LOUISIANA COASTAL PROTECTION AND RESTORATION
FINAL TECHNICAL REPORT

NONSTRUCTURAL PLAN COMPONENT APPENDIX

June 2009

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

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I. PURPOSE AND INTRODUCTION

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

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

The purpose of this appendix is to support nonstructural plan formulation for LACPR, which is discussed in the main technical report.

Nonstructural measures are one component of an integrated system. This group of measures offers strategies for reducing exposure to storm hazards through management of development in the floodplain, in combination with, or perhaps instead of, structures such as levees and floodwalls. Nonstructural measures contribute to community resiliency through risk reduction of residential structures, commercial buildings, and especially critical facilities that provide a base for emergency response and a post-storm foothold for recovery. Nonstructural measures are one line in a multiple-lines-of-defense strategy for reducing and managing hurricane risks and for providing redundant risk reduction.

A. Authority and Guidance

Section 73 of the 1974 Water Resources Development Act states that nonstructural measures will be considered for all Federal civil works projects. The Supplemental Policy Guidance Memorandum, dated 28 Aug 2006, guidance specific to the LACPR, requires that nonstructural measures be considered with other structural and ecosystem restoration measures to create a comprehensive systems approach to risk reduction from tropical events.

The LACPR Supplemental Policy Guidance Memorandum directs the effort to:

- Integrate hurricane and storm damage reduction and coastal restoration, and include nonstructural measures.

- Coordinate all measures closely with FEMA and the Department of Interior, and utilize the USACE National Nonstructural Flood Proofing Committee.

To meet that directive the Nonstructural Flood Proofing Committee provided nonstructural plan formulation and evaluation to the LACPR effort.

B. Scope

The scope of the nonstructural analysis entails three aspects of investigation. The first aspect is a holistic evaluation of the entire southern Louisiana coast for opportunities for risk reduction to identify areas for further in-depth analysis. This broad-brush, generalized analysis establishes the maximum expected performance and cost effectiveness of nonstructural measures—demonstrating the maximum contribution that nonstructural measures could make to an overall risk reduction strategy. The intended culmination of this analysis is the creation of a programmatic approach to implement nonstructural measures in a comprehensive and systematic manner.

The second aspect of the investigation is to identify demonstration projects of specific size and location where nonstructural measures could be applied in the near-term. The development of demonstration projects requires close coordination with local communities, the State, Federal and local agencies, and supports local desires for risk reduction and economic recovery. These demonstration projects are intended to discover the challenges and opportunities that exist for future collaboration among the USACE, other agencies, and local governments in implementing nonstructural measures.

The third aspect of the nonstructural analysis is to identify public and private facilities that are critical to the health and safety of the public and to develop means whereby those facilities can be flood proofed to withstand assault from the forces of tropical events. These facilities are defined as hospitals, police and fire protection facilities, water treatment and wastewater treatment plants, public administration buildings, and schools that are highly vulnerable to risk based on their location but are important to the local communities in the aftermath of storms.

The scope of the nonstructural analysis was scaled to the time allocated, level of precision of the available data, and the spatial extent of the area of analysis. The LACPR evaluation covers a 26-parish area across the entire breadth of South Louisiana. The nonstructural analysis relies on information that was developed for the LACPR effort as a whole, such as the hydrology and structure inventory, and from secondary sources, such as delineated risk zones determined by FEMA or zones targeted for redevelopment as identified by the City of New Orleans.

Because of the gross level of analysis and the nature of the hazard in South Louisiana, two nonstructural measures are primarily applied to this analysis: buyout and/or permanent relocation of structures and raising-in-place (elevation) of structures. These measures were chosen because of their direct applicability to risk reduction in light of the hazards produced during coastal storm events. They were also chosen because these measures are directly implementable by the USACE with local sponsor participation. Although these two measures were applied to the majority of structures in the study area, other nonstructural measures, such as flood proofing, berms and walls, were considered and applied as appropriate. Additionally, other nonstructural measures would entail initiation and implementation by local governing entities, such as changes to land use regulations.

