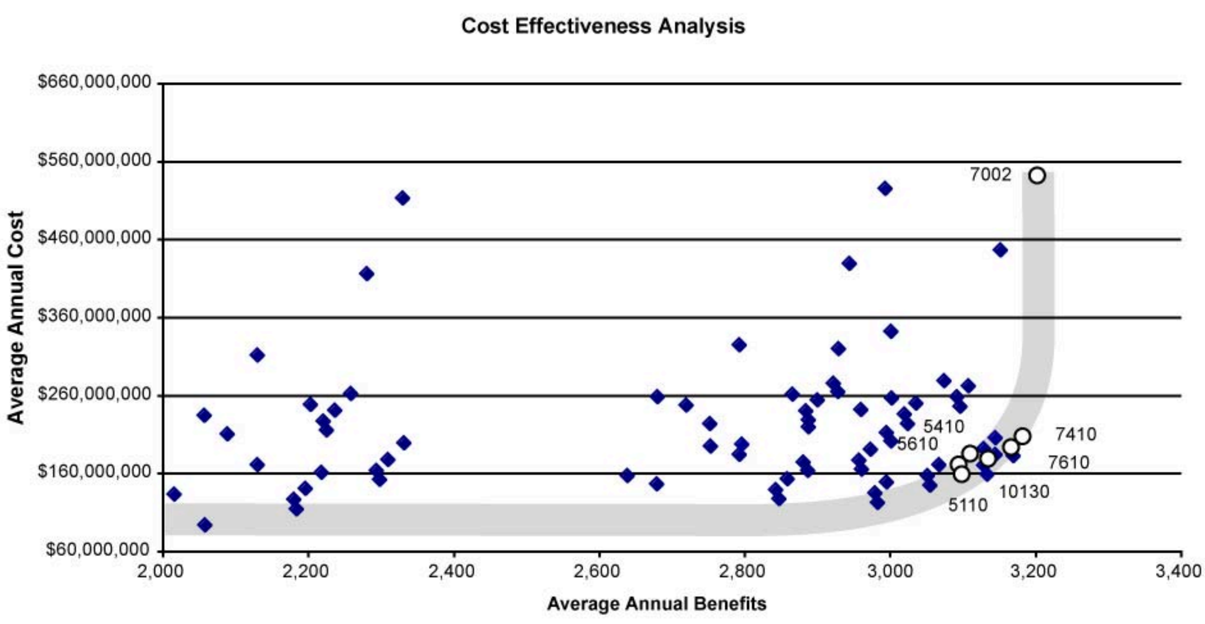


**Figure MR 3-2. Preliminary Average Annual Costs and Average Annual Benefits for the Final Array of Alternative Frameworks for Subprovinces 1 to 3.** *Note: the gray line denotes the cost efficient frontier.*

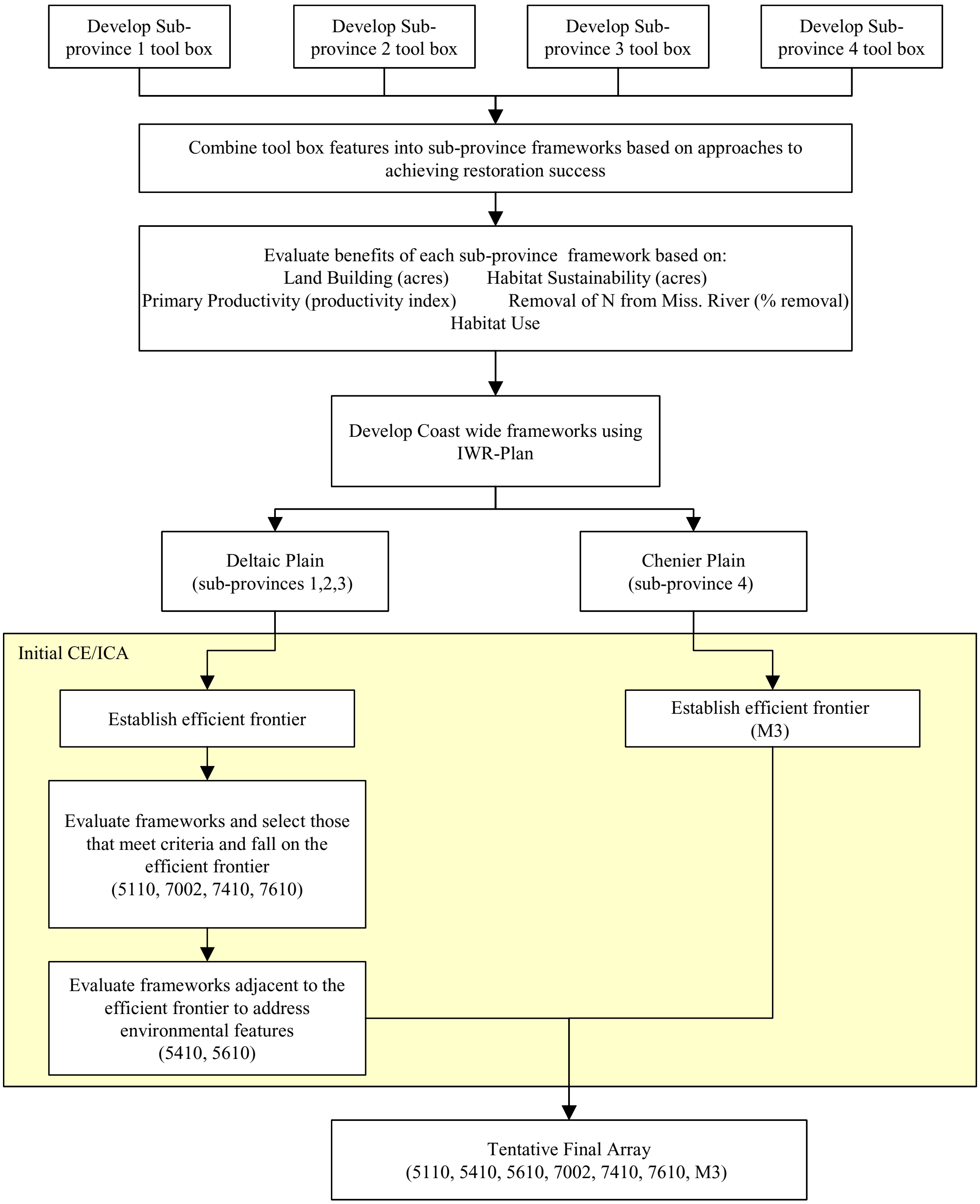


**Figure MR 3-3. Plan formulation and framework selection process: Phase III through initial CE/ICA analysis**

#### 3.3.5.3 **Development of supplemental frameworks to address completeness of final array for the Deltaic Plain**

The vertical team, executive team, and individual members of the framework development team, reviewed the cost-effectiveness analysis and the PDT effort in developing the tentative final array. Following this review, the executive team directed the PDT to develop two supplemental frameworks to attempt to further address the criteria of incorporating environmentally important features. A second framework was desired to further assess the viability of incorporating large-scale features and the possibility of producing additional frameworks to redefine the upper limit of the efficient frontier. These frameworks were also intended to address the completeness of the final array since the tentative frameworks identified by the initial analysis omitted a number of larger-scale features that were viewed as potentially critical to long-range success. The output from the ecological modeling and the experience gained from that effort provided valuable insight regarding plan effectiveness. The results of that effort were reviewed to determine what specific restoration features might be introduced to create a more complete and effective framework.

The PDT reviewed the features, model outputs, and framework components for each subprovince. At the conclusion of this effort, the PDT assembled the two supplemental frameworks (N1 and N2), which were predominantly based on framework 5610. These two supplemental frameworks were identical, except that the second supplemental framework (N2) contained the large-scale Third Delta feature. Once the features of the supplemental frameworks were identified, preliminary costs and benefits were developed for the supplemental frameworks in a manner consistent with the previously analyzed coast wide frameworks. The data were incorporated into the IWR-Plan database. A second iteration of the CE/ICA was run to determine the position of the two supplemental frameworks relative to the existing cost-efficient frontier.

The CE/ICA analysis revealed that supplemental framework N1 created fewer benefits at similar cost than those in the efficient frontier. The second supplemental framework, N2, created slightly more output, but at a significantly increased incremental cost than the tentative final array of frameworks. Neither framework plotted within the optimal range of the existing tentative final array of frameworks. In addition a review of the features included in the second supplemental framework revealed that several of the diversion features included in the framework could be redundant and potentially not compatible with the inclusion of the Third Delta feature. Framework 7002 also included the best available estimates for several of the features identified as elements of large-scale long-range concepts and included in supplemental framework N2. As a result, it was determined that the appropriate action would be to continue to develop supplemental framework N1 and include it along with framework 7002 in the final array. The inclusion of framework 7002 in the tentative final framework provides a gauge of the level of incremental cost required to achieve the maximum ecosystem benefits beyond those provided by frameworks identified as optimal in the cost effective analysis. This also provides some insight into the relative beneficial return for extremely large-scale long-range restoration features.

To further determine whether the combinable components of the supplemental framework had any specific strengths or weaknesses, another iteration of cost-effectiveness was executed for each subprovince. The study executive team reviewed this information and was able to identify an existing framework in Subprovince 2 that in combination with the N1 supplemental framework components in Subprovinces 1 and 3 could produce a modified supplemental framework that would be more complete and cost-effective. The data for the modified supplemental framework, which was labeled 10130 (based on the IWR-Plan system of numbering solution scales), was added to the IWR-Plan database. An additional iteration of the cost-effectiveness analysis revealed the new framework to be on the cost-effective curve and consistent with the position and criteria for the final array. Therefore, the seven frameworks in the tentative final array of frameworks for the Deltaic Plain were 5110, 5410, 5610, 7002, 7410, 7610, and 10130.

The final array of frameworks are all fairly close to the efficient frontier, and, given limitations of both the benefit and cost data, are within the margin of error for the efficient frontier. That is, given the level of accuracy in the model's prediction of benefits and limitations on our ability to estimate costs, it is not possible to state with certainty that the supplemental framework 10130 is less efficient than those on the efficient frontier. The exception, since the framework that produces the maximum possible output is always a component of the efficient frontier, is framework 7002, which has costs far in excess of frameworks which produce only slightly lower benefit levels, as illustrated in **figure MR 3-2**. Therefore, any of the frameworks, with the exception of 7002, could suffice as a cost-effective framework for the Deltaic Plain. **Figure MR 3-4** graphically represents the development and evaluation of the supplemental frameworks.

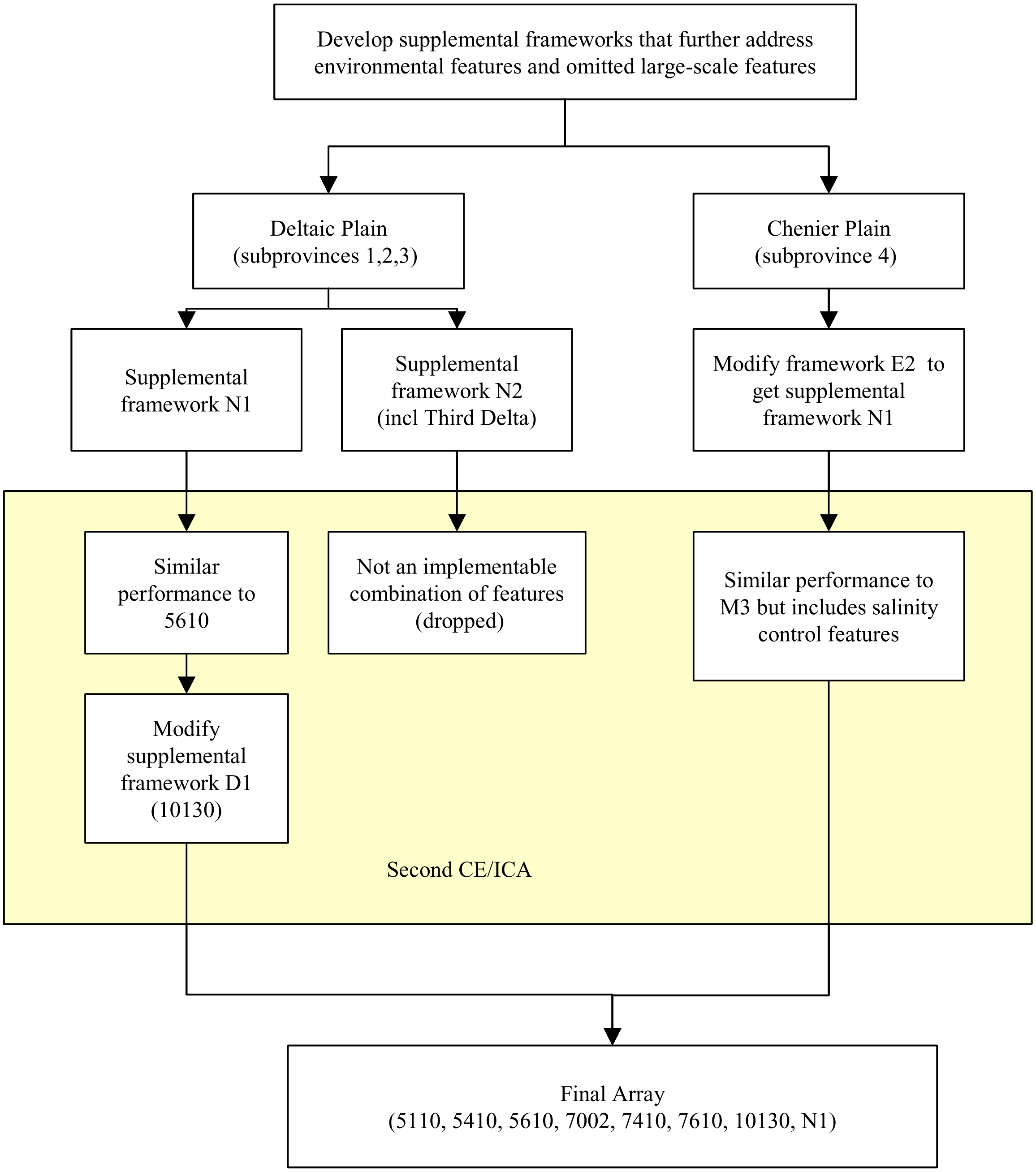


**Figure MR 3-4. Plan formulation and framework selection process: development of supplemental frameworks and second CE/ICA analysis**

### 3.3.5.4 Development of the final array for the Chenier Plain

Because habitats in the Chenier Plain were created by processes that did not include periodic overflows of the river to build and maintain land, the frameworks for Subprovince 4 were not constrained by the amount of water and sediment available in the Mississippi River and the resources used for restoration on Subprovinces 1 through 3. Consequently, the PDT evaluated Subprovince 4 separately from the other three subprovinces, which comprised the Deltaic Plain.

Because there is no nitrogen removal issue in the Chenier Plain and the habitat created in this area is expected to remain fairly uniform in quality, evaluation of Subprovince 4 frameworks was solely based on land creation. Any of the outcomes here could be combined with any of the seven frameworks in the final array for the Deltaic Plain.

The cost-effective analysis produced a cost-effective curve consisting of only one cost-effective framework, M3. The PDT reviewed the cost-effectiveness analysis results and recognized that framework M3 failed to appreciably address the core restoration strategy for the Chenier Plain of controlling estuarine salinities. In addition, the PDT suggested that the "Increase" planning scale be adopted as the minimum restoration level in this subprovince due to the relatively low rate of loss. Again, the Plan Formulation process from Phase III through the initial CE/ICA analysis is graphically depicted in **figure MR 3-3**.

#### 3.3.5.5 Development of supplemental framework for final array for the Chenier Plain

The executive team, as well as the vertical team and members of the framework development team, again reviewed the cost-effectiveness analysis and the PDT effort in identifying the cost-effective frameworks for the Chenier Plain. The executive team directed the PDT to develop a supplemental framework to better address the core strategy. While not cost-effective, the relative ability of framework E2 to better address the core restoration strategy (i.e., salinity control) was suggested as a starting point to develop the supplemental framework. During a two-day meeting of the executive team and PDT, the PDT assembled the supplemental framework, which was based on the framework E2. The criteria concerning the identification and inclusion of any environmentally important features applied in the Deltaic Plain also applied to this subprovince.

Once the features of the supplemental alternative framework were identified, costs and benefits were developed for the framework in a manner consistent with the previously analyzed alternative frameworks. This data was incorporated into the IWR-Plan database. A second iteration of the CE/ICA was run to determine the position of the supplemental alternative framework relative to the efficient frontier. Once again, the supplemental framework was intended to add to the completeness of the final array.

Eight subprovince frameworks, including the supplemental framework and the No Action Alternative, were evaluated for the Chenier Plain (**figure MR 3-5**). As stated previously, the Chenier Plain was analyzed separately and thus frameworks that are not combinable were analyzed independently.

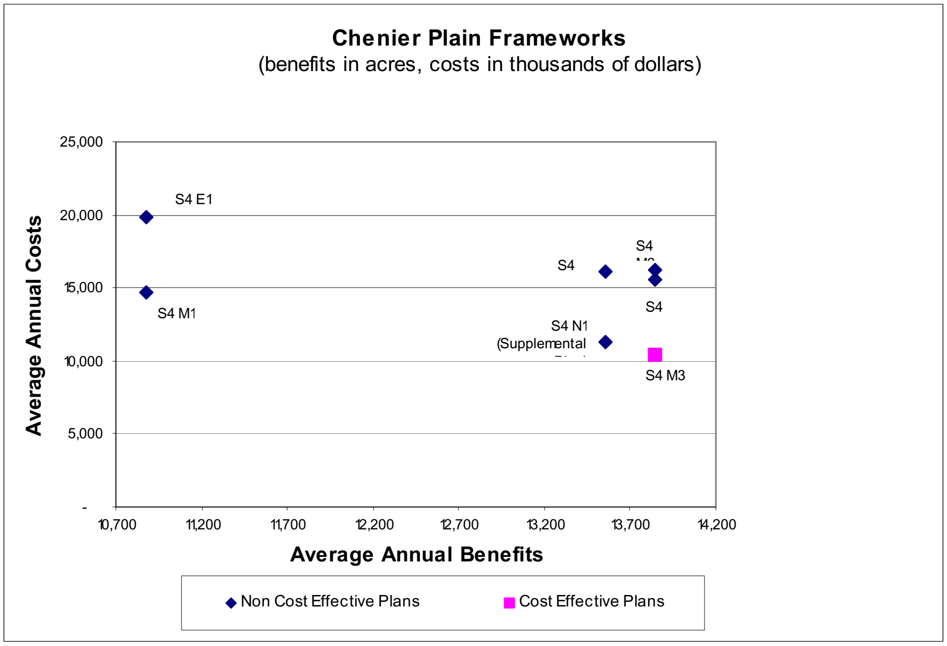


**Figure MR 3-5. Costs and Benefits (acres) for all Chenier Plain Frameworks.**

A second iteration once again resulted in the identification of only one cost-effective framework, M3. However, the added supplemental framework (N1) was similar in average annual cost but produced slightly fewer average annual benefits. The features in framework M3 failed to appreciably address the core restoration strategy for Subprovince 4, as previously identified by the PDT. Framework N1 included the major features of framework M3 in addition to features to address salinity control. As a result, framework M3 was dropped from the final array. The final array focuses on framework N1, the supplemental framework that was developed by modifying framework E2. Again, the Plan Formulation process from supplemental framework development through the second CE/ICA analysis is graphically presented in **figure MR 3-4**.

