United States Government Accountability Office

GAO

Report to Congressional Committees

September 2006

HURRICANE KATRINA

Strategic Planning Needed to Guide Future Enhancements Beyond Interim Levee Repairs

GAO-06-934

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GAO Accountability · Integrity · Reliability

Highlights

Highlights of GAO-06-934, a report to congressional committees

Why GAO Did This Study

Hurricane Katrina's storm surge and floodwaters breached levees and floodwalls causing billions of dollars of property damage, and more than 1,300 deaths. Under the Comptroller General's authority to conduct reviews on his own initiative, GAO reviewed the Army Corps of Engineers (Corps) (1) progress in repairing damage to hurricane protection projects by June 1, 2006; (2) plans and estimated costs to make other repairs and complete five existing hurricane protection projects; and (3) plans and estimated costs to add enhancements and strengthen hurricane protection for the region. GAO reviewed related laws and regulations, Corps planning documents and repair tracking reports, observed ongoing repair work, and met with key agency officials and other stakeholders.

What GAO Recommends

GAO recommends that the Corps develop a comprehensive strategy and implementation plan that incorporates all elements for rebuilding and strengthening the system to ensure that specified levels of protection are constructed in a cost-effective manner, within reasonable time frames. GAO also recommends that the Corps establish an independent task force to help support and guide its ongoing and future repair efforts.

In its response for the Corps, the Department of Defense generally concurred with GAO's recommendations.

www.gao.gov/cgi-bin/getrpt?GAO-06-934.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Anu Mittal, (202) 512-3841, mittala@gao.gov.

What GAO Found

Following Hurricane Katrina, the Corps worked quickly to repair and restore almost 169 miles of damaged levees, floodwalls, and other flood control structures to prehurricane levels of protection. Although the Corps stated that it had restored prehurricane levels of protection to the area by June 1, 2006, it used temporary solutions and developed emergency procedures to protect against flooding, in the event of a hurricane, for sections where permanent repairs could not be completed in time. For example, the Corps constructed interim gates on three canals to prevent storm surges from flooding New Orleans. When construction of one canal gate fell behind schedule and could not be completed by June 1, 2006, the Corps devised an emergency plan to drive sheet piling into the canal and close it off if a hurricane threatened before the gate was completed. More importantly, because these initial repairs were performed only on levees and floodwalls with obvious visual damage, the reliability of those adjacent to them is still unknown. The Corps originally allocated $801 million for initial repairs, but the current allocation has increased to over $1 billion.

After completing the initial repairs, the Corps plans to conduct additional repairs and construction on the existing hurricane protection system. These plans include (1) repairing all damaged pumps, motors, and pumping stations by about March 2007; (2) restoring sections of existing hurricane protection projects that have settled over time to their original design elevations; and (3) completing construction of incomplete portions of five previously authorized hurricane and flood control projects by September 2007. An additional $941 million had been allocated for this additional work, but the Corps expects actual costs will be greater because of subsequent decisions to change the design of these projects, cover the local sponsor's share, and because of rapidly escalating construction costs.

In addition, the Corps plans to undertake further work to enhance and strengthen the hurricane protection for southeastern Louisiana. These projects are estimated to take years and require billions of dollars to complete. Since September 2005, the Congress has appropriated more than $7 billion for some aspects of this work and additional appropriations are expected. According to an external review organization established by the Corps, hurricane protection systems should be deliberately designed and built as integrated systems to enhance reliability and provide consistent levels of protection. However, the Corps does not have a comprehensive strategy and implementation plan to integrate the repairs already authorized and planned and that would ensure the efficient use of federal funds. Instead, the Corps appears to be following a piecemeal approach, similar to its past practice of building projects without giving sufficient attention to the interrelationships between various elements of those projects or fully considering whether the projects will provide an integrated level of hurricane protection for the area.

Contents

Abbreviations

Corps	Army Corps of Engineers
DOD	Department of Defense

GAO
Accountability * Integrity * Reliability

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On August 29, 2005, Hurricane Katrina came ashore near Buras, Louisiana, about 60 miles southeast of New Orleans, with wind speeds of up to 127 miles per hour and a storm driven wave surge of up to 30 feet. The size and strength of the storm and subsequent flooding resulted in one of the largest natural disasters in U.S. history, as storm waters flowed over floodwalls and breached levees in Louisiana's Orleans and neighboring parishes, causing widespread flooding, billions of dollars of property damage, and more than 1,300 deaths.

The Army Corps of Engineers (Corps) began constructing hurricane protection projects in southeastern Louisiana almost 60 years ago, in the 1940s. Over the years, the Corps constructed five major hurricane and flood damage reduction projects in southeastern Louisiana, comprising about 350 miles of earthen levees and concrete floodwalls across six parishes. These projects were designed to provide various levels of hurricane protection, and generally could withstand storms with maximum wind speeds between 87 and 115 miles per hour. The hurricane protection projects in Orleans, Plaquemines, and St. Bernard parishes suffered the greatest damage from Hurricane Katrina. The Corps estimates that more than one-half of the 269 miles of federally constructed levees and floodwalls in these three parishes were damaged by the storm's winds and flood waters.

The Flood Control and Coastal Emergencies Act of 1941, as amended, authorizes the Corps to respond in cases where flooding occurs due to a storm and repair or restore flood control and hurricane protection projects including levees, floodwalls, and other flood control structures damaged or destroyed by flood waters.[1] Generally, it is Corps policy to pay for the full costs of repairs to federally constructed levees and to fund 80 percent of the cost to repair certain nonfederally constructed levees, and the local sponsor or government funds the remaining 20 percent. However, because of the unprecedented damage and loss caused by Hurricane Katrina, the Corps deviated from its usual policy and has funded

[1]33 U.S.C. § 701n(a)(1).

100 percent of the repair, restoration, and construction costs for both federal and nonfederal levees and flood control structures.

The official Atlantic hurricane season runs from June 1 to November 30, when 97 percent of all tropical storms and hurricanes normally occur. After Hurricane Katrina, the Corps stated that it would repair the 169 miles of levees, floodwalls, and other hurricane protection structures damaged by Katrina to prestorm conditions by June 1, 2006—the beginning of the 2006 Atlantic hurricane season. After June 2006, the Corps had planned to repair damaged pumps, pump motors and pump stations, restore all hurricane protection structures that had subsided over time to their authorized design heights (the elevation specified in their design), and complete construction of incomplete portions of previously authorized hurricane protection projects. In April 2006, the Federal Emergency Management Agency released advisory flood elevations for New Orleans and the surrounding area based on a 1 percent annual chance of flooding, also called a 100-year flood. In response, the Corps is revising its plans and cost estimates to raise the height of levees and floodwalls to provide the area with a 100-year level of protection. In addition, the Congress required the Corps to conduct an analysis and design for comprehensive improvements in the coastal area of Mississippi in the interest of hurricane and storm damage reduction and for several other purposes,[2] and to provide an interim report of its findings on June 30, 2006, and issue a final report by December 30, 2007.[3]

We have prepared this report under the Comptroller General's authority to conduct evaluations on his own initiative, as part of our continued effort to assist the Congress by (1) monitoring the extensive damage to southeastern Louisiana caused by Hurricane Katrina and (2) evaluating ongoing efforts to repair and strengthen the region's hurricane protection projects. Specifically, for this report we reviewed the Corps' (1) progress in repairing damage to hurricane protection projects by June 1, 2006;

[2]Developed in 1969, the Saffir-Simpson Hurricane Scale is a 1 to 5 rating based on a hurricane's maximum sustained winds. For example, a Category 5 hurricane has wind speeds greater than 155 miles per hour. Prior to this scale, the Corps built systems designed to withstand a "standard project hurricane." For some of the projects in southeastern Louisiana this was roughly equivalent to a fast-moving Category 3 storm with winds from 111 to 130 miles per hour. A standard project hurricane was assumed to strike the Louisiana coast once every 200 to 300 years.

[3]Department of Defense Appropriations Act, 2006, Pub. L. No. 109-148, 119 Stat. 2680, 2761 (Dec. 30, 2005).

(2) plans and estimated costs to make other repairs, restore levees and flood control structures to design elevations, and complete construction of previously authorized but incomplete portions of five existing hurricane protection projects; and (3) plans and estimated costs to add enhancements and strengthen hurricane protection projects for the region.

To determine the status of work to repair damage to hurricane protection projects, we tracked the progress of repairs and funds spent by reviewing weekly repair reports and daily funds status reports obtained from the Corps' New Orleans district. We interviewed officials at Corps headquarters, the New Orleans district office, as well as officials assigned to the Interagency Performance Evaluation Task Force. We also observed repairs at selected sites in Orleans and St. Bernard parishes. To determine the Corps' plans and estimated costs to repair pumps and pump stations, restore projects to design grade, and complete construction of incomplete portions of previously authorized hurricane protection projects, we reviewed documentation of the Corps' plans, estimated costs, and results of surveys and reports of damage assessments. We also interviewed New Orleans District officials about their plans and estimated costs for this work. To determine the Corps' plans, timelines and estimated costs to add hurricane project enhancements and strengthen the level of hurricane protection, we reviewed documentation of plans, estimated timelines and costs, and laws authorizing funding and authority to the Corps to make repairs and rebuild. We also interviewed New Orleans District officials on their plans, timelines and estimated costs for this work. We conducted our work between January and July 2006 in accordance with generally accepted government auditing standards.

Results in Brief

Through a combination of permanent and temporary measures, the Corps restored the level of hurricane protection that existed prior to Hurricane Katrina to Orleans, Plaquemines, and St. Bernard parishes by June 1, 2006. To restore pre-Katrina levels of protection in a period of about 9 months, the Corps worked quickly and in some instances, engineered temporary solutions because not all repairs could be completed in time. For example, the Corps has plans to build permanent gates and pumps at the points where three drainage canals in New Orleans meet Lake Pontchartrain. These structures will help stop water from the lake surging into the canals during a hurricane. However, these permanent structures could not be completed by June 1, 2006, so the Corps is installing three interim gated structures and temporary pumps that will continue to provide protection to the area for 3 to 5 years until permanent structures can be constructed. While most repairs that were needed to restore protection were completed

by June 1, 2006, some work was behind schedule. Until this work can be completed, the Corps has developed emergency procedures to protect against flooding in the event of a hurricane while repair work is ongoing. For example, because the construction of one of the interim gates along the 17th Street canal in the Orleans East Bank is behind schedule, the Corps will drive sheet pile barriers into the canal to block storm surges from Lake Pontchartrain in the event of a hurricane. Additionally, all repair work completed by June 1, 2006, was performed only on levees and floodwalls with obvious damage noted during visual inspections conducted after the hurricane. Consequently, the reliability of levees and floodwalls adjacent to those that were repaired is still unknown. In December 2005, the Corps had estimated that it would cost $841 million to repair the existing system to pre-Katrina levels. By March 2006, the Corps had awarded 59 contracts to complete the associated repairs for about $801 million. In June 2006, however, the Corps revised its cost estimates for this work and expects that when all contracted work is completed for these repairs, total costs will exceed $1 billion.

After repairing damaged sections of hurricane protection projects to pre-Katrina levels, the Corps plans additional work to repair all damaged pump stations; restore to their original authorized design heights, those sections of the hurricane protection projects that have settled over time; and construct previously authorized but incomplete portions of the five hurricane protection projects in the area. Specifically, the Corps plans to (1) repair pumps, pump motors, and pump stations damaged by the hurricane and subsequent flooding by about March 2007; (2) raise all hurricane protection structures to design elevation by September 1, 2007; and (3) complete construction of incomplete portions of previously authorized projects by September 30, 2007. The Corps originally estimated that it would cost $59 million to repair all damaged pumps, motors, and pump stations. However, to date, the Corps has allocated $70 million for the pump repairs. Estimated total costs for the other repairs and construction planned by the Corps are unknown at this time because the Corps is revising these estimates. The Corps had originally allocated $1.1 billion from the December 2005 emergency supplemental appropriation to cover the cost of additional work needed to restore elevation to sections of the hurricane protection projects that had settled over time and to complete construction of the previously authorized but incomplete segments of all five hurricane protection projects in this area. In June 2006, the Corps shifted $224 million of these funds to cover the increasing cost of repairs, leaving a balance of about $871 million allocated for this work. The Corps is also revising the cost estimates for this work to reflect design changes, escalating construction costs, and

costs to fund the portion of the work normally paid by local sponsors. According to the Corps, all of these costs may not have been adequately accounted for in the original funding allocation.

In response to new and emerging requirements from a broad range of stakeholders, the Corps continues to propose enhancements to existing hurricane protection projects as well as new projects to improve and strengthen hurricane protection for southeastern Louisiana. Implementing these enhancements and strengthening the hurricane protection system for southeastern Louisiana is in itself an immense challenge. For example, the Corps is concurrently developing options to address the Federal Emergency Management Agency's new flood control standards; devising solutions to address some of the findings of the Interagency Performance Evaluation Task Force; and trying to evaluate approaches that will meet the long term needs of local interests as well as respond to congressional requirements, as outlined in three emergency supplemental appropriations. However, we are concerned that the Corps is proceeding with over $7 billion of interim repairs and construction without a comprehensive strategy and implementation plan to ensure that these various efforts are appropriately coordinated and integrated with each other as well as with any future plans for a stronger hurricane protection system. Following Hurricane Katrina, the Corps established the Interagency Performance Evaluation Task Force and Corps officials said they used its findings and lessons learned to improve engineering practices. However, the Corps has not indicated that it plans to establish a similar organization to help guide its interim repair and restoration efforts. While the Corps' preliminary technical report issued in July 2006 provides a conceptual framework to help stakeholders make decisions about long-term strategies for building a stronger and better hurricane protection system for coastal Louisiana, it neither provided any details on what needs to be done to achieve higher levels of protection nor how current efforts will be integrated with future efforts, if authorized. One of the criticisms that has arisen from investigations of the existing hurricane protection system was that it was a system in name only and was, in fact, a series of disjointed projects that did not function together to adequately protect the area. To avoid the potential for repeating the mistakes of the past and risk creating a set of disjointed projects that may not work together, may become redundant or obsolete, and may result in an inefficient use of federal funds, we believe that it would be imprudent for the Corps to proceed with such a large scale multibillion dollar construction project without developing a comprehensive strategy and implementation plan to guide its efforts, measure progress, and ensure accountability.

