MISSISSIPPI RIVER GULF OUTLET (MRGO) ECOSYSTEM RESTORATION PLAN

FINAL ENVIRONMENTAL IMPACT STATEMENT

U.S. Army Corps of Engineers
Mississippi Valley Division
New Orleans District
7400 Leake Avenue
New Orleans, Louisiana 70118

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ENVIRONMENTAL IMPACT STATEMENT

MISSISSIPPI RIVER GULF OUTLET (MRGO) ECOSYSTEM RESTORATION STUDY LOUISIANA AND MISSISSIPPI

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EXECUTIVE SUMMARY

S.1 INTRODUCTION

This Final Environmental Impact Statement (FEIS) for the Mississippi River Gulf Outlet (hereafter MRGO) Ecosystem Restoration Plan Feasibility Report was prepared by the U.S. Army Corps of Engineers (USACE)-Mississippi Valley Division, New Orleans District (CEMVN). It includes input from Federal, as well as Louisiana and Mississippi state agencies.

The National Environmental Policy Act (NEPA) of 1969 (Public Law 91-190) requires all Federal agencies to address environmental consequences of major Federal actions on the natural and human environment. Compliance guidance for NEPA is contained in Title 40 of the Code of Federal Regulations (CFR), Parts 1500 through 1508, and in the USACE regulations 33 CFR 230 and 325, *Environmental Quality and Procedures for Implementing NEPA*. The primary intent of NEPA is to ensure that environmental information is made available to officials and citizens regarding major Federal actions.

This FEIS was prepared as an update to the Draft EIS (December 2010) that was conducted to assess the viable alternatives identified as part of the MRGO Ecosystem Restoration Plan Feasibility Report. The feasibility report will accompany this FEIS; the reports are companion documents. Plans were evaluated based on their ability to meet the study goals and objectives, compliance with environmental laws, contributions to the Federal objective of National Ecosystem Restoration (NER), and meeting the evaluation criteria of completeness, effectiveness, efficiency and acceptability.

Through evaluation and impact assessment, the feasibility report and FEIS will identify the tentatively selected plan that is the NER plan. Selecting the NER plan required careful consideration of planning goals, objectives, and constraints. The NER plan reasonably maximizes environmental benefits while passing tests of cost effectiveness and incremental cost analyses, significance of outputs and their ability to meet the evaluation criteria. The Water Resources Development Act of 2007 (WRDA 2007) requires the plan to be cost effective, environmentally acceptable, and technically feasible in order to be carried out by the Secretary of the Army.

S.2 PURPOSE AND NEED FOR ACTION

The purpose of this study was to develop a comprehensive ecosystem restoration plan to restore the Lake Borgne ecosystem and the areas affected by the MRGO navigation channel as required by Section 7013 of WRDA 2007. The period of analysis is from implementation and extends 50 years into the future from the estimated first year of construction, 2015 to 2065.

The main water resource problems identified in the study area include:

- Land loss;
- Bank/shoreline erosion;
- Habitat change and loss;
- Modification of natural hydrology;
- Decreased freshwater, sediment, and nutrient inputs;
- Saltwater intrusion;
- Retreating and eroding barrier islands;
- Ridge habitat degradation and destruction;
- Invasive species;
- Herbivory; and
- Increasing susceptibility of coastal communities to storm surge.

The natural flow and drainage patterns have been impacted by a complex levee system throughout the area, drainage channels, pipelines and other utilities, roadways, and most importantly navigation channels. Channels and other canals serve as a conduit for tidal flow and saltwater intrusion, subjecting the sensitive marsh to the erosive forces of wind and wave action.

S.3 STUDY AUTHORITY AND STUDY SPONSOR

The study is authorized by the Water Resources Development Act of 2007 Section 7013 to develop a plan that would:

- physically modify the MRGO and restore the areas affected by the navigation channel;
- restore natural features of the ecosystem that will reduce or prevent damage from storm surge;
- prevent the intrusion of saltwater into the waterway;
- integrates the recommendations of the Louisiana Coastal Area (LCA) Report and the Louisiana Coastal Protection and Restoration (LACPR) Technical Report;
- consider the use of native vegetation and diversions of freshwater to restore the Lake Borgne ecosystem.

The WRDA 2007 Section 7013 features of the MRGO plan in Tiers 1 and 2, as described in the Mississippi River-Gulf Outlet (MRGO) Ecosystem Restoration Plan Final Feasibility Report, Supplemental Report of the Chief of Engineers In Response To The Water Resources Development Act Of 2007, are conditionally authorized for construction, pending the determination by the Assistant Secretary of the Army (Civil Works) (ASA(CW)) that the project is cost-effective, environmentally acceptable, and technically feasible. This conditional authorization also assumes that a viable cost sharing sponsor(s) will be identified as required by Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5), and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213), The Tier 3 feature, consisting of the Violet, Louisiana Freshwater Diversion project, as authorized by Section 3083 of WRDA 2007 (Tier 3A), as well as certain

MRGO Ecosystem Restoration features authorized by Section 7013 of WRDA 2007 (but which are dependent upon the implementation of a freshwater diversion at or in the vicinity of Violet (Tier3B)), are recommended in the report for additional feasibility study and analysis.

The Section 7013 MRGO ecosystem restoration study is 100% Federally funded. Despite lengthy discussions with the State of Louisiana, the Government has been unable to identify a non-Federal sonsor for design and implementation of the Section 7013 Section 3083 of WRDA 2007 conditionally authorizes the the Violet, Louisiana Freshwater Diversion project and identifies the State of Mississippi and the State of Louisiana as the non-Federal sponsors for that project. Both states have been actively participating on the planning team. . USACE will continue, pursuant to Section 3083 of WRDA 2007, to coordinate with the State of Louisiana and the State of Mississippi during the further feasibility study for the Violet, Louisiana Freshwater Diversion project and with the State of Louisiana regarding those Section 7013 elements of the MRGO Ecosystem Restoration project that are determined by USACE to be dependent upon the design and implementation of the Violet diversion. Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5), and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213) requires the execution of a binding written agreement by the State of Louisiana and the State of Mississippi in order for the United States to commence construction.

S.4 STUDY AREA

The study area includes portions of the Mississippi River Deltaic Plain within coastal southeast Louisiana and parts of southwest Mississippi encompassing approximately 3.84 million acres (over 6,000 square miles).

In Louisiana, the study area includes the Pontchartrain Basin, which is comprised of the Upper, Middle, and Lower sub-basins. The Upper Pontchartrain sub-basin includes Lake Maurepas and its adjacent wetlands and swamps. Lake Maurepas receives its freshwater influences from the Amite and Tickfaw Rivers, Bayou Manchac, and other smaller rivers. The Middle Pontchartrain sub-basin is comprised of Lake Pontchartrain, its adjacent cities and towns, and surrounding wetlands. Lake Pontchartrain is affected by freshwater inflows from Pass Manchac, North Pass, and the Tangipahoa, Tchefuncte, and Bogue Falaya Rivers, some bayous, and the Bonnet Carré Spillway. The Lower Pontchartrain sub-basin includes Lake Borgne, the deauthorized MRGO, the Mississippi River, Chandeleur and Breton Sounds, portions of the Gulf of Mexico, and the surrounding wetlands, barrier islands, and communities. Lake Borgne is hydrologically linked to Lake Pontchartrain through tidal passes at the Rigolets, Chef Menteur Pass, and the manmade Inner Harbor Navigation Canal (IHNC). The Lake Borgne ecosystem is also influenced by the Pearl River to the north and receives hydrologic interchange from areas located as far west as Bayou Terre aux Boeufs Ridge, which is located between the MRGO and the Mississippi River. Major navigation channels include the Mississippi River, IHNC, and the Gulf Intracoastal Waterway (GIWW).

In Mississippi, the study area includes the Western Mississippi Sound, its bordering wetlands, and Cat Island.

S.5 PUBLIC INVOLVEMENT

The USACE invites full public participation in the NEPA process and promotes open communication for better decision-making. A scoping comment period began with the filing of the Notice of Intent (NOI) and continued through release of the Draft EIS (DEIS). Public scoping meetings were held on November 3, 2008, in Chalmette, LA and November 6, 2008, in Waveland, MS. Public meetings were held February 23, 2010 and April 20, 2010, in New Orleans, LA, to study alternatives for a freshwater diversion proposed in the vicinity of Violet, LA, and receive comments from the public. Agencies were invited by email on August 27, 2008, and by letter dated October 23, 2008, to participate in the study as cooperating agencies and provide a team member for the Project Delivery Team (PDT) as well as the Habitat Evaluation Team (HET).

The DEIS was released to the public following a Notice of Availability (NOA) that was published in the *Federal Register* on December 17, 2010. A NOA letter was mailed to the USACE New Orleans District stakeholder and NEPA mailing lists on December 17, 2010. This notice provided a description of the proposed action including the project features, a point of contact to obtain more information regarding the DEIS, and a means of commenting on the DEIS and companion MRGO Ecosystem Restoration Plan Feasibility Report.

Following the NOA, the USACE held three Public Hearings as an opportunity for the public, resource agencies, and elected officials to participate in the NEPA planning process, to provide input regarding the proposed restoration features, and to provide comments on the DEIS. Public hearings were held on January 20, 2011 in Chalmette, LA, on January 25, 2011 in Waveland, MS, and on February 8, 2011 in New Orleans, LA.

The formal comment period began with the filing of the NOA on December 17, 2010 and was extended by the USACE twice due to special requests to provide additional time to comment, coupled with an overwhelming response. The final date for the acceptance of comments was established on March 5, 2011, resulting in an overall 78-day comment period.

During the comment period, over 31,400 commenters provided written and/or verbal comments on one subject matter alone – Support of Plan Elements. The large comment response was primarily attributed to approximately 31,270 individual commenter's associated with 4 non-government organizations that submitted multiple form letters, with each set being identical in content. These form letters represented 99.5 percent of the comments received on the most common recurring comment theme.

S.6 AREAS OF CONTROVERSY AND UNRESOLVED ISSUES

Construction and operation of the MRGO, in synergistic combination with other natural and man-made factors, has caused direct, indirect and cumulative land loss, shoreline erosion, saltwater intrusion, habitat modification, and impacts to wildlife and fisheries resources throughout the project area. Determining the extent to which the MRGO contributed to these impacts and what, if any, actions would be necessary to remediate any such impacts remains a controversial issue.

The communities surrounding the MRGO include minority and/or low-income to non-minority and non-low income populations. The location of the proposed Violet, Louisiana Freshwater Diversion would be constructed in an open field that sits between two subdivisions that are predominately minority and/or low-income populations. Construction efforts such as noise, dust, traffic delays, etc., would temporarily impact those in the immediate project vicinity as well as other groups that work or live in the surrounding area. While many of the residents support marsh creation and restoration in the project area, some were opposed to the location of the proposed diversion location.

The long-term impacts of the Deepwater Horizon oil spill on coastal Louisiana are uncertain at this time (May 2012). The impacts of the oil spill could potentially impact USACE water resources projects and studies within the Louisiana coastal area, including the MRGO Ecosystem Restoration project. Potential impacts could include factors such as changes to existing, future-without, and future-with-project conditions, as well as increased project costs and implementation delays. The USACE will continue to monitor and closely coordinate with other Federal and state resource agencies and local sponsors in determining how to best address any potential problems associated with the oil spill that may adversely impact projects and studies. Supplemental planning and environmental documentation may be required as information becomes available.

S.7 RESTORATION GOALS

Restoring natural processes, such as reconnecting the floodplain with the Mississippi River system's hydrologic cycles, is the key to restoring the ecosystem and improving productivity. Restoring some degree of these natural processes holds the best promise for significant improvements to the Deltaic processes in the lower Mississippi River system. Priority was given to restoration measures that contributed to restoring natural processes.

The objectives for the MRGO Ecosystem Restoration Plan follow:

1. Restore historic salinity conditions in the study area to re-establish and maintain historic habitat types; optimize ecosystem services; and decrease stress to vegetation as measured by the monthly salinity targets in the Biloxi Marsh (as identified by Chatry et al. 1983) each month of the year, for at least four years out of every ten year period.

2. Restore native habitat acreages impacted by the MRGO and their ecosystem functions.
    a. Increase the year round spatial coverage of cypress swamp habitat in the Central Wetlands by at least 9,500 acres by 2065.
    b. Increase the year round special coverage of fresh/intermediate marsh in the Central Wetlands, Golden Triangle, MRGO, and South Lake Borgne by at least 6,800 acres by 2065.
    c. Increase the year round spatial coverage of brackish marsh in Bayou Terre aux Bouefs, the Biloxi Marsh, and the East Orleans Landbridge by approximately 18,100 acres by 2065.
    d. Increase the year round spatial coverage of vegetated wetlands in areas adjacent to the channel lost to increased tides and salinity by at least 3,900 acres by 2065.
    e. Increase the year round spatial coverage of ridge habitat along Bayou La Loutre by 2065.
3. Increase the year round spatial coverage of critical landscape features that provide hurricane and storm damage risk reduction in the study area (i.e. areas located in the Biloxi Marshes, the East Orleans Landbridge, and forested habitats).
4. Increase awareness and understanding of the significance of resources in the study area through increased recreational and educational opportunities.

S.8 MANAGEMENT MEASURES AND ALTERNATIVES

A management measure is a feature (a structural element that requires construction or assembly on-site) or an activity (a nonstructural action) that can be combined with other management measurers to form alternative plans. Measures were developed to address study area problems and to capitalize on study area opportunities. Management measures were derived from a variety of sources including prior studies, the NEPA public scoping process, and the multidisciplinary, interagency Project Delivery Team (PDT), and other private, local government, and landowner groups. Approximately 300 initial structural management measures considered can be grouped into the following categories: (non-structural measures, such as invasive species control, were integrated into structural measures and were not considered independently):

- Freshwater diversions
- Hydrologic restoration (e.g. plugs, fill, weirs, sills, gaps)
- Marsh restoration, marsh nourishment, and swamp restoration
- Shoreline protection
- Ridge restoration
- Restoration/creation of forested habitat
- Barrier island restoration
- Submerged aquatic vegetation (SAV) restoration
- Oyster reef restoration
- Vegetative planting

Alternatives were formulated to maximize environmental benefits, minimize environmental impacts and costs. A Cost Effectiveness/Incremental Cost Analysis (CE/ICA) was conducted to evaluate the benefits of alternative plans as related to cost and identify the plans that provide the greatest benefits with the least amount of incremental cost. The subset of cost effective plans were examined sequentially (by increasing scale and increment of output) to determine which plans were more efficient and achieved the greatest benefits. These plans are called "Best Buy Plans." The Corps' Institute for Water Resources (IWR)-PLAN Decision Support Software was used to generate 6,721 plan combinations. Including the no action plan (alternative A), there were 285 cost-effective plans and 19 Best Buy plans. Three Best Buy plans were selected as the final array of alternatives. Best Buy plans #2, #7, and #10 (alternatives B, C, and D, respectively) were chosen based on cost effective increments based on their contribution to addressing the study authority and achieving the planning objectives. These three plans provide a wide range of costs and outputs.

Best Buy Plan #2 (alternative B) was chosen for further consideration because it was the least costly Best Buy Plan. Alternative B does not achieve all of the goals of the study, but it does include some restoration measures for all of the targeted habitat types. Alternative B would restore or protect 19,630 acres of marsh and 10,318 acres of cypress swamp. Alternative B does not meet the target acre objectives for brackish marsh. Additionally, 10,456 acres of brackish marsh would be converted to another habitat type that would not be restored elsewhere in the study area. Therefore, it did not meet the objective to add to the total amount of each habitat type in the study area by compensating for any habitat switching. Alternative B has no features in the Biloxi Marsh and only includes two features on the East Orleans Landbridge; therefore, alternative B does not fully address the objective to restore and protect critical landscape features for storm surge reduction.

Best Buy Plan #7 (alternative C) is the first Best Buy Plan that meets all of the objectives, including reasonably maximizing restoration and protection of the Biloxi Marsh and East Orleans Landbridge. Therefore, alternative C was selected for further evaluation in the final array of alternatives because it appeared to be a complete plan for the Lake Borgne ecosystem and the areas affected by the MRGO.

Best Buy Plan #8 (alternative D) includes additional marsh creation features and additional shoreline protection in the Biloxi Marsh and East Orleans Landbridge. Alternative D improves upon alternative C by further protecting these critical landscape features, and better meets the storm surge objective. Alternative D was included for further evaluation because it was the first Best Buy Plan after alternative C to include more measures to protect both of these areas.

S.9 COMPARISON OF IMPACTS

Alternative plans were compared against each other, with emphasis on the benefits and impacts with respect to study goals and objectives and NER objectives. A brief summary of the benefits and impacts associated with each alternative is discussed below.

Alternative A. The no action alternative is required by the NEPA and represents the future without project (FWOP) condition to compare to the final array of alternatives. The no action alternative considers restoration programs that would continue into the future and are currently authorized under the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA), Coastal Impact Assistance Program (CIAP), the LCA Ecosystem Restoration Study, and other programs.

Alternative B. Alternative B would restore approximately 54 acres of ridge habitat along Bayou La Loutre in the Biloxi Marsh area, provide 122 acres of shoreline protection, restore 10,318 acres of cypress swamp habitat in the Central Wetlands, and restore 19,630 acres of wetlands in the Lower Pontchartrain sub-basin. The Violet, Louisiana Freshwater Diversion, pulsing 7,000 cubic feet per second (cfs) from April to May would influence approximately 115,078 acres. The diversion channel would result in the loss of 302 acres of prime/unique farmland and 227 acres of wetland. Restoration of the Bayou La Loutre Ridge would result in permanent impacts to 54 acres of brackish marsh.

Alternative C. Alternative C would restore approximately 54 acres of ridge habitat in the Biloxi Marsh area, provide 1,937 acres of shoreline protection, restore 10,318 acres of cypress swamp habitat in the Central Wetlands, and restore 44,188 acres of wetlands in the lower Pontchartrain sub-basin. The Violet Freshwater Diversion, pulsing 7,000 cfs from April to May would influence approximately 115,078 acres. The diversion channel would result in the loss of 302 acres of prime/unique farmland and 227 acres of wetland. Restoration of the Bayou La Loutre Ridge would result in permanent impacts to 54 acres of brackish marsh.

Alternative D. Alternative D would restore approximately 54 acres of ridge habitat in the Biloxi Marsh area, provide 2,494 acres of shoreline protection, restore 10,318 acres of cypress swamp habitat in the Central Wetlands, and restore 44,892acres of wetlands in the lower Pontchartrain sub-basin. The Violet, Louisiana Freshwater Diversion, pulsing 7,000 cfs from April to May would influence approximately 115,078 acres. The diversion channel would result in the loss of 302 acres of prime/unique farmland and 227 acres of wetland. Restoration of the Bayou La Loutre Ridge would result in permanent impacts to 54 acres of brackish marsh.

Impacts by alternative and resource are described in **table S-1**.

S.10 TENTATIVELY SELECTED PLAN

Alternative C (Figure S-1) was chosen as the tentatively selected plan based on preliminary analysis because it is the lowest cost alternative that meets all of the study objectives and provides a complete plan to restore the Lake Borgne ecosystem. The tentatively selected plan (TSP) is referenced as the federally identified plan (FIP) in the Feasibility Report. The National Ecosystem Restoration account is best achieved by alternative C, because it meets all of the study objectives, reasonably maximizes benefits for the associated costs, includes key restoration features to restore and sustain the form and function of the Lake Borgne ecosystem, and fully addresses the Congressional mandate of WRDA 2007 Section 7013.

Alternative C is a complete plan for the Lake Borgne ecosystem because it protects and restores the portions of the Lake Borgne ecosystem that are not addressed by existing and authorized restoration projects. Existing and authorized shoreline protection projects along the shores of Lake Borgne do not comprehensively address erosion in the lake. Alternative C would provide protection in the areas in between existing and authorized projects to stabilize the entire shore of Lake Borgne. Marsh restoration features included in alternative C would work synergistically with existing and authorized projects to restore the structure of the Lake Borgne ecosystem.

The restoration of historic salinity conditions is a key system driver. The Violet, Louisiana Freshwater Diversion, as authorized for design and implementation in WRDA 2007 Section 3083, would fully restore salinity conditions, mimic natural processes, and enhance the sustainability of the system through the input of freshwater, nutrients and sediment. Full restoration of historic habitat types in the area is dependent upon salinity conditions. Alternative C addresses some of the salinity impacts of the MRGO by recommending further analysis of the Violet Freshwater Diversion.

Approximately 11,222 acres of the restoration and protection features would be located in the East Orleans Landbridge/Pearl River area and approximately 9,012 acres of restoration features would be located in the Biloxi Marsh area, which have been determined to be critical landscape features with respect to storm surge. Additionally, the cypress swamp and ridge restoration features would include forested habitats, having some storm surge damage risk reduction benefits.

The plan would restore technically significant habitat, such as 3,281 acres of imperiled fresh marsh in the Central Wetlands, 10,318 acres of ecologically important cypress forest, and 54 acres of rare coastal ridge habitat. The plan would restore and nourish 12,797 acres of brackish marsh in the Hopedale and Bayou Terre aux Boeufs area south of the channel. In the Golden Triangle area, 4,317 acres of intermediate marsh would be restored on the Lake Borgne side of the IHNC Surge Barrier and 280 acres of significant urban marsh would be restored on the GIWW/MRGO side of the barrier.

Tiered Implementation Sequence

Plan recommendations include features recommended for construction (contingent upon the identification of a non-Federal sponsor), features recommended for contingent authorization subject to a decision document showing that necessary conditions have been met, features recommended for additional study, and a Monitoring and Adaptive Management Plan.

- Tier 1 includes features that have been developed to a feasibility level of detail and are not dependent on a freshwater diversion. Tier 1 features are recommended for construction through the WRDA 2007 Section 7013 authority upon the identification of a non-Federal sponsor (in red on Figure S-1).
- Tier 2 includes features with feasibility level detail that are dependent upon salinity conditions but may be sustainable without the implementation of a freshwater diversion. If future conditions and further analysis indicate that favorable conditions for ecological success and long term sustainability exist (as defined in the adaptive management plan), then these projects may be constructed. Tier 2 features would be constructed through the WRDA 2007 Section 7013 authority upon the identification of a non-Federal sponsor.
- Tier 3A includes further study of the Violet, Louisiana Freshwater Diversion under the WRDA 2007 Section 3083 authority.
- Tier 3B includes any features that are dependent on freshwater diversion, and features in Tier 2 that future conditions and further analyses indicate are not sustainable. Subsequent to the completion of Tier 3A, Tier 3B features would be constructed through the WRDA 2007 Section 7013 authority upon the identification of a non-Federal sponsor.

Assumptions factoring into the implementation sequence include elements such as production rates for building rock projects and issues like dredge equipment availability for use in marsh creation. Other implementation sequencing factors include considerations such as land loss rates (areas with higher land loss rates are proposed for construction first), required construction work order, and the limitation of alternating dredging cycles in the lobes of Lake Borgne. Shore protection work in an area subject to wave erosion would be constructed before creating a restored marsh in the same area to address the driving erosive factor first to improve the sustainability of restored marshes.

Shoreline protection, marsh restoration and nourishment, and ridge restoration features are recommended for construction, contingent upon the identification of a non-Federal sponsor. There is significant institutional knowledge regarding the construction of shoreline protection and marsh restoration features, and therefore further investigation of these features is not required. These features have been developed to a feasibility level of design, are critical to the stabilization and restoration of the study area, and are proposed to be constructed first.

Because salinity conditions in the area are changing, many features are delayed until further analysis can confirm that necessary conditions have been met. If data indicate that conditions prohibit the successful implementation of features in Tier 2, they will be deferred until long-term data indicate that they can be sustainably built.

The Violet, Louisiana Freshwater Diversion requires additional study to develop the feature to a feasibility level of detail, and is therefore recommended for further analysis. Plan features that require a freshwater diversion to be sustainable are recommended for further analysis in conjunction with the Violet Freshwater Diversion.

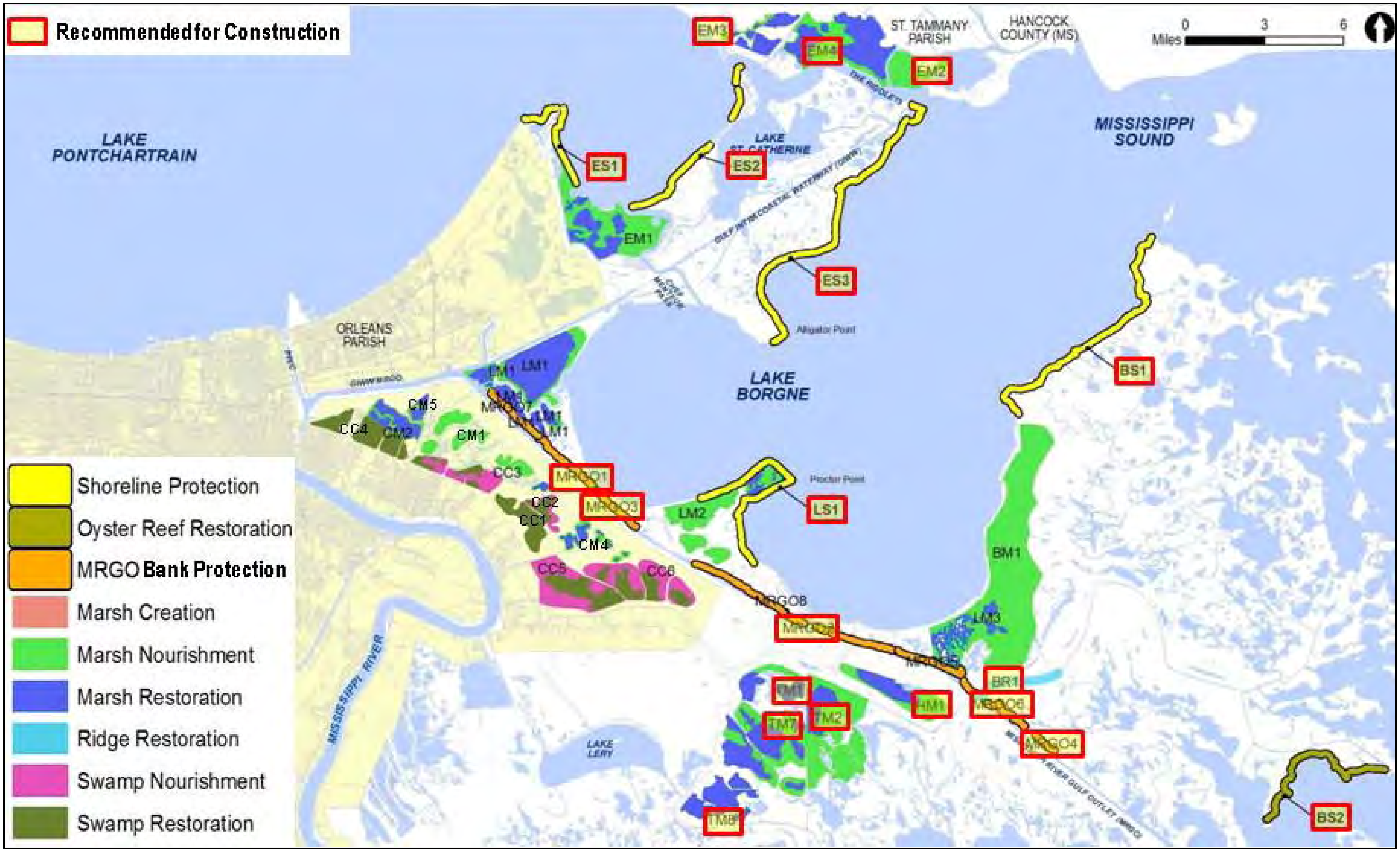


Figure S-1: Alternative C, Tentatively Selected Plan

Table S-1: Evaluation of Potential Impacts to Significant Resources by Alternative

Environmental Resources	Alternatives			
	Alternative A No Action	**Alternative B**	**Alternative C**	**Alternative D**
HYDROLOGY AND HYDRAULICS (H&H)	No direct impacts. Indirect and cumulative impacts include altered flow patterns, altered paths of tidal propagation, and loss of tidal connection. Slight reduction in salinity due to other projects. Continued loss of wetlands is expected due to lack of hydraulic connectivity and sediment source, as well salinity levels.	Flow velocities would be negligibly increased as a result of 1,000 cubic feet per second (cfs) background flow and would not impede fish passage. Increased flow velocity and local eddies expected at point of discharge during 7,000 cfs discharge. Flow velocity rapidly decreases when discharged into the MRGO.	No change in diversion flow regime so impacts would be similar to alternative B.	No change in diversion flow regime so impacts would be similar to alternative B.
WATER QUALITY	Current water quality conditions would persist; dissolved oxygen (DO) levels and bacterial concentration would persist; continued loss of wetlands reduces ability to filter and absorb pollutants.	Create 7,444 acres and nourish 12,186 acres marsh; create 4,225 acres and nourish 6,093 acres swamp; benefit water quality in terms of increased DO, reduced turbidity, and filtration and trapping of pollutants once construction completed.	Create 17,352 acres and nourish 26,836 acres marsh; create 4,225 acres and nourish 6,093 acres swamp; benefit water quality in terms of increased DO, reduced turbidity, and filtration and trapping of pollutants once construction completed.	Create 18,056 acres and nourish 26,836 acres marsh; create 4,225 acres and nourish 6,093 acres swamp; benefit water quality in terms of increased DO, reduced turbidity, and filtration and trapping of pollutants once construction completed.
WATER QUALITY (salinity)	Potential reduction of 2-3 parts per thousand (ppt) in salinity based on the proposed construction of several diversion projects in the study area.	A maximum salinity change of -1.0 to -1.4 ppt in Lake Borgne from May to December based on proposed diversion of 1,000 cfs and peak diversion flow of 7,000 cfs. Salinity in the Mississippi Territorial Waters are predicted to be reduced by -0.6 to -0.9 ppt under combined influence of Violet, Louisiana Freshwater Diversion and the 4,500 cfs of the combined Maurepas Swamp area diversions.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
NAVIGABLE WATERWAYS	Current conditions would persist. Other projects such as other freshwater diversions; MRGO closure; sector gates on the Gulf Intracoastal Waterway and Bayou Bienvenue; and construction of the storm surge barrier may affect current navigable waterways.	Mississippi River navigation would not be impacted. Navigation in the GIWW may be affected by current from diversion flow. Velocities at Bayou Bienvenue and Bayou Dupre control structures would not affect navigation. Impact to navigation in Central Wetlands area from increased velocities or gate closures.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.

Table S-1: Evaluation of Potential Impacts to Significant Resources by Alternative

Environmental Resources	Alternatives			
	Alternative A No Action	**Alternative B**	**Alternative C**	**Alternative D**
SOILS	Continued loss of sediments due to shoreline erosion and wetland loss.	Diversion channel (Alternative 1 location) would impact approx. 442 acres of soils designated as prime farmland.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
AIR QUALITY	St. Bernard, St Tammany, Orleans, and Plaquemines Parish are in attainment for all pollutants. Air quality trends would have no direct beneficial or adverse impacts.	Emissions increases from construction are not expected to cause or contribute to a violation of Federal or state ambient air quality standards.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
NOISE	No impacts anticipated from FWOP condition	No significant impacts anticipated; potential temporary impacts to communities near the diversion; may be temporary and local disturbance of some wildlife.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE (HTRW)	No potential impacts due to any associated construction activities.	An HTRW Phase I was performed for the study area, and identified a low probability of encountering contaminants of concern.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
BARRIER ISLAND RESOURCES	The Chandeleur Islands would continue to erode: it is estimated that by 2014, Breton Island would be subaerial and the entire island chain completely eroded.	No impacts from this alternative. Preliminary modeling efforts for the barrier islands indicate additional study is warranted. Additionally, modeling parameters that involve the impacts of the oil spill have to be considered and the future is uncertain based on the magnitude of the spill and the constantly changing efforts to alleviate the immediate environmental impacts.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.

Table S-1: Evaluation of Potential Impacts to Significant Resources by Alternative

Environmental Resources	Alternatives			
	Alternative A No Action	**Alternative B**	**Alternative C**	**Alternative D**
COASTAL VEGETATION RESOURCES	Loss of 131,091 acres by 2065.	Restoration plan includes 54 acres ridge; create 4,225 acres, nourish 6,093 acres swamp; create 7,444 acres, nourish 12,186 acres marsh; Diversion channel (Alternative 1 location) would adversely impact 227 acres of existing wetlands. While the project area will see an increase in wetland acreage, the system as a whole could continue to encounter some vegetative losses.	Restoration plan includes 54 acres ridge; create 4,225 acres, nourish 6,093 acres swamp; create 17,352 acres, nourish 26,836 acres marsh; Diversion channel would adversely impact 227 acres of existing wetlands. While the project area will see an increase in wetland acreage, the system as a whole could continue to encounter some vegetative losses.	Restoration plan includes 54 acres ridge; create 4,225 acres, nourish 6,093 acres swamp; create 18,056 acres, nourish 26,836 acres marsh; Diversion would adversely impact 227 acres of existing wetlands. While the project area will see an increase in wetland acreage, the system as a whole could continue to encounter some vegetative losses.
WILDLIFE RESOURCES	Continued decline in quality of wildlife habitat adversely impacts wetland dependent wildlife populations.	Restoration plan would provide 54 acres ridge; 19,630 acres of new marsh; 10,318 acres swamp habitat and protect 35,367 linear feet of shoreline vital to neotropical migratory birds; colonial nesting birds, waterfowl and mammals.	Restoration plan would provide 54 acres ridge; 44,188 acres of new marsh; 10,318 acres swamp habitat and protect 314,944 linear feet of shoreline vital to neotropical migratory birds; colonial nesting birds, waterfowl and mammals.	Restoration plan would provide 54 acres ridge; 44,892 acres of new marsh; 10,318 acres swamp habitat and protect 410,567 linear feet of shoreline vital to neotropical migratory birds; colonial nesting birds, waterfowl and mammals.
AQUATIC AND FISHERY RESOURCES	Wetland fragmentation, emergent wetland loss, shoreline and bank line erosion result in substantial decrease of critical essential fish habitat (EFH) needed for important fish life cycles, reducing the area's ability to adequately support Federally managed species.	Convert 7,444 acres of shallow open water and nourish 12,186 acres of marsh to create a more continuous emergent transitional wetland and 35,367 linear feet of shoreline protection. Based on preliminary aquatic impact analysis, results show no significant impacts to fishery species including Atlantic croaker, red drum (juveniles and adults), spotted sea trout (juveniles and adults), stripped mullet, sheepshead, Gulf menhaden, and bay anchovy. However, the potential for localized impacts to some species in areas closest to the Violet, Louisiana Freshwater Diversion could occur, as well as potential increases further away.	Creation of approximately 17,356 acres of marsh, 314,944 linear feet of shoreline protection, nourish 26,836 acres of existing marsh habitat. Based on preliminary aquatic impact analysis, results show no significant impacts to fishery species including Atlantic croaker, red drum (juveniles and adults), spotted sea trout (juveniles and adults), stripped mullet, sheepshead, Gulf menhaden, and bay anchovy. However, the potential for localized impacts to some species in areas closest to the Violet, LouisianaFreshwater Diversion could occur, as well as potential increases further away.	Similar to that of alternative C, with the following exceptions, additional 95,623 linear feet of shoreline protection, 704 acres of additional marsh created. Based on preliminary aquatic impact analysis, results show no significant impacts to fishery species including Atlantic croaker, red drum (juveniles and adults), spotted sea trout (juveniles and adults), stripped mullet, sheepshead, Gulf menhaden, and bay anchovy. However, the potential for localized impacts to some species in areas closest to the Violet, Louisiana Freshwater Diversion could occur, as well as potential increases further away.

Table S-1: Evaluation of Potential Impacts to Significant Resources by Alternative

Environmental Resources	Alternatives			
	Alternative A No Action	**Alternative B**	**Alternative C**	**Alternative D**
COMMERCIAL FISHERIES	Decline expected as habitat loss and degradation from erosion due to salinity changes lead to overfishing of the resource.	Convert 7,444 acres of shallow open water and nourish 12,186 acres of marsh to create a more continuous emergent transitional wetland and 35,367 linear feet of shoreline protection. Based on preliminary aquatic impact analysis, results show slight increase in net productivity for juvenile white shrimp and brown shrimp within Lake Borgne.	Restoration of approximately 17,356 acres of marsh, 314,944 linear feet of shoreline protection, nourish 26,836 acres of existing marsh habitat. Based on preliminary aquatic impact analysis, results show slight increase in net productivity for juvenile white shrimp and brown shrimp within Lake Borgne.	Similar to alternative C, additional 95,623 linear feet of shoreline protection, 704 acres of additional marsh created. Based on preliminary aquatic impact analysis, results show slight increase in net productivity for juvenile white shrimp and brown shrimp within Lake Borgne.
OYSTER RESOURCES	Loss of wetlands in the project area would likely alter the detritus-based food web of the oyster, thereby reducing the localized carrying capacity for oyster leases in the area.	Would borrow 87 million cubic yards (mcy) of borrow in Lake Borgne. Convert 7,444 acres of shallow open water and nourish 12,186 acres of marsh to create a more continuous emergent transitional wetland and 35,367 linear feet of shoreline protection. Based on preliminary aquatic impact analysis, results show slight decreases to oysters and spat through Lake Borgne and the Inner Biloxi Marsh.	Restoration of approximately 17,352 acres of marsh, 314,944 linear feet of shoreline protection, nourish 26,836 acres of existing marsh habitat using 152 mcy of borrow. Based on preliminary aquatic impact analysis, results show slight decreases to oysters and spat through Lake Borgne and the Inner Biloxi Marsh.	Similar to that of alternative C, additional 95,623 linear feet of shoreline and 704 acres or marsh created using an additional 2.3 mcy of borrow. Based on preliminary aquatic impact analysis, results show slight decreases to oysters and spat through Lake Borgne and the Inner Biloxi Marsh.
PLANKTON RESOURCES	No Action would have an additive impact due to increasing salinity and a transition to more marine-dominated community.	Minor changes in salinity (-0.6 to -1.4 ppt) in Lake Borgne and the Biloxi Marsh would not have a substantial effect on plankton abundance or distribution.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
WATER BOTTOMS AND BENTHIC RESOURCES	Persistence of existing conditions, including existing emergent wetlands converted to water bottoms no longer available for use by benthic species assemblages typically using this habitat.	Excavation of 87 mcy of material, to depths of ten feet with a maximum depth of twelve feet, from a total of 9,036 acres of water bottom. Based on preliminary aquatic impact analysis, results show slight increase in annual net productivity for benthic species in East Lake Pontchartrain and Lake Borgne.	Excavation of 152 mcy of material, to depths of ten feet with a maximum depth of twelve feet, from a total of 15,724 acres of water bottom. Based on preliminary aquatic impact analysis, results show slight increase in annual net productivity for benthic species in East Lake Pontchartrain and Lake Borgne.	Excavation of 154.3 mcy of material, to depths of ten feet with a maximum depth of twelve feet, from a total of 15,724 acres of water bottom. Based on preliminary aquatic impact analysis, results show slight increase in annual net productivity for benthic species in East Lake Pontchartrain and Lake Borgne.

Table S-1: Evaluation of Potential Impacts to Significant Resources by Alternative

Environmental Resources	Alternatives			
	Alternative A No Action	Alternative B	Alternative C	Alternative D
ESSENTIAL FISH HABITAT	Wetland fragmentation and emergent wetland loss contributing to the continued degradation of EFH for species utilizing this habitat such as; larvae and juvenile brown shrimp, juvenile white shrimp, all life stages of red drum, and juvenile dog snapper.	Convert 7,444 acres of shallow open water and nourish 12,186 acres of marsh to create a more contiguous emergent transitional wetland. Based on preliminary aquatic impact analysis, results show slight decrease in net productivity for juvenile red drum, white shrimp, and brown shrimp within Lake Borgne. Construction of retention dikes and reverse tidal flows could reduce utilization of Central Wetlands by certain species.	Restoration of approximately 17,352 acres of marsh, 314,944 linear feet of shoreline protection, nourish 26,836 acres of existing marsh habitat. Based on preliminary aquatic impact analysis, results same as alternative B. Construction of retention dikes and reverse tidal flows could reduce utilization of Central Wetlands by certain species.	Similar to that of alternative C, with the following exceptions, additional 95,623 linear feet of shoreline protection, and 704 acres of additional marsh created. Based on preliminary aquatic impact analysis, results same as alternative B. Construction of retention dikes and reverse tidal flows could reduce utilization of Central Wetlands by certain species.
THREATENED AND ENDANGERED (T&E) SPECIES	Loss of coastal wetland habitat resulting from the continued transition of wetland habitats and barrier island habitats to shallow open water habitats.	Approximately 87 mcy borrow materials, 122 acres impacts from shoreline protection from Gulf sturgeon critical habitat.	Approximately 152 mcy borrow material, 1,937acre impacts from shoreline protection from Gulf sturgeon critical habitat.	Approximately 154.3 mcy borrow material 2,494 acre impacts from shoreline protection from Gulf sturgeon critical habitat.
SOCIO-ECONOMIC RESOURCES - Population	The no action alternative, would have no direct, indirect, or cumulative impacts on human populations.	There are no direct impacts to human populations within the project area. Hence, this alternative would not be expected to have any cumulative effects on nearby populations.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
SOCIO-ECONOMIC RESOURCES – Community Cohesion	The no action alternative would have no impact on community cohesion	The construction of the diversion would create a new canal temporarily impacting traffic and thus affecting flow linkage between the two subdivisions and connected community residents.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
SOCIO-ECONOMIC RESOURCES – Employment and Income	The no action alternative would result in continued wetland loss and localized impacts on employment and income.	Alternative B would work synergistically with other projects and programs to support coast wide wetland-dependent employment.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
SOCIO-ECONOMIC RESOURCES - Infrastructure	The decline wetlands would contribute to the deterioration of substrate upon which infrastructure features are constructed.	Alternative B would restore or protect 30,002 acres in the project area, which would assist with protection of existing infrastructure.	Alternative C would provide greater beneficial impacts through the restoration of 24,558 acres more than alternative B.	Impacts would be slightly greater than alternative C, because 704 additional acres would be restored.

Table S-1: Evaluation of Potential Impacts to Significant Resources by Alternative

Environmental Resources	Alternatives			
	Alternative A No Action	Alternative B	Alternative C	Alternative D
SOCIO-ECONOMIC RESOURCES – Oil, Gas and Utilities Pipelines	The no action alternative could expose buried pipelines thereby increasing the risk of failure or damage due to lack of structural stability, anchor dragging, and boat collisions.	The restoration proposed for alternative B would prevent the increase in maintenance and relocation costs for pipelines in and around the project area.	Alternative C would provide more complete protection for oil and gas infrastructure than alternative B, and would produce more beneficial impacts through the restoration of 24,558 additional acres.	Impacts would be slightly greater than alternative C, because 704 additional acres would be restored.
SOCIO-ECONOMIC RESOURCES – Commercial Fisheries	Continued conversion of existing wetlands to open water habitats, continued bankline erosion and sloughing of the shoreline. Sharp declines are predicted in fisheries productivity under the no action alternative.	Alternative B would provide important fisheries habitat. Overall, the industry would be more stable near the project area due to a long-term increase in the quality of fisheries habitat.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
SOCIO-ECONOMIC RESOURCES – Oyster Leases	The loss of wetlands in the project area would likely alter the detritus-based food web of the oyster thereby reducing the localized carrying capacity for oyster leases in the area.	Creation, protection and nourishment of emergent wetlands in the project area in conjunction with other actions proposed and implemented in the vicinity would not affect the productivity of planktonic resources upon which oysters feed.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
SOCIO-ECONOMIC RESOURCES – Flood Control and Hurricane Protection Levees	The no action alternative would have no direct impacts on flood control or hurricane protection levees. Indirect impacts would result in the continued degradation of the landbridge separating Lake Borgne from the MRGO channel, the conversion of existing wetlands to open water habitats, and the continued bankline erosion and sloughing of the shoreline.	Alternative B would protect and restore marsh outside of the levees, which would help protect the levees, allowing current level of risk reduction in the project area to be maintained.	Benefits would be greater than alternative B, by providing an additional 24,558 acres of marsh benefits.	Impacts slightly greater than alternative C, by providing 704 acres of additional marsh benefits.
SOCIO-ECONOMIC RESOURCES – Navigation	As Louisiana’s coastal wetlands continue to fragment and convert to open water, the protection wetlands provide to inland waterways from wind-driven waves would be reduced.	Alternative B would work with other projects to protect adjacent waterways, such as the GIWW, from waves propagated through the lake, thus providing a safer route for inland water-borne traffic.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.

Table S-1: Evaluation of Potential Impacts to Significant Resources by Alternative

Environmental Resources	Alternatives			
	Alternative A No Action	**Alternative B**	**Alternative C**	**Alternative D**
ENVIRONMENTAL JUSTICE	With continued wetland loss, loss of valuable property, increased flooding risk of homes and businesses, impacts would affect all population groups.	Communities are located on either side of the areas where the proposed diversion would be located (Alternative 1 location). Concerns raised at public meetings include: a perceived potential for induced flooding, disapproval of the location, a perceived lack of benefits to St. Bernard Parish, and community cohesion.	Potential impacts would be the same as alternative B.	Potential impacts would be the same as alternative B.
HISTORIC AND CULTURAL RESOURCES	Continued erosion of cultural sites is expected.	Deposition of dredged material could increase the rate of subsidence and the disappearance of important sites from the archaeological record. National Register eligible sites would either have to be avoided or adverse effects would have to be mitigated.	Alternative C includes 24,558 additional acres of restoration activities, and therefore greater potential impacts.	Alternative D includes 704 additional acres of restoration activities, and therefore greater potential impacts.
RECREATION RESOURCES	Continued wetland loss and conversion of existing wetlands to open water habitats resulting in decreased structural complexity and habitat diversity of recreational fish caught and game species hunted.	Restoration should improve recreational fishing and wildlife hunting opportunities. Freshwater diversion could improve duck hunting. Freshening from diversion may push some recreational fishing further into more saline waters within the project area. Based on preliminary aquatic impact analysis, results show decrease in net productivity for spotted sea trout in the Inner Biloxi Marsh but a slight increase in net productivity for juvenile white shrimp and brown shrimp within Lake Borgne	Similar effect as alternative B for diversion feature, for wetland measures, impacts are to a greater extent.	Effects to resource similar to alternative C.

Table S-1: Evaluation of Potential Impacts to Significant Resources by Alternative

Environmental Resources	Alternatives			
	Alternative A No Action	**Alternative B**	**Alternative C**	**Alternative D**
AESTHETICS (Scenic Rivers)	Continued habitat deterioration, land loss, and conversion to open water reducing scenic qualities of area.	Temporary impacts from the Restoration Plan could include a reduction in access, reduced water quality, and possible sedimentation. However, the overall project would create and nourish 4,317 acres of marsh and 7,693 acres of swamp in the vicinity of the scenic streams restoring their viewscape to its original habitat types.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
FLOODPLAINS	A large portion of the project area is coastal marsh habitat, which would continue to degrade and increase the flood risk to developed portions of the floodplain.	Approximately 529 acres within the 500 and/or 100-year floodplain would be converted to floodway as part of the construction of the diversion channel (Alternative 1 location). Guide levees and control structures would eliminate the flood risk to communities or development in the adjacent floodplain.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.

S.11 CONCLUSIONS

The tentatively selected plan (alternative C) would restore approximately 57,472 acres of habitat in the study area, including 14,123 acres of fresh and intermediate marsh; 32,511 acres of brackish marsh; 10,318 acres of cypress swamp in the Central Wetlands; 466 acres of saline marsh; and 54 acres of ridge habitat along Bayou La Loutre. Alternative C includes approximately 71 miles of shoreline protection in Lake Borgne, along the MRGO, and in the Biloxi Marsh, including 5.8 miles of oyster reef restoration in the Biloxi Marsh. Alternative C also includes two recreation features and an adaptively managed freshwater diversion near Violet, Louisiana. These acreage values are based on WVA results, which take into account marsh creation behind the shoreline protection features.

Approximately 10,221 acres of the restoration and protection features would be located in the East Orleans Landbridge/Pearl River area and approximately 9,861 acres of restoration features would be located in the Biloxi Marsh area, which have been determined to be critical landscape features with respect to storm surge. Additionally, the cypress swamp and ridge restoration features include forested habitats, having some storm surge damage risk reduction benefits.

The Violet, Louisiana Freshwater Diversion is an important component of the plan to restore historic salinity conditions and provide freshwater and nutrients to nourish existing and restored wetlands in the study area. However, additional study is needed to improve decisions about where, when, and how to divert Mississippi River flows in a systems context. The ongoing Mississippi River Hydrodynamic and Delta Management Study will evaluate ecosystem restoration alternatives in concert with dynamic flood risk management and navigation; multipurpose management scenarios of the river; and dynamic conditions in a comprehensive systems context. The information gained from this study will improve decision-making for the Violet, Louisiana Freshwater Diversion. Therefore, the final recommendations for the MRGO Ecosystem Restoration Plan include additional analysis, design and implementation of the Violet, Louisiana Freshwater Diversion as authorized by WRDA 2007 Section 3083.

The anticipated outputs of the tentatively selected plan would help address the current trend of degradation of the Lake Borgne ecosystem, support Nationally significant resources, provide a sustainable and diverse array of fish and wildlife habitats, provide infrastructure protection, and make progress towards a more sustainable ecosystem.

S.12 RECOMMENDATIONS

The District Commander has considered all the significant aspects of this study including the environmental, social, and economic effects, the engineering feasibility, and comments received from resource agencies, the non-Federal sponsors, and the public and has determined that the tentatively selected plan is in the overall public interest and a justified expenditure of Federal funds. As a comprehensive approach to protect, stabilize, and augment the landbridge between Lake Borgne and the MRGO, the District Commander recommends the construction of rock dikes for shoreline protection along the south bank of Lake Borgne in the reaches referenced as Bayou Bienvenue, Bayou Dupre, and West of Shell Beach. The District Commander also recommends the construction of marsh creation projects in the Golden Triangle and Shell Beach area.

The total cost for the project is $2.9 billion inclusive of associated investigation, environmental, engineering and design, construction, supervision and administration, and contingency costs. The operations, maintenance, repair, replacement and rehabilitation (OMRR&R) of this project shall be the responsibility of the a non-Federal sponsor.

CHAPTER 1: **INTRODUCTION**

1.1 INTRODUCTION

This Final Environmental Impact Statement (FEIS) for the Mississippi River Gulf Outlet (hereafter MRGO) Ecosystem Restoration Plan Feasibility Report was prepared by the U.S. Army Corps of Engineers (USACE)-Mississippi Valley Division, New Orleans District (CEMVN). It includes input from Federal, as well as Louisiana and Mississippi state agencies. This National Environmental Policy Act (NEPA) of 1969 document tiers off the Louisiana Coastal Area (LCA), Final Programmatic Environmental Impact Statement (FPEIS), Record of Decision (ROD), signed January 31, 2005.

This FEIS was prepared to assess of the viable alternatives identified as part of the MRGO Ecosystem Restoration Plan Feasibility Report. The feasibility report will accompany this FEIS, the reports are companion documents. Plans are evaluated based on the ability to meet the study goals and objectives, compliance with environmental laws and regulations, contributions to the Federal objective of National Ecosystem Restoration (NER), and meeting the four evaluation criteria of completeness, effectiveness, efficiency, and acceptability.

Through evaluation and impact assessment, the feasibility report and FEIS identify the tentatively selected plan that is the NER plan as determined by the four evaluation criteria noted above. Selecting the NER plan requires careful consideration of planning goals, objectives, and constraints. The NER plan reasonably maximizes environmental benefits while passing tests of cost effectiveness and incremental cost analyses, significance of outputs and ability to meet the evaluation criteria. The Water Resources Development Act of 2007 (WRDA 2007) requires the plan to be cost effective, environmentally acceptable, and technically feasible in order to be carried out by the Secretary of the Army.

Louisiana's coastal plain contains the largest expanse of coastal wetlands in the contiguous United States and accounts for 90 percent of the total coastal marsh loss as occurring in the Nation (USACE, 2004). Louisiana coastal land loss has been ongoing since the early 1900s with commensurate harmful effects on the ecosystem and future adverse impacts to the regional economy and the Nation. The USACE, the State of Louisiana, and others, under the laws passed by Congress and as administered by the President of the United States, have been working to combat coastal land loss, not only because of the role coastal environment plays in storm protection, but also because of its contribution to the health of the natural environment, the regional and national economy, and the culture of South Louisiana.

The coastal wetlands, built by Mississippi River deltaic processes, contain diverse habitats that range from narrow natural levee and beach ridges to expanses of forested swamps and freshwater, intermediate, brackish, and saline marshes. Taken as a whole, the unique habitats, with their hydrological connections to each other, upland areas, the Gulf of Mexico, and migratory routes of birds, fish, and other species, combine to place the coastal wetlands of Louisiana among the Nation's most productive and important natural assets.

Coastal wetlands are unsurpassed in their contribution and importance to the ecosystem of the Louisiana and Mississippi gulf coast region. The wetlands are an irreplaceable natural resource that provides many benefits to local communities as well as the Nation. From a biological perspective, the wetlands provide habitat and food that sustains the biodiversity in the region from the smallest to largest scales. Beginning with a single blade of *Spartina* that provides habitat and food for microbes and snails to complex wetland landscapes that are home to crabs, shrimp, and fish and the birds and mammals that feed on them, Louisiana's wetlands are a vital National resource. From a socioeconomic perspective, the wetlands define a way of life for the commercial and recreational fishermen in the region. Additionally, the wetlands stabilize shorelines and provide a buffer for the coastal communities from storm waves and surge.

1.2 STUDY AUTHORITY AND STUDY SPONSOR

The study is authorized by Section 7013 of the WRDA 2007 to develop a plan that would:

- physically modify the MRGO and restore the areas affected by the navigation channel;
- restore natural features of the ecosystem that will reduce or prevent storm surge damage;
- prevent saltwater intrusion into the waterway;
- integrate the recommendations of the LCA Report and the Louisiana Coastal Protection and Restoration (LACPR) Technical Report; and
- consider the use of native vegetation and diversions of freshwater to restore the Lake Borgne ecosystem.

The WRDA 2007 Section 7013 features of the MRGO plan in Tiers 1 and 2, as described in the Mississippi River-Gulf Outlent (MRGO) Ecosystem Restoration Plan Final Feasibility Report, Supplemental Report of the Chief of Engineers In Response To The Water Resources Development Act Of 2007, are conditionally authorized for construction, pending the determination by the Assistant Secretary of the Army (Civil Works) (ASA(CW)) that the project is cost-effective, environmentally acceptable, and technically feasible. This conditional authorization also assumes that a viable cost sharing sponsor(s) will be identified as required by Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5), and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213), The Tier 3 feature, consisting of the Violet, Louisiana Freshwater Diversion project, as authorized by Section 3083 of WRDA 2007 (Tier 3A), as well as certain

MRGO Ecosystem Restoration features authorized by Section 7013 of WRDA 2007 (but which are dependent upon the implementation of a freshwater diversion at or in the vicinity of Violet (Tier3B)), are recommended in the report for additional feasibility study and analysis.

The Section 7013 MRGO ecosystem restoration study is 100% Federally funded. Despite lengthy discussions with the State of Louisiana, the Government has been unable to identify a non-Federal sonsor for design and implementation of the Section 7013 Section 3083 of WRDA 2007 conditionally authorizes the the Violet, Louisiana Freshwater Diversion project and identifies the State of Mississippi and the State of Louisiana as the non-Federal sponsors for that project. Both states have been actively participating on the planning team. . USACE will continue, pursuant to Section 3083 of WRDA 2007, to coordinate with the State of Louisiana and the State of Mississippi during the further feasibility study for the Violet, Louisiana Freshwater Diversion project and with the State of Louisiana regarding those Section 7013 elements of the MRGO Ecosystem Restoration project that are determined by USACE to be dependent upon the design and implementation of the Violet diversion. Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5), and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213) requires the execution of a binding written agreement by the State of Louisiana and the State of Mississippi in order for the United States to commence construction.

1.3 STUDY AREA

The study area includes portions of the Mississippi River deltaic plain in southeast Louisiana and parts of the southwest Mississippi coast (**figure 1-1**). It encompasses approximately 3.84 million acres (over 6,000 square miles).

In Mississippi, the study area includes the Western Mississippi Sound, its bordering wetlands, and Cat Island. The Lake Borgne ecosystem and areas that may have been affected by the construction, operation, and maintenance of the MRGO navigation channel are included in the study area. The MRGO channel may have affected salinity as far northwest as Lake Maurepas. To the east, the MRGO channel was dredged through open water between Breton and Grand Gosier Islands (segments of the lower Chandeleur Island chain). The MRGO channel affected portions of the Lake Borgne ecosystem to the north and potentially altered hydrology to the west as far as the Bayou Terre aux Boeufs Ridge.

Louisiana parishes in the study area include Ascension, Jefferson, Livingston, Orleans, Plaquemines, St. Bernard, St. Charles, St. James, St. John the Baptist, St. Tammany and Tangipahoa. Mississippi counties include portions of Hancock and Harrison.

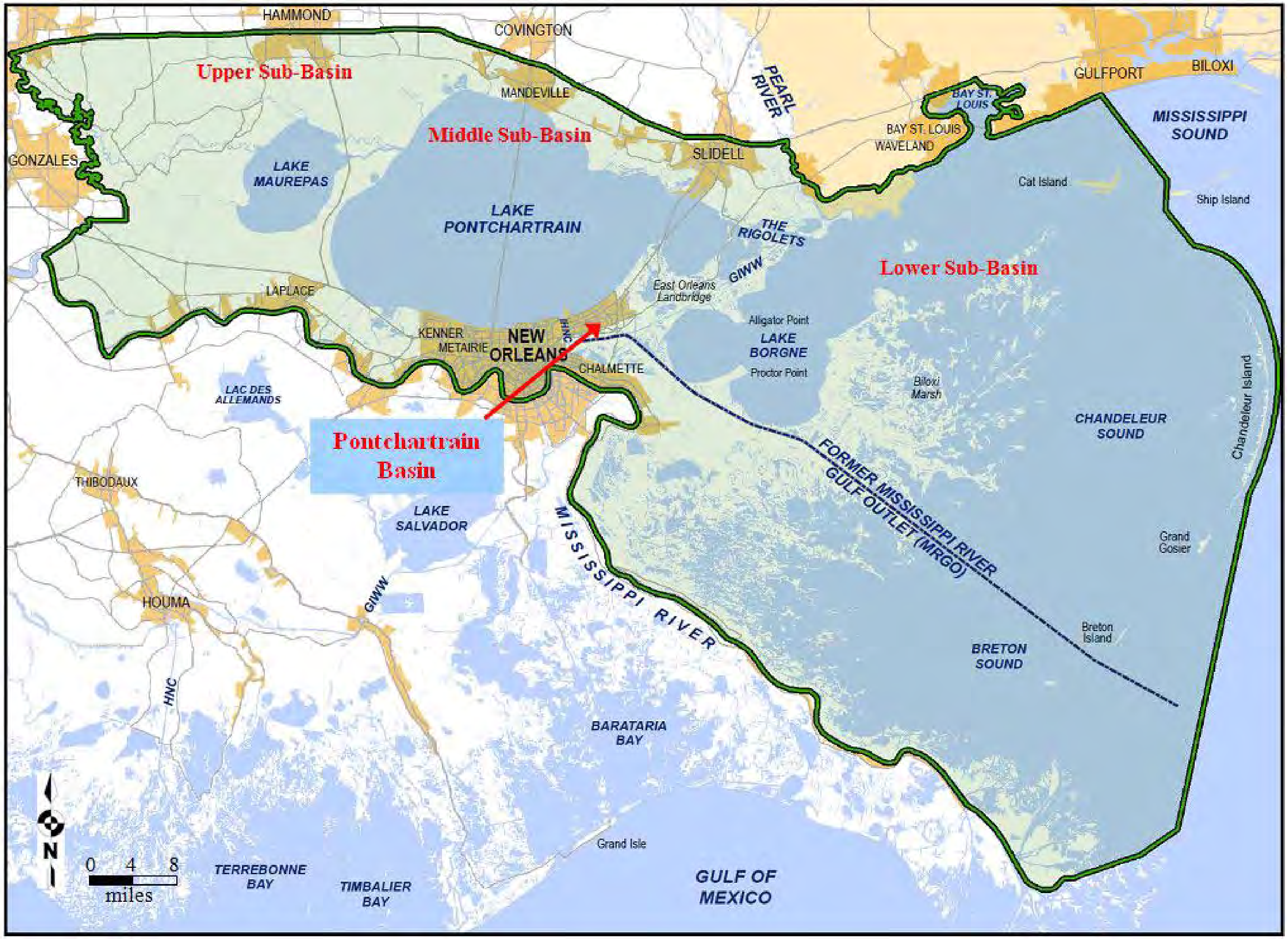


Figure 1-1: Study Area - Ponchartrain Basin and Western Mississippi Sound

In Louisiana, the study area includes the Pontchartrain Basin. The Upper Pontchartrain sub-basin includes Lake Maurepas and its adjacent wetlands and swamps. Lake Maurepas receives its freshwater influences from the Amite and Tickfaw Rivers, Bayou Manchac, and other smaller rivers.

The Middle Pontchartrain sub-basin is comprised of Lake Pontchartrain, its adjacent cities and towns, and surrounding wetlands. Lake Pontchartrain is affected by freshwater inflows from Pass Manchac, North Pass, and the Tangipahoa, Tchefuncte, and Bogue Falaya Rivers, some bayous, and the Bonnet Carré Spillway.

The Lower Pontchartrain sub-basin includes Lake Borgne, the MRGO, the Mississippi River, Chandeleur and Breton Sounds, portions of the Gulf of Mexico, and the surrounding wetlands, barrier islands, and communities. Lake Borgne is hydrologically linked to Lake Pontchartrain through tidal passes at the Rigolets, Chef Menteur Pass, and the manmade Inner Harbor Navigation Canal (IHNC). The Lake Borgne ecosystem is influenced by the Pearl River to the north and is hydrologically connected to areas located as far south as Bayou Terre aux Boeufs.

Major navigation channels include the Mississippi River, IHNC, the Gulf Intracoastal Waterway (GIWW), and a portion of the MRGO that remains authorized.

For planning and evaluation purposes, the study area, which encompasses the Pontchartrain Basin and Western Mississippi Sound, was divided into 52 planning subunits, as illustrated in **figure 1-2**. Subunits classified as fastlands (agricultural, developed, and upland areas that do not have direct and significant impacts on coastal waters) do not function as part of the estuarine Lake Borgne ecosystem (LOSR, 2002). These fastland areas are not targeted for ecosystem restoration in this study and were not included in **table 1-1**.

The restoration measures considered in this study are located in the eastern portion, or Lower Pontchartrain sub-basin, of the overall study area. Due to the absence of project related construction features in large portions of the study area, the study area was reduced in order to facilitate ease of discussion of existing conditions and potential impacts within **chapter 3** and **chapter 4**, respectively. The “smaller” study area that was focused on for discussion in this EIS includes the East Orleans Landbridge, Lake Borgne and associated marsh, the Biloxi Marsh, and Bayou Terre aux Boeufs Marsh and is herein referenced as the project area. This area includes subunits 5 through 7, 10 through 15, 17 through 19, 21 through 23, 26, 27, 32, 36a, 38, and 40 as shown on **figure 1-2**. These 39 subunits were focused on since each has at least one restoration feature located within it.

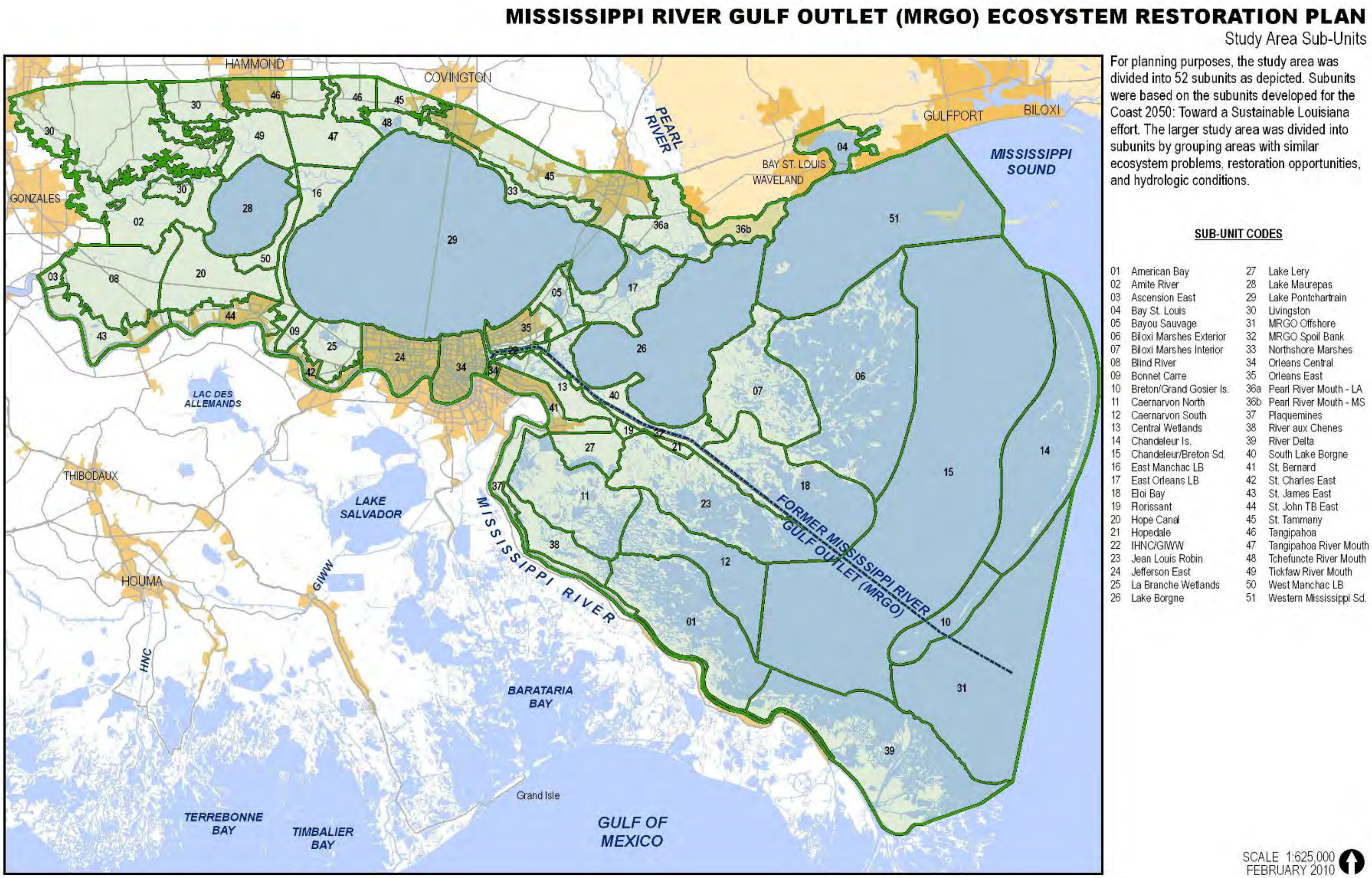


Figure 1-2: MRGO Planning Subunits

1.4 PURPOSE AND NEED FOR ACTION

The MRGO Ecosystem Restoration Plan Feasibility Report and Final Environmental Impact Statement (FEIS) were developed as a supplement to the June 2008 MRGO Deep-Draft De-Authorization Report and is intended to fully meet the requirements of Section 7013 of the WRDA 2007. The feasibility report will result in a Report of the Chief of Engineers, describing the tentatively selected plan for MRGO Ecosystem Restoration and recommending construction of features for early implementation contingent upon the identification of a non-Federal sponsor, which has been conditionally authorized for construction by Section 7013 of the WRDA 2007. The plan addresses systematic ecosystem restoration and protection of the Lake Borgne ecosystem and areas affected by the MRGO navigation channel, and includes considerations of measures to reduce or prevent damage from storm surge. The study integrates the findings of ongoing comprehensive restoration planning efforts for the study area, including the LACPR Final Technical Report, the LCA Program, and Louisiana's 2007 Comprehensive Master Plan for a Sustainable Coast.

The cumulative effects of human and natural activities in the Louisiana coastal area have severely degraded the deltaic processes and shifted the coastal area to a net land loss condition. Many studies have been conducted to identify the major contributing factors (e.g., Boesch et al., 1994; Turner, 1997; Penland et al., 2000), and many studies agree that land loss and the degradation of the coastal ecosystem are the result of both natural and human induced factors, producing conditions where wetland vegetation can no longer survive and land is lost. Establishing the relative contribution of natural and human-induced factors is difficult. In many cases, the changes in hydrologic and ecologic processes manifest gradually over decades and in large areas, while other effects occur over single days and impact relatively localized areas.

The study purpose is to develop alternative plans to restore natural features and processes in the Lake Borgne ecosystem and areas affected by the former navigation channel. Construction recommendations will be developed to restore historic habitat types and natural ecological processes in concert with other large-scale comprehensive ecosystem restoration plans. The period of analysis covers implementation and extends 50 years into the future. It begins in the first year of construction in 2015 and extends to 2065.

The main water resource problems identified in the study area and the impacts associated with the construction and maintenance of the MRGO navigation channel include:

- Wetlands loss;
- Bank/shoreline erosion;
- Habitat change and loss;
- Modification of natural hydrology;
- Decreased freshwater, sediment, and nutrient inputs;
- Saltwater intrusion;
- Retreating and eroding barrier islands;
- Ridge habitat degradation and destruction;
- Invasive species;
- Herbivory; and
- Increasing susceptibility to storm surge.

Table 1-1 describes the relevance of each subunit to the MRGO study and how problems and opportunities were addressed in each subunit. Problems are further described in **Table 1-2** for subunits where initial plan features were developed.

The initial determination whether restoration features should be developed in a subunit were based on the study authority. The authority indicates that the plan would "physically modify the MRGO and restore the areas affected by the navigation channel". Problems and opportunities were identified in subunits adjacent to the MRGO and in subunits potentially affected by MRGO construction, operation, or maintenance.

The study authority mandates the development of "a plan to restore natural features of the ecosystem that will reduce or prevent damage from storm surge". To address this portion of the authority, if a subunit was identified as a critical landscape feature in LACPR and was located in either the areas potentially affected by the MRGO or the Lake Borgne ecosystem, management measures were developed in those subunits. The study area was interpreted to include the greater Lake Borgne ecosystem, because the authority also states that the plan should include: "consideration of…diversions of fresh water to restore the Lake Borgne ecosystem". This interpretation is consistent with the study Implementation Guidance dated 28 April 2009. The Lake Borgne ecosystem was defined as areas hydrologically connected to Lake Borgne.

Table 1-1: Subunits by Geographic Area and Their Relevance to the MRGO Ecosystem Restoration Plan

(ID) Subunit Name	Relevance of Subunit to MRGO Plan
Lake Maurepas and North Lake Pontchartrain	
(16) East Manchac Landbridge (50) West Manchac Landbridge	Identified as a critical landscape feature for storm surge risk reduction in LACPR. Measures were initially developed to address ecosystem restoration problems but were screened out because initial investigations indicated that the benefits of these features were minimal based on historic shoreline erosion and land loss rates. Habitat changed from cypress swamp to intermediate marsh on the East Manchac Landbridge can be attributed to increased salinity caused by the MRGO. However, because these areas have relatively low land loss rates, the benefits of wetland creation and nourishment in this area are comparatively low.
(48) Tchefuncte River Mouth (47) Tangipahoa River Mouth (49) Tickfaw River Mouth (28) Lake Maurepas (02) Amite River (08) Blind River (20) Hope Canal (09) Bonnet Carré (25) LaBranche Wetlands (33) Northshore Marshes	Tate et al., 2002 indicates that the MRGO contributed to salinity increases as far west as Pass Manchac. Therefore, the MRGO may have contributed to increased salinity in areas hydrologically linked to Lake Maurepas. MRGO effects related to saltwater intrusion are partially addressed by the MRGO closures and are anticipated to be fully addressed by other authorized projects (Convent/Blind, Amite and Hope Canal/Maurepas Swamp freshwater reintroductions).

Table 1-1: Subunits by Geographic Area and Their Relevance to the MRGO Ecosystem Restoration Plan

(ID) Subunit Name	Relevance of Subunit to MRGO Plan
(29) Lake Pontchartrain	Lake Pontchartrain was affected by saltwater intrusion caused by the MRGO. Salinity affects are being addressed by the MRGO closures. Because it is an open water body, any problems, opportunities, or measures in the lake are linked to the nearest subunit. For example, Submerged Aquatic Vegetation (SAV) Restoration in Lake Pontchartrain is linked to the (05) Bayou Sauvage subunit.
East Orleans Landbridge and South Lake Borgne	
(36a) Pearl River Mouth - LA	Subunits 36a, 17, and 05 are part of the Lake Borgne ecosystem and are recognized as critical landscape features in LACPR. Subunit 40 was directly and indirectly impacted by the MRGO. Measures were developed to address subunit problems and opportunities. Subunit 26 was indirectly affected by the MRGO. Because it is an open water body, any problems, opportunities, or measures in the lake are linked to the nearest subunit. The spatial integrity of the MRGO/Lake Borgne Landbridge was compromised by the construction of the channel. The maintenance of the form of the lake rim is needed to restore the estuary. Measures were developed to address subunit problems and opportunities.
(17) East Orleans Landbridge	
(05) Bayou Sauvage	
(26) Lake Borgne	
(40) S. Lake Borgne	
Central Wetlands	
(13) Central Wetlands	Subunit 13 was directly and indirectly impacted by the MRGO. The channel was cut through the eastern portion of the subunit. Measures were developed to address subunit problems and opportunities.
IHNC/GIWW	
(22) IHNC/GIWW	More saline water entered these navigation channels via the MRGO. These areas are being considered as potential borrow sites.
MRGO	
(32) MRGO Spoil Bank	Subunit 32 was directly affected by the dredging and placement of material during the construction of the channel.
(31) MRGO Offshore	MRGO affects addressed by de-authorization of channel and natural shoaling.
Biloxi Marsh	
(07) Biloxi Marshes Interior	Subunits 07 and 18 were directly and indirectly impacted by the MRGO. Subunit 06 is adjacent to the Lake Borgne ecosystem and the offshore portion of the MRGO was dredged in the vicinity. Measures were developed to address subunit problems and opportunities.
(06) Biloxi Marshes Exterior	
(18) Eloi Bay	
Barrier Islands	
(14) Chandeleur Islands	Subunits 14 and 15 are adjacent to the Lake Borgne ecosystem and the offshore portion of the MRGO was dredged in the vicinity. Potential borrow sites. An offshore portion of the MRGO was dredged in subunit 10. Impacts of MRGO are addressed by de-authorization of channel and natural shoaling.
(15) Chandeleur/Breton Sound	
(10) Breton/Grand Gossier Islands	
Florissant	
(19) Florissant	Subunit 19 was indirectly impacted by the MRGO through the placement of spoil material and hydrologic changes. Measures were developed to address subunit problems and opportunities.

Table 1-1: Subunits by Geographic Area and Their Relevance to the MRGO Ecosystem Restoration Plan

(ID) Subunit Name	Relevance of Subunit to MRGO Plan
Terre aux Boeufs, Hopedale	
(21) Hopedale	Subunits 21 and 23 were indirectly impacted by the MRGO through the placement of spoil material and hydrologic changes. Measures were developed to address subunit problems and opportunities.
(23) Jean Louis Robin	
Mississippi Sound	
(04) Bay St. Louis	Part of the Lake Borgne ecosystem. Problems and opportunities addressed by Mississippi Coastal Improvements Program (MsCIP).
(36b) Pearl River Mouth (Mississippi)	
(51) Western Mississippi Sound	Part of the Lake Borgne ecosystem. Problems and opportunities addressed by MsCIP. Potential borrow area.
Caernarvon	
(11) Caernarvon North	Insufficient nexus to Lake Borgne ecosystem or MRGO.
(38) River aux Chenes	
(12) Caernarvon South	
River Delta	
(01) American Bay	Insufficient nexus to Lake Borgne ecosystem or MRGO.
(39) River Delta	

Table 1-2: Problems in Initial Feature Subunits

	Problems								
	Decreased Freshwater, Sediment and Nutrient Inputs	**Hydrologic Modification**	**Saltwater Intrusion**	**Wetland Loss**	**Ridge Habitat Degradation and Destruction**	**Bank and Shoreline Erosion**	**Habitat Change and Land Loss**	**Invasive Species and Herbivory**	**Retreating and Eroding Barrier Islands**
Lake Maurepas and North Lake Pontchartrain									
(16) East and (50) West Manchac Landbridge	X	X	X	X		X	X	X	
East Orleans Landbridge									
(36a) Pearl River Mouth – LA, (17) East Orleans Landbridge, and (05) Bayou Sauvage	X	X	X	X		X	X	X	
South Lake Borgne									
(40) South Lake Borgne	X	X	X	X	X	X	X	X	
Central Wetlands									
(13) Central Wetlands	X	X	X	X			X	X	
Biloxi Marsh									
(07) Biloxi Marshes Interior and (18) Eloi Bay	X	X	X	X	X	X	X	X	
(06) Biloxi Marshes Exterior	X	X	X	X		X	X	X	
Barrier Islands									
(10) Breton/Grand Gossier Islands	X	X							X
(14) Chandeleur Islands	X	X							X

Table 1-2: Problems in Initial Feature Subunits

	Problems								
	Decreased Freshwater, Sediment and Nutrient Inputs	Hydrologic Modification	Saltwater Intrusion	Wetland Loss	Ridge Habitat Degradation and Destruction	Bank and Shoreline Erosion	Habitat Change and Land Loss	Invasive Species and Herbivory	Retreating and Eroding Barrier Islands
Florissant									
(19) Florissant	X	X	X	X	X	X	X	X	
Terre aux Boeufs, Hopedale									
(23) Jean Louis Robin	X	X	X	X	X				
(21) Hopedale	X	X	X	X	X	X	X	X	

1.4.1 MRGO Navigation Channel

Congress authorized the MRGO in 1956 as a Federal navigation channel to provide a shorter route between the Port of New Orleans and the Gulf of Mexico (**figure 1-3)**. It was authorized as a 36-foot deep, 500-foot bottom width waterway (38-foot deep, 600-foot wide at the Gulf of Mexico entrance) extending from the IHNC Lock to the 38-foot depth contour in the Gulf of Mexico. Construction began in 1958 and was completed in 1968.

Figure 1-3: MRGO Navigation Channel

In August 2005, Hurricane Katrina caused shoaling in the MRGO channel limiting its depth to 22 feet, and thus restricted deep-draft vessel access. Rather than continue funding operation and maintenance of the channel, in June 2006, Congress requested a plan for de-authorization of the MRGO (Public Law 109-234).

In 2006, Congress directed the Secretary of the Army, acting through the Chief of Engineers, to develop a plan for de-authorization of deep-draft navigation on the MRGO in the Emergency Supplemental Appropriations Act for Defense, the Global War on Terror, and Hurricane Recovery, 2006 (Public Law 109-234). Public Law 109-234 also modified Public Law 109-148, to clarify that the $75,000,000 provided in Public Law 109-148 was to be used for "the repair, construction or provision of measures or structures necessary to protect, restore or increase wetlands, to prevent saltwater intrusion or storm surge."

In January 2008, the Chief of Engineers signed a report recommending de-authorization of a portion of the channel, construction of a closure structure across the channel at Bayou La Loutre, and development of a supplemental report to provide an ecosystem restoration plan for the areas affected by the MRGO. On June 5, 2008, the MRGO was officially de-authorized from the confluence with the GIWW to the Gulf of Mexico as a Federal navigation channel. A rock closure structure was constructed across the MRGO near the Bayou La Loutre Ridge in St. Bernard Parish, Louisiana (**figure 1-4)** in 2009.

Figure 1-4: MRGO Closure Structure at Bayou La Loutre

1.4.1.1 MRGO Impacts

The cumulative effects of human and natural coastal activities have severely degraded the Mississippi River's deltaic processes and shifted the coastal area from a dynamic balance between land gain and land loss to one of net land loss. Many studies have been conducted to identify the major contributing factors (e.g., Boesch et al., 1994; Turner, 1997; Penland et al., 2000), and many studies agree that land loss and the degradation of the coastal ecosystem are the result of both natural and human induced factors, producing conditions where wetland vegetation can no longer survive and wetlands are lost. Establishing the relative contribution of natural and human-induced factors is difficult. In many cases, the changes in hydrologic and ecologic processes manifest gradually over decades and in large areas, while other effects occur over single days and impact relatively localized areas.

Construction and operation of the MRGO contributed to wetland loss and damages to estuarine habitats in Louisiana from the outer tidal marshes in Breton Sound to the cypress forests and fresh mashes in the western reaches of the Lake Borgne basin (**figure 1-5**). Loss of marsh and cypress swamp habitats has resulted in the decline of important ecological habitat as well as natural surge and wave buffers. Indirect and cumulative impacts associated with saltwater intrusion attributable to the MRGO occurred throughout the Lake Pontchartrain Basin.

Figure 1-5: Construction of MRGO Channel (1959)

The direct and indirect habitat impacts of the construction and operation of the MRGO between 1956 and 1990 were estimated in *Habitat Impacts of the Construction of the MRGO* (USACE, 1999) (**appendix V**). MRGO channel construction, the dredging of the channel and placement of dredged material, resulted in the conversion of 19,400 acres of wetlands and 4,750 acres of shallow open water to deep open water or dredge material banks.

Other contributing factors of land loss, such as subsidence, sea level rise, and human alterations complicate the calculation of indirect impacts from the MRGO. The methodology for estimating indirect impacts utilized habitat data from the Louisiana Department of Natural Resources (LDNR) for 1956 and 1990 (USACE, 1999). Increased land loss due to the MRGO was estimated by calculating a baseline loss by mapping unit, which included all land loss factors (such as subsidence and sea level rise), as well as the MRGO, and then estimating what percentage of the baseline loss was caused by the navigation channel to develop a "without MRGO" loss rate. The percentages were developed based on the condition of the area prior to channel construction, proximity to the direct effects of the channel, and the significance of saltwater intrusion to each area. This loss rate was applied to the acres present in 1956; and the resulting 1990 acres were compared to calculate the possible increased loss. Additional losses due to erosion along the MRGO between 1990 and 2008 were calculated by Department of the Interior – United States Geological Survey (USGS) team members. The methodology used in the 1999 report was re-assessed and validated. The "without MRGO" loss rates are estimates based on a professional assessment of various contributing factors.

There are no tools available to provide a more accurate picture of what the landscape would look like if the channel had never been built. These estimates, and the methodology used to develop them, were verified as the best available quantification of MRGO impacts. A summary of the direct and indirect impacts by habitat type resulting from the construction of the MRGO is presented in **table 1-3**.

Table 1-3: Direct and Indirect Habitat Impacts of the MRGO

	Impacts from 1956 to 1990[a]	
Habitat Type	**Direct Impacts (acres lost)**	**Indirect Impacts (acres lost or converted)**
Cypress swamp	1,510	8,000
Fresh/intermediate marsh	3,370	3,350
Brackish marsh	10,310	19,170
Saline marsh	4,210	N/A
Shallow open water converted to deep water or disposal	4,750	N/A
	Additional impacts between 1990 to 2008	
Additional marsh lost adjacent to the channel[b]	460	3,400
Total Impacts	24,610	33,920

NOTES:
[a] Direct impacts are due to construction and erosion. Indirect impacts are due to salinity or hydrological changes from the MRGO (*Habitat Impacts of the Construction of the MRGO,* USACE, 1999). Habitat shifts were estimated using 1956 – 1990 habitat composition data from LDNR.
[b]Direct impacts due to additional erosion between 1990 and 2008. Indirect impacts due to increased tides and salinity.
Does not include deeper water aquatic habitat effects due to salinity increases or Lake Maurepas area to be restored by LCA projects.

It is important to note that other studies have attributed additional impacts to the MRGO. The *Mister Go Must Go* report estimates the total impact of the MRGO is 618,000 acres (Day et al., 2006). The PDT recognizes that the MRGO, as well as other contributing factors affected the salinity levels in Lake Pontchartrain and Lake Borgne; however, the team considered these concerns and determined they are being addressed by the LCA feasibility studies, MRGO closure structure, and the Lake Borgne storm surge barrier. This includes 488,400 acres of Lakes Pontchartrain and Borgne affected by salinity shifts and 64,000 acres of Lake Pontchartrain that exhibited seasonal hypoxic/anoxic conditions (low oxygen/no oxygen) due to its hydrologic connection with the MRGO channel.

Initial monitoring data indicate that the channel closure at Bayou La Loutre has decreased salinity upstream of the closure (USGS, 2009). The closure at Bayou La Loutre and authorized LCA projects are anticipated to continue to address the hypoxia and salinity impacts of the MRGO in Lakes Pontchartrain and Borgne.

Prior to construction of the MRGO, typical tidal flow within the Breton Sound area was reduced as it moved across the marsh inward toward Lake Borgne (USACE, 2004). The major tidal channels at the Chandeleur Islands are located north of Hewes Point and south of Breton Island. Measurements and modeling conducted in the 1970s demonstrate that these two tidal channels were responsible for the majority of tidal flow into and out of Chandeleur and Breton Sounds (Hart and Murray, 1978). The MRGO was dredged through the Bayou La Loutre Ridge cutting a basin boundary that limited the flow of saline water from the Breton Sound area into Lake Borgne (Rounsefell, 1964). Following construction of the MRGO, strong tidal current flow occurred through the MRGO, creating a major conduit for tidal exchange for portions of the Lake Pontchartrain Basin. In a study analyzing the typical tidal flow following construction of the MRGO, it was determined that circulation patterns were altered along the lower southeastern length of the channel and across areas between Breton Sound and Lake Borgne (Wicker et al., 1982).

The habitat changes in the study area are primarily related to saltwater intrusion, although other factors such as logging and the construction of impoundments contributed to these changes. The salinity changes based on pre- and post-channel water quality monitoring are documented in *Salinity Changes in Pontchartrain Basin Estuary, Louisiana, Resulting from Mississippi River-Gulf Outlet Partial Closure with Width Reduction, Final Report* (Tate et al., 2002). The data indicated that the salinity is lowest in the late spring and highest in the summer and fall. This is reflective of the seasonal variations in the freshwater inflows from the rivers and streams into the basin. The salinity in Lake Borgne generally ranged from 2 to 15 parts per thousand (ppt) and is influenced greatly by the Pearl River and inflows from the Rigolets and Chef Pass. Higher salinity water from the MRGO entered Lake Borgne through breaks in the marshes between the two water bodies (Tate, 2002).

A comparison of data collected pre- and post-construction of the MRGO indicate that the most notable increase in monthly average salinity occurred after 1963 (Tate, 2002). Mean monthly salinity increased for all months for the period after 1963. This increase coincides with the partial completion of the MRGO in 1963, which provided a major access for saltwater to enter Lakes Pontchartrain and Borgne. **Table 1-4** lists mean monthly pre- and post-MRGO salinity for the period 1951 to 1963 and 1963 to 1977.

Table 1-4: Pre- and Post-MRGO Salinity (ppt)

	Pass Manchac		North Shore		Little Woods		Chef Pass		Alluvia City	
Month	**Pre-**	**Post-**	**Pre-**	**Post-**	**Pre-**	**Post-**	**Pre-**	**Post-**	**Pre-**	**Post-**
January	1.1	1.5	3.0	4.0	3.9	5.0	3.8	5.7	6.8	9.8
February	1.0	1.5	2.5	3.0	3.0	6.5	.9	4.8	6.4	9.7
March	1.0	1.2	1.9	2.6	2.3	4.4	2.2	4.3	6.3	10.4
April	0.8	1.3	1.9	2.6	2.4	4.0	2.2	4.0	7.0	10.0
May	1.0	1.1	2.4	2.7	2.2	3.9	2.6	4.0	9.5	10.2
June	1.0	1.5	3.6	3.0	2.2	3.8	3.3	4.2	9.0	12.3
July	1.0	1.6	3.0	4.6	2.1	4.4	3.2	6.3	7.9	16.0
August	1.2	1.7	4.6	5.6	2.5	4.8	4.8	7.5	8.6	16.1
September	1.7	2.0	5.4	7.5	4.5	6.2	6.0	8.5	8.2	12.9
October	1.8	2.2	4.7	7.3	4.9	6.8	5.2	8.4	7.6	13.8
November	1.8	2.1	4.6	6.7	4.8	6.8	5.2	8.0	8.0	13.1
December	1.2	1.8	4.5	5.4	4.7	6.2	4.2	7.0	8.0	12.5

Monthly summaries of salinity for pre- and post-MRGO construction indicate that salinity has increased on the average (**figure 1-6**) by the following:

- 0.4 ppt Pass Manchac near Ponchatoula
- 1.1 ppt North Shore, Lake Pontchartrain
- 1.9 ppt Little Woods, Lake Pontchartrain
- 2.3 ppt Chef Menteur Pass near Lake Borgne
- 4.5 ppt Shell Beach near Bayou La Loutre

1.4.2 Land Loss

Land loss is a concern not only because of ecosystem degradation, but also because of its role in increasing susceptibility of coastal communities to storm surge. Relative sea level rise, tropical storms, shoreline erosion, modification of natural hydrology, and other factors contribute to land loss in the study area. It is difficult to single out a specific cause for land loss, which is believed to result from complex interactions between natural and human activities on the landscape.

The construction, operation and maintenance of the MRGO caused the loss of approximately 24,610 acres and indirectly to an additional loss of 33,920 acres. Approximately 63,178 acres of land is estimated to have been lost in the study area from 1985 through 2010 (Wetland Value Assessment, **appendix M**). Approximately 131,091 acres are projected to be lost between 2010 and 2065 (**appendix M**) within the study area.

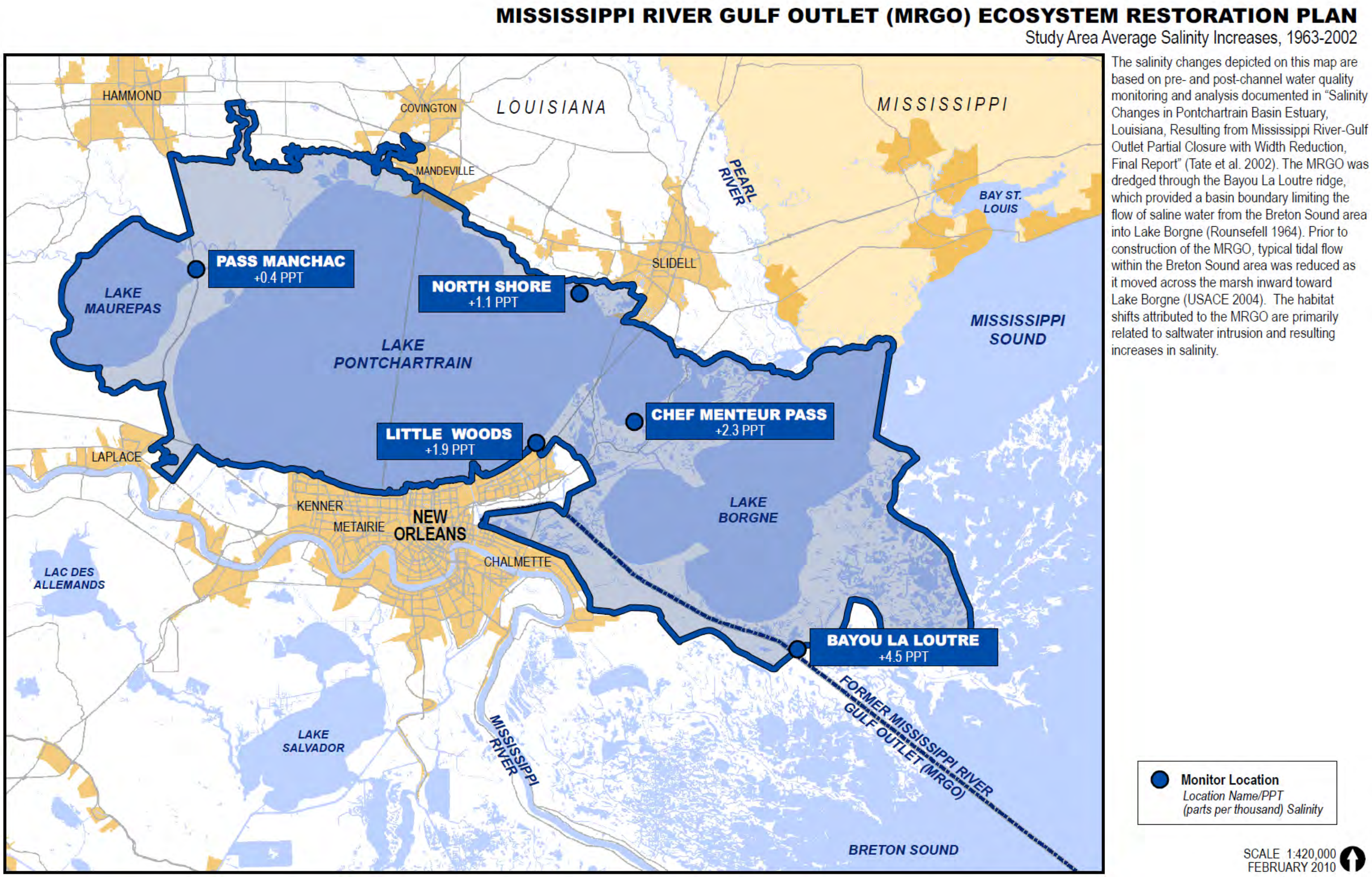


Figure 1-6: Salinity Impacts of the MRGO

Table 1-5 represents the acres lost or gained over the life of the project based on land loss rates per planning subunit. The highlighted subunits (7, 13, 17, 18, 21, 23, 32, 36 and 40) are the ones chosen in which to implement measures. Note that subunits 15, 20, 48, and 49 are gaining acreage in the future without project (FWOP).

Table 1-5: Land Loss Rates

Planning Subunit	FWOP Total Acres Lost/Gained by Year 2065	FWP Total Acres Lost/Gained by Year 2065
1	-9,926	-9,926
2	-37	-37
5	-4,483	-4,483
6	-16,806	-16,806
7	-12,922	391
8	-403	-403
9	-496	-496
10	-2,284	-2,284
11	-8,758	-8,758
12	-5,265	-5,265
13	-4,467	49*
14	-2,984	-2,984
15	277	277
16	-328	-328
17	-5,460	162
18	-6,765	98
19	-348	-348
20	476	476
21	-588	-62
22	-626	-626
23	-12,448	1,512
25	-515	-515
26	0	0
27	-2,989	-2,989
28	-34	-34
29	-542	-542
31	-9	-9
32	-1,576	33
33	-1,471	-1,471
36	-3,750	480
38	-3,888	-3,888
39	-5,667	-5,667
40	-6,439	1,202
47	-522	-522
48	670	670
49	415	415
50	-255	-255

*Subunit 13, Central Wetlands, is separated into swamp and marsh; 49 acres gained was derived by combining the two habitat totals which are marsh = 185 and swamp = -136.

1.4.3 Bank/Shoreline Erosion

Natural causes of erosion include tropical storm events and natural tidal processes. Navigation channels serve as direct routes subjecting inland areas to tidal forces and wave action thereby increasing erosion. The firmer soils of lakes, bays, and natural ridges along waterways are susceptible to wind-induced erosion. When these firmer soils erode away, organic marsh soils are directly exposed to open water wave attack.

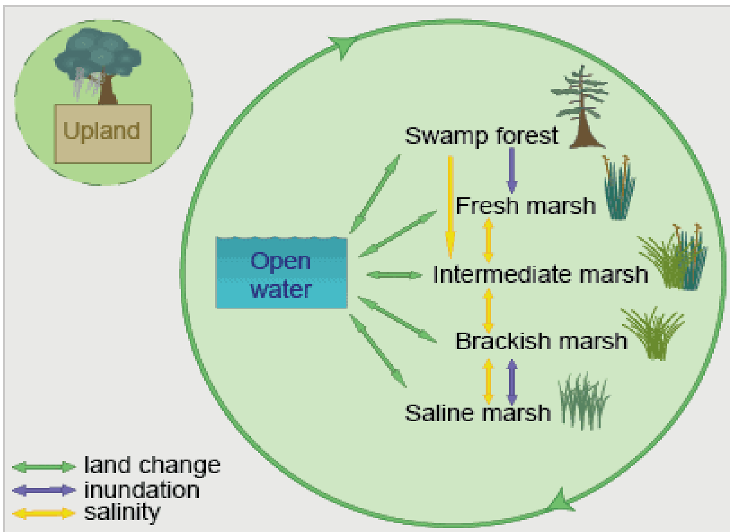
Emergent wetlands located adjacent to the MRGO are impacted by wave action from vessels and wind resulting in erosion rates between 27 and 38 feet per year (USACE, 2004). The Lake Borgne shoreline continues to erode due to wind, waves and tidal surge, at a rate of 7 feet to 15 feet per year (Barras, 2006). Interior wetlands are subsiding at a rate of 0.50 feet per century because of natural deltaic processes. **Figure 1-7** shows the average shoreline retreat rates around Lake Borgne. Shoreline retreat rates average from 9 feet per year at Alligator Point to 7 feet per year at the Golden Triangle to 27 feet per year along the north shoreline of the Biloxi Marsh (UNO, 2001).

Saucier (1963) calculated the Lake Pontchartrain shoreline retreat by 1-mile stretches of shoreline and determined that the southwestern shoreline was retreating at an average rate of 8.8 feet per year compared to 3.6 feet per year on the north shore and 5.6 feet per year on the south shore. Saucier (1963) attributed the shoreline movement to subsidence, the lack of sediment input, increasing fetch, and sea level rise.

Figure 1-7: Average Shoreline Retreat Rates

1.4.4 Habitat Change and Loss

Habitat diversity is important for a healthy ecosystem. Erosion, storm surge inundation, and salinity changes from decreased freshwater inputs or saltwater intrusion has resulted in habitat changes and loss (**figure 1-8**). In some areas, loss of habitats with high friction factors, such as swamp forests, has led to higher storm surge risk. As presented in **table 1-3**, approximately 4,750 acres of shallow water has converted to deep water habitat. The Central Wetlands area once supported a healthy productive swamp habitat. Much of the cypress swamp has deteriorated and converted to brackish marsh due to saltwater intrusion attributed to the MRGO.



(Source: CLEAR)

Figure 1-8: Potential Pathways of Change among Habitats and the Associated Driving Forces

1.4.5 Modification of Natural Hydrology

Mississippi River Levees

Seasonal flooding that provided sediments and nutrients critical to the healthy wetland productivity has been eliminated by the addition of an extensive levee system on top of the natural levee system. The levee system extends for approximately 310 miles from the Old River Control Structure to Venice, Louisiana. Sediment carried by the Mississippi River is now discharged off the coast, depriving wetlands of this vital resource. Hydrologic alterations resulting from levees, canals, and other physical alterations are the predominant stressors on the ecosystem.

Levee building along the Mississippi River at New Orleans began around 1727 and extended to Baton Rouge by 1812. Levees increased the height of the flood crest on the Mississippi River, which resulted in floodwaters discharging through breaches or crevasses. The crevasse events were sporadic, allowing Mississippi River water to enter Lake Pontchartrain on the average once every four years between 1849 and 1892 (Sikora, 1985). In 1931, the Bonnet Carré Spillway was completed, enabling the USACE to control the Mississippi River discharge and protect the City of New Orleans from flooding.

Because of the levee system, sediment no longer nourishes coastal barrier shorelines, which are starved for sediment and eroding. To exacerbate the situation, there is a measurable decline in the sediment load from the rest of the drainage basin delivered by the Mississippi River in the last 50 years (Coast, 2050).

Canals

The oil industry created a vast network of canals, pipelines, and production facilities stretching from the Gulf of Mexico inland to freshwater habitats, resulting in saltwater intrusion, particularly during droughts and storm events. A majority of the canal dredging occurred between 1950 and 1980. The excavated material from dredging canals was side-cast on adjacent marsh, resulting in altered water flow across wetland habitats. Hydrologic alterations affect important hydro-geomorphic, biogeochemical, and ecological processes, including chemical transformations, sediment transport, vegetation health, and organism migration. Dredge material piled along the banks increased the period of marsh inundation causing water logging and plant mortality. More importantly, dredge material piled along the banks blocks movement of resuspended sediments from storm events, which play a major role in sustaining marsh height (Reed et al., 1997). Canal dredging not only switched land to water, but also indirectly changed the processes essential to a healthy marsh.

1.4.6 Lake Borgne Ecosystem

The majority of the MRGO is located within the Lake Borgne ecosystem. As previously indicated, the MRGO altered natural hydrology and contributed to saltwater intrusion, which in turn caused habitat change and loss. Other factors contributing to ecosystem degradation include levees and canals, sea level rise, and subsidence.

Historically, seasonal flooding of the Mississippi River created natural levees, which influenced the direction of the river and provided sediments and nutrients to wetlands behind the levees. As the natural levees increased in height and size, the location and course of distributaries, river meanders, and river channels changed over a geologic scale of time. Construction of flood protection levees on top of existing natural levees within the watershed of the Mississippi River permanently disrupted this natural process.

Navigation channels and canals dredged for oil and gas exploration and extraction have altered the hydrology of the coastal area. North-south channels and canals have brought saltwater into fresh marshes where the salinity and sulfides killed the vegetation. Saltwater intrusion, caused by channel deepening, endangers the potable water supply of much of the New Orleans metro-area. Canals result in increases in tidal processes that increase erosion of marsh habitat. East-west canals impede sheet-flow, pond water on the marsh, stress the marsh, and result in wetland loss.

1.4.7 Retreating and Eroding Barrier Islands

Barrier islands act as a buffer to reduce the effects of ocean waves and currents on associated estuaries and wetlands. Louisiana barrier islands are the remains of an abandoned Mississippi River Delta; and their degradation is the result of natural deltaic processes. The formation of Cat Island in Mississippi was also influenced by this abandoned delta, and is distinct from other Mississippi barrier islands (Schmid, 2001). Louisiana's barrier islands are eroding at a rate of up to 65 feet per year and, according to recent USGS estimates, several will disappear by the end of the century (LACPR, 2008). **Figure 1-9** depicts an aerial view of Breton Island that was taken in 2009. Although Cat Island has lost 39 percent of the land area it had in 1848, it is the most stable of the Mississippi barrier islands.

Figure 1-9: Aerial View of Breton Island (2009)

1.4.8 Ridge Habitat Degradation and Destruction

Natural levees are ridges formed from sediments delivered over the banks of rivers and bayous during floods. These ridges assist in defining a watershed and in maintaining its natural hydrology. Ridges sustain upland shrubs and trees, providing unique habitat for certain plant and animal species. Intact ridges reduce intrusion of saltwater into fresher marsh areas. Natural factors, such as subsidence, have contributed to the destruction of the ridges. The construction of the MRGO directly affected the Bayou La Loutre Ridge by cutting the channel through the ridge. This resulted in a direct link between the Gulf of Mexico and the interior estuaries. Construction of the MRGO channel directly impacted 24,610 acres and indirectly impacted 33,920 acres, as well as contributing to the salinity patterns in Lake Pontchartrain and Lake Borgne.

1.4.9 Invasive Species

The aggressive spread of invasive species decreases native plant communities, rapidly altering ecosystem function. Disturbed ecosystems are more vulnerable to invasive species than stable ecosystems; therefore, invasive species are a severe threat to biodiversity and ecological function in the study area. The MRGO dredge material banks are largely comprised of the invasive Chinese tallowtree (*Triadica sebifera*, formerly *Sapium sebiferum*), an invasive species found in the study area that provides less value to the foraging of migrating avian species.

1.4.10 Herbivory

During the 1930s, nutria (*Myocastor coypus*) were released into the coastal wetlands. The population has rapidly expanded and their grazing and foraging for plant roots has been a major contributor to wetland losses (LACPR, 2008). Additionally, native muskrat eat-outs may also result in significant local impacts to area marshes. Although eat-outs may recover under some conditions, tropical storm impacts on an eat-out area may overnight convert such an area to permanent open water conditions (USGS, 2000).

1.4.11 Increasing Susceptibility to Storm Surge

The water control structures (levees, floodgates, etc.) that protect the developed coastal areas also contribute to subsidence and wetland loss. Continued land loss and ecosystem degradation cause developed areas to become more susceptible to storm surge, thus threatening communities and valuable infrastructure.

1.5 RESTORATION GOALS

Restoring natural processes, such as reconnecting the floodplain with the Mississippi River system's hydrologic cycles, is the key to restoring the ecosystem damaged by the construction and operation of the MRGO. Restoring some degree of these natural processes holds the best promise for significant improvements to the deltaic processes in the lower Mississippi River system. Priority was given to restoration measures that contribute to restoring natural processes.

The objectives for the MRGO Ecosystem Restoration Plan follow:

1. Restore historic salinity conditions in the study area to re-establish and maintain historic habitat types; optimize ecosystem services; and decrease stress to vegetation as measured by the monthly salinity targets in the Biloxi Marsh (as identified by Chatry et al. 1983) each month of the year, for at least four years out of every ten year period.
2. Restore native habitat acreages impacted by the MRGO and their ecosystem functions.
    a. Increase the year round spatial coverage of cypress swamp habitat in the Central Wetlands by at least 9,500 acres by 2065.
    b. Increase the year round special coverage of fresh/intermediate marsh in the Central Wetlands, Golden Triangle, MRGO, and South Lake Borgne by at least 6,800 acres by 2065.

   c. Increase the year round spatial coverage of brackish marsh in Bayou Terre aux Bouefs, the Biloxi Marsh, and the East Orleans Landbridge by approximately 18,100 acres by 2065.
   d. Increase the year round spatial coverage of vegetated wetlands in areas adjacent to the channel lost to increased tides and salinity by at least 3,900 acres by 2065.
   e. Increase the year round spatial coverage of ridge habitat along Bayou La Loutre by 2065.
3. Increase the year round spatial coverage of critical landscape features that provide hurricane and storm damage risk reduction in the study area (i.e. areas located in the Biloxi Marshes, the East Orleans Landbridge, and forested habitats).
4. Increase awareness and understanding of the significance of resources in the study area through increased recreational and educational opportunities.

1.6 STUDY OBJECTIVES

Study objectives were developed as specific targets to guide the development of measures and gauge the extent the plans meet the overarching study goals. Metrics were used to measure how the alternative plans meet the specific targets. Study objectives include targets for salinity, habitat diversity, and landscape features critical to storm surge risk reduction. Salinity targets were based on ecosystem health and oyster production. Habitat targets were based on direct and indirect habitat impacts of the MRGO navigation channel as described in **section 1.3.1**. Critical landscape targets for storm surge risk reduction were based on features identified in the LACPR Final Technical Report (LACPR, 2008). **Table 1-6** identifies the study goals and objectives, the portion of the study authority related to those objectives, problems and opportunities associated with the objectives, the management measure types identified to address specific objectives, and metrics for evaluation of alternatives.

Objective 1 – Salinity Targets
The first objective is to restore historic salinity conditions in the study area to re-establish and maintain historic habitat type; optimize ecosystem services; and decrease stress to vegetation as measured by the monthly salinity targets in the Biloxi Marsh (as identified by Chatry et al. 1983) each month of the year, for at least four years out of every ten year period, as depicted on **figure 1-10**. On April 20, 2009, the Salinity Working Group for the MRGO Ecosystem Restoration Plan confirmed the validity of the salinity targets presented in the Mississippi and Louisiana Estuarine Areas Freshwater Diversion from Lake Pontchartrain Basin to Mississippi Sound Feasibility Study (also referred to as the Bonnet Carré study) for ecosystem restoration purposes (USACE, 1984). The salinity targets are based on mean monthly averages and are graphically presented in **figure 1-11** and **table 1-7**.

Figure 1-10: Salinity Line (Chatry Line) Depicted Across Biloxi Marsh

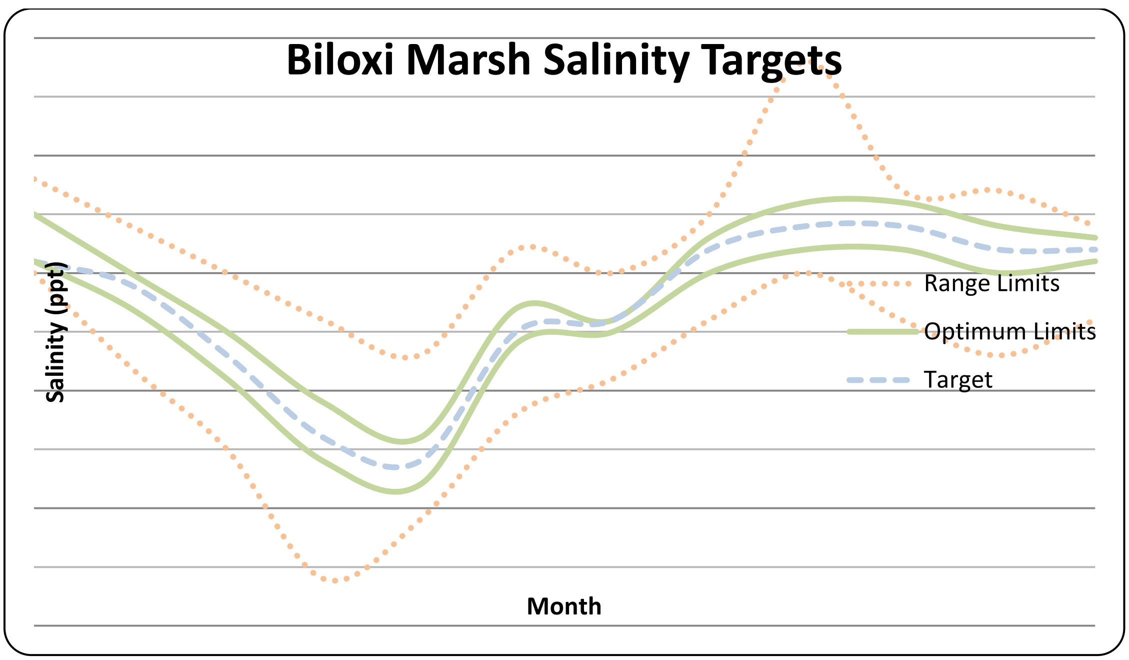


Figure 1-11: Salinity Target

Table 1-6: Goals, Objectives, Metrics and Measures

WRDA 2007 Authority	Goal(s)	Objective	Problem	Opportunity	Metric
- Sec. 7013 a(3)B(i) - Sec. 7013 a(3)B(ii) - Sec. 7013 a(3)B(iii) - Sec. 7013 a(3)B(iv) - Sec. 7013 a(3)B(v)(II) - Sec. 3083 (a) and (b) to be studied under Sec. 7013 as per WRDA 2007 implementation guidance	1. Achieve ecosystem sustainability to the greatest degree possible. 2. Restore habitat in the Lake Borgne ecosystem and the areas affected by the MRGO navigation channel.	1. Restore historic salinity conditions in the study area to re-establish and maintain historic habitat types; optimize ecosystem services; and decrease stress to vegetation as measured by the monthly salinity targets in the Biloxi Marsh as identified by Chatry et al. 1983 each month of the year, for at least four years out of every ten year period.	- Land loss - Habitat change and loss - Modification of natural hydrology - Decreased freshwater, sediment, and nutrient inputs - Saltwater intrusion	Freshwater Diversion, Hydrologic Modification	Percentage of years target can be met over the period of analysis.
- Sec. 7013 a(3)B(i) - Sec. 7013 a(3)B(ii) - Sec. 7013 a(3)B(iv) - Sec. 7013 a(3)B(v)(I)	1. Achieve ecosystem sustainability to the greatest degree possible. 2. Restore habitat in the Lake Borgne ecosystem and the areas affected by the MRGO navigation channel. 3. Restore natural features of the ecosystem that will reduce or prevent damage from storm surge.	2. Restore native habitat acreages impacted by the MRGO a. Increase the year round spatial coverage of cypress swamp habitat in the Central Wetlands by at least 9,500 acres by 2065. b. Increase the year round spatial coverage of fresh/intermediate marsh in the Central Wetlands, Golden Triangle, MRGO, and South Lake Borgne by at least 6,800 acres by 2065. c. Increase the year round spatial coverage of brackish marsh in Bayou Terre aux Boeufs, the Biloxi Marsh, and the East Orleans Landbridge by approximately 18,100 acres by 2065. d. Increase the year round spatial coverage of vegetated wetlands in areas adjacent to the channel lost to increased tides and salinity by at least 3,900 acres by 2065.	- Land loss - Habitat change and loss - Invasive species - Increasing susceptibility of coastal communities to storm surge	Swamp Restoration and Nourishment Marsh Restoration and Nourishment, Shoreline Protection, Freshwater Diversion, Ridge Restoration, SAV Restoration, Oyster Reef Restoration, Buy-outs, Vegetative Plantings, Invasive Species control, Herbivory control, Barrier Island Restoration.	1. Number of Acres restored or nourished 2. Number of Net Acres at the end of the period of analysis

Table 1-6: Goals, Objectives, Metrics and Measures

WRDA 2007 Authority	Goal(s)	Objective	Problem	Opportunity	Metric
		e. Increase the year round spatial coverage of ridge habitat along Bayou La Loutre by 2065.			
- Sec. 7013 a(3)B(i) - Sec. 7013 a(3)B(ii) - Sec. 7013 a(3)B(iv) - Sec. 7013 a(3)B(v)(I)	3. Restore natural features of the ecosystem that will reduce or prevent damage from storm surge.	3. Increase the year round spatial coverage of critical landscape features that provide hurricane and storm damage risk reduction in the study area (i.e. areas located in the Biloxi Marshes, the East Orleans Landbridge, and forested habitats).		Marsh Restoration and Nourishment, Shoreline Protection, Ridge Restoration, Freshwater Diversion, Oyster Reef Restoration, Vegetative Plantings, Invasive Species control, Herbivory control,	In critical landscape areas and forested habitat: 1. Number of AAHUs in critical areas 2. Number of Critical Acres restored or nourished 3. Number of Net Critical Acres at the end of the period of analysis
- Sec. 7013 a(3)B(i)	2. Restore habitat in the Lake Borgne ecosystem and the areas affected by the MRGO navigation channel.	4. Increase awareness and understanding of the significance of resources in the study area through increased recreational and educational opportunities.	- Land loss - Habitat change and loss - Modification of natural hydrology - Increasing susceptibility of coastal communities to storm surge	Recreation and education enhancements to ecosystem restoration features.	1. Number of restoration features including recreation components.

Table 1-7: Monthly Salinity Targets

Month	Chatry Target	Chatry Optimum Limits		Chatry Range Limits	
		Low	**High**	**Lowest**	**Highest**
January	16.4	15.5	17.5	15.0	19.0
February	14.4	13.5	15.0	11.0	17.0
March	11.6	10.5	12.5	7.5	15.0
April	8.0	7.0	9.5	2.0	13.0
May	7.0	6.0	8.0	4.5	11.5
June	12.5	12.0	13.5	9.0	16.0
July	12.7	12.5	13.0	10.5	15.0
August	15.7	15.0	16.5	13.0	17.5
September	17.0	16.0	18.0	15.0	24.0
October	16.8	16.0	18.0	13.0	18.5
November	16.1	15.0	17.0	11.5	18.5
December	15.7	15.5	16.5	13.0	17.0

NOTE: Salinity targets were estimated to the nearest 0.5 ppt using the graphical display in Chatry et at. (1983)

The salinity targets were originally developed and adopted by an ad hoc group consisting of representatives from USACE, Louisiana Department of Wildlife and Fisheries (LDWF), U.S. Department of Commerce – National Oceanic and Atmospheric Administration - National Marine Fisheries Service (NMFS), St. Bernard Parish, LDNR and the Mississippi Department of Marine Resources (MDMR) for the 1984 report to enhance fish and wildlife resources in the Pontchartrain basin and re-establish a desirable salinity regime in the historic oyster reefs on the seaward fringe of the Biloxi Marsh (USACE, 1984). The ad hoc group determined that salinity should mimic historical conditions when the Mississippi River over-topped its banks in the early part of the year. The targets were developed using ten years of data (1971-1981) from Louisiana's most productive oyster seed grounds. Oysters are an important commercial species but are also considered the best indicator species to determine the optimum salinity range for the overall commercial fishery in Louisiana (LPBF, 2006b). Oysters also directly contribute to the larger ecosystem by filtering water and providing reef surface for other organisms to grow.

The Salinity Working Group for the MRGO study noted that a target line and frequency need to be established in order to design a freshwater diversion, but that adaptive management should also be a component of freshwater reintroduction plans. Therefore, the metric for achieving this study objective is whether salinity falls within the optimal range each month, at least forty percent of the time, as described in Chatry et al., 1983. The Chatry targets are a way to measure the restoration of historic salinity regimes.

Objective 2 – Habitat Targets

The target acres for each habitat type were developed using the direct and indirect habitat impacts from the construction and operation of the MRGO between 1956 and 2008. The number of acres, presented in these objectives are considered the minimum restoration target to address the study authority **(table 1-8).**

Table 1-8: Habitat Targets (in area)

Habitat Type	Direct Loss	Indirect Loss	Indirect Gain	Net	Target
Fresh / Intermediate marsh	-3,400	-3,400		-6,800	6,800
Brackish marsh	-10,300	-19,200	11,400	-18,100	18,100
Saline marsh	-4,200		19,200	+15,000	0
Cypress swamp	-1,500	-8,000		-9,500	9,500
Shallows	-4,800		4,800*	0+*	0
Additional marsh**	-500	-3,400		-3,900	3,900
Total	**-24,700**	**-34,000**		**-23,300**	**38,300**

* Shallow water increases are difficult to quantify. Increases of this habitat type offset losses, and net gain is likely due to marsh loss.
**Additional marsh includes areas adjacent to the channel lost due to increased salinity and tides.

Although the impacts of the MRGO on the habitat of the Bayou La Loutre Ridge are not quantified, the channel made a 500-foot cut through the ridge, destroying ridge habitat and a natural salinity barrier. To address the MRGO construction impacts to this habitat, the study will evaluate measures to improve and increase ridge habitat.

The MRGO was dredged at an existing tidal inlet between Grand Gossier and Breton Islands, and may have interrupted sediment transport to Breton Island. To address this potential effect of the construction of the MRGO channel, the study evaluated measures to improve and increase barrier island habitat.

Objective 3 – Critical Landscape Features for Storm Damage Risk Reduction

Features that have been identified as critical landscape features for providing hurricane and storm damage risk reduction in the study area include:

- Areas located in the Biloxi Marshes, the East Orleans Landbridge and the Lake Maurepas Landbridge.
- Forested habitats within the Lake Borgne ecosystem.

All of these geographic locations were affected by increased salinity attributable to the MRGO, although it is noted in the planning assumptions for this study that the restoration of the Lake Maurepas area would be achieved through authorized LCA and CWPPRA projects. Portions of the channel were excavated through the Biloxi Marsh, and habitats in this area were affected by erosion along the channel and increased salinity due to saltwater intrusion from the channel. The effects of the MRGO channel on the East Orleans Landbridge are related to saltwater intrusion. Tate et al. 2002 notes that pre- and post-channel water quality monitoring and analysis indicate that salinity in the vicinity of Chef Menteur Pass increased by 2.3 ppt. Therefore, restoration in these areas is connected to portions of the study authority related to the restoration of habitats affected by the MRGO and areas that will reduce or prevent damage from storm surge.

The connection between these features and storm surge is based on the geographic structure of the estuary. The Biloxi Marsh separates Lake Borgne from the Chandeleur Sound and the Gulf of Mexico. If the Biloxi Marsh did not exist, Lake Borgne would merge with Chandeleur Sound, and the "speed bump" the marsh creates for storm surge would be removed. Similarly, if the East Orleans Landbridge disappeared, Lakes Pontchartrain and Borgne would merge to form one large lake and there would be no natural barrier to storm surge between these two bodies of water. The affect would be compounded if both landscape features were to disappear.

These landscape features are technically recognized as significant in terms of scarcity and connectivity. The continuing disappearance of wetland barriers in the study area is well documented (Morgan and Larrimore 1957, Penland and Boyd 1981, Day and Templet 1989, Kesel, 1989, Gagliano 1998, USACE 2004, LPBF, 2006a, Lopez 2006, USGS 2007). Burkett et al. 2002 describes the importance of these areas and forested habitat as a barrier contributing to the reduction of flooding levels in the Greater New Orleans area. Restoration of the Biloxi Marsh and the East Orleans Landbridge is identified as measures that can "potentially reduce the loss of life and property due to flooding" (Burkett et al. 2002).

A sensitivity analysis was performed for the LACPR Technical Report to assess the impact of barrier island and marsh features on storm surge and wave energy. Hydrodynamic modeling evaluated future scenarios for degraded and restored coastal conditions. The model was adjusted to account for changes to bathymetry and frictional resistance associated with the presence or absence of various landscape features.

The findings of the LACPR analysis indicate that the effect of coastal features on storm surge and wave energy depends on a variety of factors, including the physical characteristics of the storm, coastal geomorphic setting, and the track of a storm when it makes landfall. The complex, dynamic nature of the interaction of various factors precludes the application of constant attenuation rates, i.e., X acres of marsh will produce Y feet of surge reduction.

While the models show benefits from additional marsh, island, and landbridge habitat in some areas, the effects of allowing existing features to degrade in these areas are even more pronounced (LACPR, 2009). Therefore, the MRGO Ecosystem Restoration Plan will address the storm damage risk reduction objective by evaluating alternatives to sustain the integrity of the study area, particularly areas identified as critical landscape features. The Maurepas Landbridge, the Pontchartrain Landbridge (East Orleans Landbridge), and the Biloxi Marshes were identified in the LACPR Technical Report as critical landscape features having significant effects on surge, based on model results. Forested habitats were also considered to have different frictional coefficients in the LACPR hydrodynamic modeling, and therefore provide some benefit with regard to hurricane storm damage risk reduction.

Objective 4 – Increase Awareness and Understanding of the Significance of Resources in the Study Area Through Increased Recreational and Educational Opportunities
The landscape and habitat impacts of the construction and operation of the MRGO since 1956 have changed recreational opportunities in the study area. This objective was developed to increase opportunities for citizens to enjoy and understand the significance of the resources this study seeks to restore. Involving the public in the restoration activities and increasing awareness of the problems and opportunities in the study area could contribute to the acceptability and overall success of the plan. Providing the public with increased opportunities to interact with the ecosystem and learn about environmental principles, processes and native habitat in general could create a sense of public ownership in the restoration plan. Citizens that are more aware of the impacts of human activities to the natural environment would be more likely to support actions that restore, protect, and sustain these significant resources.

1.7 HABITAT EVALUATION TEAM

A Habitat Evaluation Team (HET) was established to assist in the plan formulation and evaluation process, as well as provide input and data for preparation of the DEIS. Membership on the HET includes participants from Louisiana, Mississippi and Federal agencies, as well as USACE members from the New Orleans and Mobile Districts, and the Engineer Research and Development Center (ERDC) as listed below:

- USACE, New Orleans District
- USACE, Mobile District
- USACE, Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS
- U.S. Fish and Wildlife Service, Louisiana
- U.S. Fish and Wildlife Service, Mississippi
- U.S. Environmental Protection Agency
- National Marine Fisheries Service, Louisiana
- National Marine Fisheries Service, Mississippi
- Natural Resources Conservation Service
- United States Geological Survey
- Bureau of Ocean Energy Management, Regulation and Enforcement
- Louisiana Department of Wildlife and Fisheries
- Office of Coastal Protection and Restoration, Louisiana
- Louisiana Department of Natural Resources
- Louisiana Department of Environmental Quality
- Mississippi Department of Marine Resources
- Mississippi Department of Environmental Quality

Additional members that participated in the Salinity Working Group include:

- Louisiana State University, Louisiana
- University of New Orleans, Louisiana

- University of Southern Mississippi, Mississippi

1.7.1 Tasks

The HET actively participated throughout the study process, providing input in the formulation of coastal restoration measures and alternatives, identifying screening criteria for evaluating the restoration plan, and quantifying the environmental impacts and benefits of those plans.

1.7.2 Guiding Principles

The team adopted several of the guiding principles established the draft LACPR Technical Report, Coastal Restoration Appendix that were applicable to this study area. The overarching principle adopted is that sustaining the integrity of the estuarine environments in coastal Louisiana, including various landscape features that make up those environments, is critical to the ecological health and social and economic welfare of the region. Model analysis conducted for the LACPR of storm surge levels and wave magnitudes demonstrate the value of coastal features to lowering storm surge risks (USACE, 2009). While the models show benefits from additional marsh, barrier island, and landbridge habitat, the effects of allowing existing features to degrade are even more pronounced.

Guiding principles include:

- Relatively intact estuarine ecosystems are a key attribute in coastal Louisiana, and alternatives should seek to enhance the resilience and self-sustainability of the estuarine environments, including protection of existing high-quality estuaries.
- Restoration of key processes and dynamics are critical to the long-term health of the ecosystem.
- Riverine diversions must be carefully sited to maximize sediment retention within the coastal ecosystem and avoid sediment loss to the Gulf of Mexico because of reduced Mississippi River sediment loads. Therefore, measures and alternatives must seek to maximize the combined benefits of diversions that seek to restore natural processes with mechanical marsh creation measures.
- Additional sources of sediments should be sought where feasible, recognizing that such measures should not contribute to ecosystem degradation in the source area.
- Measures should be combined synergistically to maximize possible cumulative benefits. Thus, the position of features within the landscape has a direct influence on the potential benefits derived.
- Capacity to assess and quantify benefits and impacts from various measure combinations may be limited due to the state-of-the-science, uncertainty with future development, relative sea level rise, and other factors. Flexibility is required in project design and implementation to permit adaptive management as conditions change and more is learned.
- A concerted monitoring and adaptive management program should be a component of the restoration plan.

1.7.3 Approach

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

1.8 NATIONAL ENVIRONMENTAL POLICY ACT

The NEPA of 1969 (Public Law 91-190) requires all Federal agencies to address environmental consequences of major Federal actions on the natural and human environment. Compliance guidance for NEPA is contained in Title 40 of the Code of Federal Regulations (CFR), Parts 1500 through 1508, and in the USACE regulations 33 CFR 230 and 325, *Environmental Quality and Procedures for Implementing NEPA*. The primary intent of NEPA is to ensure that environmental information is made available to public officials and citizens regarding major actions taken by Federal agencies, and to identify and consider concerns and issues from the public.

This FEIS analyzes and documents the potential beneficial and adverse environmental impacts of implementing the tentatively selected plan. As established by the Council on Environmental Quality (CEQ). This report incorporates by reference other environmental documents covering coastal restoration in Louisiana.

This FEIS is tiering off the LCA, FPEIS and ROD signed January 31, 2005.

This FEIS adopts, in their entirety or identified portions thereof, previous NEPA documents. All NEPA documents related to the project and study area are listed in **section 1.8.1**. Vital documents and/or portions being adopted include:

- Coast 2050: Toward a Sustainable Coastal Louisiana
- LCA Ecosystem Restoration Study
- MRGO Deep-Draft De-Authorization Project.

1.8.1 Environmental Assessments and Environmental Impact Statements

Many Environmental Assessments (EA) and EISs have been prepared to evaluate potential impacts of project-specific proposed actions within the study area.

- EIS, entitled "Lake Pontchartrain, LA and Vicinity Hurricane Protection Project Riprap shore protection with openings at Bayous Bienvenue and Dupre," 1973 and 1974.

- EIS, entitled "Lake Borgne Vicinity MRGO Bayous La Loutre, St. Malo, and Dupre", ROD signed March 1976.
- EA #15, entitled "Transfer of Land Along Mississippi River – Gulf Outlet Jourdan Road Terminal to Inner Harbor Navigation Channel," with a Finding of No Significant Impact (FONSI) signed on December 15, 1980.
- EA #38, entitled "MRGO, Foreshore Protection Test Section," with a FONSI signed on August 15, 1983.
- EA #47, entitled "MRGO Foreshore Protection," with a FONSI signed on January 23, 1985.
- EA #54, entitled "South Bank Mississippi River – Gulf Outlet – Borrow Site," with a FONSI signed on April 1, 1986.
- EA #72, entitled "MRGO Breton Sound Jetty Repairs," with a FONSI signed on May 26, 1988.
- EIS, entitled "Mississippi River – Gulf Outlet Ocean Dredged Material Final EIS," ROD signed May 1989.
- EA #143, entitled "Mississippi River – Gulf Outlet – New Canal, Remedial Dredging," with a FONSI signed on September 11, 1991.
- EA #152, entitled "MRGO St. Bernard Parish, LA, Bank Stabilization, Miles 50.5 to 55.0," with a FONSI signed on November 21, 1991.
- EA #154, entitled "Mississippi River – Gulf Outlet – Major Rehabilitation of the South Jetty in Breton Sound," with a FONSI signed on December 23, 1991. NOTE: no EA available, this is date of Memorandum to discontinue work.
- EA #162, entitled "Mississippi River – Gulf Outlet, St. Bernard and Plaquemines Parishes, LA – Marsh Enhancement/Creation and Berm Construction," with a subsequent FONSI signed on July 10, 1992.
- EA #244, entitled "MRGO Back Dike (CWPPRA), Disposal Area Marsh Protection, Back Dike," with a FONSI signed on July 30, 1996.
- EA #247, entitled "MRGO St. Bernard Parish, LA, Bank Stabilization Miles 55.0 to 56.1," with a FONSI signed on September 24, 1996.
- EA #255, entitled "MRGO, LA, Wetland Creation, Miles 15.0 to 23.0, St. Bernard and Plaquemines Parish, LA," with a FONSI signed on February 12, 1997.
- EA #269, entitled "MRGO, LA, South of Lake Borgne Additional Disposal Areas, St. Bernard Parish, LA," with a FONSI signed on March 24, 1998.
- EA #269-B, entitled "MRGO, South of Lake Borgne Additional Disposal Areas plus Deflection Dike and Floatation Channels, St. Bernard Parish, LA," with a FONSI signed on June, 2000.
- EA #269-C, entitled "MRGO, LA, Construction of Flotation Channels Miles 51.0 to 48.0, St. Bernard Parish, LA," with a FONSI signed on October 2, 2001.
- EA #274, entitled "MRGO, Additional Disposal Areas, Hopedale Marshes," with a FONSI signed on July 10, 1998.
- EA #277, entitled "MRGO, LA, Shell Beach Disposal Areas, St. Bernard Parish, LA," with a FONSI signed on September 6, 2001.
- EA #277-A, entitled "MRGO, LA, Construction of Flotation Channels Miles 49.0 to 38.0, St. Bernard Parish, LA," with a FONSI signed on October 2, 2001.

- EA #288, entitled "MRGO Mile 43 to Mile 41 North Bank Stabilization, St. Bernard Parish, LA," with a FONSI signed on November 8, 1999.
- EA #349, entitled "MRGO, Miles 32-27, Additional Disposal Areas – Hopedale Marshes, St. Bernard Parish, LA," with a FONSI signed on August 15, 2002.
- EA #354, entitled "MRGO, Additional Disposal Area Designation Miles 66.0 to 49.0, St. Bernard Parish, LA," with a FONSI signed February 9, 2004.
- EA #355, entitled "MRGO Mile 27.0 to 0," with a FONSI signed on June 30, 2003.
- EA #361, entitled "MRGO, LA, Test Installation of Articulated Concrete Mattressing, Miles 39.0 to38.0," with a FONSI signed on January 29, 2003.
- EA #402, entitled "Lake Borgne – MRGO, Shoreline Protection Project, St. Bernard Parish, LA," FONSI signed on December 16, 2004.
- EA #403, entitled "MRGO, Hopper Dredging Miles 27.0 To 66.0," FONSI signed on March 22, 2004.
- EA #411, entitled "MRGO, Installation of Articulated Concrete Mattressing, Miles 37.4 to 36.5, St. Bernard Parish, Louisiana," FONSI signed on October 19, 2004.
- PEIS #03-01, entitled "Programmatic Environmental Impact Statement for the Louisiana Coastal Area (LCA), Louisiana – Ecosystem Restoration Study," ROD signed January 31, 2006.
- EA #468, entitled "Mississippi River – Gulf Outlet Reuse of MRGO Jetty Rock St. Bernard Parish, Louisiana," FONSI signed on July 21, 2008.
- LEIS #07-04, entitled "Integrated Final Report to Congress and Legislative Environmental Impact Statement for the Mississippi River – Gulf Outlet Deep-Draft De-authorization Study," ROD signed June 5, 2008.
- FEIS #06-12, entitled "Environmental Impact Statement (EIS) for the Mississippi River-Gulf Outlet (MRGO), Louisiana, and Lake Borgne – Wetland Creation and Shoreline Protection Project," transmitted to EPA June 2009. A ROD was signed March 18, 2010.

NEPA documents currently under development within the study area include:

- PDEIS #09-01, entitled "West Shore – Lake Pontchartrain, Louisiana, Hurricane and Storm Damage Risk Reduction," 2009.
- Draft Environmental Assessment Maintenance Dredging and Disposal Of Dredged Material Mississippi and Louisiana Portions of the Gulf Intracoastal Waterway Federally Authorized Navigation Project Hancock, Harrison and Jackson Counties, Mississippi and Coastal Louisiana" 2008.
- PDEIS #07-02, entitled "NOV Hurricane Protection Project: Incorporation of Non-Federal Levees from Oakville to St. Jude, Plaquemines Parish Louisiana," Notice of Intent (NOI) filed February 26, 2007.

1.8.2 NEPA Scoping

Scoping is a critical component of the overall public involvement program to solicit input from affected Federal, state, and local agencies, Indian Tribes, and interested stakeholders. The NEPA scoping process is designed to provide an early and open means of determining the scope of issues (problems, needs, and opportunities) to be identified and addressed in the DEIS. Scoping is the process used to: a) identify the affected public and agency concerns; b) facilitate an efficient EIS preparation process; c) define the issues and alternatives that will be examined in detail in the EIS; and d) save time in the overall process by helping to ensure that relevant issues are adequately addressed. Scoping is a process, not an event or a meeting; it continues throughout the EIS (draft and final) process and may involve meetings, telephone conversations, and/or written comments.

A Notice of Intent (NOI) to prepare a DEIS for the MRGO Ecosystem Restoration Plan Study, Louisiana was published on October 2, 2008, in the *Federal Register* (Vol. 73, No. 192).

A project kick-off meeting was held on October 8, 2008, and two public scoping meetings were organized and hosted in accordance with NEPA on November 3, 2008, and November 6, 2008. Public meeting announcements were published on October 30, 2008, and November 1, 2008, in the Times-Picayune; October 31, 2008, in the St. Bernard Voice; November 1, 2008, in the Baton Rouge Advocate; November 2, 2008, in the Biloxi Gulfport Sun Herald; and November 5, 2008, in the Bay St. Louis Sea Coast Echo. The public notice was mailed to the stakeholder and NEPA mailing lists for the CEMVN and Mobile District on October 17, 2008, (**appendix A**). Scoping meeting notices were also placed on the MRGO website and the St. Bernard Parish website.

The scoping comment period began with the filing of the NOI and continues through release of the DEIS for public comment. Public scoping meetings were held on November 3, 2008, in Chalmette, Louisiana, and November 6, 2008, in Waveland, Mississippi. Greater participation was received in Chalmette, Louisiana, with approximately 79 stakeholders attending. A total of 322 comments were received during the comment period, 257 comments were expressed at the scoping meetings, and 65 written (letter, fax and email) and verbal comments were received during the comment period.

Comments were evaluated for recurring themes to gain an understanding of the key issues to address in the DEIS. Eighteen recurring themes were identified. See **table 1-9** for a full listing of recurring themes and their percentage of occurrence. The highlighted area represents the top 10 recurring themes, which account for 80 percent of the comments. All comments were reviewed by the PDT to determine the significance of each comment, regardless of the recurrence of the comment.

Table 1-9: Scoping Comment Themes by Percentage of Occurrence

Ranking	Theme	Number of Comments	Percent Occurrence
1.	Sediment diversions are needed to help restore marshes/wetlands.	51	13.5%
2.	Restore the ecosystem to pre-disturbance/historical conditions.	43	11.3%
3.	Restoring the first line of hurricane defense for public safety is a priority.	40	10.6%
4.	Focus on restoring flow of water (hydrology).	33	8.7%
5.	Implement/incorporate existing plans.	30	7.9%
6.	Restoration project needs to be started as soon as possible (ASAP)	26	6.9%
7.	Restore barrier islands (Chandeleur).	23	6.1%
8.	Socio-economic impacts need to be considered.	21	5.5%
9.	Address saltwater intrusion, but maintain brackish water in areas (Caernarvon, Bayou Bienvenue).	20	5.3%
10.	Restore ridge areas along levees that are under threat of being destroyed.	17	4.5%
11.	Dredging should be considered as a method to restore natural areas.	15	4.0%
12.	Stabilize and preserve existing land that is under threat of loss or conversion to open water.	13	3.4%
13.	Repair/restore Violet Siphon.	10	2.6%
14.	Structural methods/controls to close MRGO.	10	2.6%
15.	Rebuild levees and walls in the region (Verret to Yscloskey).	9	2.4%
16.	Use resources as efficiently as possible to get the MRGO project completed.	8	2.1%
17.	Use jetty rock for shoreline protection.	7	1.8%
18.	Opportunities for mitigation need to be identified.	3	0.8%
	Total:	***379***	***100%***

NOTE: Green highlighted rows represent the top ten themes. The number of occurrences totals 379 because a given comment can be associated with more than one theme. The percentages are based on dividing the number of occurrences of a given theme by the total number of occurrences and multiplying by 100.

Of the total of 322 comments received, 19 were off topic and not considered a part of this analysis. Two additional types of comments that did not fall into themes are identified, but not included, in the overall theme analysis. There are 16 instances in which the entire comment appears to be relevant, but does not fall easily into the identified themes. Another group of 15 comments addressed the USACE or the meeting process. Analysis of the comments shows these types of comments to be 40 percent positive and 26 percent negative with the remaining 34 percent neutral.

The scoping comments were documented in a Scoping Report and describe the public's concerns about the restoration effort and strategies for restoration efforts. See **appendix A** for the Scoping Report. Public involvement is discussed further in **chapter 5**. Registered scoping meeting participants, as well as those providing written or verbal comments, were advised of the availability of the Scoping Report on the study website at http://www.mrgo.gov.

1.8.3 Cooperating Agencies

Cooperating Agencies (as defined under 40 CFR 1501.6) include: Department of the Interior – U.S. Fish and Wildlife Service (USFWS); NMFS; Department of Agriculture – Natural Resources Conservation Service (NRCS); U.S. Environmental Protection Agency (EPA) and the Bureau of Ocean Energy Management, Regulations and Enforcement. Other participating agencies include the Louisiana Department of Environmental Quality (LDEQ), the LDWF, the LDNR, and the Mississippi Department of Marine Resources (MDMR).

1.8.4 Compliance with Laws and Executive Orders

Coordination and evaluation of required compliance with specific laws, executive orders, and other policies for the various alternatives will be achieved, in part, through the coordination of this document with appropriate agencies and the public. **Table 1-10** summarizes the level of compliance with those statutes, orders, and policies. Disclosures and findings required by these laws and orders are contained in **chapter 6** of this DEIS.

Table 1-10: Compliance with Environmental Laws, Regulations and Executive Orders

Law, Regulation or Policy	Status	Comments	Full Compliance Expected
Clean Air Act of 1970	Coordination complete	An air quality analysis was conducted. The tentatively selected plan would not significantly impact air quality. The study area would remain in attainment. LDEQ correspondence dated January 11, 2011.	Full compliance after review of FEIS by EPA and upon signing of the Record of Decision (ROD) (**appendix P**)
Clean Water Act of 1977	Coordination complete	The final 404(b)(1) evaluation is complete. Water quality certification has been met and the placement of fill material will not violate water quality standards. LDEQ correspondence dated February 02, 2012. National Pollutant Discharge Elimination System (NPDES) non-point source permit will be required and obtained before construction commences.	Consistency determination received from LDEQ and upon signing of the ROD (**appendix E; appendix S**)
National Environmental Policy Act of 1969	Coordination on-going	The DEIS has been coordinated with Federal/State Agencies. The EPA rated the DEIS document as EC-2. The FEIS addresses EPA comments.	Full compliance upon coordination of the FEIS, remaining public involvement activities completed, and upon signing of the ROD
Fish and Wildlife Coordination Act of 1958	Coordination complete	USFWS and U.S. Department of the Interior (DOI) are active team participants and have provided input on fish and wildlife resources in the project area. A final Fish and Wildlife Coordination Act Report (FWCAR) was completed in March 13, 2012. NIMFS issued A Biological Opinion (BO) on May 3, 2012.	Full compliance upon signing of the ROD (**appendix B**)

Table 1-10: Compliance with Environmental Laws, Regulations and Executive Orders

Law, Regulation or Policy	Status	Comments	Full Compliance Expected
Endangered Species Act of 1973	Coordination complete	A final BA has been submitted to NMFS and USFWS as part of the formal and informal consultation with NMFS and USFWS, respectively. USFWS issued a letter of concurrence February 8, 2012 stating project is not likely to adversely affect the West Indian Manatee or piping plover. NMFS and USFWS reviewed the final BA and issued a BO on May 3, 2012.	Full compliance upon signing of the ROD (**appendix G)**
Magnuson-Stevens Fishery Conservation and Management Act of 1976	Coordination complete	An Essential Fish Habitat (EFH) assessment is incorporated in the FEIS in section 4.18 and within the final FWCAR. Letter received from NMFS March 28, 2012	Full compliance upon signing of the ROD (**appendix B; appendix C**)
Coastal Zone Management Act of 1972	Coordination complete	The tentatively selected plan is consistent with the State of Louisiana's Coastal Resources Program per LDNR correspondence dated February 8, 2010.	Full compliance upon signing of the ROD (**appendix F**)
Coastal Barrier Resources Act and Coastal Barrier Improvement Act	Not applicable	There are no designated coastal barrier resources in the study area that would be affected by this project. These acts do not apply.	Not applicable
Marine Mammal Protection Act	Coordination complete	A final BA has been submitted to NMFS and USFWS as part of the formal and informal consultation with NMFS and USFWS, respectively. West Indian manatee are not likely to be adversely affected per USFWS concurrence in letter dated Fubruary 8, 2012. Best Management Practices for the bullnose dolphin would be implemented per consultation with NOAA. NMFS and USFWS reviewed the final BA and issued a BO on May 3, 2012.	Full compliance upon signing of the ROD (**appendix G)**
Marine Protection, Research and Sanctuaries Act	Coordination complete	Disposal of dredge material must comply with the Act.	Full compliance upon signing of the ROD
Estuary Protection Act of 1968	Coordination complete	Estuaries would be benefited by this project.	Full compliance upon signing of the ROD
Anadromous Fish Conservation Act	Coordination complete	Anadromous fish species would not be affected. The project has been coordinated with NMFS.	Full compliance after NMFS review of the FEIS and upon signing of the ROD
Migratory Bird Treaty Act and Migratory Bird Conservation Act	Coordination complete	Migratory birds would benefit by this project. A final FWCAR was completed March 13, 2012.	Full compliance upon USFWS submittal of FWCAR and upon signing of the ROD (**appendix B**)
Wild and Scenic River Act of 1968	Coordination complete	Coordination with the LDWF Scenic Streams Coordinator is on-going. A final Scenic River Use Permit would be complete in May 2012. USACE to submit final permit application. Further coordination would be deferred pending additional review of the Violet, Louisiana Freshwater Diversion.	Full compliance upon signing of the ROD (**appendix X)**

Table 1-10: Compliance with Environmental Laws, Regulations and Executive Orders

Law, Regulation or Policy	Status	Comments	Full Compliance Expected
Federal Water Project Recreation Act	Coordination complete	The principles of this Act (PL 89-72) have been fulfilled.	Full compliance upon signing of the ROD
Submerged Lands Act of 1953	Coordination complete	Coordination with LDNR and LDWF has been ongoing.	Full compliance after LDNR and LDWF review of the FEIS and upon signing of the ROD
Rivers and Harbors Act of 1899	Coordination complete	The proposed work would not obstruct navigable waters of the United States.	Full compliance upon signing of the ROD
National Historic Preservation Act of 1966	Coordination complete	A Programmatic Agreement has been agreed upon and signed between the State Historic Preservation Office (SHPO), the Advisory Council on Historic Preservation (ACHP) and two Federally recognized tribes.	Full compliance upon signing of the ROD (**appendix D)**
Resource conservation and Recovery Act (RCRA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Toxic Substances Control Act of 1976	Coordination complete	A Phase 1 hazardous, toxic, or radioactive waste (HTRW) assessment was performed February 1, 2010 to identify sites of concern in the project area and vicinity.	Full compliance upon signing of the ROD (**appendix Q**)
Farmland Protection Policy Act of 1981	Coordination complete	Portions of the proposed Violet, Louisiana Freshwater Diversion would impact prime farmlands. A Farmland Conversion Impact Rating worksheet, Form AD-1006 has been completed by NRCS per correspondence dated January 12, 2011.	Full compliance upon signing of the ROD (**appendix R**).
Executive Order (EO) 11988 Floodplain Management	Coordination complete	Portions of the proposed Violet, Louisiana Freshwater Diversion (Alternative 1 location) would be located in the 100-year and 500-year floodplain. The assessment for the diversion is programmatic and further study is required.	Full compliance after St. Bernard Parish Floodplain Administrator review of the FEIS and upon signing of the ROD
EO 11990 Protection of Wetlands	Coordination complete	Design plans for restoration features would minimize the loss and/or degradation of wetlands.	Full compliance upon signing of the ROD
EO 12898 Environmental Justice	Coordination complete	Minority or low-income com-munities are not disproportionally affected by the project.	Full compliance upon signing of the ROD
EO 13089 Coral Reef Protection	Not applicable	This project would not adversely impact coral reefs or coral reef resources.	Not applicable
EO 13112 Invasive Species	Coordination complete	Project is not expected to lead to propagation of invasive species.	Full compliance upon signing of the ROD

SOURCE: USACE.

1.8.5 Current and Authorized Restoration Projects

The MRGO Ecosystem Restoration Feasibility Report, **table 1-2** lists the existing water resources projects and their potential application to this study.

CHAPTER 2: **ALTERNATIVE FORMULATION**

2.1 INTRODUCTION

The "Economic and Environmental Principles for Water and Related Land Resources Implementation Studies" and the "Economic and Environmental Guidelines for Water and Related Land Resources Implementation Studies", generally known as the Principles and Guidelines (P&G) provides guidance for conducting Civil Works planning studies. Ecosystem restoration is one of the primary missions of the U.S. Army Corps of Engineers (USACE) Civil Works program. The objective is to contribute to the National Ecosystem Restoration (NER), which is increased in the net quantity and/or quality of desired ecosystem resources. Measurement of NER is based on changes in ecological resource quality, as a function of improvement in habitat quality and/or quantity, and is expressed in physical units such as average annual habitat units (AAHU) or acres. Restoration plans are formulated and evaluated in terms of their contribution to improvement in ecosystem value expressed in a unit measure that is non-monetary.

The Federal planning procedures follow a six-step process structured to approach a problem in a rational framework for decision-making. The MRGO Ecosystem Restoration Plan Feasibility Report that accompanies this National Environmental Policy Act of 1969 (NEPA) document provides more detail and in-depth discussion on the planning process for this study and the plan formulation (Note that throughout this document the term "MRGO" refers to the former Mississippi River Gulf Outlet navigation channel). This FEIS contains a summary of the plan formulation process and alternative development and focuses on a description of the development of reasonable alternatives to achieving ecosystem restoration. In addition, it describes those alternatives considered, but dropped for various reasons. Described below are the USACE's six planning steps and their applicability to the NEPA process:

Step 1 – Identify Problems and Opportunities. The first phase of the planning process defines study area problems and opportunities, as well as study, goals, objectives, and constraints. Because this is an ecosystem restoration study, problems and opportunities are developed to address the Federal objective of National Ecosystem Restoration (NER). Goals, objectives, and constraints are developed to help solve the problems and achieve the opportunities within the confines of legislative authority, policies, and other restrictions.

Step 2 – Inventory and Forecast Conditions. The second planning step consists of the inventory and forecast of resources within the study area. This inventory step accounts for the level or amount of a particular resource that currently exists within the study area, i.e., identification of existing conditions. This step also involves forecasting to predict what changes will occur to resources throughout the 50-year period of analysis, assuming no actions are taken to address the problems in the study area. Comparison of the existing and forecast conditions of the study area measures the problems resulting from the change in resources over time. Study area problems are quantified based on this predicted change in resources. This second step also results in the delineation of opportunities that fully or partially address the problems in the study area. An opportunity is a resource, action, or policy that, if acted upon, may alter the conditions related to an identified problem.

Step 3 – Formulate Alternatives. The third step is to generate alternative solutions. Alternative plans are formulated across a range of potential scales to demonstrate the relative effectiveness of various approaches at varying scales. Alternatives are formulated in consideration of study area problems and opportunities, as well as study goals, objectives and constraints with consideration of four criteria: completeness, effectiveness, efficiency, and acceptability.

1. **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.
2. **Effectiveness** is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.
3. **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.
4. **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.

Step 4 – Evaluate Alternatives. In the fourth step, alternative plans are evaluated for their potential results to address the specific study problems, needs, and objectives. The measure of output is expressed by the difference in amount or effect of a resource between the "No-Action Alternative" conditions and those predicted to occur with each "Action Alternative" in place. This difference is referred to as the benefits of the action alternative. This evaluation focuses on ecosystem benefits, which are measured in metrics that reflect the area, productivity, and value of habitats that are restored or conserved.

Step 5 – Compare Alternatives. The planning process continues with the fifth step, 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.

Step 6 – Select a Plan. The sixth and final step in the process is selection of the plan that best meets the study objectives and the four criteria in the Principles and Guidelines: completeness, effectiveness, efficiency, and acceptability. Using the six-step planning process, the tentatively selected plan is identified.

In developing the alternative restoration plans from which the tentatively selected plan was chosen, 299 measures were screened and evaluated through a coordinated interagency process. The restoration measures were evaluated according to planning goals, objectives, and performance metrics in which 59 measures were carried forward for detailed evaluation. The remaining measures were further evaluated and refined during the development of detailed designs, cost estimates, and quantification of ecological benefits utilizing Wetland Value Assessment methodology. Four final alternatives, which are comprised of a combination of individual measures, resulted from the evaluation process, each of which builds upon the other:

- Alternative A, No Action Plan or future without project (FWOP)
- Alternative B, MRGO Restoration Plan 2 – small restoration plan
- Alternative C, MRGO Restoration Plan 7 – medium restoration plan
- Alternative D, MRGO Restoration Plan 10 – large restoration plan

2.2 CONCEPTUAL ECOLOGICAL MODEL

2.2.1 Overview

Given the complexity of factors that drive the functioning of the ecosystem within the project area, the Engineer Research Development Center (ERDC) Environmental Laboratory (EL) assisted the habitat evaluation team (HET) in development of a conceptual ecological model (CEM) for the study. The CEM was developed to guide plan formulation and the assessment of restoration plans for the MRGO. ERDC EL investigators and the HET developed metrics and predictive models for the MRGO Restoration Study.

The development of this CEM utilized other well-documented CEM frameworks developed for this system formulated under the Louisiana Coastal Area (LCA) Ecosystem Restoration Study and Louisiana Coastal Protection and Restoration (LACPR). As presented in **chapter 1**, the MRGO navigation channel directly impacted an estimated 24,610 acres of wetlands and influenced saltwater intrusion with subsequent secondary and tertiary impacts. Nonetheless, it is noteworthy to point out that the study area is largely degradational even in the absence of the MRGO (see **figure 1-1**). Within the study area a number of restoration measures have been proposed through Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA), Coastal Impact Assistance Program (CIAP) and other programs, some of which are targeted to achieving restoration objectives specific to MRGO impacts.

Details of the CEM are provided in **appendix H**. Below is a description of the major processes considered in the model.

2.2.2 Coastal System Processes

An estuary and its immediate catchment form a complex system of ecological, physical, chemical and social processes, which interact in a highly involved and dynamic fashion. The distribution and abundance of wetland habitats in the deltaic plain has been, and continues to be, in constant flux. The changing conditions are a function of the differing salinity gradients that occur during the land building and degradation phases as well as the myriad of other key processes that influence wetland and estuarine conditions. These processes include the Deltaic Processes; Marine Processes; Fluvial Processes; Chemical Processes; and Biological Processes as briefly described below. These processes are described in detail in **chapter 3**.

The Deltaic Processes

The Mississippi River Deltaic Plain and its associated wetlands and barrier shorelines are the product of the accumulation of sediments deposited by the river and its distributaries during the past 7,000 years. Regular shifts in the river's course have resulted in four ancestral and two active delta lobes, which accumulated as overlapping, stacked sequences of unconsolidated sands and mud. As each delta lobe was abandoned by the river, its main source of sediment, the deltas experienced erosion and degradation due to compaction of loose sediment, rise in relative sea level, and storms. Marine coastal processes eroded and reworked the seaward margins of the deltas forming sandy headlands and barrier beaches. As erosion and degradation continued, segmented low-relief barrier headlands formed and eventually were separated from the mainland by shallow bays and lagoons forming barrier islands (USACE, 2009).

Marine Processes

Water fluxes in the coastal marshes are driven by the water-level differences across the estuary. These change over the long term, seasonally and daily. Long-term rises in sea level have been documented by many investigators, and recently average about 0.04 to 0.08 inches per year, but are projected to increase due to climate change (Titus and Richman, 2001). These marine processes serve to redistribute sediments and nutrients, as well as regulate salinity levels and fluxes in the estuaries.

Fluvial Processes

The Mississippi River discharges into the Gulf of Mexico. Most of the Mississippi River waters are carried westward along the coast, freshening the Gulf waters that move in and out of the Barataria and Terrebonne estuaries, rather than reaching other estuaries in the study area (USACE, 2009). Some water is discharged through Baptiste Collette, Cubit's Gap and Pass a Loutre. This plume can influence the study area, especially Breton Sound. The Mississippi River is leveed for most of its length so sediment no longer reaches many of the Louisiana marshes. The Pearl River discharges into the Lake Borgne ecosystem via the Rigolets. Other smaller rivers in the Pontchartrain watershed contribute additional water and sediments from local watersheds.

Chemical Processes

Elements and compounds can enter tidal wetlands by tidal exchange, precipitation, upland runoff, and groundwater flow. Once in the wetlands, they may be deposited on water bottoms, absorbed to particles, or adhered in the tissues of rapidly growing vascular plants.

Biological Processes

Coastal fringe marshes provide habitat for a variety of vertebrate animals including fish, birds, mammals, and reptiles. Teal (1986) stated that one of the most important functions of salt marshes is to provide habitat for migrant and resident bird populations. Some wildlife species inhabiting tidal marshes are important game animals, valuable furbearers, and provide recreational opportunities for hunters, birdwatchers, nature enthusiasts, and wildlife photographers (USACE, 2009).

The majority of wildlife species that utilize the wetlands have neither commercial nor recreational value, but simply are ecologically important members of the ecosystem. For example, the rice rat and other small mammals play a key role in marsh trophic cycles, providing food for several species of avian and mammalian predators. Many of the vertebrates that use the marsh ecosystem are highly mobile and serve as a transfer mechanism for nutrients and energy to adjacent terrestrial or aquatic ecosystems. Some of the larger vertebrates, including the muskrat and nutria, consume copious amounts of plants and, at high densities, may have significant impacts on marsh vegetation structure (USACE, 2009).

Tidal marshes provide forage, spawning sites, predation refuge, and nursery habitat for resident and nonresident fishes and macrocrustaceans. These organisms use tidal marshes or adjacent subtidal shallows either year round or during a portion of their life history. These organisms are consumed by nektonic, marine and freshwater organisms, and avian predators and represent an important link in estuarine trophic dynamics (USACE, 2009).

The key landscape features in the study area are described in **chapter 3**.

2.2.3 Important Issues in the Development of Alternatives

The HET identified specific issues (or drivers) that contributed to the conditions of the study area. Each of the following issues includes important processes, drivers or components identified as critical to the MRGO Ecosystem Restoration Plan Feasibility Report. Effects on each of these components by MRGO (before and after closure structure) and also by proposed measures have been compared (**table 2-1**). The purpose of the table is to support the team in determining which components (issues) have been or continue to be affected by MRGO, to what extent each proposed restoration measure may influence all components of concern within the study area whether or not affected by MRGO and which measures would address those issues specifically affected by MRGO. Elements in this table form the basis for the CEM.

Table 2-1: Effects of MRGO and Selected Ecosystem Restoration Measures on Selected Issues and Drivers in the MRGO Study Area

Measure / Issue / Driver	MRGO Before Closure[1]	FWOP+ MRGO Closure[2]	FWOP+ Additional Measures[3]	River Diversions[4]	Hydrologic Restoration	Marsh Restoration	Shoreline Protection[5]	Ridge Restoration	Forest Habitat/ Restoration	Barrier Islands Restoration	SAV Restoration	Oyster Reef Restoration	Swamp Restoration
Reduced Freshwater, Nutrients, Sediment Input	NA	NA	D↓ I↓	D↓	D↓ I↓	NA	NA	NA	NA	NA	NA	NA	NA
Wetland Losses	D↑ I↑	D↑ I↑	D↑ I↑	I↓	I↓	D↓	D↓	I↓	D↓	D↓ I↓	I↓	I↓	D↓
Saltwater Intrusion	D↑	I↓	D↓ I↓	D↓	D↓ I↓	I↓	NA	I↓	NA	D↓	NA	NA	I↓
Essential Fish Habitat (EFH) Degradation	D↑ I↑	D ↑I↓	D↑ I↓	I↓	D↓ I↓	D↓	D↓	I↓	NA	D↓	D↓	D↓	D↓
Natural Hydrologic Process Degradation	D↑	D[6]	D[6]	D↓	D↓	I↓	NI	I↓	NA	D↓	NI	NI	I↓
Ridge Habitat Degradation	D↑	D↓	D↑ I↑	NA	I↓	I↓	NI	D↓	NA	I↓	NI	NI	I↓
Barrier Islands Degradation	I↑	I↓	NA	NA	NA	NA	NI	NA	NA	D↓	I↓	NI	NA
Shoreline Erosion	I↑	I↑	I↑	I↓	I↓	I↓	D↓	D↓ I↓	NA	I↓	I↓	I↓	I↓
Subsidence	NA	NA	NA	I↓	I↓	I↓	NA	I↑	NA	NA	NI	NI	I↓
Sea Level Rise	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Storm Surge	NA	NA	NA	I↓	I↓	D↓	NA	D↓	D↓	D↓	I↓	NA	D↓
Marine Habitat Degradation	D↑ I↑	I↓	D↓ I↓	D↓I↓	D↓ I↓	D↓ I↓	I↑	D↓ I↓	D↓ I↓	D↓	D↓	D↓	D↓ I↓
Freshwater Habitat Degradation	D↑ I↑	I↓	D↓ I↓	D↓	D↓	D↓	I↓	I↓	I↓	I↓	D↓	NA	D↓
Lake Pontchartrain Dead Zone Expansion	D↑ I↑	D↓ I↓	D↓ I↓	I↓	I↓	NI	NI	NI	NI	NI	NA	NA	NI

Key to Cell Codes

NA = Not Applicable or measure not proposed for selected Issue/Driver	↑ Increases rate or amount (*not* "good" or "bad")
NI = Little to No Impact of Measure on Issue/Driver	↓ Decreases rate or amount (*not* "good" or "bad")
D = Direct impact of Measure on Issue/Driver	***NOTE:*** *Uncertainty, Predictability, and Strength of impact are not indicated in this table*
I = Indirect impact of Measure on Issue/Driver	

Table 2-1 Footnotes:

[1]MRGO before closure
[2]FWOP+ MRGO Closure
[3]FWOP+ Additional Measures
[4]River Diversion Measure Category includes large measures such as Violet, Louisiana Freshwater Diversion.
[5]Shoreline Protection refers to Marsh, Lake and Channel shorelines only.
[6]Closure of MRGO will not restore natural hydrologic functions and may result in a hypoxic zone within the closed, unfilled MRGO due to anticipated reduction in current velocity
.