### 3.3.5.6 <u>Details of the final array of coast wide system frameworks</u>

As stated previously, the Chenier Plain framework can be added to any of the seven Deltaic Plain frameworks to construct coast wide frameworks, resulting in seven coast wide frameworks. **Table MR 3-7** identifies the subprovince framework components of each of the system frameworks identified in the final array. The subprovince frameworks considered, and the features included in them, can be found in **tables MR 3-3** through **MR 3-6.** The final array of coast wide system frameworks identified a relatively tight grouping of possible alternatives. In comparing these alternatives, the PDT observed numerous cases of common features between the frameworks. The differences in restoration features between the frameworks, however, typically resulted in an observable difference in the make up of their beneficial outputs (i.e., the balance of marsh type and resultant species usage). The end result was that any of the frameworks in the final array could be a justifiable plan depending on the nuances applied in developing a single output value for their comparison.

In addition, the PDT recognized that the relative uncertainty of quantifying ecologic performance and sustainability versus the somewhat more certain quantification of implementation cost caused a variable effect on certainty across the range of features considered in the system wide frameworks. Particularly, larger-scale, longer range restoration features compared poorly in a comparative analysis. As a result, for the longer-range features included in the various frameworks, there were lower confidence limits that have implications for the overall timing of their implementation. Conversely, features that could be implemented and produce environmental outputs in the near-term resulted in a higher degree of confidence.

**Table MR 3-7. Overview of Final Array of Coast wide Restoration Frameworks.**

| | Framework Identification | | | | | | |
|---|---|---|---|---|---|---|---|
| | 5110 | 5610 | 5410 | 7610 | 7410 | 7002 | 10130 |
| **Subprovince 1** | | | | | | | |
| M2 | **X** | **X** | **X** | | | | |
| E1 | | | | **X** | **X** | **X** | |
| N1 (Modified M2) | | | | | | | **X** |
| **Subprovince 2** | | | | | | | |
| R1 | **X** | | | | | | |
| M1 | | | **X** | | **X** | | |
| M3 | | **X** | | **X** | | | |
| E3 | | | | | | **X** | |
| N1 (Modified R1) | | | | | | | **X** |
| **Subprovince 3** | | | | | | | |
| R1 | **X** | **X** | **X** | **X** | **X** | | |
| M1 | | | | | | **X** | |
| N1 (Modified R1) | | | | | | | **X** |
| **Subprovince 4** | | | | | | | |
| N1 (Modified E2) | **X** | **X** | **X** | **X** | **X** | **X** | **X** |

Of the 111 features listed in **tables MR 3-3** through **MR 3-6**, 79 features are contained in the final array of coast wide frameworks identified in **table MR 3-7**. Descriptions of the 79 features are found in section 3.3.6.1.

### 3.3.6 Phase VI - Development of Alternative LCA Restoration Plans

Upon the completion of Phase V efforts, with attention to the dynamic nature of the coastal ecosystem, the science and technology (S&T) uncertainties and model uncertainties, the Vertical Team and PDT redirected the plan formulation effort towards the identification of a plan that focused on critical restoration effort needs in the near-term, the next 5 to 10 years. The PDT determined that a LCA Plan would best meet the overall study objectives through inclusion of several complementary plan components that differ in scale and time. These would include:

- Near-term, highly certain feature concepts for development and implementation;
- Identified, feature-related uncertainties and potential methods or features to resolve them; and
- Large-scale and long-range feature concepts to be more fully developed.

Having identified the most efficient, effective, and complete combinations, of features within the final array of coast wide frameworks it was decided to not abandon the work that produced and screened those coast wide alternatives. The PDT believed that the formulation of frameworks and the identification and assessment of beneficial outputs accurately reflected the relative effectiveness and efficiency of the coast wide frameworks to meet the study planning objectives and affect coastal restoration. In meeting the set objectives and benefit parameters, in addition to being effective and efficient, the most critical restoration features should have been captured in these frameworks as well. The PDT determined that a resorting of the features included in the final alternative coast wide frameworks would provide a representative plan of those most promising critical restoration features.

The seven final coast wide frameworks were used as the starting point for the identification of alternative LCA near-term plans. The 79 restoration features that were combined into the coast wide frameworks of the final array primarily addressed areas of critical wetland loss, opportunities for the reestablishment of deltaic processes, and the protection and restoration of geomorphic features. The 79 features were the building blocks for alternative LCA Plans in Phase VI.

### 3.3.6.1 Description of the restoration features identified in the final array of coast wide frameworks

The PDT initially determined that the follow-on feasibility study process would analyze and optimize specific locations and dimensions for any restoration feature that would ultimately become a component of the LCA Plan that best met the objectives. Instead, general details about restoration features were included as part of this plan formulation process. For example, diversions were referred to as either small, medium, or large, where small equates to 1,000-5,000 cfs diversions, medium to 5,000-15,000 cfs diversions, and large to greater than 15,000 cfs diversions. Additionally for features involving the use of dredged sediments borrow locations are typically not specified, however, consistent with guiding principle number 4, the use of sediment sources both renewable and external to the functional coastal system are expected to be identified in final decision and NEPA documents. More detailed cost information regarding the features is available at the District upon request. The features are shown on **figures MR 3-6** through **MR 3-9**.

#### 3.3.6.1.1 *Subprovince 1 feature descriptions*

Medium diversion at American/California Bays

This restoration feature provides for a medium non-structural, uncontrolled diversion from the Mississippi River at American/California Bays. The diversion feature would consist of an armored crevasse through the existing un-leveed riverbank into the fringe marsh and open water of the bay system. The objective of this feature is to increase sediment introduction into American/California Bays. The introduction of additional sediment would facilitate organic and mineral sediment deposition, improve biological productivity, and prevent further deterioration of the marshes.

Medium to large sediment diversion at American/California Bays

This restoration feature involves a large non-structural, uncontrolled sediment diversion from the Mississippi River with sediment enrichment at American/California Bays. The diversion feature would consist of an armored crevasse through the existing un-leveed riverbank into the fringe marsh and open water of the bay system. The objective of this feature is to maximize sediment inputs and spur large-scale land building in American/California Bays. This area was historically an outflow area of the Mississippi River, which received river discharges during flooding events. The creation and restoration of wetlands in American/California Bays would have the added benefit of stabilizing the Breton Sound marshes to the north by reducing marine influences from the Gulf of Mexico.

Rehabilitate Bayou Lamoque structure as a medium diversion

This feature provides for the refurbishment and operation of a pair of diversion structures, regulating the flow of Mississippi River water into Bayou Lamoque, a former distributary of the Mississippi River. The existing Bayou Lamoque diversion structures require mechanical rehabilitation and operational security modifications. The remote location of these structures and the frequent occurrence of vandalism have resulted in an inability to ensure consistent and reliable operation. The objective of this feature is to increase and maintain riverine inflows into Bayou Lamoque. The introduction of additional freshwater would facilitate organic and sediment deposition, improve biological productivity, and prevent further deterioration of the marshes. This feature is located in the vicinity of a historic crevasse.

Medium diversion at Bonnet Carré Spillway

This restoration feature would be located at the existing Bonnet Carre Spillway and involve a reevaluation of the existing authorized project. The spillway is currently operated to remove excess water from the Mississippi River during flooding events and pass the water through the Bonnet Carre Spillway into Lake Pontchartrain. The restoration feature consists of a medium diversion with east and west branches into the La Branche wetlands and Manchac land bridge - diverted through a modified segment of the existing flood control structure and redirected through the guide levees into adjacent wetlands. The objective of the project is to decrease salinities in Lake Pontchartrain and the surrounding marshes, especially the La Branche Wetlands, and to add nutrients and some sediment to these marshes and swamps. This feature is located in the vicinity of a historic crevasse.

Small diversion at Convent/Blind River

This restoration feature involves a small diversion from the Mississippi River into Blind River through a new control structure. The objective of this feature is to introduce sediment and nutrients into the southeast portion of Maurepas Swamp. This feature is intended to operate in conjunction with the Hope Canal diversion to facilitate organic deposition in the swamp, improve biological productivity, and prevent further swamp deterioration.

Medium diversion at Fort St. Philip

This restoration feature provides for a medium diversion from the Mississippi River into marshes northeast of Fort St. Philip, between the Mississippi River and Breton Sound. Objectives of this feature are to reduce wetland loss and facilitate riverine influences to these marshes. The diversion would facilitate organic deposition in and biological productivity of the marshes by increasing freshwater circulation and providing sediment and nutrients to the system.

Small diversion at Hope Canal

This restoration feature involves a small diversion from the Mississippi River through a new control structure at Hope Canal. The objective is to introduce sediment and nutrients into Maurepas Swamp south of Lake Maurepas. The introduction of additional freshwater via the diversion would facilitate organic deposition, improve biological productivity, and prevent further deterioration of the swamp. Work for this feature has been initiated in engineering and design and NEPA compliance under CWPPRA.

Medium diversion at White's Ditch

This restoration feature, located at White's Ditch, downstream of the existing Caernarvon diversion structure, provides for a medium diversion from the Mississippi River into the central River aux Chenes area using a controlled structure. The objective of the feature is to provide additional freshwater, nutrients, and fine sediment to the area between the Mississippi River and River aux Chenes ridges. This area is currently isolated from the beneficial effects of the Caernarvon freshwater diversion. The introduction of additional freshwater would facilitate organic sediment deposition, improve biological productivity, and prevent further deterioration of the marshes. This feature is located in the vicinity of a historic crevasse. Follow-up feasibility-level analysis will determine the ultimate size of the diversion.

Sediment delivery via pipeline at American/California Bays

This restoration feature provides for sediment delivery via pipeline through programmatic sediment mining from the Mississippi River. The moderately deep (6 to 10 feet [1.8 to 3 meters]) open water in this bay system requires a large volume of sediment to create wetlands. The objective of this feature is to create wetlands in the American/California Bays.

Sediment delivery via pipeline at Central Wetlands

This restoration feature provides for placement of sediment mined from the Mississippi River into the Central Wetlands adjacent to the MRGO and Violet canal, via pipeline. The objective of this feature is to create wetlands by placing dredged sediment in the shallow (1 to 2 feet [0.3 to 0.6 meters]) open waters of the marshes. Placement of this dredged material would counteract marsh breakup by providing sediment and nutrients to renourish the area. This feature is located in the vicinity of a historic crevasse.

Sediment delivery via pipeline at Fort St. Philip

This feature provides for sediment delivery at Fort St. Philip via programmatic sediment mining from the Mississippi River. The objective of the feature is to create and/or restore marsh habitat by depositing sediment in appropriate moderately shallow (3 to 5 feet [0.9 to 1.5 meters]) open water areas in the vicinity of Fort St. Philip. Increasing the area and improving the function of these marshes would facilitate biological productivity of the marshes and reduce wetland loss.

Sediment delivery via pipeline at Golden Triangle

This restoration feature provides for sediment delivery via sediment mined from the Mississippi River and placed in the area formed by the confluence of the MRGO, GIWW, and Lake Borgne. The objective of the feature is to create and/or restore marsh habitat by depositing sediment in appropriate shallow (1 to 2 feet [0.3 to 0.6 meters]) open water in the area adjacent to these three water bodies. Increasing the area and improving the function of these marshes would facilitate biological productivity of the marshes and reduce wetland loss.

Sediment delivery via pipeline at La Branche Wetlands

The proposed restoration feature includes the dedicated dredging of sediment from the Mississippi River, which would be delivered via pipeline to shallow (1 to 2 feet [0.3 to 0.6 meters]) open waters within the La Branche Wetlands in the southwest corner of Lake Pontchartrain. The creation and restoration of these marshes would facilitate improved biological productivity and reduce wetland loss. This feature is located in the vicinity of a historic crevasse.

Sediment delivery via pipeline at Quarantine Bay

This restoration feature provides for sediment delivery to Quarantine Bay via programmatic sediment mining from the Mississippi River. The objective of the feature would be to create wetland habitat through the placement of dredge sediment in the moderately shallow (3 to 5 feet [0.9 to 1.5 meters]) open waters of Quarantine Bay.

Opportunistic use of Bonnet Carre Spillway

This restoration feature involves freshwater introductions from the Mississippi River via the opportunistic use of the existing flood control structure at the Bonnet Carre Spillway. The spillway is currently operated to remove excess water from the Mississippi River during flooding events and pass the water through the Bonnet Carre Spillway into Lake Pontchartrain. This feature would allow for freshwater introductions to be delivered to Lake Pontchartrain and the adjacent La Branche wetlands during times of high river water levels. Thus, the river introductions would help reduce salinities in the southwest corner of Lake Pontchartrain and nourish the intermediate and brackish marshes in La Branche with sediment and nutrients. This feature is located in the vicinity of a historic crevasse.

Increase Amite River Diversion Canal influence by gapping banks

This restoration feature involves the construction of gaps in the existing dredged material banks of the Amite River Diversion Canal. The objective of this feature is to allow floodwaters to introduce additional nutrients and sediment into western Maurepas Swamp. The exchange of flow would occur during flood events on the river and from the runoff of localized rainfall events. This feature would provide nutrients and sediment to facilitate organic deposition in the swamp, improve biological productivity, and prevent further swamp deterioration.

Marsh nourishment on New Orleans East land bridge

This restoration feature involves wetland creation through the dedicated dredging of sediment from lake bottom sources. The objective of this feature is to create wetlands by placing dredged sediment in the shallow open waters within the land bridge separating Lakes Pontchartrain and Borgne. This area has experienced wetland deterioration and loss due to erosion from wave energies in Lake Borgne. Reinforcing the land bridge between the two lakes would help maintain the salinity gradients in Lake Pontchartrain and ensure the long-term sustainability of the wetland ecosystems in the area.

Mississippi River Delta Management Study

This restoration concept requires detailed investigations to address the maximization of river resources, such as excess freshwater and sediment, for wetland restoration. The objective of this concept is to greatly increase the deposition of Mississippi River sediment on the shallow continental shelf, while ensuring navigation interests. Sediment, nutrients, and freshwater would be re-directed to restore the quality and sustainability of the Mississippi River Deltaic Plain, its coastal wetland complex, and the Gulf of Mexico. The study would investigate potential modifications to existing navigation channel alignments and maintenance procedures and requirements.

Mississippi River Gulf Outlet (MRGO) environmental restoration features

This restoration opportunity involves the implementation of the environmental restoration features considered in the MRGO Reevaluation Study. In response to public concerns, adverse environmental effects, and national economic development considerations, an ongoing study is re-evaluating the viability of operation and maintenance of this authorized navigation channel. Since the construction of the MRGO, saltwater intrusion and ship wake erosion have degraded large expanses of fresh and intermediate marshes and accelerated habitat switching from freshwater marshes to brackish and intermediate marshes in the Biloxi marshes, the Central Wetlands, and the Golden Triangle wetlands. This environmental restoration study would evaluate the stabilization of the MRGO banks and various environmental restoration projects, including evaluation of freshwater reintroductions into the Central Wetlands, possible channel depth modification, and other ecosystem restoration measures. Implementation of this feature would preserve estuarine wetlands and important structural features of the lake and marsh landscape.

Modification of Caernarvon diversion

The Caernarvon diversion structure, constructed on the Mississippi River in 1992 near the Breton Sound marshes, has a maximum operating capacity of 8,000 cfs (286 cms). The structure has been operated as a salinity management feature, with freshwater introductions ranging between 1,000 cfs to 6,000 cfs (36 cms to 214 cms), but in general averaging less than half of the structure's capacity. The primary purpose of the existing Caernarvon project has been to maintain salinity gradients in the central portion of Breton Sound. This operation, in effect, partially restored the historic functions of marsh nourishment (e.g., freshwater inflow, providing nutrients and sediment to the marsh, and countering the effects of subsidence). The proposed restoration feature study would assess changes in the operation of the Caernarvon project to increase wetland creation and restoration outputs for this structure. Modified operation of this structure would allow an increase in the freshwater introduction rate, perhaps 5,000 cfs (178 cms) on average, to accommodate the wetland building function of the system. This study would identify any changes to this feature's operation that would increase restoration outputs. The introduction of additional freshwater would facilitate organic and sediment deposition, improve biological productivity, and prevent further deterioration of the marshes. This feature is located in the vicinity of a historic crevasse. Any proposed change in purpose that would require modification of the existing authorization for this structure would be submitted for Congressional approval.

Rehabilitate Violet Siphon for increased freshwater influence to Central Wetlands

This restoration feature involves the rehabilitation of the existing Violet Siphon water control structure, which is located between the Mississippi River and the MRGO, in the Central Wetlands. The objectives of this feature are to improve the operation of the Violet Siphon and enhance freshwater flows into the Central Wetlands. This action would increase freshwater in the wetlands and nourish the remaining swamp and intermediate marshes. The restoration of wetlands and improvement in ecosystem function produced by this feature would be increased by the freshwater introductions via the IHNC lock feature. This feature is located in the vicinity of a historic crevasse.