In light of the billions of dollars that Congress has already appropriated to rebuild and strengthen existing southeastern Louisiana hurricane protection projects, and to ensure the most efficient use of these federal resources, we are recommending that the Corps develop a comprehensive strategy that incorporates all projects and plans for rebuilding and strengthening the system and an implementation plan that will achieve that level of protection in a cost-effective manner, within a reasonable time frame. We are also recommending that the Corps establish an evaluative organization like the Interagency Performance Evaluation Task Force, to help the Corps develop a strategic plan, monitor progress, and provide expert advice on the construction of a stronger and well-integrated hurricane protection system.

In commenting on a draft of this report, the Department of Defense (DOD) generally concurred with both of our recommendations but contended that a body like the Interagency Performance Evaluation Task Force was not the proper organization to help the Corps develop a strategic plan, monitor progress, and provide expert advice on the construction of a stronger and well-integrated hurricane protection system. The Corps plans to rely on three teams of experts to provide independent technical reviews, develop a strategic plan to construct a hurricane protection system, and monitor implementation. We believe that the Corps' proposal to use three external groups of experts satisfies the spirit of our recommendation.

Background

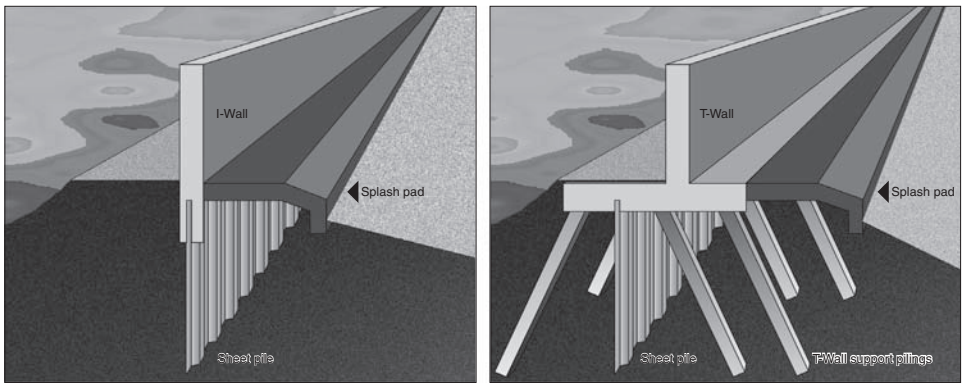
There are five major federally authorized projects comprised of more than 350 miles of levees, floodwalls, and other flood control structures across six parishes that provide hurricane protection in southeastern Louisiana. While construction of hurricane protection projects in southeastern Louisiana began almost 60 years ago, construction of three major projects began about 40 years ago in the 1960s. Segments of those were still incomplete when Hurricane Katrina struck the area in late August 2005. The projects were designed to provide protection from hurricanes with maximum wind speeds of 87 to 115 miles per hour (115 miles per hour being roughly equivalent to a Category 3 hurricane). Hurricane Katrina made landfall with wind speeds equivalent to a Category 3 hurricane, or winds up to 127 miles per hour, and record high storm surge. To determine the extent of the damage to levees and floodwalls caused by Hurricane Katrina, the Corps contracted for an initial assessment in September 2005 and a second assessment in April 2006. Both assessments were based on visual inspections of the levees and floodwalls. For the first assessment, engineers walked the levees and floodwalls in Orleans, Plaquemines and

St. Bernard parishes and looked for damage. The second assessment reexamined only those sections that were initially reported to be undamaged. The first assessment found 169 miles of damaged levees and floodwalls of which 128 miles were moderately damaged and 41 were severely damaged or destroyed. Most of the damage was found in Plaquemines Parish where 150 miles of levees and floodwalls were damaged. The second assessment of those sections initially found to be undamaged found additional cracks in the levees, soil erosion near floodwalls, and levee heights that had settled below their design elevation. Subsequently, the Corps and the contractors conducted sampling and other tests to determine the extent of the damage, but this was only done where exterior damage—such as cracks, depressions, or seepage—was observed. Both assessments documented obvious external damage but did not indicate whether other structures without visible damage—but similar in design and composition to damaged levees and floodwalls—were, in fact, damaged or weakened.

In its May 2006 draft final report, an independent team sponsored by the National Science Foundation reviewed the failures of the hurricane protection projects and concluded that the pervasiveness of problems and failures calls into question the integrity and reliability of other sections of flood protection projects that did not fail during Hurricane Katrina. In its June 2006 draft final report, the Interagency Performance Evaluation Task Force—a team of 150 experts from the Corps and about 50 federal, state, international, academic, and industrial organizations—found that repaired sections of levees and floodwalls were likely the strongest parts of the system until remaining sections could be similarly upgraded and completed. The task force report concluded that since there are many areas where protection levels are only the same as before Hurricane Katrina, the New Orleans metropolitan area remained vulnerable to storm surge and wave conditions equivalent to or greater than Hurricane Katrina.

The most severely damaged portions of the hurricane protection projects in the area were found in the three parishes of Orleans, Plaquemines, and St. Bernard. Within these three parishes, there are approximately 243 miles of earthen levees and 26 miles of floodwalls. The 26 miles of floodwalls comprised 19 miles of I-walls and 7 miles of T-walls. I-walls are vertical concrete barriers anchored to levees by steel sheet pile driven vertically into the levees. T-walls are vertical concrete barriers with a horizontal concrete base anchored by multiple steel beams driven diagonally into the levees and are stronger than I-walls (see fig. 1).

Figure 1: I-wall and T-wall



Source: U.S. Army Corps of Engineers.

Corps officials told us that T- or L-walls[4] will be constructed to replace floodwalls that were destroyed and need to be replaced.

Corps of Engineers Has the Authority and Responsibility to Rebuild and Restore Damage to Hurricane Protection Projects

Section 5 of the Flood Control Act of 1941, as amended, commonly referred to as Public Law 84-99,[5] authorizes the Corps to conduct emergency operations and rehabilitation activities when levees fail or are damaged during storms. Under the implementing regulations for Public Law 84-99, after a storm, the Corps may repair and restore federally authorized flood control projects and hurricane protection structures, or nonfederal flood control projects that were inspected and found to have met federal standards for construction and maintenance prior to the flood event.[6] Assistance for the rehabilitation of hurricane protection structures is limited to repair or restoration to the prestorm condition and level of protection (e.g., the prestorm elevation/height of levees, allowing for normal settlement).[7]

Under Corps policy, damage to federally constructed levees that have been completed and officially turned over to a nonfederal sponsor are to be

[4]An L-wall is similar to a T-wall except that the horizontal concrete base and diagonal steel beams are only on the landward side of the wall.

[5]33 U.S.C. § 701n.

[6]33 C.F.R. §§ 203.44-203.45.

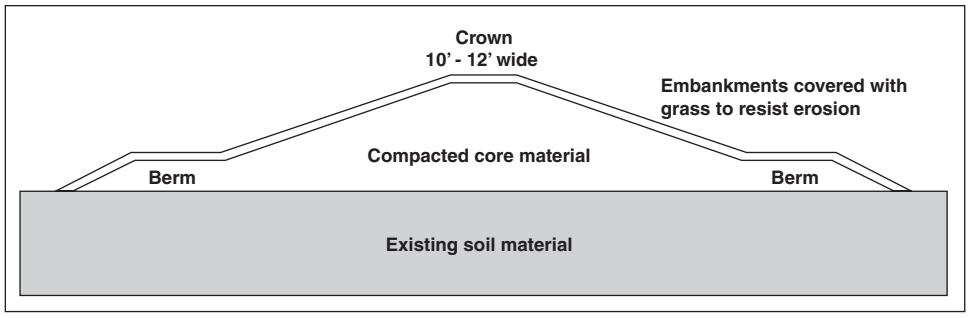
[7]33 C.F.R. § 203.49(b)(1).

repaired with 100 percent of the cost borne by the federal government and damage to nonfederally constructed levees are to be repaired with 80 percent of the cost borne by the federal government and 20 percent by the local sponsor or government. However, in September 2005, the Corps noted that Hurricane Katrina had caused unprecedented damage and loss of infrastructure in the Gulf Coast region. According to the Corps, damage to the region eroded the tax base to such an extent that local sponsors would have great difficulty funding their share of rebuilding expenses. In response, the Corps requested a one-time waiver from the Assistant Secretary of the Army for Civil Works from the policy requiring local sponsors to fund 20 percent of the cost of rehabilitating nonfederal flood and hurricane protection projects. For federally authorized projects that were under construction when Hurricane Katrina made landfall, the Corps also requested a waiver from the policy requirement that local sponsors fund a share of the repair cost. In October 2005, the Assistant Secretary of the Army for Civil Works approved both requests. In the December 2005 emergency supplemental, Congress appropriated funding to the Corps to repair levees and flood control structures damaged by Hurricane Katrina to the level of protection for which they were designed, at full federal expense.

Construction of Earthen Levees Depends on Local Building Materials and Soil Foundations

Most earthen levees are constructed with a mixture of clay and sand. The most commonly used method is to build an earthen embankment sloped on both sides and rising to a flat crown (see fig. 2).

Figure 2: Cross-Section of an Earthen Levee



Sources: U.S. Army Corps of Engineers (data); St. Louis Post-Dispatch (graphic).

Depending on local conditions and the availability of suitable materials, levees can be built in one or more stages. The number of stages is generally dependent on the ability of the local soil to provide an adequate

base, and not sink under the weight of levees, and to compact and provide suitable strength. When appropriate conditions exist, levees can be built in a single stage. In other cases, levees may need to be built in stages (also called lifts) that allow for subsidence of the foundation soil or settlement of the fill material. Between stages the levees are allowed to settle for up to 5 years. Because the soil in southeastern Louisiana has a tendency of settling, historically most levees built in the New Orleans area were required to be built in three to four stages, and construction took 15 to 20 years. Because of the urgency of the repairs that the Corps made after Hurricane Katrina, earthen levees in the New Orleans area had to be rebuilt in only several months. To do this, the Corps relied on mechanical compaction by heavy construction equipment to compensate for the normal settlement that would occur over time.

Building levees quickly can pose risks, however, as was witnessed on May 30, 2006, when a 400-foot section of a reconstructed levee in Plaquemines Parish slipped 3 to 4 feet under its own weight. Corps officials said the underlying soil was weaker than previous tests had indicated and was unable to support the weight of the newly constructed levee. To provide interim protection, the Corps constructed a small earthen berm on top of the levee to return it to approved design height by June 7, 2006.

Current Repairs to the Hurricane Protection Projects Are Limited to Prestorm or Previously Authorized Levels of Protection

By June 1, 2006, the Corps planned to complete repairs to 169 miles of southeastern Louisiana hurricane protection projects to prestorm conditions—that is, to repair most levees and floodwalls to the condition they were in before Hurricane Katrina. For 128 miles of levees with minor or moderate damage, the Corps planned to repair or fill scour (erosion) and holes. For 41 miles of levees and floodwalls with major damage, or that were completely destroyed, the Corps planned to rebuild these damaged sections entirely, including rebuilding to the original design grade, plus an allowance for settlement. The Corps only planned to repair hurricane-damaged levees and structures and did not plan to repair or replace any existing levees or floodwalls unless exterior damage was observed.

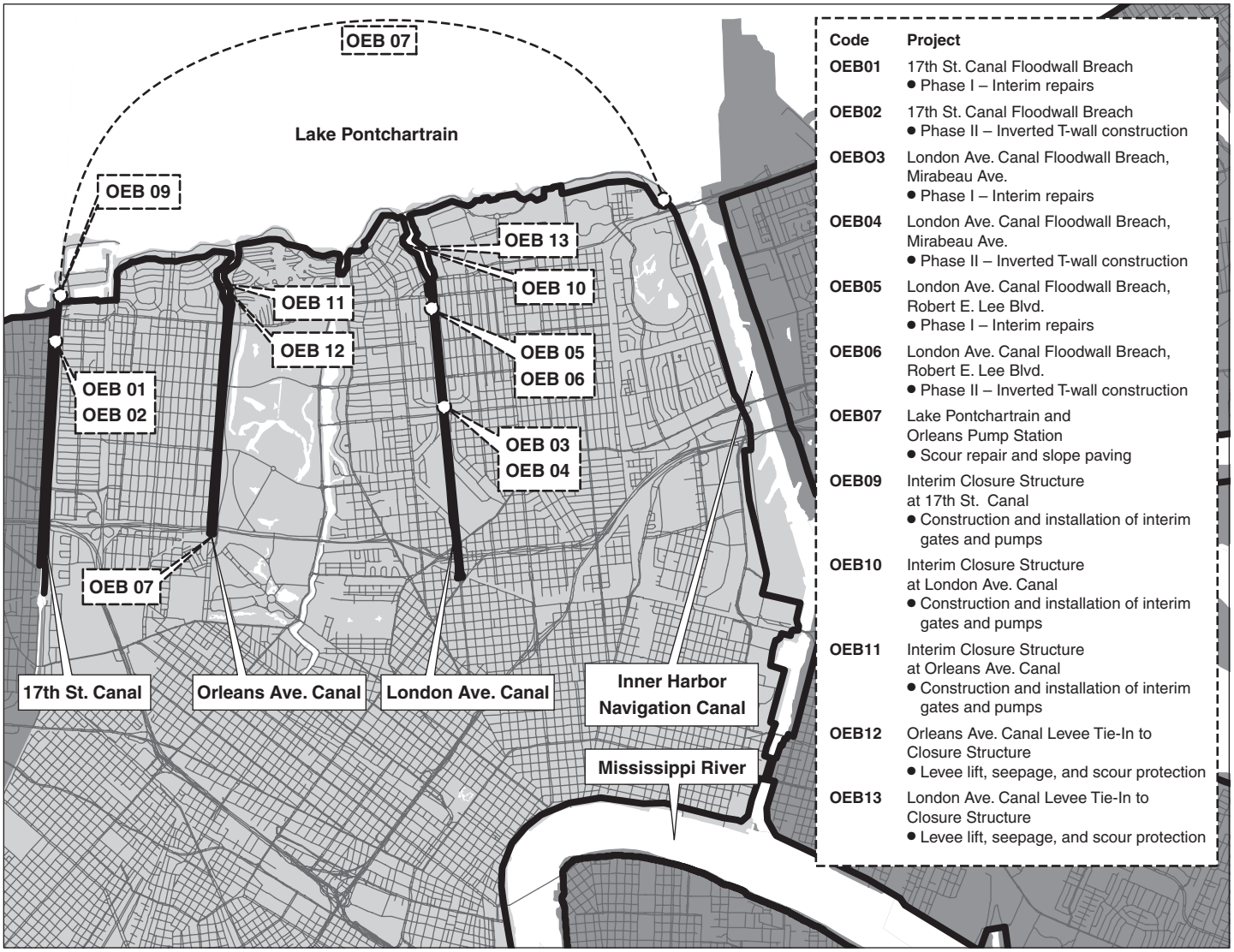
The Corps awarded 59 contracts to repair damage in three sections of the city of New Orleans (Orleans East Bank, New Orleans East and the Inner Harbor Navigation Canal, commonly called the Industrial Canal) and the parishes of Plaquemines and St. Bernard. The following sections briefly describe the location and damage caused by Hurricane Katrina for these

five areas and the number of contracts the Corps awarded for completing the repairs.