2.2.3.1 Natural Hydrologic Process Degradation (Hydrologic Barriers, Connectivity)

Construction of levees, oil and gas canals, and navigation channels has altered natural hydrology, affecting freshwater, sediment, and nutrient transport. Dredged material banks block the movement of sediment re-suspended during storms, which play a major role in sustaining land elevations (Reed et al., 1997). Channels and canals promote saltwater intrusion and increase tidal processes that impact the marsh by accelerating erosion. East-west canals impede sheetflow and cause ponding of water on the marsh. Canals and channels allow freshwater inputs to discharge quickly from wetlands to be rapidly replaced by Gulf of Mexico waters.

Dredged material banks partially impounding wetlands suffer fewer, but longer periods of flooding as well as reduced water exchange when compared to un-impounded marshes (USACE, 2004). Impoundment results in increased waterlogging and frequently, in plant death.

2.2.3.2 Ridge Habitat Degradation (Hydrologic Barriers)

Ridges are natural levees formed from sediments delivered over the banks of rivers and bayous during floods. These ridges assist in defining a watershed and in maintaining its natural hydrology. Ridges sustain upland shrubs and trees, providing unique habitat for certain plant and animal species. Intact ridges prevent intrusion of saltwater into fresher marsh. Natural factors such as subsidence have contributed to the loss of the ridges. The construction of the MRGO directly affected the Bayou La Loutre Ridge, by cutting the channel through the ridge.

2.2.3.3 Barrier Island Degradation

The barrier islands in the Louisiana portion of the study area are the remains of abandoned Mississippi River Delta lobes and their degradation is the result of the natural deltaic processes. The formation of Cat Island in Mississippi was also influenced by this abandoned delta, and it's distinct from other Mississippi barrier islands (Schmid, 2001). Barrier islands act as a buffer to reduce the effects of ocean waves and currents on associated estuaries and wetlands. Louisiana's barrier islands are eroding at a rate of up to 66 feet per year. According to recent U.S. Geological Survey (USGS) estimates, several islands will disappear by the end of the century (LACPR, 2008). Although Cat Island has lost 39 percent of the land area it had in 1848, it is the most stable of the Mississippi barrier islands. Interior elevations and the orientation of Cat Island prevent breaching and overwash by storm waves except along spits of the eastern shore (Morton, 2007). The disappearance of the barrier islands exposes coastal wetlands to the full force and effects of wave action, saltwater intrusion, storm surge, and tidal currents, accelerating wetland deterioration.

2.2.3.4 Storm Surge

Coastal storms, particularly tropical cyclone events, also exert a stochastic, but severe influence on the study area. Data obtained from the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center indicate that the storm centers of at least 16 tropical cyclones with a Saffir-Simpson Hurricane Scale of Category 2 or higher have passed within 50 miles of the study area during the interval 1851 to 2008, and at least 52 such tropical cyclones have passed within 100 miles of the study area during the same interval. The most recent tropical cyclones to affect the study area were Hurricanes Katrina and Rita, which occurred in August 2005 and September 2005, respectively, and Hurricanes Gustav and Ike, which occurred in September 2008.

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

2.2.3.5 Herbivory

During the 1930s, nutria (*Myocastor coypus)* were accidentally released into the coastal wetlands. Since then, their population has rapidly expanded and their grazing and foraging for plant roots have been a major contributor to wetland losses. Although native, muskrat eat-outs may also result in significant local impacts to area marshes. Although eat-outs may recover under some conditions, tropical storm impacts on an eat-out area may quickly convert such an area to permanent open water conditions (USGS, 2000).

2.2.3.6 Invasive Species

Invasive plant species increase and spread rapidly because the new habitat into which they are introduced is free of insects and disease that are natural controls in their native habitats. The aggressive spread of invasive species decreases stands of native plants in many areas, rapidly altering ecosystem function. Different ecosystem types vary in the species that pose problems and the degree to which they are currently impacted or threatened by invasive species (USGS, 2000). Disturbed ecosystems are more vulnerable to invasive species than stable ecosystems. Invasive aquatic species interfere with drainage and flood control, and impede navigation and recreation activities (Westbrooks, 1998).

2.2.3.7 Drought

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

2.2.3.8 Habitat Change

Habitat diversity is important for a healthy ecosystem. Erosion, storm surge inundation, and salinity changes from decreased freshwater inputs or saltwater intrusion can cause habitat switching and loss of habitat. In some areas, loss of habitats with high friction factors, such as swamp forests, can lead to higher storm surge risk.

2.2.3.9 Lake Pontchartrain Dead Zone Expansion

Hypoxic/anoxic conditions ("dead zones") have occurred in Lake Pontchartrain and the Gulf of Mexico in the past. These conditions are caused primarily by excess nitrogen in combination with stratification of more saline waters. Due to the control of the Mississippi River, nutrients pass though the study area and into the northern gulf, rather than into adjacent wetlands, which would absorb these nutrients. As a result of the MRGO closure structure and the Inner Harbor Navigation Canal (IHNC) Lake Borgne barrier structure, there are indications of a reduction of the hypoxic/anoxic zone in Lake Pontchartrain. Results of sampling conducted near the mouth of the IHNC in Lake Pontchartrain prior to and after the MRGO closure in summer 2009 indicate a substantial reduction in differences between surface and bottom salinity and dissolved oxygen (DO) levels (Dr. Michael A. Poirrier, UNO). Low DO levels (<4.0 milligrams per liter [mg/l]) have not been observed in Lake Pontchartrain since the construction of the MRGO closure.

2.2.3.10 Reduced Freshwater, Nutrient, Sediment Input

The construction of levees along the Mississippi River and its distributaries has virtually eliminated the periodic floods that provided vital freshwater, sediment and nutrients to the study area. These flood control measures have seriously altered hydrogeomorphic, biogeochemical, and ecological processes. Without inputs of freshwater, sediment, and nutrients, coastal land loss is accelerated and natural subsidence is exacerbated.

2.2.3.11 Wetland Losses (Land Loss Rate)

Perhaps the most serious and complex problem in the study area is land loss. Land loss is a critical problem not only because of ecosystem degradation, but also because of its role in increasing susceptibility to storm surge. Relative sea level rise (RSLR), tropical storms, shoreline erosion, modification of natural hydrology, and other factors contribute to land loss in the study area. The sustainability of the coastal ecosystems is threatened by the inability of many wetlands to maintain their surface elevation. Any alterations which allow marsh soils to be excessively saturated cause soil chemical changes that even the most resilient marsh plants cannot survive. Once plants die, roots no longer provide structure and integrity to marsh soils, and land loss results.

2.2.3.12 Saltwater Intrusion (Salinity)

Saltwater intrusion changes the salinity gradient, which results in habitat changes. Salinity levels exist along a gradient, which declines as the saltwater moves inland from the Gulf of Mexico. A distinct zonation of plant communities, or vegetative habitat types, differing in salinity tolerance exists along that gradient, with the species diversity of those zones increasing from salt to fresh environments. Changes to the salinity gradient are caused by a number of factors, including: the construction of levees, channels and canals, and drainage systems. Tropical storm events can introduce saltwater into fresher areas, damaging large amounts of habitat in a short period.

In addition to impacts on vegetation, increased salinity levels have negatively impacted the Louisiana oyster (*Crassostrea virginica)* fishery and its industry by shrinking the area within the seeding grounds that serve as ideal oyster habitat (Chatry et al., 1983). Chatry et al., (1983) developed an optimum salinity regime for oysters (**table 1-5**) by studying salinity, spatfall, and seed oyster production data from a 10-year time period. Meeting this established salinity regime at least 40 percent of the time was a goal of this study.

For the purposes of this study, the results of the hydrology and hydraulics (H&H) model would be used to define discharge rates at the Violet, Louisiana Freshwater Diversion necessary to meet the salinity targets in the Biloxi Marsh/Lake Borgne regions. The results are expressed by a range with consideration of the model uncertainties. The model does not provide detail flow diagrams, residual velocity fields or detailed constituent gradient information. Details of the modeling are contained in the H&H model report that is included in **appendix L**.

2.2.3.13 Shoreline Erosion (Land Loss Rate)

Tropical storm events and natural tidal processes are natural causes of erosion. Navigation channels subject inland areas to more dramatic tidal forces and wave action, thus increasing erosion. Rims of firmer soil around lakes, bays, and natural ridges along waterways are susceptible to wind-induced erosion. When these firmer soils are eroded away, organic marsh soils are directly exposed to open water wave attack.

2.2.3.14 Subsidence

The water control structures that allowed coastal areas to be developed also contribute to subsidence and wetland loss. Continued land loss and ecosystem degradation cause developed areas to become more susceptible to storm surge, thus threatening communities and valuable infrastructure.

2.3 IDENTIFICATION OF MANAGEMENT MEASURES AND INITIAL SCREENING PROCESS

Several hundred conceptual features were initially considered. These features came from previous plans and reports, as well as the NEPA public scoping process. Section 2.6 of the feasibility report provides a list of conceptual features initially considered for inclusion in this study.

Ten types of management measures were identified to address the issues that were described in **section 2.2.3** above and capitalize on ecological benefits. Management measures were considered by the Project Delivery Team (PDT) and the HET based upon the input received from the NEPA public scoping process, coordination with other resource management agencies, private, local governmental, or landowner groups, as well as information and scientific data from prior studies. Descriptions of the types of structural management measures are briefly described below and portrayed in **figure 2-1**. These structural management measures include:

- Freshwater diversions
- Hydrologic restoration (e.g. plugs, fill, weirs, sills, gaps)
- Marsh restoration, marsh nourishment, and swamp restoration
- Shoreline protection
- Ridge restoration
- Restoration/creation of forested habitat
- Barrier island restoration
- Submerged aquatic vegetation (SAV) restoration
- Oyster reef restoration
- Vegetative planting

In addition to the structural measures identified, nonstructural measures considered include invasive species control; herbivory control; and buy-outs of developed areas for ecosystem restoration purposes. Invasive species and herbivory control measures would be considered further as management measures necessary to sustain structural measures. Buy-outs of developed areas were not deemed necessary for the MRGO ecosystem restoration plan because of the large extent of non-developed areas available for restoration purposes located within the Lower Pontchartrain sub-basin.

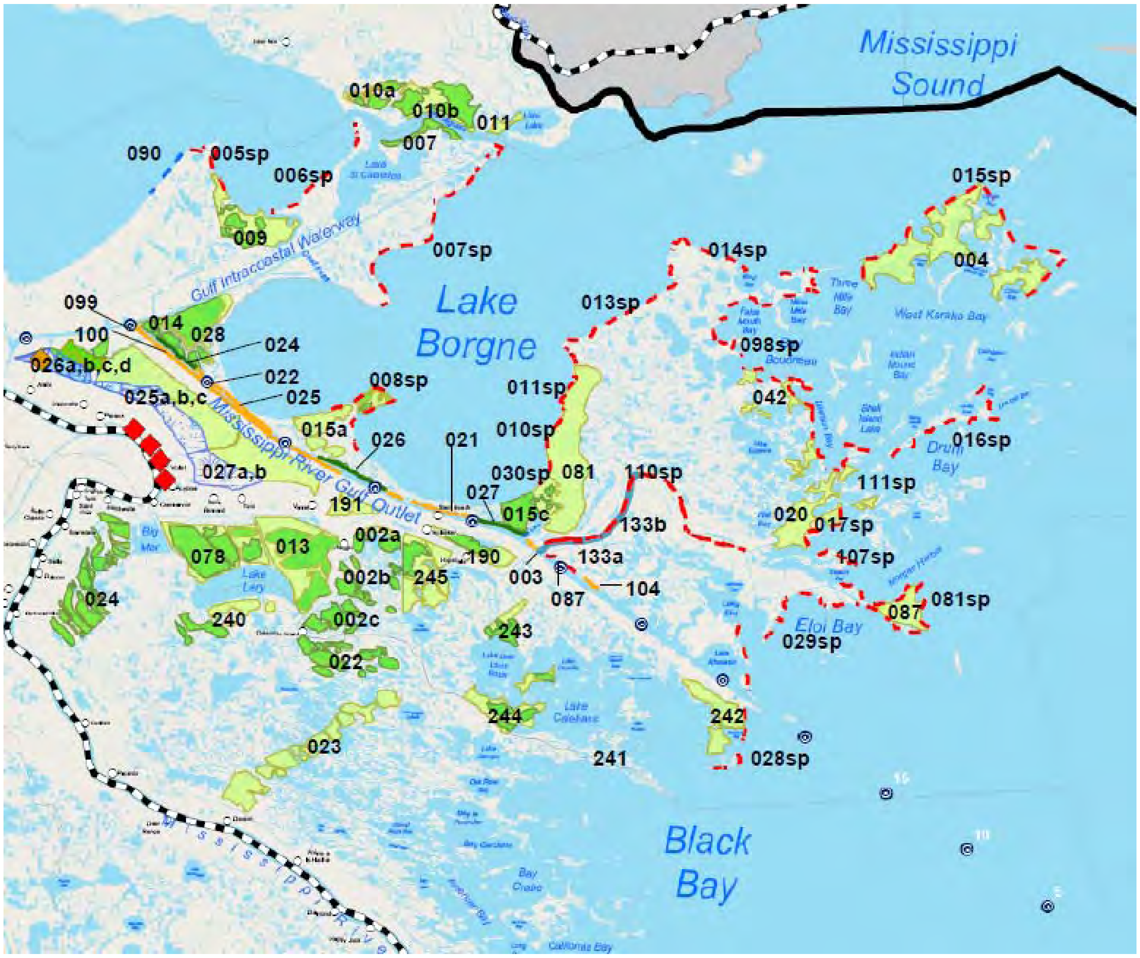


Figure 2-1: Initial Restoration Measures Considered

2.3.1 Description of Measures by Type

Below are descriptions of the types of management measures considered. Within each of these management measures, multiple specific measures (taking into account specific locations, quantities, size, etc.) were developed and screened.

2.3.1.1 Freshwater Diversion

Freshwater diversion features could address the following study area problems: decreased freshwater, sediment, and nutrient inputs; modification of natural hydrology; saltwater intrusion; habitat changes and loss; wetland loss; and human development susceptible to storm surge. Diverting freshwater from the Mississippi River into the Pontchartrain basin would nourish existing marshes to increase their productivity and build wetlands, maintain and restore salinity gradients, and reintroduce and distribute sediment and nutrients throughout the ecosystem. The benefits from diversions can increase over time and continue as long as the diversion is adaptively operated and maintained to respond to environmental conditions.

2.3.1.2 Hydrologic Restoration

Hydrologic restoration measures could address the following study area problems: modification of natural hydrology; saltwater intrusion; and habitat changes and loss; and human development susceptible to storm surge. Hydrologic restoration can be achieved through backfilling, plugging, or creating gaps in the banks of canals and channels. The construction of water control structures, such as weirs and sills, can also restore natural hydrology. Several channels and canals in the Louisiana portion of the study area were considered for backfilling, plugging, installing water control structures (such as weirs and sills), or bank gapping. Backfilling measures serve the dual purpose of controlling water flow and building land (depending upon the depth of fill). Measures to plug the channels or canals can be accomplished with lateral fill or full closure structures that would aid in salinity control, restore the natural hydrology, increase sedimentation and eventually build marsh. Measures such as weirs and sills provide partial closure and aid in sedimentation and salinity control. Bank gapping measures allow water to flow freely and restore natural hydrology, provide valuable nutrients and sediment facilitating organic deposition, improve biological productivity, and inhibit further habitat deterioration.

2.3.1.3 Marsh Restoration and Marsh Nourishment

Land loss from 1985 through 2010 in the study area is estimated to be approximately 63,178 acres. Approximately 131,091 acres is projected to be lost between 2010 and 2065 (Wetland Value Assessment in **appendix M**). Marsh restoration and nourishment features could address the following study area problems: habitat changes and loss; wetland loss; herbivory, invasive species; and human development susceptible to storm surge. One way to address marsh loss is through the placement of dredge material for marsh building to restore lost marsh or nourishment of existing marsh. Marsh restoration involves the placement of dredge material in shallow open water areas and extensively broken marsh to raise the area to marsh elevation. Following compaction and dewatering, the area would be planted with marsh vegetation according to the salinity gradient. Retention dikes, deflection dikes, and/or closures may be used to contain material within the restoration area. During marsh restoration, dredged material would be allowed to overflow into existing marsh within the restoration area to sustain the marsh.

Marsh nourishment refers to the placement of a thin layer of dredged material on broken marsh. The placement of this material facilitates the recruitment and consolidation of marsh vegetation after dewatering. Unlike marsh restoration features, no plantings are associated with marsh nourishment features. Newly restored or nourished marsh would add new sediment and nutrients to the system; combat subsidence; reduce breaching and erosion; reduce wave fetch; and allow for increased vertical accumulation of vegetation.

2.3.1.4 Swamp Restoration and Nourishment

Swamp restoration and nourishment features could address the following study area problems: habitat changes and loss; wetland loss; herbivory, invasive species; and human development susceptible to storm surge. To restore habitats affected by the MRGO, measures for cypress swamp restoration and nourishment were developed. Restoration of swamp habitat would be accomplished in the same manner as the marsh restoration described previously, however, it would be restored to a higher dewatered and settled elevation than marsh restoration features to support cypress habitat.

Swamp nourishment is proposed for existing swamp habitat that are currently at marsh elevation, and consists of placing a thin layer of dredge material to nourish the area, raise elevation, and encourage the recruitment of cypress-tupelo community species. In the areas of swamp nourishment, the elevations would be raised to a level conducive to cypress-tupleo growth, and these species would simply be allowed to volunteer due to the presence of suitable habitat, no plantings would occur in the nourishment areas.

2.3.1.5 Shoreline Protection

Shoreline protection features could address the following study area problems: habitat changes and loss; wetland loss; and human development susceptible to storm surge. Shoreline protection is considered critical for the prevention of shoreline erosion and addressing the larger problem of land loss by dissipating wave energy. High waters, wave action, wind induced currents, tidal flow, channel bathymetry, and residual tidal circulation contributes to shoreline erosion.

Shoreline protection includes the placement of materials, such as sand, shell, rock, or construction debris on-shore or off-shore. Potential construction methods include the establishment of artificial reefs, such as oyster reefs, and breakwaters off-shore as well as the placement of rock or sand on-shore. Protection measures are generally placed parallel to the shoreline and are designed to harden the shoreline and dampen wave energy.

2.3.1.6 Ridge Restoration

Ridge restoration features could address the following study area problems: habitat changes and loss; wetland loss; herbivory, invasive species; human development susceptible to storm surge; and ridge habitat degradation and destruction. Historically, natural ridges formed as smaller distributaries diverged from larger distributaries as they flowed toward the coast. Bayou La Loutre and Terre aux Boeufs are natural ridges remaining in the study area that have degraded over time due to both natural and human induced events. The breach in the Bayou La Loutre Ridge resulting from the construction of the MRGO was recently restored by the construction of a rock barrier. Additional restoration measures proposed for ridges include the placement of dredge material to reestablish historical ridge heights to sustaining ridge habitat. Ridge restoration measures include a planting plan.

2.3.1.7 Restoration/Creation of Forested Habitat

Restoration of forested habitat could address the following study area problems: habitat changes and loss; wetland loss; herbivory, invasive species; human development susceptible to storm surge; and ridge habitat degradation and destruction. Measures to restore forested habitat on the confined disposal sites along the MRGO or in combination with other measures such as swamp restoration were considered. Forested habitat is an important resource and unique habitat in the study area and provide important habitat for resident and migratory birds. Forested habitat has a higher friction factor providing increased protection to developed inland areas by reducing storm surge risk. Forested habitat historically existed in the study area but has declined over time due to tropical storms, salinity intrusion and development. During public scoping meetings, measures to restore or create forest habitat were suggested.

2.3.1.8 Barrier Island Restoration

Barrier island restoration could address the following study area problems: retreating and eroding barrier islands; habitat changes and loss; and wetland loss. Barrier island restoration was proposed as a measure to reduce storm surge and provide critical habitat for threatened piping plovers, migratory waterfowl, and other aquatic and wildlife species. Through Louisiana Coastal Protection and Restoration (LACPR) and Mississippi Coastal Improvements Program (MsCIP), the contribution of surge reduction provided by the barrier islands, in their historic, existing, and altered states, has been subject to sensitivity analyses that indicate that some surge reduction is realized by the barrier islands. Additional benefits were also predicted by creating longer and higher islands. It can only be speculated as to how much actual damage reduction the barrier islands provide, but the disappearance of the barrier islands provides the means for a dramatically increased wave climate and changes in circulation patterns along the coasts of Mississippi and Louisiana.

2.3.1.9 Submerged Aquatic Vegetation (SAV) Restoration

Submerged Aquatic Vegetation (SAV) restoration could address the habitat changes and loss problem in the study area. SAV beds provide ecosystem function benefits such as important habitat for critical fisheries and improved water quality. Worldwide, SAV coverage has been declining. For example, in 1969, an estimated 20,000 acres of SAV were documented in Mississippi Sound and coastal bays. As of 1998, only 2,000 acres were documented (Moncrieff et al., 1998).

During public scoping meetings, the re-establishment of SAV in the Mississippi Sound and Lake Pontchartrain were recommended. The sustainability of SAV is uncertain; therefore, pilot projects are recommended to determine the potential for re-establishing SAV beds in the Pontchartrain basin.

2.3.1.10 Oyster Reef Restoration

Oyster reef restoration features could address the following study area problems: habitat changes and loss; wetland loss; and human development susceptible to storm surge. During the NEPA scoping meetings, it was suggested that artificial oyster reefs should be established in the Biloxi Marshes. Artificial oyster reefs were considered for oyster production and shoreline protection. Three alternative designs for artificial oyster reefs were evaluated as shoreline protection measures, i.e., a bio-engineered reef, using crushed stone, or incorporating a berm for oysters in addition to a traditional rock shoreline protection measure. Artificial oyster reefs as shoreline protection offers an opportunity to incorporate shoreline protection benefits as well as benefits for oysters.

2.3.1.11 Vegetative Planting

Vegetative planting features could address the following study area problems: habitat changes and loss; wetland loss; herbivory, invasive species; and human development susceptible to storm surge. One way to address habitat loss is through planting appropriate native species in areas that already have the necessary elevation to maintain a particular habitat to restore and rebuild wetlands. Vegetated habitat will provide the following benefits: combat subsidence; reduce breaching and erosion; reduce wave fetch from open water areas; and allow for more vertical accumulation of vegetation.

2.3.2 Initial Formulation and Screening Process

The screening of specific measures within each type of management measure was an iterative process consisting of multiple steps to arrive at a suite of measures to formulate alternative plans. The initial formulation and screening process involved comparing measures to the study purpose and need, goals, and objectives as described below:

Step 1 –Proposed measures that did not serve the primary purpose of ecosystem restoration (e.g., levees, floodwalls) were eliminated as not in compliance with the goals and objectives of the study. Recreation features were deferred for development in conjunction with the selected plan.

Step 2 – Conceptual measures were defined spatially and input into a Geographic Information System (GIS) database. In some cases, several specific proposed marsh, swamp, or ridge restoration measures in the same area were combined into one larger measure, while other larger, more conceptual measures were segmented into smaller geographic components.

Step 3 – Once measures were geographically defined, they were screened based on their spatial effects by determining if they met one of two of the following criteria: 1) the measure addressed restoration of the Lake Borgne Ecosystem, 2) the measure addressed a MRGO ecosystem effect. Measures that did not meet one of these two criteria were eliminated from further consideration.

Step 4 – The remaining measures were then screened based on additional criteria specific to the type of measure as described in the following sections. During this portion of the screening process, measures were only compared to like measures, for example, marsh restoration measures were only compared to other marsh restoration measures.

The following sections describe the initial screening by measure type. Section 2.6.1 of the feasibility report further details the initial formulation and screening process for the individual measures. **Appendix O** contains screening tables with individual measures.

2.3.2.1 Freshwater Diversion / Initial Screening Process

The MRGO study authority calls for considering the diversion of freshwater from the Mississippi River for restoring the Lake Borgne ecosystem. Delivering river water to the Lake Borgne area could be achieved at a number of different locations along the east bank of the Mississippi River. Twenty-two freshwater diversion sites along the east bank of the Mississippi River between Convent in St. James Parish and Baptiste Collette Bayou in Plaquemines Parish were evaluated. This set of initial sites for evaluation was developed from existing reports, public input, and interagency collaboration. Freshwater diversion measures were initially screened from further consideration based upon two criteria established by the planning team. Diversion measures and sites determined to have an influence area lying entirely outside the Lake Borgne ecosystem or outside of the areas potentially affected by the MRGO were screened from further evaluation as detailed below.

Ten potential sites on the river's east bank below Caernarvon were identified in the initial planning phase (**table 2-2**). It was determined that these areas were outside of the Lake Borgne ecosystem. Therefore, potential diversion locations on the river below the existing Caernarvon Diversion were removed from further consideration. This initial screening reduced the original 43 measures to a total of 23 conceptual measures at 12 sites.

Table 2-2: Steps 3 and 4: Freshwater Diversion Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
American Bay Diversion	No	No	
California Bay Diversion	No	No	
Bohemia Mississippi River Reintroduction	No	No	
Delta Building Diversion N. of Fort St. Phillip	No	No	
Fort Jackson Sediment Diversion	No	No	
Grand Bay Diversion R1 and R2	No	No	
Bayou Lamoque Diversion R1, R2, R3, R4, and R5	No	No	
White Ditch Diversion R3 and R5	No	No	

Table 2-2: Steps 3 and 4: Freshwater Diversion Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Benney's Bay Diversion R3 and R4	No	No	
Adaptive Management through Maintenance of Existing Crevasses and Construction of New Crevasses	No	No	
Freshwater Diversion in the Vicinity of Violet	Yes	Yes	
Diversion at Hope Canal R1, R2, R3, R4, and R5	Yes	Yes	Addressed by LCA authorized project.
Diversion at Blind River R1, R2, R3, R4, and R5	Yes	Yes	Addressed by LCA authorized project.
Diversion Convent/Blind River R1, R2, R3, R4, and R5	Yes	Yes	Addressed by LCA authorized project.
Bayou Bienvenue Diversion R1 and R2	Yes	Yes	Concerns associated with constructability and impacts to existing infrastructure.
Bayou La Loutre Diversion R1 and R2	Yes	Yes	Concerns regarding efficiency, constructability, potential impacts to development, and the potential to influence the targeted areas.
Caernarvon Diversion Modification R1 and R2	Maybe	Maybe	Target influence area for MRGO Ecosystem Restoration could be served more efficiently from another location due to the hydrologic barriers formed by the bayou Terre aux Boeufs and MRGO spoil banks. Also addressed in the two authorized Caernarvon Diversion modification projects.
Bonnet Carrè Freshwater / Sediment Introduction or Opportunistic use of Bonnet Carrè Spillway	Yes	Yes	Project is already authorized and can be implemented by Congress; however WRDA 2007 Section 3083 indicates the desire of Congress to achieve the benefits of this diversion at another location. Acceptability is a concern due to opposition to a large diversion of freshwater into Lake Pontchartrain.
La Branche Diversion R1 and R2	Yes	Yes	The benefits of a diversion at this location could be achieved at Bonnet Carrè for considerably less cost.
Bayou Terre aux Boeufs Diversion R1 and R2	Yes	Yes	Target influence area for MRGO Ecosystem Restoration could be served more efficiently from another location due to the hydrologic barriers formed by the bayou Terre aux Boeufs and MRGO spoil banks.
Violet Spillway	Yes	Yes	An uncontrolled diversion was ruled out because of the need to control flows at different times of the year in order to meet salinity targets, support cypress growth, avoid flooding, adaptively manage, etc.

Table 2-2: Steps 3 and 4: Freshwater Diversion Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Effluent from Waste Water Treatment Plant	Yes	Yes	Addressed by CIAP project. Flow capability insufficient to meet the objectives.

NOTE: Bold text indicates the measure was carried forward for further consideration.

The team determined that feasibility studies and engineering and design efforts are currently underway in the LCA and CWPPRA programs for freshwater diversions to address the Upper Pontchartrain Basin/Lake Maurepas swamps portion of the study area. Therefore, new river diversions or modifications to existing structures in that vicinity were removed from further consideration. The application of this criterion reduced the number of potential sites to eight locations between the Bonnet Carrè Spillway and the existing Caernarvon Freshwater Diversion.

The location of a freshwater diversion is constrained by existing development, infrastructure, and river conditions. A freshwater diversion at Bonnet Carrè was the selected plan in the 1984 *Mississippi and Louisiana Estuarine Areas Feasibility Study Freshwater Diversion to Lake Pontchartrain and Mississippi Sound Feasibility Study* (USACE, 1984). The State of Louisiana has expressed opposition to a large diversion of freshwater into Lake Pontchartrain due to water quality concerns. A re-evaluation of this study was performed in 1996, and a Finding of No Significant Impact (FONSI) for an Environmental Assessment evaluating water quality impacts to Lake Pontchartrain was signed in July 1996. In an official reply, the State of Louisiana in July 1996, declined to participate further in the project. WRDA 2007 Section 3083 authorizes the achievement of the benefits described in *Mississippi and Louisiana Estuarine Areas Feasibility Study Freshwater Diversion to Lake Pontchartrain and Mississippi Sound Feasibility* Study through the design and implementation of a freshwater diversion at or near Violet, LA. Modification to the Bonnet Carré is still an authorized project and could be considered as part of that effort. Because it would be inefficient to build a new structure at a location where an existing structure could be modified to achieve the same benefits, a new structure at or near the Bonnet Carrè Spillway was removed from further consideration, including a new diversion in the vicinity of the La Branche Wetlands. This reduced the number of potential freshwater diversion sites to six.

A freshwater diversion could not be located between the La Branche Wetlands and the Inner Harbor Navigation Canal without impacting existing suburban and urban development in Orleans and Jefferson Parishes. Developing a plan to locate a diversion in a densely developed community without open land corridors between the river and estuary would require substantial relocation of homes, businesses, and public infrastructure. There are no existing open land corridors between the river and lake in either Jefferson Parish or Orleans Parish. Therefore, no locations in Jefferson Parish or in Orleans Parish were evaluated.

There are four open land corridors in St. Bernard Parish between the communities of Chalmette and Poydras where freshwater could be diverted from the Mississippi River for distribution in the Lake Borgne ecosystem (**figure 2-2**).

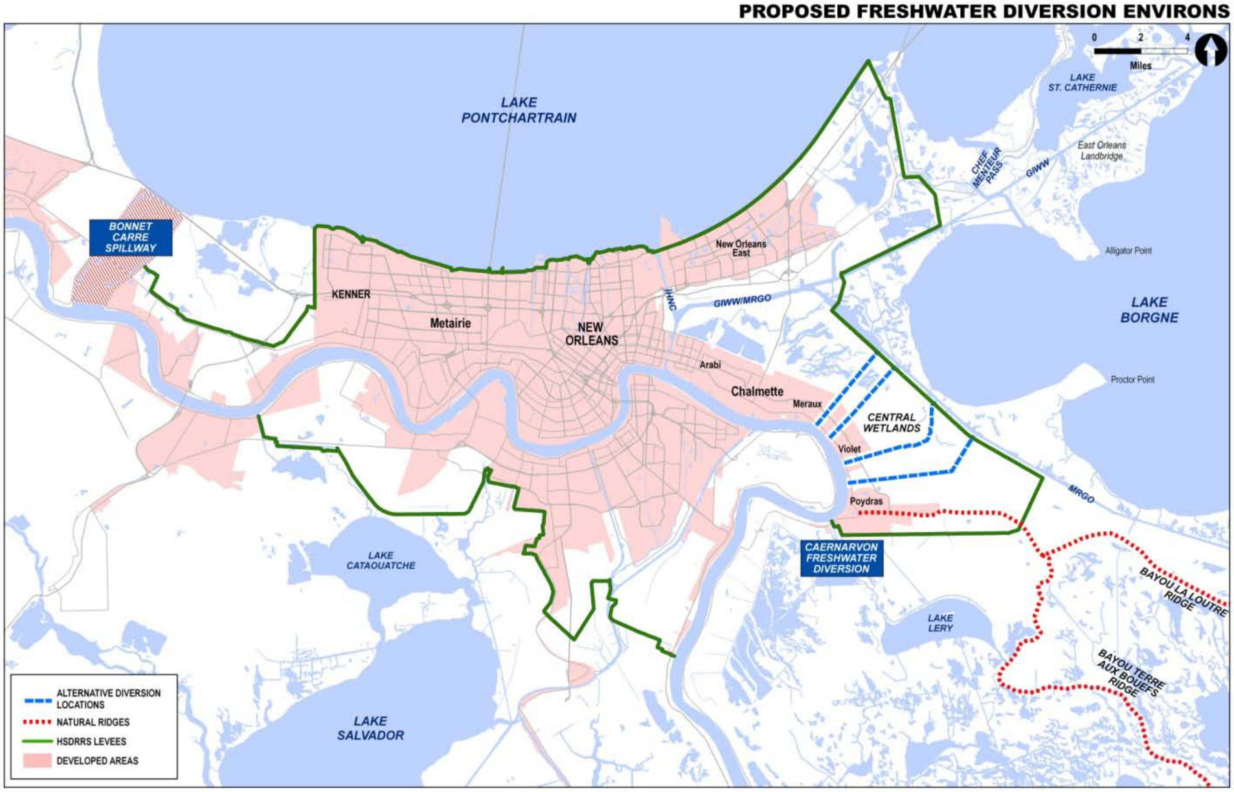


Figure 2-2: Freshwater Diversion Location Constraints

South of Poydras, there are opportunities to divert river water in the vicinity of Bayou Terre aux Bouefs and at the existing Caernarvon Diversion. The Bayou Terre aux Bouefs Ridge in St. Bernard Parish forms a hydrologic barrier that would inhibit the movement of freshwater to the areas targeted for restoration in the MRGO study. Bayou Terre aux Boeufs flows through the communities of St. Bernard, Toca, Kenilworth and Verret. A freshwater diversion at this location was proposed in LACPR to benefit the marshes located between the MRGO and Bayou Terre aux Boeufs. As noted in LACPR, the construction of a freshwater diversion at this location would require construction of a leveed conveyance channel approximately 7.16 miles in length to influence the area between Bayou Terre aux Boeufs and the MRGO. To distribute freshwater to this area would require widening and deepening the existing bayou, and adjacent residential, commercial, and industrial development would be impacted. Additional channels would be needed outside of the Chalmette Loop Levee to influence the greater Lake Borgne ecosystem. Because the Mississippi River is farther away from Lake Borgne in this location, it would be less efficient to distribute freshwater through Bayou Terre aux Boeufs than at a location where the river is closer to the lake. A freshwater diversion at Bayou Terre aux Boeufs would not provide freshwater to the Central Wetlands, Golden Triangle, and northern Lake Borgne/MRGO Landbridge, and therefore would not achieve the goals and objectives of this study. Due to concerns regarding efficiency, constructability, and potential impacts to development, diversion alternatives at Bayou Terre aux Bouefs were removed from further consideration.

Two existing LCA Caernarvon Diversion projects were being developed to maximize benefits at the Caernarvon Diversion, and the area targeted for restoration in the MRGO Ecosystem Restoration Study would be more efficiently served by a freshwater diversion that would not be impeded by the Bayou Terre aux Bouefs Ridge and the MRGO spoil bank. This assessment reduced the number of potential diversion sites to four locations in the vicinity of Violet, Louisiana in St. Bernard Parish.

Restoration of a freshwater system in the Central Wetlands may be needed to restore the swamp habitat affected by the MRGO, and sustain the restored marsh. To accomplish this restoration, a freshwater diversion is needed to establish the optimal salinity regime for the estuary. A river diversion at or near the existing Violet Canal was determined to be the best location to achieve the goals and objectives of the study. The MRGO was excavated through the eastern portion of the Central Wetlands and increased salinity in the area through salt water intrusion. The habitat of the Central Wetlands changed from a cypress swamp and fresh/intermediate marsh system to an entirely brackish system. Although salinity levels have decreased in the area due to the closure of the MRGO, a freshwater diversion may be needed to establish and maintain optimal salinity. In these preliminary analyses, a freshwater diversion located in the vicinity of Violet, Louisiana was determined to be the most effective way to restore the Central Wetlands and the salinity regime in the estuary.

Alternatives that did not include a freshwater diversion were considered in the initial development of alternatives. These alternatives were ultimately eliminated from further study as inconsistent with the study goals and objectives and the “Guiding Principles”. A small freshwater diversion would not mimic periodic overbank flooding of the Mississippi River, a key process of the estuary that preliminary analyses indicate is needed to re-establish historic salinity gradients, habitat types, and increase self-sustainability in the system.

The forecast future without project salinity conditions suggest that salinity in the study area would be reduced by the closures on the MRGO and other authorized projects. However, additional inputs of freshwater may be necessary to fully restore the historic salinity regime. The restoration and maintenance of a cypress swamp and fresh/intermediate marsh in the Central Wetlands may require the introduction of freshwater into this area. Additionally, to restore the MRGO/Lake Borgne Landbridge to a condition favorable for the propagation of intermediate marsh species, the area may require further salinity reductions beyond the forecast future without project conditions.

The “Guiding Principles” reinforce the inclusion of a freshwater diversion for this study. The freshwater diversion proposed as part of the MRGO Ecosystem Restoration Plan would assist with realizing the following guiding principles:

- Restore key processes and dynamics in the estuary;

- Enhance the resilience and self-sustainability of the estuary;
- Maximize the combined benefits of freshwater diversions that seek to restore natural processes with mechanical marsh creation measures; and
- Combine measures synergistically to maximize possible cumulative benefits.

2.3.2.2 Hydrologic Restoration Initial Screening Results

Channel/Canal Filling

Initially, 24 channel/canal backfilling measures were considered. After screening, 6 of the original fill measures were carried forward for further study. In addition, those associated with the distribution of freshwater from diversions were considered to be part of the diversion measure rather than a stand-alone measure. Some other proposed backfill areas were deemed impractical because of the cost of installing multiple retaining structures in a relatively small geographic area. Other canal backfilling features were screened out to maintain vessel access following the MRGO closure at Bayou La Loutre. The remaining 6 backfilling features were located within the footprint of the former navigation channel. See **table 2-3**.

Water Control Measures

Initially, 26 water control measures were considered. After screening, no measures were carried forward. It was determined that water control measures would be examined in conjunction with individual marsh/swamp restoration features and freshwater diversions, rather than as stand-alone measures. See **table 2-3**.

Table 2-3: Steps 3 and 4: Hydrologic Restoration Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Florissant Fill and Plant with Trees			
Hopedale Fill and Plant with Trees	No	No	
Alabama Bayou Closure	No	No	
Identify sustainable methods to benefit Bayou St. John water quality, habitat management, recreational access, and educational opportunities	No	No	
South Slough Hydrologic Restoration 1-3	No	No	
Lock Replacement	No	No	
Multiple Closures in MRGO 1-3	No	No	
Fill parallel canal to Marsh Elevation (Back Canal Bienvenue to Dupre)	No	No	

Table 2-3: Steps 3 and 4: Hydrologic Restoration Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Fill parallel canal to Marsh Elevation (Back Canal Between Dupre and Verret Levee)	Yes	Yes	Interferes with freshwater distribution. The benefits of creating marsh habitat in this location are less than the impacts to fisheries and access.
Fill parallel canal to Marsh Elevation (Back Canal Between HPL at Verret to Yscloskey)	Yes	Yes	Interferes with freshwater distribution. The benefits of creating marsh habitat in this location are less than the impacts to fisheries and access.
Fill parallel canal to Marsh Elevation (Back Canal Between Bayous Yscloskey and La Loutre)	Yes	Yes	Interferes with freshwater distribution. The benefits of creating marsh habitat in this location are less than the impacts to fisheries and access. Access over pipelines is an issue.
Fill parallel canal to Marsh Elevation (Back Canal Between Bayous Yscloskey and La Loutre)	Yes	Yes	Interferes with freshwater distribution. The benefits of creating marsh habitat in this location are less than the impacts to fisheries and access.
Fill in MRGO to Bay Bottom (Between barrier islands to Mile 27)	Yes	Yes	Interferes with freshwater distribution. The benefits of creating marsh habitat in this location are less than the impacts to fisheries and access. NOTE: Approx. 1360' of canal, in vicinity of MRGO mile 41.6, is filled in and does not require any further fill.
Fill parallel canal to Marsh Elevation (Bayou La Loutre to terminus)	Yes	Yes	Natural fill occurring; no land created.
Fill in MRGO to Marsh Elevation (GIWW to Bienvenue) Reach 1	Yes	Yes	Impractical: Three containment structures would be required in addition to IHNC surge barrier in distance of approx. 7000'.
Fill in MRGO to Marsh Elevation (GIWW to Bienvenue) Reach 2	Yes	Yes	
Fill parallel canal to Marsh Elevation (Bayou Bienvenue to Bayou Dupre inside levee)	Yes	Yes	Already filled in by previous MRGO O&M dredge disposal.
Fill parallel canal to Marsh Elevation (Bayou Dupre to Levee at Verret inside levee)	Yes	Yes	Already filled in by previous MRGO O&M dredge disposal.
Florissant Historic - Re-grade from ridge to marsh at edge of MRGO	Yes	Yes	Degrading spoil banks not seen as desirable because upland scrub-shrub provides habitat for migrating birds.

Table 2-3: Steps 3 and 4: Hydrologic Restoration Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Hopedale Historic - Re-grade ridge to marsh at edge of MRGO	Yes	Yes	Degrading spoil banks not seen as desirable because upland scrub-shrub provides habitat for migrating birds.
Sediment Delivery by Pipeline at Central Wetlands	Yes	Yes	Deferred as dependent on other diversion measures.
Sediment Delivery by Pipeline at Golden Triangle	Yes	Yes	Deferred as dependent on other diversion measures.
MRGO Sill (Water Control Structure 2-5			Deferred as dependent on other diversion measures.
Bayou La Loutre Water Control Features 1-6	Yes	Yes	Deferred as dependent on other diversion measures.
Create Channel (Bayou Restoration) 1-3	Yes	Yes	Concerns about increasing saltwater intrusion and tidal scour.
Constrict opening between Lake Borgne and MRGO	Yes	Yes	Addressed by shore protection measures along south shore of Lake Borgne and north bank of MRGO.
MRGO Sill (Water Control Structure - 1)	Yes	Yes	Channel filling in naturally.
Fill in MRGO to Marsh Elevation - A (Bienvenue to Dupre)	Yes	Yes	
Fill in MRGO to Marsh Elevation - C (Dupre to end of Levee Reach)	Yes	Yes	
Fill In MRGO to Marsh Elevation - I (Bayou La Loutre to Lake Athanasio)	Yes	Yes	
Fill in MRGO to Marsh Elevation - G (Bayou Yscloskey to Bayou Doulluts)	Yes	Yes	
Fill in MRGO to Marsh Elevation - F (End of Leveed Reach to Bayou Yscloskey)	Yes	Yes	
Fill in MRGO to Marsh Elevation - H (Bayou Doulluts to Bayou La Loutre)	Yes	Yes	

NOTE: Bold text indicates the measure was carried forward for further consideration.

2.3.2.3 Marsh and Swamp Restoration Initial Screening Results

Initially, approximately 42 marsh restoration and five swamp restoration areas were identified in Louisiana. For discussion of potential marsh restoration/creation sites in Mississippi, see MsCIP. The sites in Louisiana were screened to remove areas that were not affected by the MRGO or were outside of the Lake Borgne ecosystem. After initial screening, 19 areas were identified for further refinement of marsh restoration and nourishment measures. Three areas in the Central Wetlands were retained for further study and refinement of swamp restoration and nourishment measures (**table 2-4**).

Table 2-4: Steps 3 and 4: Marsh and Swamp Restoration Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Maintain Breton Landbridge - North	Yes	Yes	Adverse impact to hydrology in terms of freshwater.
Bayou Terre aux Boeufs Marsh Creation - B	Yes	Yes	
Caernarvon Area Marsh Creation - South	No	No	
Maintain and Restore Biloxi Landbridge and Barrier Reefs North B	No	No	
Maintain and Restore Biloxi Landbridge and Barrier Reefs South A	No	No	
Maintain and Restore Biloxi Landbridge and Barrier Reefs South B	No	No	
Maintain critical marsh shoreline and ridges of East Orleans Landbridge - B-C	Yes	Yes	
Maintain critical marsh shoreline and ridges of East Orleans Landbridge - D	Yes	Yes	Screened out as unnecessary due to existing dredge material disposal.
Maintain critical marsh shoreline and ridges of East Orleans Landbridge - A	Yes	Yes	
Maintain critical marsh shoreline and ridges of East Orleans Landbridge - E	Yes	No	
Maintain critical marsh shoreline and ridges of East Orleans Landbridge - F	Yes	No	
Maintain and Restore Biloxi Landbridge and Barrier Reefs North A	Yes	No	Marsh is intact and has not changed significantly since 1956.
Bayou Terre aux Boeufs Marsh Creation - A	No	No	
Golden Triangle Marsh Creation - East	Yes	Yes	
Maintain Lake Borgne Landbridge including Landbridge Shoreline Protection	Yes	Yes	
Maintain and Restore Biloxi Landbridge and Barrier Reefs South C	Yes	Maybe	
Biloxi Marshes - Marsh Creation Interior - C	Yes	Maybe	Marsh is intact and has not changed significantly since 1956.
Bayou Terre aux Boeufs Marsh Creation - C	No	No	
Maintain Breton Landbridge - South	No	No	
Caernarvon Area Marsh Creation - North	No	No	
Central Wetlands Swamp Creation - B	Yes	Yes	
Central Wetlands Swamp Creation - A	Yes	Yes	
Central Wetlands Swamp Creation - C	Yes	Yes	
Golden Triangle Marsh Creation - East	Yes	Yes	
Biloxi Marshes - Marsh Creation Interior - B	No	No	
Biloxi Marshes - Marsh Creation Interior - A	No	No	
Biloxi Marshes - Marsh Creation Interior - D	Yes	Maybe	
Biloxi Marshes - Marsh Creation Interior - E	Yes	Maybe	Marsh is intact and has not changed significantly since 1956.
Biloxi Marshes Marsh Creation and Shoreline Protection – A	Yes	No	Marsh is intact and has not changed significantly since 1956.

Table 2-4: Steps 3 and 4: Marsh and Swamp Restoration Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Eloi Bay Marsh Creation/Nourishment	Yes	Yes	Marsh is intact and has not changed significantly since 1956.
North Lake Lery Marsh Creation	No	No	
Biloxi Marsh' Marsh Nourishment	Yes	Yes	
Biloxi Marsh' Marsh Creation and Shoreline Protection – B	Yes	No	Marsh is intact and has not changed significantly since 1956.
Skiff Lake Marsh Creation	Yes	Maybe	Marsh is intact and has not changed significantly since 1956.
Morgan Harbor Marsh Creation	Yes	Yes	Removed from consideration due to concerns regarding impacts to oyster reefs and seed grounds.
Breton Marsh Creation - A (See Note 2)	Yes	Yes	Marsh is intact and has not changed significantly since 1956.
Breton Marsh Creation - C (See Note 2)	Yes	Yes	Marsh is intact and has not changed significantly since 1956.
Florissant Swamp Restoration	Yes	Yes	Area not historically cypress; conditions not suitable for the development of a sustainable cypress swamp.
Hopedale Swamp restoration	Yes	Yes	Area not historically cypress; conditions not suitable for the development of a sustainable cypress swamp.
Hopedale Marsh Restoration	Yes	Yes	
Florissant Marsh Restoration	Yes	Yes	
Biloxi Marshes Marsh Creation - Lake Athanasio.	Yes	Yes	Marsh is intact and has not changed significantly since 1956.
Marsh Creation South of Lake Lery	No	No	
Marsh Creation east of Lake Calebass	Yes	Yes	Removed from consideration due to concerns regarding impacts to oyster reefs and seed grounds.
Marsh Creation near St. Helena Bay	Yes	Yes	
Marsh Creation West of Lake Jean Louis Robin	Yes	Yes	
Marsh Creation West of Lake Calebass	Yes	Yes	

NOTE: Bold text indicates the measure was carried forward for further consideration.

2.3.2.4 Shoreline Protection Initial Screening Results

Initially, 58 shoreline protection measures were considered. Various shore protection alignments were initially screened to eliminate those deemed to be outside the Lake Borgne ecosystem or outside areas potentially affected by the MRGO. Breakwaters were screened out in Lake Borgne and Biloxi Marshes because they are less effective than foreshore protection. After screening, 26 shoreline protection measures were carried forward for further study (**table 2-5**).

Table 2-5: Steps 3 and 4: Shoreline Protection Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Maintain Shoreline East Orleans Landbridge – C	Yes	No	
Biloxi Marshes Shoreline Protection – A	No	No	Would only protect a small area at a high cost due to water depth and geographic constraints.
Biloxi Marshes Shore Protection Interior A	Yes	No	Off-shore protection deemed less effective than near shore protection for erosion prevention.
Biloxi Marshes Shore Protection Interior C	No	No	
Biloxi Marshes Shore Protection - South C	Yes	No	
Biloxi Marshes Shore Protection Interior B	Yes	No	Off-shore protection deemed less effective than near shore protection for erosion prevention.
Biloxi Marshes Shore Protection - South A	Yes	No	Would only protect a small area at a high cost due to water depth and geographic constraints.
Skiff Lake Shoreline Protection	No	No	Would only protect a small area at a high cost due to water depth and geographic constraints.
Maintain Lake Borgne Shoreline - B	Yes	No	State will build with surplus funds. Part of FWOP.
Maintain Shoreline East Orleans Landbridge – A	Yes	No	
Lake Borgne Shoreline Protection - B	Yes	No	State will build with surplus funds. Part of FWOP.
Shoreline Protection (Potential Creation of SAV Habitat)	Yes	No	
MRGO North Bank (MRGO Mile 23.2-20.8) O&M	Yes	Yes	Removed as inefficient. Does not protect any land, could prevent natural filling in the channel.
Maintain Shoreline East Orleans Landbridge – B	Yes	No	
Lake Borgne Shoreline Protection - A	Yes	No	State will build with surplus funds. Part of FWOP.
Biloxi Marshes Shore Protection - South B	No	No	
Biloxi Marshes Shore Protection - North A	Yes	No	
Maurepas Shoreline Protection - East	Yes	No	Marsh is intact and has not changed significantly since 1956.
Lake Borgne Shoreline Protection – C	Yes	No	
MRGO North Bank (MRGO Mile 33.8-32.6) O&M	Yes	Yes	
Morgan Harbor Shoreline Protection	Yes	No	

Table 2-5: Steps 3 and 4: Shoreline Protection Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
MRGO Shoreline Protection - H O&M	Yes	Yes	
MRGO Shoreline Protection - G	Yes	Yes	
Maurepas Shoreline Protection – West	Yes	Maybe	Removed due to low benefit numbers from initial WVA and high cost.
Eloi Bay Shoreline Protection	Yes	No	
Oyster Reef Development in Biloxi Marshes C (Foreshore Dike with 35 ' Berm for Reef)	Yes	Maybe	Reefs in area already in good condition.
Biloxi Marshes Shore Protection - North B	No	No	
MRGO Shoreline Protection - C O&M	Yes	Yes	
MRGO Shoreline Protection - D O&M	Yes	Yes	
MRGO South Bank (MRGO Mile 59-47) O&M	Yes	Yes	Screened out because WVA assigned very few benefits.
Golden Triangle Shoreline Protection	Yes	Yes	Covered by CIAP project.
MRGO Shoreline Protection - F O&M	Yes	Yes	
Bayou Dupre/Lake Borgne Shoreline Protection	Yes	Yes	Covered by USACE project.
West of Shell Beach Shoreline Protection	Yes	Yes	Covered by USACE project.
Biloxi Marshes Shoreline Protection – B	Yes	No	Would only protect a small area at a high cost due to water depth and geographic constraints.
MRGO Shoreline Protection - B	Yes	Yes	
Maintain Lake Borgne Shoreline – A	Yes	No	
MRGO Shoreline Protection - E	Yes	Yes	
MRGO South Bank (MRGO Mile 23.2-20.8) O&M	Yes	Yes	Removed as inefficient. Does not protect any land, could prevent natural filling in the channel.
MRGO South Bank (MRGO Mile 37.3-36.5) O&M	Yes	Yes	Existing Articulated Concrete Mattress in good condition.
MRGO South Bank (MRGO Mile 38.9-38.5) O&M	Yes	Yes	Existing Articulated Concrete Mattress in good condition.
MRGO South Bank (MRGO Mile 60-59) O&M	Yes	Yes	Screened out because WVA assigned very few benefits.
Jean Louis Robin Shoreline Protection	Yes	Yes	
West Lake Lery Shoreline Protection	No	No	
South Lake Lery Shoreline Restoration	No	No	
MRGO Shoreline Protection - A	Yes	Yes	In authorized part of the GIWW channel, O&M covered.
Oyster Reef Development in Biloxi Marshes A (Via Crushed Stone)	Yes	Maybe	Not as effective for shoreline protection purpose as measure #98 - Oyster Reef Development in Biloxi Marshes C (Foreshore Dike with 35' Berm for Reef)

Table 2-5: Steps 3 and 4: Shoreline Protection Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Breakwaters along Lake Borgne Shoreline	Yes	No	Not as cost effective as nearshore shoreline protection measures
Oyster Reef Development in Biloxi Marshes B (Bio-Engineered Reef)	Yes	Maybe	Not as effective for shoreline protection purpose as measure #98 - Oyster Reef Development in Biloxi Marshes C (Foreshore Dike with 35' Berm for Reef)
Biloxi Marshes Shoreline Protection - Offshore Artificial Reef	No	No	Not as cost effective as nearshore shoreline protection measures
LaBranche Wetlands Shoreline Protection	No	No	
Sink Ships for Breakwater/Artificial Reef	No	No	
Lake Maurepas Shoreline Protection – A	No	No	
Lake Maurepas Shoreline Protection – B	No	No	
St. Tammany Shoreline Protection	No	No	
Bay Boudreau Shoreline Protection	Yes	No	Duplicative with #98 Shoreline Protection

NOTE: Bold text indicates the measure was carried forward for further consideration.

2.3.2.5 Ridge Restoration Initial Screening Results

Initially, 55 ridge restoration measures were considered. The 55 measures were developed by combining five different sized ridges (historic, 50-foot, 100-foot, 150-foot, and 200-foot footprints) at 11 locations. After screening, only two ridge restoration locations on the Bayou La Loutre Ridge were carried forward for further study (**table 2-6**).

Table 2-6: Steps 3 and 4: Ridge Restoration Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Bayou La Loutre Ridge Restoration East - South Bank A 200 ft.	Yes	Yes	
Bayou La Loutre Ridge Restoration East - South Bank A 50 ft.	Yes	Yes	Crown width and slope not suitable for establishing oak ridge species.
Bayou La Loutre Ridge Restoration East - South Bank A 100 ft.	Yes	Yes	Crown width and slope not suitable for establishing oak ridge species.
Bayou La Loutre Ridge Restoration East - South Bank A 150 ft.	Yes	Yes	Crown width and slope not suitable for establishing oak ridge species.

Table 2-6: Steps 3 and 4: Ridge Restoration Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Bayou La Loutre Ridge Restoration East - South Bank A historic width	Yes	Yes	Removed due to potential negative impacts to existing vegetation and marsh.
Bayou La Loutre Ridge Restoration East - South Bank B 50 ft., 100 ft., 150 ft., 200 ft., and historic width	Yes	Yes	Removed due to potential negative impacts to existing vegetation and marsh.
Bayou La Loutre Ridge Restoration East - North Bank A: 50 ft., 100 ft., 150 ft., 200 ft., and historic width	Yes	Yes	Removed due to potential negative impacts to existing vegetation and marsh.
Bayou La Loutre Ridge Restoration East - North Bank B: 50 ft., 100 ft., 150 ft., 200 ft., and historic width	Yes	Yes	Removed due to potential negative impacts to existing vegetation and marsh.
Bayou La Loutre Ridge Restoration West - North Bank A: 50 ft., 100 ft., 150 ft., 200 ft., and historic width	Yes	Yes	Removed due to potential negative impacts to existing vegetation and marsh.
Bayou La Loutre Ridge Restoration West - South Bank A: 50 ft., 100 ft., 150 ft., 200 ft., and historic width	Yes	Yes	Removed due to potential negative impacts to existing vegetation and marsh.
Bayou Terre aux Boeufs West Ridge Restoration A: 50 ft., 100 ft., 150 ft., 200 ft., and historic width	Yes	Yes	Removed due to potential negative impacts to existing vegetation and marsh.
Bayou Terre aux Boeufs West Ridge Restoration B: 50 ft., 100 ft., 150 ft., 200 ft., and historic width	Maybe	Maybe	Removed due to potential negative impacts to existing vegetation and marsh.
Bayou Terre aux Boeufs West Ridge Restoration C: 50 ft., 100 ft., 150 ft., 200 ft., and historic width	Maybe	Maybe	Removed due to potential negative impacts to existing vegetation and marsh.
Bayou Terre aux Boeufs East Ridge Restoration A: 50 ft., 100 ft., 150 ft., 200 ft., and historic width	Maybe	Maybe	Removed due to potential negative impacts to existing vegetation and marsh.
Bayou Terre aux Boeufs East Ridge Restoration B: 50 ft., 100 ft., 150 ft., 200 ft., and historic width	Maybe	Maybe	Removed due to potential negative impacts to existing vegetation and marsh.

NOTE: Bold text indicates the measure was carried forward for further consideration.

Ridge restoration consists of stacking sediment to a height conducive to the propagation of upland habitat. In areas where natural ridges are above marsh elevation and currently support upland habitat, ridge restoration would bury existing vegetation and replace it with vegetation considered to have greater habitat value. It was determined that the benefits derived from the higher habitat value would not justify the costs associated with raising the elevation and planting these features.

Similarly, in areas where the ridges have subsided to marsh elevation, ridge restoration would result in adverse impacts to marsh that must be considered in the calculation of benefits. The Bayou Terre aux Boeufs Ridge was removed from further consideration because it was determined that the negative impacts to existing upland and marsh habitats were greater than the ecosystem benefits of ridge restoration in this location.

Portions of the south side of the Bayou La Loutre Ridge were identified that were above marsh elevation but did not have existing upland vegetation: these sections were retained for further evaluation. Ridge restoration designs were developed for these areas that minimized impacts to adjacent wetlands while providing suitable crown widths and slopes for establishing of oak ridge species.

2.3.2.6 Vegetative Planting Initial Screening Results

Initially, 11 standalone vegetative planting measures were considered, which involved planting trees on the banks of the MRGO navigation channel. All of these measures were screened out. Measures to plant trees on the north bank of the MRGO were screened out because tree planting in that location is inconsistent with both the existing and historic marsh habitat. Measures to plant trees in front of the levee were screened out because they could potentially affect the structural integrity of the levee. Measures to plant trees on the spoil bank were screened out because the spoil banks are already well vegetated (**table 2-7**).

Additional vegetative planting measures are being carried forward as integral components of other measures such as marsh, swamp, and ridge restoration.

Table 2-7: Steps 3 and 4: Vegetative Planting Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Plant Trees in Front of Levee (Mile 59 - 47)	Yes	Yes	Would violate maintenance criteria for levees.
Plant Trees on Spoil Bank - A	Yes	Yes	Disposal areas are already well vegetated and will likely develop into mature stands that could serve basically the same function as more desirable tree species.
Plant Trees on Spoil Bank - C	Yes	Yes	
Plant Trees on Spoil Bank - D	Yes	Yes	
Plant Trees on Spoil Bank - E	Yes	Yes	
Plant Trees on Spoil Bank - B	Yes	Yes	
Plant Trees on Spoil Bank - F	Yes	Yes	
Vegetative Planting Trees North Bank of MRGO - A	No	No	
Vegetative Planting Trees North Bank of MRGO - B	No	No	
Vegetative Planting Trees North Bank of MRGO - C	No	No	
Vegetative Planting Trees North Bank of MRGO - D	No	No	

NOTE: Bold text indicates the measure was carried forward for further consideration.

2.3.2.7 Barrier Island Restoration Initial Screening Results

Initially, three barrier island restoration measures were considered. After screening, two barrier island restoration measures were carried forward for further study and several variations of these alternatives were developed. Cat Island was eliminated from further study because it is part of MsCIP. The MRGO channel was dredged between Breton and Grand Gossier Islands in the Chandeleur Islands Chain, and some scientists contend that the former navigation channel disrupted sediment transport to Breton Island. However, the impact to the islands from the MRGO, if any, is difficult to quantify with any degree of certainty because the erosion and migration patterns in place since the late 1800's were still operating in 2005, with no obvious change after construction of the MRGO (Britsch, 2009). Barrier islands were not identified as critical landscape features with respect to storm surge risk reduction in the LACPR ADCIRC analyses (USACE, 2009).

Barrier island restoration was ultimately eliminated for implementation under this authority because of the insufficient nexus to MRGO effects, the Lake Borgne ecosystem, or storm surge damage risk reduction (**table 2-8**). Restoration of the barrier islands would not directly benefit the area targeted for restoration under this authority. Alternative barrier island restoration measures on the Chandeleur Island chain require further study to determine how to maximize benefits while minimizing risks to project performance. Further study of alternative barrier island restoration techniques should be conducted to protect and restore this significant coastal habitat.

Table 2-8: Steps 3 and 4: Barrier Island Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Cat Island Restoration Study	Yes	No	Would violate maintenance criteria for levees.
Chandeleur Islands (Not Breton & Grand Gossier)	No	No	
Breton and Grand Gossier Island Restoration	No	Maybe	No documented MRGO effect to the islands; channel between the islands is addressed under "Channel Filling Measures"

2.3.2.8 SAV Demonstration Project Initial Screening Results

Initially, two SAV demonstration projects were considered — one in Louisiana and one in Mississippi. The Louisiana SAV project was replaced with a breakwater/shoreline protection measure to allow expansion of established SAV on south shore of Lake Pontchartrain. The Mississippi SAV project was screened out because it has already been recommended by the MsCIP report (**table 2-9**).

Table 2-9: Steps 3 and 4: SAV Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Mississippi SAV DEMO	No	No	
Louisiana SAV DEMO	Yes	Maybe	Replaced with breakwater to provide calming to allow expansion of established SAV on south shore of Lake Pontchartrain.

2.3.2.9 Artificial Oyster Reef Initial Screening Results

Initially, one artificial oyster reef measure was considered (**table 2-10**). This artificial oyster reef measure is not being carried forward to the final array of alternatives because the area identified is already in acceptable condition regarding oysters; however, various oyster reef designs were evaluated under shoreline protection.

Table 2-10: Steps 3 and 4: Oyster Reef Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Oyster Reef Development in the Biloxi Marsh	Maybe	Maybe	Area identified already in acceptable condition regarding oysters, oyster reef designs evaluated as shoreline protection measures.

2.3.3 Summary of Initial Screening Results

Screening the measures proposed in the initial array resulted in the elimination of 240 measures and the retention of 59 measures to be carried forward for refinement and detailed evaluation. The measures that were carried forward for further evaluation were further refined to produce more detailed designs, cost estimates, and quantification of outputs, Wetland Value Assessment methodology.

2.3.4 Measures Requiring Additional Study

2.3.4.1 Recommendations for Additonal Studies

Restoring historic salinity conditions and providing freshwater and nutrients to nourish existing and restored wetlands in the study area is an important component of the plan. However, additional study is needed to improve decisions about where, when, and how to divert Mississippi River flows in a systems context. The ongoing Mississippi River Hydrodynamic and Delta Management Study will evaluate ecosystem restoration alternatives in concert with dynamic flood risk management and navigation; multipurpose management scenarios of the river; and dynamic conditions in a comprehensive systems context. The information gained from this study will improve decision-making related to a Freshwater Diversion. Therefore, the final recommendations for the MRGO Ecosystem Restoration Plan include additional analysis, design and implementation of a Freshwater Diversion at or near Violet as authorized by WRDA 2007 Section 3083.

2.3.4.2 Barrier Island Restoration

The former MRGO navigation channel was dredged through an existing tidal inlet between Grand Gosier Island and Breton Island to allow ships from the Gulf of Mexico to enter Breton Sound and onward to the Port of New Orleans. Construction and maintenance of the channel is believed to have interrupted sediment transport in the lower Chandeleur Islands limiting long-shore movement of sand from Grand Gosier Island to Breton Island. Dredged material from the MRGO was beneficially deposited on and near Breton Island between 1993 and 2005 during channel maintenance events to restore island habitat.

The *MRGO Ecosystem Restoration Plan Feasibility Study – Chandeleur and Breton Islands,* May 2010 (SBEACH Model Report) found in **appendix J** evaluated measures to improve and increase barrier island habitat on the Chandeleur Island Chain. Further study of alternative barrier island restoration techniques should be conducted to protect and restore this significant coastal habitat.

The type of benefits provided by reconstructing either the Chandeleur Islands or Breton Island alternatives can be considered identical as they provide similar habitat (supratidal, gulf intertidal, bay intertidal, and subtidal) along barrier island shorelines that are geographically close. **Table 2-11** summarizes the benefits and cost of the various barrier island restoration alternatives.

Table 2-11: Summary of Barrier Island Restoration Alternative Benefits and Costs

Alternative	Fill Volume (cy)	Cost Estimate	Net Benefits (AAHUs)	Cost per AAHU ($/AAHU)
Chandeleur Island	8,720,000	$119,568,000	1,464	$81,672
Breton Island Alt. 1	20,040,000	$178,486,000	195	$915,313
Breton Island Alt. 2	9,657,000	$88,450,000	49	$1,807,435
Breton Island Alt. 3	7,255,000	$61,038,000	67	$908,645
Breton Island Alt. 4	9,382,000	$100,279,000	70	$1,428,307
Breton Island Alt. 5	12,321,000	$83,631,000	0	-

AAHU = Average Annual Habitat Unit

2.3.4.3 Sediment Study

Due to uncertainties associated with sustaining Louisiana's coast through sediment placement, a sediment-needs budget and sources inventory should be developed. Further study of sediment loads in the lower Mississippi River is needed due to variation between sampling frequency and methods at various sites. The LCA *Mississippi River Hydrodynamic Study* is anticipated to increase available data and understanding about the sediment loads in the river. A comprehensive inventory of available borrow sources, their volumes, and any constraints associated with their use would facilitate the identification of available sediment for projects throughout the area.

2.3.4.4 Fisheries Modeling Study

A Comprehensive Aquatic Systems Model (CASM) modeling study (**appendix I**) was undertaken to evaluate the potential ecological and food web implications of diverting Mississippi River water across the Central Wetlands area into Lake Borgne and aquatic systems associated the MRGO. The CASM is a bioenergetics-based ecosystem model that simulates the daily production dynamics of modeled populations of aquatic plants and animals. The principal modeling objective was to assess the potential effects of alterations in salinity and other water quality parameters that would result from the proposed Violet, Louisiana Freshwater Diversion on selected populations of valued ecological resources in the MRGO ecosystem. The CASM was run on the diversion flow regime which was a component of all the action alternatives and therefore, did not influence the selection of the tentatively selected plan.

The CASM MRGO modeling study focused on key species of ecological, recreational, and commercial value including oysters, brown shrimp, white shrimp, blue crab, red drum, spotted sea trout, striped mullet, Gulf menhaden, bay anchovy, sheepshead, and Atlantic croaker. Gulf sturgeon was additionally included because of its endangered species status. To address different habitat requirements (e.g., salinity, depth,) juvenile (or immature) and adult stages were modeled as separate populations for oysters (i.e., spat), blue crab, brown shrimp, white shrimp, red drum, and spotted sea trout. The CASM MRGO also included zooplankton and zoobenthos as separate generalized consumer populations because of their importance as food resources in the model food web. Broadly defined populations of phytoplankton and periphyton (i.e., diatoms, green algae, bluegreen algae) were modeled as key primary producers in the CASM MRGO. The modeled food web also included four representative submerged aquatic plants. The resulting composition of primary producers and consumers defines a food web structure relevant to the MRGO ecosystem.

The CASM MRGO simulates the daily biomass of the modeled populations for 55-years for 23 selected inshore and offshore locations in the MRGO ecosystem. The CASM model domain includes approximately the southern half of Lake Pontchartrain, Lake Borgne, the Biloxi Marsh and extends eastward past Bay St. Louis and Biloxi, MS, and southwards past the Chandeleur Islands into the Gulf of Mexico. The 23 locations represent a subset of the larger domain defined by the University of New Orleans (UNO) H&H model. The UNO model was developed to characterize changes in salinity throughout this lager region projected for several MRGO future without-project and with-project conditions (i.e., freshwater diversions).

Despite the assumptions and limitations inherent in developing a complex aquatic systems model for MRGO ecosystem, the resulting CASM application appears as a useful approach for assessing the ecological impacts of freshwater diversions. The combination of environmental input data, food web structure, and literature-based bioenergetics parameters proved capable of usefully describing production dynamics of the selected aquatic populations of producers and consumers.

The CASM MRGO has been used to assess the outcomes of proposed without- and with-project alternatives in relation to ecosystem restoration actions proposed near Violet, Louisiana. The incremental effects have been calculated in evaluating the proposed freshwater diversion. The preliminary results of the CASM study are addressed in **chapter 4**. **Section 2.12.6** describes the additional CASM modeling work recommended for the project.

2.3.4.5 Recreation Components

Public comments have indicated that recreational improvements should be considered as a part of this plan. Real estate issues and the need for a local sponsor responsible for a part of the construction costs (50 percent) and maintenance and operation (100 percent) prevent full development of recreational features for inclusion in this plan. However, it is the recommendation of this study that recreation features be considered in the design and implementation phase of the plan. Three sites were identified as potential locations for recreational improvements associated with the restoration features for the tentatively selected plan (alternative C) (**appendix W**).

2.3.5 Measures Considered But Eliminated

Measures that were eliminated because they were considered the least cost effective include:

- Marsh restoration and shoreline protection on the bayside of Biloxi marshes north of Morgan Harbor
- Filling in the MRGO
- Large ridge restoration measure
- Florissant marsh restoration

2.4 ALTERNATIVE PLAN FORMULATION

Alternatives were formulated to maximize environmental benefits, avoid and minimize environmental impacts, and minimize the cost associated with the disposition of the de-authorized project. Plans were formulated in consideration of four criteria: completeness, effectiveness, efficiency, and acceptability. Alternative plans are combinations of the management measures that were carried forward after screening as described in **section 2.3**. Alternative plans and their component management measures were assessed relative to the objective of the NER.

The study utilized a geographic information system (GIS) database to catalogue study information including individual management measures, existing and authorized water projects, and existing conditions. The GIS enabled the team to visually display and manipulate information across the large study area. Additionally, the system allowed the team to build and test various alternative combinations of management measures during the course of plan formulation. Thus, the GIS is utilized as a decision support tool.

2.4.1 Preliminary Evaluation of Measures

The measures that passed through initial screening were compared against one another and assembled into alternative plans using performance outputs (benefits) and costs.

2.4.1.1 Outputs (Benefits)

Environmental outputs were measured using the Sediment and Nutrient Diversion Model (SAND2) and the Wetland Value Assessment (WVA) methodology. The SAND2 utilized outputs from the hydrologic model to determine the ecological benefits from the freshwater diversion. The outputs from the SAND2 were utilized to conduct the wetland value assessments.

The WVA methodology is similar to the Department of the Interior - U.S. Fish and Wildlife Service's (USFWS's) habitat evaluation program (HEP), in that habitat quality and quantity are measured for baseline conditions and predicted for FWOP and future with project (FWP) conditions. Separate habitat assessment models were used, including the Barrier Island, the Bayou La Loutre Ridge, the Fresh/Intermediate Marsh, the Brackish Marsh, and the Saline Marsh Community Models. Instead of the species-based approach of HEP, each model utilizes an assemblage of variables considered important to the suitability of a given habitat type for supporting a diversity of fish and wildlife species. As with HEP, these models allow a numeric comparison of each future condition and provide a combined quantitative and qualitative estimate of project-related impacts to fish and wildlife resources.

The WVA models operate under the assumption that optimal conditions for fish and wildlife habitat within a given coastal wetland type can be characterized, and that existing or predicted conditions can be compared to that optimum to provide an index of habitat quality. Habitat quality is estimated and expressed through the use of a mathematical model developed specifically for each habitat type. Each model consists of: 1) a list of variables that are considered important in characterizing fish and wildlife habitat; 2) a Suitability Index graph for each variable, which defines the assumed relationship between habitat quality (Suitability Indices) and different variable values; and 3) a mathematical formula that combines the Suitability Indices for each variable into a single value for wetland habitat quality, termed the Habitat Suitability Index (HSI).

The WVA models assess the suitability of each habitat type for providing resting, foraging, breeding, and nursery habitat to a diverse assemblage of fish and wildlife species. This standardized, multi-species, habitat-based methodology facilitates the assessment of project-induced impacts on fish and wildlife resources. The fresh/intermediate, brackish, and saline marsh WVA model consists of six variables: 1) percent of wetland covered by emergent vegetation; 2) percent open water dominated by submerged aquatic vegetation; 3) degree of marsh edge and interspersion; 4) percent of open water less than or equal to 1.5 feet deep; 5) salinity; and 6) aquatic organism access. The swamp model consists of six variables: 1) stand structure, 2) stand maturity, 3) hydrology, 4) size of contiguous forested area, 5) suitability and traversability of surrounding land use, and 6) disturbance. The ridge model consists of three variables: 1) percent canopy cover, 2) percent midstory cover, and 3) woody species diversity. The barrier island WVA model consists of seven variables: 1) percent of the total subaerial area that is classified as dune habitat; 2) percent of the total subaerial area that is classified as supratidal habitat; 3) percent of the total subaerial area that is classified as intertidal; 4) percent vegetative cover of dune, supratidal, and intertidal habitats; 5) percent vegetative cover by woody species; 6) degree of marsh edge and interspersion; and 7) beach/surf zone features.

The WVA quantifies changes in fish and wildlife habitat quality and quantity that are expected to result from a proposed wetland restoration project. The results of the WVA, measured in AAHUs, were combined with cost data to provide a measure of the effectiveness of a proposed project in terms of annualized cost per AAHU gained. In addition, the WVA methodology provides an estimate of the number of acres benefited by the project and the net acres of habitat protected/restored. The results of the WVAs (in AAHUs) were compared with annual costs in IWR-PLAN, the USACE's Institute for Water Resources (IWR) windows-based decision support software to develop alternative plans.

The WVA model was used to determine the most effective measures for each habitat type identified for restoration in the study planning objectives. The WVA methodology uses different models for each habitat type, which facilitates the comparison of restoration measures by type. The WVA model does not assign different values to different types of habitat. An AAHU of brackish marsh has the same benefit as an AAHU of ridge habitat in the WVA model, although coastal ridge habitat is extremely scarce and brackish marsh is relatively abundant. Therefore, other important considerations, such as habitat type scarcity, contribution to overall ecosystem function, whether a measure addresses a direct effect of the MRGO, and contribution to restoration of critical landscape features were evaluated qualitatively for alternative plan combinations developed by IWR-PLAN.

The HET agreed that use of the WVA methodology would be most appropriate considering the tight feasibility report schedule. The models and methods utilized to determine future acreages are presented below and in more detail in **appendix M**.

The sections below provide descriptions of the results of the SAND2 and WVA for the FWOP and various wetland restoration measures.

FWOP Wetland Acreage Projections

Wetland acreage data (1985 through 2006) was obtained from the USGS for each of the study area planning subunits. FWOP subunit wetland acreages were determined via a linear trendline through those data (**figure 2-3**). Where applicable, annual net acreage benefits associated with pre-existing or soon to be constructed restoration projects were added to the base subunit FWOP acreages to obtain revised FWOP subunit acreages.

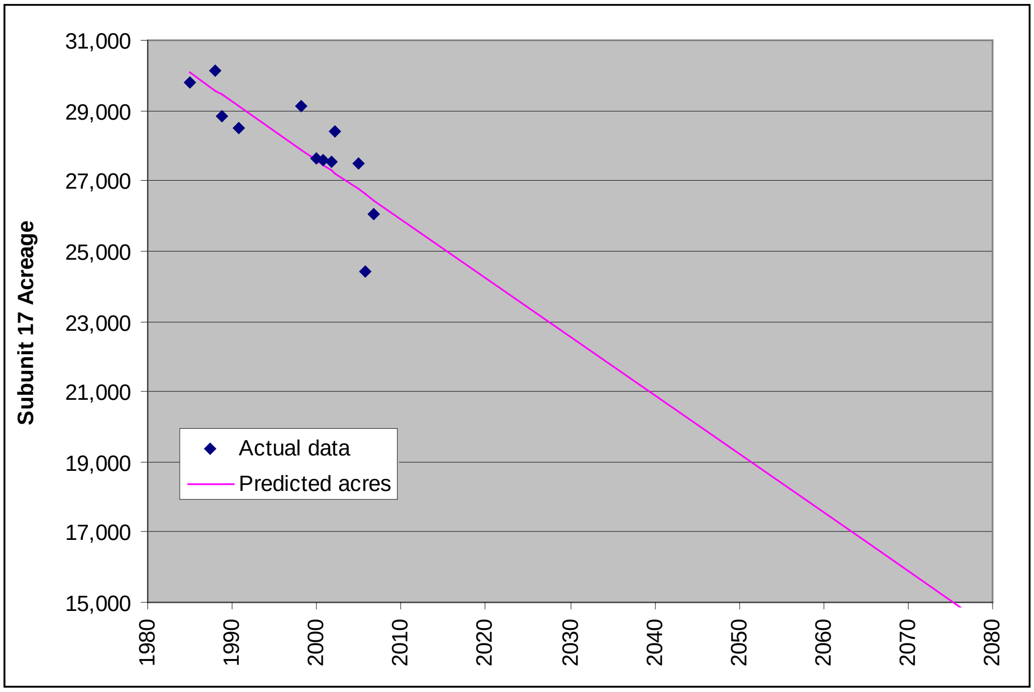


Figure 2-3: Actual and Predicted Acreage for Subunit 17

Predicting Wetland Benefits of Mississippi River Diversions - General

An assessment of wetland benefits associated with proposed Mississippi River diversion measures was undertaken. The SAND2 model was used. This model is an ERDC revision of the SAND1 (Boustany-ERDC spreadsheet model) used in the LACPR Final Technical Report. The SAND2 version differs from the SAND1 model by incorporating an improved method for determined nutrient benefits, and it includes the ability to capture diversion synergies with proposed marsh restoration measures constructed within the diversion benefit area.

Given the great uncertainties regarding future subsidence rate changes, sea-level rise changes, and many other factors that might affect future wetland loss rates over the period of analysis, there is considerable uncertainty regarding the accuracy of the predicted river diversion benefits. However, the SAND2 models do provide an objective means for comparing alternative measures and plans.

Although the period of analysis is 50 years, all environmental assessments were conducted for a 100-year period to assess the wetland acreage trajectories at and beyond the period of analysis. Utilizing the predicted FWOP wetland acreage as a basis, the SAND2 model calculates FWP benefits (in acres) via the accretion of suspended sediments (land building) together with the effects of nitrogen additions. The nitrogen benefits (in acres) are calculated as the grams of nitrogen required to produce a wetland acre multiplied by the grams of introduced nitrogen (less nitrogen lost to denitrification) = wetland acres created/supported via introduced nitrogen. Inputs required for estimating the nutrient benefits are:

1. Mississippi River Discharge
   All diversion benefit assessments utilized 25 years of Tarbert's Landing discharge data (1983-2007) repeated 4 times to create a 100-year input.

2. Diversion Discharge
   The Violet, Louisiana Freshwater Diversion was assumed to operate year-round at 1,000 cubic feet per second (cfs), except during the months of April and May, when it would operate at 7,000 cfs.

3. Nutrient Concentrations
   Monthly USGS Belle Chase nitrogen concentration data (1976 through 2007) are used to calculate nitrogen additions to diversion receiving areas.

4. Plant Productivity Rate
   Monthly above-ground emergent vegetation productivity values, by marsh type, are selectable with the model. Productivity values according to the FWOP marsh type were chosen.

5. Emergent Vegetation Percent Nitrogen
   Percent nitrogen of emergent vegetation biomass (Chabreck, 1972) is incorporated into the model, and selectable by habitat type. Percent nitrogen based on FWOP habitat type was used.

6. Denitrification Rate
   A literature reported value of $21 g/m^2/yr$ was used (Delaune and Jugsujinda, 2003; Bond, 2006; and Day et al., 2004). Denitrification was assumed to reduce the amount of introduced nitrogen available for uptake by emergent wetland vegetation.

Land building benefits under the SAND2 model were estimated utilizing a Belle Chase sediment rating curve, together with the assumed diversion discharge, to compute the volume of introduced sediment. The model's sediment retention module then applied all or a portion of the introduced suspended sediment toward accretion of new wetland acres. The sediment retention module uses the size and dimensions of the receiving area, and diversion discharge, to calculate velocities within the receiving area. Whenever receiving area velocities drop below the thresholds required keeping any one of the three sediment types (fine sand, silts, and clay) in suspension, the model calculates deposition of that sediment type. However, land building is not solely based on the accretion of introduced mineral sediments. The model automatically includes sufficient organic material to achieve the average surface soil bulk density of the selected habitat type (which was always selected as that of the FWOP condition). In addition to using the surface soil bulk density by habitat type, the model also uses depth of fill, and bulk density compaction with depth change rate to calculate a depth-averaged soil bulk density

The previously defined study area subunits were utilized as the diversion receiving areas. Required inputs to calculate acres of diversion-related land-building include; width, acreage, and average water depth, and roughness height of bottom sediments.

1. Mississippi River Sediment Concentrations
   A sediment rating curve using (1991-2004) surface suspended sediment concentration values at Belle Chase relative to Tarbert's Landing discharges (Snedden et al., 2007) was incorporated into the model to calculate suspended sediment concentrations at a given river discharge. Belle Chase sediment size fractions were also used (fine sand, silt, clay). Percent flocs (larger and heavier sediment particles) were estimated based on the FWOP salinity regime. Higher percent flocs are assumed in higher salinity receiving areas, and lower percent flocs are assumed in lower salinity receiving areas.

2. Diversion Discharge
   The Violet, Louisiana Freshwater Diversion was assumed to operate year-round at 1,000 cfs, except during the months of April and May, when it would operate at 7,000 cfs.

3. Receiving Area length
   Using ArcMap, the receiving area length was measured as the length of the primary diversion flow pathway through the receiving area.

4. Receiving Area Width
   This was calculated by dividing the receiving area length into area of the receiving area (i.e., subunit area).

5. Average Depth
   This was obtained through any available data source. If no data source was available, average depth was estimated based on field observations and professional judgment.

6. Roughness Height of Water Bottoms
   Based on Smith, 2007 and Soulsby, 1983, a roughness height for mud of 0.0006562 feet was used for all model runs.

7. Wetland Soil Bulk Density
   Based on values reported in the published literature, average surface bulk density values are selectable within the model. Surface bulk density values were selected according to the FWOP habitat type. The model computes a depth-averaged bulk density using surface bulk density, depth of fill, and bulk density change with depth inputs.

8. Maximum Tidal Velocity

   Maximum tidal velocities are required in the model's sediment retention module. Lacking velocity data for all evaluated diversion receiving areas, velocities were estimated to be 1.5 feet per second (fps) in receiving areas close to the Gulf of Mexico, and 1.0 fps in middle and upper basin diversion receiving areas.

The application of the SAND2 model to the Violet, Louisiana Freshwater Diversion was atypical because sediment and nutrient retention and losses within the immediate Central Wetlands receiving area, the deep MRGO, and Lake Borgne, would reduce diversion benefits to the more distant influence areas such as the Inner Biloxi marshes and the East Orleans Landbridge. Consequently, benefits were determined separately for the Central Wetlands, South Lake Borgne marshes, Inner Biloxi Marshes, and East Orleans Landbridge study area subunits. To assist in this effort, UNO scientists utilized a simple hydrologic model to provide estimates of diverted water, nutrients, and sediments that would be delivered to and retained within each of the receiving areas at the 1,000 cfs and 7,000 cfs diversion discharges. The reported water, nitrogen, and sediment distribution values used in the SAND2 model were derived with the inclusion of a proposed closure across the Lake Borgne shoreline opening to the MRGO, across the MRGO from Bayou Dupre. Additionally, UNO's work indicated that all sands would be deposited within the Central Wetlands, and that only fine sediments would travel further. Therefore, sand retention values were manually set to 0.0 in all receiving areas, except for the Central Wetlands model run.

Use of the SAND2 model also required input of FWOP and FWP wetland loss rates, plus initial marsh and water acreages of the receiving area. FWOP TY0 (Target Year 0) acreages (year 2014) were determined via application of a linear trend-line as described above. The SAND2 model was developed to allow input of up to three different FWOP and three FWP loss rates. Because CWPPRA projects have a 20-year project life, implementation of CWPPRA projects may cause FWOP subunit loss rates to change several times. If several CWPPRA projects occur within a subunit, they may result in more than three FWOP loss rate changes over the 100-year SAND2 analysis period. In such cases, a weighted average was utilized to combine two similar loss rate periods. In many cases, FWP marsh restoration and marsh nourishment measures also resulted in more than three loss rate changes. In such cases, a weighted average was utilized to combine two similar loss rate periods.

<u>Predicting Wetland Benefits of the Mississippi River Diversion at Violet</u>

The evaluated Violet, Louisiana Freshwater Diversion was assumed to operate year-round at 1,000 cfs, except during the months of April and May, when it would operate at 7,000 cfs. During the 7,000 cfs pulsing flow, it was determined that the Central Wetlands would only receive 1,000 cfs and the remaining 6,000 cfs would flow directly toward the MRGO and into Lake Borgne. The UNO report determined that the maximum sediment deposition (at 1,000 cfs) was 30 percent of the total introduced sediment and the maximum nitrogen uptake was 50 percent of the total introduced nitrogen. Therefore, input nutrient load in the SAND2 model run for the Central Wetlands was reduced by 50 percent and sediment retention within the area was manually set to 30 percent of the total introduced suspended sediment load.

According to the UNO report, the South Lake Borgne marshes would receive a maximum 61 percent of the total river water inputs, a maximum 50.6 percent of the suspended sediment, and a maximum 46.4 percent of the introduced nitrogen. Therefore, the SAND2 model diversion inputs to this area were reduced to 61 percent of the total. Because the percent suspended sediment input was less than the percent water input, the sediment input was manually reduced to 83 percent of introduced water's sediment load (50.6 of the total sediment/61 of the total diversion discharge = 83 percent) Similarly, the nitrogen load was reduced to 76 percent (46.4 percent total nitrogen delivered/61 percent of the total water delivered).

The East Orleans Landbridge marshes were estimated to receive a maximum of 9 percent of the total diverted discharge, a maximum of 7.5 percent of the total nitrogen, and a maximum of 8.1 percent of the total suspended sediment load. For this area, the SAND2 model nitrogen input was reduced to 83.3 percent (7.5 percent of the total nitrogen/9 percent of the total diversion input), and the suspended sediment input was reduced to 90 percent (8.1 percent of the sediment/9 percent of the introduced water).

Although the UNO report indicated that the Inner Biloxi marshes would receive 34 percent of the total diversion flows, that estimate was reduced to 30 percent since 70 percent of the diversion flows were designated as going elsewhere (61 percent to the South Lake Borgne + Golden Triangle, and 9 percent to the East Orleans Landbridge). Because the UNO report indicated that the maximum sediment delivery would be 30.4 percent of the total, and the maximum nitrogen delivery would be 28.2 percent of the total, the SAND2 sediment inputs for the Inner Biloxi marshes were adjusted to 101 percent (30.4 percent of sediment/30 percent of the water), and 94 percent of the nitrogen (28.2 percent of introduced nitrogen/30 percent of the introduced water).

Whenever FWP marsh restoration measures were proposed within a diversion receiving area, the acres of created marsh were entered into the SAND2 model as FWP created acres so that the diversion model would predict benefits both the existing and created marshes. In those cases, the SAND2 model would report the benefits of both the diversion and affected marsh restoration measures.

In some subunits, FWP shoreline protection measures were proposed within a diversion receiving area. Diversion operations were assumed not to change shoreline loss processes or rates.

Predicting Wetland Benefits of Marsh Restoration Projects

A mathematical model or formula was developed to calculate net marsh restoration project benefits (net acres = future-with project acres minus FWOP acres). Formula inputs include: created acres, year constructed, loss rate (acre/year), subsidence, and FWP year benefits loss rate reverts.

Figure 2-4 depicts marsh restoration net benefits, FWOP acres, and FWP acres in relation to time. Acres are added to existing marsh acres in the FWP. The loss rate for the FWOP acres and the created acres will be added together for the FWP acres. After the FWOP acres reach zero, remaining acres will be lost at the loss rate for the created acres.

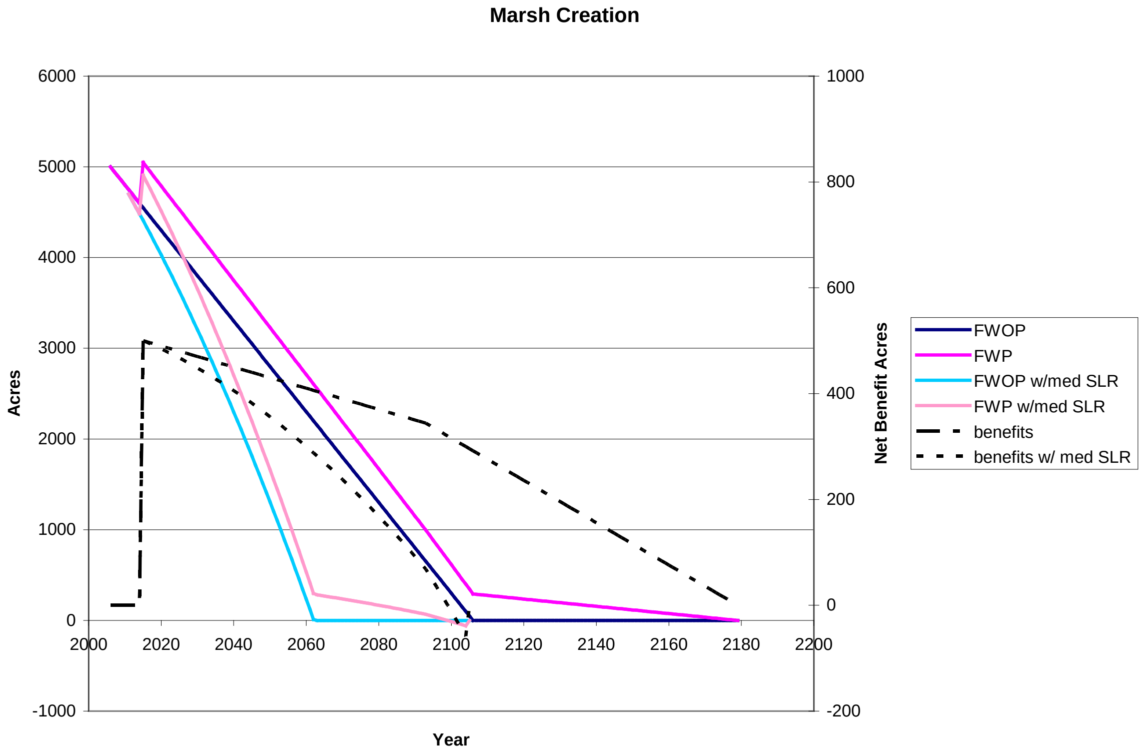


Figure 2-4: Marsh Restoration Net Benefits

Predicting Wetland Benefits of Marsh Nourishment Projects

A mathematical model or formula was developed to calculate net marsh nourishment project benefits (net acres = future-with project acres minus FWOP acres). Formula inputs include: total acres nourished, construction year, net annual benefit (acre/year), FWOP zero (the year when the FWOP marsh acreage has reached zero), subsidence, and FWP year benefits loss rate reverts.

Figure 2-5 depicts marsh nourishment net benefits, FWOP acres, and FWP acres in relation to time. The marsh nourishment project affects the area causing the land loss rate to be reduced by a factor of two. The net benefits are additive until the FWOP acreage reaches zero.

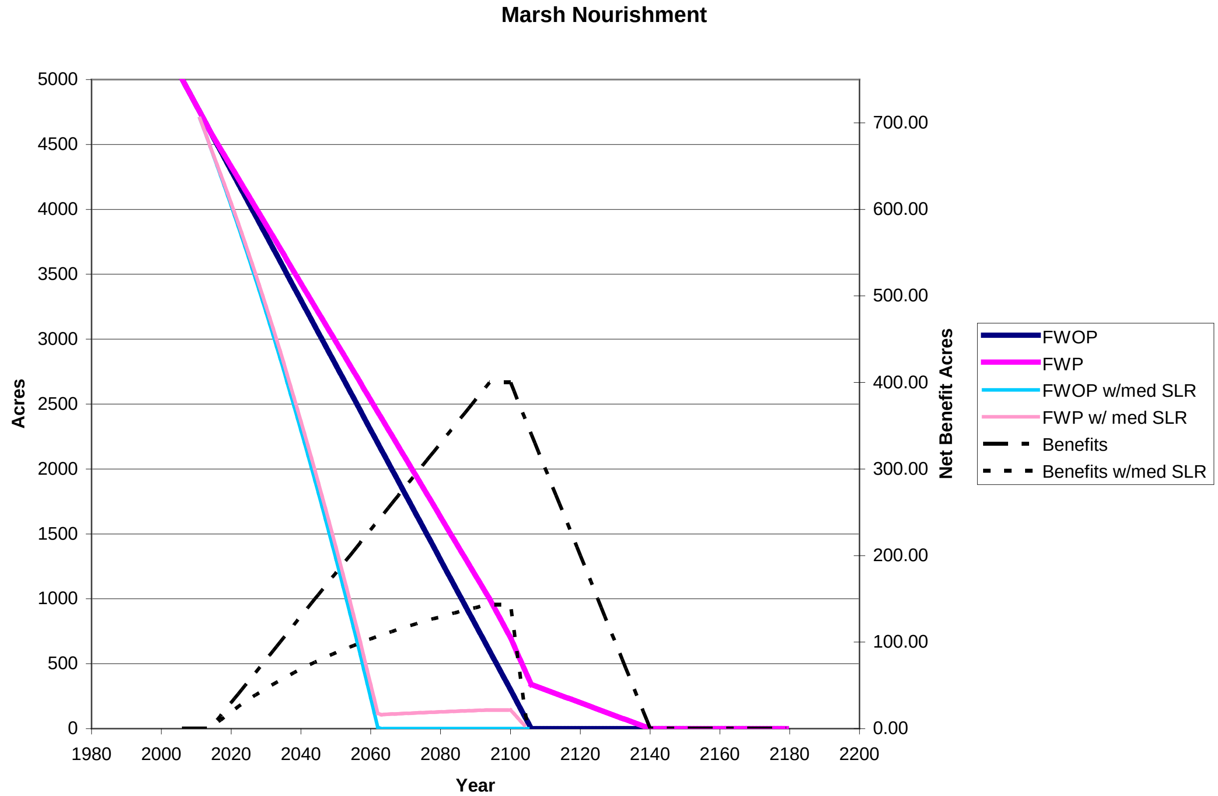


Figure 2-5: Marsh Nourishment Net Benefits

Predicting Wetland Benefits of Shoreline Protection Projects

A mathematical model or formula was developed to calculate net shoreline protection project benefits (net acres = future-with project acres minus FWOP acres). Formula inputs include: number of years benefitted, total acres, year constructed, max acreage benefitted, FWOP loss rate, FWP loss rate, and FWOP zero.

Figure 2-6 depicts shoreline protection net benefits, FWOP acres, and FWP acres in relation to time. Net benefits will accrue for the set length of time referred to as “years benefitted”. Benefits will level out and then decrease at the FWOP land loss rate once the FWOP project acreage reaches zero. Sea level rise is not considered in the shoreline protection models because it is assumed that the project is maintained as needed for 25 years.

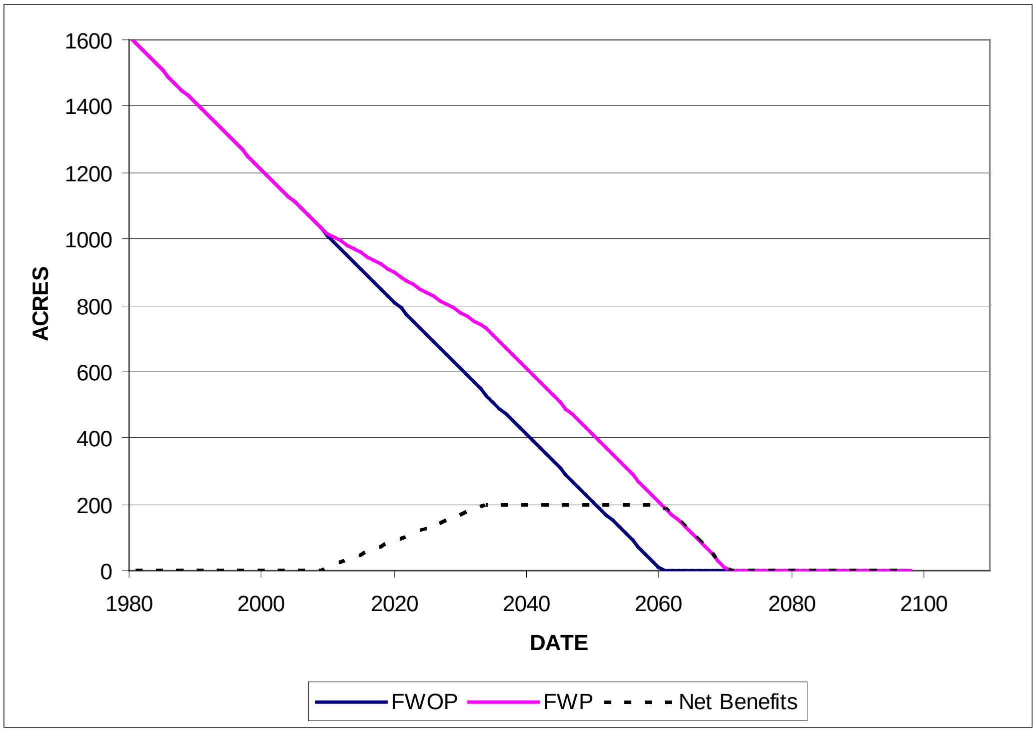


Figure 2-6: Shoreline Protection Net Benefits

Wetland Acreage Predictions Under Increased Sea Level Rise (SLR) Rates

For the medium and high scenarios, the future wetland loss rates were increased to simulate effects of increased wetland submergence. Using USACE-predicted future water levels (based on the Shell Beach gage) under medium and high SLR scenarios, those water levels were converted into RSLR rates, assuming that those water levels incorporate both subsidence and sea level rise effects. By subtracting the average accretion value of 0.3 inches per year (in/yr) (an average of accretion measurements obtained throughout the project area), from the year 2011 baseline RSLR rate of 0.4 in/yr, a net baseline submergence rate of 0.11 in/yr was calculated. Likewise, the 0.3 in/yr average accretion value was subtracted from predicted future submergence rates under both the medium and high SLR scenarios. To calculate future wetland loss rates under increased SLR scenarios, the baseline wetland loss rate, in acres lost per year, was multiplied by the year X submergence rate ratio (i.e., Submergence Rate Year X/Submergence Rate Year 2011).

Based on research conducted at the Madison Bay wetland loss hotspot in the Terrebonne Basin, it appears that when submergence reaches a certain critical threshold, plant productivity decreases rapidly and the marsh undergoes a rapid loss or collapse, when there is there inadequate sediment accretion to counter submergence. According to (Nyman et al., 2006), that threshold is 0.39 in/yr. Under the high SLR scenario, this submergence threshold is reached in year 2023. It was assumed that once that threshold was reached, the marsh would undergo rapid collapse and be totally converted to open water in 10 years. Consequently, under the high SLR scenario, marshes not receiving additional sediment would totally disappear by year 2033.

Collapse thresholds were not applied to the wetlands receiving increased input of suspended sediment from the proposed Violet, Louisiana Freshwater Diversion (i.e., the Central Wetlands, the south Lake Borgne marshes, East Orleans Landbridge, and the inner Biloxi marshes). For those areas, FWP acreages were determined using the SAND2 model benefits with high wetland loss rates due to accelerating submergence.

Assessment of Feature Sustainability under Relative Sea Level Rise

Features contained within the final array of alternatives were assessed on a Yes/No scale for each of the following four sustainability factors:

1. Elevation (Elev.) – Features at higher elevations are more sustainable under RSLR, e.g. ridges, than features at marsh elevation. (Y = features that are higher than marsh elevation; N = features that are at marsh elevation)
2. Freshwater influence (FW Influ.) – Features that are influenced by rivers or river diversions have a sustainable source of freshwater and sediment to nourish them and aid in accretion. (Y = features nourished by freshwater; N = features not nourished by fresh water)
3. Wave energy – Features that are protected from wave energy (e.g. interior marsh) are more sustainable than features subjected to high wave energy. (Y = features protected from high wave energy; N = features not protected from high wave energy)
4. Natural features – Features that are natural, living features of the ecosystem such as marsh are more sustainable than hard structures such as rock that subside more quickly and cannot sustain themselves and therefore require more operations and maintenance (O&M). (Y = natural features; N = hard features)

After each feature or groups of features was assessed for each sustainability factor, the feature was assigned numerical and qualitative scores as follows:

- Sustainability factors were convert to points: Yes (Y) = 1 point. No (N) = 0 points. If a feature included more than one component and received a Yes score for one component and a No score for the other component, it received a half point.
- Points were then totaled and converted into a qualitative score as follows: 0 = Poor; 1 = Fair; 2 = Good; 3 = Very Good; 4 = Excellent.

Table 2-12 summarizes the sustainability of each restoration feature under RSLR.

Table 2-12: Sustainability Under Relative Sea Level Rise by Feature

Area	Measure	Alternatives	Sustainability Factors				Score	
			Elev.	FW Influ.	Wave Energy	Natural feature		
Biloxi Marsh	BR1	B, C, D	Y	Y	Y	Y	4	Excellent
	BS1	C, D	N	N	N	N	0	Poor
	BS2	C, D	N	N	N	N	0	Poor
	BS3	D	N	N	N	N	0	Poor
	BM1	C, D	N	Y	N	Y	2	Good
MRGO	MRGO1	B, C, D	N	N	N	N	0	Poor
	MRGO2	B, C, D	N	N	N	N	0	Poor
	MRGO3	B, C, D	N	N	N	N	0	Poor
	MRGO4	B, C, D	N	N	N	N	0	Poor
	MRGO5	B, C, D	N	Y	N	Y/N	1.5	Fair/Good
	MRGO6	B, C, D	N	N	N	N	0	Poor
	MRGO7	B, C, D	N	Y	N	Y/N	1.5	Fair/Good
Central Wetlands	CC1 - CC6	B, C, D	Y	Y	Y	Y	4	Excellent
	CM1- CM5	C, D	N	Y	Y	Y	3	Very Good
East Orleans Landbridge	EM1	B, C, D	N	N	N	Y	1	Fair
	EM2	B, C, D	N	Y	N	Y	2	Good
	EM3	C, D	N	Y	Y	Y	3	Very Good
	EM4	C, D	N	Y	N	Y	2	Good
	EM5	D	N	N	N	Y	1	Fair
	ES1	C, D	N	N	N	N	0	Poor
	ES2	C, D	N	N	N	N	0	Poor
	ES3	C, D	N	N	N	N	0	Poor
	EV1	D	N	N	N	N	0	Poor
South Lake Borgne	LM1	B, C, D	N	Y	N	Y	2	Good
	LM2	B, C, D	N	Y	N	Y	2	Good
	LM3	B, C, D	N	Y	N	Y	2	Good
	LM4	C, D	N	Y	Y	Y	3	Very Good
	LS1	C, D	N	N	N	N	0	Poor
Terre aux Boeufs	TM1	B, C, D	N	N	Y	Y	2	Good
	TM2	B, C, D	N	N	Y	Y	2	Good
	TM7	C, D	N	N	Y	Y	2	Good
	TM8	C, D	N	N	Y	Y	2	Good
Hopedale	HM1	C, D	N	N	Y	Y	2	Good

If the sustainability scores are averaged, alternatives B, C, and D are all in the range of Fair to Good sustainability. All alternatives include the most sustainable types of features, i.e., the cypress swamp and ridge habitat. The smallest plan, alternative B is marginally more sustainable simply because it includes the least number of features. For alternatives C and D, sustainability decreases marginally as less sustainable features, such as shoreline protection, are added.

Since alternatives B, C, and D cannot be substantially differentiated based on relative sea level rise, a detailed WVA analysis of the three RSLR scenarios was only performed on the tentatively selected plan (alternative C). **Table 2-13** below shows the net acres projected under each of the three RSLR scenarios based on feature locations.

Table 2-13: Robustness of Features in Tentatively Selected Plan Under all Relative Sea Level Rise Scenarios

Feature Location	**Net Acres**			**Robust Under all Scenarios?**
	Low RSLR	**Medium RSLR**	**High RSLR**	
Lower Pearl River	1,056	905	0	No
East Orleans Landbridge	819	642	0	No
MRGO Channel	95	75	0	No
South Lake Borgne	6,326	5,031	0	No
Central Wetlands Swamp	3,793	4,914	7,340	Yes
Central Wetlands Marsh	6,478	4,785	0	No
Terre aux Boeufs	2,937	2,165	0	No
Hopedale	244	181	0	No
Bayou La Loutre Ridge	14	25	48	Yes
Biloxi Marsh	2,809	2,220	0	No
Biloxi Marsh Outer Shoreline	49	48	0	No

Although it may seem counterintuitive that the net acres for ridge and swamp increase as RSLR increases, the reason is that the WVA calculation subtracts existing and future marsh acres from the ridge and swamp footprints. As RSLR increases, the marsh acres decrease; therefore, the ridge and swamp net acres increase. Another difference is in the marsh and swamp WVA calculations. The marsh WVAs take into account changing water to land ratios over time, while the swamp WVA procedures simply multiply quality by total project area. In general, ridge and swamp are more sustainable than marsh because they have a higher elevation and would be less affected by RSLR. In general, the most sustainable features will be those will higher elevations; features being nourished by diversions; and the diversion itself.

2.4.1.2 Sustainability

The benefits analysis utilized for the MRGO Ecosystem Restoration Plan considers sustainability inherently. Because the WVA methodology utilizes historic land loss rates in the calculation of benefits, areas that have historically been more susceptible to risks such as tropical storms, subsidence, and sea level rise, will have fewer AAHUs than areas that have not been as susceptible to these factors. The SAND2 methodology accounts for the greater sustainability of features nourished by the freshwater diversion by assigning more AHHUs to features in the diversion influence area. Additionally, the WVA methodology assigns greater benefits to features that include natural vertical accretion than protection features like shoreline protection that require maintenance.

The initial WVA analysis was conducted for each feature individually and did not consider synergies with other restoration projects proposed as part of this plan. The initial WVAs did consider existing, authorized and planned projects that were included in the FWOP condition. The Violet Freshwater Diversion was assumed to be operational in 2015 in the analysis.

2.4.1.3 Costs

Preliminary costs were developed for measures remaining after initial screening. Material quantities were developed for each measure based on assumptions about existing land elevations, required containment dikes and interior weirs, access channels, borrow sources and shoreline protection sections. Further information on these assumptions can be found in the **appendix U**.

The preliminary cost estimates for the MRGO Ecosystem Restoration Plan Feasibility Study were prepared based on readily available New Orleans District data and quantities provided by Waterways Section, Civil Branch. The estimated costs were based upon an analysis of each line item evaluating quantity, production rate, and time, together with the appropriate equipment, labor, and material costs or the costs were based on in-house knowledge and experience by New Orleans District cost engineers who estimated similar projects. Cost Estimates were developed using historical data, CEDEP, and Mii estimating software.

The project consists of various combinations of marsh restoration, marsh nourishment, ridge restoration, swamp nourishment and shoreline protection. The marsh restoration, marsh nourishment, and swamp nourishment were constructed using typical dredge and fill techniques from nearby borrow sources such as interior bays, Lake Borgne, Lake Lery, Breton Sound, and the Mississippi River. It is anticipated that cutterhead pipeline dredges would excavate the native material and pump it to the project sites. The largest dredge that could do the work was typically chosen given the large quantities and long pump distances. Dredge size was limited by the available depth in the access route and the proposed borrow areas (24-inch to 30-inch dredge sizes assumed). Nourishment and restoration areas included earthen retention dikes, weirs, and earth and sheetpile closure structures as required. Given the remote locations of the projects, all work is assumed to be marine based. All materials for the shoreline protection alternatives will be delivered by barge. All features were estimated based on standard construction methods all of which are common to the New Orleans District and South Louisiana.

The estimates assumed access was available to proposed areas unless otherwise stated. Following preliminary planning, further investigations were made to verify accessibility assumptions. Each measure cost was developed independently and assumed equipment availability is not an issue. Contingencies of 20 to 30 percent were added to all cost estimates based on the level of uncertainty to produce conservative worst-case scenario costs for planning purposes while detailed engineering information was collected and analyzed. E&D of 4 percent and S&A of 6 percent were also added to each estimate. The initial costs developed for planning purposes reflected only construction costs and did not include real estate, OMRR&R, or adaptive management. Some costs changed when site specific geotechnical and survey data were applied. The cost-effectiveness of features was re-evaluated when detailed information became available. Costs were developed with October 2011 price levels using a four percent discount rate and 0.04655 amortization factor. The detailed cost-estimates did not significantly alter the cost-effectiveness of any plan feature.

Table 2-14 provides the costs and benefits generated for the formulation and analysis of plans.

Table 2-14: Measures Retained for Plan Formulation

Geographic Area	Measure Label	Total AAHU	Annual Cost
E. Orleans Landbridge	010a	147	1,318,785
E. Orleans Landbridge	010b	578	7,610,542
E. Orleans Landbridge	011	156	648,743
E. Orleans Landbridge	007	89	1,889,288
E. Orleans Landbridge	009	500	2,385,457
E. Orleans Landbridge	005sp	74	758,201
E. Orleans Landbridge	006sp	77	958,944
E. Orleans Landbridge	007sp	188	3,012,971
E. Orleans Landbridge	090	15	330,464
S. Lake Borgne	028	84	1,236,516
S. Lake Borgne	014	832	5,911,103
S. Lake Borgne	015a	551	2,348,644
S. Lake Borgne	008sp	128	1,979,597
S. Lake Borgne	015c	569	1,965,753
S. Lake Borgne	030sp	7	130,898
S. Lake Borgne	Fill in MRGO[1]	1,932	159,995,564
MRGO Channel	099	0.01	143,223
MRGO Channel	100	0.02	813,422
MRGO Channel	024	22	1,400,723
MRGO Channel	021	20	340,306
MRGO Channel	022	20	326,590
MRGO Channel	025	7	175,561
MRGO Channel	027	32	1,770,019
MRGO Channel	026	40	2,736,228
MRGO Channel	087	5	316,098
MRGO Channel	104	3	104,483
Central Wetlands	025a	271	6,207,018
Central Wetlands	025b	134	3,283,973
Central Wetlands	026a	158	5,020,967
Central Wetlands	026b	303	2,856,953
Central Wetlands	026c	136	1,446,291
Central Wetlands	026d	33	1,350,766
Central Wetlands	026e	196	14,406,107
Central Wetlands	027a	369	7,055,378
Central Wetlands	027b	384	8,860,530
Biloxi	081	373	5,873,225
Biloxi	042	73	6,446,604
Biloxi	020	159	4,796,356
Biloxi	010sp[2]	100	1,397,042
Biloxi	011sp[2]	91	566,508

Table 2-14: Measures Retained for Plan Formulation

Geographic Area	Measure Label	Total AAHU	Annual Cost
Biloxi	013sp[2]	179	2,639,700
Biloxi	014sp	142	4,414,464
Biloxi	98asp	66	2,171,273
Biloxi	98bsp	120	4,863,397
Biloxi	111sp	58	1,901,045
Biloxi	017sp	31	1,239,152
Biloxi	107sp	35	1,223,905
Biloxi	029asp[3]	137	2,084,680
Biloxi	110	130	4,994,804
Bayou La Loutre Ridge	133a	8	865,399
Bayou La Loutre Ridge	133a + 133b	14	1,510,834
Terre aux Boeufs	002a	358	2,266,837
Terre aux Boeufs	002b	823	9,815,257
Terre aux Boeufs	002c	552	5,087,244
Terre aux Boeufs	245	1,545	4,829,628
Terre aux Boeufs	243[4]	425	1,354,619
Terre aux Boeufs	244[4]	984	4,217,112
Terre aux Boeufs	241[4]	1,051	5,186,676
Terre aux Boeufs	242[4]	972	2,066,854
Florissant	191	12	1,576,410
Hopedale	190	186	2,054,465
Jetty Realignment	029bsp + 028[5]	232	3,392,549

Notes:
[1] Exclusive of other MRGO measures.
[2] Subsequently removed from consideration as the State of Louisiana is planning to build these features with surplus funds.
[3] Due to survey findings that water depths are infeasible for traditional foreshore protection, measure was changed to oyster reef restoration.
[4] Subsequently removed due to impacts to oyster reefs and seed grounds.
[5] Due to survey findings, this measure was removed from further consideration.

2.4.1.4 Relative Sea Level Rise Considerations

Potential increases in RSLR, as noted in the future without project conditions, could impact the costs and benefits developed for these features. These potential impacts and associated OMRR&R and/or adaptive management actions were assessed for all of the features retained for plan formulation. OMRR&R actions for shoreline protection features were calculated as part of the project costs. Additional adaptive management measures associated with increased RSLR scenarios were also incorporated into the project costs for shoreline protection features.

For marsh restoration features, a ratio of 64 percent land to 36 percent water was used as a threshold for when re-nourishment would be required. The land/water ratio is based on the total amount of land remaining in any feature at the end of a period of analysis.

The land/water ratio is based on standard practices used in Louisiana coastal wetlands restoration. The WVA methodology for coastal marsh community models outlines six variables used in determining project benefits. Of the six WVA variables, Variable V3, marsh edge and interspersion, addresses habitat values as a ratio of land to water expressed as a marsh class. Variable V3 was used to determine the threshold for marsh restoration adaptive management actions associated with increased relative sea level rise. Variable V3 takes into account the relative juxtaposition of marsh and open water for a given marsh to open water ratio, and is measured by comparing the project area to sample illustrations depicting different degrees of interspersion. Interspersion is especially important when considering the value of an area as foraging and nursery habitat. Certain interspersion classes can be indicative of marsh degradation, a factor taken into consideration in assigning suitability indices to the various interspersion classes.

A relatively high degree of interspersion in the form of tidal channels and small ponds (Class 1) is assumed to be optimal; tidal channels and small ponds offer interspersion, yet are not indicative of active marsh deterioration. Numerous small marsh ponds (Class 2) offer a high degree of interspersion, but can be indicative of the onset of marsh break-up and deterioration, and are therefore assigned a lower SI of 0.6. Large ponds (Class 3) and open water areas with little surrounding marsh (Class 4) offer lower interspersion values and usually indicate advanced stages of marsh loss. Also grouped within Class 3 are areas of “carpet” marsh which contain no or relatively insignificant tidal channels, creeks, trenasses, ponds, or other features of interspersion but may still provide habitat for aquatic organisms during tidal flooding. Class 5 is characterized by very small marsh islands (i.e., less than 5 percent emergent marsh) or areas made up entirely of open water.

Habitat of this type provides little to no marsh edge and its function as nursery habitat for marine organisms or foraging habitat for avian predators has been significantly reduced. Although habitats represented by this classification are predominantly unvegetated open water areas, they still provide habitat for many fish and shellfish species and provide loafing areas for waterfowl and other waterbirds. Also grouped within Class 5 are areas characterized as solid land with no interspersion features and little to no vegetation. Newly created marsh with no ponds, creeks, or other tidal features would fall within this class.

The descriptions provided in the WVA methodology use aerial photographs of representative sites to guide the visual assessment of the quality or state of any particular wetland habitat. The representative photo used to assess the land to water ratio as a percentage for OMRR&R and adaptive management estimates is Interspersion Class 2. A ratio was developed from the photo and the result was a ratio of 64 percent land to 36 percent water.

The 50 year land loss totals for the MRGO restoration project were calculated by USFWS using the three levels of RSLR. Total numbers under the low and medium RSLR rates shows there are no instances where OMRR&R would be required for marsh restoration and nourishment areas when using the land to water ratio of 64 percent to 36 percent. The total amount of land remaining for any single project feature at the end of 50 years for the low RSLR is no less than 83 percent. The total amount of land remaining for any single project feature at the end of 50 years for the medium RSLR is no less than 69 percent. OMRR&R and adaptive management measures would address risks and uncertainties.

Under the high sea level rise rate, all wetland restoration features lose significant amounts of land below the 64 percent threshold, and all shoreline protection features would require significant adaptive management actions. Because it has been determined that the submergence threshold is reached in year 2023 under the high RSLR rate, it was determined that land/water ratios should be monitored to determine if the high RSLR scenario is occurring. Implications of RSLR at the high rate to infrastructure in coastal areas throughout the nation would be significant. If land/water ratios trends indicate the high RSLR rate is occurring, Federal investment in construction would cease and the OMRR&R plan would require significant changes to maintain project benefits.

2.5 COST EFFECTIVENESS/INCREMENTAL COST ANALYSIS

A Cost Effectiveness/Incremental Cost Analysis (CE/ICA) was conducted to evaluate the benefits of alternative plans as related to cost and identify the plans that provide the greatest benefits with the least amount of incremental cost. “Cost effective” refers to the plan that costs less and yields more output for less money than the other alternatives. Subsequently, through incremental cost analysis, a variety of alternatives are evaluated to arrive at a “best” level of output within the limits of both the sponsor’s and the USACE’s capabilities.

The subset of cost effective plans were examined sequentially (by increasing scale and increment of output) to determine which plans were more efficient and achieved the greatest benefits. These plans are called “Best Buys.” “Best Buy” plans provide the greatest increase in output at the lowest average cost and have the lowest incremental costs per unit of output.

In most analyses, there are multiple Best Buy plans. As the outputs produced increase in the Best Buy plans, the average costs per unit of output and incremental costs per unit of output increase as well. As a result, the incremental analysis does not point to the selection of any single plan. The results must be considered with other decision-making criteria such as significance of outputs, acceptability, completeness, effectiveness, risk and uncertainty, and reasonableness of costs to support the selection and recommendation of a particular plan.

2.5.1 Institute for Water Resources (IWR) Plan Steps

The USACE’s Institute for Water Resources (IWR) has developed procedures and software for conducting CE/ICA. IWR-PLAN Decision Support Software was used in performing the CE/ICA. As a result of the computational limitations of the IWR-PLAN software, over 50 individual measures could not be run in the IWR-PLAN at the same time (combining all measures). Therefore, separate runs in each major geographic area were made to reduce the number of possible combinations and meet the limitations of the IWR-PLAN software.

Some scale of restoration in each of these geographic areas was considered necessary to address the portions of the study authority to "restore the areas affected by the navigation channel" and "restore natural features of the ecosystem that will reduce or prevent damage from storm surge."

The Biloxi Marsh geographic area consists of Subunits 07 - Biloxi Marshes Interior, and 18 - Eloi Bay. These subunits compose a unique geomorphologic feature that has been identified as a critical landscape feature for storm surge damage risk reduction and is technically significant, in terms of scarcity and connectivity, as a geologic barrier for storm surge reduction (USGS 1994, USACE 2009, Walmsley et al. 2009, Howes et al. 2010, Shepard et al. 2011). The Biloxi Marsh also supports oyster reef habitat, which is arguably the most imperiled marine habitat on earth (Beck et al. 2011). This area is institutionally significant because it is protected by significant legislation promoting the conservation of the nation's wetlands and estuaries in general, and the significance of the Gulf of Mexico ecosystem as recognized by President Obama's administration in particular (EPA et al. 2011). This area is publically significant because of its recreational value and importance as an area that can "potentially reduce the loss of life and property due to flooding" (Burkett et al. 2002). The primary problems in this area are the lack of freshwater and sediment, and wind driven shoreline erosion. Unlike other subunits, this area has relatively low subsidence rates due to its unique geomorphology. The Bayou La Loutre Ridge is located in the Biloxi Marsh subarea; however, because it was determined that some scale of ridge needed to be included in the plan, these restoration features were evaluated in IWR-PLAN separately.

The East Orleans/South Lake Borgne geographic area is composed of Subunits 36a - Pearl River Mouth – LA, 17 - East Orleans Landbridge, 05 - Bayou Sauvage, 40 - South Lake Borgne and 26 - Lake Borgne. Subunits 36a, 17, and 05 form the East Orleans Landbridge area. This area is recognized as a critical landscape feature with respect to storm surge damage risk reduction (USGS 1994, USACE 2009, Walmsley et al. 2009, Howes et al. 2010, Shepard et al. 2011). Subunit 40 - South Lake Borgne covers the MRGO/Lake Borgne Landbridge, the strip of marsh separating the MRGO from the lake. The spatial integrity of the MRGO/Lake Borgne Landbridge was compromised by the construction of the channel. South Lake Borgne is considered a critical landscape feature to protect the form and function of the estuary, which is recognized as an institutionally significant resource by President Obama's administration. These subunits were grouped together because the areas are contiguous and create a structural framework for the estuary. This landscape feature is publically important because of its role in the potential reduction loss of life and property due to flooding and recreational value. There are numerous state, local, and NGO plans for restoration that demonstrate this significance (LPBF 2006, Lopez 2006, Day et al. 2006, Lopez et al. 2010). Because these areas are important to the overall integrity of the estuary, IWR-PLAN was used to facilitate the development of the most cost-effective combination of measures for all components of the area.

The Terre aux Boeufs/Hopedale geographic area is composed of Subunits 23 - Jean Louis Robin, and 21 - Hopedale. These subunits are south of the MRGO and have been primarily affected by the channel through the placement of spoil material and hydrologic changes. Bayou Terre aux Boeufs forms the boundary of Subunit 23, and is considered to be the southeast boundary of the hydrologic impacts of the channel. This area is technically significant because it contributes to the spatial integrity of the ecosystem (USGS 1994, USACE 2009, Walmsley et al. 2009, Howes et al. 2010, Shepard et al. 2011). This area also supports imperiled oyster reef habitat (Beck et al. 2011). The significant legislation protecting estuarine and wetland resources, President Obama's and previous Presidential administration's commitments to this ecosystem demonstrate it is an institutionally important resource. The area's public importance is recognized by its inclusion in several Federal, state, and local restoration plans.

The Central Wetlands (Subunit 13) is isolated from the rest of the study area by levees and floodgates, and was considered a separate geographic area for this reason. Additionally, the Central Wetlands presents a unique set of problems and opportunities because of its proximity to the Mississippi River and the containment provided by the levees. Similarly, the Florissant area (Subunit 19) is isolated from other portions of the study area, and was therefore evaluated separately.

The restoration of the Central Wetlands is important to achieve the goals and objectives of this study because of the magnitude of the effects of the channel in this area and the significant resources it historically supported. The channel was excavated and spoil material was placed on the northeastern border of this subunit. The resulting saltwater intrusion resulted in the mortality of the remaining cypress forest and fresh marsh in the area. Fresh marsh is ranked as imperiled by the Louisiana Natural Heritage Program because it has undergone the largest reduction in acreage of any of the marsh types in the state over the past 20 years due to saltwater intrusion, demonstrating its technical, institutional and public significance (LDWF 2011).

The following describes the steps that were taken to identify the most cost efficient plans.

Step 1 – Four separate CE/ICA runs were made for each of the following geographic areas:

- **Biloxi Marsh** (three marsh areas; ten shoreline segments)
- **MRGO** (eight narrowing/shoreline features)
- **East Orleans/South Lake Borgne** (nine marsh areas; four shoreline segments; SAV measure)
- **Terre aux Boeufs/Hopedale** (five marsh areas and 1 shoreline protection feature)

Step 2 – The incremental cost box graphs (incremental cost per unit vs. output) for the above areas were evaluated and a subset of Best Buy plans for each geographic area were selected to run as scales in a combined IWR run. Scales were selected as follows:

- **Minimum scales –** Selected Best Buy plans that contained at least two measures, i.e. plans with only one measure were not selected.

- **Intermediate scales –** Selected one or more plans based on cost effective increments, i.e. where large amount of outputs could be gained for minimal additional cost.
- **Maximum scales –** In order to develop the full cost effectiveness curve, the largest Best Buy Plan was always selected, i.e. plan that contained all measures in that group.

Step 3 - Repeated the CE/ICA using scales of alternatives as described below:

- **Biloxi Marsh –** four scales selected based on Steps 1 and 2.
- **MRGO –** five scales based on Steps 1 and 2; in addition, backfilling in the MRGO channel between Bayou Bienvenue and Bayou La Loutre was added as a scale for a total of six scales.
- **East Orleans/South Lake Borgne –** five scales based on Steps 1 and 2.
- **Terre aux Boeufs/Hopedale –** three scales based on Steps 1 and 2.
- **Ridge –** Partial ridge vs. full ridge – two scales.
- **Florissant –** one scale.
- **Central Wetlands –** Swamp only vs. swamp plus marsh – two scales.

All solutions were combinable. In Step 3 of the CE/ICA, each plan was formulated to contain at least one scale of ridge and one scale of Central Wetlands.

As noted previously, one limitation of the WVA model is that all habitat types are considered to have equal value. In an abstract evaluation of cost per AAHU, the restoration measures proposed for the Central Wetlands and the remnant Bayou La Loutre Ridge were not as effective as many of the measures in other areas. However, the inclusion of some restoration measure in these areas is considered necessary to fulfill the requirements of the study authority.

- The former MRGO navigation channel was constructed through the Central Wetlands and the Bayou La Loutre Ridge, directly impacting these areas.
- The Central Wetlands is the only area in the immediate vicinity of the MRGO that could support cypress swamp habitat.
- The only natural ridge in the immediate vicinity of the MRGO is the Bayou La Loutre Ridge.
- Cypress swamp and coastal ridge habitat are increasingly scarce and provide unique habitat and ecological functions.
- The restoration of cypress swamp in the Central Wetlands is widely supported by the adjacent communities, non-governmental organizations (NGOs), state and local government, and resource agencies.

The inclusion of some scale of restoration in these areas was integral to the development of the plan. This constraint was added to the IWR-PLAN formulation process to ensure the program produced a wide range of alternatives that met the study objectives.

2.5.2 Institute for Water Resources (IWR) Plan Results

IWR-PLAN generated 6,721 plan combinations. Including the no action alternative (Plan #1), there were 285 cost-effective plans and 19 Best Buy plans with costs up to $6.5 billion. **Table 2-15** lists the descriptions of each of the Best Buy plans. A summary of the costs and benefits associated with the plans generated in IWR is provided in **table 2-16**.

Table 2-15: Best Buy Plan Descriptions

Best Buy	Description
1	No action.
2	Central Wetlands: Cypress measures CC1-CC6 and Violet Diversion South Lake Borgne: LM1-3 East Orleans Landbridge: EM1 and 2 MRGO: MRGO 1-7 Biloxi Marsh: BR1 Bayou Terre aux Bouefs: TM1-2, JS1 (later determined to be infeasible due to water depths)
3	BB2 plus TM7, TM8, HM1
4	BB3 plus EM3 and 4, ES1 and 2
5	BB4 plus CM1-5
6	BB5 plus BM1, BS1, BS2
7	BB6 plus LM4, ES3, LS1
8	BB7 plus MRGO1-2 (later included in all action plans)
9	BB8 plus EM5, EV1
10	BB9 plus BS3
11	BB10 plus MRGO3-4 (later included in all action plans)
12	BB11 plus additional shoreline protection in Biloxi Marsh
13	BB12 plus MRGO5 (later included in all action plans)
14	BB13 plus MRGO6-7 (later included in all action plans)
15	BB14 plus MRGO8 (later included in Plans C and D)
16	BB15 plus backfilling MRGO to marsh elevation from Bayou Bienvenue to Bayou La Loutre
17	BB16 plus additional shoreline protection in the Biloxi Marsh
18	BB17 plus additional ridge restoration
19	BB18 plus Florissant

Table 2-16: Best Buy Plans

Plan #	Output (HU*)	Annual Cost	Average Cost ($/HU)	Incremental Cost ($)	Incremental Output (HU)	Incremental Cost per Output
1	0.00	0.00				
2	6,132	65,660,087	10,708	65,660,087	6,132	10,708
3	7,693	82,617,053	10,739	16,956,966	1,561	10,863
4	8,569	93,263,525	10,884	10,646,472	876	12,154
5	9,173	101,670,185	11,084	8,406,660	604	13,918
6	9,862	112,267,790	11,384	10,597,605	689	15,381
7	10,262	118,496,874	11,547	6,229,084	400	15,573
8	10,302	119,163,770	11,567	666,896	40	16,672

Table 2-16: Best Buy Plans

Plan #	Output (HU*)	Annual Cost	Average Cost ($/HU)	Incremental Cost ($)	Incremental Output (HU)	Incremental Cost per Output
9	10,406	121,383,522	11,665	2,219,752	104	21,344
10	10,591	125,718,961	11,870	4,335,439	185	23,435
11	10,601	125,999,005	11,886	280,044	10	28,004
12	11,342	151,603,401	13,367	25,604,396	741	34,554
13	11,374	153,373,420	13,485	1,770,019	32	55,313
14	11,401	155,090,241	13,603	1,716,821	27	63,586
15	11,441	157,826,469	13,795	2,736,228	40	68,406
16	13,224	310,652,025	23,492	152,825,556	1,783	85,713
17	13,297	317,098,629	23,847	6,446,604	73	88,310
18	13,303	317,744,064	23,885	645,435	6	107,573
19	13,315	319,320,474	23,982	1,576,410	12	131,368

*Habitat Unit

The Best Buy plans that were generated in IWR-PLAN addressed the goals and objectives of the study in varying degrees. The PDT determined that the plans included for further consideration should be selected from the Best Buy plans, as all of these plans maximize restoration benefits for the associated costs.

2.5.3 Selection of the Final Array of Alternatives

See Section 2.7.3 of the feasibility report for a detailed description of the selection of the final array of alternatives. In addition to the No Action Plan (plan #1), three Best Buy plans were selected for the final array. Best Buy plans #2, #7, and #10 (alternative B, C, and D, respectively) were chosen based on cost effective increments, i.e. where large amount of outputs could be gained for minimal additional cost. These plans also represent a wide range of costs and outputs. A brief description of Best Buy Plans #2 through #19 follows.

Best Buy Plan #2 (alternative B) was selected for further consideration because it was the least costly Best Buy Plan. Alternative B does not achieve all of the goals of the study, but it does include some restoration measures for all of the targeted habitat types. Alternative B would restore or protect 9,518 acres of fresh and intermediate marsh, 10,253 acres of brackish marsh, 10,431 acres of cypress swamp, and 257 acres of saline marsh. Alternative B does not meet the target acre objectives for brackish marsh. Additionally, 11,424 acres of brackish marsh would be converted to another habitat type that would not be restored elsewhere in the study area. Therefore, it did not meet the objective to add to the total amount of each habitat type in the study area by compensating for any habitat switching. Alternative B did not contain any features in the Biloxi Marsh and only includes one feature on the East Orleans Landbridge; therefore, alternative B does not fully address the objective to restore and protect critical landscape features for storm surge reduction.

Best Buy Plans #3 to #5 also do not meet the objectives for brackish habitat, habitat switching objectives, or contribute substantially to the restoration and protection of the East Orleans Landbridge and the Biloxi Marsh. Therefore, these plans were not considered further.
Best Buy Plan #6 includes restoration features in the Biloxi Marsh and more features that protect the East Orleans Landbridge. Plan #6 does not meet the target for increasing brackish marsh.

Best Buy Plan #7 (alternative C) is the first Best Buy Plan that meets all of the objectives, including reasonably maximizing restoration and protection of the Biloxi Marsh and East Orleans Landbridge. Therefore, alternative C was selected for further evaluation in the final array of alternatives because it is a complete plan for the Lake Borgne ecosystem and the areas affected by the MRGO. Alternative C was the first Best Buy plan to include Feature LS1, which is a key Lake Borgne restoration component. Feature LS1 would work synergistically with the Bayou Dupre and west of Shell Beach shoreline protection features currently under construction, and Feature LM2 to restore and protect the Proctor Point area. Alternative C addresses the gaps left by existing and authorized restoration projects. Alternative C includes the necessary shoreline protection and marsh restoration features to form a complete plan for the ecosystem.

Best Buy Plan #8 includes more shoreline protection features in the MRGO.

Best Buy #9 includes the additional features in Best Buy #8 as well as additional features in the East Orleans Landbridge.

Best Buy #10 (alternative D) includes the features in Plans #8 and #9, and also adds additional shoreline protection in the Biloxi Marsh. Because of these additions, alternative D improves upon alternative C by further protecting these critical landscape features, and better meets the storm surge objective. Alternative D was included for further evaluation because it was the first Best Buy after alternative C to include more measures to protect both of these critical landscape features.

Best Buy Plan #11 adds additional protection features along the MRGO/Lake Borgne Landbridge. The incremental cost difference between Best Buy Plans #10 and #11 is relatively small. However the incremental cost per unit of output is relatively low.

Best Buy Plan #12 includes the features in plan #11 and increases the amount of shoreline protection and marsh restoration in the Biloxi Marsh at a relatively low incremental cost. However, it was determined that alternative D met the storm surge objective, and that plan #12 would not be carried forward, although it may better meet this objective. Potential risks and uncertainties regarding extensive foreshore protection in the Biloxi Marsh were raised by Federal cooperating partner agencies, and were an additional consideration in the decision to not carry this alternative forward.
The incremental costs associated with Best Buy Plans #13 to #15 were not considered reasonable for the relatively minor amount of associated benefits. Plan #16 provides a

substantial increase in benefits, but the total estimated construction costs for plan #16 were considered too great for the associated ecosystem outputs. Best Buy Plans #17 to #19 were considered too costly for the incremental benefits provided.

Table 2-17 summarizes the Final Array of Alternatives estimated construction costs, AAHUs, and acres restored.

Table 2-17: Final Array of Alternatives

Plan	Estimated Construction Cost[1]	Measure AAHUs[2]	Plan AAHUs[3]	Acres Restored[4]
A	$0	0	0	0[5]
B	$1.7 B ($67 M annual)	6,008	13,608	30,250
C	$2.9 B ($124 M annual)	10,324	17,575[6]	58,861
D	$3.1 B ($130 M annual)	10,399	17,116	59,823

NOTES:
1. Based on preliminary costs. Does not include real estate, OMRR&R, or adaptive management costs.
2. The AAHUs presented in this column are the total AAHUs of all measures in the plan added together and does not consider interactions between restoration features, except for whereas influenced by the freshwater diversion. The influence of the authorized Violet Freshwater Diversion was considered in the calculation of all benefits in this table.
3. The AAHUs in this column are based on the Wetland Value Assessments (WVAs) for the entire plan, and does consider synergies.
4. The acres in this column are the total acres restored, nourished, and protected by the plan.
5. The table shows only the costs and benefits associated with this plan. Therefore, all values are zero for the no-action plan.
6. This number is reflective of the initial WVAs that were performed for the project in the plan formulation phase. WVAs were revised for the Tentatively Selected Plan based on a revised WVA methodology. In this final plan analysis, the Violet Freshwater Diversion was assumed operational in 2027. The total AAHUs for Plan C considering synergies is now 33,839 because the revised methodology considers the value of existing habitat, significantly increasing total benefits.
The historic rate of sea level rise was selected for primary display of ecological benefits in this table because this rate is supported by data.

Table 2-18 below provides a summary of measures contained within each alternative plan.

Table 2-18: Restoration Features Included in the Final Array

Area	Measure	Description	Plan B	Plan C	Plan D
Biloxi Marsh	BM1	8,000 acres of marsh nourishment along the south shore of Lake Borgne. 11 million cubic yards of material would be obtained from South Lake Borgne Borrow Cycle 6.		Y	Y
	BS1	Approximately 50,637 linear feet (9.5 miles) of shoreline protection along the southeast shore of Lake Borgne. This feature begins at the northern terminus of the Biloxi Marsh Shoreline Protection Project (PO-72) south of Point aux Marchettes and extends north to Malheureax Point.		Y	Y
	BS2	Approximately 30,750 linear feet (5.8 miles) of artificial oyster reef development on the Chandeleur Sound side of the Biloxi Marsh between Eloi Point and the mouth of Bayou La Loutre.		Y	Y
	BS3	67,623 linear feet (12.8 miles) of shoreline protection extending from the south shore of Treasure Bay, around Point Paulina and Point Lydia to the north side of the mouth of Bayou La Loutre.			Y
	BR1	Approximately 54.1 acres of ridge restoration on the south bank of Bayou La Loutre. 400,000 cubic yards of silty sand material to be obtained from the Mississippi River between river miles 83R and 85R.	Y	Y	Y

Table 2-18: Restoration Features Included in the Final Array

Area	Measure	Description	Plan B	Plan C	Plan D
MRGO	MRGO1	3,850 feet (0.75 miles) of new foreshore protection between MRGO miles 56.6 and 57.4. This stone protection feature is embedded within the limits of MRGO7.	Y	Y	Y
	MRGO2	Repair and maintenance of approximately 21,630 linear feet (4.1 miles) of foreshore protection between Mile 44.5 and 40 of the MRGO.	Y	Y	Y
	MRGO3	Repair and maintenance of existing approximately 26,650 linear feet (5 miles) of foreshore protection between approximately Mile 56 to 51 of the MRGO.	Y	Y	Y
	MRGO4	Repair and maintenance of approximately 11,770 linear feet (2.2 miles) of existing retention dike MRGO Miles 36.6 to 37.1 and MRGO Miles 33.9 to 32.9.	Y	Y	Y
	MRGO5	202 acres of marsh would be restored behind 13,685 linear feet of vinyl sheet pile wall to establish the shoreline. 3 million cubic yards of material would be obtained from South Lake Borgne Borrow Cycle 4.	Y	Y	Y
	MRGO6	8,132 linear feet (1.5 miles) of new, non-continuous foreshore protection between MRGO miles 36.0 and 34.4, immediately east of the existing stone closure of the MRGO. MRGO6 ties into an existing foreshore dike immediately downstream.	Y	Y	Y
	MRGO7	110 acres of marsh restoration adjacent to approximately 9,170 linear feet of bankline reclamation, consisting of 9,700 linear feet of vinyl sheet pile wall. 1.65 million cubic yards of material would be obtained from North Lake Borgne borrow cycle 5.	Y	Y	Y
	MRGO8	236 acres of marsh restoration adjacent to approximately 17,785 linear feet of bank reclamation constructed using vinyl sheet pile wall. 3.5 million cubic yards of material would be obtained from South Lake Borgne Cycle 4. Approximately 14,225 linear feet (2.6 miles) of new foreshore protection would also be included between approximate channel miles 51.0 and 48.3.		Y	Y
	SHELL BEACH	Recreation Feature - 343 lf of boardwalk into the MRGO, 805 lf of shoreline boardwalk to 5 picnic shelters (two handicap accessible), interpretive signage, bathrooms, parking, solar lighting and vegetative plantings.	Y	Y	Y
Central Wetlands	CC1	1,020 acres of cypress swamp restoration and 935 acres of cypress swamp nourishment in the area north of the existing Violet Canal along the 40Arpent Levee. 6 million cubic yards of borrow material to be obtained from North Lake Borgne Borrow Cycle 9.	Y	Y	Y
	CC2	250 acres of cypress swamp restoration and 250 acres of swamp nourishment to the northeast of CC1. 1.7 million cubic yards of borrow material to be obtained from North Lake Borgne Borrow Cycle 9.	Y	Y	Y
	CC3	370 acres of cypress swamp restoration and 790 acres of swamp nourishment along the Forty Arpent Levee south of Paris Road. Approximately 3.7 million cubic yards of material to be obtained from North Lake Borgne Borrow Cycle 9.	Y	Y	Y
	CC4-A	400 acres of cypress restoration in the Bienvenue Triangle. Approximately 2.6 million cubic yards of silty sand material to be obtained from the Mississippi River between river miles 84.45R and 83R.	Y	Y	Y
	CC4-B	1,065 acres of cypress swamp restoration in the open water areas adjacent to the Forty Arpent Levee north of Paris Road. 7.8 million cubic yards of borrow material to be obtained from North Lake Borgne	Y	Y	Y

Table 2-18: Restoration Features Included in the Final Array

Area	Measure	Description	Plan B	Plan C	Plan D
		Borrow Cycle 9.			
	CC5	1,120 acres of swamp restoration and 1,550 acres of swamp nourishment south of the Violet Canal along the Forty Arpent Levee and the Chalmette Loop Levee. 7.8 million cubic yards of borrow material to be obtained from North Lake Borgne Borrow Cycle 10.	Y	Y	Y
	CC6	2,568 acres of swamp nourishment in the southwest corner of the Central Wetlands. 5.2 million cubic yards of borrow material would be obtained from North Lake Borgne Borrow Cycle 10.	Y	Y	Y
	CM1	1,240 acres of marsh nourishment south of Paris Road between cypress restoration feature CC3 and the Chalmette Loop Levee. Approximately 1.5 million cubic yards of material would be obtained from GIWW/MRGO Reach 1 starting at mile 66, as well as the turning basin at mile 65.5 and the Michoud Canal project that ties into MRGO/GIWW at mile 60.		Y	Y
	CM2	795 acres of marsh restoration and 190 acres of marsh nourishment north of Paris Road. Approximately 4.72 million cubic yards of material would be obtained from North Lake Borgne Borrow Cycle 2.		Y	Y
	CM3	300 acres of marsh restoration and 215 acres of marsh nourishment in the area north of Bayou Dupre and south of MRGO. 1.6 million cubic yards of borrow material would be obtained from North Lake Borgne Borrow Cycle 7.		Y	Y
	CM4	97.5 acres of marsh restoration and 128.5 acres of marsh nourishment south of Bayou Dupre. 600,000 cubic yards of dredged material would be obtained from North Lake Borgne Borrow Cycle 7.		Y	Y
	CM5	245 acres of marsh restoration and 70 acres of marsh nourishment in the area north of Bayou Bienvenue and Paris Road. 1 million cubic yards of material would be obtained from GIWW/MRGO Reach 1 starting at mile 66, as well as the turning basin at mile 65.5 and the Michoud Canal project that ties into MRGO/GIWW at mile 60.		Y	Y
	VIOLET	7,000 cfs capacity freshwater diversion from the Mississippi River to the MRGO in the vicinity of Meraux.	Y	Y	Y
	VIOLET REC	Recreation Feature - 6,500 linear feet of guide levee multi-use path, 4,500 linear feet of path at the base of the levee, 15 picnic shelters, interpretive signage, bathrooms, parking, solar lighting and vegetative plantings along the Violet Freshwater Diversion.			
	BAYOU REC	Recreation Feature 100 linear feet of platform, 995 linear feet of boardwalk into the swamp, 4 picnic shelters, interpretive signage, bathrooms, parking, solar lighting and vegetative plantings in the Bienvenue Triangle.			
East Orleans	EM1	1,175 acres of marsh restoration and nourishment of 2,830 acres of surrounding marsh in the area bounded by the Lake Pontchartrain shoreline, Chef Menteur Pass, and the levee. Approximately 8.1 million cubic yards of material would be obtained from North Lake Borgne Borrow Cycle 5.	Y	Y	Y
	EM2	1,095 acres of marsh nourishment on Hog Island, located between the west and east mouth of the West Pearl River. Approximately 1.3 million cubic yards of dredged material would be obtained from Northeast Lake Borgne Borrow Cycle 8.	Y	Y	Y
	EM3	861 acres of marsh restoration and 180 acres of adjacent marsh nourishment in the area bounded by Highway 433, Little Lagoon, Salt Bayou and Highway 90. Approximately 4.1 million cubic yards of dredged material would be obtained from Northeast Lake Borgne		Y	Y

Table 2-18: Restoration Features Included in the Final Array

Area	Measure	Description	Plan B	Plan C	Plan D
		Borrow Cycle 8.			
	EM4	2,625 acres of marsh restoration and 1,455 acres of adjacent marsh nourishment in the area bounded by Salt Bayou to the north, the West Pearl River to the east, the Rigolets to the south and Highway 80 to the north. Approximately 9.2 million cubic yards of material would be obtained from North east Lake Borgne Borrow Cycle 8.		Y	Y
	EM5	704 acres of brackish marsh restoration in the area on the south side of the Rigolets from Sawmill Pass to Counterfeit Pass. 2.6 million cubic yards of dredged material would be obtained from Lake Borgne Borrow Area 8.			Y
	ES1	20,530 linear feet (3.8 miles) of shoreline protection from the south shore of Lake Pontchartrain to the terminus of the existing Bayou Chevee shoreline protection feature.		Y	Y
	ES2	30,750 (5.8 miles) linear feet of shoreline protection in Lake Pontchartrain between Chef Menteur Pass and The Rigolets.		Y	Y
	ES3	69,900 linear feet (13.2 miles) of foreshore protection along Lake Borgne between Alligator Point and The Rigolets.		Y	Y
	EV1	Three Submerged Aquatic Vegetation (SAV) protection structures 5,000 linear feet in length, consisting of five 750 feet low level rock weirs spaced 100 feet apart. This feature is located along the south shore of Lake Pontchartrain from near the former mouth of Turtle Bayou to the railroad bridge.			Y
South Lake Borgne	LS1	45,000 linear feet (8.5 miles) of shoreline protection beginning at the terminus of the Bayou Dupre supplemental shoreline project, extending around Proctor Point to the West of Shell Beach supplemental funding shoreline protection.	Y	Y	Y
	LM1	3,253 acres of marsh restoration from open water and nourishment of 1,064 adjacent acres in the Golden Triangle, south of the IHNC Surge Barrier. Approximately 14.3 million cubic yards of borrow to be obtained from North Lake Borgne Borrow Cycle 1.	Y	Y	Y
	LM2	225 acres of marsh restoration and 2,628 acres of marsh nourishment in the area between Proctor Point and the MRGO. Approximately 4.45 million cubic yards of borrow material to be obtained from North Lake Borgne Borrow Cycle 1.	Y	Y	Y
	LM3	911 acres of marsh creation and 950 acres of marsh nourishment in South Lake Borgne north of Lena Lagoon in the area bounded by the lake, Bayou St. Malo, MRGO, and Doulluts Canal. Approximately 6.4 million cubic yards of borrow to be obtained from South Lake Borgne Borrow Cycle 6.		Y	Y
	LM4	225.5 acres of marsh restoration and nourishment of 54.8 adjacent acres of marsh in the portion of the Golden Triangle bordered by the GIWW, the IHNC Surge Barrier, and the MRGO. Approximately 1.16 million cubic yards of borrow material would be obtained from North Lake Borgne Borrow Cycle 1.		Y	Y
Terre aux Boeufs	TM1	798 acres of marsh restoration and 223 acres of marsh nourishment, requiring approximately 3.8 million cubic yards of material to be obtained from South Lake Borgne Borrow Cycle 4.	Y	Y	Y
	TM2	770 acres of marsh restoration and 2,734 acres of marsh nourishment in the vicinity of Lake Ameda. Approximately 8.8 million cubic yards of borrow material would be obtained from South Lake Borgne Borrow Cycle 4.	Y	Y	Y
	TM7	2,255 acres of brackish marsh restoration and up to 3,338 acres of		Y	Y

Table 2-18: Restoration Features Included in the Final Array

Area	Measure	Description	Plan B	Plan C	Plan D
		adjacent marsh nourishment on the east side of Bayou Terre aux Boeufs. 11.5 million cubic yards of material would be obtained from Lake Lery if available, but it is currently assumed that material will be obtained from Lake Borgne Borrow Area 2.			
	TM8	1,511 acres of marsh restoration on the east side of Bayou Terre aux Boeufs in the vicinity of Delacroix. 9.7 million cubic yards of material will be obtained from South Lake Borgne Borrow Cycle 8.		Y	Y
Hopedale	HM1	757 acres of marsh restoration and the nourishment of 973 acres of adjacent marsh, located in the Hopedale area bordered by MRGO to the northeast. 4.5 million cubic yards of dredged material would be obtained from South Lake Borgne Borrow Cycle 4.		Y	Y

2.5.3.1 Violet, Louisiana Freshwater Diversion

All of the action plans include the design and implementation of the Violet, Louisiana Freshwater Diversion as authorized in WRDA 2007 Section 3083, as an important feature to increase the sustainability of the plan. The forecasted FWOP salinity conditions suggest that salinity in the study area would be reduced by the closure of the MRGO and other authorized projects. However, additional inputs of freshwater may be necessary to fully restore the historic salinity regime. The MRGO was excavated through the eastern portion of the Central Wetlands, which resulted in saltwater intrusion and increased salinity in the area. The habitat of the Central Wetlands changed from a cypress swamp and fresh/intermediate marsh system to an entirely brackish system. In order to restore the habitat type adversely affected by the former navigation channel, a freshwater system must be established in the Central Wetlands area.

The preliminary yearly operational scheme of the Violet, Louisiana Freshwater Diversion to benefit cypress swamp and marsh restoration as part of the MRGO Ecosystem Restoration Plan Feasibility Report is based on the required hydroperiod and depth constraints of bald cypress (*Taxodium distichum*) phenology and seasonal water levels based on the Mississippi River stage. Because of the specific requirements of bald cypress, it was used as an indicator of conditions conductive to swamp tupelo (*Nyssa aquatica*) and other constituents of forested wetland. In addition, maiden cane (*Panicum hemitomon*) and bull tongue (*Sagittaria lancifolia*) are dominant species of fresh/intermediate marsh and marsh-hay cordgrass (*Spartina patens*) of brackish marsh. These species are often used as indicators of ecosystem health and restoration success (see Operations Scheme in **appendix M**).

Four potential locations for a freshwater diversion were evaluated to convey water from the Mississippi River to the Lake Borgne ecosystem. **Figure 2-7** displays the four potential diversion locations. Additional information regarding the evaluation of the proposed locations for the Violet, Louisiana Freshwater Diversion is included in **section 2.6.2**.

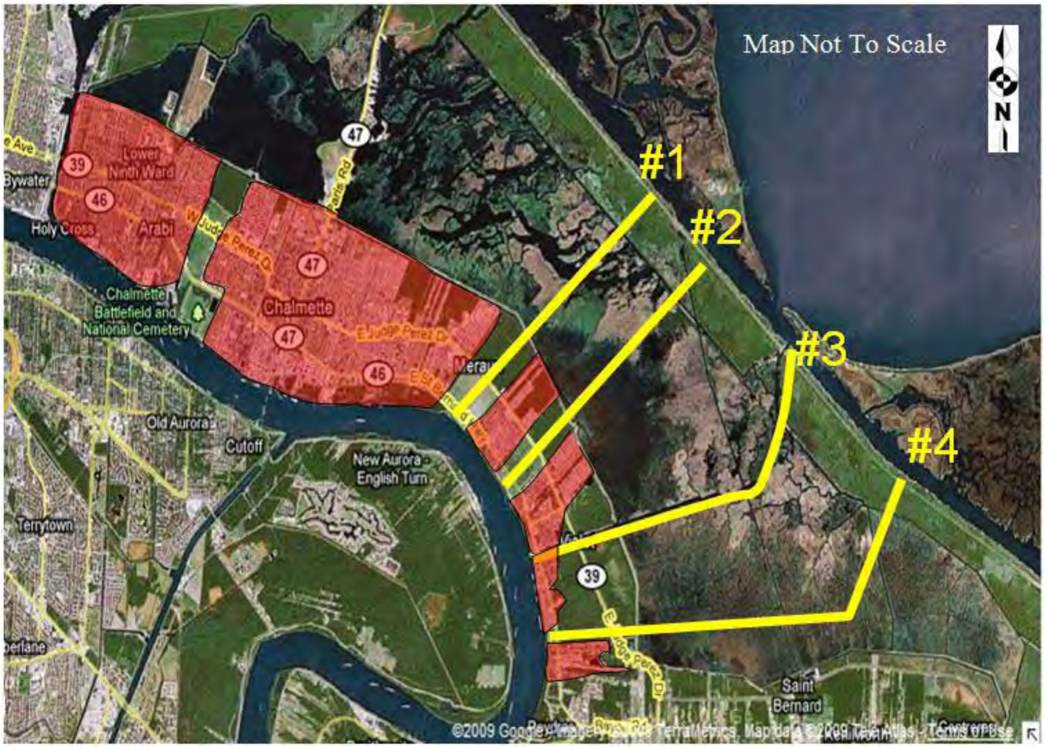


Figure 2-7: Alternative Diversion Locations

2.5.3.2 Recreational Components

Summary of Recreation Features

The Recreation Development Plan recommends recreational features for the MRGO Ecosystem Restoration project in concurrence with facilities that are approved in ER 1105-2-100 for ecosystem restoration projects. When implementation funds are appropriated, a non-Federal sponsor, yet to be identified, would participate in a cost-sharing agreement for construction of the recreation plan. Accordingly, the non-Federal share will be 50 percent of the recreation development costs. Non-Federal sponsors are responsible for 100 percent of lands, easements, rights-of-way, utility or public facility relocations, and dredged or excavated material disposal areas (LERRD), and operation, maintenance, repair, rehabilitation, and replacement (OMRR&R). The value of LERRD is credited to the 50 percent share. For a more detailed discussion of the recreation features, drawings, and benefit-cost ratios presented below, see **appendix W**.

The recommended recreational features are ancillary to the ecosystem restoration project, work harmoniously with the measures of the restoration project and are proposed on fee title lands for cost-sharing. All of the recreation features recommended were first identified through USACE meetings with community groups and non-governmental organizations (NGOs) from St. Bernard and Orleans Parishes. Additionally, **appendix W** refers to the Louisiana Department of Culture, Recreation and Tourism's Statewide Comprehensive Outdoor Recreation Plan (SCORP), which presents findings from focus group meetings regarding locally preferred outdoor recreation activities. A third source, the University of Wisconsin, prepared a recreation needs report for St. Bernard Parish and part of Orleans Parish. All three of these resources are used in identifying the recommended recreation features, including development of the benefits of each recreation development. All three sites offer American's with Disabilities Act (ADA) accessible features, including parking lots, bathrooms, access to boardwalks, ramps, and picnic shelters.

Bienvenue Triangle Recreation Feature

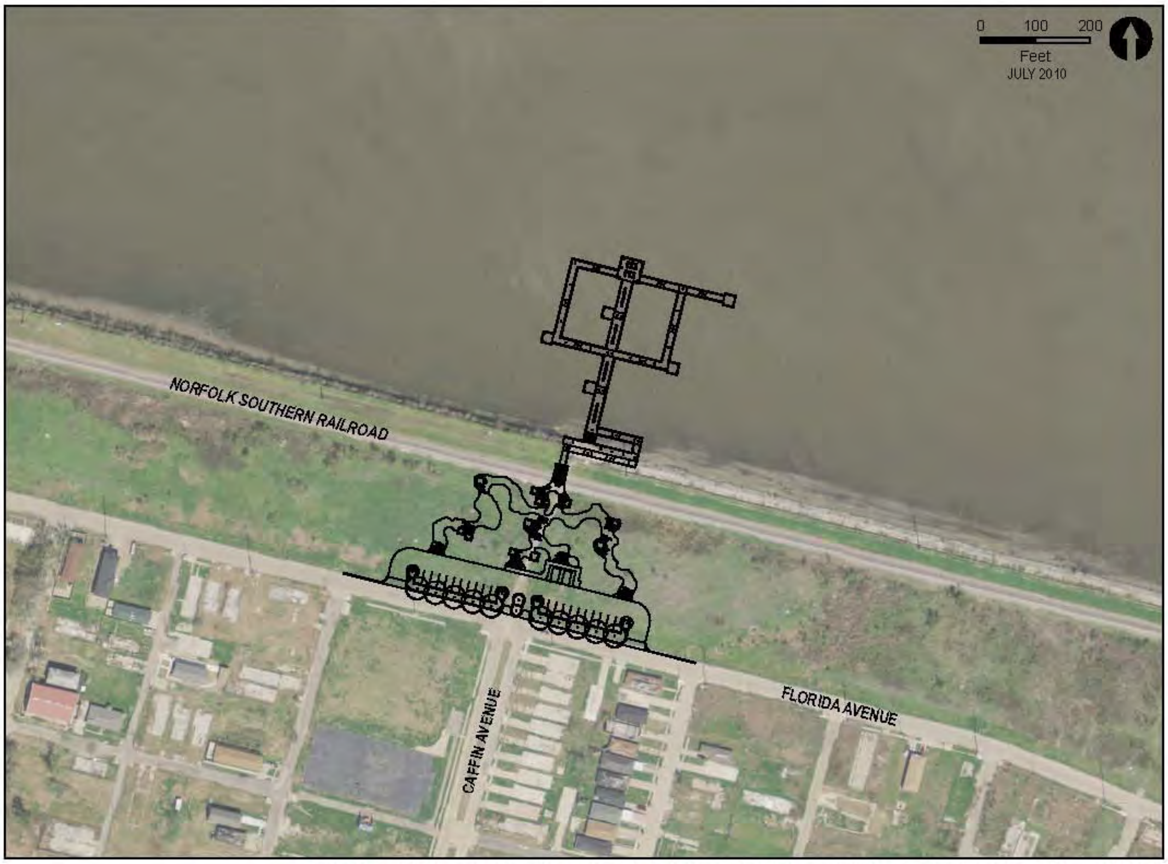
Existing Condition

The site of the proposed recreation feature is located in Orleans Parish's Bienvenue Triangle. Located at the terminus of Caffin Avenue, the site currently offers a viewing platform overlooking the marsh. The platform is used by the neighborhood, tourists and schools, both recreationally and as an educational tool. Martin Luther King Elementary School located on Caffin Avenue and North Claiborne Avenue currently uses the platform for teaching students about environmental principles, processes and a general education concerning marshland, habitat, and wildlife.

Proposed Improvement

The entrance of the proposed recreation features would offer interpretive signage detailing the history of the Bienvenue Triangle including various functions to the community, the wetlands' restoration mission, the project development process, educational programming, and sustainable design elements. Opportunities for increasing the recreational and environmental education experience include development of a nature boardwalk through the marsh with interpretive signs describing viewsheds, plants, processes, and wildlife within the area. This recreation feature would be constructed before wetland restoration begins to afford viewing opportunities of the stages of cypress swamp creation. Also, the local sponsor could develop wetland research pilot sites adjacent to the boardwalk which schools could use to develop test sites of certain types of marsh grasses and other research projects related to wetland restoration. Information from the University of Wisconsin report revealed the need for children's programs; such as some discussion about plants and animals living in the bayou and wetland preservation efforts. Signage explaining the proposed marsh creation project would educate children about wetland restoration and ways to counter man-made and natural environmental degradation. A multi-use, nature boardwalk would provide access to the restored wetland, while a bird watching boardwalk would provide access for viewing wildlife in a very secluded structure. An enlarged land-based viewing platform and shelter/classroom in the swamp would also provide space for larger groups visiting the site.

Constraints to development include the Alabama Great Southern Railroad (a.k.a. Norfolk Southern Railroad) and local sponsor real estate acquisition. Discussion regarding pedestrian access crossing the railroad must be finalized. Currently, the railroad is crossed to gain access to the existing platform. An at-grade, ADA compliant crossing is proposed, such as is available at other crossings to recreational features in the City of



New Orleans. Finally, the local sponsor must obtain real estate fee title for recreation development lands. The land between Florida Avenue and the railroad track is owned by the City of New Orleans Sewerage and Water Board, the railroad is owned by Norfolk Southern Railroad, the levee is owned by the New Orleans Levee Board, and the swamp is owned by less than five owners.