Post authorization change for the diversion of water through Inner Harbor Navigation Canal for increased freshwater influence into Central Wetlands

This restoration feature calls for a post-authorization modification of the IHNC lock. Modifications would incorporate culverts and controls to divert freshwater from the Mississippi River through the IHNC to the Central Wetlands. The objectives of this feature are to introduce freshwater and nutrients into the intermediate and brackish marshes of the Central Wetlands, boost plant productivity, and reduce elevated salinities. This restoration feature could also increase the benefits produced by the Violet Siphon structure rehabilitation restoration feature.

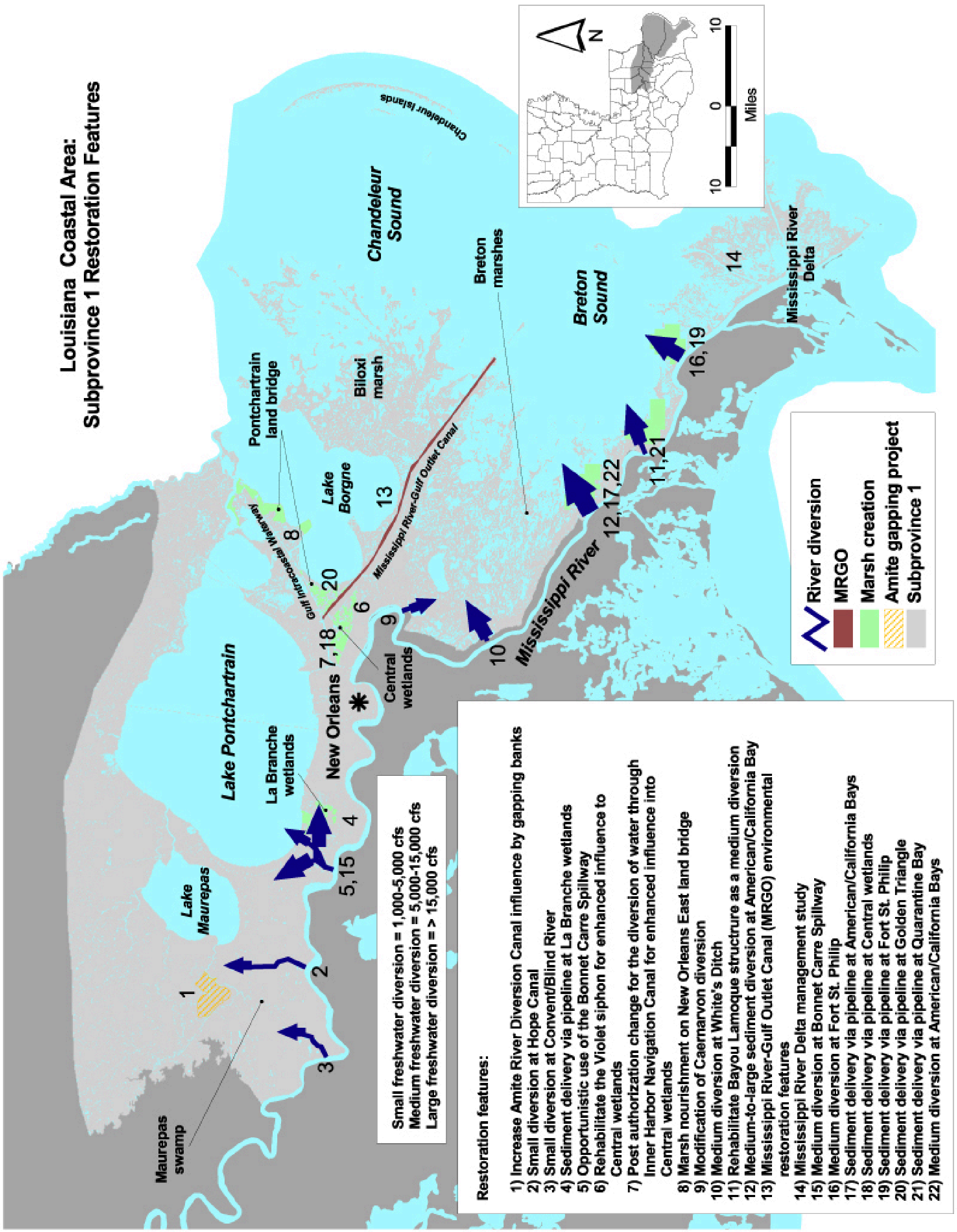


**Figure MR 3-6. Subprovince 1 Restoration Features Identified in the Final Array of Coast Wide Frameworks.**

#### 3.3.6.1.2 *Subprovince 2 Feature Descriptions*

Large diversion at Boothville with sediment enrichment

This restoration feature provides for a large nonstructural, uncontrolled sediment diversion from the Mississippi River near Boothville into the Yellow Cotton/Hospital Bays area. The objective of this feature is to create wetlands by diverting sediment in the moderately deep (6 to 10 feet [1.8 to 3 feet]) open waters of Yellow Cotton / Hospital Bays. The freshwater and nutrients would also increase vegetative stability in the fringing marshes and along the Bayou Grand Liard ridge. Ultimately, sediment would reach and supplement the barrier shoreline between Red Pass and the Empire to the gulf waterway. Sediment enrichment assumes use of 20-inch (51 centimeter) dredge at capacity for three months yielding 1,468,000 cubic yards (1,120,000 cubic meters) each year. The diversion would maximize sediment and nutrient inputs and spur large-scale land building in the extreme southeastern portion of Barataria Bay.

Small diversion at Donaldsonville

This restoration feature involves a small diversion from the Mississippi River through a new control structure at Donaldsonville. The objective is to introduce freshwater, sediment, and nutrients into upper Bayou Verret, which is located to the northwest of Lac Des Allemands, to improve water quality and promote plant productivity. The wetland ecosystem in the area is classified as wetland forest, consisting primarily of bottomland hardwood forests. This feature is intended to operate in conjunction with three other small diversions in the area.

Small diversion at Edgard

This restoration feature involves a small diversion from the Mississippi River through a new control structure at Edgard. The objective is to introduce freshwater, sediment, and nutrients into Bayou Fortier, which is located to the northeast of Lac Des Allemands, to improve water quality and promote plant productivity. The wetland ecosystem in the area is classified as wetland forest, consisting primarily of bottomland hardwood forest. This feature is intended to operate in conjunction with three other small diversions in the area.

Medium diversion at Edgard with sediment enrichment

This restoration feature involves a medium diversion from the Mississippi River through a new control structure at Edgard. The objective is to introduce freshwater, sediment, and nutrients into Bayou Fortier, which is located to the northeast of Lac des Allemands, to improve water quality and promote plant productivity. The wetland ecosystem in the area is classified as wetland forest, consisting primarily of bottomland hardwood forest. Sediment enrichment would involve use of 12-inch (31 centimeter) dredge for three months. Discharge of effluent upstream of the diversion intake would allow the capture of silts and very fine sands only.

Medium diversion at Fort Jackson - Alternative to Boothville diversion

This restoration feature provides for a medium non-structural, uncontrolled sediment diversion from the Mississippi River near Fort Jackson into the Yellow Cotton/Hospital Bays area. The objective of this feature is to create wetlands by diverting sediment in the moderately deep (6 to 10 feet [1.8 to 3 feet]) open waters of Yellow Cotton/Hospital Bays. The associated freshwater and nutrients would also increase vegetative stability in the fringing marshes and along the Bayou Grand Liard ridge. The diversion would maximize sediment and nutrient inputs and spur land building in the extreme southeastern portion of Barataria Bay.

Large diversion at Fort Jackson with sediment enrichment - Alternative to Boothville diversion

This restoration feature provides for a large (50,000 to 100,000 cfs [1,800 to 3,600 cms]) non-structural, uncontrolled sediment diversion from the Mississippi River near Fort Jackson into the Yellow Cotton/Hospital Bays area. The objective of this feature is to create wetlands by diverting sediment in the moderately deep (6 to 10 feet [1.8 to 3 feet]) open waters of Yellow Cotton / Hospital Bays. The associated freshwater and nutrients would also increase vegetative stability in the fringing marshes and along the Bayou Grand Liard ridge. Sediment enrichment assumes use of 20-inch (51 centimeter) dredge at capacity for three months yielding 1,468,000 cubic yards (1,120,000 cubic meters) each year. Ultimately, sediment would reach and supplement the barrier shoreline between Red Pass and the Empire to the gulf waterway. The diversion would maximize sediment and nutrient inputs and spur large-scale land building in the extreme southeastern portion of Barataria Bay.

Small diversion at Lac des Allemands

This restoration feature involves a small diversion from the Mississippi River through a new control structure at Lac des Allemands. The objective is to introduce freshwater, sediment, and nutrients into Bayou Becnel, which is located to the north of Lac des Allemands, to improve water quality and promote plant productivity. The wetland ecosystem in Bayou Becnel and surrounding Lac des Allemands area is classified as wetland forest, consisting primarily of bottomland hardwood forest. This feature is intended to operate in conjunction with three other small diversions in the area.

Medium diversion at Lac des Allemands with sediment enrichment

This restoration feature involves a medium diversion from the Mississippi River through a new control structure at Lac des Allemands. The objective is to introduce freshwater, sediment, and nutrients into Bayou Becnel, which is located to the north of Lac des Allemands, to improve water quality and promote plant productivity. The wetland ecosystem in Bayou Becnel and surrounding Lac des Allemands area is classified as wetland forest, consisting primarily of bottomland hardwood forest. Sediment enrichment would involve use of 12-inch (31 centimeter) dredge for three months. Discharge of effluent upstream of the diversion intake would allow the capture of silts and very fine sands only. This feature is intended to operate in conjunction with three small diversions in the area.

Medium diversion with dedicated dredging at Myrtle Grove

This restoration feature involves a medium diversion of the Mississippi River near Myrtle Grove through a new control structure. The diversion would provide additional sediment and nutrients to nourish highly degraded existing fresh to brackish wetlands in shallow open water areas. This reintroduction would ensure the long-term sustainability of these marshes by increasing plant productivity, thereby preventing future loss. The introduction of sediment to this area would also promote the infilling of shallow open water areas both through deposition and marsh expansion. Dedicated dredging of sediment mined from the Mississippi River would complement this feature. This feature is located in the vicinity of a historic crevasse. Work has been initiated on engineering and design and NEPA compliance under CWPPRA.

Large diversion at Myrtle Grove with sediment enrichment

This restoration feature involves a large sediment diversion from the Mississippi River near Myrtle Grove through a new control structure. The diversion would provide additional sediment and nutrients to nourish highly degraded existing fresh to brackish wetlands in shallow open water areas throughout the central Barataria basin. This reintroduction would allow the creation of new wetland in expansive open water and bay areas and ensure the long-term sustainability of currently degraded marshes by increasing plant productivity, thereby preventing future loss. The additional introduction of sediment by enrichment assumes use of 30-inch dredge at capacity for three months yielding 6,293,000 cubic yards [4,810,000 cubic meters] each year. This feature is located in the vicinity of a historic crevasse.

Small diversion at Pikes Peak

This restoration feature involves a small diversion from the Mississippi River through a new control structure at Pikes Peak. The objective is to introduce freshwater, sediment and nutrients into Bayou Chevreuil, which is located to the north of Lac Des Allemands, to improve water quality and promote plant productivity. The wetland ecosystem in the area is classified as wetland forest, consisting primarily of bottomland hardwood wetlands. This feature is intended to operate in conjunction with three other small diversions in the area.

Barataria Basin barrier shoreline restoration

This restoration feature involves mining of offshore sediment sources to reestablish sustainable barrier islands. The feature is based on designs developed in the LCA Barataria Barrier Island Restoration study and assumes a 3,000-foot [914 meter] wide island footprint. This feature originally considered restoration elements for all the major reaches of the Barataria barrier-shoreline chain. However, for inclusion in the near-term plan some consideration to the most critically needed elements of the chain. The most critical areas of this chain, however, include the Caminada-Moreau Headland (an area between Belle Pass and Caminada Pass) and Shell Island (a barrier island in the Plaquemines barrier island system). These barrier shoreline segments are critical components of the Barataria shoreline. The Shell Island segment has been nearly lost and failure to take restorative action could result in the loss of any future options for restoration. This would result in permanent modification of the tidal hydrology of the Barataria

Basin. The Caminada-Moreau Headland protects the highest concentration of near-gulf oil and gas infrastructure in the coastal area. This reach of the Barataria shoreline also supports the only land-based access to the barrier shoreline in the Deltaic Plain. These critical endpoints in the Barataria chain also serve as sources of material for the littoral system delivering sediment to the remainder of the chain.

Implement the LCA Barataria Basin Wetland Creation and Restoration Study

This feature involves implementation of components of the LCA Barataria Basin Wetland Creation and Restoration Study. The wetlands in the lower Barataria Basin have experienced wetland deterioration due to subsidence, a lack of circulation, saltwater intrusion, and a paucity of sediment and nutrients. Sediment dredged from offshore borrow sites would be placed at specific sites near Bayou Lafourche in the Caminada Headland to create and restore marsh and ridge habitat in the area.

Modification of Davis Pond diversion

The Davis Pond diversion structure, constructed in 2002 in upper Barataria Basin, has a maximum operating capacity of 10,600 cfs [378 cms]. The structure has been operated as a salinity management feature, with freshwater introductions from the Mississippi River ranging from 1,000 cfs up to 5,000 cfs [36 cms to 178 cms] averaging, to this point in time, considerably less than half of the structure's capacity. The primary purpose of the existing Davis Pond project has been to maintain salinity gradients in the central portion of Barataria Basin. This operation, in effect, partially restored the historic functions of marsh nourishment (e.g., freshwater inflow, providing nutrients and sediment to the marsh, and countering the effects of subsidence). This restoration feature study would assess changes in the operation of the Davis Pond project to increase wetland creation and restoration outputs. Modified operation of this structure could potentially result in an increase in the freshwater introduction rate, perhaps 5,000 cfs [178 cms] on average, to accommodate the wetland building function of the system. This study would identify changes to feature's operation that would increase restoration outputs. The introduction of additional freshwater would facilitate organic and sediment deposition, improve biological productivity, and prevent further deterioration of the marshes. This feature is located in the vicinity of a historic crevasse. Any proposed change in purpose that would require modification of the existing project authorization would be submitted for Congressional approval.

Sediment delivery via pipeline at Bastian Bay/Buras

This restoration feature provides for sediment delivery via pipeline through programmatic sediment mining from the Mississippi River. The moderately deep (6 to 10 feet [1.8 to 3 feet]) open water in this bay system requires a large volume of sediment to create wetlands. The objective of this feature is to create wetlands in the highly degraded Bastian Bay and Buras area.

Sediment delivery via pipeline at Empire

This restoration feature provides for sediment delivery via pipeline through programmatic sediment mining from the Mississippi River. The moderately deep (6 to 10 feet [1.8 to 3 feet]) open water in Bay Adams and Barataria Bay requires a large volume of sediment to create wetlands. The objective of this feature is to create wetlands in the highly degraded areas south and west of Empire.

Sediment delivery via pipeline at Main Pass (Head of Passes)

This feature provides for sediment delivery via programmatic sediment mining from the Mississippi River utilizing a sediment trap above the Head of Passes. The estimated annual yield of dredge material from the sediment trap is 9 million cubic yards [6.9 million cubic meters]. The objective of this feature is to create wetlands in the degraded areas in the east and west portions of the Mississippi River Delta south of Venice.

Third Delta (Subprovinces 2 & 3)

This feature provides for a large diversion from the Mississippi River through a new control structure in the vicinity of Donaldsonville. This feature provides for an approximately 240,000 cfs diversion at maximum river stage. Flows would be diverted into a newly constructed conveyance channel (parallel to Bayou Lafourche) extending approximately 55 miles [88 kilometers] from the initial point of diversion to the eventual point of discharge. Diverted flow would be divided equally at a point north of the GIWW to enable the creation of a deltaic wetlands complex in each of the Barataria and Terrebonne Basins. A possible alternative configuration would involve a 120,000 cfs [4300 cms] diversion at maximum river stage into the Barataria Basin only. Enrichment of this diversion would also be considered and assumes use of 30-inch [77 cm] dredge at capacity for three months yielding 6,293,000 cubic yards [4,810,000 cubic meters] each year. The study requires detailed investigations of flood control, drainage, and navigation impacts in addition to environmental and design efforts because it would require construction either through wetlands or prime farmland.