Orleans East Bank

Orleans East Bank is located south of Lake Pontchartrain, from the 17th Street Canal to the Inner Harbor Navigation Canal, and along the western bank of the Inner Harbor Navigation Canal to the Mississippi River. About 19 miles of levees and floodwalls are along the Orleans Lakefront, the Inner Harbor Navigation Canal and three drainage canals—17th Street, Orleans Avenue, and London Avenue—which drain rainwater from New Orleans into Lake Pontchartrain (see fig. 3).

Figure 3: Orleans East Bank in New Orleans, Louisiana and Repair Project Sites



Sources: U.S. Army Corps of Engineers; Stanley Consultants.

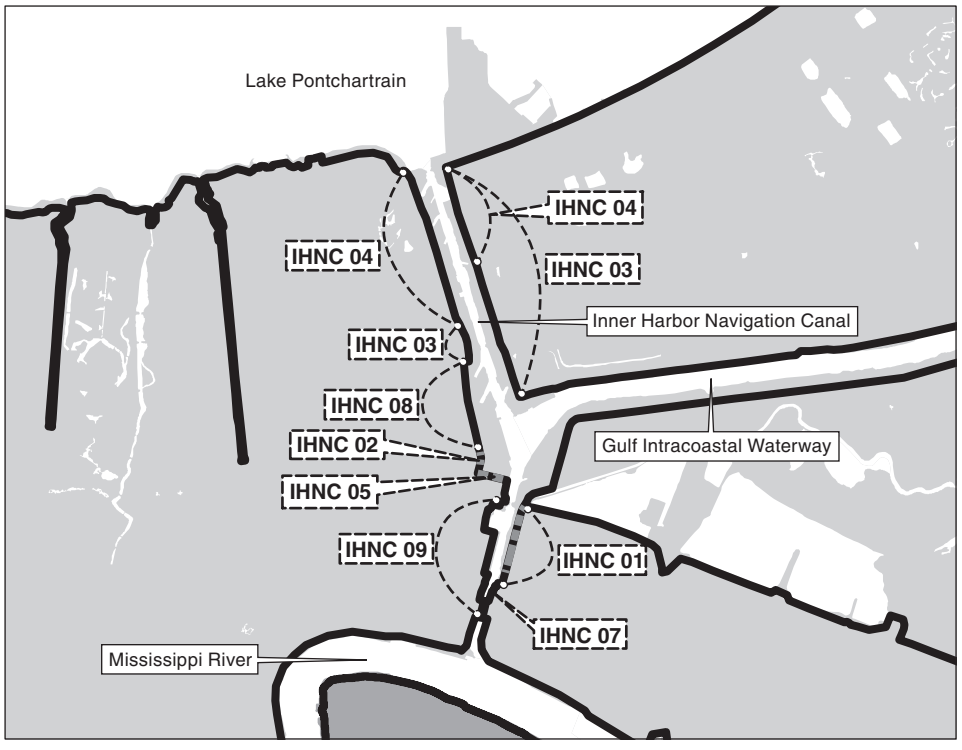
A total of about one mile of levees and floodwalls were damaged along the 17th Street Canal and two sides of the London Avenue Canal. There was also intermittent minor erosion, and all 13 of the area's pump stations were damaged. The Corps constructed interim sheet pile walls at the breach sites along the drainage canals and contracted for the construction of permanent T-walls at each of the breach sites. However, the Corps was

concerned about the integrity of the canal walls that were not breached during Hurricane Katrina. The Corps chose to construct interim closure structures (gates) where the canals empty into Lake Pontchartrain to reduce storm surge from entering the canals during hurricanes and storms. According to Corps officials, the Corps did not have the authority to construct permanent gates; so, in late January and early February 2006, the Corps awarded contracts for the construction of three interim gates and 34 pumps along the three drainage canals. A total of 12 contracts were awarded for the Orleans East Bank area.

Inner Harbor Navigation Canal

The Inner Harbor Navigation Canal is a 5.5 mile long waterway that connects the Mississippi River to Lake Pontchartrain. The east and west sides of the Industrial Canal are lined by a total of 12.3 miles of levees and floodwalls (see fig. 4).

Figure 4: Inner Harbor Navigation Canal, New Orleans, Louisiana and Repair Project Sites



Code	Project
IHNC01	East Side N. Claiborne Ave. to Florida Ave. • Floodwall construction
IHNC02	West Side France Rd. to Benefit St. • Floodwall construction
IHNC03	Gulf Intracoastal Waterway to Lake Pontchartrain (East) and Almonaster to Hwy. 90 (West) • Floodwall construction
IHNC04	Hwy. 90 to Lake Pontchartrain (West) and Dwyer to Hayne Blvd. (East) • Floodwall construction
IHNC05	West Side, Vicinity France Rd. Ramp to Inner Harbor Navigation Canal • Floodwall construction
IHNC07	East Side, Lock to Claiborne Ave. • Floodwall repairs
IHNC08	West Side, North of Benefit St. to Almonaster • Scour repair and floodwall construction
IHNC09	West Side, Lock to Florida Ave. • Floodwall construction

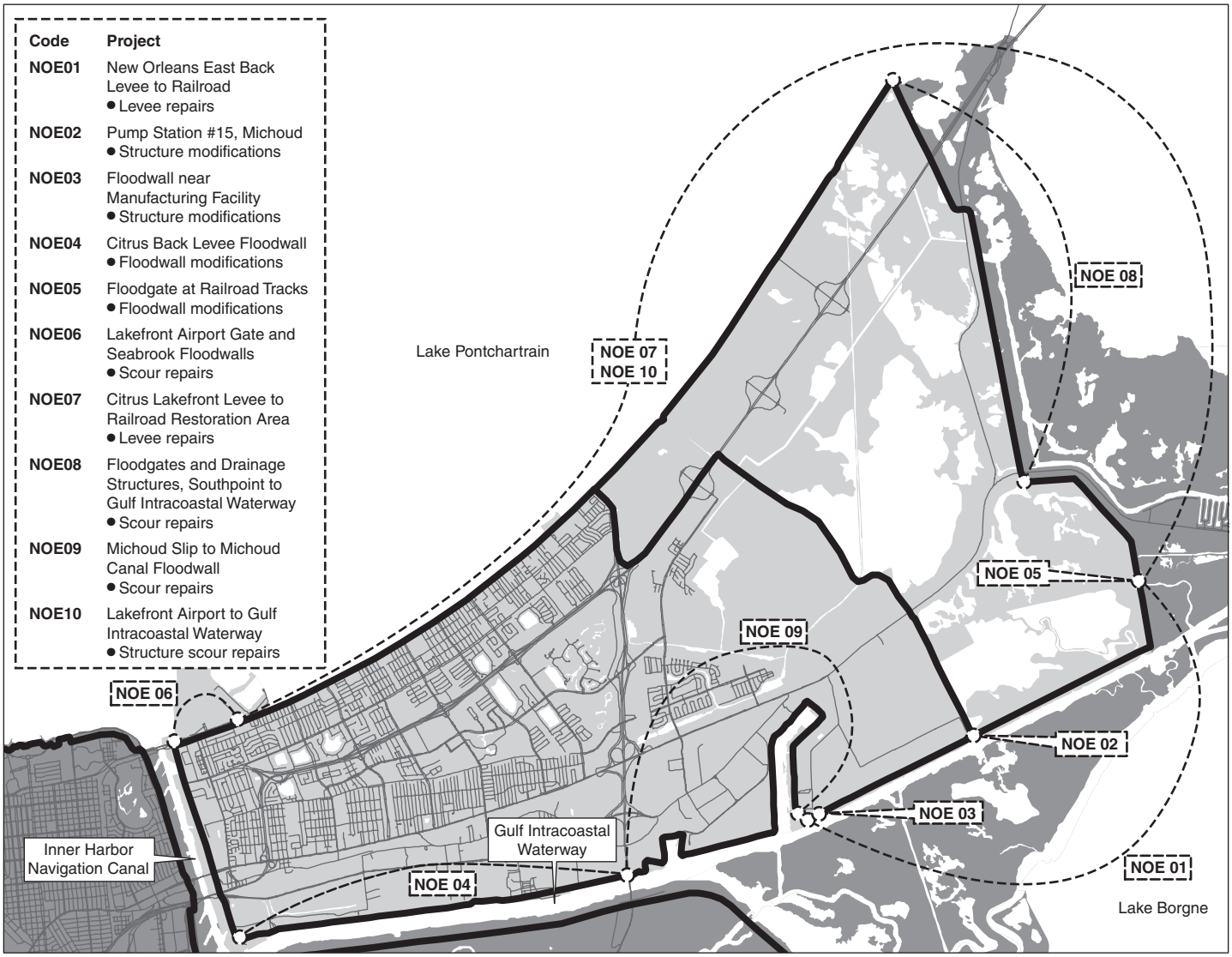
Sources: U.S. Army Corps of Engineers; Stanley Consultants.

A total of 5 miles of levees and floodwalls were damaged by Hurricane Katrina along the Inner Harbor Navigation Canal. Two breaches occurred on the western side of the Inner Harbor Navigation Canal, near the intersection of the Gulf Intracoastal Waterway and the Inner Harbor Navigation Canal, and two separate large breaches occurred on the lower eastern side, resulting in major flooding to New Orleans' Lower Ninth Ward. The Corps awarded eight contracts to repair and completely rebuild damaged and destroyed levees and floodwalls along the Inner Harbor Navigation Canal.

New Orleans East

New Orleans East is bounded by the east bank of the Inner Harbor Navigation Canal on the west, Lake Pontchartrain to the north, Bayou Sauvage National Wildlife Refuge to the east, and the Gulf Intracoastal Waterway to the south. The area has 39 miles of exterior levees and floodwalls and eight pump stations (see fig. 5).

Figure 5: New Orleans East in New Orleans, Louisiana and Repair Project Sites



Sources: U.S. Army Corps of Engineers; Stanley Consultants.

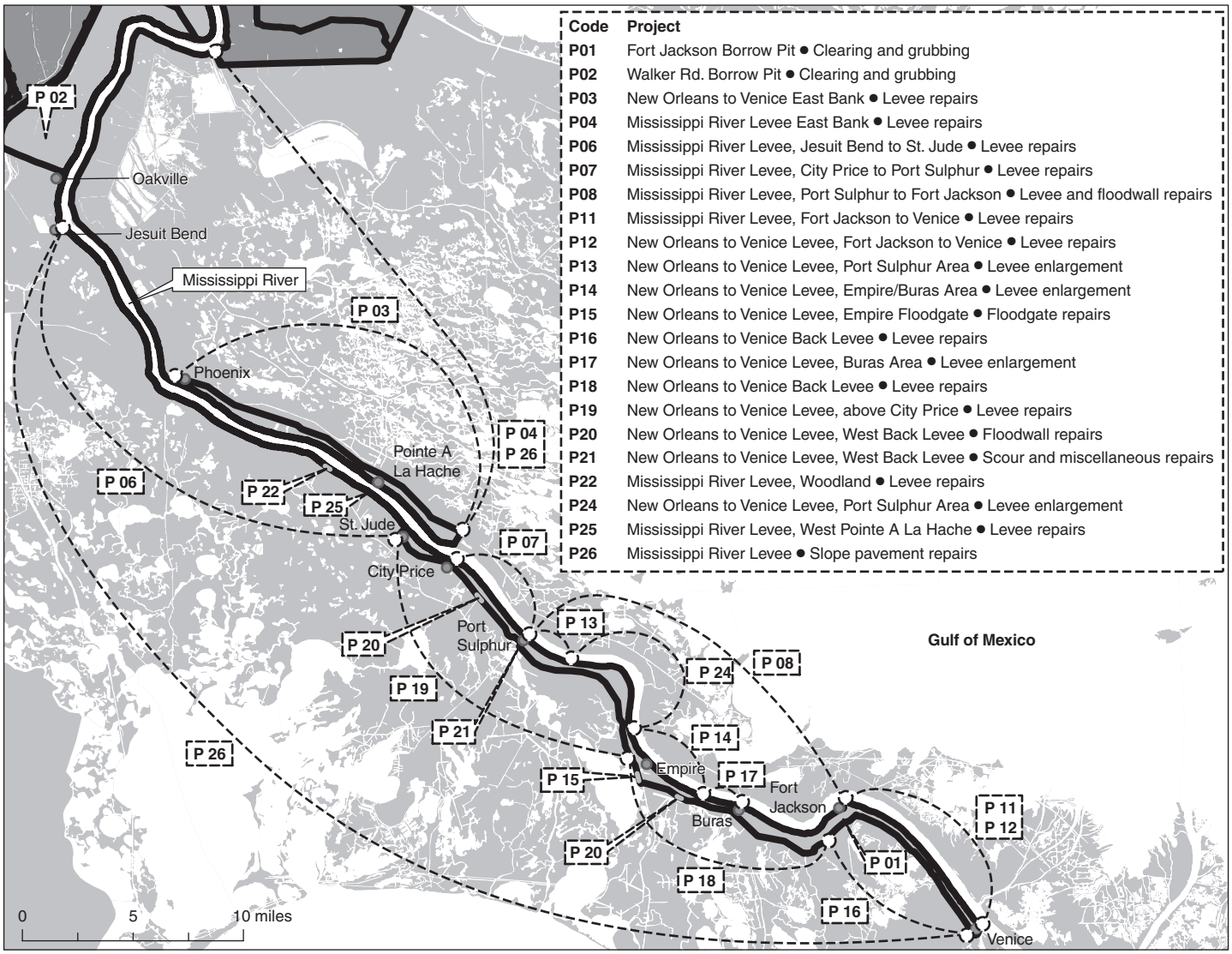
The hurricane damaged 4.6 miles of levees and floodwalls and all eight pump stations. Ten contracts were awarded to repair this damage.