The recommended design for the Bienvenue Triangle recreation feature is Option A, and is shown in **figure 2-8**; its selection is based upon the benefit-to-cost ratio (BCR). Two designs, Option A and B, were developed based upon input from community groups in the Lower 9th Ward. Both Option A and B were evaluated in terms of benefits and costs and the resulting ratio was the basis for selection. Option A has the higher BCR, 1.14, and is one of three recommended recreation features for the MRGO Ecosystem Restoration project.

Figure 2-8: Bienvenue Triangle Overlook Recreational Feature – Option A

The recommended plan for the Bienvenue Triangle consists of a 100 linear feet of platform, 995 linear feet of boardwalk into the swamp, four picnic shelters, interpretive signage, bathrooms, parking, solar lighting and vegetative plantings. Option A is the recommended plan for the Bienvenue Triangle.

Violet, Louisiana Freshwater Diversion Recreation Feature

Existing Condition
Currently, the site is used as agricultural land and offers no recreational opportunity.

Proposed Improvement
Recreational features are proposed to compliment and use the Violet Freshwater Diversion, a conveyance of water to nearby swamp and marsh land, as an activity resource. Recreation features at the proposed Violet, Louisiana Freshwater Diversion site in St. Bernard Parish include multi-use paths, open space, picnic tables and shelters, interpretive signage in a park setting with landscaping, trees and lighting. The multi-use path would be located along the top of the guide levees and meander off the levee to areas with picnic tables and interpretive signage. The trail could also connect to the adjacent park at the old Archbishop Hannan site and lead to other bike paths in the area. A parking lot would also be provided on-site. Interpretive signage would provide a description of the diversion's function for restoring freshwater to the Central Wetlands and the general purpose of the ecosystem project surrounding the MRGO.

The recommended design for the Violet Diversion recreation feature is Option B and shown in **figure 2-9**; its selection was based upon the BCR. Two designs, Option A and B, were evaluated and Violet, Louisiana Freshwater Diversion, Option B has the higher BCR, 5.62 and is the second of three recommended recreation features for the MRGO Ecosystem Restoration project.

The recommended plan for the Violet, Louisiana Freshwater Diversion recreation feature consists of 6,500 linear feet of guide levee multi-use path, 4,500 linear feet of path at the base of the levee, 15 picnic shelters (including three handicap accessible), interpretive signage, bathrooms, parking, solar lighting and vegetative plantings. Option B is the recommended plan for the Violet, Louisiana Freshwater Diversion.

Shell Beach Recreation Feature

Currently, the shoreline of Shell Beach, located in St. Bernard Parish at the end of Yscloskey Road where it meets the MRGO, is often used by fisherman. Fishermen are confronted with a rocky, jagged shoreline and snakes in the area. The shoreline is used extensively on the weekends by many in the area. Additionally, a memorial is located at this location which lists the names of those who lost their lives as a result of Hurricane Katrina. The recreational plan will attempt to incorporate the memorial in a way that is both respectful and functional.

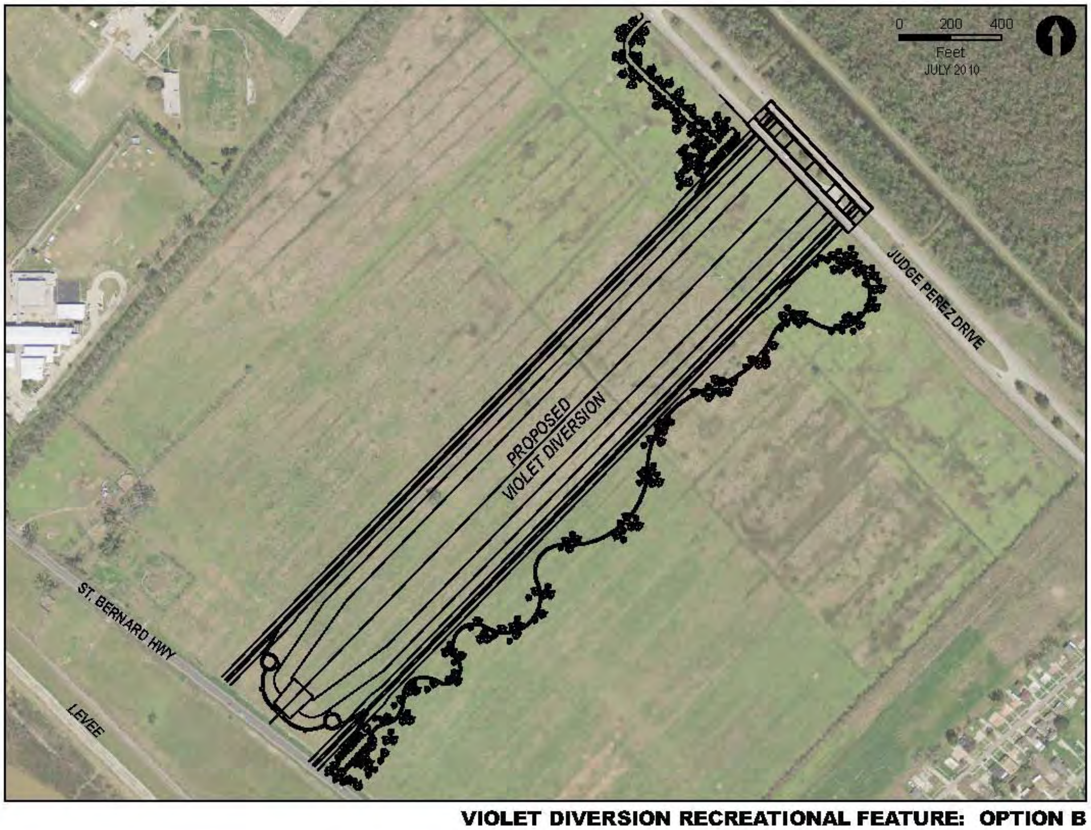


Figure 2-9: Violet, Louisiana Freshwater Diversion Recreational Feature – Option B

Opportunities for recreational development feature include a boardwalk into the MRGO for fishing and wildlife viewing and to gain access to other spots along the shore including picnic tables and shelters. Two designs, Option A and B, were based upon input from the Coastal Zone Administration of St. Bernard Parish. Both Option A and B were evaluated in terms of benefits and costs and the resulting ratio is the basis for selection. Shell Beach Option B has the higher BCR, 2.02 and is the third and final recommended recreation feature for the MRGO Ecosystem Restoration project.

The recommended recreation feature for Shell Beach is Option B that consists of 343 linear feet of boardwalk into the MRGO, 805 linear feet of shoreline boardwalk to five picnic shelters (two handicap accessible), interpretive signage, bathrooms, parking, solar lighting and vegetative plantings. Option B is the recommended plan for Shell Beach and is presented in **figure 2-10**.

Figure 2-10: Shell Beach Recreational Feature – Option B

2.6 DESCRIPTION OF ALTERNATIVES CONSIDERED

2.6.1 Alternative A - No Action Plan (FWOP Condition)

The no action alternative is required by the NEPA and represents the FWOP condition by which alternatives considered in detail are compared. The no action alternative considers restoration programs that would continue into the future, and that in the absence of this restoration plan, would continue to be proposed and implemented under CWPPRA, CIAP, LCA, and other programs.

The study area would continue to be subjected to natural and human land-loss factors such as tropical storms, subsidence, erosion, sea level rise, oil and gas exploration, and saltwater intrusion. Wetland loss throughout the study area would continue at the same or accelerated rates. Critical landscape features would continue to erode and degrade, potentially increasing storm surge damages. Large uncertainties surround land loss rates including climate change; sea level rise rates; subsidence rates; changes in frequency and intensity of tropical storm events; and/or changes in drought conditions. All of these factors could contribute to the acceleration of degradation of the study area. Continued wetland fragmentation and the eventual conversion to shallow open water habitat would have negative consequences on a variety of important environmental resources in the study area.

As a result of the devastating effect of Hurricane Katrina which made landfall in 2005, several important hurricane protection projects are under construction in the study area that are expected to have significant impacts on the future conditions of the area without implementation of this restoration study.

An important project in the area includes the IHNC sector gate for flood control and navigation. A surge barrier, similar to a floodwall but much larger, would be constructed near the confluence of the GIWW and the MRGO, generally running north-south from a point just east of Michoud Canal on the north bank of the GIWW and just south of the existing Bayou Bienvenue flood control structure (**figure 2-11)**. Navigation gates would be constructed where the barrier crosses the GIWW and Bayou Bienvenue to reduce the risk of storm surge coming from Lake Borgne and/or the Gulf of Mexico.

Another navigation gate would be constructed near Seabrook, where the IHNC meets Lake Pontchartrain, to block storm surge from entering the IHNC from the lake.

Figure 2-11: IHNC Surge Barrier

As described in **chapter 1**, the MRGO closure structure was constructed and completed in July 2009. These projects individually and cumulatively are anticipated to change the future environmental conditions of the basin regardless of whether a restoration plan is implemented or not. Important among the anticipated changes is the reduction in salinity levels in the area as demonstrated by the hydrologic modeling discussed in more detail in **chapter 3**. More in-depth discussions of the impacts are described further in **chapter 4** for the applicable resources affected.

Hurricanes Katrina and Rita resulted in a total marsh loss of over one third of the total wetland losses predicted by the Coast 2050 Report (LCWCRTF and WCRA, 1999). Within the Lake Borgne and MRGO area, approximately 663 acres of wetlands were converted to open water (Barras, 2006). This loss rate exceeded the average background loss rate of approximately 144 acres per year from 1988 to 2004 (Morton et al., 2005). In the northern and eastern shorelines of Lake Borgne, new water bodies formed and existing water bodies expanded (USGS, 2006).

In the FWOP conditions, wetland losses would be offset to some extent by other Federal, state, local, and private restoration efforts. Under Section 7006 of the WRDA 2007, the LCA program has authority for feasibility-level reports of six near-term critical restoration features. The projects that are considered a part of the FWOP conditions for this study include:

- **Medium Diversion at White Ditch –** The draft recommended plan includes diverting up to 35,000 cfs of freshwater from the Mississippi River left descending bank at river mile 60.0 into the Breton Sound basin as well as restore thirty-one acres of ridge and terrace habitat and restore 385 acres of marsh. The diversion influence area is approximately 98,000 acres.
- **Amite River Diversion and Canal Modification; 500 cfs freshwater diversion**. This project is currently in the feasibility phase with a final report expected in December 2010. This project would construct gaps in the existing banks of the Amite River Diversion Canal 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. Nutrients and sediment would be provided to facilitate organic deposition in the swamp, improve biological productivity, and prevent further swamp deterioration. This project is designed to complement two other LCA projects: the Hope Canal Diversion and Convent/Blind River Diversion, and one proposed Coastal Impact Assistance Program project, Hydrologic Restoration in Swamps West of Lake Maurepas.
- **Hope Canal freshwater diversion; 1,000 cfs freshwater diversion**. 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.
- **Blind/Convent River Diversion; 3,000 cfs freshwater diversion**. This project is currently in the feasibility phase with a final report expected in December 2010. The project would involve construction of a small siphon(s) over the Mississippi River levee or construction of a concrete multi-barrel box culvert(s) in the Mississippi River in the vicinity of Convent. Freshwater from the Mississippi River would flow into a conveyance channel and eventually distributed through a network of small conveyance ditches in the project area.

Other restoration projects occurring in the study area that would have an effect on FWOP conditions include:

- CWPPRA PO-29 River Reintroduction into Maurepas Swamp.
- CWPPRA PO-30 Lake Borgne Shoreline Protection project has been completed.
- CWPPRA PO-32 Lake Borgne and MRGO Shoreline Protection project. This project was authorized in April 2003. Phase I design was complete in 2005 and phase II design was complete in 2007. Construction of the Lake Borgne portion has been completed and the MRGO portion has been proposed for deauthorization. Anticipated net acres benefited are 266 acres.
- CWPPRA PO-34 Alligator Bend Marsh Restoration and Shoreline Protection. This project is currently in planning and design. Construction is anticipated to start in October 2011 and end in September 2012. Anticipated net acres benefited would be 127 acres.
- CWPPRA PO-36 (EB) Orleans Landbridge shoreline protection and marsh restoration. The goal of the project is to protect approximately 1,400 acres.
- Lake Borgne and MRGO Shoreline Protection and accretion behind shoreline protection structures – Area 1 Doulluts Canal to Jahncke's Ditch. Construction would commence in 2010 and protect approximately 3.8 acres/year and restore approximately 17 acres by 2030.
- Lake Borgne and MRGO Shoreline Protection - Area 3 Doulluts Canal to Lena's Lagoon. Construction would commence in 2010 and is anticipated to stop land loss and restore approximately 8.2 acres per year.
- USACE 3rd and 4th Supplemental Funds - Lake Borgne Shoreline Protection and Marsh Restoration Project. This restoration project would create and nourish marsh in the Golden Triangle and Shell Beach area and protect shoreline in the Shell Beach area. Anticipated net acres benefited would be approximately 29 acres per year.
- CIAP, The Rigolets Shoreline Protection and Marsh Restoration – Grand Coin Pocket, tier 2. Anticipated net acres benefited would be 100 acres.
- CIAP, Lake Pontchartrain Shoreline Protection and Marsh Restoration – Irish Bayou to Chef Menteur Pass, tier 2. Anticipated net acres benefited would be 46 acres.
- CIAP, Fritchie Marsh Stormwater Diversion.
- State shoreline protection project along the Interior Biloxi Marsh funded with Federal surplus funds.
- WRDA 2007 - The Violet, Louisiana Freshwater Diversion Project – Project to construct a freshwater diversion to meet or maximize the ability to meet the benefits identified in the Bonnet Carré Feasibility Study and Report prepared in 1984. The Violet WRDA 2007 project is pending the findings of this study.
- The New Orleans Sewerage and Water Board, in collaboration with St. Bernard Parish, has developed preliminary engineering alternatives for the use of treated wastewater for wetlands enhancement in the Central Wetlands as part of the CIAP program. The wastewater tertiary treatment plans that have been developed for Orleans and St. Bernard Parishes are seen as critical components to restore the area. The distribution of treated wastewater is needed to supplement the Violet,

Louisiana Freshwater Diversion, particularly in the northern portion of the subunit. If the funds appropriated under the CIAP program are insufficient to complete the necessary work to maximize the use of treated wastewater for wetlands enhancement in the Central Wetlands, these actions should be considered for inclusion as part of this plan, due to the sensitivity of the MRGO Ecosystem Restoration Plan to the implementation of these actions.

As a result of the LCA diversion projects in the Upper Pontchartrain sub-basin and the Hurricane and Storm Damage Risk Reduction System (HSDRRS) storm barriers, the salinity regime in the Lower Pontchartrain sub-basin is anticipated to change from baseline conditions. **Table 2-19** demonstrates the projected FWOP salinity range based on the H&H modeling results discussed further in **chapter 3** as well as the H&H Modeling Report included in **appendix L**.

Table 2-19: Base and Predicted FWOP Salinity Range for Lake Borgne Ecosystem

	1 (Lake Borgne)		**2 (Lake Borgne)**		**13 (Interior Biloxi Marsh)**		**14 (W. MS Sound)**		**73 (Interior Biloxi Marsh)**		**74 (Interior Biloxi Marsh)**	
BOX	**Base**	**FWOP**	**Base**	**FWOP**	**Base**	**FWOP**	**Base**	**FWOP**	**Base**	**FWOP**	**Base**	**FWOP**
January	4-6	3-5	5-8	5-7	8-10	7-11	14-21	13-19	7-11	7-10	13-19	11-16
February	2-4	1-3	4-7	4-6	5-8	5-8	12-1 8	10-15	5-8	5-7	11-17	9-13
March	2-3	1-3	3-5	3-5	5-8	5-7	11-17	10-15	4-7	4-6	10-15	8-12
April	2-4	2-3	3-5	3-4	6-9	5-8	13-19	11-17	5-8	4-7	11-16	7-11
May	3-6	3-5	3-5	3-4	8-10	7-10	15-22	13-19	6-9	5-8	11-17	8-11
June	4-7	3-6	3-6	3-5	9-14	8-12	16-24	14-21	7-10	6-9	12-18	8-12
July	5-8	4-7	4-6	3-5	10-14	8-12	17-24	15-22	7-11	6-9	13-18	9-14
August	6-10	5-8	4-7	4-6	11-16	10-14	18-26	16-24	8-13	7-11	14-21	12-17
September	7-10	6-9	5-8	4-7	11-17	10-15	18-26	17-25	9-13	8-12	15-22	13-19
October	7-11	6-10	5-9	5-7	12-18	11-17	19-27	18-25	10-14	9-13	17-24	15-21
November	7-11	6-10	6-9	5-8	12-18	11-16	19-27	17-25	10-14	9-13	17-24	15-21
December	6-9	5-8	6-9	5-8	10-15	10-14	17-25	16-23	9-13	8-12	16-23	14-20

The Box numbers correspond to the numbers assigned to the boxes in the H&H model and represent specific areas within the Lower Pontchartrain sub-basin. For instance, Box 2 refers to the Lake Borgne area; box 14 represents the West Mississippi Sound, box 73 is the Interior Biloxi Marsh. As is demonstrated in the table, salinity levels are projected to change in the Lake Borgne area by only 1 part per thousand (ppt) to 2 ppt on average.

2.6.2 Action Alternatives

2.6.2.1 Violet, Louisiana Freshwater Diversion

Alternatives that did not include a freshwater diversion were considered in the initial development of alternatives. These alternatives were ultimately eliminated from further study as inconsistent with the study goals and objectives and the “Guiding Principals”. A small freshwater diversion would not mimic periodic overbank flooding of the

Mississippi River, a key process of the estuary that must be restored to re-establish historic salinity gradients, habitat types, and increase self-sustainability in the system.

The restoration of historic salinity conditions is a key system driver. The Violet, Louisiana Freshwater Diversion, as authorized for design and implementation in WRDA 2007 Section 3083, would fully restore salinity conditions, mimic natural processes, and enhance the sustainability of the system through the input of freshwater, nutrients and sediment. Full restoration of historic habitat types in the area is dependent upon salinity conditions.

Additional study is needed to improve decisions about where, when, and how to divert Mississippi River flows in a systems context. The ongoing Mississippi River Hydrodynamic and Delta Management Study will evaluate ecosystem restoration alternatives in concert with dynamic flood risk management and navigation; multipurpose management scenarios of the river; and dynamic conditions in a comprehensive systems context. The information gained from this study will improve decision-making for the Violet, Louisiana Freshwater Diversion. Therefore, the final recommendations for the MRGO Ecosystem Restoration Plan include additional analysis, design and implementation of the Violet, Louisiana Freshwater Diversion as authorized by WRDA 2007 Section 3083.

The restoration and maintenance of a cypress swamp and fresh/intermediate marsh in the Central Wetlands may require the introduction of freshwater into this area. Additionally, to restore the MRGO/Lake Borgne Landbridge to a condition favorable for the propagation of intermediate marsh species, the area may require further salinity reductions beyond the forecast future without project conditions. However, hydrodynamic modeling conducted for the study indicates that the salinity regime can be achieved at all four of the locations in the vicinity of Violet. All locations are therefore identical with respect to benefits.

Additionally, significant reliance on the implementation of other authorized projects is inconsistent with the risk-aware planning framework for this study. Sensitivity analyses indicate that without the implementation of other planned freshwater diversions, specifically the Convent/Blind River and Hope Canal/Maurepas Swamp River Reintroduction projects, only partial restoration of the salinity regime can be accomplished without the implementation of freshwater reintroduction as part of this plan or under the WRDA 2007 Section 3083 authority.

The “Guiding Principles” reinforce the inclusion of a freshwater diversion for this study. The freshwater diversion proposed as part of the MRGO Ecosystem Restoration Plan would assist with realizing the following guiding principles:

- Restore key processes and dynamics in the estuary;
- Enhance the resilience and self-sustainability of the estuary;
- Maximize the combined benefits of freshwater diversions that seek to restore natural processes with mechanical marsh creation measures; and
- Combine measures synergistically to maximize possible cumulative benefits.

Four sites on the east bank in St. Bernard Parish were evaluated as potential diversion locations. These sites are located between the Inner Harbor Navigation Canal and the community of Poydras. Generally open land corridors between the river and the Forty Arpent Levee were identified. Other locations in the area were not considered because of existing residential development (i.e. the Lower 9th Ward, Arabi, Chalmette, etc.), existing industrial development (Domino Sugar, Port of St. Bernard, refineries, etc.), and cultural resources (Chalmette National Historic Battlefield and Cemetery).
Four alternative locations for a freshwater diversion located at or near the existing Violet Canal were evaluated to convey water from the Mississippi River to the Lake Borgne ecosystem. The diversion sites in the Violet vicinity considered are:

- Alternative Location 1 – Located at approximate Mississippi River Mile 86 in St. Bernard Parish on an open parcel of land called the Sinclaire Tract in the community of Meraux.
- Alternative Location 2 – Located at approximate Mississippi River Mile 85 in St. Bernard Parish on an open parcel of land between the communities of Meraux and Violet.
- Alternative Location 3 – Located at approximate Mississippi River Mile 84 in St. Bernard Parish at the existing Violet Canal.
- Alternative Location 4 – Located at approximate Mississippi River Mile 82 in St. Bernard Parish on an open parcel of land between the communities of Violet and Poydras.

The Violet, Louisiana Freshwater Diversion is proposed to extend from the Mississippi River and Tributaries (MRT) Levee at the river to the Forty Arpent levee via a controlled conveyance channel. A gated structure would be built at the river to allow flow through the MRT levee into a conveyance channel leading to a structure at the Forty Arpent Canal. The proposed river diversion channel would flow out through the Central Wetlands to an outfall structure in the Chalmette Loop Levee and discharge through a structure into the MRGO. Openings to adjacent channels in the Central Wetlands would provide the freshwater and nutrients required to maintain the restored cypress swamp. If needed, a structure at the Back Dike Canal would maintain shallow draft navigation in the Central Wetlands above and below the new diversion channel. The diversion design includes a closure structure on Lake Borgne at Dupre Cut. The structure would be open to shallow draft navigation and would function to better conduct the freshwater via the MRGO. Freshwater would filter through adjacent marsh channels to the greater Lake Borgne ecosystem.

Violet, Louisiana Freshwater Diversion Flow Analysis

The Salinity Working Group for the MRGO study noted that a target line and frequency need to be established to design a freshwater diversion, but that adaptive management should also be a component of freshwater reintroduction plans. Therefore, the metric for achieving the salinity regime objective is whether salinity falls within the optimal range each month, at least forty percent of the years in a decade, as described in Chatry et al. 1983. The Chatry targets are a way to measure the restoration of historic salinity regimes.

Hydrodynamic modeling evaluated a variety of discharge scenarios between 1,000 and 30,000 cfs. A variety of diversion alternatives between 5,000 and 10,000 cfs were found to be effective in meeting this goal. At 5,000 cfs, the target is met in the range of 32 percent to 36 percent. At 7,000 cfs alternatives range between 32 percent and 48 percent. At 10,000 cfs the range in meeting the Chatry targets is from 38 percent to over 50 percent.

Assuming that the Maurepas Swamp diversions are operated to maintain salinities below 1 ppt, the 1,000/7,000 cfs proposed Violet, Louisiana Diversion meets the Chatry target 32 percent of the time.

With a constriction at Dupre Cut, the 1,000/7,000 cfs diversion lowers salinity to meet the target 37 percent.

When the Convent / Blind diversion is increased to a constant 3,000 cfs or the proposed Violet Diversion is increased to flow 7,000 cfs year round, the Chatry target is met 43 percent of the time.

Table 2-20: Diversion Scenarios: Percent of Time Salinity Targets are Met
(40 Percent Minimum to Achieve Objective)

Flow (cfs)	Historic	Baseline	FWOP Scenarios		FWP Scenarios***					
			FWOP*	FWOPD**	A1	A2	A3	A4	A2D	A4D
0	3.9%	6.1%	27.4%	33.7%						
1,000					26.7%					
5,000						33.7%				
7,000					31.7%	36.7%		43.6%	43.0%	48.1%
10,000						41.6%	46.2%			
15,000							55.2%			
20,000							63.3%			
30,000							75.4%			

NOTES:
*FWOP indicates future without project conditions with Maurepas Swamp salinities maintained below 1 ppt.
** FWOPD includes the selected alternative for the Blind River Diversion, which is a constant 3,000 cfs flow.
***See below for FWP Scenarios

Alternative	Gap between MRGO and Lake Borgne - Open or Closed	Diversions at Maurepas Swamp
A1	Open	< 1ppt
A2	Closed	< 1ppt
A3	Open	< 1ppt
A4	Closed	< 1ppt
A2D	Closed	4,500 cfs
A4D	Closed	4,500 cfs

Hydrodynamic modeling performed for the study indicates that based on average conditions, the diversion would need to be operated at 1,000 cfs for the majority of the year with a 7,000 cfs pulse beginning mid-April and continuing through May to achieve the salinity targets and habitat goals for the study. Because "average" conditions very rarely occur in nature, the freshwater diversion is planned to be adaptively managed to respond to actual environmental conditions. When measured salinity is at or below target levels, the diversion flow amounts could be reduced accordingly; when salinity readings are high, the diversion flow could be increased. Particularly, the flow of the Pearl River and rainfall levels need to be monitored and responded to in operations planning and execution. Other potential issues that need to be considered in the development of a detailed operations plan include: localized flooding in the portion of the Central Wetlands between the Forty Arpent Levee and the Chalmette Loop Levee; drastic changes in volume of water on a month to month time frame; observed adverse or beneficial ecological impacts; and weather events such as tropical systems, cold fronts, and rainfall events.

Use of the Existing Violet Canal

Some stakeholders have expressed a preference for a diversion that can be located in the existing Violet Canal. On May 4, 2010, the St. Bernard Parish Council adopted Resolution SBPC #637-05-10 stating that the St. Bernard Parish Government, in conjunction with the St. Bernard Parish Coastal Zone Advisory Committee, is "fully supportive of the restoration of the Central Wetlands area of St. Bernard Parish, but unanimously opposes another canal being dug to deliver the freshwater that can be delivered by using the existing conveyance and delivery canal." To address these concerns, the capacity and benefits of the existing canal were investigated to determine what benefits could be achieved.

Based on preliminary analysis, the implementation of the proposed 1,000/7,000 cfs freshwater diversion, independent of other restoration measures, is anticipated to produce 14,637 net acres of wetlands at the end of 50 years. A diversion operating at 1,000 cfs constant flow would produce 7,323 net acres over the same period of analysis. The addition of a 2,000 cfs pulse in April and May would increase the benefits in net acres by 1,594 acres, for a total of 8,917 net acres.

The MIKE21 modeling conducted for this study indicates that a 1,000 cfs diversion would influence salinity in the Central Wetlands. A 1,000 cfs diversion, along with the introduction of dredged material could maintain salinities below 2 ppt throughout the subunit most of the time. Higher salinities would occur locally during periods of high inflow with a 1,000 cfs diversion. A smaller diversion would have some benefits outside of the Central Wetlands by adding nutrients, freshwater, and suspended solids into the ecosystem. However, the ability to significantly regulate salinity with a 1,000 cfs diversion would be limited to the Central Wetlands. The restoration of cypress swamp in all of the areas proposed may not be possible due to the uncertainties associated with increasing salinities during periods of high inflow of saltier water into the Central Wetlands.

Achievement of the salinity targets is anticipated to increase commercial harvests of oysters in the Biloxi Marsh, white shrimp, blue crab, croaker, menhaden, and catfish (USACE 1984). Diversions that do not include a 7,000 cfs or greater pulse in April and May would not achieve the targets, and therefore would not produce the same benefits to commercial and recreational fisheries. Smaller diversions would not restore salinity conditions in the Lake Borgne estuary, and would not mimic the natural overbank flooding of the Mississippi River. Additionally, a smaller diversion would not provide opportunities for adaptive management to restore and maintain the habitat type objectives. For these reasons, smaller diversions located in the existing Violet Canal will be further investigated in the feasibility phase of analysis with appropriate NEPA documentation.

Violet, Louisiana Freshwater Diversion Site Evaluation

As part of the preliminary alternatives analysis, four alternative locations were evaluated in the vicinity of Violet. These sites are numbered 1 to 4 from north to south moving downriver. Locations 1, 2, and 4 are located in undeveloped areas. Location 3 is the existing Violet Canal. Because hydrodynamic modeling indicates that all of the locations would produce the same benefits, the locations were evaluated to determine differences in potential costs and impacts.

Figure 2-12: Alternative Locations for the Violet, Louisiana Freshwater Diversion Considered in Initial Analysis

Eleven site selection factors to consider in evaluating the potential diversion locations. These factors are identified in **table 2-21**. Each of the factors was identified to help highlight significant considerations for site comparison including sizing, costs, impacts, and construction considerations. A GIS system was used to overlay diversion footprints between the river and the MRGO within each of the four corridors. Using the GIS system and field observations, each of the factors was identified and the results were tabulated for comparison of the preliminary alternative locations.

Table 2-21: Alternative Violet, Louisiana Freshwater Diversion Location Comparison

Site Selection Factor	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Number of Businesses, Residences and Secondary Structures (Relocations)	0	1	121	0
Number of Scenic Streams	0	0	4	2
Number of Roads	2	2	10	2
Wetland Acres (acres)	227	267	738	836
Number of Levees	2	2	4	2
Number of Cultural and Historic Resources	0	1	3	2
Docks/Maritime Infrastructure	0	0	7	1
Utilities & Pipelines	2	2	4	5
Diversion Channel Length (miles)	4.19	4.32	5.53	6.27

Table 2-21: Alternative Violet, Louisiana Freshwater Diversion Location Comparison

Site Selection Factor	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Community Facilities	0	1	1	0
Number of Bridge Replacements	0	0	1	0

Alternative Location 1 (**figure 2-13**) was preliminarily considered to be the best hydraulic location for the freshwater diversion, because it is the shortest, most-efficient route to the MRGO; however, the diversion will be further investigated in the feasibility phase of analysis with appropriate NEPA documentation. The distribution of freshwater throughout the Central Wetlands is more efficient at this location because it is centrally located. Alternative 1 also has the fewest wetland impacts of all four locations and may not involve any potential cultural or historic resources.

Figure 2-13: Alternative Location 1

Alternative Location 2 (**figure 2-14**) is a comparable hydraulic location to Alternative Location 1. However, Alternative 2 would impact historic oak trees and a pecan grove. The pecan grove includes an area designated for local schools to use as an outdoor learning center, and therefore impacts business and community facilities. Alternative 2 also has greater wetland impacts than Alternative 1. Because Alternatives 1 and 2 are hydraulically similar, and Alternative Location 1 has less wetland impacts and no cultural/historic or community impacts, Location 2 was removed from further consideration.

Figure 2-14: Alternative Location 2

Alternative Location 3 (**figure 2-15**) is the site of the existing Violet Canal. The use of this site would require the relocation of approximately 121 structures. Alternative 3 has the greatest potential impacts to businesses, homes, scenic streams, roads, bridges, levees, cultural and historic resources, docks and other maritime infrastructure. The existing Violet Canal site would impact 738 acres of wetlands, and is over a mile longer than Locations 1 and 2. Despite these potential impacts, this location was retained for further evaluation with Alternative Location 1, due to stakeholder interest.

Figure 2-15: Alternative Location 3

Location 4 (**figure 2-16**) is the longest route, and the land between the Mississippi River and the Forty Arpent Levee is at a higher elevation than at the other locations, which would require the largest structures of all four locations. Additionally, distribution to the northern portion of the Central Wetlands would be difficult from this location. Alternative 4 would require the largest structures due to its location on the river. Alternative 4 has the greatest potential impacts to existing wetlands, utilities and pipelines. The site includes in-river maritime infrastructure used for docking vessels that support the Military Sealift Command. Therefore, Location 4 was removed from further consideration.

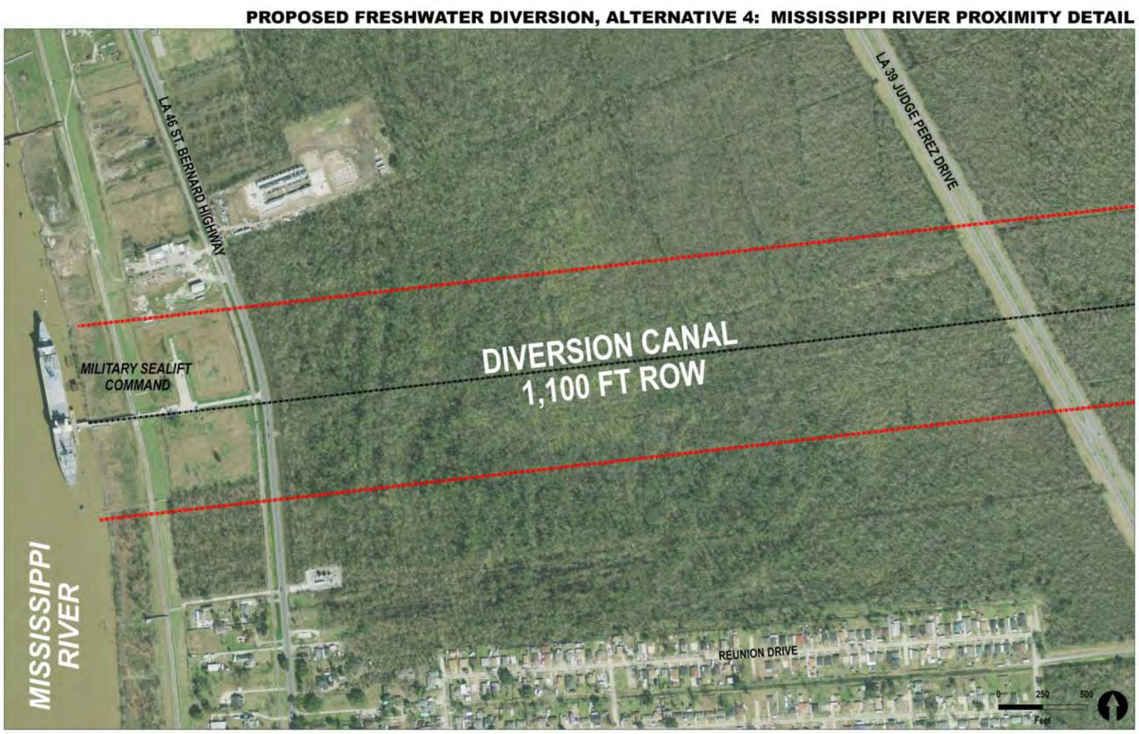


Figure 2-16: Alternative Location 4

Violet, Louisiana Freshwater Diversion Preliminary Capacity Evaluation

A preliminary alternative analysis was conducted using a 15,000 cfs diversion size to determine if the existing Violet Canal (Location 3) or Alternative Location 1 would be the best site for the proposed freshwater diversion. Preliminary analyses indicated that an approximately 15,000 cfs freshwater diversion would be needed to restore the salinity regime for the area. Although subsequent hydrodynamic modeling conducted for this study indicates that a 7,000 cfs diversion would be sufficient to achieve the targets in average conditions, in order to account for the effects of drought and RSLR, the design capacity of the diversion is actually larger than 7,000 cfs. Therefore, the use of 15,000 cfs in this screening analysis is sufficient to determine the scale of design differences between the two sites. This initial analysis concluded that Alternative Location 1 was preferable to the use of the existing canal for a number of reasons.

From the preliminary analysis, it was indicated that the Violet Canal location would require a 50-foot wider and 1-foot deeper channel than Alternative Location 1. In addition, the outflow channel length for the Violet Canal site is over a mile longer; therefore, dredging quantities, impacts to existing marsh, and costs would be greater than Alternative Location 1. In this preliminary analysis, the structure size for Alternative Location 1 was four 35-foot x 15-foot box culverts in comparison to four 40-foot x 15-foot box culverts for Location 3. A culvert is a conduit used to enclose a flowing body of water and allow water to pass underneath a road, railway, or embankment, such as a levee. The findings of the more detailed design for the preliminary site i.e. Alternative Location 1 and volume, which considered increased RSLR indicate that the difference between the designs for the two locations would be even greater.

Data Report for Violet Canal Freshwater Diversion and Mississippi River Gulf Outlet Water Control Structure analyzed 2,000 cfs, 5,000 cfs and 10,000 cfs diversions at the Violet Canal site (LDNR, 1996). This report found that a 5,000 cfs diversion would require additional dredging of the existing canal and the 10,000 cfs diversion would require significant dredging of the existing canal. The channel sizes used to develop quantities for the 10,000 cfs diversion in the 1996 report are smaller than the calculated quantities for the recommended plan diversion because the 1996 report did not consider RSLR or the ability to achieve the salinity targets for the study at least 40 percent of the time. Considering these factors, a significant widening of the existing channel would be necessary to convey the required diversion flows. The existing canal is approximately 100 feet wide on average. In order to convey the required flows, the channel would need to be widened to 500 feet at the bottom, resulting in a top width of nearly 600 feet.

Because the Violet Canal would require larger structures, a longer channel, and multiple relocations, the cost of constructing the freshwater diversion at this site appears to be considerably more than Alternative Location 1. There appear to be no additional environmental benefits associated with the use of the existing canal. Because the same restoration outputs can be produced with fewer impacts and lower costs at Alternative Location 1, the use of the existing canal is not the most cost-effective or efficient location to site the freshwater diversion.

Violet, Louisiana Freshwater Diversion Recommendations

The Violet, Louisiana Freshwater Diversion is an important component of the plan to restore historic salinity conditions and provide freshwater and nutrients to nourish existing and restored wetlands in the study area. However, additional study is needed to improve decisions about where, when, and how to divert Mississippi River flows in a systems context. The ongoing Mississippi River Hydrodynamic and Delta Management Study will evaluate ecosystem restoration alternatives in concert with dynamic flood risk management and navigation; multipurpose management scenarios of the river; and dynamic conditions in a comprehensive systems context. The information gained from this study will improve decision-making for the Violet, Louisiana Freshwater Diversion. Therefore, the final recommendations for the MRGO Ecosystem Restoration Plan include additional analysis, design and implementation of the Violet, Louisiana Freshwater Diversion under and in accordance with its authorization in WRDA 2007 Section 3083.

Environmental Impacts Analysis

Based on all of the preliminary analysis performed for the Violet, Louisiana Freshwater Diversion, the Alternative Location 1 shown in **figure 2-17** was considered the best hydraulic location; however, the diversion will be further investigated in the feasibility phase of analysis with appropriate NEPA documentation. For the purposes of impact analysis for this FEIS, the footprint for the Alternative Location 1 was utilized. In order to run the models, such as CASM, to develop the potential impacts and benefits of the overall project, parameters for the diversion had to be established and utilized. Therefore, in the **chapter 4** impacts analysis for each environmental resource, the parameters of Alternative Location 1 for the Violet, Louisiana Freshwater Diversion were used.

2.6.2.2 Alternative B - MRGO Restoration Plan 2

Alternative B would restore approximately 54 acres of ridge habitat along Bayou La Loutre in the Biloxi Marsh area, provide 122 acres of shoreline protection, create and nourish 10,319 acres of cypress swamp habitat in the Central Wetlands, and create and nourish 19,630 acres of wetlands in the Lower Pontchartrain sub-basin. The freshwater diversion, pulsing 7,000 cfs from April to May would influence approximately 115,078 acres. Reference **figure 2-18** for alternative B features. The diversion channel at Alternative Location 1 would result in the permanent loss of 302 acres of prime/unique farmland and 227 acres of wetland. Restoration of the ridge would result in permanent impacts to 54 acres of wetland. A description of the restoration measures proposed for this alternative are included in **appendix U**, along with the preliminary engineering footprints for each individual measure.

2.6.2.3 Alternative C - MRGO Restoration Plan 7

Alternative C would restore approximately 54 acres of ridge habitat in the Biloxi Marsh area, provide 1,937 acres of shoreline protection, create and nourish 10,318 acres of cypress swamp habitat in the Central Wetlands, and create and nourish 44,188 acres of wetlands in the Lower Pontchartrain sub-basin. The freshwater diversion, pulsing 7,000 cfs from April to May would influence approximately 115,078 acres. The diversion channel at Alternative Location 1 would result in the permanent loss of 302 acres of prime/unique farmland and 227 acres of wetland. Restoration of the ridge would result in permanent impacts to 54 acres of wetland. Reference **figure 2-19** for alternative C features. A description of the restoration measures proposed for this alternative are included in **appendix U**, along with the preliminary engineering footprints for each individual measure.

2.6.2.4 Alternative D - MRGO Restoration Plan 10

Alternative D would restore approximately 54 acres of ridge habitat in the Biloxi Marsh area, provide 2,494 acres of shoreline protection, create and nourish 10,318 acres of cypress swamp habitat in the Central Wetlands, and create and nourish 44,892 acres of wetlands in the Lower Pontchartrain sub-basin. The freshwater diversion, pulsing 7,000 cfs from April to May would influence approximately 115,078 acres. The diversion channel at Alternative Location 1 would result in the permanent loss of 302 acres of prime/unique farmland and 227 acres of wetland. Restoration of the ridge would result in permanent impacts to 54 acres of wetland. Reference **figure 2-20** for alternative D features. A description of the restoration measures proposed for this alternative are included in **appendix U**, along with the preliminary engineering footprints for each individual measure.

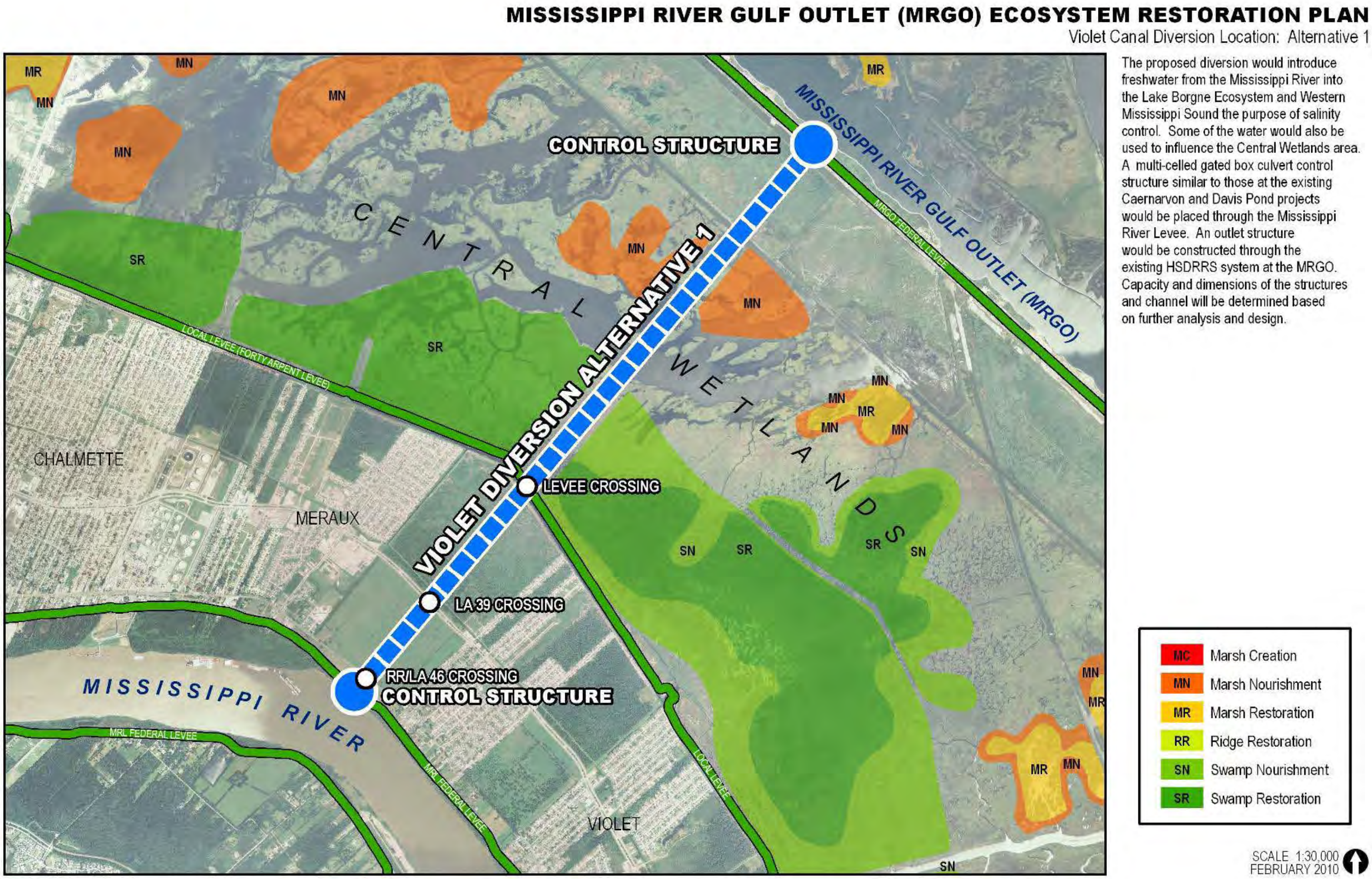


Figure 2-17: Alternative Location 1 for the Violet Freshwater Diversion

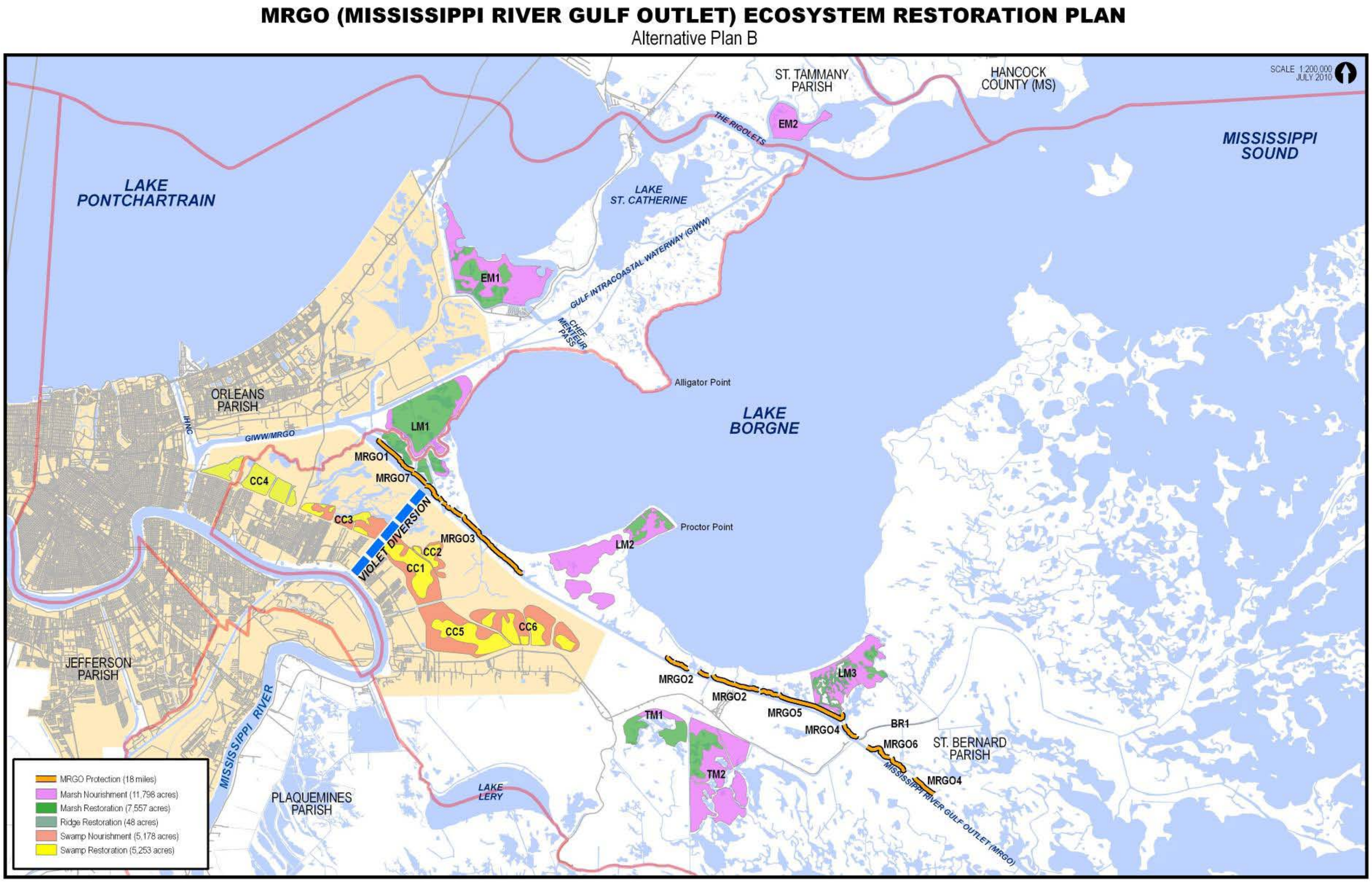


Figure 2-18: Alternative B – MRGO Restoration Plan 2

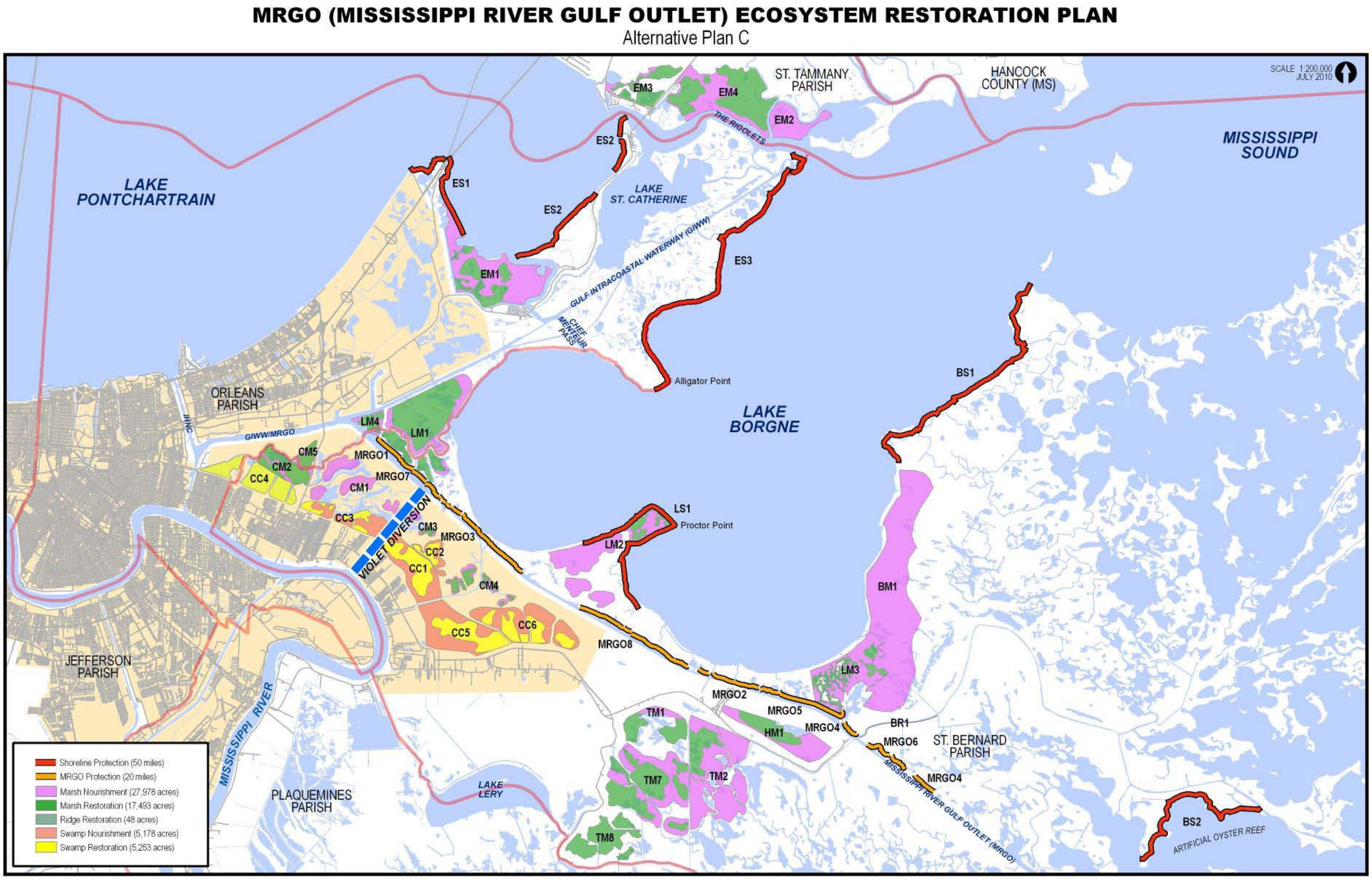


Figure 2-19: Alternative C – MRGO Restoration Plan 7

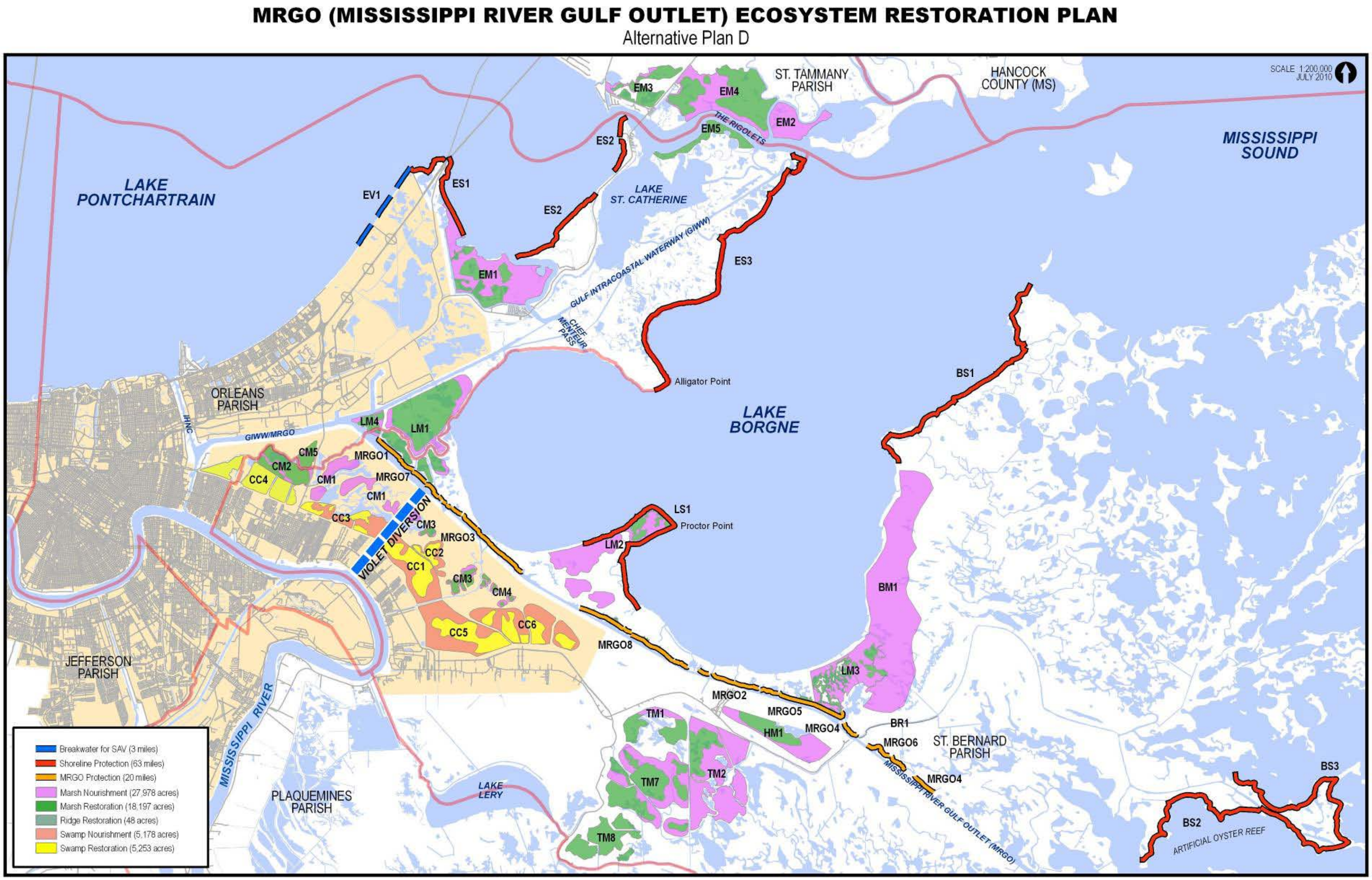


Figure 2-20: Alternative D – MRGO Restoration Plan 10

2.7 EVALUATION OF ALTERNATIVE PLANS

The evaluation of effects, or comparison of the future without-project and with-project conditions for each alternative, is a requirement of NEPA and Engineering Regulation (ER) 1105-2-100. The evaluation was conducted by assessing or measuring the differences between each without- and with-project condition and by appraising those differences. The evaluation consisted of four general tasks described below:

1. Forecast the most likely with-project condition expected under each alternative plan,
2. Compare each with-project condition to the without-project condition and document the differences between the two,
3. Characterize the beneficial and adverse effects by magnitude, location, timing and duration, and
4. Identify the plans that will be further considered in the planning process, based on a comparison of the adverse and beneficial effects and the evaluation criteria.

Plans were evaluated based on the following criteria: all relevant resources, outputs and plan effects, contributions to the Federal objective National Ecosystem Restoration, the study goals and objectives, compliance with environmental protection requirements, the Planning Guidance Notebook's four evaluation criteria (completeness, effectiveness, efficiency and acceptability), and other criteria deemed significant by participating stakeholders.

Ecosystem restoration alternatives must also be evaluated based on CE/ICA and significance of ecosystem outputs must be determined. Display of the environmental quality account is required for this study using a minimum of two categories of effects: costs and ecosystem restoration outputs.

MRGO Ecosystem project was evaluated first by individual measures. Then plans were combined based on cost effectiveness. Three plans were selected as the final array of plans for further evaluation. The final three plans were evaluated by a combination of measures within a subunit for each of the three final array plans. There were five subunits including A-Biloxi, D-Central Wetlands, E-East Orleans Landbridge, F-Terre aux Boeufs, and H-Hopedale. The subunits that are influenced by the diversion (A-Biloxi, D-Central Wetlands, and E-East Orleans Landbridge) were evaluated with the diversion. There were a total of 74 WVA evaluations completed to date (see **table 2-22** for final array of WVA results).

Habitat acreage, shoreline erosion, and interior marsh loss rate data were obtained from the USGS. WVA projections were made by members of the HET, which included representatives of the CEMVN, USFWS, OCPR, Department of Commerce – National Marine Fisheries Service (NMFS), NRCS, and Louisiana Department of Wildlife and Fisheries (LDWF). Prior to making those projections, HET members made onsite field inspections in June and October 2009.

Table 2-22: Final Array of WVA Results

Feature	AAHU*	Net Acres (TY50)	TY1 Acres FWOP	TY1 Acres FWP	TY50 Acres FWOP	TY50 Acres FWP
Alternative B – MRGO Restoration Plan 2						
A-Biloxi	11.7	+19	58	61	43	62
D-Central Wetlands	7,365.6	+9,543	16,324	18,212	11,841	21,384
E-East Orleans Landbridge	4,419.1	+6,138	44,750	42,282	33,016	39,154
F-Terre aux Boeufs	1,811.8	+3,358	9,651	10,459	6,923	10,281
Total Alternative B	**13,608.1**	**+19,058**	**70,783**	**71,014**	**51,823**	**70,881**
Alternative C – MRGO Restoration Plan 7						
A-Biloxi	1,948.6	+3,013	56,237	55,930	42,602	45,615
D-Central Wetlands	7,463.4	+9,543	16,324	18,218	11,841	21,384
E-East Orleans Landbridge	5,120.1	+7,546	48,570	42,788	36,323	43,869
F-Terre aux Boeufs	3,043.6	+5,566	10,823	10,846	7,763	13,329
H-Hopedale	164.3	+299	1,363	1,365	1,064	1,363
Total Alternative C	**17,575.7**	**+25,967**	**133,317**	**129,147**	**99,593**	**125,560**
Alternative D – MRGO Restoration Plan 10						
A-Biloxi	2,018.6	+3,197	56,749	57,239	42,848	46,045
D-Central Wetlands	7,616.7	+9,543	16,324	18,217	11,841	21,384
E-East Orleans Landbridge	4,408.9	+7,699	48,570	29,102	36,323	44,022
F-Terre aux Boeufs	2,907.8	+5,566	10,823	10,846	7,763	13,330
H-Hopedale	164.3	+299	1,363	1,365	1,064	1,363
Total Alternative D	**17,116.3**	**+26,304**	**133,829**	**116,769**	**99,839**	**126,144**

*AAHUs are based on individual plan measures within five planning units.

Field data, results from similar projects in the area, SBEACH models, and hydrologic models were used in conjunction with the above-discussed mathematical models to compute a HSI value for each target year (TY). Target years were established when significant changes in habitat quality or quantity were expected during the 50-year period of analysis, under FWP and FWOP conditions.

The product of an HSI and the acreage of available habitat for a given target year is known as the HU. The HU is the basic unit for measuring project effects on fish and wildlife habitat. Future HUs change according to changes in habitat quality and/or quantity. Results are annualized over the period of analysis to determine the AAHUs available for each habitat type.

The change in AAHUs for each FWP scenario, compared to FWOP project conditions, provides a measure of anticipated impacts. A net gain in AAHUs indicates that the project is beneficial to the habitat being evaluated; a net loss of AAHUs indicates that the project is damaging to that habitat type. In determining FWP conditions, all project-related direct (construction) impacts were assumed to occur from TY1 through TY10 for marsh restoration and nourishment, TY1 through TY5 for the Violet, Louisiana Freshwater Diversion, and TY1 for shoreline protection and the ridge.

Using the WVA methodology, impact assessments were conducted by the HET for the Final Array of Alternative Plans with the resulting benefits shown in **table 2-11**. Alternative C is estimated to produce the greatest benefit to habitat based on the highest valued of AAHUs (17,575.7) compared to alternatives B and D. Over a 50-year period, TY50, 25,967 acres of additional habitat is anticipated under alternative C (FWP) compared to TY50 FWOP conditions. Based on this initial WVA analysis, alternative C was deemed the best alternative that would produce the greatest benefit to fish and wildlife resources.

Once a best alternative determination was made, the CASM was run to model the effect of the tentatively selected plan on fisheries productivity. The CASM was run on the diversion flow regime which was a component of all the action alternatives and therefore, did not influence the selection of the tentatively selected plan.

2.7.1 Risks and Uncertainties

Risk is the product of the likelihood of failure and its consequences. There are significant risks and uncertainties associated with all ecosystem restoration plans in the study area. The adaptive management plan will address specific risks and uncertainties associated with the implementation of the selected alternative, and potential changes to the plan to respond to and minimize the potential effects of these unknown variables that could affect plan performance and/or costs (see **appendix T**). The following section describes major sources of risk and uncertainty and how they could impact each alternative in the final array.

Tropical Storms

Tropical storm events can directly and indirectly contribute to coastal land loss through erosion from increased wave energies, removal and/or scouring of vegetation from storm surge and saltwater intrusion into estuaries and interior wetlands. Wetland loss and degradation of large areas can occur in a short period of time from storms.

Approximately 52,480 acres of marsh were permanently or temporarily converted to open water in the study area following Hurricane Katrina, an area roughly equivalent to the amount of restoration proposed by the tentatively selected plan (Barras, 2009). There is a risk that a single storm event, or multiple storms in a short period of time, could significantly reduce or eliminate anticipated benefits of restoration plans in areas susceptible to storm surge and shearing. All of the features of the tentatively selected plan (and the associated costs and benefits) are at some risk from storm damage. The extent of potential damage is dependent upon several unknown variables, including: the track and intensity of the storm, the development stage of the project, changes in future conditions in the study area, and variability of project performance from forecast conditions due to other factors of risk and uncertainty.

Sediment-rich areas impacted by storms are able to re-vegetate naturally if they are not disturbed by additional storms (Barras, 2009). Therefore, the proposed placement of dredged material in the study area could promote the natural recovery of areas affected by storms. The nutrients and suspended solids associated with the freshwater diversion would also assist in minimizing the adverse effects of storms to restored marsh.

Brackish and saline marsh communities appear to be more resilient to shearing than fresh and intermediate communities (Barras, 2009). The majority of fresh and intermediate marsh areas proposed for restoration in the tentatively selected plan are located in the Central Wetlands, where storm damage risk is reduced by the Chalmette Loop Levee. Intermediate marsh restoration proposed along the Lake Borgne/MRGO Landbridge would remain susceptible to storm surge and shearing. However, these areas would be more resilient than the existing marsh due to the anticipated benefits of proposed shoreline protection, dredged material placement, vegetative planting, and nourishment from the proposed freshwater diversion. Although these areas could be significantly damaged by a storm event, the proposed action would decrease the extent of damage and increase the likelihood that these areas could recover naturally compared to existing and FWOP conditions.

The brackish features in the Terre aux Boeufs and Hopedale areas are located in interior areas that are less susceptible to scouring and removal of vegetation than areas directly adjacent to large open water areas. The anticipated benefits of restoration in these areas could be significantly reduced by a storm, particularly if marsh vegetation was not well established. Some of the sediment placed in these areas could be lost in a storm event. However, because there is a buffer between these features and large open water areas, it is less likely that the benefits of restoration features in this area would be lost entirely.

Depending on the track and intensity of the storm, the proposed ridge feature at Bayou La Loutre could reduce potential storm damage to adjacent areas, including features LM3 and BM1. The ridge feature would be more resilient when fully vegetated than during construction. However, if the ridge feature was damaged during construction, it is likely that sediment would be dispersed throughout the adjacent marsh areas, benefitting those areas while reducing or eliminating the benefit to the proposed ridge.

The predicted benefits of features EM1, EM2, EM3, and EM4 are at risk of scouring and shearing from storms. Depending on the track and intensity of a storm, the benefits in these areas could be significantly reduced. However, without restoration, the destruction of these areas could increase storm damage risk in the study area.

The benefits of shoreline protection features could be reduced by a storm through the displacement of rocks and damage to the structures. Repair of storm damage to these features would increase the anticipated costs to maintain the anticipated erosion reduction benefits, reducing the cost-effectiveness of these features.

Increased Sea Level Rise

Increased sea level rise could convert emergent wetlands to shallow open water, and shallow open water to deeper water habitat, reducing or eliminating the effectiveness of restoration plans. Proposed restoration features adjacent to open water are more susceptible to the effects of increased sea level rise than more interior areas.

Climate Change

Extreme changes in climate could result in conditions that cannot support the types of habitat restored, reducing the effectiveness of the restoration plan. Extreme climate change could essentially eliminate the benefits of vegetative plantings, if the change resulted in fatality. The adaptive management plan includes provisions for monitoring climate change and triggers for adjusting plan implementation to these potential changes (see **appendix T**).

Errors in Analysis

Future conditions are inherently uncertain. The forecast of future conditions is limited by existing science and technology. Future conditions described in this study are based on an analysis of historic trends and the best available information. Some variation between forecast conditions and reality is certain. Restoration features were developed in a risk-aware framework to minimize the degree to which these variations would affect planning decisions. However, errors in analysis or discrepancies between forecast and actual conditions could affect the effectiveness of plans.

All of the models used in this study are abstract mathematical representations of reality. Models simulate complex systems by simplifying real processes into expressions of their most basic variables. These tools assist with finding optimal solutions to problems, testing hypothetical situations, and forecasting future conditions based on observed data. No model can account for all relevant variables in a system. The interpretation of model outputs must consider the limitations, strengths, weaknesses and assumptions inherent in model inputs and framework. Inaccurate assumptions or input errors could change benefits predicted by models used in this study. The potential for significant changes due to errors has been reduced through technical review, sensitivity analyses, and quality assurance procedures. However, there is inherent risk in reducing complex natural systems into the results of mathematic expressions driven by the simplified interaction of key variables.

Salinity

Salinity is a specific source of potential analytical variability because salinity in the study area is changing. For instance, salinity in the MRGO in the vicinity of the Central Wetlands was reduced to approximately 4 to 7 ppt following the closure of the MRGO. Coastwide Reference Monitoring Stations indicate that Central Wetlands salinity is lower than 4 ppt and is continuing to decline. Contributing factors include the closure of MRGO, the closure of Bayou Dupre during the construction of the Chalmette Loop Levee, the construction of the IHNC Surge Barrier, and the concurrent operation of the existing Violet Siphon. If salinity is different from predicted conditions, it may not be possible to support the habitat type planned for that area.

Implementation

The timing and availability of financial resources for implementation is a major uncertainty that must be considered. If the plan is not implemented in the near future, the problems in the study area will continue to degrade conditions. The impact of the uncertainties associated with the future condition of the study area could increase restoration costs, decrease restoration benefits, or both. The uncertainties associated with implementation are increased because a non-Federal sponsor has not been identified for the majority of the plan.

All plans in the final array of alternatives require phased implementation, which can reduce risk. With phased implementation, costs are expended periodically, rather than all at once, which reduces risk to the monetary investment. Phased implementation also provides the opportunity to adjust project design and develop lessons learned from projects built in the initial phase.

The relative risk of each plan is based on the differences in consequences. Because it has the lowest benefits and costs, Plan A involves no action, and therefore the risk to the ecosystem is greatest under this scenario. The risk associated with Plan B is less than Plan A, because some key restoration features, would be implemented. Plan B reduces the risk to some critical landscape features, but does not provide as much restoration and protection as Plan C. The risk to ecosystem form and function is less with Plan C than Plans A and B, because it includes more actions to protect and restore key geographic components of the ecosystem. Plan D provides the most restoration features of all of the plans evaluated in the final array, and further decreases the risk to ecosystem form and function. **Table 2-23** evaluates the susceptibility of plan features to risks.

Table 2-23: Relative Sustainability of Features

Measure	Relative Susceptibility to Risk					
	Tropical Storms	Climate Change	Increased RSLR	Analytical Variability	Implementation	Overall Risk
EM2	High	Moderate	High	Moderate	Moderate	Moderate-High
EM3	Moderate	Moderate	High	Moderate	Moderate	Moderate
EM4	Moderate	Moderate	High	Moderate	Moderate	Moderate
EM1	Moderate	Moderate	High	Moderate	Moderate	Moderate
EM5	High	Moderate	High	Moderate	Moderate	Moderate-High
ES1	High	Low	High	Low	Low	Moderate
ES2	High	Low	High	Low	Low	Moderate
ES3	High	Low	High	Low	Low	Moderate
EV1	High	Low	High	Low	Low	Moderate
MRGO1	High	Low	High	Low	Low	Moderate
MRGO2	High	Low	High	Low	Low	Moderate
MRGO3	High	Low	High	Low	Low	Moderate
MRGO4	High	Low	High	Low	Low	Moderate
MRGO5	High	Moderate	High	Moderate	Moderate	Moderate-High
MRGO6	High	Low	High	Low	Low	Moderate
MRGO7	High	Moderate	High	Moderate	Moderate	Moderate-High
MRGO8	High	Moderate	High	Moderate	Moderate	Moderate-High
LM1	High	Moderate	High	Moderate	Moderate	Moderate-High

Table 2-23: Relative Sustainability of Features

Measure	Relative Susceptibility to Risk					
	Tropical Storms	**Climate Change**	**Increased RSLR**	**Analytical Variability**	**Implementation**	**Overall Risk**
LM2	High	Moderate	High	Moderate	High	Moderate-High
LM3	High	Moderate	High	Moderate	Moderate	Moderate-High
LM4	Low	Moderate	High	Moderate	Low	Moderate
LS1	High	Low	High	Low	Low	Moderate
CC1 –CC6	Low	Moderate	Moderate	Moderate	Moderate	Moderate
CM1-CM5	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
TM1	High	Moderate	High	Moderate	Moderate	Moderate-High
TM2	High	Moderate	High	Moderate	Moderate	Moderate-High
TM7	High	Moderate	High	Moderate	Moderate	Moderate-High
TM8	High	Moderate	High	Moderate	Moderate	Moderate-High
HM1	High	Moderate	High	Moderate	Moderate	Moderate-High
BR1	High	High	Low	High	Moderate	High
BS1	High	Low	High	Low	Low	Moderate
BS2	High	Moderate	High	Moderate	Low	Moderate-High
BS3	High	Low	High	Low	Low	Moderate
BM1	High	Moderate	High	Moderate	Moderate	Moderate-High

All of the alternatives in the final array of alternatives are equally likely to be impacted by these risk factors. The relative risk of each alternative is based on the differences in consequences. Because it has the lowest benefits and costs, alternative A has the lowest risk. However, because alternative A involves no action, the ecosystem is more at risk under this scenario. Alternative B involves more risk than alternative A in terms of risks to benefits and investments, but risk to existing marsh and ecosystem function would be less than alternative A. Because alternative C has greater anticipated benefits and requires a larger investment than alternative B, the associated risks are greater. Conversely, because alternative C has greater benefits than alternatives A and B, the overall risk to the ecosystem is less than with alternatives A and B. Similarly, alternative D involves more restoration features and greater benefits in critical landscape features than alternative C. Therefore, the risk of loss of benefits and investment is greater, but risk to ecosystem form and function is reduced.

2.7.2 Assessment of Sustainability for Relative Sea Level Rise Scenarios

Features contained within the final array of alternatives were assessed on a Yes/No scale for each of the following four sustainability factors:

1. Elevation – Features at higher elevations are more sustainable under relative sea level rise, e.g. ridges, than features at marsh elevation. (Y = features that are higher than marsh elevation; N = features that are at marsh elevation)
2. Freshwater influence – Features that are influenced by rivers or river diversions have a sustainable source of freshwater and sediment to nourish them and aid in accretion. (Y = features nourished by freshwater; N = features not nourished by fresh water)

3. Wave energy – Features that are protected from wave energy (e.g. interior marsh) are more sustainable than features subjected to high wave energy. (Y = features protected from high wave energy; N = features not protected from high wave energy)
4. Natural features – Features that are natural, living features of the ecosystem such as marsh are more sustainable than hard structures such as rock that subside more quickly and cannot sustain themselves and therefore require more O&M. (Y = natural features; N = hard features)

After each feature or groups of features was assessed for each sustainability factor, the feature was assigned numerical and qualitative scores as follows:

- Sustainability factors were convert to points: Yes (Y) = 1 point. No (N) = 0 points. If a feature included more than one component and received a Yes score for one component and a No score for the other component, it received a half point.
- Points were then totaled and converted into a qualitative score as follows: 0 = Poor; 1 = Fair; 2 = Good; 3 = Very Good; 4 = Excellent.

Table 2-24: Sustainability under Relative Sea Level Rise by Feature

			Sustainability Factors					
Area	**ID**	**Plans**	**Elevation**	**FW Influence**	**Wave Energy**	**Natural Feature**	**Score**	
East Orleans Landbridge	EM2	B, C (TSP), D	N	Y	N	Y	2	Good
	EM3	C (TSP), D	N	Y	Y	Y	3	Very Good
	EM4	C (TSP), D	N	Y	N	Y	2	Good
	EM1	B, C (TSP), D	N	N	N	Y	1	Fair
	EM5	D	N	N	N	Y	1	Fair
	ES1	C (TSP), D	N	N	N	N	0	Poor
	ES2	C (TSP), D	N	N	N	N	0	Poor
	ES3	C (TSP), D	N	N	N	N	0	Poor
	EV1	D	N	N	N	N	0	Poor
MRGO	MRGO1	B, C (TSP), D	N	N	N	N	0	Poor
	MRGO2	B, C (TSP), D	N	N	N	N	0	Poor
	MRGO3	B, C (TSP), D	N	N	N	N	0	Poor
	MRGO4	B, C (TSP), D	N	N	N	N	0	Poor
	MRGO5	B, C (TSP), D	N	Y	N	Y/N	1.5	Fair/Good
	MRGO6	B, C (TSP), D	N	N	N	N	0	Poor
	MRGO7	B, C (TSP), D	N	Y	N	Y/N	1.5	Fair/Good
	MRGO8	C (TSP), D	N	Y	N	Y/N	1.5	Fair/Good
South Lake Borgne	LM1	B, C (TSP), D	N	Y	N	Y	2	Good
	LM2	B, C (TSP), D	N	Y	N	Y	2	Good
	LM3	B, C (TSP), D	N	Y	N	Y	2	Good
	LM4	C (TSP), D	N	Y	Y	Y	3	Very Good
	LS1	C (TSP), D	N	N	N	N	0	Poor
tral Wet land	CC1 – CC6	B, C (TSP), D	Y	Y	Y	Y	4	Excellent

Table 2-24: Sustainability under Relative Sea Level Rise by Feature

Area	ID	Plans	Sustainability Factors				Score	
			Elevation	FW Influence	Wave Energy	Natural Feature		
	CM1-CM5	C (TSP), D	N	Y	Y	Y	3	Very Good
Terre aux Boeufs	TM1	B, C (TSP), D	N	N	Y	Y	2	Good
	TM2	B, C (TSP), D	N	N	Y	Y	2	Good
	TM7	C (TSP), D	N	N	Y	Y	2	Good
	TM8	C (TSP), D	N	N	Y	Y	2	Good
	HM1	C (TSP), D	N	N	Y	Y	2	Good
Biloxi Marsh	BR1	B, C (TSP), D	Y	Y	Y	Y	4	Excellent
	BS1	C (TSP), D	N	N	N	N	0	Poor
	BS2	C (TSP), D	N	N	N	N	0	Poor
	BS3	D	N	N	N	N	0	Poor
	BM1	C (TSP), D	N	Y	N	Y	2	Good

If the sustainability scores are averaged, Plans B, C, and D are all in the range of Fair to Good sustainability (1-2). All plans include the most sustainable types of features, i.e. the cypress swamp and ridge habitat. The smallest plan, Plan B is marginally more sustainable simply because it includes the least number of features. For Plans C and D, sustainability decreases marginally as less sustainable features, such as shoreline protection, are added.

Relative Sea Level Rise Scenario Analysis Conclusions

Under the medium scenario, the cost-effectiveness of all of the action plans would decrease. To achieve the level of benefits projected for the historic rate under the medium scenario, additional lifts and maintenance of restoration features beyond predicted OMRR&R actions may be required. The alternative to increased maintenance would be significantly reduced benefits.

Under the low and medium sea level rise scenarios, it does not appear that land/water ratios would be altered to the extent that habitat-switching would occur in the restored areas. Adaptive management actions could mitigate potential switching under these sea level rise scenarios.

The diminished output of the alternative plans under the high sea-level rise scenario requires serious consideration. The recommendations for this study include an assessment of sea level rise rates and appropriate responses.

2.8 COMPARISON OF ALTERNATIVE PLANS

Alternative plans were compared against each other, with emphasis on benefits and impacts with respect to study goals and objectives and NER objectives. **Table 2-25** provides a summary of how each alternative plan meets the study objectives.

Table 2-25: Comparison of Alternatives to Study Objectives

Objective	Alternative A	Alternative B	Alternative C	Alternative D
1. Salinity Target	No	Yes	Yes	Yes
2. Cypress (Minimum 9,500 acres)	No	Yes	Yes	Yes
3. Fresh/Intermediate (Minimum 6,800 acres)	No	Yes	Yes	Yes
4. Brackish (Minimum 18,100 acres)	No	No	Yes	Yes
5. Additional Marsh, Types lost through erosion (Minimum 3,900 acres)	No	No	Yes	Yes
6. Ridge Habitat	No	Yes	Yes	Yes
7. Landscape Features for Surge Reduction[a]	No	Yes 5,100 acres	Yes 20,523 acres	Yes 21,165 acres

[a] Landscape features for surge reduction include acres restored, nourished or protected on the East Orleans Landbridge and the Biloxi Marsh.

2.9 IDENTIFICATION OF THE TENATIVELY SELECTED PLAN

The tentatively selected plan is the NER plan as determined by the evaluation criteria discussed in **section 2.7**. The CASM Model is a tool in determining the effects of the plan on fisheries productivity. Once the tentatively selected plan was determined, the CASM was run on the diversion flow regime, which was a component of all the action alternatives and therefore, did not influence the selection of the tentatively selected plan. The NER plan reasonably maximizes environmental benefits while passing tests of cost effectiveness and incremental cost analyses, significance of outputs, acceptability, completeness, efficiency, and effectiveness. WRDA 2007 requires the plan to be cost effective, environmentally acceptable, and technically feasible in order to be carried out by the Secretary of the Army. Additional factors to consider include the involvement of other agencies and the reasonableness of costs.

Alternative C is the tentatively selected plan and NER plan for this study because it is the first Best Buy Plan that meets all of the objectives, including reasonably maximizing the storm surge benefit objective. Other plans were evaluated that provide additional benefits, but the increases in costs were not considered reasonable given the relative outputs. Alternative C is cost-effective, and maximizes the opportunities to achieve the objectives of the study for the least cost. The incremental costs associated with alternative C are considered reasonable for the significance of the outputs achieved.

The anticipated outputs of the tentatively selected plan would help address the current trend of degradation of the Lake Borgne ecosystem, support Nationally significant resources, provide a sustainable and diverse array of fish and wildlife habitats, provide infrastructure protection, and make progress towards a more sustainable ecosystem.

The implementation of the tentatively selected plan is anticipated to restore significant ecosystem function, structure, and dynamic processes through a comprehensive systems-based approach. The tentatively selected plan would restore unique habitat in a nationally significant watershed. The costs associated with the tentatively selected plan are significant, and would represent a continuing national commitment to the protection and restoration of one of the nation's most productive estuaries. There is no construction cost associated with the no action alternative; however, the loss of unique habitat and natural resources that would result from this alternative would represent unacceptable costs to the nation.

The tentatively selected plan would restore rare and unique habitat, including coastal ridge, cypress swamp, and fresh marsh. These habitat types are institutionally and technically significant due to relative scarcity and importance. The study area includes environmental resources that are protected by the Endangered Species Act of 1973; Fish and Wildlife Conservation Act of 1980; Fish and Wildlife Coordination Act of 1958, as amended; Migratory Bird Conservation Act; Migratory Bird Treaty Act; and Executive Order (EO) 13186 Migratory Bird Habitat Protection.

The USFWS, in a letter dated October 31, 2008, formally requested that significant fish and wildlife resources be fully considered and addressed in this study, including: seabirds, shorebirds, wading birds, migratory and resident waterfowl, and estuarine-dependent fishes and shellfishes.

Coastal Louisiana's wetlands support neotropical and other migratory avian species such as rails, gallinules, shorebirds, wading birds, and numerous songbirds, as well as many different furbearers, rabbits, deer, and alligators. Louisiana coastal wetlands provide neotropical migratory birds' essential stopover habitat on their annual migration route. The coastal wetlands in the study area provide important and essential fish and wildlife habitats, used for shelter, nesting, feeding, roosting, cover, nursery, and other life requirements.

Emergent wetlands and shallow open water areas in the study area provide important habitat and EFH. By letter dated October 27, 2008, the NMFS indicated water bodies and wetlands in the study area provide nursery and foraging habitats supportive of a variety of economically important marine fishery species. Some of these species also serve as prey for other fish species managed under the Magnuson-Stevens Act by the Gulf of Mexico Fishery Management Council and highly migratory species managed by NMFS.

Wetlands of national interest that would benefit from the implementation of the tentatively selected plan include those found in the Bayou Sauvage National Wildlife Refuge and the Pearl River and Biloxi Wildlife Management Areas (WMA).

In October 2009, President Obama formed the Louisiana-Mississippi Gulf Coast Ecosystem Restoration Working Group, co-led by the White House CEQ and the Office of Management and Budget (OMB) and comprising senior-level officials from the

NOAA, the Environmental Protection Agency (EPA), and the Departments of the Army USACE, Homeland Security, the Interior, and Transportation. The Working Group has developed a Roadmap for Restoring Ecosystem Resiliency and Sustainability in the Louisiana and Mississippi Coast. One of the findings of this roadmap is that "bold and decisive action is needed now to curtail the rate of wetland loss and barrier island erosion in the area and to restore some of these lost features and ecosystem services."

The Administration has repeatedly demonstrated a commitment to coastal restoration in Louisiana. President Barack Obama made the following statement during his 2009 visit to the Gulf Coast:

> *"We've already seen 220 miles worth of levees and flood walls repaired, and we are working to strengthen the wetlands and barrier islands that are the first line of defense for the Gulf Coast. This isn't just critical to this region's physical protection, it's critical to our environment, it's critical to our economy."*
> - President Barack Obama, October 15, 2009

During this visit, the Council on Environmental Quality visited the Bienvenue Triangle in the Central Wetlands. Restoration of this area is a key component of the study.

The nation derives significant benefits from the coastal Louisiana ecosystem: protection for the production and transport infrastructure for about 30 percent of the nation's oil and gas supply; the Nation's second largest commercial fishery; and navigation and port facilities which together support America's number one port complex by tonnage.

2.9.1 Description of the Tentatively Selected Plan

The tentatively selected plan (alternative C) would restore approximately 57,472 acres of habitat in the study area, including 14,123 acres of fresh and intermediate marsh; 32,511 acres of brackish marsh; 10,318 acres of cypress swamp; 466 acres of saline marsh; and 54 acres of ridge habitat. Alternative C includes approximately 71 miles of shoreline protection. These acreage values are based on WVA results, which take into account marsh creation behind the shoreline protection features.

Approximately 10,221 acres of the restoration and protection features would be located in the East Orleans Landbridge/Pearl River area and approximately 9,861 acres of restoration features would be located in the Biloxi Marsh area, which have been determined to be critical landscape features with respect to storm surge. Additionally, the cypress swamp and ridge restoration feature would include forested habitat, which has been demonstrated as having some storm surge damage risk reduction benefits.

Further analysis and implementation of a freshwater diversion in the vicinity of Violet is a key component of the tentatively selected plan. The freshwater diversion is a system driver to create conditions conducive to the full restoration of historic salinity levels in the vicinity of the MRGO. The Violet, Louisiana Freshwater Diversion would mimic natural processes and enhance the sustainability of the system through the input of freshwater, nutrients, and sediment.

Below is a summary of the construction techniques that would be used for each restoration component. Specific construction and implementation information for each proposed restoration site is included in **appendix U** on the engineering footprints for each feature.

2.9.1.1 Marsh Restoration

A hydraulic dredge would be used to discharge slurry into shallow water areas and degraded marsh areas. Material would be obtained from study area borrow sites as noted for each feature. Slurry would be discharged to an elevation conducive to the development of wetlands habitat following dewatering and compaction. It is anticipated that the final result of this dredge material placement would be a combination of wetlands, mud flat, and shallow water habitat within the placement site. Following compaction and dewatering, the area would be planted with marsh vegetation appropriate for the site.

In general for marsh restoration, it was assumed that existing elevations within the marsh restoration site average -0.5 foot and that adjacent marsh is approximately +1.5 feet. Maximum slurry elevation would be +4.0 feet. Retention dikes and interior weirs were included where needed. Dikes would be constructed from adjacent borrow and would be at +6.0 feet with a 5-foot crown width and 1 vertical on 3 horizontal side slopes and a 40-foot interior berm. Interior weirs will be built from adjacent borrow to an elevation of +3.0 feet with a 5-foot crown width and 1 vertical on 3 horizontal side slopes. In some cases, closures comprised of either adjacent earthen borrow material, sheet pile or stone may be required in order to retain the dredged slurry.

Earthen dikes/closures would be allowed to degrade naturally. If earthen dikes/closures do not sufficiently degrade to provide fisheries and tidal ingress/egress following appropriate settlement of dredge material placed within the disposal area, earthen dikes/closures would be mechanically breached and/or degraded within three years of construction, as necessary.

Canal Closures

An earthen plug would be constructed in the canal utilizing sediments from the canal. The earthen plug would serve to prevent the flow of sediment laden water from the dredging activity to flow outside of the designated area of impact. The method for plugging canals would be the same for marsh nourishment as well as swamp restoration and nourishment features.

Weirs

Interior low-level earthen weirs may be constructed within the marsh restoration areas to facilitate sediment deposition to enhance wetlands development. Borrow material for weir construction would be taken from within the restoration area. Earthen dikes/closures would be allowed to degrade naturally. If earthen dikes/closures do not sufficiently degrade to provide fisheries ingress/egress and tidal exchange after settlement of dredge material, earthen dikes/closures would be mechanically breached and/or degraded within three years of construction, as necessary.

Planting Plan

Below is a summary of the planting plan for the marsh restoration features. Refer to **appendix Z**.

Fresh and Intermediate Marsh

Location within the marsh depends on their ability to withstand depth and length of flooding. The CWPPRA estimate for vegetative planting is 625 plants/acre planted on 8-foot center on rows 8 feet apart. Some are available commercially and can be propagated.

Some of the dominant marsh plants in freshwater and intermediate wetlands are: maidencane (*Panicum hemitomon),* bull tongue (*Sagittaria lancifolia),* giant cutgrass (*Zizaniopsis miliacea*) California bulrush (*Schoenoplectus californicus*), coast cockspur (*Echinochloa walteri),* marsh-hay cordgrass (*Spartina patens*), and Common reed (*Phragmites australis*).

Brackish Marsh

CWPPRA estimate for vegetative planting is 875 plants/acre planted on 7-foot centers on rows 7 feet apart. Some are available commercially and can be propagated. Species usually dominant in a brackish marsh are: marsh-hay cordgrass (*Spartina patens),* saltgrass (*Distichlis spicata),* American bulrush (*Schoenoplectus americanus),* black needle rush (*Juncus roemerianus),* seashore paspalum (*Paspalum vaginatum*), and switchgrass (*Panicum virgatum*). The low marsh is typically dominated by (*Spartina alterniflora*).

2.9.1.2 Marsh Nourishment

For marsh nourishment it was assumed that existing marsh is between +0.5 foot and 1.0 foot and fill would be to +2.0 feet. Retention dikes and interior weirs were included where needed. Dikes would be constructed from adjacent borrow and would be at +6.0 feet with a 5-foot crown width and 1 vertical on 3 horizontal side slopes and a 40-foot interior berm. Interior weirs will be built from adjacent borrow to an elevation of +3.0 feet with a 5-foot crown width and 1 vertical on 3 horizontal side slopes. In some cases, closures comprised of either adjacent earthen borrow material, sheet pile or stone may be required in order to retain the dredged slurry.

Dredged material would be obtained from study area borrow sites as noted for each feature. The elevation of marsh nourishment areas varies from +1.0 foot to +1.5 feet. Material would be allowed to overflow existing emergent marsh vegetation and into waterbodies within the project boundaries; some shallowing of these features would be anticipated.

Unlike marsh restoration features, no plantings are associated with marsh nourishment features. Dikes/closures would be allowed to degrade naturally and would be breached and/or degraded within 3 years following construction to provide fisheries access if they do not sufficiently degrade following settlement of dredged material.

2.9.1.3 Swamp Restoration

Swamp restoration is proposed in shallow water areas that were historically cypress-tupelo swamps. Swamp restoration consists of pumping dredged material from borrow areas, as noted for each feature, to a maximum elevation of +4.5 feet within containment dikes. Swamp restoration areas would be planted with cypress trees.

The construction of swamp restoration features is similar to marsh restoration features as described above. In general, for swamp restoration an existing average elevation of -1.0 foot to -3.0 feet was assumed based on the bathymetry available with an adjacent marsh elevation of +1.5 feet. The maximum slurry elevation would be +4.5 feet and effluent would be discharged on adjacent swamp/marsh lands for nourishment. Retention dikes would be constructed where needed. Dikes would be constructed from adjacent borrow to an elevation of +6.5 feet with a 5-foot crown width and 1 vertical on 3 horizontal side slopes and a 40-foot interior berm. In some cases, closures comprised of either adjacent earthen borrow material, sheet pile or stone may be required in order to retain the dredged slurry. Dikes would be allowed to degrade naturally and would be breached and/or degraded within three years following construction to provide fisheries access if they do not sufficiently degrade following settlement.

General Operations Scheme

The Violet diversion presents the opportunity to aid in reestablishment of natural hydrologic cycles conducive to bald cypress and tupelo establishment, growth, and reproduction. The Coastal Wetland Forest Conservation and Use Science Working Group (CWFCU-SWG) was commissioned by the Governor of Louisiana with the mission "to provide information and guidelines for the long-term utilization, conservation, and protection of Louisiana's coastal wetland forest ecosystem, from both environmental and economic perspectives" (CWFCU-SWG, 2005). The subsequent research, findings, and recommendations are invaluable tools when determining conditions needed for establishment, growth, and reproduction of bald cypress swamp and were incorporated in determining the operational scheme. The general operations scheme is presented in **appendix M**.

Adaptive management for (1) habitat switching; and (2) pulsing to reach target salinity.

1. No pulsing in the first 2 years to 3 years to achieve habitat switching and allow cypress seedlings time to establish.
2. After first 2 years to 3 years, ramp up pulsing from few days – one week pulse toward a two week pulsing cycle (cycle includes maximum pulsing of no more than 2 weeks with 2 weeks of no flow between pulses) to achieve target salinity.
3. Every 3 years to 5 years a drawdown should be initiated to elevation -4.0 feet to -6.0 feet below surface beginning in March for cypress regeneration. After seed fall to achieve successful reestablishment of cypress, the area should not be flooded (soils saturated but no water above the -4.0 feet elevation) during growing season (March – November) for the next two growing seasons.
4. After drawdown, flows should be introduced slowly – not more than +2.0 inches initially and gradually increasing over the year not to exceed +8.0 inches by the end of that growing year.
5. Flows for months other than pulsing or drawdown months would be at a level to achieve fresh wetlands (0 ppt to 0.5 ppt mean growing season March to November) with a maximum peak of 2 ppt or less.

Planting Plan

Below is a summary of the planting plan for the swamp restoration features. Refer to **appendix Z**.

Construction of cypress swamp habitat would begin at the completion of the Violet Diversion. An average of 200 bald cypress per acre with 75 percent bare-root seedlings or saplings and 25 percent container-grown would be planted from October through March. All of the cypress trees would have a nutria protection device. Threes would be monitored monthly for survivorship and replaced as necessary.

Initially the diversion would operate at a reduced level for the first two to three years after swamp plantings to allow for establishment and habitat switching. Every three to five years, a drawdown should be initiated in March, after seed fall and dispersal, to approximately four to six inches below swamp surface. The drawdown should continue through the growing season until November to aid in reestablishment.

2.9.1.4 Swamp Nourishment

Swamp nourishment is proposed for areas that are currently at marsh elevation, and consists of placing a layer of dredge material to nourish the area, raise elevation to approximately +2.0 feet, and encourage the recruitment of cypress-tupelo community species. The depth of dredged material would be determined on a site-by-site basis to adjust for varying topography.

2.9.1.5 Shoreline Protection

These features consist of either foreshore (shore between high water and low water) rock dikes or rock dikes placed near the existing shoreline to dissipate wave energy before it reached the shoreline. Foreshore rock dikes would be constructed by placing rock in a linear mound at the -1.5 foot to -2.0 feet depth contour, to a height above the water's surface.

Shoreline protection designs were based on designs for existing features constructed in similar locations. The work consists of protection on the north and south banks of the MRGO, the shore of Lake Borgne, the Biloxi Marsh, the East Orleans Landbridge, and other areas as shown on the engineering footprints in **appendix U**.

Work along the banks of the MRGO consists mainly of repairs to existing foreshore dikes. Existing dikes would be brought up to elevations range from +3.0 feet to +6.0 feet depending on the location. Crown widths range from 4 feet to 5 feet. For areas with no existing dike a concrete panel wall to elevation +4.0 feet was assumed.

Protection along the Biloxi Marsh consists of a stone dike constructed of 5,000 pound stone with a crown width of 8 feet to 10 feet and a top elevation of from +4.0 feet to +8.0 feet. Gulf-side slope would be 1 vertical on 3 horizontal and land side slop would be 1 vertical on 2 horizontal. To minimize subsidence, the dike section would be underlain with a 2-foot crushed stone blanket.

Protection along Lake Borgne consists of a rock dike to elevation +4.0 feet with a crown width of 4 feet and 1 vertical on 2 horizontal side slopes. The dike would be constructed on geotechnical filter fabric to minimize settlement.

Protection along the East Orleans Landbridge would consist of a rock foreshore dike constructed to a crown elevation of +3.5 feet with a 5-foot crown and 1 vertical on 2 horizontal side slopes. The dike would be constructed on a layer of geotextile fabric to minimize settlement.

Based on recommendations from the USFWS, the shoreline protection features would include fish dips in the final design. Fish dips are breaks or low points in the shoreline protection feature, which allow aquatic organisms to access the marsh habitat behind the rock features. This exchange is important for both spawning and feeding of numerous aquatic species. The fish dips would be included every 1,000 feet, with a 25-foot bottom width set to the pre-project water bottom elevation. The 1,000-foot spacing would be adjusted based on existing exchange points, as well as coordinated consulting with the NMFS.

Oyster Reefs

Oyster larvae develop a shell and feed on algae, drifting on currents and riding the tide. By the third week, they attach themselves to a hard surface - usually other oysters - here they transform into a tiny oyster called spat and bond with others to form a reef. As oyster reefs decline larvae have less of a chance of finding a suitable surface. Globally, scientists estimate an 85 percent loss of native oyster reef habitat.

Oyster reefs are the ecosystem engineers of bays and estuaries. They provide important services to people and nature by improving water quality through filtering impurities from the water, providing food and habitat for a variety of marine and estuarine fish and invertebrates and providing a natural coastal buffer.

The plan is to create 30,750 linear feet (5.8 miles) of potential artificial oyster reef development on the Chandeleur Sound side of the Biloxi Marsh from Eloi Point to the south side of the mouth of Bayou La Loutre. There would be three sections: 1) loose shells; 2) interlocking triangular structures; and 3) concrete rings, each 2.5 miles long with the loose shells in the middle. The purpose of this demonstration measure is to determine which oyster reef alternative is the most beneficial to oyster production over time.

Oyster Reef Alternatives

Loose Oyster Shells
Using loose oyster shells would mimic the natural process of oyster production. Two and a half miles of reef would be created. Shells should be stacked within approximately 3 feet of water to a height of approximately 3-4 feet and a width of approximately 10 feet. Shells may be mixed with riprap or contained in mesh bags. If contained in mesh bags, approximately 56,000 bags will be needed and stacked with a 4 bag base, 2 bag middle base and single bag top layer. If mixed with riprap, the configuration would be a 1 part riprap to 2 parts oyster shells at the same height and width as the bags. **Figure 2-21** depicts the Oyster Reef Alternative – Loose Oyster Shells.

Figure 2-21: Oyster Reef Alternative - Loose Oyster Shells

Interlocking, Triangular Welded Steel Structures

Interlocking triangular structures made of welded steel with space for mesh bags of oyster shells,– a technique proven to be highly successful in a Nature Conservancy project in Texas, is one alternative to construct 2.5 miles of oyster reefs within the project area. Once in place, these artificial reefs come alive as oyster larvae attach to the structures and grow. To create a reef of 2.5 miles approximately 1,500 units (steel triangles with each side approximately 3 feet long x 2 feet high x 1 foot wide) and approximately 1,200 cubic yards recycled oyster shell would be placed in approximately 3 feet of water. **Figure 2-22** depicts the Oyster Reef Alternative – Interlocking, Triangular Welded Steel Structures.

Figure 2-22: Oyster Reef Alternative - Interlocking, Triangular Welded Steel Structures

Interlocking Concrete Rings
These interlocking concrete rings (5 feet in diameter) use the same concept as the triangular welded steel structures. These are designed specifically for the soft substrate of Louisiana's coast (www.nature.org). Concrete rings with oyster shells show significantly more success than simply plain concrete rings (Dehon, 2010). To create 2.5 miles of reef, three rows would be placed approximately 1 foot from each other within approximately 4-5 feet of water. **Figure 2-23** depicts the Oyster Reef Alternative – Interlocking Concrete Rings.

Figure 2-23: Oyster Reef Alternative - Interlocking Concrete Rings

2.9.1.6 Ridge Restoration

A ridge restoration feature is proposed on the south side of Bayou La Loutre. Restoration would consist of the placement of dredged silty sand material to be obtained from the Mississippi River. The initial elevation of the ridge would be approximately +8 feet, with a crown width of 25 feet and 1:8 side slopes. The base width of the ridge would vary, with an average width of approximately 120 feet. A 50-foot access corridor on the south side would be designated for construction equipment. Access along Bayou La Loutre may require excavation to the channel’s authorized depth. If excavation is required material excavated for floatation would be placed in the footprint of the proposed ridge restoration work. The ridge would be planted to develop forested habitat as described in the planting plan for this study (**appendix Z**).

Planting Plan

Based on the ongoing studies and evaluation of current projects, the following guidelines have been developed. A layered, phased approach may be the most suitable to help stabilize the ridge, promote growth of the different tree stories, and create habitat for neotropical migrant birds.

Side slopes of the ridge affected by tides would be seeded for critical area cover and/or planted with herbaceous species in much the same manner as above based on salinity and depth of flooding. Plantings on the bayou-side of the ridge should mimic the pattern outlined for shorelines with no protection while behind the ridge would be planted as applicable marsh is.

Side slopes of the ridge not affected by the tides as well as the ridge top are suitable for midstory/shrub-scrub species such as wax myrtle (*Myrica cerifera*), groundsel bush (*Baccharis halimifolia*), marsh elder (*Iva frutescens*), and yaupon (*Ilex vomitoria*). These would aid in stabilization and provide needed habitat for neo-tropical migrants. It is suggested to plant bare-root seedlings with typically 200 to 300 plant/acre density. Other woody species such as red mulberry (*Morus rubra*), hackberry/sugarberry (*Celtis laevigata*), California desert-thorn (*Lycium carolinianum*), and green ash (*Fraxinus pennsylvanica*) could also be used on the high side slopes.

Hardwoods should be planted on upper sides of the ridge slopes and the ridge top. Several species typically grow on ridge tops based on studies of cheniers, dredge material banks, and a few natural ridges left in the deltaic plain. Hardwoods such as live oak (*Quercus virginiana),* sugarberry (*Celtis laevigata*), dwarf palmetto (*Sabal minor*), and red cedar (*Thuja occidentalis*) would likely be suitable for high ridge planting. Seedlings should be planted on 8-foot by 8-foot spacing totaling about 680 trees/acre. Chinese Tallow control would be included in operations and management.

2.9.1.7 Access Corridors

Access corridors for construction equipment and dredge pipeline are depicted in the plan view for each feature (**appendix U**). Access corridors would be a maximum of approximately 350 feet in width and would cross over wetlands and shallow water as necessary. Access corridors for some features may occur across existing levees and different methods would be utilized to best prevent compromise of the levee while allowing access. The level of protection provided by these levees would be maintained throughout construction, and any damage to levee vegetation would be repaired upon removal of the construction equipment. The construction or designation of staging areas would be necessary for construction equipment; however, they have not been identified at this time. At the point when staging areas are identified, if they do not fall within the area assessed for project impacts, a supplemental NEPA document would be required prior to construction.

Where access corridors cross existing wetlands, board roads would be utilized for equipment and pulling pipe. Upon completion of construction, the wetlands impacted by the board roads would be restored by dredge material. It is anticipated that a thin layer of dredged slurry would overflow and nourish adjacent marsh.

2.9.1.8 Flotation Access Channels

Flotation access channels would be excavated, as needed, in shallow water areas to allow construction equipment to access the project features. If necessary, flotation access channels would be excavated by a mechanical dredge. It is estimated that access channels would average approximately -2 feet. Flotation access channel material would be used in dike/closure construction or refurbishment, to backfill flotation access channels, or would be placed adjacent to and behind the dikes and closures in shallow water to a maximum initial elevation conducive to wetlands development following consolidation of the material. Flotation access channel material used to backfill the flotation access channels following completion of disposal work would be temporarily stockpiled on the water bottom adjacent to the flotation access channel.

If existing canals are used for access, they may be dredged to facilitate flotation of pipeline and other necessary equipment from the dredging reach to pipeline discharge sites within the designated staging areas. Dredge material removed from existing canals would be placed on adjacent existing levees and/or into shallow water on either side of canals. Canal dredge material placed in shallow water areas would be placed to a height conducive for wetlands development.

2.9.1.9 Implementation Approach

Three areas of uncertainty were identified as most likely to affect ecological success and sustainability: salinity, implementation, and increased RSLR. Based on these factors, features were divided into tiers.

- Tier 1 includes features that have been developed to a feasibility level of detail and are not dependent on a salinity conditions or other factors to be sustainable. Tier 1 features are recommended for construction.
- Tier 2 includes features with feasibility level detail that are dependent upon salinity conditions but may be sustainable without the implementation of a freshwater diversion. If future conditions and further analysis indicate that favorable conditions for ecological success and long term sustainability exist (as defined in the adaptive management plan), then these projects may be constructed.
- Tier 3 includes further study of the Violet Freshwater Diversion, features dependent on freshwater diversion, and features in Tier 2 that further analyses indicate favorable conditions for ecological success and long term sustainability do not exist.

Salinity

Salinity is a specific source of potential analytical variability because salinity in the study area is changing. For instance, salinity in the MRGO in the vicinity of the Central Wetlands was reduced to approximately 4 to 7 ppt following the closure of the MRGO. Coastwide Reference Monitoring Stations indicate that Central Wetlands salinity is lower than 4 ppt and is continuing to decline. Contributing factors include the closure of MRGO, the closure of Bayou Dupre during the construction of the Chalmette Loop Levee, the construction of the IHNC Surge Barrier, and the concurrent operation of the existing Violet Siphon. FWOP scenarios include the baseline conditions at Violet Siphon, Caernarvon, and Bonnet Carré Spillway leakage and openings. Planned diversions at Maurepas Swamp (Convent/Blind River, Hope Canal/Maurepas Swamp River Reintroduction), Caernarvon operation modifications, and the Central Wetlands Wastewater Treatment Program are also included in the FWOP conditions.

Salinity is changing in the study area. Current conditions in the Central Wetlands are optimum for intermediate marsh species and the FWOP scenario predicts that conditions will be favorable for fresh marsh species and cypress swamp in the future. However, because conditions are variable and assumptions may not be accurate, all features that are dependent upon salinity conditions or freshwater diversions to be sustainable are not included in Tier 1.

Implementation

Following the identification of the TSP, a construction sequence was developed. Assumptions factoring into the construction sequence include production rates for building rock projects, dredge equipment availability, land loss rates, and the limitation of alternating dredging cycles in the lobes of Lake Borgne.

The timing and availability of financial resources for implementation is a major uncertainty that must be considered given current Federal budgetary constraints. If the plan is not implemented in the near future, conditions will continue to degrade. The impact of the uncertainties associated with the future condition of the study area could increase restoration costs, decrease restoration benefits, or both. The uncertainties associated with implementation are increased because a non-Federal sponsor has not been identified.

Funding assumptions, as detailed in the **appendix U**, were required for planning purposes and to develop costs and benefits for the plan. Construction sequencing assumed optimal funding appropriations and an aggressive schedule to complete implementation as soon as realistically possible. Given the considerable need for the plan, Federal interest, significance of resources, and the conditional authorization for implementation, an aggressive implementation sequence was considered appropriate. The implementation of the HSDDRS demonstrates National interest in study area resources and the magnitude of what can be achieved when stakeholders are united in purpose. However, current budgetary conditions and the lack of a non-Federal sponsor make it very likely that reality will differ from these optimal assumptions. Risk and uncertainties related to implementation have been assessed in the Cost Risk Analysis, as detailed in the **appendix U**. However, due to uncertainties associated with the timing and availability of funding for the plan, only features that are sustainable without the implementation of any other feature are recommended for construction at this time.

Increased Relative Sea Level Rise

A detailed WVA analysis of the three relative sea level rise scenarios was performed for the TSP. **Table 2-26** below shows the net acres projected under each of the three relative sea level rise scenarios based on feature locations.

Table 2-26: Robustness of Features in TSP under all Relative Sea Level Rise Scenarios*

	LOW RSLR		MEDIUM RSLR		HIGH RSLR	
Features	**AAHU**	**Net Acres**	**AAHU**	**Net Acres**	**AAHU**	**Net Acres**
Biloxi Marsh (BM1, BS1-2)	1,685	1,819	1,948	602	401	0
Bayou La Loutre Ridge (BR1)	33	19	34	55	49	55
Central Wetlands Marsh (CM1-5)	5,275	2,593	9,289	5,668	8,934	0
Central Wetlands Swamp (CC1-6)	4,600	6,387	4,843	9,577	5,584	11,332
East Orleans Landbridge (EM1, ES 1-3)	2,110	1,568	1,612	581	718	0
Lower Pearl River (EM2-4)	419	3,379	505	1,303	121	0
Lake Borgne (LM1-4, LS1)	18,112	7,965	18,034	11,940	10,021	0
Hopedale (HM1)	176	736	192	286	70	0
Terre Aux Bouefs (TM1-2, 7-8)	1,595	5,123	1,678	2,008	519	0
TOTAL	**33,839**	**29,353**	**37,980**	**31,930**	**26,322**	**11,387**

* All benefits in this table include the influence of the authorized Violet Diversion.

Although it may seem counterintuitive that some AHHUs and net acres for some features increase as relative sea level rise increases, the reason is that the WVA calculation subtracts existing and future without project marsh acres from project footprints. As relative sea level rise increases, future marsh acres decrease. For example, the ridge produces 55 net acres. Under the historic (low) rate of sea level rise, the ridge would replace 36 acres of marsh that is anticipated to continue to exist in the future; therefore the net acres are 19. In the medium and high sea level rise scenarios, no marsh acres are anticipated to exist in the FWOP condition, therefore, 55 net acres are produced. Under the medium scenario, the cost-effectiveness of all of the action plans would decrease. The medium scenario requires more OMRR&R actions than the historic rate of sea level rise. The alternative to increased maintenance would be significantly reduced benefits. The plan includes OMRR&R and adaptive management measures that are anticipated to maintain predicted benefits under the low and medium sea level rise scenarios.

The diminished output of the TSP under the high RSLR scenario necessitates a systematic approach to assess and respond to the high level of sea level rise scenario. Sea level rise rates will be monitored in the pre-construction, construction, and post construction phases. Data will be evaluated at key decision points. An assessment of relative sea level rise trends would be made prior to partnership agreements, PED, construction award and any cost shared Adaptive Management actions. If at any time data indicate that the high level of RSLR is occurring, additional Federal investments in the plan would be re-assessed.

Priority of Features for Tier 1

The first features proposed for implementation in Tier 1 are LS1, MRGO1, and MRGO6 because these areas are critical for ecosystem structure (maintaining the MRGO landbridge), subject to high rates of erosion, in close proximity to the MRGO, and are currently unprotected. The next features proposed for construction are located in areas that have been identified as critical landscape features, including BS1, BS2, ES1, ES2, ES3, BR1, EM2, EM3, and EM4. These geographic areas are significant structural elements to maintain ecosystem function and reduce storm surge damage risk. The shoreline protection features fill in gaps between existing and planned projects to provide a complete plan to address erosion along Lake Borgne and the East Orleans Landbridge. Most of the features in the second priority phase are in areas of relatively low land loss rates, and are therefore more sustainable. Feature BR1 is considered one of the most sustainable features under the high RSLR scenario because of its elevation. Features HM1, TM1, TM2, TM7, and TM8 are the next features proposed for implementation because they are located in interior areas that are less susceptible to sea level rise. In the last phase of Tier 1, the one-time repair of existing shoreline protection projects MRGO2, MRGO3, MRGO4, and the Shell Beach recreation feature associated with MRGO2 are proposed for implementation. These features are the lowest priority within Tier 1 because they currently have some protection.

Priority of Features for Tier 2

In Tier 2, features inside the HSDRRS are prioritized for construction. These features are considered to be more likely to exhibit favorable conditions for ecological success and sustainability because of their location behind existing infrastructure that provides protection from storms and saltwater intrusion. These features include CC4-A, CC4 (Sites 2, 3, 4), CM2, CM5, LM4 and the Bienvenue Triangle recreation feature associated with CC4-A. The features in the Central Wetlands included in Tier 2 are located north of Paris Road and therefore have more barriers to saltwater intrusion than features south of Paris Road. Feature CC4-A is considered the highest priority in this tier because of high public interest, proximity to the City of New Orleans, and its educational value.

Priority of Features for Tier 3

Further study of the Violet Freshwater Diversion as authorized by WRDA 2007 Section 3083 is the highest priority for Tier 3, because all of the features included in this tier are dependent upon the implementation of a freshwater diversion for salinity or to ensure long-term sustainability. Implementation priority of these features would be determined following additional analysis.

The Monitoring and Adaptive Management Plan (MAMP) for the study describes a systematic approach to reduce and address some of the uncertainties associated with the study. An initial adaptive increment of cypress restoration would be constructed in the Bienvenue Triangle area for monitoring and adaptively management. The knowledge lessons learned from this initial adaptive increment will be applied to future cypress

restoration projects. Additionally, there are some uncertainties regarding the potential water quality impacts of dredging in Lake Borgne. The MAMP outlines a monitoring program to reduce uncertainties and apply knowledge gained to future projects.
The MAMP for this study has developed decision criteria, also referred to as AM triggers, to determine if and when AM opportunities should be implemented. These criteria are described below and are based on the monitoring of indicators.

Table 2-27: Adaptive Management Threshold and Trigger Matrix

Indicator	Threshold	Ecological Success Criteria	Response Options
Salinity	Threshold set by Snedden and Steyer, in review	Trigger set if marsh types change 2 classes (fresh to brackish) across years or if swamp/fresh meet salinity threshold	Alter freshwater input. Potential options include: bank gapping, salinity barriers, diversion operation, or freshwater management through other projects in the area potentially including Borgne Barrier, Bonnet Carré Spillway, Small Diversion at Convent Bline River, Maurepas Swamp Diversion.
Plant Mortality – emergent marsh and (plantings)	Threshold set by marsh collapse expert panel; (plantings – 70% survival at year 1) – Table 3	Trigger set at low range of marsh collapse thresholds	Control salinity and/or inundation. Potential methods include nourishment to enhance elevation, diversion operation or other method of altering freshwater input into the system, and managed habitat switching (replant with vegetation type suitable for observed conditions – i.e., replant previous brackish marsh area with saline marsh species types)
Land/Water Ratio	Threshold set by WVA	Trigger set if land lost episodic (marsh dieback)	Enhance elevation
Elevation	Threshold set by high inundation depth	Trigger set when elevation by marsh type less than reference	Enhance elevation
Oyster Recruitment	Threshold set on sufficient oyster reef development to protect identified marsh	Presence/absence of oyster settlement at 2-3 years	Seed with juveniles/stock adults
Water Quality	TBD	TBD	Evaluate options for increasing freshwater input and hydrologic restoration measures such as bank gapping and salinity barriers.

The plan includes an implementation sequence that was used to help in the assessment of wetlands benefits and that is based upon performance support logic. The implementation sequence provides a time scale of when projects would be constructed and is based upon assumptions about ecological conditions, construction capabilities, and performance assurances. Assumptions factoring into the sequence include elements such as production rates for building rock projects and issues like dredge equipment availability for use in marsh creation. Other implementation sequencing factors include considerations such as land loss rates, required construction work order, and ecosystem drivers.

Table 2-28 provides brief description of each restoration feature included in the tentatively selected plan and proposed implementation approaches.

Table 2-28: Implementation Table[1]

Measure	Description
TIER 1 RECOMMENDED FOR CONSTRUCTION (CONTINGENT UPON IDENTIFICATION OF NON-FEDERAL SPONSOR)	
LS1	45,000 linear feet (8.5 miles) of shoreline protection beginning at the terminus of the Bayou Dupre supplemental shoreline project, extending around Proctor Point to the West of Shell Beach supplemental funding shoreline protection.
MRGO1	3,850 feet (0.75 miles) of new foreshore protection between MRGO miles 56.6 and 57.4. This stone protection feature is embedded within the limits of MRGO7.
MRGO6	8,132 linear feet (1.5 miles) of new, non-continuous foreshore protection between MRGO miles 36.0 and 34.4, immediately east of the existing stone closure of the MRGO. MRGO6 ties into an existing foreshore dike immediately downstream.
BS1	Approximately 50,637 linear feet (9.5 miles) of protection along the southeast shore of Lake Borgne from the Biloxi Marsh Shoreline Protection Project (PO-72) south of Point aux Marchettes extending north to Malheureax Point.
BS2	Approximately 30,750 linear feet (5.8 miles) of artificial oyster reef development between Eloi Point and the mouth of Bayou La Loutre.
ES1	20,530 linear feet (3.8 miles) of shoreline protection from the south shore of Lake Pontchartrain to the existing Bayou Chevee shoreline protection feature.
ES2	30,750 (5.8 miles) linear feet of shoreline protection in Lake Pontchartrain between Chef Menteur Pass and The Rigolets.
ES3	69,900 linear feet (13.2 miles) of foreshore protection along Lake Borgne between Alligator Point and The Rigolets.
BR1	Approximately 54.1 acres of ridge restoration on the south bank of Bayou La Loutre. 400,000 cubic yards of silty sand material would be required.
EM2	1,095 acres of marsh nourishment on Hog Island, located between the west and east mouth of the West Pearl River using 1.3 million cubic yards of dredged material.
EM3	861 acres of marsh restoration and 180 acres nourishment bounded by Highway 433, Little Lagoon, Salt Bayou and Highway 90 using 4.1 million cubic yards of material.
EM4	2,625 acres of marsh restoration and 1,455 acres of nourishment bounded by Salt Bayou, the West Pearl River, the Rigolets, and Highway 80. Approximately 9.2 million cubic yards of material would be required.
HM1	757 acres of marsh restoration and nourishment of 973 located in the Hopedale area using 4.5 million cubic yards of dredged material.
TM1	798 acres of marsh restoration and 223 acres of marsh nourishment south of Bayou La Loutre in the Terre aux Boeufs area using 3.8 million cubic yards of material.
TM2	770 acres of marsh restoration and 3,396 acres of marsh nourishment in the vicinity of Lake Ameda. Approximately 8.8 million cubic yards of material would be required.
TM7	2,255 acres of marsh restoration and 2,144 acres of adjacent marsh nourishment to the east of Bayou Terre aux Boeufs using 12.4 million cubic yards of material.
TM8	1,511 acres of marsh restoration on the east side of Bayou Terre aux Boeufs in the vicinity of Delacroix. 9.7 million cubic yards of material would be required.

Measure	Description
MRGO2	One time repair of approximately 21,630 linear feet (4.1 miles) of existing foreshore protection between Mile 44.5 and 40 of the MRGO.
MRGO3	One time repair of approximately 26,650 linear feet (5 miles) of existing foreshore protection between approximately Mile 56 to 51 of the MRGO.
MRGO4	One time repair of approximately 11,770 linear feet (2.2 miles) of existing retention dike between MRGO Miles 36.6 to 37.1 and MRGO Miles 33.9 to 32.9.
SHELL BEACH	Recreation feature to be constructed following repair of MRGO2. 343 lf of boardwalk into the MRGO, 805 lf of shoreline boardwalk, 5 picnic shelters (two handicap accessible), interpretive signage, bathrooms, parking, solar lighting and plantings.
TIER 2 RECOMMENDED FOR CONSTRUCTION IF CONDITIONS FAVORABLE FOR ECOLOGICAL SUCCESS AND SUSTAINIBILITY ARE DOCUMENTED	
CC4-A	400 acres of cypress restoration in the Bienvenue Triangle. Approximately 2.6 million cubic yards of material to be obtained from Mississippi River.
CC4 (Sites 2,3,4)	1,065 acres of cypress swamp restoration in the open water areas adjacent to the Forty Arpent Levee north of Paris Road using 7.8 million cubic yards of material.
CM2	795 acres of marsh restoration and 190 acres of marsh nourishment north of Paris Road using approximately 4.7 million cubic yards of material.
CM5	245 acres of marsh restoration and 70 acres of nourishment in the area north of Bayou Bienvenue and Paris Road using 1million cubic yards of material.
LM4	225.5 acres of marsh restoration and nourishment of 54.8 acres in the portion of the Golden Triangle bordered by the GIWW, the IHNC Surge Barrier, and the MRGO. Approximately 1.2 million cubic yards of material are required.
BAYOU REC	Recreation feature associated with CC4-A. 100 linear feet of platform, 995 linear feet of boardwalk into the swamp, 4 picnic shelters, interpretive signage, bathrooms, parking, solar lighting and vegetative plantings in the Bienvenue Triangle.
TIER 3 RECOMMENDED FOR FURTHER STUDY	
Tier 3A	
VIOLET	The Violet Freshwater Diversion as authorized in WRDA 2007 Section 3083. A freshwater would enhance and sustain the benefits of the FIP. Additional study would be carried out under WRDA 2007 Section 3083 and subject to the cost-share provisions in that authority.
Tier 3B	
EM1	1,175 acres of marsh restoration and 2,830 acres nourishment bounded by Lake Pontchartrain, Chef Menteur, and the levee using 8.1 million cubic yards of material.
LM1	3,253 acres of marsh restoration and nourishment of 1,064 acres in the Golden Triangle, south of the IHNC Surge Barrier using 14.3 million cubic yards of material.
LM2	225 acres of marsh restoration and 2,628 acres of marsh nourishment in the area between Proctor Point and the MRGO using 4.5 million cubic yards of material.
LM3	911 acres of marsh restoration and 950 acres nourishment in South Lake Borgne north of Lena Lagoon in the area bounded by the lake, Bayou St. Malo, MRGO, and Doulets Canal using 6.4 million cubic yards of material.
BM1	8,000 acres of marsh nourishment along the south shore of Lake Borgne using 11 million cubic yards of material.
MRGO5	202 acres of marsh restoration using 3.0 million cubic yards of material located behind 13,685 linear feet (2.5 miles) of vinyl sheet pile wall to establish the shoreline.
MRGO7	110 acres of marsh restoration using 1.65 million cubic yards of material adjacent to 9,700 linear feet (1.8 miles) of vinyl sheet pile wall.
MRGO8	236 acres of marsh restoration using 3.5 million cubic yards of material adjacent to 17,785 linear feet (3.3 miles) of vinyl sheet pile wall and 14,225 linear feet (2.6 miles) of new foreshore protection between approximate channel miles 51.0 and 48.3.

Measure	Description
CM1	1,240 acres of marsh nourishment south of Paris Road between cypress restoration feature CC3 and the Chalmette Loop Levee using 1.5 million cubic yards of material.
CM3	300 acres of marsh restoration and 215 acres of marsh nourishment north of Bayou Dupre and south of MRGO using 1.6 million cubic yards of borrow material.
CM4	97.5 acres of marsh restoration and 128.5 acres of marsh nourishment south of Bayou Dupre using 600,000 cubic yards of dredged material.
CC1	1,020 acres of swamp restoration and 935 acres nourishment north of the existing Violet Canal along the Forty Arpent levee using 6.0 million cubic yards of material.
CC2	250 acres of cypress swamp restoration and 250 acres of swamp nourishment to the northeast of CC1 using 1.7 million cubic yards of material.
CC3	370 acres of swamp restoration and 790 acres nourishment along the Forty Arpent Levee south of Paris Road using 3.7 million cubic yards of material.
CC5	1,120 acres of swamp restoration and 1,550 acres nourishment south of the Violet Canal along the Forty Arpent Levee and the Chalmette Loop Levee. 7.8 million cubic yards of borrow material would be required.
CC6	2,568 acres of swamp nourishment in the Central Wetlands southwest corner. 5.2 million cubic yards of borrow material would be required.

Note 1. Measures are listed in order of priority for Tiers 1 and 2 as described in detail in Section 2.13.

Figure 2-24 illustrates the tentatively selected plan timetable.

Figure 2-24: MRGO Tentatively Selected Plan Implementation Timetable

2.9.1.10 Borrow Sites

The tentatively selected plan would restore and/or protect approximately 10,318 acres of cypress swamp, 14,123 acres of fresh and intermediate marsh, 32,511 acres of brackish marsh, 466 acres of saline marsh, and 54 acres of ridge habitat. The implementation of the tentatively selected plan would require a significant amount of sediment. **Figure 2-25** illustrates the proposed borrow site for each feature included in the tentatively selected plan.

Potential borrow sources for swamp and marsh restoration features include the Mississippi River, the IHNC/GIWW, the MRGO, Lake Pontchartrain, Lake Lery, Lake Borgne, Breton Sound, and offshore sources including the MRGO offshore dredged material disposal site (ODMDS). Barges could be used to bring material from other locations in the region; however, the cost of transporting material by barge generally costs about twice as much as pumping material via pipeline from a nearby source. Other sources of material from outside of the study area were not considered a practicable option due to the costs associated with obtaining, transporting, and stockpiling the needed volume of material.

Lake Borgne

Lake Borgne is a viable borrow source for most of the areas evaluated for restoration in this study. Lake Borgne is designated critical habitat for Gulf sturgeon, and therefore no actions should be undertaken that may jeopardize the continued existence of species listed as endangered or threatened under the Endangered Species Act or resutls in the likelihood of destruction or adverse modification of critical habitat. Lake Borgne includes some sandy bottoms that are the preferred foraging habitat for these species. These areas were surveyed and excluded from consideration as potential borrow sources.

The proposed borrow plan is detailed in **figure 2-25**. As the borrow plan depicts, borrow sites would be located a minimum of 3,000 feet from the Lake Borgne shoreline to minimize potential impacts to hydraulic conditions (e.g., wave climate), as well as to avoid existing oyster leases to the maximum extent practicable. Borrow material would be excavated with a hydraulic dredge and transported via pipeline to wetland creation and nourishment sites. Designated borrow areas are estimated larger than needed for each feature to ensure that adequate material is available in the event that environmental or cultural resources are discovered during construction that require avoidance. Borrow areas would be designed to minimize hypoxic (lack of dissolved oxygen) formation by minimizing the depth of the dredge cut to the maximum extent practicable. In addition, adaptive management and monitoring would be utilized to minimize any potential hypoxic formation as described below.

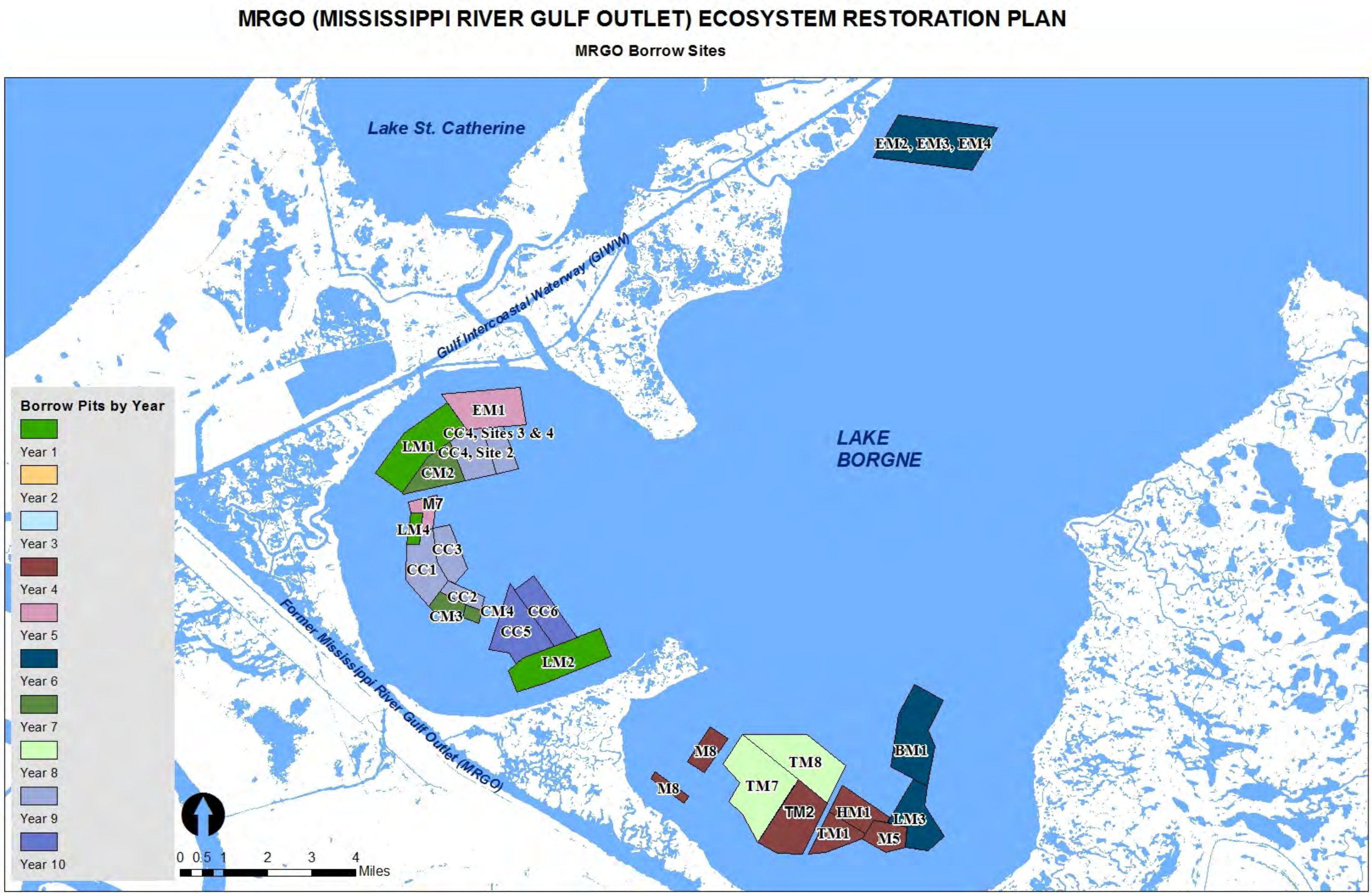


Figure 2-25: Borrow Sites for Tentatively Selected Plan

A phased implementation plan is proposed to remove borrow material from Lake Borgne. Borrow would be removed from the lake gradually over 10 implementation cycles that would allow no more than 2.5 percent of the lake bottom to be impacted during any given implementation cycle. The implementation plan actually spans 14 years with a monitoring period in place for two years after test borrow pits are dredged. A cycle does not necessarily last for 365 days and some features could take 12 to 16 months to complete. The borrow plan limits dredging to one lobe of Lake Borgne per implementation cycle, therefore isolating increased turbidity to one lobe of the lake. A minimum of 365 days of dredging would occur in one lobe before switching to the other lobe. As a new implementation cycle is being initiated, the borrow areas disturbed in the previous cycle for that lobe would have recovered sufficiently to support foraging and to allow benthic species to recover between implementation cycles. The availability of borrow material associated with the phased borrow plan has dictated the construction implementation schedule for the restoration features that were previously depicted in **table 2-28**.

To ensure that water quality is not sacrificed within Lake Borgne, MVN has included two years of water quality monitoring into the proposed action. Three test borrow pits would be constructed in implementation cycle number 1. The first pit would be constructed to 15 feet deep below the water surface, the second pit would be constructed to the proposed depth of 20 feet deep below the water surface, and a third pit would be constructed to approximately 25 feet deep below the water surface. These three test borrow pits would impact approximately 2,191 acres of water bottom in Lake Borgne. After the borrow pits are constructed, monthly water quality monitoring would be used to determine if hypoxia formation was occurring within the borrow pits. Once the two years of monitoring is complete, the remaining borrow pits would be adjusted to ensure that hypoxia formation would not result within the remaining borrow pits. The MVN believes that the design of the borrow pits, coupled with the proposed water quality monitoring, would ensure that the proposed action would only temporarily impact the water quality of Lake Borgne.

In consultation with NMFS, two years of water quality monitoring are included in the plan. Three test borrow pits would be constructed in implementation cycle 1. Pit 1 would be constructed to 15 feet deep below the water surface, Pit 2 would be constructed to the proposed depth of 20 feet deep below the water surface, and Pit 3 would be constructed to approximately 25 feet deep below the water surface. After the borrow pits are constructed, monthly water quality monitoring would be used to determine if hypoxia formation was occurring within the borrow pits. When monitoring is complete, the remaining borrow pits would be adjusted to ensure that hypoxia formation would not result within the remaining borrow pits. The design of the borrow pits and water quality monitoring is proposed to ensure that impacts to the water quality of Lake Borgne would be temporary and localized. In addition, USACE will collect data describing Gulf sturgeon movements within the Lower Pontchartrain Sub-basin and recovery rates of Gulf sturgeon prey species in response to re-colonization of muddy-sand substrate that would assist in future assessments of impacts to Gulf sturgeon prey items.

Lake Pontchartrain

Lake Pontchartrain is a viable borrow source for features located on the East Orleans Landbridge. Like Lake Borgne, the portion of Lake Pontchartrain closest to these features is designated critical habitat for Gulf sturgeon. However, the sandy bottoms of Lake Pontchartrain were identified as preferred foraging habitat for this species. Therefore this borrow source was not considered further as other sources that are not preferred foraging habitat were identified closer to proposed restoration features.

MRGO Channel

Legally, it is unclear whether dredging the MRGO channel for non-navigation purposes is contrary to the Congressional intent. However, public preference for filling in the channel and restoring the area to historic conditions is documented in the Scoping Report for this study and numerous other public documents:

- The *Final Environmental Impact Statement (EIS) for the Mississippi River-Gulf Outlet (MRGO), Louisiana, and Lake Borgne – Wetland Creation and Shoreline Protection Project*, a USACE document, states that "use of the MRGO channel as a borrow source was considered to be contrary to the Congressional intent, as described in House Report No. 109-359, that funds provided in P.L. 109-148 for authorized operation and maintenance activities along the MRGO not be used to conduct any dredging of the MRGO channel." This reasoning may have limited applicability to the MRGO ecosystem restoration plan.
- Louisiana House Concurrent Resolution 34 (2005) to "suspend any current appropriations or authorizations for expenditure of funds to dredge the Mississippi River Gulf Outlet, to direct the United States Army Corps of Engineers not to engage in any dredging activities on the Mississippi River Gulf Outlet, and to begin the necessary process to return the waterway to wetlands marsh status as close as possible to what it was prior to establishment of the canal."
- *MRGO Must Go A Guide for the Army Corps Congressionally-Directed Closure of the Mississippi River Gulf Outlet* (Endorsed by LSU, Coalition to Restore Coastal Louisiana, Lake Pontchartrain Basin Foundation, Environmental Defense Fund, Gulf Restoration Network, National Wildlife Federation, Louisiana Wildlife Federation, American Rivers, and St. Bernard Parish).

Dredging the MRGO to obtain borrow material for wetland restoration is a potentially unacceptable alternative. However, because Lake Borgne (the closest available borrow source) is critical habitat for Gulf sturgeon, all viable alternatives must be investigated to avoid and minimize potential impacts to critical habitat to the extent practicable.

The PDT analyzed MRGO as a borrow option for marsh creation features. Using the channel could supply <10 percent of the identified 150+ mcy of sediment need for the entire tentatively selected plan. Dredging the channel would provide some cost savings (estimated at -$20 million) over the Lake Borgne option. As illustrated above, MRGO dredging for borrow is a publicly sensitive issue that was adamantly opposed in some scoping comments.

Consultation with NMFS on the critical habitat impacts is being conducted. The USACE BA determined there to be no likelihood of destruction or adverse modification of critical habitat for the Gulf sturgeon. The plan that is presented may be further refined as a result of this consultation.

Analyses were conducted for using the MRGO as a potential borrow source between the closures at Bayou Bienvenue (IHNC Surge Barrier) and Bayou La Loutre. Assuming dredging to -40 feet by 500 feet with a 1 foot over-depth, approximately 15.5 mcy of material would be available for use in restoration projects.

The practicability and acceptability of the use of the MRGO must also be considered. "An alternative is practicable if it is available and capable of being done after taking into consideration cost, existing technology, and logistics *in light of overall project purposes*" (40 CFR 230.10 emphasis added). The purpose of the study is to restore areas affected by the MRGO. The area that was dredged to create the channel is the most directly affected area.

Degrading the MRGO spoil banks south of the Chalmette Loop Levee to marsh elevation was considered as a restoration feature that would also provide material. This alternative was rejected by the majority of the PDT, because the spoil bank provides more storm surge protection than it would as marsh.

Mississippi River

The cost per unit associated with moving sediments from the river to restoration areas is significantly higher than using sediments from the nearest source. All things being equal, using river sediment for a restoration area with an average pumping distance of 20,000 feet (3.8 miles) would cost approximately 25 to 30 percent more than using material from Lake Borgne. Dredging costs are positively correlated to distance: the cost of transporting material via pipeline for an average distance of 50,000 feet is about twice as much for an average distance of 20,000 feet. Because dredging at depths greater than 70 feet necessitates costly modifications to dredging equipment, it is not always feasible to dredge the nearest location on the river. It is possible to load dredged river sediment onto barges and transport it to a restoration site. However, this process costs considerably more than dredging and distributing via pipeline. Other factors influencing the feasibility of using Mississippi River sediment include considerations for laying pipe across levees, land, and roads rather than water, and potential impacts to navigation.

Lake Lery

Lake Lery is a viable borrow source for features in the vicinity of Bayou Terre aux Boeufs. However, a number of other restoration plans currently under development are considering Lake Lery, and it is uncertain if it will be available for use in the implementation of this plan.

GIWW/Michoud Canal

Features in the Central Wetlands could utilize sediment from the adjacent GIWW channel between Miles 66 and 60. The channel would be dredged to its authorized depth to provide material for restoration features. The Michoud Canal is another potential source of sediment for use in this vicinity.

MRGO Offshore Dredged Material Disposal Site (ODMDS)

The MRGO ODMDS is located off of Breton Island and was used as a disposal site for material dredged for the MRGO navigation channel. This location would be considered as a borrow source for barrier island restoration. This site is not a practicable site for inland marsh and swamp restoration features, because it is located between 30 miles to 70 miles away from these features.

Sand Deposits at Chandeleur and Breton Islands

There are sand deposits at the northern end of Chandeleur Island and the southern end of Breton Island that could provide a source of material for barrier island restoration. These deposits were described in a report by Coastal Planning and Engineering, Inc. and the Pontchartrain Institute for Environmental Sciences (Thomson, 2010). Mining at these sites would have minimal impact with regard to littoral sediment transport because these sands are at the terminus of the littoral system and there are no downdrift features that would be impacted.

2.10 ADAPTIVE MANAGEMENT

Section 2039 of WRDA 2007 directs the Secretary of the Army to ensure that, when conducting a feasibility report for a project (or component of a project) for ecosystem restoration, the recommended project includes a plan for monitoring the success of the ecosystem restoration. The implementation guidance for Section 2039, in the form of a CECW-PB Memo dated 31 August 2009, also requires that an adaptive management plan (see **appendix T**) be developed for all ecosystem restoration projects. It is recommended that adaptive management be conducted substantially in accordance with the recommendations made in the MRGO Ecosystem Restoration Plan Feasibility Report.

The adaptive management plan for the selected alternative addresses the potential impacts of increased SLR rates (see **appendix T**). The implementation plan provides opportunities for adaptive management by constructing marsh restoration features with the lowest land loss rates first. If SLR increases in the initial implementation phase, the plan can be assessed for potential adjustments to changing conditions. This strategy allows for the initial investment to be made in features expected to retain benefits for the longest period.

Recent climate research by the Intergovernmental Panel on Climate Change (IPCC) predicts continued or accelerated global warming for the 21st Century and possibly beyond, which will cause a continued or accelerated rise in global mean sea level (MSL). Coastal marshes may accrete at a rate that keeps pace with a slow rate of SLR; however, as the rate of SLR increases, coastal mashes cannot maintain their elevation, and they submerge and are transformed to open water. Some Louisiana marshes are able to survive current SLR conditions; increased SLR may approach or cross this critical threshold (USGS website).

Engineering Circular No. 1165-2-211 dated July 1, 2009, provides USACE guidance for incorporating the direct and indirect physical effects of projected future RSLR in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects. The National Research Council's (NRC's) 1987 report *Responding to Changes in Sea Level: Engineering Implications* recommends a multiple scenario approach to deal with key uncertainties for which no reliable or credible probabilities can be obtained. In the context of USACE planning, multiple scenarios address uncertainty and help to develop better risk-informed alternatives. The final array of alternatives were evaluated using "low," "intermediate," and "high" rates of future RSLR for both "with" and "without" project conditions as shown in **table 2-29**.

Table 2-29: Relative Sea Level Rise Projections Over the Period of Analysis

Scenario	Based On	RSLR	
Low	Historic rates	1.8 feet	0.55 meters
Medium	NRC Curve I	2.2 feet	0.69 meters
High	NRC Curve III	3.7 feet	1.12 meters

The "high" rate exceeds the upper bounds of IPCC estimates from both 2001 and 2007 to accommodate for the potential rapid loss of ice from Antarctica and Greenland.

Under the medium and high scenarios, the cost-effectiveness of all of the action plans would decrease significantly. To maintain the level of benefits projected for the historic rate for the medium and high scenarios, additional lifts and maintenance of restoration features would be required, significantly increasing the costs of the alternatives. The alternative to increased maintenance would be significantly reduced benefits.

2.11 ENVIRONMENTAL COMMITMENTS

Measures developed during alternative formulation were designed to first avoid adverse environmental effects and where adverse effects could not be avoided they were minimized to the greatest extent possible.

Section 2039 of WRDA 2007 directs the Secretary of the Army to ensure that, when conducting a feasibility report for a project (or component of a project) for ecosystem restoration, the recommended project includes a plan for monitoring the success of the ecosystem restoration. The implementation guidance for Section 2039, in the form of a CECW-PB Memo dated August 31, 2009, also requires that an adaptive management plan be developed for all ecosystem restoration projects (see **appendix T**).

Throughout the planning process, efforts were made to avoid impacts to the extent practicable. The tentatively selected plan would impact approximately 227 acres of intermediate marsh and shallow open water that would be excavated for the outfall channel. However, restoration of approximately 17,352 acres of marsh habitat, nourishment of 26,836 cumulative acres of emergent marsh habitat, and restoration of 54 acres of ridge habitat would mitigate for wetland impacts resulting from construction activities.

Best management practices would be included in construction specifications and they would be employed during construction activities to minimize environmental effects. Many of these best management measures are required by Federal, state, or local laws and regulations, regardless of whether they are specifically identified in this document or not. Project implementation would comply with all relevant Federal, state, and local laws, ordinances, regulations, and standards during the implementation of the preferred alternative. Implementation of the environmental commitments would be documented to track execution and completion of the environmental commitments.

A summary of the environmental and related commitments made during the planning process and incorporated into the proposed project plan are listed below:

1. Ensure construction contractors limit ground disturbance to the smallest extent feasible.
2. Use accepted erosion control measures during construction.
3. Use board roads where dredge pipelines or equipment would cross existing marsh.
4. Conduct a search for bald eagle, other raptors and colonial nesting wading bird active nests within three-quarter of a mile from proposed disturbance activities prior to construction. Appropriate protective measures and no-work distance restrictions would be implemented to avoid or minimize nest disturbance if active nests are identified.
5. Contact pipeline and gas well companies prior to construction activities to identify and avoid existing hazards.
6. Implement best management practices and measures contained in erosion control guidelines to control soil erosion from construction areas.
7. Implement measures to control fugitive dust during construction.
8. Implement a program to compensate for losses of archaeological sites (if any) that would occur as a result of construction and operation of the proposed project.
9. All retention dikes constructed for marsh creation/restoration features would contain an opening of at least 100 feet in width and have a depth as deep as the

deepest natural entrance into the disposal site in order to accommodate the escape of protected species.

10. Ensure construction contractors are educated on the Marine Mammal Protection Act of 1972 (MMPA) and the Endangered Species Act (ESA) and the species of concern.
11. Conduct a search for coastal bottlenose dolphins, sea turtles, and Gulf sturgeon within marsh creation/restoration sites. Appropriate best management practices (BMP) would be implemented to avoid or minimize potential entrapment of these protected species. These BMPs are included in detail in the contract and include the following:
    a. Observe the area to be enclosed for protected species at least 24 hours prior to and during closure of any levee, dike or structure. This is best accomplished by small vessel or aerial surveys with at least two experienced marine observers on board scanning for protected species.
    b. If any protected species are sighted within the area to be enclosed all appropriate precautions shall be implemented by the Contractor to ensure protection of the animal. These precautions shall include avoiding direct contact with and not feeding the protected species.
    c. Any sightings of protected species within an enclosed project site shall be reported immediately to the COE.
    d. If observers' note the animals are not leaving the area, but are visually disturbed, stressed, or their health is compromised then the COE may require any pumping activity to cease until the animals either leave on their own or are moved under the direction of NMFS. NMFS would then conduct any necessary measures (detailed in contract) to ensure protection of the species.
    e. In addition to those environmental and related commitments, several construction technicians and visual monitoring would be undertaken to further protect any protected species in construction areas.

Chapter 6 also contains a detailed list of USFWS (Service) positions and recommendations that USACE concurs with (see **section 6.6.1**) as well as NMFS EFH conservation recommendations that the USACE concurs with (see **section 6.9.1**).

2.12 MODEL DEVELOPMENT AND UNCERTAINTIES

2.12.1 Predicting Future Conditions

Predicting future conditions is in itself uncertain. As described in **chapter 1**, there are several important hurricane risk reduction projects currently under construction in the immediate project area. These levees and barriers individually and cumulatively are expected to have significant impacts on the future conditions of the area without implementation of this restoration study. Water quality monitoring conducted by USGS in the MRGO channel just prior to construction of the closure structure and after construction commenced indicate the system is in a state of flux and trying to establish a new equilibrium. Once the IHNC barrier is completed along with the other proposed gated structures it is likely the system would continue to be in a state of flux trying to establish a new equilibrium for several years. Water quality monitoring conducted by USGS is indicating a reduction in salinity that would affect aquatic and fishery conditions in the FWOP conditions for this studied 50-year period of analysis. Because these conditions are in a state of flux it is difficult at this time to predict with accuracy what the future outcome would look like without this restoration plan. Important among the anticipated changes is the reduction in salinity levels in the area as demonstrated by the hydrologic modeling summarized in **chapter 3**. The boxes covering the Biloxi Marsh (13, 74, 78) indicate a salinity reduction by approximately 1-2 ppt. More in-depth discussions of the impacts are described further in **chapter 4** for the applicable resources affected.

In addition to construction of the HSDRRS projects, Section 7006 of WRDA 2007 authorized feasibility studies for LCA near-term critical restoration features. Authorized near term projects in the Upper Pontchartrain Basin include a small diversion at Hope Canal; a small diversion at Convent/Blind River and Bank Gapping for Amite River Diversion canal. Authorized near term critical projects in the Lower Pontchartrain Basin includes re-authorization of Caernarvon Freshwater Diversion and a medium diversion at White's ditch. As per WRDA 2007, Section 7006(e)(3) the Secretary of the Army submitted a favorable Report of the Chief of Engineers for the Convent/Blind River, Amite River Diversion Canal Modification and White's Ditch projects on December 30, 2010. The construction of the LCA restoration projects plays an integral part in predicting the future conditions of the MRGO ecosystem restoration study. The UNO box model demonstrates that with these restoration projects operating in the Upper Pontchartrain sub-basin, salinity conditions in the Lower Pontchartrain sub-basin achieve the Chatry targets in all months except May where it is met 33.7 percent of the time. The FWOP condition in which impacts are assessed in this EIS is based on the authorized LCA projects discharging a total of 4,500 cfs in the Upper Pontchartrain sub-basin. Without construction of one or all of these projects, the FWOP conditions were modeled to maintain a salinity level of <1 ppt in Maurepas. With this FWOP condition, the Chatry targets are still maintained 11 months of the year, except May where the Chatry target is met 27 percent of the time.

Although numerous scientific studies have been conducted within the Louisiana coastal environments, considerable uncertainty remains regarding key ecological processes and the efficacy of some of the proposed restoration measures. Limitations in analytical tools to assess ecosystem responses also exist, and were compounded by the short timeframe in which the MRGO ecosystem restoration study was formulated. These limitations and uncertainties substantiate the value of a truly adaptive approach to the ecosystem restoration plan and suggest that some plan components, such as the freshwater diversion, may require further and more detailed study prior to implementation. Many details concerning the construction and operation of the diversion structure were unavailable at the time of this assessment.

Some variation between forecast conditions and reality is without a doubt. The degree to which these variations affect planning decisions in this study may be offset by recognizing the uncertainties and associated risks in the decision-making process. Large uncertainties such as climate change; SLR; subsidence; timing, frequency and intensity of tropical storm events and/or changes in drought conditions affect outcome of projections for future conditions. Each one of these factors, alone or in combination contributes to the degradation within the study area.

2.12.2 Uncertainties Related to Implementation

The timing and availability of financial resources for implementation is a major uncertainty that must be considered. If the plan is not implemented in the near future, the problems in the study area will continue to degrade conditions. The impact of the uncertainties associated with the future condition of the study area could increase restoration costs, decrease restoration benefits, or both. The uncertainties associated with implementation are increased because a non-Federal sponsor has not been identified.

All plans in the final array of alternatives require phased implementation, which can reduce risks. With phased implementation, costs are expended periodically, rather than all at once, which reduces risk to the monetary investment. Phased implementation also provides the opportunity to adjust project design and develop lessons learned from projects built in the initial phase.

Risk and uncertainties related to implementation have been assessed in the Cost Risk Analysis, as detailed in the Engineering Appendix. However, due to uncertainties associated with the timing and availability of funding for the plan, only features that are sustainable without the implementation of any other feature are recommended for construction at this time.

The first features proposed for implementation are in Tier 1 and include LS1, MRGO1 and MRGO6 because these areas are critical for ecosystem structure (maintaining the MRGO landbridge), subject to high rates of erosion, in close proximeity to the MRGO, and are currently unprotected. The next features in Tier 1 proposed for construction are located in areas that have been identified as critical landscape features, including BS1, BS2, ES1, ES2, ES3, BR1, EM2, EM3, and EM4. These geographic areas are significant structural elements to maintain ecosystem function and reduce storm surge damage risk. The shoreline protection features fill in gaps between existing and planned projects to provide a complete plan to address erosion along Lake Borgne and the East Orleans Landbridge. Most of the features in the second priority phase are in areas of relatively low land loss rates, and are therefore more sustainable. Feature BR1 is considered one of the most sustainable features under the high RSLR scenario because of its elevation. Features HM1, TM1, TM2, TM7, and TM8 are the next features proposed for implementation because they are located in interior areas that are less susceptible to sea level rise. In the last phase of Tier 1, the one-time repair of existing shoreline protection projects MRGO2, MRGO3, MRGO4, and the Shell Beach recreation feature associated with MRGO2 are proposed for implementation. These features are the lowest priority within Tier 1 because they currently have some protection.

In Tier 2, features inside the HSDRRS are prioritized for construction. These features are considered to be more likely to exhibit favorable conditions for ecological success and sustainability because of their location behind existing infrastructure that provides protection from storms and saltwater intrusion. These features include CC4-A, CC4 (Sites 2, 3, 4), CM2, CM5 , LM4 and the Bienvenue Triangle recreation feature associated with CC4-A. The features in the Central Wetlands included in Tier 2 are located north of Paris Road and therefore have more barriers to saltwater intrusion than features south of Paris Road. Feature CC4-A is considered the highest priority in this tier because of high public interest, proximity to the City of New Orleans, and its educational value.

Further study of the Violet, Louisiana Freshwater Diversion as authorized by WRDA 2007 Section 3083 is designated as Tier 3A because it is the highest priority for Tier 3, as all of the features in Tier 3B are dependent upon the implementation of a freshwater diversion for salinity or to ensure long-term sustainability. Implementation priority of these features would be determined following additional analysis.

2.12.3 UNO Mass Balance Model Uncertainties

Modeling efforts have uncertainties. The quantification, understanding, and minimization of these uncertainties are critical for the correct interpretation of model results. Uncertainty may arise in the input data, in the geometry of the model grid, and/or in the data used to verify and calibrate the model.

Uncertainty in the input data results from having to define freshwater flows from the rivers and streams in the Pontchartrain Basin and along the Mississippi Coast. Input flows for the numerous ungaged areas were assumed to be similar to the input in the gaged areas. While this is a valid assumption, it adds some uncertainty to the model.

Uncertainties in the model geometry can be more significant than those in the input data. Large areas are approximated with an average depth and the boxes have an area for runoff and a contributing area for evaporation. All of these areas and depths are estimated based on the best available data.

Field data for calibration and validation can contribute the highest uncertainty to the modeling effort as data are critical in interpreting model results. Much of the data are spot data, and the exact time with respect to the tide and meteorological forcing is unknown. The ensemble of measurements was assumed to indicate average conditions. The UNO Mass Balance model had previously been validated for Lake Pontchartrain and Lake Maurepas, but was not validated for the Lake Borgne and Biloxi Marsh. The data was utilized to ascertain if the model reproduces seasonal trends.

The calibration and validation process for the expanded model was not thoroughly undertaken due to the limited data; therefore, uncertainty in the model results exists. Based on the model calibration error of 17 percent, a standard error in the prediction of the salinity in any cell can be +/-17 percent. Despite the uncertainties, the UNO Mass Balance model is a good, efficient tool to investigate the impact of proposed diversions.

2.12.4 Sediment and Nutrient Diversion (SAND2) Model Uncertainties

The combination of relative sea level rise and river/marsh disconnection has created a deficit of available soil and accompanying land loss in a large portion of coastal Louisiana. The Congress recently charged the USACE, State of Louisiana, and other Federal and local agencies with restoring the coastal wetlands of Louisiana and Mississippi. Many alternative combinations of restoration measures have been proposed, and assessment of the advantages and disadvantages of these efforts must be made to determine the optimal design. One technique being applied for coastal restoration is the reconnection of rivers to coastal marshes through flow diversions.

Freshwater flow diversions offer significant nutrient and sediment inputs to marshes that induce both organic and inorganic accumulation of soil. Boustany (2007) presented a screening level model for assessing both the nutrient and sediment benefits of flow diversion over long time scales.

As stated in **section 2.10.2**, given the short schedule the SAND2 model was utilized. The SAND2 version differs from the SAND1 model by incorporating an improved method for determined nutrient benefits, plus it includes the ability to capture diversion synergies with proposed marsh restoration measures constructed within the diversion benefit area.

Given the great uncertainties regarding future subsidence rate changes, SLR changes, and many other factors that might affect future wetland loss rates over the period of analysis, there is considerable uncertainty regarding the accuracy of the predicted river diversion benefits. However, the SAND models do provide an objective means for comparing alternative measures and plans.

The SAND2 model results are limited due to the exclusion of a variety of important system processes. Some of the major assumptions and limitations of the model were:

- Benefits of flow diversion are independent (in reality the benefits are likely non-linearly coupled due to vegetation inducing sediment deposition and sedimentation increasing suitable habitat for vegetation);
- Nutrients serve as a reduction in land loss, not a source of land gain benefits (Deposition of particulate organic matter neglected);
- Spatial uniformity – vegetation, roughness, bulk density, and other parameters are highly heterogeneous in coastal marshes;
- Temporal resolution is only represented intra-annually, not continuously. Rectangular wetland geometry;
- No vegetative component to settling/roughness;
- Organic accumulation is not considered as a function of time even though biomass production is highly seasonal;

- No habitat switching with time;
- Canals are not accounted for as a sediment loss mechanism;
- Sheet-flow was assumed for all diversion flow rates;
- No sediment re-suspension due to rainfall, tidal flows, waves, or hurricanes;
- Uniform distribution of sedimentation; and
- Nutrient recycling neglected.

2.12.5 Wetland Value Assessment Model Uncertainties

The WVAs were initially run by groupings by geographic locations (Biloxi, East Orleans Landbridge, Central Wetlands, Terre aux Boeufs, and Hopedale). Preliminary WVAs were run on restoration measures based on the percentage of each feature within the larger group. The Final Array of alternative plans was evaluated with full WVAs. Additional information includes impacts to wetlands for the diversion footprint and access footprints for each measure and dredging capabilities (see below for details). Correlation and interactions between the restoration measures within each geographic location were based on the expertise and experience of the HET. For the initial geographic group of WVAs, the HET established dependencies on measures that influenced each other as follows:

- Shoreline protection features were initially grouped with the adjacent marsh creation/nourishment features.
- Further into the study, each feature was evaluated individually before alternative plans were combined.
- Within the diversion influence areas the entire subunit with all its features were evaluated together.
- A simplifying assumption was made where shoreline protection measures protected portions of a marsh creation measure. Rather than determine actual interactions, the interacting shoreline protection and marsh creation measures were treated independently according to their respective protocols. The only exception to this was that of the MRGO Channel Narrowing measures, where marsh creation measures along the MRGO are protected by concrete panels. For those measures, it was assumed that marsh creation measures reduced the loss of created marsh by 50 percent, and the shoreline protection measures reduced the remaining loss by 50 percent, resulting in a combined 75 percent reduction in FWOP loss (polygon40 – South Lake Borgne polygon).

FWP analyses considered changes from processes such as equilibrium, storm events, and subsidence, and resulted in an overall change in the platform area or in the conversion of one WVA habitat type to another. Salinity was based on modeling results. Most subunits consisted of one major habitat type. Only Subunit 23 (Terre aux Boeufs) had two habitat types (saline and brackish); therefore, different WVA models were used to reflect the habitat difference.

- Fresh/intermediate – average salinity during the growing season (March through November)

- Brackish and saline – average annual salinity
- Swamp – mean high salinity for March through October

As part of the Corps certification process, the Wetland Value Assessment (WVA) Models were evaluated for their appropriateness of use in the Corps planning process. As a result, changes to the existing WVA marsh models were made. The changes primarily addressed concerns regarding how the existing WVA marsh models assigned greater habitat values to wetlands that had a greater amount of vegetated area. That assignment of values is consistent with the authorization and goals of the CWPPRA program (i.e., restoration of vegetated wetlands) and is therefore appropriate for its evaluations. Revisions to the WVA marsh models were incorporated to reduce the degree of influence vegetated areas had on project benefits and to reflect the habitat values for most species utilizing all natural habitats within each marsh type. See **appendix B** for WVA assumptions.

During the later stages of the MRGO project planning, these changes to the WVA models were applied to the final TSP WVAs. Since the new WVA models were applied to only the final TSP, a sensitivity analysis was run to determine if the changes in the model would have affected the outcome of alternative selection. Please see **table 2-30**.

There were no apparent equivalent trends or relationships regarding the amount of change to calculated benefits (i.e., AAHUs) for each individual project feature resulting from the change in models. However, the relative degree of benefits produced (high, medium and low) by each project feature appeared to be generally consistent between the models. All three sea–level rise rates were evaluated using the revised WVA models and again, no equivalent changes were noted between the analyses. As previously seen, the relative degree of benefits appeared to be consistent. It is believed that individual site conditions (e.g., greater subsidence or shoreline erosion rates, etc.) for each project feature can produce differences between the models as well as the sea-level rise rates. Those individual site conditions can confound any predictions regarding specific definable differences in benefits calculated by the different models and those resulting from application of different sea-level rise rates.