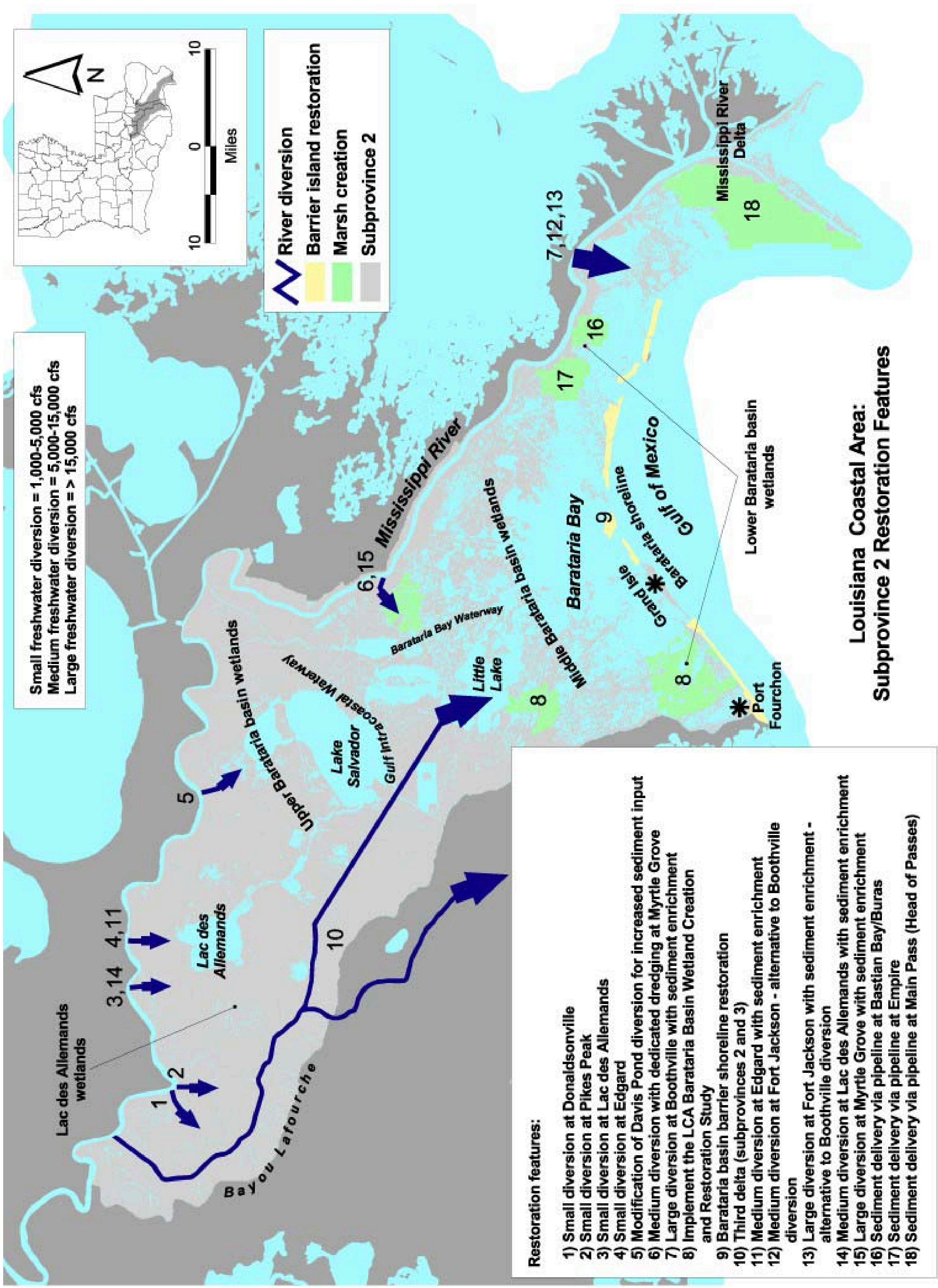


**Figure MR 3-7. Subprovince 2 Restoration Features Identified in the Final Array of Coast Wide Frameworks.**

### 3.3.6.1.3 *Subprovince 3 feature descriptions*

Backfill pipeline canals

This restoration feature provides for the backfilling of pipeline canals south of Catfish Lake. The Twin Pipeline canals in this area are crossed by numerous oilfield canals, which have greatly altered natural water circulation patterns. The 63,300 feet [19,300 meters] of pipeline canals would be filled at strategic locations to restore primary water circulation through Grand Bayou Blue. The retention time of Atchafalaya and Bayou Lafourche (pumped) flows would be increased to benefit affected wetlands.

Small Bayou Lafourche reintroduction

This restoration feature would reintroduce flow from the Mississippi River into Bayou Lafourche. The piped flow would be continuous and would freshen and reduce loss rates for the wetlands between Bayous Lafourche and Terrebonne, south of the GIWW.

Convey Atchafalaya River water to Northern Terrebonne marshes - via a small diversion in the Avoca Island levee, repairing eroding banks of the GIWW, and enlarging constrictions in the GIWW below Gibson and in Houma, and Grand Bayou conveyance channel construction/enlargement

This restoration feature would increase existing Atchafalaya River influence to central (Lake Boudreaux) and eastern (Grand Bayou) Terrebonne marshes via the GIWW by introducing flow into the Grand Bayou basin by enlarging the connecting channel (Bayou L'Eau Bleu) to capture as much of the surplus flow (max. 2000 to 4000 cfs [70 to 140 cms]) that would otherwise leave the Terrebonne Basin. Several alternatives would be evaluated through hydrologic models; however in all cases, gated control structures would be installed to restrict channel cross-section to prevent increased saltwater intrusion during the late summer and fall when riverine influence is typically low. Some alternatives may include auxiliary freshwater distribution structures. This feature also includes increasing freshwater supply through repairing banks along the GIWW, enlarging constrictions in the GIWW, and diverting additional Atchafalaya River freshwater through the Avoca Island Levee and into Bayou Chene/GIWW system.

Freshwater introduction south of Lake De Cade

This restoration feature is intended to improve Atchafalaya flows to Terrebonne wetlands between Lake De Cade, Bayou du Large, and Lake Mechant by constructing three small conveyance channels along the south shore of Lake De Cade to the Small Bayou La Pointe area. Channel flows would be controlled by structures that could be actively operated. Lowering salinities and increasing nutrient inputs would reduce intermediate marsh losses.

Freshwater introduction via Blue Hammock Bayou

This restoration feature would increase flow from the Atchafalaya River to the southwest Terrebonne wetlands by increasing the cross-section of Blue Hammock Bayou. This would increase the distribution of Atchafalaya flows from Four League Bay to the Lake Mechant wetlands. Grand Pass and Buckskin Bayou, outlets of Lake Mechant, would be reduced in cross section to increase the retention and benefits of Atchafalaya nutrients, sediment, and freshwater in these estuarine wetlands. Additional marsh would also be created with dredged material.

Increase sediment transport down Wax Lake Outlet

This restoration feature would increase sediment transport down Wax Lake Outlet by extending the outlet northward through Cypress Island to connect to the Atchafalaya Main Channel. Currently, the Wax Lake Outlet flows passes over the relatively shallow Six Mile Lake before entering the outlet. This restoration feature would connect the deep outlet directly to the deep Atchafalaya Main Channel thereby increasing bed load sediment transported to the Wax Lake Outlet Delta.

Maintain land bridge between Caillou Lake and Gulf of Mexico

This restoration feature would maintain the land bridge between the gulf and Caillou Lake by placing shore protection in Grand Bayou du Large to minimize saltwater intrusion. This feature would involve rock armoring or marsh creation to plug/fill broken marsh areas on the west bank of lower Grand Bayou du Large, to prevent a new channel from breaching the bayou bank and allowing a new connection with Caillou Lake. Some gulf shore armoring would be needed to protect these features from erosion on the gulf shoreline. Gulf shoreline armoring might be required where shoreline retreat and loss of shoreline oyster reefs has allowed increased water exchange between the gulf and the interior water bodies (between Bay Junop and Caillou Lake). Some newly opened channels would be closed to restore historic cross-sections of exchange points. By reducing marine influences in these interior areas, this feature would allow increased freshwater influence from Four League Bay to benefit area marshes.

Maintain land bridge between Bayous du Large and Grand Caillou

This restoration feature provides for construction of a land bridge between Bayous du Large and Grand Caillou south of Falgout Canal and northeast of Caillou Lake. A grid of numerous trenasses, a small human-made channel for navigation, has artificially increased the hydrologic connection between interior marshes with Caillou Lake and adjoining water bodies. This problem would be addressed by depositing hydraulically dredged material to close the trenasses and areas of broken marsh to create a continuous berm of "high marsh" in the area. This berm would separate the higher, healthy brackish/saline marshes bordering the northeast end of Caillou Lake from the deteriorating inland intermediate/brackish marshes. It would also allow the freshwater flowing down the HNC and Bayou Grand Caillou to have a greater influence on interior marshes through existing water exchange points along Bayou Grand Caillou, north of the proposed land bridge.

Maintain northern shore of East Cote Blanche Bay at Point Marone

This restoration feature would protect the north shore of East Cote Blanche Bay from Point Marone to Jackson Bayou. Bay shoreline would be stabilized to protect the interior wetland water circulation patterns in the Cote Blanche Wetlands CWPPRA project. The feature was designed to increase the retention time of the Atchafalaya flows moving from the GIWW to East Cote Blanche Bay.

Maintain Timbalier land bridge

This restoration feature provides for maintaining the Timbalier land bridge in the upper salt marsh zone. A 2,000-foot-wide (610 meter), 21-mile-long (34 kilometer), segmented marsh and low ridge land form (roughly 5,000 acres [2000 ha]) would be constructed from the east bank of Bayou Terrebonne near Bush Canal to the west bank of Bayou Lafourche near the southern terminus of the hurricane protection levee. This landform would be constructed by depositing hydraulically dredged material and could resemble the long, linear, segmented dredge material disposal islands in Atchafalaya Bay. The nine major bayous, which connect the upper subbasin to the downstream lakes and bays, would remain open; among others, they include Grand Bayou Blue and Bayous Pointe Au Chien, Jean La Croix, Barre, and Tambour. The proposed land bridge alignment is in the upper salt Marsh zone, minimizes impacts to existing oyster leases, and avoids most of the oil and gas fields in the Timbalier Subbasin.

Multi-purpose operation of Houma Navigation Canal (HNC) Lock

The restoration feature involves the multi-purpose operation of the proposed HNC Lock, located at the southern end of the HNC. The Morganza to the Gulf Hurricane Protection Study includes construction of the lock, but does not include the multi-purpose operation of the lock. The objective of this feature is to make more efficient use of Atchafalaya River waters and sediment flow, as well as maintain salinity regimes favorable for area wetlands. The proposed structure would be operated to restrict saltwater intrusion and distribute freshwater and sediment during times of high Atchafalaya River flow. The current project is designed to limit saltwater intrusion, but with a minor modification would provide additional benefits to the wetlands by increasing retention time of Atchafalaya River water in the Terrebonne Basin wetlands. An increased retention time would provide additional sediment and nutrients to nourish the wetlands and would benefit the forested wetlands, and fresh, intermediate, and brackish marshes adjacent to the lock and canal; the Lake Boudreaux wetlands to the north; the Lake Mechant wetlands to the west; and the Grand Bayou wetlands to the east.

Penchant Basin Restoration

This restoration feature involves the implementation of the Penchant Basin Plan. This would increase the efficiency of Bayou Penchant to convey flows from the area wetlands as Atchafalaya River stages fall after spring floods, and reduce excessive water levels in the upper Penchant Subbasin. Increased outlet capacities would utilize flow, increasing circulation and retention in tidal wetlands below the large fresh floating marsh area.

Rebuild Historic Reefs - rebuild historic barrier between Point Au Fer and Eugene Island and construct segmented reef/breakwater/jetty along the historic Point Au Fer Barrier Reef from Eugene Island extending towards Marsh Island to the west

This restoration feature would increase the rate of Atchafalaya Delta growth and would increase the Atchafalaya River influence in Atchafalaya Bay, Point Au Fer Island, and Four League Bay by rebuilding the historic barrier between Point Au Fer and Eugene Island. This barrier would separate these areas from the gulf following the historic Point Au Fer reef alignment. The barrier could be a reef, a barrier island, an intertidal spit, or a segmented breakwater. The barrier would increase delta development by reducing the erosive wave effects. Atchafalaya River freshwater influence would be increased in the interior areas of the Atchafalaya Basin. Constructing a segmented reef/breakwater/jetty along the historic Point Au Fer barrier reef from Eugene Island extending towards Marsh Island to the west would produce similar beneficial effects in the western portion of Atchafalaya Bay. The barrier would join the Bayou Sale natural levee feature.

Acadiana Bays Estuarine Restoration

This restoration feature provides for rebuilding historic Point Chevreuil Reef toward Marsh Island, and rehabilitating the Bayou Sale natural levee between Point Chevreuil and the gulf. The natural levee would be rebuilt in the form of a shallow sub-aqueous platform, small islands, and/or reefs. The historic shell reefs were removed by shell dredging. This feature was designed to help restore historic hydrologic conditions in the Teche/Vermilion Basin.

Rehabilitate northern shorelines of Terrebonne/Timbalier Bays

This feature provides for the rehabilitation of the northern shorelines of Terrebonne/Timbalier Bays with a segmented breakwater from the Seabreeze area to the Little Lake area. This feature would rebuild and maintain the historic shoreline integrity around Terrebonne and Timbalier Bays by constructing segmented barriers along the west side of Terrebonne Bay, across the historic shoreline alignment along the northern sides of both bays, and along the eastern side of Timbalier Bay.

Relocate the Atchafalaya Navigation Channel

This restoration feature consists of relocating the Atchafalaya Navigation Channel. The navigation channel route through the delta has been identified as the greatest impediment to the delta's growth. By rerouting the channel between the delta lobes, and by using a passive hydraulic structure at the point of departure in the Lower Atchafalaya River, river sediment would be used more efficiently in the growing delta.

Terrebonne Basin barrier shoreline restoration

This feature originally considered restoration elements for all the major reaches of the Terrebonne barrier-shoreline chain. However, for inclusion in the near-term plan some consideration to the most critically needed elements of the chain. This restoration feature provides for the restoration of the Timbalier and Isles Dernieres barrier island chains. This would simulate historical conditions by reducing the current number of breaches, enlarging (width and dune crest) of the Isles Dernieres (East Island, Trinity Island, and Whiskey Island), Timbalier Island, and East Timbalier Island.

Stabilize banks of Southwest Pass

This restoration feature would maintain the integrity of Southwest Pass channel connecting southwestern Vermilion Bay with the Gulf of Mexico by protecting its bay and gulf shorelines. This feature would involve the construction of a dike and armoring of the banks of the pass to maintain the existing pass dimensions.

Gulf shoreline stabilization at Point Au Fer Island

This feature provides for stabilizing of the gulf shoreline of Point Au Fer Island. The purpose is to prevent direct connections from forming between the gulf and interior water bodies as the barrier island is eroded. In addition to gulf shoreline protection, this feature would prevent the fresher bay side water circulation patterns from being influenced directly by the gulf, thus protecting the estuarine habitat, which has higher quality wetland habitats, from conversion to marine habitat.

Alternative operational schemes of Old River Control Structure (ORCS)

This feature would evaluate alternative ORCS operational schemes with a goal of increasing the sediment load transported by the Atchafalaya River for the purpose of benefiting coastal wetlands. Detailed studies of this feature would determine: impacts (beneficial and adverse) to the interior of the Atchafalaya Basin; the degree to which flow and sediment redistributions would be required; and the increased costs of maintaining the flood control, navigation, and environmental features along the Lower Mississippi, Red, and Atchafalaya Rivers.

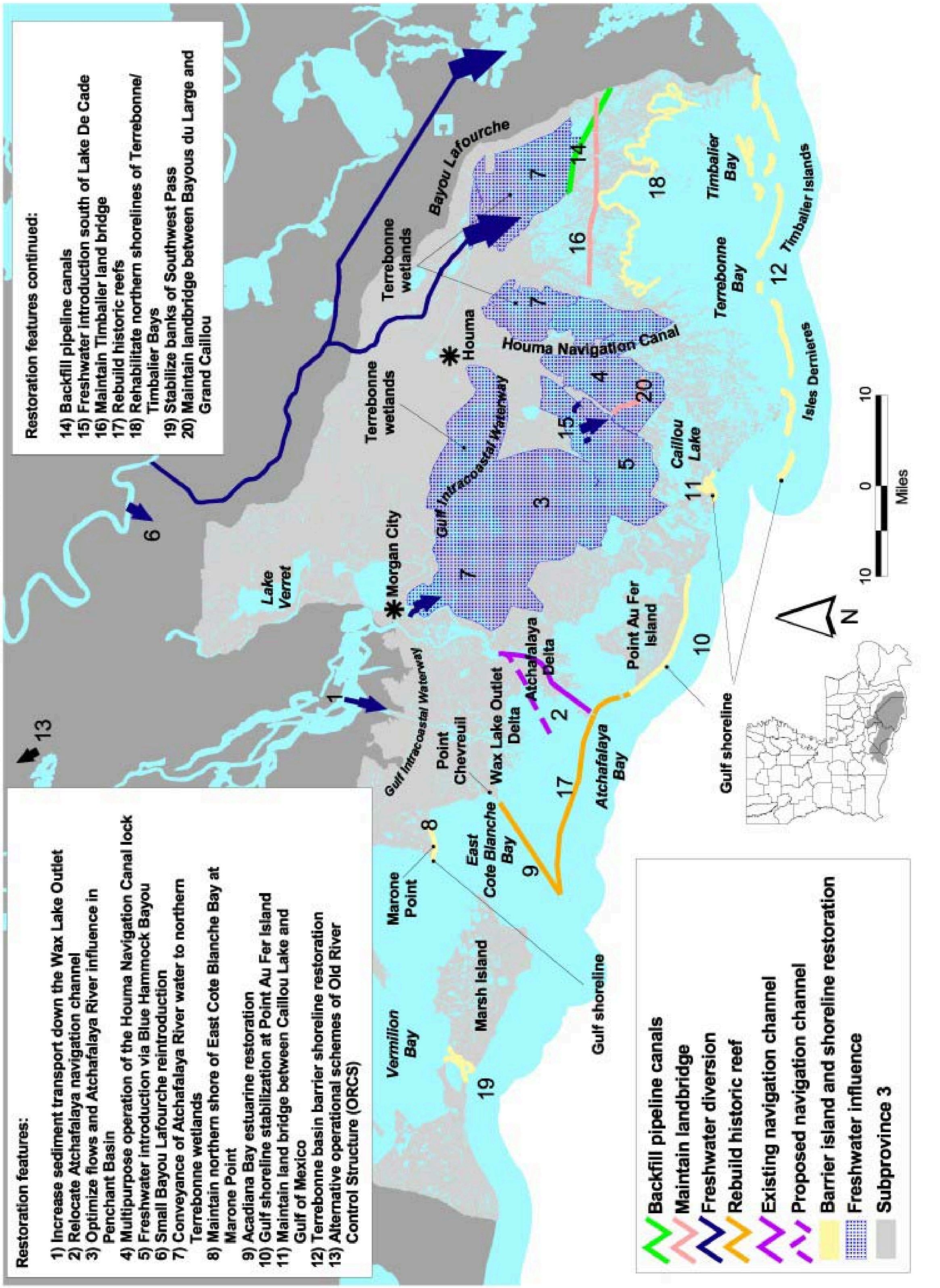


**Figure MR 3-8. Subprovince 3 Restoration Features Identified in the Final Array of Coast Wide Frameworks.**

#### 3.3.6.1.4 *Subprovince 4 feature descriptions*

Black Bayou bypass culverts

This restoration feature involves the replacement of the Calcasieu Lock in the GIWW west of the Hwy 384 Bridge and uses the old lock for freshwater introduction to the upper Calcasieu estuary from the Mermentau Basin. This feature also incorporates freshwater introduction via the Black Bayou Culverts feature at the intersection of Black Bayou and Hwy 384.

Calcasieu Ship Channel Beneficial Use

This feature capitalizes on the existing navigation maintenance activity by expanding beneficial use of dredged material from the Calcasieu Ship Channel. It accomplishes this by extending the application of material dredged from the channel for routine maintenance beyond the normal standard. Average annual maintenance dredging volume is approximately 4 million cubic yards (3.1 million cubic meters). The expanded use of this material would result in wetland creation over 50 years of application.