II. NONSTRUCTURAL MEASURES

Nonstructural flood proofing measures as applied within the USACE planning arena can be defined as any combination of structural or nonstructural changes or adjustments incorporated in the design, construction, or alteration of individual structures or properties that will reduce flood damages. Simply stated, flood proofing includes any effort to reduce flood damage to individual structures and their contents. The term "nonstructural" is used in this report to distinguish Federal actions from the traditional larger Federal structural measures considered for risk reduction.

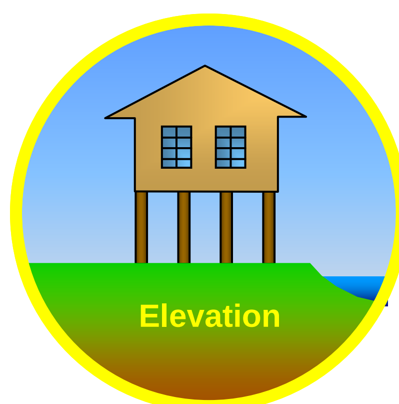
A. Variety

Nonstructural measures remediate risk, not by altering the nature of the hazard, but by removing vulnerable people and property from the storm and flood threat or by protecting vulnerable assets by actions taken to those assets. Nonstructural measures include wet and dry flood proofing, flood warning, raising-in-place from lifting on pilings or on fill, relocations of property improvements, and buyouts of properties. Except for flood warning systems, nonstructural measures generally take effect on privately-owned property and require that the non-Federal sponsor take an active role in implementation.

Flood proofing measures either reduce the number of times the structure is flooded or limit the potential damage to the structure and its contents when it is flooded. There are four general approaches to flood proofing:

- Elevating the structure.
- Relocating the structure.
- Constructing barriers such as floodwalls or berms to stop floodwaters from damaging the structure.
- Modifying the structure through flood proofing and relocating contents to minimize flood damage.

1. Elevation

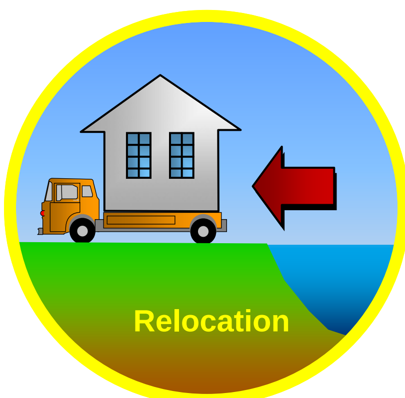


Elevation involves raising structures in place so that the lowest floor is above the flood level for which flood proofing protection is designed. The building is raised and set on a new or extended foundation. Temporary living expenses may be paid to the property owner as needed during the elevation process.

2. Relocation and Buyout

Buying out or relocating a structure is the most dependable way to flood proof. Buyouts entail selling the structure to the non-Federal sponsor for demolition or salvage, evacuating the property, and relocating the property owner to another site outside the 100-year floodplain.

In addition to receiving fair market value for the property acquired, owners of real property acquired for Federal projects are entitled to receive relocation assistance under Public Law 91-646, the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970. Such assistance generally consists of a replacement housing payment and payment for moving expenses. A displaced homeowner may receive up to $22,500 in supplemental housing assistance to acquire a comparable replacement dwelling over the acquisition price of their property. Generally the replacement housing payment is the difference between the fair market value of the home acquired and the cost to acquire a comparable home at a site with reduced flood risk, typically outside the 100-year floodplain. The displaced homeowner is entitled to decent, safe, and sanitary accommodations as part of relocation assistance.



Property relocation involves lifting and moving the flood-prone structure to another location away from flood hazards. This process involves physically moving the improvement to a site outside the floodplain. Temporary relocation assistance is provided as part of the cost of relocating structures.

3. Small Floodwalls and Berms (with/without Closures)

Small floodwalls and berms are located away from the structure to be protected and prevent the encroachment of floodwaters. They may completely surround the structure or protect only the low side of the property. These small structures are distinguished from large public investments by their scale and location on privately-owned land. Unlike some other flood proofing measures, a well-designed and constructed freestanding floodwall or berm results in no floodwater forces on the structure itself. Consequently, as long as the floodwall or berm is not overtopped or otherwise failed, the structure is not exposed to damaging hydrostatic or hydrodynamic forces. With these kinds of measures, there is no need to make structural alterations to the building or structure to be protected. These measures require installation of a sump pump or other feature to drain seepage water flowing through or under the berm or floodwall, and rainwater falling inside the berm or floodwall.