Table 2-30: Wetland Value Assessment Sensitivity Levels

Final TSP Feb. 24, 2012	AAHU Low RSLR				AAHU Medium RSLR				AAHU High RSLR			
	Low New Certified WVAs	Low Original WVAs	Difference Old Minus New	% Difference	Medium New Certified WVAs	Medium Original WVAs	Difference Old Minus New	% Difference	High New Certified WVAs	High Original WVAs	Difference Old Minus New	% Difference
Inner Biloxi Marsh	1,684	1,591	-93	-5.9%	1,947	1,540	-407	-26.4%	401	434	33	7.7%
Bayou La Loutre Outer SP	0.5	0.3	-0.2	-53.2%	0.4	0.2	-0.2	-71.3%	0.2	0.1	-0.1	-50.7%
Bayou La Loutre Ridge	33	38	5	13.0%	34	40	5	13.3%	49	56	6	11.4%
Central Wetlands Marsh	5,275	6,231	956	15.3%	9,289	9,990	700	7.0%	8,934	8,753	-180	-2.1%
Central Wetlands Swamp	4,600	5,230	630	12.0%	4,843	5,398	556	10.3%	5,584	5,926	342	5.8%
Diversion Footprint Impacts	-165	-134	32	-23.6%	-155	-127	27	-21.3%	-95	-72	22	-30.6%
East Orleans Landbridge	2,110	1,908	-202	-10.6%	1,612	1,300	-312	-24.0%	718	718	0	0.0%
Lower Pearl River	419	1,709	1,290	75.5%	505	1,492	987	66.1%	121	558	437	78.3%
Lower Lake Borgne Marsh	18,112	15,573	-2,538	-16.3%	18,034	14,935	-3,099	-20.8%	10,021	9,421	-599	-6.4%
Hopedale	176	468	292	62.3%	192	421	230	54.5%	70	196	125	64.1%
Inner Terre Aux Bouefs	1,595	3,277	1,681	51.3%	1,678	2,951	1,272	43.1%	519	1,189	670	56.3%
Total	**33,839**	**35,891**	**2,052**	**6.0%**	**37,980**	**37,940**	**-41**	**-0.1%**	**26,322**	**27,179**	**856**	**3.0%**

Diversion

An operations plan for the diversion is not planned until the planning, engineering and design phase of the study is funded for construction. Without modeling the operations, assumptions were incorporated in the WVA modeling effort. The HET assumed that freshwater flows over 7,000 cfs would overwhelm the Central Wetlands and potentially result in flooding to Paris Road given the existing two structure openings at Bayou Dupre and Bayou Bienvenue. As a result, it was further assumed and demonstrated by the H&H Mike 21 model that not more than 1,000 cfs would flow through the Central Wetlands area. The effects of the diversion on the flooding of Paris Road are unknown, but assumed that as long as flows did not exceed 1,000 cfs in the Central Wetlands it may not be an issue. To control the pulsing diversion flows in the Central Wetlands, a water control structure would be built in the channel to regulate the height of the water in the Central Wetlands. It was assumed that existing openings would remain open and any structures constructed would be constructed to the same diameter and dimensions that currently exist. The WVAs would have to be re-evaluated if the assumption changes as a result of this method.

Marsh Creation and Dredging

An implementation plan had not been developed at the time of the WVA; therefore, for purposes of the analysis, the HET incorporated dredge production in marsh creation, marsh nourishment, and swamp creation benefits developed from several scenarios. The details of these scenarios can be found in the WVA report located in **appendix M**. The HET assumed dredge production at 15,000 cubic yards per day and water depths based on engineering assumptions for each feature. The HET dredging scenarios provided by the engineers to determine annual wetland creation acreage and assumed that two dredges were operating year round. The HET prioritized wetland creation areas by subunit, based on subunit loss rates (low loss rate areas by subunit are constructed first, high loss rate areas last). It was further assumed that marsh and swamp creation would begin in 2015 (TY1).

At this stage of the feasibility report, marsh and swamp settlement curves were not prepared; therefore, it is assumed that enough borrow would be utilized to construct marsh and swamp features to a height conducive to sustaining these habitats. Without settlement curves, specific borrow quantities are based on previous projects and knowledge of the soil types where the features would be constructed.

Marsh creation utilizes retention features to build up marsh to required elevation. In some cases, existing marsh or shoreline protection features would act as retention. Overflow from marsh creation would nourish surrounding existing marsh. After compaction and dewatering, containment features would be breached to allow exchange of materials. Breaching is assumed to occur in most cases within one year of construction unless naturally degrades on its own.

2.12.6 Land Change Uncertainties

In addition to sea-level rise, future climate change would influence the quantity and timing of freshwater delivery to coastal estuaries. Future changes in the flow regime of the Mississippi River are important considerations for the design and operation of river diversions to restore the coast of Louisiana. As indicated in *Historical and Projected Coastal Louisiana Land Changes: 1978-2050, USGS (*Barras et al., 2004), climate projections agree that precipitation regimes in the future would be characterized by more frequent high-intensity rainfall events and that runoff regimes would therefore become more intense.

2.12.7 Comprehensive Aquatic Ecosystem Model (CASM) Uncertainties

By definition, simplifications and assumptions were necessary in developing the MRGO version of the CASM. Nevertheless, the resulting model successfully addressed the original modeling objectives. It is possible to use the current CASM MRGO to project the effects of freshwater diversions on modeled populations. One possible recommendation would be to accept the model in its current form. However, it would be possible to refine the model by revisiting some of its basic assumptions and making necessary modifications – assuming additional data might become available. The following recommendations are offered as possible improvements to the CASM MRGO:

- Physical transport of dissolved and suspended constituents (e.g., nutrients, particulate organic carbon, plankton) can influence spatial-temporal patterns of productivity in hydrodynamically complex systems such as the MRGO ecosystem. Future refinements to the model could include more direct linking of a physical model to the CASM MRGO. The CASM has been integrated with the USACE Adaptive Hydrology Model (ADH) in separate applications for Navigation Pool 5 on the Upper Mississippi River (Bartell et al., in prep.) and the Caernarvon Diversion on the Lower Mississippi River (Savant et al., in prep). Similar integration may be possible to provide more realistic physical transport for the CASM MRGO.
- Additional spatial resolution could be incorporated to provide more accurate whole-system estimates of the potential effects of freshwater diversions on MRGO food webs. The model currently estimates these large-scale effects based on the 23 modeled locations, each multiplied by the surface area associated with the modeled location. Increased spatial resolution would likely result from more sophisticated coupling of the CASM MRGO to a physical model (e.g., ADH).
- The modeled food web and associated bioenergetics parameters represents one hypothesis concerning ecological structure and function. The model reflects a preliminary consensus opinion concerning important populations of producers and consumers and realistic estimates of model parameters as determined by calibration. However, critical model parameters, for example, maximum growth rates and light saturation constants for phytoplankton, and maximum consumption and respiration rates for consumers (especially oysters, Gulf sturgeon), might be

measured directly for the MRGO populations. In addition, key resource agencies (e.g., NMFS, USFWS, LDWF) recommended some changes to the trophic interactions currently specified in the model. For example, the model incorrectly specifies predation by Atlantic croaker on juvenile red drum, which is not supported by empirical analysis of local croaker diets. Concerns were also expressed regarding the effects of aggregating diverse zooplankton and zoobenthos communities into corresponding single modeled populations (i.e., "zooplankton, zoobenthos") on model performance. Detailed sensitivity/uncertainty analysis of model results to current model assumptions regarding food web structure and input parameter values could help future structural revisions to the model and assist in the selection of key parameters to measure under field conditions.

- Reviewing resource agencies have identified potential revisions to the model in relation to spatial-temporal patterns of biomass production by certain modeled populations. For example, modeled Gulf sturgeon biomass appears greater than expected, given the listed status of this fish. Oyster production appears to be overestimated in the modeled portion of Lake Pontchartrain. In contrast, population production by several of the forage fish (e.g., striped mullet, Bay anchovy, Gulf menhaden) populations seem underestimated. Predation rates on these forage fish populations by other modeled fish populations may require additional review and revision. In addition, predation rates by higher trophic level fish (e.g., Atlantic croaker) on forage populations should be further examined; the absence of fishing mortality on Atlantic croaker and other fish populations might be overestimating the effects of predation on the forage populations.
- The initial model results suggest that modifications of the spatial occurrences of some populations are required. For example, modeled population biomass values for Node 9 seem high, given that this node is largely terrestrial. Additionally, sea trout are not growing in model nodes 1-5, where observations and experience suggest otherwise.
- The resource agencies also recommended that seasonal differences in the production of white shrimp and brown shrimp need to be further examined. The well-defined seasonal differences in the production of these species are not well reflected in the current simulations. Similarly, oyster spat and juvenile shrimp production should also demonstrate more pronounced seasonal pulses of biomass than in the current model results.
- Evaluation and refinement of the environmental input factors based on additional data, if available, might further improve model performance. For example, in the absence of nutrient loading data and more sophisticated physical transport, daily concentrations of dissolved inorganic nitrogen, dissolved inorganic phosphorus, and silica (diatoms) provide initial conditions that influence phytoplankton growth. It might be possible to develop nutrient loading values based on more realistic models of flow in combination measured concentrations from major nutrient sources. Measured concentrations in the reservoir that currently drive the model could then be more properly used in refined calibration of the CASM MRGO or as additional indicators of overall model performance.

- In response to agency review, the method for deriving the 55-year sequence of environmental input data should be further evaluated to determine if cyclic climate patterns relevant to the MRGO region can be more realistically represented.
- One of the greatest limitations in evaluating current model performance is the comparative absence of benthic invertebrate and fish standing stock information for the MRGO ecosystem.

Implementation of any or all of these recommendations can improve performance of the CASM MRGO. At the same time, specification of performance criteria would greatly facilitate further evaluation of the current model and guide any future refinements. In basic research, models are developed with the intent of falsifying them. Model failures generate new testable hypotheses that can advance science and in turn improve the model. In management, the contrasting emphasis is on model reliability within specified performance criteria. The question, "how good is good enough?" needs to be translated into objective performance criteria (i.e., model:data comparisons) that are usually based on some goodness of fit estimator. Development of such criteria for the CASM MRGO could improve the efficiency of continued model refinement and evaluation until the model is deemed adequate. Nevertheless, the recommended revisions to the model should be performed to the extent possible given time and resources. The FWOP and FWP scenarios should then be re-run with the revised model to (1) determine the significance of the model revisions on the preliminary CASM MRGO results used to develop the DEIS and (2) to provide more accurate model results to revise the DEIS as necessary.

2.12.8 Oil Spill Uncertainties

The long-term impacts of the Deepwater Horizon oil spill on coastal Louisiana are uncertain at this time. The impacts of the oil spill as well as the various actions taken to address oil spill impacts (e.g., use of oil dispersants, creation of sand berms, use of Hesco baskets, rip-rap, sheet piling and other actions) could potentially impact USACE water resources projects and studies within the Louisiana coastal area, including the MRGO Ecosystem Restoration project. Potential impacts could include factors such as changes to existing, future-without, and future-with-project conditions, as well as increased project costs and implementation delays. The USACE will continue to monitor and closely coordinate with other Federal and state resource agencies and local sponsors in determining how to best address any potential problems associated with the oil spill that may adversely impact project implementation. Supplemental planning and environmental documentation may be required as information becomes available. If at any time petroleum or crude oil is discovered on project lands, all efforts would be taken to seek clean up by the responsible parties, pursuant to the Oil Pollution Act of 1990 (33 U.S.C. 2701 et seq.).

The USACE, New Orleans District Regulatory Branch has considered and responded to approximately 58 emergency permits related to the Deepwater Horizon oil spill. The State of Louisiana received a permit to dredge and fill to construct a six sand berm reaches along the shoreline of the Chandeleur Islands/Breton National Wildlife Refuge westward to Baptiste Collette Bayou and along the seaward shoreline of Timbalier Island eastward to Sandy Pont. Material to construct the berms would be dredged from Ship Shoal, South Pelto, the Mississippi River Offshore Disposal Site, Pass a Loutre, St. Bernard Shoal and Hewes Point (see http://www.mvn.usace.army.mil/pao/mvnoilspill.asp for information on permits issued within the MRGO study area).

As is evident from the numerous ongoing actions, the dynamic nature of the impacts associated with the Deepwater Horizon oil spill will likely require additional consideration in the near future for USACE Civil Works projects. Potential impacts and affects are briefly described by environmental constraint below:

- **Hydraulics and Hydrology Modeling –** No impacts to this resource have occurred within the project area from the oil spill and conditions will continue to be monitored.
- **Water Quality** - There is the potential for contamination and decreased water quality from the oil and chemical dispersants. Tar balls, sheen, and heavy oil was reported in portions of Lake Borgne, the Western Mississippi Sound, Chandeleur Sound, and Breton Sound increasing the potential for decreased water quality and possible contamination in these portions of the project area (http://www.wlf.louisiana.gov/oilspill). Water quality testing in Lake Borgne and other areas is ongoing and these results will shed more light on to the level of possible contamination and impacts to water quality from the spill in the long-term.
- **Navigable Waterways –** No navigable waterways were closed due to the oil spill and the only impacts included decontamination stations near the mouth of the River for all vessels entering the Mississippi River.
- **Soils -** No impacts to this resource have occurred within the project area from the oil spill and conditions will continue to be monitored as circumstances change.
- **Air Quality** - The oil spilled into the Gulf, and the dispersants sprayed on the oil, contain some chemicals that evaporate into the air and could be carried via the wind toward shore. The EPA has set up a network of stationary and mobile monitors along the coastline. If the winds shift or the oil moves, it may be expected to see a change in EPA air monitoring results from other locations. Since the MRGO project area is approximately 40+ miles away from the immediate oil impact site, the air quality impacts may not be as significant.
- **Noise -** No impacts to this resource have occurred within the project area from the oil spill and conditions will continue to be monitored as circumstances change.
- **Hazardous, Toxic, and Radioactive Waste -** No impacts to this resource have occurred within the project area from the oil spill and conditions will continue to be monitored as circumstances change. The potential impacts from the use of dispersants are an unknown quantity at this time and will require further study.
- **Barrier Island Resources** - Oil is significant, but has not completely surrounded the Chandeleur Island shoreline. Oil has been reported in sea grass and wetlands on the western side of the islands. The USACE has approved emergency permits

for the construction of sand berms on the island chain. The purpose of the berms is to trap oil before it reaches the delicate and fragile wetlands.

- **Coastal Vegetation Resources** - At the time of publication, oil spill related impacts had been reported in the saline, brackish and intermediate marshes of the Biloxi marsh region, the East Orleans Landbridge and the Lake Borgne area. The extent of the impact on coastal vegetation, both acute and chronic, cannot be quantified with the oil still coming ashore in the vast expanse of coastal marshes in Southeast Louisiana. Natural Resource Damage Assessments will be required to evaluate the primary and secondary impacts on the coastal marsh habitat.
- **Wildlife Resources –** There have been numerous documented incidents of various bird species, including the brown pelican, directly impacted by oil on the barrier islands, as well as confirmed sea turtle deaths. While much of the project area has yet to be directly affected by the oil spill, substantial indirect effects are likely to have occurred to many birds and some mammals, and will continue for an extended period.
- **Aquatic and Fishery Resources -** Impacts to fisheries populations within the project area, based upon ongoing water quality studies and fisheries sampling events, is unknown. The results of these sampling efforts by Federal and state agencies will eventually quantify potential short- and long-term impacts.
- **Commercial Fisheries -** Impacts to commercial fisheries included the closure of certain fishing grounds in both Federal and state waters throughout large portions of the Gulf and other coastal waters. A potentially lingering impact includes the National perception that seafood taken from the Gulf may be unsafe for consumption.
- **Oyster Resources -** Oyster beds were closed throughout the project area and most of coastal Louisiana. Testing of oysters meant for human consumption is ongoing. At this time there is no definitive results of the impacts and potential contamination of oyster beds. In order to help prevent oil entering the marsh, several freshwater diversions were opened. The impacts of these freshwater spikes on oysters is still unknown
- **Water Bottoms and Benthic Resources** - The extent of oil and dispersants currently located on the sea floor is unknown. There is a potential for suffocation of benthic invertebrates.
- **Plankton Resources** - The presence of oil and dispersants in the estuarine waters of the Louisiana marshes is anticipated to have impacts on the vast plankton resources that are dependent on the tidal marshes. The extent of the short-term and long-term impacts of oil on plankton species will require in-depth study to assess the adverse effects of the oil on the plankton of the Gulf of Mexico and interdependent estuarine life stages.
- **Essential Fish Habitat -** Ongoing water quality studies and fisheries sampling events are currently being conducted. Impacts to EFH within the project area, based upon these sampling efforts, are unknown. The results of these sampling efforts by Federal and state agencies will eventually quantify potential short- and long-term impacts.
- **Threatened and Endangered Species -** Potential impacts include direct impacts to endangered species critical habitat and reduction in available uncontaminated

habitat refuges. Coordination with the USFWS, NMFS, and LDWF is ongoing in determining how to best address potential problems associated with the oil spill that may adversely impact the threatened and endangered species that are found within the project area.

- **Socioeconomic and Human Environment -** According to an economic analysis conducted by Dun and Bradstreet (*2010 Deepwater Horizon Oil Spill: Preliminary Business Impact Analysis for Coastal Areas in the Gulf States*, Dunn & Bradstreet, June 7, 2010) there are 315 Louisiana businesses and 78 Mississippi businesses that are directly related to the seafood industry in the Gulf of Mexico and could be severely impacted by the oil spill. These negative impacts would in turn alter the socioeconomic stability of the coastal communities of Louisiana and Mississippi as related to population, employment and income, community cohesion, etc. Data is not available as of the time of this analysis (August 2010) to estimate specific impacts.
- **Environmental Justice -** No impacts to this resource have occurred within the project area from the oil spill and conditions will continue to be monitored as circumstances change.
- **Recreational Resources** - In the short-term, recreational fishing is being significantly impacted by the ongoing oil spill. Recreational fishing areas are currently open but can close at any time due to movement of the oil sheen. Regardless if fishing areas are open or closed, recreational fishing is impacted by the perception of negative effects of oil and chemical dispersants. In the long-term, recreational fishing could be impacted by the effect of the oil spill on fishery habitat and spawning areas.
- **Aesthetics** - The oil globules, particles and the sheen that flows along the top of the water, are a dramatic visual blight to any landscape setting. However, loss of plant materials could impact scenic quality by reducing color and texture in the numerous marshes, wetlands and swamps throughout the ecosystem restoration project area. Wildlife plays an integral role in the scenic quality of the landscape, providing focal points and drama to the scenery. The loss of habitat would cause wildlife to move to another area or, as a worst case scenario, die off completely.
- **Scenic Streams –** There have been no reports of tar balls, sheen, or oil within the Central Wetlands area or the Golden Triangle marsh area where the seven scenic streams within the project area are located. However, if oil would eventually infiltrate these areas, impacts could include the loss of plant material and harm to wildlife which in turn reduces the aesthetic value of the area and diminishes the publics' ability to enjoy these scenic streams.

2.12.9 Engineering Level of Design

The engineering level of effort for the proposed restoration features is considered at full feasibility level of design except for the Violet, Louisiana freshwater diversion which is still preliminary. However, the preliminary engineering that has been conducted thus far provides adequate detail regarding the location and design components associated with the Violet, Louisiana freshwater diversion. Furthermore, the preliminary level of engineering detail is considered adequate as it relates to determining environmental impacts. The possibility remains that as this feature is further refined, additional surveys and borings would need to be obtained and supplemental NEPA documentation would be necessary for unidentified impacts resulting from project changes.

2.13 RESEARCH AND TECHNOLOGY DEVELOPMENT NEEDS

Although many studies have been conducted in the Louisiana coastal area, most were limited in geographic extent or technical scope. Therefore, while much has been learned from previous efforts, many scientific and technical uncertainties remain. As listed in the LACPR Coastal Appendix, some areas of high uncertainty include:

- availability of sediment (riverine and offshore)
- subsidence rates and sea level rise
- benefits and impacts of pulsed freshwater diversions
- channel evolution in freshened areas
- effect of diversions on Mississippi River sediment transport
- cumulative effect of multiple diversions in a basin or region
- over freshening of estuaries
- fisheries impacts associated with river diversions
- pipeline conveyance technologies and costs
- thin-layer sediment placement techniques
- salt transport inland with sediments from offshore
- benthic habitat impacts

To effectively use existing knowledge and gain the increased understanding necessary to deal with the issues described above, it is essential that appropriate predictive tools are developed. The tools include numerical modeling approaches to predicting patterns of water level, salinity, and sediment distribution. Hydrologic models must be developed, which specifically encompass flows across marsh surfaces and through channels and structures, must be developed. Ecological models must address marsh accretion (mineral and organic), nutrient budgets, and soil biogeochemical processes.

To fully achieve the ecosystem goals of this study, a better understanding of ecological and biogeomorphic processes and functions is needed. Critical questions still need answers, such as "What is the effect on ecosystem sustainability of a seasonal river diversion that increases the annual range of salinity within the receiving basin? How important to coastal marshes is nutrient input alone vs. freshwater and sediment delivery from the river? How does this vary with marsh type?"

Due to uncertainties associated with sustaining Louisiana's coast through sediment placement, a sediment-needs budget and sources inventory should be developed. Further study of sediment loads in the lower Mississippi River is needed due to variation between sampling frequency and methods at various sites. The *LCA Mississippi River*

Hydrodynamic Study is anticipated to increase available data and understanding about the sediment loads in the river.

CHAPTER 3: **AFFECTED ENVIRONMENT**

3.1 INTRODUCTION

The National Environmental Policy Act (NEPA), 40 CFR Part 1500 et seq., provides guidance for the preparation of environmental impact statements (EIS). The Affected Environment chapter includes a description of the existing environment within the study area, as well as more specific descriptions of conditions within the proposed project area. Guidance for preparation of the Affected Environment chapter is contained in Section 1502.15 of the Council on Environmental Quality (CEQ) regulations. The regulation states that this section shall contain data and analysis “commensurate with the importance of the impact, with less important material summarized, consolidated, or simply referenced.”

This chapter provides a description of the physical, biological, and socioeconomic environments occurring within the study area as a result of past and present actions. Emphasis is placed on resources of particular concern such as water quality, hydrology, wetlands, fisheries, threatened and endangered (T&E) species and associated critical habitat. Of particular concern in the Pontchartrain Basin are the increases in salinity intrusion and the accelerated loss of wetland vegetation due partly to the construction of the Mississippi River Gulf Outlet Navigation Channel (MRGO). The MRGO was deauthorized early in June 2008 and a rock closure structure was completed in July 2009 near the Bayou La Loutre Ridge (**figure 3-1**).

Figure 3-1: MRGO Closure Structure at Bayou La Loutre Completed July, 2009

3.2 SIGNIFICANT RESOURCES

The U.S. Corps of Engineers (USACE) Engineering Regulation 1105-2-100 provides guidance for ecosystem restoration studies. The USACE policy recommends the identification of significant resources within the study area and consideration provided for the effects of the restoration plan on those resources during the evaluation process. Resources protected or governed through legislation or valued in technical reports and by the public are considered significant. Institutional sources include global or National publications and conservation status rankings as well as protection plans and statutes. Input on locally significant resources was obtained during scoping meetings, stakeholder group meetings and from local, state, and Federal resource agencies. Technical sources ranged from national and regional research papers to local college, university, agency, and group expertise.

Louisiana's coastal areas are economically, recreationally, and ecologically important to the region, the Nation, and internationally. The loss and restoration of Louisiana's coastal wetlands have been a concern and issue of major importance for many decades.

The existing conditions of the affected environment represent the baseline conditions against which future conditions are evaluated. The affected environment is described by resource categories. **Table 3-1** lists the identified resources that are discussed in this chapter as well as the state or Federal legislation governing the importance of the resource.

Table 3-1: Significant Resource and Institutional Recognition

Significant Resource	Institutional Recognition
General Biological Resources	Executive Order (EO) 11988 Floodplain Management
	National Environmental Policy Act of 1969
	Coastal Zone Management Act of 1972
	Water Resources Development Acts of 1976, 1986, 1990, 1992
Barrier Island Resources	Coastal Barrier Resources Act of 1982
Aquatics and Fisheries	Marine Mammal Protection Act
	Anadromous Fish Conservation Act
	Fish and Wildlife Conservation Act of 1980
	Fish and Wildlife Coordination Act of 1958, as amended
	Marine Protection, Research and Sanctuaries Act
	Fishery Conservation and Management Act
Essential Fish Habitat	Magnuson-Stevens Fishery Conservation and Management Act of 1976, as amended (MSA)
	Magnuson-Stevens Act Reauthorization of 2006
Threatened and Endangered Species (T&E)	Endangered Species Act of 1973
Wildlife	Fish and Wildlife Conservation Act of 1980
	Fish and Wildlife Coordination Act of 1958, as amended
	Migratory Bird Conservation Act
	Migratory Bird Treaty Act
	EO 13186 Migratory Bird Habitat Protection

Table 3-1: Significant Resource and Institutional Recognition

Significant Resource	Institutional Recognition
Coastal and Migratory Birds	Bald and Golden Eagle Protection Act (BGEPA)
Prime and Unique Farmlands	Farmland Protection Policy Act of 1981
Invasive Species	EO 13112 Invasive Species
Wetlands	EO 11990 Protection of Wetlands
	Clean Water Act (CWA)
	Estuary Protection Act of 1968
	North American Wetlands Conservation Act
	Emergency Wetlands Resources Act of 1986
Scenic Streams	Louisiana Scenic Rivers Act (LSRA) - Acts 1988, No. 947, §1, eff. July 27, 1988
Recreation	Federal Water Project Recreation Act of 1965, as amended
	Land and Water Conservation Fund Act of 1965, as amended
Aesthetics	National Environmental Policy Act of 1969
Cultural Resources	Section 106, National Historic Preservation Act of 1966
	36 CFR Part 800, Protection of Historic Properties
Air Quality	Clean Air Act of 1963, as amended
	Louisiana Environmental Quality Act of 1983
	29 CFR, part 1910, Occupational Safety and Health Standards
Noise	Noise Control Act of 1972
	Title 29 Code of Federal Regulations (CFR), Part 1910, subpart G
Water Quality	Clean Water Act of 1977
Hazardous, Toxic, and Radioactive Waste (HTRW)	ER 1165-2-132
	42 U.S.C. 6905 Resource Conservation and Recovery Act
	Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
Environmental Justice	EO 12898
Social Economic Resources	National Environmental Policy Act of 1969

3.3 STUDY AREA

The study area covers approximately 3.86 million acres (over 6,000 square miles) which includes portions of the Mississippi River Deltaic Plain in southeast Louisiana and parts of southwest Mississippi (**figure 3-2**). In Mississippi, the study area includes the Western Mississippi Sound, the surrounding wetlands, and Cat Island. In Louisiana, the study area includes the Pontchartrain Basin, which is comprised of the Upper, Middle, and Lower sub-basins. The Upper Pontchartrain sub-basin includes Lake Maurepas and its adjacent wetlands and swamps. The Middle Pontchartrain sub-basin is comprised of Lake Pontchartrain, the adjacent cities and towns, and surrounding wetlands.

As described in **chapter 1**, the Lower sub-basin includes Lake Borgne, the deauthorized MRGO, the Mississippi River, Chandeleur and Breton Sounds, portions of Western Mississippi Sound and the Gulf of Mexico, including the surrounding wetlands, barrier islands, and communities. Lake Borgne is hydrologically linked to Lake Pontchartrain through tidal passes at the Rigolets, Chef Menteur Pass, and the manmade Inner Harbor Navigation Canal (IHNC). The Lake Borgne ecosystem is also influenced by the Pearl River to the north and receives hydrologic interchange from areas located as far south as the River Aux Chenes Ridge, which is located between the MRGO and the Mississippi River. Major navigation channels include the Mississippi River, IHNC, and the Gulf Intracoastal Waterway (GIWW).

Figure 3-2: Study Area – Pontchartrain Basin and Western Mississippi Sound

Following identification and screening of features and formulation of final alternatives, the proposed project area was identified as the Lower Pontchartrain sub-basin.

3.4 GEOMORPHIC AND PHYSIOGRAPHIC SETTING

Most of the present landmass of southeast Louisiana was formed by deltaic processes of the Mississippi River. Over the past 7,000 years, the Mississippi River deposited massive volumes of sediment in five deltaic complexes. The study area lies within the Mississippi Delta Region (**figure 3-3**) comprised of three geomorphic regions, which are divided further into multiple smaller geomorphic areas.

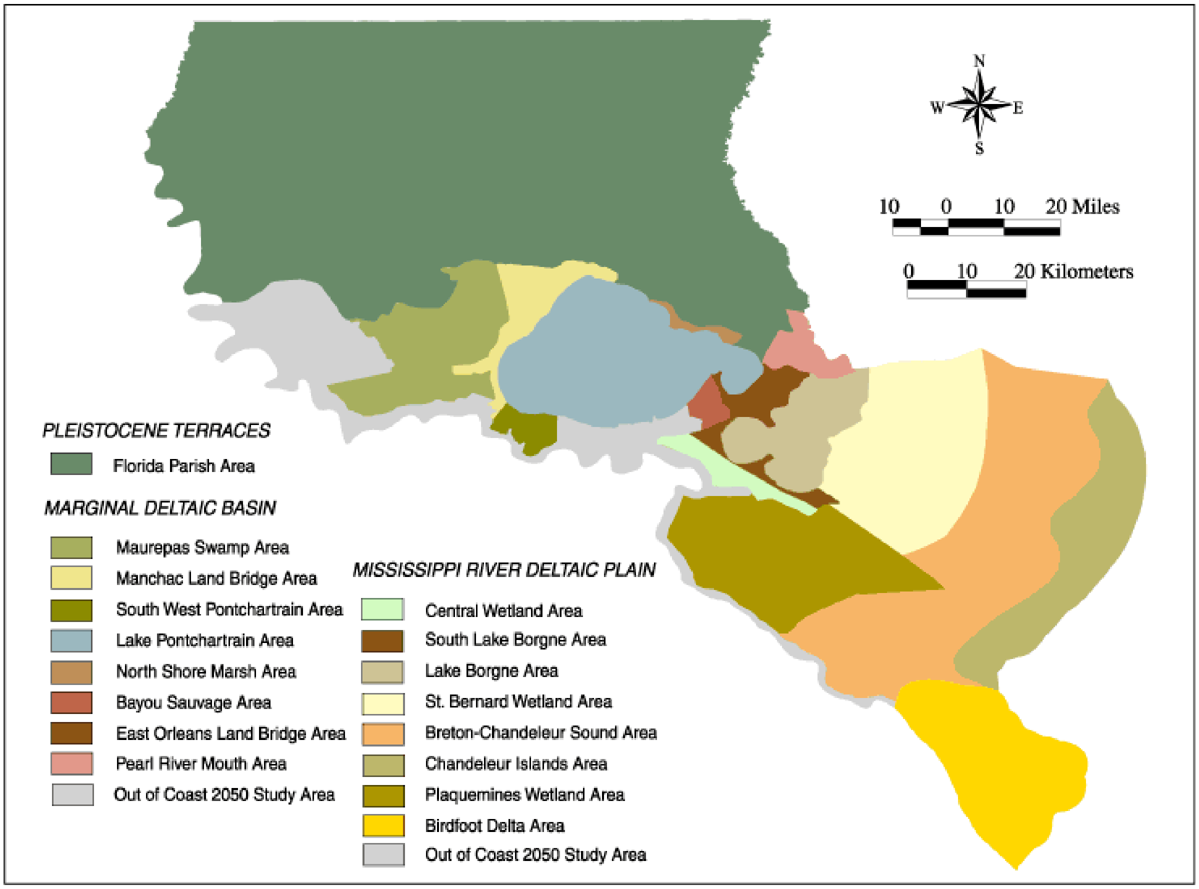


Figure 3-3: Mississippi Deltaic Region (Coast 2050)

The Pleistocene Terrace Region is the area north of Lakes Maurepas, Pontchartrain, and Borgne. This region is defined as the area north of the Mississippi River Deltaic Plain and the lowlands surrounding Lakes Pontchartrain and Maurepas.

The Marginal Deltaic Basin is comprised of estuarine marshes and forested wetlands of the Lakes Pontchartrain and Maurepas. This region includes some of the largest remaining tracts of forested wetlands in the Lower Mississippi River Valley. The Marginal Deltaic Basin is divided into the following eight geographic areas: Maurepas Swamp, Manchac Landbridge, Southwest Pontchartrain, Lake Pontchartrain, North Shore Marsh, Bayou Sauvage, East Orleans Landbridge, and Pearl River Mouth (**figure 3-4**).

The Marginal Deltaic Basin lies within the coastal zone of Louisiana and is influenced by wetland loss, subsidence, saltwater intrusion and shoreline erosion. USACE data indicates relative sea level rise in the region of less than 0.5 feet per century, but in many localized areas, the rate is greater. Shoreline erosion is taking place around the entire perimeter of Lakes Pontchartrain, Maurepas, and Borgne, except at armored sections.

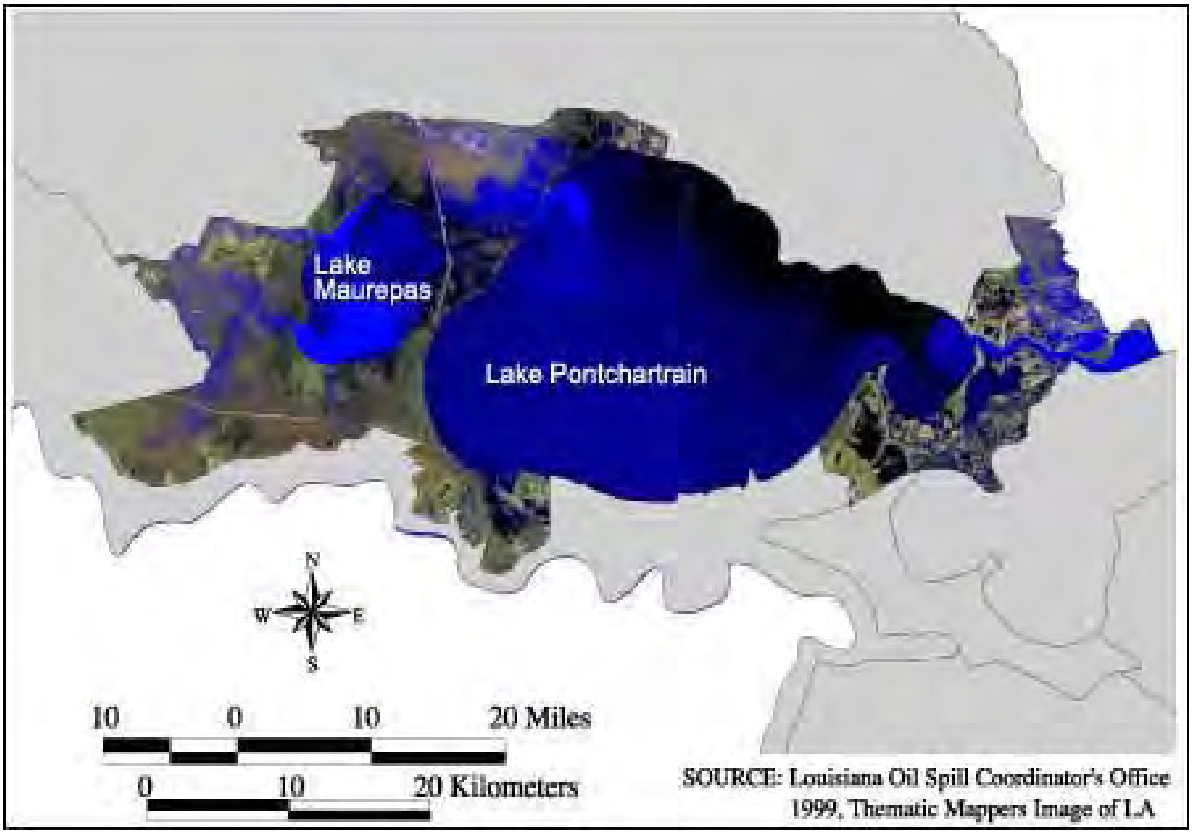


Figure 3-4: Marginal Deltaic Basin

The Mississippi River Deltaic Region lies south of the lakes. The salinity gradient within this region decreases from east (saltwater of the Gulf of Mexico) to west (fresher waters in the coastal plain) through the Pontchartrain Basin (**figure 3-5**).

The proposed restoration features of this study are located within the St. Bernard Deltaic Complex, the oldest deltaic complex within the Mississippi Deltaic Plain Region. The areas contained in this geomorphic region are associated with the delta-building cycle of the Mississippi River and are removed from Lake Pontchartrain.

The Mississippi River Deltaic Plain Region is divided into the following geographic areas: Central Wetlands, South Lake Borgne, Lake Borgne, St. Bernard Wetland, Breton-Chandeleur Sound, Chandeleur Island, Plaquemines Wetland, and Birdfoot Delta. The Central Wetlands, Lake Borgne, South Lake Borgne and Chandeleur Island Areas are all part of the St. Bernard Delta. The Mississippi River naturally abandoned this older delta lobe when it switched its course some 2,000 years ago and began building the Lafourche Delta. Consequently, land building declined in this portion of the Lake Pontchartrain Basin well before European settlement. USACE data show relative sea level rise in the region ranging from less than 0.5 foot per century to one foot to four feet per century, making it the most rapidly subsiding portion of the Lake Pontchartrain Basin. The Chandeleur Islands mark the outer edge of this system, but they are migrating landward. Wetlands consist of poorly consolidated soils and elevations are slightly above mean gulf level. Uplands adjacent to the deltaic plains are geologically older with higher elevation and firmer soils. Narrow alluvial ridges, resembling finger-like patterns that were formed by overbank processes, extend toward the Gulf of Mexico. The ridges serve as natural levees, having higher elevation and firmer soils and occur along active, abandoned distributaries of the Mississippi River (Coast, 2050). The natural and man-made ridges form hydrologic basin divides and are more resistant to erosion than wetlands.

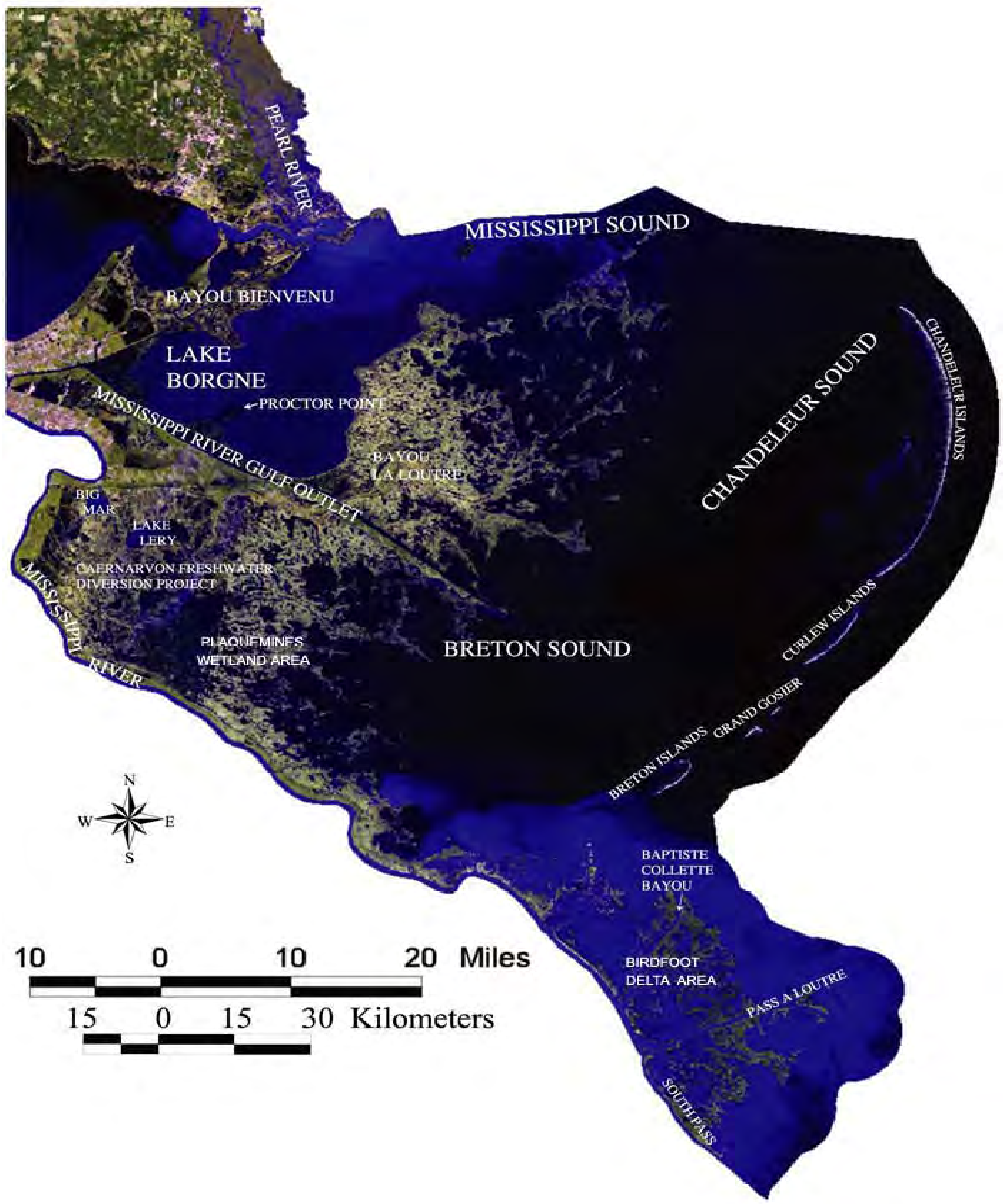


Figure 3-5: Mississippi River Deltaic Region

Construction of the MRGO impacted the natural geomorphology and hydrology of the St. Bernard Deltaic Complex. In an analysis of the tidal flow across the region, it was demonstrated that the Bayou La Loutre Ridge served as a basin boundary. Dredging through the ridge interrupted the circulation pattern along the southeastern length of the channel and the areas between Breton Sound and Lake Borgne (Wicker et al., 1982).

3.5 COASTAL SYSTEM PROCESSES

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

3.5.1 The Deltaic Processes

The 186-mile wide Mississippi River Deltaic Plain and its associated wetlands and barrier shorelines are the product of the continuous accumulation of sediments deposited by the River and its distributaries during the past 7,000 years. Regular shifts in the River's course have resulted in four ancestral and two active delta lobes, which accumulated as overlapping, stacked sequences of unconsolidated sands and muds. As each delta lobe was abandoned by the River, its main source of sediment, the deltas experienced erosion and degradation due to compaction of loose sediment, rise in relative sea level, and catastrophic storms. Marine coastal processes eroded and reworked the seaward margins of the deltas forming sandy headlands and barrier beaches. As erosion and degradation continued, segmented low-relief barrier islands formed and eventually were separated from the mainland by shallow bays and lagoons (LACPR, 2008).

The result of the building and subsequent abandonment of these delta lobes by the River was the construction of a modern deltaic coastal plain. Each delta cycle lasts about 1,000 years, and the most recent delta (the Mississippi Birdfoot Delta) is approaching the end of that time scale (LACPR, 2008). These processes are discussed in detail in the Louisiana Coastal Area (LCA) (2004) report.

3.5.2 Mud Stream

Every active subdelta has a “mud-stream” that consists of the fine grained sediments (silts and clay) that stay in suspension beyond the immediate area of the active distributary outlets and move along the coast in response to coastal currents (Morgan et al., 1953; van Lopik, 1955; Adams et al., 1978; van Heerden, 1983; Wells and Roberts, 1980; Kemp, 1986; Roberts, 1998). Twenty-five percent or more of the transported sediment escapes deposition in the immediate area of the distributary outlets and is carried away in the mud-stream. Distributary outlets that discharge into deep waters (far out on the continental shelf or beyond the shelf edge, as in the case of the modern Birdfoot Delta) may deposit mud-stream sediment on the sea bottom of the shelf or into the depths of the gulf. In the case of the modern Mississippi River Delta, mud-stream sediments are largely lost to the land building and maintenance processes.

3.5.3 Marine Processes

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

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

3.5.4 Fluvial Processes

The largest source of freshwater and sediment in the study area is the Mississippi River. The Pearl River and other smaller rivers contribute additional water and sediments from local watersheds. Flow is strongly seasonal, peaking in late spring, fed by melting snow and spring rains in the Upper Mississippi watershed. Flows on the Mississippi River are independent of local rainfall because of the size of the watershed, but freshwater and sediment from local rivers and streams along the coast is supplied mainly during periods of heavy local rainfall (LACPR, 2008).

The inactive delta of the Mississippi River (the part that has been abandoned by the River) is isolated from direct riverine input by natural and artificial levees. The Mississippi and Pearl Rivers discharge into the Gulf of Mexico. Most of the Mississippi River waters are carried westward along the coast, freshening the Gulf of Mexico waters that move in and out of the Barataria, Terrebonne, and Vermilion estuaries, rather than reaching estuaries in the study area (LACPR, 2008).

3.5.5 Chemical Processes

Elements and compounds can enter tidal wetlands by tidal exchange, precipitation, upland runoff, and groundwater flow. Once in the wetlands, they may be deposited on water bottoms, adsorbed to particles, or taken up and fixed in the tissues of rapidly growing vascular plants. These substances may be incorporated or otherwise transformed by microbial assemblages associated with the complex of surfaces provided by the sediment, live plants, litter, and detritus (LACPR, 2008).

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

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

3.5.6 Biological Processes

Coastal fringe marshes provide habitat for a variety of vertebrate wildlife including fish, birds, mammals, and reptiles. Teal (1986) stated that one of the most important functions of salt marshes is to provide habitat for migrant and resident bird populations. Some wildlife species inhabiting tidal marshes are important game animals (e.g., mallard [*Anas platyrhynchos*] and American wigeon [*A. americana*]), whereas the muskrat (*Ondatra zibethicus*) and raccoon (*Procyon lotor*) are valuable furbearers. The American alligator (*Alligator mississippiensis*) is harvested for both its skin and meat. Many of the birds that commonly use coastal fringe wetlands, especially larger species such as ospreys, herons, egrets, and Roseate Spoonbills (*Ajaia ajaia*) provide recreational opportunities for birdwatchers, nature enthusiasts, and wildlife photographers (LACPR, 2008).

The majority of wildlife species that utilize tidal marsh have neither commercial nor recreational value, but simply are ecologically important members of the ecosystem. For example, the rice rat (*Oryzomys palustris*) and other small mammals play a key role in marsh trophic cycles, providing food for several species of avian and mammalian predators. Many of the vertebrates that use the marsh ecosystem are highly mobile and serve as a transfer mechanism for nutrients and energy to adjacent terrestrial or aquatic ecosystems. Some of the larger vertebrates, including the muskrat and nutria (*Myocastor coypus*), consume copious amounts of forage and at high densities may have significant impacts on marsh vegetation (LACPR, 2008).

Tidal marshes provide forage habitat, spawning sites, and a predation refuge, and serve as a nursery for resident and nonresident fishes and macrocrustaceans. These organisms use tidal marshes or adjacent subtidal shallows, either year round or during a portion of their life history, as nurseries. A number of ecologically and economically important nekton and benthic species are dependent on the availability of suitable tidal marsh habitat. Nekton refers to the aggregate of actively swimming aquatic organisms in a particular body of water. Estuarine-dependent species such as the penaeid shrimp (*Farfantepenaeus* spp., *Litopenaeus* spp.), the blue crab (*Callinectes sapidus*), the sciaenids (*Cynoscion* spp., *Sciaenops ocellatus*, *Leiostomus xanthurus*, *Micropogonias undulatus*, and *Bairdiella chrysoura*, etc.), and others use tidal marshes and shallow, subtidal bottoms as nurseries. The ubiquitous killifishes (*Fundulus* spp.), grass shrimp (*Palaemonetes* spp.), and gobies (*Gobiosoma* spp., *Gobionellus* spp., *Microgobius* spp., etc.) are characteristic residents of Atlantic and Gulf Coast intertidal wetlands. These organisms are consumed by nektonic and avian predators and are considered to represent an important link in marsh-estuarine trophic dynamics (LACPR, 2008).

Most evidence suggests that resident organisms (e.g., killifishes, grass shrimps) utilize the entire marsh surface across the range from low to high elevations, but that the dense vegetation characteristic of high marsh habitats may offer greater protection from natant predators than low marshes. However, resident nekton are also widely distributed throughout the lower intertidal marsh early and late in the tidal cycle in Louisiana and Mississippi (Rozas and Reed, 1993; Fulling et al., 1999; Hendon et al., 2000), and may use these areas as staging areas prior to marsh flooding. Resident nekton can make extensive use of high marsh when spring tide conditions facilitate access to the upper intertidal zone. Several resident killifish species, including *Fundulus grandis, F. similis, F. pulverus*, and *Adinia xenica*, rely on availability of high intertidal marsh, coincident with spring tidal events, for use as spawning sites (Greeley and MacGregor, 1983; Greeley, 1984; Greeley et al., 1986; Greeley et al., 1988). Killifishes also use tidal marshes for foraging sites; as Rozas and LaSalle (1990) noted, the Gulf killifish (*F. grandis*) consumed more prey when it had access to the marsh surface than when it was confined to subtidal areas by low tides (LACPR, 2008).

3.6 HYDROLOGY – HYDRAULICS

3.6.1 Historic and Existing Conditions

Prior to the construction of levees on the Mississippi River, the River would overflow its banks during periodic floods. Flow from the River into Breton Sound was via various bayous such as Bayous Bienvenue, Dupre, and La Loutre that were part of the remnant tributary system that extended from the Mississippi River eastward to the Biloxi Marsh and Mississippi Sound. These channels were used by smaller crafts, mostly commercial and recreational fishing. With the construction of levees, and the strengthening of these levees with the Mississippi River and Tributaries (MRT) program, the River no longer overflows into the project area. The only introduction of river water into the project area is from the Caernarvon Freshwater Diversion structure to the south of the project area, a small amount from lockage at the IHNC lock, and the Bonnet Carré Spillway to the north of the project area.

The Bonnet Carré Spillway is periodically operated for flood control. The frequency of operation is about once a decade. During operation of the structure, large volumes of river water (up to a capacity of 250,000 cubic feet per second [cfs]) are introduced into Lake Pontchartrain to lessen flow and stages in the River. During high river stages (but not high enough to necessitate operation of the structure) there is leakage through the needles of the structure. This leakage is on the order of 5,000 cfs to 10, 000 cfs.

The project area is an estuary in which freshwater, predominantly from run-off into the Pontchartrain Basin and the Pearl River Basin, mixes with the saltwater of the Gulf of Mexico. The tides in the Gulf near the project area are mostly diurnal with a spring tide range of 1.9 ft. to 2.3 ft. During periods with flood discharges in the Pearl and Pontchartrain Basins, salinity levels in the project area tend to be reduced. During periods of drought conditions in the Basins, salinity levels in the project area will tend to increase.

There are three navigation channels in the project area, which may have modified the hydrologic regime of the Biloxi Marsh. These are the IHNC, the GIWW, and the recently de-authorized MRGO.

The IHNC Lock, connecting the Mississippi River and Lake Pontchartrain, was completed in 1923 with the construction of the IHNC lock at the Mississippi River preventing high stages in the River from producing strong currents in the channel. In the 1930s, the GIWW was constructed from the mid-point of the IHNC going east and later routed through the IHNC lock. The construction of the GIWW east of the IHNC allowed for additional tidal exchange with Lake Pontchartrain, in addition to the larger channels of the Rigolets and Chef Menteur Pass.

Prior to construction of the MRGO, a typical tidal flow from the Breton Sound area was reduced as it moved across the marshes and wetlands inward toward the Lake Pontchartrain. There are a number of factors resulting from construction of the MRGO that have contributed to the alteration of circulation patterns and water quality along the length of the MRGO and outward into the surrounding wetlands and marshes. The MRGO provided a more direct flow of more saline, higher density water inland toward areas of St. Bernard and eastern Orleans Parishes. Dredging through of the Bayou La Loutre Ridge, as a basin boundary, significantly altered circulation patterns in areas along the lower southeastern length of the channel and across areas between Breton Sound and Lake Borgne.

Dredging performed for construction of the MRGO to an approximate depth of 36 feet resulted in the generation of an abundance of dredged material. The dredged material was deposited in a continuous strip along the channel's southwestern limits. Dredged material deposition interrupted the local circulation patterns of natural waterways that transect areas along the length of the MRGO.

The sector gates on the GIWW and Bayou Bienvenue presently being constructed for the authorized improvements to the Hurricane and Storm Damage Risk Reduction System (HSDRRS) would alter flow patterns in and near the western end of the project area. Construction of this storm surge barrier structure includes dredging of an access channel to construct the floodwall. The access channel connects the MRGO with the GIWW across the Golden Triangle. The gates across Bayou Bienvenue and the GIWW would remain open, except when a storm is approaching.

Construction of the storm surge barrier structure would alter the flow path of tidal propagation into the Central Wetlands area through the Bayou Bienvenue control structure. Whereas, prior to the construction of this project, tidal flow in and out of the Bayou Bienvenue control structure came from multiple directions (i.e. from across the MRGO as well as from north and from south in the MRGO), with this barrier in place the tidal flow no longer comes from the south in the MRGO. Likewise the completed MRGO closure structure at the Bayou La Loutre Ridge has altered tidal flow paths to the Bayou Dupre control structure. The tidal connection with Breton Sound via the MRGO has been blocked. Modeling of the project area with the UNO Mass balance model has shown a slight reduction in salinity in the project area, but not sufficient to alleviate the need of a freshwater diversion to restore historic conditions.

The Lake Borgne storm surge barrier would prevent saltwater intrusion into the interior marshes to the west of the barrier in storm situations, while minimally impeding tidal flows under normal circumstances. This barrier would not influence salinity in marshes to the east of the barrier, nor would it influence salinity within the Central Wetlands area as the gates of the Bayou Dupre and Bayou Bienvenue control structures are closed during tropical events.

Modeling scenarios for the barrier structures indicate that the proposed flood protection levee could raise the water levels by 0.1 foot or less (see Hydrology and Hydraulics (H&H) Report, **appendix L**). However, the authors of this modeling study caveat their results as follows: "this change in average water volume represents a difference of less than 1 inch of water depth distributed across the region. This difference in volume may be smaller than the precision achievable with present computational resources."

3.7 WATER QUALITY

3.7.1 Historic and Existing Conditions

This resource is institutionally significant because of the NEPA of 1969; the Clean Water Act (CWA) of 1972; the Coastal Zone Management Act of 1972; and the Estuary Protection Act of 1968. Water quality is technically significant because it is an important factor in the physical, chemical, and biological processes throughout the entire estuarine system. This resource is publicly significant because the public demands clean water and healthy wildlife and fishery species for recreational and commercial use. The CWA established a process for each state to monitor and report on its surface and groundwater quality. The Environmental Protection Agency (EPA) compiles and summarizes the data from the state reports and transmits them to Congress along with an analysis of the status of nationwide water quality. Requirements for this process are found in Section 305(b) of the CWA. The National Water Quality Inventory 305(b) Report to Congress identifies widespread water quality problems of national significance and describes various programs to restore and protect water quality. The Section 305(b) Water Quality Report (2008) prepared by the Louisiana Department of Environmental Quality (LDEQ) summarizes the monitoring data that characterizes the quality of waters in the project area (**table 3-2**).

Table 3-2: 2008 Louisiana Water Quality – 303(d) List

Subsegment Number	Subsegment Description	PCR	SCR	F&WP	ONR	OYS	Suspected Cause of Impairment	Suspected Source of Impairment
LA041401	New Orleans East Levee Water Bodies	N	N	N	-	-	Fecal Coliform / Dissolved Oxygen	Municipal / Sanitary Sewer Overflows
LA041805	Lake Borgne Canal (also known as the Violet Canal)	F	F	N	N	-	Dissolved Oxygen / Turbidity	Natural Sources / other Permitted Small Flow Discharges
LA041806	Pirogue Bayou	F	F	N	F	-	Dissolved Oxygen	Natural Conditions
LA041807	Terre Beau Bayou	F	F	N	F	-	Dissolved Oxygen	Natural Conditions
LA041808	New Canal	F	F	N	-	-	Dissolved Oxygen	Natural Conditions
LA042102	River Aux Chenes	F	F	F	-	N	Fecal Coliform	Wildlife other than Waterfowl

SOURCE: Final Draft 2008 Louisiana Water Quality Integrated Report – Category 5 and 5RC "303(d) List"
NOTES:
F – Indicates that the water body fully supports the resource.
N – Indicates that the water body does not support the resource.

The LDEQ assesses four categories for water use under the Louisiana Environmental Regulatory Code (LAC Title 33, Chapter 11) that apply to those portions of the study area within Louisiana:

a. Primary Contact Recreation (PCR) includes activities such as swimming, water skiing, tubing, snorkeling, skin diving, and other activities that involve prolonged body contact with water and probable ingestion.
b. Secondary Contact Recreation (SCR) includes fishing, wading, recreational boating, and other activities that involve only incidental or accidental body contact and minimal probability of ingesting water.
c. Fish and Wildlife Propagation (F&WP) includes the use of water by indigenous fishes and invertebrates, reptiles, amphibians, and other aquatic biota consumed by humans for habitat, food, resting, reproduction, and cover.
d. Oyster Propagation (OYS) includes the use of water to maintain biological systems that support economically important species of oysters, clams, mussels, and other mollusks consumed by humans, so that their productivity is preserved and the health of human consumers of these species is protected.

According to guidance provided by the EPA, a water body may fall within one of three use support categories depending on the percent of measurements for any one physical or chemical parameter that exceeds the state's numerical water quality standards. These categories include Fully Supporting, Partially Supporting, and Not Supporting. In the case where more than one parameter defines a designated use, support for each designated use is defined by the poorest performing parameter. General water quality criteria against which ambient concentrations are evaluated to make use support decisions are promulgated in the Louisiana Administrative Code, Title 33, Part XI, Chapter 11. General criteria include numeric values for temperature, hydrogen ion (pH), dissolved oxygen (DO), turbidity, and total dissolved solids (TDS). The general criteria concentrations applicable in the study area are: temperature less than 95°F, pH range of 6.5 to 9 standard units, DO greater than 4 milligrams per liter (mg/l), turbidity less than 50 NTU, and total suspended solids less than 500 mg/l. A detailed breakdown of each category is given in **table 3-3**.

Table 3-3: Summary of Use Support Categories

		Support Classification for Measured Parameter		
Designated Use	**Measured Parameter**	**Fully Supporting**	**Partially Supporting**	**Not Supporting**
Primary Contact Recreation (PCR)	Fecal coliform	0-25% do not meet criteria	--	>25% do not meet criteria
Designated swimming months of May - October only.	Temperature	0-30% do not meet criteria	>30-75% do not meet criteria	>75% do not meet criteria
Secondary Contact Recreation (SCR) (All months)	Fecal coliform	0-25% do not meet criteria	--	>25 % do not meet criteria

Table 3-3: Summary of Use Support Categories

Designated Use	Measured Parameter	Support Classification for Measured Parameter		
		Fully Supporting	Partially Supporting	Not Supporting
Fish and Wildlife Propagation (F&WP)	Dissolved oxygen[3]	0-10% do not meet minimum of 3.0 ppm and median > criteria of 5.0 ppm	--	>10% do not meet minimum of 3.0 ppm or median < criteria of 5.0 ppm
	DO	0-10% do not meet criteria	>10-25% do not meet criteria	>25% do not meet criteria
	Temperature, pH, chloride, sulfate, TDS, turbidity	0-30% do not meet criteria	>30-75% do not meet criteria	>75% do not meet criteria
	Metals and Toxics	< 2 exceedances of chronic or acute criteria in most recent consecutive 3-year period, or 1-year period for newly tested waters	--	2 or more exceedances of chronic or acute criteria in most recent consecutive 3-year period, or 1-year period for newly tested waters
Drinking Water Source (DWS)	Color, fecal coliform	0-30% do not meet criteria	>30-75% do not meet criteria	>75% do not meet criteria
	Metals and Toxics	< 2 exceedances of drinking water criteria in most recent consecutive 3-year period, or 1-year period for newly tested waters		2 or more exceedances of drinking water criteria in the most recent consecutive 3-year period, or 1-year period for newly tested waters
Outstanding Natural Resource (ONR)	Turbidity	0-10% do not meet criteria	>10-25% do not meet criteria	>25% do not meet criteria
Agriculture (AGR)	None	--	--	--
Oyster Production (OYS)	Fecal coliform	Median fecal coliform < 14 MPN/100 ml; and < 10% of samples < 43 MPN/100 ml	--	Median fecal coliform > 14 MPN/100 ml; and > 10% of samples > 43 MPN/100 ml
Limited Aquatic and Wildlife (LAW)	DO	0-10% do not meet criteria	>10-25% do not meet criteria	>25% do not meet criteria

ppm = parts per million; TDS = Total Dissolved Solids; MPN = Most Probable Number, DO = Dissolved Oxygen
SOURCE: EPA, 2010

In the project area, F&WP and OYS were identified as being impaired in some areas. The EPA and LDEQ identified low DO levels and high fecal coliform levels as the suspected causes for impairment for both categories, but were not able to identify the sources of these problems (LDEQ, 2005). Coliform levels along the MRGO have usually exceeded the LDEQ criteria, indicating a widespread area of water and wetlands that are subject to bacterial pollution. The suspected source is runoff from nearby populated areas in St. Bernard and Orleans Parishes. Measured DO levels at Bayou Dupre have consistently been above the minimum state standard and EPA criteria. With rare exceptions, the pH measurements have been within the desirable range of 6.5 to 9.0. Toxic substances, including heavy metals and synthetic organics, have been measured above EPA criteria levels, but no patterns consistently exceeding the criteria for particular substances have been observed. The Louisiana Department of Health and Hospitals (LDHH), Office of Public Health, Molluscan Shellfish Program (LDHH, 2007) prohibited the harvesting of oysters for human consumption from leases in the project area south of the Lake Borgne shoreline through February 2008, at which time the prohibition was re-evaluated and lifted. A recent search of the LDHH Molluscan Shellfish Program website in April 2010 confirmed that no oyster harvesting areas within the project area were closed.

The Mississippi Department of Environmental Quality (MDEQ) assesses three categories for water use under Mississippi State Code of 1972 as amended (MSC Title 49, Chapter 17) that apply to those portions of the project area within Mississippi. Waters classified for Shellfish Propagation are for propagation and harvesting shellfish for sale or use as a food product. These waters must meet the requirements set forth in the latest edition of the *National Shellfish Sanitation Program, Manual of Operations, Part I, Sanitation of Shellfish Growing Areas*, as published by the U. S. Public Health Service. Waters that meet the criteria for Shellfish Propagation are also considered suitable for recreational purposes. Recreation includes activities such as swimming and water skiing that involve prolonged body contact with water. Fish and wildlife includes activities such as fishing and propagation of fish, aquatic biota, and wildlife. Waters that meet the Fish and Wildlife Criteria are also considered suitable for Secondary Contact Recreation (MDEQ, 2007).

All data on existing water quality described below in **sections 3.7.1.1** through **3.7.1.6** was taken from the *Preliminary Assessment of Potential Water Quality Impacts for a Proposed Freshwater Diversion in the Vicinity of Violet, Louisiana* (USACE, 2010).

3.7.1.1 Mississippi River Existing Water Quality

The general water quality statistics for the Mississippi River during 1990 to 2010 from aggregated samples taken by the U.S. Geological Survey (USGS) and LDEQ are presented in **table 3-4**. This information was taken from the *Preliminary Assessment of Potential Water Quality Impacts for a Proposed Diversion in the Vicinity of Violet, Louisiana* (USACE, 2010).

Table 3-4: Mississippi River Group General Summary Statistics from 1990-2010

General	Units	Mean	Number of Observations	Max	Median	Min
Dissolved Oxygen	mg/l	8.83	529	25.2	8.4	0.1
Water Temperature	F	65.1	549	90.8	64.7	32.2
Sulfate	mg/l	47	530	488	43.4	9.3
Total Dissolved Solids	mg/l	271	369	630	268	67

Table 3-4: Mississippi River Group General Summary Statistics from 1990-2010

General	Units	Mean	Number of Observations	Max	Median	Min
pH	SU	7.94	531	16.2	7.73	0.1
Specific Conductance, Field	µmhos/cm	401	515	839	394	0.1
Nitrate+Nitrite Nitrogen	mg/l	1.55	453	9.38	1.41	0.02
Total Organic Carbon	mg/l	5.5	399	28	4.9	2
Turbidity	NTU	50	478	252	42	1.6
Total Suspended Solids	mg/l	88	434	800	72.5	2

SOURCE: USACE, 2010.

DO concentrations are normally well above values cited as being desirable for maintenance of well-balanced fish populations. Measured DO at the Mississippi River sites averaged 8.8 mg/l. During this period, violations of the State DO standard of 5.0 mg/l were noted in only two percent of the 529 observations reported. The State of Louisiana has also published numerical standards for temperature (90°F) and ambient concentrations of chloride (CL - 75 mg/l), sulfate (SO_4 - 120 mg/l), pH (6.0-9.0), and TDS (400 mg/l). Data were not available for chloride at the stations and time period used for this water quality report. The average water temperature was 66°F with a maximum of 91°F.

Violations of state standards for SO_4, pH, and TDS occurred during the time period investigated. While the average sulfate concentration was 47 mg/l, values were reported up to 488 mg/l. Values exceeded the sulfate threshold in less than one percent of the samples collected in the Mississippi River. The pH data, taken from LDEQ and USGS sample locations, averaged 7.9 with a range from 0.10 to 16.2, although low and high values are likely erroneous (due to their extremely acidic and basic values). Within the dataset analyzed, pH exceeded the numerical standards set by the State of Louisiana. TDS averaged 271 mg/l compared to the 400 mg/l standard for this reach of the Mississippi River. TDS values were reported up to 630 mg/l. The Mississippi River exceeded the TDS threshold in two percent of the samples collected. Specific conductance averaged 400 µmhos/cm with a maximum value of 839 µmhos/cm; therefore, this reach of the Mississippi River is classified as a freshwater system. Freshwater streams ideally should have conductivity between 150 to 500 µmhos/cm to support diverse aquatic life.

The Mississippi River has a high concentration of nitrogen with the majority of inorganic nitrogen in the form of nitrate and nitrite (NO_x). This reach of the River had an average NO_x concentration of 1.55 mg/l. The average total organic carbon was 5.48 mg/l with a maximum of 28 mg/l.

The River is normally characterized by highly turbid waters due to the enormous suspended sediment load transported. Data from the USGS indicates that approximately 77 percent of the River's suspended sediment discharge is transported as silt and clay (particles smaller than 0.062 millimeter in diameter). Maximum concentrations generally occur in late winter or early spring and have an average composition of about 82 percent silt and clay, with about 18 percent sand in the upper 20 percent of the water column. The suspended sediment concentration in the reach investigated averaged 88 mg/l and turbidity averaged 50 NTU. The maximum turbidity level was 252 NTU. The Mississippi River exceeded the turbidity standard of 150 NTU in two percent of the samples analyzed.

The average fecal coliform concentration in the Mississippi River was 297 cfu/100ml. This average value is greater than the value of 200 cfu/100ml for the primary contact recreation standard, which is exceeded in 18 percent of the samples. The comparison of the observed bacteria densities in the Mississippi River to the state shellfish harvesting standards, fecal coliform median most probable number (MPN) shall not exceed 14 fecal coliform cfu/100 ml, and not more than 10 percent of the samples shall exceed a MPN of 43 cfu/100 ml. The fecal coliform concentrations exceed 43 cfu/100ml in 83 percent of the samples for the Mississippi River.

Agricultural and industrial chemicals, such as pesticides and volatile and semi-volatile organic compounds (VOCs), are discharged to surface waters from several sources and make their way into the Mississippi River. Several pesticides in the Mississippi River exceed Louisiana freshwater chronic and acute criteria. Chemicals such as organochlorine insecticides: DDT, DDE, chlordane, dieldrin, endrin heptachlor, and toxaphene are detected frequently.

Data for unfiltered concentrations of trace metals and trace inorganics indicate that high trace metal concentrations are associated with suspended particulates in the River. The trace metals lead, mercury, copper and chromium have been detected at average concentrations of 2.66, 0.12, 6.62 and 3.27 µg/l respectively. Such high concentrations are indicative of the impact of industrial and urban stormwater discharges to the River. The trace metals lead, mercury, copper, and chromium consistently exceed the freshwater chronic criteria. Data also indicates potential problems associated with recurrent high concentrations of copper and chromium, which exceed the acute criteria.

3.7.1.2 Central Wetlands Area Existing Water Quality

The general water quality statistics for the Central Wetlands area over the time period of 1990 to 2010 from aggregated samples (USACE, 2010) are presented in **table 3-5**. The Central Wetlands area, shown on **figure 3-31** in **section 3.24.2.1**, is a large tract of tidal marsh habitat located within the hurricane levee protection system between the MRGO and communities along the Mississippi River in St. Bernard Parish. DO concentrations fluctuate widely, with values ranging from 1.01 mg/l to 12.73 mg/l. Measured DO in the Central Wetlands area averaged 6.1 mg/l during the period of 1990 to 2010, and violations of the State DO standard of 4.0 mg/l were noted in 24 percent of the 240 observations reported. The State of Louisiana has not published numerical standards for CL, SO_4 and TDS. A pH range of 6.5 to 9.0 and temperature criteria of 95°F have been established by the State of Louisiana for this water segment (**table 3-5**). Data were not available for chloride at the stations and time period of this investigation. The average water temperature was 72°F with a maximum of 90°F. The average sulfate concentration was 836 mg/l, and values were reported up to 2,756 mg/l. The pH averaged 7.3 with a range from 6.28 to 8.24. TDS averaged 9,822 mg/l with a maximum value of 22,460 mg/l. The specific conductance averaged 15,786 µmhos/cm with a range of 227 µmhos/cm to 30,900 µmhos/cm. Therefore, the Central Wetlands area fluctuates between freshwater and brackish to marine salinity.

Table 3-5: Central Wetlands Area Group General Summary Statistics from 1990-2010

General	Units	Mean	Number of Observations	Max	Median	Min
Dissolved Oxygen	mg/l	6.11	240	12.7	5.8	1.01
Water Temperature	F	71.6	248	89.9	74.3	44.1
Sulfate	mg/l	836	248	2,756	789	38.6
Total Dissolved Solids	mg/l	9,822	248	22,460	9,730	72.0
pH	SU	7.34	248	8.2	7	6.28
Specific Conductance, Field	µmhos/cm	15,786	240	30,900	15,600	227
Nitrate+Nitrite Nitrogen	mg/l	0.16	193	1.7	0.08	0.01
Total Organic Carbon	mg/l	9.99	144	28.9	8.5	2.0
Turbidity	NTU	13.29	248	140	11.0	1.0
Total Suspended Solids	mg/l	23.93	248	260	18.8	4.0

SOURCE: USACE, 2010.

The average NO_x concentration in the Central Wetlands area was 0.157 mg/l with values ranging from 0.01 mg/l to 1.72 mg/l. The average total organic carbon was 9.97 mg/l with a maximum of 28.9 mg/l. The suspended sediment concentration averaged 24 mg/l, and the turbidity averaged 13 NTU during the period 1990 through 2010. The maximum turbidity level was 140 NTU. The maximum turbidity level established by the State of Louisiana for estuarine lakes, bays, bayous, and canals is 50 NTU. The Central Wetlands area exceeded this criterion in two percent of the 248 samples collected.

The sanitary quality of the waters in the Central Wetlands area, as characterized by observed fecal coliform bacteria densities, was 92 cfu/100ml, and the primary contact and oyster propagation standards were exceeded (five percent and 44 percent respectively). Several pesticides have been detected in the Central Wetlands area. It is important to note that the Central Wetlands area is not designated for drinking water or oyster propagation. Additionally, vinyl chloride was found to exceed the drinking water supply in 100 percent of the samples. No pesticide concentrations exceeded the acute or chronic aquatic life criteria for freshwater, marine, or brackish water in the Central Wetlands area. However, 1,2-dichloroethane was found to exceed the human health standards for drinking water supply in three percent of the samples. Several trace metals have been detected in the Central Wetlands area. Mercury and lead exceeded the chronic freshwater aquatic life criteria (100 percent and one percent respectively). Additionally, mercury exceeded the marine and brackish chronic criteria.

3.7.1.3 Mississippi River Gulf Outlet (MRGO) Existing Water Quality

The general water quality statistics for the MRGO, over the time period of 1990 to 2010, from aggregated samples (USACE, 2010) are presented in **table 3-6**. DO concentrations are relatively stable with values ranging from 4.48 mg/l to 10.4 mg/l. During this period, violations of the State DO standard of 5.0 mg/l were noted in 9 percent of the 23 observations reported. The State of Louisiana has not published numerical standards for CL, SO_4, pH, and TDS. A pH range of 6.5 to 9.0 and temperature criteria of 95°F have been established by the State of Louisiana for this water segment. Data were not available for chloride at the stations and time period of this investigation. The average water temperature was 73°F with a maximum of 90°F. The average sulfate concentration was 1,709 mg/l, and values were reported up to 8,912 mg/l. The pH averaged 7.72 with a range from 7.33 to 8.36. TDS averaged 15,823 mg/l with a maximum value of 23,340 mg/l. The specific conductance averaged 23,970 µmhos/cm with a range of 16,680 µmhos/cm to 34,350 µmhos/cm; therefore, the MRGO fluctuates from brackish to marine salinity.

Table 3-6: MRGO Group General Summary Statistics from 1990-2010

General	Units	Mean	Number of Observations	Max	Median	Min
Dissolved Oxygen	mg/l	7.34	23	10.40	6.91	4.48
Water Temperature	F	73.5	23	89.7	72.9	40.9
Sulfate	mg/l	1,709	23	8,912	1,251	826
Total Dissolved Solids	mg/l	15,823	23	23,340	15,440	11,120
pH	SU	7.72	23	8.36	7.68	7.33
Specific Conductance, Field	µmhos/cm	23,970	23	34,350	23,410	16,680
Nitrate+Nitrite Nitrogen	mg/l	0.08	12	0.27	0.06	0.02
Total Organic Carbon	mg/l	6.96	16	10.40	6.80	5.20
Turbidity	NTU	9.50	23	19.00	8.20	2.60
Total Suspended Solids	mg/l	19.23	23	40.50	19.30	4.00

SOURCE: USACE, 2010.

The average NO_x concentration in the MRGO was 0.078 mg/l with values ranging from 0.02 mg/l to 0.27 mg/l. The average total organic carbon was 6.96 mg/l with a maximum of 10.4 mg/l. The suspended sediment concentration averaged 19 mg/l, and the turbidity averaged 9.5 NTU during the period 1990 through 2010. The maximum turbidity level was 19 NTU. The maximum turbidity level established by the State of Louisiana for estuarine lakes, bays, bayous, and canals is 50 NTU. The MRGO did not exceed this criterion in any of the 23 samples collected.

The sanitary quality of the waters in the MRGO, as characterized by observed fecal coliform bacteria densities, was 17 cfu/100ml, and the oyster propagation standard was exceeded in eight percent of samples. Several pesticides have been detected in the MRGO. No pesticide concentrations exceeded the acute or chronic aquatic life criteria for freshwater, marine, or brackish water in the MRGO. Several trace metals have been detected in the MRGO; however, only mercury exceeded the chronic freshwater, marine, and brackish aquatic life criteria.

3.7.1.4 Lake Borgne Wetlands Area Existing Water Quality

The general water quality statistics for the Lake Borgne Wetlands Area (LBWA), over the time period of 1990 to 2010, from aggregated samples (USACE, 2010) are presented in **table 3-7**. DO concentrations were relatively constant with values ranging from 4.17 mg/l to 11.33 mg/l. Measured DO in the LBWA averaged 7.5 mg/l during the period of 1990 - 2010. During this period, violations of the State DO standard of 4.0 mg/l were not noted in the 108 observations reported. The State of Louisiana has not published numerical standards for CL, SO_4, and TDS. A pH range of 6.5 to 9.0 and temperature criteria of 95°F has been established by the State of Louisiana for this water segment. Data were not available for chloride at the stations and time period of this investigation. The average water temperature was 72°F with a maximum of 90°F. The average sulfate concentration was 807 mg/l, and values were reported up to 1,691 mg/l. The pH averaged 7.5 with a range from 6.39 to 8.04. TDS averaged 10,318 mg/l with a maximum value of 18,880 mg/l. The specific conductance averaged 15,984 µmhos/cm with a range of 21.5 to 28,600 µmhos/cm; therefore the LBWA fluctuates from freshwater to marine salinity.

The average NO_x concentration in the LBWA was 0.10 mg/l with values ranging from 0.05 mg/l to 0.55 mg/l. The average total organic carbon was 7.5 mg/l with a maximum of 20.6 mg/l. The suspended sediment concentration averaged 20 mg/l, and the turbidity averaged 11 NTU during the period 1990 through 2010. The maximum turbidity level was 36.5 NTU. The maximum turbidity level established by the State of Louisiana for estuarine lakes, bays, bayous, and canals is 50 NTU. The LBWA did not exceed this criterion in any of the 248 samples collected.

Table 3-7: LBWA Group General Summary Statistics from 1990-2010

General	Units	Mean	Number of Observations	Max	Median	Min
Dissolved Oxygen	mg/l	7.55	108	11.33	7.22	4.17
Water Temperature	F	71.1	108	89.5	73.3	46.2
Sulfate	mg/l	806.94	108	1,691	768.50	375
Total Dissolved Solids	mg/l	10,319	107	18,880	9,840	4,724
pH	SU	7.52	108	8.04	7.53	6.39
Specific Conductance, Field	µmhos/cm	15,985	107	28,600	15,270	21.5
Nitrate+Nitrite Nitrogen	mg/l	0.10	47	0.55	0.08	0.05
Total Organic Carbon	mg/l	7.54	51	20.6	7.0	2.0
Turbidity	NTU	10.82	108	36.5	9.0	3.2
Total Suspended Solids	mg/l	19.97	108	81.0	16.0	4.0

SOURCE: USACE, 2010.

The sanitary quality of the waters in the LBWA, as characterized by observed fecal coliform bacteria densities, was 36 cfu/100ml with oyster propagation standard exceeded in 21 percent of the 102 samples collected. Several pesticides have been detected in the LBWA. No pesticide concentrations exceeded the acute or chronic aquatic life criteria for freshwater, marine, or brackish water in the LBWA. However, 1,2-dichloroethane and carbon tetrachloride were both found to exceed the human health standards for drinking water supply in 10 percent of the samples. Several trace metals have been detected in the LBWA; however, no trace metals exceeded the numerical criteria established by the State.

3.7.1.5 Lake Borgne Existing Water Quality

The general water quality statistics for Lake Borgne, over the time period of 1990 to 2010, from aggregated samples (USACE, 2010) are presented in **table 3-8**. DO concentrations were relatively constant with values ranging from 5.67 mg/l to 10.71 mg/l, which is expected as the flushing time averages 17 days. Measured DO in Lake Borgne averaged 7.8 mg/l during the period of 1990- 2010. During this period, violations of the State DO standard of 5.0 mg/l were not observed in the 23 observations reported. The State of Louisiana has not published numerical standards for CL, SO_4, and TDS. A pH range of 6.5 to 9.0 and temperature criteria of 95°F have been established by the State of Louisiana for this water segment. Data were not available for chloride at the stations and time period of this investigation. The average water temperature was 72°F with a maximum of 87°F. The average sulfate concentration was 626 mg/l, and values were reported up to 2,033 mg/l. The pH averaged 7.4 with a range from 6.91 to 7.83. TDS averaged 7,391 mg/l with a maximum value of 15,700 mg/l. The specific conductance averaged 11,830 µmhos/cm with a range of 1,256 µmhos/cm to 26,100 µmhos/cm; therefore, Lake Borgne fluctuates from brackish to marine water conditions.

Table 3-8: Lake Borgne Group General Summary Statistics from 1990-2010

General	Units	Mean	Number of Observations	Max	Median	Min
Dissolved Oxygen	mg/l	7.84	23	10.71	7.61	5.67
Water Temperature	F	71.6	23	87.4	74.2	46.6
Sulfate	mg/l	626	24	2,033	497	1.30
Total Dissolved Solids	mg/l	7,391	24	15,700	6,279	2,068
pH	SU	7.36	23	7.83	7.38	6.91
Specific Conductance, Field	µmhos/cm	11,830	23	26,100	9,520	1,256
Nitrate+Nitrite Nitrogen	mg/l	0.08	14	0.14	0.08	0.05
Total Organic Carbon	mg/l	7.19	17	9.4	7.1	5.3
Turbidity	NTU	11.76	24	50	8.8	2.8
Total Suspended Solids	mg/l	18.06	23	72	14.0	4.5

SOURCE: USACE, 2010.

The average NO_x concentration in Lake Borgne was 0.084 mg/l with values ranging from 0.05 mg/l to 0.14 mg/l. The average total organic carbon was 7.2 mg/l with a maximum of 9.4 mg/l. The suspended sediment concentration averaged 18 mg/l, and the turbidity averaged 12 NTU during the period 1990 through 2010. The maximum turbidity level was 50 NTU. The maximum turbidity level established by the State of Louisiana for estuarine lakes, bays, bayous, and canals is 50 NTU. Lake Borgne did not exceed this criterion in any of the 24 samples collected.

The sanitary quality of the waters in Lake Borgne, as characterized by observed fecal coliform bacteria densities, was 18 cfu/100ml, and the oyster propagation standard was exceeded in nine percent of the 23 samples collected. Several pesticides have been detected in Lake Borgne; however, no pesticide concentrations exceeded the acute or chronic aquatic life criteria for freshwater, marine, or brackish water in Lake Borgne. Vinyl chloride was found to exceed the drinking water supply in 100 percent of the samples. Several trace metals have been detected in Lake Borgne; however, no trace metals exceeded the numerical acute or chronic aquatic life criteria established for freshwater, marine, or brackish water.

3.7.1.6 Biloxi Marsh Existing Water Quality

The general water quality statistics for Biloxi Marsh, over the time period of 1990 to 2010, from aggregated samples (USACE, 2010) are presented in **table 3-9**. DO concentrations were relatively constant with values ranging from 4.35 mg/l to 11.33 mg/l. Measured DO in the Biloxi Marsh averaged 7.3 mg/l during the period of 1990 to 2010. During this period, violations of the State DO standard of 4.0 mg/l were not observed in the 138 observations reported. The State of Louisiana has not published numerical standards for CL, SO_4, and TDS. A pH range of 6.5 to 9.0 and temperature criteria of 95°F has been established by the State of Louisiana for this water segment. Data were not available for chloride at the stations and time period of this investigation. The average water temperature was 73°F with a maximum of 90°F. The average sulfate concentration was 1,569 mg/l, and values were reported up to 3,837 mg/l. The pH averaged 7.7 with a range from 6.25 to 8.58. TDS averaged 18,130 mg/l with a maximum value of 36,860 mg/l. The specific conductance averaged 27,210 µmhos/cm with a range of 21 µmhos/cm to 43,500 µmhos/cm; therefore, the Biloxi Marsh fluctuates from a brackish to marine water body.

Table 3-9: Biloxi Marsh Group General Summary Statistics from 1990-2010

General	Units	Mean	Number of Observations	Max	Median	Min
Dissolved Oxygen	mg/l	7.26	138	11.33	6.81	4.35
Water Temperature	F	73.0	138	89.3	76.4	37.6
Sulfate	mg/l	1,569	138	3,837	1,455	186.00
Total Dissolved Solids	mg/l	18,130	138	36,860	18,220	7,700
pH	SU	7.77	138	8.58	7.80	6.25
Specific Conductance, Field	µmhos/cm	27,210	138	43,500	27,240	21.30
Nitrate+Nitrite Nitrogen	mg/l	0.11	72	0.80	0.05	0.03
Total Organic Carbon	mg/l	6.57	76	10.30	6.45	0.52
Turbidity	NTU	14.82	138	60.00	12.00	1.50
Total Suspended Solids	mg/l	29.91	137	133.00	22.50	0.30

SOURCE: USACE, 2010.

The average NO_x concentration in the Biloxi Marsh was 0.106 mg/l with values ranging from 0.03 mg/l to 0.8 mg/l. The average total organic carbon was 6.6 mg/l with a maximum of 10.3 mg/l. The suspended sediment concentration averaged 30 mg/l, and the turbidity averaged 15 NTU during the period 1990 through 2010. The maximum turbidity level was 60 NTU. The maximum turbidity levels established by the State of Louisiana for estuarine lakes, bays, bayous, and canals are 50 NTU. The Biloxi Marsh exceeded this criterion in three percent of the 138 samples collected.

The sanitary quality of the waters in the Biloxi Marsh, as characterized by observed fecal coliform bacteria densities, was 11 cfu/100ml, and the oyster propagation standard was exceeded in four percent of the 144 samples collected. Several pesticides have been detected in the Biloxi Marsh; however, no pesticide concentrations exceeded the acute or chronic aquatic life criteria for freshwater, marine, or brackish water in the Biloxi Marsh. Vinyl chloride was found to exceed the drinking water supply in 100 percent of the samples. Several trace metals have been detected in the Biloxi Marsh; however, only mercury exceeded the chronic freshwater, marine, and brackish aquatic life criteria.

3.7.1.7 Mississippi Territorial Waters Existing Water Quality

A survey was taken in 2005, *Water Quality Study of Bays in Coastal Mississippi* (EPA, 2005), to provide water quality information for each of the major bay systems feeding Mississippi Sound. Water quality sampling, in-situ monitoring, and sediment sampling were conducted at selected stations within each bay or riverine system to provide an estimate of pollutant concentrations. The sampling area (see **figure 3-6**) encompassed four major bay systems on the Mississippi Coast including Bayou Casotte (including Bangs Lake), the Pascagoula/West Pascagoula River systems, the Back Bay of Biloxi, and St. Louis Bay (including Bayou Caddy, and the Pearl River). **Table 3-10** shows the water quality indicators taken from several sample points in the Mississippi coastal area.

Table 3-10: Mississippi Coastal Area Water Quality Indicators

System	Station	Dissolved Oxygen (mg/l)	Salinity (ppt)	pH	Total Nitrogen (mg/l)	Total Phosphorus (mg/l)
Bangs Lake	BL1	6.38	23.54	7.47	0.81	0.18
Bayou Casotte	BC1	4.61	29.2	7.86	0.31	0.21
Bayou Casotte	BC2	4.54	29.1	7.78	0.266	0.54
Bayou Casotte	BC3	4.32	29.4	7.77	0.315	0.38
Bayou Casotte	BC4	11.46	25	7.81	1.955	17
W. Pascagoula River	WPR1	5.35	4.07	7.48	0.44	0.05
W. Pascagoula River	WPR2	4.48	10.43	6.47	0.54	0.036
Pascagoula River	PR1	4.94	28.53	7.8	0.346	0.087
Pascagoula River	PR2	4.1	2.86	7.02	0.532	0.052
Escatawpa River	ER1	4.12	24.1	7.69	0.5	0.063
Escatawpa River	ER2	2.54	7.2	6.66	0.589	0.041
Back Bay of Biloxi	BBB1	6.33	15.07	7.88	0.73	0.04
Back Bay of Biloxi	BBB2	6.25	12.76	7.49	0.77	0.041
Back Bay of Biloxi	BBB3	6.24	8.66	7.33	1.25	0.046
Back Bay of Biloxi	BBB4	6.03	4.32	7.03	0.87	0.049
Back Bay of Biloxi	BBB5	5.46	5.01	6.94	1.041	0.033
Back Bay of Biloxi	BBB6	3.32	3.2	6.9	1.51	0.14
St. Louis Bay	SLB1	7.09	15.24	7.8	0.6	0.03
St. Louis Bay	SLB2	8.03	13.82	7.87	0.73	0.036
St. Louis Bay	SLB3	7.59	14.34	7.8	0.76	0.54
St. Louis Bay	SLB4	7.21	12.55	7.67	0.72	0.031
St. Louis Bay	SLB5	7.73	12.02	7.84	0.7	0.026
St. Louis Bay	SLB6	5.91	11.57	7.63	0.81	0.026
St. Louis Bay	SLB7	7.34	10.55	7.78	0.77	0.025
Wolf River	WR1	7.49	14.27	7.35	0.77	0.061
Jordan River	JR1	6.74	6.5	6.88	1.04	0.032
Bayou La Croix	BLC1	4.04	7.41	7.11	0.76	0.029
Bayou Caddy	BCD1	6.16	9.15	7.49	1.04	0.093
Pearl River	Pearl1	3.9	2.22	6.91	0.78	0.062

SOURCE: EPA, 2005.

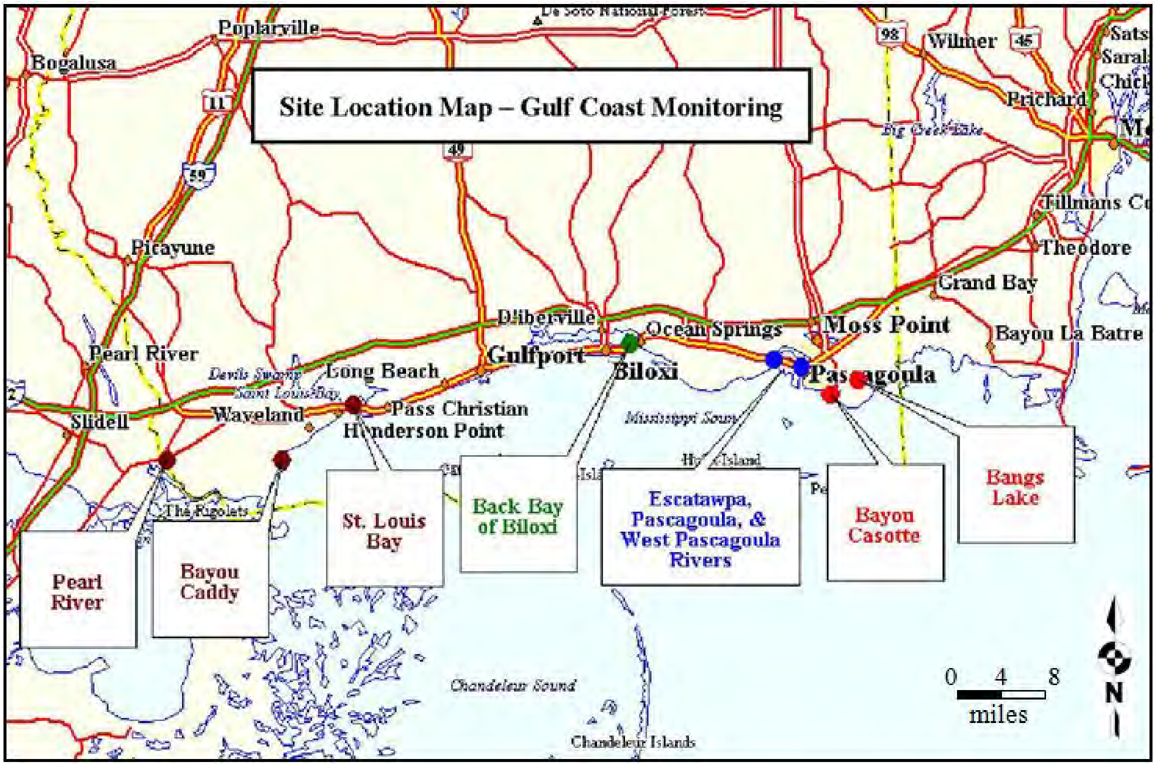


Figure 3-6: Site Location Map – Gulf Coast Water Quality Monitoring

Results of the survey of coastal Mississippi showed few detectable priority pollutant compounds in the surveyed bays and rivers. In general, the compounds present in surface waters were low in concentrations compared to EPA National Ambient Water Quality Criteria for priority toxic pollutants. In addition to this report done by the EPA, the State of Mississippi conducts its own water quality assessment for all surface waters in the state. Data for the pertinent rivers that drain into the Mississippi Sound was taken from the State of *Mississippi Water Quality Assessment 2008 Section 305(b) Report* (MDEQ, 2008). The area of interest summarized below covers the southern edge of Mississippi's contiguous land mass, which borders the Mississippi Sound, and the coastline along the Mississippi Sound, totaling approximately 84 linear miles. The total area of estuarine waters is approximately 758 square miles. This area includes the St. Louis Bay, Back Bay of Biloxi, Pascagoula Bay, and Mississippi Sound. As noted earlier, the MDEQ assesses three categories for water use under Mississippi State Code of 1972, as amended.

These three categories include Shellfish Propagation, Recreational Use, including Primary and Secondary Contact Recreation, and Fish and Wildlife Usage. **Table 3-11** lists the water bodies that influence water quality in the Mississippi Sound, their uses, and assessment status.

Table 3-11: 2008 Mississippi Water Quality Assessment – 303(d) List

Water Body Name	Use	Assessment Status
Bayou Casotte	Aquatic Life Support	Not Attaining
Biloxi River	Aquatic Life Support	Attaining
Bay St. Louis Beach	Primary Contact Recreation	Not Attaining
Biloxi Beach	Primary Contact Recreation	Attaining
Gulfport Beach	Primary Contact Recreation	Not Attaining
Wolf River	Aquatic Life Support	Attaining
East Pascagoula River	Fish Consumption	Not Attaining
Escatawpa River	Secondary Contact Recreation Fish Consumption	Attaining Not Attaining
West Pascagoula River	Fish Consumption	Not Attaining
Pearl River	Primary Contact Recreation Fish Consumption	Attaining Attaining

SOURCE: MDEQ, 2008.

3.7.2 Altered Hydrology

The MRGO extends approximately 70 miles from Breton Sound to eastern New Orleans, and traverses wetlands and marshes in Plaquemines, St. Bernard, and eastern Orleans Parishes. A hydrologic study across areas of the current channel was conducted from 1959 to 1961 to evaluate the major hydrologic parameters, including circulation and salinity, prior to opening the MRGO to marine traffic in 1963 (Rounsefell, 1964). These data indicated that the Bayou La Loutre Ridge provided a basin boundary that limited the flow of saline water from the Breton Sound area into Lake Borgne. An analysis of typical tidal flow across the region indicates that since construction of the MRGO, circulation patterns have been altered along its length in areas between Breton Sound and Lake Borgne (Wicker et al., 1982).

Prior to construction of the MRGO, typical tidal flow from the Breton Sound area was reduced as it moved across the marshes and wetlands inward toward Lake Borgne (USACE, 2004). Concurrent tidal flow into and across Lake Borgne toward Shell Beach did not encounter similar forces of resistance and arrived at Shell Beach with more energy relative to the inward tidal flow originating from the Breton Sound area (Rounsefell, 1964). The present circulation and tidal flow patterns across this area are typically inward from Breton Sound and appear to closely resemble a reversal of the earlier circulation patterns that characterized this area prior to construction of the MRGO.

There are a number of factors resulting from construction of the MRGO that have contributed to the alteration of circulation patterns and water quality along the length of the MRGO and outward into the surrounding wetlands and marshes. The MRGO provides a more direct flow of more saline, higher density water inland toward areas of Plaquemines, St. Bernard, and eastern Orleans Parishes (Wicker et al., 1981). At high tide, the MRGO provides a direct passage for tidal exchange and allows any freshwater surpluses to exit regularly at low tide and be replaced by the inflow of more saline water. The reduced integrity of the Bayou La Loutre Ridge, as a basin boundary, since construction of the MRGO has significantly altered circulation patterns in areas along the lower southeastern length of the channel and across areas between Breton Sound and Lake Borgne.

Dredging performed for construction of the MRGO to an approximate depth of 36 feet resulted in the generation of an abundance of dredge material. In most areas, the dredge material was deposited in a continuous strip along the channel's southwestern limits. Dredge material deposition interrupted the local circulation patterns of natural waterways that transect areas along the length of the MRGO. This disruption of water flow caused wetlands on the southwestern side of the dredge material to become semi-impounded (Wicker et al., 1982).

The de-authorization of the MRGO from the Gulf of Mexico to Mile 60 at the southern bank of the GIWW and construction of the authorized MRGO closure structure at Bayou La Loutre; a flood control sector gate and bypass barge gate on the GIWW; a new navigable flood control sector gate at Bayou Bienvenue; and a braced concrete wall across the MRGO located southeast of the existing Bayou Bienvenue flood control structure and across the marsh (Golden Triangle area) between these waterways have already begun and will continue to affect the salinity levels within the project area. Since the closure of the MRGO at Bayou La Loutre, there have been noticeable decreases in salinity levels recorded in the MRGO, Lake Borgne, Central Wetlands area, and even into Lake Pontchartrain. While the decrease in salinity has changed water quality, it could also result in the long-term effect of changing some of the marsh habitat types in the Central Wetlands and Lake Borgne. Along with the decrease in salinity, a sharp increase in hypoxic and anoxic conditions in the MRGO has also been noted since the construction of the closure at Bayou La Loutre. It is believed that these hypoxic and anoxic conditions are the result of decreased water movement and turnover since the closure was constructed. Hypoxic conditions or hypoxia is a phenomenon that occurs in aquatic environments as DO becomes reduced in concentration to a point detrimental to aquatic organisms living in the system. When the DO concentration is in the range between one percent and 30 percent, the water body is classified as hypoxic. An aquatic system lacking DO (zero percent saturation) is termed anoxic.

3.7.2.1 MRGO Salinity

Over the past 6,000 to 7,000 years, salinity in the project area has shifted with the major deltaic meandering of the Mississippi River. Modern efforts to control flooding and improve navigation include numerous bank stabilization, channel alignment, dredging, lock, dam, levee, and spillway projects on the Mississippi River. Such alterations to the Mississippi River and surrounding wetlands have increased salinity in the project area by altering the flow of freshwater in the region (LCA, 2004).

The influence of the MRGO on traversed areas and outward into surrounding wetlands, marshes, and waterways was determined by the USACE by comparing the findings of investigations conducted prior to channel construction with data collected from these same areas following completion of construction activities (USACE, 1999). Alteration of salinity in waters along the channel and outward in adjacent areas was first observed in studies conducted immediately following channel construction (USACE, 1962). Observations indicated that the influx of more saline water into these areas following MRGO construction provided a salinity increase that has fluctuated over time. The magnitude of this increase in salinity across the subjected areas are typically a function of numerous hydrological and ecological factors that include the intensity of saline water influx, variation in circulation patterns, and the sensitivity of the habitat within the impacted area.

Mean annual salinity data collected from stations that have been influenced by the influx of more saline waters since construction of the MRGO is presented in **table 3-12**.

Table 3-12: Mean Salinity Data from Stations Affected by MRGO

Yearly Average Salinity (ppt) and Ranges								
	Lake Borgne		Lena's Lagoon		Stump Lagoon		Lake Eloi	
Year	Avg	Range	Avg	Range	Avg	Range	Avg	Range
1960-61	5	3-8	7.5	3.5-15	---	---	18	7-31
1961-62	4	1-9	8	1-17.5	9	3-22	11.5	2-17.5
1962-63	10.5	7-14	16	11-26	20	17-24	24.5	18-31
1963-64	4	1-8.5	12	9-16	15	10.5-18	21.5	15-31
1964-65	7	3-10	12	7-16	13	6-18.5	14	8-23
1965-66	10	6-18	14	8-20	16	6.5-20	15	8-21
1966-67	10	5-13	13.5	4.5-19	14.5	11-19.5	16	10-24
1967-68	10	7.5-13.5	14	8.5-19	14	10-18	16	10-21
2001	5.2	2.6-9.5	---	---	---	---	16.6	12-21.5

SOURCES: Fontenot and Rogillio, 1970; LDEQ, 2001.

The locations of Lake Eloi, Stump Lagoon, Lena Lagoon, and Lake Borgne are shown on **figure 3-7**. Mean annual salinity data for the period from 1960 to 1968 are based upon discrete sampling at three week intervals and demonstrates an observed net increase in salinity following channel construction (Fontenot and Rogillio, 1970). Variations in salinity increases appears to be dependent upon the initial salinity of the area prior to construction activities and highly influenced by the influx migration distance within the channel and outward beyond the channel limits into various energy absorbing habitats.

Lake Eloi located along the southeastern region of the channel has shown minimal fluctuations in salinity over time due to its proximate location to the more saline source waters of inland tidal flow and the maintenance of circulation patterns. The observed salinity variations at Stump Lagoon and Lena Lagoon display the direct influence from the influx of more saline waters across these areas. Fluctuations in the salinity of Lake Borgne appear to be influenced by rainfall and tidal flow from the southeast and less influenced by the MRGO and altered water circulation patterns.

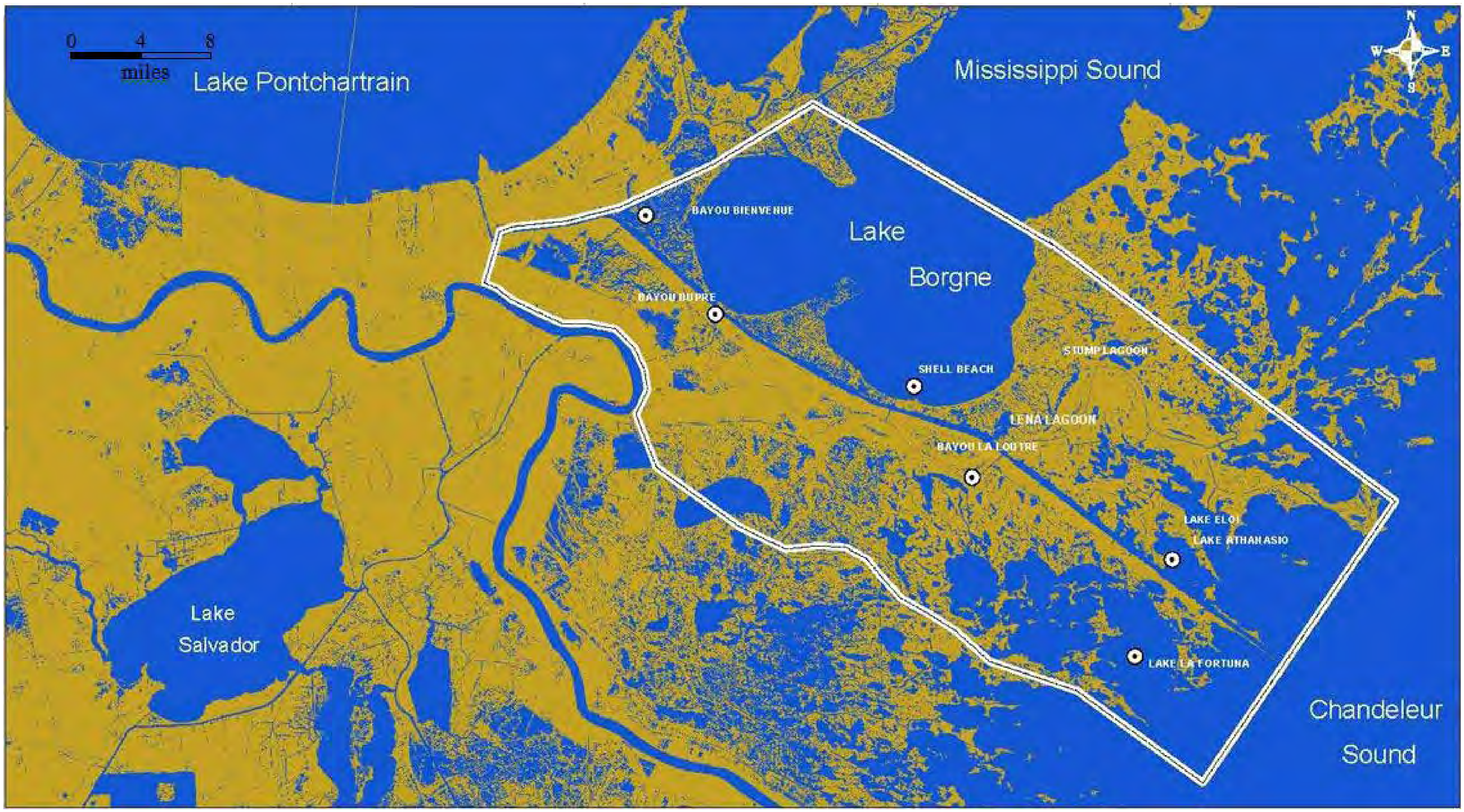


Figure 3-7: Primary Area Station Locations

The direct and indirect habitat impacts of the construction and operation of the MRGO between 1956 and 1990 were estimated in *Habitat Impacts of the Construction of the MRGO* (USACE, 1999) (**appendix V**). MRGO channel construction, the dredging of the channel and placement of dredged material, resulted in the conversion of 19,400 acres of wetlands and 4,750 acres of shallow open water to deep open water or dredge material banks.

Further data, demonstrating the influence of construction of the MRGO on the salinity regime at monitoring stations located throughout the length of the channel, are presented in **table 3-13**. A comparison of data prior to channel construction and following completion of construction demonstrates the steep increase in salinity, which has resulted from the influx of more saline waters inland along the deepened channel passageway. Salinity data from LDEQ monitoring stations, where available, indicates that the influence of the channel in these areas continues to occur. The inland reduction of salinity in areas along the channel appears to be primarily determined by the distance of influx from the more saline source waters. The IHNC receives input from the MRGO via the GIWW and flows into Lake Pontchartrain. Monthly salinity data in 2001 for the IHNC had a mean value of 6.5 parts per thousand (ppt) (LDEQ, 2001) and appeared similar to surface salinity in areas of Lake Pontchartrain near the entrance of the IHNC (Schurtz and St. Pe', 1984).

Table 3-13: MRGO Influence on Salinity Regime

Yearly Average Salinity (ppt) Pre and Post MRGO			
	Pre-MRGO	Post-MRGO	
Station	1959-1961	1962-1964	2001
Bayou Bienvenue	1.62	10	8
Bayou Dupre	2.39	7.8	9.3
Shell Beach	3.5	11.8	---
Hopedale	4.5	13	---
Bayou La Loutre	5.5	13.5	14.1
Lake Athansio	14.2	21.5	---
Lake Fortuna	16.8	21.5	---

SOURCES: Amstutz 1964; LDEQ 2001; Kerlin, 1979

In January 2009, construction began on a rock closure structure that was placed across the MRGO just to the south of the intersection of the MRGO and Bayou La Loutre. Since the closure's completion in July 2009, there have been significant changes in the salinity in the MRGO as well as adjoining water bodies in the project area. Salinity levels in the MRGO have decreased substantially, with lower salinity numbers also observed in the GIWW, Lake Borgne, and Lake Pontchartrain, as well as adjoining marsh habitat including the Central Wetlands area. **Table 3-14** displays the yearly average salinity for certain areas of the project area before and after the construction of the closure based on model results from August of 2009.

Table 3-14: MRGO Closure Influence on Salinity Regime

Yearly Average Salinity (ppt) Pre and Post MRGO Closure			
Box Location	**Pre-Closure**	**Post-Closure**	**% Change**
MRGO at Bayou La Loutre	17.01	8.87	48%
Lake Borgne	8.16	5.62	32%
Central Wetlands	14.67	5.26	64%
GIWW	14.72	5.07	66%
Lake Pontchartrain	6.12	4.01	35%

SOURCE: MRGO Closure Report, USACE, 2009.

Along with substantial changes in salinity, a hypoxic zone has also developed as a result of the closure structure. On the downstream side, a hypoxic zone has developed from the closure in the bottom-most 35 plus feet of water, probably in response to lack of water movement, with uniform salinity through the water column except near the surface. The hypoxic zone on the upstream side of the closure is generally near the bottom of the channel, and the oxygen content increases toward the surface.

3.7.2.2 Lake Pontchartrain Salinity

The Lake Pontchartrain estuary is located north of New Orleans and has an approximate mean salinity of four ppt and a surface area of 629 square miles (Abadie and Poirrier, 2000). Lake Pontchartrain receives tidal input of saline waters from eastern estuaries through Chef Menteur Pass and the Rigolets, which connect to Lake Borgne and the IHNC, which links the lake and the GIWW and MRGO. Since construction of the MRGO was completed in 1968, higher saline waters entering Lake Pontchartrain have increased salinity in areas of the southern and eastern parts of the lake.

The higher saline waters that enter Lake Pontchartrain from the IHNC produce salinity stratification in the water column, resulting in low bottom DO concentrations in southern regions of the estuary (Poirrier, 1978). Salinity stratification in the water column occurs when higher saline, denser waters are introduced into lower saline, less dense waters. Water entering Lake Pontchartrain from the IHNC is distinctly stratified with denser bottom water having higher salinity than that identified in Lake Pontchartrain. Salinity stratification and low bottom water DO concentrations are not apparent in the saline waters that enter Lake Pontchartrain from the natural tidal passes because of the similarity in salinity of these waters and Lake Borgne.

The presence and degree of salinity stratification in southern regions of Lake Pontchartrain appear to be influenced by vertical mixing from wind action and the movement of water in and out of the IHNC. A direct correlation has been developed between established salinity stratification and low DO concentration in the bottom waters of Lake Pontchartrain (Schurtz and St. Pe', 1984). DO concentrations appear at their lowest levels in the summer and fall when salinity stratification is occurring and the salinity gradient between bottom and surface water is greatest. A non-mixing condition results from the density difference between the more saline bottom water and the upper less saline water in the stratified water column.

The hypoxic conditions of near-bottom water associated with salinity stratification in the overlying water column can affect the diversity and distribution of benthic organisms (Junot et al., 1983). The impact on diversity and distribution can be attributed to the identified low oxygen levels in near-bottom waters that are associated with salinity stratification that occur near the IHNC. Further studies have identified the absence or low densities of large *Rangia cuneata* clams (Rangia clams) from sites located north of the IHNC as an indicator that episodic hypoxia, resulting from salinity stratification, has affected the establishment of older larger Rangia clams in the area (Abadie and Poirrier, 2000).

Station to station differences in bottom salinity and the resulting variation in water column stratification appear to vary with depth and distance from the IHNC. The importance of wind action on the development of salinity stratification in Lake Pontchartrain is seen by the typical seasonal occurrence of stratification across southern areas of the estuary in the spring, summer, and fall. During the winter months, strong northerly winds across the area promote vertical mixing of the water column and diminished stratification. Studies indicate stratified water is seldom identified west of the Causeway Bridge, may occur east of the Lakefront Airport, and, under favorable conditions, may extend northward by several miles into Lake Pontchartrain (Poirrier, 1978). Salinity stratification in southern Lake Pontchartrain in the area of the IHNC has also been identified in other investigations (Swenson, 1980).

Salinity stratification has also been identified in greater magnitude in large bottom dredge holes (borrow pits) located across the estuary. The water quality dynamics of these borrow pits have been investigated and provide additional information on the characteristics of more saline water that enters Lake Pontchartrain from the IHNC (Franze and Poirrier, 2000). Borrow pits may be dredged to depths in excess of 65 feet. The increased water column depth within the area of these pits is characterized by well-defined salinity stratification that is determined by distance from the IHNC. A borrow pit investigated in these studies is located approximately 4,000 feet north of the Lakefront Airport and displayed well-defined salinity stratification patterns. Studies conducted from 1998 to 2000 of this pit area identified surface salinity ranging from 2.4 ppt to 10.8 ppt and bottom salinity ranging from 15.8 ppt to 24.4 ppt. The variation in spatial surface salinity and the gradient of salinity stratification within southern Lake Pontchartrain dredge pits is further evidence of the influence of the IHNC and the influx of more saline waters on this area of the estuary.

The USACE Engineer Research and Development Center's Coastal and Hydraulics Laboratory ran a numerical model investigation entitled Salinity Changes in Pontchartrain Basin Estuary, Louisiana, resulting from Mississippi River-Gulf Outlet Partial Closure Plans (USACE, 2009). In the Historical Salinity section of the report, data for five stations in the project area were analyzed. The stations are Pass Manchac near Ponchatoula, Lake Pontchartrain at Little Woods, Chef Menteur Pass near Lake

Borgne, Lake Pontchartrain at North Shore all in the secondary area, and Bayou La Loutre at Alluvial City in the primary area. The mean pre- and post-MRGO salinity information is from 1951 to 1963 and 1963 to 1977 respectively and is presented in **table 3-15**. The table shows that the salinity increased at all five stations throughout the years after the MRGO was opened.

Table 3-15: Salinity for Pre- and Post-MRGO Salinity (ppt)

	Alluvial City		Pass Manchac		North Shore		Little Woods		Chef Menteur Pass	
Month	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
January	6.8	9.8	1.1	1.5	3.0	4.0	3.8	5.0	3.8	5.7
February	6.4	9.7	1.0	1.5	2.5	3.0	3.0	6.5	2.9	4.8
March	6.3	10.4	1.0	1.2	1.9	2.6	2.3	4.4	2.2	4.3
April	7.0	10.0	0.8	1.3	1.9	2.6	2.4	4.0	2.2	4.0
May	9.5	10.2	1.0	1.1	2.4	2.7	2.2	3.8	2.6	4.0
June	9.0	12.3	1.0	1.5	3.6	3.0	2.2	3.8	3.3	4.2
July	7.9	16.0	1.0	1.6	3.0	4.6	2.1	4.4	3.2	6.3
August	8.6	16.1	1.2	1.7	4.6	5.6	2.5	4.8	4.8	7.5
September	8.2	12.9	1.7	2.0	5.4	7.5	4.5	6.2	6.0	8.5
October	7.6	13.8	1.8	2.2	4.7	7.3	4.9	6.8	5.2	8.4
November	8.0	13.1	1.8	2.1	4.6	6.7	4.8	6.8	5.2	8.0
December	8.0	12.5	1.2	1.8	4.5	5.4	4.7	6.2	4.2	7.0

SOURCE: USACE, 2009.

3.7.2.3 Lake Maurepas Salinity

Lake Maurepas is located at the western end of Lake Pontchartrain. The Manchac Landbridge separates the two lakes. Manchac Pass and numerous waterways transect the landbridge between Lake Maurepas and the more saline waters of western Lake Pontchartrain. Water quality data from 2001 identified increasing salinity in Lake Maurepas and the south Maurepas Swamp (Lee Wilson and Associates, Inc. et al., 2001). Salinity data records collected from the USACE station at Pass Manchac indicate that during the 1998 to 2000 drought period, mean annual salinity was higher than in previous years. Salinity increases in Lake Maurepas are supported by comparing mean monthly salinity from the 1955 to 1981 period to mean monthly data for the 1998 to 2000 period. An average monthly increase of two ppt to three ppt was observed during the two-year sampling period.

The main sources of freshwater input into Lake Maurepas are the Blind River, the Tickfaw River, the Amite Diversion Canal, and area rainfall runoff. During the typical low rainfall season that occurs from summer to fall, highest mean monthly salinity have been identified in Lake Maurepas.

Due to the distance of Lake Maurepas to the IHNC, and from the tidal passes from Lake Borgne, the possible impact from the MRGO on the Lake Maurepas area is not clearly defined.

3.7.2.4 Mississippi Territorial Waters Salinity

Six rivers empty into the Mississippi Sound including the Pearl River, Wolf River, Jordan River, Biloxi River, and the East and West Pascagoula Rivers. The influx of rivers creates a salinity gradient within the Sound (Priddy et al., 1955). Both east-west and north-south gradients occur in the Sound in addition to vertical gradients. Generally, positive salinity gradients exist from the mainland seaward and vertically from surface to bottom (GMFMC, 1998). Surface salinity is influenced by the discharge of freshwater from large rivers and is reduced during periods of higher flow in late spring and early summer (Thompson et al., 1999). Temperature follows expected salinity trends (MsCIP, 2008). Overall salinity levels within Mississippi Sound are shown in **tables 3-16** through **3-18** and give the salinity levels at points which have the greatest influence on the Mississippi Sound including St. Louis Bay, Biloxi Bay, and the Pascagoula area. These salinity values were taken at sample points throughout the sound and the bays and rivers that feed into it and are shown on **figures 3-8** through **3-10**.

St. Louis Bay is a small bay in the northwest portion of the Mississippi Sound. The Wolf and Jordan Rivers flow into this bay before reaching the Sound, as well as Bayou Portage, Bayou La Croix, and Indian Bayou. These waterways constitute the bulk of freshwater entering the system. Salinity levels for St. Louis Bay were taken at ten stations throughout the bay and two stations southwest of the bay at Bayou Caddy and Pearl River in 2005 and are noted in **table 3-16** and shown on **figure 3-8**.

Table 3-16: Existing Salinity in St. Louis Bay

Station	Depth (feet)	Salinity (ppt)		
		Max	Average	Min
SLB1	11	15.29	15.24	15.21
SLB2	6	14.65	14.04	13.77
SLB3	8	14.51	14.15	13.25
SLB4	4	13.07	12.72	12.5
SLB5	5	12.26	12.11	12.02
SLB6	7	12.83	11.9	11.55
SLB7	5	11.15	10.74	10.53
WR1	4	9.02	8.03	7.06
JR1	9	9.28	882	7.49
BLC1	9	7.72	6.31	5.12
BCD1	9	14.27	14.26	14.27
Pearl1	17	4.26	3.34	2.15

SOURCE: Water Quality Study of Bays in Coastal Mississippi, EPA 2005.

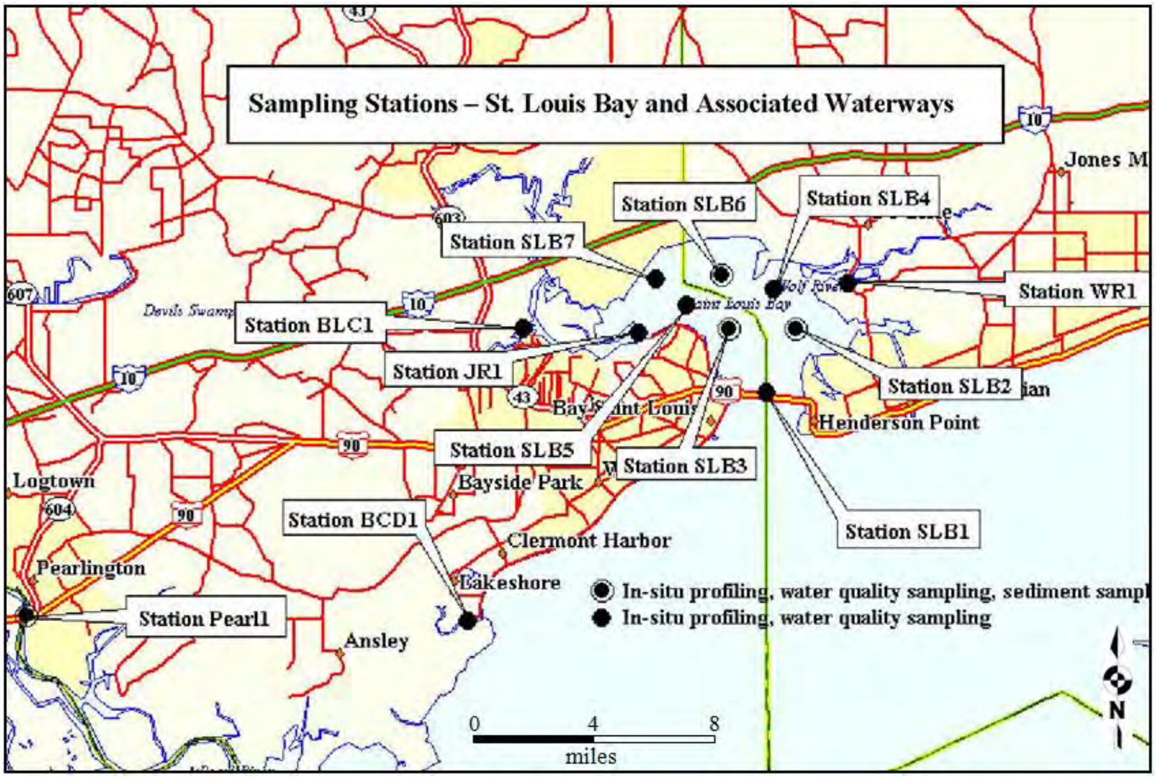


Figure 3-8: Site Location Map – St. Louis Bay and Associated Waterways

Biloxi Bay is a long, narrow bay in the central portion of the Mississippi Sound. Bernard Bayou and the Biloxi River flow into the bay on the west end, the Tchoutacabouffa River enters from the north at the midpoint of the bay, and Old Fort Bayou enters on the eastern end just before the bay's connection with the Sound. These waterways constitute the bulk of freshwater entering the system. Salinity levels for Biloxi Bay were taken at six stations throughout the bay in 2005 and are noted in **table 3-17** and shown on **figure 3-9**.

Table 3-17: Existing Salinity in Biloxi Bay

Station	Depth (feet)	Salinity (ppt)		
		Max	Average	Min
BBB1	12	21.52	16.83	13.34
BBB2	11	15.28	12.25	8.59
BBB3	7	11.59	8.83	7.8
BBB4	10	6.75	4.5	4.07
BBB5	9	8.83	5.7	4.13
BBB6	15	4.53	3.38	2.43

SOURCE: Water Quality Study of Bays in Coastal Mississippi, EPA 2005.

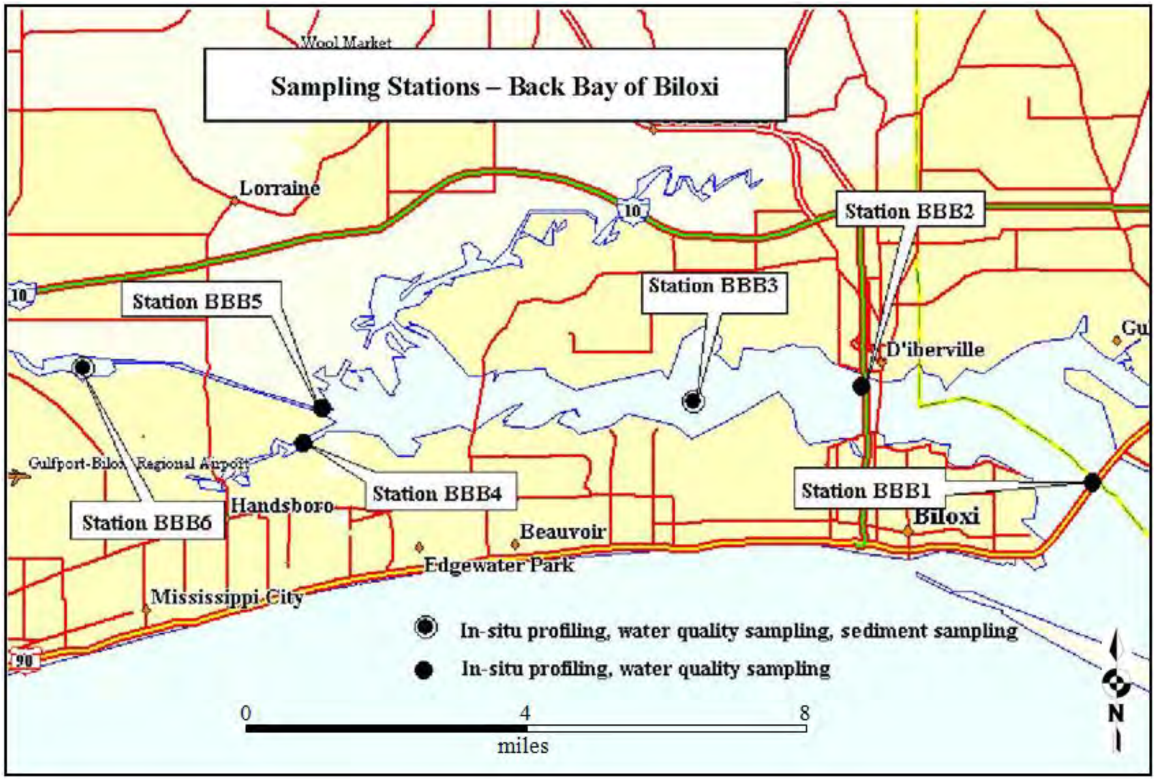


Figure 3-9: Site Location Map – Back Bay of Biloxi

Pascagoula Bay is actually just a portion of the eastern end of the Mississippi Sound. The West Pascagoula River, Pascagoula River, and Escatawpa River empty into the Mississippi Sound at Pascagoula Bay. These waterways constitute the bulk of freshwater entering the system on the eastern end. Salinity levels for Pascagoula Bay were taken at six stations located at various locations on each of the rivers in 2005 and are noted in **table 3-18** and shown on **figure 3-10**.

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Table 3-18: Existing Salinity in Pascagoula Bay

Station	Depth (feet)	Salinity (ppt)		
		Max	Average	Min
WPR1	26	25	20.45	5.63
WPR2	28	11.81	5.96	0.72
PR1	40	30.28	26.86	5.2
PR2	23	26.46	14.26	2.21
ER1	23	28.02	18.81	3.69
ER2	19	21.45	13.62	1.8

SOURCE: Water Quality Study in Bays in Coastal Mississippi, EPA 2005.

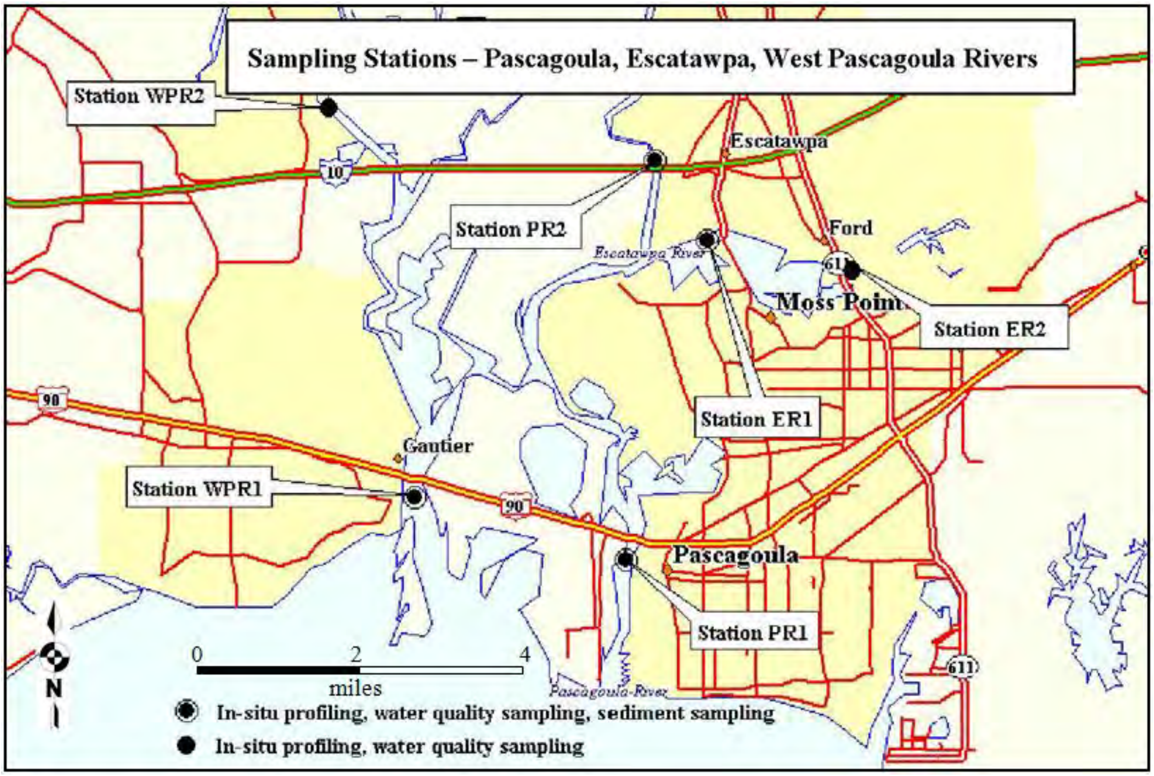


Figure 3-10: Site Location Map – Pascagoula, Escatawpa, West Pascagoula Rivers

3.7.2.5 Lake Pontchartrain Hypoxic/Anoxic Zone

A hypoxic/anoxic (H/A) zone in Lake Pontchartrain was first described by Poirrier (1978). Hypoxic conditions or hypoxia is a phenomenon that occurs in aquatic environments as DO becomes reduced in concentration to a point detrimental to aquatic organisms living in the system. When the DO concentration is in the range between one percent and 30 percent, the water body is classified as hypoxic. An aquatic system lacking DO (zero percent saturation) is termed anoxic.

The H/A zone's existence was verified by extensive water quality sampling done by LDEQ in 1980 and 1982 (Schurtz and St. Pe', 1984). This zone appears to be caused primarily because the MRGO carries bottom water in excess of 20 ppt, which enters the IHNC and then Lake Pontchartrain during the flood tide cycle (Georgiou and McCorquodale, 2002). This saline water sinks to the bottom, where it moves with bottom lake currents and can cover at least 1/6 of the lake's bottom (Schurtz and St. Pe', 1984). This stratified water inhibits both mixing and oxygenation, generally leading to H/A conditions near the lake bottom. This H/A zone appears most often in the spring and summer (Abadie and Poirrier, 2001).

As a result of the MRGO closure structure, Dr. Poirrier of the University of New Orleans (UNO) reports that results of sampling conducted near the mouth of the IHNC in Lake Pontchartrain prior to and after closure in summer 2009 indicate a substantial reduction in differences between surface and bottom salinity and DO levels. Monitoring conducted by USGS during the late summer and early fall of 2009 of borrow pits along the south shore of Lake Pontchartrain indicate that DO at depths below 15 feet dropped to below .75 mg/l and lower and salinity averaged approximately 12.7 at depths of 15 feet and lower in mid-September 2009 and 7.0 ppt at all depths in October 2009 (**appendix S**).

3.8 NAVIGABLE WATERWAYS

3.8.1 Historic and Existing Conditions

The major navigation channels in the project area include the Mississippi River Deep Draft Navigation Channel, the IHNC, the GIWW and the MRGO. Lake Borgne is hydrologically-linked to Lake Pontchartrain through tidal passes at the Rigolets, Chef Menteur Pass, and the manmade IHNC. Although the Rigolets and Chef Menteur Pass are navigable, they are used mainly by commercial fishing and recreational vessels, as are many of the small bayous and canals in the project area.

The Mississippi River Deep Draft Navigation Channel is Federally maintained by the USACE to insure navigation in the Mississippi River. The IHNC, connecting the Mississippi River and Lake Pontchartrain, was completed in 1923 with the construction of the IHNC lock at the Mississippi River. The lock allows for navigation by preventing high stages in the Mississippi River from producing strong currents in the channel. In the 1930s, the GIWW was constructed from the mid-point of the IHNC going east and by 1949 went west all the way to Brownsville, Texas.

Other Federally maintained channels in the project area are Bayous Dupre, La Loutre, St. Malo and Yscloskey. Bayou Dupre was authorized by the Rivers and Harbors Act of 1937. The authorization was for a 6-foot deep by 80–foot wide channel from the Highway 39 Bridge at Violet to Lake Borgne and thence a 6-foot deep by 100-foot wide channel to the 6-foot contour in Lake Borgne. Construction was completed in 1939. The 7.3 mile channel extended almost two miles out into Lake Borgne. A contemporary navigation chart (NOAA chart 11371) shows the channel markers extending about 1.4 miles into Lake Borgne and the water depths as being 7 feet. Bayous La Loutre, St. Malo, and Yscloskey were also authorized by the Rivers and Harbors Act of 1937. These are all small depth (5 feet or 6 feet) narrow channels (30 feet or 40 feet) with construction completed in 1956. Maintenance dredging has not been required.

Prior to construction of the MRGO (1958-1968), main navigation channels were the IHNC, GIWW, and the Mississippi River. Bayous Bienvenue, Dupre, and La Loutre that were part of the remnant tributary system that extended from the Mississippi River eastward to the Biloxi Marsh and Mississippi Sound and were used by smaller crafts, mostly commercial and recreational fishing. Construction of the MRGO cut thorough these bayous. Construction also breached the Bayou La Loutre Ridge resulting in direct connection of Lake Borgne to the Gulf of Mexico through Breton Sound.
The MRGO was completed in 1968 and extended approximately 70 miles from Breton Sound to eastern New Orleans, traversing wetlands and marshes in Plaquemines, St.

Bernard, and eastern Orleans Parishes. Following completion of construction, the size and draft of vessels using the MRGO increased to meet the competitive demand for more efficient movements of bulk commodities. With the construction of the Lake Pontchartrain and Vicinity Hurricane Protection Project, control structures were constructed at Bayous Bienvenue and Dupre to allow tidal flow and navigation while maintaining the integrity of the Chalmette Loop Levee System. Structures at Bayous Bienvenue and Dupre allow for passage of small recreational and commercial fishing vessels into the Central Wetlands where they are home-ported in small marinas and along marginal docks along the bayous.

The MRGO was deauthorized in 2008 and the closure structure near Bayou La Loutre was completed in August 2009 resulting in changes to navigation. Hurricane Katrina silted in much of the MRGO channel across Breton Sound with the result that large vessels are no longer able to transit Breton Sound and reach eastern Orleans Parish. Construction of the closure structure on the southern part of the La Loutre Ridge has changed navigation in the project area. Instead of a direct route down the MRGO to reach Breton Sound or the Gulf of Mexico, vessels must now use the Bayou La Loutre channel. Bayou La Loutre is also a Federal channel authorized by the Rivers and Harbors Act of 1937. The authorization for Bayous La Loutre, St. Malo and Yscloskey called for a channel 5 feet by 40 feet for deep water in Lake Borgne to the shoreline at the mouth of Bayou Yscloskey; a channel 6 feet by 40 feet for deep water in Lake Borgne through Bayous St. Malo, La Loutre and Eloi to deep water in Lake Eloi (Breton/Chandeleur Sound); and a channel 5 feet by 30 feet in Bayou la Loutre between Hopedale and Bayou St. Malo. Total length on improvements was 30 miles and all construction was completed by 1956.

Sector gates on the GIWW and Bayou Bienvenue being constructed as part of the authorized improvements to the HSDRRS will alter navigation in and near the western end of the project area. The operation of the sector gates should have minimal impact on passage of vessels, since the structures will remain open except for storm conditions. The access construction channel for the storm surge barrier structure will connect the MRGO with the GIWW across the Golden Triangle allowing another navigable route for small vessels, but this channel will not be a maintained channel. However, the storm surge barrier will close off the existing connection. Navigation in the MRGO and the Central Wetlands is now relegated to small recreational craft and smaller commercial vessels, generally fishing and shrimp boats, small barges and tugs. The use of the MRGO is relegated to a conduit between Bayou Dupre and Bayou La Loutre.

There presently exists a channel (part of the Bayou Dupre authorized channel) that allows passage from the MRGO into Lake Borgne. This channel has been reduced to an approximately 500 feet width by a recently constructed rock dike structure that was built to reduce erosion and restore shoreline along the tangent formed by the MRGO and the western shoreline of Lake Borgne.

3.9 SOILS AND SEDIMENTS

3.9.1 Historic and Existing Conditions

Soil resources are institutionally significant under the following statutes and memoranda: the CEQ Memorandum of August 11, 1980, entitled "Analysis of Impacts on Prime or Unique Agricultural Lands in Implementing the NEPA," EO 11990 – Protection of Wetlands; and Agriculture and Food Act of 1981 (Public Law 97-98), which includes the Farmland Protection Policy Act (FPPA). Soil plays a significant role in the environment because it supports vegetative growth and open-water benthic productivity in coastal habitats. This resource is publicly significant because of the high value the public places on agricultural production and wildlife supported by the soils in the area.

Within coastal areas, soils provide a critical biotic component of ecosystems, affecting biogeochemical processes, species composition, productivity, and other factors essential to ecosystem integrity and functioning (Brady and Weil, 2002; Anderson and Lockaby, 2007). Soil types in the study area are formed in materials (i.e., gravel, sand, silt, and clay) that were deposited over time during seasonal and intermittent flooding events (USACE, 2009). Soils with finer textures (fine silts and clay) are predominantly located farther away from major waterways than soils dominated by heavier textures (i.e., sands and gravels) because the heavier materials drop out of suspension in the water column first as flowing water slows down. Therefore, relatively fine textures are often found on natural river levees in the backswamp farther away from the river.

The project area includes both hydric and non-hydric soils (NRCS, 2007). Hydric soils are saturated all or part of the year and are a defining characteristic of wetlands. Somewhat poorly drained, poorly, and very poorly drained soils are typically found in topographically lower landscape positions or depressions that are subject to prolonged, excessive, or frequent saturation. Lands near or in the outer fringes of the coastal plain marshes are usually made up of hydric soils in areas that are temporarily or permanently flooded. Somewhat well drained and well drained non-hydric soils are typically found on topographically higher landscape positions farther away from open water bodies and wetland areas. **Figure 3-11** below shows the distribution of hydric soils within the study area. An accumulation of organic material in the surface soil horizon, evident across most of the project area, is typical of hydric soils due to slow decomposition under anaerobic conditions during saturation. Soil samples from Maurepas Swamp had soil bulk densities typically seen in fresh and intermediate marshes (lesser salinity than salt marshes) and the soil pH was slightly acidic (typical of organic soils with low bulk densities) (e.g., Hatton, 1981); higher bulk densities were measured in areas receiving agricultural and other runoff (Shaffer et al., 2003). The low bulk densities and corresponding high organic matter content were likely the result of insufficient sediment input since the leveeing of the Mississippi River. According to the Department of Agriculture – Natural Resources Conservation Service (NRCS) soil survey report of the Plaquemines and St. Bernard Parishes, the project areas in the middle and lower sub-basins consist of mucky clay/muck soils.

Study Area Soils

The dominate soil series in the Livingston, Plaquemines, St. Bernard, Orleans, and St. Tammany Parishes study areas are shown in the table below followed by brief descriptions of the major soil types in each (see **table 3-19**).

Table 3-19: Dominant Soil Series of the Study Area

Parish	Soils
Livingston	
Soils on uplands	Calhoun, Bude
Soils on streams or marine terraces	Colyell, Encrow, Myatt, Satsuma,
Soils on floodplains	Ouachita and Guyton
Soils in Marshes and swamps that are frequently flooded and ponded	Barbary, Maurepas
Orleans	
Soils on a natural levee protected from flooding	Sharkey, Commerce
Soils in Marshes and swamps that are frequently flooded and ponded	Clovelly, Lafitte, Gentilly
Soils in former swamps that are drained and protected from flooding	Harahan, Westwego, Allemands
Soils on dredge material banks and sandy ridges that are rarely or frequently flooded	Aquents
Plaquemines	
Soils on a natural levee protected from flooding	Sharkey, Commerce
Soils in Marshes and swamps that are frequently flooded and ponded	Larose, Kenner, Allemands, Clovelly, Lafitte, Gentilly, Bellpass, Timbalier, Scatlake
Soils in former swamps that are drained and protected from flooding	Harahan, Westwego,
Soils on dredge material banks and sandy ridges that are rarely or frequently flooded	Aquents
St. Bernard	
Soils on a natural levee protected from flooding	Sharkey, Commerce
Soils in Marshes and swamps that are frequently flooded and ponded	Barbary, Lafitte, Clovelly, Timbalier, Bellpass, Scatlake, Fausse
Soils in former swamps that are drained and protected from flooding	Harahan, Westwego
Soils on dredge material banks and sandy ridges that are rarely or frequently flooded	Aquents
St. Tammany	
Soils on streams or marine terraces	Guyton, Abita, Brimstone
Soils in Marshes and swamps that are frequently flooded and ponded	Clovelly, Lafitte, Larose, Allemands, Kenner
Soils in former swamps that are drained and protected from flooding	Aquents

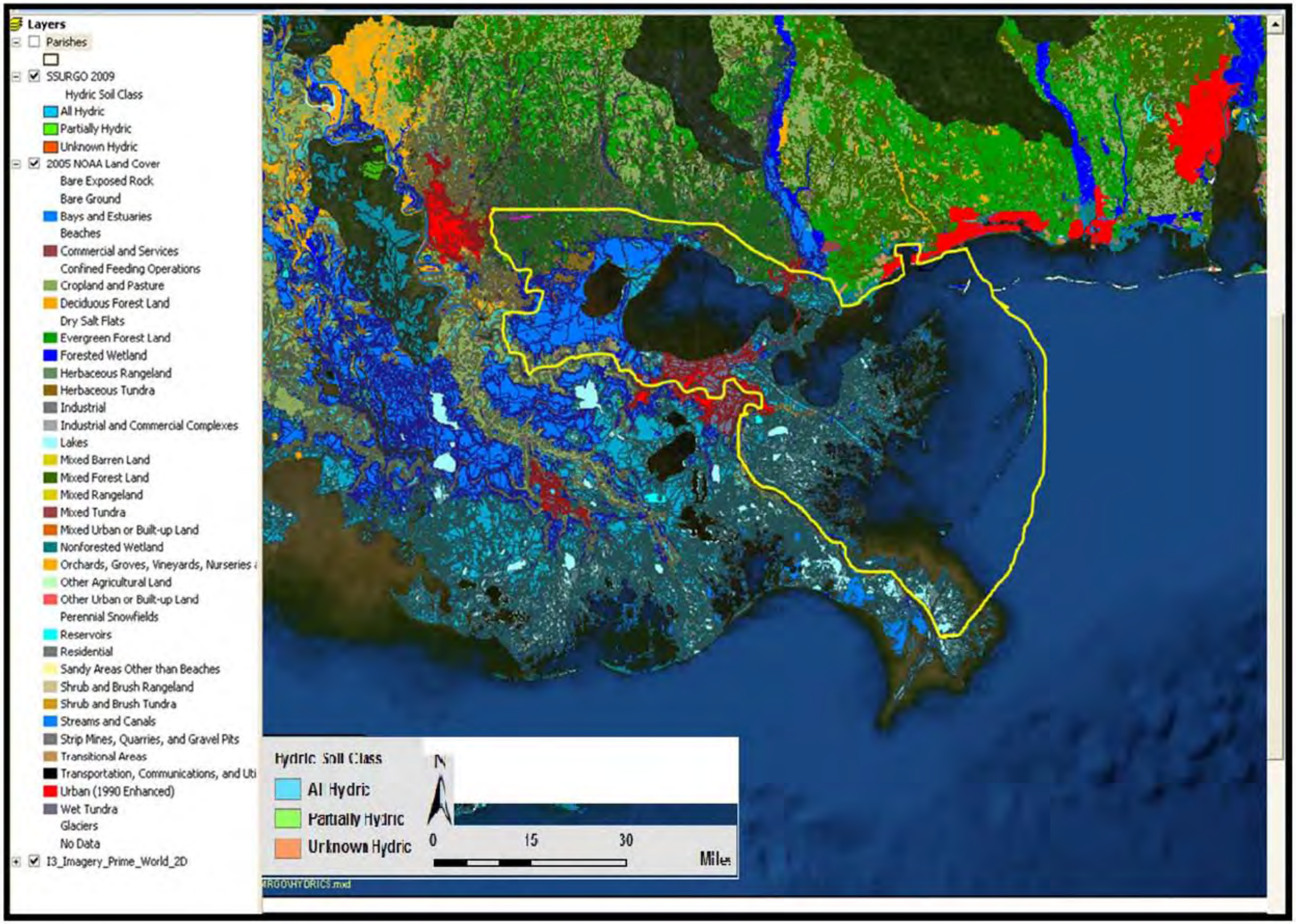


Figure 3-11: Distribution of Hydric Soils in Study Area – Pontchartrain Basin and Western Mississippi Sound

Abita

The Abita series consists of deep, somewhat poorly drained, slowly permeable soils that formed in silty sediments on low, broad stream or marine terraces of late Pleistocene age with slopes ranging from zero percent to five percent.

Allemands

The Allemands series consists of very deep, very poorly drained, soils that are rapidly permeable in the organic materials and very slowly permeable in the underlying clay horizons. These soils are on the landward side of low coastal freshwater marshes and formed in decomposed herbaceous material over alluvial sediments with slopes ranging from zero percent to 0.2 percent.

Aquents

Aquents are young soils that have very little horizon development. The soils in this group are found in marshes and formed in alluvium. They are frequently flooded. They are deep (often greater than 80 inches to a restrictive feature) and are very poorly drained.

Barbary

The Barbary series consists of very deep, very poorly drained, very slowly permeable soils. These soils formed in geologically recent (less than 10,000 years old) clayey sediments that have been deposited in water and are continuously saturated and flooded. These soils are mainly on low, broad, ponded backswamps of the lower Mississippi River Alluvial Plain with a slope of less than one percent.

Bellpass

The Bellpass series consists of very deep, very poorly drained, very slowly permeable soils that formed in moderately thick herbaceous organic materials overlying clayey sediments in saline coastal marshes with slopes ranging from zero percent to 0.2 percent. These soils are flooded very frequently by saltwater during high tides.

Brimstone

The Brimstone series consists of deep, poorly drained, slowly permeable soils that are high in exchangeable sodium. They formed in loamy sediments on low late Pleistocene age terraces. These soils are on broad flats at intermediate elevations with slopes that are zero percent to one percent. Water runs off the surface at a slow rate.

Bude

The Bude series consists of somewhat poorly drained, slowly permeable soils with a fragipan. They formed in a silty mantle, less than four feet thick, and the underlying loamy sediments. These are nearly level to gently sloping soils on uplands and terraces in the Southern Mississippi Valley Silty Uplands Major Land Resource Area with slopes ranging from zero percent to five percent.

Calhoun

The Calhoun series consists of level, poorly drained, slowly permeable soils. These soils formed from loess or loess-like material with low sand content. They mainly are at low local elevations on Pleistocene age terraces, and less commonly on floodplains with slopes ranging from zero percent to one percent.

Clovelly

The Clovelly series consists of very deep, very poorly drained, very low permeability soils. These soils formed in moderately thick accumulations of herbaceous organic material overlying clayey alluvial sediments. These soils are on broad coastal marshes that are nearly continuously flooded with brackish water with slopes ranging from zero percent to 0.2 percent.

Commerce

The Commerce series consists of deep, somewhat poorly drained, moderately slowly permeable soils that formed in loamy alluvial sediments. These soils are on level to undulating alluvial plains of the Mississippi River and its tributaries with a slope that is dominantly less than one percent, but ranges up to five percent.

Colyell

The Colyell series consists of somewhat poorly drained slowly permeable soils that formed on low terraces in a thin mantle of loess over late Pleistocene age sediments with slopes ranging from one percent to three percent.

Encrow

The Encrow series consists of poorly drained, slowly permeable soils that formed in a blanket of mixed loess and local alluvium over clayey late Pleistocene age sediments. They are at low local elevations on level or depressed areas on terraces with slopes ranging from zero percent to one percent.

Fausse

The Fausse series consists of very deep, very poorly drained, very slowly permeable soils that formed in clayey alluvium. These soils are found in low, ponded backswamp areas of the lower Mississippi River alluvial plain with slopes that are less than one percent.

<u>Gentilly</u>

The Gentilly series consists of very deep, very poorly drained, very slowly permeable slightly to moderately saline soils. These soils formed in thin accumulations of herbaceous plant remains and clayey alluvium over consolidated clayey deposits with slopes that are less than one percent. Typically they occur on subsiding distributaries of the Mississippi River.

<u>Guyton</u>

The Guyton series consists of very deep, poorly drained and very poorly drained, slowly permeable soils that formed in thick loamy sediments. These soils are on coastal plain local stream floodplains and in depressional areas on late Pleistocene age terraces with slopes ranging from zero percent to one percent.

<u>Harahan</u>

The Harahan series consists of very deep, poorly drained, very slowly permeable soils. They formed in moderately thick firm clayey alluvium overlying fluid clayey sediments. These soils are on broad backswamp positions on the lower Mississippi River flood plain. Slopes range from 0 to 1 percent.

<u>Kenner</u>

The Kenner series consists of very deep, very poorly drained, very slowly permeable, organic soils. These soils formed in herbaceous plant remains stratified with clayey alluvium. They are in freshwater marshes along the Gulf of Mexico with slopes ranging from zero percent to 0.2 percent.

<u>Lafitte</u>

The Lafitte series consists of very deep, very poorly drained, moderately rapidly permeable organic soils that formed in herbaceous plant remains over sediments. These soils are in intermediate and brackish marshes in the extreme lower Mississippi River Delta and coastal areas with slopes ranging from zero percent to 0.2 percent.

<u>Larose</u>

The Larose series consists of very deep, very poorly drained, very slowly permeable soils that formed in fluid clayey sediments in freshwater coastal marshes. The sediments were deposited under water and have never air-dried and consolidated with slope ranging from zero percent to 0.2 percent. These soils are subject to flooding by runoff and tides.

Maurepas

The Maurepas series consists of very deep, very poorly drained, rapidly permeable organic soils that formed in woody plant remains. These soils are in large backswamps of the lower Mississippi River delta and associated coastal areas with slopes that are less than one percent.

Myatt

The Myatt series consists of deep, poorly drained, moderately slowly permeable soils on stream terraces and upland flats of the coastal plain. They are saturated during the winter and spring. Water runs off the surface slowly with slopes ranging from zero percent to two percent.

Ouachita

The Ouachita series consists of deep, well drained, moderately slowly permeable soils that formed in loamy alluvium mainly from coastal plains uplands. These level to nearly level soils are on floodplains and natural levees along streams in the western coastal plains with slopes ranging from zero percent to three percent.

Satsuma

The Satsuma series consists of somewhat poorly drained soils that formed in mixed loess and loamy stream terrace deposits of late Pleistocene age. Permeability is moderate in the upper part of the subsoil and slow in the lower part of the subsoil with slopes ranging from one percent to three percent.

Scatlake

The Scatlake series consists of very deep, very poorly drained, very slowly permeable soils. These soils formed in unconsolidated saline clayey and organic sediments. These soils are in saline marsh areas along the Gulf Coast with slopes ranging from zero percent to 0.2 percent.

Sharkey

The Sharkey series consists of very deep, poorly and very poorly drained, very slowly permeable soils that formed in clayey alluvium. Sharkey soils are on the floodplain, lower parts of natural levees, in backswamps and abandoned channels and on interfluves and low terraces of the Mississippi River with a slope that is dominantly less than one percent, but ranges to five percent.

Timbalier

The Timbalier series consist of very deep, very poorly drained, rapidly permeable soils that formed in thick herbaceous, highly decomposed organic material. These soils are on saline Gulf Coast marshes and are very frequently flooded by saltwater during high tides with slopes ranging from zero percent to 0.2 percent.

Westwego

The Westwego series consists of a level poorly drained mineral soil with a slope that is typically less than 1 percent. These soils are in swamps that have been drained and are protected from most flooding. The elevation of these soils ranges from sea level to about 3 feet above sea level.

3.9.2 Prime and Unique Farmlands

The FPPA (Public Law 97-98; U.S.C. 4201 *et seq*.) states that Federal agencies must "minimize the extent to which Federal programs contribute to the unnecessary conversion of farmland to nonagricultural uses…" However, the FPPA definition of farmland does not include land already in or committed to urban development. Prime farmlands are designated by the NRCS and are lands that have the best combination of physical and chemical characteristics for agricultural production. Unique farmlands are used for the production of specific high value food and fiber crops. It has the special combination of soil quality, location, growing season, and moisture supply needed to economically produce sustained high quality and/or high yields of a specific crop when treated and managed according to acceptable farming methods; examples of such crops are citrus, tree nuts, olives, cranberries, fruit, and vegetables.

3.9.3 Sediments

This section describes the general sediment characteristics within the project area including the Mississippi River, MRGO, GIWW – Lake Borgne, Michoud Channel, Lake Lery, Breton Sound, and offshore sources such as the former MRGO Ocean Dredged Material Disposal Site (ODMDS).

Lake Borgne

Existing soil boring data from Lake Borgne indicate that the sediment is mainly organic clay and clay with minor amounts of silt and silty sand. Sediment sampling of Lake Borgne was conducted by the USACE in 2007 at a depth of 10 feet for all samples. Of 50 sediment samples taken by USACE, 42 of them were classified as clay. Some of the clays have a high percentage of organic matter and are thus considered "organic clays." Five of the remaining eight samples were classified as peat (decomposed organic matter), and three were classified as silty sand.

In terms of sediment contamination within Lake Borgne, brief summaries of report and data evaluations are provided below.

The United States Coast Guard (USCG), National Response Center, maintains a database of reported oil and chemical spills for U.S. waterways. A search was conducted for any spills reported within the last 20 years in the projects vicinity, including Lake Borgne, Bayous Bienvenue, Dupre, and Yscloskey, the MRGO, and GIWW between the lake and MRGO. Four minor oil and fuel spills were reported in the lake between 1998 and 2005 (Report #'s 443981, 615335, 739379, and 777114). A minor oil spill was reported in Bayou Bienvenue in 2006 (report # 796247). A larger spill of automotive gasoline (70 gallons) was reported west of the MRGO in Bayou Dupre in 1996 (report #344785). Based on review of the USCG reports, the USACE-CEMVN does not have a reason to believe that sediments within the lake are contaminated.

Sediment chemistry data for Lake Borgne was provided by the EPA, Gulf Ecology Division. Sediment samples were collected from 13 sites in the lake between 1991 and 2005, including four post-Hurricane Katrina collections. The sediment data were reviewed for the presence of 141 contaminants of concern (COC), including metals, poly-aromatic hydrocarbons (PAHs) pesticides, polychlorinated biphenyls (PCBs), semivolatiles, and volatiles.

The concentrations of detected contaminants were compared to a set of screening values developed by National Oceanic and Atmospheric Administration (NOAA) to identify substances which may potentially threaten resources of concern at the marsh creation sites. A contaminant with concentrations near conservative screening values may pose little potential threat or only limited toxicity to sensitive species. A contaminant with concentrations above upper threshold screening values are more likely toxic or frequently can be expected to have adverse biological effects.

Thirty-five contaminants were detected at quantifiable levels from the 13 sediment samples. Detected contaminants included 15 metals, 15 PAHs (including measures of total PAHs, high molecular weight PAHs, and low molecular weight PAHs), three pesticides (including total DDT), and one VOC. Of the detected contaminants only arsenic, cadmium, chromium, nickel, and fluorine exceeded either a total exposure limit (TEL) or environmental risk limit (ERL) screening benchmark. Arsenic exceeded a TEL at two stations. Cadmium exceeded a TEL at six stations, and ERL at two stations. Nickel exceeded a TEL at eight stations. Chromium and fluorine each exceeded a TEL at one station.

There were no instances of more than two COC exceeding a conservative benchmark at a single station. Based on comparison to these screening values, little or no adverse biological effects would be expected as a result of the discharge of lake sediments into the marsh creation sites. Lake Borgne has limited natural sediment replenishment sources. In addition, there are no longshore transport sources. As a result, little sediment accretes in Lake Borgne.

Other Potential Borrow Areas

The sediments within the portion of the Mississippi River that are being considered for use as a borrow site are primarily comprised of silty sand with less organic matter than sediments in Lake Borgne. There are sand deposits at the southern end of Breton Island that could provide a source of material for future barrier island restoration feature.

3.10 AIR QUALITY

3.10.1 Historic and Existing Conditions

The Clean Air Act of 1963 (CAA), which was last amended in 1990, requires EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment. These standards are significant as they set limits to protect the public health of humans and of public welfare including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

The Federal CAA requires that all states comply with the NAAQS developed for seven pollutants: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), and two forms of particulate matter (PM_{10} – particulate matter with a diameter of 10 micrometers or less; and $PM_{2.5}$ - particulate matter with a diameter of 2.5 micrometers or less). The NAAQS include primary and secondary standards. The primary standards were established at levels sufficient to protect public health with an adequate margin of safety. The secondary standards were established to protect the public welfare from the adverse effects associated with pollutants in the ambient air. The primary and secondary standards are presented in **table 3-20**.

The study area boundary includes the parishes of Ascension, Jefferson, Livingston, Orleans, Plaquemines, St. Bernard, St. Charles, St. James, St. John the Baptist, St. Tammany, and Tangipahoa in Louisiana and counties Hancock and Harrison in Mississippi. Of the counties/parishes in the study area, Ascension and Livingston are nonattainment for the 8-hour ozone standard (standard effective prior to May 2008, 0.08 parts per million [ppm]). Currently, all parishes/counties in the construction portion of the study area are in "attainment" for all criteria pollutants. Although the project area includes waterways within the Mississippi counties, this section will only discuss existing air quality conditions in the project area as described in **chapter 1**.

Air monitoring stations within the project area include Meraux, Chalmette High School, Chalmette VISTA, and Algiers Entergy. Air quality data were collected at these monitoring stations for the St. Bernard Air Monitoring Project that began in May, 2006. O_3, SO_2, Hydrogen Sulfide (H_2S) and VOC data were collected from 2006 - 2008. The VOC samples were analyzed for 107 VOC compounds, including many LDEQ Toxic Air Pollutants (TAPs) and EPA Hazardous Air Pollutants (HAPs). The data collected in this project indicates that the air quality in the Chalmette area of St. Bernard Parish is meeting all EPA and state ambient air standards (*St. Bernard Air Monitoring Project Final*

Report, Office of Environmental Assessment, Air Quality Assessment Division, July 30, 2009).

Table 3-20: National Ambient Air Quality Standards for the Seven Criteria Pollutants

Pollutant	Primary Standards		Secondary Standards		Attainment Status for Louisiana
	Level	Averaging Time	Level	Averaging Time	
Carbon Monoxide	9 ppm (10 mg/m^3)	8-hour [a]	None		Attainment
	35 ppm (40 mg/m^3)	1-hour [a]			Attainment
Lead	0.15 µg/m3 [b]	Rolling 3-Month Average	Same as Primary		Not Designated
	1.5 µg/m^3	Quarterly Average	Same as Primary		Not Designated
Nitrogen Dioxide	0.053 ppm (100 µg/m^3)	Annual (Arithmetic Mean)	Same as Primary		Attainment
	0.100 ppm	1-hour [c]	None		
Particulate Matter (PM_{10})	150 µg/m^3	24-hour [d]	Same as Primary		Attainment
Particulate Matter ($PM_{2.5}$)	15.0 µg/m^3	Annual [e] (Arithmetic Mean)	Same as Primary		Attainment
	35 µg/m^3	24-hour [f]	Same as Primary		Attainment
Ozone	0.075 ppm (2008 std)	8-hour [g]	Same as Primary		EPA will make designations under this standard in 2010
	0.08 ppm (1997 std)	8-hour [h]	Same as Primary		Based on 2006-2008 monitored data, all areas are in attainment and the State will be requesting redesignation by EPA
	0.12 ppm	1-hour [i]	Same as Primary		Based on monitored data, all areas are in attainment and LA is requesting from EPA the Clean Data Determination in accordance with EPA's Clean Data Policy
Sulfur Dioxide	0.03 ppm	Annual	0.5 ppm	3-hour [a]	Attainment
		(Arithmetic Mean)	(1,300 µg/m^3)		Attainment
	0.14 ppm	24-hour [a]			Attainment

NOTES:
[a] Not to be exceeded more than once per year.
[b] Final rule signed October 15, 2008.
[c] To attain this standard, the 3-year average of the 98th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 0.100 ppm (effective January 22, 2010).
[d] Not to be exceeded more than once per year on average over 3 years.
[e] To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m^3.
[f] To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m^3 (effective December 17, 2006).
[g]To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm (effective May 27, 2008).
[h] [1] To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm. [2] The 1997 standard—and the implementation rules for that standard—will remain in place for implementation purposes as EPA undertakes rulemaking to address the transition from the 1997 ozone standard to the 2008 ozone standard. [3] EPA is in the process of reconsidering these standards (set in March 2008).
[i] [1] EPA revoked the 1-hour ozone standard in all areas, although some areas have continuing obligations under that standard ("anti-backsliding"). [2] The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is < 1.

In accordance with Section 107(d) of the Clean Air Act Amendments of 1990, designation recommendations for the 2008 8-hour O_3 NAAQS (0.075 ppm) were published on March 27, 2008 (73 FR 16436). These LDEQ designation recommendations are based on a review of the quality-assured ozone monitoring data for the period 2006-2008. The recommended designations classified as nonattainment for ozone include Ascension, Jefferson, Livingston, and St. John Parishes in the study area. It will be necessary to monitor the final EPA designations made to these parishes for the duration of the proposed project.

A final rule introducing a new 1-hour NOx ambient air standard was published in the Federal Register on February 9, 2010. The final rule is effective on April 12, 2010. There are no monitors in place at this time to determine attainment status in Louisiana parishes.

A final rule establishing a new 1-hour SO_2 ambient air standard was published in the Federal Register on June 22, 2010. EPA is also reworking the existing 24-hour and annual primary SO_2 standards. The final rule is effective on August 23, 2010. Monitors are not in place to determine attainment status for any Louisiana parishes at this time.

EPA is also considering a new 8-hour standard for ozone (less than the current 0.075 ppm standard). It is possible that an increased number of parishes may be classified as non-attainment for ozone in Louisiana.