Chenier Plain freshwater management and allocation reassessment

This restoration opportunity requires detailed investigations involving water allocation needs and trade-off analysis in the eastern Chenier Plain, including the Teche/Vermilion Basin, to provide for wetland restoration and support continued agriculture and navigation in the region. A series of navigation and salinity control structures are currently authorized and operated in the eastern portion of the Chenier Plain. These structures maintain a freshwater source for agricultural applications and prevention of salinity intrusion in the area. Tidal stages have predominantly exceeded stages within the managed area creating a ponding issue for the fresh and intermediate marshes in the area. In addition, the natural ridges that define this area continue to be impacted by erosion, further threatening the ability for continued management and sustainability of the interior marshes. The study would address water management and allocation issues including salinity control, drainage, and fisheries accessibility.

Dedicated dredging for marsh restoration

This restoration feature would apply dredged material from offshore sources beneficially to restore subsided wetlands on Sabine National Wildlife Refuge (NWR) and adjacent properties. Locations for marsh restoration would be north and northwest of Browns Lake on Sabine NWR. Average open water depth is 1.5 to 2 feet (0.4 to 0.6 meters) deep.

East Sabine Lake hydrologic restoration

This restoration feature involves restoration of East Sabine Lake between Sabine Lake and Sabine NWR Pool 3. This feature would include salinity control structures at Willow Bayou, Three Bayou, Greens Bayou, and Right Prong of Black Bayou. Sediment terracing would also be used in shallow open water areas along with shoreline protection along Sabine Lake and some smaller structures.

Freshwater introduction at Highway 82

This restoration feature provides for drainage of "excess" freshwater from the Mermentau Basin Lakes Subbasin across Hwy 82 to the Chenier Subbasin at the Highway 82 area between Rollover Bayou and Superior Canal to the eastern portion of Rockefeller Refuge. This introduction would involve the replacement or modification of culverts under Hwy 82. The objective of this feature is to relieve elevated stages in the northern area and provide freshwater input to the brackish and intermediate marshes to the south. This feature is intended to work in concert with four other restoration feature located along the Hwy 82 alignment.

Freshwater introduction at Little Pecan Bayou

This restoration feature provides for drainage of "excess" freshwater from the Mermentau Basin Lake Subbasin across Hwy 82 to the Chenier Subbasin west of Rockefeller Refuge at the Thibodeaux Bridge. This introduction would involve the replacement or modification of culverts under Hwy 82. The objective of this feature is to relieve elevated stages in the northern area and provide freshwater input to the brackish and intermediate marshes to the south. This feature is intended to work in concert with four other restoration feature located along the Hwy 82 alignment.

Freshwater introduction at Pecan Island

This restoration feature provides for drainage of "excess" freshwater from the Mermentau Basin Lake Subbasin across Hwy 82 near Pecan Island to the Chenier Subbasin. This introduction would involve the replacement or modification of culverts under Hwy 82. The objective of this feature is to relieve elevated stages in the northern area and provide freshwater input to the brackish and intermediate marshes to the south. This feature is intended to work in concert with four other restoration feature located along the Hwy 82 alignment.

Freshwater introduction at Rollover Bayou

This restoration feature provides for drainage of "excess" freshwater from the Mermentau Basin Lake Subbasin across Hwy 82 at Rollover Bayou to the Chenier Subbasin. This introduction would involve the replacement or modification of culverts under Hwy 82. The objective of this feature is to relieve elevated stages in the northern area and provide freshwater input to the brackish and intermediate marshes to the south. This feature is intended to work in concert with four other restoration feature located along the Hwy 82 alignment.

Freshwater Introduction at South Grand Chenier

This restoration feature provides for drainage of "excess" freshwater from the Mermentau Basin Lakes Subbasin from the Mermentau River across Hwy 82 to the Chenier Subbasin Hog Bayou watershed. This introduction would involve the replacement or modification of culverts under Hwy 82. The objective of this feature is to relieve elevated stages in the northern area and provide freshwater input to the brackish and intermediate marshes to the south. This feature is intended to work in concert with four other restoration feature located along the Hwy 82 alignment.

Stabilize Gulf shoreline near Rockefeller Refuge

This restoration feature provides for gulf shoreline stabilization from Mermentau Ship Channel to near Rollover Bayou east of Rockefeller Refuge. Stabilization methods include rock foreshore dikes, offshore reefs, or segmented breakwaters, similar to Holly Beach breakwaters, placed closer to shore and with narrower gaps. The objective of this feature is the prevention of shoreline breaching into the landward brackish and intermediate marshes.

Modify existing Cameron-Creole watershed structures

The Cameron-Creole watershed feature, constructed in 1989, consists of 5 large concrete water control structures and a 16 mile-long levee along the shoreline of Calcasieu Lake. Three of the five structures (Grand Bayou, Bois Connine Bayou, and Lambert Bayou) are adjustable structures with slide gates and the remaining two (Mangrove Bayou and No Name Bayou) are fixed crest weir structures. The fixed crest weir sill heights may be set too high. This higher setting could be contributing to the impoundment problem within Cameron-Creole marshes adjacent to those structures. If the weir sills for these two structures could be modified to lower weir crests, reduced impoundment, greater water flow, and increased fisheries access (above that afforded by the vertical fish slots already present in the structures) would occur independent of salinity control at Calcasieu Pass.

New Lock at the GIWW

This feature consists of a new lock at the GIWW east of Alkali Ditch with dimensions of 75 to 110 feet (23 to 34 meters) wide by 15 feet (4.6 meters) deep. This restoration feature would limit the exchange of water between the Sabine River and the GIWW eastward to the Calcasieu River. The existing circulation pattern provides a mechanism for the intrusion of higher salinity waters transmitted by the deeper navigation channels in each of the rivers to reach the interior marshes. The objective of the feature is the reduction of circulation of higher salinity water through the Calcasieu-Sabine sub-basin, thereby reducing future wetlands loss.

Salinity control at Alkali Ditch

This restoration feature provides salinity control at the Alkali Ditch, northwest of Hackberry at the GIWW, with a gated structure or rock weir with barge bay. The existing dimensions of the feature are approximately 150 to 200 feet (45 to 60 meters) wide by 8 to10 feet (2.4 to 3 meters) deep; the structure or weir with approximate dimensions 70 feet wide (21 meters) by 8 feet (2.4 meters) deep. The objective of this feature is to regulate saltwater intrusion in order to stabilize the brackish and intermediate marshes in the area and reduce future loss.

Salinity control at Black Bayou

This restoration feature calls for a salinity control structure with boat bay at the mouth of Black Bayou (either a gated structure or a rock weir), located at the intersection of Black Bayou and the northeastern shoreline of Sabine Lake. The existing bayou dimensions are 150 to 200 feet (45 to 60 meters) wide by 10 feet (3 meters) deep. The objective of this feature is to regulate saltwater intrusion in order to stabilize the brackish and intermediate marshes in the area and reduce future loss.

Salinity control at Black Lake Bayou

This restoration feature calls for salinity control in Long Point Bayou with a gated structure or rock weir located in Long Point Bayou north of Sabine NWR near Hwy 27, west of the Calcasieu Ship Channel. The existing dimensions are 40 feet wide (12 meters) by 5 feet (1.5 meters) deep. The structure's approximate dimensions are 10 to 15 feet (3 to 4.5 meters) wide by 4 feet (1.2 meters) deep boat bay. The objective of this feature is to regulate saltwater intrusion in order to stabilize the brackish and intermediate marshes in the area and reduce future loss.

Salinity control at Highway 82 Causeway

This restoration feature provides for a rock weir at Hwy 82 Causeway located in the southern portion of Sabine Lake north of Sabine Pass and the Sabine-Neches Waterway. Existing dimensions of the facility equal approximately 3,400 feet wide by approximately 4 feet deep, except at the approximate 10 feet (3 meters) deep center channel. The objective of this feature is to regulate saltwater intrusion in order to stabilize the brackish and intermediate marshes in the area and reduce future loss.

Salinity control at Long Point Bayou

This restoration feature provides for salinity control in Long Point Bayou with a gated structure or rock weir located in Long Point Bayou north of Sabine NWR near Hwy 27, west of the Calcasieu Ship Channel. The existing dimensions are 40 feet wide by 5 feet deep. The structure's approximate dimensions are 10 to 15 feet (3 to 4.5 meters) wide by 4 feet (1.2 meters) deep boat bay. The objective of this feature is to regulate saltwater intrusion in order to stabilize the brackish and intermediate marshes in the area and reduce future loss.

Salinity control at Oyster Bayou

This restoration feature provides for salinity control in Oyster Bayou with a gated structure or rock weir. The location in Oyster Bayou is about 1 mile west of the Calcasieu Ship Channel, which is 100 to 150 feet wide by 10 feet deep; with an approximately 15 to 20 foot (4.5 to 6 meters) wide by 4 foot (1.2 meters) deep boat bay. The objective of this feature is to regulate saltwater intrusion in order to stabilize the brackish and intermediate marshes in the area and reduce future loss.

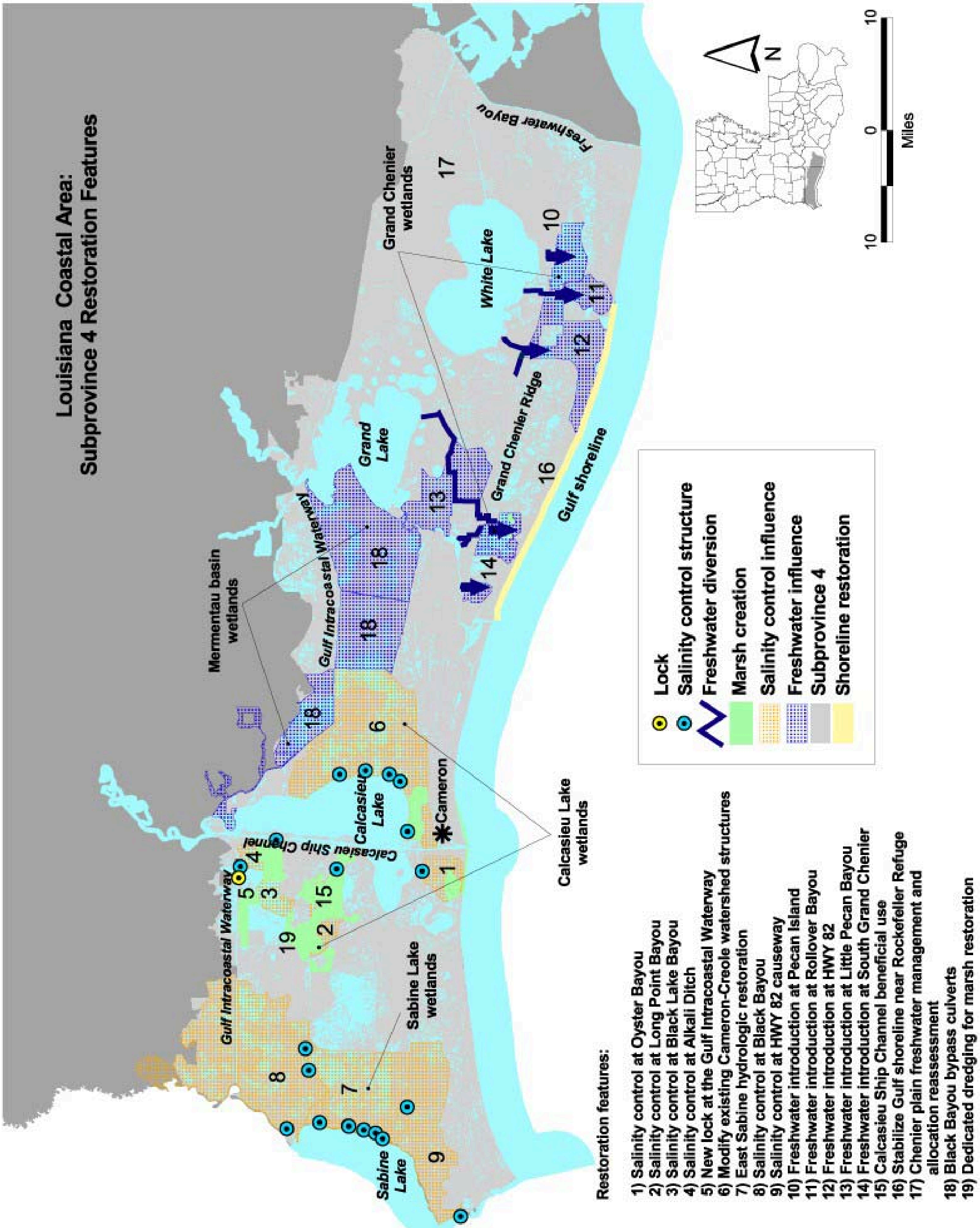


**Figure MR 3-9. Subprovince 4 Restoration Features Identified in the Final Array of Coast Wide Frameworks.**

### 3.3.7 Development of Sorting and Critical Needs Criteria

The PDT determined that use of initial sorting criteria and follow-on critical needs criteria-based evaluations was an appropriate method to determine which of the 79 features would best meet near-term requirements. Criteria were developed to identify which restoration features would be placed into the various component categories described in Section 3.3.6. In addition, the criteria helped identify the ability of each restoration feature to address critical needs.

The initial step in identifying these criteria was the gathering of input by the PDT. The Vertical Team, Framework Development Team, and the PDT developed a methodology to: 1) sort the restoration features into the component categories of the alternative LCA Plans; and 2) identify the relative value of a restoration feature in addressing critical ecologic needs in the coastal landscape. The criteria were designated as either "sorting" or "critical needs" criteria. The PDT designated three sorting criteria, and four critical needs criteria.

#### 3.3.7.1 Sorting criteria

##### 3.3.7.1.1 *Sorting Criterion #1 - Engineering and design complete and construction started within 5 to 10 years*

A restoration feature would meet this criterion if, over the next 5 to 10 years:

- Required feasibility-level decision documents could be completed;
- Necessary NEPA documentation could be completed;
- Pre-construction engineering & design (PED) could be completed; and
- Construction authorization could be obtained and construction could be initiated.

If a restoration feature did not meet this criterion, it was not viewed as a potential near-term restoration opportunity, but rather a potential candidate for large-scale and long-range study.

##### 3.3.7.1.2 *Sorting Criterion #2 - Based upon sufficient scientific and engineering understanding of processes*

A restoration feature would successfully meet this criterion if it contained:

- Opportunities for which there is currently a sound understanding based in science and technology; and
- Science and engineering principles that have been applied within Louisiana and successfully achieved a beneficial ecosystem response.

Features that did not meet this criterion were not considered as potential near-term restoration opportunities. Instead, the scientific and/or engineering uncertainties associated with these restoration features provided a basis for the feature to be a potential candidate for a demonstration project.

#### 3.3.7.1.3 ***Sorting Criterion #3 - Implementation is independent; does not require another restoration feature to be implemented first***

If a feature was not deemed to be independent, other features that potentially had overlapping or duplicative effects were identified, and the interdependent features were combined. This combination of features was then reassessed to determine if, as a composite, the group of features met the initial two sorting criteria and classified appropriately. The intent of this criterion was to ensure that those features with overlapping hydrologic or ecologic influence area were considered simultaneously in their design development. This criterion was meant to apply specifically to, but not be limited to, those features that would be implemented in the near-term restoration effort. The realization of individual feature benefits is not dependent on implementation of all features. Once they have been synergistically designed, each feature will be of an appropriate scale to operate independently without being redundant with other features within the influence area.

The sorting criteria were applied sequentially. In other words, if a feature failed to meet criterion #2, then it was not reviewed to assess whether it met criterion #3. The process of applying these sorting criteria is represented in the flow diagram in **figure MR 3-10**.

### 3.3.7.2 <u>Critical needs criteria</u>

If a restoration feature met all of the sorting criteria, it was then assessed against the critical needs criteria. The application of the criteria was done in an annotated manner so that the reasoning for applicability of each feature versus the criteria could be readily assessed. This approach allowed the PDT to make relative comparisons of different features based on common criteria and fine tune the overall value of features in addressing the critical ecologic and human needs of the system. The following criteria were applied to potential near-term course of action features as defined.

#### 3.3.7.2.1 ***Critical Needs Criterion #1 - Prevents future land loss where predicted to occur***

One of the most fundamental drivers of ecosystem degradation in coastal Louisiana has been the conversion of land (mostly emergent vegetated wetland habitat) to open water. One of the most fundamental critical needs is to stem this loss. Thus, the projection of the future condition of the ecosystem must be based upon the determination of future patterns of land and water. Future patterns of land loss were based on the USGS open file report 03-334 “Historical and Predicted Coastal Louisiana Land Changes: 1978-2050” (appendix B HISTORIC AND PROJECTED COASTAL LOUISIANA LAND CHANGES: 1978-2050). This also applies to future predicted conversion of cypress swamp in areas with existing fragmenting marsh.

#### 3.3.7.2.2 *Critical Needs Criterion #2 - (Sustainability) Restores fundamentally impaired (or mimics) deltaic function through river reintroductions*

This criterion refers to opportunities that would restore or mimic natural connections between the river and the basins (or estuaries), including distributary flows, crevasses, and over-bank flow. Mechanical marsh creation with river sediment was also viewed as mimicking the deltaic function of sediment introduction if supported by sustainable freshwater and nutrient reintroduction.

#### 3.3.7.2.3 *Critical Needs Criterion #3 - (Sustainability) Restores or preserves endangered critical geomorphic structure*

This criterion identifies opportunities that would restore or maintain natural geomorphic structures such as barrier islands, distributary ridges, cheniers, land bridges, and beach and lake rims. These geomorphic structures are essential to maintaining the integrity of coastal ecosystems. Those structures that are endangered or "nearly lost" in the near-term are especially critical.

#### 3.3.7.2.4 ***Critical Needs Criterion #4 - Protects vital socioeconomic resources***

This criterion identifies proposed opportunities that would potentially protect vital local, regional, and national social, economic, and cultural resources. These resources include cultures, community, infrastructure, business and industry, and flood protection.

### 3.3.7.3 Application of the criteria

Following the identification of these restoration criteria and the method for their application, the PDT made an initial assessment of the 79 restoration features. This assessment indicated that the methodology could be applied effectively to identify potential alternative plans (**figure MR 3-10**).