Plaquemines Parish

Plaquemines Parish includes long, narrow strips of land on both sides of the Mississippi River between New Orleans and the Gulf of Mexico. The Mississippi River levees protect the parish from floods coming down the river, and the New Orleans to Venice hurricane protection project

(portions of which are not yet completed) protects against hurricane-induced tidal surges. The distance between these Gulf-side levees, called back levees, and the Mississippi River levees is less than 1 mile, in most places. Plaquemines Parish has a total of 169 miles of levees and floodwalls and 18 pump stations (see fig. 6).

Figure 6: Plaquemines Parish, Louisiana and Repair Project Sites



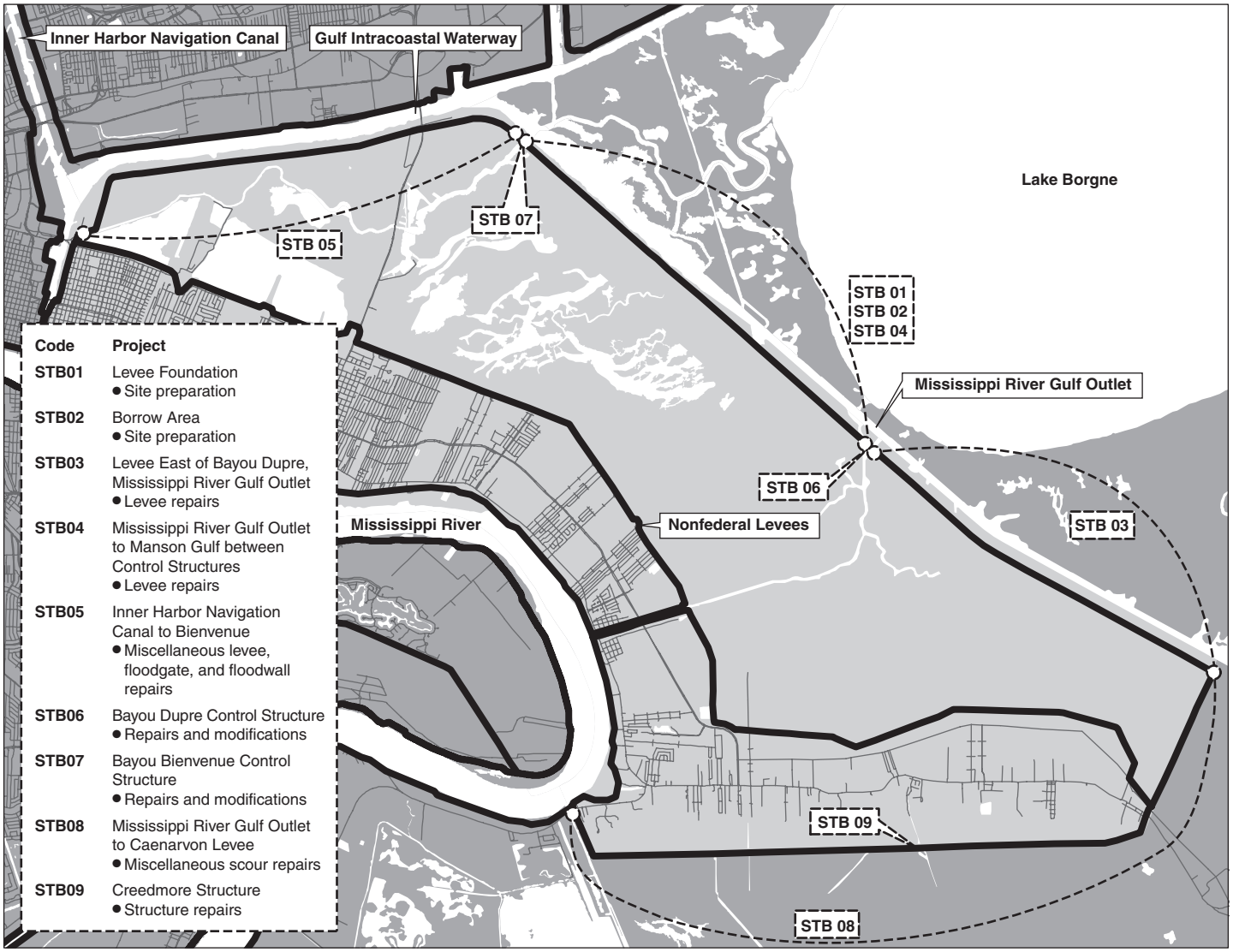
Sources: U.S. Army Corps of Engineers; Stanley Consultants.

In Plaquemines Parish, a total of 150 miles of levees and floodwalls were damaged along with 18 pump stations. The Corps awarded 20 contracts to repair and rebuild levees and floodwalls damaged by Hurricane Katrina in Plaquemines Parish. According to the Corps, there was considerable erosion scour along the total length of the levees. The Mississippi River levees were also damaged by numerous ships and barges that crashed into them. Five of the 6 miles of floodwalls along the Mississippi River were also destroyed but will be replaced with earthen levees because the Corps determined that the underlying foundation could not support the weight of a concrete floodwall.

St. Bernard Parish

In St. Bernard Parish, levees and floodwalls extend along the Gulf Intracoastal Waterway to the north, along the Mississippi River Gulf Outlet to the east and south, and then turn west toward the Mississippi River, continuing along the river to the Inner Harbor Navigation Canal along the western side. St. Bernard Parish has 30 miles of exterior levees and floodwalls, 22 miles of nonfederal interior levees, and eight pump stations (see fig. 7).

Figure 7: St. Bernard Parish and Repair Project Sites



Sources: U.S. Army Corps of Engineers; Stanley Consultants.

In St. Bernard Parish, 8 miles of exterior levees and floodwalls were damaged, 14 miles of nonfederal interior levees (back levees) were damaged and all eight pump stations and two control structures were damaged. The Corps awarded nine contracts to repair and rebuild the levees, floodwalls, and flood control structures in St. Bernard Parish.

Independent Research Teams Have Studied the Cause of Hurricane Protection Failure

Following Hurricane Katrina, several independent review teams began studies to determine the cause of hurricane protection failures in southeastern Louisiana. These teams included the Interagency Performance Evaluation Task Force, Independent Levee Investigation Team sponsored by the National Science Foundation, and the American Society of Civil Engineers External Review Panel. The Interagency Performance Evaluation Task Force and Independent Levee Investigation Team have issued preliminary reports of their findings and conclusions. The American Society of Civil Engineers External Review Panel was assembled to review the Interagency Performance Evaluation Task Force work and conclusions. On June 1, 2006, the Interagency Performance Evaluation Task Force issued a draft final report that concluded that the levees and floodwalls in New Orleans and southeastern Louisiana did not perform as a system and that it was a system in name only. According to the report, the hurricane system's performance was compromised by the incompleteness of the system, the inconsistency in the levels of protection, and the lack of redundancy. Inconsistent levels of protection were caused by differences in the quality of materials used in the levees and variations in elevations due to subsidence and construction below design specifications. Corps officials said they considered the findings and recommendations of the Interagency Performance Evaluation Task Force when making decisions about how to repair levees and floodwalls damaged by Hurricane Katrina.

Billions of Dollars Have Been Appropriated for Post-Katrina Hurricane Protection Repairs and Construction

The Corps has received over $7 billion dollars to restore hurricane protection and complete construction on existing hurricane protection projects in southeastern Louisiana through three emergency supplemental appropriations.[8] In September and December 2005, the Corps received a total of $3.299 billion in the second and third emergency supplemental appropriations. In September 2005, the second emergency supplemental appropriation provided the Corps with $400 million for repair of flood control and hurricane protection projects.[9] In December 2005, the third

[8]There have been four emergency supplemental appropriations in response to Hurricane Katrina. The first emergency supplemental appropriation, Pub. L. No. 109-61, 119 Stat. 1988 (Sept. 2, 2005), was used to fund, among other things, other Corps emergency missions, such as unwatering. The Corps did not use the appropriation to repair levees destroyed or damaged by the storm. The second, third and fourth emergency supplementals appropriated funds to the Corps to repair and rebuild damage caused by Hurricane Katrina.

[9]Second Emergency Supplemental Appropriations Act to Meet Immediate Needs from the Consequences of Hurricane Katrina, 2005, Pub. L. No. 109-62, 119 Stat. 1990, 1991 (Sept. 8, 2005).

supplemental appropriation provided the Corps with $2.899 billion, of which $2.3 billion was provided for emergency response to and recovery from coastal storm damages and flooding from hurricanes Katrina and Rita.[10] The Corps has allocated nearly $2.1 billion to the New Orleans District to repair damage to existing hurricane protection, rebuild existing projects to original authorized height, and complete unconstructed portions of previously authorized hurricane protection projects. In turn, the New Orleans District has allocated nearly $1.9 billion for this work.

In June 2006, through the fourth emergency supplemental appropriation, the Congress provided almost $4 billion to the Corps to strengthen the region's hurricane defenses and restore areas of coastal wetlands. The legislation included specific provisions for southeastern Louisiana hurricane protection and flood reduction project enhancements (canal closures, selective levee armoring, and storm proofing pump stations), and incorporating nonfederal levees in Plaquemines Parish into the federal levee system.[11] The June 2006 emergency supplemental also provided general construction funding that the Corps plans to use to, among other things, raise levee heights for certain hurricane protection projects in order to certify them in the National Flood Insurance Program (also called a 100-year flood level of protection). Table 1 summarizes the estimated costs and funds allocated for the Corps' planned work to date.

[10]Emergency Supplemental Appropriations Act to Meet Immediate Needs Arising from the Consequences of Hurricane Katrina, 2005, Pub. L. No. 109-61, 119 Stat. 2680, 2761-2763 (Dec. 30, 2005).

[11]Emergency Supplemental Appropriations Act for Defense, the Global War on Terror, and Hurricane Recovery, 2006, Pub. L. No. 109-234; 120 Stat. 418, 453-455 (June 15, 2006).

Table 1: Initial Estimated Costs and Funds Allocated for Corps' Plans and Projects

Corps plans and projects	Initial estimated cost	Funds allocated
Repair damage to existing hurricane protection	$841 million	$1,018 million[a]
Rebuild existing projects to original authorized height	Not estimated	$342 million[a]
Complete unconstructed portions of previously authorized hurricane protection projects	$529 million	$529 million
Repair pumps, pump motors, and pump stations	$59 million	$70 million
Enhance hurricane protection to provide protection from a 100-year flood	Not estimated	$495.3 million
Enhance hurricane protection to provide protection from a Category 5 hurricane	Not estimated	Funds have not been allocated

Source: GAO analysis of Army Corps of Engineers' budgetary and other documents.

[a]The Corps allocated $801 million to repair damage to existing hurricane protection and $566 million to rebuild existing projects to original authorized height. In June 2006, the Corps shifted $224 million from funds allocated to rebuild existing projects to fund repair cost increases; that is, the Corps reallocated $217 million to fund repairs to the existing hurricane protection and $7 million to fund repairs to other hurricane and coastal protection projects.

At the Start of the 2006 Hurricane Season, Most Prehurricane Protection Had Been Restored to Southeastern Louisiana

On June 1, 2006, the Corps reported that 100 percent of prehurricane protection levels had been restored to southeastern Louisiana. However, work continued on almost half of the contracts because some were behind schedule while other contracts were not scheduled to be completed until as late as March 2007. In instances where the Corps determined it could not complete permanent repairs by June 1, 2006, the Corps installed temporary structures or levee supports and developed emergency procedures to protect against flooding in the event of a hurricane. The Corps originally allocated $801 million for this phase of the repairs; however, the current allocation for total costs for this phase is just over $1 billion.