4. Dry Flood Proofing

Dry flood proofing involves sealing the walls of structures such as buildings with waterproofing compounds, impermeable sheeting, or other materials and using closures for covering and protecting openings from floodwaters. Dry flood proofing is most applicable in areas of shallow, low-velocity flooding.

Dry flood proofing has limited applicability depending on flood depth, hydrodynamic forces, and building type. Conventionally constructed brick veneer on a wood frame or concrete block walls should not be flood proofed above a height of 3 feet because of the danger of structural failure from hydrostatic forces. Residential construction is not dry flood proofed as a matter of policy.

5. Wet Flood Proofing

If dry flood proofing is impossible or too costly, another option is wet flood proofing, which allows the structure to flood inside while ensuring minimal damage to the building and any contents. By allowing the force of the water to pass through a building, the interior flooding allows hydrostatic force on the inside of the building walls to equally counteract the hydrostatic force on the outside, thus eliminating the chance of structural failure. Wet flood proofing is most applicable to nonresidential buildings such as high-rise office buildings where the ground floor can be converted to an open lobby while other building uses are elevated to upper floors.

B. Flood Proofing Matrix

A flood proofing matrix (**Table 1**) has been included in this appendix to better associate the relationship of flood characteristics, site characteristics, and structure characteristics to the applicability of particular flood proofing measures. Aspects of the matrix are described as follows:

<u>Flooding characteristics</u>. This characteristic addresses four basic phenomena of floods: flood depth, flood velocity, warning time prior to a flood event, and the presence of ice and debris. Each of these flood characteristics is critical when applying the appropriate measure to mitigate flood effects.

Site characteristics. This characteristic addresses two basic site issues: (1) flooding, either coastal or riverine and (2) soil type, either permeable or impermeable. Coastal locations, especially at a beachfront location, dictate the use of site specific measures more so than does riverine flooding. Soil type becomes an issue if the soil has high permeability which excludes certain measures from consideration.

Building characteristics. Structure foundation, structure construction, and structure condition are very important elements for consideration when applying nonstructural measures. These factors, especially structure condition and structure foundation, dictate the appropriate use of various nonstructural measures.

National Economic Development (NED), National Ecosystem Restoration (NER), Recreational Opportunities and Social Characteristics. These characteristics deal directly with issues relative to the ability to implement and the impacts of implementing a flood damage reduction measure. Issues such as cost and the factors of cost such as flood insurance, emergency response, and disaster relief are important elements for consideration. Hydrologic and environmental impacts; potential for induced development; compatibility with ecosystem restoration or recreation uses; and population impacts are also important considerations for nonstructural measure implementation.