During the week of April 19 to 23, 2004, a series of public scoping meetings were held across the LCA Study area. These meetings provided the public and stakeholder groups an opportunity to comment on the modification of the study and the specific criteria for identifying alternative LCA Plans. The participants were provided with an overview of the criteria and methodology, the written definition of each criterion's application, and a list of the 79 features. This information was also made available on the study's web site along with additional feature details. The meeting participants were encouraged to comment on and/or modify the criteria and methodology developed by the PDT, as well as to provide input on additional criteria that they considered appropriate. Finally, attendees were encouraged to take materials to other interested parties who were not able to attend or direct them to the study's web site to submit their comments.

The public input was compiled and used to make adjustments to the criteria or to the criteria's application to individual features. In addition, public input allowed the PDT to make final assessments of the appropriate components of the alternative LCA Plans.

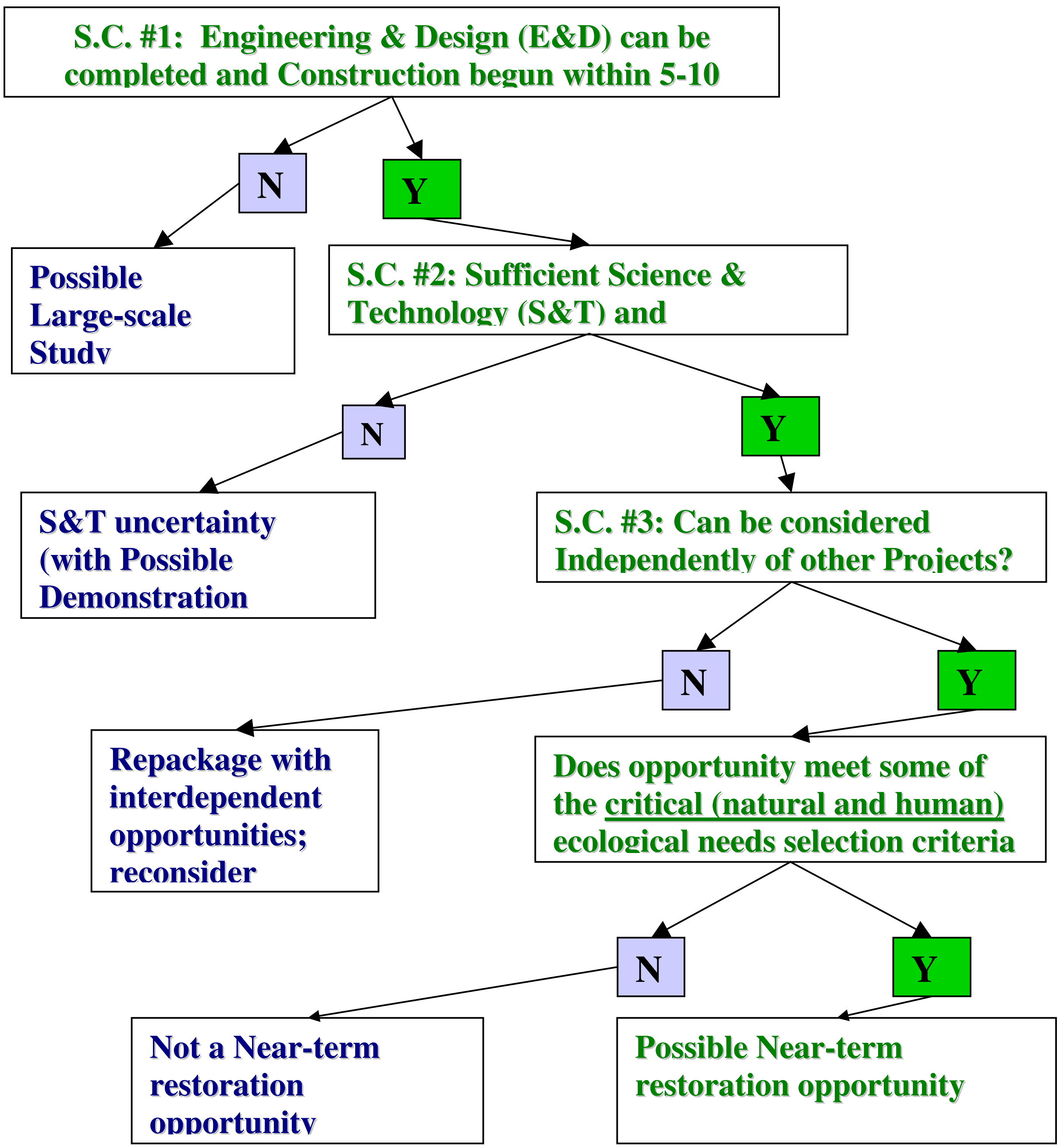


**Figure MR 3-10. LCA Sorting Process Flow Diagram**.

## 3.4 SORTING CRITERIA APPLICATION RESULTS

During Phase VI, each of the 79 restoration features was analyzed through the three Sorting Criteria (**figure MR 3-11**) and four Critical Needs Criteria. These criteria were designed to determine whether or not a restoration feature should be incorporated as a near-term component in one or more of the LCA alternative plans. In addition, if it was determined that a feature was to be included in the near-term course of action, the criteria helped determine in which component category it would best fit. For example a restoration feature could represent a potential near-term critical restoration feature or a potential large-scale study for a promising restoration concept. Alternatively, an overarching scientific or technological uncertainty could be associated with a restoration feature that would first require the development and implementation of an appropriately scaled demonstration project prior to the implementation of the feature.

### 3.4.1 Results of Applying Sorting Criterion #1: Engineering and Design (E&D) can be Completed and Construction Started within 5 to 10 Years

Application of Sorting Criterion #1 winnowed down the number of potential restoration features from 79 to 61. Those restoration features deemed too complex to have feasibility-level decision documents complete and construction begun within the next 5 to 10 years of plan implementation did not successfully pass through this sorting criterion and were instead considered for inclusion in the LCA Plan alternatives as potential large-scale studies. **Table MR 3-8** lists those restoration features that did not meet Sorting Criterion #1 and were, therefore eliminated from further consideration as near-term plan restoration features.

**Table MR 3-8. Restoration Features Eliminated using Sorting Criterion #1: Features Whose E&D Could not be Completed and Construction Started Within the Next 5 to 10 Years.**

**Subprovince 1**
- Medium diversion at Bonnet Carre Spillway
- Post authorization for the diversion of water through Inner Harbor Navigation Canal for increased influence into Central Wetlands
- Medium to large sediment diversion at American/California Bays
- Mississippi River Delta Management Study (Subprovinces 1 & 2)

**Subprovince 2**
- Medium diversion at Edgard with sediment enrichment
- Large diversion at Boothville with sediment enrichment
- Medium diversion at Fort Jackson - Alternative to Boothville diversion
- Large diversion at Fort Jackson with sediment enrichment - Alternative to Boothville diversion
- Medium diversion at Lac des Allemands with sediment enrichment
- Large diversion at Myrtle Grove with sediment enrichment
- Third Delta (Subprovinces 2 & 3)

**Subprovince 3**
- Relocate the Atchafalaya Navigation Channel
- Increase sediment transport down Wax Lake Outlet
- Alternative operational scheme of the Old River Control Structure (ORCS)
- Acadiana Bays Estuarine Restoration
- Rebuild historic reefs - Rebuild historic barrier between Point Au Fer and Eugene Island and construct segmented reef/breakwater/jetty along the historic Point Au Fer barrier reef from Eugene Island extending towards Marsh Island to the west

**Subprovince 4**
- Chenier Plain freshwater management and allocation reassessment*
    - Freshwater introduction at South Grand Chenier
    - Freshwater introduction at Pecan Island
    - Freshwater introduction at Rollover Bayou
    - Freshwater introduction at Highway 82
    - Freshwater introduction at Little Pecan Bayou
- New lock at the GIWW

** These features did not pass Sorting Criterion #3, were repackaged and are considered as a potential large-scale study within the Chenier Plain Freshwater Management and Allocation Study*

### 3.4.2 Results of Applying Sorting Criterion #2: Sufficient S&T and Engineering Understanding of Processes

Of the 61 features that met Sorting Criterion #1, 28 did not successfully meet Sorting Criterion #2 because they contained some form of scientific or technical uncertainty that would require resolution prior to their implementation. The various types of uncertainties are described in section 3.1 PLANNING CONSTRAINTS. These uncertainties may be resolved by the development and implementation of an appropriately scaled demonstration project (the specific features may suggest demonstration project locations). **Table MR 3-9** lists features that did not meet Sorting Criterion #2 and were, therefore eliminated from further consideration as near-term course of action restoration features.

**Table MR 3-9. Restoration Features Eliminated Using Sorting Criterion #2: Features Having Significant Uncertainties About Science and Technology and Engineering Understanding of Processes.**

**Subprovince 1**
- Marsh nourishment on New Orleans East land bridge
- Sediment delivery via pipeline at La Branche wetlands
- Sediment delivery via pipeline at American/California Bays
- Sediment delivery via pipeline at Central Wetlands
- Sediment delivery via pipeline at Ft. St. Philip
- Sediment delivery via pipeline at Golden Triangle
- Sediment delivery via pipeline at Quarantine Bay
- Opportunistic use of Bonnet Carre Spillway

**Subprovince 2**
- Implement the LCA Barataria Basin Wetland Creation and Restoration Study
- Sediment delivery via pipeline at Bastian Bay/Buras
- Sediment delivery via pipeline at Empire
- Sediment delivery via pipeline at Main Pass (Head of Passes)

**Subprovince 3**
- Maintain land bridge between Bayous du Large and Grand Caillou

- Maintain Timbalier land bridge
- Backfill pipeline canals
- Freshwater introduction south of Lake De Cade
- Freshwater Introduction via Blue Hammock Bayou

**Subprovince 4**

- Salinity control at Alkali Ditch
- Salinity control at Highway 82 Causeway
- Salinity control at Oyster Bayou
- Salinity control at Long Point Bayou
- Salinity control at Black Lake Bayou
- Black Bayou Bypass culverts
- Dedicated dredging for marsh restoration
- Stabilize Gulf shoreline near Rockefeller Refuge
- Modify existing Cameron-Creole watershed structures
- East Sabine Lake hydrologic restoration
- Salinity control at Black Bayou

### 3.4.3 Results of Applying Sorting Criterion #3: Implementation is Independent; Does not Require Other Restoration Feature to be Implemented First

The remaining 33 features were next subjected to Sorting Criterion #3 to determine their independence from other restoration features. When running these remaining features through Sorting Criterion #3, 12 features were deemed to be independent (received a “Yes” for this criterion). These 12 features then proceeded to the Critical Needs Criteria evaluation. The 21 features that were determined to be interdependent (received a “No” for this criterion) were combined with other dependent features(s), as appropriate, to create “restoration opportunities”. The combined restoration opportunities were evaluated again using Sorting Criteria 1, 2, and 3. One of the restoration opportunities, Freshwater Reintroductions into Subprovince 4, (consisting of five features) failed to pass Sorting Criterion #1 and was reserved as a potential concept for large-scale studies and eliminated from consideration as a near-term restoration opportunity. The remaining 6 restoration opportunities (consisting of 16 features) passed both criteria 1 and 2 and were included for further consideration as near-term restoration opportunities. **Table MR 3-10** identifies the 12 restoration features and 6 combined restoration opportunities (made up of 16 restoration features) that were further evaluated using the Critical Needs Criteria. **Figure MR 3-11** provides a graphic representation of the Sorting Criteria Evaluation Process.

**Table MR 3-10. Restoration Features and Restoration Opportunities that Passed Sorting Criteria 1 to 3.**

**Subprovince 1**

- MRGO Environmental Restoration Features
- Maurepas Swamp Reintroductions Restoration Opportunity
  This restoration opportunity includes the following features:
  - Small diversion at Hope Canal
  - Small diversion at Convent / Blind River
  - Increase Amite River Diversion Canal influence by gapping banks
- Upper Breton Sound Reintroductions Restoration Opportunity
  This restoration opportunity includes the following features:
  - Modification of Caernarvon diversion
  - Medium diversion at White's Ditch
- Lower Breton Sound Reintroductions Restoration Opportunity
  This restoration opportunity includes the following features:
  - Rehabilitate Bayou Lamoque structure as a medium diversion
  - Medium diversion at American / California Bays
- Rehabilitate Violet Siphon for increased influence to Central Wetlands
- Medium diversion at Fort St. Philip

**Subprovince 2**

- Barataria Basin barrier shoreline restoration
- Mid-Barataria Basin Reintroductions Restoration Opportunity
  This restoration opportunity includes the following features:
  - Modification of Davis Pond diversion for increased sediment input
  - Medium diversion with dedicated dredging at Myrtle Grove
- Lac Des Allemands Area Reintroductions Restoration Opportunity
  This restoration opportunity includes the following features:
  - Small diversion at Lac Des Allemands
  - Small diversion at Donaldsonville
  - Small diversion at Pikes Peak
  - Small diversion at Edgard

**Subprovince 3**

- Small Bayou Lafourche reintroduction
- Terrebonne Marsh Restoration Opportunity
  This restoration opportunity includes the following features:
  - Optimize flows and Atchafalaya River influence in Penchant Basin
  - Multi-purpose operation of Houma Navigation Canal (HNC) Lock
  - Convey Atchafalaya River water to Terrebonne Marshes via a small diversion in the Avoca Island Levee, repairing eroding banks of the GIWW, and enlarging constrictions in the GIWW below Gibson and in Houma, and Grand Bayou conveyance channel construction / enlargement
- Terrebonne Basin barrier shoreline restoration
- Maintain land bridge between Caillou Lake and Gulf of Mexico
- Gulf shoreline stabilization at Point Au Fer Island
- Maintain northern shore of East Cote Blanche Bay at Point Marone
- Rehabilitate Northern Shorelines of Terrebonne / Timbalier Bays
- Stabilize banks of Southwest Pass

**Subprovince 4**

- Calcasieu Ship Channel Beneficial Use

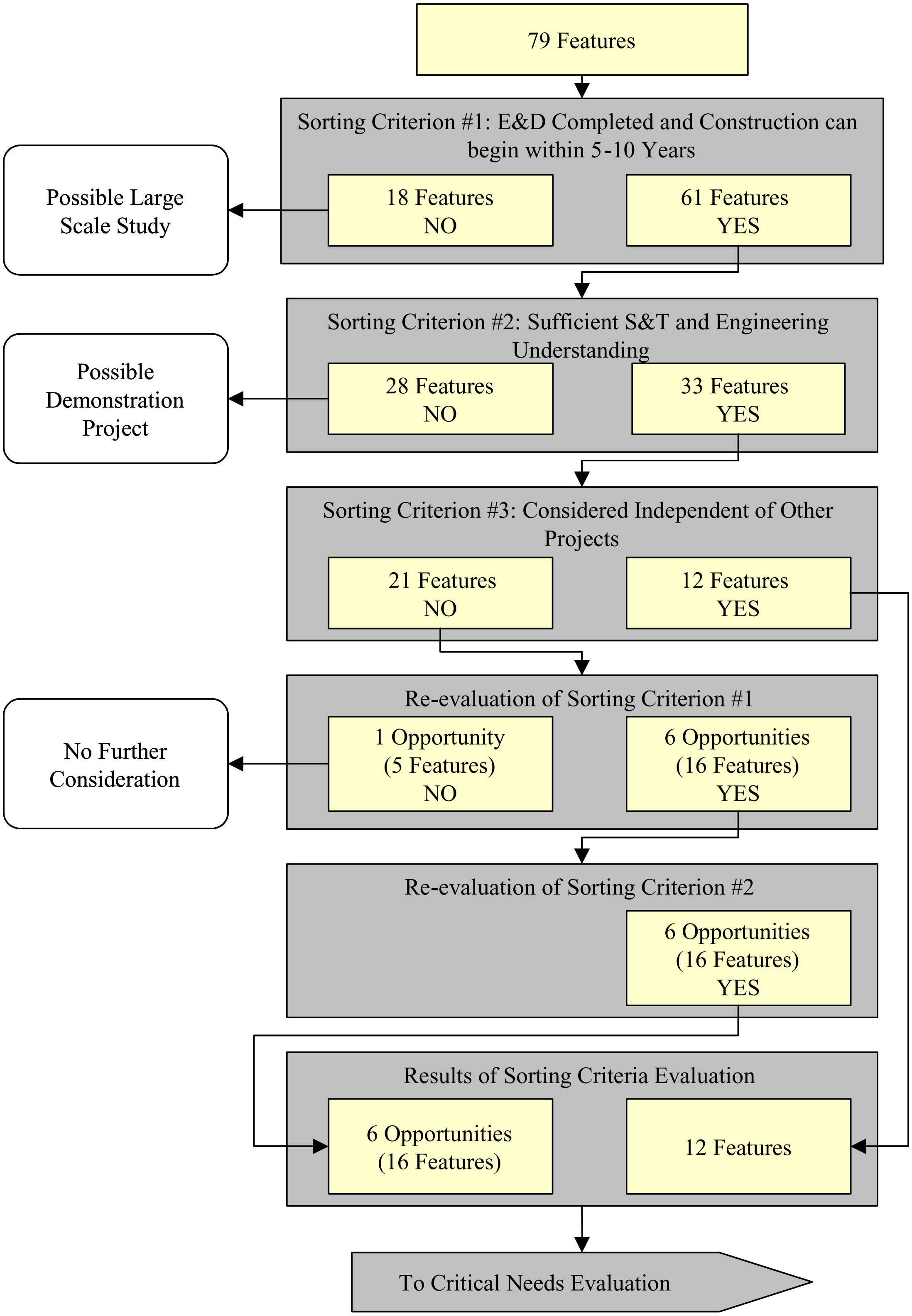


**Figure MR 3-11. Application of Sorting Criteria to Restoration Features and Opportunities.**

## 3.5 CRITICAL NEEDS CRITERIA APPLICATION RESULTS

Following the application of Sorting Criteria, the 12 restoration features and 6 restoration opportunities (made up of 16 restoration features) were further evaluated using the Critical Needs Criteria. Annotated comments were developed for each feature and opportunity to identify the particular Critical Need Criteria that a component met (or did not meet), as well as the relative ability of the feature or opportunity to address them. After evaluating the 12 features and 6 restoration opportunities using the Critical Needs Criteria, seven features and five restoration opportunities (made up of 14 restoration features) were determined to meet the Critical Needs Criteria. These features and opportunities were used to form the basis of the alternative near-term courses of action. Alternately, five features and one restoration opportunity (made up of two restoration features) did not meet the Critical Needs Criteria, and were not considered for inclusion in the near-term course of action. Below are the annotated comments of the results of the assessment of individual features and restoration opportunities following application of the four Critical Needs Criteria.