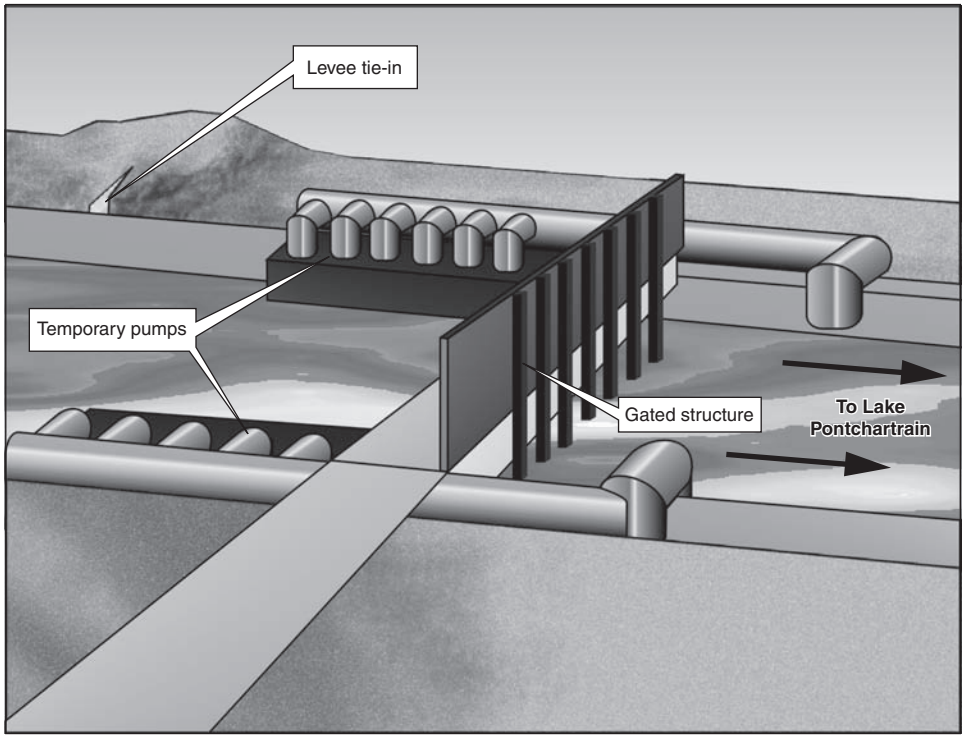
To restore 100 percent of prehurricane levels of protection in southeastern Louisiana by the start of the 2006 hurricane season, the Corps worked quickly to award contracts for a variety of work to be performed in a relatively short period of time. Between October 2005 and March 2006, the Corps awarded 59 contracts to repair and rebuild earthen levees, concrete floodwalls, and other hurricane protection structures, and to construct interim repairs in areas where final repairs could not be completed by

June 1. To complete repairs quickly, some contractors worked 24 hours a day, and Corps project managers monitored the progress of the work. As of June 1, 2006, the Corps reported that 22.7 miles of new levees and 195 miles of scour repairs were completed. Although the Corps reported that 100 percent of prehurricane levels of protection had been restored by June 1, 2006, as of July 18, 2006, 27 of the 59 contracts were not completed. Of those 27 contracts, the Corps projected that 20 would be completed by September 30, 2006, and the remaining 7 contracts would be completed by March 2007. The remaining work includes grading, compacting, and shaping the levees, as well as grass seeding and fertilizing.

In some instances, to restore prehurricane levels of protection, the Corps decided to change the design of the existing hurricane structure. For example, in the Orleans East Bank, the Corps determined that it did not have the time to assess the stability of existing canal walls nor could it complete repairs to all of the breaches along the drainage canals before June 1, 2006. As a result, at a cost of $111 million, the Corps decided to install interim gated closure structures (gates) on all three canals—17th Street, London Avenue, and Orleans Avenue—where they intersect Lake Pontchartrain to prevent storm surge from entering the canals and to install 34 temporary pumps to drain floodwaters from the Orleans East Bank portion of the city (see fig. 8). According to Corps officials, the agency planned to install interim gates and temporary pumps because it did not have the authority to install permanent gates and pumps under its emergency flood control authority. The Corps expects the interim gates and temporary pumps to remain in place for 3 to 5 years, after which the Corps will construct permanent gates and pumps. The 2006 emergency supplemental appropriation provides $530 million for permanent gates and pumps at the three drainage canals.[12]

[12]Emergency Supplemental Appropriations Act for Defense, the Global War on Terror, and Hurricane Recovery, 2006, Pub. L. No. 109-234, 120 Stat. 418, 454 (June 15, 2006).

Figure 8: Graphic of Interim Gates and Temporary Pumps



Source: U.S. Army Corps of Engineers.

According to the Corps, the interim gates will be operated manually, and the temporary pumps will not be enclosed. If a major storm or hurricane should occur, the Corps plans to close the gates when water levels in the 17th Street and London Avenue canals reach 5 feet and the water level in the Orleans Avenue canal reaches 9 feet. The Corps is reviewing the results of recent soil samples collected in the area and may change its plans, depending on these results, a Corps official said. The temporary pumps being installed by the Corps can only pump out a portion of the drainage water that would normally be pumped into the canals during a storm event. As a result of the restriction being placed on the water levels pumped into the canals and the limited pump capacity of the temporary pumps, the Corps has acknowledged that some flooding could occur from the heavy rainfall that normally occurs during a hurricane.

In instances where the Corps did not expect permanent repairs to be completed by June 1, 2006, the Corps devised some interim and temporary solutions to provide the same level of protection that existed before

Hurricane Katrina. For example, as of June 1, 2006, construction of one of the three interim gates—the 17th Street canal gate—was behind schedule. The Corps estimated it would be completed by September 15, 2006. If a hurricane threatens before the interim gate is in place, the Corps plans to drive sheet piling in front of the Hammond Highway Bridge that crosses the 17th Street canal to close off the canal from Lake Pontchartrain. On June 12, 2006, the Corps announced that the temporary pumps built for the drainage canals could not provide the required pumping capacity. The Corps plans to procure replacement pumps with different specifications for the 17th Street canal and repair new pumps already installed at the Orleans Avenue and London Avenue canals. Under normal conditions, the Corps said it would have conducted hydraulic modeling and testing to determine the correct pump configuration. The Corps did not perform modeling and testing, officials said, because the process can take months, and there was insufficient time to do so before the start of the hurricane season. If the canals must be closed due to a hurricane, before pumping capacity is restored at the drainage canals, the Corps plans to use a combination of temporary and portable pumps.

Similarly, in Plaquemines Parish, the Corps made temporary repairs to 5 miles of levees along the Mississippi River after the Corps concluded that a floodwall located on top of a section of levee was not reliable. The Corps decided to add a temporary reinforcement because there was not enough time to replace 5 miles of floodwalls before the start of the 2006 hurricane season. To provide this interim protection, the Corps added compacted clay along the backside of the damaged levee. The Corps subsequently determined that the foundation soil in this area would be unable to support the weight of floodwalls, so the Corps has decided to construct a full earthen levee embankment instead. However, this permanent structure is not scheduled to be completed until March 2007.

The Corps allocated about $801 million to repair levees and floodwalls to pre-Katrina conditions. An additional $217 million was needed to fund the $125 million costs to increase the pumping capacity of the new temporary pumps for the drainage canals and $92 million to fund such things as (1) additional work that has been required on existing repair contracts, relating to weakened levees in Plaquemines parish, the three drainage canal gates, and two hurricane protection and flood reduction projects; (2) contingency measures that had to be implemented until the temporary gates on the drainage canals are completed; and (3) costs to acquire nearby real estate for construction of the gates and associated levees. The Corps allocated these additional funds from the $566 million that was allocated by the Corps for raising all hurricane protection structures to

their authorized design elevations, which is discussed in greater detail in the next section of this report.

Cost Estimates for Restoring Southeastern Louisiana Hurricane Protection Projects to Originally-Designed Levels and Completing Construction of Incomplete Portions Continue to Rise

Beyond the repairs that were to be completed by June 1, 2006, the Corps has additional plans to continue repairs, restoration, and construction activities on other portions of the existing five southeastern Louisiana hurricane protection and flood control projects. The Corps plans to (1) repair all damaged pumps, motors, and pump stations by about March 2007; (2) restore sections of the five hurricane protection and flood control projects that have settled over time to their original design elevation; as well as (3) complete construction of previously authorized but incomplete portions of these hurricane protection and flood control projects by September 2007. Although $1.165 billion was originally allocated for this work, the Corps expects actual costs will be greater because the original allocation did not reflect design changes, additional costs to fund the local sponsor's share, and rapidly escalating construction costs. Further, in June 2006, the Corps shifted $224 million from this allocation to pay for the additional costs to repair damaged levees and floodwalls, leaving only $941 million for this work.

The Corps Plans to Repair Damaged Pumps, Motors, and Pump Stations by March 2007

The Corps plans to repair pumps and pump motors at 66 of 75 pump stations damaged by flood waters that were caused by Hurricane Katrina.[13] The pump stations are located in Orleans, St. Bernard, and Plaquemines parishes as well as in neighboring Jefferson Parish. Pumps remove storm runoff from city streets. The Corps plans to make electrical and mechanical repairs to pumps and motors—such as rewiring motors and replacing pump bearings—and structural repairs to pump stations, such as repairing roof tops. As of June 2006, the Corps had planned to complete repairs to all of these pumps, pump motors, and pump stations by March 2007, for an estimated cost of $59 million. However, to date, the Corps has allocated $70 million for the pump repairs. A Corps project manager said that five contracts have been awarded for $7.7 million, as of June 2006, and that he expects to award a total of 25 contracts for this work.

[13]Immediately following Hurricane Katrina, the Federal Emergency Management Agency dried and cleaned some flooded pumps and motors in an effort to quickly restore prehurricane pumping capacity to the region.

In April 2006, three pump motors that were flooded during Hurricane Katrina caught fire during a rainstorm and shut down, raising questions about the reliability of other pumps that had also been flooded. The possible failure of pumps due to fires combined with (1) the restrictions placed on the level of water that can be pumped into the canals because of uncertainty about the integrity of the canal floodwalls and (2) the reduced capacity of the temporary pumps to remove water from the canals has led to widely reported concerns about flooding from rainwater during a hurricane. In response to these concerns, the Corps accelerated plans to repair all damaged pumps, motors, and pump stations. A Corps official estimated it would take several weeks to repair each of the larger and older pump motors. The Corps plans to repair pumps and pump motors by taking some of them offline one at a time, thereby maintaining as much of the available pumping capacity at each pumping station as possible.

Restoration of Hurricane Protection to Authorized Design Elevations Is Expected by September 2007

The Corps plans to raise the height of all federal and some nonfederal levees, floodwalls, and other hurricane protection structures within the southeastern Louisiana area, which have settled over the years, to their original design elevation by September 1, 2007. In December 2005, the Corps surveyed levees not damaged by Hurricane Katrina and estimated that about 48 miles of levees were 1 to 2½ feet below design elevation in St. Bernard, Orleans, Plaquemines, and Jefferson parishes. The Corps estimated that restoring these levees to their designed height would cost $50.8 million. However, the Corps allocated $566 million from funds provided in the December 2005 emergency supplemental appropriation to raise not only the heights of these levees but also the heights of floodwalls and other structures in southeastern Louisiana, which may have settled over time, to their original design height. The primary difference between the Corps' initial cost estimate and the funds allocated in the emergency supplemental is the higher cost of raising floodwalls and other structures, compared with the cost of raising only about 48 miles of levees. In July 2006, the Corps estimated that 94 miles of levees, about 16 miles of floodwalls, 89 gates, and 2 control structures were below design elevation in Orleans, Plaquemines and St. Bernard parishes. According to a Corps official, the agency is revising the plans and estimated costs for this work to include the costs of raising all settled floodwalls and the cost of replacing all I-walls with T-walls or L-walls.

As of July 2006, the Corps had not announced the results of its second damage assessment. Currently, this work is still scheduled to be completed by September 1, 2007. As of June 2006, funds allocated for this work were reduced to $342 million because, as previously mentioned,

$224 million was shifted to help fund the escalating costs to repair damaged levees and floodwalls to pre-Katrina levels by June 1, 2006, and to fund repairs to hurricane damage at other hurricane protection and coastal protection projects. According to a Corps official, cost estimates for this work were to be available by July 15, 2006, after which the Corps plans to determine if it needs to request more funds.

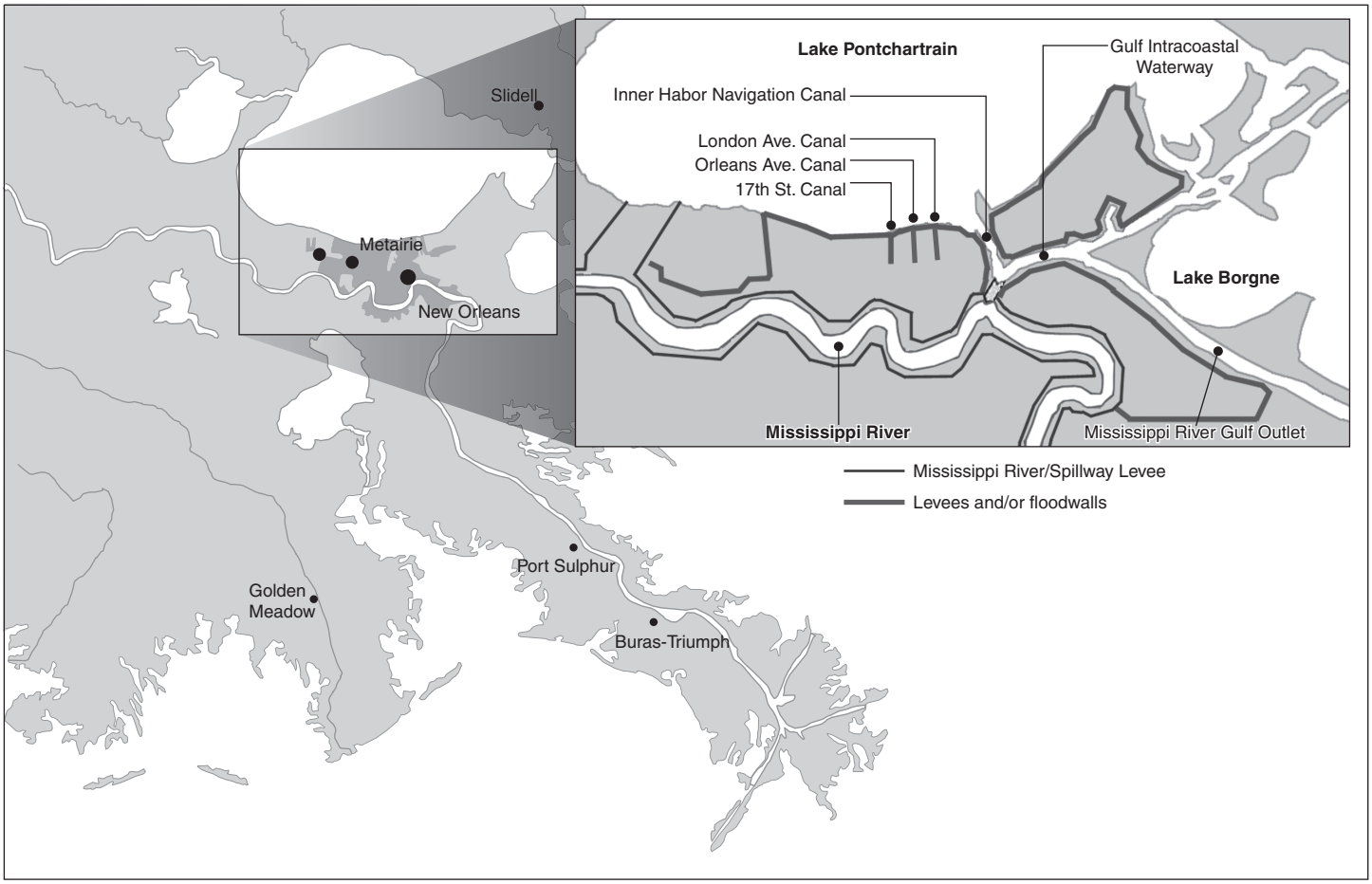
Completion of Previously Authorized but Unconstructed Portions of Five Hurricane and Flood Reduction Projects Expected by September 2007