Greenhouse Gases

Greenhouse gases (GHGs) are the gases that absorb heat (infrared rays) released by the sun-warmed surface of the earth and reflect some of these rays back toward the earth, contributing to the greenhouse effect and potentially to climate change.
The main GHGs that enter the atmosphere as a result of human activities are as follows:

a. Carbon Dioxide (CO_2)
b. Methane (CH_4)

c. Nitrous Oxide (N_2O)
d. Fluorinated Gases

The EPA published its finding that greenhouse gases threaten public health in the Federal Register on December 15, 2009, setting the stage for a series of rules to begin regulating GHG emissions.

3.11 NOISE

3.11.1 Historic and Existing Conditions

The Noise Control Act of 1972 regulates and promotes both an environment for all Americans free from noise that jeopardizes their health or welfare and the Occupational Safety and Health Standards (29 CFR, part 1910) regarding protection against the effects of noise exposure. Noise levels exceeding sound pressure levels are technically significant because noise can negatively affect the physiological or psychological well-being of an individual (Kryter, 1994). These effects can range from annoyance to adverse physiological responses, including permanent or temporary loss of hearing, and other types of disturbance to humans and animals, including disruption of colonial nesting birds. Noise is publicly significant because of the public's concern for the potential annoyance and adverse effects of noise on humans and wildlife.

Occupational noise exposure is regulated by Title 29 CFR, Part 1910, subpart G. The United States Department of Labor - Occupational Safety and Health Administration (OSHA) is the enforcing agency. OSHA has established noise exposure standards to protect the hearing of employees. Noise exposure for the construction industry is regulated by Title 29 CFR, Part 1926.52, and Occupational Noise Exposure.

Both the City of New Orleans and the Parish of St. Bernard have noise ordinances addressing loud machinery. Noise is typically associated with human activities and habitations, such as operation of commercial and recreational boats, water vessels, air boats, and other recreational vehicles; operation of machinery and motors; and human residential-related noise (air conditioner, lawn mower, etc.). Much of the project area is a remote and uninhabited marsh with low ambient noise levels. The noise from distant urban areas surrounding the uninhabited portions of the project area contributes little, if any, to the natural noise levels of the area.

The Federal and municipal regulations above are addressed strictly to human receptors. Significant impacts of noise to terrestrial and aquatic animals probably have been related to localized situations where dredging and/or construction have occurred. As discussed in **section 4.9** the proposed restoration project, impacts to aquatic animals (especially fishes) may be relatively significant in some areas.

3.12 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

3.12.1 Historic and Existing Conditions

The USACE is obligated under Engineer Regulation (ER) 1165-2-132 to assume responsibility for the reasonable identification and evaluation of all HTRW contamination within the vicinity of the tentatively selected plan. USACE policy is to avoid the use of project funds for HTRW removal and remediation activities. Costs for necessary special handling or remediation of wastes (e.g., those regulated by the Resource Conservation and Recovery Act [RCRA]), pollutants and other contaminants, which are not regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), will be treated as project costs if the requirement is the result of a validly promulgated Federal, state or local regulation.

The discharge of dredge material into waters of the U.S. is regulated under the CWA, and the Marine Protection, Research and Sanctuaries Act governs the transportation of dredge material to ocean waters for the purpose of disposal. The RCRA hazardous waste management regulations, promulgated pursuant to RCRA (42 U.S.C. 6905) specifically exempt dredge material from the hazardous waste definition if that material is covered by:

a. a permit issued under Section 404 of the Clean Water Act, 33 U.S.C. 1344;
b. a permit issued under Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972 33 U.S.C. 1413; or
c. the administrative equivalent of such permits where the work involves a USACE civil works project, 40 C.F.R. 261.4(g), 63 F.R. 65874, 65921; November 30, 1998.

ER 1165-2-132 states, dredge material and sediments beneath navigable waters proposed for dredging qualify as HTRW only if they are within the boundaries of a site designated by the EPA or a state for a response action (either a removal or a remedial action) under CERCLA, or if they are a part of a National Priority List (NPL) site under CERCLA.

As reported in the *Phase I Environmental Site Assessment Report, Mississippi River Gulf Outlet Ecosystem Restoration, February 1, 2010,* (see **appendix Q**), during review of historic records, the presence of a former World War II training facility, known as the Shell Beach, Anti-Aircraft Training Center (AATC), located on the southern shoreline of the eastern half of Lake Borgne was identified. Based on review of historic documents and information obtained from personnel interviews, ammunition was shot from both large and small caliber weapons at targets that were towed above Lake Borgne.

Magnetic surveys of the shoreline protection area between Doulluts Canal and Jahncke's Ditch were conducted by USACE Baltimore District, munitions and explosives of concern (MEC) dredging experts. These surveys did not identify the presence of MEC in the dredge material deposited within an existing shoreline protection project. The MEC dredging experts reported a low probability of encountering MEC in the project area.

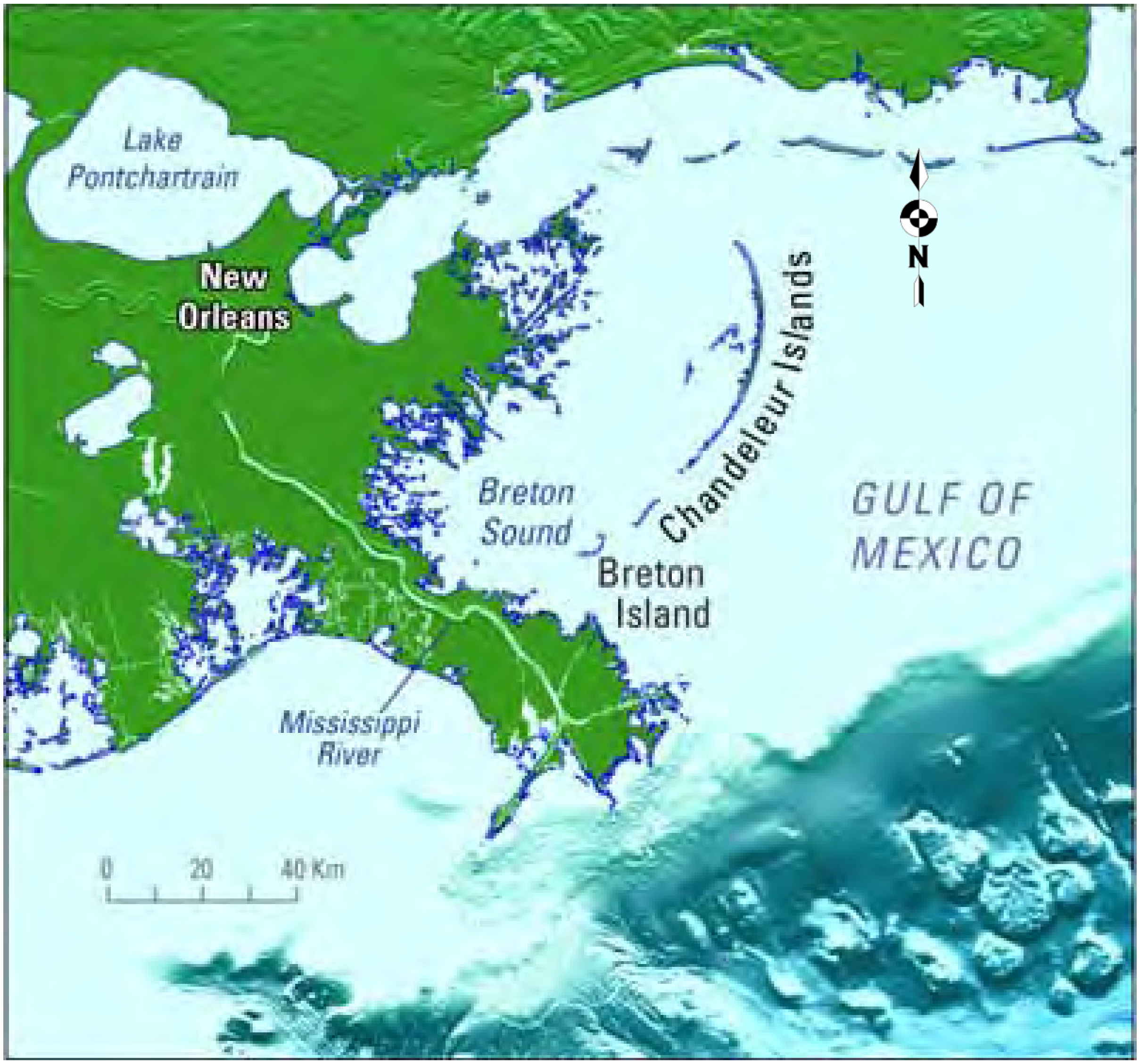
The MEC dredging experts also recommended that borrow area sediments be monitored during the project for MEC.

3.13 BARRIER ISLAND RESOURCES

3.13.1 Historic and Existing Conditions

The Chandeleur Islands, formed 1,800 years ago as the rim of the St. Bernard Lobe of the Mississippi River delta, are composed of an 50-mile long arcuate-shaped barrier island chain located in southeast Louisiana approximately 60 miles east of the City of New Orleans on the north-central coast of the Gulf of Mexico (**figure 3-12** shows the general location while **figure 3-13** and **figure 3-14** exhibits the configuration of the islands). Accessible only by seaplane or boat, the islands are separated from the Louisiana mainland wetlands by the approximately 15-mile to 25-mile wide Breton and Chandeleur Sounds, where water depths average 10 feet to 15 feet. They are the oldest transgressive barrier island arc in the Mississippi River delta plain system. The Chandeleur Islands barrier system is divided into two sections: North Chandeleur Islands (New Harbor, North and Freemason islands and Chandeleur Island) and South Chandeleur Islands (Breton, Grand Gosier, and Curlew islands). The North Chandeleur Islands extend from Hewes Point to Curlew Island Pass and the South Chandeleur Islands extend from Curlew Island to Breton Island. These islands are extremely dynamic, but in their present state they are characterized by a relatively sand-rich northern section (north of Redfish Point) and a sand-starved southern section that extends south to Breton Island (**figures 3-13** and **3-14**).

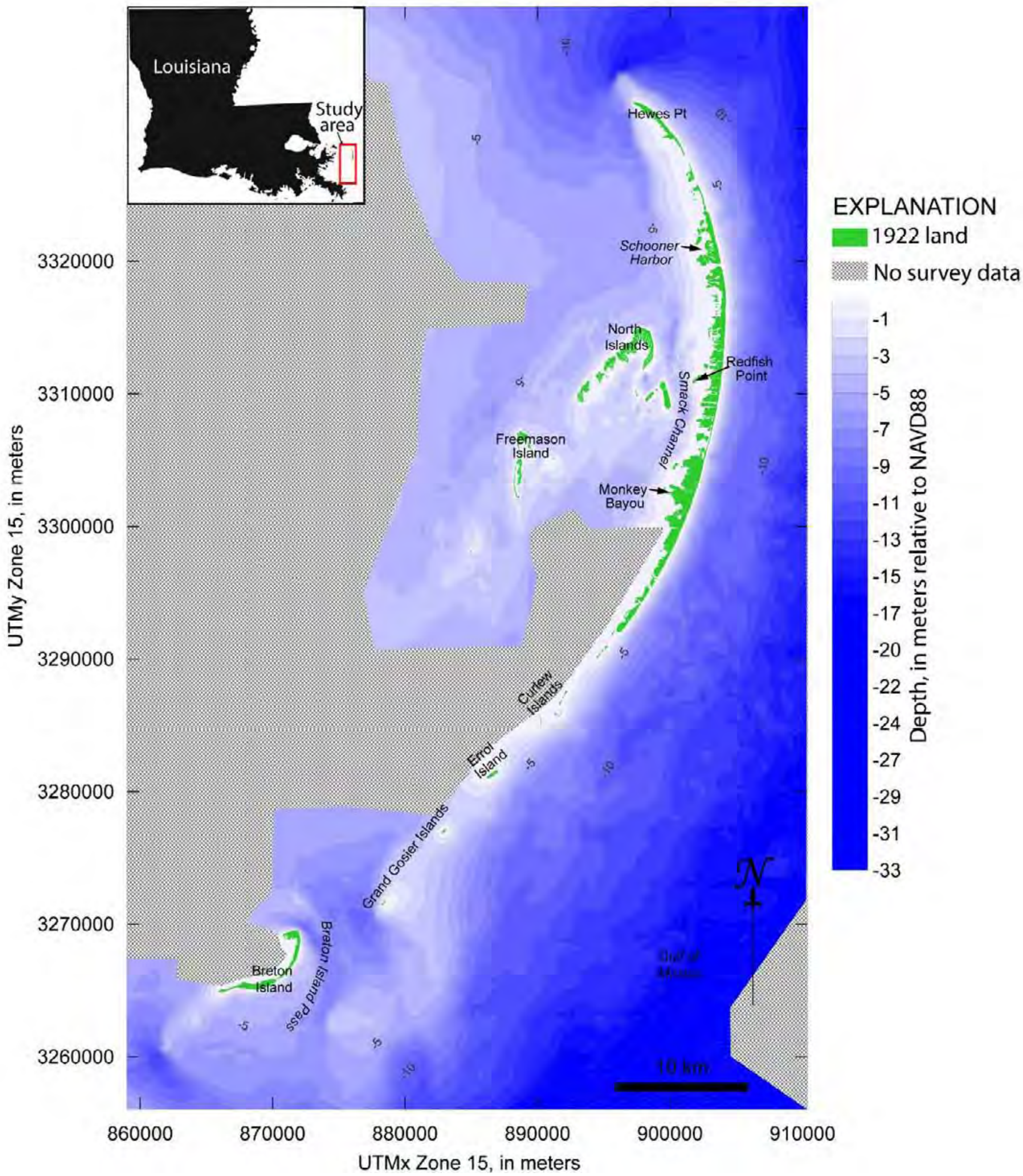
In 1904, the island chain became the Nation's second wildlife refuge, Breton National Wildlife Refuge (URL http://www.fws.gov/breton/) and in 1975, it became part of the National Wilderness Preservation System. The islands have been home to wildlife, a lighthouse station (destroyed by Hurricane Katrina), a quarantine station, a small fishing village, and even an oil-production facility.



SOURCE: Dreher, Flocks and Lavoie, December 2007

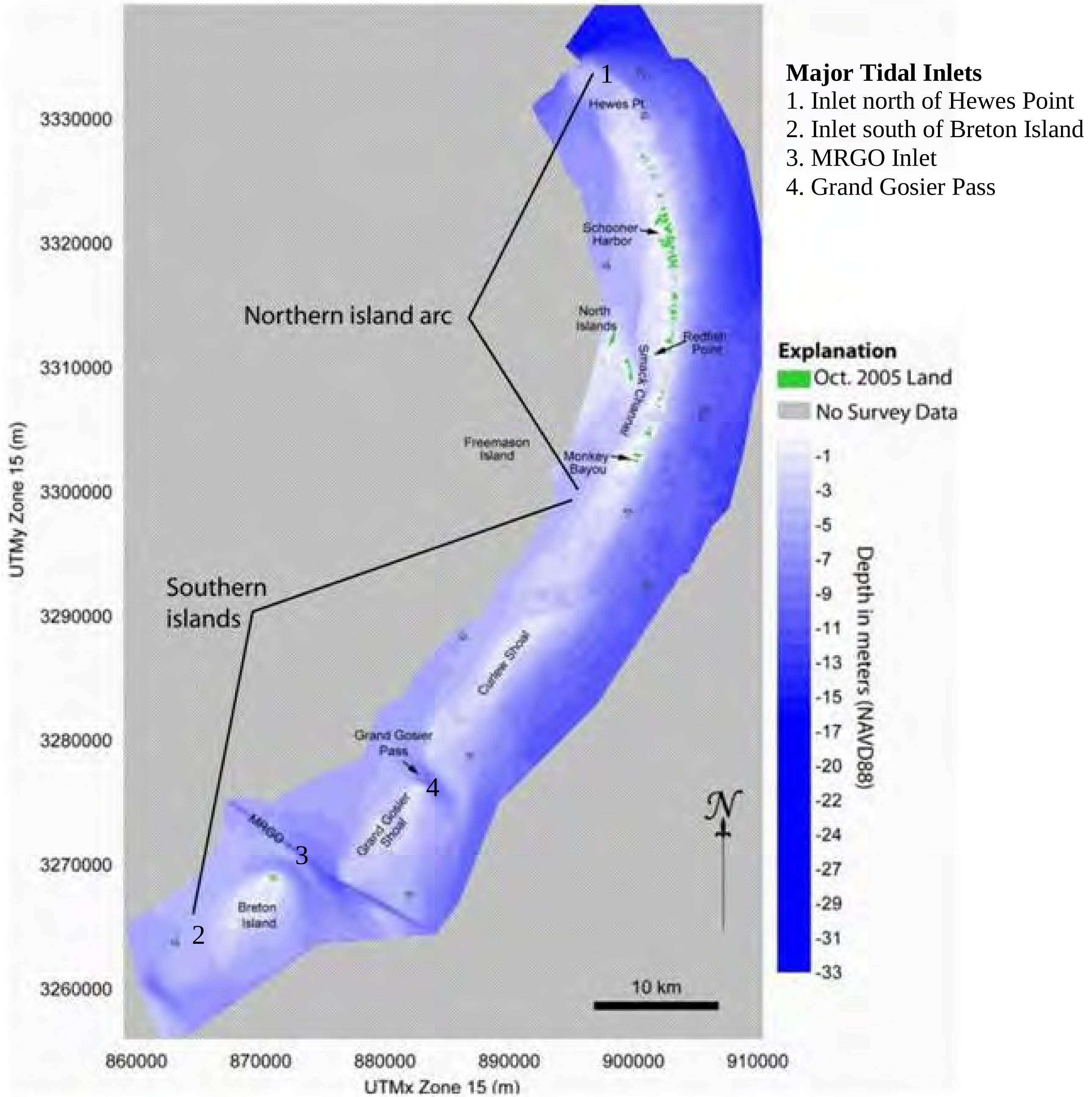
Figure 3-12: Chandeleur Islands, Breton Island, and Breton Sound

This section is primarily based on findings and discussions presented in two studies: *Sand Resources, Regional Geology, and Coastal Processes of the Chandeleur Islands Coastal System — an Evaluation of the Resilience of the Breton National Wildlife Refuge* (Lavoie, 2009), a study conducted by the USGS and the University of New Orleans-Pontchartrain Institute for Environmental Sciences (UNO-PIES) and funded by the U.S. Fish and Wildlife Service; and, *MRGO Ecosystem Restoration Feasibility Study, Chandeleur and Breton Islands* (December 2009; revised April 2010) conducted by Coastal Planning & Engineering, Inc. and the UNO-PIES and funded by USACE.



SOURCE: Miner, Kulp, Weathers and Flocks, 2009

Figure 3-13: Shoreline Configuration and Bathymetry for the 1920s



SOURCE: Miner, Kulp, Weathers and Flocks, 2009

Figure 3-14: Shoreline Configuration and Bathymetry for 2005

3.13.2 Shoreline Changes: History and Storm Impacts

The Chandeleur Islands were produced by marine reworking of seaward portions of abandoned Mississippi River delta lobes beginning approximately 1,800 years ago; a process dominated by lateral spit accretion downdrift from a central deltaic headland sediment source. Lateral transport along the Chandeleurs has produced up to a 33-foot thick spit platform deposit and a series of relict recurved spits that today are overlain by back-barrier marsh. During island landward retreat (approximately 50 feet/year from 1855-2008), sands from the subsurface relict spit deposits are liberated in the nearshore, providing a local sand source to the active littoral system. Where barrier marshes overlie relict deltaic or lagoonal muds instead of relict sandy spits, shorelines are sand-starved, and island disintegration rates are highest.

The long-term reduction in barrier island sand volume (a trend that was accelerated by Hurricane Katrina) inhibits the islands from maintaining subaerial exposure by means of landward transfer of sand by overwash processes and subsequent colonization of overwash deposits by back-barrier marsh vegetation. During the past two decades, landward transfer of sand has been limited to post-storm recovery periods and is facilitated by: (1) landward migration of offshore bars that weld to marsh islets, (2) recurved spit formation at hurricane-cut inlets, (3) aeolian processes constructing dunes wind tidal flats, and (4) shoal aggradation and landward migration. In their present state, the islands are sediment-starved, and these recovery processes appear to have exhausted most of the available sand supply, limiting further recovery.

According to the USGS, there is a transition from relatively sediment-rich barriers (1855 to 1922) that built new land in the back-barrier by overwash, flood tidal delta, and recurved spit formation to sediment-starved barriers that no longer build new back-barrier land and begin to thin in places (1922 to 2005). Once the thinning has reached the point where no back-barrier marsh exists, the barriers cross the transgressive submergence threshold. They become mobile sand bodies that migrate landward through a cycle encompassed by storm destruction that is typically followed by emergence landward of their former positions during calm weather.

The northern Chandeleur Islands have been in a constant state of shoreline retreat and decreasing island area during the past century. There have been two periods of time when a temporary reversal of the shoreline erosion trend occurred: 1) between 1965 (post-Hurricane Betsy) and 1969 (pre-Hurricane Camille) when the shoreline moved seaward; and 2) between 2002 and 2004 recovery period following Hurricane Georges in 1998 and prior to the impacts of Hurricane Ivan in late 2004 (Lavoie, 2009).

The southern Chandeleur Islands are ephemeral barrier islands undergoing early stages of transgressive submergence and conversion to an inner shelf shoal. Storm intensity and frequency are the major controls on island/shoal evolution. The islands are destroyed and converted to submerged shoals during period of high storm frequency and historically have emerged and naturally rebuilt as relatively robust barrier shorelines during extended periods of calm weather. Curlew and Grand Gosier Islands recovered from complete destruction between 1969 (post Hurricane Camille) and 1998 (pre Hurricane Georges) resulting in the development of backbarrier marsh, mangrove swamp, and submerged seagrass beds landward of the islands. The submergence of the southern islands and subsequent reemergence at a location landward of their pre-storm positions result in the landward translation of the entire barrier island (Lavoie, 2009).

The most significant shoreline damage was from Hurricane Katrina in 2005 when sand from the islands' marsh platforms along the entire island chain were stripped and exposed to waves. For over 50 percent of the shore, the marsh platforms continued to erode rapidly. The massive reduction in land cover at the Chandeleur Islands is exhibited in **figure 3-13** and **figure 3-14**. The eroded conditions have not changed since Hurricane Katrina.

3.13.3 Tidal Inlets

A tidal inlet is a shore-perpendicular channel along a barrier shoreline that cuts through a barrier island and connects the gulf with bays, lagoons, marsh, and tidal creeks (Brown, 1928; Escoffier, 1940; Davis and Fitzgerald, 2004). Tidal currents maintain the inlet channel by flushing sediment that is transported alongshore by waves. There are four large tidal inlets responsible for the majority of tidal exchange between the Gulf of Mexico and the Chandeleur/Breton Sound and numerous (greater than 60) ephemeral hurricane-cut inlets along the northern island arc.

The major tidal inlets in the Chandeleur Islands system are the channels that flank the terminal spits of the barrier arc and include the inlet north of Hewes Point and an inlet that is south of Breton Island (see **figure 3-14**). These two flanking channels are responsible for the majority of tidal flow into and out of Chandeleur and Breton Sounds (Hart and Murray, 1978). The north inlet extends from the back-barrier and curves around Hewes Point, where maximum channel depths are greater than 50 feet. Lateral spit accretion towards the north at Hewes Point has forced a northerly migration of this inlet.

The inlet at the southern extent of the Chandeleur Islands located south of Breton Island has migrated south and undergone considerable infilling. Strong tidal currents flow through this broad channel.

The MRGO intersects the Chandeleur Islands just north of Breton Island and was cut through the existing tidal inlet of Breton Island Pass (**figure 3-14**). Although the natural inlet configuration was downdrift-offset (the inlet channel was oriented to the south in an alongshore direction), the MRGO trends perpendicular to the shoreline. The MRGO construction did not result in the abandonment of the natural channel in favor of the engineered one, and both channels remained open. The MRGO required frequent maintenance dredging to remove sand before being decommissioned in 2008. Strong tidal currents flow through the MRGO because it is a major conduit for tidal exchange for much of the Lake Pontchartrain Basin.

Grand Gosier Pass is a natural tidal inlet located between Curlew and Grand Gosier Shoals and trends perpendicular to the shoals (**figure 3-14**). This inlet was not present on the 1870s bathymetric charts, but by 2007 had scoured to a depth of greater than 30 feet. The date of inlet formation is not known, but the inlet is denoted on navigational charts dating to the 1950s (McBride et al., 1992). An ebb tidal delta has developed here as indicated by a seaward excursion of the 10-foot contour offshore of Curlew Shoal since the 1870s.

Historically, numerous ephemeral hurricane-cut inlets along the barrier chain have been active for several years after a storm impact and then fill in to form a continuous barrier shoreline along the northern arc during extended periods of calm weather (Kahn, 1986). Since Hurricane Katrina, more than 60 hurricane cut tidal inlets have remained open. Based on the 2006 bathymetric surveys, widths range from approximately 250 to 10,000 feet and maximum depths exceed 10 feet.

3.13.4 Spits

A spit is a sandy ridge attached to land at one end and terminating in open water at the other (Evans, 1942). Spits are built by lateral accretion of sand due to wave-induced transport. Spits accrete laterally over the subaqueous spit platform, which progrades ahead of the subaerial spit. Seasonal variations in wave approach and the refraction of waves bending around the spit end often form a hook-shaped recurved spit that extends into the back-barrier. Lateral accretion of a terminal spit (at the end of a barrier island) usually results in development of a thick sand body because the leading edge of the prograding spit fills a relatively deep inlet channel. Hewes Point is the terminal spit system at the northern end of the Chandeleur Islands and is prograding, due to northerly longshore transport, into the marginal deltaic basin that flanks the St. Bernard Delta Complex.

3.13.5 Barrier Shoals

The barrier shoals that occur along the Chandeleur Islands are present in the southern portion south of Monkey Bayou and include Curlew and Grand Gosier Shoals (formerly Curlew Island and Grand Gosier Island). These are actually ephemeral barrier islands that are destroyed during storms and reemerge during extended fair weather periods (Otvos, 1981; Penland and Boyd, 1985; Fearnley et al., 2009; Miner et al., 2009d). Recent increased storm frequency and a decrease in sediment supply has inhibited island emergence since Hurricane Katrina (Fearnley et al., 2009). The same factors leading to submergence and inhibiting reemergence have also forced other historically more stable portions of the Chandeleur Islands into ephemeral island/shoal mode.

3.13.6 Back-Barrier Platform, Habitat and Submerged Aquatic Vegetation

Over the years, the islands have provided sanctuary for endangered wildlife species that seasonally inhabit them. In addition, they have supported vital habitats such as submerged aquatic vegetation (SAV) and back-barrier salt marshes by reducing wave energy and allowing shallow water habitats to exist over large, shallow expanses (Hester, Spalding and Franze, Spring 2005). The northern island arc (north of Monkey Bayou) is backed by a broad (maximum width about 1.5 miles), sandy platform that averages about 3 to 6 feet in depth (Miner et al., 2009c) and is blanketed by SAV (Porrier and Handley, 2006; Bethel and Martinez, 2008). Storm-generated flood tidal deltas have formed landward of deeper hurricane-cut inlets. The back-barrier platform is intersected by channels that were scoured during storms. Coastal SAV meadows that are critical habitat for juvenile aquatic species, sea turtles, Florida Manatee, and wintering migratory waterfowl in the northern Gulf of Mexico are rapidly declining (Byron and Heck, 2006; Poirrier and Handley, 2006; Michot et al., 2008).

3.13.6.1 Plant Communities

The Chandeleur Islands are an important and dynamic component of the coastal landscape with plant assemblages ranging from terrestrial dune habitats to swales and intertidal back-barrier marshes. They also offer unique, isolated habitats and support species and communities that are not found along the rest of the Louisiana Gulf mainland shoreline. Without vegetation, barrier islands can be harsh environments with wind-blown sand, salt spray and soils with low nutrients. Currently, the presence of vegetation protects the islands from both high wind and wave energy and allows for the formation of protective dunes. Subsequently, dune vegetation serves to reduce wind velocity, causing sand deposition, which in turn stimulates plant growth leading to additional dune creation. This loop process facilitates other barrier plant communities and lends to the structural and protective role that barrier islands play in the estuarine ecosystem (Hester, Spalding and Franze, Spring 2005).

3.13.6.2 Wildlife and Habitat Associations

Among myriads of coastal creatures, most of Louisiana's T&E coastal species such as sea turtles, brown pelicans, piping plovers, and Gulf sturgeon rely on barrier island habitat for survival. The elimination of barrier islands because of erosion, lack of sedimentation from rivers, and vegetation necessary for the formation of protective dunes clearly pose a risk to these species. These plant and animal species thrive on the delicate balance of wave energy influence, salinity, marshland, and other factors and conditions that exist in the Chandeleur Islands.

Ten Federally T&E species found in coastal Louisiana are strictly dependent on the sheltered conditions from barrier islands for their survival. Of these, the loggerhead sea turtle (*Caretta caretta*) is the only sea turtle known to nest in Louisiana with the female turtles selecting high-energy beaches on barrier strands adjacent to continental landmasses. The Chandeleur Islands contain the only such nesting sites in Louisiana (O'Connell, Franze, Spalding and Poirrier, Spring 2005).

In addition to supporting T&E species, the Chandeleur Islands also serve as a stopover for migratory birds and a shelter to plant life and SAV. They also provide a barrier that reduces the wave and wind action from the frequent storms and hurricanes protecting the wetland resources on the islands as well as estuaries, habitat and populated communities on the mainland Louisiana coastline.

3.13.6.3 Submerged Aquatic Vegetation

SAV adjacent to the Chandeleur Islands is composed of seagrass beds/seagrass meadows. Seagrass is dependent upon the calm, shallow bays provided by islands. Seagrasses are important in stabilizing shoals on the bay side of the islands. Seagrass species at the Chandeleurs include turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*), shoal grass (*Halodule wrightii*), star grass (*Halophila engelmanii*), and wigeon grass (*Ruppia maritima*) (Porrier and Handley, 2006). The northern Chandeleur Islands provide a relatively pristine seagrass habitat due to their distance from pollution sources and high turbid water such as Biloxi, Mississippi, the mouth of Pearl River, and passes of Lake Pontchartrain. The southern Chandeleur chain does not support significant seagrass meadows due to high freshwater, plant nutrients, and turbidity levels from the Mississippi River and by the constantly changing morphology of the southern islands. These seagrass beds are extremely resilient to hurricanes and recover rapidly after storms when destroyed; however, the occurrence, distribution and abundance of seagrass at the Chandeleur Islands is directly related to the presence of a fronting barrier island (Poirier and Handley, 2006; Bethel and Martinez, 2008). The island dissection and rapid land loss associated with Hurricane Katrina has resulted in decreased suitable conditions for the seagrass colonization (Bethel and Martinez, 2008).

Seagrass meadows provide important physical benefits to the stability of the Chandeleur Islands by baffling water flow and reducing wave energy and current velocity (Koch et al., 2006; Chen et al., 2007). This process results in back-barrier sediment trapping (vertical accretion) and protection of back-barrier marsh shorelines from wave attack in Chandeleur Sound. The latter is important at the Chandeleurs because of the large fetch distance across Chandeleur Sound, especially during the passage of winter cold fronts.

3.13.7 Sediment Dynamics

With regard to longshore sediment transport, the arcuate barrier island trend is characterized by a bidirectional system with material moving from the central arc to the flanks. The nodal point is in the central portion of the Chandeleurs. Typically, south of this point, the longshore current is directed southwards, and north of the point, longshore currents are directed northwards. The seasonal variations in wind dominance cause an imbalance in transport gradients through time by forcing higher rates of transport potential in a northward direction (Georgiou and Schindler, 2009). Significant wave heights along the northern portion of the barrier have a peak of 1.5 feet based on a 25-

year hourly average. Significant wave heights in excess of 3.3 feet occur approximately 4 percent of the year and greater than 6.6-foot waves have a return period of less than one percent (Georgiou and Schindler, 2009). Net longshore transport rates north of the nodal point that are directed northwards have rates increasing away from the nodal point toward the flanks reaching values greater than 144,000 cubic yards/year (Georgiou and Schindler, 2009). Transport rates south of the nodal point that are generally directed to the south have potential rates reaching about 150,000 cubic yards/year (Georgiou and Schindler, 2009).

Under non-storm conditions, significant sediment transport is restricted to the upper shoreface, landward of the 16-foot isobath (Penland and Boyd, 1981); however, recent studies along Louisiana barrier islands demonstrate that storm-associated seafloor scour and transport occurs at depths greater than 50 feet (Miner et al., 2009a; 2009b; Allison et al., 2007). Recent observational and numerical modeling studies suggest that storm wave-induced currents play a major role in sediment transport within the lower shoreface zone and inner continental shelf off of Louisiana coast (Jaffe et al., 1997; Teague et al., 2006; Miner et al., 2009a; Georgiou and Schindler, 2009b).

3.14 COASTAL VEGETATION RESOURCES

Coastal vegetation resources are institutionally significant because of the Coastal Barrier Resources Act of 1982; Coastal Zone Management Act of 1972; Emergency Wetlands Resources Act of 1986; Estuary Protection Act of 1968; Fish and Wildlife Conservation Act of 1980; the Fish and Wildlife Coordination Act of 1958, as amended; Migratory Bird Conservation Act; Migratory Bird Treaty Act (MBTA); Endangered Species Act of 1973; MSA; NEPA of 1969; the North American Wetlands Conservation Act; the Water Resources Development Acts of 1976, 1986, 1990, and 1992; CWA; EO 11990 Protection of Wetlands; and EO 13186 Migratory Bird Habitat Protection. Coastal vegetation resources are technically significant because they are a critical element of coastal habitats. In addition, coastal vegetation resources serve as the base of primary productivity, contribute to ecosystem diversity, provide habitat for fish and wildlife, and are an indicator of the health of coastal habitats. Coastal vegetation resources are publicly significant because of the high priority that the public places on their aesthetic, recreational, and commercial value. Overall, plant communities provide protection against substrate erosion and contribute food and physical structure for cover, nesting, and nursery habitat for wildlife and fisheries. Continued degradation and loss of existing wetland areas, in concert with truncation of replenishing processes, will accelerate decline in the interdependent processes of plant production and vertical maintenance necessary for a stable ecosystem.

The USFWS, in a letter dated October 31, 2008, (**appendix B**), formally requested that significant fish and wildlife resources and important habitats be fully considered and addressed in the DEIS including: emergent marsh, SAV, and shallow open water habitats. The Department of Commerce – National Marine Fisheries Service (NMFS), in a letter dated October 27, 2008, (**appendix C**), indicated that in addition to being designated as essential fish habitat (EFH), the water bodies and wetlands in the study area provide nursery and foraging habitat supportive of a variety of important marine fishery species.

Coastal wetlands, as well as nearshore marine and estuarine habitat, are the nursery grounds for the entire marine food chain in the Gulf of Mexico. Numerous species of marine flora and fauna begin their life cycles in these wetland, marine, and estuarine habitats. Pollution, development, and other factors are destroying and degrading these habitats throughout the Gulf of Mexico region. As these habitats are destroyed, species that form the base of the food chain are depleted. Ultimately, the entire Gulf of Mexico ecosystem is threatened by the accelerated destruction of these habitats. Failure to address the loss of these habitats threatens the long-term health of the entire ecosystem.

Coastal wetlands include swamps, tidal flats, coastal marshes, and bayous. They form sheltered coastal environments often in conjunction with river deltas, barrier islands, and estuaries. Coastal wetlands are rich in wildlife resources and provide nesting grounds and important stopovers for waterfowl and migratory birds, as well as spawning areas and valuable habitats for commercial and recreational fish. The intertidal and subtidal bottoms of coastal wetland habitats are populated by diverse benthic communities. The structure of the benthic communities is dependent upon several physical characteristics such as substrate composition, vegetative types, salinity, water temperature, and water depth. According to the National Coastal Condition Report II (2005), Gulf Coast estuaries are among the most productive natural systems producing more food per acre than the most productive Midwestern farmland and are second only to Alaska for domestic landings of commercial fish and shellfish.

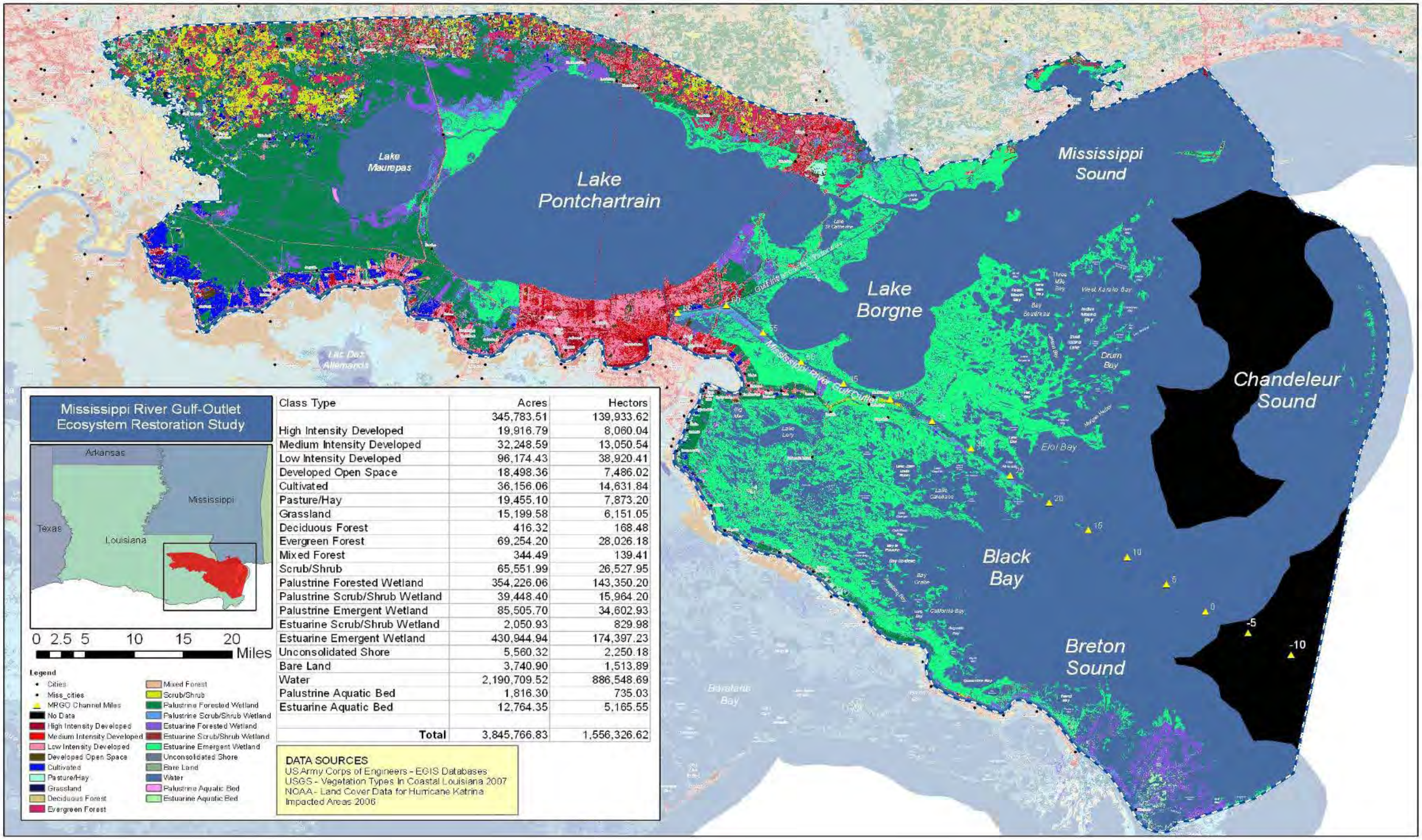
3.14.1 Land Cover

The study area encompasses approximately 3.8 million acres. Land cover within the study area is shown in **figure 3-15**. The vegetation classification descriptions and acreage within the study area are described in the following sections and can be found in **figure 3-16**.

3.14.2 Wetland Vegetation

Wetland vegetation is adapted to withstand long-term inundation and saturated, oxygen-depleted soils. Wetlands within the study area are comprised of palustrine (or freshwater) and estuarine (or saltwater) wetlands. These are further divided into forested, shrub/scrub, and emergent wetlands. Unconsolidated shores are also included as wetlands. There is over 912,000 acres of wetlands within the study area comprised of:

a. Palustrine Forested Wetland = 354,226 acres
b. Palustrine Scrub/Shrub Wetland = 39,448 acres
c. Palustrine Emergent Wetland = 85,505 acres
d. Estuarine Scrub/Shrub Wetland = 2,050 acres
e. Estuarine Emergent Wetland = 430,944 acres



Class Type	Acres	Hectors
	345,783.51	139,933.62
High Intensity Developed	19,916.79	8,060.04
Medium Intensity Developed	32,248.59	13,050.54
Low Intensity Developed	96,174.43	38,920.41
Developed Open Space	18,498.36	7,486.02
Cultivated	36,156.06	14,631.84
Pasture/Hay	19,455.10	7,873.20
Grassland	15,199.58	6,151.05
Deciduous Forest	416.32	168.48
Evergreen Forest	69,254.20	28,026.18
Mixed Forest	344.49	139.41
Scrub/Shrub	65,551.99	26,527.95
Palustrine Forested Wetland	354,226.06	143,350.20
Palustrine Scrub/Shrub Wetland	39,448.40	15,964.20
Palustrine Emergent Wetland	85,505.70	34,602.93
Estuarine Scrub/Shrub Wetland	2,050.93	829.98
Estuarine Emergent Wetland	430,944.94	174,397.23
Unconsolidated Shore	5,560.32	2,250.18
Bare Land	3,740.90	1,513.89
Water	2,190,709.52	886,548.69
Palustrine Aquatic Bed	1,816.30	735.03
Estuarine Aquatic Bed	12,764.35	5,165.55
Total	3,845,766.83	1,556,326.62

Figure 3-15: Land Cover in Study Area

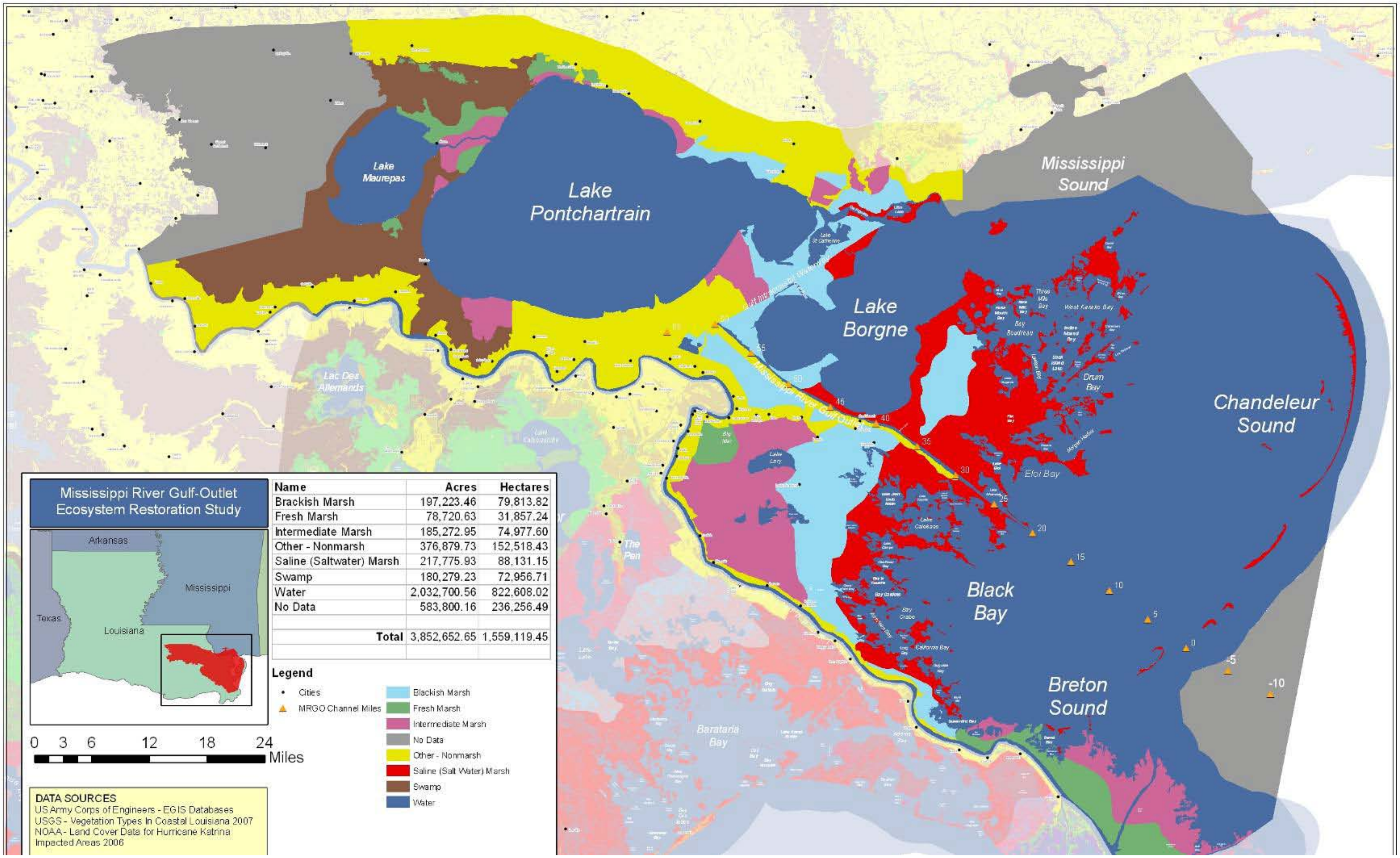


Figure 3-16: Vegetation Types

3.14.3 Plant Community Types

The Louisiana and Mississippi coastal vegetative landscapes are characterized by a diversity of plant communities that have been previously classified and mapped according to major association or type (Penfound and Hathaway, 1938; O'Neil, 1949; Chabreck et al., 1968; Chabreck, 1970, 1972b; Cowardin et al., 1979; Chabreck and Linscombe, 1978, 1988; Visser et al., 1998, 1999, 2000; Omnerik, 1986; and Chabreck et al., 2001).

These habitats are strongly influenced by the salinity regime of the surface water. Historically, the habitats were maintained by freshwater introduced through rivers, such as the Mississippi River, and other natural water sources. The construction of flood protection levees has limited the flow of freshwater into the marsh, while the construction of canals has allowed intrusion of saltwater into the estuary. These and other changes have resulted in an unnatural shift of habitats inland. Soils may be highly organic and prone to settlement. Each plant species adapts to a range of environmental conditions, and those species that are adapted to similar conditions form communities or associations that are best able to grow and successfully compete for a particular site.

In habitats within a narrow range of physical conditions, such as those with extreme salinity, species diversity is reduced. Since the source of saltwater in coastal Louisiana and Mississippi is the Gulf of Mexico, salinity levels exist along a gradient, which declines further inland. Plant species richness increases from saltwater to freshwater marshes and dominance decreases (Gosselink, 1984). Salinity predominantly drives the change in vegetation types among fresh, intermediate, brackish, and saline habitats.

Below are descriptions of the major plant community types within the study area along with approximate acreages. The community types are based on the classification scheme developed by the USGS.

3.14.3.1 Swamp (0-3 ppt Salinity) – 180,279 Acres

Swamps in the study area are dominated by bald cypress (*Taxodium distichum)* and water tupelo (*Nyssa aquatica*), which have regenerated since extensive logging of virgin forest more than 70 years ago. The Louisiana swamps generally lack a mature canopy as was present in the forests before logging occurred and have lower productivity where isolated from riverine influences (Shaffer et al., 2003). The greatest potential to restore and sustain coastal forests is near the Mississippi River where freshwater reintroductions may be implemented. Other local sources of freshwater may be municipal wastewater or storm water. Economically important natural resources associated with these swamps include fisheries of crawfish *(Procambarus clarkii)*, blue catfish (*Ictalurus furcatus*), and channel catfish (*Ictalurus punctatu*s), as well as logging.

3.14.3.2 Freshwater Marsh (0-3 ppt Salinity) – 78,720 Acres

Fresh marsh has the highest plant diversity of all the coastal habitat types including as many as 93 species. Productivity is higher in freshwater marshes than forested swamps. In the fresh marsh the dominant plant species are maidencane (*Panicum hemitomon*), arrowhead (*Sagittaria falcate*), spikerush (*Eleocharis* spp.), and alligatorweed (*Alternanthera philoxeroides*). Floating and submerged aquatic plants are common and are significant for waterfowl. Freshwater and intermediate marshes contain SAV such as pondweed (*Potamogeton pectinatus*), southern naiad (*Najas guadalupensis*), coontail (*Ceratophyllum demersum*), and wild celery (*Vallisneria americana*). Dense mats of submerged aquatic vegetation harbor very large concentrations of macroinvertbrates, such as damselfly and dragonfly nymphs, midges, beetles, aquatic worms, snails and crawfish. These are all rich protein sources for migrating waterfowl. The amount and type of submerged aquatic vegetation is dependent on the salinity level.

Economically important natural resources include fisheries of crawfish, blue catfish, and channel catfish. Waterfowl hunting and largemouth bass (*Micropterus salmoides*) fishing are important recreational activities.

Portions of the these freshwater systems have been designated as critical habitat for the threatened Gulf sturgeon (*Acipenser oxyrinchus desotoi*), an anadromous fish that use both the Pearl and Pascagoula River systems for staging, spawning, migration routes, and feeding. The juvenile Gulf sturgeon may spend several years upriver before migrating to the ocean. This valuable habitat is important for survival of the species.

The freshwater marsh serves as havens for shrimp, crabs, and other invertebrates during periods of drought, which cause higher salinity within the estuary and salt marshes.

Many species of waterfowl and other avian species use these freshwater systems. They are important components of the Central and Mississippi Flyway, the direct route of migrating waterfowl (i.e. their north-south route). Many avian species use coastal Louisiana and Mississippi as overwintering grounds and forage on the diverse invertebrates, plant roots, and tubers.

3.14.3.3 Intermediate Marsh (2-8 ppt Salinity) – 185,272 Acres

Intermediate marshes have a lower species diversity than freshwater marsh, but may have higher productivity. Dominant plant species in the intermediate marsh are saltmeadow cordgrass (*Spartina patens*) with Common reed (*Phragmites australis*), arrowhead, and waterhyssop (*Bacopa monnieri*). This habitat provides important nurseries for brown shrimp (*Farfantepenaeus aztecus*), white shrimp *(Litopenaeus setiferu*s), blue crab *(Callinectes sapidu*s), and Gulf menhaden or pogy *(Brevoortia patronu*s). Soils have very high organic content. Important species are rangia clams *(Rangia cuneata)* and Common reed. Clams are important for filtration and may compose a significant portion of the biomass in lakes or bays. Common reed is an aggressive and highly tolerant plant. Its root system is dense and resists shoreline erosion. Submerged aquatic vegetation within lakes and bays are vital to secondary productivity. Economically important natural resources include fisheries of blue crab, shrimp, catfish, and drum. Waterfowl hunting and recreational fishing are important recreational activities.

3.14.3.4 Brackish Marsh (4-18 ppt Salinity) – 197,223 Acres

Brackish marshes have the lowest plant diversity, but may be the most productive type of marsh within the study area. The dominant plant species are emergent saltmeadow cordgrass, saltgrass (*Distichlis spicata*), smooth cordgrass (*Spartina alterniflora*), needlegrass rush (*Juncus roemerianus*), and three-cornered grass (*Scirpus olneyi*). Oysters *(Crassostrea virginica*) are an exceptionally significant component of the habitat due to filtration, biomass, reef building, and commercial value. Historically, natural reefs had more vertical structure and were larger than managed oyster beds. Natural oyster reefs have generally been lost due to mining or salinity increases. Presently, oysters are located further inland and generally have little vertical reef due to harvesting practices. Economically important natural resources include several fisheries such as shrimp, blue crab, oyster, drum, mullet, and Gulf menhaden. Waterfowl hunting and recreational fishing are important recreational activities. Speckled trout, redfish, and flounder are popular sport fish.

3.14.3.5 Salt Marsh and Barrier Islands (8-29 ppt Salinity) – 231,345 Acres

Generally, salt marshes contiguous with the coast and salt marshes associated with the offshore barrier islands have high overall species diversity compared to brackish. Smooth cordgrass and saltmeadow cordgrass dominate the saline marsh with needlegrass rush, saltgrass and turtleweed (*Batis maritima*) as subdominants (Gosselink, 1984). In addition to their special ecologic value, these habitats have high aesthetic and recreational value. These habitats contain rookeries for a variety of birds including T&E species. Some islands also have true seagrasses on their bay side lagoons and provide habitat for the endangered West Indian manatee (*Trichechus manatus)* during migration.

Hancock County, Mississippi Marsh

The Hancock County Marsh is the second largest continuous marsh area in Mississippi. It is located in Western Hancock County adjacent to Louisiana along the Mississippi Sound. The Hancock County Marsh consists of extensive marshes that have suffered from lack of sediment and freshwater resulting in increased saltwater intrusion and coastal erosion. The lack of sediment has resulted in a reduction of natural accretion and marsh building. The boundary of this 13,570-acre preserve includes all of the adjoining marshlands bordering the Mississippi Sound from the Pearl River to Point Clear. This saline marsh area includes a historically significant captured relic barrier island (Campbell Island) and an Indian shell midden (Cedar Island) over 1,600 years old. Included within the marshes are several low ridges and small hummocks that are above mean high tide. Most important of these areas are Point Clear Island and Campbell Island, which are sandy areas with characteristics similar to the barrier islands. The islands of this marsh support several rare plant species including one of the rarest shrubs in the U.S., the tiny-leaved buckthorn (*Sageretia minutiflora*), found on the shell midden. The marsh area is also well-known for an abundance of waterfowl.

The largely mesohaline area of Bayou Caddy and Point Clear Island consists of a mosaic of elevation zones bordering both sides of old dune/ridge systems (Point Clear Island and Campbell Island to the west) that are forested (pines, cedar, oak). The Pearl River and associated river swamp are freshwater tidal with bald-cypress, blackgum (*Nyssa sylvatica* var *biflora),* and water tupelo balancing the swamp canopy. This area is experiencing saltwater intrusion as less freshwater inflows from the west due to extensive levee systems of the Mississippi River and smaller systems in Plaquemines Parish in coastal Louisiana. As the salt tolerance of species in the tidal marshes and seagrasses is exceeded, changes in the food web and reductions in fish and shellfish productivity occur. Also, the yield of estuarine-dependent fisheries, such as shrimp, will be influenced by the quality of the habitat over time.

3.14.4 Invasive Species

Invasive species are a major cause of the extinction of native species (second only to habitat loss). Disturbed ecosystems are more vulnerable to invasive species than stable ecosystems. Invasive plant species often increase and spread rapidly because the new habitat into which they are introduced is often free of insects and diseases that are natural controls in their native habitats. Invasive species frequently out-compete native plants and alter ecosystem function. Ecosystems vary in their vulnerability to invasion (USGS 2000).

In the study area, water hyacinth (*Eichhornia crassipes*), alligator weed (*Alternanthera philoxeroides*), hydrilla (*Hydrilla verticillata*), common salvinia (*Salvinia minima*), giant salvinia (*Salvinia molesta*), and variable-leaf milfoil (*Myriophyllum heterophylum*) are invasive aquatic vegetative species, displacing native aquatics and degrading water and habitat quality (LACPR, 2008). Chinese tallowtree and sea-side cedar (*Tamarix gallica*) interrupt natural succession of native prairie, scrub-shrub, and woody species because of their tolerance to flooding and salt stress (LACPR, 2008). Cogongrass (*Imperata cylindrica*) is a fast-growing perennial grass that is infesting Gulf coast wetlands, savannas, and forests (LACPR, 2008). Invasive species occurring in coastal vegetation within the study area are listed in **table 3-21** below:

Table 3-21: Invasive Species Occurring in Coastal Vegetation

Invasive Species	Distribution
Nutria (*Myocastor coypus*)	Louisiana and Mississippi
Water Hyacinth (*Eichhornia crassipes*)	Study Area within Louisiana
Cogon grass (*Imperata cylindrica*)	Ascension, St. James, St. Tammany, Livingston, Tangipahoa, St. Tammany, Saint Bernard, and Orleans Parishes, Louisiana, as well as Hancock and Harrison Counties, Mississippi
Chinese Tallow Tree (*Sapium sebiferum*)	Louisiana and Mississippi
Parrot Feather (*Myriophyllum aquaticum*)	Louisiana
Giant Salvinia (*Salvinia molesta*)	Mississippi
Common Reed (*Phragmites Australia*)	Louisiana and Mississippi

Nutria are large semi-aquatic rodents introduced from South America. Nutria are smaller than a beaver, but larger than a muskrat; unlike beavers or muskrats; however, nutria have a round, slightly haired tail. Nutria breed year round and are extremely prolific. Nutria live in fresh, intermediate, and brackish marsh feeding on vegetation that is vital to sustaining Louisiana's coastline. These animals consume approximately 25 percent of their weight daily. Because of the nutria's feeding habits, high population densities are damaging to wetland vegetation and further wetland loss (**figure 3-17**). Nutria predominately feed on the base of plant stems and dig for roots and rhizomes in the winter. Their grazing can strip large patches of marsh, and their digging overturns the marsh's upper peat layer.

Imported from fur farms, nutria were released in the Louisiana marshes in the 1930s. In the late 1940s, nutria were promoted as biological agents for controlling aquatic weeds, primarily water hyacinth, and were transplanted throughout southeastern Louisiana. In 1965, nutria were added to the protected wildlife list as nutria furs were promoted as a natural resource.

The 1980s aerial surveys confirmed coastal marshes, particularly southeastern marshes, were being damaged by nutria. The Louisiana Department of Wildlife and Fisheries (LDWF) began more extensive aerial damage surveys in 1993. Survey results indicate that nutria damage in recent years is concentrated in the deltaic plain in southeastern Louisiana. Aerial surveys reveal an estimate of 80,000 acres of marsh damaged by nutria. This estimate is considered conservative since only the worst (most obvious) nutria eat-outs can be detected from aerial surveys.

The first coast-wide nutria herbivory survey was flown in 1998 and continued through 2001 as part of the Nutria Harvest and Wetland Demonstration Program. The Louisiana Coast-wide Nutria Control Program was introduced in 2002, and since implementation of that program, the number of impacted marsh acres has dropped to 23,141 acres.

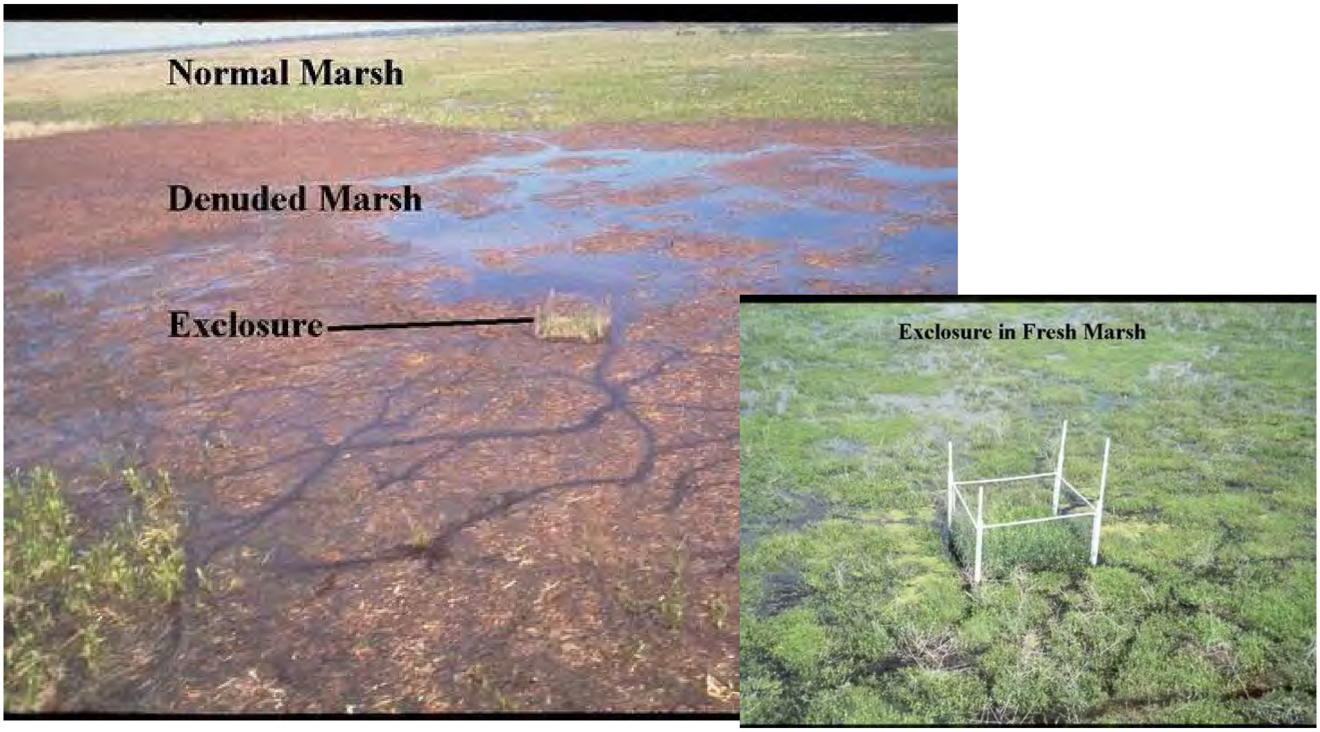


Figure 3-17: Nutria Damage in Louisiana Marsh (Louisiana Department of Wildlife and Fisheries)

Table 3-22 shows the annual totals of nutria damage sites and damaged acres documented for years 1998 to 2008 within the study area.

Table 3-22: Estimated Annual Number of Wetland Acres Damaged by Nutria

Date	Estimated Damage Acres*
1998	23,960
1999	27,356
2000	25,939
2001	22,139
2002	21,185
2003	21,888
2004	16,906
2005	14,260
2006	12,315
2007	9,244
2008	6,171

SOURCE: Louisiana Department of Wildlife and Fisheries.
*When extrapolated to a coastwide estimate, the acres impacted over these years ranges from 102,585 to 23,141 acres (damaged acres x 3.75). The 3.75 multiplication factor comes from the area actually surveyed along transect lines (0.5 miles) and the distance between transect lines (1.87 miles).

Water hyacinth (*Eischhornia crassipes*) is an aquatic plant that forms thick green mats, which fill bayous, canals, and lakes. The plant mats deplete the water body's supply of oxygen, asphyxiating fish and other aquatic organisms. The water hyacinth was first brought to U.S. as part of the 1884 Cotton Exposition held in New Orleans, when the Japanese delegation distributed several plants imported from Venezuela. In natural waterways near agricultural communities, it thrives on the constant supply of nutrients from fertilizer runoff. The water hyacinth can reproduce asexually, breaking into small pieces, which can each form a complete organism.

Cogongrass (*Imperata cylindrica*) is a fast-growing perennial grass that is infesting Gulf Coast wetlands, savannas, and forests. Considered one of the top-ten worst weeds in the world, cogongrass invades dry to moist natural areas and forms dense colonies with extensive root/rhizome systems that displace native plant and animal species. The plant was first reported in Grand Bay, Alabama in 1912. It spread through the Gulf Coast states as the seeds were distributed as packing material for Satsuma oranges. Cogongrass was also intentionally introduced in other southern states as a potential forage crop. Following the storms of 2005, cogongrass has increased its percent coverage in most of the coastal preserve systems and other areas of coastal Mississippi. Cogongrass has been recorded in parts of Louisiana (Center for Aquatic & Invasive Plants, 2000) and recently has been found to be locally abundant in a few areas (LCA, 2008).

Chinese tallowtree (*Triadica sebifera*, also referred to as *Sapium sebiferum*) because of its tolerance to flooding and salt stress, rapidly colonize higher disturbed open ground and interrupt the natural succession of native prairie, scrub shrub, and woody species. Escaped populations of Chinese tallowtree have established extensive, self-replacing monocultures that have radically altered ecosystems (USGS, 2000). Chinese tallowtree is an extremely fast-growing generalist that tolerates shade, full sun, drought, flood, and alkaline, acidic, or saline soils. Mature specimens can produce 100,000 seeds in a season, which are dispersed by moving water and many different species of birds. Prolific reproduction combined with a high germination rate and rapid growth easily leads to single species stands of the tree within 10 years. Reduction in biodiversity can have direct effects on dependent wildlife. Chinese tallow is now naturalized in all the southeastern coastal states and Arkansas.

Parrot Feather (*Myriophyllum aquaticum*) is a member of the water-foil family that prefers warmer, milder climates and is spread quickly via plant fragments through waterways and drainage systems. Its escape from cultivation through its extensive use in outdoor aquaria and water gardens has been a major factor in the spread of the plant. *M. aquaticum* is a very hardy species that is established in a wide range of aquatic habitats. It prefers nutrient rich, quiet, or slow-moving shallow waters, but can tolerate the salinity of coastal waters and emergent sections withstand routine water level fluctuations.

Giant salvinia (*Salvinia molesta*), or floating fern, occurs in still or slow-moving freshwaters including lakes, ponds, ditches, canals, or sluggish streams and rivers. Giant salvinia is native to southern Brazil/South America. Giant salvinia has been found in all Gulf Coast states, in the Atlantic coast states of Georgia, South Carolina, North Carolina, and Virginia, and in Arizona, California, and Hawaii. This fern represents a significant danger to still or sluggish freshwater systems. It is believed to have spread naturally throughout the tropics and subtropics. The ornamental trade for fish and ponds is responsible for expansion of its distribution. It consists of a free-floating rootless aquatic fern that forms dense mats. The dense mats over lakes and slow-moving rivers impede the movement of commercial and recreational watercraft, limit fishing access, may alter fisheries by preventing oxygen and light from entering water, and degrade waterside aesthetics. Following the hurricane events of 2005, the State of Mississippi experienced a rise in the colonization of this invasive species.

Common reed (*Phragmites australis*) is often found in savannahs, upper marshes, shell middens, and barrier islands. Common reed is known to have been at least an occasional wetland plant in North America for 3,000 years, so it is considered native. The concern is that it is being overtaken by a more aggressive, introduced strain of the same species. There are 27 different strains of *P. australis* recognized, so identification of the strain based on morphological characteristics can be difficult. There appears to be a Gulf Coast strain of the species that is invasive.

3.14.5 Rare, Unique and Imperiled Vegetative Communities

The following unique communities, nestled within the broader vegetative habitats, are important in that they contribute to the extensive diversity of the coastal ecosystem and are the basis for its productivity, and stability.

3.14.5.1 Marine Submerged Aquatic Vegetation Communities

Seagrass beds, or marine SAV, are vascular plants that occur in shallow, relatively clear offshore marine systems with unconsolidated substrate. The primary seagrass species present are turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*), shoal grass (*Halodule wrightii*), and widgeon grass (*Ruppia maritima*). They are currently restricted to the northern shores of the barrier islands and small patches throughout the immediate shorelines. Approximately 20,000 acres of SAV were present in Mississippi Sound prior to 1969; however, in late 1969, Hurricane Camille caused a substantial destruction of these areas (Moncrieff, 1998).

The overall distribution of SAV among Mississippi's barrier islands has also decreased considerably in the same time period following Hurricane Camille, with Cat Island losing approximately 430 acres and Ship Island losing approximately 1,280 acres. Areas of SAV along the western portion of coastal Mississippi's mainland have also declined. Buccaneer State Park is estimated to have lost about 150 acres. By 1975, vascular seagrasses had been reduced to 33 percent and algal cover had been reduced by 41 percent. Additional losses of seagrass beds from 1971 to 1975 occurred as a result of the prolonged exposure to low salinity-water during the springs and winters of those years.

Seagrasses in Mississippi Territorial Waters are threatened by the cumulative effects of both natural events and anthropogenic activities in the coastal environment. The primary factors contributing to the decline of seagrass populations in the Mississippi Territorial Waters are an overall decline in water quality, physical loss of habitat, decreased availability of light, extended periods of depressed salinity, and physical disturbances, such as tropical storms and hurricanes. Seagrass habitat loss in Mississippi Sound coincides with areas where rapid coastal erosion and massive long-term movement of sand have occurred (Moncrieff et al., 1998). Coastal development is likely to result in indirect and cumulative adverse effects on seagrass beds by contributing to elevated nutrient levels, higher sediment loads, and the introduction of contaminants leading to degraded water quality.

Increased turbidity within Mississippi Territorial Waters causes less light penetration through the water column, which results in the lack of SAV photosynthesis. Replanting seagrass beds has been found to be expensive and not always successful. It is imperative that a public outreach and awareness building campaign begin that would include signage and materials to promote recreational boat use that is compatible with these sensitive areas.

Seagrass meadows in Louisiana waters occur on shallow shoals in protected waters behind barrier islands. Seagrass meadows decrease in the western bays of Chandeleur and Curlew Islands and in the shoals near Freemason, North, and New Harbor Islands. The southern Chandeleur chain, including Breton and Gosier Islands, are nine miles (15 kilometers) to 19 miles (30 kilometers) from major passes of the Mississippi River. This chain does not support significant seagrass meadows (Poirrier & Handley, 2007).

3.14.5.2 Estuarine Submerged Aquatic Vegetation Communities

Composed primarily of water celery (*Vallisneria americana*), widgeon grass, southern naiad (*Najas guadalupensis*), and horned pondweed (*Zannichellia palustris*), these brackish SAV communities grow in sand/mud bottom substrates in shallow, protected waters with low turbidity. Activities that cause long-term increases in turbidity in the waters surrounding the beds are a serious threat to their viability. This community is ranked as imperiled by the Louisiana Natural Heritage Program.

3.14.5.3 Coastal Mangrove Thicket

Dominated by black mangrove (*Avicennia germinans*), this estuarine community has several important ecological functions - the extensive root systems stabilize shorelines and reduce erosion, provide cover and food, improve surrounding water quality by filtering nutrients and suspended sediments, and provide nesting areas for colonial water birds.

3.14.5.4 Coastal Dune Grassland

Also known as maritime grasslands, coastal dune grassland occurs on beach dunes, relatively elevated backshore areas above intertidal beaches on barrier islands and mainland shores. The frequent flooding, erosion, and shifting dune substrate constantly influence the dynamic community composition. Marsh-hay cordgrass is usually the dominant species, but saltgrass, seashore paspalum (*Paspalum vaginatum*), beach panicgrass (*Panicum amarum*), seacoast bluestem (*Schizachyrium maritimum*), and broomsedges (*Andropogon* spp.) are common associates.

The islands of Breton Sound have undergone a dramatic reduction in size. Erosion exacerbated by several major storm events has all but reduced the area to a shoal and has eliminated the original dune features that previously characterized the islands.

3.14.5.5 Live Oak Forest

Live oak (*Quercus virginiana*) forests occur principally on natural levees, ridges, or frontlands and on islands within marshes and swamps in the coastal zone of the study area. Live oak dominates the stand, but water oak (*Quercus nigra*), American elm (*Ulmus americana*), sugarberry (*Celtis laevigata*), red maple (*Acer rubrum*), and green ash (*Fraxinus pennsylvanica*) are usually prominent community members. There are only a small number of populations known to exist, and they are vulnerable to extirpation (local extinction).

3.14.5.6 Coastal Live Oak-Hackberry Forest

Also known as chenier maritime forest, this natural community formed on abandoned beach ridges primarily in southwest Louisiana, although abandoned beach ridges and stream levees in the southeast are also locally known as cheniers. Live oak and hackberry (also referred to as sugarberry) are the dominant canopy species, and other common species are red maple, sweet gum (*Liquidambar styraciflua*), water oak, green ash, and American elm. These species populate ridges composed primarily of reworked sand and shell that are normally four to five feet above sea level. Cheniers serve as natural hydrologic buffers providing some protection for the interior marshes against saltwater intrusion.

3.15 WILDLIFE RESOURCES

3.15.1 Historic and Existing Conditions

The significance of wildlife resources is demonstrated by the multitude of legislative acts that exist to manage and conserve the resource. Pivotal among these are the NEPA; the Coastal Zone Management Act; the Estuary Protection Act; the Fish and Wildlife Coordination Act of 1958, as amended; the Migratory Bird Conservation Act of 1929, as amended; the Migratory Bird Treaty Act (MBTA); the Endangered Species Act of 1973, as amended; the Fish and Wildlife Conservation Act of 1980; the North American Wetlands Conservation Act; EO 13186 Migratory Bird Habitat Protection; and the Marine Mammal Protection Act. Wildlife resources are critical elements of the coastal barrier ecosystem and important indicators of the health of coastal habitats. Wildlife resources are also important recreational and commercial resources as well and are regarded highly by the public for their aesthetic, recreational, and commercial value.

The USFWS, in a letter dated October 31, 2008, formally requested that the EIS fully consider and address significant fish and wildlife resources, including: seabirds, shorebirds, wading birds, migratory and resident waterfowl, and estuarine-dependent fishes and shellfishes (**appendix B**). In addition, USFWS requested that important habitats (such as emergent marsh, submerged aquatic vegetation, and shallow open water) also be addressed in the DEIS. The USFWS identified several T&E species and critical habitat (Gulf sturgeon and critical habitat, pallid sturgeon, piping plover and critical habitat, brown pelican, West Indian manatee, and sea turtles) of concern within the study and project areas in southern Mississippi and Louisiana. T&E species and critical habitats are addressed in **section 3.18** and **section 6.8**.

Kerlin (1979) described the wetlands of St. Bernard Parish, south of Lake Borgne, as being “second only to the marshes of the lower Mississippi River Delta in importance to waterfowl in southeastern Louisiana.” The area supported at least 250,000 ducks during the winter and was important for the production of muskrat, nutria, mink, river otter, and raccoon – all staples of the Louisiana fur industry.

Since about 1970, waterfowl and furbearers have declined in the lower sub-basin (Kerlin, 1979); however, they are still present. Alligators have also declined, but are still present (Kinler and Campbell, 2002). Birds found in the study area include nine species of wading birds, more than five species of seabirds, four species of shorebirds, six species of songbirds, and several raptor species. Game mammals present are swamp rabbit, raccoon, fox/gray squirrels, and whitetail deer. Non-game mammals include opossum, nine-banded armadillo, and several species of bats, rodents, and shrews (LCWCRTF & WCRA, 1999).

Coastal Louisiana's wetlands support millions of neotropical and other migratory avian species, such as rails, gallinules, shorebirds, wading birds, and numerous songbirds, as well as many different furbearers, rabbits, deer, and alligators. The rigors of long distance flight require most neotropical migratory birds to rest and refuel several times before they reach their final destination. Louisiana coastal wetlands provide neotropical migratory birds’ essential stopover habitat on their annual migration route. The coastal wetlands in the study area provide important and essential fish and wildlife habitats, especially transitional habitat between estuarine and marine environments, used for shelter, nesting, feeding, roosting, cover, nursery, and other life requirements.

Emergent fresh, intermediate, and brackish wetlands are typically used by many different wildlife species, including: seabirds; wading birds; shorebirds; dabbling and diving ducks; raptors; rails; coots; and gallinules; other emergent brackish marsh residents and migrants; nutria; muskrat; mink, river otter, and raccoon; rabbits; deer; and American alligator. Emergent saline marshes are typically utilized by: seabirds; wading birds; shore birds; dabbling and diving ducks; rails, coots, and gallinules; other saline marsh residents and migrants; nutria; muskrat; mink, river otter, and raccoon; rabbits; deer; and American alligator (LCWCRTF & WCRA, 1999).

Open water habitats such as Lake Borgne provide wintering and multiple use functions for brown pelicans, seabirds, and other open water residents and migrants. Open water habitats in the project area provide wintering and multiple use functions for: brown pelicans; seabirds; dabbling and diving ducks; coots, and gallinules; and other open water residents and migrants (LCWCRTF & WCRA, 1999).

The bald eagle was officially removed from the List of Endangered and Threatened Species as of August 8, 2007. However, it continues to be protected under the MBTA and the Bald and Golden Eagle Protection Act (BGEPA). Bald eagles are currently winter breeding residents in southern Mississippi and Louisiana.

The Chandeleur Barrier Island Chain is home to the world's largest concentration of Sandwich terns. These terns nest regularly on the chain and range in numbers from 50,000 to 100,000. USGS biologists estimate that the tern population on the Chandeleur Chain is 55 percent to 91 percent of the total U.S. breeding population and 34 percent to 61 percent of the entire world’s population. The barrier islands provide important habitat for 20,000 redhead ducks that winter in the area each year. Other birds found on the islands include: white and brown pelicans, gulls, terns, black skimmers, endangered piping plovers and other shorebirds and seabirds (LCWCRTF & WCRA, 1999).

Personnel from the LDWF, USFWS and NRCS provided relevant (since 1985) trends in wildlife for the 1998 Coast 2050 Study (LCWCRTF & WCRA, 1999). They assessed common wildlife in the planning subunit of the Middle and Lower Pontchartrain Basin. The study showed that populations of seabirds, shorebirds, dabbling and diving ducks, and raptors have been generally steady since 1985. Around Lake Pontchartrain, populations of furbearers, game mammals, and alligators have been in slight decline. In the lower basin, these animals have generally been decreasing since 1985. **Table 3-23** shows the status, functions of interest, trends, and projections through 2050 for avifauna, furbearers, game mammals, and reptiles within the current project area (LCWCRTF & WCRA, 1999).

Note that **table 3-23** indicates that wildlife numbers have declined in many parts of the project area. These include wading birds, shorebirds, ducks, raptors, rails, coots, gallinules, open water resident birds, open water migrant birds, furbearers, game mammals, and alligators. Many factors are likely to have affected some of the animals, but many of these factors stem from changes in habitat which are related to encroaching salinity that occurred directly or indirectly after the installation / operation of the MRGO. For example, the loss of marsh would have removed or degraded cover, food, and nesting structure. Another major factor for some of the native furbearers and game mammals has been the proliferation of the invasive nutria. Nutria typically feed on the base of plant stems, consuming large quantities of plant matter that are important for most native herbivores. Nutria also dig for roots and rhizomes in a manner that disturbs the soil/sediment (LeBlanc, 1994; USGS, 2001).

Table 3-23: Status, Functions of Interest, Trends, and Projections through 2050 for Avifauna, Furbearers, Game Mammals, and Reptiles within the Project Area (LCWCRTF & WCRA, 1999)

			Avifauna																																											
	1988 Habitat		Brown Pelican				Bald Eagle				Seabirds				Wading Birds				Shorebirds				Dabbling Ducks				Diving Ducks				Geese				Raptors				Rails, Coots, and Gallinules			
Mapping Unit	Type	% of Unit	Function	Status	Trends	Projections	Function	Status	Trends	Projections	Function	Status	Trends	Projections	Function	Status	Trends	Projections	Function	Status	Trends	Projections	Function	Status	Trends	Projections	Function	Status	Trends	Projections	Function	Status	Trends	Projections	Function	Status	Trends	Projections	Function	Status	Trends	Projections
MIDDLE PONTCHARTRAIN BASIN																																														
Lake Pontchartrain	OW	100	W	MO	I	I		NH			MU	MO	SY	SY		NH				NH			W	LO	SY	SY	W	HI	SY	SY		NH				NH			W	LO	SY	SY
North Shore Marshes	OW	27	W	MO	I	I		NH			MU	MO	SY	SY		NH				NH			W	LO	SY	SY	W	LO	SY	SY		NH				NH			W	LO	SY	SY
	IM	25		NH				NH			MU	MO	SY	SY	MU	HI	I	SY	MU	HI	SY	SY	W	LO	SY	SY	W	LO	SY	SY		NH			MU	LO	SY	SY	MU	LO	SY	SY
	BM	40		NH				NH			MU	MO	SY	SY	MU	HI	I	SY	MU	HI	SY	SY	W	LO	SY	SY	W	LO	SY	SY		NH			MU	LO	SY	SY	MU	LO	SY	SY
	HF	6		NH			NE	LO	SY	SY		NH				NH				NH			MU	LO	SY	SY		NH				NH			MU	HI	I	D		NH		
Bayou Sauvage	OW	23	W	LO	I	I		NH			MU	MO	SY	SY		NH				NH			W	MU	SY	SY	W	MO	SY	SY		NH				NH			W	MO	SY	SY
	FM	36		NH				NH			MU	LO	SY	SY	MU	HI	I	SY	MU	HI	SY	SY	W	MO	SY	SY	W	MO	SY	SY		NH			MU	LO	SY	SY	MU	MO	SY	SY
	IM	8		NH				NH			MU	MO	SY	SY	MU	HI	I	SY	MU	HI	SY	SY	W	MO	SY	SY	W	MO	SY	SY		NH			MU	LO	SY	SY	MU	MO	SY	SY
	HF	26		NH				NH				NH				NH				NH			MU	LO	SY	SY		NH				NH			MU	HI	SY	D		NE		
East Orleans Landbridge	OW	39	W	MO	I	I		NH			MU	MO	SY	SY		NH				NH			W	MO	SY	D	W	MO	SY	D		NH				NH			W	MO	SY	SY
	BM	56		NH				NH			MU	MO	SY	D	MU	HI	SY	D	MU	HI	SY	D	W	MO	SY	D	W	MO	SY	D		NH			MU	LO	SY	D	MU	MO	SY	SY
Pearl River Marsh	OW	28	W	LO	I	I		NH			MU	MO	SY	SY		NH				NH			W	MO	SY	SY	W	MO	SY	SY		NH				NH			W	MO	SY	SY
	FM	1		NH			NE	LO	SY	SY	MU	LO	SY	SY	MU	HI	I	SY	MU	HI	SY	SY	W	MO	SY	SY	W	MO	SY	SY		NH			MU	LO	SY	SY	MU	MO	SY	SY
	IM	17		NH				NH			MU	MO	SY	SY	MU	HI	I	SY	MU	HI	SY	SY	W	MO	SY	SY	W	MO	SY	SY		NH			MU	LO	SY	SY	MU	MO	SY	SY
	BM	15		NH				NH			MU	MO	SY	SY	MU	HI	I	SY	MU	HI	SY	SY	W	MO	SY	SY	W	MO	SY	SY		NH			MU	LO	SY	SY	MU	MO	SY	SY
	HF	21		NH			NE	LO	SY	SY		NH				NH				NH			MU	LO	SY	SY		NNH				NH			MU	HI	I	D		NH		
LOWER PONTCHARTRAIN BASIN																																														
Central Wetlands	OW	29	W	LO	I	I		NH			MU	HI	SY	SY		NH				NH			W	LO	D	D	W	LO	D	D		NH				NH			W	LO	D	D
	FM	5		NH				NH			MU	LO	SY	D	MU	HI	I	SY	MU	HI	SY	SY	W	LO	D	D	W	LO	D	D		NH			MU	LO	SY	SY	MU	LO	D	D
	BM	45		NH				NH			MU	HI	SY	D	MU	HI	I	SY	MU	HI	SY	SY	W	LO	D	D	W	LO	D	D		NH			MU	LO	SY	SY	MU	LO	D	D
	AU	26		NH				NH				NH			ST	LO	I	SY	MU	LO	I	SY		NH				NH				NH				NH				NH		
South Lake Borgne	OW	42	W	MO	I	I		NH			MU	HI	SY	SY		NH				NH			W	LO	D	D	W	LO	D	D		NH				NH			W	LO	D	D
	BM	24		NH				NH			MU	HI	SY	D	MU	HI	SY	D	MU	HI	SY	D	W	LO	D	D	W	LO	D	D		NH			MU	LO	SY	D	MU	LO	D	D
	SM	32		NH				NH			MU	HI	SY	D	MU	HI	SY	D	MU	HI	SY	D	W	LO	D	D	W	LO	D	D		NH				NH			MU	LO	D	D
Lake Borgne	OW	100	W	MO	I	I		NH			MU	HI	SY	SY		NH				NH				NH			W	HI	SY	SY		NH				NH				NH		
Biloxi Marshes	OW	76	W	MO	I	I		NH			MU	HI	SY	SY		NH				NH			W	MO	SY	SY	W	HI	SY	SY	W	LO	SY	SY		NH				NH		
	BM	10		NH				NH			MU	HI	SY	D	MU	HI	SY	D	MU	HI	SY	D	W	MO	SY	SY	W	MO	SY	SY	W	LO	SY	SY	MU	LO	SY	D	MU	MO	SY	SY
	SM	14		NH				NH			MU	HI	SY	D	MU	HI	SY	D	MU	HI	SY	D	W	MO	SY	SY	W	MO	SY	SY	W	LO	SY	SY		NH			MU	MO	SY	SY
Eloi Bay	OW	69	W	MO	I	I		NH			MU	HI	SY	SY		NH				NH			W	MO	SY	SY	W	MO	SY	SY	W	LO	SY	SY		NH				NH		
	BM	5		NH				NH			MU	HI	SY	D	MU	HI	SY	D	MU	HI	SY	D	W	MO	SY	SY	W	MO	SY	SY	W	LO	SY	SY	MU	LO	SY	D	MU	MO	SY	SY
	SM	20		NH				NH			MU	HI	SY	D	MU	HI	SY	D	MU	HI	SY	D	W	LO	SY	SY	W	LO	SY	SY	W	LO	SY	SY		NH			MU	MO	SY	SY
	AU	5		NH				NH				NH			ST	LO	I	SY	MU	LO	I	SY		NH				NH				NH				NH				NH		
Chandeleur Sound	OW	100	W	HI	I	I		NH			MU	HI	SY	SY		NH				NH				NH			W	MO	SY	SY		NH				NH				NH		
Chandeleur Islands	OW	87	W	HI	I	I		NH			MU	HI	SY	SY		NH				NH				NH			W	MO	SY	SY		NH				NH				NH		
	AB	8	W	HI	I	I		NH			MU	HI	SY	D		NH				NH			W	LO	SY	SY	W	MO	SY	SY		NH				NH				NH		
	SM	2	NE	HI	I	I		NH				NH				NH				NH			W	LO	SY	SY	W	MO	SY	SY		NH				NH			MU	LO	SY	SY
	BB	3	NE	HI	I	I		NH			MU	HI	SY	D		NH				NH				NH				NH				NH				NH				NH		

TYPE: OW = Open Water; BM = Brackish Marsh; SM = Salt Marsh; IM = Intermediate Marsh; FM = Fresh Marsh; HF = Hardwood Forest; AU = Agriculture/Upland; BB = Barrier Beach; AB = Aquatic Bed; **Function:** NE = Nesting; ST = Stopover Habitat; W = Wintering; MU = Multiple Use;
Status: NH = Not Historically Present; NL = No Longer Present; LO = Low Numbers; MO = Moderate Numbers; HI = High Numbers; **Trends** (since 1985) / **Projections** (through 2050): SY = Steady; D = Decrease; I = Increase; U = Unknown.

Table 3-23: Status, Functions of Interest, Trends, and Projections through 2050 for Avifauna, Furbearers, Game Mammals, and Reptiles within the Project Area (LWCRTF & WCRA, 1999) (Continued)

	1988 Habitat		Avifauna (continued)																Furbearers												Game Mammals												Reptiles			
			Other Marsh / OW Residents				Other Woodland Residents				Other Marsh / OW Migrants				Other Woodland Migrants				Nutria				Muskrat				Mink, Otter, and Raccoon				Rabbit				Squirrel				Deer				American Alligator			
Mapping Unit	**Type**	**% of Unit**	**Function**	**Status**	**Trends**	**Projections**	**Function**	**Status**	**Trends**	**Projections**	**Function**	**Status**	**Trends**	**Projections**	**Function**	**Status**	**Trends**	**Projections**	**Function**	**Status**	**Trends**	**Projections**	**Function**	**Status**	**Trends**	**Projections**	**Function**	**Status**	**Trends**	**Projections**	**Function**	**Status**	**Trends**	**Projections**	**Function**	**Status**	**Trends**	**Projections**	**Function**	**Status**	**Trends**	**Projections**	**Function**	**Status**	**Trends**	**Projections**
MIDDLE PONTCHARTRAIN BASIN																																														
Lake Pontchartrain	OW	100	MU	MO	SY	SY		NH			MU	MO	SY	SY		NH				NH				NH				NH				NH				NH				NH				NH		
North Shore Marshes	OW	27	MU	MO	SY	SY		NH			MU	MO	SY	SY		NH			MU	MO	SY	SY	MU	MO	SY	SY	MU	LO	SY	SY		NH				NH				NH			MU	MO	I	SY
	IM	25	NE	HI	SY	SY		NH			NE	HI	SY	SY		NH			MU	MO	SY	SY	MU	MO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY		NH			MU	LO	SY	SY	MU	MO	I	SY
	BM	40	NE	HI	SY	SY		NH			NE	HI	SY	SY		NH			MU	MO	SY	SY	MU	MO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY		NH			MU	LO	SY	SY	MU	MO	I	SY
	HF	6		NH			NE	HI	I	D		NH			MU	HI	SY	D	MU	LO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY
Bayou Sauvage	OW	23	MU	MO	SY	SY		NH			MU	MO	SY	SY		NH			MU	MO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY		NH				NH				NH			MU	MO	I	I
	FM	36	NE	HI	SY	SY		NH			NE	HI	SY	SY		NH			MU	MO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY		NH			MU	LO	SY	SY	MU	MO	I	I
	IM	8	NE	HI	SY	SY		NH			MU	MO	SY	SY		NH			MU	MO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY		NH			MU	LO	SY	SY	MU	MO	I	I
	HF	26		NH			NE	HI	I	D		NH			MU	HI	SY	D	MU	LO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY	MU	MO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY
East Orleans Landbridge	OW	39	MU	MO	SY	SY		NH			MU	MO	SY	SY		NH			MU	LO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY		NH				NH				NH			MU	LO	SY	SY
	BM	56	NE	HI	SY	SY		NH			MU	HI	SY	D		NH			MU	LO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY		NH			MU	LO	SY	SY	MU	LO	SY	SY
Pearl River Marsh	OW	28	MU	MO	SY	SY		NH			MU	MO	SY	SY		NH			MU	MO	SY	SY	MU	MO	SY	SY	MU	MO	SY	SY		NH				NH				NH			MU	MO	SY	SY
	FM	1	NE	HI	SY	SY		NH			MU	HI	SY	SY		NH			MU	MO	SY	SY	MU	MO	SY	SY	MU	MO	SY	SY	MU	LO	SY	SY		NH			MU	LO	SY	SY	MU	MO	SY	SY
	IM	17	NE	HI	SY	SY		NH			MU	HI	SY	SY		NH			MU	MO	SY	SY	MU	MO	SY	SY	MU	MO	SY	SY	MU	LO	SY	SY		NH			MU	LO	SY	SY	MU	MO	SY	SY
	BM	15	NE	HI	SY	SY		NH			MU	HI	SY	SY		NH			MU	MO	SY	SY	MU	MO	SY	SY	MU	MO	SY	SY	MU	LO	SY	SY		NH			MU	LO	SY	SY	MU	MO	SY	SY
	HF	21		NH			NE	HI	I	D		NH			MU	HI	SY	D	MU	LO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY	MU	LO	SY	SY
LOWER PONTCHARTRAIN BASIN																																														
Central Wetlands	OW	19	MU	MO	SY	SY					MU	LO	SY	SY		NH			MU	LO	D	D	MU	LO	D	D	MU	LO	D	D		NH				NH				NH			MU	LO	D	D
	FM	5	NE	HI	SY	SY					MU	HI	SY	SY		NH			MU	LO	D	D	MU	LO	D	D	MU	LO	D	D	MU	LO	D	D		NH			MU	LO	D	D	MU	LO	D	D
	BM	45	NE	HI	SY	SY					MU	HI	SY	SY		NH			MU	LO	D	D	MU	LO	D	D	MU	LO	D	D	MU	LO	D	D		NH			MU	LO	D	D	MU	LO	D	D
	AU	26		NH			NE	LO	I	SY					MN	LO	SY	SY	MU	LO	D	D	MU	LO	D	D	MU	LO	D	D	MU	MO	SY	SY		NH			MU	MO	SY	SY	MU	LO	D	D
South Lake Borgne	OW	42	MU	MO	SY	SY					MU	MO	SY	SY		NH			MU	LO	D	D	MU	LO	D	D	MU	LO	D	D		NH				NH				NH			MU	LO	D	D
	BM	24	NE	HI	SY	D					MU	HI	SY	D		NH			MU	LO	D	D	MU	LO	D	D	MU	LO	D	D	MU	LO	D	D		NH			MU	LO	D	D	MU	LO	D	D
	SM	32	NE	HI	SY	D					MU	HI	SY	D		NH			MU	LO	D	D	MU	LO	D	D	MU	LO	D	D	MU	LO	D	D		NH			MU	LO	D	D	MU	LO	D	D
Lake Borgne	OW	100	MU	MO	SY	SY					MU	MO	SY	SY		NH				NH				NH				NH				NH				NH				NH				NH		
Biloxi Marshes	OW	76	MU	MO	SY	SY					MU	MO	SY	SY		NH			MU	LO	D	D	MU	LO	D	D	MU	LO	D	D		NH				NH				NH			MU	LO	D	D
	BM	10	NE	HI	SY	D					MU	HI	SY	D		NH			MU	LO	D	D	MU	LO	D	D	MU	LO	D	D	MU	LO	SY	SY		NH				NH			MU	LO	D	D
	SM	14	NE	HI	SY	D					MU	HI	SY	D		NH			MU	LO	D	D	MU	LO	D	D	MU	LO	D	D	MU	LO	SY	SY		NH				NH			MU	LO	D	D
Eloi Bay	OW	69	MU	MO	SY	SY					MU	MO	SY	SY		NH			MU	LO	D	D	MU	LO	D	D	MU	LO	D	D		NH				NH				NH			MU	LO	D	D
	BM	5	NE	HI	SY	D					MU	HI	SY	D		NH			MU	LO	D	D	MU	LO	D	D	MU	LO	D	D	MU	LO	SY	SY		NH				NH			MU	LO	D	D
	SM	20	NE	HI	SY	D					MU	HI	SY	D		NH			MU	LO	D	D	MU	LO	D	D	MU	LO	D	D	MU	LO	SY	SY		NH				NH			MU	LO	D	D
	AU	5		NH			NE	LO	I	SY	MU	NH			MU	LO	SY	SY	MU	LO	D	D	MU	LO	D	D	MU	LO	D	D	MU	MO	SY	SY		NH			MU	LO	SY	SY	MU	LO	D	D
Chandeleur Sound	OW	100	MU	MO	SY	SY					MU	MO	SY	SY		NH				NH				NH				NH				NH				NH				NH				NH		
Chandeleur Islands	OW	87	MU	MO	SY	SY					MU	MO	SY	SY		NH				NH				NH				NH				NH				NH				NH				NH		
	AB	8		NH								NH				NH				NH				NH				NH				NH				NH				NH				NH		
	SM	2		NH								NH				NH				NH				NH				NH				NH				NH				NH				NH		
	BB	3	MU	MO	SY	D					MU	MO	SY	D		NH				NH				NH				NH				NH				NH				NH				NH		

TYPE: OW = Open Water; BM = Brackish Marsh; SM = Salt Marsh; IM = Intermediate Marsh; FM = Fresh Marsh; HF = Hardwood Forest; AU = Agriculture/Upland; BB = Barrier Beach; AB = Aquatic Bed; **Function:** NE = Nesting; ST = Stopover Habitat; W = Wintering; MU = Multiple Use; **Status:** NH = Not Historically Present; NL = No Longer Present; LO = Low Numbers; MO = Moderate Numbers; HI = High Numbers; **Trends** (since 1985) / **Projections** (through 2050): SY = Steady; D = Decrease; I = Increase; U = Unknown.

3.16 AQUATIC AND FISHERY RESOURCES

3.16.1 Historic and Existing Conditions

Fishery resources, including both finfish and shellfish, are institutionally, ecologically, and publicly important. They are institutionally important because of the Fish and Wildlife Coordination Act of 1958, as amended; Endangered Species Act of 1973; MSA, as amended; Magnuson-Stevens Act Reauthorization of 2006; Coastal Zone Management Act; and Estuary Protection Act. They are ecologically important because they occupy various trophic levels in the aquatic environment. They are publicly important because of the high priority placed on their aesthetic, recreational, and commercial value.

The NMFS oversees and manages our Nation's domestic fisheries through development and implementation of fishery management plans and actions. The Magnuson-Stevens Act (first enacted in 1976, amended in 1996, and reauthorized in 2006) is the primary law governing marine fisheries management in United States Federal waters to end overfishing, promote market-based management approaches, improve science, serve a larger role in decision-making, and enhance international cooperation.

Major water bodies within the study area include Lake Maurepas, Lake Pontchartrain, Lake Borgne, Breton Sound, Chandeleur Sound, and Mississippi Territorial Waters. By letter dated October 27, 2008, the NMFS indicated that these water bodies and adjacent wetlands provide nursery and foraging habitats which support varieties of economically important marine fishery species, including striped mullet (*Mugil cephalus*), Atlantic croaker (*Micropogonias undulatus*), Gulf menhaden (*Brevoortia patronus*), spotted and sand sea trout (*Cynoscion nebulosus* and *C. arenarius* respectively), southern flounder (*Paralichthys lethostigma*), black drum (*Pogonias cromis*), and blue crab (*Callinectes sapidus*). Some of these species also serve as prey for other fish species managed under the Magnuson-Stevens Act by the Gulf of Mexico Fishery Management Council (GMFMC) (e.g., mackerel, snapper, and grouper) and highly migratory species managed by NMFS (e.g., billfish and shark).

The existing emergent wetlands and shallow open water within the project area provide important habitat and EFH, including transitional habitat between estuarine and marine environments used by migratory and resident fish, as well as other aquatic organisms for nursery, foraging, spawning, and other life requirements. Historically and currently, the area provides valuable recreational and commercial fishing habitat, oyster culture, and nursery areas for a wide variety of finfish and shellfish (Rounsefell, 1964; Penland et al., 2002).

3.16.1.1 Mississippi Territorial Waters

Large amounts of freshwater empty into Mississippi Territorial Waters from the east by the Pascagoula and Alabama Rivers, from the west by the Pearl River and to an extent, the Mississippi River further west. Several nutrient-rich freshwater coastal streams and rivers, such as the Wolf, Biloxi, and Tchoutacabouffa Rivers, empty into Mississippi Territorial Waters between the Pascagoula and Pearl Rivers, providing great productivity.

Recent studies have determined that, of the approximate 1,200 species of fish found within the northern Gulf of Mexico, excluding the southern Florida reef habitats, almost 400 species are found on the Mississippi-Alabama Continental Shelf. Prime habitat is provided within Mississippi Territorial Waters for various life stages of red snapper (*Lutjanus campechanus*), tuna (*Thunnus* spp.), red drum (*Sciaenops ocellatus*), Spanish mackerel (*Scomberomorus maculatus*), king mackerel (*Scomberomorus cavalla*), grouper (*Epinephelus* spp.), spotted sea trout (*Cynoscion nebulosus*), crevalle jack (*Caranx hippos*), cobia (*Rachycentron canadum*), amberjack (*Seriola* spp.), marlin (*Makaira* spp.), and various species of sharks.

3.16.1.2 Louisiana Estuaries

Rounsefell (1964) characterized fishery resources in marsh and bayou areas traversed by the MRGO using bimonthly sampling data collected by Texas Agricultural and Mechanical Research Foundation from July 1959 to March 1961 (El-Sayed, 1961). Estuarine/marine species dominated fish communities with spotted sea trout, Atlantic croaker, anchovy (*Anchoa* spp.); and sand sea trout ranking among the top 10 species in every area sampled, however only two freshwater species, blue catfish (*Ictalurus furcatus*) and sunfish (*Lepomis* spp.), ranked among the top ten species. Four non-migratory estuarine species ranked among the top ten species in each of the lower salinity areas. Four marine species were among the top ten most abundant species in higher salinity areas (El-Sayed, 1961). The five most widespread and economically important fish species: spotted sea trout, Atlantic croaker, anchovy, sand sea trout, and Gulf menhaden, were more abundant in higher salinity areas. The five fish species most landed during recreational fishing in Louisiana are the red drum, black drum, spotted sea trout, Atlantic croaker, and sand sea trout (Pattillo et al., 1997). Neither brown shrimp (*Farfantepenaeus axtecus*) nor white shrimp (*Litopenaeus setiferus*) exhibited notable salinity preferences and were transient residents of the marshes. Small blue crabs were most abundant in low salinity waters (Rounsefell, 1964).

Of the 22 species of freshwater fishes documented by Fontenot and Rogillio (1970) in the study region, nine freshwater species disappeared after the completion of the MRGO. These species included shovelnose sturgeon (*Scaphirhynchus platorynchus*), chain pickerel (*Esox niger*), four species of sunfish, largemouth bass (*Micropterus salmoides*), and sauger (*Sander canadensis*). Fontenot and Rogillio (1970) attributed the timing of their disappearance as "…during the latter half of the project due to an increase in salinity as a result of saltwater intrusion from the newly constructed MRGO."

The most significant source of recent data identified for the project area was a very large sampling database developed and maintained by the LDWF (2000). LDWF conducted extensive sampling of coastal marshes, bayous, and lakes extending between Lake Pontchartrain and Breton Sound for several decades. The data was collected from 1967 until 2000, with the exception of three missing years: 1970, 1971, and 1972. However, this data did not assess conditions prior to construction of the MRGO (LDWF, 2000).

Shellfish and finfish were included in the first three years of data. Beginning in 1976, the majority of reported catch data were brown, white, and pink shrimp (*Farfantepenaeus duorarum*). Due to database size and lack of summarized information, two sampling stations located closest to the project area were chosen to characterize existing conditions within the study area. As presented below, findings from two key monitoring stations support the trend of aquatic species conversion in the project area to a predominately marine species composition due to an increase in salinity.

LDWF trawl data (LDWF, 2000) show the response of fisheries in the project area to the introduction of higher salinity waters. Estuarine fishes remained dominant in the area along with a few freshwater fishes. The most likely freshwater fish to be found in marine conditions were white crappie (*Pomoxis annularis*), alligator gar (*Atractosteus spatula*), and blue catfish. However, finfish species collected from the two selected sampling stations indicate the beginning of a trend toward the emergence of a predominantly marine species in these areas. As salinity levels increased in areas immediately adjacent to the MRGO, more marine fishes, such as Atlantic midshipman (*Porichthys plectrodon*), leatherjacket (*Oligoplites saurus*), gray snapper (*Lutjanus griseus*), and crevalle jack, began to appear in the sampling trawls (LDWF, 2000).

3.16.2 Commercial Fisheries

Located within the very center of what fisheries biologists term the “Fertile Fisheries Crescent,” within the northern part of the Gulf of Mexico lies what has been referred to as “the core of the Gulf’s $800-million fishing industry.” Of the total fishery products of the United States, 28 percent to 30 percent are produced in the Gulf of Mexico.

Louisiana’s coastal estuaries are one of the most productive in the nation. This large expanse of coastal wetlands and estuaries provides support during critical life stages of important commercial species. As such, Louisiana has historically been an important contributor to the Nation’s domestic fish and shellfish production and one of the primary contributors to the Nation’s food supply for protein.

The most recent landings in 2008 for commercial fisheries in Louisiana, estimated at approximately 918.5 million pounds, were the largest for any state within the continental United States, second only to Alaska (NMFS, 2010). These landings represent over ten percent of total landings in the United States, valued at approximately $274.9 million. This productivity is ideal for sport fishermen, commercial fishing, and local recreational use (MsCIP, 2008). Mississippi’s fishing industry accounted for approximately $1.1 billion of Mississippi’s annual economy prior to Hurricane Katrina. According to the Mississippi Department of Marine Resources (MDMR), the Mississippi shrimping industry accounted for five to seven percent of all shrimp landings in the United States, with the total value of commercial landings amounting to $39.3 million in 2007 (NMFS, 2010). **Table 3-24** shows landings of all the fisheries species combined in the State of Louisiana for 2005 through 2008 including finfish, shrimp, crabs, clams, and oysters.

Table 3-24: Annual Landing Statistics for all Fisheries Species Combined for the State of Louisiana, 2005 – 2008

Year	Metric Tons	Pounds	Value ($)
2005	385,231	849,280,372	251,687,265
2006	416,628	918,498,167	278,111,830
2007	452,382	951,000,000	259,600,000
2008	416,616	918,471,079	274,885,853
Grand Totals	1,600,857	3,617,249,618	1,064,284,948

SOURCE: NOAA 2007.

Table 3-25 lists the commercially and recreationally important fishes grouped by fishery classification and the statewide value for each group.

Table 3-25: Dollar Value of Representative Game and Commercial Fisheries Species Occurring in Louisiana and Mississippi Territorial Waters

Common Name	Scientific Name	Value in 2008 Dollars ($)
Marine Species		
Brown shrimp	*Farfantepenaeus aztecus*	31,907,169
White shrimp	*Litopenaeus setiferus*	115,345,298
Pink shrimp	*Farfantepenaeus duorarum*	14,562
Atlantic croaker	*Micropogonias undulates*	32,583
Red drum	*Sciaenops ocellatus*	42,329
Black drum	*Pogonias cromis*	1,836,754
Sea trout	*Cynoscion* sp.	108,859
Sheepshead	*Archosargus probatocephalus*	354,188
Southern flounder	*Paralichthys lethostigma*	111,382
Striped mullet	*Mugil cephalus*	780,096
Gulf menhaden	*Brevoortia patronus*	64,301,799
Herrings	*Cluperids*	280,498
Eastern American oyster	*Crassostrea virginica*	45,687,910
Blue crab	*Callinectes sapidus*	32,206,576
Freshwater Species		
Alligator gar	*Atractosteus spatula*	521,396
Catfish	*Ictalurus* spp.	1,734,832
Flathead catfish	*Pylodictis olivaris*	161,872
Gizzard shad	*Dorosoma cepedianum*	281,627
Buffalo	*Ictiobus* sp.	614,734
Freshwater drum	*Aplodinotus grunniens*	74,922

SOURCE: Gulf States Marine Fisheries Commission (GSMFC) 2009.

Blue Crab

In 2008, Gulf region landings of blue crab totaled 49 million pounds valued at $39.1 million (NMFS, 2010). Louisiana is the leading blue crab producer in the United States, producing 32 percent of the Nation’s total in 2008 (NMFS, 2010). Statewide, a total of 41.5 million pounds of blue crab were landed in 2008, valued at $31.8 million (NMFS, 2010). Mississippi produced 450,037 pounds from its waters, valued at $446,756. Blue crabs are an important commercial species in the Lake Pontchartrain Basin. A decline in blue crab landings from Lake Pontchartrain in the 1970s resulted in a mean annual catch of 1.4 million pounds, or only about nine percent of the total state landings, compared to 2.6 million pounds, or about 27 percent, in 1959-64 (Thompson and Stone, 1980). By the years 1978 to 1981, mean annual catch had increased to 2.1 million pounds or about 12 percent of the total state catch (Thompson and Stone, 1980).

Trawl surveys within the project area (Rounsefell, 1964) revealed that blue crab abundance declined as salinity increased. Rounsefell (1964) observed that small blue crabs (less than 2 inches) were most abundant in the open, low-salinity waters of Lake Borgne. Slightly larger crabs (2 inches to 4 inches) were more abundant in the Bayou Dupre area, indicating that smaller crabs tend to migrate toward shallow and low-salinity areas while growing. Mature female crabs eventually migrate considerable distances over a few days to reach higher salinity water for spawning and hatching.

Shrimp

In 2008, Gulf region landings of shrimp were the Nation's largest with 184.5 million pounds valued at $354.5 million (NMFS, 2010). In Louisiana, a total of 24.9 million pounds of brown shrimp and 63.7 million pounds of white shrimp were landed in 2008, valuing at $22.7 million and $107.4 million respectively (NMFS, 2010). In Mississippi Territorial Waters, a total of 5.4 million pounds of brown shrimp and 3.2 million pounds of white shrimp were landed in 2008, valuing at $92 and $7.9 million respectively (NMFS, 2010). Pink shrimp landings for 2008 totaled 901 pounds ($756 value) and 5,066 pounds ($13,777 value) for Louisiana and Mississippi respectively.

3.16.3 Oyster Resources

American eastern oysters (*Crassostrea virginica*) are indigenous to coastal Louisiana and Mississippi Territorial Waters, providing a rich ecological and commercial resource. Salinity plays a key role in oyster sustainability (Eastern Oyster Biological Review Team, 2007). Adult oysters can tolerate salinity from 0 ppt to 42 ppt with an optimal range of 14 ppt to 28 ppt (EOBRT, 2007). Waters with lower salinity fail to support biological function, while more saline waters promote disease and predation. Oysters grow faster in areas with fluctuating salinity within their normal ranges compared to constant salinity (Pierce and Conover, 1954). Since they are sessile and cannot relocate with changing water quality conditions, adult oysters are more prone to impacts from changes in water quality than mobile fish and crustaceans.

In 2008, the Gulf region led the United States in oyster production with 20.5 million pounds, 63 percent of the national total (NMFS, 2010). In Louisiana, a total of 12.8 million pounds of oyster were harvested in 2008 with a value of $31.9 million (NMFS, 2010). Although oyster habitat has been lost due to coastal erosion and other habitat alterations, Louisiana remains a top oyster producer with more than 350,000 acres generating around $35 million a year in economic activity (Louisiana Oyster Task Force, 2001). For the 2008-2009 oyster season, LDWF reported 373,030 sacks of oysters harvested from within the project area and adjacent water bodies (LDWF, 2009). The Louisiana oyster industry has been experiencing many stressors over the past several decades that threaten long-term sustainability of both the industry and resource (Coleman, 2003). Increasing coastal land loss is reducing the amount of marsh that provides shelter to reefs, and saltwater intrusion is exacerbating disease and predation. In addition, the industry is faced with changing environmental conditions, fluctuating market demands, public perception issues, and increased competition. **Figure 3-18** shows the location of oyster reefs and seeding grounds within Louisiana territorial waters encompassing the project.

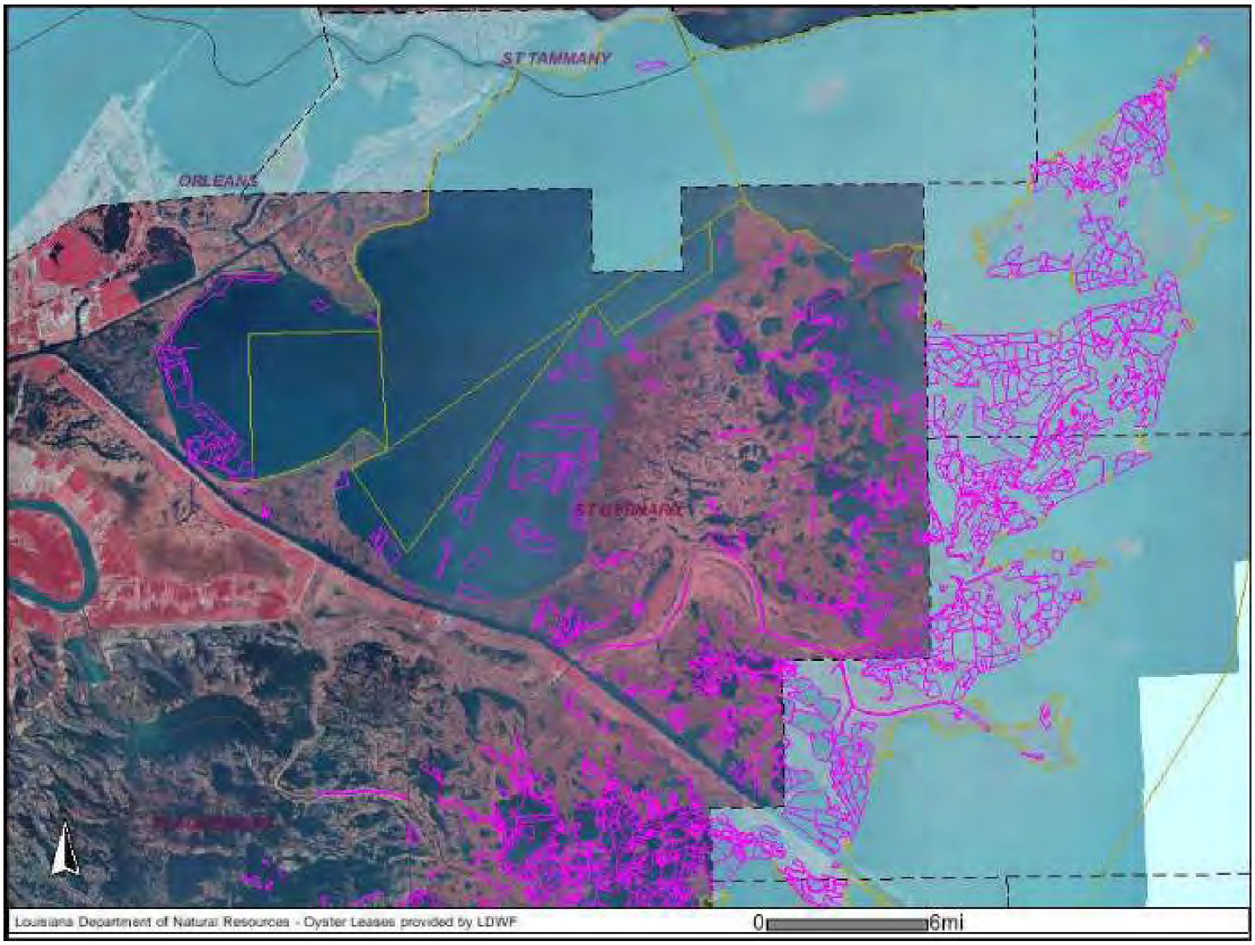


Figure 3-18: Location of Oyster Reefs and Seeding Grounds within the Louisiana Portion of the Project Area (Outlines in Purple)

Oyster reefs of commercial importance are subtidal and form aggregates covering thousands of acres within Mississippi territorial waters. The areal extent of these oyster reefs is estimated at 10,000 acres to 12,000 acres, of which over half is located in Mississippi territorial waters south of Pass Christian. In 2008, 2.6 million pounds of oyster were harvested in Mississippi with a total value of $6.9 million (NMFS, 2010). For the 2008-2009 oyster seasons, MDMR reported a total catch of 385,949 sacks from

16,261 boat trips (MDMR, 2009). **Figure 3–19** shows the location of oyster reefs and seeding grounds within the Mississippi territorial waters of the project.

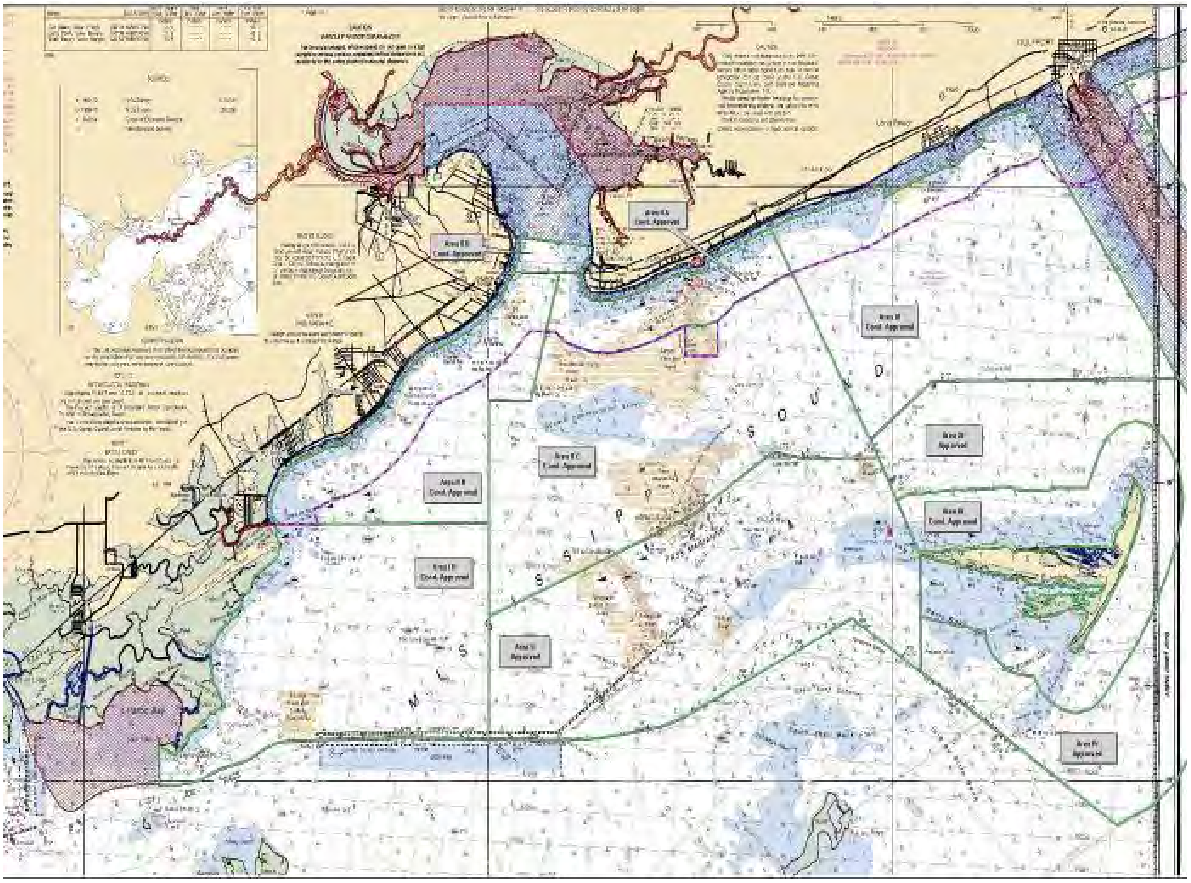


Figure 3-19: Location of Oyster Reefs and Seeding Grounds within the Mississippi Territorial Waters

3.16.4 Water Bottoms and Benthic Resources

Benthic resources are significant institutionally, technically, and publicly. They are institutionally important, from acts such as NEPA of 1969; Coastal Zone Management Act; and the Estuary Protection Act. They are technically important, due to their ability to regulate or modify most chemical, physical, biological, and geological processes throughout an entire estuarine system, known as the “benthic effect” (Day et al., 1989). They are publicly important, considering members of the epibenthic community, such as oysters and mussels, provide commercial as well as recreational fisheries.

The benthic resources of an estuary regulate or modify most physical, chemical, geological, and biological processes throughout the entire estuarine system via what is called a “benthic effect” (Day et al., 1989), Benthic animals are directly or indirectly involved in most physical and chemical processes that occur in estuaries (Day et al., 1989). Oysters are part of the epibenthic community (i.e., living on the surface of the substrate). As described in **section 3.16.3**, they are important components of commercial and recreational fisheries in the project area. In addition, they create reef habitat that is used by many marine and estuarine organisms.

Benthic community structure is not static. There are seasonal, as well as yearly, changes in benthic communities. Benthic communities are storehouses of organic matter and inorganic nutrients, as well as sites for many vital chemical exchanges and physical interactions. Day et al., (1989) describe categories (based on size and location within substrate) and functional groups (based on feeding mode) of estuarine benthic organisms, which include macrobenthic (e.g., mollusks, polychaetes, decapods); microbenthic (e.g., protozoa); meiobenthic (e.g., nematodes, harpacticoid copepods, tubellaria); epibenthic; infauna (e.g., most bivalves); interstitial fauna (e.g., beach meiofauna, tardigrades); suspension-feeders (e.g., bryozoans and many bivalves); filter-feeders (e.g., poriferans, tunicates, bivalves); nonselective deposit feeders (e.g., gastropods); selective deposit feeders (e.g., nematodes, sand dollars, fiddler crabs); raporial feeders and predators (e.g., star fish and gastropod drills); and parasites and commensuals (e.g., parasitic flatworms and copepods, pea crabs).

According to Mitsch and Gosselink (1993), the salt marsh is a major producer of detritus for both the salt marsh system and adjacent estuary. Mitsch and Gosselink (1993) point out that detritus exported from marshes is more important to the estuary than phytoplankton-based production in the estuary. Detritus and shelter found along marsh edges make salt marshes important nursery areas for many commercially important fish and shellfish. Salt marshes have been shown at times to be both sources and sinks of nutrients, particularly nitrogen.

Within a salt marsh, less than ten percent of above-ground primary production of salt marsh is grazed by aerial consumers. Most plant biomass dies and decays, and its energy is processed through the detrital pathway. Major benthic consumer groups of detritus include bacteria and fungi, microalgae, meiofauna, and microfauna (Mitsch and Gosselink, 1993).

A benthic survey was performed by USACE Engineer Research Development Center (ERDC) to assess potential benthic species assemblages within Lake Borgne and Biloxi Marsh (Lake Borgne 2008). A total of 111 infaunal samples and seven sediment grain size samples were collected between May 21, 2007 and May 24, 2007. Depths at sample sites ranged from 5 feet to 10 feet, salinity ranged from 9.1 ppt to 11.2 ppt, and DO concentrations ranged from 6.0 mg/l to 8.0 mg/l. Sediments sampled were poorly sorted sandy mud with a mean grain size in the range of very coarse silts. Total silts and clays accounted for more than 64 percent of the sediment with the remainder dominated by very fine sand. Sediments in proposed access channel sites differ somewhat with innermost (shoreward) stations dominated by peat and outermost stations resembling those of borrow areas.

The benthic species assemblage of the study area is dominated by polychaetes (62 percent), bivalves (14 percent), and amphipods (11 percent). The most abundant species, the polychaete *Mediomastus ambiseta*, accounts for more than 28 percent of all animals collected. Other important polychaete species include *Parandalia americana, Streblospio benedicti, Sigambra bassi, Glycinde solitaria, Nereis succinea, Pectinaria gouldii,* and *Capitella* sp. The most abundant bivalve mollusks are *Macoma mitchelli, Mulinia lateralis,* and *Mulinia pontchartrainensis*. Amphipods are dominated by *Ampelisca abdita, Ameroculodes* sp., and *Cerapus benthophilus*. Other numerically abundant species include the gastropod *Acetocina canaliculata*, two unidentified species of nemerteans, and the oligochaete *Tubificoides* sp. Together, these 18 species comprised nearly 94 percent of all animals encountered. This assemblage is typical of soft bottom, mesohaline (5.0 ppt to 18 ppt) communities throughout the northern Gulf of Mexico and similar to previous reports from Lake Borgne.

3.17 PLANKTON RESOURCES

3.17.1 Historic and Existing Conditions

Plankton communities are comprised of plants (phytoplankton) and animals (zooplankton). Plankton serve an important role in the trophic dynamics of the coastal waters of Louisiana and Mississippi. Phytoplankton are the primary producers of the water column and form the base of estuarine food web. Zooplankton provide the trophic link between phytoplankton and intermediate level consumers, such as aquatic invertebrates, larval fish, and smaller forage fish species (Day et al., 1989).

Phytoplankton are also important for their role in nutrient cycling through photosynthesis and are the major source of autochthonous organic matter in most estuarine ecosystems (Day et al., 1989). Perret et al. (1971) provided a summary of zooplankton across the coastal estuaries of Louisiana in the late 1960s. The dominant member of the zooplankton community throughout that study was the copepod (*Acartia tonsa*). The largest concentrations of zooplankton were in Breton Sound, while lowest concentrations were in Chandeleur Sound and Lake Borgne east of the Mississippi River, Lakes Barre and Raccourci, and Terrebonne and Timbalier Bays. Species diversity was greatest in Breton Sound and Mississippi River, East Bay, Garden Island Bay, and West Bay areas.

Rotifers, copepods, and cladocerans are the dominant organisms in freshwater. In intermediate and brackish waters, the *Acartia tonsa* and copepod nauplii were found to be the most numerous zooplankters. The inshore saline waters were also found to have copepod nauplii and *Acartia tonsa* as the most common zooplankters, with more abundant numbers in saline waters than brackish waters (Conner and Day, 1987). Changes in zooplankton density have been directly correlated to the breeding cycle of holoplanktonic copepods.

Plankton form the lowest trophic food level for many larger organisms important to commercial and recreational fishing. In addition, there is a public health concern with noxious plankton blooms (red and brown tides) that produce toxins, and large-scale blooms can lead to hypoxic conditions, resulting in fish kills.

3.18 ESSENTIAL FISH HABITAT

3.18.1 Historic and Existing Conditions

Essential fish habitat (EFH) is defined as “those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity.” **Table 3-26** and **table 3-27** list the Federally managed species within the project area, as well as, representative EFH known to occur within the Gulf of Mexico (Louisiana and Mississippi Territorial Waters). The 1996 amendments to the MSA set forth a mandate for the NMFS of the NOAA, regional Fishery Management Council (FMC), and other Federal agencies to identify and protect EFH of economically important marine and estuarine fisheries including critical habitat needed for various life stages. The public places a high value on seafood and recreational and commercial opportunities provided by EFH. Specific categories of EFH include all estuarine waters and substrates (mud, sand, shell, rock, and associated biological communities), subtidal vegetation (seagrasses and algae), and adjacent intertidal vegetation (marshes and mangroves).

In a letter dated October 27, 2008, NMFS identified EFH resources within the study area (including Mississippi Territorial Waters) as estuarine emergent wetlands; SAV/seagrass beds; mud, sand, and shell substrates; and the estuarine and marine water column. Detailed information on Federally managed fisheries and their EFH is provided in the 2005 Generic Amendment of the Fishery Management Plans (FMP) for the Gulf of Mexico prepared by the Gulf of Mexico Fishery Management Council (GMFMC).

In addition to being designated as EFH for species listed in **Table 3-27**, water bodies and adjacent wetlands within the project area provide nursery and foraging habitats which support a variety of economically important marine fishery species, including striped mullet, Atlantic croaker, Gulf menhaden, spotted and sand seatrout, southern flounder, black drum, and blue crab. Some of these species also serve as prey for other fish species managed under the MSA by GMFMC (e.g., mackerels, snappers, and groupers) and highly migratory species managed by NMFS (e.g., billfishes and sharks).

Table 3-26: Life Stages of Federally Managed Species and EFH Present in the Project Area

Species	Life stage	System	EFH
Brown shrimp	Larvae	Marine	<269 feet; sand/shell/soft bottom, SAV, emergent marsh, oyster reef
	Juvenile	Estuarine	<59 feet; SAV, sand/shell/soft bottom, emergent marsh, oyster reef
	Adult	Marine	<46-360 feet; sand/shell/soft substrate
White shrimp	Juvenile	Estuarine	<98 feet; SAV, soft bottom, emergent marsh
Pink shrimp	Juvenile	Estuarine	<213 feet; sand/shell substrate
Gulf Stone Crab	Eggs	Estuarine/Marine	<59 feet; sand/shell/soft bottom
	Larvae/post larvae	Estuarine/Marine	<59 feet; oyster reefs, soft bottom
	Juvenile	Estuarine	<59 feet; sand/shell/soft bottom, oyster reef

Table 3-26: Life Stages of Federally Managed Species and EFH Present in the Project Area

Species	Life stage	System	EFH
Red Drum	Larvae/post larvae	Estuarine	All estuaries, SAV, sand/shell/soft bottom, emergent marsh
	Juvenile	Estuarine/Marine	Gulf of Mexico (GOM) <16 feet west from Mobile Bay; all estuaries SAV, sand/shell/soft/hard bottom, emergent marsh
	Adult	Estuarine/Marine	GOM 3-150 feet west from Mobile Bay; all estuaries SAV, pelagic, sand/shell/soft/hard bottom, emergent marsh
Lane Snapper	Larvae	Estuarine/Marine	13-433 feet; reefs, SAV
	Juvenile	Estuarine/Marine	<65 feet; SAV, mangrove, reefs, sand/shell/soft btm.
Dog Snapper	Juvenile	Estuarine/Marine	SAV, mangrove, emergent marsh
Dwarf Sand Perch	Juvenile	Marine	hard bottom
King Mackerel	Larvae	Marine	30-590 feet
	Juvenile	Marine	<30 feet; pelagic
	Adults	Marine	115-590 feet; pelagic
Spanish Mackerel	Eggs	Marine	<164 feet
	Larvae	Marine	30-275 feet
	Juvenile	Estuarine/Marine	<164 feet; pelagic
	Adults	Estuarine/Marine	<246 feet; pelagic
Cobia	Eggs	Marine	
	Larvae	Marine	36-174 feet
	Juvenile	Marine	16-600 feet; pelagic
Bonnethead Shark	Juvenile	Marine	Inlets, estuaries, coastal waters <82 feet, Florida Keys to Cedar Key; Louisiana and Texas
Atlantic Sharpnose Shark	Adults	Marine	<164 feet Mississippi Sound and Galveston to Laguna Madre, Texas

Table 3-27: Representative Categories of EFH Known to Occur Within the Gulf of Mexico Region (Louisiana and Mississippi Territorial Waters)

Estuarine Areas	Marine Areas
Estuarine emergent wetlands	Water column
Mangrove wetlands	Vegetated bottoms
Submerged aquatic vegetation (SAV)	Non-vegetated bottoms
Algal flats	Live bottoms
Mud, sand, shell, and rock substrates	Coral reefs
Estuarine water column	Geological features
	Continental shelf features

SOURCE: NMFS EFH Gulf of Mexico Region, 2008.

Brown Shrimp (*Farfantepenaeus aztecus*)

There is a high probability that juvenile brown shrimp could occur within the estuarine open water and in SAV habitats located within the project area. Both post-larval and juvenile life stages of brown shrimp are likely to use open water in the IHNC as a conduit to estuarine open water, emergent marsh, and SAV in Lake Pontchartrain. It is thought that this species occupies and migrates through the project area from the Gulf of Mexico via three main routes: the GIWW and Lake Borgne, the Golden Triangle marsh, and Bayou Bienvenue. Prior to its de-authorization, the MRGO provided access for the largest number of organisms compared to the GIWW and Lake Borgne because it provided the most direct route with a strong tidal pulse.

Adult brown shrimp typically inhabit offshore waters (Patillo et al., 1997), such as those off the coast of Louisiana, although individual adults may occur within the project vicinity in open water habitat with turbid waters and soft sediments (Patillo et al., 1997; Lassuy, 1983c). Post-larval brown shrimp feed on phytoplankton, zooplankton, epiphytes, and detritus. Juveniles and adults prey primarily on amphipods, polychaetes, and chironomid larvae as well as algae and detritus (Patillo et al., 1997; Lassuy, 1983c).

Post-larval brown shrimp have been captured in salinity from essentially fresh (Swingle, 1971) to 69 ppt (Simmons, 1957) with 19 ppt being optimal within this given range (Lassuy, 1983).

White Shrimp (*Litopenaeus setiferus*)

Juvenile white shrimp are common to abundant within the project vicinity from July through October (GMFMC, 2004). Post-larval white shrimp seek shallow, estuarine water with muddy sand bottoms high in organic detritus or vegetative cover; while juvenile white shrimp inhabit turbid estuaries, marsh edges, and SAV (Patillo et al., 1997). Post-larval white shrimp use soft muddy or peat-like bottoms for burrowing (Muncy, 1984). White shrimp can be replaced by brown shrimp in muddy areas due to competition for habitat (Muncy, 1984). GMFMC (2004) maps show that adult white shrimp habitat includes Irish Bayou, Lake Catherine, Lake Borgne, and the eastern shore of Lake Pontchartrain.

Like brown shrimp, post-larval white shrimp feed on phytoplankton, zooplankton, epiphytes, and detritus. Juveniles and adults prey on amphipods, polychaetes, and chironomid larvae and also consume algae and detritus (Patillo et al., 1997).

Post-larval white shrimp prefer a mesohaline salinity regime; juveniles prefer lower salinity habitats (6 to 8 ppt); and larger late juvenile stage individuals prefer brackish habitats (10 to 18 ppt). Adult white shrimp spend most of their life offshore, where they spawn in waters that have salinity of approximately 23-27 ppt.

Pink Shrimp (*Farfantepenaeus duorarum*)

According to the GMFMC (2004), juvenile pink shrimp are expected to occur in the project vicinity; however, (Patillo et al., 1997) indicate occurrences are rare. Juveniles may prefer SAV meadows, where they burrow into coarse substrate; post-larval pink shrimp prefer a mixture of course sand/shell/mud with immature stages found on substrates with vegetative detritus. Although densities of pink shrimp are considered highest in SAV habitat by (Patillo et al., 1997) the GMFMC (2004) clarifies that juveniles prefer high salinity SAV over low salinity SAV. Post-larval pink shrimp feed on phytoplankton, zooplankton, epiphytes, and detritus. Juveniles and adults consume algae and detritus (Darnell, 1961) and prey on amphipods, polychaetes, and chironomid larvae (Patillo et al., 1997).

Gulf Stone Crab (*Menippe mercenaria*)

Gulf stone crabs are found within areas of high salinity within the project area. Larval stone crabs are sensitive to lower salinity, while adults sometimes considered euryhaline, are typically found in higher salinity approaching full seawater (Linberg and Marshall, 1984). Considered to be eurythermal, they have been collected in temperatures ranging from 46ºF to 90ºF (Bender, 1971). However, on the lower end of the range they seal themselves in burrows, while at the higher end of the range typically seek the coolness of deeper water.

Planktonic larvae develop in estuarine/marine environments near oyster reefs or soft bottoms with optimal salinity ranging from 30 to 35 ppt (Linberg and Marshall, 1984). In studies conducted within laboratories, Ong and Costlow (1970) found that no larvae stone crabs survived in waters with salinity equal to or less than 10 ppt. Larvae stone crab prey on other planktonic larval stages and zooplankton, while juvenile and adults consume polychaetes, bivalves, oyster drills, and fish (Linberg and Marshall, 1984).

EFH exist for three stages of the Gulf stone crab (eggs, larvae/post larvae, and juvenile) within the project vicinity, including, sand; shell; soft bottoms; or oyster reefs at depths less than 59 feet in marine or estuarine habitats.

Red Drum (*Sciaenops ocellatus*)

Adult and juvenile red drum occurs in a variety of habitats within the project vicinity. Both adults and juveniles can be found in the project vicinity's shallow open water and brackish emergent marsh habitats year round; however, adults are more common April through October (GMFMC, 2004), and juvenile red drum are common to abundant year-round (GMFMC, 2004; Nelson et al., 1992). Adult red drum may also occur in the scour holes north and south of the Seabrook Bridge, in emergent marsh in Lake Pontchartrain, and in open waters and emergent marsh within and adjacent to the GIWW, the IHNC, the MRGO, and the Golden Triangle marsh.

Spawning typically occurs outside the project vicinity (GMFMC, 2004) in deeper water near the mouths of bays and inlets (Pearson, 1929) near the Gulf of Mexico. Planktonic red drum larvae are carried by currents into bays and estuaries (Peters and McMichael, 1987), such as Lake Pontchartrain, where they settle into the tidally influenced emergent wetlands (Stunz et al., 2002a). Juvenile red drum prefer specific habitat types, occurring at higher densities in SAV (Stunz et al., 2002a). They grow faster in SAV as well as in brackish emergent marsh and oyster reefs (Stunz et al., 2002b). Additionally, juvenile red drum prefers a mesohaline (5 to 16 ppt) to euryhaline salinity regime (16 to 36 ppt), and growth rates are highest between 65ºF and 88ºF (GMFMC, 2004).

Red drum is considered predators in estuaries, and the project site is considered an area of high abundance of the red drum (Reagan, 1985). They are considered intermediate feeders due to their use of the bottom for foraging (eating oysters, clams, and blue crabs), as well as the pelagic habitat to hunt for prey fish species. Locally in Louisiana, red drum are also known for their preference for crabs (LDWF, 2009b). Juvenile red drum show preferences for fish, crabs, and shrimp, particularly mysid shrimp (Reagan, 1985). Adult red drum feed primarily on fish, shrimp, and crabs. Fish, primarily menhaden (*Brevoortia*) and anchovies (*Anchoa* spp.), are an important source of food in the winter and spring, while crabs and shrimp are important in the summer and fall (Reagan, 1985).

Lane Snapper (*Lutjanus synagris*)

EFH only occurs for the larvae and juvenile lane snapper within the project vicinity. Lane snapper occur within a wide variety of habitats, from coral reefs in clear water to turbid, brackish water over soft substrates (Borone et al., 1986). Croker (1962) indicates, most snappers (including the lane snapper) spawn in groups in an offshore marine environment. Larval lane snapper prefer an estuarine/marine environment with depths ranging from 13 to 433 feet. While adult lane snappers prefer marine areas with hard bottoms and reefs, juvenile lane snapper prefer mangrove areas with sand, shell, or soft bottoms at depths less than 66 feet. As such, lane snappers feed on a wide variety of organisms (Borone et al., 1986), such as crabs, shrimp, worms, gastropods, and cephlapods. Lane snapper are typically found in waters with temperatures ranging from 61ºF to 84ºF, and salinity of 19.1 to 35.0 ppt (Borone et al., 1986). While adults typically live offshore with salinity near the higher end of the range, juveniles use estuaries as nursery areas.

Dog Snapper (*Lutjanus jocu*)

Juvenile dog snapper are typically found in estuaries, mangrove, emergent marsh, and submersed aquatic vegetation, which is EFH included in the project vicinity. They have been collected at depths ranging from 6 to 131 feet, although they typically inhabit the water column between 16 to 98 feet. Dog snappers feed on a wide variety of organisms such as, crabs, shrimp, worms, gastropods, and cephlapods nocturnally. Dog snapper are typically found in waters with temperatures ranging from 61ºF to 84ºF, and salinity of approximately 19 to 35 ppt. While adults typically live offshore with salinity near the higher end of the range, juveniles use estuaries as nursery areas.

Dwarf Sand Perch (*Diplectrum bivittatum*)

Inhabiting bays and seagrass beds at depths from 3 to 262 feet, the sand perch is primarily a warm-water, inshore fish occasionally observed offshore associated with wrecks and reefs or occasionally deep channels. EFH only exist for juvenile life stages within the project area. The sand perch lives in holes in the sandy bottom or under rocks. The holes are either pre-existing, made by other organisms, or the sand perch excavates a new hole. It lies on the bottom, vibrating its body to push the sand away. As a bottom inhabitant of reefs and rocky areas, the sand perch feeds primarily on benthic crustaceans, including shrimps, crabs, and amphipods, as well as small fishes such as small sea bass (*Centropristis* spp.), sea robins (*Prionotus* spp.), gobies, blennies, flatfishes (*Symphurus* spp.), and filefish (*Monacanthus* spp.). Sand perch are synchronously hermaphroditic fish - individual fish possess both male and female organs, producing sperm and eggs at the same time.

King Mackerel (*Scomberomorus cavalla*) and Spanish Mackerel (*Scomberomorus maculatus*)

Water temperature and salinity levels are the most important factors governing distribution of both king and spanish mackerel (Godcharles and Murphy, 1986). Both species prefer water temperature ranging from 70ºF to 81ºF, rarely being collected in temperature below 64ºF. All life stages (eggs, larvae, juvenile, adult) inhabit waters with salinity ranging from 32 to 35 ppt (Godcharles and Murphy, 1986). Both of these species in the juvenile and adult stages are primarily pelagic carnivores. Juveniles of both species are piscivorous (primarily feeding on schooling fish), but king mackerels have a preference for invertebrates.

Both species in the larvae stage are planktonic in marine environments from depths of 30 to 590 feet. Juvenile king mackerel prefer a marine pelagic environment at depths less than 30 feet, while juvenile spanish mackerel use more estuarine/marine environment at depths less than 164 feet. Adult phases of both species are pelagic, while king mackerel prefer marine environments and spanish mackerel use estuarine/marine environments at depths of 115 to 591 feet and less than 246 feet, respectively.

Cobia (*Rachycentron canadum*)

Cobia are found nearly worldwide in tropical, sub-tropical, and warm temperature waters ranging from approximately 61ºF to 90ºF with salinity ranging from 22.5 to 44.5 ppt (NMFS, 2010). Eggs and larvae are typically found offshore in water depths from 36 to 174 feet, while early juvenile stages tend to move toward more inshore areas, inhabiting coastal areas, bays, beaches, and river mouths. Occasionally entering estuaries, adults are more prevalent on the continental shelf and in coastal waters. They can be found within varying depths of the water column; however, they are more of a pelagic species (NMFS, 2010). Habitats vary from mud, rock, sand and gravel bottoms, over coral reefs, and in mangrove sloughs. Along coastal inshore areas they can be found around pilings and buoys, as well as drifting and stationary objects. Cobia migrate to areas with high food abundance, typically eating crabs and other crustaceans, benthic invertebrates, and fish.

Bonnethead Shark (*Sphyrna tiburo*)

Bonnethead sharks are found on the continental and insular shelves, on inshore and coastal areas, over mud and sand bottoms, and on coral reefs and occur in shallow water including estuaries, shallow bays and over coral reefs. They feed primarily on crustaceans, consisting mostly of blue crabs, but also shrimp, mollusks and small fish. They are subtropical, brackish/marine fish with depths ranging from 33 to 262 feet.

Juveniles are typically found in inlets of estuaries and coastal waters less than 82 feet, typically warmer than 70ºF.

Atlantic Sharpnose Shark (*Rhizoprionodon terraenovae*)

Atlantic sharpnose sharks are abundant in continental shelves, from the intertidal to deeper waters at depths of 33 to 918 feet and often occur close to the surf zone off sandy beaches, and also enclosed bays, sounds, and harbors, in estuaries and river mouths, mostly over sandy or muddy bottoms. During summer months, juveniles, subadults, and adults inhabit shallow inshore waters (Benson, 1982). An offshore migration occurs in the fall, as they often tend to concentrate in even deeper offshore waters during the winter (Benson, 1982). They feed on small bony fishes such as menhaden and parrotfish (Benson, 1982), shrimp, crabs, segmented worms and mollusks. Females migrate inshore during summer months to give birth.

3.19 THREATENED AND ENDANGERED SPECIES

3.19.1 Historic and Existing Conditions

Within the State of Louisiana there are 30 animal and three plant species (some with critical habitats) under the jurisdiction of the USFWS and/or the NMFS, presently classified as endangered or threatened. The USFWS and the NMFS share jurisdictional responsibility for sea turtles and the Gulf sturgeon. Of the animals and plants under USFWS and/or NMFS jurisdiction, nine animal species and no plant species are potentially found within the project area (see **table 3-28** and also **appendix G**). Although some of these species may have historically occurred within the project area, those species that may be potentially impacted by the tentatively selected plan are described in detail within **appendix G**. In Louisiana, Plaquemines and St. Bernard Parishes have experienced some of the most dramatic environmental changes within the state over the past century. These changes have stressed listed species in Louisiana as their habitats are lost or modified. Some species that historically may have inhabited the project area, but are now extirpated are the red wolf (*Canis rufus*) and the Louisiana black bear (*Ursus americanus luteolus*). Other species that were listed on the Endangered Species List, but have since then been de-listed because population levels have improved are the bald eagle (*Haliaeetus leucocephalus*) and the brown pelican (*Pelecanus occidentalis*).

Red wolf (*Canis rufus*)

The red wolf is one of the world's most endangered wild canids. Once common throughout the southeastern United States, red wolf populations were decimated during the 1960s due to intensive predator control programs and loss of habitat. The last remnant population of red wolves was found along the Gulf Coasts of Texas and Louisiana. Those individuals were trapped and used for a captive breeding program. The USFWS declared red wolves extinct in the wild in 1980 (USFWS, 2007). At one time red wolves may have occurred in the project area, but no documented sightings have occurred since they were declared extinct in the wild.

Table 3-28: Threatened and Endangered Species

Species	State	Critical Habitat	Status	Jurisdiction	
				USFWS	NFMS
Animal					
Louisiana Black Bear (*Ursus americanus luteolus*)	LA		T	X	
West Indian Manatee (*Trichechus manatus*)	LA		E	X	
Brown Pelican (*Pelecanus occidentalis*)	LA		E	X	
Piping Plover (*Charadrius melodus)*	LA	X	T	X	
Red Cockaded Woodpecker (*Picoides borealis*)	LA		E	X	
Dusky Gopher Frog (*Rana sevosa*)	LA		E	X	
Ringed Map Turtle (*Graptemys oculifera*)	LA		T	X	
Hawksbill Sea Turtle (*Eretomchelys imbricata*)	LA		E	X	X
Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)	LA		E	X	X
Leatherback Sea Turtle (*Dermochelys coriacea*)	LA		E	X	X
Green Sea Turtle (*Chelonia mydas*)	LA		T	X	X
Loggerhead Sea Turtle (*Caretta caretta*)	LA		T	X	X
Pallid Sturgeon (*Scaphirhynchus albus*)	LA		E	X	
Gulf Sturgeon (*Acipenser oxyrinchus desotoi*)	LA	X	T	X	X
Alabama Shad (*Alosa alabamae*)	LA		C	X	
Plant					
Inflated Healsplitter (*Potamilus inflatus*)	LA		T	X	
Louisiana Quillwort (*Isoetes louisianensis*)	LA		E	X	

Louisiana Black Bear (*Ursus americanus luteolus*)

The Louisiana black bear was listed as a threatened species in 1992. The Louisiana black bear is a subspecies of the American black bear, found in Louisiana, south Mississippi and east Texas. This bear is usually black in color and typically weighs 150 to 300 pounds as an adult (USFWS, 2008). The Louisiana black bear was numerous during colonial times and may have inhabited the project area, but no documented cases exist in this area for the twentieth century.

Bald Eagle (*Haliaeetus leucocephalus*)

Bald eagles live near rivers, lakes, and marshes where they can find fish, their staple food (USFWS, 2009a). The successful recovery of bald eagle populations within the continental United States resulted in the delisting of the species from the Endangered Species List by the USFWS on August 9, 2007. Bald eagles may occur in the project area but no nest trees are documented within the area of direct project impacts.

Brown Pelican (*Pelecanus occidentalis*)

The listed brown pelican, completely extirpated from Louisiana by the 1960s (source: http://www.lacoast.gov/articles/bps/2/index.htm), now commonly feeds in adjacent shallow estuarine waters, using sand spits and offshore sand bars as resting and roosting areas. Brown pelicans commonly breed on Breton Island, which is within the project area. They also forage in the waters of Breton and Chandeleur Sounds and Lake Borgne. Major threats to this species include chemical pollutants, colony site erosion, disease, and human disturbance. Brown pelicans live in coastal regions along the Gulf and feed primarily on fish. The successful recovery of the brown pelican population within the continental United States resulted in the delisting of the species from the Endangered Species List by the USFWS on November 17, 2009. Brown pelicans inhabit the area, but are highly mobile and expected to move to the nearby Chandeleur Islands while restoration operations are occurring on Breton Island.

Piping Plover (*Charadrius melodus*)

The piping plover (including the threatened [Great Plains] and endangered [Great Lakes] populations) was listed as T&E on December 11, 1985. The piping plover is a shorebird that inhabits open beaches, alkali flats, and sandflats of North America. It breeds primarily along the Atlantic coast from North Carolina to southern Canada, along rivers and wetlands of the northern Great Plains, from Nebraska to the southern prairie provinces, and along portions of the western Great Lakes. The species may occasionally use exposed flats in the project area, especially around the Chandeleur and Breton Islands. In winter, most individuals are found on coastal beaches and sand flats from the Carolinas to Yucatan, while some scatter through the Bahamas and West Indies (Haig, 1992). Wintering plovers feed by probing for invertebrates at or just below the surface on exposed wet sand in wash zones; intertidal ocean beach; wrack lines; wash over passes; mud-, sand-, and algal-flats; and shorelines of streams, ephemeral ponds, lagoons, and salt marshes. Beaches adjacent to foraging areas are used for roosting and preening. Small sand dunes, debris, and sparse vegetation within these adjacent beaches provide shelter from wind and extreme temperatures (source: http://www.fws.gov/plover/facts.html). Major threats to this species include: loss and degradation to breeding habitat, disturbance of breeding plovers by humans and pets, non-motorized beach activities, motor vehicles, beach cleaning, predation, winter habitat loss, severe cold weather and storms, hurricanes, and oil spills and other contaminants (source: http://www.fws.gov/northeast/pipingplover/recplan/threats.html).

West Indian Manatee (*Trichechus manatus*)

The West Indian manatee was listed as endangered on June 2, 1970. The West Indian manatee is a large gray or brown aquatic mammal. Adults average approximately 10 feet in length and weigh up to 2,200 pounds. Manatees inhabit both salt and freshwater of sufficient depth (5 feet to usually less than 20 feet) throughout their range. A few individuals have been known to stray as far north as the southern Virginia coast and as far west as the coastal waters of Louisiana (USFWS, 2001). The West Indian manatee may occasionally enter Lakes Pontchartrain and Maurepas, and associated coastal waters and marshes of Louisiana (USFWS, 2006). In 2001, a manatee was observed passing through the IHNC into the Mississippi River (USFWS, 2006). Manatees are found within local waterways only during months with warm enough conditions. Manatee populations have declined due to collisions with watercraft, entrapment in flood control structures, poaching, habitat loss, and pollution. Populations may also be adversely affected by cold weather and red tide outbreaks. While rare, the potential exists for the manatee to be within the project area.

Gulf Sturgeon (*Acipenser oxyrhynchus desotoi*)

The Gulf sturgeon was listed as threatened throughout its range on September 30, 1991. Gulf sturgeon live in the estuaries and coastal shelf regions of the Gulf of Mexico during the cooler months of the year (October to March). Distribution of Gulf sturgeon in Louisiana extends from the Mississippi River east to the Pearl River. The majority of these sturgeon have their origins in the Pearl River system, where the largest population occurs (Carr, Tatman, & Chapman, 1996). Gulf sturgeon have been reported in rivers and lakes of the Lake Pontchartrain Basin, and adjacent estuarine areas (USFWS, 2006). Within Louisiana, portions of the Pearl and Bogue Chitto Rivers, Lake Pontchartrain east of the Causeway Bridge, Little Lake, the Rigolets, Lake St. Catherine, and Lake Borgne were designated as critical habitat for the Gulf sturgeon on March 19, 2003, (*Federal Register* Volume 68, No. 53). According to the final critical habitat designation, elements essential for Gulf sturgeon conservation are habitat components supporting feeding, resting, sheltering, reproduction, and migration. Important physical features include: abundant prey items within riverine habitats; riverine spawning sites; riverine aggregation areas; appropriate flow regime and water quality characteristics; sediment quality; and safe and unobstructed migratory pathways (e.g., a river unobstructed by a permanent structure, or a dammed river that still allows for passage). Poor water quality, over-fishing and habitat alterations that limit or prevent spawning have negatively affected Gulf sturgeon populations.

Pallid Sturgeon (*Scaphirynchus albus*)

The pallid sturgeon was listed as endangered throughout its range on October 9, 1990. The pallid sturgeon is a bottom oriented, large river obligate inhabiting the Missouri and Mississippi Rivers from Montana to Louisiana and the Atchafalaya River. The pallid sturgeon is adapted to the predevelopment habitat conditions that historically existed in these large rivers (USFWS, 2009b). The pallid sturgeon was listed due to the apparent lack of recruitment for over 15 years, and the habitat threats existing at the time of listing. Destruction and alteration of habitats by human modification of the river system is believed to be the primary cause of decline in reproduction, growth, and survival of the pallid sturgeon. The curtailment of range and habitat destruction/modification were primarily attributed to the construction and operation of dams on the upper Missouri River and modification of riverine habitat by channelization of the lower main stem Missouri and Mississippi Rivers. Dams substantially fragmented pallid sturgeon range in the upper Missouri River. However, free-flowing riverine conditions currently exist throughout the lower 2,000 miles (60 percent) of the pallid sturgeon's historical range. (USFWS, 2009) Until this past decade, they were considered a rare occurrence in the Lower Mississippi. New information from recent collection efforts indicates that the Mississippi River currently supports substantial numbers of wild fish. Since 1997, more than 200 pallid have been collected at more than 60 locations in the Mississippi River between the confluence of the Missouri River and New Orleans (Bettoli, 2006). When listed, there were only 28 recognized records of pallid sturgeon from the Mississippi River, with no recognized records from the Atchafalaya River. (USFWS, 2009)

Sea Turtles

Five listed sea turtle species may occur in the project area, but typically are found in Gulf of Mexico waters: the Kemp's Ridley sea turtle, Atlantic green sea turtle, hawksbill sea turtle, loggerhead sea turtle, and leatherback sea turtle. All sea turtles occurring within the Gulf of Mexico are generally found in and around the Breton and Chandeleur Sounds. The barrier island restoration feature would be the portion of the project area where there is the likelihood of encountering these turtles.

Green Sea Turtle (*Chelonia mydas*)

The green sea turtle was listed as threatened in U.S. waters, except for the Florida breeding population which was listed as endangered, on July 28, 1978. Due to the inability to distinguish between these populations away from the nesting beach, green turtles are considered endangered wherever they occur in U.S. waters. The green sea turtle is one of the largest marine turtles with adult weights averaging between 250 to 450 pounds (Dundee, 1989). In the Atlantic and Gulf of Mexico waters, the green sea turtle typically inhabits areas adjacent to the coastline and has been known to have a range spanning from Texas to as far north as Massachusetts (NOAA-1).

Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)

The Kemp's ridley sea turtle was listed as endangered throughout its range, on December 2, 1970. The Kemp's ridley sea turtle is the smallest of the sea turtles with adults reaching an approximate length of two to 2.5 feet and weighing around 110 pounds (Dundee, 1989). During the months of May to October, this species can be found in and around the shoreline of Louisiana with adults occupying areas around the mouth of the Mississippi River during the spring and summertime (LDWF, 2005).

Loggerhead Sea Turtle (*Caretta caretta*)

The loggerhead sea turtle was listed as threatened throughout its range on July 28, 1978. The loggerhead sea turtle is also one the larger marine turtles with average adult lengths ranging from 3 to 7 feet and weighing approximately 300 to 1,100 pounds (Dundee, 1989). In Louisiana, this species has been found nesting on the Chandeleur Islands, Isle Dernieres, and Grand Isle in Terrebonne Parish (Dundee, 1989).

Hawksbill Sea Turtle (*Eretmochelys imbricata*)

The hawksbill sea turtle was listed endangered throughout its range on June 2, 1970. Commercial harvest, habitat degradation, coastal development, disease, and predation have all contributed to the decline of the species. In the Gulf region, this species has been sighted along the Florida coast, specifically in the reef, as well as along the Texas coastline.

Leatherback Sea Turtle (*Dermochylys coriacea*)

The Leatherback sea turtle was listed as endangered throughout its range on June 2, 1970. Commercial harvest, habitat degradation, coastal development, disease, and predation have all contributed to the decline of the species. The leatherback typically inhabits deep ocean waters, but migrates to barrier islands and coastal beaches to nest. Nesting of leatherback sea turtles in Florida occurs from April to July, while nesting of this species in Louisiana has never been reported.

3.20 SOCIOECONOMIC AND HUMAN ENVIRONMENT

3.20.1 Historic and Existing Conditions

This resource is institutionally significant because of the National Environmental Policy Act of 1969; the Estuary Protection Act; the Clean Water Act; the River and Harbors Acts; the Watershed Protection and Flood Protection Act; and the Water Resources Development Acts. Of particular relevance is the degree to which the proposed action affects public health, safety, and economic well-being and the quality of the human environment. This resource is technically significant because the social and economic welfare of the Nation may be positively or adversely impacted by the proposed action. This resource is publicly significant because of the public's concern for health, welfare, and economic and social well-being from water resources projects.

3.20.2 Population

The study area includes portions of the Mississippi River Deltaic Plain within coastal southeast Louisiana and parts of southwest Mississippi encompassing approximately 3.8 million acres (over 6,000 square miles) of land and open water. In Louisiana, the study area includes the Upper, Middle, and Lower Lake Pontchartrain sub-basins. In Mississippi, the study area includes the western Mississippi Sound, its bordering wetlands, and Cat Island. These areas include portions of the Pearl River and the coastal stream hydrologic basins in Mississippi. The study area was developed to encompass the Lake Borgne ecosystem and areas that may have been affected by the MRGO navigation channel. The MRGO channel may have affected salinity as far west as Lake Maurepas. To the east, the MRGO channel was dredged through open water between the Breton and Grand Gossier Islands. The MRGO channel affected portions of the Lake Borgne ecosystem to the north and altered hydrology potentially as far south as the River Aux Chenes Ridge.

Louisiana parishes in the study area include Ascension, Jefferson, Livingston, Orleans, Plaquemines, St. Bernard, St. Tammany, St. Charles, St. James, St. John the Baptist, and Tangipahoa Parishes. Mississippi counties in the study area include Hancock and Harrison. The 2008 estimated population for the study area parishes and counties in Louisiana and Mississippi respectively, are shown in **table 3-29**.

Table 3-29: 2008 Estimated Population – Post Katrina

Parish / County	Population
Louisiana	
Ascension	101,789
Jefferson	436,181
Orleans	311,853
Livingston	120,256
Plaquemines	21,276
St. Bernard	37,722
St. Tammany	228,456
St. Charles	51,546
St. James	21,331
St. John the Baptist	46,994
Tangipahoa	117,001
Mississippi	
Hancock	40,140
Harrison	178,460

SOURCE: US Census Bureau

Due to the absence of project related construction features in large portions of the study area, the study area was reduced in order to facilitate ease of discussion of existing conditions and potential impacts. The proposed project footprints (also known as measures) are located in mostly remote and uninhabited coastal wetlands within St. Bernard and Orleans Parishes. There are no communities or human populations identified at the census block level within the specific project footprints. However, there are some population centers near the project footprints. These include the towns of Arabi, Meraux, Violet, and Poydras located in St. Bernard Parish, along with the larger City of Chalmette. To the northwest in Orleans Parish is Michoud, which falls in the Greater New Orleans area. Orleans Parish had a population of 484,674 in 2000; in contrast, the estimated post-storm population in July 2009 was 354,850 (http://www.gnocdc.org/census_pop_estimates.html). St. Bernard Parish reported a population of 67,229 persons in 2000. The post-storm population reported in July 2009 was reported to be 40,655 persons. Post-storm July 2009 population estimates for the smaller population centers were calculated by multiplying active residential address by zip code by the average number of members per household. **Table 3-30** summarizes the July 2009 population for cities and towns within the project area. Among the areas near the project footprints, Chalmette is reported to be the largest population center, followed by Michoud and Violet, respectively.

Table 3-30: July 2009 Census Populations of Cities and Towns near the Project Area

City, Town, or Municipality	Population
Arabi	4,103
Chalmette	17,279
Meraux	3,907
Violet	5,499
Poydras	4,269
Michoud[1]	7,705

[1] Michoud is included in the Greater New Orleans Metropolitan Area
SOURCE: (http://www.gnocdc.org)

3.20.3 Community Cohesion

A community can be defined as a group of people that share common behavior patterns, such as social interactions, use of local facilities, participation in local organizations, shared attitudes, and identification with and commitment to a particular area. Based on a review of U.S. Census data and local population studies, it can be concluded that many of the population centers near the proposed project areas were well established prior to Hurricane Katrina. Long-standing residency in an area typically increases community interaction and cohesion among residents. According to 2000 census data, 42.3 percent of Violet householders living in owner-occupied housing moved into those units between the years of 1970 and 1989; an additional 10.8 percent moved into those units in 1969 or earlier. For Chalmette the numbers are more drastic: 39.7 percent of Chalmette householders living in owner-occupied housing moved into those units between the years of 1970 and 1989, and an additional 25.0 percent moved into those units in 1969 or earlier. Results for population centers are shown in **table 3-31**.

Table 3-31: Tenure by Year Householder Moved into Unit for Owner-Occupied Housing Units (%)

City, Town, or Municipality	1999 to March 2000	1995 to 1998	1990 to 1994	1980 to 1989	1970 to 1979	1969 or earlier
Arabi	5.2	11.8	11.2	13.0	12.8	46.0
Chalmette	6.1	16.2	13.0	15.2	24.5	25.0
Meraux	8.8	21.6	20.7	19.9	17.4	11.5
Violet	7.8	21.4	17.7	24.9	17.4	10.8
Poydras	7.9	21.1	19.1	27.5	19.3	5.1
Michoud[1]	7.6	18.6	16.9	35.6	16.7	4.6

[1] Michoud is included in the Greater New Orleans Metropolitan Area
SOURCE: (http://www.gnocdc.org)

Housing statistics beyond the year 2000 are not yet available from the census. However, despite the displacement of many residents in these areas due to the impact of Hurricane Katrina, local population studies as well as the rise in the number of community activist groups show that a consistent repopulation has been occurring. Strong ties to neighborhoods and a desire to return to previous communities have propelled this repopulation, and post-Katrina studies indicate that this trend should continue.