Table 1. Flood Damage Reduction Matrix

		FLOOD DAMAGE REDUCTION MEASURES																		
		NON-STRUCTURAL MITIGATION MEASURES															STRUCTURAL MITIGATON MEASURES			
														NFIP						
FLOOD DAMAGE REDUCTION MATRIX		Elevation on Foundation Walls	Elevation on Piers	Elevation on Posts or Columns	Elevation on Piles	Elevation on Fill	Relocation	Buyout/ Acquisition	Floodwalls and Levees	Floodwalls and Levees with Closures	Dry Flood Proofing	Wet Flood Proofing	Flood Warning Preparedness	Flood Plain Regulation	Flood Insurance	Flood Mitigation 1	Channel	Levee/Wall	Dams	Diversions
Flooding Characteristics	**Flood Depth**																			
	Shallow (<3 ft)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Moderate (3 to 6 ft)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Deep (greater than 6 ft)	Y	N	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Flood Velocity																			
	Slow (less than 3 fps)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Moderate (3 to 5 fps)	N	N	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y
	Fast (greater than 5 fps)	N	N	N	Y	N	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y
	Flash Flooding																			
	Yes (less than 1 hour)	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y
	No	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Ice and Debris Flow																			
	Yes	N	N	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y
	No	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Site Characteristics	**Site Location**																			
	Coastal Flood Plain																			
	Beach Front	N	N	N	Y	N	Y	Y	N	N	N	N	Y	Y	Y	Y	N	[2]	N	N
	Interior (Low Velocity)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	N
	Riverine Flood Plain	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Soil Type																			
	Permeable	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Impermeable	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Building Characteristics	**Structure Foundation**																			
	Slab on Grade	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Crawl Space	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Basement	Y	N	N	N	N	Y	Y	Y	Y	N	Y	Y	y	Y	Y	Y	Y	Y	Y
	Structure Construction																			
	Concrete or Masonry	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Metal	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Wood	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Structure Condition																			
	Excellent to Good	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Fair to Poor	N	N	N	N	N	N	Y	Y	Y	N	N	Y	Y	Y	[3]	Y	Y	Y	Y
NED/NER/Recreation/Social Characteristics	**Economic**																			
	Structure Protected	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	[5]	N	Y	Y	Y	Y	Y
	Cost to Implement	M	M	M	M	M	H	H	M	M	L	L	L	L	L	H/M	H	H	H	H
	Potential Flood Insurance Cost Reduction (Residential)	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	Y	-	Y	Y	Y	Y	Y
	Potential Flood Insurance Cost Reduction (Commercial)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	-	Y	Y	Y	Y	Y
	Potential Adverse Flooding Impact on Other Property	N	N	N	N	Y	N	N	Y	Y	N	N	N	Y	N	N	Y	Y	Y	Y
	Reduction in Admin Costs of NFIP	N	N	N	N	Y	Y	Y	N	N	N	N	N	[6]	-	[3]	[7]	[7]	[7]	[7]
	Reduction in Costs of Disaster Relief	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Reduction in Emergency Costs	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	[3]	Y	Y	Y	Y
	Reduction in Damage to Public Infrastructure	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	[3]	Y	Y	Y	Y
	Potential for Catastrophic Damages if Design Elevation Exceeded	N	N	N	N	N	N	N	Y	Y	Y	N	N	N	N	N	N	Y	Y	N
	Promotes Flood Plain Development	N	N	N	N	N	N	N	N	N	N	N	N	N	[8]	N	Y	Y	Y	Y
	Environmental																			
	Ecosystem Restoration Possible	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N
	Potential Adverse Environmental Impact	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	Y	Y
	Recreation																			
	Recreation Potential	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	[3]	N	N	Y	N
	Social																			
	Community Remains Intact	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	[4]	Y	Y	Y	Y
	Population Protected	N	N	N	N	N	Y	Y	N	N	N	N	Y	N	N	[3]	Y	Y	Y	Y
	Potential Structure Marketability Increase	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	[5]	N	Y	Y	Y	Y	Y

[1] NFIP Flood Mitigation may vary but it is usually buyout/acquisition
[2] Not generally recommended
[3] Buyout/acquisition only
[4] Elevation only
[5] Post Flood Insurance Rate Map construction only
[6] Post FIRM structures elevation on fill
[7] Yes, if project provides 100 year or greater protection
[8] Yes, if in floodplains less frequent than the 100-year
Y – Yes
N – No
L – Low
M – Medium
H – High

C. Characteristics

An advantage of nonstructural measures includes the flexibility of their scale. Nonstructural measures can be implemented incrementally, on a structure-by-structure basis, or programmatically, across whole neighborhoods or communities. Also little time is required to implement nonstructural measures as compared with implementation of large-scale structural measures. The benefits of nonstructural measures are realized immediately upon implementation to each structure affected.

Nonstructural measures are differentiated from structural measures in that they are affected generally to privately-owned land whereas structural measures are implemented on publicly-held land that has been acquired by a non-Federal sponsor. Nonstructural measures can be either implemented voluntarily or mandatorily based on the political will of the non-Federal sponsor. Nonstructural measures, such as buyouts and relocations, can provide opportunities for alternate uses of the vacated floodplain, such as ecosystem restoration, recreational development, or urban green space if sufficient contiguous parcels are purchased for evacuation.

All nonstructural flood proofing measures can be effective in reducing damages from floods for which the measure was designed. However, the only way to ensure complete safety from storm or flood risk is either through buyout and demolition of structures or relocating structures to a site outside the floodplain.