By September 30, 2007, the Corps plans to complete the construction of all previously authorized but incomplete portions of the five hurricane protection and flood reduction projects in southeastern Louisiana. In December 2005, the Corps estimated the cost of completing these five projects to be $529 million. However, the Corps is revising its cost estimates due to escalating construction costs and design changes that have occurred since Hurricane Katrina. The Corps' costs will also increase because local sponsors are no longer required to share any of the costs incurred to complete these projects. Details of the five projects are described below.

Lake Pontchartrain, Louisiana and Vicinity Hurricane Protection Project

The Lake Pontchartrain and Vicinity Hurricane Protection Project is located in St. Bernard, Orleans, Jefferson, and St. Charles parishes in southeastern Louisiana, in the vicinity of the city of New Orleans and between the Mississippi River and Lake Pontchartrain. The project includes a series of control structures, concrete flood walls, and about 125 miles of earthen levees designed to protect residents living between Lake Pontchartrain and the Mississippi River levees from storm surges in the lake (see fig. 9).

Figure 9: Lake Pontchartrain, Louisiana and Vicinity Hurricane Protection Project



Sources: U.S. Army Corps of Engineers (data); MapArt (graphic).

This project was designed to provide protection from a standard project hurricane (equivalent to a fast-moving Category 3 hurricane). The Flood Control Act of 1965[14] authorized the project that, at the time of Hurricane Katrina, was 90 percent complete in St. Bernard and Orleans parishes, 70 percent complete in Jefferson Parish, and 60 percent complete in St. Charles Parish. The pre-Katrina scheduled completion date for this project was 2015, at an estimated cost of $738 million, where the estimated federal share was $528 million and the estimated local sponsor share was

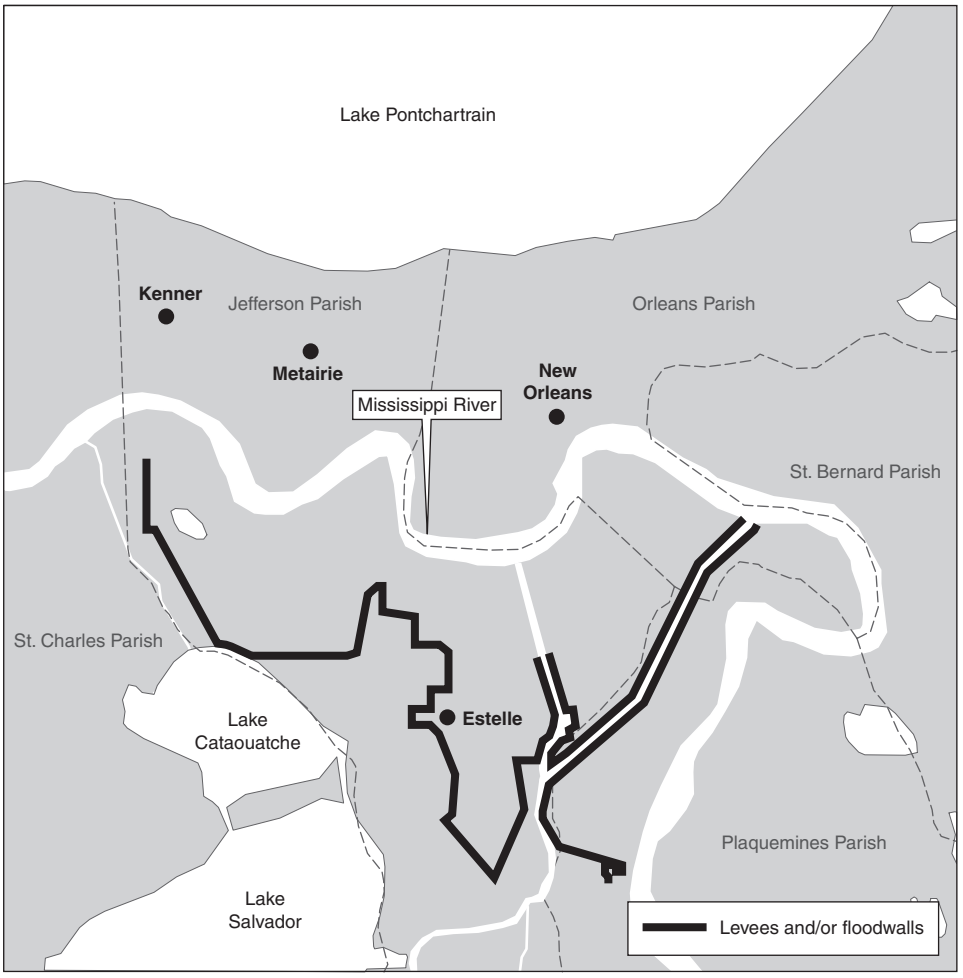
[14]Pub. L. No. 89-298, § 204, 79 Stat. 1073, 1077.

$210 million. At the time of the storm, estimated costs to complete the remainder of the project were $121 million. This estimate is expected to increase due to higher construction costs following Hurricane Katrina.

West Bank and Vicinity, New Orleans, Louisiana Hurricane Protection Project

The West Bank and Vicinity Hurricane Protection Project is located on the west bank of the Mississippi River in the vicinity of the city of New Orleans and in Jefferson, Orleans, and Plaquemines parishes. The project is designed to provide hurricane protection to residents from storm surges from Lakes Cataouatche and Salvador, and waterways leading to the Gulf of Mexico. The project encompasses 66 miles of earthen levees and floodwalls (see fig. 10).

Figure 10: West Bank and Vicinity, New Orleans, Louisiana Hurricane Protection Project



Sources: U.S. Army Corps of Engineers (data); MapArt (graphics).

This project was designed to provide Category 3 level of hurricane protection. The Water Resources Development Act of 1986 authorized this project.[15] At the time of Hurricane Katrina, the project was 38 percent complete. The pre-Katrina completion date for this project was 2016, at an estimated cost of $331 million, where the federal estimated share was $215 million and the estimated local sponsor share was $116 million. At

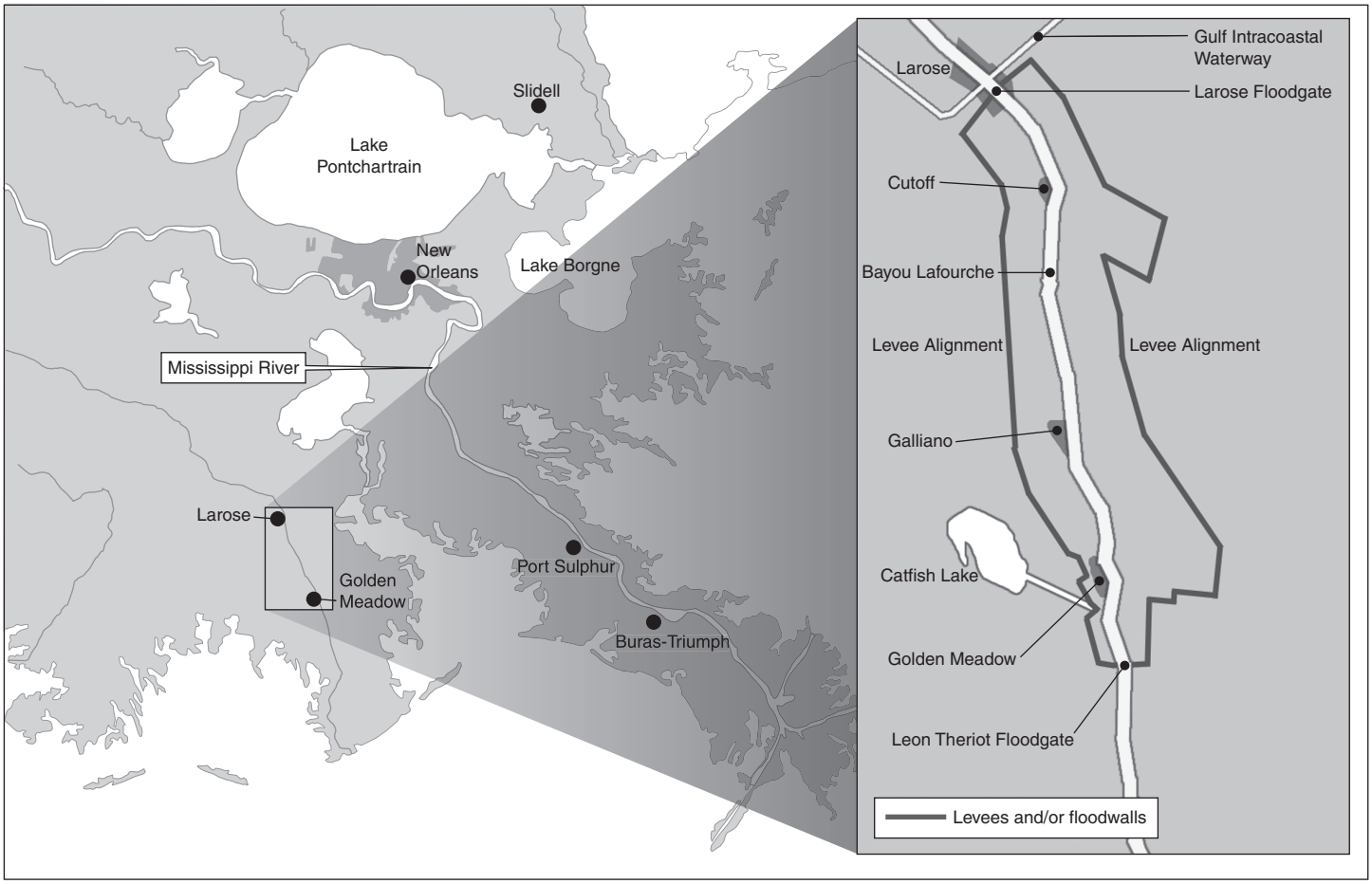
[15]Pub. L. No. 99-662, § 401, 100 Stat. 4082, 4128.

the time of the storm, estimated costs to complete the remainder of the project were $148 million; however, the Corps expects the final cost to be much higher. The design for this project includes 4 miles of T-walls, and since the cost of T-walls has escalated, officials said they expect the cost to complete the project will increase as well.

Larose to Golden Meadow, Louisiana Hurricane Protection Project

The Larose to Golden Meadow, Louisiana Hurricane Protection Project is located in southeastern Louisiana, about 30 miles southwest of New Orleans, along Bayou Lafourche and between the communities of Larose and Golden Meadow in Lafourche Parish. The project is a ring-shaped levee about 40 miles in length (see fig. 11).

Figure 11: Larose to Golden Meadow, Louisiana Hurricane Protection Project



Sources: U.S. Army Corps of Engineers (data); MapArt (graphic).

According to Corps officials, this project was designed to provide a 100-year level of hurricane protection to about 2,300 acres of residential and commercial land and 9,400 acres of agricultural land. The Flood Control Act of 1965[16] authorized this project that, at the time of Hurricane Katrina, was about 96 percent complete. The pre-Katrina completion date of this project was 2007, at an estimated cost of $116 million, where the federal estimated share was $81 million and the estimated local sponsor was $35 million. At the time of the storm, estimated costs to complete the remainder of the project were $4 million. However, according to the project manager, significant settlement has occurred throughout the project and levees are between 1 to 1 ½ feet below design elevation. Further, when this project was designed in the early 1970s, a nearby marsh was expected to help slow storm surge. Since that time, the local environment has changed causing the marsh to disappear and, according to the project manager, the Corps is reconsidering the project design and may have to recommend raising the height of the levees in order to provide authorized levels of protection, which could significantly increase the costs of the project.