3.20.4 Employment and Income

The project footprints are located in mostly remote and uninhabited coastal wetlands within St. Bernard and Orleans Parishes. There are no communities or human populations within the specific project footprints; hence, there is no employment or income base. However, the population centers near the project footprints do support sources of income related to oil and gas exploration as well as commercial and recreational fishing. Based on the 2005-2007 American Community Survey 3-year Estimates, in Orleans Parish nearly 10 percent of the labor force was employed in occupations connected with the petroleum industry. Corresponding information for St. Bernard Parish is not reported for this time period due to the large-scale displacement of persons after Hurricane Katrina.

In general, the petroleum industry in the state accounts for almost 25 percent of the total state revenues and employs more than 116,000 people (about 6 percent of the state's total workforce). These workers earn almost twelve percent of the total wages paid in Louisiana. Indirect employment levels in support industries make this economic sector more important than is indicated by the direct employment figures. However, the recent British Petroleum oil leak in the Gulf of Mexico as well as the 6-month moratorium on deep water exploration and production makes it difficult to provide data reflective of the current employment situation.

The most recent data show median household income in 2008 for Arabi as $44,906; for Chalmette $48,561; for Meraux $60,514; for Violet $43,683; and for Poydras $35,489. Data was not available for Michoud. (http://www.city-data.com/city/Louisiana.html)

3.20.5 Infrastructure

The project footprints are located in mostly remote and uninhabited coastal wetlands within St. Bernard and Orleans Parishes. In St. Bernard Parish, the Alabama Great Southern Railroad (a.k.a. Southern Norfolk), E. St. Bernard Highway, and E. Judge Perez Highway are all adjacent to the Mississippi River levee and would be crossed by the Violet Freshwater Diversion. Other than buried oil, gas, and utilities pipelines and communication and cable lines that pass through the area, there is no infrastructure (roads, buildings, etc.) within the rest of the project footprints.

3.20.6 Oil, Gas and Utility

The total assessed value of interstate pipelines alone in Louisiana is over $600 million and the pipeline industry employs 4,855 persons with an annual payroll of $250 million. Louisiana is laced with thousands of pipelines conveying oil, gas, and other liquid and gaseous materials for short and long distances.

There are 13 utility crossings along the MRGO managed by seven companies that are provided in **table 3-32** and shown in **figure 3-20**. The Air Products and Chemical Company has pipelines at Miles 58.9 and 58.7. The Tenneco Company has a pipeline at

Mile 57.9 and two pipelines at Mile 42.7. The Collins Pipeline Company has a pipeline at Mile 57.7. The Southern Natural Gas Company has four pipelines at Miles 54.7, Mile 54.7, Mile 54.6, and Mile 23.7. The Chevron Pipeline Company has a pipeline at Mile 45.6. The Bellsouth Company has a telephone cable line at Mile 41.6. The LA Intrastate Gas Company has a pipeline at Mile 26.5. **Figure 3-21** displays the existing pipelines and oil and gas wells located in Lake Borgne.

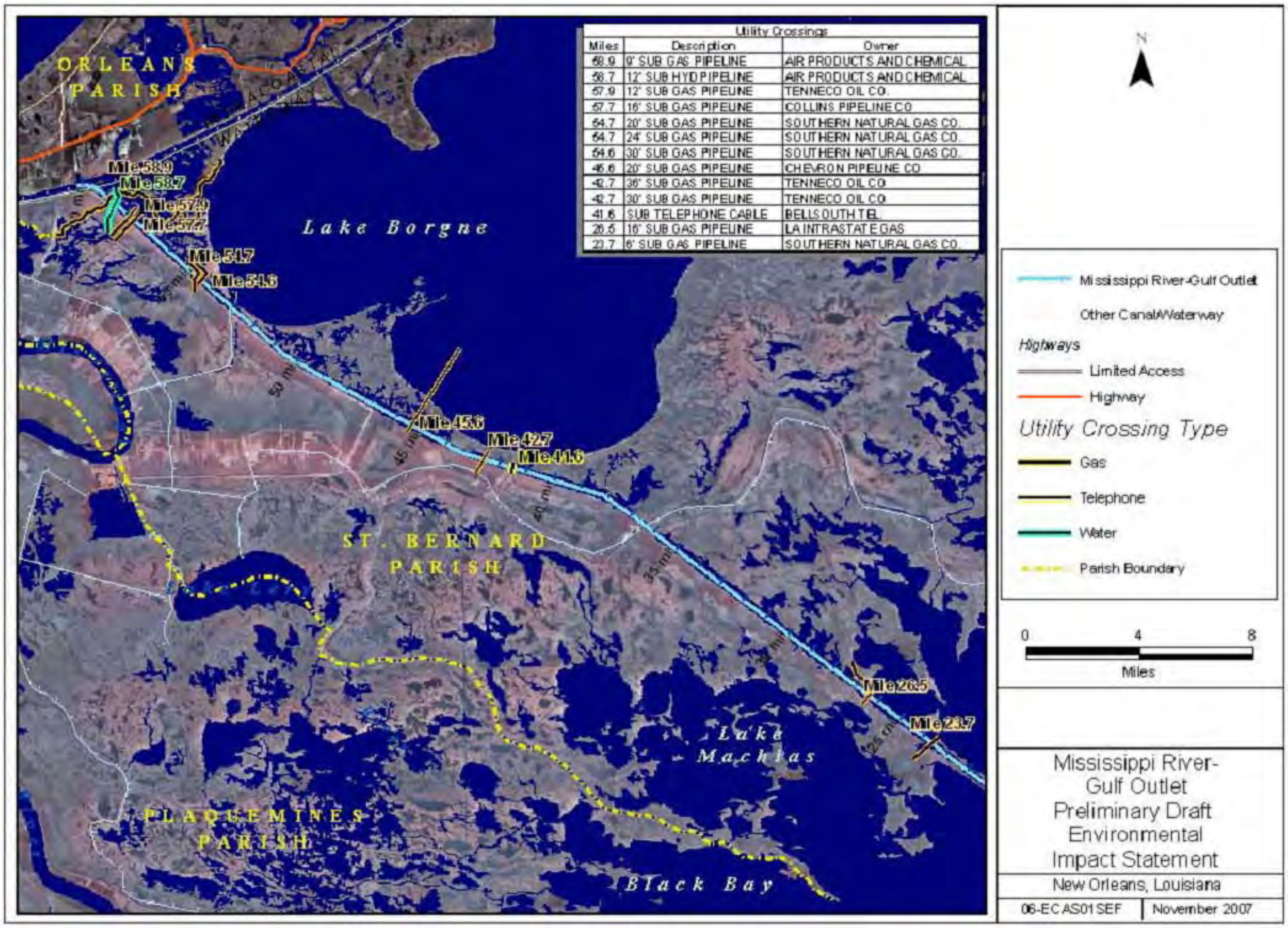


Figure 3-20: Utility Crossings in and near the Project Area

Table 3-32: MRGO Utility Crossings and Owners

Mile Marker	Description	Owner
58.9	9” Sub Gas Pipeline	Air Products and Chemical
58.7	12” Sub Hyd Pipeline	Air Products and Chemical
57.9	12” Sub Gas Pipeline	Tenneco Oil Co.
57.7	16” Sub Gas Pipeline	Collins Pipeline Co.
54.7	20” Sub Gas Pipeline	Southern Natural Gas Co.
54.7	24” Sub Gas Pipeline	Southern Natural Gas Co.
54.6	30” Sub Gas Pipeline	Southern Natural Gas Co.
45.6	20” Sub Gas Pipeline	Chevron Pipeline Co.
42.7	36” Sub Gas Pipeline	Tenneco Oil Co.

Table 3-32: MRGO Utility Crossings and Owners

Mile Marker	Description	Owner
42.7	30" Sub Gas Pipeline	Tenneco Oil Co.
41.6	Sub Telephone Cable	Bellsouth Telephone
26.5	16" Sub Gas Pipeline	LA Intrastate Gas
23.7	6" Sub Gas Pipeline	Southern Natural Gas Co.

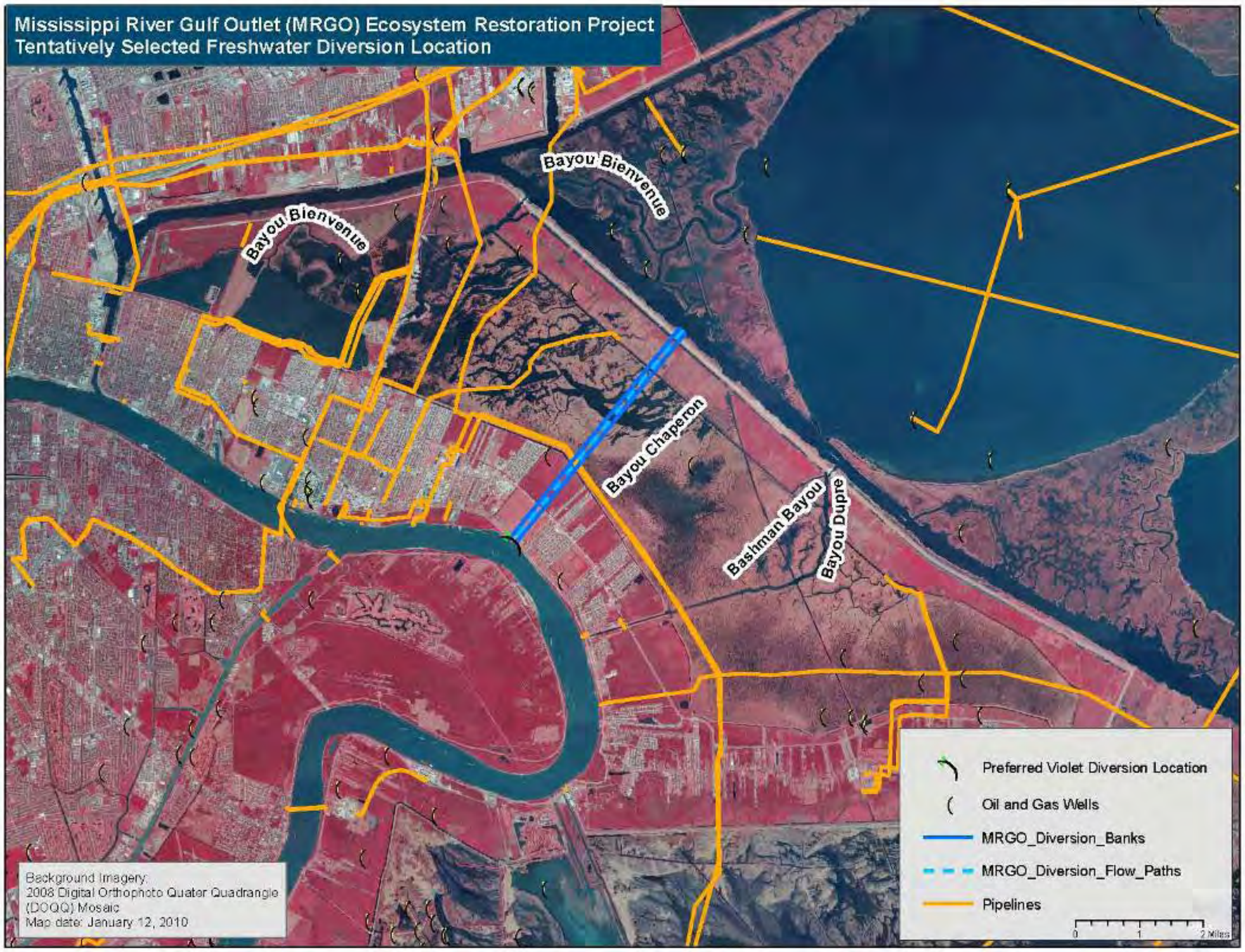


Figure 3-21: Pipelines and Oil and Gas Wells in Lake Borgne and Vicinity

3.20.7 Flood Control and Protection Levees

Continued degradation of the landbridge separating Lake Borgne from the MRGO channel, the conversion of existing wetlands to open water habitats, and the continued bank-line erosion and sloughing of the shoreline are concerns for southern Louisiana. The project footprints do not presently contain any flood control or hurricane protection structures. However, a portion of the hurricane protection system, a series of levees and floodgates designed to protect against storm surges associated with tropical systems, is located immediately adjacent to these areas to the north and west (see **figure 3-22**).

Alternative plan formulation considered providing shoreline protection measures along the MRGO to protect portions of the HSDRRS. Along the southwestern shoreline of the MRGO, a portion of the HSDRRS levee extends from Mile 47 to Mile 60 to protect the population centers of Chalmette, Arabi, Poydras, Meraux, and Violet. This levee system is built to a height of 20.0 feet North American Vertical Datum (NAVD88) and has floodgates at Bayou Dupre and Bayou Bienvenue. A levee along the northern shoreline of the GIWW protects portions of eastern New Orleans and Michoud, and levees along the IHNC protect portions of eastern New Orleans and Arabi. Many of these levees were damaged during Hurricane Katrina and have been rebuilt.

There are on-going efforts to raise the level of protection to conform to the updated requirement for a 100-year level of protection. The floodwall proposed for the HSDRRS would be located in the northwest corner of the project area (see **figure 3-22**). It would consist of a floodwall constructed to an elevation of 26 feet above the average water level with a closure structure across the MRGO channel south of Bayou Bienvenue and sector gates across Bayou Bienvenue and the GIWW that would be closed during storm surge situations (USACE, 2008).

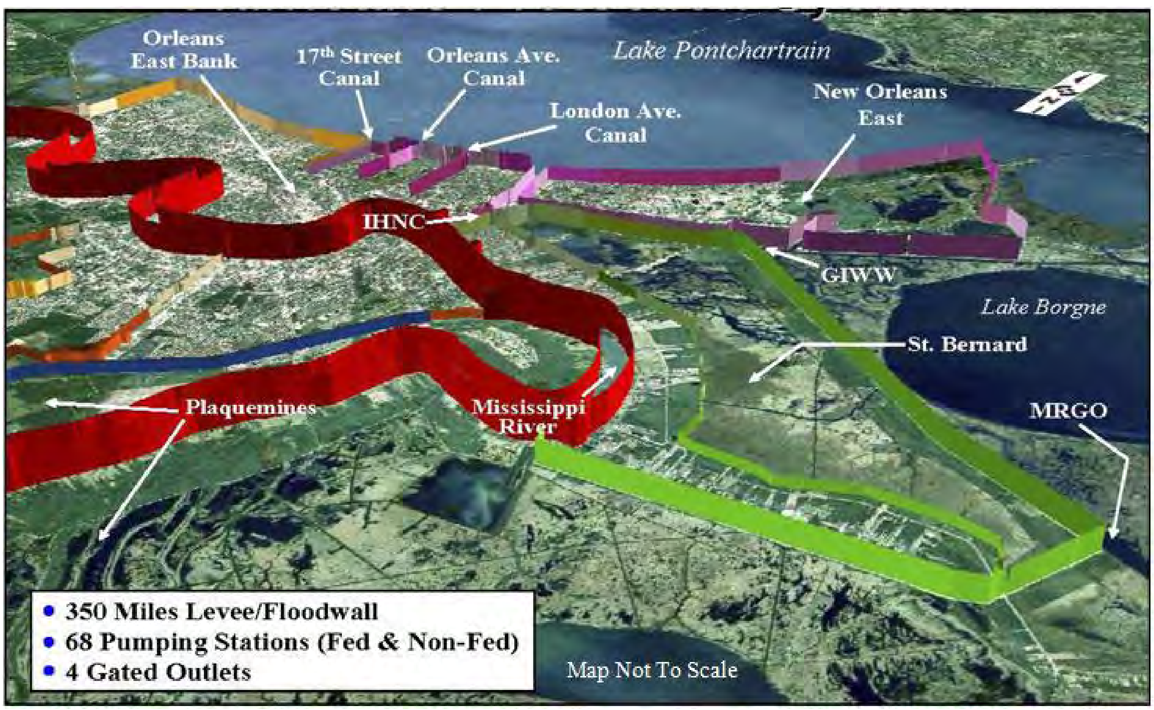


Figure 3-22: Flood Protection Features near the Project Area

3.21 ENVIRONMENTAL JUSTICE

Environmental Justice (EJ) is institutionally significant because of Executive Order (EO) 12898 of 1994 (EO 12898) and the Department of Defense's Strategy on Environmental Justice of 1995, which direct Federal agencies to identify and address any disproportionately high adverse human health or environmental effects of Federal actions to minority and/or low-income populations. Minority populations are those persons who identify themselves as Black, Hispanic, Asian American, American Indian/Alaskan Native, and Pacific Islander. A minority population exists where the percentage of minorities in an affected area either exceeds 50 percent of the total population or is meaningfully greater than in the general population. Low-income populations as of 2000 are those whose income are $22,050 for a family of four and are identified using the Census Bureau's statistical poverty threshold. The Census Bureau defines a "poverty area" as a Census tract with 20 percent or more of its residents below the poverty threshold and an "extreme poverty area" as one with 40 percent or more below the poverty level. This is updated annually at http://aspe.hhs.gov/poverty/09poverty.shtml. This resource is technically significant because the social and economic welfare of minority and low-income populations may be positively or disproportionately impacted by the proposed actions. This resource is publicly significant because of public concerns about the fair and equitable treatment (fair treatment and meaningful involvement) of all people with respect to environmental and human health consequences of federal laws, regulations, policies, and actions.

A potential disproportionate impact may occur when an adverse impact is predominately borne by the percent minority (50 percent) and/or percent low income population (20 percent) in an EJ study area which may be greater than those in the reference community. For purposes of this analysis, all Census Block Groups within a one mile radius of the project footprint are defined as the EJ study area. St. Bernard Parish, which has the nearest and most significant community population in the MRGO area, is considered the reference community of comparison, whose population is therefore considered the EJ reference population for comparison purposes within various city limits. In some instances, parish figures may be used for unincorporated areas located within one mile of the proposed project footprint.

The methodology, consistent with EO 12898, to accomplish this EJ analysis includes, identifying low-income and minority populations within the MRGO project area using up-to-date socio-economic statistics, aerial photographs, 2000 U.S. Census records, Environmental Systems Research Institute, Inc. (ESRI) estimates, as well as conducting community outreach activities such as public meetings. Despite the 2000 U.S. Census being nine years old, it serves as a logical baseline of information and is the primary deciding variable per data accuracy and reliability for the following reasons:

- Census 2000 data is the most accurate source of data available due to the sample size of the Census decennial surveys. With one of every six households surveyed, the margin of error is negligible.

- The Census reports data at a much smaller geographic level than other survey sources, providing a more defined and versatile option for data reporting.
- Census information sheds light upon the demographic and economic characteristics of the area prior to Hurricane Katrina. By accounting for the absent population, the analysis does not exclude potentially low income and minority families that wish to return home.

3.21.1 Historic Conditions

The concept of "environmental justice" is rooted in Title VI of the Civil Rights Act of 1964, which prohibited discrimination based on race, color and national origin, and other nondiscrimination statutes as well as other statutes including the National Environmental Policy Act of 1969, the Uniform Relocations Assistance and Real Property Acquisition Policies Act of 1970, and 23 U.S.C Section 109 (h). In 1971, the CEQ's annual report acknowledged racial discrimination adversely affects the environment of the urban poor. During the next ten years, activists maintained that toxic waste sites were disproportionately located in low-income and areas populated by "people of color." By the early 1980s, the environmental justice movement had increased its visibility and broadened its support base (Commission for Environmental Equality, 2009).

This led to the United Church of Christ (UCC) undertaking a nationwide study and publishing Toxic Waste and Race in the United States (UCC, 1987). This eventually gained the attention of the federal government and in 1992 the EPA's Office of Environmental Equity was established. In 1994, EJ was institutionalized within the federal government through EO 12898 (EPA, 1995a), which focused federal attention on human-health and environmental conditions in minority and low-income communities (EPA, 1995a, 1995b, 1995c, 1995d).

EO 12898 requires greater public participation and access to environmental information in affected communities. The results of early efforts and research (UCC, 1987) into EJ suggested that environmental amenities and toxic waste sites were not uniformly distributed among income groups, classes, or ethnic communities. Disparities of this nature may have been and continue to be the result of historical circumstances, lack of community participation, or simply inadequate or inappropriate oversight. Consequently, dialogue with some community groups were not conducted and their concerns not considered in the decision making process on local or federal actions.

3.21.2 Existing Conditions

Biloxi Marsh

The proposed Biloxi Marsh area extends from Biloxi, Mississippi to Eloi Bay along the eastern coastal wetlands of St. Tammany Parish, Louisiana. According to the 2000 U.S. Census, minority persons accounted for 15.8 percent of the population compared to 38.6 statewide. The low income figures for this area was 10 percent compared to 19.6 statewide. As these figures are less than state figures for Louisiana and because no minority or low-income populations have been identified that would be adversely impacted by the proposed project as determined above this area did not receive further EJ consideration per requirements of EO 12898.

MRGO Shoreline Protection

The proposed MRGO Shoreline Protection project area is located along the MRGO shoreline in St. Bernard Parish, Louisiana. According to the 2000 U.S. Census, minority persons accounted for 17.6 percent of the population compared to 38.6 statewide. The low income figures for this area was 13.1 percent compared to 19.6 statewide. As these figures are less than both parish and state figures for Louisiana and because no minority or low-income populations have been identified that would be adversely impacted by the proposed project as determined above this area did not receive further EJ consideration per requirements of EO 12898.

Central Wetlands Area

The proposed Central Wetlands area is within one mile of residential areas and extends from Verret, Louisiana to Arabi, Louisiana in the Central Wetlands along the MRGO. According to the 2000 U.S. Census, minority persons accounted for 48 percent of the population compared to 38.6 statewide. The low income figures for this area was 17.6 percent compared to 19.6 statewide. As these figures are significantly higher than both county and state figures for Louisiana and because this area is inhabited by such a large minority and/or low-income populations it received further EJ consideration, such as additional outreach efforts, per requirements of EO 12898.

Violet, Louisiana Freshwater Diversion

The proposed Violet Freshwater Diversion is located in the community of Violet, Louisiana. According to the 2000 U.S. Census, minority persons accounted for 46.5 percent of the population compared to 38.6 statewide and 17.6 parish-wide. The low income figures for this area were 21.7 percent compared to 19.6 statewide and parish-wide. The minority and low-income populations in Violet are more than parish and state figures for Louisiana. While the city of Violet does not meet the 50 percent population standard it does, however, exceed the 20 percent low-income population standard and therefore has received further EJ consideration per requirements of EO 12898. The proposed project footprint is adjacent to two subdivisions that are predominately minority neighborhoods and thus meet EO 12898 requirements.

East Orleans Landbridge

The proposed East Orleans Landbridge area extends from the Rigolets in Louisiana to Shell Beach along the western shoreline of Lake Borgne. According to the 2000 U.S. Census, minority persons accounted for 19 percent of the population compared to 38.6 statewide. The low income figures for this area was 11.8 percent compared to 19.6 statewide. As these figures are less than both parish and state figures for Louisiana and because no minority or low-income populations have been identified that would be adversely impacted by the proposed project as determined above this area did not receive further EJ consideration per requirements of EO 12898.

Terre aux Boeufs

The proposed Terre aux Boeufs area extends from Reggio, Louisiana to Black Bay along the Central Wetlands and eastern coastal wetlands of St. Bernard Parish, Louisiana. According to the 2000 U.S. Census, minority persons accounted for 16 percent of the population compared to 38.6 statewide. The low income figures for this area was 13.1 percent compared to 19.6 statewide. As these figures are less than both parish and state figures for Louisiana and because no minority or low-income populations have been identified that would be adversely impacted by the proposed project as determined above this area did not receive further EJ consideration per requirements of EO 12898.

Florissant

The proposed Florissant area is located along Florissant Highway in a wetland area adjacent to the MRGO. According to the 2000 U.S. Census, minority persons in St. Bernard Parish, Louisiana accounted for 16 percent of the population compared to 38.6 statewide. The low income figures for this area was 13.1 percent compared to 19.6 statewide. As these figures are less than both parish and state figures for Louisiana and because no minority or low-income populations have been identified that would be adversely impacted by the proposed project as determined above this area did not receive further EJ consideration per requirements of EO 12898.

Hopedale

The proposed Hopedale area is located in a wetland adjacent to Hopedale Highway in St. Bernard Parish, Louisiana. According to the 2000 U.S. Census, minority persons accounted for 16 percent of the population compared to 38.6 statewide. The low income figures for this area was 13.1 percent compared to 19.6 statewide. As these figures are less than both parish and state figures for Louisiana and because no minority or low-income populations have been identified that would be adversely impacted by the proposed project as determined above this area did not receive further EJ consideration per requirements of EO 12898.

3.22 HISTORIC AND CULTURAL RESOURCES

3.22.1 Louisiana

Prehistoric and historic archaeological sites, as well as standing structures, are generally located along the natural levees bordering active streams and abandoned stream channels. Any projects that cross or run along such geographic features will have the possibility of impacting historic properties that may be eligible for listing on the National Register of

Historic Places (NRHP). Adverse impacts to historic properties can be mitigated by either avoiding the historic properties or by performing data recovery (excavation). Identification of historic properties is made through a Phase I survey which simply identifies the location, extent, and depth of potential historic properties. If these potential historic properties cannot be avoided, then a Phase II study is required. In a Phase II study, the sites are tested by standard archaeological procedures to determine if they are indeed eligible for the NRHP or if standing structures are involved, then more detailed research will be performed. If a site is found to be eligible and the project cannot be designed to avoid such properties, full scale excavations will be conducted for archaeological sites and buildings will be recorded following the procedures of the Historic American Buildings Survey or the Historic American Engineering Record.

High probability areas for archaeological sites are the ridges adjacent to Bayou La Loutre and Bayou Terre aux Boeufs. One site situated along Bayou La Loutre is listed on the NHRP. Other areas with the possibility of encountering important cultural resources are the off-shore borrow areas, especially in and around Lake Borgne. The potential exists for finding boats and ships which took part in the 1814-1815 Battle of New Orleans in Lake Borgne. Archaeological sites are very common along the shorelines of Lakes Maurepas, Pontchartrain and Borgne. Archaeological sites are also common along the rivers and bayous draining into these bodies of water, especially along the lower reaches of these streams.

Historic plantations are very common along the main channel of the Mississippi River. These are often represented by the remains of sugar mills and plantation related grave yards. Important vernacular house types are also situated along the Mississippi River and along the upper reaches of Mississippi River distributaries.

3.22.2 Mississippi

Southern Mississippi is within the coastal plain which forms the northern margin of the Gulf of Mexico. Most of the coastal plain consists in Pleistocene deposits and is bordered by saltwater marshes. The coastal zone of Mississippi is comprised to the Mississippi Sound while the extreme western portion of the Mississippi coast is within the Pearl River basin.

The prehistory of southern Mississippi dates from the Paleo-Indian period (10,000 – 6,000 B.C.) to the Mississippi period (A.D. 1200 – 1700). Historic settlement of the Mississippi coast dates to 1699 when Pierre Le Moyne, Sieur d’Iberville founded Fort Maurepas near modern day Ocean Springs.

Site types range from shell middens along streams and on beaches, historic forts and settlements and shipwrecks.

Previous investigations in the area include Lauro, 1995; Smith et al., 2007; and USACE, 1995.

3.23 RECREATIONAL RESOURCES

3.23.1 Historic Conditions

Historically, many residents of New Orleans and the surrounding areas, such as Jefferson and St. Bernard Parishes, constructed fishing camps along the old US 90 corridor near Lake Catherine and along the natural ridges in St. Bernard Parish in communities such as Yscloskey, Hopedale, and Delacroix. As these areas grew in popularity for recreational fishing and hunting, supporting facilities such as marinas and boat launches developed. Consumptive recreational uses both in Louisiana and Mississippi waters have traditionally been saltwater fishing along with recreational crabbing, shrimping, freshwater fishing, and hunting for waterfowl, deer, and small game in wooded swamps and along natural ridges. Non-consumptive activities, hiking, boating, bird watching, camping, and picnicking, attract far fewer participants.

The project area has traditionally provided excellent saltwater fishing opportunities. Anglers have traveled from throughout the region to fish in these waters, especially for the nationally televised Redfish Cup.

As throughout much of coastal Louisiana, the project area has experienced substantial coastal erosion, loss of wetlands and increasing salinity levels. Some of the effects were exacerbated by past and recent hurricanes. As wooded swamp, marsh habitat, and submerged aquatic vegetation in the area have disappeared, waterfowl habitat has diminished and duck hunting opportunities have decreased.

Along with coastal erosion, the area has experienced substantial subsidence and together these forces have deteriorated wooded swamps and natural ridges that formerly supported habitat for deer and other small game species. As this habitat has diminished, hunting opportunities have decreased.

3.23.2 Louisiana Recreational Resources

Recreation areas that were examined in the project area include two National Wildlife Refuges (NWR), two Wildlife Management Areas (WMA), and one State Historic Site (SHS), as well as other significant recreation areas. These areas alone represent approximately 100,000 acres that are visited annually nearly 450,000 times for recreational purposes. Recreation areas include 15 miles of trails for hiking and biking, 38 boat ramps, four fishing piers, one classroom space, two visitor centers or museums, two picnic shelters, and one historic site. These recreation areas provide opportunities for hunting, hiking, biking, boating, bird watching, fishing and crabbing, crawfishing, shrimping, education, camping, picnicking, and playing.

Recreation resources are publicly significant because of: the high value that the public places on fishing, boating, and hunting as measured by the large number of fishing and hunting licenses sold in Louisiana and the large per-capita number of recreation boat registrations in Louisiana.

The **table 3-33** below shows the number of fishing licenses, hunting licenses and boat registrations in the project area.

Table 3-33: FY 2008 Boater Registrations, Fishing / Hunting Licenses

Parish / County	Fishing Licenses					Hunting Licenses		Boater Registrations
	Resident-Freshwater	Resident-Saltwater	Non-Resident (NR) - Freshwater	NR - Saltwater	NR - Salt Season	Resident	Non-Resident	
St. Bernard	2,686	2,683	308	300	101	1,043	14	2,294
Plaquemines	3,104	3,136	1,215	1,211	160	822	34	3,340
Orleans	4,844	4,837	960	909	117	1,523	59	4,157
St. Tammany	26,512	25,837	4,834	4,324	1,179	9,756	336	18,054
Jefferson	49,267	49,131	11,406	11,151	1,571	13,319	369	19,258
Hancock, MS	961	232	166	26	6	584	85	4,943
Harrison, MS	7,515	983	1,181	142	56	3,937	417	15,170

The fishing industry alone is the second largest industry in the state, and has brought in over one billion dollars in the last year from waterways east of Lake Pontchartrain. Fishing and boating marinas will get damaged from hurricanes, and some completely obliterated, but because of the high demand of this recreational activity, marinas rebuild almost immediately. This industry has proven to be strong, and it is important to maintain and prolong the surrounding land area, including the boat launches.

There are several boat launches throughout the project area. People enjoy pleasure boating and fishing in and around these recreational launches. Typical launch sites within St. Bernard and Plaquemines Parishes east of the Mississippi River are detailed below.

a. The Belair Pump Station launch provides a gravel ramp approximately 18 feet wide by 15 feet in length. There is parking for 15 vehicles; however, no lighting, power, water or services are available. The launch is located at a pipeline canal which could possibly be taken to the other pipeline canals that run east into the marsh or connect to River aux Chenes and head south into various small lakes, bays, canals, and eventually Breton Sound.
b. The Pointe a la Hache Marina Boat Launch provides two concrete boat ramps, each 15 feet wide by 20 feet in length. There is also an electric boat lift as well as parking for approximately 870 vehicles. The launch provides lighting, power, and water along with a fuel station and a small grocery store and bait shop. The marina has a launch, as well as in-water slips located at the back levee on a canal that runs parallel to the Mississippi River. Numerous bayous and cut offs of this canal provide access to bays and lakes in the marsh, all of which eventually lead to Breton Sound.
c. Dean's Free Boat Launch provides two concrete ramps, each 11 feet wide by 22 feet in length. There is parking for approximately 93 vehicles and lighting is provided. The launch does not have available power, water, or other services. The launch is located at the end of a company canal and runs south connecting to

a bayou which leads into Lake Lery. From the lake, there is a connection to Bayou Lery near Delacroix which provides access to various bays and canals on its way to Breton Sound.

d. The End of the World Marina is located in Delacroix and is a pay launch that costs $5.00. It provides a shell ramp approximately 37 feet wide by 25 feet in length. There is parking for 156 vehicles and lighting is provided. There is no power, water, or other services provided. Serigne's Boat Launch is also located in Delacroix and is a pay launch. The launch does not have a ramp, but provides an electric lift. There is parking for 355 vehicles, as well as lighting, fuel, and water. There is also a small grocery and bait shop. Both of these launches are at the end of the Delacroix community located on Bayou Lery. The bayou can be taken all the way to Breton Sound and also has numerous bayous and canals off the main bayou into the surrounding marsh.

e. Hopedale Marina and Convenience Store is a pay launch that costs $5.00. The facility includes a concrete ramp approximately 21 feet wide by 8 feet in length. There is also an electric lift and parking for 146 vehicles. No lighting or power is provided, but water and fuel are available. There is also a convenience store and bait shop. The launch is located on Bayou La Loutre and provides access to the MRGO and Breton Sound to the east. There are also several pipeline canals off the bayou that run south into the marsh, bays, and lakes.

f. The Reggio Marina is a pay launch that costs $5.00 and includes a gravel ramp approximately 23 feet wide by 30 feet in length and a concrete ramp 26 feet wide by 30 feet in length. There is also an electric lift and parking for 143 vehicles. Fuel, water, power, and lighting are all available, as well as a small grocery store. The launch is located at the juncture of a pipeline canal and Bayou Lery. The pipeline canal connects to Lake Amedee and various outlets into the marsh area.

g. Frank Campo's Marina is a pay launch that costs $7.00 to $12.00. There is no ramp, but an electric lift is provided as well as parking for 61 vehicles. Power, water, fuel, and lighting are provided. The launch is located at the MRGO and Shell Beach with access to Lake Borgne, Bayou La Loutre, and Breton Sound via the MRGO.

h. The Breton Sound Marina is a pay launch that provides a concrete ramp 28 feet in width by 4 feet in length, as well as an electric lift. Parking is available for 464 vehicles and water, fuel and lighting are also available. There is a small grocery and bait shop. The launch is located on Bayou La Loutre at the MRGO and several pipeline canals off the bayou provide access to the marsh and lagoons to the south. The MRGO provides direct access to Breton Sound.

i. Bayou Bienvenue Marina is a pay launch that costs $5.00. The facility includes two concrete ramps approximately 25 feet wide by 50 feet in length and 15.5 feet wide by 32 feet in length. There is parking for 203 vehicles, as well as 58 launched stalls. Water, power and lighting is provided, but fuel is not available. There is also a small store, Bait Incorporated, which sells tackle and lubricants. The launch is located on Bayou Bienvenue near Parish Road just north of Chalmette. The bayou can be taken out to the MRGO, surrounding marsh, or into Lake Borgne.

j. The launch near Fort Pike is a free public launch located at the Fort Pike Commemorative Area. The facility includes a concrete ramp approximately 20 feet wide by 40 feet in length. There is parking for 157 vehicles; however, no lighting, power, water or services are available. The launch is located on the Rigolets with direct access to Lake Pontchartrain or Lake St. Catherine. The Rigolets can also be taken east into Lake Borgne and the Mississippi Sound.
k. Pip's Launch is a pay launch that charges $4.00 and includes a concrete ramp 22 feet in width by 20 feet in length, as well as an electric lift. There is parking for 143 vehicles and power, fuel, and water are available. There is also a small grocery store. The launch is located between the Hopedale Marina and Breton Sound Marina on Bayou La Loutre and provides access to the same areas.

3.23.2.1 Recreational Resource Facilities in the Project Area

The following table lists the state and Federal recreational facilities that are located in the project area and provides information about size and annual usage. For many sites, visitors are not counted because no parking or entrance fees are collected and there are many entrances to the areas.

The state- and Federally-managed facilities in the project area vary widely in terms of the recreational opportunities provided. The table is based on data gathered through a review of publicly available brochures, contacts with park or refuge managers, and site visits. It provides details about the availability of different types of recreational opportunities at each of the facilities.

The 2003-2008 Louisiana Statewide Comprehensive Outdoor Recreation Plan (SCORP) (available online June 1, 2008 through http://www.crt.state.la.us/parks/iSCORP.aspx) provides a statewide inventory of recreation resources and identifies recreational needs. While regions defined in the SCORP do not fit perfectly within the study area, SCORP Region 1 is a larger region which includes the project area. The state- and Federally-managed areas described above represent just a portion of the more than 282,000 acres of recreational facilities inventoried for SCORP Region 1. Federal, state, parish, and municipal public recreational facilities provide more than 196,000 acres for hunting, 123 boat ramps, 1,833 picnic tables, ten beaches, and 320-acres for camping with 263 tent sites and 1,739 trailer sites. The SCORP-prioritized needs in this region include improving access to enable fishing and boating, funding to support consumptive and non-consumptive activities on all public recreation areas, more wilderness or primitive camping areas, identifying and acquiring large tracts of waterfront lands for large scale parks, and addressing the dwindling state of marine resources.

Other recreational features are provided by parishes and historic communities that attract visitors to a variety of heritage and cultural festivals, historical sites, and parks offering opportunities for active and passive recreation that include tennis courts, soccer and softball fields, swimming pools, and golf courses.

Funds from the Land and Water Conservation Fund (LWCF) have supported 47 different recreational projects in the study area since 1964. LWCF projects in the project area have provided numerous boat ramps and other facilities that enhance opportunities for recreation. Actual LWCF expenditures not adjusted for inflation exceed $10 million in the study area. **Table 3-34** summarizes the number and cost of projects implemented in parishes in the project area. (Source: http://waso-lwcf.ncrc.nps.gov/public/index.cfm)

Table 3-34: LWCF Expenditures in Study Area for Recreational Resources

Parish	Number of Projects	Actual[1] LWCF Funds Expended
Orleans	25	$6,610,700.95
St. Bernard	3	$1,214,738.78
St. Tammany	19	$2,258,501.45
Total	47	$10,083,941.18

[1]Dollar values expended in the years since 1964 are not adjusted for inflation.

3.23.3 Mississippi Recreational Resources

Buccaneer State Park is located in the project area in Hancock County. Due to damage from Hurricane Katrina, it has been closed since 2005. The two miles of the western tip of Cat Island are within the boundaries of the Gulf Islands National Seashore under the jurisdiction of the National Park Service. The island is only accessible by private boat. Recreational opportunities include beaches, hiking, and overnight camping.

Other recreational opportunities in the state territorial waters of Mississippi that are in the project area include saltwater fishing and boating. The Mississippi Charter Boat Captain's Association has an organized membership of over 120 and offers recreational fishing experiences in the Mississippi sound, the Louisiana marshes and the Gulf of Mexico. The charter boats regularly take trips to all of the barrier islands including the Chandeleur Islands and to the Louisiana and Biloxi marsh. The Association states that the variety of fish population in the Mississippi waters is enhanced by the estuaries of the Back Bay and the Louisiana marsh, the "nursery-grounds" of the Gulf of Mexico. Recreational fish caught also include Spanish mackerel, kings, bull redfish, bonito, and tarpon from mid-spring through fall. Bottom fishing includes trout, black drum, spadefish, flounder, ground mullet, sheepshead, and croaker during the short winter season. They also venture out to the offshore oil rigs for red snapper, grouper, bluefish, smoker kings, amberjack, and dolphin (Mahi-Mahi). A popular trip for recreational fishing enthusiasts is wade or skiff-fishing for speckled trout and redfish at Chandeleur Island.

Table 3-35: State and Federal Recreation Areas

Name	Parish Location	Managed By	Size in Acres	Estimated Number of Visitors During 2008	Brief Description	Trails	Boating	Hunting or Trapping	Fishing	Observe Birds, Wildlife	Educational Programs	Play, Picnic, Swim	Camping	Other
Bayou Sauvage NWR	Orleans	U.S. Fish and Wildlife Service	23,000	400,000	Park is entirely within the city limits of New Orleans and is the nation's largest urban wildlife refuge.	3-mile hiking trail; another 9-mile biking trail	1 boat ramp; motor boating and non-motor boating	No	Fishing from boat, bank; craw-fishing, crabbing	Yes; observation deck	Classroom space, educational programming, interpretive panels	Yes; 1 picnic shelter	No	
Biloxi WMA	St. Bernard	Louisiana Department of Wildlife and Fisheries	39,583	Data not available	Biloxi WMA is accessible only by boat via commercial launches at Hopedale and Shell Beach. The area is owned and leased to the Louisiana Department of Wildlife and Fisheries by the Biloxi Marsh Lands Corporation.	No	Motor boating	Small game, waterfowl, birds, alligator	Boat, bank fishing, crabbing, shrimping, shellfishing	Yes	No	No	No	
Breton NWR	St. Bernard	U.S. Fish and Wildlife Service	Data not available	Data not available	Breton NWR is the second oldest refuge in the country and was 100 years old on October 4th, 2004. President Theodore Roosevelt heard about the destruction of birds and their eggs on Chandeleur and Breton Islands in 1904 and soon afterward created Breton NWR.	No	Motor boating	No	Fishing from boat, bank; crabbing	Yes	No	No	No	
Fort Pike SHS	St. Tammany	Louisiana Department of Culture, Recreation and Tourism	94	0 [This park was temporarily closed]	Fort Pike, a military installation, was completed in 1826. The park offers educational programs and demonstrations.	No	1 boat ramp	No	No	Yes	Museum, historic site, educational programming, interpretive panels	Picnic tables	No	
Pearl River WMA	St. Tammany	Louisiana Department of Wildlife and Fisheries	35,031	48,066	Pearl River WMA includes Honey Island Swamp, one of the least altered river swamps in the country.	1-mile trail for hiking and all-terrain vehicles	7 boat ramps on or near WMA; motor, non-motorized boating	Deer, small game, waterfowl, birds, alligator	Boat, bank fishing, crawfishing, crabbing, shrimping, shell fishing	Yes	No	Area for water skiing, wind surfing	Unimproved camping	Shooting range

3.24 AESTHETICS

3.24.1 Historic and Existing Conditions

3.24.1.1 East Orleans Landbridge

The East Orleans Landbridge area’s landscape is made up primarily of marshland with a slight introduction of trees and forestation (within the limits of the Bayou Sauvage National Wildlife Refuge). There is a variety of permanent water features, both natural and man-made, that dot the landscape within the project area. The terrain is relatively flat and characteristic of the lands present in the region. Primary view sheds to the proposed site are offered via Highway 90 and watercraft. The proposed site is made up of single-family residential land uses. Attached to many of these residential uses are somewhat light-industrial/ commercial uses related to the fishing that takes place here. One final land use is public/ natural, pertaining to the Bayou Sauvage National Wildlife Refuge. View sheds along Highway 90 are very dramatic showing all forms of the landscape features and forms discussed above.

The site is extremely remarkable, due to the wildlife refuge. There are several sites along Highway 90 that offer excellent views into the refuge.

The nature of this project area presents an outdoor recreator’s dream with fishing and nature observation as the most predominant potential forms of outdoor recreation in and around the project area. Other forms of potential recreation could include some hiking and biking, though it will most likely be limited to the Highway 90 corridor only.

Figure 3-23: Bayou Sauvage near Highway 90

Figure 3-24: Bayou Sauvage near Highway 90

The Bayou Sauvage area's landscape is made up primarily of a broad mixture of forestation, marshland, wetland and swampland. There is a variety of permanent water features that dot the area within Bayou Sauvage National Wildlife Refuge adding to the variety of terrain and landscape found there. The terrain is relatively flat and characteristic of the lands present in the region. Primary view sheds to the proposed site are offered via Highway 90, Highway 11 and Interstate 10 (I-10). The proposed site is relatively devoid of any kind of development and is primarily a natural area. View sheds along Highway 90 are very dramatic showing all forms of the landscape features and forms discussed above.

Land uses in the area include public, natural areas and what appears to be industrial along the eastern border of the project area. The site is extremely remarkable, due to the wildlife refuge. There are several sites along Highway 90 that offer excellent views into the refuge via boardwalks and piers. Parking and pavilions are available at most of these sites.

3.24.1.2 Central Wetlands

The Central Wetlands' landscape is made up primarily of marshland, wetland and swamp mixed with a variety of water bodies and canals. The terrain is predominantly flat and open with low growing grasses, some scrub shrub and the occasional medium sized tree.

The site is very accessible. The route of Interstate 510 (I-510) traverses near the center of the proposed project area. This route offers a variety of dramatic views into the landscape. The best views come from the I-510 Bridge. There are a variety of land uses along the I-510 corridor including residential, commercial, and some industrial.

Figure 3-25: Central Wetlands from I-510

Figure 3-26: Central Wetlands from I-510

3.24.1.3 Pearl River Mouth – LA

The Pearl River Mouth (LA) area's landscape is made up primarily of marshland with dense trees and forestation and a variety of water bodies and channels leading out to the channel between Lake Pontchartrain and Lake Borgne. The primary developed areas are located along the northern and southwestern borders of the study area (within the project area boundaries). This developed area is relatively compact with land uses focusing on single-family residential. The rest of the project area remains natural and scenic, especially around the Pearl River WMA, which, more or less, forms the eastern boundary of this particular project area. Highway 90 and LA 433 are the major thoroughfares in the area and offer fantastic view sheds into the site. Both highways offer views into the more natural areas of the site. Other view sheds are offered via watercraft, from the waterways and channels connecting Lake Pontchartrain and Lake Borgne.

3.24.1.4 Pearl River Mouth – MS

The Pearl River Mouth (MS) area's landscape is made up primarily of marshland with dense trees and forestation and a variety of water bodies and channels leading out to Lake Borgne. The primary developed areas are located along the northern border of the project area (just outside and adjacent to the project area boundaries). This developed area has land uses focusing on single-family residential. The rest of the project area remains natural and scenic, especially around the Pearl River WMA, located on the western side of the study area. There are no major thoroughfares traversing the study area and no public view sheds from the interior. Other view sheds are offered via watercraft, from the waterways and channels connecting to Lake Borgne.

3.24.1.5 Biloxi Marshes Exterior

The Biloxi Marshes Exterior area's landscape is made up primarily of marshland. The marshland here is much denser than that found in Biloxi Marshes Exterior. The terrain is flat and aquatic. There are no view sheds to the site except from the water located within the site itself, or that of Lake Borgne (located to the west). There are no thoroughfares, nor is there any development available to offer view sheds into the project area.

The remote nature of the area presents an outdoor recreator's dream with fishing and nature observation as the most predominant potential forms of outdoor recreation in and around the project area.

3.24.1.6 Biloxi Marshes Interior

The Biloxi Marshes Interior area's landscape is made up primarily of marshland and large, open water features. The terrain is flat and aquatic. There are no view sheds to the site except from the water of Mississippi Sound (located to the north) or Chandeleur / Breton Sound (located to the east). There are no thoroughfares, nor is there any development available to offer view sheds into the project area.

The remote nature of the area presents an outdoor recreator's dream with fishing and nature observation as the most predominant potential forms of outdoor recreation in and around the project area.

3.24.1.7 Eloi Bay

The Eloi Bay area's landscape is made up primarily of marshland and large, open water features. The terrain is flat and aquatic. There are no view sheds to the site except from the water of Eloi Bay itself (located to the southeast). There are no thoroughfares, nor is there any development available to offer view sheds into the project area. Access is strictly offered only by watercraft.

The site is located in the vicinity of the Biloxi Marshes. The remote nature of the area presents an outdoor recreator's dream with fishing and nature observation as the most predominant potential forms of outdoor recreation in and around the project area.

3.24.1.8 Hopedale

The Hopedale area's landscape is made up primarily of marshland mixed with some forestation and small water bodies. The terrain is predominantly flat and is characteristic of similar sites found in the region. The site is located in an area that is very remote. The nearest major thoroughfare is LA 624, which offers excellent views into the surrounding marshland and water features.

The site is located in the vicinity of Terre aux Boeufs and the MRGO dredge material bank. The remote nature of the area presents an outdoor recreator's dream with fishing, hunting, and nature observation as the most predominant potential forms of outdoor recreation in and around the project area.

3.24.1.9 IHNC/GIWW

The IHNC/GIWW area's landscape is made up primarily of a dense, industrialized, urban environment with some small natural areas along the banks of the waterways. There are many crossing thoroughfares traversing the proposed project area. All of these thoroughfares offer small and simple views into the project area. Vegetation is minimal within the proposed site, offering little in the way of screening and buffering, much less natural areas or other areas of interest. As a somewhat redeeming feature, views from the water channels themselves may offer better views of natural, relatively undisturbed sites along the MRGO. The site is located to the northwest of the Central Wetlands.

3.24.1.10 Terre aux Boeufs

The Terre aux Boeufs area's landscape is made up primarily of marshland, wetland and swamp mixed with a variety of water bodies and canals leading out to Chandeleur / Breton Sound to the southeast. The terrain is predominantly flat and characteristic of other aquatic terrains and landscapes in the region.

The site is located just south of Florissant, Hopedale and the MRGO dredge material bank. The site's location is extremely remote. Access to the site is offered via LA 300 and LA 624, both of which offer a variety of dramatic views into the marshland and natural areas in the vicinity The nearest developed areas (which includes residential, commercial, and some industrial) is located along LA 300 and 624. This development is just inside and adjacent to the project area boundary.

Figure 3-27: Terre aux Boeufs near LA 624

The remote nature of the area presents an outdoor recreator's dream with fishing and nature observation as the most predominant potential forms of outdoor recreation in and around the project area.

Figure 3-28: Terre aux Boeufs near LA 624

3.24.1.11 Lake Borgne

The Lake Borgne area's features are completely aquatic but surrounded on "roughly" three sides by land or land like features. Access to the site is granted through some local roads. Primary access takes place from other connecting waterways, such as the marshlands and canals landside, and the Mississippi Sound to the northeast. View sheds are open and vast, with no obstructions. The Lake itself can be accessed only by watercraft.

3.24.1.12 South Lake Borgne

The South Lake Borgne area's landscape is made up primarily of marshland and open water features leading out to Lake Borgne. The terrain is flat and aquatic. There are no view sheds to the site except from the water of the MRGO or Lake Borgne. There are no thoroughfares, nor is there any development available to offer view sheds into the project area.

The remote nature of the area presents an outdoor recreator's dream with fishing and nature observation as the most predominant potential forms of outdoor recreation in and around the project area.

3.24.1.13 MRGO Dredge Material Bank

The MRGO dredge material bank area's landscape is made up primarily of marshlands mixed with some forestation, water features and the levee system. Though this site is not included to directly receive any of the proposed restoration measures, it is central to the project area, and therefore important to mention. The terrain varies due to the local levee system, but appears to be relatively flat and open with low growing grasses, some scrub shrub and the occasional medium sized tree. The site is very remote with access via the MRGO and watercraft or from atop the levee system. There is no development located in this project area. It remains natural, scenic and relatively untouched.

The MRGO dredge material bank is located along the southern (or western, depending on point of view) bank of the MRGO itself, extending the length of the waterway from Orleans East to Chandeleur/Breton Sound. The remote nature of the area presents an outdoor recreator's dream with fishing and nature observation as the most predominant potential forms of outdoor recreation.

3.24.1.14 Western Mississippi Sound

The West Mississippi Sound's features are almost completely aquatic. The northern border of the proposed site offers view sheds from the beaches along the gulf coast of Mississippi and Cat Island (located in the southeastern corner of the proposed site) offers views in a 360 degree panorama. View sheds are open and vast, with no obstructions. While Cat Island can be accessed only by watercraft, the gulf coast beaches can be accessed from any number of local streets and thoroughfares.

The landscape of Cat Island is made up of sand dunes, low growing foliage plants and what appears to be marshland. The terrain is relatively flat with some slight variations in elevation along the areas with denser foliage and along the dunes of the beaches.

3.24.2 Scenic Streams

3.24.2.1 Historic and Existing Conditions

The Louisiana Scenic Rivers Act of 1988 was established to preserve, protect, and enhance the wilderness qualities, scenic beauties, and ecological regimes of rivers and streams in the state. There are seven identified scenic streams located within the project area (see **figure 3-29**). These include: Bayou Dupre, Lake Borgne Canal (Violet Canal), Bashman Bayou, Terre Beau Bayou, Pirogue Bayou, Bayou Bienvenue, and Bayou Chaperon.

The portion of Bayou Bienvenue classified as scenic is located within the Golden Triangle Marsh area and includes the portion of the bayou from Bayou Villere to Lake Borgne. The remaining six scenic streams are all located within the Central Wetlands area. The portion of Bayou Dupre protected as scenic is from the Violet Canal to Terre Beau Bayou; the Violet Canal is protected from the Forty Arpent Canal to Bayou Dupre; Bashman Bayou is protected from its origin to Bayou Dupre; Terre Beau Bayou is protected from Bayou Dupre to the New Canal; and Pirogue Bayou is protected from Bayou Dupre to the New Canal. Bayou Chaperon is protected as a scenic stream along its entire length.

The general landscape surrounding the scenic streams within the project area consists mainly of coastal marsh habitat. As noted above, six of the scenic streams are located within the Central Wetlands area which consists of flat, open marshland vegetated with numerous grass species, some scrub/shrub habitat, and the occasional medium-sized tree.

Bayou Chaperon is located in the mid-portion of the Central Wetlands area. Near the start of the bayou at the Forty Arpent Canal, the open marsh land is scattered with small to medium-sized cypress trees, giving a glimpse as to what the area looked like in the past. As the bayou proceeds northeast the few cypress trees give way to open brackish marsh habitat that is fairly contiguous with few open water areas. The bayou terminates at a large open water body near the MRGO dredge material bank.

The remaining five scenic streams are interconnected in the southern portion of the Central Wetlands area. The scenic portion of the Violet Canal runs from the 40-Arpent Canal to its connection with Bayou Dupre. The viewshed along this stretch of the canal consists of open marsh habitat with a narrow bank that runs along both sides of the canal and rises a few feet above the surrounding marsh. The banks on both sides of the canal consist of scrub/shrub habitat including baccharis, palmetto, and elderberry with scattered small to medium-sized trees, mostly live oaks and hackberry, interspersed along the banks.

Bashman Bayou, Bayou Dupre, Terre Beau Bayou, and Pirogue Bayou all interconnect between the terminus of the Violet Canal and the MRGO dredge material bank. The surrounding viewshed consists of fairly contiguous marshland with a few open ponds and smaller tributaries off the main bayous. Just beyond the scenic portion of Bayou Dupree near its entrance to the MRGO are several fishing camps and a lock structure, all of which are visible from portions of Bayou Dupre, Bashman Bayou, and Terre Beau Bayou. For all of the scenic streams in this area, views to the east of Lake Borgne and associated marsh habitats are blocked by the dense shrub/scrub habitat of the MRGO dredge material bank and the hurricane protection levees.

Bayou Bienvenue is located just north of the Central Wetlands area within the Golden Triangle Marsh. This marsh area is bordered by the MRGO to the southwest, the GIWW to the north, and Lake Borgne to the east. The scenic portion of the bayou extends from the juncture with Bayou Villere to the entrance into Lake Borgne. The habitat surrounding the bayou consists of very broken brackish marsh with large areas of open water. There is also a fairly large pipeline canal that cuts across the bayou just east of Bayou Villere.

In accordance with LDWF policy concerning the protection of those water bodies classified as scenic, any construction within 100 feet of a scenic stream requires a scenic streams permit. In those areas where the construction limits are more than 100 feet from the scenic stream, the implementation of best management practices (BMPs) would be required to prevent sediment runoff during construction. These BMPs would include, but are not limited to, the use of stacked hay bales or silt fences, mulching and reseeding, use of buffer zones, and the collection and treatment of storm water runoff prior to discharge into a scenic stream, where appropriate.

The Mississippi Scenic Stream Stewardship Act was passed in the 1999 Legislative Session and was signed into law on March 16, 1999. This legislation created the Scenic Streams Stewardship Program, which began August 9, 1999. The goal of the program is to encourage voluntary private conservation efforts by riparian (stream-side) landowners. In a non-regulatory framework, landowners will be assisted in voluntary management agreements which seek to maintain scenic values while ensuring their rights to continue customary uses along the stream. There are no scenic streams in the immediate coastal areas surrounding the Mississippi Sound or St. Louis Bay that would need to be reviewed as part of this study.

Figure 3-29: Scenic Streams and Central Wetlands Area

3.25 FLOODPLAINS

3.25.1 Historic and Existing Conditions

Protection of floodplains and floodways is required by EO 11988, Floodplain Management and 23 CFR Part 650, *Location and Hydraulic Design of Encroachments of Floodplains*. These regulations were designed to minimize permanent encroachments within the 100-year floodplain and to avoid land use development inconsistent with floodplain values. During periods of high water, floodplains serve to moderate flood flow, provide water quality maintenance, and serve as temporary habitat for a number of plant and animal species. The Flood Insurance Rate Maps (FIRM) available for the project area were reviewed to determine if any regulated floodplains or floodways are located within the project area.

The majority of the project area is located in undeveloped coastal areas that generally are not part of any type of regulated floodplain or floodway. The main portions of the project area that are managed and mapped under the FEMA Flood Insurance Rate Mapping System include the developed portions of St. Bernard Parish between the Mississippi River and the Forty Arpent Canal. All of the maps for this area where modified after Hurricane Katrina and the Base Flood Advisory Maps include LA-AA36 through LA-AA43, LA-BB34 through LA-BB40, LA-CC33 through LA-CC39, LA-Z36 through LA-Z44, and LA-41 through LA-45.

Based on these maps, the majority of the project area, including everything located outside the Hurricane Protection System is within Zone VE as classified by FEMA. Zone VE are areas within the 100-year floodplain and also susceptible to high velocity mainly from wave action. The portions of St. Bernard Parish within the Hurricane Protection System are either Zone C or Zone A. Zone C denotes areas of minimal flood hazard and above the 500-year flood level. Zone C may have ponding or local drainage problems that don’t warrant a detailed study or designation as a base floodplain. These areas are mainly directly adjacent to the Mississippi River. The remainder of the Parish is within Zone A. The area classified as Zone A is in the 100-year floodplain meaning it has a 1 percent chance of flooding annually.

CHAPTER 4: **ENVIRONMENTAL CONSEQUENCES**

4.1 INTRODUCTION

In this document, the deauthorized Mississippi River Gulf Outlet navigation channel is referred to as the "MRGO."

The no action alternative must always be included in an Environmental Impact Statement (EIS). The no action alternative is an analysis of the future without project (FWOP) condition. The no action alternative (alternative A) serves as a benchmark against which the impacts of the other alternatives can be compared.

The no action alternative would have direct, indirect, and cumulative impacts related to coastal land loss, which is expected to continue into the future without action. Without action, the key systemic problems in the study area would persist over the period of analysis.

- **Land loss**: 131,100 acres of emergent wetlands are projected to be converted to open water (USGS, 2010).

- **Bank/shoreline erosion**: Erosion would continue threatening the structure of the ecosystem and the integrity of critical landscape features.

- **Habitat change and loss**: Wetland losses, saltwater intrusion, and further modification of natural hydrology would result in an increasingly homogenous system. Rare and unique habitat would become increasingly scarce.

- **Modification of natural hydrology**: Land loss would result in the convergence of open water areas into larger waterbodies, further altering the study area hydrology.

- **Decreased freshwater, sediment, and nutrient inputs**: Authorized freshwater diversion projects in the study area would not fully address the need for additional freshwater, sediments, and nutrients to nourish emergent vegetation and counteract subsidence and sea level rise.

- **Saltwater intrusion**: The channel closures at Bayou La Loutre and the Inner Harbor Navigation Canal (IHNC) are projected to decrease saltwater intrusion into the IHNC and Lake Pontchartrain via the MRGO. However, land loss and shoreline erosion would continue to allow more saline waters into the study area estuaries.

- **Retreating and eroding barrier islands**: The entire Chandeleur Island chain is projected to convert to subsurface shoals within the period of analysis.

- **Ridge habitat degradation and destruction**: The Bayou La Loutre Ridge would continue to subside to marsh elevation.

- **Invasive species and herbivory**: Without action, invasive vegetation will continue to out-compete native species. Nutria would continue to destroy emergent wetlands.

- **Increasing susceptibility to storm surge**: As emergent vegetation along the marsh edge continues to degrade and erode, interior marshes and human development will become increasingly exposed to the open waters of the Gulf of Mexico.

For comparison of alternatives, the period of analysis is from 2015 to 2065. The 50-year period begins with the first year of operation (2015 – first year when benefits would be realized) and extends to 2065.

Based on all of the preliminary analysis performed for the Violet, Louisiana Freshwater Diversion, Alternative Location 1 was considered the best hydraulic location; however, the diversion will be further investigated in the feasibility phase of the analysis with appropriate NEPA documentation. For the purposes of impact analysis for this FEIS, the footprint for the Alternative Location 1 was utilized. In order to run the models, such as CASM, to develop the potential impacts and benefits of the overall project, parameters for the diversion had to be established and utilized. Therefore, in the **chapter 4** impacts analysis for each environmental resource, the parameters of Alternative Location 1 for the Violet, Louisiana, Freshwater Diversion were used.

4.2 TENTATIVELY SELECTED PLAN SUMMARY

The tentatively selected plan (TSP) referenced throughout **chapter 4** as alternative C, would restore and protect approximately 57,472 acres of habitat in the study area, including 14,123 acres of fresh and intermediate marsh; 32,511 acres of brackish marsh; 10,318 acres of cypress swamp; 466 acres of saline marsh; and 54 acres of ridge habitat. The tentatively selected plan also identifies 71 miles of shoreline protection including 5.8 miles of oyster reef restoration. The tentatively selected plan is the National Ecosystem Restoration Plan.

Recommendations are divided into tiers by the level of uncertainty regarding conditions for ecological success and long-term sustainability, including the need for additional study.

- Tier 1 includes features that have been developed to a feasibility level of detail and are not dependent on a freshwater diversion. Tier 1 features are recommended for construction. Tier 1 would restore and protect 21,684 acres of marsh, 54 acres of ridge, and includes 61 miles of shoreline protection (including 5.8 miles of oyster reef restoration)
- Tier 2 includes features with feasibility level detail that are dependent upon salinity conditions but may be sustainable without the implementation of a

freshwater diversion. If future conditions and further analysis indicate that favorable conditions for ecological success and long term sustainability exist (as defined in the adaptive management plan), then these projects may be constructed. Tier 2 would restore 1,580 acres of marsh and 1,465 acres of cypress swamp.

- Tier 3 includes further study of the Violet Freshwater Diversion, any features that are dependent on freshwater diversion, and features in Tier 2 that future conditions and further analyses indicate are not sustainable.

Following the identification of the TSP, a construction sequence was developed. Assumptions factoring into the construction sequence include production rates for building rock projects, dredge equipment availability, land loss rates, and the limitation of alternating dredging cycles in the lobes of Lake Borgne.

The timing and availability of financial resources for implementation is a major uncertainty that must be considered given current Federal budgetary constraints. If the plan is not implemented in the near future, conditions will continue to degrade. The impact of the uncertainties associated with the future condition of the study area could increase restoration costs, decrease restoration benefits, or both. The uncertainties associated with implementation are increased because a non-Federal sponsor has not been identified.

Funding assumptions, as detailed in the **appendix U**, were required for planning purposes and to develop costs and benefits for the plan. Construction sequencing assumed optimal funding appropriations and an aggressive schedule to complete implementation as soon as realistically possible. Given the considerable need for the plan, Federal interest, significance of resources, and the conditional authorization for implementation, an aggressive implementation sequence was considered appropriate. The implementation of the HSDDRS demonstrates National interest in study area resources and the magnitude of what can be achieved when stakeholders are united in purpose. However, current budgetary conditions and the lack of a non-Federal sponsor make it very likely that reality will differ from these optimal assumptions. Risk and uncertainties related to implementation have been assessed in the Cost Risk Analysis, as detailed in the **appendix U**. However, due to uncertainties associated with the timing and availability of funding for the plan, only features that are sustainable without the implementation of any other feature are recommended for construction at this time.

4.3 ENVIRONMENTAL CONSEQUENCES SUMMARY TABLE

Impacts by alternative and resource are described in **table 4-1**.

Table 4-1: Evaluation of Potential Impacts to Significant Resources by Alternative

Environmental Resources	Alternatives			
	Alternative A No Action	Alternative B	Alternative C	Alternative D
HYDROLOGY AND HYDRAULICS (H&H)	No direct impacts. Indirect and cumulative impacts include altered flow patterns, altered paths of tidal propagation, and loss of tidal connection. Slight reduction in salinity due to other projects. Continued loss of wetlands is expected due to lack of hydraulic connectivity and sediment source, as well salinity levels.	Flow velocities would be negligibly increased as a result of 1,000 cubic feet per second (cfs) background flow and would not impede fish passage. Increased flow velocity and local eddies expected at point of discharge during 7,000 cfs discharge. Flow velocity rapidly decreases when discharged into the MRGO.	No change in diversion flow regime so impacts would be similar to alternative B.	No change in diversion flow regime so impacts would be similar to alternative B.
WATER QUALITY	Current water quality conditions would persist; dissolved oxygen (DO) levels and bacterial concentration would persist; continued loss of wetlands reduces ability to filter and absorb pollutants.	Create 7,444 acres and nourish 12,186 acres marsh; create 4,225 acres and nourish 6,093 acres swamp; benefit water quality in terms of increased DO, reduced turbidity, and filtration and trapping of pollutants once construction completed.	Create 17,352 acres and nourish 26,836 acres marsh; create 4,225 acres and nourish 6,093 acres swamp; benefit water quality in terms of increased DO, reduced turbidity, and filtration and trapping of pollutants once construction completed.	Create 18,056 acres and nourish 26,836 acres marsh; create 4,225 acres and nourish 6,093 acres swamp; benefit water quality in terms of increased DO, reduced turbidity, and filtration and trapping of pollutants once construction completed.
WATER QUALITY (salinity)	Potential reduction of 2-3 parts per thousand (ppt) in salinity based on the proposed construction of several diversion projects in the study area.	A maximum salinity change of -1.0 to -1.4 ppt in Lake Borgne from May to December based on proposed diversion of 1,000 cfs and peak diversion flow of 7,000 cfs. Salinity in the Mississippi Territorial Waters are predicted to be reduced by -0.6 to -0.9 ppt under combined influence of Violet, Louisiana Freshwater Diversion and the 4,500 cfs of the combined Maurepas Swamp area diversions.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
NAVIGABLE WATERWAYS	Current conditions would persist. Other projects such as other freshwater diversions; MRGO closure; sector gates on the Gulf Intracoastal Waterway and Bayou Bienvenue; and construction of the storm surge barrier may affect current navigable waterways.	Mississippi River navigation would not be impacted. Navigation in the GIWW may be affected by current from diversion flow. Velocities at Bayou Bienvenue and Bayou Dupre control structures would not affect navigation. Impact to navigation in Central Wetlands area from increased velocities or gate closures.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.

Table 4-1: Evaluation of Potential Impacts to Significant Resources by Alternative

Environmental Resources	Alternatives			
	Alternative A No Action	**Alternative B**	**Alternative C**	**Alternative D**
SOILS	Continued loss of sediments due to shoreline erosion and wetland loss.	Diversion channel (Alternative 1 location) would impact approx. 442 acres of soils designated as prime farmland.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
AIR QUALITY	St. Bernard, St Tammany, Orleans, and Plaquemines Parish are in attainment for all pollutants. Air quality trends would have no direct beneficial or adverse impacts.	Emissions increases from construction are not expected to cause or contribute to a violation of Federal or state ambient air quality standards.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
NOISE	No impacts anticipated from FWOP condition	No significant impacts anticipated; potential temporary impacts to communities near the diversion; may be temporary and local disturbance of some wildlife.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE (HTRW)	No potential impacts due to any associated construction activities.	An HTRW Phase I was performed for the study area, and identified a low probability of encountering contaminants of concern.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
BARRIER ISLAND RESOURCES	The Chandeleur Islands would continue to erode: it is estimated that by 2014, Breton Island would be subaerial and the entire island chain completely eroded.	No impacts from this alternative. Preliminary modeling efforts for the barrier islands indicate additional study is warranted. Additionally, modeling parameters that involve the impacts of the oil spill have to be considered and the future is uncertain based on the magnitude of the spill and the constantly changing efforts to alleviate the immediate environmental impacts.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.

Table 4-1: Evaluation of Potential Impacts to Significant Resources by Alternative

Environmental Resources	Alternatives			
	Alternative A No Action	**Alternative B**	**Alternative C**	**Alternative D**
COASTAL VEGETATION RESOURCES	Loss of 131,091 acres by 2065.	Restoration plan includes 54 acres ridge; create 4,225 acres, nourish 6,093 acres swamp; create 7,444 acres, nourish 12,186 acres marsh; Diversion channel (Alternative 1 location) would adversely impact 227 acres of existing wetlands. While the project area will see an increase in wetland acreage, the system as a whole could continue to encounter some vegetative losses.	Restoration plan includes 54 acres ridge; create 4,225 acres, nourish 6,093 acres swamp; create 17,352 acres, nourish 26,836 acres marsh; Diversion channel would adversely impact 227 acres of existing wetlands. While the project area will see an increase in wetland acreage, the system as a whole could continue to encounter some vegetative losses.	Restoration plan includes 54 acres ridge; create 4,225 acres, nourish 6,093 acres swamp; create 18,056 acres, nourish 26,836 acres marsh; Diversion would adversely impact 227 acres of existing wetlands. While the project area will see an increase in wetland acreage, the system as a whole could continue to encounter some vegetative losses.
WILDLIFE RESOURCES	Continued decline in quality of wildlife habitat adversely impacts wetland dependent wildlife populations.	Restoration plan would provide 54 acres ridge; 19,630 acres of new marsh; 10,318 acres swamp habitat and protect 35,367 linear feet of shoreline vital to neotropical migratory birds; colonial nesting birds, waterfowl and mammals.	Restoration plan would provide 54 acres ridge; 44,188 acres of new marsh; 10,318 acres swamp habitat and protect 314,944 linear feet of shoreline vital to neotropical migratory birds; colonial nesting birds, waterfowl and mammals.	Restoration plan would provide 54 acres ridge; 44,892 acres of new marsh; 10,318 acres swamp habitat and protect 410,567 linear feet of shoreline vital to neotropical migratory birds; colonial nesting birds, waterfowl and mammals.
AQUATIC AND FISHERY RESOURCES	Wetland fragmentation, emergent wetland loss, shoreline and bank line erosion result in substantial decrease of critical essential fish habitat (EFH) needed for important fish life cycles, reducing the area's ability to adequately support Federally managed species.	Convert 7,444 acres of shallow open water and nourish 12,186 acres of marsh to create a more continuous emergent transitional wetland and 35,367 linear feet of shoreline protection. Based on preliminary aquatic impact analysis, results show no significant impacts to fishery species including Atlantic croaker, red drum (juveniles and adults), spotted sea trout (juveniles and adults), stripped mullet, sheepshead, Gulf menhaden, and bay anchovy. However, the potential for localized impacts to some species in areas closest to the Violet, Louisiana Freshwater Diversion could occur, as well as potential increases further away.	Creation of approximately 17,356 acres of marsh, 314,944 linear feet of shoreline protection, nourish 26,836 acres of existing marsh habitat. Based on preliminary aquatic impact analysis, results show no significant impacts to fishery species including Atlantic croaker, red drum (juveniles and adults), spotted sea trout (juveniles and adults), stripped mullet, sheepshead, Gulf menhaden, and bay anchovy. However, the potential for localized impacts to some species in areas closest to the Violet, Louisiana Freshwater Diversion could occur, as well as potential increases further away.	Similar to that of alternative C, with the following exceptions, additional 95,623 linear feet of shoreline protection, 704 acres of additional marsh created. Based on preliminary aquatic impact analysis, results show no significant impacts to fishery species including Atlantic croaker, red drum (juveniles and adults), spotted sea trout (juveniles and adults), stripped mullet, sheepshead, Gulf menhaden, and bay anchovy. However, the potential for localized impacts to some species in areas closest to the Violet, Louisiana Freshwater Diversion could occur, as well as potential increases further away.

Table 4-1: Evaluation of Potential Impacts to Significant Resources by Alternative

Environmental Resources	Alternatives			
	Alternative A No Action	**Alternative B**	**Alternative C**	**Alternative D**
COMMERCIAL FISHERIES	Decline expected as habitat loss and degradation from erosion due to salinity changes lead to overfishing of the resource.	Convert 7,444 acres of shallow open water and nourish 12,186 acres of marsh to create a more continuous emergent transitional wetland and 35,367 linear feet of shoreline protection. Based on preliminary aquatic impact analysis, results show slight increase in net productivity for juvenile white shrimp and brown shrimp within Lake Borgne.	Restoration of approximately 17,356 acres of marsh, 314,944 linear feet of shoreline protection, nourish 26,836 acres of existing marsh habitat. Based on preliminary aquatic impact analysis, results show slight increase in net productivity for juvenile white shrimp and brown shrimp within Lake Borgne.	Similar to alternative C, additional 95,623 linear feet of shoreline protection, 704 acres of additional marsh created. Based on preliminary aquatic impact analysis, results show slight increase in net productivity for juvenile white shrimp and brown shrimp within Lake Borgne.
OYSTER RESOURCES	Loss of wetlands in the project area would likely alter the detritus-based food web of the oyster, thereby reducing the localized carrying capacity for oyster leases in the area.	Would borrow 87 million cubic yards (mcy) of borrow in Lake Borgne. Convert 7,444 acres of shallow open water and nourish 12,186 acres of marsh to create a more continuous emergent transitional wetland and 35,367 linear feet of shoreline protection. Based on preliminary aquatic impact analysis, results show slight decreases to oysters and spat through Lake Borgne and the Inner Biloxi Marsh.	Restoration of approximately 17,352 acres of marsh, 314,944 linear feet of shoreline protection, nourish 26,836 acres of existing marsh habitat using 152 mcy of borrow. Based on preliminary aquatic impact analysis, results show slight decreases to oysters and spat through Lake Borgne and the Inner Biloxi Marsh.	Similar to that of alternative C, additional 95,623 linear feet of shoreline and 704 acres or marsh created using an additional 2.3 mcy of borrow. Based on preliminary aquatic impact analysis, results show slight decreases to oysters and spat through Lake Borgne and the Inner Biloxi Marsh.
PLANKTON RESOURCES	No Action would have an additive impact due to increasing salinity and a transition to more marine-dominated community.	Minor changes in salinity (-0.6 to -1.4 ppt) in Lake Borgne and the Biloxi Marsh would not have a substantial effect on plankton abundance or distribution.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
WATER BOTTOMS AND BENTHIC RESOURCES	Persistence of existing conditions, including existing emergent wetlands converted to water bottoms no longer available for use by benthic species assemblages typically using this habitat.	Excavation of 87 mcy of material, to depths of ten feet with a maximum depth of twelve feet, from a total of 9,036 acres of water bottom. Based on preliminary aquatic impact analysis, results show slight increase in annual net productivity for benthic species in East Lake Pontchartrain and Lake Borgne.	Excavation of 152 mcy of material, to depths of ten feet with a maximum depth of twelve feet, from a total of 15,724 acres of water bottom. Based on preliminary aquatic impact analysis, results show slight increase in annual net productivity for benthic species in East Lake Pontchartrain and Lake Borgne.	Excavation of 154.3 mcy of material, to depths of ten feet with a maximum depth of twelve feet, from a total of 15,724 acres of water bottom. Based on preliminary aquatic impact analysis, results show slight increase in annual net productivity for benthic species in East Lake Pontchartrain and Lake Borgne.

Table 4-1: Evaluation of Potential Impacts to Significant Resources by Alternative

Environmental Resources	Alternatives			
	Alternative A No Action	**Alternative B**	**Alternative C**	**Alternative D**
ESSENTIAL FISH HABITAT	Wetland fragmentation and emergent wetland loss contributing to the continued degradation of EFH for species utilizing this habitat such as; larvae and juvenile brown shrimp, juvenile white shrimp, all life stages of red drum, and juvenile dog snapper.	Convert 7,444 acres of shallow open water and nourish 12,186 acres of marsh to create a more contiguous emergent transitional wetland. Based on preliminary aquatic impact analysis, results show slight decrease in net productivity for juvenile red drum, white shrimp, and brown shrimp within Lake Borgne. Construction of retention dikes and reverse tidal flows could reduce utilization of Central Wetlands by certain species.	Restoration of approximately 17,352 acres of marsh, 314,944 linear feet of shoreline protection, nourish 26,836 acres of existing marsh habitat. Based on preliminary aquatic impact analysis, results same as alternative B. Construction of retention dikes and reverse tidal flows could reduce utilization of Central Wetlands by certain species.	Similar to that of alternative C, with the following exceptions, additional 95,623 linear feet of shoreline protection, and 704 acres of additional marsh created. Based on preliminary aquatic impact analysis, results same as alternative B. Construction of retention dikes and reverse tidal flows could reduce utilization of Central Wetlands by certain species.
THREATENED AND ENDANGERED (T&E) SPECIES	Loss of coastal wetland habitat resulting from the continued transition of wetland habitats and barrier island habitats to shallow open water habitats.	Approximately 87 mcy borrow materials, 122 acres impacts from shoreline protection from Gulf sturgeon critical habitat.	Approximately 152 mcy borrow material, 1,937acre impacts from shoreline protection from Gulf sturgeon critical habitat.	Approximately 154.3 mcy borrow material 2,494 acre impacts from shoreline protection from Gulf sturgeon critical habitat.
SOCIO-ECONOMIC RESOURCES - Population	The no action alternative, would have no direct, indirect, or cumulative impacts on human populations.	There are no direct impacts to human populations within the project area. Hence, this alternative would not be expected to have any cumulative effects on nearby populations.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
SOCIO-ECONOMIC RESOURCES – Community Cohesion	The no action alternative would have no impact on community cohesion	The construction of the diversion would create a new canal temporarily impacting traffic and thus affecting flow linkage between the two subdivisions and connected community residents.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
SOCIO-ECONOMIC RESOURCES – Employment and Income	The no action alternative would result in continued wetland loss and localized impacts on employment and income.	Alternative B would work synergistically with other projects and programs to support coast wide wetland-dependent employment.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
SOCIO-ECONOMIC RESOURCES - Infrastructure	The decline wetlands would contribute to the deterioration of substrate upon which infrastructure features are constructed.	Alternative B would restore or protect 30,002 acres in the project area, which would assist with protection of existing infrastructure.	Alternative C would provide greater beneficial impacts through the restoration of 24,558 acres more than alternative B.	Impacts would be slightly greater than alternative C, because 704 additional acres would be restored.

Table 4-1: Evaluation of Potential Impacts to Significant Resources by Alternative

Environmental Resources	Alternatives			
	Alternative A No Action	Alternative B	Alternative C	Alternative D
SOCIO-ECONOMIC RESOURCES – Oil, Gas and Utilities Pipelines	The no action alternative could expose buried pipelines thereby increasing the risk of failure or damage due to lack of structural stability, anchor dragging, and boat collisions.	The restoration proposed for alternative B would prevent the increase in maintenance and relocation costs for pipelines in and around the project area.	Alternative C would provide more complete protection for oil and gas infrastructure than alternative B, and would produce more beneficial impacts through the restoration of 24,558 additional acres.	Impacts would be slightly greater than alternative C, because 704 additional acres would be restored.
SOCIO-ECONOMIC RESOURCES – Commercial Fisheries	Continued conversion of existing wetlands to open water habitats, continued bankline erosion and sloughing of the shoreline. Sharp declines are predicted in fisheries productivity under the no action alternative.	Alternative B would provide important fisheries habitat. Overall, the industry would be more stable near the project area due to a long-term increase in the quality of fisheries habitat.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
SOCIO-ECONOMIC RESOURCES – Oyster Leases	The loss of wetlands in the project area would likely alter the detritus-based food web of the oyster thereby reducing the localized carrying capacity for oyster leases in the area.	Creation, protection and nourishment of emergent wetlands in the project area in conjunction with other actions proposed and implemented in the vicinity would not affect the productivity of planktonic resources upon which oysters feed.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
SOCIO-ECONOMIC RESOURCES – Flood Control and Hurricane Protection Levees	The no action alternative would have no direct impacts on flood control or hurricane protection levees. Indirect impacts would result in the continued degradation of the landbridge separating Lake Borgne from the MRGO channel, the conversion of existing wetlands to open water habitats, and the continued bankline erosion and sloughing of the shoreline.	Alternative B would protect and restore marsh outside of the levees, which would help protect the levees, allowing current level of risk reduction in the project area to be maintained.	Benefits would be greater than alternative B, by providing an additional 24,558 acres of marsh benefits.	Impacts slightly greater than alternative C, by providing 704 acres of additional marsh benefits.
SOCIO-ECONOMIC RESOURCES – Navigation	As Louisiana's coastal wetlands continue to fragment and convert to open water, the protection wetlands provide to inland waterways from wind-driven waves would be reduced.	Alternative B would work with other projects to protect adjacent waterways, such as the GIWW, from waves propagated through the lake, thus providing a safer route for inland water-borne traffic.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.

Table 4-1: Evaluation of Potential Impacts to Significant Resources by Alternative

Environmental Resources	**Alternatives**			
	Alternative A No Action	**Alternative B**	**Alternative C**	**Alternative D**
ENVIRONMENTAL JUSTICE	With continued wetland loss, loss of valuable property, increased flooding risk of homes and businesses, impacts would affect all population groups.	Communities are located on either side of the areas where the proposed diversion would be located (Alternative 1 location). Concerns raised at public meetings include: a perceived potential for induced flooding, disapproval of the location, a perceived lack of benefits to St. Bernard Parish, and community cohesion.	Potential impacts would be the same as alternative B.	Potential impacts would be the same as alternative B.
HISTORIC AND CULTURAL RESOURCES	Continued erosion of cultural sites is expected.	Deposition of dredged material could increase the rate of subsidence and the disappearance of important sites from the archaeological record. National Register eligible sites would either have to be avoided or adverse effects would have to be mitigated.	Alternative C includes 24,558 additional acres of restoration activities, and therefore greater potential impacts.	Alternative D includes 704 additional acres of restoration activities, and therefore greater potential impacts.
RECREATION RESOURCES	Continued wetland loss and conversion of existing wetlands to open water habitats resulting in decreased structural complexity and habitat diversity of recreational fish caught and game species hunted.	Restoration should improve recreational fishing and wildlife hunting opportunities. Freshwater diversion could improve duck hunting. Freshening from diversion may push some recreational fishing further into more saline waters within the project area. Based on preliminary aquatic impact analysis, results show decrease in net productivity for spotted sea trout in the Inner Biloxi Marsh but a slight increase in net productivity for juvenile white shrimp and brown shrimp within Lake Borgne	Similar effect as alternative B for diversion feature, for wetland measures, impacts are to a greater extent.	Effects to resource similar to alternative C.

Table 4-1: Evaluation of Potential Impacts to Significant Resources by Alternative

Environmental Resources	Alternatives			
	Alternative A No Action	**Alternative B**	**Alternative C**	**Alternative D**
AESTHETICS (Scenic Rivers)	Continued habitat deterioration, land loss, and conversion to open water reducing scenic qualities of area.	Temporary impacts from the Restoration Plan could include a reduction in access, reduced water quality, and possible sedimentation. However, the overall project would create and nourish 4,317 acres of marsh and 7,693 acres of swamp in the vicinity of the scenic streams restoring their viewscape to its original habitat types.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.
FLOODPLAINS	A large portion of the project area is coastal marsh habitat, which would continue to degrade and increase the flood risk to developed portions of the floodplain.	Approximately 529 acres within the 500 and/or 100-year floodplain would be converted to floodway as part of the construction of the diversion canal (Alternative / Location. Guide levees and control structures would eliminate the flood risk to communities or development in the adjacent floodplain.	Impacts would be similar to alternative B.	Impacts would be similar to alternative B.

4.4 HYDROLOGY – HYDRAULICS

4.4.1 Alternative A - No Action Plan

Direct Impacts

In the FWOP condition (no action alternative) there would be no direct adverse impacts to hydrology; however, through other programs such as Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA), Coastal Impact Assistance Program (CIAP), and Louisiana Coastal Area (LCA), there are direct beneficial impacts from other freshwater diversion projects proposed or authorized for construction within the study area. These diversions would be expected to have some impacts to the hydrology in the basin. Based upon storm surge and wave modeling in support of the Louisiana Coastal Protection and Restoration (LACPR) evaluation of comprehensive hurricane risk reduction, the loss of wetland areas increases storm surge and wave potential (draft LACPR report, 2008). However, with the present level of scientific knowledge it is difficult to determine the acreage of wetlands lost, and because the levee heights and alignments, shoreward depths, and storm characteristics all affect the height of storm surge, thus it is difficult to determine the effect of wetland loss in the project area on storm surge.

Indirect Impacts

Programs such as CWPPRA, CIAP, and LCA as well as ongoing hurricane risk reduction projects would have indirect impacts on the study area. An example of ongoing or recently constructed projects includes the MRGO rock closure structure that was completed in August 2009. This structure, along with the sector gates on the GIWW and Bayou Bienvenue planned for the authorized improvements to the Greater New Orleans Hurricane and Storm Damage Risk Reduction System (HSDRRS), would alter flow patterns in and near the western end of the project area. Construction of this storm surge barrier structure would include dredging of an access channel on the Lake Borgne side of the floodwall (USACE, 2008). The access channel would connect the MRGO with the GIWW across the Golden Triangle, but would close off an existing connection. The net effect has been determined to be negligible. The gates across Bayou Bienvenue and the GIWW would remain open, except when a storm surge is present or anticipated.

Construction of the storm surge barrier structure would alter the flow path of tidal propagation into the Central Wetlands area through the Bayou Bienvenue control structure. Whereas, prior to the construction of this project (which at the time of this writing, although not near completion, has reached a point of effecting the changes of tidal flow), tidal flow in and out of the Bayou Bienvenue control structure came from multiple directions (i.e. from across the MRGO as well as from north and from south in the MRGO), with this barrier in place the tidal flow no longer comes from the south in the MRGO. Likewise the completed MRGO closure structure at the Bayou La Loutre Ridge has altered tidal flow paths to the Bayou Dupre control structure. The tidal connection with Breton Sound via the MRGO has been severed. Modeling of the project area with the UNO Mass balance model has shown a slight reduction in salinity in the project area, but not sufficient to alleviate the need of a freshwater diversion.

The HSDRRS barrier would prevent salt-water intrusion into the interior marshes to the west of the barrier in storm situations, while minimally impeding tidal flows under normal circumstances. This barrier would not influence salinity outside of the barrier, nor would it influence salinity within the Central Wetlands area as the gates of the Bayou Dupre and Bayou Bienvenue control structures are closed during tropical events.

Modeling scenarios for the barrier structures indicate that the proposed flood protection levee could raise the water levels by 0.1 foot (0.03 m) or less, (USACE, 2008). However, the authors of this modeling study caveat their results as follows: "this change in average water volume represents a difference of less than one inch of water depth distributed across the region. This difference in volume may be smaller than the precision achievable with present computational resources."

Because of the high uncertainty inherent in sea level rise projections, the Mississippi Coastal Improvements Program (MsCIP) and the LACPR efforts used scenarios to evaluate the effects of different relative sea level rise (RSLR) rates over a 50-year planning period. The RSLR values used for the MsCIP scenarios were 0 feet, 2 feet, and 3.4 feet (MsCIP, 2008). The RSLR values used for the LACPR scenarios were 1.3 feet and 2.6 feet (LACPR, 2008). Relative sea level rise has the potential to accelerate the land loss problem through several feed-back mechanisms. Open water areas could become deeper thus allowing for more wave growth and thus more shoreline erosion which could increase wind fetch length again enhancing wave growth. Relative sea level rise could also inundate some vegetation and create additional open water areas. The greater extent of open water could increase the tidal prism allowing for greater tidal exchange with the more saline waters of the Gulf of Mexico. Increased salinity in the project area should be anticipated for the no action alternative. Because the magnitude of relative sea level rise is uncertain and the resulting increase in the wetland loss rate is equally uncertain, it is difficult to quantify the magnitude of the increase of salinity in the project area for the no action alternative.

Cumulative Impacts

Cumulative impacts include the synergistic effect of alternative A on hydrology with the additive combination of similar wetland degradation and wetland loss impacts to hydrology and hydraulics throughout coastal Louisiana, as well as the benefits and impacts to other state and Federal projects in the vicinity as detailed in **chapter 2**. Under alternative A, no restoration projects would be implemented and, therefore, would not contribute incrementally to cumulative impacts on hydrology and hydraulics in the project area. Other reasonably foreseeable state and Federal projects, as described in **chapter 2** would combine to have further impacts on hydrology and hydraulics in the project area.

4.4.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

Proposed wetland creation and nourishment and shoreline protection features associated with alternative B would not directly alter existing hydrology and hydraulics. Hydrologic connectivity between the wetland creation and nourishment sites and Lake Borgne would be temporarily disrupted by the construction of retention dikes. However, retention dikes would be designed to naturally degrade following completion of construction thereby maintaining hydrologic connectivity with Lake Borgne and other associated waterbodies. Fish access gaps incorporated into shoreline protection features would maintain hydrologic connectivity between the shoreline and adjacent waterbodies. The potential borrow sites in Lake Borgne would be located at least 3,000 feet from shorelines. This would prevent potential borrow site-induced changes to the wave climate thereby reducing the risk of increased shoreline erosion rates.

Indirect Impacts

The flow regime for this plan is for freshwater diversion flow of 1,000 cubic feet per second (cfs) ten and a half months of the year with a pulse to 7,000 cfs during the months of mid-April through May. The two-tiered diversion scheme is to address two separate project goals. The 7,000 cfs flow is to meet salinity goals for the month of May in the Biloxi Marsh area. For the other months of the year the existing salinity levels in the Biloxi marsh meet the specified criteria for enhanced oyster production. Because of the distance from the diversion location, relatively large flows are required to effect a relatively small (but significant) salinity reduction in the Biloxi marsh area. The 1,000 cfs flow is designed to maintain the Central Wetlands area as a fresh system so as to enable the establishment of a cypress swamp.

The introduction of Mississippi River (fresh) water into the project area would change flow patterns, water levels, and salinity in the project area. Each of these three items (flow patterns, water levels, and salinity) is discussed separately for both the 1,000 cfs flow and the 7,000 cfs flow, both inside and outside of the Central Wetlands area.

The preliminary design for the proposed Violet, Louisiana Freshwater Diversion consists of culverts under the Mississippi River levee and the highway and railroad adjacent to the levee, a channel through the Central Wetlands area and culverts under the hurricane levee and T-wall adjacent to the MRGO. By adjusting the opening of the culverts under the hurricane levee, water levels in the Central Wetlands area can be managed for optimal growth and regeneration of the cypress swamp. By throttling the opening size during the 7,000 cfs flow the cypress swamp can be totally inundated for the purpose of reducing competition from other plants that are not as flood tolerant as cypress. By completely opening the culverts during the 1,000 cfs flow, it would be possible to lower the water level below ground elevation to allow for cypress regeneration.

Inside the Central Wetlands area, flows from the diversion would not produce large currents. A diversion channel sized to carry the 7,000 cfs flow with velocities of 2 feet per second would be dug through the Central Wetlands area. This channel would be more than adequate to handle the smaller 1,000 cfs. Flows through the culverts would be of a larger magnitude (approximately 6 feet per second [fps] for the 7,000 cfs flow).

However these flows would discharge into the MRGO, which would act essentially as a large reservoir. There would be flow from the discharge point through the estuary and out to sea, but the volume of flow would be significantly less than the tidal volume of flow. Thus, the flow velocities in and beyond the MRGO reservoir would be very slow. The only significant velocities would be at the discharge point where the flow from the culverts drains into the MRGO reservoir. This would create local eddies, but the flow velocity would rapidly diminish away from the discharge point. If the 1,000 cfs flow is directed toward the existing control structures (Bayou Bienvenue control structure and Bayou Dupre control structure), assuming an equal distribution, the velocities in the throat of the structures would be increased (or decreased on the incoming tide) by about one foot per second. These velocities would be significantly less than the existing tidal velocities and are less than current velocities that would impede fish passage.

Water levels outside of the Central Wetlands area would not be measurably increased away from the immediate area of the discharge point. Water levels inside the Central Wetlands area would be managed. The greatest hydrologic impact of the project would be on salinity. The Central Wetlands area would become an essentially fresh system. Salinity as far away as the Biloxi Marsh and the western Mississippi Sound would experience a slight reduction in salinity, especially in the late spring months resulting from the 7,000 cfs pulse during April and May. Areas between the Biloxi Marsh and the Central Wetlands area would be progressively freshened westward. This means that the western portion of Lake Borgne may have salinity reductions to the extent that oyster production may be impacted.

Cumulative Impacts

Cumulative impacts to hydrology and hydraulics would primarily be associated with incremental impacts of reasonably foreseeable future wetland restoration and shoreline protection features in and near the project area as well as throughout coastal Louisiana. As described above in the direct and indirect sections, alternative B would not add incrementally to the direct impacts to hydrology and hydraulics, but would contribute to indirect cumulative impacts.

4.4.3 Alternative C - MRGO Restoration Plan 7

Direct Impacts

Direct impacts to hydrology and hydraulics associated with alternative C would be the same as the impacts from alternative B, as delineated in **section 4.3.2**, since the flow regime and the timing are the same.

Indirect Impacts

Indirect impacts to hydrology and hydraulics associated with alternative C would be the same as the impacts from alternative B, as delineated in **section 4.3.2**, since the flow regime and the timing are the same.

Cumulative Impacts

Cumulative impacts to hydrology and hydraulics associated with alternative C would be the same as the impacts from alternative B, as delineated in **section 4.3.2**, since the flow regime and the timing are the same.

4.4.4 Alternative D - MRGO Restoration Plan 10

Direct Impacts

Direct impacts to hydrology and hydraulics associated with alternative D would be the same as the impacts from alternative B, as delineated in **section 4.3.2**, since the flow regime and the timing are the same.

Indirect Impacts

Indirect impacts to hydrology and hydraulics associated with alternative D would be the same as the impacts from alternative B, as delineated in **section 4.3.2**, since the flow regime and the timing are the same.

Cumulative Impacts

Cumulative impacts to hydrology and hydraulics associated with alternative D would be the same as the impacts from alternative B, as delineated in **section 4.3.2**, since the flow regime and the timing is the same.

4.5 WATER QUALITY

4.5.1 Alternative A - No Action Plan

Direct Impacts

The no action alternative would have direct adverse and beneficial impacts on water quality from the implementation of freshwater diversions or other programs, such as CWPPRA, CIAP, and LCA, within the project area. These diversions could have both adverse and beneficial impacts to water quality depending on the quality of the source water, as well as physical location conditions of the receiving waters. Current water quality conditions, as described in **chapter 3**, would likely persist and coastal wetlands could continue to be affected by natural and man-made factors that have both beneficial and adverse effects on water quality. Emergent wetland plants would likely continue to diminish as land loss and subsidence convert marshes to open water. The continual loss of emergent wetland plants under existing conditions, some of which absorb and transform pollutants in the air and water, could reduce the amount of pollution absorbed/transformed, which would likely have direct adverse effects on water quality.

DO levels at Bayou Dupre, located in the Central Wetlands portion of the project area, as well as other areas along the MRGO have measured consistently above the minimum criteria levels for both the state and Environmental Protection Agency (EPA). With rare exceptions, the pH measurements have been within the desirable range of 6.5 to 9.0. Toxic substances, including heavy metals and synthetic organics, have been measured above EPA criteria levels, but no patterns consistently exceeding the criteria for particular substances have been observed in the project area. Existing programs, such as the National Pollutant Discharge Elimination System (NPDES), Louisiana Department of Environmental Quality's (LDEQ's), and Mississippi Department of Environmental Quality's (MDEQ's) Nonpoint Source Pollution Program, Louisiana Department of Natural Resources (LDNR's) Coastal Nonpoint Pollution Program, and Total Maximum Daily Loads (TMDLs), would continue. The Lake Pontchartrain Basin Foundation (LPBF) activities, such as water quality monitoring, habitat protection, environmental education, and public events, would be expected to continue.

The de-authorization of the MRGO from the Gulf of Mexico to Mile 60 at the southern bank of the GIWW and construction of a closure structure at Bayou La Loutre have been completed. A flood control sector gate and bypass barge gate on the GIWW, a navigable flood control lift gate at Bayou Bienvenue, a braced concrete wall across the MRGO located southeast of the existing Bayou Bienvenue flood control structure, and a concrete floodwall across the marsh (Golden Triangle area) between these waterways have already begun. Since the closure of the MRGO at Bayou La Loutre, there have been noticeable decreases in salinity levels recorded in the MRGO, Lake Borgne, Central Wetlands area, and even into Lake Pontchartrain. These salinity decreases would be anticipated to remain or decrease further under the no action alternative. While the decrease in salinity has changed water quality, it could also result in the long-term effect of changing some of the marsh habitat types in the Central Wetlands area and Lake Borgne. Along with the decrease in salinity, an increase in hypoxic and anoxic conditions in the MRGO below the closure structure has also been noted since the construction of the closure at Bayou La Loutre. Indications are that these hypoxic and anoxic conditions are the result of decreased water movement and turnover since the closure was constructed. Under the no action alternative, these conditions could continue, resulting in deteriorating water quality conditions for the MRGO, Lake Borgne, and associated marsh and open water habitat.

Wetland losses could potentially be offset to some extent by projects stated in the previous paragraph as well as other Federal, state, local, and private restoration efforts.

Under Section 7006 of the Water Resources Development Act of 2007 (WRDA 2007), the LCA program has authority for feasibility-level reports of six near-term critical restoration features. Future projects that are planned independently of the tentatively selected plan in this FEIS and would affect baseline water quality conditions within the study area include:

l. Medium Diversion at White Ditch – The draft recommended plan would divert up to 35,000 cfs of freshwater from the Mississippi River left descending bank at river mile (RM) 60.0 into the Breton Sound Basin, as well as create 31 acres of ridge and terrace habitat and restore 385 acres of marsh. The diversion influence area is approximately 98,000 acres.
m. Convent/Blind River Diversion – 3,000 cfs
n. Hope Canal / Maurepas Swamp Freshwater Diversion – 1,000 cfs

Other restoration projects occurring in the study area that have and would have an effect on future baseline water quality conditions include:

- CWPPRA PO-29 River Reintroduction into Maurepas Swamp.
- CWPPRA PO-30 Lake Borgne Shoreline Protection project has been completed.
- CWPPRA PO-32 Lake Borgne and MRGO Shoreline Protection project. This project was authorized in April 2003. Phase I design was complete in 2005 and phase II design was complete in 2007. Construction of the Lake Borgne portion has been completed and the MRGO portion has been proposed for deauthorization. Anticipated net acres benefited are 266 acres.
- CWPPRA PO-34 Alligator Bend Marsh Restoration and Shoreline Protection. This project is currently in planning and design. Construction is anticipated to start in October 2011 and end in September 2012. Anticipated net acres benefited would be 127 acres.
- CWPPRA PO-36 (EB) Orleans Landbridge Shoreline Protection and Marsh Creation. The goal of the project is to protect approximately 1,400 acres.
- Lake Borgne and MRGO Shoreline Protection and accretion behind shoreline protection structures – Area 1 Doulluts Canal to Jahncke's Ditch. Construction would commence in 2010 and protect approximately 3.8 acres per year and restore approximately 17 acres by 2030.
- Lake Borgne and MRGO Shoreline Protection – Area 3 Doulluts Canal to Lena's Lagoon. Construction would commence in 2010 and is anticipated to stop land loss and restore approximately 8.2 acres per year.
- USACE 3rd and 4th Supplemental Funds - Lake Borgne Shoreline Protection and Marsh Restoration Project. This restoration project would create and nourish marsh in the Golden Triangle and Shell Beach area and protect shoreline in the Shell Beach area. Anticipated net acres benefited would be approximately 29 acres per year.
- CIAP, The Rigolets Shoreline Protection and Marsh Creation – Grand Coin Pocket, tier 2. Anticipated net acres benefited would be 100 acres.
- CIAP, Lake Pontchartrain Shoreline Protection and Marsh Creation – Irish Bayou to Chef Menteur Pass, tier 2. Anticipated net acres benefited would be 46 acres.
- CIAP, Fritchie Marsh Stormwater Diversion.
- State Shoreline Protection Project along the interior Biloxi Marsh funded with Federal surplus funds.

- WRDA 2007 – The Violet, Louisiana Freshwater Diversion Project – Project to construct a freshwater diversion to meet or maximize the ability to meet the benefits identified in the Bonnet Carré Feasibility Study and Report prepared in 1984. The Violet WRDA 2007 project is pending the findings of this study.
- CIAP-Violet Diversion.
- Orleans Parish Sewerage and Water Board plan to redirect wastewater effluent from the Mississippi River into the Central Wetlands to provide nutrients and freshwater to restore cypress swamp as well as fill and plant cypress trees.

Information taken from the *Preliminary Hydrodynamic and Hydraulic Modeling for a Proposed Freshwater Diversion in the Vicinity of Violet, Louisiana* (USACE, 2010) states that future conditions under the no action alternative are based on the following: existing diversions at Violet Siphon, Bonnet Carré, and Caernarvon, and planned diversions at Maurepas Swamp (Convent/Blind River, Hope Canal or Maurepas Swamp River Reintroduction), Caernarvon, and the Orleans Parish Sewerage and Water Board Waste Water Treatment Program. Planned diversions from the lower Mississippi River located below the Caernarvon Diversion were not included in the model. The diversion value for the Violet Siphon is 100 cfs, which is assumed to be the yearly average. The flow at Bonnet Carré is the same as the flow used for the calibration/historic run - 240,000 cfs. The combined diversions into the Maurepas swamp area (Convent/Blind River Diversion – 3,000 cfs, Hope Canal / Maurepas Swamp River Reintroduction - 1,000 cfs) have a potential capacity of 4,500 cfs under the no action alternative. Input flows for the Caernarvon diversion were increased by roughly 25 percent in line with the projected increase in the capacity of the structure.

The Chatry goal for salinity levels, established based on the 1984 Feasibility Study, "Freshwater Diversion to Lake Pontchartrain Basin and Mississippi Sound**"** and agreed to by the Habitat Evaluation Team (HET) and Salinity Working Group as the target for salinity levels with the implementation of the MRGO Restoration project, states that the target salinity levels within the Biloxi Marsh for optimum oyster production range from 12 ppt to 17 ppt for the months of June through March and 7 ppt to 8 ppt for April and May. The model results indicate that the planned Caernarvon diversion does modify the salinity regime in the Biloxi Marsh. For the month of April, salinity decreases compared to the baseline condition and the amount of time that salinity is under the Chatry target increases from 41 percent to 86.9 percent in the future for existing conditions (no action alternative). This reduction in salinity from the diversions infers that additional diversions may not be necessary during April. Salinity in the month of May were also lowered, and the target salinity is predicted to be met 27.4 percent of the time under the no action alternative. These are significant improvements, and indicate that additional management changes may help meet the targeted salinity goals to improve water quality in the project area. This modeling scenario also verifies that additional freshwater diversions will be necessary in lowering salinity levels in the Biloxi Marsh to meet the 40 percent Chatry goal.

Indirect Impacts

The programs discussed above would continue to develop or remain in place under the existing conditions in order to ensure protection of Louisiana's and Mississippi's public health and natural resources. Other reasonably foreseeable efforts that would likely improve water quality conditions include Federal, state, local, and private ecosystem restoration projects. The continued degradation of water quality under the no action alternative would result in a decline in overall water quality within the project area; however, other activities that have adverse effects on water quality would continue to occur into the future, such as continued urban storm-water runoff and the discharge of untreated or poorly-treated sewerage.

Cumulative Impacts

Cumulative impacts to water quality would be the synergistic effect of combined wetland loss and continued salinity increases throughout the project area and larger study area in combination with the reasonably foreseeable future restoration and diversion projects that would be implemented under other state and Federal efforts. Under the alternative A, there would be no restoration projects implemented. As the wetland habitats continue to deteriorate and convert to open water, salinity would continue to increase, turbidity from wave action would increase, and the ability for pollution and storm water runoff from urban areas to be filtered before entering local waterbodies would be reduced.

All of these actions would contribute to decreased water quality in coastal and inland waters. These negative impacts could be offset, to some extent, under the no action alternative by the five reasonably foreseeable future diversions that were discussed above as well as numerous other wetland restoration and shoreline protection projects listed in the direct impacts section. Along with features authorized under HSDRRS and the MRGO closure structure, the water quality in the project area could see some improvements.

The closure structure near Bayou La Loutre has reduced tidal exchange between Lake Borgne and Breton Sound, which has reduced salinity in the project area. It is projected that this closure could reduce salinity by up to 6.6 ppt. Additionally the closure structure and sector gates on the GIWW and lift gates on Bayou Bienvenue under construction near the confluence of the GIWW and the MRGO channel for the authorized improvements to the HSDRRS would alter flow patterns in the project area. Along with these potential improvements, the proposed diversions mentioned above that would be constructed under other authorizations could further reduce salinity in the area by 2-3 ppt. While these other restoration and diversion projects could offset some of the adverse impacts to water quality in the project area, the continued loss of habitat throughout coastal Louisiana in combination with continued loss in the project area would ultimately continue to reduce water quality. The continued adverse impacts to water quality could lead to a reduction in the quality of the waterbodies for fish and wildlife propagation, particularly commercially viable species, and a reduction in human usage of the area waters for both primary and secondary contact recreational uses.

4.5.2 Alternative B - MRGO Restoration Plan 2

The project has the potential to improve the water quality within the project area by returning salinity to historical conditions, as outlined by Section 3083 of the WRDA 2007. Section 3083 states that a freshwater diversion and other habitat restoration efforts must be designed to meet, or maximize the ability to meet, salinity levels identified by (Chatry et al., 1984), while creating and nourishing marsh habitat, which traps pollutants and sediments.

Direct Impacts

The majority of the direct impacts would be associated with dredging, placement of borrow material, and placement of rock during project construction. These activities would result in elevated levels of turbidity, re-suspension of pollutants or other trapped sediments, hypoxic conditions at borrow locations, and rapid changes to salinity levels and temperature at the placement sites. The rapid changes in salinity levels could result from mixing of the water column, while temperature could be affected by turbidity as well as mixing of the water column. Colder and more saline water would be deeper in the water column and could be brought to the surface during construction efforts. The majority of the borrow material would be placed in existing open water habitats, so that once the material has dispersed and settled to project goal elevations, water quality would begin to return to ambient conditions several hours after dredging operations ceased. Therefore, the adverse impacts during project construction would be temporary and localized.

In order to reduce impacts to critical habitat within Lake Borgne, areas of hard bottom, including sand and shell, would be avoided for potential borrow locations. The result is that the majority of borrow locations would be in areas with bottom sediments composed of silt and clay soils. These types of soils are finer in size and require a longer time period to settle out of the water column after disturbance. Therefore, the duration and potential impact of turbidity from suspended sediments during construction of the restoration measures to water quality could be longer than if sediments with a greater sand component were utilized.

Borrow Sites

The restoration measures implemented with alternative B would require approximately 87 mcy of borrow material. Direct impacts for alternative B borrow would include up to 9,036 acres of disturbance to the bottom sediments associated with the borrow pits. Dredging in the borrow sites would result in short-term adverse effects on marine water quality, including localized increases in turbidity and slight decreases in DO at the location of the drag head and in the surrounding sediment plume. Suspended sediment concentrations would be elevated during and for a period (several hours) after dredging operations. No other water quality parameters would be anticipated to be substantially affected during dredging operations.

The overall DO levels in Lake Borgne could experience a slight decrease throughout the ten years of dredging activity and could potentially continue long-term post-construction. The current depths of borrow pits could lead to anoxic or hypoxic conditions. To avoid the potential for this impact, monitoring water quality during the ten years of dredging could show that modifications to borrow pits through adaptive management may alleviate potential impacts from decreased DO levels.

Access and Floatation Channels

The creation of access channels to move dredged material to the placement sites and the creation and backfilling of floatation channels, which would be used to access the proposed shoreline protection areas, would include approximately 122 acres of disturbances to the bottom sediments and result in direct adverse impacts on water quality during construction. Excavation and backfilling within these channels would cause temporary localized increases in turbidity, slight temperature increases, and DO decrease. Dredge sediments would begin to settle out from the water column immediately following construction activities with larger particles, such as sand, settling out within minutes and finer particles, including silts and clays, taking several hours to several days to completely clear from the water column.

Placement and Construction Sites

Alternative B would result in the placement of fill material and other construction activities (i.e., creation of dikes and a breakwater) at the sites listed below.

Marsh Restoration:

- Conversion of 7,444 acres of open water and fragmented marsh to freshwater, brackish, and saline marsh habitat.
- Nourishment of 12,186 acres of existing marsh habitat.
- 4,468 acres of perimeter retention dikes and earthen weirs for conversion of open and fragmented marsh to freshwater, brackish, and saline marsh.

Cypress Swamp Restoration:

- Conversion of 4,225 acres of open water to cypress swamp.
- Nourishment of an additional 6,093 acres of swamp.
- 1,143 acres of perimeter retention dikes needed for the cypress swamp creation.

Ridge Restoration:

- 54 acres of ridge being increased in elevation.

Shoreline Protection Measures:

- 35,367 linear feet of rock breakwater would be constructed to protect marsh habitat and reduce shoreline erosion.

Creation of marsh habitats, retention dikes, elevation of ridges, and shoreline protection measures would all cause temporary localized increases in turbidity, re-suspension of pollutants or other trapped sediments, and rapid changes to temperature. The duration of construction-related impacts due to dredging in Lake Borgne would persist over a period of ten years. Increased vegetation growth and productivity from marsh habitat would benefit water quality in terms of increased DO, reduced turbidity, and filtration and trapping of pollutants once all project construction was completed. The shoreline protection measures would substantially reduce the potential for erosion of the restored marsh areas, and therefore would reduce the potential for elevated levels of turbidity from eroded sediments becoming suspended in the water column.

Violet, Louisiana Freshwater Diversion Channel

Section 3083 of the WRDA 2007 authorized a diversion of freshwater from the Mississippi River at or near Violet, Louisiana in order to reduce salinity levels in the region of Western Mississippi Sound and the Biloxi Marsh in St. Bernard Parish, Louisiana. Section 3083 states that the freshwater diversion must be designed to meet, or maximize the ability to meet, salinity levels identified by (Chatry et al., 1984), needed for overall ecosystem maintenance. Modeling also indicated that the combination of the closure of the MRGO, the closure of the existing connection between the MRGO and Lake Borgne, and the Violet, Louisiana Freshwater Diversion of around 7,000 cfs during the months of April and May would be capable of reducing salinity within the Biloxi Marsh by 2 ppt to 3 ppt. In months other than April and May, a diversion rate of approximately 1,000 cfs is proposed.

The monthly quantity and quality of Mississippi River water to be diverted was used to calculate a constituent load for nitrate plus nitrite, total nitrogen, total phosphorus, and total suspended solids, which could all have significant adverse effects on the overall water quality within the Violet, Louisiana Freshwater Diversion channel and receiving water bodies (primarily Lake Borgne). Constituent loads were then modified by the reduction and dispersion of water via the Central Wetlands area for flows of 1,000 cfs, followed by the reduction and dispersion of water in the associated Lake Borgne wetlands. For flows of 7,000 cfs, travel times through the Central Wetlands area would be shortened compared to lower flows and slower moving water, such that little treatment within the Central Wetlands area would be expected.

Lake Borgne is a fairly shallow water body with a tidal range - approximately twice that of nearby Lake Pontchartrain - so it has relatively short residence times for river waters which are mixed with ocean waters. In addition, circulation within Lake Borgne is not restricted by physical barriers, and storm fronts generating considerable wave energy commonly occur. The configuration of and circulation conditions in Lake Borgne helps to minimize the potential for algal blooms (which result in decreased DO) from poor water quality delivered to the lake from the Violet, Louisiana Freshwater Diversion, particularly during higher diversion flows when larger amounts of pollutants would be in the water. However, as is noted in **section 4.18.2**, the initial introduction of river water into estuarine systems may have a short-term impact on plankton populations in the adjacent coastal waters including Lake Borgne. In areas of Lake Borgne where the borrow areas are located, the eventual influx of freshwater from the Violet Diversion could result in salinity stratification. An increase in algal, or plankton populations, as well as salinity stratification could potentially decrease the DO levels in Lake Borgne.

Construction of the Violet, Louisiana Freshwater Diversion channel would have direct impacts on 529 acres including 227 acres of brackish marsh and open waters within the Central Wetlands area. The Violet, Louisiana Freshwater Diversion would result in long-term changes in water quality and salinity levels in the Central Wetlands area, Biloxi Marsh, and West Mississippi Sound. The Central Wetlands area would be converted from a brackish system into a freshwater habitat from the introduction of large amounts of freshwater from the Mississippi River. Sufficient flows of freshwater would meet the Chatry et al (1984) salinity targets for oyster development in Biloxi Marsh. In Western Mississippi Sound, changes in salinity would be in the range of an approximately one ppt decline; changes in total nitrogen, total suspended solids, and chlorophyll-a would be expected to be minor to non-detectable.

Within the Central Wetlands area, diversion quantities would be likely to create conditions where salinity would be similar to the Mississippi River itself. During the months with inflows of 1,000 cfs (June to March), the quantity diverted would be approximately 2,000 acre-feet per day, a volume capable of covering the Central Wetlands area to a water depth of up to 2 inches each day. The quantity of water available, even during the low-flow months, is sufficient to introduce a volume of water capable of reducing salinity stress for remnant Cypress trees and other salinity-sensitive species.

Within the MRGO, diversions of Mississippi River water through the Central Wetlands area would likely result in noticeable increases in turbidity, especially during the 7,000 cfs flows during the months of April and May. It is likely that differences in salt content are sufficiently large that diverted water from the Mississippi River may form a localized layer of freshwater on top of the saltier waters of the MRGO, especially during high freshwater inflow months of April and May. Consequently, it is possible that salinity-based stratification of the water column could occur within the MRGO. Stratification of the water column could in turn create conditions where biological oxygen demand (BOD) of materials within the bottom waters could bring about subsequent declines in the levels of DO in the bottom waters of the MRGO.

Although levels of total suspended solids and total nitrogen would likely increase substantially in Lake Borgne with diversions (especially in April and May), changes in levels of chlorophyll-a would be much more modest due to the already-turbid nature of Lake Borgne (which reduces light availability needed for algal growth) and the shallow and well-flushed nature of the system.

Information taken from the *Preliminary Hydrodynamic and Hydraulic Modeling for a Proposed Freshwater Diversion in the Vicinity of Violet, Louisiana* (USACE, 2010) indicates a maximum salinity change of -1.0 ppt to -1.4 ppt in Lake Borgne from May to December based on the proposed diversion base flow of 1,000 cfs and a peak diversion flow of 7,000 cfs. Salinity in the Mississippi Territorial Waters is predicted to be reduced by -0.6 to -0.9 ppt under the combined influence of the 1,000 cfs Violet, Louisiana Freshwater Diversion with 7,000 cfs pulse and the 4,000 cfs of the combined Maurepas Swamp Area diversions.

Despite the overall conclusion that water quality impacts would not be of sufficient concern to override the value of diversion projects such as that anticipated for Violet (Caffrey et al., 2002), a number of water quality related impacts can be identified. These include the following: 1) a decrease in salinity in Lake Borgne sufficient to adversely affect oyster production; 2) the lowering of water temperatures in the Central Wetlands area and MRGO due to the cooler temperatures of diverted Mississippi River water; and 3) elevated levels of metals, bacteria, and various organochlorine compounds in areas nearest the diversion. The impact, if any, of these potential stressors would increase with proximity to the diversion itself, and the size and intensity of the potential impact would likely be maximal during times of maximum discharge rates (i.e., April and May).

Hazardous Waste Procedures

The dredging contractor would be responsible for proper storage and disposal of any hazardous material such as oils and fuels used during the dredging, transport, and pump-out operations. The EPA and United States Coast Guard (USCG) regulations require the treatment of waste (e.g., sewage, graywater) from dredge plants and tender/service vessels and prohibit the disposal of debris into the marine environment. The dredge contractor would be required to implement a marine pollution control plan to minimize any direct impacts to water quality. No accidental spills of diesel fuel from the dredge plant or tender vessels would be expected. Personnel would implement USCG-approved safety response plans to prevent and minimize any impacts associated with a spill.

Indirect Impacts

Indirect impacts from alternative B would include the potential for temporary nutrient enrichment associated with suspended sediments during dredging and fill placement operations, as well as the freshwater diversion that could possibly lead to localized increased algae blooms. Localized short-term increases in turbidity could possibly lead to temporary displacement of estuarine organisms. Borrow activities could slightly increase the temperature of the ambient water by increasing the solar absorption through increased suspended sediments. However, any such construction related impacts would be expected to be minor and conditions would return to ambient following construction, while impacts from the freshwater diversion would be long term in nature.

Borrow pit dimensions may influence the potential formation of DO deficits. The tendency for a borrow pit to accumulate organic material can be reduced by: 1) limiting the depth of the pit; 2) increasing the pits surface area; and 3) decreasing side-slopes that transition from the pit to adjacent water bottoms. A shallow and broad “pan-shaped” borrow pit would facilitate circulation with adjacent waters, thereby decreasing the likelihood that organic material would become entrained, as well as allow for periodic flushing of the pit during storm events. In contrast, narrow and deep pits would be less influenced by circulation in the overlying water column and would require greater energy for flushing of organic material. Shallower pits would require less energy to mix the water column and would facilitate the mixing with adjacent waters (FEIS for MRGO and Lake Borgne Wetland Creation and Shoreline Protection, USACE 2009).

Borrow pits in Lake Borgne that would be utilized as a sediment source for marsh creation projects would have dimensions restrictive of DO deficit formation. Borrow pits would be pan-shaped with large surface area (acreages would differ by borrow site locations) and relatively shallow depths (not to exceed 12 feet below existing depth) and would gradually transition from adjacent water bottoms to project depth (side slopes of 2:1). The borrow pits would be located some distance from sources of rock inputs for shoreline protection measures (3,000 feet minimum distance from shoreline or tidal passes), and sedimentation rates within the project area are relatively low without the presence of predominant organic layers. Moreover, circulation within Lake Borgne is not restricted by physical barriers, and storm fronts generating considerable wave energy commonly occur. Proposed borrow pit dimensions combined with observed characteristics of the project area would therefore not be expected to favor the formation of DO deficits.

Cumulative Impacts

Water quality throughout coastal Louisiana and the project area is a constantly changing resource that is influenced by many different factors. Salinity fluctuates based on freshwater inputs including rainfall, runoff, and man-made diversions. These inputs, along with tidal movement and storm related wave action, in turn have an effect on turbidity and nutrient levels. Finally the quality, type, and amount of wetland habitats in the area influence all of the water quality aspects in terms of filtration, wave absorption, and tidal movements.

The wetland losses that continue to affect the region and project area would be offset by both the restoration efforts proposed under alternative B, as well as other reasonably foreseeable future projects in the region. Project benefits, listed above under direct impacts, would be partially supplemented by the overall net acres created, nourished, and protected by other Federal, state, local, and private restoration efforts in **section 2.6.1**. Along with 4,000 cfs of potential freshwater inputs though the upper Pontchartrain sub-basin and up to 35,000 cfs at White Ditch, the Violet freshwater diversion would introduce 1,000 cfs with a 7,000 cfs pulse and an influence area of 115,078 acres. Alternative B would work together with those projects to provide more complete protection of marsh habitat that would result in long-term beneficial impacts on water quality in the region. These restoration efforts include 19,630 acres of marsh and 10,318 acres of swamp creation and nourishment as well as 35,367 linear feet of shoreline protection.

Cumulative impacts from alternative B in combination with the reasonably foreseeable future projects would primarily provide long-term improvement of water quality within the project area because of the restoration of emergent wetlands serve as natural filters for improving water quality (Day et al., 1998). By restoring and protecting these critical marsh habitats, including the Biloxi Marsh and East Orleans Landbridge, alternative B would help prevent the degradation of water quality in Lake Borgne and Lake Pontchartrain that would likely occur as the marsh is eroded.

While the overall cumulative impacts from this restoration project should have a net positive benefit in terms of habitat creation and protection, there are several external factors that could offset a portion of these benefits. The project area in southeast Louisiana is located along the Gulf Coast and is susceptible to tropical cyclone activity every year from June through November. There is a moderate risk every year for a tropical storm or hurricane to impact the area causing land loss and inundation with saline waters that would have an immediate and long-term impact to the restoration features and project area as a whole. A second key factor in the potential cumulative effects to the region is from the oil and gas industry. Oil and gas exploration, production, and transportation are major economic drivers in the project area and coastal Louisiana. A comprehensive list of future projects would be very difficult to develop due to the private and rapidly changing nature of the industry. However, it is prudent to assume the potential for future impacts from dredging, due to the development of oil and gas infrastructure including pipelines, platforms, or exploration activities, to the restoration features or other wetland habitat in the project area. In addition, there are potential impacts to water quality from oil spills that may occur within the project area.

4.5.3 Alternative C - MRGO Restoration Plan 7

Alternative C shares many of the same restoration features as discussed for alternative B including a freshwater diversion and ridge restoration; however, this alternative includes additional restoration measures not identified under alternative B. The type of restoration measures between alternative C and alternative B are the same with differences being in the acreage of marsh creation and the linear feet of shoreline protection put in place. In addition to the measures proposed for alternative B, this alternative includes 9,908 acres of additional marsh creation in the Biloxi Marsh, Central Wetlands area, and East Orleans Landbridge areas and 279,577 linear feet of additional shoreline protection in the Biloxi Marsh, Central Wetlands area, MRGO Channel, and East Orleans Landbridge areas.

Direct Impacts

Borrow Sites

In addition to the impacts stated previously, construction of the restoration measures for alternative C would require approximately 152 mcy of borrow material. This would include 15,724 acres of water bottom being disturbed for the creation of borrow pits. This borrow material would come from various sources in Lake Borgne and surrounding water bodies. Borrow pit creation, as well as an additional 1,937 acres of disturbance for access channels and excavation of floatation channels to move the material and the placement of shoreline protection would cause temporary local increases in turbidity, slight temperature increases, and DO decrease. Dredged sediments would begin to settle out from the water column immediately following construction activities with larger particles, such as sand, settling out within minutes and finer particles, including silts and clays, taking several hours to several days to completely clear from the water column.

The overall DO levels in Lake Borgne could experience a slight decrease throughout the ten years of dredging activity and could potentially continue long-term post-construction. The current depths of borrow pits could lead to anoxic or hypoxic conditions. To avoid the potential for this impact, monitoring water quality during the ten years of dredging could show that modifications to borrow pits through adaptive management may alleviate potential impacts from decreased DO levels.

Placement and Construction Sites

Alternative C would result in the placement of fill material and other construction activities (i.e., creation of dikes and a breakwater) at the additional sites listed below.

Marsh Restoration:

- Alternative C would convert 17,352 acres of open water and fragmented marsh to freshwater, brackish, and saline marsh habitat.
- Nourish 26,836 acres of existing marsh habitat.
- Approximately 8,905 acres of perimeter retention dikes and earthen weirs.

Cypress Swamp Restoration:

- Conversion of 4,225 acres of open water to cypress swamp.
- Nourish an additional 6,093 acres of swamp.
- 1,143 acres of perimeter retention dikes needed for the cypress swamp restoration.

Ridge Restoration:

- Consist of 17,500 feet, approximately 54 acres, of ridge being increased in elevation.

Shoreline Protection Measures:

- 314,944 linear feet of shoreline protection measures consisting of rock breakwater would be constructed to protect marsh habitat and reduce shoreline erosion.

Direct impacts associated with alternative C would be very similar to those discussed under alternative B including temporary increases in turbidity, re-suspension of pollutants or other trapped sediments, hypoxic conditions at borrow locations, and rapid changes to temperature. The duration of construction-related impacts due to dredging in Lake Borgne would persist over a period of ten years. However, the results of the restoration measure would include increased vegetation growth and productivity of marsh habitat, which would in turn benefit water quality in terms of increased DO, reduced turbidity, and filtration and trapping of pollutants once all project construction was completed.

Violet, LouisianaFreshwater Diversion Channel

Information taken from the *Preliminary Hydrodynamic and Hydraulic Modeling for a Proposed Freshwater Diversion in the Vicinity of Violet, Louisiana* (USACE, 2010) indicates a maximum salinity change of -1.0 ppt to -1.4 ppt in Lake Borgne from May to December based on the proposed diversion base flow of 1,000 cfs and a peak diversion flow of 7,000 cfs. Salinity in the Mississippi Territorial Waters are predicted to be reduced by -0.6 ppt to -0.9 ppt under the combined influence of the 1,000 cfs Violet, Louisiana Freshwater Diversion with 7,000 cfs pulse and the 4,500 cfs of the combined Maurepas Swamp Area diversions.

Recreation Features

Three recreational sites have been identified for construction as part of this restoration project. The first feature would be located at the Bienvenue Triangle marsh area at the terminus of Caffin Avenue in Orleans Parish. The second would be developed on either side of the proposed Violet, Louisiana Freshwater Diversion between St. Bernard Highway and Judge Perez Drive in St. Bernard Parish. The third feature would be developed in Shell Beach at the terminus of Ycloskey Highway at the MRGO in St. Bernard Parish. All of the recreation features are further discussed in **section 2.5.3.2** and **appendix W**.

The Bienvenue Triangle and Shell Beach recreation features consist of boardwalks over the water as well as parking and picnic areas on land. Impacts to water quality would consist of the potential for increased surface water runoff during rain events from the improved surfaces. Less than one acre of impervious surfaces would be constructed with these two features. The Violet Diversion Park would have similar impacts with approximately 3.5 acres of impervious surface, trails and parking, being constructed and potentially increasing water runoff during rain events. Overall the potential impacts to water quality from these recreation features would be minimal.

Indirect Impacts

Indirect impacts associated with alternative C would be similar to those described under alternative B.

Cumulative Impacts

Cumulative impacts associated with alternative C would be similar to those described under alternative B.

4.5.4 Alternative D - MRGO Restoration Plan 10

Alternative D shares many of the same restoration features as discussed for alternative B and alternative C, including a freshwater diversion and ridge restoration; however, this alternative includes additional restoration measures not identified under either alternative B or alternative C. The type of restoration measures proposed for alternative D and alternatives B and C are the same with differences being in the acreage of marsh creation and the linear feet of shoreline protection put in place, as well as repair work to existing foreshore protection and submerged aquatic vegetation (SAV) protection measures. In addition to the measures proposed for alternative B and alternative C, this alternative includes 704 acres of additional marsh creation in the Biloxi Marsh, Central Wetlands area, Hopedale, and East Orleans Landbridge areas and 95,623 linear feet of additional shoreline protection in the Biloxi Marsh, Central Wetlands area, Lake Borgne, the MRGO, and East Orleans Landbridge areas.

Direct Impacts

Borrow Sites

In addition to the impacts stated above, construction of the restoration measures for alternative D would require approximately 154.3 mcy of borrow material. This would include 15,724 acres of water bottom being disturbed for the creation of borrow pits. This borrow material would come from various sources in Lake Borgne and surrounding water bodies. Borrow pit creation, as well as an additional 2,494 acres of disturbance for access channels and excavation of floatation channels to move the material and the placement of shoreline protection would cause temporary local increases in turbidity, slight temperature increases, and DO decrease. Dredge sediments would begin to settle out from the water column immediately following construction activities with larger particles, such as sand, settling out within minutes and finer particles, including silts and clays, taking several hours to several days to completely clear from the water column.

The overall DO levels in Lake Borgne could experience a slight decrease throughout the ten years of dredging activity and could potentially continue long-term post-construction. The current depths of borrow pits could lead to anoxic or hypoxic conditions. To avoid the potential for this impact, monitoring water quality during the ten years of dredging could show that modifications to borrow pits through adaptive management may alleviate potential impacts from decreased DO levels.

Placement and Construction Sites

Alternative D would result in the placement of fill material and other construction activities (i.e., creation of dikes and a breakwater) at the additional sites listed below.

Marsh Restoration:

- Conversion of 18,056 acres of open water and fragmented marsh to freshwater, brackish, and saline marsh habitat.
- Nourish 26,836 acres of existing marsh habitat.
- Approximately 8,914 acres of perimeter retention dikes and earthen weirs.

Cypress Swamp Restoration:

- Conversion of 4,225 acres of open water to cypress swamp.
- Nourish an additional 6,093 acres of swamp.
- 1,143 acres of perimeter retention dikes needed for the cypress swamp restoration.

Ridge Restoration:

- Consist of 17,500 feet, approximately 54 acres, of ridge being increased in elevation.

Shoreline Protection Measures:

- 410,567 linear feet of shoreline protection measures consisting of rock breakwater would be constructed to protect marsh habitat and reduce shoreline erosion.

In addition to the similar measures described under alternative B and alternative C, alterative D would have 15,000 linear feet of submerged aquatic vegetation (SAV) protection structures that would be constructed in Lake Pontchartrain just off the existing eastern shoreline. The structures would be 5,000 feet in length with each structure consisting of five 750-foot low level rock weirs at 100 foot spacing.

Direct impacts associated with alternative D would be very similar to those discussed under alternative B including temporary increases in turbidity, re-suspension of pollutants or other trapped sediments, hypoxic conditions at borrow locations, and rapid changes to temperature. The duration of construction-related impacts due to dredging in Lake Borgne would persist over a period of ten years. However, the results of the restoration measure would include increased vegetation growth and productivity of marsh habitat, which would in turn benefit water quality in terms of increased DO, reduced turbidity, and filtration and trapping of pollutants once all project construction was completed.

Violet, Louisiana Freshwater Diversion Channel
Information taken from the *Preliminary Hydrodynamic and Hydraulic Modeling for a Proposed Freshwater Diversion in the Vicinity of Violet, Louisiana* (USACE, 2010) indicates a maximum salinity change of -1.0 ppt to -1.4 ppt in Lake Borgne from May to December based on the proposed diversion base flow of 1,000 cfs and a peak diversion flow of 7,000 cfs. Salinity in the Mississippi Territorial Waters are predicted to be reduced by -0.6 ppt to -0.9 ppt under the combined influence of the 1,000 cfs Violet, Louisiana Freshwater Diversion with 7,000 cfs pulse and the 4,500 cfs of the combined Maurepas Swamp Area diversions.

Indirect Impacts

Indirect impacts associated with alternative D would be similar to those described under alternative B and alternative C.

Cumulative Impacts

Cumulative impacts associated with alternative D would be similar to those described under alternative B and alternative C.

4.6 NAVIGABLE WATERWAYS

4.6.1 Alternative A - No Action Plan

Direct Impacts

There would be no direct navigation impacts associated with alternative A, the no action plan.

Indirect Impacts

Indirect impacts would result from the MRGO closure and IHNC Barrier. There are two major Federal navigation projects in the project area, the Mississippi River and the GIWW and several small Federal navigation projects (Bayou Dupre, Bayou La Loutre, Bayou St. Malo, and Bayou Yscloskey). These projects were completed a half century ago and have not required any maintenance dredging.

The Mississippi River and the GIWW would not be impacted by the no action plan. In addition to these two authorized projects, the MRGO was de-authorized after Hurricane Katrina and officially closed July 2009 with the construction of a rock closure structure near the Bayou La Loutre Ridge. The IHNC surge barrier structure is presently being constructed on the MRGO just south of the Bayou Bienvenue gate. Both Bayou Bienvenue and Bayou Dupre have control structures that allow for passage of small recreational and commercial fishing vessels.

Navigation through these control structures would not be impacted by the no action alternative. Under alternative A, the rock closure structure on the MRGO and the Hurricane Risk Reduction Barrier currently under construction to prevent storm surge from entering the IHNC would have an indirect impact on navigation. The MRGO closure structure has altered small craft navigation. Access to Breton Sound is no longer possible via the direct route of the MRGO. Access is now via Bayou La Loutre and other waterways. Construction of the storm surge barrier has eliminated a direct route between the Bayou Bienvenue gate and the Bayou Dupre gate via the MRGO. Boat traffic now will have to go through the Bayou Bienvenue gate east of the MRGO.

Cumulative Impacts

As there are no projects proposed that would directly or indirectly impact navigable waterways within the project area, alternative A would not contribute to the overall cumulative impacts on navigable waterways.

4.6.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

It is anticipated that the Mississippi River Deep Draft Navigation Channel would not be impacted from implementation of the proposed diversion. When the diversion is operated at peak flow, currents would be expected on or near the batture, but not in the deep draft navigation channel. The river is approximately 2,250 feet in width at the location of the proposed diversion. The authorized width of the navigation channel is 750 feet. Thus 1,500 feet of the river is outside of the authorized navigation channel. Assuming that the channel is twice as far from the inside of the bend as from the outside of the bend, the navigation channel is, at a minimum, 500 feet from the diversion intake location. Further assuming radial flow into the diversion structure and an average flow depth of 20 feet for out of channel locations, the average current contribution 500 feet from the structure would not exceed 0.2 fps. This current magnitude is insignificant in a river that has mean currents up to 7 fps or 8 fps. At peak flows, the proposed diversion is slightly less than the peak flows for the Davis Pond and Caernarvon diversions. Neither of these two projects has reported any impacts on the navigation channel.

Navigation in the GIWW may be affected by a slight current from the diversion flow. Assuming roughly half of the 1,000 cfs diversion flow goes out the Bayou Bienvenue structure this flow would also go out through the GIWW navigation gates. Some of the Bayou Bienvenue flow may also go through Seabrook into Lake Pontchartrain. If all of the 500 cfs flow assumed to go out Bayou Bienvenue goes through the GIWW navigation gates the velocity increase would be on the order of 0.1 fps (500 cfs / two – 16-foot deep by 150-foot wide gates). This 0.1 fps velocity is significantly less than the normal tidal flows through the gates.

Similar to the velocities through the GIWW navigation gates, velocities in the throat of the Bayou Bienvenue and Bayou Dupre control structures would also be much less than the tidal velocities. Assuming that 500 cfs goes through each of the structures, the induced velocity would be less than one fps (500 cfs / 56-foot wide by 10-foot deep).

Potential management schemes may be developed to periodically flood the Central Wetlands to reduce or eliminate competition to the cypress and tupelo trees. These efforts would mimic naturally swamp inundation to promote tree growth and health. The management scenario and methodology for implementing the proposed periodic flooding have not yet been finalized. There could be the potential for these management scenarios to impact navigation through the Bayou Dupre and Bayou Bienvenue control structures, either through increased velocities or by gate closures.

Indirect Impacts

Indirect impacts would result from the MRGO closure and IHNC Barrier in combination with the changes to current and flow velocities associated with the Violet, Louisiana Freshwater Diversion.

Cumulative Impacts

As described above, alternative B would contribute minor direct and indirect impacts to the overall cumulative impacts on navigable waterways from wetland loss and degradation throughout coastal Louisiana, as well as the benefits and impacts of other Federal, state, and local projects in the vicinity, as detailed in **chapter 2**.

4.6.3 Alternative C - MRGO Restoration Plan 7

Direct Impacts

Direct impacts to navigable waterways associated with alternative C would be the same as the impacts from alternative B.

Indirect Impacts

Indirect impacts to navigable waterways associated with alternative C would be the same as the impacts from alternative B.

Cumulative Impacts

Cumulative impacts to navigable waterways associated with alternative C would be the same as the impacts from alternative B.

4.6.4 Alternative D - MRGO Restoration Plan 10

Direct Impacts

Direct impacts to navigable waterways associated with alternative D would be the same as the impacts from alternative B.

Indirect Impacts

Indirect impacts to navigable waterways associated with alternative D would be the same as the impacts from alternative B.

Cumulative Impacts

Cumulative impacts to navigable waterways associated with alternative D would be the same as the impacts from alternative B.

4.7 SOILS

4.7.1 Alternative A - No Action Plan

Direct Impacts

There would be no direct impacts to soils associated with alternative A, the no action plan.

Indirect Impacts

The ongoing conversion of wetlands to shallow open water under existing conditions would continue under the no action alternative. The projected loss of wetlands in the study area is 131,091 acres over the 50-year period of analysis; this would include the loss of wetland soil types over this area. The Clovelly muck and Lafitte muck soil types would primarily be lost, with some loss of Fausse clay soils. Net primary productivity within the project area would continue to decline and existing wetland vegetation would continue to diminish.

Cumulative Impacts

Cumulative impacts of the projected loss of soil resources from the project area would be in addition to the loss of soil resources throughout Louisiana and Mississippi. The LCA Study (USACE, 2004) estimated coastal Louisiana would continue to lose land at a rate of approximately 6,600 acres per year over the next 50 years. It is estimated that an additional net loss of 328,000 acres may occur by 2050, which is almost 10 percent of Louisiana's remaining coastal wetlands. However, these wetland soil losses would be offset to some extent by restoration projects implemented through other programs.

4.7.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

The Violet, Louisiana Freshwater Diversion channel has been identified as the only restoration measure in the study area that has a quantifiable direct impact to soils in the project area. Construction of the Violet, Louisiana Freshwater Diversion channel would impact a total of approximately 718 acres. This includes the northern portion of the canal, which would be constructed within a natural area, reach, and the southern portion, which would be constructed within an agricultural area.

Construction of the southern portion of the Violet, Louisiana Freshwater Diversion channel, a new bridge, and rail crossings over the diversion canal would result in the permanent loss of approximately 641 acres of farmland from an area that extends from the east bank the Mississippi River to Forty Arpent Canal and between Maureen Lane to the south and St. Marie Drive on the north (**figure 4-1**). Approximately 442 acres of this area are designated as prime and/or unique farmlands; in compliance with the Farmland Protection Policy Act (FPPA), the U.S. Army Corps of Engineers (USACE) would consult with the Department of Agriculture – Natural Resources Conservation Service (NRCS) to determine the precise acreage that would be affected by construction of the Violet, Louisiana Freshwater Diversion by submitting Form AD-1006, the Farmland Conversion Impact Rating (FCIR).

Construction of the northern segment of the Violet, Louisiana Freshwater Diversion channel from the Forty Arpent Canal to Lake Borgne would impact approximately 77 acres, 28 of which are water and 49 of which are a mucky, poorly drained soil. The northern segment of the Violet, Louisiana Freshwater Diversion channel would not have any impact on farmland including prime or unique farmlands (**figure 4-1**).

Restoration measures under alternative B would potentially create 7,444 acres of wetlands and/or marshland and would have beneficial long-term effect on soils in the project area. Initially, wetland and/or marsh creation would be accomplished by the placement of fill/borrow material from Lake Borgne to raise the elevation of land to that of adjacent marshland for the re-establishment of vegetation. The retention diking, weirs, and shoreline protection measures used to provide maintenance to newly restored areas would have a direct beneficial long-term impact on nearby soils by reducing their exposure to erosion.

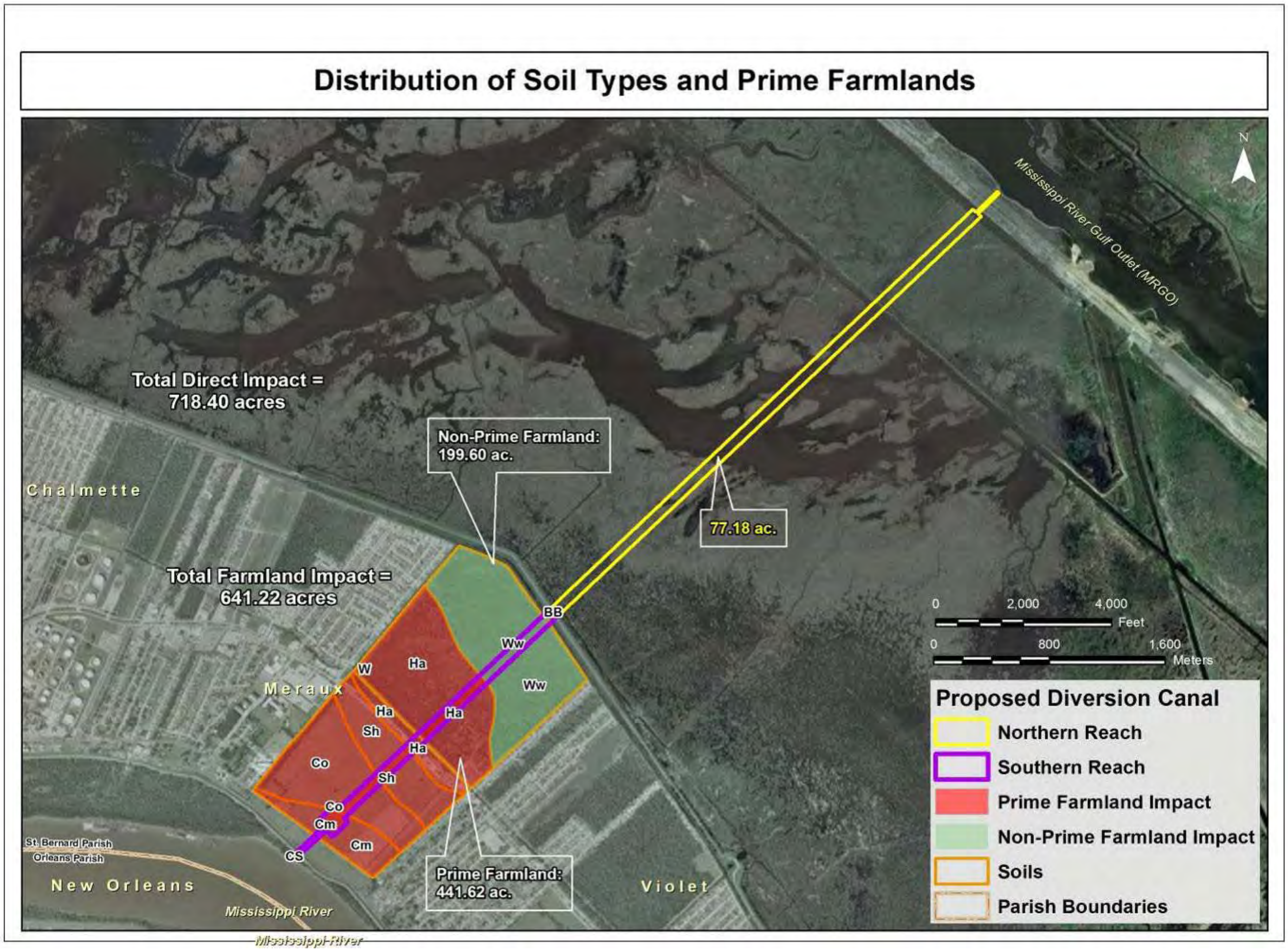


Figure 4-1: Distribution of Soil Types and Farmland (Prime and Non-Prime) in the Vicinity of the Proposed Violet, Louisiana Freshwater Diversion Channel

SOURCE of Soil Layer: Natural Resources Conservation Service, Soil survey area: St. Bernard Parish, Louisiana

Indirect Impacts

Potential indirect impacts in the project area from the restoration measures implemented for alternative B (including freshwater diverted by the Violet, Louisiana Freshwater Diversion channel, diking, weirs, and shoreline protection, all aimed at restoring the historical sediment regime and hydrology) would result in long-term beneficial impacts on soils in the project area by nourishing existing wetlands and/or marshes with sediment that would in turn increase their productivity, build wetlands, and reintroduce and distribute sediment and nutrients throughout the ecosystem. No indirect impact on prime or unique farmland would be expected as the result of the restoration activities under alternative B.

Cumulative Impacts

Cumulative long-term impacts on soils in the project area would occur from the restoration measures proposed for alternative B combined with direct and indirect impacts from other reasonably foreseeable future regional projects such as freshwater diversion, fill/borrow, diking, weir, and shoreline protection. The proposed construction of the diversion channel itself would result in direct loss of 284 acres of prime/unique farmland and 227 acres of wetland. Overall, the beneficial cumulative impacts would be the creation and increase the productivity of wetland/marsh, the restoration of salinity gradients, and the reintroduction and distribution of sediment and nutrients throughout the ecosystem.

4.7.3 Alternative C - MRGO Restoration Plan 7

Direct Impacts

Potential direct impacts for alternative C would be the same as the impacts discussed for alternative B.

Indirect Impacts

Potential indirect impacts for alternative C would be the same as the impacts discussed for alternative B.

Cumulative Impacts

Potential cumulative impacts for alternative C would be the same as the impacts discussed for alternative B, except alternative C will provide a significantly larger (279,577 linear feet) length of shoreline protection, the same amount of cypress swamp habitat in the Central Wetlands, and also restore a significantly larger (24,558 acres) area of wetlands in the lower Pontchartrain sub-basin. Alternative C will have the same potential for the beneficial cumulative impacts would be the creation and increase the productivity of wetland/marsh, the restoration of salinity gradients, and the reintroduction and distribution of sediment and nutrients throughout the ecosystem.

4.7.4 Alternative D - MRGO Restoration Plan 10

Direct Impacts

Potential direct impacts for alternative D would be the same as the impacts discussed for alternative B.

Indirect Impacts

Potential indirect impacts for alternative D would be the same as the impacts discussed for alternative B.

Cumulative Impacts

Potential cumulative impacts for alternative D would be similar to the impacts discussed for alternative B, except alternative D would provide a slightly larger (95,623 linear feet) length of shoreline protection, the same amount of cypress swamp habitat in the Central Wetlands, and restore a significantly larger (25,262 acres) area of wetlands in the lower Pontchartrain sub-basin. Alternative D will have the same potential for beneficial cumulative impacts would be the creation and increase the productivity of wetland/marsh, the restoration of salinity gradients, and the reintroduction and distribution of sediment and nutrients throughout the ecosystem.

4.8 SEDIMENTS

4.8.1 Alternative A - No Action Plan

Direct Impacts

There would be no direct impacts to sediments associated with alternative A, the no action plan.

Indirect Impacts

Programs discussed in **chapter 2** would continue to develop or remain in place under the existing conditions in order to ensure protection of Louisiana’s and Mississippi’s coastal and natural resources. Other reasonably foreseeable efforts that would likely improve and restore critical habitat include Federal, state, local, and private ecosystem restoration projects. These projects include diversions and restoration which could have an effect on sediment availability.

Cumulative Impacts

Without the proposed restoration projects and borrow needs, alternative A would not contribute to sediment needs and cumulative impacts to sediment within the project area. Potential impacts to sediments would occur as a result of the reasonable foreseeable future Federal, state, and local projects in the vicinity that would require sediment, as detailed in **chapter 2**.

4.8.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

Effects of implementing alternative B would be related primarily to localized and temporary disturbance of water bottoms during placement of shoreline protection features and also during dredging and placement of borrow materials. Disturbance to benthic species would likely occur from increased turbidity, temperature, and BOD and decreased DO due to hydraulic dredging, marsh creation, and placement of shoreline protection activities. Some smothering of benthic organisms could also occur from the sedimentation of the dredge plume, but these potential impacts could be minimized through the use of silt curtains or other construction measures to minimize dredging impacts. Once construction is completed it is anticipated that water quality would return to pre-construction conditions.

These actions would directly impact benthic organisms within the proposed borrow areas, flotation access channels, wetland creation, and shoreline protection footprints by directly removing them along with the sediment as well as burying benthos within the placement sites. Other direct impacts to the benthos would be localized and confined to construction areas.

Along with impacts to water quality and benthic organisms, the dredging process and associated turbidity would redistribute finer particles throughout the Lake Borgne system as well as expose chemicals, metals, and other pollutants that could be trapped in the sediments. Also, the impacts of the Deepwater Horizon oil spill on coastal Louisiana are uncertain at this time (August 2010). This spill could potentially adversely impact USACE abilities to utilize the sediments in Lake Borgne as potential borrow sources for wetland restoration.

Indirect Impacts

Programs discussed in **chapter 2** would continue to develop or remain in place under the existing conditions in order to ensure protection of Louisiana's and Mississippi's coastal and natural resources. Other reasonably foreseeable efforts that would likely improve and restore critical habitat include Federal, state, local, and private ecosystem restoration projects. These projects include diversions and restoration which could have an effect on sediment availability.

Cumulative Impacts

Cumulative impacts would be the synergistic effect of projects requiring borrow throughout coastal Louisiana, and the potential borrow impacts and benefits of other Federal, state, and local projects in the vicinity, as detailed in **chapter 2**.

4.8.3 Alternative C - MRGO Restoration Plan 7

Direct Impacts

Direct impacts to sediments associated with alternative C would be the same as the impacts from alternative B.

Indirect Impacts

Indirect impacts to sediments associated with alternative C would be the same as the impacts from alternative B.

Cumulative Impacts

Cumulative impacts to sediments associated with alternative C would be the same as the impacts from alternative B.

4.8.4 Alternative D - MRGO Restoration Plan 10

Direct Impacts

Direct impacts to sediments associated with alternative D would be the same as the impacts from alternative B.

Indirect Impacts

Indirect impacts to sediments associated with alternative D would be the same as the impacts from alternative B.

Cumulative Impacts

Cumulative impacts to sediments associated with alternative D would be the same as the impacts from alternative B.

4.9 AIR QUALITY

4.9.1 Alternative A - No Action Plan

Direct Impacts

Under the no action alternative, the current air quality trends would be expected to continue. The no action alternative would have no direct beneficial or adverse impacts on air quality.

Indirect Impacts

A large portion of the project area is a remote and uninhabited marsh. Under the no action alternative, air quality would continue to be subject to institutional recognition and further regulations. However, air quality in the study area could potentially decline should the following occur: continued population growth, further commercialization and industrialization, increased numbers of motor vehicles, and increased emissions from various engines. These impacts would be coupled with the continued loss of Louisiana coastal wetland vegetation that would no longer be available to remove gaseous pollutants.

Cumulative Impacts

Under the no action alternative, there would likely be no changes to onsite air quality or construction development projects in the MRGO study area expected to significantly change levels of any pollutant of concern. Therefore, there would be no significant cumulative air quality impacts as a result of the no action alternative.

4.9.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

Under alternative B, direct impacts to ambient air quality would result from construction activities within the project area. The air emissions would be mobile in nature, temporary, and localized by construction "feature." There are more than 30 construction features of alternative B that would use a total of approximately 87 mcy of borrow to create and nourish 19,630 acres of marsh and 10,318 acres of swamp; construct 35,367 linear feet of shoreline protection; and construct 3,890 acres of retention dikes, 1,721 acres of earthen weirs, and 54 acres of ridge restoration. Each feature would consist of one or more of these construction activities. Construction would take place in three Louisiana parishes, including St. Bernard, Orleans, and St. Tammany, with the majority of construction in St. Bernard Parish. Construction activity would span a 10-year period.

Emissions of criteria pollutants would be generated during construction activities from the following sources:

- Combustion of diesel fuel from construction and support equipment;
- Disturbance and movement of soils; and
- Combustion of diesel fuel or gasoline from cars and trucks used by workers to get to and from the construction areas.

Operation of construction equipment and support vehicles would generate Volatile Organic Compounds (VOCs), Particulates of 10 microns or less in diameter (PM_{10}), Particulates of 2.5 microns or less in diameter ($PM_{2.5}$), Nitrous Oxides (NO_x), Carbon Monoxide (CO), Ozone (O_3), and Sulfur Dioxide (SO_2) emissions from diesel or gasoline engine combustion.

Calculations were performed to estimate the total combustible air emissions on an annual basis from a "worst case" scenario associated with alternative B. It was assumed that several construction activities would take place simultaneously, such as shoreline protection (potentially two work crews in different features), swamp and marsh nourishment (one crew), construction of retention dikes, earthen weirs, ridges (one crew), and the Violet, Louisiana Freshwater Diversion construction (one crew). The quantity of equipment needed for each activity can be limited by the availability of such equipment, or the availability of construction materials such as rock needed for shoreline restoration.

Air emissions were calculated for the operation of tug boats, dredgers, draglines and other construction and support equipment, such as cranes, bulldozers, and crew boats using emission factors from the EPA-approved emission model NONROAD6.2. If there was no emission factor for a particular type of equipment, an emission factor was chosen that represented emissions from a diesel engine of similar horsepower.

Fugitive dust calculations were made for disturbing soils during marsh and swamp creation and nourishment, and construction of retention dikes, ridges, and shoreline protection. These emissions were calculated using emission factors from Mid-Atlantic Regional Air Management Association using the emission factor of 0.11 ton per acre per month. This is a more current standard than EPA's 1985 *Compilation of Air Pollutant Emission Factors*, also known as AP-42 (EPA, 2001). The construction work would take place mainly in remote, uninhabited areas with no roadways nearby; therefore, fugitive dust is not anticipated to obstruct visibility on roadways.

Vehicle traffic due to construction workers commuting and supply delivery trucks driving to and from the construction areas would temporarily increase air emissions in the project area. The emissions from supply trucks and workers commuting to work were included in the air emission analysis.

Assumptions were made regarding the type and quantity of equipment needed and hours of operation for each construction activity. The assumptions, emission factors, and resulting calculations are presented in **appendix P**. A summary of the worst case emissions are presented in **table 4-2**.

Table 4-2: Total (Worst Case) Air Emissions (tons/year) from Alternative B Construction Activities Pollutant Total (tons/year)

Pollutant	Total Emissions (Tons/Year)
Carbon Monoxide (CO)	145
Volatile Organic Compounds (VOCs)	32
Nitrous Oxides (NO_x)	403
Particulate matter < 10 microns (PM_{10})	90
Particulate matter < 2.5 microns ($PM_{2.5}$)	37
Sulfur Dioxide (SO_2)	54

During construction, proper and routine maintenance of all vehicles and other construction equipment would be implemented to ensure that emissions are within the design standards of all construction equipment.

The air emissions generated from alternative B would be mobile in nature and would be emitted from geographically separate construction sites (features) located within three separate Louisiana parishes (St. Bernard, Orleans, and St. Tammany). The features would be constructed over a 10-year period. The emissions would be generated mainly in remote, uninhabited areas. The worst case emissions conservatively assume operation year round.

Air emissions from alternative B would be temporary and are not anticipated to significantly impair air quality in the region. Increases in emissions or direct impacts on ambient air quality from alternative B would be expected to be short-term and minor and would not be expected to cause or contribute to a violation of Federal or state ambient air quality standards.

Indirect Impacts

Over the period of analysis, alternative B would restore approximately 30,002 acres of emergent wetland, swamp, and ridge habitat that would help improve local air quality by reducing particulates and gaseous air pollutants. Various research findings from the Urban Forestry Network indicated that increasing the acreage of trees and other vegetation in coastal Louisiana would improve air quality in the region, which would provide positive benefits for residents in the project area.

Cumulative Impacts

By its very nature, air pollution is largely a cumulative impact. Ambient air quality standards are violated or approach non-attainment levels due to past development. Attainment of the NAAQS standards can be jeopardized by increasing emissions-generating activity in a specified region. The parishes defined in the MRGO study area (St. Bernard, Orleans, and St. Tammany) are classified as attainment for all pollutants.

A project is usually considered not significant (less than NAAQS) for cumulative impacts of PM10, NOx, SO2, and CO for projects that are principally development projects, or where the majority of the emissions of these pollutants is attributable to motor vehicle and construction sources. Therefore, cumulative impacts from the MRGO construction activities within the impact study area would be considered less than significant.

In the event that outside projects are constructed simultaneously, it is possible that cumulative emissions may temporarily exceed the significance thresholds. This impact, if it occurs, would be short-term, and would be dependent on the construction schedules for other projects. If other proposed projects are constructed simultaneously, a significant temporary cumulative impact may occur for all pollutants. Implementation of mitigation measures can reduce cumulative emissions to below a level of significance.

Cumulative impacts include the incremental effects of projects that may have an individually minor, but a collectively significant, impact on air quality. The change in the environment and increase of emissions when added to other closely related past, present, or reasonably foreseeable future projects, can result from individually minor, but collectively significant, projects taking place over a period of time.

Since the development of the MRGO project would not result in long-term significant impacts to regional air quality during on-going operations, the project's incremental contribution to this significant impact would also be less than significant.

The incremental impacts would likely be so small as to be "de minimus" may be determined to be not cumulatively considerable. A "de minimus" contribution is one that leaves the environmental conditions "essentially the same" whether or not the project is implemented.

4.9.3 Alternative C - MRGO Restoration Plan 7

Direct Impacts

Under alternative C, direct impacts to ambient air quality would be similar to those described under alternative B, except that the amount of borrow needed and the acreages of construction features would be different. The more than 30 construction features of alternative C would use a total of approximately 152 mcy of borrow to create and nourish 44,188 acres of marsh and 10,318 acres of swamp; construct 314,944 linear feet of shoreline protection; and construct 6,924 acres of retention dikes, 3,124 acres of earthen weirs, and 54 acres of ridge restoration. Each feature would consist of one or more of these construction activities. Construction would take place in three Louisiana parishes including St. Bernard, Orleans, and St. Tammany, with the majority of construction in St. Bernard Parish. Construction activity would span a 10-year period.

Emissions of criteria pollutants would be generated during construction activities from the following sources:

- Combustion of diesel fuel from construction and support equipment;
- Disturbance and movement of soils; and
- Combustion of diesel or gasoline from commuter cars and trucks of workers.

Operation of construction equipment and support vehicles would generate VOCs, PM_{10}, $PM_{2.5}$, NO_x, CO, O_3, and SO_2 emissions from diesel and/or gasoline engine combustion.

Calculations were performed to estimate the total combustible air emissions on an annual basis from a "worst case" scenario associated with alternative C. It was assumed several construction activities would take place simultaneously such as shoreline protection (potentially two work crews in different features), swamp and marsh nourishment (two crews), dike retention construction (one crew), and diversion construction (one crew). The quantity of equipment needed for each activity can be limited by the availability of such equipment, or the availability of construction materials. Alternative C would construct six times the amount of shoreline protection as alternative B; however, the number of crews may be limited by the availability of rock. For this alternative, the number of crews for shoreline protection construction is assumed to be limited to two. Alternative C would nourish/create twice the amount of marsh/swamp as alternative B; therefore, the crews needed for swamp/marsh creation/nourishment would be double that of alternative B, with two crews. Dike retention crews are estimated at one for alternative C, as less than twice the acreage of retention dikes, earthen weirs, and ridges would be constructed compared to alternative B. The Violet, Louisiana Freshwater Diversion construction remains constant for all three alternatives.

Air emissions and fugitive dust emissions were calculated in the same way as for alternative B. A summary of the worst case emissions for alternative C are presented in **table 4-3**.

During construction, proper and routine maintenance of all vehicles and other construction equipment would be implemented to ensure that emissions are within the design standards of all construction equipment.

The air emissions generated from this proposed project would be mobile in nature and would be emitted from geographically separate construction sites (features) located within three separate Louisiana parishes (St. Bernard, Orleans, and St. Tammany). The features would be constructed over a 10-year period. The emissions would be generated mainly in rural, uninhabited areas. The worst case emissions above conservatively assume operation year round.

Table 4-3: Total (Worst Case) Air Emissions (tons/year) from Alternative C Construction Activities Pollutant Total (tons/year)

Pollutant	**Total Emissions (Tons/Year)**
Carbon Monoxide (CO)	183
Volatile Organic Compounds (VOCs)	40
Nitrous Oxides (NO_x)	524
Particulate matter < 10 microns (PM_{10})	97
Particulate matter < 2.5 microns ($PM_{2.5}$)	43
Sulfur Dioxide (SO_2)	70

Air emissions from alternative C would be temporary and would not be anticipated to significantly impair air quality in the region. Increases in emissions or impacts on ambient air quality would be expected to be short-term and minor and would not be expected to cause or contribute to a violation of Federal or state ambient air quality standards.