D. Contribution to Systems Approach – Redundancy and Resiliency

Redundancy of risk reduction measures is a critical aspect of a hurricane risk reduction system. Nonstructural measures can function in combination with other risk reducing structural or ecosystem restoration measures to provide multiple lines of defense for the region. While structural components of the system are intended to provide a reduction in damages from storm surges, a complementary system of nonstructural measures can facilitate post-storm recovery in the event that the structural components are exceeded. Nonstructural measures reduce the adverse consequences when storm flooding does occur. As a redundant feature, nonstructural measures contribute to management of the risk of interior flooding, whether from rainfall or from hurricane surges exceeding the channel capacity, levees and floodwalls. An added benefit of this redundant system is found in the timing of implementation. Because nonstructural measures can typically be implemented in less time, they would reduce flood risk prior to completion of structural measures. Upon completion of the structural measures, the combined measures would provide redundancy to the risk reduction system.

Nonstructural measures also contribute to the resiliency of the communities in the region. Through a program of nonstructural activities, homes and businesses would be flood proofed, relocated or elevated and critical facilities would be designed and constructed with hardened features. Through these measures the region would improve its ability to recover from storm events. The integration of structural, nonstructural, and ecosystem restoration measures creates a redundant system that contributes to community resiliency.

III. NONSTRUCTURAL PLAN FORMULATION

Nonstructural measures were formulated at the planning unit or watershed level across the LACPR planning area. Scales of measures were formulated at target levels of risk reduction for the LACPR evaluation which were established at the 100-year, 400-year, and the 1000-year stages. In compliance with the planning objectives for LACPR, nonstructural measures were formulated with the primary goal of reducing risk (limiting exposure) to population and property and with a secondary goal of managing risk to critical facilities.

The physical aspects of storms are a major consideration when formulating nonstructural measures at specific sites. Certain nonstructural measures function better given defined flooding conditions or when other interests are a consideration. For example, the only nonstructural measure that is reliable under high-velocity surge conditions is buyout of property and permanent evacuation of the population at risk. Conversely, flood proofing, such as raising-in-place either on fill or piers, works well for low-velocity flooding conditions. Raising-structures-in-place is effective when an interest exists in maintaining a local tax-base and when flooding conditions and structural integrity warrant its application, so long as elevating does not put the structure at further risk in the wind field. Also relocation of structures and population into clusters at flood-free sites can address both risk reduction and community cohesion concerns. There exist situations where it is infeasible to achieve a secure level of risk reduction. In such cases, managing risk can be achieved by flood proofing assets in place such as to facilities critical to the health and safety of the resident population.

For purposes of the LACPR plan formulation, two nonstructural measures, buyouts/relocations and raising-in-place, were investigated based either on the severity and nature of the risk or the expectation that redevelopment in the aftermath of Hurricanes Katrina and Rita would allow for building construction modifications, such as raising the flood threshold of buildings to targeted levels of risk reduction. Although these two measures were applied to the majority of structures in the study area, other nonstructural measures, such as flood proofing, berms and walls, were considered and applied as appropriate with regard to specific demonstration projects.

If a building is subject to flooding depths greater than 3 feet, elevating or relocating the structure are the most effective measures of flood proofing. Dry flood proofing is not appropriate because water depths greater than 3 feet may cause a hydrostatic force large enough to render structural damage or cause walls to collapse unless the building has been designed to accommodate such forces. Flood proofing with berms and floodwalls for depths less than 3 feet can be undertaken, but it may require devices to control seepage under the berm or floodwall.

A. Objectives for Nonstructural Plan Formulation

The primary objective of the LACPR effort is to reduce overall risk to population and economic assets from tropical events along the Louisiana coast while trying to preserve or restore the wetlands. Generally risk can be described as the product of exposure, defined as vulnerable people or assets, and the probability of occurrence of a threat resulting in undesirable consequences to people and assets at risk. Protective measures can be formulated to reduce risk from tropical events in two ways, either by reducing the probability of the adverse consequences of the occurrence or by reducing the exposure to the occurrence thereby reducing the consequences themselves. Structural measures are formulated to reduce risk by increasing protection with physical structures such as barriers and levees that are designed to withstand the onslaught of a tropical event. Nonstructural measures are formulated to reduce the exposure to the threat by either elevating or removing vulnerable people and assets away from the threat. This approach to nonstructural plan formulation is applied to the formulation and evaluation of measures for the LACPR effort.