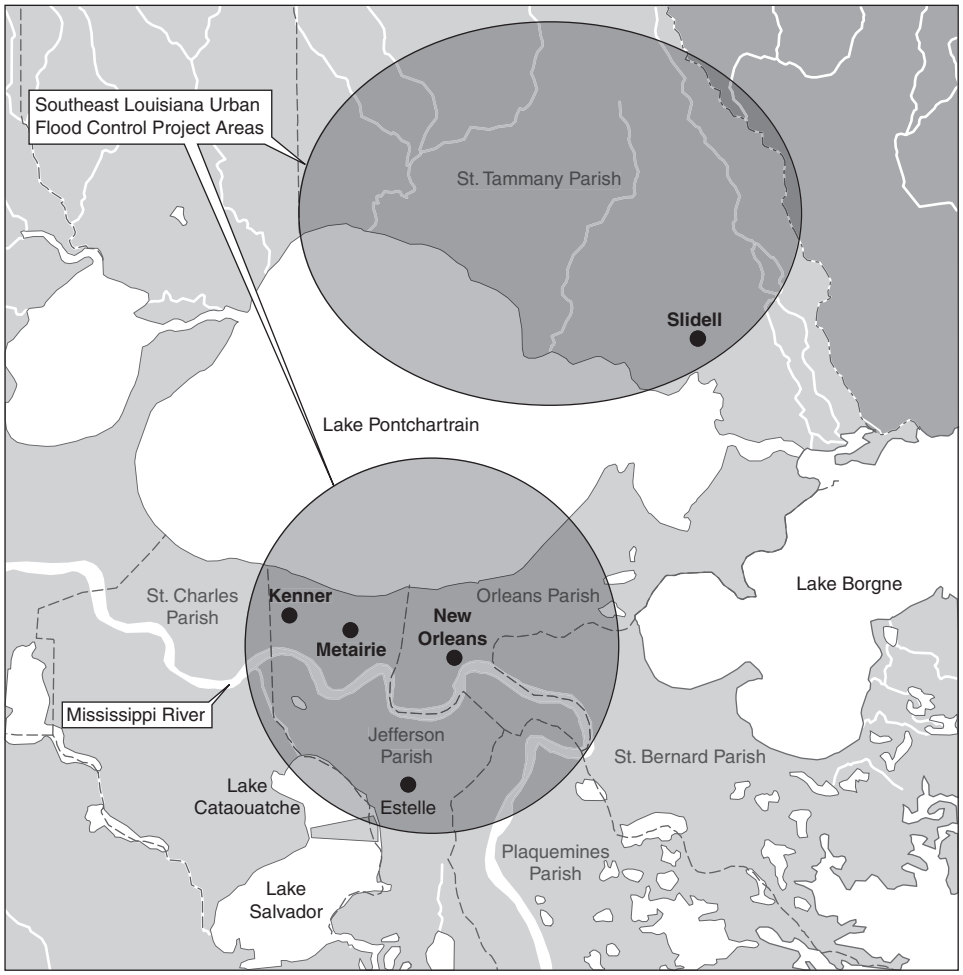
Southeast Louisiana Urban Flood Control Project

The Southeast Louisiana Urban Flood Control Project is located on the east bank of the Mississippi River, in Orleans Parish, and on the east and west banks of the Mississippi River, in Jefferson Parish and St. Tammany Parish. The project was designed to provide drainage and flood protection from a 10-year rainfall event[17] and encompasses major drainage lines and canals, additional pumping capacity, and new pump stations (see fig. 12).

[16]Pub. L. No. 89-298, § 204, 79 Stat. 1073, 1077.

[17]A 10-year flood means there is a 10 percent annual chance of flood.

Figure 12: Southeast Louisiana Urban Flood Control Project



Sources: U.S. Army Corps of Engineers (data); MapArt (graphics).

Note: Shading indicates areas where drainage and flood protection work is planned or in progress.

The project was originally authorized by the Energy and Water Development Appropriations Act, 1996[18] and the Water Resources Development Act of 1996.[19] At the time of Hurricane Katrina, the project was about 60 percent complete. The pre-Katrina completion date for this

[18]Pub. L. No. 104-46, § 108, 109 Stat. 402, 408.

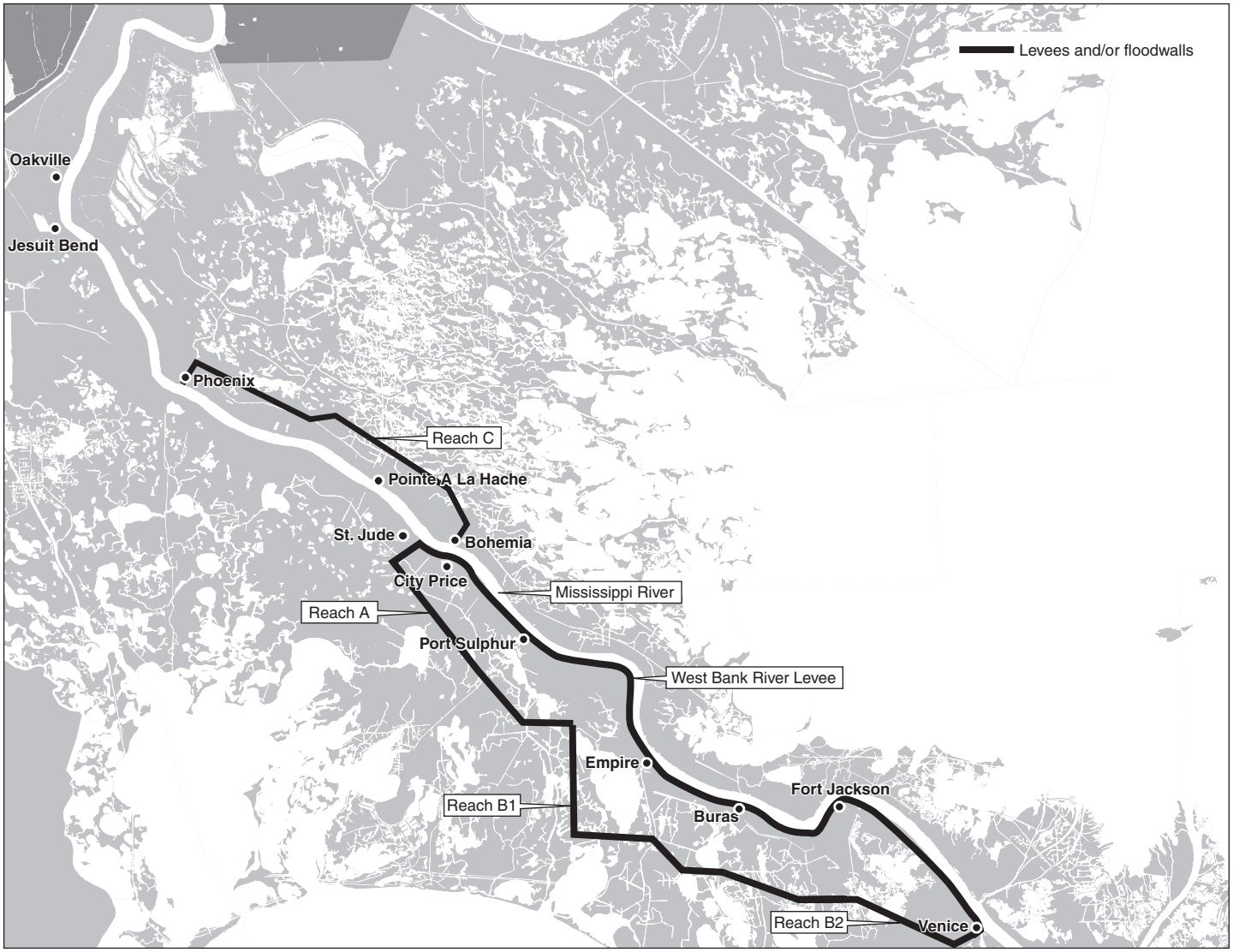
[19]Pub. L. No. 104-303, § 533, 110 Stat. 3658, 3775.

project was 2009, at an estimated cost of $908 million, of which the federal estimated share was $678 million and the estimated local sponsor share was $230 million. At the time of the storm, estimated costs to complete the remainder of the project were $225 million (this estimate has been revised to $339 million). According to a Corps official, this estimate will increase further because costs for engineering and construction have escalated in the months following Hurricane Katrina.

New Orleans to Venice, Louisiana Hurricane Protection Project

The New Orleans to Venice Hurricane Protection Project is located along the east bank of the Mississippi River from Phoenix, Louisiana—about 28 miles southeast of New Orleans—down to Bohemia, Louisiana, and along the west bank of the river from St. Jude, Louisiana—about 39 miles southeast of New Orleans—down to the vicinity of Venice, Louisiana. The project was designed to provide protection from hurricane tidal overflow from a 100-year storm and consists of 87 miles of enlarged levees built on the back side of the ring of levees (see fig. 13).

Figure 13: New Orleans to Venice, Louisiana Hurricane Protection Project



Sources: U.S. Army Corps of Engineers (data); Stanley Consultants (graphic).

Note: Reaches shown above are back levees.

This project was authorized under the River and Harbor Act of 1962.[20] At the time of Hurricane Katrina, the project was about 84 percent complete.

[20]Pub. L. No. 87-874, § 203, 76 Stat. 1173, 1184.

The pre-Katrina completion date for this project was 2018, at an estimated cost of $253 million, where the federal share was $177 million and the estimated local sponsor share was $76 million. At the time of the storm, estimated costs to complete the remainder of the project were $32 million. According to a Corps official, estimated costs to complete this project are expected to increase due, in part, to design changes.

The Corps Lacks a Comprehensive Approach for Planning and Managing the Multiple Restoration, Construction, and Future Enhancements Proposed for Southeastern Louisiana Hurricane Protection

In response to various requirements and directives from stakeholders, the Corps has already developed or is in the process of developing a number of plans and projects that will further restore, construct, and/or enhance hurricane protection for southeastern Louisiana, to make it stronger and better. Constructing these projects may take years and require billions of dollars in federal funds. However, the Corps does not have a comprehensive strategic plan to ensure that all of these efforts are effectively integrated and an implementation plan to ensure funding allocations are made in the most efficient manner possible, avoiding redundancies and misuse of resources.

In addition to the repairs and construction activities already described in prior sections of this report, a number of requirements and directives placed on the Corps over the last several months have required it to modify existing plans or develop new plans for hurricane protection in southeastern Louisiana:

- The 2006 emergency supplemental appropriation provided nearly $4 billion to the Corps to enhance hurricane protection in southeastern Louisiana.[21] Specific provisions provided $530 million for permanent pumps and closures for New Orleans' three drainage canals; $350 million for two navigable closures to prevent hurricane surge from entering the Inner Harbor Navigation Canal and the Gulf Intracoastal Waterway; $250 million to storm-proof existing interior drainage pump stations in Jefferson and Orleans parishes; $170 million to armor critical sections of New Orleans levees; and $215 million to include nonfederal levees in Plaquemines Parish into the federal system, which means the levees will be repaired and built to Corps standards and eligible for future rehabilitation. These projects are in addition to the other work described in prior sections of this report.

[21]Pub. L. No. 109-234, 120 Stat. 418, 453-55 (June 15, 2006).

- The 2006 emergency supplemental also appropriated nearly $1.6 billion to the Corps to reinforce or replace floodwalls in the New Orleans metropolitan area and provided that at least $495 million of the amounts appropriated for construction be used to raise levees for the Lake Pontchartrain and West Bank levee projects to provide a level of protection necessary to satisfy the certification requirements of the National Flood Insurance Program (often referred to as the 100-year flood standard.) In April 2006, the Federal Emergency Management Agency announced the release of new advisory flood elevations for New Orleans and the surrounding area based on a 1 percent annual chance of flooding, or a 100-year flood. The Corps' restoration plans for hurricane protection did not meet these new elevation requirements. In response, the Corps revised its plans and estimated costs to raise the height of levees and floodwalls to provide the area with a 100-year level of protection. The Corps estimated it would need an additional $4.1 billion to upgrade all of the floodwalls and raise levees to meet the new standard by 2010. The Corps' estimate included $2.5 billion to raise the height of levees in all of the New Orleans area, except for lower Plaquemines Parish, in some cases by as much as 7 feet, which included $900 million to complete other levee work in the area and upgrade or replace existing I-walls with T-walls. In lower Plaquemines Parish, the estimated cost to replace all I-walls with T-walls is $1.6 billion.

- As required by the 2006 Energy and Water Development Appropriations Act[22] and Department of Defense Appropriations Act,[23] the Corps is conducting a study of flood control, coastal restoration, and hurricane protection measures for the southeastern Louisiana coastal region. The Corps must propose design and technical requirements to protect the region from a Category 5 hurricane.[24] The two laws appropriated a total of $20 million to the Corps for this study. The Corps was required to provide a preliminary technical report to Congress by June 30, 2006 (which was issued on July 10, 2006) and a final technical report by December 30, 2007. The final study must consider alternative designs to protect against a storm surge produced by a Category 5 hurricane originating from the Gulf of Mexico. According to the Corps, alternatives being considered include a structural design consisting of a contiguous line of earthen or concrete walls along southern coastal Louisiana, a nonstructural alternative

[22]Pub. L. No. 109-103, 119 Stat. 2247 (Nov. 19, 2005).

[23]Pub. L. No. 109-148, 119 Stat. 2680, 2761 (Dec. 30, 2005).

[24]Pub. L. No. 109-148, § 5009, 119 Stat. 2680, 2814 (amending Pub. L. No. 109-103).

involving only environmental or coastal restoration measures, or a combination of those alternatives. The Corps' July 2006 preliminary technical report did not specifically identify which alternatives the Corps would recommend but instead provided a conceptual framework for both structural and nonstructural components that should be considered in developing long-term solutions for the region. Although the cost to provide a Category 5 level of protection for the southeastern Louisiana coastal region has not yet been determined, it would be in addition to the over $7 billion already provided to the Corps in the three emergency supplemental appropriations discussed in previous sections of this report.

- Finally, the Corps is responding to the findings and recommendations from the Interagency Performance Evaluation Task Force and its review of the existing hurricane protection and why it failed. For example, the task force reported that overtopping and erosion caused most breaches to levees and floodwalls and recommended armoring to prevent scour from overtopping, thereby reducing the chance of breaching. As discussed above, the 2006 emergency supplemental appropriation provided $170 million to armor critical areas on levees.