There are three recreational features (Bienvenue Triangle, Violet Diversion Park, and Shell Beach) considered for alternative C. The details for these recreational developments are described in **appendix W**. The construction of these features will include boardwalks, picnic shelters, trails, and parking lots. These minor construction activities will have minimal impacts to the total MRGO Project construction emissions.

Indirect Impacts

Indirect impacts under alternative C would be similar to those described under alternative B, except that alternative C would restore approximately 54,560 acres of emergent wetlands and ridge habitat that would help improve local air quality by reducing particulates and gaseous air pollutants. As with alternative B, research findings indicated that increasing the acreage of trees and other vegetation in coastal Louisiana would improve air quality in the region, which would provide positive benefits for residents in the project area.

Cumulative Impacts

Cumulative impacts under alternative C would be similar to those described under alternative B.

4.9.4 Alternative D - MRGO Restoration Plan 10

Direct Impacts

Under alternative D, direct impacts to ambient air quality would be similar to those described under alternative C, except that the amount of borrow needed and the acreages of some construction features are slightly different. The more than 30 construction features of alternative D would use a total of approximately 154.3 mcy of borrow to create and nourish 44,892 acres of marsh and 10,318 acres of swamp; construct 410,567 linear feet of shoreline protection; and construct 6,933 acres of retention dikes, 3,124 acres of earthen weirs, and 54 acres of ridge restoration. Each feature would consist of one or more of these construction activities. Construction would take place in three Louisiana parishes including St. Bernard, Orleans, and St. Tammany, with the majority of construction in St. Bernard Parish. Construction activity would span a 10-year period.

Air emissions and fugitive dust emissions were calculated in the same way as for alternative C. The same number of crews is estimated as for alternative C; therefore, the estimate of worst case emissions would be the same in source, quantity, and nature as those presented for alternative C in **table 4-3**.

Indirect Impacts

Indirect impacts under alternative D would be similar to those described under alternative B, except that alternative D would restore approximately 55,264 acres of emergent wetlands and ridge habitat that would help improve local air quality by reducing particulates and gaseous air pollutants. As with alternative B, research findings indicated that increasing the acreage of trees and other vegetation in coastal Louisiana would improve air quality in the region, which would provide positive benefits for residents in the project area.

Cumulative Impacts

Cumulative impacts under alternative D would be similar to those described under alternative B.

4.10 NOISE

4.10.1 Alternative A - No Action Plan

Direct Impacts

Under the no action alternative, there would be no direct impacts on noise. If ecosystem restoration measures are not implemented, existing noise levels would continue. A large portion of the project area is a remote and uninhabited marsh with low ambient noise levels.

Indirect Impacts

Under the no action alternative, there would be no indirect impacts on noise. If ecosystem restoration measures are not implemented, existing noise levels would continue. A large portion of the project area is a remote and uninhabited marsh with low ambient noise levels.

Cumulative Impacts

The no action alternative would not contribute to cumulative impacts on noise. If ecosystem restoration measures are not implemented, existing noise levels would continue. A large portion of the project area is a remote and uninhabited marsh with low ambient noise levels.

4.10.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

Construction activities associated with implementing alternative B would temporarily increase noise levels in the project area. However, most of the project area is remote and unpopulated, so noise impacts would not affect any nearby human communities. After completion of construction activities, noise levels would return to preconstruction conditions.

Some noise impacts may be expected from construction activities, although construction equipment would be limited in the level of noise that can be emitted. Institutional recognition of noise, such as provided by the regulations for Occupational Noise Exposure (29 CFR Part 1910.95) under the Occupational Safety and Health Act of 1970, as amended, would continue. This regulation requires that noise levels emitted from construction equipment must be below 90 dBA for exposures of eight hours per day or more. Noise impacts from construction activities associated with alternative B would be anticipated to be minor, localized, and temporary.

Wildlife and fish would likely temporarily leave the local project areas during construction activities due to noise impacts. However, tolerance of unnatural disturbance varies among species. There is an abundance of technical and scientific literature on “acoustic ecology,” addressing insects, fishes, frogs, lizards, birds, and mammals. By far the most studied are birds and marine mammals (Rabin, et al., 2003; Ord and Stamps, 2008; Francis, et al., 2009). In the local project areas, occasional and localized noise from construction may disturb breeding birds. For example, construction noise could interfere with bird communications (bird songs attempting to attract mates, providing “alert signals” to other individuals, and/or “begging” [for food] by nestlings).

Because impacts are anticipated to be minor, localized, and temporary, no significant direct impacts to wildlife, fishes, or breeding birds would be anticipated.

Because sound travels faster and is much less attenuated in water than in air some of the proposed dredging or construction activities may adversely affected. Some aquatic organisms (e.g., fish) are particularly sensitive to high-energy noise sources that produce a short, sharp, low-frequency sound. For example, such exposures may damage fish sensory organs and other related tissues (McCauley, et al., 2003). Sound travels faster and is much less attenuated in water than air. This can result in interference with aquatic mammals and fish communications. For example, dolphins have complex acoustic signals (especially between females and their young), and many fishes that occur in the project area (e.g., silver perch, croakers) use acoustic signals in their breeding activities. However, most individuals of such animals are likely to avoid the immediate disturbances before serious sound levels become dangerous.

Indirect Impacts

No additional sources of noise, such as indirect commercial or industrial development, would be expected to be constructed as a result of alternative B. Therefore, this alternative would have no indirect significant impacts on noise.

Cumulative Impacts

Cumulative impacts would result principally from potential short-term disruption to fish and wildlife behavior due to construction noise and similar impacts from other reasonably foreseeable future Federal, state, local, and private restoration activities. Long-term adverse cumulative impacts due to noise would not be expected with implementation of alternative B. No significant adverse noise impacts were identified due to potential increases in the cumulative sound levels of the project areas.

However, it is reasonable to anticipate increased boat traffic noise in some portions of the cumulative created and/or improved habitats. The enhanced swamp forests, for example, are likely to gradually increase wildlife populations that may be sensitive to noise, as well as increase recreational boating and commercial fishing vessel use. Similar increases in other restored habitats could also produce more traffic noise.

4.10.3 Alternative C - MRGO Restoration Plan 7

Direct Impacts

Direct impacts would be similar to alternative B, but alternative C would provide more creation and/or nourishment of marsh habitat, with increased temporary disruptions to local fishes and wildlife.

Indirect Impacts

No additional sources of noise, such as indirect commercial or industrial development, would be expected to be constructed as a result of alternative C. Therefore, this alternative would have no indirect significant impacts on noise.

Cumulative Impacts

Cumulative impacts would be similar to alternative B, but alternative C would affect a larger area due to the creation and/or nourishment of marsh habitat. No significant adverse noise impacts were identified due to potential increases in the cumulative sound levels of the project areas.

However, it is reasonable to anticipate increased boat traffic noise in some portions of the cumulative created and/or improved habitats. The enhanced swamp forests, for example, are likely to gradually increase the variety and density of some migratory and resident wildlife species that may be sensitive to noise impacts. Similar increases in other restored habitats could also produce more vessel use and, therefore, increase traffic noise levels.

4.10.4 Alternative D - MRGO Restoration Plan 10

Direct Impacts

Direct impacts would be similar to alternative B, but alternative D would provide more creation and/or nourishment of marsh habitat, with increased temporary disruptions to local fishes and wildlife.

Indirect Impacts

No additional sources of noise, such as indirect commercial or industrial development, are expected to be constructed as a result of alternative D. Therefore, this alternative would have no indirect significant impacts on noise.

Cumulative Impacts

Cumulative impacts would be similar to alternative B, but alternative D would affect a larger area due to the creation and/or nourishment of marsh habitat. No significant adverse noise impacts were identified due to potential increases in the cumulative sound levels of the project areas.

However, it is reasonable to anticipate increased boat traffic noise in some portions of the cumulative created and/or improved habitats. The enhanced swamp forests, for example, are likely to gradually increase the variety and density of some migratory and resident wildlife species that may be sensitive to noise impacts. Similar increases in other restored habitats could also produce more vessel use and, therefore, traffic noise levels.

4.11 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

USACE performed a Phase I Environmental Site Assessment (ESA) in accordance with the scope and limitations of the American Society for Testing and Materials (ASTM) "Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process, E 1527-05", for the project area defined as: the MRGO and surrounding areas of Lake Borgne, Orleans, St. Tammany, St. Bernard, and Plaquemines Parishes.

Reference **appendix Q** for the Phase I report and associated appendices.

The records search showed numerous areas of significance. Eastern Orleans Parish is heavily populated with various industries generating and handling large quantities of hazardous substances and wastes. Most of these locations are one mile or more from the closest project area borders. There are few records of significant accidents, spills, and violations in the area that could possibly suggest a release into the project areas. A few facilities lie on project borders or within the designated project areas; however, these location did not present records suggesting a significant release of hazardous materials.

St. Bernard and Plaquemines Parishes are generally less developed than Orleans Parish; however, there are several notable petroleum and natural gas facilities in the area. There are no records indicating a significant release into the project areas and the distance of the majority of the facilities from the project areas suggest these facilities are of minimal concern. A few facilities of interest lie in close proximity to the project borders or within the designated project areas; however, these locations did not present records suggesting a significant release of hazardous materials.

In the areas of St. Tammany Parish investigated there are no significant areas of concern.

Past Phase I and Phase II ESAs have been performed throughout the current project areas. During the de-authorization of MRGO in 2007, a Phase I ESA was performed by BEM Systems Inc. on the MRGO area. The report did not present any documentation of significant release of hazardous materials in the project areas. The report notes the concern of the presence of the petroleum industry throughout the area. The report noted the likelihood of petroleum releases in the area that were unreported from pipelines and gas/oil wells which are ubiquitous throughout the areas (**appendix Q**). Another general concern noted in the 2007 Phase I ESA is contamination transport due to past flooding.

There are nearby areas of development with facilities of environmental significance, which may have contributed indirectly to hazardous materials reaching project areas through significant area flooding.

A specific site of concern was noted; the former Shell Beach Anti-Aircraft Training Center, one-half mile north of MRGO Mile Marker 42 on the east side of Lake Borgne (**appendix Q**). This area should be handled with extreme caution in the case on encountering ammunition. The report suggested full soil and sediment chemical analysis to ensure proper handling of dredged material. It is assumed that this recommendation was not based on records, interviews, prior knowledge or site reconnaissance results, but on a conservative judgment based on the land/water usage of the area.

Several Phase II ESAs have been performed in the vicinity of the project areas. Between the years 2007 to 2009, there has been no analytical data showing elevated levels of contaminants of concern (COCs) surpassing RECAP screening standards. Site reconnaissance was limited due to the size of the project areas and remoteness. Facilities of interest could not be closely investigated since they are private properties and access was not granted. However, there is no documentation to suggest that there has been a significant release from the facilities investigated into the project areas. Several levees that bordered project areas were driven by vehicle in search of possible recognized environmental concerns (RECs), of which, none were found.

It is suggested by the Environmental Team ED-F that further investigation, possibly analytical testing, be explored for project areas in the vicinity of developed areas. The project areas are heavily used by the petroleum industry.

The nature of surrounding land usage is very suspect despite the lack of reported incidents, lack of significant findings in past Phase I ESAs, and insignificant analytical data from past Phase II ESAs. North of the MRGO in eastern Orleans Parish is very industrial. Petroleum companies are also located throughout St. Bernard Parish. Industrial land usage can be of concern due to contaminant transport to project areas by flooding. Caution is advised in all areas of petroleum exploration, including wells and pipelines.

The historical Shell Beach Anti-Aircraft facility just north of Mile Marker 42 of the MRGO could present issues of unspent ammunitions, which should be handled with extreme caution.

Unexpectedly encountered environmental issues should be handled appropriately, and as project areas approach developed areas, more caution is advised.

4.11.1 Alternative A - No Action Plan

Direct Impacts

Consistent with E 1527-05, a Phase I ESA investigation of the project area was conducted. Based on the finding, the no action alternative would have no direct impacts on HTRW sites in the study area. A large portion of the project area is remote and uninhabited marsh. HTRW would continue to be subject to institutional recognition and further regulations.

Indirect Impacts

Consistent with E 1527-05, a Phase I ESA investigation of the project area was conducted. Based on the finding, the no action alternative would have no indirect impacts on HTRW sites in the study area. A large portion of the project area is remote and uninhabited marsh. HTRW would continue to be subject to institutional recognition and further regulations.

Cumulative Impacts

Consistent with E 1527-05, a Phase I ESA investigation of the project area was conducted. Based on the finding, the no action alternative would not contribute to the cumulative impacts on HTRW sites in the study area. A large portion of the project area is remote and uninhabited marsh. HTRW would continue to be subject to institutional recognition and further regulations.

4.11.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

Direct impacts associated with alternative B would be the same as those described under alternative A.

Indirect Impacts

Indirect impacts associated with alternative B would be similar to those described under alternative A.

Cumulative Impacts

Cumulative impacts associated with alternative B would be similar to those described under alternative A.

4.11.3 Alternative C - MRGO Restoration Plan 7

Direct Impacts

Direct impacts associated with alternative C would be the same as those described under alternative A.

Indirect Impacts

Indirect impacts associated with alternative C would be similar to those described under alternative A.

Cumulative Impacts

Cumulative impacts associated with alternative C would be similar to those described under alternative A.

4.11.4 Alternative D - MRGO Restoration Plan 10

Direct Impacts

Direct impacts associated with alternative D would be the same as those described under alternative A.

Indirect Impacts

Indirect impacts associated with alternative D would be similar to those described under alternative A.

Cumulative Impacts

Cumulative impacts associated with alternative D would be similar to those described under alternative A.

4.12 BARRIER ISLAND RESOURCES

The restoration of the Chandeleur and Breton Islands are unique from other barrier island projects as this restoration is planned to mimic the natural processes that encompass the early stages of barrier island evolution including lateral transport of sand to the flanks from a centralized sand source. This would enhance the islands' ability to naturally build back-barrier marsh, dunes, and a sandy shoreline. The proposed design is broken down into two sections that are prioritized based on predicted effectiveness and longevity: (1) Chandeleur Islands, and (2) Breton Island.

4.12.1 Alternative A - No Action Plan

Chandeleur and Breton Islands would continue to deteriorate without the implementation of a restoration program. It is projected that by 2014, Breton Island would have no remaining subaerial acreage and the entire Chandeleur Island chain (that includes Breton Island) would be completely eroded. Without the Chandeleur and Breton Barrier Islands, important gradients and ecotones would not exist in landward bays and wetlands, resulting in decreases in estuarine habitat complexity followed by decreases in overall species diversity and biomass (Hester et al., 2005). Survival of some of the T&E species, in particular the loggerhead sea turtle, may be threatened. The Chandeleur and Breton Islands exclusively provide the high-energy beaches essential for their nesting sites in the region (see **section 3.13.5.2**) and these would be lost without restoration efforts (O'Connell et al., 2005). Other T&E species such as the piping plover and brown pelican also thrive on the islands and would lose habitat if the islands continue to deteriorate. Without the Chandeleur and Breton Islands, wetland resources on the islands as well as estuaries, wetland and aquatic habitats, and populated communities on the mainland Louisiana coastline to the west would have no barrier to shield against the wave and wind action from the frequent storms and hurricanes from the Gulf of Mexico.

With respect to island restoration, preliminary modeling efforts of proposed alternatives, as discussed in **section 2.3.4** and shown in **appendix J**, indicate that additional study is warranted for the Chandeleur and Breton Barrier Island Chain. While variables utilized in the preliminary modeling efforts were valuable and feasible, it was deemed necessary for the engineering team to further develop feasibility design and costs. Therefore, more studies and development would be conducted at a later date.

4.13 COASTAL VEGETATION RESOURCES

4.13.1 Alternative A - No Action Plan

The no action alternative would result in continued direct adverse impacts on coastal vegetation resources as there would be no construction activities. Marsh habitat would continue to be restored through other restoration projects and programs, such as the CWPPRA, the CIAP, and the LCA as described in **chapter 2**, but not at a magnitude to completely restore natural processes and features vital to the long-term success of the watershed. Without action, the coastal vegetation resources of the project area would continue to decline through bankline erosion, sloughing of the shoreline, and continued fragmentation and conversion of existing brackish and saline marsh to shallow open water habitats. Continuing adverse impacts to coastal vegetation would result from both human activities and natural processes including continued shoreline erosion and subsidence, increased saltwater intrusion, increased water velocities, and increased herbivory.

Direct Impacts

With no action, 9,850 acres of emergent wetlands in the project area are predicted to be lost over the next 50 years. Approximately 6,255 acres of brackish marsh and 3,595 acres of saline marsh are projected to be lost. Overall, the majority of direct land loss would be expected to occur to interior wetlands. However, substantial wetland losses would also be predicted to occur along the shoreline due to erosion. In addition, if landbridges are breached, existing vegetated wetlands along these critical landbridges would be converted to open water; and those wetlands remaining in the area would be exposed to greater hydrologic forcing factors (tidal flow and wave action).

Indirect Imapcts

Indirect impacts include the continued loss of intermediate and brackish marsh from saltwater intrusion. Loss rates would accelerate as marsh is lost and converted to open water, allowing increased salinity further inland and into previously buffered marshes.

Cumulative Imapcts

Cumulative impacts include the synergistic effect of "no action" with the additive combination of coast wide wetland loss and degradation, as well as the benefits and impacts of reasonably foreseeable future state and Federal projects in the vicinity, as detailed in **section 4.1.1**.

The WRDA 2007 authorized design and implementation of a freshwater diversion at or near Violet, Louisiana, to reduce salinity in the western Mississippi Sound, enhance oyster production, and promote the sustainability of coastal wetlands. Feasibility modeling indicates it would require up to 7,000 cfs to accomplish these goals. Coupled with the closure structure on the MRGO at the Bayou La Loutre Ridge, the diversion at or near Violet, Louisiana would add freshwater to the surrounding waters. This addition of freshwater could result in a conversion of some saline marshes to brackish marshes in the Biloxi Marsh portion of the project area. However, such wetland conversion would probably have little effect on the species composition of the wetlands in the project area other than a slight shift towards less salt tolerant species. The introduction of nutrients would likely increase the productivity of the nearby marshes.

4.13.2 Alternative B - MRGO Restoration Plan 2

Alternative B incorporates all restoration measures under consideration within the areas described in **section 2.10**. These discussions detail both the negative and positive impacts of restoration measures by area as it pertains to redistribution of the coastal vegetation zones due primarily to changes in area hydrology and salinity. The greatest potential to restore and sustain coastal forests is near the Mississippi River where freshwater reintroductions may be implemented. Other local sources of freshwater may be municipal wastewater or storm water. Cumulative impacts to coastal vegetation by alternative B would be the incremental impact of the implementation of alternative B together with present and reasonably foreseeable future projects.

Direct Impacts

Implementation of alternative B includes freshwater diversion via the proposed Violet, Louisiana Freshwater Diversion channel, freshwater introduction from the East Orleans POTW effluent discharge, restoration of approximately 19,630 acres of marsh habitats, 10,318 acres of cypress swamp, and 54 acres of ridge habitat that provide 35,367 linear feet of shoreline protection.

The LCA Study (USACE, 2004) estimated wetland habitat net losses in the project region at 2,880 acres/year or approximately 15 percent of the all wetlands in the project area in just the last 22 years. Alternative B would reverse this trend and convert 7,444 acres of open water to emergent wetland habitat and nourish 12,186 acres of existing habitat.

The Violet, Louisiana Freshwater Diversion would be constructed along the east bank of the Mississippi River for the introduction of freshwater into the Central Wetlands area and adjacent open water and ancillary wetlands. The structure would be engineered to deliver a minimum discharge of 1,000 cfs and with pulsing capacity of 7,000 cfs. Additionally, the effluent discharge from the East Orleans Sewerage Treatment Plant would provide an additional 167 cfs of nutrient-laden freshwater to the Central Wetlands on the western end of the cypress swamp/fresh marsh complex. Alternative B would convert 4,225 acres of open water to cypress swamp and nourish an additional 6,093 acres of swamp.

The influx of freshwater would be the principal influence on the overall impacts to coastal vegetation. These impacts would be manifested through corresponding habitat shifts and a possible redistribution of the vegetation zones. Closure of the MRGO has already produced tangible reductions in salinity in the Lake Borgne area. Changes to the marsh or coastal vegetation zones would be dictated by the salinity tolerances of the dominant vegetation along with available nutrients and zone elevation (hence the importance of specific site elevations as it relates to flooding and duration).

The results of the salinity modeling reported in the 2010 Hydraulics & Hydrology Modeling Report indicate a maximum salinity reduction of 1.0 ppt to1.4 ppt in Lake Borgne from May to December based on the proposed diversion base flow of 1,000 cfs and a peak diversion flow of 7,000 cfs. Salinity reductions in this predicted range should not substantially alter or shift the existing emergent habitat zones in the Biloxi Marsh, East Orleans, or South Lake Borgne regions.

The results of the aquatics model adapted to assess the ecological effects of the proposed freshwater diversion on the emergent vegetation community surrounding the MRGO indicated that the year-to-year variations in the systemic environmental parameters (i.e., water temperature, nutrient input, etc.) of the project area were primarily responsible for the changes in net productivity rather than the predicted influx of water from the diversion. The findings of the aquatics modeling could be reasonably interpreted to infer no adverse impacts on the productivity of emergent coastal vegetation in the project vicinity.

Earthen retention dikes would be constructed from borrow taken from within each marsh creation site. The dike features would be mechanically breached or degraded within three years of construction, if natural degradation has not sufficiently removed the earthen material. Impacts from the construction of retention dikes would be considered temporary and would be mitigated by recruitment of native vegetation and/or the planting of the areas. Approximately 3,890 acres of temporary retention dikes would be constructed under this alternative.

Flotation access channels would be excavated, as needed, in shallow water areas to allow construction equipment access to some project features (shore protection sites and marsh creation areas). The materials would be temporarily stockpiled on water bottoms adjacent to the excavated channel. Flotation access channel material would be used to backfill the flotation access channels following completion of the work. Increased turbidity would be the most immediate impact from the excavation and construction activities. Once the activities have been completed and the dredge material is returned to the previously excavated areas, natural recruitment and rehabilitation of the disturbed areas should occur.

The area under the influence of the diversion would also be expected to experience a revitalization of SAV, such as pondweed, southern naiad, coontail, and wild celery. These plants grow from the bottom of shallow marsh ponds and lagoons and would benefit from the lower salinity and water clarity as demonstrated by similar SAV growth in the vicinity of the Caernarvon Freshwater Diversion project. Wave action, currents, temperature, salinity, substrate characteristics, and light penetration (turbidity) determine species assemblage (LNDR, 1987). Of these parameters, salinity and turbidity would be affected the most by the proposed activities. Impacts would decrease as the distance from the point of disturbance increases.

Salinity in the Mississippi Territorial Waters is predicted to be reduced by 0.6 ppt to 0.9 ppt under the combined influence of the 1,000/7,000 cfs of the Violet, Louisiana Freshwater Diversion and the 4,000 cfs of the Maurepas Swamp Area diversions. This minimal reduction in salinity is well within the tolerance of the dominant emergent and submergent coastal vegetation species of the fringing coastal marshes and seagrass beds of the Mississippi coastline. Therefore, there would be no impact on coastal vegetation.

According to Moncreiff et al., (1998), by 1998 Mississippi had lost virtually all but one of its marine seagrass species. Only *Halodule wrightii* (shoal grass) existed in any measurable acreage in the Mississippi Sound. Two additional species of seagrasses, *Ruppia maritima* and *Vallisneria americana*, occur along the shoreline in the vicinity of St. Louis Bay in Hancock County. Elevated nutrient levels and higher sediment loads have been attributed to the decline in the seagrass beds along with the catastrophic disturbance of the sea floor by major hurricanes. The salinity fluctuations anticipated as a result of alternative B should not have an adverse impact on the seagrass beds in the Mississippi Territorial Waters.

The most prevalent direct impacts would an increase in cypress swamp habitat through nourishment and creation, increased marsh habitat, and a corresponding reduction in saltwater intrusion.

Indirect Impacts

One indirect impact of the introduction of nutrient-rich river water and discharge effluent is the potential for eutrophication. The MRGO Salinity Working Group anticipates the introduction of nutrients to the aquatic ecosystem following river diversion and POTW effluent discharge would enhance productivity of the ecosystem in the long term.

Predictions of the water quality responses in both Lake Borgne and the Biloxi marsh to the probable loading from various constituents in a Mississippi River diversion found minimal to non-detectable adverse impacts to water quality in the Biloxi Marsh (USACE, 2010). Changes expected in the concentrations of total nitrogen, total suspended solids, and chlorophyll-a would be expected to be minor in the Biloxi Marsh area, even with diversion flows sufficient to meet or maximize the salinity targets for oyster development (USACE, 2010).

The Salinity Working Group noted that although levels of total suspended solids and total nitrogen would increase substantially in Lake Borgne, the already turbid nature of Lake Borgne in concert with the shallow and well-flushed nature of the lake system does not provide evidence that sufficient adverse changes to nutrient concentrations would impact coastal vegetation. The systematic flushing of the lake and marsh complex would be expected to minimize the potential for eutrophication.

Cumulative Impacts

The area where the potential cumulative impacts would primarily occur would be the Lower Pontchartrain sub-basin, which includes Lake Borgne, the deauthorized MRGO, Biloxi Marshes and out toward the Chandeleur and Breton Sounds. In Mississippi, the area includes the Western Mississippi Sound, including the bordering wetlands and Cat Island.

Construction of several freshwater diversion projects (other than the Violet, Louisiana Freshwater Diversion) in the study area, have been projected to have a 2-3 ppt reduction in salinity in the Lake Pontchartrain sub-basin. The input of freshwater from the proposed Violet, Louisiana Freshwater Diversion is projected to reduce salinity change from -1.0 to -1.4 ppt in Lake Borgne closer to the source while salinity reductions in the Mississippi Sound are predicted to be -0.6 to -0.9 ppt under the influence of the Violet, Louisiana Freshwater Diversion. The combined diversion effects on salinity are a reduction of -3.0 to -4.4 ppt in the Lake Borgne vicinity and -2.6 to -3.9 ppt in the Mississippi Sound. The greater reduction in salinity predicted would be attributable to the cumulative effects of the diversions in the Lake Pontchartrain Basin rather than the effects of the Violet, Louisiana Freshwater Diversion. The salinity anticipated would be within the tolerance range for the dominant intermediate and brackish water species present in the project area. The reduction in salinity would have little or no effect on the coastal vegetation resources of these habitats.

The combined effect of the introduction of freshwater to retard increasing future salt water intrusion along with the proposed march nourishment and restoration plantings should have a positive impact through stabilizing or increasing intermediate and brackish marsh habitat.

While the overall cumulative impacts from alternative B would have a net positive benefit in terms of habitat creation and protection, there are several external factors that could offset a portion of these benefits. The project area in southeast Louisiana is located along the Gulf Coast and is susceptible to tropical cyclone activity every year from June through November. There is a moderate risk every year for a tropical storm or hurricane to impact the area causing land loss and inundation with saline waters that would have an immediate and long-term impact to the restoration features and project area as a whole. A second key factor in the potential cumulative effects to the region is from the oil and gas industry. Oil and gas exploration, production, and transportation are major economic drivers in the project area and coastal Louisiana. A comprehensive list of future projects would be very difficult to develop due to the private and rapidly changing nature of the industry. However, it is prudent to assume the potential for future impacts from dredging, due to the development of oil and gas infrastructure including pipelines, platforms, or exploration activities, to the restoration features or other wetland habitat in the project area. In addition, potential oil spills would have negative impacts on coastal vegetation.

4.13.3 Alternative C - MRGO Restoration Plan 7

Similar to alternative B, this alternative includes a freshwater diversion and limited ridge restoration; however, this alternative includes restoration and creation measures not identified in alternative B. The type of restoration measures between alternative C and alternative B are essentially the same with the difference being an increase in the acreage created and linear feet of shoreline protection proposed within a planning subunit.

Direct Impacts

Implementation of alternative C includes freshwater diversion via the proposed Violet, Louisiana Freshwater Diversion channel, freshwater introduction from the East Orleans POTW effluent discharge, restoration of approximately 44,188 acres of marsh habits, 10,318 acres of cypress swamp, and 54 acres of ridge habitat that provide 314,944 linear feet of shoreline protection. Alternative C is estimated to convert 17,352 acres of exiting open water to emergent wetlands habitat and nourish 26,836 acres of existing marsh habitat and 6,093 acres of swamp.

In addition to the measures proposed in alternative B, this alternative includes 24,558 acres of additional marsh restoration and nourishment, plus 314,944 linear feet of shoreline protection measures in the Biloxi Marsh, East Orleans, and South Lake Borgne areas. An additional 6,924 acres of retention dikes would be required for implementation of this alternative. Wetland vegetation in these areas would be temporarily impacted by dike and channel construction. However, these earthen retention dikes would breached or degraded within three years of construction, if necessary.

Impacts from implementation of alternative C would be similar to alternative B; however, the quantity of acreage impacts would be greater.

Indirect Impacts

Indirect impacts to coastal vegetation by alternative C would be similar to alternative B with a greater quantity of acreage impacted.

Cumulative Impacts

Alternative C would contribute to the cumulative impacts to coastal vegetation to a similar degree to those described in alternative B with a great quantity of acreage impacts due to additional engineering measures. These impacts would result from the combined effects of the existing and proposed diversion projects in the study area together with the freshwater influx from Violet, Louisiana Freshwater Diversion along with the added effects of the additional engineering measures proposed for this alternative. Due to the very small fluctuation in salinity, no substantial cumulative impact would be anticipated in the Mississippi Territorial Waters.

4.13.4 Alternative D - MRGO Restoration Plan 10

Alternative D is similar to the other action alternatives, but with additional restoration measures not identified in alternative C. The restoration measures identified for alternative C and alternative D are essentially the same with the contrast being an increase in acreage created and length of shoreline protected within a planning subunit. In addition to the measures proposed in alternative C, this alternative includes 704 acres of additional wetland restoration and nourishment as well as 95,623 linear feet of shoreline protection.

Direct Impacts

Implementation of alternative D includes freshwater diversion via the proposed Violet, Louisiana Freshwater Diversion channel, freshwater introduction from the East Orleans POTW effluent discharge, restoration of approximately 18,056 acres of marsh habitats, 4,225 acres of cypress swamp, and 54 acres of ridge habitat that provide 410,567 linear feet of shoreline protection.

Impacts from implementation of alternative D would be similar to alternatives B and C with the quantity of impacts being greater for this alternative. Alternative D would convert 18,056 acres of open water to emergent wetlands habitat and nourish 26,836 acres of marsh habitat and 6,093 acres of swamp.

As with alternatives B and C, alternative D would provide significant benefits to coastal vegetation within the project area. Forested wetlands and emergent marsh habitats would receive the input of freshwater nutrients from the diversion in addition to the lower salinity derived from the increased freshwater input to the area. In addition, the additional sediment from borrow areas would increase marsh elevations and compensate for anticipated ongoing land subsidence and sea level rise.

Indirect Impacts

Indirect impacts to coastal vegetation by alternative D would be similar to those described in alternative B with a greater quantity of acreage impacted due to additional engineering measures.

Cumulative Impacts

Cumulative impacts to coastal vegetation under alternative D would be similar to those described in alternative B due to additional engineering measures. These impacts would result from the synergistic effects of all the existing and proposed diversion projects in the study area combined with the freshwater influx from Violet, Louisiana Freshwater Diversion along with the added effects of the additional engineering measures proposed for this alternative. Due to the very small fluctuation in salinity, no substantial cumulative impact would be anticipated in the Mississippi Territorial Waters.

4.14 WILDLIFE RESOURCES

4.14.1 Alternative A - No Action Plan

Direct Impacts

Under alternative A, there would be no direct adverse impacts to wildlife resources.

Indirect Impacts

Habitat quality would decline as wetlands continue to deteriorate and fragment, specifically in the critical landbridges within the project area. As interior wetlands convert to open water, there would be an expected loss of species richness. The continued degradation and loss of wetland habitat would also likely result in a localized decrease in wildlife use of the area. In general, for most amphibians, reptiles, birds, and mammals, the fresh, intermediate, and brackish wetlands are required or preferred to open water habitats (Chabreck, 1988).

The Coast 2050 Plan shows the status, functions of interest, trends, and projections through 2050 for avifauna, furbearers, game mammals, and reptiles across the state by mapping units (LCWCRTF & WCRA, 1999). The South Lake Borgne mapping unit encompasses the landbridge between the MRGO and Lake Borgne, and the Lake Borgne mapping unit encompasses the open waters of Lake Borgne northward to the Rigolets (see **table 3-23**). Bald eagles, geese, woodland residents or migrant birds, and squirrels are not historically present in these mapping units. Avian resources in the study area would be expected to either remain steady or decline with the exception of brown pelican, which would be expected to increase use of open water habitats in both mapping units. Most other wildlife resources would be expected to decline with the no action alternative.

Cumulative Impacts

Without an extensive ecosystem restoration plan, marsh habitat in the project area would continue to be restored through other restoration projects and programs, such as those authorized for construction through CWPPRA, CIAP, and LCA; these projects would cumulatively benefit wildlife, but not on a large enough scale to completely restore natural processes and features vital to the long-term success of the watershed. Adverse cumulative impacts would result from the no action alternative as follows:

- continued conversion of existing vegetated wetlands used as foraging, nesting, and over-wintering habitat to open water habitats;
- continued bankline erosion and sloughing of the shoreline; and
- continued encroachment of salinity in areas with brackish and freshwaters.

4.14.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

During construction, marsh creation and restoration activities would temporarily affect wildlife by disrupting their activities and displacing them (and their prey) from the immediate construction zone. These impacts would be temporary and localized. Once construction is complete, most if not all wildlife and prey species would return to the area. Any habitat impacted during construction would be restored before leaving the area. Board roads and marsh buggies would be used in access routes crossing existing wetlands. When the access is no longer needed, the board roads would be removed, and the impacted wetlands would be restored by pumping dredged material onto the site to a height conducive to marsh restoration.

Indirect Impacts

Under alternative B, the restoration plan would create and nourish 19,630 acres of marsh and 10,318 acres of swamp, protect 35,367 linear feet of shoreline, and restore 54 acres of unique ridge habitat that would be used by resident and migrant avian species for nesting, rearing of young, resting, and foraging activities. The freshwater diversion would impact approximately 529 acres. The restored habitat would provide important stopover habitat for neotropical migrants and wintering habitat for waterfowl. Brackish and saline marsh is an important nesting habitat for avian species, such as anhinga, least bittern, and seaside sparrow (Frederick and Siegel-Causey, 2000; Gibbs, et al., 2009; Post and Greenlaw, 1994). This alternative would create, nourish, and protect estuarine areas frequented by wintering waterfowl.

Cumulative Impacts

Cumulative impacts would be the synergistic effect with the additive combination of impacts and benefits for overall net acres created, nourished, and protected by other reasonably foreseeable future Federal, state, local, and private restoration efforts, as summarized in **chapter 2**. Incremental impacts, as a result of alternative B, would combine with CWPPRA projects to provide more complete protection of the landbridge and its associated wetland habitats. Wildlife species, including migratory birds, game animals, furbearers, reptiles, amphibians, and invasive species (especially nutria and feral hogs) that use the project area would also benefit from the cumulative effects of creating, nourishing, and protecting the wetlands. Overall, cumulative effects would be positive through the anticipated increase in wildlife diversity based on the Coast 2050 Plan.

As summarized in **chapter 2**, substantial efforts among the various organizations involved in restoration have agreed on combined present and proposed activities. Reasonably foreseeable activities could ideally follow a similar approach. However, many factors such as global climate change, scientific advancements, and human behavior may alter some potential activities.

4.14.3 Alternative C - MRGO Restoration Plan 7

Direct Impacts

Direct impacts would be similar to alternative B, except that alternative C would include the creation and nourishment of 44,188 acres of marsh and 10,318 acres of swamp, the protection of 314,944 linear feet of shoreline, and the restoration of 54 acres of ridge habitat. The freshwater diversion would influence approximately 529 acres.

Indirect Impacts

Indirect impacts associated with alternative C would be similar to those described under alternative B.

Cumulative Impacts

Cumulative impacts associated with alternative C would be similar to those described under alternative B, except that creation and nourishment of marsh and shoreline protection could be greater.

4.14.4 Alternative D - MRGO Restoration Plan 10

Direct Impacts

Direct impacts would be similar to alternative B, but alternative D would create and nourish 44,892 acres of marsh, as well as 10,318 acres of swamp, protect 410,567 linear feet of shoreline, and restore 54 acres of ridge habitat. The freshwater diversion would influence approximately 529 acres.

Indirect Impacts

Indirect impacts associated with alternative D would be similar to those described under alternative B.

Cumulative Impacts

Cumulative impacts associated with alternative D would be similar to those described under alternative B or alternative C, except that creation and nourishment of marsh and shoreline protection could be greater than either alternatives B or C.

4.15 AQUATIC AND FISHERY RESOURCES

An aquatics model (**appendix I**) has been utilized to assess direct and indirect ecological effects of proposed freshwater diversions into Lake Borgne and associated coastal and marine areas that define the MRGO ecosystem (subsequently referred to as the aquatics model). The aquatics model is a bioenergetics-based ecosystem model that simulates the daily production dynamics (gC/m^2) of modeled populations of aquatic plants and animals. The principal modeling objective was to assess the potential effects of alterations in salinity and other water quality parameters that would result from the proposed freshwater diversion on selected populations of valued ecological resources in the MRGO ecosystem (Bartell et al., 2010).

The aquatics modeling study focused on key species of ecological, recreational, and commercial value including oysters, brown shrimp, white shrimp, blue crab, red drum, spotted sea trout, striped mullet, Gulf menhaden, bay anchovy, sheepshead, and Atlantic croaker. Gulf sturgeon was additionally included because of its threatened species status. To address different habitat requirements (e.g., salinity, depth,) juvenile (or immature) and adult stages were modeled as separate populations for oysters, blue crab, brown shrimp, white shrimp, red drum, and spotted sea trout. The aquatics modeling also included zooplankton and zoobenthos as separate generalized consumer populations because of their importance as food resources in the model food web. Broadly defined populations of phytoplankton and periphyton (i.e., diatoms, green algae, bluegreen algae) were modeled as key primary producers in the aquatics model. The modeled food web also included four representative submerged aquatic plants: *Myriophyllum*, *Vallisneria*, *Halodule*, and *Thalassia*. The modeled emergent aquatic plant community consisted of individual populations of *Distichlis, Phragmites, Sagittaria, Juncus,* and *Spartina*. The resulting composition of primary producers and consumers defines a food web structure relevant to the MRGO ecosystem. The aquatics model exists as perhaps the most complex aquatic food web model ever developed (Bartell et al., 2010).

The aquatics model was used to simulate the daily biomass of the modeled populations for 55 years for 23 selected inshore and offshore locations in the MRGO ecosystem. The aquatics model domain includes approximately the southern half of Lake Pontchartrain, Lake Borgne, the Biloxi Marsh and extends eastward past Bay St. Louis and Biloxi, and southwards past the Chandeleur Islands into the Gulf of Mexico. The 23 locations represent a subset of the larger domain defined by the University of New Orleans (UNO) hydrology and hydraulics model. The UNO model was developed to characterize changes in salinity throughout this larger region projected for several MRGO future without-project and with-project conditions (i.e., freshwater diversions) (Bartell et al., 2010).

The aquatics model was used to assess changes in fisheries production. These models predict changes in Federally managed species (addressed in **section 4.18**) and other commercially important fishery species (addressed in **section 4.14**), which, combined with other factors, were used to predict annual net productivity and biomass within the modeled project area (Bartell et al., 2010).

The daily values of the environmental factors that determine the growth of the populations included in the aquatics model were developed from several sources. Importantly, the salinity values for each of the 23 locations modeled by the aquatics model were obtained from the University of New Orleans (UNO) model results for selected without-project and with-project (i.e., freshwater diversion) conditions. The UNO model also provided corresponding values of nitrogen, phosphorus, and total suspended solids to the aquatics model. Daily surface light intensities were summarized from 30 years of data recorded at the New Orleans International Airport. Water temperatures were developed from limited UNO results (i.e., node 18) and interpolations based on the CRMS monitoring program. Depths were obtained from recent USGS bathymetry surveys (Bartell et al., 2010).

4.15.1 Alternative A - No Action Plan

Direct Impacts

The no action alternative would result in the persistence of existing conditions, such as wetland fragmentation and emergent wetland loss, as well as, shoreline and bank-line erosion contributing to the continued degradation of aquatic habitat. Over time this would result in a substantial decrease of habitat needed for support the life stages of numerous fish species, therefore reducing the area’s ability to adequately support fishery resources. Distribution and abundance of aquatic organisms show no significant impacts based on aquatics modeling. Reduction in emergent wetlands would result in shifts of predator/prey relationships, decline in fish productivity, and reduced recreational fishing opportunities.

Continued restoration of emergent marsh and shoreline habitat, authorized through programs such as CWPPRA, CIAP, and LCA, as detailed in **chapter 2**, would benefit aquatic and fishery resources; however, these would not be as beneficial on a large scale as the MRGO Restoration program, which would restore natural processes and features vital to long-term success of aquatic and fisheries resources.

Based upon the aquatics model (Bartell et al., 2010) results and *Preliminary Hydrodynamic and Hydraulic Modeling for a Proposed Freshwater Diversion in the Vicinity of Violet, Louisiana* (USACE, 2010), under the no action alternative there would be no significant impacts to net productivity for the following modeled species from 2015 to 2065: Atlantic croaker, red drum (juveniles and adults), spotted sea trout (juveniles and adults), striped mullet, sheepshead, Gulf menhaden, and bay anchovy.

As there would be no dredging, wetland restoration, or shoreline protection construction activities proposed under the no action alternative, there would be no construction-related impacts to aquatic and fishery resources.

Indirect Impacts

Indirect impacts would include continued degradation and loss of habitat used for spawning, foraging, cover, nursery, and other life requirements, especially the transitional habitat between estuarine and marine environments. Indirect impacts to species that do not utilize the wetlands, but whose prey species utilize the wetlands would cause competition between resident and migratory fish and other aquatic species for decreasing wetland resources.

Cumulative Impacts

Under the no action plan, cumulative impacts to aquatic and fishery resources would result from primarily indirect impacts from habitat deterioration. The combination of wetland loss within the MRGO ecosystem restoration project area, together with impacts of other coastal wetland loss would impact foraging, cover, nursery, and spawning habitat. Some of these impacts would be offset by implementation of reasonably foreseeable future restoration activities in or near the project vicinity such as: CWPPRA PO-30 project; the MRGO 2006 Lake Borgne Shoreline Protection, (Doullut's Canal to Jahncke's Ditch), St. Bernard Parish, LA (06-C-0210) project; the MRGO 2007 North Bank Foreshore Dike Construction and Repairs, Mile 44.4 to Mile 39.9 (Non-Continuous), St. Bernard Parish, LA (07-C-0089) project; and other wetland restoration efforts authorized under the LCA Plan in WRDA 2007. Features of the authorized HSDRRS as well as the closure structure on the MRGO channel near the Bayou La Loutre Ridge could affect the hydrology of the study area. The closure structure near Bayou La Loutre has reduced tidal exchange between Lake Borgne and Breton Sound, which has reduced salinity in the project area. Additionally, a 2-3 ppt salinity decrease is expected within Lake Borgne from freshwater diversion projects such as the 1,000 cfs Hope Canal / Maurepas Diversion; and the 3,000 cfs Blind/Convent River Diversion; all of which have been authorized under Section 7006 of the WRDA 2007. The Convent Blind River Diversion is in the feasibility phase with a final report due in December 2010.

Adverse cumulative impacts associated with the no action alternative would include the continued deterioration of habitat quality and quantity in the project area causing coastal land losses and deterioration of critical habitats along large areas of southeastern Louisiana and the Gulf Coast. This deterioration of habitat quality would further stress species that are dependent on these habitats for all or a part of their life cycle. Adverse cumulative impacts would be offset, to some degree, by the positive impacts of implementing the reasonably foreseeable future state and Federal projects (detailed in **chapter 2**) as mentioned above.

4.15.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

Implementation of alternative B includes a freshwater diversion at/near the Violet Canal, restoration of approximately 19,630 acres of marsh habitats, and 10,318 acres of cypress swamp.

Alternative B would convert some open water to emergent wetland habitat and nourish 12,186 acres of existing marsh habitat and 6,093 acres of swamp. Placement of dredged material for marsh restoration could bury aquatic resources resulting in localized mortality. Most fish species would likely escape the direct impacts of project construction.

The restoration and creation of wetlands through the beneficial use of dredged material would have a positive effect on commercial and recreational fisheries. Wetlands play an important role in providing habitat for foraging, spawning, rearing, and cover for most fish species, such as spotted and sand seatrout, red drum, Atlantic croaker, and sheepshead. Recreational fisheries are of major importance to the local and state economies.

Access channels would be necessary for access to marsh restoration sites, which would directly impact 122 acres of water bottom habitat and various wetland habitats in each of the subunits within the project area. Dredged material from the flotation channels would be side cast onto adjacent marsh resulting in direct impacts to water bottoms accessible to fish within the area. However, this would be offset by the creation and nourishment of important emergent wetlands within the project area. Access channels would be backfilled using the side cast material once construction was complete. Excavation of access channels and placement of dredged material would cause temporary local increases in turbidity, slight temperature increase, and DO decrease. Best management practices (BMPs) would be implemented to reduce areas affected by return water.

Borrow pits would be required to provide the necessary material for the restoration projects. Approximately 9,036 acres of water bottom would be directly impacted from creation of borrow pits and associated impacts to the water quality would be similar to that discussed for the flotation channels. Borrow would be taken from Lake Borgne at depths of ten feet, with a maximum depth of twelve feet. They may be relatively permanent features on the bottom in this low-energy system. However, excavation of borrow pits to these depths (10 feet to 12 feet) will not change the physical and geochemical properties as existing data indicates uniform sediment composition at these depths. These post-dredging lake bottoms should remain suitable for fishery resources in the area.

For some marsh restoration measures, retention dikes would need to be constructed to contain dredged material. Sediment needed for dike construction would be excavated to the inside of the containment cell. Approximately 3,890acres of marsh would be directly impacted by construction of the retention dikes. The retention dikes would be temporary in nature being mechanically degraded after project construction.

Approximately 35,367 linear feet of shoreline protection would be constructed. In order to facilitate the movement of aquatic and fish species between open water and marsh habitat, fish dips would be incorporated in the final design of these features. The frequency and design of the fish dips would be coordinated with the USFWS and NMFS.

Initial influxes of freshwater from diversion structures would result in reductions in salinity and would also result in a shift of fish species to higher salinity parts of the project area. Longer freshwater diversions could result in basin-scale fisheries displacement. However, species-specific variables, structure location, flow rates, as well as, environmental conditions would also control the degree to which the displacement may occur. Predicting these effects is difficult due to many complicated and interrelated factors.

The restoration of the Central Wetlands involves an alteration of the existing hydrologic conditions that may result in reverse tidal flow at the water control structures at Bayou Bienvenue and Bayou Dupre, as a result of the Violet, Louisiana Freshwater Diversion and the construction of 1,143 acres of retention dikes for swamp creation and nourishment. These impacts could potentially result in the loss or reduction in marine fishery productivity in the Central Wetlands, and the potential conversion of EFH to an area no longer supportive of federally managed marine fishery species.

The Violet, Louisiana Freshwater Diversion would be constructed to discharge freshwater into the Central Wetlands, as well as, adjacent open water and wetland areas. The structure would be designed to discharge a minimum of 1,000 cfs with a pulsing capacity of 7,000 cfs. The diversion would be operated to provide freshwater during the months of April and May, to meet salinity targets for four out of every 10 years. This would decrease the salinity within the project area (including Mississippi territorial waters) by 0.6 ppt to 0.9 ppt. Historical data show salinity ranging in this area from 3 ppt to 27 ppt with the higher salinity from late summer to early fall and the lower salinity from winter to late spring. Based upon salinity modeling, this change would not be substantial enough to affect the fisheries population within Lake Borgne and surrounding water bodies included within the MRGO Ecosystem Restoration Project.

The Caernarvon Freshwater Diversion structure has the capacity to produce similar flows (up to 8,000 cfs) as the proposed Violet, Louisiana Freshwater Diversion. Louisiana Department of Wildlife and Fisheries (LDWF) conducted pre- and post-construction monitoring showing increased catch rates at seven of the eight sampling stations for red drum, sheepshead, Atlantic croaker, and Gulf menhaden once the Caernarvon Freshwater Diversion was operational. Only spotted sea trout showed a post-construction decrease, which may have been caused by a severe freeze in 1989. Although spotted sea trout have shown decreases at the Caernarvon area sampling locations, charter boat captains have reported that overall catches have not been affected detrimentally, although they have reported displacement since the diversion has been operational.

Based on results from the Caernarvon Freshwater Diversion, it is clear that freshwater diversions can have negative short-term impacts on some fisheries populations while also enhancing the productivity of other fisheries. Such was the case with the Caernarvon Freshwater Diversion reviving two fisheries (shad and largemouth bass) near the diversion itself.

Based upon (Bartell et al., 2010) the aquatics modeling results for alternative B and *Preliminary Hydrodynamic and Hydraulic Modeling for a Proposed Freshwater Diversion in the Vicinity of Violet, Louisiana* (USACE, 2010), there would be no significant impacts to net productivity for the following modeled species: Atlantic croaker, red drum (juveniles and adults), spotted sea trout (juveniles and adults), stripped mullet, sheepshead, Gulf menhaden, and bay anchovy.

Indirect Impacts

Indirect impacts include protection, creation, and nourishment of marsh habitat, and protecting habitat for aquatic resources within the project area. Shoreline protection features would not only prevent the erosion of interior emergent wetlands, but would also protect interior shallow ponds, which are essential nursery habitats for many fishery species. Shoreline protection features would also prevent the conversion of transitional wetland habitats, including inner marsh and marsh edge habitats, to less productive habitat categories, such as open water. Alternative B would not only increase the areal extent of habitat, but would also improve the quality of transitional wetland habitats used by fish for spawning, nursery, forage, cover, and other life requirements. Some species serve as prey for others; therefore, predator populations may indirectly benefit, albeit to an unknown extent.

Low dissolved oxygen (DO) levels could be a potential impact during construction activities in Lake Borgne and continue to persist after construction. Additionally, there is the potential that the Violet, Louisiana Freshwater Diversion could exacerbate low DO conditions in Lake Borgne, due to the high level of nutrients causing algal blooms. The potential for this impact could be monitored in the future after implementation addressed with adaptive management.

Lagged potential for diversions is overall enhancement of estuarine productivity, such as additional vegetation providing important habitat for larval fish and decomposition of vegetation augmenting the detrital food web.

Cumulative Impacts

Project benefits under alternative B would be partially supplemented by the overall net acres created, nourished, and protected by other reasonably foreseeable future Federal, state, local, and private restoration efforts including: CWPPRA 33,690 acres; State 2,543 acres; Vegetation 535 acres; Section 204/1135, Beneficial Use 226 acres; WRDA 16,000 acres for a total of 53,009 acres. The CWPPRA PO-30 has been completed and PO-32 Lake Borgne portion has been constructed and the MRGO portion has been proposed for deauthorization under CWPPRA. These projects provide shoreline protection near to or adjacent to feature in this plan, and would protect additional portions of the landbridge between Lake Borgne and the MRGO channel. Additionally, there will be a maximum 1 to 1.4 ppt reduction in salinity in addition to the 2 ppt to 3 ppt for the no action alternative salinity change in Lake Borgne from May to December based upon the proposed Violet, Louisiana Freshwater Diversion in combination with the 4,000 cfs of the combined Maurepaus Swamp area diversions. The combination of these diversions is predicted to reduce salinity in the Mississippi Territorial Waters by 0.6 to 0.9 ppt. Alternative B would work synergistically with those projects to provide more complete protection for the land in the project area, and increased habitat resources for aquatic and fishery resources.

Cumulative impacts to listed species would result from the incremental impacts of the anticipated restoration features, in combination with the numerous other reasonably foreseeable future restoration projects that would occur in southeastern Louisiana. These projects would slow the rate of shoreline retreat and restore some of the delicate wetland habitats within the area. Aquatic and fishery resources that utilize the project area would benefit from the effects of creating, nourishing, and protecting the wetlands. Detailed impacts from other state and Federal projects can be viewed in **chapter 2**.

4.15.3 Alternative C - MRGO Restoration Plan 7

Direct Impacts

Alternative C is similar to alternative B with the following exceptions, an increase in the acreage of proposed wetland creation and linear feet of shoreline protection creating additional habitat to be utilized by aquatic and fishery resources within a planning subunit. Alternative C would include the creation/nourishment of approximately 44,188 acres of marsh habitats and provide 314,944 linear feet of shoreline protection.

Impacts from implementation of alternative C would be similar to alternative B; however, the quantity of impacts would be greater. Borrow pits would be required to 15,724 acres of water bottom. Approximately 6,924 acres of marsh would be directly impacted by construction of the retention dikes. Direct impacts include the loss of 1,937 acres of water bottom for the construction of rock breakwater structures for shoreline protection.

Preliminary aquatics model results show direct impacts to fishery resources would be similar to those described under alternative B.

The restoration of the Central Wetlands involves an alteration of the existing hydrologic conditions that may result in reverse tidal flow at the water control structures at Bayou Bienvenue and Bayou Dupre, as a result of the Violet, Louisiana Freshwater Diversion and the construction of 1,948 acres of retention dikes for swamp creation and nourishment. These impacts could potentially result in the loss or reduction in marine fishery productivity in the Central Wetlands, and the potential conversion of EFH to an area no longer supportive of federally managed marine fishery species.

Indirect Impacts

Indirect impacts associated with alternative C would be similar to those described under alternative B.

Cumulative Impacts

Cumulative impacts for alternative C would be similar to those of alternative B.

4.15.4 Alternative D - MRGO Restoration Plan 10

Direct Impacts

Alternative D is similar to alternative C with the following exceptions. There would be an additional 95,923 linear feet of shoreline protection, 704 acres of marsh creation/nourishment, and an additional 9 acres of water bottoms impacted from the use of retention dikes for marsh restoration under alternative D.

Preliminary aquatics model results show direct impacts to fishery resources would be similar to those described under alternative B.

The restoration of the Central Wetlands involves an alteration of the existing hydrologic conditions that may result in reverse tidal flow at the water control structures at Bayou Bienvenue and Bayou Dupre, as a result of the Violet, Louisiana Freshwater Diversion and the construction of 1,948 acres of retention dikes for swamp creation and nourishment. These impacts could potentially result in the loss or reduction in marine fishery productivity in the Central Wetlands, and the potential conversion of EFH to an area no longer supportive of federally managed marine fishery species.

Indirect Impacts

Indirect impacts associated with alternative D would be similar to those described under alternative B.

Cumulative Impacts

Cumulative impacts for alternative D would be similar to those of alternative B.

4.16 COMMERCIAL FISHERIES

4.16.1 Alternative A - No Action Plan

Direct Impacts

The no action alternative would result in the persistence of existing conditions, such as wetland fragmentation and emergent wetland loss, as well as, shoreline and bank line erosion contributing to the continued degradation of aquatic habitat. Over time this would result in a substantial decrease of habitat needed for support the life stages of numerous fish species, therefore reducing the area's ability to adequately support commercial fishery resources. Distribution and abundance of aquatic organisms would likely decrease, indirectly impacting species linked in the food web to directly affected species. Reduction in emergent wetlands would result in shifts of predator/prey relationships and decline in commercial fish productivity.

Continued restoration of emergent marsh and shoreline habitat, authorized through programs such as CWPPRA, CIAP, and LCA, as detailed in **chapter 2**, would benefit aquatic and fishery resources; however, these would not be as beneficial on a large scale as the MRGO Restoration program, which would restore natural processes and features vital to long-term success of aquatic and fisheries resources.

Based upon the aquatics model (Bartell et al., 2010) results and *Preliminary Hydrodynamic and Hydraulic Modeling for a Proposed Freshwater Diversion in the Vicinity of Violet, Louisiana* (USACE, 2010), under the no action alternative there would be no significant impacts to net productivity for the following modeled species from 2015 to 2065: white shrimp (juveniles and adults), brown shrimp (juveniles and adults), as well as, blue crab (juveniles and adults).

As there would be no dredging, wetland restoration, or shoreline protection construction activities proposed under the no action alternative, there would be no construction-related impacts to commercial fishery resources.

Indirect Impacts

Indirect impacts would result in the persistence of existing conditions including the continued conversion of existing wetlands to open water habitats, continued bankline erosion, and sloughing of the shoreline. Wetland habitat provides important spawning, forage, and shelter habitat for a number of commercial fish species would be expected to decrease in the future. Indirect impacts to species that do not utilize the wetlands, but whose prey species utilize the wetlands would cause competition between resident and migratory fish and other aquatic species for decreasing wetland resources. The Coast 2050 Report (LCWCRTF & WCRA, 1999) predicts that coastal wetland loss would impact most commercially important species, including black drum, brown and white shrimp, and blue crab, leading to declining abundances in the project area.

Cumulative Impacts

No restoration projects would be implemented under alternative A. Cumulative impacts to commercial fisheries would result from a combination of continued loss of habitat within the project area. These losses would be offset somewhat from the benefits of restoration activities that are anticipated to occur within or near the project vicinity such as: CWPPRA PO-30 project; the MRGO 2006 Lake Borgne Shoreline Protection, (Doullut’s Canal to Jahncke’s Ditch), St. Bernard Parish, LA (06-C-0210) project; the MRGO 2007 North Bank Foreshore Dike Construction and Repairs, Mile 44.4 to Mile 39.9 (Non-Continuous), St. Bernard Parish, LA (07-C-0089) project; and other wetland restoration efforts authorized under the LCA Plan in WRDA 2007. Features of the authorized HSDRRS as well as the closure structure on the MRGO channel near the Bayou La Loutre Ridge could affect the hydrology of the study area. The closure structure near Bayou La Loutre has reduced tidal exchange between Lake Borgne and Breton Sound, which has reduced salinity in the project area. Additionally, a 2-3 ppt salinity decrease is expected within Lake Borgne from freshwater diversion projects such as the 1,000 cfs Hope Canal / Maurepas Diversion; and the 3,000 cfs Blind/Convent River Diversion; all of which have been authorized under Section 7006 of the WRDA 2007. The Convent Blind River Diversion is currently in the feasibility phase with a final report due in December 2010.

Adverse cumulative impacts associated with the no action alternative would be the additive effect of the continued deterioration of habitat quality and quantity in the project area causing continued coastal land losses and deterioration of critical fish habitat along large areas of southeastern Louisiana and the Gulf Coast that would further stress species that are dependent on these habitats for all or a part of their life cycle. Negative cumulative impacts would be offset, to some degree, by the positive impacts of implementing the reasonably foreseeable future state and Federal projects as mentioned above. Additional state and Federal projects in the vicinity are detailed in **chapter 2**.

4.16.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

Direct impacts would be localized, temporary, and primarily related to construction activities that would make the areas unavailable to conduct commercial fishing activities. Following completion of construction activities, those areas would become available for commercial fishery activities. This alternative includes excavation of 87,000,000 cubic yards of material, to depths of ten feet with a maximum depth of twelve feet, from a total of 9,036 acres of water bottom in Lake Borgne. Placement of this material for emergent wetland creation and nourishment would cover approximately 19,630 acres of shallow open water and existing fragmented marsh. Dredging floatation access for construction activities would impact 122 acres of water bottoms. Material dredged for retention dikes would be placed over approximately 3,890 acres of shallow water bottoms and marsh.

It is anticipated that borrow pits would have no impact on commercial fishing trawling equipment. Each of these species (white shrimp, brown shrimp and blue crab) follows a circular migration which encompasses a broad range of estuarine salinity. For instance, productivity for commercial harvest is incorrectly equated to higher salinity due to targeting late juvenile and adult stages of these species. Though higher salinity tends to favor higher harvest, they are not directly linked to absolute productivity. Sampling by LDWF confirmed significant nursery use by juvenile brown shrimp (salinity 0.3 to 5 ppt), juvenile white shrimp, and juvenile blue crab (both found in salinity as low as 0.2 ppt). LDWF also conducted pre- and post-construction sampling events for the Caernarvon Freshwater Diversion using trawls and seines at 21 sampling locations located throughout Breton Sound estuary. Post-construction sampling showed a decrease in catch per unit effort (CPUE) for brown shrimp, while white shrimp showed an increase in CPUE. CPUE data was inconclusive for blue crab. Commercial landing data collected from local seafood dealers yielded no detectable post-construction effect. The Caernarvon Freshwater Diversion has resulted in a shift of the optimal harvest zones from the interior marshes to more seaward marshes and waterbodies, while no significant reductions of either three of these species has been recorded. Similar results could be produced from the Violet, Louisiana Freshwater Diversion; however, they are unknown at this time.

The restoration of the Central Wetlands involves an alteration of the existing hydrologic conditions that may result in reverse tidal flow at the water control structures at Bayou Bienvenue and Bayou Dupre, as a result of the Violet, Louisiana Freshwater Diversion and the construction of 1,143 acres of retention dikes for swamp creation and nourishment. These impacts could potentially result in the loss or reduction in marine fishery productivity in the Central Wetlands, and the potential conversion of EFH to an area no longer supportive of federally managed marine fishery species.

Based upon (Bartell et al., 2010) aquatics modeling results and *Preliminary Hydrodynamic and Hydraulic Modeling for a Proposed Freshwater Diversion in the Vicinity of Violet, Louisiana* (USACE, 2010) there would be no significant impacts to the following modeled species: white shrimp (juveniles and adults), brown shrimp (juveniles and adults), as well as, blue crab (juveniles and adults).

Indirect Impacts

Over the period of analysis alternative B would protect, create, and nourish transitional emergent wetlands providing important habitat that would support populations of commercially important fish species and enhance commercial fishing opportunities.

The Caernarvon Freshwater Diversion has created low salinity marsh expanding the nursery habitat required for juvenile development of brown and white shrimp, as well as blue crab. Similar results could be produced from the Violet, Louisiana Freshwater Diversion; however, they are unknown at this time.

Low dissolved oxygen (DO) levels could be a potential impact during construction activities in Lake Borgne and continue to persist after construction. Additionally, there is the potential that the Violet, Louisiana Freshwater Diversion could exacerbate low DO conditions in Lake Borgne, due to the high level of nutrients causing algal blooms. The potential for this impact could be monitored in the future after implementation addressed with adaptive management.

Cumulative Impacts

Cumulative impacts to commercial fisheries would be the result from the combination of continued wetland loss and habitat changes and the benefits anticipated from alternative B combined with other restoration efforts. Project benefits would be partially supplemented by the overall net acres created, nourished, and protected by other Federal, state, local, and private restoration efforts including: CWPPRA 33,690 acres; State 2,543 acres; Vegetation 535 acres; Section 204/1135, Beneficial Use 226 acres; WRDA 16,000 acres for a total of 53,009 acres. The CWPPRA PO-30 has been completed and PO-32 Lake Borgne portion has been constructed and the MRGO portion has been proposed for deauthorization under CWPPRA. These projects provide shoreline protection near to or adjacent to feature in this plan, and would protect additional portions of the landbridge between Lake Borgne and the MRGO channel.

Additionally, there will be a maximum 1 to 1.4 ppt in addition to the 2 ppt to 3 ppt for the no action alternative salinity change in Lake Borgne from May to December based upon the proposed Violet, Louisiana Freshwater Diversion in combination with the 4,000 cfs of the combined Maurepaus Swamp area diversions. The combination of these diversions is predicted to reduce salinity in the Mississippi Territorial Waters by -0.6 to -0.9 ppt. Alternative B would work synergistically with those projects to provide more complete protection for the land in the project area, and increased habitat resources for aquatic and fishery resources. Cumulative impacts to commercial fish species would be related to the incremental impacts of the anticipated restoration features. The combination of this effort with the numerous other restoration projects occurring in southeastern Louisiana will be the slowing of the rate of shoreline retreat and restoring some of the delicate wetland habitats within the area. Detailed impacts from other state and Federal projects can be viewed in **chapter 2**. Commercial fish species that utilize the project area would benefit from the effects of creating, nourishing, and protecting the wetlands.

4.16.3 Alternative C - MRGO Restoration Plan 7

Direct Impacts

Direct impacts are similar to alternative B with 44,188 acres of marsh creation and 314,944 linear feet for shoreline protection, which would lead to more disruption to areas fished by commercial fishermen. Impacts would be longer due to the fact that construction/dredging activities would last longer.

The restoration of the Central Wetlands involves an alteration of the existing hydrologic conditions that may result in reverse tidal flow at the water control structures at Bayou Bienvenue and Bayou Dupre, as a result of the Violet, Louisiana Freshwater Diversion and the construction of 1,948 acres of retention dikes for swamp creation and nourishment. These impacts could potentially result in the loss or reduction in marine fishery productivity in the Central Wetlands, and the potential conversion of EFH to an area no longer supportive of federally managed marine fishery species.

Indirect Impacts

Indirect impacts associated with alternative C would be similar to those described under alternative B.

Cumulative Impacts

Cumulative impacts associated with alternative C would be similar to those described under alternative B.

4.16.4 Alternative D - MRGO Restoration Plan 10

Direct Impacts

Direct impacts are similar to alternative C with an additional 704 acres of marsh creation and 95,623 linear feet for shoreline protection.

The restoration of the Central Wetlands involves an alteration of the existing hydrologic conditions that may result in reverse tidal flow at the water control structures at Bayou Bienvenue and Bayou Dupre, as a result of the Violet, Louisiana Freshwater Diversion and the construction of 1,948 acres of retention dikes for swamp creation and nourishment. These impacts could potentially result in the loss or reduction in marine fishery productivity in the Central Wetlands, and the potential conversion of EFH to an area no longer supportive of federally managed marine fishery species.

Indirect Impacts

Indirect impacts associated with alternative D would be similar to those described under alternative B.

Cumulative Impacts

Cumulative impacts associated with alternative D would be similar to those described under alternative B.

4.17 OYSTER RESOURCES

4.17.1 Alternative A - No Action Plan

Direct Impacts

Direct impacts from the no action alternative include potential reduction in salinity of two to three ppt based upon proposed construction of several diversion projects that would be expected to be implemented without the MRGO restoration including: 1,000 cfs diversion at the Hope Canal; and a 3,000 cfs diversion at the Blind/Convent River. The Convent Blind River diversion project is in the feasibility stage with a final report due in December 2010. Work has been initiated under CWPPRA for the Hope Canal diversion. Reductions of 2-3 ppt in salinity could result in a decrease of net productivity in oyster beds within the Lake Borgne area due to salinity being lower than target optimums. Dugas (1977) and Eleuterius (1977) reported that areas containing average salinities ranging from 10 to 16 ppt support the maximum oyster production in Louisiana and Mississippi, respectively, resulting in a seaward shift in oyster productivity; however, the extent of these impacts are currently unknown.

Reductions in salinity further east in Mississippi Territorial Waters from the proposed freshwater diversions mentioned above would be less than 2-3 ppt, albeit to an unknown extent. However, with productive oyster reefs in the Mississippi Territorial Waters ranging from 2-22 ppt, no impacts are anticipated to occur.

No impacts to oyster reefs from sedimentation from these diversions are expected given their geographical location to one another.

Indirect Impacts

Indirect impacts would result from the persistence of existing conditions including the continued conversion of existing transitional estuarine wetlands to open water habitats, as well as bankline erosion and sloughing of the shoreline. The continued loss of transitional estuarine wetlands due to sediment starvation and sea level rise would adversely affect the local detritus-based oyster food web. Organic detritus, derived mainly from vascular plants, is a major food source for estuarine consumers including oysters (Day et al., 1989). Loss of estuarine wetlands not only reduces detritus, which is used directly by oysters, but also reduces catabolic products (i.e., process by which complex substances are converted to more simple compounds) that are more often utilized by primary producers (e.g., phytoplankton), which can then be used by oysters and other species (Kilgen and Dugas, 1989). As discussed in **chapter 3**, oysters depend on estuarine wetlands for protection and food when they are juveniles. Hence, the loss of wetlands in the project area would likely alter the detritus-based food web of the oyster, thereby reducing the localized carrying capacity for oyster leases in the area.

Based upon (Bartell et al., 2010) aquatics modeling results (see **section 4.13** for description) and *Preliminary Hydrodynamic and Hydraulic Modeling for a Proposed Freshwater Diversion in the Vicinity of Violet, Louisiana* (USACE, 2010) there would be no significant impacts to oysters or oyster spat production under alternative A.

Cumulative Impacts

Cumulative impacts include the combined effect of the no action plan together with the anticipated benefits of restoration activities in or near the project vicinity from reasonably foreseeable future projects such as: CWPPRA PO-30 project; the MRGO 2006 Lake Borgne Shoreline Protection, (Doullut's Canal to Jahncke's Ditch), St. Bernard Parish, LA (06-C-0210) project; the MRGO 2007 North Bank Foreshore Dike Construction and Repairs, Mile 44.4 to Mile 39.9 (Non-Continuous), St. Bernard Parish, LA (07-C-0089) project; and other wetland restoration efforts authorized under the LCA Plan in WRDA 2007. Features of the authorized HSDRRS as well as the closure structure on the MRGO channel near the Bayou La Loutre Ridge could affect the hydrology of the study area. Additionally, a 2-3 ppt salinity decrease is expected within Lake Borgne from freshwater diversion projects such as the 1,000 cfs Hope Canal / Maurepas Diversion; and the 3,000 cfs Convent Blind River Diversion; all of which have been authorized under Section 7006 of the WRDA 2007. The Convent Blind River Diversion is currently in the feasibility phase with a final report due in December 2010.

The adverse incremental impacts associated with the no action alternative would include the continued deterioration of oyster habitat quality and quantity in the project area and also large areas of southeastern Louisiana and the Gulf Coast. However, reductions in salinity from the proposed freshwater diversion projects may result in a seaward shift in oyster bed productivity, albeit to an unknown extent. Negative cumulative impacts of wetlands loss would be offset, to some degree, by the positive impacts of implementing the state and Federal projects as mentioned above. Additional state and Federal projects in the vicinity are detailed in **chapter 2**.

4.17.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

Alternative B would result in the excavation of 87 mcy of borrow material, thereby impacting up to 9,036 acres of water bottom. Borrow locations that would be located within historical oyster leases have been removed from restoration measures. There is still potential for impacts, for example, from water quality changes such as increased turbidity due to dredging and construction activities. The magnitude of such impacts remains highly uncertain. Measures to reduce impacts, such as seasonal windows and turbidity screens, could be employed during construction work.

Impacts to oysters and oyster leases would be primarily associated with the dredging of borrow material and floatation access. These dredging related impacts to oyster leases located near borrow areas, as well as, flotation access channels would include increased turbidity, siltation, entrainment of oyster larvae during dredging operations, temperature changes, increased BOD due to the introduction of organic matter into water column, and decreased DO. Turbidity impacts as a result of dredging and construction would be temporary, with the anticipation that ambient water quality conditions would return once all activities have ceased after 10 years in the area. Isolated impacts from individual subprojects would be shorter in duration. However, direct impacts to the bottom habitat may persist for many years as the borrow footprints fill with sediment.

Oysters found within flotation access channels would suffer major disturbance and/or mortality from dredging and construction. However, access channels, shoreline protection, borrow sites and wetland creation/nourishment sites would be designed to avoid oyster leases and nearby Louisiana Oyster Seed Grounds using best management practices. Wetland creation/nourishment sites would be constructed using retention dikes and silt curtains to prevent or reduce dredged slurry runoff, turbidity, and other construction-related impacts.

Preliminary aquatics model results (Bartell et al., 2010) for alternative B showed decreases in annual net productivity (gC/m^2) of oysters (based upon +/- 20 percent model error) at target year 2015 for east Lake Pontchartrain (Nodes 3,4,5), Golden Triangle (Node 9), Lake Borgne (Nodes 1, 2, 9) and Inner Biloxi (Nodes 8, 73). These areas id not historically support oyster reefs prior to the construction of the MRGO (LDWF – Dugas, 1979). Additional decreases were predicted within the Golden Triangle at target year 2040, and Lake Borgne at target year 2065. Upper Lake Borgne (Node 1) and Inner Biloxi (Nodes 8, 73) model results show decreases based upon oyster spat modeling across all of the target years. However, oyster monthly productivity (metric tons/km^2) shows a decrease in productivity would be caused by the Violet, Louisiana Freshwater Diversion during the months of August and September. When integrated over the entire modeled area and project planning horizon, the preliminary aquatics modeling results and associated model uncertainties indicate an average 5 percent reduction in oyster production and 6 percent reduction in oyster spat production. These potential impacts could be interpreted as insignificant impact, given the uncertainties associated with the aquatics and UNO models.

Pre- and post-construction monitoring of the Caernarvon Freshwater Diversion by LDWF biologists at 41 stations within the Breton Sound estuary are similar to the aquatics modeling results run for the Violet, Louisiana Freshwater Diversion. They are also similar to what has happened to oysters at interior stations (closer to the diversion) likely due to extended periods of reduced salinity lower than 5 ppt. However, outward migration of the optimal production zone has revived beds that had become dormant due to excessive salinity. Oyster production had increased dramatically in the first three years of the Caernarvon Freshwater Diversion according to dockside surveys with fishermen. A more seaward shift in productivity as a result of the Caernarvon Freshwater Diversion was predicted in the 1984 EIS. Similar results could be produced from the Violet, Louisiana Freshwater Diversion; however, they are unknown at this time.

Information taken from the *Preliminary Hydrodynamic and Hydraulic Modeling for a Proposed Freshwater Diversion in the Vicinity of Violet, Louisiana* (USACE, 2010) indicates a maximum reduction in salinity of 1.0 ppt to 1.4 ppt in Lake Borgne from May to December based on the proposed diversion base flow of 1,000 cfs and a peak diversion flow of 7,000 cfs. Salinity in the Mississippi Territorial Waters is predicted to be reduced by 0.6 ppt to 0.9 ppt under the combined influence of the 1,000 cfs Violet Freshwater Diversion with 7,000 cfs pulse and the 4,500 cfs of the combined Maurepas Swamp Area diversions. Adult oysters can tolerate salinity from 0 to 42 ppt with an optimal range of 14 ppt to 28 ppt (EOBRT, 2007). Waters with lower salinity fail to support biological function, while more saline waters promote disease and predation. Oysters grow faster in areas with fluctuating salinity within their normal ranges compared to constant salinity (Pierce and Conover, 1954). Within Mississippi sound productive oyster reefs range from 2 ppt to 22 ppt (Eleuterius, 1977). No impacts would be anticipated to occur to oyster leases from the diversion caused by sedimentation or such slight changes in salinity within the Lake Borgne area as well as the entire project area.

Indirect Impacts

Indirect impacts to oyster resources from alternative B would include the creation of additional wetland habitat and a reduction in shoreline erosion. During the period of analysis, alternative B would create and nourish a net total of 19,630 acres of emergent wetlands that would provide protection and food resources (nutrients and detritus) for oyster resources in the area. Plankton productivity would increase along with the production of organic matter through decomposition processes. The resulting dissolved organic matter can be utilized directly by primary producers and subsequently used by oysters (Kilgen and Dugas, 1989). Alternative B would also provide 35,367 linear feet of shoreline protection to prevent erosion of emergent marsh shoreline thereby indirectly benefitting oysters.

Oyster natural predators include, oyster drill (*Thais haemastoma*), blue crab, stone crab, and black drum (*Pogonias cromis*). Based upon (Bartell et al., 2010) preliminary aquatics model results and *Preliminary Hydrodynamic and Hydraulic Modeling for a Proposed Freshwater Diversion in the Vicinity of Violet, Louisiana* (USACE, 2010) it appears that there would be no impacts to oysters natural predators. However, it must be emphasized that given the uncertainties associated with the hydrodynamic and hydraulic modeling, the preliminary aquatics model results could be fairly interpreted as no significant impacts on the resources of interest. There would be insignificant impacts to blue crab (juveniles and adults).

When the Caernarvon Freshwater Diversion became operational, LDWF data indicates that approximately 8,200 oyster leases were held in coastal Louisiana. Most of these leases were within the interior marshes of the Breton Sound estuary, and most public grounds were on the outside. These outside reefs are public (owned by LDWF) and provide an important source of juvenile "seed" oysters throughout southeast Louisiana. LDWF post-diversion monitoring has shown increased seed production on public oyster reefs, as well as, a shift in oyster fishermen becoming more reliant on public oyster seed grounds. Similar results could be produced from the Violet, Louisiana Freshwater Diversion; however, they are unknown at this time.

Low dissolved oxygen (DO) levels could be a potential impact during construction activities in Lake Borgne and continue to persist after construction. Additionally, there is the potential that the Violet, Louisiana Freshwater Diversion could exacerbate low DO conditions in Lake Borgne, due to the high level of nutrients causing algal blooms. The potential for this impact could be monitored in the future after implementation addressed with adaptive management.

Cumulative Impacts

Cumulative impacts include the combined effect of Alternative B together with the anticipated benefits of restoration activities in or near the project vicinity from reasonably foreseeable future projects such as: CWPPRA PO-30 project; the MRGO 2006 Lake Borgne Shoreline Protection, (Doullut's Canal to Jahncke's Ditch), St. Bernard Parish, LA (06-C-0210) project; the MRGO 2007 North Bank Foreshore Dike Construction and Repairs, Mile 44.4 to Mile 39.9 (Non-Continuous), St. Bernard Parish, LA (07-C-0089) project; and other wetland restoration efforts authorized under the LCA Plan in WRDA 2007. Features of the authorized HSDRRS as well as the closure structure on the MRGO channel near the Bayou La Loutre Ridge could affect the hydrology of the study area. Additionally, a 2-3 ppt salinity decrease is expected within Lake Borgne from freshwater diversion projects such as the 1,000 cfs Hope Canal / Maurepas Diversion; and the 3,000 cfs Convent Blind River Diversion; all of which have been authorized under Section 7006 of the WRDA 2007. The Convent Blind River Diversion is currently in the feasibility phase with a final report due in December 2010.

The incremental beneficial impacts associated with alternative B would offset the continued deterioration of oyster habitat quality and quantity in the project area and along large areas of southeastern Louisiana and the Gulf Coast. However, reductions in salinity from the proposed freshwater diversion projects may result in a seaward shift in oyster bed productivity, albeit to an unknown extent. In addition, negative cumulative impacts of wetlands loss would be offset, to some degree, by the positive impacts of implementing the state and Federal projects as mentioned above. Additional state and Federal projects in the vicinity are detailed in **chapter 2**.

4.17.3 Alternative C - MRGO Restoration Plan 7

Direct Impacts

Impacts are similar to alternative B with an additional 24,558 acres of emergent marsh created/nourished, as well as, an additional 279,577 linear feet of shoreline protection. Additional wetland nourishment/creation and shoreline protection features would include additional dredging disturbing more water bottom causing increased turbidity, temperature, and BOD and decreased DO.

Indirect Impacts

Indirect impacts associated with alternative C would be similar to those described under alternative B.

Cumulative Impacts

Cumulative impacts associated with alternative C would be similar to those described under alternative B.

4.17.4 Alternative D - MRGO Restoration Plan 10

Direct Impacts

Impacts are similar to alternative C with additional 704 acres of emergent marsh created/nourished, as well as, an additional 95,623 linear feet of shoreline protection. Additional wetland nourishment/creation and shoreline protection features would include additional dredging disturbing more water bottoms causing increased turbidity, temperature, and BOD and decreased DO.

Indirect Impacts

Indirect impacts associated with alternative D would be similar to those described under alternative B.

Cumulative Impacts

Cumulative impacts associated with alternative D would be similar to those described under alternative B.

4.18 WATER BOTTOMS AND BENTHIC RESOURCES

4.18.1 Alternative A - No Action Plan

Direct Impacts

The no action alternative, by not implementing shoreline protection and wetland creation/nourishment, would have no direct impacts on water bottoms and benthic resources.

Indirect Impacts

Indirect impacts of not implementing proposed action restoration measures would result in persistence of existing conditions, including the loss of existing emergent wetlands as they convert to open water. As a result of the change in habitat type, benthic communities are anticipated to change. Other indirect impacts include decreasing availability of nutrients and detritus, as well as, and a conversion of primarily estuarine benthic species to more marine open water species.

Cumulative Impacts

Under the no action alternative, dredging impacts for borrow would not occur in Lake Borgne and, as a result, alternative A would not contribute to direct cumulative impacts on water bottoms and benthic resources. However, under alternative A, water bottom and benthic resources associated with wetland habitat would continue to deteriorate into the future. These negative impacts would be offset somewhat by benefits of other reasonably foreseeable future restoration activities that would be implemented in or near the project vicinity such as: CWPPRA PO-30 project; the MRGO 2006 Lake Borgne Shoreline Protection, (Doullut's Canal to Jahncke's Ditch), St. Bernard Parish, LA (06-C-0210) project; the MRGO 2007 North Bank Foreshore Dike Construction and Repairs, Mile 44.4 to Mile 39.9 (Non-Continuous), St. Bernard Parish, LA (07-C-0089) project; and other wetland restoration efforts authorized under the LCA Plan in WRDA 2007. Features of the authorized HSDRRS as well as the closure structure on the MRGO channel near the Bayou La Loutre Ridge could affect the hydrology of the study area. The closure structure near Bayou La Loutre has reduced tidal exchange between Lake Borgne and Breton Sound, which has reduced salinity in the project area. Additionally, a 2-3 ppt salinity decrease is expected within Lake Borgne from freshwater diversion projects such as the, 1,000 cfs Hope Canal / Maurepas Diversion; and the 3,000 cfs Blind/Convent River Diversion; all of which have been authorized under Section 7006 of the WRDA 2007. The Blind/Convent River Diversion is currently in the feasibility phase with final reports expected in December 2010.

Adverse cumulative impacts associated with the no action alternative would include continued deterioration of habitat quality and quantity in the project area causing continued coastal land losses and deterioration of critical habitats along large areas of southeastern Louisiana and the Gulf Coast would further stress benthic species dependent on these habitats for all or a part of their life cycle. Negative cumulative impacts would be offset, to some degree, by the positive impacts of implementing the state and Federal projects as mentioned above. Additional state and Federal projects in the vicinity are detailed in **chapter 2**.

Under the no action alternative, preliminary aquatics modeling results from (Bartell et al., 2010) shows a slight increase of annual net productivity due to the Violet, Louisiana Freshwater Diversion for benthic species (gC/m^2) in east Lake Pontchartrain (Nodes 3, 4, 5) at target years 2015 and 2065 and Lake Borgne (Nodes 2 and 9) at target year 2015. More details for the aquatics modeling can be found within **appendix I**.

4.18.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

This alternative includes excavation of 87 mcy of material, to depths of 10 feet with a maximum depth of 12 feet, from a total of 9,036 acres of water bottom. Placement of this material for emergent wetland creation and nourishment would cover approximately 19,630 acres of shallow open water and existing fragmented marsh, as well as 10,318 acres for swamp creation and nourishment. Placement of rock for shoreline protection features would cover 122 acres (35,367 linear feet). Material dredged for retention dikes and earthen weirs would be placed over approximately 5,611 acres of shallow water bottoms and marsh.

Effects of implementing alternative B would be related primarily to localized and temporary disturbance of water bottoms during placement of shoreline protection features and also during dredging and placement of borrow materials. Direct impacts to the benthic community would include removal and entrainment with the dredged sediment. Additional disturbance to benthic species would likely occur from increased turbidity, temperature, and BOD and decreased DO due to hydraulic dredging, marsh creation, and placement of shoreline protection activities. Some smothering of benthic organisms could also occur from the sedimentation of the dredge plume, but these potential impacts could be minimized through the use of BMPs to minimize dredging impacts. Once construction is completed it is anticipated that water quality would return to pre-construction conditions.

These actions would directly impact benthic organisms within the proposed borrow areas, flotation access channels, wetland creation, and shoreline protection footprints by directly removing them along with the sediment as well as burying benthos within the placement sites. Other direct impacts to the benthos would be localized and confined to construction areas.

Dredging sediment would have a significant and immediate negative impact on the local benthic community. The primary direct effect would be the removal of sediment and entrainment of the infauna and epifauna that reside within and on the sediment. Because the majority of the benthos live in the upper 15 cm (6 in) of sediment, dredging to a depth of approximately 10 feet to 12 feet would result in a significant decrease in the abundance, biomass, and number of species of benthic organisms in the immediate area of the dredge footprint. It is expected that there would be a negligible impact on the regional benthic ecosystem because; (1) the benthic assemblages within the borrow sites are not unique and similar to assemblages in adjacent areas, and (2) the spatial extent of the dredged area is small compared to the broad area of the nearshore coastal environment.

Existing boring data from Lake Borgne indicates that the sediment composition is relatively uniform over the proposed dredging depth (10 feet to 12 feet). Therefore, changes in the physical and geochemical properties of the pre- and post-dredging lake bottom should be negligible. Anaerobic sediment will be exposed after dredging is completed. The post-dredging lake bottom should remain suitable for burrowing, feeding, and larval settlement of the benthos.

Because of the dynamic nature of benthic communities and their variability over time, the recolonization and recovery of the dredged areas can proceed at various rates. In addition, dredging activities will take place over a period of time and therefore, dredged areas will be in various stages of recovery. Dependent of the time of year, benthos can recolonize the dredged area in varying degrees via larval recruitment as well as from immigration of adults from adjacent, undisturbed areas. Benthic abundances and total species numbers may reach predredge ranges relatively quickly (within several months to a year); however, it may take several years before the benthic community recovers to its predredge levels of community composition and biomass.

In the early stages of recovery of the benthic community, there could be shifts in the dominant species in the dredged areas. There are species with life history characteristics, such as multiple reproductive events per year that allow them to rapidly recolonize unoccupied space. These opportunistic species are adapted to exploit suitable habitat when it becomes available.

The timing of dredging would be important factor in determining the eventual recovery of the dredged area because many benthic species have distinct reproductive and recruitment periods. Recovery would be primarily from larval recruitment and adult immigration for adjacent undisturbed areas.

There would be additional direct impacts on benthos from dredging activities. Settlement of sediment from the turbidity plumes created by the dredging operation would bury benthos outside the dredging footprint. The extent and the thickness of the sediment is dependent on the grain size of the sediment as well as the hydrodynamic conditions within the project area. Mobile benthic species are able to burrow through deposited sediment, while more sedentary species may be suffocated.

Preliminary aquatics modeling results from (Bartell et al., 2010) the revised model showed a slight increase of annual net productivity for benthic species (gC/m^2) in east Lake Pontchartrain (Nodes 3, 4, 5) at target years 2020 and other modeled years (e.g., 2014, 2017, 2025). Increases in benthic species resulted for Lake Borgne (Nodes 2, 9) in the same years. Benthic production increased in nearly all of the modeled years for the Golden Triangle (Node 9). Across the entire project monthly benthic productivity would be higher in the month of September within the Lake Borgne and Biloxi Marsh. Uncertainties associated with the preliminary aquatics modeling results are on the order of ~+/-20 percent. Therefore, the minimal increases and decreases in modeled benthic productivity could be reasonably interpreted as no adverse impact.

Indirect Impacts

Dredging activities would cause temporary habitat degradation to existing benthic habitats and species with various life requirements. However, these impacts would be temporary and benthos would likely re-colonize areas disturbed from dredging activities. Actions taken to reduce potential impacts during construction could include use of retention dikes to minimize runoff and overland flow, as well as reduced sediment movement and erosion into adjacent waterways and marshes, except were restoration and nourishment activities are desired. These actions could also help to minimize increases in turbidity and suspended particulates and restrict such impacts to the immediate construction area.

Low dissolved oxygen (DO) levels could be a potential impact during construction activities in Lake Borgne and continue to persist after construction. Additionally, there is the potential that the Violet, Louisiana Freshwater Diversion could exacerbate low DO conditions in Lake Borgne, due to the high level of nutrients causing algal blooms. The potential for this impact could be monitored in the future after implementation addressed with adaptive management.

Wetland habitats protected, created, and nourished by alternative B would indirectly benefit benthic resources by increasing dissolved organic compounds and detritus that would in turn provide food resources for benthic organisms. This would eventually increase local epifauna (such as oysters), which would indirectly help reduce turbidity, regenerate ammonia and phosphorus, and provide food sources for birds, fish, and people (Day et al., 1989).

Cumulative Impacts

The incremental impacts to water bottoms and benthic resources described above would contribute to the overall cumulative impacts to these resources from other activities in the project area, such as dredging projects, infrastructure projects, and continuing wetland habitat deterioration. Impacts to benthic resources would result from the removal of sediment, as well as the placement of material on water bottoms. The cumulative impacts would be offset somewhat by project benefits derived by anticipated Federal, state, local, and private restoration efforts including: CWPPRA 33,690 acres; State 2,543 acres; Vegetation 535 acres; Section 204/1135, Beneficial Use 226 acres; WRDA 16,000 acres for a total of 53,009 acres.

The CWPPRA PO-30 has been completed and PO-32 Lake Borgne portion has been constructed and the MRGO portion has been proposed for deauthorization under CWPPRA. These projects provide shoreline protection near to or adjacent to feature in this plan, and would protect additional portions of the landbridge between Lake Borgne and the MRGO channel. Additionally, there will be a maximum 1-1.4 ppt salinity reduction in addition to the 2-3 ppt salinity change for the no action alternative in Lake Borgne from May to December based upon the proposed Violet, Louisiana Freshwater Diversion in combination with the 4,500 cfs of the combined Maurepaus Swamp area diversions. Together, these diversions are predicted to reduce salinity in the Mississippi Territorial Waters by -0.6 to -0.9 ppt. Alternative B would work synergistically with those projects that are reasonably foreseeable to occur to provide greater habitat quality for benthic resources in the area. The combination of these efforts will result in the slowing of the rate of shoreline retreat and restoration of wetland benthic habitats within the area. Detailed impacts from other state and Federal projects can be viewed in **chapter 2**. Alternative B would contribute to those projects and provide more complete protection of marsh habitat that would preserve these resources in the project area.

4.18.3 Alternative C - MRGO Restoration Plan 7

Direct Impacts

Direct impacts for this alternative would be similar to those described for alternative B, with the following exceptions. Alternative C includes the excavation of 152 mcy of material from 15,724 acres of water bottom in Lake Borgne to depths of 10 feet, with a maximum depth of 12 feet. Placement of this material for emergent wetland creation and nourishment would cover approximately 44,188 acres of shallow open water and existing fragmented marsh. Placement of rock for shoreline protection features and dredging floatation access for construction activities would impact 1,937 acres (314,944 linear feet) of water bottoms. Of these potential impacts, 1,705 acres of impacted water bottoms are located in Lake Borgne, which is designated as critical habitat for Gulf sturgeon. Approximately 382 acres of impact would be permanent impacts from construction of the rock shoreline protection. The remaining 1,323 acres would be temporary construction related impacts from flotation channel excavation and placement and access corridors. Material dredged for retention dikes and earthen weirs would be placed over approximately 10,048 acres of shallow water bottoms and marsh. As a result of the additional dredging requirements and placement acreages, more benthic habitat and water bottom would be directly impacted. Construction-related impacts would be longer as the dredging activities would be increased.

Impacts to benthic resources from the Violet, Louisiana Freshwater Diversion would be the same for alternative C as they are for alternative B.

Indirect Impacts

Indirect impacts associated with alternative C would be similar to those described under alternative B.

Cumulative Impacts

Cumulative impacts associated with alternative C would be similar to those described under alternative B.

4.18.4 Alternative D - MRGO Restoration Plan 10

Direct Impacts

Direct impacts for this alternative would be similar to those described in alternative B, with the following exceptions. Alternative D uses 154.3 mcy of borrow material from 15,724 acres of water bottoms in Lake Borgne. Placement of this material for emergent wetland creation and nourishment would cover approximately 44,892 acres of shallow open water and existing fragmented marsh. Placement of rock for shoreline protection would impact 2,494 acres (410,567 linear feet). Of these potential impacts, 1,705 acres of impacted water bottoms are located in Lake Borgne, which is designated as critical habitat for Gulf sturgeon. Approximately 382 acres of impact would be permanent impacts from construction of the rock shoreline protection. The remaining 1,323 acres would be temporary construction related impacts from flotation channel excavation and placement and access corridors. Material dredged for retention dikes and earthen weirs would be placed over approximately 10,057 acres of shallow water bottoms and marsh.

Impacts to benthic resources from the Violet, Louisiana Freshwater Diversion would be the same for alternative D as they are for alternative B.

Indirect Impacts

Indirect impacts associated with alternative D would be similar to those described under alternative B.

Cumulative Impacts

Cumulative impacts associated with alternative D would be similar to those described under alternative B.

4.19 PLANKTON RESOURCES

4.19.1 Alternative A - No Action Plan

Direct Impacts

The no action alternative would result in no direct adverse impacts on plankton resources. Marsh habitat would continue to be restored through other restoration projects and programs such as CWPPRA, CIAP, and LCA that would benefit plankton resources; however, these would not be as beneficial at a magnitude which would completely restore natural processes and features vital to the long-term success of the watershed. The no action alternative would result in the continued degradation and eventual loss of wetlands.

Without the freshwater diversion and the proposed engineering measures, saltwater intrusion would continue in the project area. With the continued increase in salinity, the plankton community would begin to transition to a more marine-dominated community as estuarine wetlands continue to degrade with sea level rise and subsidence.

Indirect Impacts

The indirect impact of not implementing wetlands creation/nourishment and shoreline protection features would result in the continuing loss of wetlands. This loss of wetlands would result in a decrease of available nutrients and detritus, which could lead to the alteration of the distribution and abundance estuarine-dependent plankton species.

Cumulative Impacts

Because there are no restoration projects proposed under alternative A the no action alternative would not contribute incrementally to the cumulative impacts on plankton resources. Reasonably foreseeable restoration projects would be expected to positively benefit resources through improvement in water quality.

4.19.2 Alternative B - MRGO Restoration Plan 2

Alternative B incorporates all marsh restoration/creation and shoreline protection measures proposed for implementation under this alternative. These discussions detail both negative and positive impacts of restoration measures as they pertain to redistribution of the plankton resources due primarily to changes in area salinity.

Salinity appears to be one of the main controlling factors of zooplankton diversity. The introduction of freshwater through diversion sites could alter the community composition and distribution of zooplankton in the project area. While some zooplankton is euryhaline, others have distinct salinity preferences (Day et al., 1989).

Freshwater introduced from the Mississippi River would provide an influx of colder, nutrient-laden water that would spread through the Central Wetlands area and lower Lake Borgne ecosystem. Zooplankton peaks in the area east of the Mississippi River have been recorded in May, when the average temperature was 54^{o}F and the average salinity was 17.0 ppt (Perret et al., 1971). Maximum flow from the Violet, Louisiana Freshwater Diversion would be approximately 7,000 cfs during the months of April and May, which would be capable of reducing salinity within the Biloxi Marsh by 2 ppt to 3 ppt in May (on average) (2010, draft summary document, USACE).

Direct Impacts

The proposed release of river water through the Violet, Louisiana Freshwater Diversion channel and into the Lake Borgne and Biloxi Marsh ecosystems would result in a greater reduction of ambient salinity in the adjacent Lake Borgne region than in the more distant Biloxi Marsh. There appears to be no compelling evidence that changes in water quality would be sufficiently adverse in the overall restoration of the Biloxi Marsh and Lake Borgne ecosystem and therefore have an effect on plankton within these ecosystems (Corps Salinity Working Group, 2010). Projected salinity changes of 2 ppt to 3 ppt resulting from maximum diversion flows would have only minor temporal and spatial effect on plankton in Lake Borgne and little to no impact in the Biloxi Marsh. Plankton species that are primarily eurythermal and euryhaline would not likely be impacted by the higher flows and resulting low salinity changes. The initial introduction of river water into estuarine systems may have dramatic short-term impacts on plankton populations in adjacent coastal waters (Hawes and Perry, 1978).

The results of the aquatics model adapted to assess the ecological effects of the proposed freshwater diversion on the plankton community indicated the natural year-to-year variations in the systemic environmental parameters (i.e., water temperature, nutrient input, etc.) of the project area would be more responsible for the changes in net productivity than any changes resulting from the influx of water from the diversion. The findings of the aquatics modeling indicate that there would be no adverse impact on plankton productivity in the project vicinity.

Indirect Impacts

With only minor projected salinity changes in Lake Borgne, only slight water quality changes projected in the Biloxi marsh area and the well-flushed nature of the Lake Borgne and Biloxi marsh systems, no substantial indirect impacts would be anticipated from the influx of freshwater.

Cumulative Impacts

The cumulative impacts would result from the synergistic effects of the existing and proposed diversion projects in the study area combined with the freshwater influx from Violet, Louisiana Freshwater Diversion along with the added effects of the engineering measures proposed for this alternative. Due to the very small fluctuation in salinity, no substantial cumulative impact would be anticipated in the Mississippi Territorial Waters.

4.19.3 Alternative C - MRGO Restoration Plan 7

Similar to alternative B, this alternative includes a freshwater diversion; however, this alternative includes restoration and creation measures not identified in alternative B. The type of restoration measures between alternative C and alternative B are essentially the same with the difference being an increase in the acreage created and linear feet of shoreline protected proposed within a planning subunit. As a result, the potential impacts to plankton would be expected to be similar to those described under alternative B.

Direct Impacts

The direct impacts of the implementation of this alternative would be additional habitat and food sources for plankton provided through the increased emergent and submerged vegetation established in the marsh creation and restoration acreage. Increased nutrients and detritus flushed from marsh areas into open water by diversion flows would provide additional food sources for phyto and zoo-plankton.

Indirect Impacts

With only minor projected salinity changes in Lake Borgne and the well flushed nature of the Lake Borgne system, no substantial indirect impacts would be anticipated from the influx of freshwater. Additionally, with little to no salinity change projected in the Biloxi marsh ecosystem, no substantial indirect impacts would be anticipated from the influx of freshwater.

Cumulative Impacts

Cumulative impacts from implementation of alternative C would be similar to the impacts of alternative B. The cumulative impacts would result from the synergistic effects of the existing and proposed diversion projects in the study area combined with the freshwater influx from Violet, Louisiana Freshwater Diversion along with the added effects of the engineering measures proposed for this alternative. Due to the very small fluctuation in salinity, no substantial cumulative impact would be anticipated in the Mississippi Territorial Waters.

4.19.4 Alternative D - MRGO Restoration Plan 10

Alternative D incorporates all restoration measures under consideration for this alternative. The impacts of restoration measures would be directly related to possible redistribution of the plankton resources due primarily to changes in area hydrology.

Alternative D is similar to the other action alternatives with the addition of restoration measures not identified in alternative C. The restoration measures identified for alternative C and alternative D are essentially the same with the difference being increases in wetland acreage that would be created and linear feet of shoreline protection within a planning subunit. In addition to the measures proposed in alternative C, this alternative includes 704 acres of additional wetland restoration and wetland nourishment, as well as 95,623 linear feet of shoreline protection measures.

Direct Impacts

The direct impacts of implementation of alternative D would be similar to alternative B and alternative C. The minor changes in salinity (-0.6 ppt to -1.4 ppt) projected would not be anticipated to have a substantial effect on the distribution of plankton species in Lake Borgne or the Biloxi marshes.

Indirect Impacts

With only minor projected salinity changes in Lake Borgne and the well flushed nature of the Lake Borgne system, no substantial indirect impacts would be anticipated from the influx of freshwater. Additionally, with little to no salinity change projected in the Biloxi marsh ecosystem, no substantial indirect impacts would be anticipated from the influx of freshwater.

Cumulative Impacts

Cumulative impacts from implementation of alternative D would be similar to the impacts of alternatives B and C The cumulative impacts would result from the synergistic effects of all the existing and proposed diversion projects in the study area combined with the freshwater influx from Violet, Louisiana Freshwater Diversion along with the added effects of the engineering measures proposed for this alternative. Due to the very small fluctuation in salinity, no substantial cumulative impact is anticipated in the Mississippi Territorial Waters.

4.20 ESSENTIAL FISH HABITAT

4.20.1 Alternative A - No Action Plan

Direct Impacts

The no action plan would result in the persistence of existing conditions, including; wetland fragmentation and emergent wetland loss, as well as shoreline and bankline erosion. These conditions would contribute to the continued degradation of EFH for species utilizing these habitats such as larvae and juvenile brown shrimp, juvenile white shrimp, all life stages of red drum, and juvenile dog snapper. Under the no action alternative, no changes would be anticipated to EFH for Gulf stone crab, and adult brown shrimp or marine pelagic species such as; king and Spanish mackerel, cobia, bonnethead, and Atlantic sharpnose shark.

Under the no action alternative, estuarine emergent wetlands and submerged aquatic vegetation would substantially decrease due to the continued lack of sediment input and SLR. These areas would convert to open water marine environments and reduce the area's ability to adequately support larvae and juvenile brown shrimp, juvenile white shrimp, all life stages of red drum, larvae lane snapper, as well as juvenile dog snapper.

These habitat changes would shift predator/prey relationships and decrease fish productivity for species utilizing these habitats, which would reduce recreational and commercial fishing opportunities.

No impacts would be anticipated under the no action alternative for adult brown shrimp, Gulf stone crab, dwarf sand perch, Spanish and king mackerel, cobia, bonnethead shark, and Atlantic sharpnose shark, all of which use marine environments (**table 3-23**). Other important marine EFH occurring within the project vicinity such as non-vegetated bottoms, water column, and vegetated bottoms would not be impacted.

Aquatics modeling was used to assess changes in fisheries productivity (see **section 4.13** for CASM description). Preliminary aquatics modeling results (Bartell et al., 2010) show no significant impacts to Federally-managed species under the no action alternative.

Indirect Impacts

Continued degradation and loss of wetlands, especially transitional habitat between estuarine and marine environments (used for spawning, foraging, cover, nursery, and other life requirements), would also result in the degradation and loss of important EFH such as; inner marsh and marsh edge, estuarine water column, and mud, sand, shell, substrates. The distribution and abundance of aquatic organisms would decrease, indirectly impacting other species linked in the food web to directly affected species.

Cumulative Impacts

Cumulative impacts to EFH would result from the combination of wetland loss and conversion of water bottoms. Without habitat restoration under alternative A, habitat losses would continue and EFH would be impacted. EFH impacts would be partially offset through the benefits of restoration activities in or near the project vicinity such as: CWPPRA PO-30 project; the MRGO 2006 Lake Borgne Shoreline Protection, (Doullut's Canal to Jahncke's Ditch), St. Bernard Parish, LA (06-C-0210) project; the MRGO 2007 North Bank Foreshore Dike Construction and Repairs, Mile 44.4 to Mile 39.9 (Non-Continuous), St. Bernard Parish, LA (07-C-0089) project; and other wetland restoration efforts authorized under the LCA Plan in WRDA 2007. Features of the authorized HSDRRS as well as the closure structure on the MRGO channel near the Bayou La Loutre Ridge could affect the hydrology of the study area. The closure structure near Bayou La Loutre has reduced tidal exchange between Lake Borgne and Breton Sound, which has reduced salinity in the project area. Additionally, a 2-3 ppt salinity decrease is expected within Lake Borgne from freshwater diversion projects such as the, 1,000 cfs Hope Canal Diversion; and the 3,000 cfs Blind/Convent River Diversion; all of which have been authorized under Section 7006 of the WRDA 2007. The Blind/Convent River Diversion is currently in the feasibility phase with final reports expected in December 2010.

Adverse impacts to EFH associated with the no action alternative would be the continued deterioration of habitat quality and quantity in the project area. This habitat deterioration of critical habitats along large areas of southeastern Louisiana and the Gulf Coast will further impact Federally-managed species dependent on these habitats for all or a part of their life cycle. Negative impacts would be offset, to some degree, by the positive impacts of implementing the state and Federal projects as mentioned above. Additional state and Federal projects in the vicinity are detailed in **chapter 2**. The LCA Study (USACE, 2004) estimated a net loss of 328,000 acres of coastal wetland habitats may occur by 2050, which is nearly 10 percent of Louisiana's remaining coastal wetlands. As described previously, these habitats provide EFH to several species within the project area.

4.20.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

Implementation of alternative B would convert 7,444 acres of shallow open water to wetlands and nourish 12,186 acres of marsh to create a more continuous emergent transitional wetland habitat. This habitat would provide grounds for spawning, nursing, foraging, cover, as well as various other life requirements important to Federally managed species within the MRGO Ecosystem Restoration project area. An increase in vegetation and productivity would also reduce competition between resident and migratory fish species for limited resources.

Placement of rock for shoreline protection and dredged material for retention dikes would directly impact 35,367 linear feet and 122 acres of existing EFH, respectively, making it unavailable to fisheries species. However, the loss of EFH would be offset by the increase in the quality of EFH by the newly created and nourished emergent wetland habitat. It is important to note that retention dikes will degrade once construction is complete; thereby, rendering the habitat once again available for fisheries species. During construction activities it is anticipated fish species would temporarily avoid the immediate area.

Access channels necessary for marsh restoration sites would directly impact water bottom and various wetland habitats that are EFH to a number of Federally managed species. Dredged material from the flotation channels would be sidecast on adjacent marsh, causing temporary localized increases in turbidity, slight temperature increase and BOD, and DO decrease. Material dredged would be used beneficially for important emergent wetland nourishment and creation. BMPs would be used to reduce disturbances to EFH and fish mortality during construction including use of silt curtains and retention dikes to minimize runoff and overland flow, as well as reduced sediment movement and erosion into adjacent waterways and marshes, except were restoration and nourishment activities are desired. These actions could also help to minimize increases in turbidity and suspended particulates and restrict such impacts to the immediate construction area.

The Violet, Louisiana Freshwater Diversion would be constructed to discharge freshwater into the Central Wetlands, as well as, adjacent open water and wetland areas. The structure would be designed to discharge a minimum of 1,000 cfs and a maximum of

7,000 cfs. The diversion would be operated to provide freshwater during the months of April and May, for 4 out of 10 years. This would decrease the salinity within the project area (including Mississippi territorial waters) from 0.6 ppt to 0.9 ppt. Historical data show salinity ranging in this area from 3 ppt to 27 ppt with the higher salinity from late summer to early fall and lower salinity from winter to late spring. Based upon salinity modeling, the salinity change from the Violet, Louisiana Freshwater Diversion would not be substantial enough to affect the fisheries population or EFH within this given area. With minor changes in the salinity levels (0.6 ppt to 1.4 ppt decrease) from the Violet Canal diversion, it is anticipated that there would be no adverse impacts to EFH within Louisiana and Mississippi territorial waters. However, impacts to turbidity would increase closer to the source of the diversion during periods of high flow (April through May, maximum flow of 7,000 cfs), although BMPs would be used during construction to ensure impacts were temporary and localized. Impacts from increased turbidity may include reduced feeding opportunities from visual predators and gill clogging. However, it is anticipated that species would move out of areas currently under construction.

With the implementation of these restoration measures, alternative B would help protect EFH within the project area such as emergent marsh, oyster reefs, and SAV being utilized by Federally managed species within estuarine environments. Since all construction measures are taking place within the estuarine environment, it is anticipated that marine EFH would not be impacted.

Based upon (Bartell et al., 2010) preliminary aquatics modeling results and *Preliminary Hydrodynamic and Hydraulic Modeling for a Proposed Freshwater Diversion in the Vicinity of Violet, Louisiana* (USACE, 2010), there would be a decrease in net productivity (gC/m^2) for juvenile red drum at Nodes 2 and 9 within Lake Borgne, and Nodes 8 and 73 within the inner Biloxi Marsh. Juvenile white and brown shrimp also show slight decreases in productivity within Lake Borgne (Nodes 2, 9) and upper Lake Borgne (Node 1). Modeled monthly productivity (metric tons/km^2) for white shrimp in September shows impacts, albeit to an unknown extent.

The model results indicate locations and years within the modeled domain and planning horizon characterized by both increases and decreases in the production of modeled fishes, brown shrimp, white shrimp, and blue crab. However, it must be emphasized that given the uncertainties associated with the hydrodynamic and hydraulic modeling, the preliminary aquatics modeling results when integrated over the modeled area and time horizon could be fairly interpreted as no significant impacts on the resources of interest.

Indirect Impacts

Indirect impacts include protection, creation, and nourishment of marsh habitat, and EFH. Shoreline protection features would not only prevent the erosion of interior emergent wetlands, but would also protect interior shallow ponds, which are essential nursery habitats for many fishery species. Shoreline protection features would also prevent the conversion of transitional wetland habitats, including inner marsh and marsh edge habitats, to less productive EFH categories, such as open water. Alternative B would not only increase the areal extent of EFH, but would also improve the quality of transitional wetland habitats used by fish for spawning, nursery, forage, cover, and other life requirements. Some species serve as prey; therefore, predator populations may indirectly benefit, albeit to an unknown extent.

Low dissolved oxygen (DO) levels could be a potential impact during construction activities in Lake Borgne and continue to persist after construction. Additionally, there is the potential that the Violet, Louisiana Freshwater Diversion could exacerbate low DO conditions in Lake Borgne, due to the high level of nutrients causing algal blooms. The potential for this impact could be monitored in the future after implementation addressed with adaptive management.

Cumulative Impacts

As described above, alternative B will result in direct and indirect impacts to EFH. These impacts would contribute incrementally to the cumulative impacts from ongoing habitat losses from natural occurring processes, as well as activities such as dredging, oil and gas development, and infrastructure development. Impacts to EFH would be offset from habitat restoration proposed under alternative B, as well as those from other anticipated restoration efforts. Project benefits would be partially supplemented by the overall net acres created, nourished, and protected by other Federal, state, local, and private restoration efforts including: CWPPRA 33,690 acres; State 2,543 acres; Vegetation 535 acres; Section 204/1135, Beneficial Use 226 acres; WRDA 16,000 acres for a total of 53,009 acres. The CWPPRA PO-30 has been constructed and PO-32 Lake Borgne portion has been constructed and the MRGO portion has been proposed for deauthorization under CWPPRA. These projects provide shoreline protection near to or adjacent to feature in this plan, and would protect additional portions of the landbridge between Lake Borgne and the MRGO channel. Additionally, there will be a maximum 1-1.4 ppt reduction in salinity in addition to the 2-3 ppt salinity change in Lake Borgne from May to December based upon the proposed Violet, Louisiana Freshwater Diversion in combination with the 4,500 cfs of the combined Maurepaus Swamp area diversions. In combination, these diversions are predicted to reduce salinity in the Mississippi Territorial Waters by -0.6 to -0.9 ppt.

Alternative B would work synergistically with those projects to provide increased habitat resources and EFH quality for Federally-managed fish species. The combination of this effort with the numerous other restoration projects occurring in southeastern Louisiana will be the slowing of the rate of shoreline retreat and restoring some of the delicate wetland habitats within the area. Detailed impacts from other state and Federal projects can be viewed in **chapter 2**. Alternative B would incrementally provide additional EFH with other restoration projects proposed within the region and provide more complete protection for the associated EFH in project area.

4.20.3 Alternative C - MRGO Restoration Plan 7

Direct Impacts

Alternative C would restore approximately 17,352 acres of marsh habitats, 4,225 acres of cypress swamp, and add 314,944 linear feet of shoreline protection. Alternative C would convert open water to emergent wetland habitat and nourish 26,836 acres of existing marsh habitat and 6,093 acres of swamp.

Approximately 10,048 acres of marsh would be directly impacted by construction of the perimeter dikes and earthen weirs. Direct impacts include the loss of 1,937 acres of water bottom for the construction of rock breakwater structures for shoreline protection. Of these potential impacts, 1,705 acres of impacted water bottoms are located in Lake Borgne, which is designated as critical habitat for Gulf sturgeon. Approximately 382 acres of impact would be permanent impacts from construction of the rock shoreline protection. The remaining 1,323 acres would be temporary construction related impacts from flotation channel excavation and placement and access corridors.

With the implementation of these restoration measures, alternative C would help protect EFH within the project area such as emergent marsh, oyster reefs, and SAV being utilized by Federally managed species within estuarine environments. Since all construction measures are taking place within the estuarine environment, it is anticipated that marine EFH would have no impacts.

Excavation of access channels and placement of dredged material would cause temporary localized increases in turbidity, slight temperature increase and BOD, and DO decrease. Material dredged would be used beneficially for important emergent wetland nourishment and creation. BMPs would be used to reduce disturbances to EFH and fish mortality during construction including use of silt curtains and retention dikes to minimize runoff and overland flow, as well as reduced sediment movement and erosion into adjacent waterways and marshes, except were restoration and nourishment activities are desired. These actions could also help to minimize increases in turbidity and suspended particulates and restrict such impacts to the immediate construction area.

Indirect Impacts

Indirect impacts associated with alternative C would be similar to those described under alternative B.

Cumulative Impacts

Cumulative impacts associated with alternative C would be similar to those described under alternative B.

4.20.4 Alternative D - MRGO Restoration Plan 10

Direct Impacts

Impacts for alternative D are similar to that of alternative C, with the following exceptions, additional 557 acres of shoreline protection, 9 acres of retention dikes, and 704 acres of marsh created.

Excavation of access channels and placement of dredged material would cause temporary localized increases in turbidity, slight temperature increase and BOD, and DO decrease. Material dredged would be used beneficially for important emergent wetland nourishment and creation. BMPs would be used to reduce disturbances to EFH and fish mortality during construction including use of silt curtains and retention dikes to minimize runoff and overland flow, as well as reduced sediment movement and erosion into adjacent waterways and marshes, except were restoration and nourishment activities are desired. These actions could also help to minimize increases in turbidity and suspended particulates and restrict such impacts to the immediate construction area.

With the implementation of these restoration measures, alternative D would help protect EFH within the project area such as emergent marsh, oyster reefs, and SAV being utilized by Federally managed species within estuarine environments. Since all construction measures would take place within the estuarine environment, it is anticipated that marine EFH would have no impacts.

Indirect Impacts

Indirect impacts associated with alternative D would be similar to those described under alternative B.

Cumulative Impacts

Cumulative impacts associated with alternative D would be similar to those described under alternative B.

4.21 THREATENED AND ENDANGERED SPECIES

4.21.1 Alternative A - No Action Plan

Direct Impacts

As a result of the devastating effect of Hurricane Katrina that made landfall in 2005, several important hurricane protection projects are under construction in the study area that are expected to have significant impacts on the future conditions of the area without implementation of this restoration study. These projects individually and cumulatively are anticipated to change the future environmental conditions of the basin regardless of whether a restoration plan is implemented or not. Important among the anticipated changes, is the reduction in salinity levels from the construction of the MRGO closure structure and from freshwater in-puts from other projects in the project area, as demonstrated by the hydrologic modeling discussed in more detail in **chapter 2**.

Shoreline retreat, subsidence, and habitat switching is expected to continue at the current rates. The net primary productivity within the project area would continue to decline and existing wetlands vegetation would continue to diminish. Without the input of sediment within the project area, the conversion of existing fragmented emergent wetland habitat to shallow open water habitat would indirectly impact threatened and endangered species. The loss of coastal habitat, fish and wildlife resources, and EFH supported by this habitat is one cause of decline among threatened and endangered species that live within the project area.

Land loss in the project area would reduce the availability of habitat for T&E species. Piping plover would lose access to some forage and roosting habitat as it shifts to shallow open water. As interior marshes are lost, shoreline retreat rates increase. The coastal habitat utilized by sea turtles would continue to be impacted from this accelerated shoreline retreat rate. The continued erosion in the southern lobes of Lake Borgne may result in additional salt water intrusion into the Central Wetlands area resulting in additional cypress swamp loss. This loss could affect the availability of nesting habitat for the recently delisted bald eagle. Conversely, the recently delisted brown pelicans will gain access to more shallow water foraging areas, resulting from the shoreline retreat and Gulf sturgeon could gain more foraging areas as more open water habitat is created.

Indirect Impacts

The primary consequence of not implementing the MRGO ecosystem restoration, shoreline protection, and freshwater diversion in the project area would be the continued degradation and loss of emergent wetland habitats used by many different fish and wildlife species for shelter, nesting, feeding, roosting, cover, nursery, and other life requirements. The loss and deterioration of transitional wetland habitats over time could continue to indirectly affect, to an undetermined degree, all listed species that may potentially utilize the project area including: Gulf sturgeon, piping plovers, green sea turtles, Kemp’s Ridley sea turtles, loggerhead sea turtles, hawksbill sea turtle, leatherback sea turtle, and the West Indian manatee. The recovery of some sensitive/delisted species such as brown pelican, bald eagle, and colonial nesting birds could be indirectly impacted if habitat loss goes unabated.

Without the construction of the proposed Violet, Louisiana Freshwater Diversion, the pallid sturgeon would not run the risk of entrainment. Though catch data has indicated that the pallid sturgeon population is not large within this stretch of river there would be a decreased risk of take with the no action alternative.

Cumulative Impacts

Negative cumulative impacts to threatened and endangered species would be offset, to some extent, by the positive benefits of the reasonably foreseeable restoration activities in and near the project area. These include: the CWPPRA PO-30 project; the MRGO 2006 Lake Borgne Shoreline Protection, (Doullut's Canal to Jahncke's Ditch); St. Bernard Parish, LA (06-C-0210) project; the MRGO 2007 North Bank Foreshore Dike Construction and Repairs, Mile 44.4 to Mile 39.9 (Non-Continuous); St. Bernard Parish, LA (07-C-0089) project; and other wetland restoration efforts authorized under the LCA Plan in WRDA 2007. Features of the authorized HSDRRS, as well as the closure structure on the MRGO channel near the Bayou La Loutre Ridge would affect the hydrology of the study area. The closure structure near Bayou La Loutre has reduced tidal exchange between Lake Borgne and Breton Sound, which has reduced salinity in the project area. It is projected that this closure could reduce salinity by up to 6.6 ppt. Additionally, the closure structure and sector gates on the GIWW and Bayou Bienvenue planned near the confluence of the GIWW and the MRGO channel for the authorized improvements to the HSDRRS would alter flow patterns in the project area.

Adverse cumulative impacts associated with the no action alternative would be the result of the continued deterioration of habitat quality and quantity in the project area. Loss of suitable habitat can limit the recovery of listed species. The continued coastal land losses and deterioration of critical habitats along large areas of southeastern Louisiana and the Gulf Coast would further stress the species that are dependent on these habitats for all or a part of their life cycle. Cumulative effects on listed species would be offset, to some degree, by the positive impacts of implementing the other state and Federal projects mentioned above.

4.21.2 Alternative B - MRGO Restoration Plan 2

Compliance with the Endangered Species Act (7 U.S.C. 136; 16 U.S.C. 460 et seq.) is being coordinated with the USFWS and the NMFS for those species under their respective jurisdictions. A final BA is included in the FEIS in **appendix G**. The USACE has provided a copy of the BA to the USFWS and NMFS and initiated formal consultation with the USFWS on potential impacts to the endangered pallid sturgeon (*Scaphirhynchus albus*), and initiated formal consultation with NMFS on potential impacts to the threatened Gulf sturgeon (*Acipenser oxyrhynchus desotoi*) and its critical habitat and the five species of sea turtles that may be in the project area. NMFS issued a biological opinion (BO) on May 3, 2012, which is also included in **appendix G**.

Direct Impacts

Alternative B would restore and/or protect approximately 10,318 acres of cypress swamp, 19,630 acres of wetlands in the Lower Pontchartrain sub-basin, 54 acres of ridge habitat, and provide 122 acres of shoreline protection. The freshwater diversion, pulsing 7,000 cfs from April to May would influence approximately 115,078 acres. The dredging for this alternative will result in the direct impacts and disposal of material during the restoration process, and the construction and operation of the diversion and associated outfall management features, will result in tangible environmental changes within the project area. Reference **figure 2-9** for alternative B features.

Gulf sturgeon critical habitat would experience permanent and temporary impacts from implementation of this alternative. Direct impacts include the permanent loss of water bottom from placement of the shoreline protection features as well as temporary impacts associated with a 150 feet by 500 feet flotation channel necessary for access during the construction. Approximately 35,367 linear feet (122 acres) of shoreline protection measures would permanently remove water bottoms from critical habitat eliminating use of this area by Gulf sturgeon. This construction would occur in waters typically less than 2 meters deep and is not expected to adversely affect Gulf sturgeon that may be in the project area. Ecological benefits from this alternative include the protection of valuable shoreline from transitioning into more fragmented emergent marsh.

Temporary impacts would include dredging of floatation channels parallel to the shoreline protection features and access dredging to the floatation channels for shoreline protection feature construction. Dredged flotation channel material would be used in dike/closure construction or refurbishment, would be stockpiled adjacent to the channel to backfill flotation access channels, or behind the dikes and closures in shallow water to an elevation conducive to wetlands development. Floatation channel excavation would disturb 699 acres of critical habitat. Floatation channel dredged material placement would disturb 694 acres of critical habitat. Access channel excavation to the floatation channels would disturb 118 acres of critical habitat. Excavation of floatation/access channels, placement of dredged material, and backfilling of the floatation/access channels would cause temporary local increases in turbidity, slight temperature increase, and DO decrease.

The borrow sites for the proposed action fall largely within the designated critical habitat for the Gulf sturgeon. Lake Borgne water bottoms were determined to be the most cost-effective and feasible borrow source for construction of the remaining restoration features requiring sediment. Impacts to the prey items within Critical habitat Unit 8, which includes Lake Pontchartrain, Lake Borgne, and the Mississippi Sound, would result from the implementation of the tentatively selected plan during the construction of shoreline protection features, borrow material removal, flotation access channel construction, and stock piling of flotation access material within Lake Borgne. The proposed action could result in a permanent change to the bathymetry of approximately 15,724 acres of Lake Borgne following the removal of borrow material. In order to reduce impacts to critical habitat, hard bottom areas would be avoided because it is considered preferred foraging habitat for the Gulf sturgeon. Although hard bottom areas would provide better material for restoration features and the duration of the potential impacts of turbidity could be reduced if sediments with a greater sand component were utilized, it was ultimately determined that impacts to Gulf sturgeon would be minimized by avoiding these essential foraging habitat locations. Lake Pontchartrain is the closest site for a few of the marsh creation features. However, the portion of Lake Pontchartrain in the study area close to the marsh creation features is also designated critical habitat for Gulf sturgeon. Due to the sandy composition of Lake Pontchartrain bottoms in the vicinity, these areas are considered prime foraging habitat, and were removed by the CEMVN from consideration as a potential borrow source.

This alternative would require dredging 87 mcy of borrow material from 9,036 acres of Lake Borgne to a depth of 10 feet plus 2 feet of allowable overdredge from Gulf sturgeon critical habitat. During any given construction year, it is believed that up to three hydraulic dredges will be working within Lake Borgne at any given time. Entrainment of Gulf sturgeon is not expected since hydraulic dredges are slow moving and use of them is not known to impact the species. During borrow dredging operations Gulf sturgeon would be unable to utilize these construction areas. The removal of the lake bottom will result in the loss of all benthic organisms established within the borrow areas. However, the benthic community is expected to recover quickly from these impacts. This oligohaline estuarine zone is composed of opportunistic species that respond rapidly to dynamic abiotic factors such as salinity and DO, and populations can rapidly recover by recruitment from adjacent coastal waters. Resistance and resilience to periodic habitat disturbance, the presence of natural cycles in distribution and abundance, and the occurrence of alternate community states have to be considered in evaluating habitat quality and restoration status (Poirrier, Spalding, and Franze). There will be a temporary decrease in the amount of Gulf sturgeon prey species available within Lake Borgne at the location of the borrow pits; however, the borrow sites have been situated so as to avoid the hard bottom substrates Gulf sturgeon prefer to forage over. Access from borrow sites to marsh restoration sites would not involve dredging any primary constituent elements within critical habitat. A detailed analysis of the impacts to the Gulf sturgeon can be found within the biological assessment in **appendix G**.

The BO issued by NMFS concluded that the project activities in the Lower Pontchartrain Sub-basin will not reduce the critical habitat's ability to support the Gulf sturgeon's conservation. Following project activities it is expected that the majority of the benthic community structure in the 16,694 acres to be dredged will return to, or return nearly to, pre-project status (i.e., in terms of species diversity, species richness, species abundance), with some inherent natural variability. NMFS does not expect the 382 acres of adverse impacts to the abundance of prey items resulting from the construction of foreshore protection barriers to appreciably reduce the value of Gulf sturgeon critical habitat.

The proposed freshwater diversion at Violet, Louisiana would be constructed along the eastern side of the Mississippi River at river mile (RM) 84 to discharge freshwater into the Central Wetlands and adjacent open water and wetland areas. The structure would be designed to discharge a minimum of 1,000 cfs and a maximum of 7,000 cfs. The diversion would be operated to provide freshwater during the months of April and May for four out of ten years to meet the Chatry salinity targets. Impacts near the diversion will include a shift to more freshwater tolerant species near the diversion during the months of operation. Resistance and resilience to periodic habitat disturbance, the presence of natural cycles in distribution and abundance, and the occurrence of alternate community states have to be considered in evaluating habitat quality and restoration status (Poirrier, Spalding, and Franze). The freshwater diversion will reduce the salinity to values that were historically recorded before the MRGO was constructed. The freshwater input will result in prey and predatory fish populations to shift slightly within the project area. The operation of the Violet, Louisiana Freshwater Diversion will mimic historic conditions when Mississippi River experience flood stages and over topped its banks, freshening of the Lake Pontchartrain/Lake Borgne ecosystem. Gulf sturgeon are either making their way to or already in their spawning grounds in the rivers at the time the diversion will be operated in April and May. Any juvenile Gulf sturgeon that could possibly still be in the area would not be affected by the lowered salinity as they typically reside in areas with lower salinity during this part of the year. As such, the CEMVN expects that the reduction in salinity should have little effect on resident populations of Gulf sturgeon as the aquatic modeling suggests.

West Indian manatees are infrequent visitors to Louisiana. Sightings of the West Indian manatee in Louisiana have primarily occurred in Lakes Pontchartrain and Maurepas, and associated coastal waters and streams (i.e., Amite, Blind, Tchefuncte, and Tickfaw Rivers) and from a few rare sightings along the Gulf coast during the summer months (i.e., June through September) There is no known resident population within the State. To avoid potential impacts to manatees during restoration activities the following standard protective measures would be implemented;

- All contract personnel associated with the project should be informed of the potential presence of manatees and the need to avoid collisions with manatees, which are protected under the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973.
- All construction personnel are responsible for observing water-related activities for the presence of manatee(s).
- Temporary signs should be posted prior to and during all construction/dredging activities to remind personnel to be observant for manatees during active construction/dredging operations or within vessel movement zones (i.e., work area), and at least one sign should be placed where it is visible to the vessel operator.
- Siltation barriers, if used, should be made of material in which manatees could not become entangled, and should be properly secured and monitored.
- If a manatee is sighted within 100 yards of the active work zone, special operating conditions should be implemented, including: no operation of moving equipment within 50 feet of a manatee; all vessels shall operate at no wake/idle speeds within 100 yards of the work area; and siltation barriers, if used, should be re-secured and monitored. Once the manatee has left the 100-yard buffer zone around the work area on its own accord, special operating conditions are no longer necessary, but careful observations would be resumed.
- Any manatee sighting should be immediately reported to the U.S. Fish and Wildlife Service (337/291-3100) and the LDWF, Natural Heritage Program (225/765-2821).

Also, to prevent entrapment of manatee inside of dredged material receiving areas that have dikes or other retention features that enclose an area of open water, the area would be inspected for the presence of manatee: 1) before complete closure of the confining features; and 2) again before material is discharged in to the receiving area. Any manatee that is sighted should be allowed to leave the area before work resumes.

Adherence to the protection measures would help ensure that any manatee that wanders into the project area would not be adversely affected. The disturbance to the manatee would only be temporary during project construction, and would result in temporary displacement. The manatees would likely move to another area for foraging or resting purposes, and there would be other available areas to which the animals may relocate. Since Louisiana has no resident population of West Indian manatee and the protection measures will be adhered to, it is expected that the proposed MRGO ecosystem restoration project is “Not Likely to Adversely Affect” the species.

Since no barrier island restoration components are incorporated in this alternative; direct impacts to piping plover and the green, Kemp’s Ridley, loggerhead, hawksbill, and leatherback sea turtles are not expected.

The CEMVN has worked to reduce any negative impacts to the Gulf sturgeon or its critical habitat that could result from the proposed action by not borrowing material from areas that are found to be prime foraging habitat for the Gulf sturgeon, designating borrow sites larger than needed (so that avoidance of undiscovered environmental issues can take place), situating shoreline protection measures in waters 2 meters or less in depth, backfilling floatation/access channels, and alternating the removal of borrow material between the northern and southern lobes of Lake Borgne will reduce impact to the primary constituent elements of the Gulf sturgeon. Benthic community recovery within borrow sites will be monitored following implementation cycle 1. Once removed, Gulf sturgeon would once again be able to forage within these areas. Although the proposed construction of this alternative will affect Gulf sturgeon critical habitat, given the previous information, the CEMVN believes the action may affect the species and would not likely adversely affect critical habitat. The CEMVN is engaged in formal consultation with the NMFS. NMFS included two conservation recommendations in their BO, which they believe could work to minimize or avoid effects from the proposed action on the Gulf sturgeon. The USACE had stated that the recommendations would be implemented as part of the project. The conservation recommendations include: 1) Gather data describing recovery rates of Gulf sturgeon prey species in response to re-colonization of muddy-sand substrate that would assist in future assessments of impacts to Gulf sturgeon prey items; and 2) Gather data describing Gulf sturgeon movements within the Lower Pontchartrain Sub-basin.

In order for NMFS to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, NMFS would be notified of the implementation of any conservation recommendations, or other updates as the project is implemented.

The threatened loggerhead is the most abundant species of sea turtle occurring in U.S. waters. The nearshore waters of the Gulf of Mexico are believed to provide important developmental habitat for juvenile loggerheads. Studies conducted on loggerheads stranded on the lower Texas coast (south of Matagorda Island) have indicated that stranded individuals were feeding in nearshore waters shortly before their death (Plotkin et al., 1993). Loggerhead sea turtles may be found within the project area. Habitat in Louisiana that is suitable for Loggerheads to nest on is typically associated with that of barrier islands. CEMVN believes that the proposed action will only temporarily disrupt foraging loggerhead sea turtles that may be in the area. Coastal erosion and habitat loss is one limiting factor for the successful recovery of sea turtle populations in the Louisiana coastal zone. Coastal restoration efforts such as the MRGO project, should prove to be beneficial to the loggerhead sea turtle. After the selection of a barrier island restoration alternative, coordination regarding the specific impacts of this proposed action will need to be conducted. After assessing the MRGO project area along with the needs of the loggerhead sea turtle, CEMVN concludes that the MRGO ecosystem restoration project is “Not Likely to Adversely Affect” the species.

The nearshore waters of the Gulf of Mexico are believed to provide important developmental habitat for juvenile Kemp's ridley sea turtles. Ogren (1988) suggests that the Gulf coast, from Port Aransas, Texas, through Cedar Key, Florida, represents the primary habitat for subadult ridleys in the northern Gulf of Mexico. Stomach contents of Kemp's ridleys along the lower Texas coast had a predominance of nearshore crabs and mollusks, as well as fish, shrimp and other foods considered to be shrimp fishery discards (Shaver, 1991). Analyses of stomach contents from sea turtles stranded on upper Texas beaches apparently suggest similar nearshore foraging behavior (Plotkin, pers. comm.). Impacts to Kemp’s Ridley sea turtle population should be negligible or non-existent. The potential temporary removal of food sources by dredging operations may cause the Kemp’s Ridley sea turtle to forage elsewhere along the Gulf coast until the area is re-colonized by prey species. Coastal erosion and habitat loss is one limiting factor for the successful recovery of sea turtle populations in the Louisiana coastal zone. After assessing the MRGO project area along with the needs of the Kemp’s Ridley sea turtle, CEMVN concludes that the MRGO ecosystem restoration project is “Not Likely to Adversely Affect” the species.

The hawksbill turtle is relatively uncommon in the waters of the continental United States, preferring coral reefs, such as those found in the Caribbean and Central America. The likelihood of encountering a hawksbill sea turtle in waters of the U.S. is low. Hawksbill sea turtles typically nest on beaches in the Caribbean and Central America. Given the habitat preferences, the CEMVN concludes that the MRGO restoration project is “Not Likely to Adversely Affect” the species.

The likelihood of encountering a leatherback sea turtle in waters of the U.S. is low. Leatherback sea turtles typically are found in deep ocean waters and typically nest on beaches along Central America and Costa Rica. Given the habitat preferences, the CEMVN concludes that the MRGO restoration project is “Not Likely to Adversely Affect” the species.

Currently, green turtles are uncommon in offshore waters of the northern Gulf, but abundant in some inshore embayments. Given the lack of extensive back-barrier marsh and sea grass beds and the low incidence of sightings in the proposed project areas, adverse impacts to the green sea turtle population are not expected. Additionally, the use of a hydraulic cutterhead-type dredge is not known to take sea turtles. After assessing the MRGO project area along with the needs of the Green sea turtle, CEMVN concludes that the MRGO ecosystem restoration project is "Not Likely to Adversely Affect" the species.

Piping plover is a shorebird that inhabits open beaches, alkali flats, and sandflats of North America. Ideal wintering habitat for the piping plover on the Gulf of Mexico coast would contain large sand flats or sand-mud flats adjacent to a tidal pass or tidal inlet (Haig, 1985; Nicholls, 1989). A thin layer of mud covering the sand seems to attract plovers, due to possible food or refuge association (Nicholls, 1989). Nicholls observed that barrier beaches with over wash areas or sections of old marshes also attract plovers. Plovers are attracted to intertidal areas with little to no emergent vegetation. The project area contains no known areas other than the Chandeleur Barrier Islands that would provide this type of suitable habitat for the piping plover. Restoration features were discussed for this proposed action but it was determined that further analysis would be required. No restoration of the barrier islands is associated with this alternative. Given this information, CEMVN concludes that the proposed construction in this alternative would have no effect on the Piping Plover species.

Indirect Impacts

Indirect impacts would include protection, creation, and nourishment of 19,630 acres of marsh habitat, which would improve diversity of habitat types within the project area by preventing these areas to all become shallow open water. Shoreline protection features would not only prevent the erosion of interior emergent wetlands but would also protect interior shallow ponds, which are essential nursery habitats for many fishery species. Shoreline protection features would also prevent the conversion of transitional wetland habitats, including essential inner marsh and marsh edge habitats, to open water. An increase in the acreage of transitional habitat would result in decreased inter- and intra-specific competition between resident and migratory fish species and would sustain a larger variety and greater diversity of species.

Water diversions are used for flood control, water supply, and habitat restoration in the lower Mississippi River (LMR) but their impacts on imperiled sturgeon populations are unknown. USACE sponsored sampling efforts have shown catch data that suggests that pallid sturgeon populations decline as you progress further downstream (RM 0 to RM 320). Pallid and shovelnose sturgeon, as well as evidence of recruitment are noticeably present with RM 80-160 of the LMR. The proposed diversion at Violet will be located at RM 85. This falls within a reach of the MRGO that ERDC has shown has a population of pallid sturgeon that are showing signs of recruitment. This increased presence of adult, sub-adult, post-larval, and larval pallid sturgeon within the LMR suggests that there is an increased potential of entrainment of small sized sturgeon in diversions. The extent of impacts to this sturgeon population from entrainment in water diversion structures is currently not quantifiable. Further population analysis is needed to be able to project the size of the LMR pallid population and what impact pallid sturgeon entrainment has on this population. Given this current information CEMVN concludes that there is a risk of entrainment of pallid sturgeon by this diversion structure and that therefore the proposed MRGO ecosystem restoration project "May Affect" the species.

Cumulative Impacts

The direct and indirect impacts described above for alternative B would contribute to the overall cumulative impacts to listed species within the project area. Listed species would continue to be adversely affected by other sources such as dredging projects, oil and gas development, oil spills, and infrastructure development. Cumulative impacts on listed species would include adverse effects from habitat deterioration as well and the benefits from other restoration efforts. Project benefits from alternative B would be partially supplemented by the overall net acres created, nourished, and protected by other anticipated Federal, state, local, and private restoration efforts including: CWPPRA 33,690 acres; State 2,543 acres; Vegetation 535 acres; Section 204/1135, Beneficial Use 226 acres; and WRDA 16,000 acres for a total of 53,009 acres. The CWPPRA PO-30 has been constructed and PO-32 Lake Borgne portion has been constructed and the MRGO portion has been proposed for deauthorization under CWPPRA. These projects provide shoreline protection near to or adjacent to features in this plan, and would protect additional portions of the landbridge between Lake Borgne and the MRGO channel.

Alternative B would work synergistically with the other reasonably foreseeable projects to provide more complete protection and restoration of listed species habitat in the project area. The combination of beneficial habitat impacts from alternative B with the numerous other restoration projects occurring in southeastern Louisiana would slow the rate of shoreline retreat and restore some of the important habitat for listed species within the area. These coastal habitats are requisites for some portion of the life cycle of all of the listed species that occur within the project area. The improvement of this habitat will reduce at least one stressor that is hindering the recovery of these listed species.

4.21.3 Alternative C - MRGO Restoration Plan 7

The following is a summary of impacts to the threatened and endangered species from the proposed action. For a complete analysis please review the biological assessment included in **appendix G**.

Direct Impacts

Impacts would be similar to alternative B except this alternative includes additional restoration measures and borrow requirements not identified in alternative B. The tentatively selected plan would restore and/or protect approximately 10,318 acres of cypress swamp, 44,188 acres of wetlands in the Lower Pontchartrain sub-basin, 54 acres of ridge habitat, and provide 314,944 linear feet of shoreline protection. Reference **figure 2-10** for alternative C features. To create these additional features, 152 mcy of borrow material would be removed 15,724 acres of Gulf sturgeon critical habitat within Lake Borgne. Additional borrow pits would be required to provide the necessary material for the restoration projects and would impact approximately 6,924 acres of marsh would be directly impacted by construction of the perimeter dikes. Direct impacts include the loss of 1,937 acres of water bottom for the construction of rock breakwater structures for shoreline protection, as well as flotation channels. The additional 1,881 acres of shoreline protection would even further abate shoreline loss within the area. Restoring the additional 17,493 acres of wetland will provide more habitat diversity and ecological benefits for the T&E species within the lower Pontchartrain basin.

The additional dredging and disposal of material associated with this action will require that more of the Gulf sturgeon critical habitat be disturbed by dredging and construction activities. 471 acres of permanent impacts to Gulf sturgeon critical habitat would occur from the construction of the shoreline protection features. 1,511 acres of temporary impacts to Gulf sturgeon critical habitat would result from the excavation of flotation access channels (138), stockpiling of dredged material (134), and the excavation of access channels (14) to access the flotation access channels. This increased need for borrow will increase the duration of construction activities within Lake Borgne resulting in longer duration and quantity of direct impacts to water quality. This will result in less of the lake being accessible to the Gulf sturgeon for the duration of dredging activities. Given this information, CEMVN concludes that the proposed construction in this alternative “May Affect” the Gulf sturgeon species and that formal consultation with the NMFS has been initiated. NMFS issued a biological opinion (BO) on May 3, 2012, which is included in **appendix G**.

Impacts to pallid sturgeon, piping plover, West Indian manatee, and the green, Kemp’s Ridley, loggerhead, hawksbill, and leatherback sea turtles will be the same as in alternative B.

Indirect Impacts

Indirect impacts associated with alternative C would be similar to those described under alternative B.

Cumulative Impacts

Cumulative impacts associated with alternative C would be similar to those described under alternative B.

4.21.4 Alternative D - MRGO Restoration Plan 10

Direct Impacts

Impacts would be similar to alternative C except this alternative includes additional restoration measures not identified in alternative C. Alternative D would restore and/or protect approximately 10,318 acres of cypress swamp, 44,892 acres of wetlands in the

Lower Pontchartrain sub-basin, 54 acres of ridge habitat, and provide 410,567 linear feet of shoreline protection. Reference **figure 2-11** for alternative D features.

To create these additional features 154.3 mcy of borrow material would be removed from the bottom of Lake Borgne. Approximately 6,933 acres of marsh would be directly impacted by construction of the perimeter dikes. Direct impacts include the loss of an additional 466 acres of water bottom for the construction of rock breakwater structures for shoreline protection, as well as flotation channels. The additional borrow material required for these restoration measures will require additional impacts to Gulf sturgeon critical habitat from the associated excavation of borrow material.

Indirect Impacts

Indirect impacts associated with alternative D would be similar to those described under alternative C.

Cumulative Impacts

Cumulative impacts associated with alternative C would be similar to those described under alternative B.

4.22 SOCIOECONOMIC AND HUMAN ENVIRONMENT

The recreation features proposed for Bayou Bienvenue, the Violet, Louisiana Freshwater Diversion, and Shell Beach are not anticipated to cause any socioeconomic impacts on the project footprints. Utility connections would be from existing utility lines and there would be no disruptions or relocations. Additionally, solar lighting would be used whenever possible. The only possible socioeconomic impact would be to community cohesion as described in its section below.

4.22.1 Population

4.22.1.1 Alternative A - No Action Plan

Direct Impacts

The no action alternative would have no direct impacts on human populations. Under the no action alternative, no restoration efforts would take place under this authority. Under the no action plan, communities closer to the MRGO would continue to be impacted by storm surge and flooding during major storm events, incurring associated cost in damage to housing, local economy and commercial structures. Portions of the HSDRRS have been built to provide some protection to the population centers of Chalmette, Arabi, Poydras, Meraux, and Violet.

Indirect Impacts

The no action alternative would have no indirect impacts on human populations.

Cumulative Impacts

Cumulative impacts of implementing the no action alternative would be the additive combination of impacts to persons in the area by this and other Federal, state, local, and private restoration efforts. The no action alternative would work synergistically with other restoration and protection projects to provide critical and essential marsh restoration, which, in turn, would provide some protection to communities in the area that may otherwise be damaged due to continued erosion and land loss. The no action alternative would not contribute to any impact to persons in the area rather, the MRGO would contribute toward achieving and sustaining a coastal ecosystem that would support and protect the environment, local economy and culture of the region.

4.22.1.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

There are no human populations within the project footprints, and the proposed action would have no direct effects outside of these footprints. Hence, this alternative would not be expected to have any direct effects on nearby populations. The location of the proposed Violet, Louisiana Freshwater Diversion would not require the acquisition of any residential structures or businesses in the area.

Indirect Impacts

There are no human populations within the project footprints, and the proposed action would have no direct effects outside of these footprints. Hence, this alternative would not be expected to have any direct effects on nearby populations.

Cumulative Impacts

Cumulative impacts of implementing alternative B would be the additive combination of impacts to persons in the area by this and other anticipated Federal, state, local, and private restoration efforts. Alternative B would work synergistically with other restoration and protection projects to provide critical and essential marsh restoration, which, in turn, would provide some protection to communities in the area that may otherwise be damaged due to continued erosion and land loss. Alternative B would not contribute to any impacts to persons in the area, rather, the MRGO would contribute toward achieving and sustaining a coastal ecosystem that would support and protect the environment, local economy and culture of the region.

4.22.1.3 Alternative C - MRGO Restoration Plan 7

Direct, indirect, and cumulative impacts associated with alternative C would be the same as the impacts from alternative B.

4.22.1.4 Alternative D - MRGO Restoration Plan 10

Direct, indirect, and cumulative impacts associated with alternative C would be the same as the impacts from alternative B.

4.22.2 Community Cohesion

4.22.2.1 Alternative A - No Action Plan

Direct Impacts

The no action alternative would have no direct impacts on community cohesion.

Indirect Impacts

The no action alternative would have no indirect impacts on community cohesion.

Cumulative Impacts

The no action alternative would not contribute to cumulative impacts on community cohesion.

4.22.2.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

Alternative B, which includes implementing shoreline protection, wetland creation/nourishment, and the Violet, Louisiana Freshwater Diversion, would have minimal direct impacts on community cohesion. The only project footprint that borders a neighborhood is that of the Violet, Louisiana Freshwater Diversion. The construction of this diversion would create a new canal in a field measuring approximately 3,150 feet in width that currently separates two subdivisions. The field is an open track of agricultural land that contains no paths or walkways connecting the two subdivisions. No residential or business displacement is anticipated under this alternative. The addition of a canal in this empty field should minimally affect the neighborhood's community cohesion.

Indirect Impacts

Indirect impacts of implementing shoreline protection, wetland creation/nourishment, and the Violet, Louisiana Freshwater Diversion should be minimal. Although the construction of the diversion may increase feelings of separation between the two subdivisions, there is a proposal to add recreation features as part of the Violet, Louisiana Freshwater Diversion design. These proposed recreation features should draw more residents to the site than would have previously gathered in an open agricultural field. The coming together of residents for recreational purposes at this site may, in fact, strengthen the community cohesion of the neighborhood. The recreation features proposed for Bienvenue Triangle and Shell Beach would likely have the same positive effect.

The proposed Violet, Louisiana Freshwater Diversion will require the relocation of two highways in the area. These highways are currently used by Fire and Emergency Medical Services (EMS) personnel to respond to emergencies locally and within the region. In order to minimize impacts during the construction phase of the channel, a bypass road would be temporarily constructed to divert traffic from E. Judge Perez Drive while the diversion channel is constructed. A bridge will be built over the channel to maintain traffic movement along E. Judge Perez Drive. Similarly, traffic along St. Bernard Highway will be maintained by constructing a bypass road.

Cumulative Impacts

Cumulative impacts include the incremental effect of alternative B with the combination of impacts and benefits for overall net acres created, nourished, and protected by other anticipated Federal, state, local, and private restoration efforts. For example, the coming together of residents for recreational purposes at the Violet Freshwater Diversion site may, in fact, outweigh any negative feelings of physical separation and actually strengthen the community cohesion of the neighborhood. The recreation features proposed for Bienvenue Triangle and Shell Beach would likely have the same positive effect.

4.22.2.3 Alternative C MRGO Restoration Plan 7

Direct, indirect, and cumulative impacts associated with alternative C would be the same as the impacts from alternative B.

4.22.2.4 Alternative D MRGO Restoration Plan 10

Direct, indirect, and cumulative impacts associated with alternative D would be the same as the impacts from alternative B.

4.22.3 Infrastructure

4.22.3.1 Alternative A - No Action Plan

Direct Impacts

The no action alternative would have no direct impacts on infrastructure.

Indirect Impacts

Indirect impacts to infrastructure would result from the persistence of existing conditions including impacts related to continuing coastal land loss.

Cumulative Impacts

The projected continued coast wide decline of emergent wetlands would contribute to the deterioration of substrate upon which infrastructure features (e.g., oil, gas and water pipelines and telephone and electric transmission wires) are constructed. The no action plan would not propose any restoration projects to offset the deterioration of wetlands. As a result, the cumulative effects of land loss and degradation could lead to increased costs for maintaining and repairing existing infrastructure. However, these impacts would be somewhat offset by construction of the CWPPRA PO 30 project and similar anticipated projects.

4.22.3.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

Implementing this alternative would have a temporary disruption of rail and highway service (Alabama Great Southern Railroad (Norfolk), E. St. Bernard Highway, and E. Judge Perez Highway). As part of this alternative, a control structure 500 feet long in the Mississippi River with four 13-foot by 13-foot gated box culverts would be built. Bypass routes for the railroad and E. St. Bernard Highway (totaling approximately 2,750 feet) would be built before beginning construction of the diversion structure at the Mississippi River. Railroad access would be maintained throughout the bypass construction process, and the bypass would be designed to allow railroads to maintain existing speeds. Therefore there would be no rail delays. Delays along E. St. Bernard Highway would occur for less than one week as the two-lane road is reduced to one lane of traffic during the tie-in process. Once completed, the Alabama Great Southern Railroad (Norfolk) tracks and E. St. Bernard Highway would pass over the structure, and the temporary bypass routes would be removed. Similarly, a temporary bypass road would be constructed at E. Judge Perez Highway at the proposed diversion alignment. The bypass route would be approximately 3,450 feet long. A small bridge would be constructed at the existing roadway alignment, and the approach over the diversion structure would be elevated above grade when the road is reconstructed. As with the bypass for E. St. Bernard Highway, delays along E. Judge Perez Highway would occur for less than one week as the two-lane road is reduced to one lane of traffic during the tie-in process. Travel would resume on the reconstructed highway along its existing alignment.

Indirect Impacts

Over the 50-year period of analysis, this alternative would protect, create and nourish emergent wetlands that would reduce shoreline erosion and land loss thereby reducing the need for relocation, repair or replacement of infrastructure.

Cumulative Impacts

Alternative B would result in direct and indirect impacts that would contribute to the cumulative impacts on infrastructure within the project area. The combination of impacts and benefits under alternative B for overall net acres created, nourished, and protected together with other anticipated Federal, state, local, and private restoration efforts would provide more protection for the landbridge, which would continue to provide protection to existing infrastructure in the project areas.

4.22.3.3 Alternative C - MRGO Restoration Plan 7

Direct, indirect, and cumulative impacts associated with alternative C would be the same as the impacts from alternative B.

4.22.3.4 Alternative D - MRGO Restoration Plan 10

Direct, indirect, and cumulative impacts associated with alternative D would be the same as the impacts from alternative B.

4.22.4 Employment and Income

4.22.4.1 Alternative A - No Action Plan

Direct Impacts

The no action alternative would have no direct impacts on employment or income.

Indirect Impacts

Indirect impacts would result in the persistence of existing conditions including continued wetland loss and degradation of the Lake Borgne-MRGO ecosystem. This continued wetland loss would have localized impacts on employment and income. For example, the effects of wetland loss and degradation of the Lake Borgne-MRGO Landbridge would lead to a decline in transitional wetland habitats, an important EFH which, in turn, could lead to some undetermined level of jobs and income losses in local fishery related employment and income.

Cumulative Impacts

As described above, the no action plan would have no direct impact and some indirect impact on employment and income in the area. Other anticipated state and Federal projects in the project area would be expected to provide some construction jobs. In addition, habitat restoration from these other projects would be expected to offset job and income losses that would otherwise be expected to occur due to habitat declines for Federally-managed species. Although these other anticipated projects and programs would provide some undetermined level of positive benefits to employment and income, they would not be sufficient to offset the impacts of the long-term, coast wide wetland losses projected for Louisiana (USACE, 2004). Coastal Louisiana's continued wetland loss and the resulting depletion of wetland-dependent natural resources (fisheries, oysters, hunting, recreation, etc.) could likely result in a decline of job opportunities and personal income throughout rural coastal areas (USACE, 2004). Other supporting economic activities such as marinas, bait and tackle shops could also be adversely impacted by the degradation and eventual loss of these wetlands and wetland-dependent resources. The loss of storm buffering provided by wetlands could result in the need for greater expenditures for maintaining and repairing existing infrastructure. This could provide localized employment and income benefits. However, these benefits would likely be offset by the expenditures necessary for maintaining, upgrading and constructing new hurricane and flood protection.

4.22.4.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

There may be a temporary increase in local employment due to the construction activities related to implementation. There should be no permanent effects on employment and income.

Indirect Impacts

Over the 50-year period of analysis alternative B would protect, create and nourish thousands of acres of emergent wetlands that would benefit, to some undetermined level, local employment in wetland-dependent jobs such as commercial and recreational fisheries, ecotourism. Creation of the wetlands would provide benefits for supporting economic activities such as marinas, bait and tackle shops, and other fishery dependent business activities.

Cumulative Impacts

Cumulative impacts would be the synergistic effect with the additive combination of impacts and benefits for overall net acres created, nourished, and protected by other anticipated Federal, state, local, and private restoration efforts. Alternative B would work synergistically with these other projects and programs to provide not only more complete protection for the Lake Borgne-MRGO landbridge but also help support coast wide wetland-dependent employment.

4.22.4.3 Alternative C - MRGO Restoration Plan 7

Direct, indirect, and cumulative impacts associated with alternative C would be the same as the impacts from alternative B.

4.22.4.4 Alternative D - MRGO Restoration Plan 10

Direct, indirect, and cumulative impacts associated with alternative D would be the same as the impacts from alternative B.

4.22.5 Oil, Gas And Utilities

4.22.5.1 Alternative A - No Action Plan

Direct Impacts

The no action alternative would have no direct impacts on oil, gas, and utilities pipelines.

Indirect Impacts

Indirect impacts would result in the persistence of existing conditions including the fragmentation and degradation of the Lake Borgne - MRGO landbridge. These conditions would expose buried pipelines thereby increasing the risk of failure or damage due to lack of structural stability, anchor dragging, and boat collisions.

Cumulative Impacts

The no action plan would not contribute to direct cumulative impacts on oil, gas, and utilities in the project area. It would contribute incrementally to indirect impacts because without restoration projects being implemented, degradation of wetlands and the MRGO landbridge would likely increase the exposure of buried infrastructure to impacts.

4.22.5.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

Pipelines would be relocated by directionally drilling and replacing the pipelines underneath the channel. Water and sewer mains, power lines, communication lines and cable lines would also require relocation. Relocations would be conducted to minimize any impacts to service.

Indirect Impacts

Restoration features could potentially reduce some maintenance costs through increased protection of buried pipelines compared to the no action alternative. Alternative B is designed to be constructed in a manner that would avoid the need to relocate any pipelines in the project area.

Cumulative Impacts

Alternative B would work synergistically with other anticipated Federal, state, local, and private restoration projects to provide more complete protection for the landbridge, which would prevent the increase in maintenance and relocation costs for pipelines in and around the project area.

4.22.5.3 Alternative C - MRGO Restoration Plan 7

Direct, indirect, and cumulative impacts associated with alternative C would be the same as the impacts from alternative B.

4.22.5.4 Alternative D - MRGO Restoration Plan 10

Direct, indirect, and cumulative impacts associated with alternative D would be the same as the impacts from alternative B.

4.22.6 Flood Control And Protection Levees

4.22.6.1 Alternative A - No Action Plan

Direct Impacts

The no action alternative would have no direct impacts on flood control or hurricane protection levees.

Indirect Impacts

Indirect impacts would result in the persistence of existing conditions including the continued degradation of the landbridge separating Lake Borgne from the MRGO channel, the conversion of existing wetlands to open water habitats, and the continued bank-line erosion and sloughing of the shoreline.

Cumulative Impacts

Cumulative impacts on flood control and hurricane protection levees include the synergistic effect on the no action alternative with the additive combination of coast wide impacts to flood control and hurricane protection levees due to wetland loss and degradation, as well as the benefits and impacts of other anticipated state and Federal projects in the vicinity. Based upon recent sensitivity studies conducted by ERDC in support of the LACPR evaluation of comprehensive hurricane protection analysis and designs, the loss of wetland areas increases storm surge and wave potential at the hurricane protection system. These increases are amplified in areas where the levees have irregular shapes and form “pockets” or “funnels”. However, because the acreage of wetlands lost, levee heights and alignments, shoreward depths and storm characteristics all affect the height of storm surge, it is difficult to determine at this stage of scientific knowledge the effect of wetland loss in the area around Lake Borgne on storm surge. Consequently, degradation of the landbridge could expose existing flood control infrastructure, including the authorized flood control structure for the HSDRRS located in the western portion of the Golden Triangle, more directly to the wave climate of Lake Borgne, potentially resulting in higher erosion rates and increased maintenance needs.

4.22.6.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

Wetland creation and shoreline protection would have no direct impact on flood control or hurricane protection structures.

Indirect Impacts

Over the 50-year period of analysis alternative B would protect, create and nourish thousands of acres of emergent wetlands that would maintain the Lake Borgne - MRGO landbridge. However, increasing the acreage of wetlands in the project area (landbridge between Lake Borgne and the MRGO) may not significantly reduce storm surge or wave heights in this area. Rather, protecting wetlands (preventing their loss) would have a net effect of lowering storm surge and wave heights, to some undetermined level, compared to the no action alternative future condition with extensive wetland loss. Although a significant increase in wetland acreage in the area could have an effect on significantly reducing storm surge and wave heights, the acreage required to accomplish this has not been quantified.

Cumulative Impacts

Cumulative impacts to flood control and hurricane protection structures would primarily be associated with incremental impacts of similar wetland and protection features. Cumulative impacts would be the synergistic effect with the additive combination of impacts and benefits for overall net acres created, nourished, and protected by other Federal, state, local, and private restoration efforts. Alternative B would work cooperatively with those projects to provide more complete protection for the landbridge, which would continue to provide the current level of storm surge reduction in the project area and vicinity.

The landbridge between Lake Borgne and the MRGO channel would continue to fragment and degrade albeit to a lesser degree with implementation of the following shoreline protection projects:

- CWPPRA PO 30;
- the MRGO 2006 Lake Borgne Shoreline Protection, (Doulluts Canal to Jahncke's Ditch), St. Bernard Parish, LA (06-C-0210) project; and
- the MRGO 2007 North Bank Foreshore Dike Construction and Repairs, Mile 44.4 to Mile 39.9 (Non-Continuous), St. Bernard Parish, LA (07-C-0089).

4.22.6.3 Alternative C - MRGO Restoration Plan 7

Direct, indirect, and cumulative impacts associated with alternative C would be the same as the impacts from alternative B.

4.22.6.4 Alternative D - MRGO Restoration Plan 10

Direct, indirect, and cumulative impacts associated with alternative D would be the same as the impacts from alternative B.

4.23 ENVIRONMENTAL JUSTICE

4.23.1 Alternative A - No Action Plan

Direct Impacts

Under the no action alternative, no restoration efforts would take place under this authority. Under the no action plan, communities closer to the MRGO would continue to be impacted by storm surge and flooding during major storm events, incurring associated cost in damage to housing, local economy and commercial structures. Portions of the HSDRRS have been built to provide some protection to the population centers of Chalmette, Arabi, Poydras, Meraux, and Violet, Louisiana. The communities surrounding the MRGO include minority and/or low-income to non-minority and non-low income populations. All persons, irrespective of race or income status, would be equally impacted in a future without project conditions. Therefore, no disproportionately high or adverse human health or environmental effects on minority or low-income populations would occur.

Indirect Impacts

No disproportionately high or adverse human health or environmental indirect impacts on minority or low-income populations is anticipated under this alternative.

Cumulative Impacts

Cumulative impacts of implementing the no action alternative include the additive combination of impacts to minority and/or low-income populations from the no action alternative and other Federal, state, local, and private restoration efforts. The no action alternative would work synergistically with other restoration and protection projects to provide critical and essential marsh restoration, which, in turn, would provide some protection to communities in the area that may otherwise be damaged due to continued erosion and land loss. The no action alternative would not contribute to any additional Environmental Justice (EJ) issues rather, the MRGO would contribute toward achieving and sustaining a coastal ecosystem that would support and protect the environment, local economy and culture of the region.

4.23.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

Under the alternative B, restoration efforts would take place under this authority. Communities closer to the MRGO, as in other coastal communities, would continue to be impacted by storm surge and flooding during major storm events, incurring associated cost in damage to housing, local economy and commercial structures. However, portions of the HSDRRS have been built along the southwestern shoreline of the MRGO, with a portion of the HSDRRS levee extending from Mile 47 to Mile 60 that would help to protect the population centers of Chalmette, Arabi, Poydras, Meraux, and Violet.

The communities surrounding the MRGO include minority and/or low-income to non-minority and non-low income populations. The location of the proposed Violet, Louisiana Freshwater Diversion would be constructed in an open field which sits between two subdivisions that are predominately minority and/or low-income populations. No residences or businesses have been displaced due to this alternative. Construction efforts such as noise, dust, traffic delays, etc., would temporarily impact those in the immediate project vicinity as well as other groups that work or live in the surrounding area. These temporary impacts will equally affect all population groups in the project area and, therefore, will not result in a disproportionately high adverse impact on minority and/or low-income populations in the area. This alternative is not anticipated to adversely impact or contribute to existing interior drainage issues expressed by residents of the subdivisions.