### 3.5.1 Features Having Major "Critical Needs Criteria" Value

#### 3.5.1.1 <u>Subprovince 1</u>

<u>MRGO Environmental Restoration Features</u>

These features address Critical Needs Criteria 1, 3, and 4. Specifically, these features have the potential to: prevent predicted future land loss and restore previously degraded wetlands; stabilize and restore the endangered, critical lake rim geomorphic structure; and protect vital socioeconomic resources, such as developments located adjacent to the MRGO.

<u>Maurepas Swamp Reintroductions Opportunity</u>

The Maurepas Swamp Reintroduction Opportunity includes the following features:

- Small diversion at Hope Canal
- Small diversion at Convent / Blind River
- Increase Amite River Diversion Canal influence by gapping banks

This near-term restoration opportunity evaluates several features that have the potential to address Critical Needs Criteria 1, 2, and 4. Specifically, this opportunity has the potential to: prevent future cypress swamp degradation and transition currently predicted to occur; restore the deltaic process impaired by levee and dredged material bank construction; and protect vital socioeconomic and public resources, such as the growing eco-tourism industry resident in the Maurepas Swamp and the Maurepas Wildlife Management Area.

Upper Breton Sound Reintroductions Opportunity

The Upper Breton Sound Reintroduction Opportunity includes the following features:

- Modification of Caernarvon diversion
- Medium diversion at White's Ditch

This near-term restoration opportunity evaluates several features that have the potential to address Critical Needs Criteria 2 and 4. Specifically, this opportunity has the potential to restore the deltaic process impaired by levee construction at locations where historic crevassing has occurred and protect vital socioeconomic resources located in areas along the east bank of the Mississippi River in Plaquemines Parish within hurricane flood protection levees. This opportunity also includes features that capitalize on existing structures, such as the Caernarvon diversion.

### 3.5.1.2 Subprovince 2

Barataria Basin Barrier Shoreline Restoration

This restoration feature has multiple components, some of which have potential to address Critical Needs Criteria 1, 3, and 4. This near-term critical feature has been defined as restoration of the Caminada Headland and Shell Island reaches. These elements of the Barataria barrier-shoreline directly meet specific critical need criteria internal and external to the feature footprint. The feature has the potential to: preventing future land loss where currently predicted to occur; restoring immediately endangered, critical geomorphic structure at the gulfward boundary of the Barataria system; and providing immediate protection of vital socioeconomic resources, such as oil and gas infrastructure located on the leeward side of these islands. In addition the elements of this feature are related to the support and function of all the other elements of the Barataria barrier-shoreline chain. All other elements of this barrier-shoreline are currently being considered for restoration action under other programs. However, this feature does entail some aspects of technical uncertainty in the availability and quality of source material, delivery material by pipeline, and durability.

Mid-Barataria Basin Reintroductions Opportunity

The Mid-Barataria Basin Reintroduction Opportunity includes the following features:

- Modification of Davis Pond diversion
- Medium diversion with dedicated dredging at Myrtle Grove

This near-term restoration opportunity evaluates several features that have the potential to address Critical Needs Criteria 1, 2, and 4. Specifically, this opportunity has the potential to: prevent future land loss where currently predicted to occur; restore the deltaic process impaired by the construction of levees at locations where historic crevassing has occurred, as well as improve water quality; and protect vital socioeconomic resources located in the central and upper portions of the Barataria Basin. This opportunity would also capitalize on the existing Davis Pond diversion structure.

Lac des Allemands Area Reintroductions Opportunity

The Lac des Allemands Area Reintroductions Opportunity includes the following features:

- Small diversion at Lac Des Allemands
- Small diversion at Donaldsonville
- Small diversion at Pikes Peak
- Small diversion at Edgard

This near-term restoration opportunity evaluates several features that have the potential to address Critical Needs Criteria 1, 2, and 4. Specifically, this opportunity has the potential to: prevent significant future land loss where currently predicted to occur; restore the deltaic process impaired by levee construction in areas where historic crevassing has occurred, prevent swamp degradation and stagnation; and protect vital socioeconomic resources such as the eco-tourism industry and residents in the upper Barataria Basin.

#### 3.5.1.3 Subprovince 3

Small Bayou Lafourche Reintroduction

This feature would reintroduce flow from the Mississippi River into Bayou Lafourche and addresses Critical Needs Criteria 1, 2, and 4. Specifically, this feature has the potential to: prevent future land loss where predicted to occur; restore a fundamentally impaired deltaic process by reintroducing water to a historic distributary of the Mississippi; and protect vital community and socioeconomic resources by supplementing channel flow and stabilizing water quality.

Terrebonne Basin Barrier Shoreline Restoration

This near-term critical feature has been defined as restoration of the Isle Dernieres and East Timbalier reaches of the Terrebonne barrier-shoreline chain. All other elements of this barrier-shoreline are currently being considered for restoration action under other programs. This restoration feature has multiple components, some of which have potential to address Critical Needs Criteria 1, 3, and 4. Specifically, this feature has the potential to: prevent future barrier island losses where predicted to occur; restore endangered, critical geomorphic structure; and protect vital socioeconomic resources such as oil and gas infrastructure and fisheries. However, this feature entails some aspects of technical uncertainty in the availability and quality of source material, delivery of material by pipeline, and durability.

Maintain Land Bridge Between Caillou Lake and Gulf of Mexico

This restoration feature addresses Critical Needs Criteria 1 and 3. This feature would stem shoreline retreat and prevent further breaches that have allowed increased water exchange between the gulf and the interior water bodies (between Bay Junop and Caillou Lake). Prevention of increased marine influence would reduce interior wetland loss as well as preserve the potential for long-range restoration. Closure of newly opened channels would restore historic cross-sections of exchange points, would reduce marine influences in interior areas, and allow increased freshwater influence from Four League Bay to benefit area marshes.

Gulf Shoreline Stabilization at Point Au Fer Island

This feature addresses Critical Needs Criteria 1, 3, and 4. Specifically, this feature has the potential to: prevent future shoreline retreat, where predicted to occur; restore endangered, critical geomorphic structure by stabilizing the island shoreline; and protect vital community and socioeconomic resources.

Terrebonne Marsh Restoration Opportunity

The Terrebonne Marsh Restoration Opportunity includes the following features:

- Optimize flows and Atchafalaya River influence in Penchant Basin
- Multi-purpose operation of Houma Navigation Canal (HNC) Lock
- Convey Atchafalaya River water to Terrebonne Marshes via a small diversion in the Avoca Island levee, repairing eroding banks of the GIWW, and enlarging constrictions in the GIWW below Gibson and in Houma, and Grand Bayou conveyance channel construction/enlargement

This near-term restoration opportunity evaluates several features that have the potential to address Critical Needs Criteria 1, 2, and 4. Specifically, this opportunity has the potential to: prevent future land loss where predicted to occur; restore fundamentally impaired deltaic processes through the re-introduction of Atchafalaya River water; and protect vital community and socioeconomic resources in the area, such as waterborne commerce and oil and gas infrastructure.

#### 3.5.1.4 Subprovince 4

Calcasieu Ship Channel Beneficial Use

This feature addresses Critical Needs Criteria 1 and 4. Specifically, this feature has the potential to prevent future land loss where predicted to occur and protect vital community and socioeconomic resources of agricultural land use and oil and gas infrastructure. It also capitalizes on the existing navigation maintenance activity.

### 3.5.2 Features and Opportunities Having Limited or No "Critical Needs Criteria" Value

#### 3.5.2.1 Subprovince 1

Lower Breton Sound Reintroductions Opportunity

The Lower Breton Sound Reintroductions Opportunity includes the following features:

- Rehabilitate Bayou Lamoque structure as a medium diversion
- Medium diversion at American/California Bays

This near-term restoration opportunity evaluates two features that have the potential to address Critical Needs Criteria 2 and 4. This opportunity also includes features that capitalize on existing structures, such as the Bayou Lamoque diversion. While this opportunity has some limited potential to restore the deltaic process in locations where historic crevassing has occurred, the proposed scale does not afford an appreciable influence on the critical need in the area. As a result, this opportunity was not included in any alternative plans.

Rehabilitate Violet Siphon for Increased Influence into Central Wetlands

This feature has some effectiveness meeting Critical Needs Criteria 1 and 2. However, the existing structure has currently been rehabilitated and is operating to capacity on a regulated schedule. Therefore, this feature was not included in any alternative plans.

Medium Diversion at Fort St. Philip

This feature has limited impact meeting Critical Needs Criterion #2. Specifically, this feature appears to have some limited potential to restore deltaic process in the area. However, the major ecologic need in the area is the introduction of large volumes of sediment. The assessment of this feature was that it fell low in the priority of possible critical near-term actions and was therefore not included in any alternative plans.

#### 3.5.2.2 Subprovince 3

Maintain Northern Shore of East Cote Blanche Bay at Point Marone

This feature addresses Critical Needs Criteria 1 and 3 to a minor extent. Specifically, this feature has the potential to prevent some limited future shoreline retreat where predicted to occur and restore some geomorphic structure by stabilizing a small portion of this bay shoreline. The assessment of this feature was that it fell low in the priority of possible critical near-term actions and was therefore not included in any alternative plans.

Rehabilitate Northern Shorelines of Terrebonne/Timbalier Bays

This feature addresses Critical Needs Criteria 1 and 4. Specifically, this feature has the potential to prevent future shoreline retreat where predicted to occur and protect vital community and socioeconomic resources. This feature potentially duplicates the effects of the Terrebonne Basin Barrier-shoreline Restoration feature. The assessment of this feature is that in the near-term the immediate stabilization of the existing barrier-shoreline features is a more effective option. While this feature could be investigated in conjunction with the barrier-shoreline feature, it was not included in any alternative plans.

Stabilize Banks of Southwest Pass

Consideration of critical near-term criteria applied to assess the extent to which critical ecologic needs in the coast would be addressed, this feature was deemed less effective. While qualifying, with some effect relative to critical needs criteria, this feature does not appear to produce appreciable enough changes in the ecosystem to include in any alternative plans. The feature may be further investigated in conjunction with the large-scale Acadiana Bays Estuarine Restoration Study.

## 3.6 ALTERNATIVE PLAN EVALUATION RESULTS

As detailed previously, application of the three sorting criteria and four critical needs criteria was the basis for development of alternative plans composed of near-term critical features, candidate large-scale studies, and candidate science and technology demonstration projects. The sorting criteria application that determined what were the possible near-term critical features among the 79 initial features was considered fixed. The best opportunity to develop alternative plans resided in the application of the critical needs criteria to determine the near-term critical features. While each of the critical needs criteria were supporting and complimentary, it was possible to discern alternative combinations of near-term critical features by applying the criteria individually or in varying combinations.

Alternative plans, which include differing restoration features and restoration opportunities, were developed for evaluation based on the ability of the alternative to meet one or more of the Critical Needs Criteria. Alternatives represent combinations of specific features or actions that are capable of achieving the identified planning objectives through significantly different ecologic modifications or technical methods and thereby represent clearly different options for achieving restoration. **Table MR 3-11** presents the 15 Alternative Plans (plus the No Action Alternative), provides the corresponding plan name (represented by the letters A – O), and identifies which Critical Needs Criterion/Criteria each specific alternative strived to meet. For example, Alternative Plans A, B, D, and H all focus on meeting one of the Critical Needs Criteria (1 through 4 respectively). The remaining 11 Alternative Plans were formulated to include all remaining possible mathematical combinations of the 4 Critical Needs Criteria.

**Table MR 3-11. Possible Alternative Plan Combinations Based on the Critical Needs Criteria.**

| Alternative Plan | Criterion 1 (Prevent Future Land Loss) | Criterion 2 (Riverine Reintroductions) | Criterion 3 (Restore Geomorphic Structure) | Criterion 4 (Protects Vital community & socioeconomic resources) |
|---|---|---|---|---|
| A | X | | | |
| B | | X | | |
| C | X | X | | |
| D | | | X | |
| E | X | | X | |
| F | X | X | X | |
| G | | X | X | |
| H | | | | X |
| I | X | | | X |
| J | | X | | X |
| K | X | X | | X |
| L | X | | X | X |
| M | | | X | X |
| N | X | X | X | X |
| O | | X | X | X |
| P (No Action) | | | | |

Using the annotated comments that resulted from the Critical Needs Criteria evaluation process, specifically the consensus opinion on which Critical Needs Criteria a restoration feature or opportunity best addresses, the PDT populated each of the 15 alternative plans with the restoration features and opportunities that successfully passed through both Screening and Critical Needs Criteria. For example, Alternative A includes all viable restoration features and opportunities that address Critical Needs Criteria 1 (preventing future land loss). Continuing the example, Alternative C is comprised of all viable restoration features and opportunities that address both Critical Needs Criteria 1 and 2 (prevent future land loss and utilizing riverine reintroductions). A summary of the restoration features and restoration opportunities included in each of the 15 alternative plans is detailed in **table MR 3-12**.

**Table MR 3-12. Alternative Plan Make-up.**

| | | Alternative Plans | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** | **K** | **L** | **M** | **N** | **O** |
| **Restoration Feature or Opportunity** | MRGO Environmental Restoration Features | X | | X | X | X | X | X | X | X | X | X | X | X | X | X |
| | Maurepas Swamp Reintroduction Opportunities | X | X | X | | X | X | X | X | X | X | X | X | X | X | X |
| | Barataria Basin Barrier Shoreline Restoration | X | | X | X | X | X | X | X | X | X | X | X | X | X | X |
| | Small Bayou Lafourche Reintroduction | X | X | X | | X | X | X | X | X | X | X | X | X | X | X |
| | Mid-Barataria Basin Reintroduction Opportunity | X | X | X | | X | X | X | X | X | X | X | X | X | X | X |
| | Upper Breton Sound Reintroduction Opportunity | | X | X | | | X | X | X | X | X | X | X | X | X | X |
| | Calcasieu Ship Channel Beneficial Use | X | | X | X | X | X | X | | X | | X | X | X | X | X |
| | Terrebonne Marsh Restoration Opportunity | X | X | X | | X | X | X | X | X | X | X | X | X | X | X |
| | Terrebonne Basin Barrier Shoreline Restoration | X | | X | X | X | X | X | X | X | X | X | X | X | X | X |
| | Maintain Land Bridge Between Caillou Lake and Gulf of Mexico | X | | X | X | X | X | X | | X | | X | X | X | X | X |
| | Gulf Shoreline Stabilization at Point Au Fer Island | X | | X | X | X | X | X | X | X | X | X | X | X | X | X |
| | Las des Allemands Area Reintroductions Opportunity | X | X | X | | X | X | X | | X | X | X | X | | X | X |

Evaluation of the 15 alternatives was based on the identification of appreciably different alternative plans to meet the study objectives and Critical Needs Criteria. As **table MR 3-12** clearly shows, all of the restoration features and measures available to make up the suite of alternative plans were found in more than one Alternative Plan. This is due to the fact that all available restoration features and measures met multiple Critical Needs Criteria. For example, the MRGO Environmental Restoration Feature met Critical Needs Criteria 1, 3, and 4. Because of this, the process of identifying and delineating appreciably different alternative plans was one in which the 15 alternative plans underwent intense scrutiny. A discussion of the composition of, and similarities and differences between, alternative plans follows.

### 3.6.1 Alternative Plans Designed to Meet Only 1 Critical Needs Criterion

Alternative A (the independent application of Critical Needs Criterion #1 (*prevention of predicted land* loss), resulted in a plan combination that excluded diversions in the Breton Sound Basin, but was inclusive of all other potential near-term features and opportunities. As such, Alternative A was grouped into the numerous alternative plans that sought to meet multiple Critical Needs Criteria.

Alternative B (the independent application of Critical Needs Criterion #2 (*sustainability through restored deltaic function*), also produced broad inclusion of potential features and opportunities, but uniformly excluded all barrier shoreline and marsh creation through dredged material use features. Alternative B also excluded any near-term opportunities in the Chenier Plain. However, this alternative was appreciably different from the other 15 alternatives, and was carried forward for further evaluation.

Alternative D (the independent application of Critical Needs Criterion #3 (*sustainability through restoration of geomorphic structure*), produced a combination of features and opportunities focused on barrier shoreline restoration and direct land building focused on maintaining a protective structure. However, this alternative was appreciably different from the other 15 alternatives, and was carried forward for further evaluation.

Alternative H (the independent application of Critical Needs Criterion #4 (*protection of vital socioeconomic resources*), resulted in a diverse combination of features and opportunities that excluded restoration features and opportunities that did not directly benefit infrastructure or property. However, inclusion of Critical Needs Criterion #4 with any other criteria also provided a minor supplemental effect to most other possible alternative combinations. The absence of Critical Needs Criterion #4, in combination with any other criteria, results in only 2 to 3 feature or opportunity exclusions in any of those plans. In addition, Critical Needs Criterion #4, while defining a critical outcome of coastal restoration, could be more appropriately viewed as a synergistic factor in comparison to the critical needs for direct physical restoration of the landscape. As a result, it was determined that the independent application of criterion #4 did not produce a viable alternative plan. Therefore, Alternative H was not considered as a viable alternative plan.

### 3.6.2 Alternative Plans Designed to Meet Multiple Critical Needs Criteria

Alternative plans seeking to meet multiple Critical Needs Criteria, particularly those that included Critical Needs Criterion #2, quickly reached full inclusion of all or nearly all the potential restoration features and opportunities. Three of the Alternative Plans (Alternatives E, J, and M), while intending to focus on meeting different Critical Needs Criteria, were comprised of almost the same restoration features and opportunities (+/- 4 features/opportunities). Likewise, eight of the Alternative Plans (Alternatives C, F, G, I, K, L, N, and O) had the exact same make-up i.e., they included all potential restoration features and opportunities. These 11 alternative plans were therefore grouped because, due to their similarity, they did not provide a true alternative choice (they were not appreciably different). For the purpose of continued alternative plan evaluation, these 11 alternatives, and Alternative A described previously, were grouped and represented by Alternative Plan N because its inclusion of all potential restoration features and opportunities was an outcome of its design to meet all four Critical Needs Criteria.