  Although the long-term solutions for southeastern Louisiana have not yet been determined and may not be decided for some time, the Corps is proceeding with over $7 billion of already authorized repair and restoration work without a comprehensive strategy to guide its efforts. Without such a strategy, we believe that the Corps may end up replicating past missteps, which occurred because it was required to follow a piecemeal approach to developing the existing hurricane protection that, according to experts, is not well integrated. For example, the draft final report issued May 2006 by the investigation team sponsored by the National Science Foundation stated (1) that there was a failure to integrate the individual parts of a complex hurricane system, (2) that insufficient attention was given to creating an integrated series of components to create a reliable overall system, and (3) that projects were engineered and constructed in piecemeal fashion to conform to incremental appropriations. In its June 2006 draft final report, the Interagency Performance Evaluation Task Force also concluded that hurricane protection systems should be deliberately designed and built as integrated systems to enhance reliability and provide consistent levels of protection.

  According to the Corps, the technical report due to the Congress in December 2007 will include the long-range strategy that will provide an integrated and comprehensive review of flood control, coastal restoration, and hurricane and storm damage reduction measures for the southeastern

Louisiana region, and the preliminary framework for this strategy is included in the report provided to the Congress on July 10, 2006. However, according to a senior Corps official, there is currently no other strategic plan in place to guide its efforts. We are concerned that the Corps has embarked on a multibillion dollar repair and construction effort in response to the appropriations it has already received, without a guiding strategic plan, and appears to be simply doing whatever it takes to comply with the requirements placed on it by the Congress and other stakeholders. Consequently, we are concerned that the Corps is once again, during this interim period, taking an incremental approach that is based on funding and direction provided through specific appropriations and is at risk of constructing redundant or obsolete structures that may be superseded by future decisions, thereby increasing the overall costs to the federal government for this project.

During the past 4 years, we reported that the Corps' planning for civil works projects were fraught with errors, mistakes, and miscalculations and used invalid assumptions and outdated data.[25] We recommended, and the Corps agreed, that an external peer review of its plans and decisions was needed, especially for high risk and costly proposed projects. In the aftermath of Hurricane Katrina, the Corps established the Interagency Performance Evaluation Task Force and used the task force's findings and lessons learned to improve its engineering practices and policies to provide hurricane protection. However, the task force is set to dissolve once its final report is released in September 2006, and the Corps has not indicated that it plans to establish another similar body to help guide its interim repair and restoration efforts, monitor progress, or provide expert advice.

Conclusions

Following Hurricane Katrina—one of the largest natural disasters in U.S. history—the Army Corps of Engineers rapidly repaired and restored almost 169 miles of damaged levees, floodwalls, and other flood control structures to prehurricane levels of protection in time for the start of the 2006 hurricane season. Now that these urgent repairs have been completed, the Corps is beginning to implement a variety of other plans to make many additional repairs and enhancements to existing southeastern Louisiana hurricane protection projects that may cost billions of dollars

[25]GAO, *Corps of Engineers: Observations on Planning and Project Management Processes for the Civil Works Program*, GAO-06-529T (Washington, D.C.: Mar. 15, 2006).

and take years to complete. Further, additional enhancements are being considered to increase the overall level of protection for the area to protect against even larger hurricanes that may add many billions of dollars and many years to the scope of the Corps efforts.

Currently, the Corps does not know what ultimate level of protection will be authorized for southeastern Louisiana and therefore cannot make strategic decisions about which components of a hurricane protection system will most effectively provide the required level of protection. Nonetheless, the Corps has been appropriated over $7 billion to continue repairs and construction on five existing hurricane protection projects in the area. However, it does not have a comprehensive strategy to guide these efforts and appears to be simply doing whatever it takes to comply with the requirements placed on it by the Congress and other stakeholders. We believe that taking such an incremental and piecemeal approach for such a complex and expensive repair and restoration project is imprudent and that, even for these interim repairs and enhancements, the Corps should be fully considering project interrelationships to avoid unnecessary duplication and redundancy, and to reduce federal costs. We also believe that relying on an independent body like the Interagency Performance Evaluation Task Force to help guide and oversee this process will help ensure that the Corps obtains objective and reliable support as it implements these authorized enhancements to the existing hurricane protection projects.

Recommendations for Executive Action

In order to construct a hurricane protection system that provides the appropriate level of protection to southeastern Louisiana and ensures the most efficient use of federal resources, we are making the following two recommendations:

The Army Corps of Engineers should develop (1) a comprehensive strategy that includes an integrated approach for all projects and plans for rebuilding and strengthening the system and (2) an implementation plan that will achieve the specific level of protection in a cost-effective manner, within a reasonable time frame.

The Army Corps of Engineers should establish an evaluative organization like the Interagency Performance Evaluation Task Force, to assist in its efforts in developing a strategic plan, monitoring progress, and providing expert advice for constructing a stronger and well-integrated hurricane protection system.

Agency Comments and Our Evaluation

We provided a draft of this report to the Department of Defense (DOD) for its review and comment. In commenting on a draft of the report, DOD concurred with our first recommendation that the Army Corps of Engineers develop (1) a comprehensive strategy to integrate projects and plans for rebuilding and strengthening hurricane protection and (2) an implementation plan that will provide a specific level of protection in a cost-effective manner within a reasonable time frame. DOD partially concurred with our second recommendation that the Army Corps of Engineers establish an evaluative organization to assist in its efforts to develop a strategic plan, monitor progress, and provide expert advice for constructing a stronger and well-integrated hurricane protection system, because it believes that a body like the Interagency Performance Evaluation Task Force is not the proper mechanism for this work. According to DOD, the Corps will rely on three teams of experts to plan and monitor the construction of a hurricane protection system. First, an independent technical review person or team will identify, explain, and comment on the assumptions underlying the Corps' economic, engineering, and environmental analyses for each project, and evaluate the soundness of Corps' models and planning methods. Second, the team currently reviewing flood control, coastal restoration, and hurricane and storm damage reduction measures for the southeastern Louisiana region will assist the Corps in developing a strategic plan for constructing a stronger and well-integrated hurricane protection system. Lastly, the Corps has assembled a Federal Principals Group consisting of senior leaders from federal agencies to guide the development of a comprehensive plan and monitor implementation of the plan. We believe that the Corps' proposal to use three external groups of experts satisfies the spirit of our recommendation. DOD's comments are included in appendix I.

We are sending copies of this report to the Honorable Donald H. Rumsfeld, Secretary of Defense, and interested congressional committees. We will also provide copies to others on request. In addition, the report will be available, at no charge, on the GAO Web site at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-3841 or MittalA@gao.gov. Contact points for our Office of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff that made major contributions to this report are listed in appendix II.

Anu Mittal
Director, Natural Resources
and Environment

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Committee on Appropriations
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Appendix I: Comments from the Department of Defense

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
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WASHINGTON DC 20310-0108

AUG 21 2006

Ms. Anu K. Mittal
Director
Natural Resources and Environment
United States Government Accountability Office
441 G Street, N.W.
Washington, D.C. 20548-0001

Dear Ms. Mittal:

This is the Department of Defense response to the GAO draft report, "Hurricane Katrina: Strategic Planning Needed to Guide Future Enhancements Beyond Interim Levee Repairs," dated July 28, 2006 (GAO CODE 360655/GAO-06-934). Comments on the draft report are enclosed.

Without endorsing the findings of your draft report, I generally agree with the recommendations that are included. However, I am concerned that the findings and conclusions do not adequately represent how the emergency need, strategic planning, and technical challenges go hand in hand in determining the best path forward. It is still an emergency situation along the Gulf Coast and the Corps of Engineers is moving forthright to re-establish lines of defense. I am extremely confident that the repair, restoration, and strengthening of the risk reduction measures for the greater New Orleans area are incorporating findings of independent review groups and assessing modifications that may be needed for the projects to function as an integrated, holistic system. The Louisiana Coastal Protection and Restoration (LaCPR) effort is also identifying risk reduction measures that can form a system that will provide enhanced protection of coastal communities and infrastructure and restore coastal ecosystems. The existing measures of repair and strengthening are essential to the ultimate survival of one of the Nation's great cities and will be integrated components of the holistic system.

Very truly yours,

John Paul Woodley, Jr.
Assistant Secretary of the Army
(Civil Works)

Enclosure

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GAO DRAFT REPORT DATED JULY 28, 2006
GAO-06-934 (GAO CODES 360655)

"HURRICANE KATRINA: STRATEGIC PLANNING NEEDED TO GUIDE FUTURE ENHANCEMENTS BEYOND INTERIM LEVEE REPAIRS"

DEPARTMENT OF DEFENSE COMMENTS
TO THE GAO RECOMMENDATION

RECOMMENDATION 1: The GAO recommended that the Army Corps of Engineers develop (a) a comprehensive strategy that includes an integrated approach for all projects and plans for rebuilding and strengthening the system; and (b) an implementation plan that will achieve the specific level of protection in a cost-effective manner, within a reasonable timeframe. (p. 41/GAO Draft Report)

DOD RESPONSE: Concur. The Corps is actively developing a comprehensive watershed strategy for hurricane and storm risk reduction for coastal Louisiana and Mississippi. We will ensure the measures for rebuilding and strengthening the hurricane projects funded with recent appropriations are integrated into the comprehensive system. This work is part of an existing project management plan that identifies the tasks, schedule, and resources required to implement the system repair and strengthening in the most timely and cost-effective manner.

The Corps has also developed a corporate framework that not only incorporates lessons learned in restoring hurricane and storm damage reduction in New Orleans, but for application in its nationwide program as well. The Corps is committed to comprehensively design, construct, maintain, and update its systems with full participation of all stakeholders. The Corps will develop a more comprehensive, probabilistic method for planning and design of systems that considers a broader variety of storm characteristics and storm generated conditions. As part of this comprehensive framework, the Corps will provide optimized engineered systems with integrated structural and non-structural risk reduction solutions, across the range of probabilistic levels of protection. The Corps is committed to continually reassess design standards, rigorously apply internal quality assurance and quality control reviews and implement an independent peer review process of appropriate planning and design documents, and make organizational changes throughout its programs to better plan, engineer, construct, operate, maintain, and manage its systems. The Corps is further committed to inform and facilitate a national dialog with stakeholders and public professionals on establishing public protection guidelines, or risk and reliability tolerances, for engineered systems. In the research arena, the Corps

will focus its efforts to improve the resilience of structures, to seek new knowledge and capabilities for updating design criteria, and to discover new approaches for creating adaptive planning and design capabilities and products.

Further, the Corps has developed a long range strategy that integrates and capitalizes on the latest results of the Interagency Performance Evaluation Task Force (IPET), the American Society of Civil Engineers' (ASCE) External Review Panel (ERP), and National Academies review. This is being incorporated with the Louisiana Coastal Protection and Restoration (LACPR) effort currently underway. This effort will be a comprehensive review of flood control, coastal restoration, and hurricane and storm damage reduction measures for the Louisiana coastal region, resulting in a technical report to Congress due in December 2007. A preliminary report was furnished to Congress in July 2006.

RECOMMENDATION 2: The GAO recommended that the Army Corps of Engineers establish an evaluative organization like the Interagency Performance Evaluation Task Force, to assist in its efforts in developing a strategic plan, monitoring progress, and providing expert advice for constructing a stronger and well-integrated hurricane protection system. (p. 41/GAO Draft Report)

DOD RESPONSE: Partially concur. The Corps of Engineers is currently assembling an external peer review group to assist in the evaluation of the recently funded repairs and modifications to the hurricane protection system and to assist in guiding the development of the comprehensive system plan. The expertise to advise the strategic planning can be brought to bear without establishing another organization.

The Corps of Engineers values the analyses and assistance being provided by the IPET as well as that of other external and independent evaluation groups. While the IPET is providing scientific and engineering answers to questions about the performance of the New Orleans hurricane and flood protection system during Hurricane Katrina it is also advising other ongoing efforts including the repair and strengthening of the system and the investigation of measures that could potentially improve the level of risk reduction. While the IPET is a successful example of the independent technical review (ITR) process that the Corps of Engineers currently employs for its projects, we do not believe it is the proper mechanism for this project.

ITR is an ongoing part of the Corps' project development process intended to confirm that technical work is done in accordance with clearly established professional principles, practices, codes and criteria. This typically includes but is not limited to: economic and environmental assumptions and projections, evaluation data, economic analyses, environmental analyses, engineering analyses (including hydrology and hydraulics, geotechnical, and structural

analyses), methods for integrating risk and uncertainty and for conducting trade-offs, and the use of models in the evaluation of engineering, economic and environmental effects. A qualified person or team not involved in the day-to-day technical work supporting the development of the project performs ITR, including experts from other agencies, universities and consultants. Due to the potential risk and the magnitude of the hurricane protection system, an external peer review by a qualified team outside of the Corps will be conducted to identify, explain and comment upon assumptions that underlie economic, engineering, and environmental analyses, as well as to evaluate the soundness of models and planning methods.

The Corps of Engineers is also employing a wide array of experts in the strategic planning as part of the LACPR effort. The Corps and the State of Louisiana have assembled a team of expert scientists and engineers from more than 30 organizations including universities, private firms, environmental organizations, State and Federal governmental agencies, and international groups.

We have also assembled a Federal Principals Group consisting of senior leaders of the applicable Federal agencies to both guide the development of our comprehensive watershed plan and monitor implementation of the plan. The purpose of the project is to identify risk reduction measures that can be integrated to form a system that will provide enhanced protection of coastal communities and infrastructure, as well as for restoration of coastal ecosystems. The scope of the project is to address the full range of flood control, coastal restoration, and hurricane protection measures available, including those needed to provide comprehensive "Category 5" protection. In addition to the experts on the team, a separate team of experts from the Corps' Hurricane and Storm Damage Reduction Center of Expertise as well as an external group of experts are providing support.

Appendix II: GAO Contact and Staff Acknowledgments

GAO Contact

Anu Mittal, (202) 512-3841 or MittalA@gao.gov

Staff Acknowledgments

In addition to the contact named above, Edward Zadjura, Assistant Director; John Delicath, James Dishmon, Doreen Feldman, Christine Frye, John Kalmar, Carol Kolarik and Omari Norman made key contributions to this report.

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