Indirect Impacts

No disproportionately high or adverse human health or environmental indirect impacts on minority or low-income populations is anticipated under this alternative. Beneficial impacts to minority and/or low-income populations are expected to occur under this alternative. A recreation development plan is proposed to maintain the community cohesion between two subdivisions near Violet, which will be called the Violet, Louisiana Park. Additionally, recreational improvements to the New Shell Beach fishing area and the Bienvenue Triangle pier near the Martin Luther King Elementary School in the Lower-ninth ward are proposed for recreation and educational use. These proposed improvements are an additional benefit to the local community, which continues to rebuild after Hurricane Katrina. Community groups in the project vicinity would benefit from the proposed improvements and experience some impacts with the proposed alternative B. Therefore, no disproportionately high or adverse human health or environmental effects on minority or low-income populations is anticipated under this alternative.

Cumulative Impacts

Cumulative impacts of implementing the alternative B include the combination of impacts to minority and/or low-income populations from this alternative and other

Federal, state, local, and private restoration efforts. Alternative B would work synergistically with other restoration, improvement and protection projects to provide critical and essential marsh restoration, which, in turn, would provide some protection to communities in the area that may otherwise be damaged due to continued erosion and land loss. Alternative B would not contribute to any adverse EJ issues, rather, the MRGO would contribute toward achieving and sustaining a coastal ecosystem that would support and protect the environment, local economy and culture of the region.

4.23.3 Alternative C - MRGO Restoration Plan 7

Direct Impacts

Under the alternative C, restoration efforts would take place under this authority. Communities closer to the MRGO, as in other coastal communities, would continue to be impacted by storm surge and flooding during major storm events, incurring associated cost in damage to housing, local economy and commercial structures, however, portions of the HSDRRS have been built along the southwestern shoreline of the MRGO, with a portion of the HSDRRS levee extending from Mile 47 to Mile 60 that would help to protect the population centers of Chalmette, Arabi, Poydras, Meraux, and Violet.

The communities surrounding the MRGO include minority and/or low-income to non-minority and non-low income populations. The location of the proposed Violet, Louisiana Freshwater Diversion would be constructed in an open field which sits between two subdivisions that are predominately minority and/or low-income populations. No residences or businesses have been displaced due to this alternative. Construction efforts would result in an increase in noise, dust and cause some traffic delays in the area. These temporary impacts will equally affect all population groups in the project areas and, therefore, will not result in a disproportionately high adverse impact on minority and/or low-income populations in the area. These effects would temporarily impact those in the immediate project vicinity as well as other groups that work or live in the surrounding area. However, these are only temporary in nature. This alternative is not anticipated to adversely impact or contribute to existing interior drainage issues expressed by residents of the subdivisions.

Indirect Impacts

No disproportionately high or adverse human health or environmental indirect impacts on minority or low-income populations is anticipated under this alternative. Beneficial impacts to minority and/or low-income populations are expected to occur under this alternative. A recreation development plan is proposed to maintain the community cohesion between two subdivisions near Violet, which will be called the Violet Park. Additionally, recreational improvements to the New Shell Beach fishing area and the Bienvenue Triangle pier near the Martin Luther King Elementary School in the Lower-ninth ward are proposed for recreation and educational use. These proposed improvements are an additional benefit to the local community, which continues to rebuild after Hurricane Katrina. Community groups in the project vicinity would benefit from the proposed improvements and experience some impacts with the proposed alternative C. Therefore, no disproportionately high or adverse human health or environmental effects on minority or low-income populations is anticipated under this alternative.

Cumulative Impacts

Cumulative impacts of implementing the alternative C include the combination of impacts to minority and/or low-income populations from this alternative and other Federal, state, local, and private restoration efforts. Alternative C would work synergistically with other restoration, improvement and protection projects to provide critical and essential marsh restoration, which, in turn, would provide some protection to communities in the area that may otherwise be damaged due to continued erosion and land loss. Alternative C would not contribute to any adverse EJ issues, rather, the MRGO would contribute toward achieving and sustaining a coastal ecosystem that would support and protect the environment, local economy and culture of the region.

4.23.4 Alternative D - MRGO Restoration Plan 10

Direct Impacts

Direct impacts would be similar to alternative C. Therefore, no disproportionately high or adverse human health or environmental effects on minority or low-income populations is anticipated to occur.

Indirect Impacts

Indirect impacts would be similar to alternative C. Therefore, no disproportionately high or adverse human health or environmental effects on minority or low-income populations is anticipated to occur.

Cumulative Impacts

Cumulative impacts would be similar to alternative C. Therefore, no disproportionately high or adverse human health or environmental effects on minority or low-income populations is anticipated to occur.

4.24 HISTORIC AND CULTURAL RESOURCES

4.24.1 Alternative A - No Action Plan

Direct Impacts

The no action alternative would have no direct beneficial or adverse impacts on historic and cultural resources; however, adverse indirect and cumulative impacts would result from the no action alternative as follows.

Indirect Impacts

Without implementation of ecosystem restoration measures, future conditions would include continued conversion of current marsh to open water habitats, continued bankline erosion and sloughing of the shoreline. The erosion caused by natural forces and human activity would continue to adversely affect existing cultural resources in the study area. The loss of land within the study area threatens the existence and integrity of these sites.

Cumulative Impacts

Alternative A would not cause any direct impacts and, therefore, would contribute to cumulative direct impacts to historic and cultural resources. Without any restoration projects proposed, the no action alternative would indirectly contribute to cumulative impacts through the continuation of bankline and shoreline erosion.

4.24.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

Only one archaeological site could be affected by this alternative. Deposition of dredged material on this site would increase the rate of subsidence and the disappearance of this site from the archaeological record. National Register eligible sites would either have to be avoided or adverse effects would have to be mitigated. A variety of mitigative measures are possible, ranging from data recovery to other types of documentation. Mitigation could take place at the site directly affected or could be concentrated at any one site. Decisions on mitigative strategies would be made under a Memorandum of Agreement among the CEMVN, the Louisiana State Historic Preservation Officer (SHPO) and any interested Indian groups. Sites unevaluated for National Register eligibility would either have to be avoided or further research would be carried out in order to determine National Register eligibility.

Effects to submerged resources and borrow dredging is unknown. Survey of flotation channels and shoreline protection using sidescan sonar, magnetometer and subbottom profiler has not identified any submerged archaeological or nautical resources. Survey of offshore borrow areas will be performed using sidescan sonar and magnetometer.

Indirect Impacts

Implementation of ecosystem restoration measures under alternative B could work to reduce continued conversion of current marsh to open water habitats, continued bankline erosion and sloughing of the shoreline. The erosion caused by natural forces and human activity would continue to adversely affect existing cultural resources in the study area. The loss of land within the study area threatens the existence and integrity of these sites.

Cumulative Impacts

Previous projects along Lake Borgne (Gagliano et al., 1975; Heller et al., 2009; Jones and Franks 1993; Labadia et al., 2007; Warren, 2004; Wiseman et al., 1979) have identified cultural resources along natural streams and along the shoreline of lakes as being the areas with the highest probability of finding archaeological and historic sites. While there have been many projects conducted in the MRGO region, the construction of all have failed to have an adverse effect on historic properties. None of these projects; however, considered the effects on archaeological sites located offshore as this project will as none of these projects have attempted to identify offshore sites. Locating and treating offshore sites would be a challenge and would take close consultation with the Louisiana SHPO and interested tribes. At this time it is impossible to say whether the previous projects had an adverse effect on offshore sites.

4.24.3 Alternative C - MRGO Restoration Plan 7

Direct Impacts

As above, deposition of dredged material would increase the rate of erosion. Ridge restoration along Bayou La Loutre could also destroy historic properties. However, shoreline protection would decrease the amount of erosion on sites located along the edge of Lakes Borgne and Pontchartrain. Shoreline protection could adversely affect sites located offshore. Offshore sites could be avoided by placing gaps in the rockwork. This, however, would increase on shore erosion and could adversely affect shoreline sites. Any National Register eligible or unevaluated sites would be treated as under alternative B.

Indirect Impacts

Implementation of ecosystem restoration measures under alternative C could work to reduce continued conversion of current marsh to open water habitats, continued bankline erosion and sloughing of the shoreline. The erosion caused by natural forces and human activity would continue to adversely affect existing cultural resources in the study area. The loss of land within the study area threatens the existence and integrity of these sites.

Cumulative Impacts

Previous projects along Lake Borgne (Gagliano et al., 1975; Heller et al., 2009; Jones and Franks 1993; Labadia et al., 2007; Warren, 2004; Wiseman et al., 1979) have identified cultural resources along natural streams and along the shoreline of lakes as being the areas with the highest probability of finding archaeological and historic sites. While there have been many projects conducted in the MRGO region the construction of all have failed to have an adverse effect on historic properties. None of these projects; however, considered the effects on archaeological sites located offshore as this project will as none of these projects have attempted to identify offshore sites. Locating and treating offshore sites would be a challenge and would take close consultation with the Louisiana SHPO and interested tribes. At this time it is impossible to say whether the previous projects had an adverse effect on offshore sites.

4.24.4 Alternative D - MRGO Restoration Plan 10

Direct Impacts

This is the largest plan and incorporates all elements and additional acreages of the previous two alternatives. It has the potential to adversely affect two known sites that have an undetermined status for National Register eligibility but are clearly National Register eligible. As with the above plans, ridge construction along Bayou La Loutre has the potential to adversely affect sites. Deposition of dredged material has the potential to increase the rate of subsidence and may bury the sites removing them from the archaeological record. Offshore rock placement and the excavation of floatation channels may adversely affect off shore sites. Excavation of off shore borrow areas may adversely affect historic shipwrecks. As with alternative C, the construction of shoreline protection would protect sites along the shoreline of Lakes Borgne and Pontchartrain, though it may harm offshore sites. Gaps in the rockwork would increase the rate of erosion at those locations and decisions may have to be made as to whether to protect shore line sites while damaging sites that are not located off shore.

Indirect Impacts

Implementation of ecosystem restoration measures under alternative D could work to reduce continued conversion of current marsh to open water habitats, continued bankline erosion and sloughing of the shoreline. The erosion caused by natural forces and human activity would continue to adversely affect existing cultural resources in the study area. The loss of land within the study area threatens the existence and integrity of these sites.

Cumulative Impacts

Previous projects along Lake Borgne (Gagliano et al., 1975; Heller et al., 2009; Jones and Franks 1993; Labadia et al., 2007; Warren, 2004; Wiseman et al., 1979) have identified cultural resources along natural streams and along the shoreline of lakes as being the areas with the highest probability of finding archaeological and historic sites. While there have been many projects conducted in the MRGO region the construction of all have failed to have an adverse effect on historic properties. None of these projects, however considered the effects on archaeological sites located offshore as this project will as none of these projects have attempted to identify offshore sites. Locating and treating offshore sites would be a challenge and would take close consultation with the Louisiana SHPO and interested tribes. At this time it is impossible to say whether the previous projects had an adverse effect on offshore sites. The proposed project will have little if no effect on sites along the Mississippi coast, the Pearl River basin or the Mississippi Sound.

4.25 RECREATIONAL RESOURCES

4.25.1 Alternative A - No Action Plan

Recreational resources may be affected both positively and negatively by the various projects that would be implemented without the MRGO Ecosystem measures. These projects include a variety of measures supported by a number of sources including CWPPRA, WRDA 2007, and HSDRRS. These projects include freshwater diversions, storm water management, marsh creation and nourishment, shoreline protection, barrier island restoration, and hydrologic restoration, as well as levees, floodgates, and locks. The following discussion addresses potential effects of these projects on recreational resources in the project area, which would likely occur if the no action alternative is implemented.

Direct Impacts

Freshwater diversion projects at Amite and Convent Rivers and Maurepas Swamp River Reintroduction would likely benefit freshwater fishing and waterfowl hunting by increasing and enhancing the habitat for freshwater fish species and waterfowl but may increase access distance to saltwater fishing as saltwater species migrate towards the Gulf of Mexico. During high flow periods, turbidity and associated reduction in water quality may temporarily reduce both freshwater and saltwater fishing and waterfowl hunting opportunities.

Marsh creation projects for Biloxi marshes, Lake Lery, and the East Orleans Landbridge are supported through the CIAP and would likely benefit recreation by providing additional habitat for waterfowl and birds, which would enhance opportunities for bird watching and hunting. Enhanced marsh habitat would likely also benefit fishing in the area as marshes are very productive nursery habitat for fish. However, in the short term, during the process of delivering sediment to these areas for building marshes, increased levels of turbidity may deter fish from the area, which would be temporarily detrimental for recreational fishing in the immediate area. There is a possibility that marsh creation could impact boating access if newly created marshes impede familiar and direct access routes to fishing areas.

The Cypress Marsh Restoration project of the Bayou Bienvenue Central Wetlands is supported through the CIAP and designed to restore the natural structure and function of the ecosystem in the deteriorating wetlands. The project would rebuild wetlands where subsidence has been occurring. Ultimately the project should improve wetland habitat, which would benefit recreational fishing. However, as waters become less saline, the project may have an effect on saltwater fishing as anglers would have to travel further towards the Gulf to catch desired saltwater species.

A shoreline restoration project in the Lake Lery area supported through CWPPRA (BS-16) will be accomplished with measures designed to cause silt and sediment to accumulate along shorelines. Restored shorelines will provide additional nursery habitat for fish, which would benefit recreational fishing. In limited locations, such projects may benefit fishing by providing opportunities for bank fishing. Shoreline restoration would provide general benefits by minimizing impacts and protecting important fish and wildlife areas from the effects of coastal storm surge.

Barrier island restoration projects for the Chandeleur Islands supported through CWPPRA (PO-27) will similarly benefit the Breton National Wildlife Refuge recreational area by potentially reducing damage from storm surge and this would benefit recreation by increasing the availability of unique habitat areas for fish and birds.

Hydrologic restoration projects supported through CWRRPA (PO-24) and designated for the Hopedale area will restore natural flows of water. Such projects may benefit recreational fishing and bird watching as natural habitats are protected and the numbers and diversity of species increases.

Planned structural measures include improvements of existing levees as part of the HSDRRS in New Orleans East, St. Bernard Parish and along the GIWW including areas near the Bayou Sauvage National Wildlife Refuge. Excavation of borrow pits near Lake Lery to implement structural measures would disturb the sediment in the nearby waters which may impact nearby fish habitat; this effect would be temporary. Another potential effect of structural measures associated with increased levee heights and associated flood protection measure may be reduced access across flood control structures, possibly resulting in the need for longer access roads where possible.

Four major floodgate projects are planned as part of the HSDRRS for the project area. Their locations will be at GIWW East, Bayou Bienvenue, Violet Canal/Bayou Dupre, and MRGO. When water levels rise more than two feet above sea level, these floodgates are to be closed. This could impact access to recreational resources. Boat launches and marinas located near these floodgates inside the flood protection system would not be able to provide boaters access to the recreational resource outside the flood protection system when the gates were closed. In turn, there is the potential for floodgates to restrict boaters' access to recreational resources in the area. However, marinas located inside the flood protection system would benefit by having a reduced risk of damage from storm surge and experiencing shorter periods with loss of function.

Indirect Impacts

Depending upon the success of barrier island restoration efforts, the long term benefit for recreation may be increased opportunities for camping on the islands.

Cumulative Impacts

The cumulative impacts of the other ongoing and reasonably foreseeable projects are expected to generally benefit recreation resources. The no action alternative would not contribute to cumulative impacts to recreation resources. The risk of destruction of recreational infrastructure such as boat ramps, marinas, and fishing piers by storm surge would be reduced and habitat areas supporting recreational fish and wildlife resources would be enhanced. The closure structure on the MRGO channel near the Bayou La Loutre Ridge is affecting the hydrology of the study area. The closure structure near Bayou La Loutre has reduced tidal exchange between Lake Borgne and Breton Sound, which has reduced salinity in the project area. Additionally, a 2-3 ppt salinity decrease is expected within Lake Borgne from freshwater diversion projects, such as the 1,000 cfs Hope Canal / Maurepas Diversion; and the 3,000 cfs Blind / Convent River Diversion; all of which have been authorized under WRDA 2007, Section 7006. These projects would potentially enhance freshwater based recreation, as well as stabilize and maintain saltwater based recreation.

4.25.2 Alternative B - MRGO Restoration Plan 2

In summary, alternative B contains a freshwater diversion at Violet that would be constructed in year 2027. It includes 29,948 acres of swamp and marsh restoration and nourishment throughout the study area, ridge restoration near Bayou La Loutre and protection of 35,367 linear feet of shoreline.

Direct Impacts

Direct impacts to recreational resources include those effects from marsh and swamp nourishment, restoration of natural ridges, and shoreline protection measures. Measures to stabilize marsh and swamp habitats and to restore deteriorated wetlands would be beneficial to recreational fishing by enhancing the sustainability of productive nursery habit for this resource. Restoring marsh and swamp improves nursery habitat in the interior marshes, which could improve recreational fishing opportunities in offshore waters, including Mississippi waters, as juveniles become adults and move to deeper waters. By using estuaries during their early life stages, estuarine-dependent species may increase survivorship because these habitats offer more protection from predation and damaging wave action (Able and Fahay, 1998; Minello, 1993; Minello and Zimmerman, 1983). Another benefit of estuarine use is access to increased food sources (Turner and Brody, 1983; Zimmerman et al, 2000). This need for a protected nursery habitat with high local productivity is especially crucial for key commercial and recreational species. For example, a study that analyzed 21 years of coastal Louisiana fishery data revealed that 9 of the 10 most abundant fishery species collected by trawls (including invertebrates and fishes) were estuarine dependent (Chesney, Baltz, and Thomas, 2000). Without access to estuaries during their early life stages, populations of commercial and recreational species such as brown shrimp (*Farfantepenaeus aztecus*), white shrimp (*Litopenaeus setiferus*), blue crab (*C. sapidus*), Gulf menhaden (*B. patronus*), Atlantic croaker (*Micropogonias undulatus*), and spotted sea trout (*Cynoscion nebulosus*) would likely decline over time.

Development of additional marsh and swamp habitat is potentially beneficial for bird watching as it would support more birds and increase the diversity of species in the area. Waterfowl hunting opportunities may increase due to increased and enhanced freshwater habitat. Potential negative effects include temporary turbidity and reduced water quality associated with construction of marsh and swamp restoration projects and near borrow areas in Lake Borgne during excavation. An effect of marsh creation is the potential for reduced access to fishing areas as boaters would have to potentially navigate around newly created land area. Restoration of natural ridges would provide stabilization and potentially additional habitat for deer, small game, and birds, which would be beneficial for hunting and bird watching. Restored ridges would also enhance protection available to adjacent swamps and marshes during coastal storms, which would also potentially benefit recreational resources.

As described for the no action alternative, shoreline protection would potentially benefit recreational fishing by providing additional productive nursery habitat for fish and can be expected to benefit recreation by providing an enhanced level of protection to resource lands from effects of coastal storm surge. Potential effects of shoreline protection measures would be the temporary displacement of fish populations due to increased turbidity both near the shorelines and near borrow areas during project implementation.

In year 2027, the Violet Canal freshwater diversion would be constructed to discharge freshwater into the Central Wetlands, as well as, adjacent open water and wetland areas. Review of LDWF Caernarvon data helps to understand the potential effects of a further freshening of the project area on recreational fishing. As was discussed in the commercial fishery section of this report (citation), LDWF conducted pre- and post-construction sampling events for the Caernarvon Freshwater Diversion using trawls and seines at 21 sampling locations located throughout Breton Sound estuary. Post-construction sampling showed a decrease in catch per unit effort (CPUE) for brown shrimp, while white shrimp showed an increase in CPUE.

Alternative B may result in impact to recreational shrimping opportunities in the MRGO project area. Sampling by LDWF confirmed significant nursery use by juvenile brown shrimp (salinity 0.3 to 5 ppt), juvenile white shrimp, and juvenile blue crab (both found in salinity as low as 0.2 ppt). Most shrimp thrive in a saltwater environment; however, in years with heavy freshwater flow through Caernarvon, brown shrimp catches decreased in quantity, while white shrimp catches improved. If there is a long term lowering of salinity levels, the brown shrimp may migrate further south into the lower reaches of the study area, but white shrimp may thrive closer to the diversion canal.

CPUE data was inconclusive for blue crab (citation). Commercial landing data collected from local seafood dealers yielded no detectable post-construction effect. However, LDWF data on spotted sea trout (aka speckled trout) shows sea trout catch was positively related to salinity of stations within the Breton Sound Basin, meaning trout catch was higher at the higher-salinity stations within the basin. The Caernarvon Freshwater Diversion has resulted in a shift of the optimal harvest zones from the interior marshes to more seaward marshes and water bodies, while no significant reductions of either three of the species has been recorded. Similar results could be produced from the Violet, Louisiana Freshwater Diversion.

Potential impacts to recreational fisherman could include longer travel distances towards the Gulf of Mexico for saltwater based opportunities. In the long term, the distribution of saltwater fish species would be further south resulting in longer travel time to reach quality saltwater fishing opportunities. On the other hand, decreases in salinity within the intermediate marsh zone could potentially enhance conditions for freshwater fish species and improve habitat for waterfowl hunting within this portion of the project area.

While some habitat transition based on decreased salinity levels is anticipated, overall benefits associated with marsh creation, and improved aquatic habitat for fisheries and waterfowl should result in improved recreational experiences during normal flow conditions. In addition, deer and other small game hunting could improve over time due to stabilization and improved ridge habitat.

Indirect Impacts

Marsh creation projects would likely benefit fishing well beyond the project area as marshes are very productive nursery habitat for saltwater fish that live in open waters. Depending upon the success of barrier island restoration efforts, the long-term benefit for recreation may be increased opportunities for camping on the islands. Potential indirect impacts from alternative B would primarily consist of effects on recreational fishing from increased turbidity to the water bodies of Lake Borgne and other areas due to dredging and placement of borrow material. These impacts could include fish species temporarily migrating away from these disturbed conditions. Impacts from the dredging and placement of borrow material, including an increase in water turbidity, could last for ten years, which is the timeframe of the implementation plan.

Recreational boating would also be affected by the proposed action. Floating pipelines would convey dredged material from borrow areas to sites being restored. These pipelines would, in some cases, block access to fishing areas and fisherman may have to travel longer distances to arrive at their preferred destination. However, canals that are frequently used by fisherman would not be blocked as the pipeline crossing these locations would be submerged.

Cumulative Impacts

The cumulative effects of the alternative B measures together with those of ongoing and reasonably foreseeable projects would be beneficial to recreational resources. In combination, these projects would create, restore, nourish, and protect important marsh, swamp and ridge habitat that would support fish and wildlife and the increase in freshwater habitat for waterfowl and birds. This in turn should increase freshwater based recreational activities while maintaining and stabilizing saltwater based recreation activities. Slowing or reversing land loss and marsh erosion may protect or increase recreation resources, such as boat ramps, marinas, and park facilities.

Specifically, marsh creation measures being proposed in the MRGO Bank Stabilization project would increase fish habitat production and therefore have a positive impact on recreational fishing resources. Proposed river diversions at Caernarvon and White Ditch would increase vegetative growth (especially in fresh habitats) and promote land building thereby leading to increased recreation opportunities.

Cumulative impacts of these projects, along with the closure of the deep-draft MRGO channel, would have some level of localized changes to salinity regimes over the Future Without-Project conditions. The CWPPRA PO-30 project has been authorized for construction, and portions of the original CWPPRA PO-32 project are currently under construction as part of the HPS authority. Both of those projects will construct shoreline protection features near or adjacent to the features in this plan, and will protect portions of the landbridge area between the MRGO channel and Lake Borgne. Most importantly, marsh creation in the project area would positively impact recreational fishing and hunting. The localized reduction of salinities and the increased acres of freshwater habitats would result in a concomitant increase of freshwater recreation activities and a decrease of saltwater recreation activities in areas of freshwater reintroduction; as well as an overall positive effect on most wildlife-dependent recreation activities. Potential impacts would include longer transit distances to the Gulf of Mexico for saltwater based opportunities and a temporary reduction in the recreational activity during project construction.

Reducing land loss and possible land building may protect valuable infrastructure that supports certain recreation activities. Potentially, cumulative impacts of the above mentioned projects could therefore reduce loss of recreation-based infrastructure and access thereby decreasing expenses related to relocation, repair, or replacement.

Together these ongoing, planned and proposed measures for the study area would help to maintain, stabilize, and potentially enhance economic benefits relative to recreation.

4.25.3 Alternative C - MRGO Restoration Plan 7

Direct Impacts

The anticipated direct impacts of alternative C measures are similar to those described for alternative B, but would include additional measures. Alternative C measures add shoreline protection to the shores of Lake Borgne and Lake Pontchartrain and more extensive shoreline protection near Eloi Bay; and additional marsh nourishment and restoration measures in the Central Wetlands and marsh restoration measures along Bayou Terre aux Boeufs and Lake Calebass.

The direct effects of alternative C would be the restoration, and nourishment of 54,506 acres of swamp and marsh and 314,944 linear feet of shoreline protection.

These additional measures and resultant increased number of acres of swamp and marsh restored and nourished would further improve the habitat for recreational resources in the study area and would likely result in an increase in recreational opportunities. It would also further enhance protection of recreational resources from the devastating effects of storm surge.

Indirect Impacts

The anticipated indirect impacts of alternative C measures would be similar to those described for alternative B.

Cumulative Impacts

The anticipated indirect impacts of alternative C measures would be similar to those described for alternative B.

4.25.4 Alternative D - MRGO Restoration Plan 10

Direct Impacts

The anticipated direct impacts of alternative D measures are similar to those described for alternative C, plus alternative D additional measures. Alternative D measures add shoreline protection along the east bank of the MRGO and more extensive shoreline protection near Eloi Bay.

The direct effects of alternative D would be the restoration, and nourishment of 55,210 acres (just slightly more than alternative C) of swamp and marsh and 410,567 linear feet of shoreline protection.

Indirect Impacts

The anticipated indirect impacts of alternative D measures would be similar to those described for alternative B.

Cumulative Impacts

The anticipated cumulative impacts of alternative D measures would be similar to those described for alternative B.

4.26 AESTHETICS

4.26.1 Alternative A - No Action Plan

Direct Impacts

The visual complexity surrounding the MRGO project area is related to its geomorphic features including ridge, swamp, marsh, and open water. All of these elements are critical systems inclusive to the MRGO study area. Together, all of these elements provide pleasing aesthetic scenery to the public from certain points of view, especially those areas closest to national parks, national refuges, wildlife management areas or other state or nationally designated areas. Direct impacts would evolve from the natural processes of the area and the associated changes to these geomorphic structures.

Indirect Impacts

Indirect impacts can also be derived from the conversion of wetland and marshlands into open water. These landscape types provide excellent habitat for a variety of wildlife and fisheries. Excellent examples of habitat and their associated wildlife typically provide the viewer with focal points and accents (typically made up of both the landscape and the wildlife) that make a view shed dynamic, scenic and memorable.

Cumulative Impacts

Cumulative impacts as a result of implementing the no action alternative would include the incremental impacts to visual (aesthetic) resources resulting from the past, present, and reasonably foreseeable future impacts associated with conversion and loss of marsh, wetland and/ or swamps from natural processes and anthropogenic sources. Landscape changes would continue to occur in the future as a result of the conversion of marsh, wetland, and swamp habitat to open water. Without implementation of wetland creation and other protection measures, continued conversion of existing fragmented wetlands to open water habitats would persist. Degradation of the land would convert existing view sheds of marsh and wetland to more open water views. Because they lack vertical and horizontal features, open water does not provide a viewer with the necessary elements of form, line, texture, and color that make a view scenic and memorable such as is provided by an expanse of salt marsh.

4.26.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

Those aesthetic features that are unique to a particular landscape or bring unique design to a landscape. These features typically adhere to the basic design elements of form, line, texture, color, and repetition.

The proposed marsh and swamp nourishment and restoration, ridge restoration, and shoreline protection projects would work to reclaim former land mass that has been converted to a more open water setting. The reclamation would present the possibility of creating vertical features (derived from future landscape and vegetation growth) that, along with ground features could work to frame the large open water areas beyond. This creates an aesthetic setting that is much more desirable and contains the basic design elements of form, line, texture, and color.

Many of the proposed project sites (including the sites at Terre aux Boeufs, Biloxi Marsh, and South Lake Borgne) are very remote with few public view sheds. The other sites (near Central Wetlands and East Orleans Landbridge) feature residential development and major thoroughfares that have access to superior view sheds throughout the project area. Highways 300, 624, 46, 39, 90, and 11, along with Interstates 10 and 510 would be impacted by the proposed alternative. Land restoration would increase the visual characteristics of the project area.

Other impacts result from the proposed Violet, Louisiana Freshwater Diversion. The diversion itself would not negatively impact the aesthetics within its project vicinity. However; the impacts associated with the potential marsh nourishment and restoration would be extremely positive.

Indirect Impacts

Marsh nourishment and restoration projects would increase habitat for wildlife, which would be expected to increase wildlife populations. Wildlife typically provides the viewer with focal points and accents that make a view shed dynamic, scenic, and memorable.

Another indirect impact would be the addition of the recreation features at Bienvenue Triangle, Shell Beach, and Violet Diversion. In terms of aesthetics, the designs presented in the plan would serve to create space that is memorable and unique and bring people into the marsh, wetland, and landscape restoration areas. Viewers would be provided the unique opportunity of seeing restoration in progress, while it’s happening. These recreational features would also bring unique view sheds to places that would typically not be available to the public.

Cumulative Impacts

Cumulative impacts to aesthetics would be the result of implementing alternative B together with ongoing and reasonably foreseeable projects that would restore and enhance marsh, wetland, and swamp habitat within the project area. Restoration act ivies would convert existing view sheds of open water into marsh, wetland, swamp, or a variety of landscape types that frame large bodies of open water and use the basic design elements of form, line, texture, color, and repetition to create an aesthetically pleasing view shed.

Reasonably foreseeable projects across southern Louisiana include the Louisiana Coastal Restoration projects, which include a number of diversion projects, marsh and swamp restoration and nourishment, and shoreline protection; CWPPRA projects that include diversions, marsh creation, shoreline protection, and siphons; lock replacement projects; and operation and maintenance projects, like that found at Bonnet Carrè Spillway. Future and existing freshwater diversions for Davis Pond, Caernarvon, Myrtle Grove and White Ditch will impact the MRGO study area by providing needed nutrients and fresh water to the area, augmenting alternative B objectives. Past, present, and future projects of this type would maintain existing and future marshes, thereby diminishing open water areas and creating land mass.

4.26.3 Alternative C - MRGO Restoration Plan 7

Direct Impacts

Direct impacts associated with alternative C would be similar to those presented in alternative B. Alternative C is planned on a grander scale and includes greater implements of marsh nourishment and restoration throughout the project area, increased swamp nourishment and restoration in the Central Wetlands area, increased shoreline protection on the eastern side of the Biloxi Marshes, as well as other shoreline protection along the shores of Lake Borgne, and the eastern shore of Lake Pontchartrain near the East Orleans Landbridge and Pearl River Mouth project sites.

The proposed recreational features at Bienvenue Triangle, Violet, Louisiana Freshwater Diversion and Shell Beach would have direct impacts to the aesthetic (visual resources) of the project areas that they are associated with. Each recreational feature has been designed to provide access for viewing and understanding the overall ecosystem restoration process, as well as providing sources for recreation to local and regional participants. The designs themselves are not overly embellished and, over time, would blend in well with their surroundings, creating a haven for nature observation and other recreational possibilities that will bring the viewer directly inside the ecosystem itself. The view sheds would be unobstructed from these features, adding to the visual quality and experience of the three project areas.

Indirect Impacts

Indirect impacts associated with alternative C would be similar to those presented in alternative B. Alternative C is planned on a grander scale and includes more marsh nourishment and restoration throughout the project area, increased swamp nourishment and restoration in the Central Wetlands project area, increased shoreline protection on the eastern side of the Biloxi Marshes, as well as other shoreline protection along the shores of Lake Borgne, and the eastern shore of Lake Pontchartrain near the East Orleans Landbridge and Pearl River Mouth project sites. These elements, in turn, would indirectly work to increase habitat and opportunities for wildlife growth and development.

Cumulative Impacts

Cumulative impacts associated with alternative C would be similar to those presented in alternative B.

4.26.4 Alternative D - MRGO Restoration Plan 10

Direct Impacts

Direct impacts associated with alternative D would be similar to those presented in alternative B and alternative C. Alternative D is planned on a grander scale and includes greater implements of marsh nourishment and restoration throughout the project area. This includes new sites on the eastern edge of the Biloxi Marshes and the northern side of the East Orleans Landbridge near the Pearl River Mouth. Other features include increased shoreline protection on the eastern side of the Biloxi Marshes, Terre aux Boeufs and the northern (or eastern depending on point of view) shore of the MRGO itself, as well as other shoreline protection that includes breakwaters along the eastern shore of Lake Pontchartrain near the East Orleans Landbridge.

Indirect Impacts

Indirect impacts associated with alternative D would be similar to those presented in alternative B and alternative C. Alternative D is planned on a grander scale and, as with alternative C, includes greater implements of marsh and swamp nourishment and restoration, and increased shoreline protection. These elements, in turn, would indirectly work to increase habitat and opportunities for wildlife growth and development.

Cumulative Impacts

Cumulative impacts associated with alternative D would be similar to those presented in alternative B and alternative C.

4.26.5 Scenic Streams

4.26.5.1 Alternative A - No Action Plan

Direct Impacts

The no action alternative would have no direct adverse or beneficial impacts to the seven scenic streams located within the project area in Louisiana. There are no scenic streams in the immediate coastal areas surrounding the Mississippi Sound or St. Louis Bay; therefore, there would be no direct impacts to scenic streams in Mississippi from the continuation of existing conditions under alternative A.

Indirect Impacts

Under the no action alternative, the continued degradation of marsh habitat would result in a gradual decline in overall habitat quality within the study area, which would indirectly adversely affect scenic streams in the project areas within Louisiana. The continued decline in habitat quality is the result of continued fragmentation of the marsh and creation of large open water areas. As the marsh deteriorates, the natural aesthetics of a marsh lined bayou transitions to open water with little aesthetic value including an eventual loss of the actual channel itself. The eventual result could be the loss of these Louisiana scenic streams completely to open water. Because there are no scenic streams in the immediate coastal areas surrounding the Mississippi Sound or St. Louis Bay, there would be no indirect impacts to scenic streams in Mississippi from the no action alternative.

Cumulative Impacts

Cumulative impacts would include the synergistic effect of the no action alternative on scenic streams with the additive combination of similar impacts throughout coastal Louisiana, as well as the benefits and impacts of other state and Federal projects in the vicinity, as detailed in **section 2.6.1**. Cumulative adverse and beneficial impacts to the scenic streams located within the project area in Louisiana would result from the implementation of freshwater diversion projects or other programs, such as CWPPRA, CIAP, and LCA, within the study area. These projects and programs could have both adverse and beneficial impacts to scenic streams by reducing water clarity and interrupting flow patterns; however, the introduction of freshwater into the system could potentially benefit surrounding marsh habitat by helping to slow the marsh deterioration that has plagued the area in the recent past. Without implementation of wetland creation/nourishment and shoreline protection features, marsh habitat deterioration would continue as land loss and subsidence convert marshes to open water.

4.26.5.2 Alternative B - MRGO Restoration Plan 2

Direct Impacts

Direct impacts for alternative B would result from disturbances to the existing habitats along scenic streams in Louisiana to create/nourish marsh habitats and construct temporary retention dikes and earthen weirs. The majority of the direct detrimental impacts would occur during project construction in terms of turbidity, placement of material in existing marsh and open water habitats, the construction of retention dikes along project sites, and placement and creation of access channels to move material to the project sites. These impacts would be temporary and localized. While the aesthetics and viewsheds along the scenic streams will be temporarily directly impacted during construction, the long-term result would be the overall improvement of habitat necessary to create the natural landscapes for which these scenic streams were originally protected. Over time, the containment dikes and other earthwork would be removed to allow for the reestablishment of natural habitats and viewsheds for scenic streams.

In the Golden Triangle marsh area where the scenic portion of Bayou Bienvenue is located, measure LM1 would include the creation and nourishment of marsh habitat. Approximately 3,253 acres of shallow water and 1,064 acres of adjacent areas of existing marsh would be filled to an elevation conducive to create marsh and marsh restoration, not to exceed +1.25 feet over marsh. To assist in marsh creation and hold in this dredged sediment, 595 acres of containment dikes and 538 acres of earthen weirs would be created in the area. These temporary earthen dikes would be created along portions of Bayou Bienvenue and would directly impact the habitat adjacent to the bayou. A portion of these dikes would be constructed along the entire western bank of the scenic portion of Bayou Bienvenue and a small section of the eastern bank. The overall goal of measure LM1 is to create and nourish viable brackish marsh habitat consistent with historic habitats once found in the Golden Triangle marsh area.

Within the Central Wetlands area, there would be six measures constructed under alternative B. Of these six measures, only four (CC1, CC2, CC5, and CC6) are adjacent to or in proximity to designated scenic streams. These four measures would create a total of 2,390 acres of swamp. Another 5,303 acres of swamp would be nourished by the four project measures. These measures would include the construction of retention dikes and earthen weirs, which would impact 691 acres of existing marsh habitat.

Measure CC1 in the area north of the existing Violet Canal along the Forty Arpent Levee consists of the restoration of approximately 1,020 acres of shallow water to be filled to an elevation conducive to swamp creation and approximately 935 acres of existing marsh to be restored by placement of a thin layer of sediment not to exceed +1.0 foot over marsh. This measure would include 205 acres of retention dikes, a portion of which runs parallel to the Violet Canal. Along with potential impacts to the Violet Canal, a large portion of Bayou Chaperon is located within the area affected by measure CC1. Potential impacts could include a reduction in access, reduced water quality, and sedimentation. Further engineering analysis is being performed to determine the length and cost for the construction of additional retention dikes along either side of Bayou Chaperon. The retention dikes would prevent effluent from entering the scenic stream and reduce potential impacts.

With measure CC2, approximately 250 acres of shallow water would be filled to an elevation conducive to swamp creation and approximately 250 acres of existing marsh in the area would be restored by placement of a thin layer of sediment not to exceed +1.0 foot over marsh. A portion of the 66 acres impacted by the construction of retention dikes is in proximity to the northern portion of Bayou Chaperon.

Measure CC5 is located in the area south of the Violet Canal along the alignment of the Forty Arpent Levee and the Chalmette Loop Levee. Approximately 1,120 acres of shallow water would be filled to an elevation conducive to swamp creation and approximately 1,550 acres of existing marsh would be restored by placement of a thin layer of sediment not to exceed +1.0 foot over marsh. Measure CC5 would also have 216 acres of impact relevant to the construction of retention dikes. A portion of these dikes run parallel to the Violet Canal and could potentially result in direct impacts to the scenic stream. These impacts include the direct loss of the 216 acres of habitat that parallel the Violet Canal as well as visual impacts from the natural habitat being converted to an earthen dike to hold in the fill material.

With measure CC6, approximately 2,568 acres of existing marsh would be restored by placement of a thin layer of sediment not to exceed +1.0 foot over marsh in an effort to restore swamp habitat. This measure is not expected to directly impact any scenic streams. While this measure is not expected to directly impact any scenic streams, both Pirogue Bayou and Terre Beau Bayou are in close proximity and could have water quality impacts during restoration work as discussed under indirect impacts. Measure CC6 would also have 162 acres of impact relevant to the construction of retention dikes.

Due to the absence of any scenic streams in the immediate coastal areas surrounding the Mississippi Sound or St. Louis Bay, there would be no direct impacts to scenic streams in Mississippi from construction of alternative B.

Indirect Impacts

Indirect impacts of wetland creation and nourishment and retention dike construction would include temporary increases in turbidity levels and sedimentation in scenic streams. Other indirect impacts primarily consist of long-term improvement to the scenic streams by preserving and re-establishing the natural habitats that both protect and add to the aesthetic qualities of this resource. By protecting these critical marsh habitats, including the Biloxi Marsh and Eastern Orleans Landbridge, alternative B would help prevent the degradation of marsh habitat in the areas surrounding scenic streams in the project areas within Louisiana. Due to the absence of any scenic streams in the immediate coastal areas surrounding the Mississippi Sound or St. Louis Bay, there would be no indirect impacts to scenic streams in Mississippi from construction of alternative B.

Cumulative Impacts

Cumulative impacts to the seven scenic streams in the project area would primarily be associated with combined impacts of wetland creation, nourishment, and shoreline protection projects. Cumulative impacts would include the overall effect with the additive combination of impacts and benefits for overall net acres created, nourished, and protected by other Federal, state, local, and private restoration efforts as summarized in **section 2.6.1**. Alternative B, combined with those projects, would provide more complete protection of marsh habitat that would preserve the integrity and aesthetic quality of the scenic streams in the project area.

While the overall cumulative impacts from alternative B should have a net positive benefit on scenic streams, there are several external factors that could offset a portion of these benefits. The project area in southeast Louisiana is located along the Gulf Coast and is susceptible to tropical cyclone activity every year from June through November. There is a moderate risk every year for a tropical storm or hurricane to impact the area causing land loss and inundation with saline waters that would have an immediate and long-term impact to the restoration features and project area as a whole. A second key factor in the potential cumulative effects to the region is from the oil and gas industry. Oil and gas exploration, production, and transportation are a major economic driver in the project area and coastal Louisiana. A comprehensive list of future projects would be very difficult to develop due to the private and rapidly changing nature of the industry. However, it is prudent to assume the potential exists for future adverse impacts to scenic streams from dredging, due to the development of oil and gas infrastructure including pipelines, platforms, or exploration activities, in the project area.

4.26.5.3 Alternative C - MRGO Restoration Plan 7

Alternative C shares all of the restoration measures discussed for alternative B with the addition of measures CM3 and CM4, which are described below.

Direct Impacts

Measure CM3 in the area north of Bayou Dupre and south of the MRGO consists of the restoration of approximately 300 acres of shallow water to be filled to an elevation conducive to marsh creation and approximately 215 acres of existing marsh to be restored by placement of a thin layer of sediment not to exceed +1.0 foot over marsh. The measure would include 154 acres of impacts relevant to retention dikes and would have an additional 54 acres of impacts from earthen weirs. A portion of the retention dikes parallel Bayou Dupre from its juncture with the Violet Canal north to its juncture with Bashman Bayou. Along with these potential impacts to Bayou Dupre, one of the areas of marsh creation and nourishment runs the length of Bashman Bayou to the east and would also have two sections of earthen weir constructed parallel to the bayou. Potential impacts to Bashman Bayou could include reduction in access, reduced water quality, and sedimentation of the channel. While the reduction in access and reduced water quality would be temporary during construction, the sedimentation of the channel would be a permanent impact that may require dredging of the channel once construction is complete.

With measure CM4, approximately 98 acres of shallow water would be filled to an elevation conducive to marsh creation and approximately 129 acres of existing marsh would be restored by the placement of a thin layer of sediment not to exceed +1.0 foot over the marsh. A portion of the 132 acres impacted by the construction of retention dikes runs parallel to portions of Bayou Dupre, Pirogue Bayou, and Terre Beau Bayou. All of the areas of marsh creation and nourishment are located adjacent to portions of Bayou Dupre, Pirogue Bayou, and Terre Beau Bayou. Potential impacts to these scenic streams could include reduction in access, reduced water quality, and sedimentation of the channel. While the reduction in access and reduced water quality would be temporary during construction, the sedimentation of the channel would be a permanent impact that may require dredging of the channel once construction is complete.

Due to the absence of any scenic streams in the immediate coastal areas surrounding the Mississippi Sound or St. Louis Bay, there would be no direct impacts to scenic streams in Mississippi from construction of alternative C.

Three recreational sites have been identified for construction as part of this alternative. All three recreation features are detailed in **appendix W**. Due to the fact that these features are located over five miles from the scenic streams, no impacts from the recreation features are expected.

Indirect Impacts

Indirect impacts associated with alternative C would be similar to those described under alternative B.

Cumulative Impacts

Cumulative impacts associated with alternative C would be similar to those described under alternative B.

4.26.5.4 Alternative D - MRGO Restoration Plan 11

Alternative D shares all of the same restoration measures as discussed for alternative C.

Direct Impacts

Direct impacts associated with alternative D would be the same as those described under alternative C.

Indirect Impacts

Indirect impacts associated with alternative D would be similar to those described under alternative B.

Cumulative Impacts

Cumulative impacts associated with alternative D would be similar to those described under alternative B.

4.27 FLOODPLAINS

4.27.1 Alternative A - No Action Plan

Direct Impacts

Under the no action alternative, there would be no direct impacts to the floodplain. A large portion of the project area is coastal marsh habitat which would continue to degrade and increase the flood risk to developed portions of the floodplain.

Indirect Impacts

Flood protection and restoration programs discussed in **chapter 2** would continue to develop or remain in place under existing conditions in order to ensure protection of Louisiana's and Mississippi's coastal and natural resources. Other reasonably foreseeable efforts that would likely improve and restore critical habitat include Federal, state, local and private ecosystem restoration projects. These projects include diversions and restoration which would have an effect on the floodplain.

Cumulative Impacts

Cumulative impacts would be the synergistic effect of projects requiring development in the floodplain throughput coastal Louisiana, and the potential floodplain impacts and benefits from other Federal, state, and local projects in the vicinity, as detailed din **chapter 2**.

4.27.2 Alternative B – MRGO Restoration Plan 2

Direct Impacts

All of the restoration features involve marsh or swamp restoration and nourishment, shoreline protection, and ridge restoration and would be developed in uninhabited areas outside of the floodplain areas that are managed by the floodplain coordinator and fall under the jurisdiction of EO 11988.

The proposed Violet, Louisiana Freshwater Diversion would be constructed in the vicinity of Violet, Louisiana. The diversion feature would connect the Mississippi River to the MRGO and Lake Borgne and would be located in portions of the 500 and 100-year floodplain. The channel that would be created as part of the diversion would have guide levees on either side and would not pose a flood risk to any of the communities or developments within the floodplain. Approximately 529 acres within the Hurricane Protection System would be converted to floodway as part of the construction of the diversion canal.

Indirect Impacts

Programs discussed in **chapter 2** would continue to develop or remain in place under existing conditions in order to ensure protection of Louisiana's and Mississippi's coastal and natural resources. Other reasonably foreseeable efforts that would likely improve and restore critical habitat include Federal, state, local and private ecosystem restoration projects. These projects include diversions and restoration which would have an effect on the floodplain.

Cumulative Impacts

Cumulative impacts would be the synergistic effect of projects requiring development in the floodplain throughput coastal Louisiana, and the potential floodplain impacts and benefits from other Federal, state, and local projects in the vicinity, as detailed din **chapter 2**.

4.27.3 Alternative C – MRGO Restoration Plan 7

Direct Impacts

Direct impacts to floodplains associated with alternative C would be the same as the impacts from alternative B.

Indirect Impacts

Indirect impacts to floodplains associated with alternative C would be the same as the impacts from alternative B.

Cumulative Impacts

Cumulative impacts to floodplains associated with alternative C would be the same as the impacts from alternative B.

4.27.4 Alternative D – MRGO Restoration Plan 10

Direct Impacts

Direct impacts to floodplains associated with alternative D would be the same as the impacts from alternative B.

Indirect Impacts

Indirect impacts to floodplains associated with alternative D would be the same as the impacts from alternative B.

Cumulative Impacts

Cumulative impacts to floodplains associated with alternative D would be the same as the impacts from alternative B.

4.28 ANY ADVERSE ENVIRONMENTAL IMPACTS WHICH CANNOT BE AVOIDED SHOULD THE TENTATIVELY SELECTED PLAN BE IMPLEMENTED

The tentatively selected plan includes conversion of 17,352 acres of open water and fragmented marsh to freshwater, brackish, and saline marsh habitat and nourishing 26,836 acres of existing marsh habitat. Approximately 4,225 acres of open water would be converted into cypress swamp and an additional 6,093 acres of swamp would be nourished. Ridge restoration would consist of 17,500 feet, approximately 54 acres, of ridge being increased in elevation. Approximately 314,944 linear feet of shoreline protection measures consisting of rock breakwater would be implemented to protect marsh habitat and reduce shoreline erosion. However, in order to facilitate the construction of these restoration measures some adverse impacts, while only temporary, could occur within the project area. Lake Borgne is designated as critical habitat for the endangered Gulf Sturgeon and borrow material for these restoration measure would need to be taken from the lake bottom. Lake Borgne includes some sandy bottoms that are the preferred foraging habitat for these species. These areas were surveyed and excluded from consideration as potential borrow sources. Approximately 152 mcy of borrow material or roughly 15,724 acres of water bottom could be disturbed for the creation of borrow pits. This borrow material would come from various sources in Lake Borgne and surrounding water bodies.

A phased implementation plan is proposed to remove borrow material from Lake Borgne. Borrow would be removed from the lake gradually over 10 implementation cycles that would allow no more than 2.5 percent of the lake bottom to be impacted during any given implementation cycle. The implementation plan actually spans 14 years with a monitoring period in place for two years after test borrow pits are dredged. A cycle does not necessarily last for 365 days and some features could take 12 to 16 months to complete. The borrow plan limits dredging to one lobe of Lake Borgne per implementation cycle; therefore, isolating increased turbidity to one lobe of the lake. A minimum of 365 days of dredging would occur in one lobe before switching to the other lobe.

The tentatively selected plan would assist in the long-term productivity of the Lower Pontchartrain Basin ecological community by improving the water quantity, water quality, nutrients, and sediments in the basin. This, in turn, would facilitate the growth and productivity of emergent marsh and the invertebrates, fish, and wildlife that utilize these habitats. The tentatively selected plan would also result in enhancing the long-term productivity of the natural communities throughout the region. These long-term beneficial effects of the tentatively selected plan outweigh the adverse environmental impacts resulting primarily from project construction.

As part of the restoration efforts, the construction of a freshwater diversion near Violet, LA is also being considered. While additional study is needed to improve decisions regarding where, when, and how to provide a freshwater diversion, construction of the Violet, Louisiana Freshwater Diversion channel (Alternative 1 location) would have direct impacts on 118 acres, which includes 59 acres of brackish marsh and open waters within the Central Wetlands area. The Violet, Louisiana Freshwater Diversion would result in long-term changes in water quality and salinity levels in the Central Wetlands area, Biloxi Marsh, and West Mississippi Sound. These changes would restore the system to pre-existing conditions thought to have occurred before construction of the MRGO. The Alternative 1 location for the diversion would be constructed in an open field which sits between two subdivisions that are predominately minority and/or low-income populations. Construction efforts such as noise, dust, traffic delays, etc., would temporarily impact those in the immediate project vicinity as well as other groups that work or live in the surrounding area. Enhancement measures are proposed in order to maintain the community cohesion between the two subdivisions.

4.29 ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES INVOLVED IN THE IMPLEMENTATION OF THE TENTATIVELY SELECTED PLAN

NEPA requires that environmental analysis include identification of “any irreversible and irretrievable commitments of resources which would be involved in the tentatively selected plan should it be implemented.” Irreversible and irretrievable resource commitments are related to the use of nonrenewable resources and the effects that the use of these resources have on future generations. Irreversible effects primarily result from use or destruction of a specific resource (e.g., energy and minerals) that cannot be replaced within a reasonable time frame. Irretrievable resource commitments involve the loss in value of an affected resource that cannot be restored as a result of the action (e.g., extinction of a T&E species or the disturbance of a cultural site).

The tentatively selected plan would result in the direct and indirect commitments of resources. These would be related mainly to construction components. Energy typically associated with construction activities would be expended and irretrievably lost under all of the alternatives excluding the no action alternative. Fuels used during the construction and operation of dredging equipment and barges would constitute an irretrievable commitment of fuel resources.

For the tentatively selected plan, most resource commitments are neither irreversible nor irretrievable. The dredging of borrow material from Lake Borgne is considered reversible although it is anticipated that the natural infilling of the borrow pits may take several years. Given the hydrodynamics of the lake and similar pits constructed in Lake Pontchartrain, there is little accretion and sediment movement in the lakes. Benthic communities would be removed and lost along with the sediment during dredging operations. Benthic communities would also take several years to recover. Fish and plankton would be entrained in the dredge during the dredging of the borrow areas. These losses will be irretrievable. However, most impacts to fish and plankton are short term and temporary and would only occur during dredging and construction activities. For example, access channels that would be dredged and retention dikes that are constructed would be restored to natural conditions after construction.

While additional study is needed to improve decisions regarding where, when, and how to provide a freshwater diversion, a few impacts resulting from construction of the Violet, Louisiana Freshwater Diversion structure (Alternative 1 location) are long-term and permanent including the conversion of 118 acres, which includes 59 acres of brackish marsh in the Central Wetlands area, to the diversion canal. Other impacts including disruption of community cohesion that may have a longer effect can be reduced through appropriate enhancement measures and best management practices. There are no irreversible or irretrievable commitments of resources which would preclude formulation or implementation of reasonable alternatives for this project.

4.30 RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

NEPA Section 102(2)(c)(iv) and 40 CFR 1502.16 requires that an EIS include a discussion of the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity. This section describes how the tentatively selected plan would affect the short-term use and the long-term productivity of the environment.

For the tentatively selected plan, "short-term" refers to the temporary phase of construction of the proposed project, while "long-term" refers to the operational life of the proposed project and beyond. **Chapter 4** of this document evaluates the direct, indirect, and cumulative effects that could result from the tentatively selected plan.

Construction of the tentatively selected plan would result in short-term construction-related impacts within parts of the project area and would include to some extent interference with local traffic, minor limited air emissions, and increases in ambient noise levels, disturbance of fisheries and wildlife, increased turbidity levels, lower DO, and disturbance of recreational and commercial fisheries. These impacts would be temporary and would occur only during construction, and are not expected to alter the long-term productivity of the natural environment.

The tentatively selected plan would assist in the long-term productivity of the Lower Pontchartrain Basin ecological community by improving the water quantity, water quality, nutrients, and sediments. This in turn would facilitate the growth and productivity of emergent marsh and the invertebrates, fish, and wildlife that utilize these habitats. The tentatively selected plan would also result in enhancing the long-term productivity of the natural communities throughout the region. These long-term beneficial effects of the tentatively selected plan would outweigh the impacts to the environment resulting primarily from project construction.

With an increase in the amount wetland habitat and increase in wetland habitat quality, fish populations would experience beneficial impacts. These improvements in productivity would beneficially impact long-term commercial and recreational fishing in the study region.

CHAPTER 5: **PUBLIC INVOLVEMENT**

5.1 GENERAL

The U.S. Army Corps of Engineers (USACE) invites full public participation in the National Environmental Policy Act (NEPA) process and promotes open communication between the public and the USACE for better decision-making. All persons and organizations that have an interest in the tentatively selected plan, including minority, low-income, disadvantaged, and Native American groups, are urged to participate in the NEPA environmental analysis process. The scoping process is useful in helping the USACE focus the Environmental Impact Statement (EIS) on issues of importance to the public and other interested agencies and organizations.

The President's Council on Environmental Quality (CEQ) guides public participation opportunities with respect to the tentatively selected plan on environmental regulations. Compliance guidance for NEPA is contained in Title 40 of the Code of Federal Regulations (CFR), Parts 1500 through 1508, and in the USACE regulations 33 CFR 230 and 325, *Environmental Quality and Procedures for Implementing NEPA.* These regulations provide for six major elements of public participation available in conjunction with preparation of this EIS including:

1) Notice of Intent (NOI),
2) Scoping
3) Public review of the Draft EIS (DEIS),
4) Public hearing on the DEIS,
5) Public release of the Final EIS (FEIS) and 30-day waiting period, and
6) Publication of the Record of Decision (ROD).

5.2 AGENCY COORDINATION

A project kick-off meeting was held on October 8, 2008, to present the study authority, purpose, goals, and objectives. Federal, state, and local agencies from Louisiana and Mississippi participated in the discussions.

Agencies were invited by email on August 27, 2008, and by letter dated October 23, 2008, to participate in the study as cooperating agencies and provide a team member for the Project Delivery Team (PDT) and Habitat Evaluation Team (HET). Informal agency coordination meetings occurred throughout the period when the Preliminary Draft Environmental Impact Statement (PDEIS) was being prepared to discuss issues and clarify information.

Preparation of the MRGO Ecosystem Restoration Plan Feasibility Report ("MRGO" former Mississippi River Gulf Outlet Navigation Channel) and DEIS has been coordinated with appropriate Congressional, Federal, state, and local interests, as well as environmental groups and other interested parties as listed below:

- United States Fish and Wildlife Service, Louisiana and Mississippi
- United States Environmental Protection Agency, Region VI
- National Marine Fisheries Service, Louisiana and Mississippi
- Natural Resources Conservation Service, Louisiana
- State Historic Preservation Officer
- Advisory Council on Historic Preservation,
- Louisiana’s Governor’s Executive Assistant for Coastal Activities
- Louisiana Department of Wildlife and Fisheries
- Louisiana Department of Natural Resources, Coastal Management Division
- Louisiana Department of Natural Resources, Coastal Restoration Division
- Louisiana Department of Environmental Quality
- Mississippi Department of Environmental Quality
- Mississippi Department of Marine Resources
- Lake Pontchartrain Basin Foundation (LPBF)
- American Rivers

5.3 PUBLIC INVOLVEMENT ACTIVITIES TO DATE

Throughout the study, public and stakeholder involvement was encouraged and facilitated. Several stakeholder forums were facilitated by the USACE, including a Central Wetlands Forum, Recreation Forum, LPBF Ridge Restoration Workshop, and St. Bernard Parish Central Wetlands Workshop. Other stakeholder engagements included participation in quarterly non-Government Organization meetings and small group meetings. A full discussion of stakeholder and public involvement activities, as related to the feasibility report and DEIS is included in the accompanying MRGO Ecosystem Restoration Plan Feasibility Report, Chapter 5.

5.3.1 Study Website

The MRGO website, http://www.mrgo.gov, is dedicated to not only the MRGO Ecosystem Restoration Feasibility Report, but many other aspects, including the MRGO De-Authorization Study and MRGO Navigation Channel Closure. In addition to general information about the MRGO, it includes an interactive map, fact sheets, presentations, past documents, posters from public meetings, handouts from public meetings, and a calendar of events.

This site was used to announce the NEPA scoping meetings as well as a record of the materials used and distributed at the meetings. A comment button on the left navigation panel is provided for the public to submit comments. The site is updated as new products and reports are released.

5.3.2 Scoping

Scoping was discussed in **chapter 1**, **section 1.4.4**. The scoping comment period began with the filing of the NOI and continues through release of the DEIS for public comment. Public scoping meetings were held on November 3, 2008, in Chalmette, Louisiana and November 6, 2008, in Waveland, Mississippi. Higher participation was received in Chalmette, Louisiana with approximately 79 stakeholders attending. A total of 322 comments were received during the comment period; 257 comments were expressed at the scoping meetings and 65 written (letter, fax and email) and verbal comments were received during the comment period. The scoping report is available in **appendix A**.

5.3.3 Summary of Major Scoping Issues

The top five recurring themes account for 52 percent of the comments and are briefly described below:

5.3.3.1 Use Sediment Diversions for Wetland Restoration

Of the 379 occurrences, 13.5 percent suggested that sediment diversions are needed for restoration of the marshes and wetlands. Comments specifically mention the Biloxi Marsh and the Central Wetlands. Sediment from the Mississippi River was suggested as a source by several attendees, (e.g., *"Mississippi River sediment should be routed to marsh restoration."*) One commenter asked why more marshes are not planned, such as in the White Ditch area. The subject matter expert explained that there are limited areas suitable for borrowing marsh material.

Several comments indicated that sediment, and not just freshwater, must be moved and managed. (e.g., *"Ensure that the diversion projects actually moved sediment and not just freshwater and that the sediment is managed so it doesn't all go to one place, but it goes to where it needs to go to restore the marshes."* and *"Must capture the bottom water instead of just the effluent."*)

The use of spillways was mentioned as being necessary to build the marshland (e.g., "*Spillways only way to re-build Marsh along with sediment,"* and "*Spillways build marshland."*). One individual suggested to "*Pump material into the wetlands using huge hopper dredges such as the WB Fairway (59,000 m^3) to restore the wetlands."*

5.3.3.2 Restore the Ecosystem to Pre-Disturbance/Historical Condition

The next most dominant theme, which appeared in 11.3 percent of the comments, emphasized the need to restore the ecosystem to the state that existed prior to the MRGO. As stated by one person, "*Restoration goal should be to make area like before Corps built MRGO*." One commenter suggested, "*Use aerial documentation of pre-MRGO to establish baseline of restoration."* Comments of record received from American Rivers and the Department of the Interior - U.S. Fish and Wildlife Service (USFWS) reiterated the need to restore the ecosystem to pre-MRGO conditions.

Of the 43 comments regarding the ecosystem, 50 percent specifically mention cypress trees or forests. There was also concern about invasive plants caused by the ecosystem imbalance, such as water hyacinths and salvia.

5.3.3.3 Restoring the First Line of Hurricane Defense for Public Safety is a Priority

Prioritizing public safety by restoring the first line of hurricane defense appeared in 10.6 percent of the comments, almost as frequently as the top two occurring themes. As one comment indicated, "*public safety is priority #1*." Almost all of the comments reflected the opinion that the barrier islands were the first line of defense. The barrier islands were mentioned specifically seven times. Other lines of defense mentioned include marshes and wetlands, vegetation, reefs, and the total ecosystem. Comments indicated that levees were the third line of defense.

More specifically, from one of the breakout groups came the comment: *"Several times it was brought up that we need to address the first line of defense at the south end of the basin and in the Chandeleur Islands area. In that area they talk specifically about drop armoring, marsh creation."*

5.3.3.4 Focus on Restoring Flow of Water (Hydrology)

Hydrology appeared in 8.7 percent of the comments. This was sometimes stated succinctly, as in "*restore natural hydrology*," but more frequently appeared in combination with other themes, such as maintaining proper freshwater and salinity levels. One individual saw this as a priority: *"If I had to choose an issue, I would say get more freshwater back into the marshes – addressing saltwater intrusion should be the priority for the Corps."*

Suggestions included: *"slow down the water as it flows into the channel—mud should be dropped at the end of the MRGO;" "fill the canal that runs parallel to the channel with rock in order to truly solve the problem because the flow of water will be diverted into that canal when the channel is closed;"* and *"freshwater diversions should be pulsed so that the salinity of the water is not affected to a point where it's detrimental to the area."*

There were also some concerns, questions, and proposals for the use of treated wastewater for diversions.

5.3.3.5 Implement/Incorporate Existing Plans

Participants indicated in 7.9 percent of theme occurrences that they were anxious for existing plans to be implemented or incorporated. Typical of the comments grouped under this theme were, *"I believe we should be taking the plans that already exist, prioritizing our steps and putting the plan into action."*

Also included in this theme were comments indicating the need for a comprehensive approach, such as, "*a comprehensive systemic approach is needed, rather than the project-by project approach they are currently seeing.*"

Of the top five themes, this is the most negative in tone, since some of the comments indicated a level of frustration typified by statements such as, *"Studies have been done already, why not just refer to them?"*

5.3.4 Environmental Justice Public Outreach Efforts

An Environmental Justice (EJ) meeting was held at W. Smith Elementary School in St. Bernard Parish in the community of Violet on February 22, 2010, to present information about the diversion and to assess the concerns of residents and businesses in the local area. The meeting was videotaped and recorded by a court reporter. While many of the residents support marsh creation and restoration in the project area, many were opposed to the location of the proposed diversion location and suggested the USACE, Mississippi Valley Division, New Orleans District (CEMVN) utilize the existing canal/diversion in the area. Concern was raised about interior drainage and flooding issues as well as salinity levels and sediment placement. Further outreach efforts are being conducted to target the communities adjacent to the diversion to develop enhancement measures that would not interfere with community cohesion and further explain in detail how the diversion is designed, how it works, and its potential impacts.

5.3.5 Public Meeting

A public meeting was held at Holy Cross Church, in New Orleans, Louisiana on April 20, 2010, to study alternatives for a freshwater diversion proposed in the vicinity of Violet, Louisiana, and receive comments from the public. Approximately 70 people participated in the meeting. Concern was expressed for construction of the diversion structure in St. Bernard Parish and the potential for increased flooding. Participants questioned what additional alternative locations were considered and whether the CEMVN considered the old water plant at the historic battlefield to the north or measures to utilize the existing Violet Siphon. Concerns were also expressed regarding adverse impacts of freshwater on the recreation and commercial fisheries. Positive comments were expressed for the extensive restoration measures proposed, but participants wanted the study to move more quickly toward constructible features.

5.4 STAKEHOLDER FORUM

5.4.1 USACE Central Wetlands Forum

Over fifty participants attended an open public forum on Central Wetlands restoration projects and concepts at the New Orleans District Assembly Room on April 2, 2009. Attendees included non-governmental organizations, community members, local elected officials, academics, state and Federal agency representatives and USACE representatives. The purpose of the forum was to share information and identify data gaps; discuss the physical requirements for restoration; develop common restoration goals; discuss implementation alternatives; and determine what restoration measures should be evaluated as part of the MRGO Ecosystem Restoration Study. Presentations were made by the MRGO Ecosystem Restoration Study PDT, the New Orleans Sewerage and Water Board, LSU School of Landscape Architecture, and the Environmental Defense Fund.

5.4.2 USACE Recreation Forums

A recreation forum was held at the USACE New Orleans District on September 28, 2009, to gather information in order to estimate the impact of the various restoration measures on the recreational activities of the study area, including fishing, boating, hunting, park or refuge access and usage, area-wide recreational access and usage. Invitations were sent to NGOs, various public agencies and private citizens involved in recreation (charter boat operators, hunting and fishing clubs, boat ramp operators, marinas, etc.).

Several groups from the Lower 9th Ward in Orleans Parish expressed a desire to meet with USACE staff to share recreation studies discussing community needs and potential designs for the Bienvenue Triangle viewing platform. Two meetings were held with various groups; the first occurred on June 3, 2010 in the Lower 9th Ward and the second took place on June 10, 2010 at Tulane and Xavier’s Center for Bioenvironmental Research. Recreation designs and studies prepared by NGOs and university students were presented during the meetings. Discussions centered around recreation plans for Bienvenue Triangle prepared by the University of Colorado and results of a survey administered by the University of Wisconsin students at the platform, which gathered data on recreation use at the Triangle platform.

A meeting with local St. Bernard parish officials took place June 17, 2010 to present the USACE’s recreation feature design for Shell Beach. Comments and ideas shared by St. Bernard officials resulted in modifications to the proposed recreation plan. The Bienvenue Triangle and Shell Beach recreation features are presented in **section 2.5.3.2**.

5.4.3 USACE/Lake Pontchartrain Basin Foundation Ridge Restoration Workshop

In partnership with the Lake Pontchartrain Basin Foundation, the USACE co-sponsored a coastal ridge restoration workshop on October 26, 2009. The purpose of the interdisciplinary workshop was to advance the understanding of these coastal restoration features. Issues addressed included: identifying measurable benefits of these features; practical development of design goals; construction techniques; ridge vegetation; and the high probability of cultural resource issues. Ridge restoration opportunities for the MRGO Ecosystem Restoration Study were discussed at this workshop. Participants included members of the academic community, non-governmental organizations, engineers, planners, landscape architects, and other stakeholders.

5.4.4 St. Bernard Parish Central Wetlands Workshop

The St. Bernard Parish Government hosted a Central Wetlands Workshop on January 6, 2010. Members of the MRGO Ecosystem Restoration PDT participated in the workshop, as well as the District Commander, and Deputy District Engineer for Project Management. Restoration priorities were identified and alternative implementation strategies were discussed at this workshop.

5.5 U.S. FISH AND WILDLIFE COORDINATION

A scope of work and funding was provided to the USFWS, Lafayette Field office so that office could assist with the development of restoration alternatives, become an active participant in PDT and HET meetings, participate in site visits, and assist with habitat assessments. The USFWS provided a final Fish and Wildlife Coordination Act Report on March 13, 2012 to document existing and future conditions including impacts, as well as to present USFWS positions and recommendations and conservation measures.

5.6 DRAFT ENVIRONMENTAL IMPACT STATEMENT

The DEIS was made available for public review and comment. A Notice of Availability (NOA) was published in the *Federal Register* on December 17, 2010, to inform the public that the DEIS had been released. A notice of availability letter was mailed to the USACE New Orleans District stakeholder and NEPA mailing lists also on December 17, 2010. This notice provided a description of the proposed action including the project features, points of contact to obtain more information regarding the DEIS, and a means of commenting on the DEIS and companion MRGO Ecosystem Restoration Plan Feasibility Report. The DEIS was available for review by agencies, organization, and individuals for an extended 78-calendar day comment starting with the publication of the NOA in the *Federal Register* on December 17, 2010 through March 5, 2011.

5.6.1 DEIS Public Hearings

Three Public Hearings were scheduled on January 20, 2011, January 25, 2011 and February 3, 2011. Due to inclement weather, the February 3, 2011 meeting was rescheduled for February 8, 2011. Public meeting notices were published in advance of each meeting in local newspapers including *The Times-Picayune*, *The St. Bernard Voice*, and *The Sun Herald.*

The Public Hearings were scheduled as an opportunity for the public, resources agencies, and elected officials to participate in the NEPA planning process, to provide input regarding the proposed restoration features, and to provide comments on the DEIS and feasibility report. Information on the locations and participation at the Public Hearings is shown in **table 5-1.** The number of individuals that provided a verbal comment at each meeting is also presented. **Appendix Y**, Public Hearing Record and DEIS Comment Summary, provides additional details regarding the Public Hearings.

Table 5-1: MRGO DEIS Public Hearing Summary

Date	Location	Attendees	Speakers/Commenters
January 20, 2011	C.F. Rowley Alternative School; Chalmette, LA	261	19
January 25, 2011	Leo Seal Community Center; Waveland, MS	73	14
February 8, 2011	Light City Christian Academy; New Orleans, LA	104	22
Total		**438**	**55**

5.6.2 DEIS Public/Agency Comment and Response

Verbal comments received at each of the Public Hearings were made part of the Public Hearing transcript and were included within the comment database. During the comment period, over 31,400 individual commenters provided written comments (via email, letter, and fax) and/or verbal comments on one recurring subject matter alone – Support of Plan Elements. The large comment response was primarily attributed to approximately 31,270 individual commenters associated with 4 non-government organizations that submitted multiple form letters, with each set being identical in content. These form letters represented 99.5 percent of the comments received on the most common recurring comment theme. Individuals associated with one organization alone submitted 10,325 identical comments, representing 33 percent of the total comments received on this specific subject matter.

As comments were received, each was read and entered into a database. Names, organizations, addresses, and emails were all entered. Comments were initially identified under “major topics” and then by “recurring themes” to gain an understanding of key issues. Major topics included the diversion; sediment; additional plan features; and funding; just to name a few. Since each commenter generally commented on more than one issue, the comments were categorized among the 64 recurring themes or similar issues. All comments were reviewed to determine significance of each comment regardless of the recurrence of the comment.

Appendix Y presents summarizes the comments received during the comment period and the responses to comments for recurring comment themes.

5.6.3 Final Environmental Impact Statement

The FEIS has been updated to include refinements in the plan including further engineering associated with the restoration measures. Where applicable, comments received on the DEIS have been incorporated into the FEIS. The FEIS will be made available for public review and comment. A Notice of Availability (NOA) will be published in the *Federal Register* on June 22, 2012, to inform the public that the FEIS has been released. A 30 day wait period will follow the NOA to provide interested parties with an additional opportunity to review and comment upon the FEIS.

5.6.4 Record Of Decision

A Draft ROD is being released along with the final EIS and is subject to change upon receipt of comments on the final report.

CHAPTER 6: **ENVIRONMENTAL REQUIREMENTS**

This chapter documents the coordination and compliance efforts regarding statutory authorities including: environmental laws, regulations, executive orders, policies, rules, and guidance. Consistency of the tentatively selected plan with other Louisiana coastal restoration efforts is also described.

Relevant Federal statutory authorities and executive orders are listed in **table 6-1**. Relevant State of Louisiana statutory authorities are listed in **table 6-2**. Full compliance with statutory authorities would be accomplished upon agency review and concurrence of resource effects and consistency determinations, upon review of the Final Environmental Impact Statement by appropriate agencies and the public, and the signing of a Record of Decision (ROD).

6.1 CLEAN AIR ACT – AIR QUALITY DETERMINATION

Compliance with the Clean Air Act (42 U.S.C.A. §7401) has been coordinated with the Air Quality Section of the Louisiana Department of Environmental Quality (LDEQ). As required by *Louisiana Administrative Code*, Title 33 (LAC 33:III.1405 B), an air quality applicability determination has been developed for the tentatively selected plan. This includes consideration of the proposed action for the category of general conformity, in accordance with the Louisiana General Conformity, State Implementation Plan (LDEQ, 1994). An air quality determination has been calculated, based upon direct and indirect air emissions. Generally, since no other indirect Federal action, such as licensing or subsequent actions, would likely be required or related to the restoration construction actions, it is likely that indirect emissions, if they would occur, would be negligible. Therefore, the air quality applicability determination analysis was based upon direct emission for estimated construction hours. Considering that total emissions for each work item separately (or even when all work items are summed) would not exceed the threshold limit applicable to volatile organic compounds (VOCs) for parishes where the most stringent requirement (50 tons per year in serious non-attainment parishes) is in effect, (see General Conformity, State Implementation Plan, Section 1405 B.2), the VOC emissions for the proposed construction would be classified as *de minimus* and no further action would be required. LDEQ correspondence dated January 11, 2011 indicates that "Currently, St. Bernard Parish is classified as attainment with the National Ambient Air Quality Standards and has no general conformity determination obligations."

6.2 CLEAN WATER ACT – SECTION 401 WATER QUALITY

Under provisions of the Clean Water Act (33 U.S.C. § 1251) of 1972, any project that involves the placement of dredge or fill material in waters of the United States or wetlands, or mechanized clearing of wetlands would require water quality certification from the LDEQ, Office of Environmental Services. An application for water quality certification describing the impacts of the proposed action to water quality as described in **section 4.4**, along with a copy of the DEIS, has been provided to the LDEQ. LDEQ correspondence dated February 2, 2012 indicates "that the requirements for a Water Quality Certification (WQC) has been met… therefore, the Department hereby issues a WQC to the U.S. Army Corps of Engineers – New Orleans District."

Table 6-1: Relevant Federal Statutory Authorities and Executive Orders
(Note: This list is not complete or exhaustive)

Abandoned Shipwreck Act of 1987	Marine Mammal Protection Act of 1972
American Indian Religious Freedom Act of 1978	Marine Protected Areas (EO 13158) of 2000
Anadromous Fish Conservation Act of 1965	Marine Protection, Research, and Sanctuaries Act of 1972
Archaeological Resources Protection Act of 1979	Migratory Bird Conservation Act of 1929
Archaeological and Historical Preservation Act of 1974	Migratory Bird Treaty Act of 1918
Bald Eagle Protection Act of 1940	Migratory Bird Habitat Protection (EO 13186) of 2001
Clean Air Act of 1970	National Environmental Policy Act of 1969
Clean Water Act of 1977	National Historic Preservation Act of 1966
Coastal Barrier Improvement Act of 1990	National Invasive Species Act of 1996
Coastal Barrier Resources Act of 1982	Native American Graves Protection and Repatriation Act of 1990
Coastal Wetlands Planning, Protection, and Restoration Act of 1990	Neotropical Migratory Bird Conservation Act of 2000
Coastal Zone Management Act of 1972	Noise Control Act of 1972
Coastal Zone Protection Act of 1996	Nonindigenous Aquatic Nuisance Prevention and Control Act of 1996
Comprehensive Environmental Response, Compensation, and Liability Act of 1980	North American Wetlands Conservation Act of 1989
Consultation and Coordination with Indian Tribal Governments (EO 13175) of 2000	Oil Pollution Act of 1990
Deepwater Port Act of 1974	Outer Continental Shelf Lands Act of 1953
Emergency Planning and Community Right-to-Know Act of 1986	Pollution Prevention Act of 1990
Emergency Wetlands Restoration Act of 1986	Prime or Unique Farmlands, 1980 CEQ Memorandum
Endangered Species Act of 1973	Protection and Enhancement of the Cultural Environment (EO 11593) of 1971
Environmental Quality Improvement Act of 1970	Protection and Enhancement of Environmental Quality (EO 11991) of 1977
Estuaries and Clean Waters Act of 2000	Protection of Children from Environmental Health Risks and Safety Issues (EO 13045) of 1997
Estuary Protection Act of 1968	Protection of Cultural Property (EO 12555) of 1986
Estuary Restoration Act of 2000	Protection of Wetlands (EO 11990) of 1977
Exotic Organisms (EO 11987) of 1977	Reclamation Projects Authorization and Adjustments Act of 1992
Farmland Protection Policy Act of 1981	Recreational Fisheries (EO 12962) of 1995
Federal Actions to Address Environmental Justice in Minority Populations & Low-Income Populations (EO 12898, 12948) of 1994, as amended	Resource Conservation and Recovery Act of 1976
Federal Compliance with Pollution Control Standards (EO 12088) of 1978	Responsibilities of Federal Agencies to Protect Migratory Birds (EO 13186) of 2001
Federal Emergency Management (EO 12148) of 1979	Rivers and Harbors Acts of 1899, 1956
Federal Water Pollution Control Act of 1972	River and Harbor and Flood Control Act of 1970
Federal Water Project Recreation Act of 1965	Safe Drinking Water Act of 1974
Fish and Wildlife Conservation Act of 1980	Submerged Land Act of 1953
Fish and Wildlife Coordination Act of 1958	Sustainable Fisheries Act of 1996
Flood Control Act of 1944	Toxic Substances Control Act of 1976
Floodplain Management (EO 11988) of 1977	Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646)
Food Security Act of 1985	Water Resources Development Acts of 1976, 1986, 1990, 1992, and 2007
Greening of the Government Through Leadership in Environmental Management (EO 13148) of 2000	Water Resources Planning Act of 1965
Historic Sites Act of 1935	Watershed Protection & Flood Prevention Act of 1954
Historical and Archaeological Data-Preservation Act of 1974	Water Pollution Control Act Amendments of 1961
Indian Sacred Sites (EO 13007) of 1996	Wild and Scenic River Act of 1968
Invasive Species (EO 13112) of 1999	Wilderness Act of 1964
Land & Water Conservation Fund Act of 1965	
Magnuson-Stevens Fishery Conservation and Management Act of 1976, as amended	

Table 6-2: Relevant State Statutory Authorities
(Note: this list is not complete or exhaustive)

Air Control Act	Louisiana Threatened and Endangered Species and Rare & Unique Habitats
Archeological Treasury Act of 1974	Protection of Cypress Trees
Louisiana Coastal Resources Program	Water Control Act
Louisiana Natural and Scenic Rivers System Act	

6.3 CLEAN WATER ACT – SECTION 404(B)(1)

The United States Army Corps of Engineers (USACE) is responsible for administering regulations under Section 404(b)(1) of the Clean Water Act. Potential project-related impacts subject to these regulations, such as the discharge of dredged material into shallow open water areas to create wetlands and the placement of rock for shoreline protection, is evaluated in accordance and compliance with Section 404(b)(1) of the Clean Water Act (**appendix E**). The evaluation of potential impacts to water quality indicate that, on the basis of the guidelines, the proposed disposal sites for the discharge of dredged material and stone comply with the requirement of these guidelines, with the inclusion of appropriate and practicable best management practices to minimize adverse effects to the aquatic ecosystem.

6.4 COASTAL ZONE MANAGEMENT ACT OF 1972

Section 307 of the Coastal Zone Management Act of 1972 (16 U.S.C. 1456(c)(1)(A)) directs Federal agencies proposing activities or development projects (including civil work activities), whether within or outside the coastal zone, assure that those activities or projects are consistent, to the maximum extent practicable, with the approved state coastal zone management program. A Coastal Zone Consistency Determination is included in **appendix F** and was submitted to the Louisiana Department of Natural Resources (LDNR) for consistency review concurrent with the release of the DEIS for public comment. Implementation of the tentatively selected plan is considered consistent, to the maximum extent practicable, with the approved Louisiana State Coastal Management Program. LDNR correspondence dated February 8, 2011 indicates "The project, as proposed in the application, is consistent with the Louisiana Coastal Resources Program (LCRP)".

6.5 FARMLAND PROTECTION POLICY ACT

Congress passed the Farmland Protection Policy Act (FPPA) as a result of a substantial decrease in the amount of open farmland. The purpose of the Act is to minimize the extent to which Federal actions contribute to the unnecessary and irreversible conversion of farmland to nonagricultural uses. Approximately 442 acres of soils designated as prime and unique farmland would be impacted by the construction of the diversion canal (Alternative 1 location). The area is currently utilized as pasture. A Farmland

Conversion Impact Rating (FCIR) Form AD 1006 was prepared and submitted to the Department of Agriculture – Natural Resources Conservation Service (NRCS) for evaluation. Correspondence dated January 12, 2011 includes completion of Form AD 1006 by NRCS (**appendix R**).

6.6 FISH AND WILDLIFE COORDINATION ACT OF 1958

The USACE and the Department of the Interior - U.S. Fish and Wildlife Service (USFWS) have formally committed to work together to conserve, protect, and restore fish and wildlife resources while ensuring environmental sustainability of our Nation's water resources under the January 22, 2003, Partnership Agreement for Water Resources and Fish and Wildlife. Accordingly, in a letter dated October 31, 2008, the USFWS entered into an agreement to serve as a Cooperating Agency (per National Environmental Policy Act (NEPA) section 1501.6) in developing the EIS for the proposed project in accordance with applicable NEPA and Council on Environmental Quality (CEQ) guidance. Participation of the USFWS includes: 1) participating in meetings and field trips to obtain baseline information on project-area fish and wildlife resources; 2) evaluating the proposed project's impacts to wetlands and associated fish and wildlife resources, and assisting in the development of measures to avoid, minimize, and/or compensate for those impacts; and 3) providing technical assistance in the development of a biological assessment (BA) describing the impacts of the proposed activity to Federally listed threatened and endangered (T&E) species and/or their critical habitat. In the October 31, 2008, letter, the USFWS also provided specific guidance on avoiding impacts to West Indian manatees (*Trichechus manatus*); Brown pelicans (*Pelecanus occidentalis*); and endangered and threatened sea turtles. A final Fish and Wildlife Coordination Act Report (FWCAR) was provided by USFWS on March 13, 2012 (**appendix B**). Positions and recommendations by the USFWS, also referred to as the Service, are listed below in **section 6.6.1**.

6.6.1 Service Positions and Recommendations

The TSP will benefit the fish and wildlife resources of the MRGO Ecosystem Restoration area by providing freshwater, nutrients, and sediments, and restoring ridge, swamp and marsh habitats in the study area thus facilitating increasing organic production, increasing biological productivity, increasing habitat diversity, and reducing wetland loss. Approximately 37,980 AAHUs and 31,930 net acres of fresh/intermediate, brackish, and saline marsh, swamp and ridge habitats would benefit by the proposed project at the end of the period of analysis given an intermediate sea level rise scenario. The Service supports implementation of the TSP and respectfully request the following fish and wildlife recommendations be implemented concurrently with project construction:

1. Regarding the barrier island component of the MRGO Ecosystem Restoration; the Service recommends, with support from NMFS and LDWF, the selection of a barrier island component be a part of the TSP. The Service feels the design and evaluation of the barrier island alternatives was sufficient to warrant selection,

though further engineering would be required prior to construction. Breton Island is a National Wildlife Refuge, managed by the Service and is of National importance. Recent scientific investigations (Lavoie, D, ed., 2009; Thomson et al., 2009) demonstrate the long-term impacts to this important refuge as a result of the MRGO channel. Therefore, the Service recommends amelioration of the areal loss of Breton Island due to the construction and maintenance of the MRGO channel should be appropriately addressed in the TSP. The Corps should contact the Service regarding a compatibility determination, Wilderness Act provisions and special use permits that may be necessary to conduct activities on Breton NWR. The Corps is encouraged to establish and continue coordination with the Service until construction of any project feature is complete and prior to any subsequent maintenance. Points of contacts for the Service are: Kenneth Litzenberger, Project Leader for the Service's Southeast National Wildlife Refuges and Neil Lalonde (985) 882-2000, Refuge Manager for the Breton Island NWR.

USACE Response. The USACE recognizes the importance of the barrier island chain and the need for restoration; however, we believe that additional study is warranted before a sustainable restoration plan can be recommended for construction. Given the uncertainties of conditions at this time due to the oil spill and recovery efforts, USACE would seek additional authority for further study before recommending a viable restoration plan. The Corps will continue to coordinate with the Service throughout the study process.

2. A reevaluation of benefits should be conducted for features during future phases of this project as uncertainties (e.g., implementation schedule, O&M, etc.) are resolved. Further detailed benefits analysis should be coordinated with the State and federal natural resource agencies

   USACE Response. Concur. Benefits would be reevaluated during future phases of the project. USACE will continue to coordinate with the state and federal resource agencies.

3. The Corps should contact the Service regarding a compatibility determination, and special use permits that may be necessary to conduct activities on Bayou Sauvage NWR. The Corps should establish and continue coordination with the Service until construction of any project feature is complete and prior to any subsequent maintenance. Points of contacts for the Service are: Kenneth Litzenberger, Project Leader for the Service's Southeast National Wildlife Refuges and Neil Lalonde (985) 882-2000, Refuge Manager for the Breton Island NWR.

   USACE Response. The Corps will continue to coordinate with the Service throughout the study process.

4. The final recommendations for the MRGO Ecosystem Restoration Plan include additional analysis, design and implementation of the Violet, Louisiana Freshwater Diversion as authorized by WRDA 2007 Section 3083. This means the Violet, Louisiana Freshwater Diversion will be funded and constructed under a different authorization than the authorization for the MRGO Ecosystem Restoration Plan. The Service recommends any additional study, design, and implementation include the Service and other resource agency involvement. In addition if the diversion location or other aspects of the diversion change significantly from what was analyzed in the MRGO Ecosystem Restoration Plan, the Service recommends the Sediment and Nutrient Diversion model (SAND2) and Wetland Value Assessment benefits analysis be revised to reflect the changes.

   USACE Response. Concur. The Service and other resource agencies would be included in any additional study, design and implementation of the Diversion.

5. The Service recommends the operational plans for the Violet Diversion be evaluated to include more flexibility of flow (flows between 1000cfs and 7000cfs) to achieve optimal habitat conditions favorable to nearby intermediate marsh and to bald cypress germination, growth, and reproduction by controlling depth and duration of inundation and salinity levels. As the operational plan for the Violet Diversion is further developed, future hydrological and fisheries (i.e., CASM) modeling, and updated habitat assessments (i.e., Wetland Value Assessments) should be conducted.

   USACE Response. The USACE plans to adaptively manage the freshwater flows from the diversion to promote a sustainable swamp habitat and fresh/intermediate marsh in the Central Wetlands. Additional hydrologic modeling and aquatic modeling would be conducted during additional studies of the diversion. The diversion would be operated in coordination with other diversions planned in the watershed to achieve the goals and objectives of the study.

6. The Service recommends, with support from NMFS and LDWF, the diversion operational plan be developed in a way to avoid or minimize adverse impacts to marine fisheries and Essential Fish Habitat (EFH) while maximizing freshwater and nutrient input to the extent practicable to meet habitat objectives.

   USACE Response. Concur.

7. The Service and LDWF recommend salinity meters be placed in appropriate locations to assist in determining when target salinities are met.

   USACE Response. Seven hourly recorders will be deployed to measure salinity, temperature, water level and turbidity at three sites located along the MRGO / Lake Borgne Landbridge, three sites in the Biloxi Marsh, and one site located in the western Mississippi Sound.

8. The Service recommends the diversion be adaptively managed to enhance surrounding wetlands, that habitat switching (as a result of re-introduced river water) is allowed to occur in a manner that is not detrimental or destructive to the ecological processes, and that the diversion allows for draw down periods sufficient for cypress regeneration and cypress growth.

   USACE Response. The diversion would be adaptively managed to achieve the study goals and objectives and minimize adverse effects to the extent practicable.

9. The Service recommends, with support from LDWF, a comprehensive examination of the river and all existing and proposed diversions to coordinate their operation and ensure that their operation will maximize their restoration capabilities. The ongoing Mississippi River Hydrodynamic and Delta Management Study could be utilized to address this issue.

   USACE Response. USACE supports the need for a comprehensive plan to coordinate the water needs of the basin. The Mississippi River Hydrodynamic and Delta Management Study is anticipated to address those needs with full participation by natural resource agencies.

10. The Service recommends, with support from NMFS and LDWF, establishment of a committee similar to review the operation and monitoring and adaptive management results of the Violet diversion and when necessary, provide recommendations regarding any future operational and maintenance changes. The Service and other natural resource agencies are amenable to participate on this committee.

    USACE Response. Concur. An adaptive management planning team, including members from other natural resource agencies would be established for recommending project and program adaptive management actions.

11. The large quantity of borrow material proposed to be taken from Lake Borgne, which is designated Gulf sturgeon critical habitat, for the TSP may have an adverse effect to fisheries, EFH, and the threatened Gulf sturgeon by: 1) alteration in water bottom substrate habitat: 2) direct removal of benthos from a large area which may (at least temporarily) reduce food availability for fishery organisms; 3) other sessile resources, such as oysters could be affected; and 4) by continually moving the dredge, the resuspended sediments will take longer to settle and could prolong the periods of high turbidity associated with dredging operations. The Service recommends, with support from NMFS and LDWF, careful consideration be given to the affects of taking all borrow, including monitoring for benthos and water quality, from Lake Borgne and consideration should be give to obtaining borrow from other "outside" sources, such as the Mississippi River, and adjacent bays, and offshore areas. Over the period of analysis, search for borrow from outside sources should continue as alternative sources may become economically feasible or as new advances in technology become available.

USACE Response. Concur. Additional analyses on borrow areas has been conducted and the borrow plan modified, in coordination with NMFS, to minimize adverse impacts to fisheries, EFH, and the threatened Gulf sturgeon including additional borrow sources. The corps will continue to consider sources outside of Lake Borgne throughout the study process.

12. The NMFS is responsible for consultations regarding impacts to the Gulf sturgeon and its critical habitat for the MRGO Ecosystem Restoration project. Therefore, please contact Dr. Stephania Bolden (727/824-5312) in St. Petersburg, Florida, for information concerning that species and its critical habitat. Should the proposed project directly or indirectly affect the Gulf sturgeon or its critical habitat in Louisiana, further consultation with that office will be necessary.

    USACE Response. The NMFS has been a member of the habitat evaluation team throughout the planning process. The Corps will continue to coordinate with both NMFS offices.

13. The Service, with support from NMFS and LDWF, recommends the Lake Borgne borrow plan should initially specify monitoring three different depths of borrow sites for a minimum of two-years post dredging and prior to continued excavation. The Service recommends monitoring of water quality parameters are included in the MAMP in order to assess if anoxic or hypoxic conditions occur. If anoxia is a problem at 10 feet below the existing sediment surface with a +/- 5 foot tolerance, then the borrow sites will have to be dug shallower and other borrow source options explored to minimize impacts to estuarine water bottoms and EFH. The Service, NMFS, and LDWF recommend a summary of the Monitoring and Adaptive Management Plan for borrow be included in the Feasibility Study or Environmental Impact Statement. The Service, NMFS, and LDWF also recommend that all borrow sites be at least 1,000 feet from the shoreline to help avoid increasing shoreline erosion via increased wave height.

    USACE Response. All borrow sites would be excavated at a minimum of 3,000 feet from the Lake Borgne shoreline. Three test sites would be dredged and monitored to determine the maximum depth of future borrow pits. If anoxia is a problem at 15 feet below water surface, then the borrow sites would be dug shallower and other borrow source options would be explored. This is part of the adaptive management plan. A brief summary of this test pit monitoring plan is included in the borrow section of the EIS.

14. The proposed borrow areas in Lake Borgne do include private leases as well as public oyster seed grounds. LDWF manages the public seed grounds and should be consulted before final borrow locations are determined.

    USACE Response. Concur. Borrow sites would be excavated at a minimum of 3,000 feet from the Lake Borgne shoreline. LDWF is an active member of the habitat evaluation team.

15. The Service recommends that all shoreline protection features include one fish dip every 1,000 feet (ft) constructed to a 25 ft bottom width to the pre-project elevation. On a case by case basis the 1,000 ft distance can be adjusted, in consultation with NMFS, to incorporate existing water exchange points.

    USACE Response. Concur. During the detail design phase for each feature, USACE would closely coordinate with USFWS and NMFS before implementation of these measures.

16. The Service and NMFS recommends the retention dikes constructed for swamp and marsh creation and nourishment areas be gapped and degraded within three years of use if they have not naturally degraded on their own. Please coordinate gapping and degrading efforts with the Service and NMFS.

    USACE Response. Concur. The dike features would be mechanically breached or degraded within three years of construction, if natural degradation has not sufficiently removed the earthen material.

17. The Service and LDWF recommend a buffer of at least 500 feet be placed around existing hard bottom and oyster leases to minimize impacts to those resources.

    USACE Response. Non-concur. Designated borrow areas are estimated larger than needed for each feature to ensure that adequate material is available in the event that environmental or cultural resources are discovered during construction that require avoidance. Hard bottom areas would be avoided because they are considered preferred habitat for the Gulf sturgeon. Borrow sites would be located a minimum of 3,000 feet from the Lake Borgne shoreline to avoid existing oyster leases to the maximum extent practicable. However, in the southern lobe proposed borrow sites do overlap existing oyster leases and these oyster leases would be impacted by dredging acitivity.

18. The Monitoring and Adaptive Management Plan, as it is further developed, should be provided to the Service, NMFS, and LDWF for continued review, comment, and input.

    USACE Response. Concur.

19. If a proposed project feature is changed significantly or is not implemented within one year of the Endangered Species Act consultation letter, we recommend that the Corps reinitiate coordination with the Service and NMFS to ensure that the proposed project would not adversely affect any Federally listed threatened or endangered species or their critical habitat.

    USACE Response. Concur.

20. The proposed Violet Freshwater Diversion structure off the Mississippi River has the potential to entrain pallid sturgeon, that effect should be addressed in the diversions future planning studies. Should the proposed project directly or indirectly affect the pallid sturgeon or its habitat, further consultation with this office will be necessary.

    USACE Response. Concur. The Corps would coordinate with the Service during the future planning studies of the diversion.

21. Avoid adverse impacts to nesting bald eagles, gulls, terns, and/or black skimmers, wading birds, and brown pelicans through the careful design of project features and timing of construction. A qualified biologist should inspect the proposed work area for the presence of undocumented nesting colonies and bald eagles during the nesting season (i.e., September 15 through March 31 for brown pelican, September 1 through February 15 for wading bird nesting colonies, September 16 through April 1 for colonies containing nesting gulls, terns, and/or black skimmers, and October through mid-May for bald eagles).

    - To minimize disturbance to colonies containing nesting wading birds (i.e., herons, egrets, night-herons, ibis, and roseate spoonbills), anhingas, and/or cormorants, all activity occurring within 1,000 feet of a rookery should be restricted to the non-nesting period (i.e., September 1 through February 15, exact dates may vary within this window depending on species present).
    - For colonies containing nesting brown pelicans, all activity occurring within 2,000 feet of a rookery should be restricted to the non-nesting period (i.e., September 15 through March 31). Nesting periods vary considerably among Louisiana's brown pelican colonies so it is possible that this activity window could be altered based upon the dynamics of the individual colony.
    - For colonies containing nesting gulls, terns, and/or black skimmers, all activity occurring within 650 feet of a rookery should be restricted to the non-nesting period (i.e., September 16 through April 1, exact dates may vary within this window depending on species present).
    - If a bald eagle nest is discovered within or adjacent to the proposed project area, then an evaluation must be performed to determine whether the project is likely to disturb nesting bald eagles. That evaluation may be conducted on-line at: http://www.fws.gov/southeast/es/baldeagle. Following completion of the evaluation, that website will provide a determination of whether additional consultation is necessary and those results should be forwarded to this office.

    USACE Response. Concur.

22. Land clearing associated with project features should be conducted during the fall or winter to minimize impacts to nesting migratory birds, when practicable.

    USACE Response. The USACE will, to the extent practicable, implement land clearing activities during the fall and winter. When this is not feasible, the USACE would coordinate with the USFWS and conducted surveys for nesting colonies and bald eagles prior to initiating work activities.

23. Further detailed planning of project features (e.g., Design Documentation Report, Engineering Documentation Report, Plans and Specifications, or other similar documents) should be coordinated with the Service and other State and Federal natural resource agencies, and shall be provided an opportunity to review and submit recommendations on all work addressed in those reports.

    USACE Response. Concur

24. A report documenting the status of implementation, maintenance, and adaptive management measures should be prepared every three years by the managing agency and provided to the Corps, the Service, NMFS, U.S. Environmental Protection Agency (EPA), Louisiana Department of Natural Resources (LDNR), Office of Coastal Protection and Restoration (OCPR), and LDWF. That report should also describe future management activities, and identify any proposed changes to the existing management plan.

    USACE Response. Concur. The adaptive management team would be the responsible party for preparation of this report.

25. The Service recommends minimizing impacts to marsh from marsh buggy activities. Options to achieve that minimization include limiting the repetitive use of a route or to build temporary boardwalks over marsh where feasible and then backfilling the boardwalk area if needed. In areas with large marsh creation features that have minimal access routes, such as the inner Terre Aux Bouef marsh features, the Service recommends that work begin at the farthest location and proceed to the outer edges of the site to minimize the amount of damage.

    USACE Response. Concur. USACE plans to utilize boardwalks over existing marsh to reduce marsh impacts and backfill impacted marsh when the boardwalks are removed. USACE would restore the farthest location of Bayou Terre aux Boeufs and work to the outer edges to minimize adverse impacts to existing and newly restored marsh. Marsh buggies would be required to avoid repetitive use of the same tracts to reduce marsh impacts. Any impacts to existing marsh would be backfilled to the extent practicable.

26. The Service recommends the CASM model should be updated to incorporate conditions from the oil spill in the adaptive management plan. This model should also use the corrected assumptions.

    USACE Response. Funding and time constraints limit the ability to re-run any models at this stage. An update of the CASM model could potentially take place during PED phase.

27. Due to the significant acreage of marsh that will be accessed for swamp and marsh creation/nourishment, the Service request the Corps quantify the estimated acreage of flotation and construction access canal impacts to shallow open water habitat.

    USACE Response. Concur. Additional analyses on flotation access and construction access will be conducted during the detailed planning, engineering and design phase following approval of the recommended plan.

6.7 ENDANGERED SPECIES ACT OF 1973

Compliance with the Endangered Species Act (7 U.S.C. 136; 16 U.S.C. 460 *et seq*.) is being coordinated with the USFWS and the National Oceanic and Atmospheric Administration (NOAA) for those species under their respective jurisdictions. A final BA will be included with the public release of the FEIS in **appendix G**. The USACE has provided a copy of the BA to the USFWS and NOAA and has requested the initiation of formal consultation with the USFWS on potential impacts to the endangered pallid sturgeon (*Scaphirhynchus albus)*, and requested the initiation of formal consultation with NOAA on potential impacts to the threatened Gulf sturgeon (*(Acipenser oxyrhynchus desotoi)* and its critical habitat.

The Lake Pontchartrain, Lake Borgne and Mississippi Sound are designated as critical habitat for the Gulf sturgeon and the Chandeleur Barrier Island Chain is designated as critical habitat for the piping plover. Reference **section 4.19** and the final BA located in **appendix G** for additional information on the pallid sturgeon, Gulf sturgeon and piping plover as well as critical habitat constituents. The effects determination for the pallid sturgeon and piping plover and its critical habitat is not likely to adversely affect the continued existence of the species. The effects determination for the Gulf sturgeon and its critical habitat may affect, but is not likely to adversely affect the continued existence of the species. Preliminary aquatic modeling for the Gulf sturgeon and restoration measures and benefits analysis for the barrier islands have been completed and results are discussed in **section 4.19**.

The use of recommended primary activity exclusion zones and timing restrictions would be utilized, to the maximum extent practicable, to avoid project construction impacts to any T&E species or their critical habitat within the project area. The USACE would continue to closely coordinate and consult with the USFWS and the NMFS regarding T&E species under their jurisdiction that may be potentially impacted by implementing the proposed action.

In a letter from the USFWS dated February 8, 2012, the agency agreed with the USACE determination that implementation of the proposed MRGO Ecosystem Restoration Project is not likely to adversely affect the endangered West Indian manatee and the threatened piping plover, or its critical habitat.

In a Biological Opinion (BO) from the NMFS dated May 3, 2012, the agency stated that the action, as proposed, may affect, but is not likely to adversely affect sea turtles and Gulf sturgeon. It is also the NMFS opinion that the project is likely to adversely affect Gulf sturgeon critical habitat, but is not likely to destroy or adversely modify it.

NMFS included two conservation recommendations in their BO, which they believe could work to minimize or avoid effects from the proposed action on the Gulf sturgeon. The USACE has stated that the recommendations would be implemented as part of the project. The conservation recommendations include: 1) Gather data describing recovery rates of Gulf sturgeon prey species in response to re-colonization of muddy-sand substrate that would assist in future assessments of impacts to Gulf sturgeon prey items; and 2) Gather data describing Gulf sturgeon movements within the Lower Pontchartrain Sub-basin.

In order for NMFS to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, NMFS would be notified of the implementation of any conservation recommendations or the other updates as the project is implemented.

6.8 LOUISIANA STATE RARE, THREATENED AND ENDANGERED SPECIES, AND NATURAL COMMUNITIES COORDINATION

The USACE reviewed the database maintained by the Louisiana Natural Heritage Program that provides the most recent listing and locations for rare, T&E species of plants and animals and natural communities within the State of Louisiana. The proposed action would not adversely impact any rare, T&E species, or unique natural communities. The proposed action would increase the extent of fresh, intermediate, brackish and saline marsh as well as swamp habitat and ridge habitat in the project area (see also **section 4.11**).

6.9 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT OF 1996 AND THE MAGNUSON-STEVENS ACT REAUTHORIZATION OF 2006 (ESSENTIAL FISH HABITAT)

As directed by the Magnuson-Stevens Fishery Conservation and Management Act (Public Law 104-297), the USACE has coordinated with the NMFS and that agency's experts on various marine organisms, as well as EFH. The NMFS provided a letter dated October 27, 2008, to help guide the development of the DEIS for the proposed action (**appendix C**). The NMFS identified shrimp, red drum, reef fish, and stone crabs as species managed by the Gulf of Mexico Fishery Management Council that have EFH in the project area. They also listed estuarine emergent wetlands, mud, sand and shell substrates, and estuarine and marine water column as primary categories of EFH in the project area. The analysis of potential impacts of the tentatively selected plan on EFH is described in **section 4.18**. Consultation with NMFS has been completed. NMFS provided a letter on the DEIS dated February 11, 2011 with EFH recommendations. The USACE responded March 3, 2012 accepting the NMFS recommendations (see **section 6.9.1**). The NMFS submitted a final letter on March 28, 2012 stating that all EFH conservation recommendations have been satisfactorily addressed and a further consultation under the Magnuson-Stevens Act was <u>not</u> necessary. EFH conservation recommendations are listed below in **section 6.9.1**.

6.9.1 NOAA/NMFS

1. To avoid and minimize impacts to EFH and associated marine fisheries resources, specific details and documents for each restoration feature of the tentatively selected plan (TSP) shall be provided to NMFS for evaluation, discussion, review and comment during the preliminary engineering and design (PED) stage.

   USACE Response: Concur. Detailed documents will be provided to NMFS during the PED stage.

2. The borrow pits in Lake Borgne initially shall be limited to no deeper than 15 feet below the water surface (i.e., total water depth) unless monitoring and adaptive management, or modeling of the hydrology of the borrow pits clearly indicate deeper pits would have little impact on water quality.

   USACE Response: Concur. USACE in coordination with NMFS has developed a borrow plan and Monitoring and Adaptive Management Plan (MAMP) to minimize impacts to water quality. This includes three test pits to determine the depth at which water quality might be affected.

3. The MAMP shall be revised to include monitoring of benthic communities and dissolved oxygen (DO) levels within borrow areas in Lake Borgne. Water quality monitoring shall be conducted at least during April through October for a minimum of three years post-dredging to verify the relative success of the borrow pit design in avoiding impacts to water quality. Specific conductance, temperature, DO, and pH shall be sampled from the bottom to the surface in five-foot profiles. Samples shall be collected at least one time during April, September, and October. Samples shall be collected twice, about two weeks apart, during May, June, July, and August. Benthos should be sampled annually pre- and post-construction to evaluate changes in community structure. This information shall be used to adaptively manage borrow site design to minimize adverse impacts, if any.

   USACE Response: Both pre- and post-construction monitoring will be utilized to determine project success. Nutrient sampling will be designed in coordination with Louisiana Department of Environmental Quality, if needed as to not contribute to low dissolved oxygen (DO) conditions. Hourly salinity, temperature, water level, and turbidity monitoring will be initiated in PED and maintained throughout construction and 10 years post-construction at seven locations within the project area. Gulf sturgeon have been found to feed primarily on species associated with sandy, polyhaline habitats which are absent from Lake Borgne. Nearby boring data indicates that the sediment stratification within Lake Borgne is fairly uniform. Fat clay interspersed with small bands of lean clay, silty sand and pear are the predominant sediments occurring in the project area, based on this data. Once borings are completed for the borrow pits, if sediment composition does not conform to the before mentioned assumption of uniformity, then consultation with the resource agencies would be re-initiated to document impacts to sediment composition and the benthic assemblage.

4. The retention dikes constructed for marsh creation and nourishment areas shall be gapped and degraded within three years of used in a manner acceptable to NMFS.

   USACE Response: Concur. The dike features would be mechanically breached or degraded within three years of construction, if natural degradations have not sufficiently removed the earthen material.

5. Shoreline protection features in the TSP shall include 25-foot wide gaps down to pre-project depth elevations for fisheries ingress and egress every 1,000 linear feet, unless otherwise refined in coordination with NMFS during PED. Scour aprons may be incorporated so as not to decrease the pre-project water depth, or offset sections of rock in front of or behind foreshore rock dikes may be included to minimize erosion in the vicinity of gaps.

   USACE Response: Concur. During the detail design phase for each feature, USACE would closely coordinate with USFWS and NMFS before implementation of these measures.

6.10 MIGRATORY BIRD TREATY ACT AND MIGRATORY BIRD CONSERVATION ACT

No migratory birds would be adversely affected by project activities. The project is in compliance with the Migratory Bird Conservation Act, 16 U.S.C. 715-715d, 715e, 715f-715r; 45 Stat. 1222 and the Migratory Bird Treaties and other international agreements listed in the Endangered Species Act of 1973, as amended, Section 2(a)(4). A final FWCAR was completed on March 13, 2012 and is included in **section 6.6.1**.

6.11 NATIONAL HISTORIC PRESERVATION ACT OF 1966

In compliance with Section 106 of the National Historic Preservation Act of 1966, as amended and 36 CFR 800, Federal agencies are required to identify and consider potential effects that their undertakings might have on significant historic properties, district, site, building, structure, or object that is included in or eligible for inclusion in the National Register. Additionally, a Federal agency shall consult with any tribe that attaches religious and cultural significance to such properties. Agencies shall afford the State Historic Preservation Officer (SHPO) and tribes a reasonable opportunity to comment before decisions are made. National Register eligible sites would be avoided to the maximum extent possible and any potential adverse effects would be mitigated. A variety of mitigation measures are possible, ranging from avoidance to data recovery to other types of documentation. Mitigation can take place at the site directly affected or can be concentrated at any one site. Decisions on mitigation strategies would be made under a Memorandum of Agreement among the USACE, the Louisiana SHPO, and any consulting Indian groups. Sites unevaluated for National Register eligibility would either have to be avoided or further research would be carried out in order to determine National Register eligibility.

Cultural surveys are currently underway for terrestrial sites and for shoreline protection. The borrow sites identified for use in the first five years of implementation are in the process of being surveyed. Additional cultural resource surveys are anticipated, but may not be complete prior to finalizing this NEPA document; therefore, a programmatic agreement is required. A Programmatic Agreement for the treatment of cultural resources was prepared and was provided to SHPO and the Advisory Council on Historic Preservation (ACHP) for comment. Letters of interest were also sent to all Federally recognized tribes with interest within the New Orleans District (**appendix D**). Two tribes, the Jena Band of Choctaw and the Chitimacha Tribe of Louisiana, expressed interest in being consulting parties to the Programmatic Agreement. A Programmatic Agreement was finalized and signed by the SHPO, ACHP, the Jena Band of Choctaw and the Chitimacha Tribe of Louisiana on a path forward in identifying and preserving cultural resources that may occur in or be affected by the project.

6.12 RESOURCE CONSERVATON AND RECOVERY ACT (RCRA) AS AMENDED BY THE HAZARDOUS AND SOLID WASTE AMENDMENTS (HSWA) OF 1984

A Phase I Environmental Site Assessment ESA was performed as part of this project and complies with the requirements of RCRA and HSWA. The ESA that was completed on February 1, 2010 can be found in **appendix Q**.

6.13 EXECUTIVE ORDER 11988, FLOOD PLAIN MANAGEMENT

This Executive Order (EO) instructs Federal agencies to avoid development in floodplains to the maximum extent feasible. The current project is not a "development," but rather a floodplain restoration action. This project is being developed in compliance with EO 12898. The proposed Violet, Louisiana Freshwater Diversion (Alternative 1 location) would be coordinated with the St. Bernard Parish Floodplain Administrator for a final determination upon further study of the freshwater diversion.

6.14 EXECUTIVE ORDER 11514, PROTECTION OF ENVIRONMENT

EO 11514, Protection and Enhancement of Environmental Quality, directs Federal agencies to "*initiate measures needed to direct their policies, plans and programs so as to meet national environmental goals.*" This project complies with EO 11514.

6.15 EXECUTIVE ORDER 11990, PROTECTION OF WETLANDS

EO 11990, Protection of Wetlands, works to avoid to the extenet possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative. The overall goals of this project include the restoration and nourishment of approximately 59,363 acres of habitat in the study area, including 13,790 acres of fresh and intermediate marsh; 34,460 acres of brackish marsh; 10,431 acres of cypress swamp; 723 acres of saline marsh. This project complies with the goals of EO 11990.

6.16 EXECUTIVE ORDER 13186, MIGRATORY BIRD HABITAT PROTECTION

Section 3a and e of EO 13186 directs Federal agencies to evaluate the effects of their actions on migratory birds, with emphasis on species of concern, and inform the USFWS of potential negative effects to migratory birds. Implementation of the tentatively selected plan is not anticipated to have a measurable negative effect on migratory bird populations and in fact, would benefit migratory bird population as a whole by restoring valuable wetlands, swamp barrier island and ridge habitat.

6.17 EXECUTIVE ORDER 12898, ENVIRONMENTAL JUSTICE

Title VI, Section 601 of the Civil Rights Act of 1964 (Public Law 88-352) states:

"No person in the United States shall, on the grounds of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance." On February 11, 1994, President Clinton issued EO 12898 regarding Federal actions to address environmental justice (EJ) issues in minority populations and low-income populations:

> *"To the greatest extent practicable and permitted by law, and consistent with the principles set forth in the report on the National Performance Review, each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions, the District of Columbia, the Commonwealth of Puerto Rico, and the Commonwealth of the Mariana Islands."*

EJ is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. EO 12898 focuses Federal attention on the environmental and human health conditions in the minority and low-income communities, enhances the provisions of nondiscrimination in Federal programs affecting human health and the environment, and promotes meaningful opportunities to the access of public information and participation in matters relating to minority and low-income communities and their environment. The EO is directed internally to all Federal departments and Federal agency heads to take the appropriate steps to identify and address any disproportionately high and adverse human health or environmental effects of Federal programs, policies, and activities on minority and low-income populations.

Potential EJ issues have been considered throughout the entire study process, and will continue to be considered through project implementation. As part of the NEPA process, a scoping input request was provided to the public and interested parties. Four scoping comments were received and did not identify any potential EJ issues. The USACE is committed to ensuring that any potential EJ issues are addressed as the study proceeds. As project specifications were developed, one area of concern was identified in the Violet area where a proposed diversion would be located. While the proposed wetland creation and nourishment and shoreline protection measures would equally impact all potential users (e.g., commercial and recreational fishers) in the area, the Violet, Louisiana Freshwater Diversion (Alternative 1 location) is located between two subdivisions that are classified as minority and/or low-income.

6.18 EXECUTIVE ORDER 13112, INVASIVE SPECIES

On February 3, 1999, President Clinton issued EO 13112 establishing the National Invasive Species Council to prevent the introduction of invasive species, provide for their control, and to minimize the economic, ecological, and human health impacts resulting from invasive species. The tentatively selected plan is consistent with EO 13112. Only native plant species would be utilized in the implementation of the tentatively selected plan. Implementation of the tentatively selected plan would adhere to programs and authorities preventing the introduction or spread of invasive species in the study area.

6.19 WILD AND SCENIC RIVER ACT OF 1968

The Louisiana Scenic Rivers Act of 1988 was established to recognize and implement the Federal law of 1968, to preserve, protect, and enhance the wilderness qualities, scenic beauties, and ecological regimes of rivers and streams in the state. In accordance with LDWF policy concerning the protection of those water bodies classified as scenic, any construction within 100 feet of a scenic stream requires a scenic streams permit. A scenic streams permit is being completed as part of this FEIS and coordination with the LDWF Scenic Streams Coordinator is ongoing to minimize and prevent impacts to those scenic streams potentially affected by the project. In those areas where the construction limits are more than 100 feet from the scenic stream, the implementation of best management practices (BMPs) would be required to prevent sediment runoff during construction. These BMPs would include, but are not limited to, the use of stacked hay bales or silt fences, mulching and reseeding, use of buffer zones, and the collection and treatment of storm water runoff prior to discharge into a scenic stream, where appropriate. A final Scenic River Use Permit would be complete and submited to the LDWF in May 2012 as part of the FEIS. Further coordination would be deferred pending additional review of the Violet Diversion and final engineering on those restoration features noted as impacting a scenic stream.

6.20 MARINE MAMMAL PROTECTION ACT OF 1972

According to NOAA website http://nmfs.noaa.gov/pr/laws/mmpa/ the Marine Mammal Protection Act (MMPA) was enacted in October 21, 1972 and amended in 1994. All marine mammals are protected under the MMPA.

The MMPA was enacted in response to increasing concerns among scientists and the public that significant declines in some species of marine mammals were caused by human activities. The Act established a national policy to prevent marine mammal species and population stocks from declining beyond the point where they ceased to be significant functioning elements of the ecosystems of which they are a part.

The MMPA prohibits, with certain exceptions, the "take" of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the U.S.

The following commitments have been made to ensure compliance with the MMPA and ESA:

1. Ensure construction contractors are educated on the MMPA and the ESA and the species of concern.

2. Conduct a search for coastal bottlenose dolphins, sea turtles, and Gulf sturgeon within marsh creation/restoration sites. Appropriate best management practices (BMPs) would be implemented to avoid or minimize potential entrapment of these protected species. These BMPs are included in detail in the contract and include the following:

    - Observe the area to be enclosed for protected species at least 24 hours prior to and during closure of any levee, dike or structure. This is best accomplished by small vessel or aerial surveys with at least two experienced marine observers on board scanning for protected species.
    - If any protected species are sighted within the area to be enclosed, all appropriate precautions shall be implemented by the Contractor to ensure protection of the animal. These precautions shall include avoiding direct contact with and not feeding the protected species.
    - Any sightings of protected species within an enclosed project site shall be reported immediately to the USACE.
    - If observers' note the animals are not leaving the area, but are visually disturbed, stressed or their health is compromised, then the USACE may require any pumping activity to cease until the animals either leave on their own or are moved under the direction of NMFS. NMFS would then conduct any necessary measures (detailed in the contract) to ensure protection of the species.

CHAPTER 7: **CONCLUSIONS AND RECOMMENDATIONS**

7.1 AREAS OF CONTROVERSY AND UNRESOLVED ISSUES

Construction and operation of the MRGO (former Mississippi River Gulf Outlet Navigation Channel), in synergistic combination with other natural and man-made factors, has caused direct, indirect and cumulative land loss, shoreline erosion, saltwater intrusion, habitat modification, and impacts to wildlife and fisheries resources throughout the project area. Determining the extent to which the MRGO contributed to these impacts and what, if any, actions would be necessary to remediate any such impacts remains a controversial issue.

7.1.1 Proposed Violet, Louisiana Freshwater Diversion

The Violet, Louisiana Freshwater Diversion is an important component of the plan to restore historic salinity conditions and provide freshwater and nutrients to nourish existing and restored wetlands in the study area. However, additional study is needed to improve decisions about where, when, and how to divert Mississippi River flows in a systems context. The ongoing Mississippi River Hydrodynamic and Delta Management Study will evaluate ecosystem restoration alternatives in concert with dynamic flood risk management and navigation; multipurpose management scenarios of the river; and dynamic conditions in a comprehensive systems context. The information gained from this study will improve decision-making related to the Violet, Louisiana Freshwater Diversion. Therefore, the final recommendations for the MRGO Ecosystem Restoration Plan include additional analysis, design and implementation of the Violet, Louisiana Freshwater Diversion as authorized by WRDA 2007 Section 3083.

The location of the proposed Violet, Louisiana Freshwater Diversion (Alternative 1 location) would be constructed in an open field that is located between two subdivisions that are predominately minority and/or low-income populations. Construction operations such as noise, dust, and traffic diversions would temporarily impact residents located in the immediate project vicinity as well as others that work or live in the surrounding area. A recreation feature that includes multi-use paths, open space, picnic tables and shelters is proposed adjacent to the Violet, Louisiana Freshwater Diversion to enhance the quality of life for residents of Violet (see **section 2.5.3.2**)

<u>St. Bernard Resident Concerns</u>

A meeting was held at W. Smith Elementary School in Violet on February 22, 2010 to present information about the freshwater diversion and to assess the concerns of residents and businesses (see **section 5.3.4**). While many of the residents that attended the meeting indicated support for marsh creation and restoration within the project area, many were opposed to the location of the proposed diversion and suggested that the USACE should utilize the existing canal/diversion in the area. Concern was raised about interior drainage and flooding issues as well as salinity levels and sediment placement.

A public meeting was held at Holy Cross Church in New Orleans on April 20, 2010 to further present information regarding the freshwater diversion and to receive comments from the public (see **section 5.3.5**). Meeting attendees expressed concern for construction of the diversion structure and the potential for increased flooding. Participants questioned what additional alternative locations were considered and whether the USACE considered the old water plant at the historic battlefield to the north or measures to utilize the existing Violet Siphon. Concerns were also expressed regarding adverse impacts of freshwater on recreation and commercial fisheries. Positive comments were expressed for the extensive restoration measures proposed.

St. Bernard Parish Government Position on the Proposed Violet, Louisiana Freshwater Diversion

On May 4, 2010, the St Bernard Parish Council – the governing authority for the parish, formally adopted Resolution SBPC #637-05-10 stating that the St. Bernard Parish Government, in conjunction with the St. Bernard Parish Coastal Zone Advisory Committee, is “adamantly opposed to the proposed freshwater diversion project.” The Resolution (partial) further states the following:

- “the existing Violet Canal can be, and should be retro-fitted to deliver the freshwater that the 2007 Water Resources Development Act (WRDA) mandates;”
- “The St. Bernard Parish Coastal Zone Advisory Committee is fully supportive of the restoration of the Central Wetlands area of St. Bernard Parish, but unanimously opposes another canal being dug to deliver the freshwater that can be delivered by using the existing conveyance and delivery canal.”

These concerns were reiterated by St. Bernard Parish President Craig Taffaro, Jr. at the July 20, 2011 Public Hearing.

USACE Response

The USACE recognizes the concerns that have been brought forth by the St. Bernard Parish Council as well as residents of the parish and is committed to resolving these issues.

7.1.2 Deepwater Horizon Oil Spill

The long-term impacts of the Deepwater Horizon oil spill on coastal Louisiana are uncertain at this time (May 2012). The impacts of the oil spill as well as the various emergency actions taken to address oil spill impacts could potentially impact USACE water resources projects and studies within the Louisiana coastal area, including the MRGO Ecosystem Restoration project. Potential impacts could include factors such as changes to existing, future-without, and future-with-project conditions, as well as increased project costs and implementation delays. The USACE will continue to monitor and closely coordinate with other Federal and state resource agencies and local sponsors in determining how to best address any potential problems associated with the oil spill that may adversely impact project implementation. Supplemental planning and environmental documentation may be required as information becomes available.

7.2 CONCLUSIONS

The tentatively selected plan (alternative C) would restore approximately 57,472 acres of habitat in the study area, including 14,123 acres of fresh and intermediate marsh; 32,511 acres of brackish marsh; 10,318 acres of cypress swamp; 466 acres of saline marsh; and 54 acres of ridge habitat. Alternative C includes approximately 71 miles of shoreline protection and adaptively managed freshwater diversion near Violet, Louisiana.

Approximately 10,221 acres of the restoration and protection features would be located in the East Orleans Landbridge/Pearl River area and approximately 9,861 acres of restoration features would be located in the Biloxi Marsh area, which have been determined to be critical landscape features with respect to storm surge. Additionally, the cypress swamp and ridge restoration feature would include forested habitat demonstrated as having some storm surge damage risk reduction benefits.

The Violet, Louisiana Freshwater Diversion is an important component of the plan to restore historic salinity conditions and provide freshwater and nutrients to nourish existing and restored wetlands in the study area. However, additional study is needed to improve decisions about where, when, and how to divert Mississippi River flows in a systems context. The ongoing Mississippi River Hydrodynamic and Delta Management Study will evaluate ecosystem restoration alternatives in concert with dynamic flood risk management and navigation; multipurpose management scenarios of the river; and dynamic conditions in a comprehensive systems context. The information gained from this study will improve decision-making related to the Violet, Louisiana Freshwater Diversion. Therefore, the final recommendations for the MRGO Ecosystem Restoration Plan include additional analysis, design and implementation of the Violet, Louisiana Freshwater Diversion as authorized by WRDA 2007 Section 3083..

The anticipated outputs of the tentatively selected plan would help address the current trend of degradation of the Lake Borgne ecosystem, support Nationally significant resources, provide a sustainable and diverse array of fish and wildlife habitats, provide infrastructure protection, and make progress towards a more sustainable ecosystem.

Before the ecosystem restoration plan can be implemented, a non-Federal sponsor would need to be identified and a cost sharing agreement executed. The States of Louisiana and Mississippi have been identified as potential non-Federal sponsors. The non-Federal share will be 35 percent of the costs of implementing the ecosystem restoration plan, except for the Violet, Louisiana Freshwater Diversion for which the non-Federal share is 25 percent. The non-Federal sponsor is responsible for providing all lands, easements, rights-of-way, utility or public facility relocations, and dredged or excavated material disposal areas and performance of all relocations required for the project (LERRDs), and 100 percent of the costs of operation, maintenance, repair, rehabilitation, and replacement (OMRR&R). The value of LERRDs will be credited toward the non-Federal cost share.

In accordance with WRDA 2007 Section 3083, implementation of the Violet, Louisiana Freshwater Diversion would be cost shared 75 percent Federal, 25 percent non-Federal, with the States of Louisiana and Mississippi providing the non-Federal cost share. The provision of LERRDs and the costs of OMRR&R are a non-Federal responsibility.

The States of Louisiana and Mississippi have expressed support for the tentatively selected plan. The State of Mississippi has issued a letter of intent to USACE expressing its understanding of and willingness to provide its required cost share for the Violet, Louisiana Freshwater Diversion, although the letter of intent notes the state's belief that the USACE should pursue full federal funding for the project.

The State of Louisiana disagrees with USACE over the cost-share requirements for plan implementation and has expressed its unwillingness to participate in plan implementation unless it is undertaken at full (100%) federal cost. The USACE will continue to coordinate with the States of Louisiana and Mississippi to finalize the ecosystem restoration plan and to identify a non-Federal sponsor to cost share in plan implementation.

7.3 RECOMMENDATIONS

The District Commander has considered all the significant aspects of this study including the environmental, social, and economic effects, the engineering feasibility, and the comments received from other resource agencies, the non-Federal sponsors, and the public and has determined that the tentatively selected plan presented in this report is in the overall public interest and a justified expenditure of Federal funds. As a comprehensive approach to protect, stabilize, and augment the landbridge between Lake Borgne and the MRGO, the District Commander recommends the construction of rock dikes for shoreline protection along the south bank of Lake Borgne in the reaches referenced as Bayou Bienvenue, Bayou Dupre, and West of Shell Beach. The District Commander also recommends the construction of marsh creation projects in the Golden Triangle, Central Wetlands, Terre aux Bouefs, Hopedale, Pearl River, and Shell Beach areas.

Recommendations are divided into tiers by the level of uncertainty regarding conditions for ecological success and long-term sustainability including the need for additional study.

- Tier 1 includes features that have been developed to a feasibility level of detail and are not dependent on a freshwater diversion. Tier 1 features are recommended for construction through the WRDA 2007 Section 7013 authority upon the identification of a non-Federal sponsor.

- Tier 2 includes features with feasibility level detail that aren't dependent upon salinity conditions but may be sustainable without the implementation of a freshwater diversion. If future conditions and further analysis indicate that favorable conditions for ecological success and long term sustainability exist (as defined in the adaptive management plan), then these projects may be constructed. Tier 2 features would be constructed through the WRDA 2007 Section 7013 authority upon the identification of a non-Federal sponsor.

- Tier 3A includes further study of the violet, Louisiana Freshwater diversion under the WRDA 2007 Section 3083 authority. The non-Federal cost-share responsibilities for the Violet, Louisiana Freshwater Diversion would be consistent with the 75 percent/25 percent Federal/non-Federal cost-share identified in Section 3083 if WRDA 2007, together with such other items of cost-share responsibilities as may be identified in the Feasibility Report for the project, as approved by the decision of the Chief of Engineers.

- Tier 3B includes any features that are dependent on freshwater diversion, and features in Tier 2 that future conditions and further analyses indicate are not sustainable. Subsequent to the completion of Tier 3A, Tier 3B features would be constructed through the WRDA 2007 Section 7013 authority upon the identification of a non-Federal sponsor.

Table 2-28 provides the TSP feature descriptions by tier and Figure 2-24 depicts the TSP timetableRecommendations are .

CHAPTER 8: **DISTRIBUTION LIST AND OTHER**

8.1 DISTRIBUTION LIST

Preparation of this FEIS was coordinated and distributed to appropriate Congressional, Federal, state and local interests, as well as environmental groups and other interested parties. The following agencies, as well as other interested parties would receive copies of this revised FEIS. The complete distribution lists are provided in **appendix K**.

- U.S. Department of the Interior, Fish and Wildlife Service
- U.S. Environmental Protection Agency, Region VI
- U.S. Department of Commerce, National Oceanic and Atmospheric Administration Fisheries, National Marine Fisheries Service
- U.S. Natural Resources Conservation Service, State Conservationist
- Advisory Council on Historic Preservation
- Governor's Executive Assistant for Coastal Activities
- Louisiana Department of Wildlife and Fisheries
- Louisiana Department of Natural Resources, Coastal Management Division
- Louisiana Department of Natural Resources, Coastal Restoration Division
- Louisiana Department of Environmental Quality, PER-REGC
- Louisiana Department of Environmental Quality, EP-SIP
- Louisiana State Historic Preservation Officer

8.2 LIST OF PREPARERS

Many individuals were involved with the completion of this document. Listed below are those staff members who played a role in the development of the MRGO Ecosystem Restoration Plan DEIS and FEIS.

Name	Job Description/Experience/ Education/Registration	Subject Matter
USACE, MVN		
Behrens, Elizabeth	Environmental Manager/Biologist, Ecological Planning and Restoration Section/16 years/B.S. Wildlife Management – Louisiana State University	Biological Assessments
Brandstetter, Charles	Lead Structural Engineer/13 years/B.S. and M.S. Civil Engineering – University of New Orleans/P.E.	Structural Engineer
Britsch, Del	Geologist/27 years/Ph.D./Registered P.G.	Geology, Sediment Sources, Subsidence, Land Loss
Broussard, Darrel	Project Manager/20 years/B.S. Physics, MBA	Sr. Project Manager
Broussard, Richard	Lead Civil Engineer/Technical Manager (MVN)/ 33 years/ BSCE, University of New Orleans/ EI in LA	Dredging for navigation, flood control, coastal restoration and foreshore protection
Boyce, Mayely	Assistant District Council (MVN)/4 years/J.D/M.E.M. - Duke University	Legal Review

Name	Job Description/Experience/ Education/Registration	Subject Matter
Chaisson, Kathryn	Geotechnical Engineer/3 years/B.S. Geological Engineering	Geotechnical Design
Darville, Jennifer	Technical Editor and Writer/MVN 10 years/M.A. English - University of New Orleans	Technical Writer/Editor/Document Administration
Deloach, Pamela	Project Engineer/26 years/B.S. Civil Engineering – University of Alabama	Project Engineering
DeMarcay, Gary	Archaeologist (MVN)/24 years/MA Anthropology - Texas A&M University	Cultural Resources
Feldmeier, Paula	Assistant District Counsel (MVN)/8 years/J.D. - Mercer University; L.L.M. in Environmental Law – University of Denver	Legal Review
Gilmore, Tammy	Environmental Resources Specialist, Regional Planning and Environmental Division, South New Orleans Environmental Branch/3 years/B.S. Biology – Southeastern Louisiana University	Environmental Manager
Glisch, Eric	Environmental Engineer, Hydraulics and Hydrologic Branch/4 years/E.I.T., B.S. in Civil and Environmental Engineering – University of Wisconsin	Section 404 Permit and Coastal Zone Consistency
McCaffrey, Kelly	Landscape Architect (MVN)/9 years/B.L.A. Landscape Architecture – Mississippi State University	Aesthetics/Visual Resources
Miller, Gregory	Senior Planner (MVN)/22 years/B.S. Marine Science and International Business - University of Alabama, M.A. Marine Affairs - University of Rhode Island	Plan Formulation, Project Management, and Public Involvement
Napolitano, Matthew	Regional Economist, Regional Planning and Environmental Division, South New Orleans Economic Branch/17 years/B.A. Economics – University of Pennsylvania, M.B.A. – Tulane University	Socioeconomic and Human Environment
Parker, Thomas	Environmental Resource Specialist (MVN)/2 years/B.A. Biology, University of Colorado at Denver	Endangered Species and Biological Assessment
Perez, Andrew	Outdoor Recreation Planner/11 years/M.U.R.P. – University of North Carolina	Recreation Specialist
Petitbon, John	Civil/Cost Engineer/23 years/BSCE Louisiana State University, E.I.T.	Cost Engineer
Richardson, Jerica	Archaeologist (MVN)/13 years/B.A., Anthropology, Mississippi State University	Environmental Justice
Stiles, Sandra	Chief, Ecological Planning and Restoration Section/ MVD RTS Environmental Compliance/26 years/B.S. Animal Science at Oklahoma State University	Environmental Manager/Biologist
Taylor, Ron	Hydraulics Engineer (MVN)/9 years/B.S. Civil Engineering, University of New Orleans/P.E.-LA	Functional Team Leader Engineering, Hydraulic Engineering
Whalen, Daniel	Regional Economist/B.S. Economics University of New Orleans/ MBA University of New Orleans.	Socioeconomics Impacts
URS		
Boers, Aaron	Environmental Scientist (URS)/5 years/B.S. Environmental Science – University of Wisconsin, Ph.D. Botany – University of Wisconsin	Section 404 Permit, Coastal Zone Consistency and Scenic Streams Permit
Chaisson, Angela	Senior Project Manager/Senior NEPA Specialist (URS)/ 26 years/B.S., Wildlife Resources - West Virginia University/Certified Wildlife Biologist, The Wildlife Society	Independent Technical Review of EIS Sections

Name	Job Description/Experience/ Education/Registration	Subject Matter
Conner, J.V.	Senior Ecologist (URS)/45 years/Ph.D. - Tulane University	Wildlife, Noise
Esmail, Muna	Senior Environmental Engineer (URS)/11 years/B.S. Civil Engineering - Tulane University	Air Quality
Goh, Yong	Sr. Project Scientist/Environmental Specialist/27 years/Ph.D. - Soil Chemistry, Morphology and Classification, MS – Agronomy, Soil Science, Experimental Statistics, BS – Agronomy, Soil Science – Louisiana State University	Soils
Kunza, Amy	Environmental Scientist (URS)/5 years/B.S. Botany – University of Georgia, M.S. Biology – University of Houston	Section 404 Permit, Coastal Zone Consistency and Scenic Streams Permit
LeBlanc, Jim	Sr. Environmental Scientist/31 years/B.S. Marine Science - Nicholls State University	Coastal Vegetation Resources; Plankton Resources
Magiera, Doree	Senior Project Manager (URS)/28 years/B.S. Civil Engineering - Texas A&M University	Project Management
Marler, Bradley	Senior Project Scientist/22 years/M.S. Wildlife Ecology/Fisheries Management – Mississippi State University	Barrier Islands, URS Independent Technical Review
Martinez, Jonathan	Environmental Planner (URS)/9 years/B.S. Forestry and Ecosystem Management – Louisiana State University	Environmental Lead/Water Quality and Scenic Streams
Muller, Brandon	Wildlife Biologist (URS)/6 years/B.S. Wildlife and Fisheries Management – Louisiana State University	Aquatic/Fisheries Resources, Commercial Fisheries, Oyster Resources, Water Bottoms and Benthic Resources, and Essential Fish Habitat
Pollock, Jeff	Environmental Scientist (URS)/4 years/B.S. Ecology – University of Georgia, Ph.D. Aquatic Ecology – University of Alabama	Section 404 Permit, Coastal Zone Consistency and Scenic Streams Permit
Qualls, Ying	Environmental Scientist/20 years/B.A. City & Regional Planning/University of Louisiana Lafayette	Barrier Reef Resources
Reidenauer, Jeffrey	Senior Project Manager/Senior NEPA Specialist (URS)/24 years/Ph.D. and M.S., Biological Oceanography, Florida State University, B.S., Marine Biology, Fairleigh Dickenson University/Certified Senior Ecologist, Ecological Society of America/Professional Wetland Scientist, Society of Wetland Scientists	Independent Technical Review of EIS Sections
Atkins		
Carson, Josh	Environmental Scientist (Atkins)/4 years/ B.S. in Biology, Baldwin-Wallace College	Project Manager
Lanford, Caroline	Lead Planner/11 years/M.U.R.P University of New Orleans/American Institute of Certified Planners (AICP)	Plan Formulation, Project Manager Support
Spalding, Elizabeth	Senior Staff Scientist II (Atkins)/11 years' experience in Louisiana coastal ecosystem assessment and restoration/M.S. Biology–University of New Orleans and B.S. degrees in Biology and Business – Indiana University	Estuarine Ecology: Flora and Fauna
Winer, Harley	Coastal/Hydraulic/Civil Engineer (Atkins)/21 years/Ph.D. University of Florida/P.E.- LA, MS, AL, FL	Hydraulic Engineering

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8.4 GLOSSARY

Adaptive Management An interdisciplinary approach acknowledging an insufficient information base for decision-making; that uncertainty and change in managed resources are inevitable; and that new uncertainties will emerge. An iterative approach that includes monitoring and involves scientists, engineers and others who provide information and recommendations that are incorporated into management actions; results are then followed with further research, recommendations, and management actions.

Air Quality Determination The Louisiana Department of Environmental Quality ensures that projects do not adversely affect air quality through this determination as a requirement of the Clean Air Act.

Alternative Plan Combinations of management measures that collectively meet study goals and objectives within the defined study constraints.

Amplitude The maximum absolute value of a periodically varying quantity.

Anadromous Ascending rivers from the sea for breeding.

Anoxia Absence of oxygen.

Anthropogenic Caused by human activity.

Average Annual Habitat Unit (AAHU) Represents a numerical combination of habitat quality and quantity (acres) existing at any given point in time. The habitat units resulting from the future without- and future with-project scenarios are annualized and averaged over the period of analysis, to determine AAHUs.

Benefits Valuation of positive performance measures.

Benthic Living on or in sea, lake, or stream bottoms.

Biomass	The total mass of living matter (plant and animal) within a given unit of environmental area.
Bottomland Hardwood Forest	Low-lying forested wetlands found along streams and rivers.
Brackish Marsh	Intertidal plant community typically found in the area of the estuary where salinity ranges between 4-15 ppt.
Clean Water Act Section 404 (b) (1)	There are several sections of this Act which pertain to regulating impacts to wetlands. The discharge of dredged or fill material into waters of the United States is subject to permitting specified under Title IV (Permits and Licenses) of this Act and specifically under Section 404 (Discharges of Dredge or Fill Material) of the Act.
Coastal Zone Consistency Determination	The U.S. Environmental Protection Agency reviews plans for activities in the coastal zone to ensure they are consistent with Federally approved State Coastal Management Programs under Section 307(c)(3)(B) of the Coastal Zone Management Act.
Congressional Authorization	Authorization for investigation to prepare necessary feasibility-level report to be recommended for authorization of potential future project construction by Congress.
Connectivity	Property of ecosystems that allows for exchange of resources and organisms throughout the broader ecosystem.
Constraint	A limitation or restriction on plans. Planning constraints may not be absolute restrictions, but rather something to minimize or avoid.
Control Structure	A gate, lock, or weir that controls the flow of water.
Cumulative Impacts	The combined effect of all direct and indirect impacts to a resource over time.
Decomposition	Breakdown or decay of organic materials.
Degradation Phase	The phase of the deltaic cycle when sediments are no longer delivered to a delta, and it experiences erosion, dieback, or breakup of marshes.

Deltaic Cycle	The repeating pattern of delta development, progression, and abandonment. As sediments are deposited at the mouth of the distributary channels, the delta progresses seaward. The main channel then switches to a new course with a shorter reach to the depositional basin. Abandoned delta lobes decrease in elevation due to continued subsidence and sediment compaction, resulting in retreat of the shoreline. Abandoned lobes may be partially or wholly covered by new lobes during later deltaic cycles.
Deltaic Deposits	Mud and sand deposited at the mouth of a river.
Deltaic Plain	The land formed and reworked as the Mississippi River switched channels in the eastern part of the Louisiana coastal area.
Detritus	The remains of plant material that has been destroyed or broken up.
Dewatering	The process of dredged sediments compacting while losing water after being deposited.
Discharge	The volume of fluid passing a point per unit of time, commonly expressed in cubic feet per second (cfs), millions of gallons per day (mgpd), or gallons per minute (gpm).
Dissolved Oxygen	Oxygen dissolved in water, available for respiration by aquatic organisms. One of the most important indicators of the condition of a water body.
Direct Impacts	Those effects that result from the initial construction of a measure (e.g., marsh destroyed during the dredging of a canal). Contrast with “Indirect Impacts.”
Diurnal	Relating to or occurring in a 24-hour period; daily.
Diversion	A turning aside or alteration of the natural course or flow of water. In coastal restoration this usually consists of such actions as channeling water through a canal, pipe, or conduit to introduce water and water-borne resources into a receiving area.
Dredged Material Embankments (Side-cast Banks, Excavated Material Banks)	Dredged material removed from canals and piled in a linear mound along the edge of canals.

Dynamic	Characterized by continuous change and activity.
Ecological	Refers to the relationship between living things and their environment.
Ecosystem	An organic community of plants and animals viewed within its physical environment (habitat); the ecosystem results from the interaction between soil, climate, vegetation, and animal life.
Ecosystem Restoration	Activities that seek to return an organic community of plants and animals and their habitat to a previously existing or improved natural condition or function.
Effectiveness	Having an intended or expected effect. One of the USACE four requirements for a project.
Efficiency	The quality of exhibiting a high ratio of output to input. One of the USACE four requirements for a project.
Egress	A path or opening for going out; an exit.
Embankment	A linear mound of earth or stone existing or built to hold back water or to support a roadway.
Encroachment	Entering gradually into an area not previously occupied, such as a plant species distribution changing in response to environmental factors such as salinity.
Endangered Species	Animals and plants that are threatened with extinction.
Enhance	To augment or increase/heighten the existing state of an area.
Environmental Impact Statement (EIS)	A document that describes the positive and negative environmental effects of a tentatively selected plan and the possible alternatives to that action. The EIS is used by the Federal government and addresses social issues as well as environmental ones.
Estuary	A semi-enclosed body of water with freshwater input and a connection to the sea where freshwater and saltwater mix.
Estuarine	Related to an estuary.

Eustatic Sea Level Rise Change in global average sea level brought about by an increase in the volume of the world ocean [Intergovernmental Panel of Climate Change (IPCC) 2007b]. See also Relative Sea Level Rise.

Evaporation The process by which any substance is converted from a liquid state into, and carried off in, vapor; as, the evaporation of water.

Exotic Species Animal and plant species not native to the area; usually undesirable (e.g., hyacinth, nutria, tallow tree, giant salvinia).

Feasibility Report A description of a tentatively selected plan, previously outlined in a general fashion in a Reconnaissance Report, that will satisfy the Federal interest and address the problems and needs identified for an area. It must include an assessment of impacts to the environment (either in an Environmental Assessment, or the more robust Environmental Impact Statement), an analysis of alternative methods of completion, and the selection of a Tentatively Selected Plan through the use of a cost-effectiveness analysis.

Feature A constructible increment of an alternative plan.

Final Array The final grouping of the most effective coast-wide plans from which a final recommendation can be made.

Foreshore Dikes An embankment of earth and rock built to prevent floods or erosion that is built in the area of a shore that lies between the average high tide mark and the average low tide mark.

Fresh Marsh Intertidal herbaceous plant community typically found in that area of the estuary with salinity ranging from 0 ppt to 3 ppt.

Furbearer An animal whose skin is covered with fur (mammal), especially fur that is commercially valuable, such as muskrat, nutria, and mink.

Geomorphic Related to the geological surface configuration.

Gradient A slope; a series of progressively increasing or decreasing differences in a system or organism.

Habitat The place where an organism lives; part of physical environment in which a plant or animal lives.

Habitat Loss The disappearance of places where target groups of organisms live. In coastal restoration, usually refers to the conversion of marsh or swamp to open water.

Habitat Units (HUs) Represent a numerical combination of quality (HSI) and quantity (acres) existing at any given point in time. The HUs resulting from the future without- and future with-project scenarios are annualized and averaged over the period of analysis, to determine AAHUs. The "benefit" of a project can be quantified by comparing AAHUs between the future without- and future with-project scenarios. The difference in AAHUs between the two scenarios represents the net benefit attributable to the project in terms of habitat quantity and quality.

Hazardous, Toxic, and Radioactive Wastes (HTRW) Wastes that contain toxic constituents, or that may cause hazardous chemical reactions, including explosive or flammable materials, or radioactive wastes, which, improperly managed, may present a hazard to human health or the environment.

Herbaceous A plant with no persistent woody stem above ground.

Hydrodynamic The continuous change or movement of water.

Hydrology The pattern of water movement on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

Hypoxia The condition of low dissolved oxygen concentrations.

Indirect Impacts Those effects that are not as a direct result of project construction, but occur as secondary impacts due to changes in the environment brought about by the construction. Contrast with "Direct Impacts."

Infrastructure The basic facilities, services, and installations needed for the functioning of a community or society, such as transportation and communications systems, water and power lines, and public institutions including schools, post offices, and prisons.

Ingress An entrance or the act of entering.

Inorganic Not derived from living organisms; mineral; matter other than plant or animal.

Interdistributary Deposits Sand and mud deposited between the river channels or between bayous.

Intermediate Marsh Intertidal herbaceous plant community typically found in that area of the estuary with salinity ranging from 2 ppt to 5 ppt.

Intertidal Alternately flooded and exposed by tides.

Invertebrates Animals without backbones, including shrimp, crabs, oysters, and worms.

IWR-PLAN A decision support software program that assists with plan formulation by combining user-defined solutions to planning problems and calculating the effects of each combination, or "plan." The program can assist with plan comparison by conducting cost effectiveness and incremental cost analyses, identifying the plans which are best financial investments, and displaying the effects of each on a range of decision variables.

Larvae The stage in some animals' life cycles between egg and adult (most invertebrates).

Leeward Sheltered from the wind; away from the wind.

Levee A linear mound of earth or stone built to prevent a river from overflowing; a long, broad, low ridge built by a stream on its flood plain along one or both banks of its channel in time of flood.

Maintain To keep in existing state.

Marsh Creation A type of management measure that creates marsh in open water and nourishes the surrounding existing marsh. Marsh creation will include vegetative plantings. See also Marsh Nourishment.

Marsh Nourishment A type of management measure that nourishes existing marsh and decreases the depth of nearby open water.

Methodology A set of practices, procedures, and rules.

Mineral Substrate Soil composed predominately of mineral rather than organic materials; less than 20 percent organic material.

Mudflats Flat, unvegetated wetlands subject to periodic flooding and minor wave action.

National Ecosystem Restoration (NER) USACE standard for cost-effectiveness based on ecosystem, not economic, benefits.

Natural Features	This term from the Congressional language is interpreted to mean those features that serve a primarily ecosystem restoration purpose rather than features that primarily serve another purpose such as levees or floodwalls.
Near-shore Currents	Movement of water parallel to the shoreline. Usually generated by waves breaking on the shore at an angle other than perpendicular.
National Environmental Policy Act (NEPA)	Ensures that Federal agencies consider the environmental impacts of their actions and decisions. NEPA requires all Federal agencies to consider the values of environmental preservation for all significant actions and prescribes procedural measures to ensure that those values are fully respected.
Net Gain	The amount of cumulative land gain less land loss, when gain is greater than loss.
Net Loss	The amount of cumulative land gain less land loss, when gain is less than loss.
No Action Alternative	The alternative in the DEIS which describes the ecosystem of the coastal area if no restoration efforts/projects were done.
Nursery	A place for larval or juvenile animals to live, eat, and grow.
Objectives	More specific statements than "Goals," describing how to achieve the desired targets.
Organic	Composed of or derived from living things.
Oscillations	Fluctuations back and forth, or up and down.
Oxidation of Organic Matter	The decomposition (rotting, breaking down) of plant material through exposure to oxygen.
Oxygen-depleted	Situation of low oxygen concentrations where living organisms are stressed.
Period of Analysis	The time horizon for which project benefits, deferred construction costs, and operation, maintenance, repair, rehabilitation, and replacement costs are analyzed. For this study, the period of analysis is from 2015 to 2065.

Planning Scale	Planning term that reflects the degree to which environmental processes would be restored or reestablished, and the resulting ecosystem and landscape changes that would be expected over the next 50 years. This uppermost scale is referred to as "Increase." No net loss of ecosystem function is "Maintain." Reducing the projected rate of loss of function is "Reduce." The lowest possible scale was no further action above and beyond existing projects and programs.
Potable Water	Water that is fit to drink.
ppt	Parts per thousand. The salinity of ocean water is approximately 35 ppt.
Prime Farmland	Land that has the best combination of physical and chemical characteristics for producing food, feed, fiber, forage, oilseed, and other agricultural crops with minimum inputs of fuel, fertilizer, pesticides, and labor, and without intolerable soil erosion. One of the categories of concern in the DEIS.
Productivity	Growth of plants and animals.
Progradation	The phase during the deltaic cycle where land is being actively accreted through deposition of river sediments near the mouth.
Programmatic Environmental Impact Statement (PEIS)	An Environmental Impact Statement that supports a broad authorization for action, contingent on more specific detailing of impacts from specific measures.
Province	A major division of the coastal area of Louisiana. (e.g., Deltaic Plain and Chenier Plain).
Pulsing	Letting a diversion flow periodically at a high rate for a short time, rather than continuously.
Quantitative	Able to assign a specific number; susceptible to measurement.
Rebuild	To some extent, build back a structure/landform that had once existed.
Reconnaissance Report	A document prepared as part of a major authorization that examines a problem or need and determines if sufficient methods and Federal interest exists to address the problem/need. If so, then a "Feasibility Report" is prepared, which details the solution and its impacts further.

Reduce or prevent damage from storm surge	This phrase from the Congressional language is interpreted as "hurricane and storm damage risk reduction" as used in LACPR. This interpretation is consistent with LACPR, e.g. we cannot prevent, we can only reduce risk; and hurricane and storm damage risk results from factors in addition to storm surge including, but not limited to, waves.
Rehabilitate	To focus on historical or pre-existing ecosystems as models or references while emphasizing the reparation of ecosystem processes, productivity, and service.
Relative Sea Level Rise	Sea level rise measured by a tide gauge with respect to the land upon which it is situated. Relative sea level rise occurs where there is a local change in the level of the ocean relative to the land, which might be due to ocean rise and/or land level subsidence.
Restore	Return a wetland to an approximation of its condition or function prior to disturbance by modifying conditions responsible for the loss or change; reestablish the function and structure of that ecosystem.
Risk	A measure of the probability and severity of undesirable consequences (including, but not limited to, loss of life, threat to public safety, environmental and economic damages).
Saline Marsh	Intertidal herbaceous plant community typically found in that area of the estuary with salinity ranging from 12-32 ppt.
Salinity	The concentration of dissolved salts in a body of water, commonly expressed as parts per thousand (ppt).
Salt Marshes	See "Saline Marsh."
Scoping	Soliciting and receiving public input to determine issues, resources, impacts, and alternatives to be addressed in the DEIS.
Sea level	Long-term average position of the sea surface.
Sediment Plume	Caused by sediment rich rainwater runoff entering the ocean. The runoff creates a visible pattern of brown water that is rich in nutrients and suspended sediments that forms a kind of cloud in the water spreading out from the coastline. Commonly forms at river and stream mouths, near sloughs, and along coasts where a large amount of rain runoff flows directly into the ocean.

Sheet Flow	Flow of water, sediment, and nutrients across a flooded wetland surface, as opposed to through channels.
Shoaling	The shallowing of an open-water area through deposition of sediments.
Social	Relating to human society and its modes of organization.
Socioeconomic	Involving both social and economic factors.
Stabilize	To fix the level or fluctuation of; to make stable.
State Historic Preservation Office (SHPO)	The part of the Louisiana Department of Culture, Recreation, and Tourism that deals with Native American sites and other archaeological/historic sites.
Storm Overwash	The process by which sand is transposed landward over the dunes during a storm event by waves.
Storm Surge	An abnormal and sudden rise of the sea along a shore as a result of the winds of a storm.
Strategy	Ecosystem restoration concept from the Coast 2050 Plan.
Submergence	Going under water.
Subprovince	The divisions of the two Provinces (see "Province") into smaller groupings: 1) east of the Mississippi River; 2) west of the Mississippi River to Bayou Lafourche; 3) Bayou Lafourche to Freshwater Bayou; 4) Freshwater Bayou to Sabine River.
Subsidence	The gradual downward settling or sinking of the Earth's surface with little or no horizontal motion.
Sustain	To support and provide with nourishment to keep in existence; maintain.
Target	A desired ecosystem state that meets and objective or set of objectives.
Terrestrial Habitat	The land area or environment where an organism lives; as distinct from water or air habitats.
Toxicity	The measure of how poisonous something is.

Transpiration The process by which water passes through living plants into the atmosphere.

Turbidity The level of suspended sediments in water; opposite of clarity or clearness.

Uncertainty Uncertainty is the result of imperfect knowledge concerning the present or future state of a system, event, situation, or (sub) population under consideration. There are two types of uncertainty: aleatory and epistemic. Aleatory uncertainty is the uncertainty attributed to inherent variation which is understood as variability over time and/or space. Epistemic uncertainty is the uncertainty attributed to lack of knowledge about the system (e.g., what value to use for an input to a model or what model to use). Uncertainty can lead to lack of confidence in predictions, inferences, or conclusions.

Upland A general term for non-wetland elevated land above low areas along streams or between hills.

Water Resources Development Act (WRDA) A bill passed by Congress that provides authorization and/or appropriation for projects related to the conservation and development of water and related resources.

Weir A dam placed across a canal or river to raise, divert, regulate or measure the flow of water.

Wetland Value Assessment (WVA) A quantitative habitat-based assessment methodology used to determine wetland benefits of restoration measures. The WVA quantifies changes in fish and wildlife habitat quality and quantity that are expected to result from a proposed wetland restoration project. The results of the WVA, measured in AAHUs, can be combined with cost data to provide a measure of the effectiveness of a proposed project in terms of annualized cost per AAHU gained. In addition, the WVA methodology provides an estimate of the number of acres benefited or enhanced by the project and the net acres of habitat protected/restored.

8.5 ACRONYMS, ABBREVIATONS AND SYMBOLS

AAHU Average Annual Habitat Unit

AATC Anti-Aircraft Training Center

ACHP	Advisory Council on Historic Preservation
ADA	American's with Disabilities Act
ADH	Adaptive Hydrology Model
AGR	Agriculture
ASAP	As Soon as Possible
ASTM	American Society for Testing and Materials
BA	Biological Assessment
BCR	Benefit-to-Cost Ratio
BGEPA	Bald and Golden Eagle Protection Act
BMP	Best Management Practices
BOD	Biological Oxygen Demand
CAA	Clean Air Act of 1963
CASM	Comprehensive Aquatic Systems Model
CEDEP	Cost Engineering Dredge Estimating Program
CEM	Conceptual Ecological Model
CEMVN	United States Army Corps of Engineers – Mississippi Valley Division, New Orleans District
CE/ICA	Cost Effectiveness/Incremental Cost Analysis
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
cfu/100 ml	Colony Forming Unit per Milliliter
CH_4	Methane
CIAP	Coastal Impact Assistance Program
CL	Chloride
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COC	Contaminants of Concern
CPUE	Catch per Unit Effort

CWA	Clean Water Act
CWFCU-SWG	Coastal Wetland Forest Conservation and Use Science Working Group
CWPPRA	Coastal Wetland Planning, Protection and Restoration Act
cy	Cubic Yard
dBA	A-weighted decibel
DDT	Dichlorodiphenyltrichloroethane
DEIS	Draft Environmental Impact Statement
DO	Dissolved Oxygen
DOI	U.S. Department of the Interior
DWS	Drinking Water Source
E&D	Engineering and Design
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EJ	Environmental Justice
EL	Environmental Laboratory
EMS	Emergency Medical Services
EO	Executive Order
EPA	Environmental Protection Agency
ER	Engineering Regulation
ERDC	Engineer Research Development Center
ERL	Environmental Risk Limit
ESA	Environmental Site Assessment
ESRA	Environmental Systems Research Institute, Inc.
F&WP	Fish and Wildlife Propagation
FEIS	Final Environmental Impact Statement
FCIR	Farmland Conversion Impact Rating
FMC	Fishery Management Council
FMP	Fishery Management Plan
FONSI	Finding of No Significant Impact
FPEIS	Final Programmatic Environmental Impact Statement

FPPA	Farmland Protection Policy Act
fps	Feet per Second
FWCAR	Fish and Wildlife Coordination Act Report
FWOP	Future without Project
FWP	Future with Project
GHGs	Green House Gases
GIWW	Gulf Intracoastal Waterway
GIS	Geographic Information System
GMFMC	Gulf of Mexico Fishery Management Council
GOM	Gulf of Mexico
GSMFC	Gulf States Marine Fisheries Commission
H&H	Hydrology and Hydraulics
H/A	Hypoxic/Anoxic
H_2S	Hydrogen Sulfide
HAPs	Hazardous Air Pollutants
HEP	Habitat Evaluation Program
HET	Habitat Evaluation Team
HSDRRS	Hurricane and Storm Damage Risk Reduction System
HSI	Habitat Suitability Index
HTRW	Hazardous, Toxic, and Radioactive Waste
HU	Habitat Unit
IHNC	Inner Harbor Navigation Canal
IPCC	Intergovernmental Panel on Climate Change
IWR	Institute for Water Resources
LACPR	Louisiana Coastal Protection and Restoration
LAW	Limited Aquatic and Wildlife
LBWA	Lake Borgne Wetlands Area
LCA	Louisiana Coastal Area
LDEQ	Louisiana Department of Environmental Quality
LDHH	Louisiana Department of Health and Hospitals

LERRD	lands, easements, rights-of-way, utility or public facility relocations, and dredged or excavated material disposal area
LDNR	Louisiana Department of Natural Resources
LDWF	Louisiana Department of Wildlife and Fisheries
LMR	Lower Mississippi River
LPBF	Lake Pontchartrain Basin Foundation
LWCF	Land and Water Conservation Fund
MAMP	Monitoring and Adaptive Management Plan
MBTA	Migratory Bird Treaty Act
MEC	Munitions and Explosives of Concern
mcy	Million Cubic Yards
MDEQ	Mississippi Department of Environmental Quality
MDMR	Mississippi Department of Marine Resources
mg/l	Milligrams per Liter
mg/m^3	Milligrams per Cubic Meter
$\mu g/m^3$	Micrograms per Cubic Meter
µmhos/cm	Micromhos per Centimeter
MMPA	Marine Mammal Protection Act of 1972
MPN	Most Probable Number
MRGO	Former Mississippi River Gulf Outlet Navigation Channel
MRT	Mississippi River and Tributaries
MSA	Magnuson-Stevens Fishery Conservation and Management Act of 1996
MsCIP	Mississippi Coastal Improvements Program
MSL	Mean Sea Level
N_2O	Nitrous Oxide
NAAQS	National Ambient Air Quality Standards
NAVD	North American Vertical Datum
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NGO	Non-governmental Organization
NMFS	Department of Commerce – National Marine Fisheries Service

NO_x	Nitrous Oxides (Nitrate and Nitrite)
NO_2	Nitrogen Dioxide
NOA	Notice of Availability
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent to Prepare an Environmental Impact Statement
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRC	National Research Council
NRCS	Department of Agriculture – Natural Resources Conservation Service
NRHP	National Register of Historic Places
NTU	Nephelometric Turbidity Limits
NWR	National Wildlife Refuge
O&M	Operations and Maintenance
O_3	Ozone
OCPR	Office of Coastal Protection and Restoration
ODMDS	Offshore Dredged Material Disposal Site
OMB	Office of Management and Budget
OMRR&R	Operation and Maintenance, Repair, Rehabilitation and Replacement
ONR	Outstanding Natural Resource
OSHA	United States Department of Labor – Occupational Safety and Health Administration
OYS	Oyster Propagation
P&G	Principles and Guidelines
PAH	Poly-Aromatic Hydrocarbons
Pb	Lead
PCB	Polychlorinated Biphenyls
PCR	Primary Contact Recreation
PDEIS	Preliminary Draft Environmental Impact Statement
PDT	Project Delivery Team
PED	Preliminary Engineering and Design
PEIS	Programmatic Environmental Impact Statement

pH	Hydrogen Ion
PM	Particulates of Matter
ppm	Parts per Million
ppt	Parts per Thousand
REC	Recognized Environmental Concern
RCRA	Resource Conservation and Recovery Act
RM	River Mile
ROD	Record of Decision
RSLR	Relative Sea Level Rise
S&A	Supervision and Administration
SAND1	Sediment and Nutrient Diversion Model vs. 1
SAND2	Sediment and Nutrient Diversion Model vs. 2
SAV	Submerged Aquatic Vegetation
SCORP	Statewide Outdoor Recreation Plan
SCR	Secondary Contact Recreation
SHPO	State Historic Preservation Officer
SHS	State Historic Site
SLR	Sea Level Rise
SO_2	Sulfur Dioxide
SO_4	Sulfate
T&E	Threatened and Endangered
TAPS	Toxic Air Pollutants
TDS	Total Dissolved Solids
TEL	Total Exposure Limit
TMDL	Total Maximum Daily Loads
TSP	Tentatively Selected Plan
TY	Target Year
UCC	United Church of Christ
UNO	University of New Orleans
UNO-PIES	University of New Orleans-Pontchartrain Institute for Environmental Sciences

USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USDA	United States Department of Agriculture
USFWS	Department of Interior – United States Fish and Wildlife Service
USGS	Department of Interior – United States Geological Survey
VOC	Volatile Organic Compounds
WMA	Wildlife Management Area
WRDA 2007	Water Resource Development Act of 2007
WVA	Wetlands Value Assessment

8.6 INDEX