### 3.6.3 Comparison of Alternative Plans

Summarizing the analysis results detailed above, three appreciably different alternatives (Alternative Plans B, D, and N) arose. A comparison of the restoration features and construction costs estimates for these three alternative plans is provided in **table MR 3-13**.

**Table MR 3-13. Comparison of Alternative Plan Feature Combinations and Construction Costs.**

| Potential Near-term Features | Alternative Near-term Plans | | |
|---|---|---|---|
| | B | D | N |
| Mississippi River Gulf Outlet Environmental Environmental Restoration Features | | $80,000,000 | $80,000,000 |
| Maurepas Swamp Reintroductions -- | | | |
| Small Diversion at Convent / Blind River | $28,564,000 | | $28,564,000 |
| Small Diversion at Hope Canal | $33,029,000 | | $33,029,000 |
| Amite River Diversion (spoil bank gapping) | $2,855,000 | | $2,855,000 |
| Barataria Basin Barrier Shoreline Restoration -- Caminada Headland, Shell Island | | $181,000,000 | $181,000,000 |
| Small Bayou Lafourche Reintroduction | $90,000,000 | | $90,000,000 |
| Medium Diversion with Dedicated Dredging at Myrtle Grove | $146,700,000 | | $146,700,000 |
| Calcasieu Ship Channel Beneficial Use of Dredged Material | | $100,000,000 | $100,000,000 |
| Modifcation of Caernarvon Diversion for Marsh Creation | $1,800,000 | | $1,800,000 |
| Modifcation Davis Pond Diversion for Marsh Creation | $1,800,000 | | $1,800,000 |
| Terrebonne Marsh Restoration Opportunities -- | | | |
| Optimize Flows & Atchafalaya River Influence in Penchant Baisn | $9,720,000 | | $9,720,000 |
| Multi-purpose Operation of the Houma Navigation Canal (HNC) Lock | $0 | | $0 |
| Convey Atchafalaya River Water to Northern Terrebonne Marshes | $132,200,000 | | $132,200,000 |
| Terrebonne barrier shoreline restoration -- Isle Derniere, E. Timbalier | | $84,850,000 | $84,850,000 |
| Maintain Land Bridge between Caillou Lake and Gulf of Mexico. | | $41,000,000 | $41,000,000 |
| Medium Freshwater Diversion at White's Ditch | $35,200,000 | | $35,200,000 |
| Stabilize Gulf Shoreline at Point Au Fer Island | | $32,000,000 | $32,000,000 |
| Lac des Allemands area Reintroductions -- | | | |
| Small Diversion at Lac des Allemands | $17,330,000 | | $17,330,000 |
| Small Diversion at Donaldsonville | $16,670,000 | | $16,670,000 |
| Small Diversion at Pikes Peak | $12,940,000 | | $12,940,000 |
| Small Diversion at Edgard | $13,100,000 | | $13,100,000 |
| **Total Near-term Plan Construction Cost** | **$541,908,000** | **$518,850,000** | **$1,060,758,000** |

Alternative Plan B focused on restoration of deltaic processes (Critical Needs Criterion #2), and included 15 restoration near-term features and opportunities, all with combinations of river diversion features. Alternative Plan B exhibits some shortcomings because it does not address critical geomorphic structures. Alternative Plan D focused on restoration of geomorphic structure (Critical Needs Criterion #3), and included 11 restoration features and opportunities including shoreline protection, barrier island restoration, and marsh creation. Alternative Plan D exhibits some shortcomings because it does not address the river reintroductions. The body of knowledge concerning application of coastal restoration strategies in Louisiana suggests that while Alternative Plans B and D would have appreciable environmental benefits, they each exhibit some weaknesses in addressing the complete range of study planning objectives and Critical Needs Criteria.

Conversely, Alternative Plan N encompasses all four Critical Needs Criteria and exhibits potential for long-term sustainability because it contains the geomorphic structures, which serve to protect and buffer the diversion feature influence areas from erosive coastal wave action and storm surge. Additionally, the river diversion features contained in Alternative Plan N are more sustainable than other types of restoration features because they receive continuous sediment and nutrient nourishment from the river. **Figure MR 3-12** provides a graphical representation of this discussion.

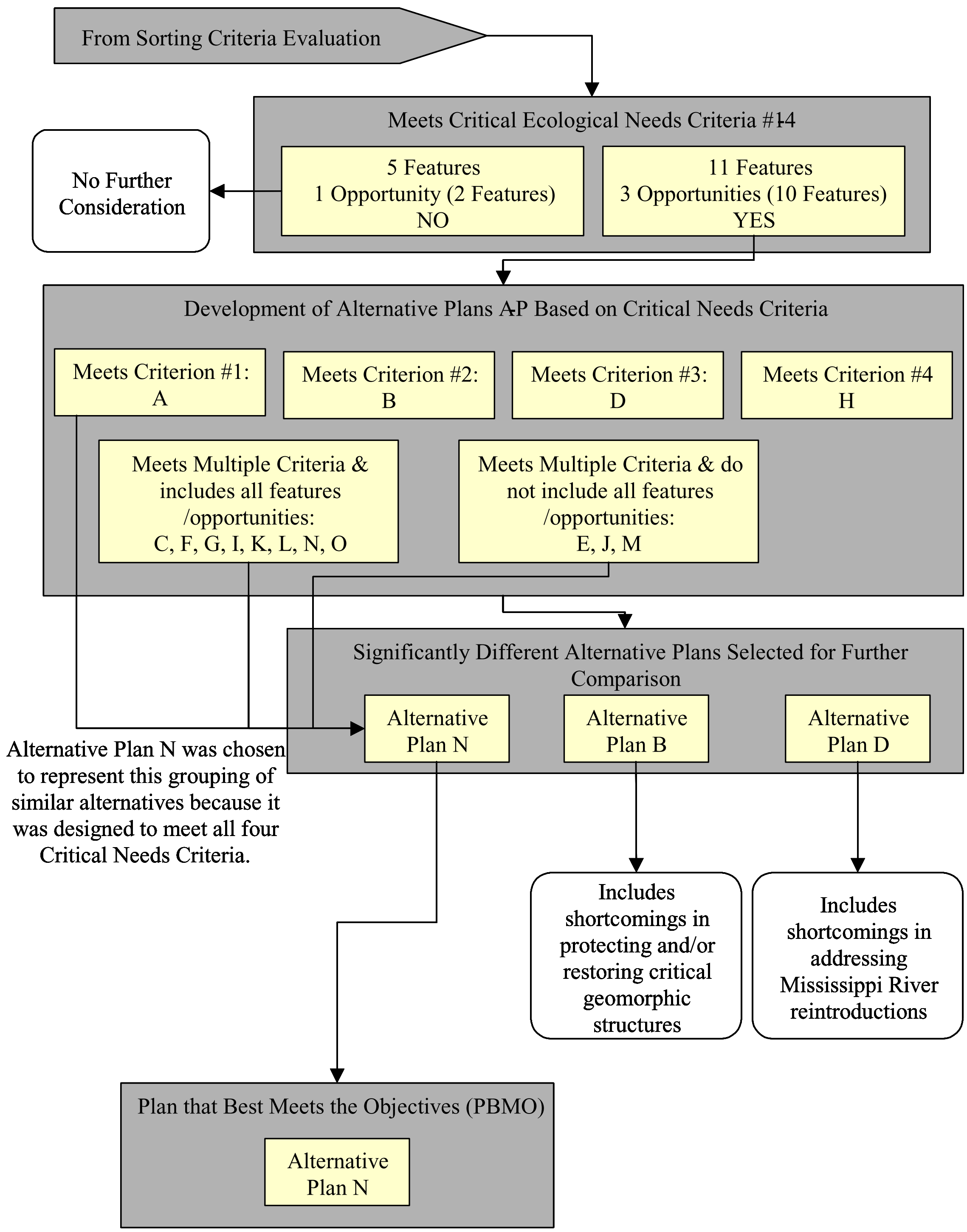


**Figure MR 3-12: Alternative Plan Development and Selection Based on Critical Needs Criteria.**

## 3.7 PLAN FORMULATION RESULTS

### 3.7.1 Description of the Plan that Best Meets the Objectives

As discussed in section 3.2 PLAN FORMULATION RATIONALE and section 3.3 PLAN FORMULATION, the purpose of the LCA Study was to meet study objectives and thus identify a plan that is effective in addressing the most critical needs within the Louisiana coastal area. The most critical needs are located in those areas of the coast that, without attention, would experience a permanent or severely impaired loss of system stability and function. As such, the development and evaluation of alternative plans focused on identifying combinations of restoration features that best addressed these critical need areas.

The alternative plan that best meets the planning objectives (PBMO) is Alternative Plan N. Of the three alternative plans selected for further comparison, Alternative Plan N best meets the planning objectives and the Critical Needs Criteria.

In addressing the most critical ecologic needs of the Louisiana coast, this plan is also effective in meeting the defined study objectives. As presented previously in this report, the study objectives are as follows:

Hydrogeomorphic Objectives

1. Establish dynamic salinity gradients that reflect natural cycles of freshwater availability and marine forcing (tidal action or exchange).
2. Increase sediment input from sources outside estuarine basins, and manage existing sediment resources within estuarine basins, to sustain and rejuvenate existing wetlands and rebuild marsh substrate.
3. Maintain or establish natural landscape features and hydrologic processes that are critical to sustainable ecosystem structure and function.

Ecosystem Objectives

1. Sustain productive and diverse fish and wildlife habitats.
2. Reduce nutrient delivery to the Continental shelf by routing Mississippi River waters through estuarine basins while minimizing potential adverse effects.

### 3.7.2 Effectiveness of the Plan in Meeting the Study Objectives

The PBMO addresses the most immediate and critical needs of the ecosystem in attaining the study objectives. The rehabilitation of the coastal ecosystem by promoting the distribution of riverine freshwater, nutrients, and sediment using natural processes and ensuring the structural integrity of the estuarine basins is key to this sustainable solution. A sustainable ecosystem would support Nationally important living resources, provide a sustainable and diverse array of fish and wildlife habitats, reduce nitrogen delivery to offshore gulf waters, and provide infrastructure protection and a sustainable resource base necessary to support NER goals.

The PBMO accomplishes the stated Hydrogeomorphic Objective 1. In the Deltaic Plain, the PBMO identifies reintroductions of freshwater from the Mississippi River in multiple locations from small to moderate scales.

The PBMO also addresses Hydrogeomorphic Objective 2 as the recommended actions for the Deltaic Plain are founded primarily on the introduction of Mississippi River water, nutrients, and suspended sediment. The PBMO identifies one restoration feature and three restoration opportunities (composed of seven features) for the introduction of Mississippi River water and recommendations for the investigation of rehabilitation or modification of two existing diversion structures in the Deltaic Plain. In addition, the PBMO identifies two restoration features capitalizing on the direct introduction of Mississippi River sediment. The PBMO directs attention to many areas where the prevention of wetland loss is critical to maintaining the ability to provide sustainable coastal restoration in the future. In the Chenier Plain, the PBMO focuses on providing continued stability to preserve the viability of future restoration actions.

Major components of the PBMO in the Deltaic Plain are directed at meeting Hydrogeomorphic Objective 3. The conservation and restoration of barrier islands and shorelines are large components of protecting the coastline from storm damage. Restoration features of the PBMO include a critical headland area and a critical land bridge in the deltaic plain. Proposed features and opportunities, located across the entire coast, assure that landscape features are restored and maintained to provide additional potential protection from storm damage.

Ecosystem Objective 1 is addressed by the PBMO, which contributes to the increased introduction of Mississippi River water, nutrients, and suspended sediment, the improved management of Atchafalaya River water, nutrients, and suspended sediment in the Deltaic Plain, and the expansion of beneficial use of dredged material in the Chenier Plain. The features recommended in the Deltaic Plain provide significant improvements in connectivity and material exchange.

While the overall quantity of wetland area is projected to increase with the execution of the proposed restoration effort, the cumulative quantities of suitable habitat are projected to decline for some species in localized areas of the coast. However, it was estimated that the overall useable amounts of the various habitat types would remain relatively plentiful throughout the 50-year period analyzed. Based on earlier ecological model analysis, certain saline species are anticipated to experience the most notable change in habitat levels. For most species across the coast, suitable habitat levels are expected to remain at or slightly below current levels. It is expected that many freshwater-associated species should see increases in levels of suitable habitat. These trade-offs are consistent with the reintroduction of deltaic land building processes. Even with the anticipated changes in cumulative habitat suitability, overall diversity is expected to remain relatively high and close to current conditions in keeping with the ecosystem objective.

The effectiveness of the PBMO in achieving Ecosystem Objective 2 has also been taken into account. The Action Plan for Reducing, Mitigating and Controlling Hypoxia in the

Northern Gulf of Mexico states that the best current science indicates that efforts to reduce nutrient loadings in the Mississippi River Basin should be aimed at achieving a 30 percent reduction (from the average discharge in the 1980-1996 time frame) in nitrogen discharges to the Gulf (on a 5-year running average) to be consistent with the coastal goal for reducing the aerial extent of hypoxia in the Gulf. Based on an average annual loading of 1.6 million metric tons, a 30 percent reduction would be 480,000 tons annually (CENR 2000). The PBMO would make a small contribution towards meeting this goal. However, the knowledge gained from implementation of the projects in the PBMO and from the large-scale studies could greatly facilitate the implementation of larger reintroduction projects, which could provide greater benefits in terms of reducing Gulf hypoxia.

#### 3.7.2.1 Environmental operating principles/achieving sustainability

Striving to achieve environmental sustainability is a core objective both for the development and for the implementation of an NER plan. Although the result of the LCA Study effort does not identify the final NER plan, the PBMO is focused on producing economic and environmental outcomes that will support and reinforce one another over both the near and long-term. The recognition of the interdependence of biological resources and the physical and human environment has driven the development of many of the guiding principals and tools applied in this study. As a result, the restoration features and opportunities that make up the PBMO produce balance and synergy between human development activities and natural systems.

The restoration features and opportunities in the PBMO that point toward additional investigations are intended to continue to shape activities and decisions currently under the authority of the USACE in order to increase the continued viability of the natural systems within which they occur. The PBMO is also intended to provide a mechanism to continue to assess and address cumulative impacts to the environment, and to achieve consistency by applying a systems approach to the full life cycle of all related water resources activities in the Louisiana coastal area.

#### 3.7.2.2 Components of the Plan that Best Meets the Objectives (PBMO)

The PBMO consists of the components addressed below. These combined components represent the best near-term approach for addressing coastal wetlands loss in Louisiana. The features and opportunities addressed below are viewed as representative of the most likely anticipated action and provide an optimal starting points for the detailed investigations that will lead to project justification and implementation. The projects that are ultimately authorized for construction would be optimized for location, scale, and beneficial output to be documented in a decision document supporting final NEPA compliance prior to implementation.

##### 3.7.2.2.1 *Near-term critical restoration features and opportunities*

The first principal component of the PBMO is the group of features and opportunities identified to meet the critical near-term ecosystem needs of the Louisiana coastal wetlands. The restoration features and opportunities representing solutions to the Critical Needs included in the PBMO are:

- MRGO environmental restoration features
- Maurepas Swamp Reintroductions:
  - Small diversion at Hope Canal
  - Small diversion at Convent/Blind River
  - Increase Amite River Diversion Canal influence by gapping banks
- Barataria Basin barrier shoreline restoration
- Small Bayou Lafourche reintroduction
- Medium diversion with dedicated dredging at Myrtle Grove
- Calcasieu Ship Channel Beneficial Use
- Modification of Caernarvon diversion
- Modification of Davis Pond diversion
- Terrebonne marsh restoration opportunities:
  - Optimize flows and Atchafalaya River influence in Penchant Basin
  - Multi-purpose operation of Houma Navigation Canal (HNC) Lock
  - Convey Atchafalaya River water to Northern Terrebonne marshes via a small diversion in the Avoca Island levee, repairing eroding banks of the GIWW, enlarging constrictions in the GIWW below Gibson and in Houma and Grand Bayou conveyance channel construction/enlargement
- Terrebonne Basin barrier shoreline restoration
- Maintain land bridge between Caillou Lake and Gulf of Mexico
- Medium diversion at White's Ditch
- Gulf shoreline stabilization at Point Au Fer Island
- Lac des Allemands area Reintroductions:
  - Small diversion at Lac des Allemands
  - Small diversion at Donaldsonville
  - Small diversion at Pikes Peak
  - Small diversion at Edgard

#### 3.7.2.2.2 *Large-scale and long-term concepts requiring detailed study*

The second principal component of the PBMO is the identification of large-scale, long-range studies of long-term restoration concepts. These long-range initiatives typically define fundamental changes to the hydrogeomorphic or ecologic structure, function, or management of the Louisiana coast. These concepts, which represent major opportunities for coastal restoration, require detailed study and development to determine the probable impacts (beneficial and adverse) of such features in order to determine if these projects are desirable and can be integrated into the plan for coastal restoration. These concepts also include some levels of uncertainty, which are typically so extensive in scale that resolution through a demonstration project is impractical. As a general rule, large-scale diversions (flow greater than 15,001 cfs [54 cms]) were deemed impractical in the near-term because of their being mutually exclusive with important concepts such as Third Delta. River resource hydrodynamic studies would necessarily evaluate these larger scale diversions in concert. The large-scale and long-term concepts identified in the PBMO include:

- Mississippi River Hydrodynamic Study
- Mississippi River Delta Management Study
- Third Delta Study
- Chenier Plain Freshwater and Sediment Management and Allocation Reassessment Study
- Acadiana Bays Estuarine Restoration Feasibility Study
- Upper Atchafalaya Basin Study (This study would include evaluation of alternative operational schemes of Old River Control Structure and will be funded under MR&T)

**3.7.2.2.3** ***Science and Technology (S&T) Program and potential demonstration projects***

The third principal component of the PBMO is the establishment of a S&T Program to address both near and long-term uncertainties in the implementation and execution of the plan. A portion of this component would include the execution of focused demonstration projects to resolve specific uncertainties and provide insight to the programmatic short and long-range implementation of the PBMO.

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