As stated, the primary objective of nonstructural plan formulation for LACPR is to reduce risk to population and assets in combination with wetland restoration. Secondary goals of the nonstructural analysis are to manage risk to critical facilities and, also, to manage residual risk to population and assets following some Federal action.

Additional objectives of the nonstructural demonstration projects are as follows:

1. Demonstrate to governments, agencies, and residents of South Louisiana that nonstructural measures can be implemented by the USACE to reduce risk associated with hurricane storm surge and flooding; and
2. Demonstrate that non-Federal sponsors exist who support implementation of nonstructural measures.

In order to truly maximize opportunities to reduce storm surge and flood risk across South Louisiana from hurricanes, it is imperative that all “tools,” structural, nonstructural, and coastal restoration, be implemented where appropriate based on cost effectiveness and potential for risk reduction.

B. Planning and Evaluation Assumptions

Some basic assumptions are necessary to complete the plan formulation and evaluation of nonstructural measures. These assumptions apply mostly to the overall effort, but bear repeating for this appendix. These assumptions are as follows:

1. The Fourth Emergency Supplemental work to the metropolitan New Orleans levee system is assumed to be complete and to provide uniform risk reduction from the 100-year event. This defines the near-term without project base condition for LACPR.

2. This effort assumes that all new development, during the reconstruction post-2005 hurricanes, conforms to base floor elevations established for compliance with the National Flood Insurance Program (NFIP). Economic damages projected over the project life from future development will reflect NFIP compliance.

3. For the purpose of this initial effort, the assumption is that all property owners will participate in the nonstructural measure proposed and the commensurate level of risk reduction will be realized. For consistency, relocation assistance is included as a cost component of nonstructural buyout measures. This assumption is consistent with the performance assumption of structural measures, i.e., 100 percent performance with full reliability, and, therefore, allows for an unbiased comparison of performance and cost effectiveness with structural measures.

4. The economic analysis is based on second quarter 2005 and 2050 conditions which were projected to the census block level from population growth estimates and redevelopment assumptions that were applied to the entire planning area. The housing inventory is assumed to mirror the resident population with no allowances for vacant and abandoned structures. The reader is referred to the *Economics Appendix* for a full description of the referenced method and the development of the structure inventory. However, a brief summary of the population and land use scenarios follows:

   Projections of population, number of households, and total non-agricultural employment for each of the five Metropolitan Statistical Areas (MSAs), New Orleans, Baton Rouge, Houma, Lafayette, and Lake Charles, and for each of the non-MSA parishes in southern Louisiana were developed for two future development scenarios: "high employment" and "business as usual." The projections considered factors such as net migration of population, employment demand by sectors of the economy, distribution of personal income, and residential construction patterns to project population, number of households, and non-agricultural employment for the period 4th Quarter 2005 through the year 2075.

   Two land use allocation scenarios (compact and dispersed) were also developed for each future development scenario. The specific location of the future development was primarily based on the existing and projected transportation systems in each area. However, other factors, including current and projected commercial activity, land elevation, susceptibility to flooding and other hazards, and environmental constraints such as wetlands, were also considered. The projected location and types of residential dwelling units varied under each of the two land use allocation scenarios.

   The "high employment" future development scenario was combined with the dispersed land use allocation scenario as the first future economic development scenario, and the "business as usual" future development scenario was combined with the compact land use allocation scenario as the second future economic development scenario. The "high employment" future development with dispersed land use allocation was considered the scenario with the highest damage or residual risk potential, while the "business as usual" future development with compact land use allocation was considered the lowest potential damage or residual risk scenario. These two economic development scenarios were combined with two relative sea level rise projections to calculate the range of potential damage or residual risk throughout the period of analysis.

5. The period of analysis for all alternatives is from 2010 to 2075. Metric values (e.g. costs, impacts, etc.) are compounded or discounted to 2025 as the common base year for comparison of alternatives. Year 2025 also constitutes the first year in which full benefits are expected to be realized from nonstructural measure implementation. Nonstructural measures are expected to be implemented uniformly over a 15-year period, from 2010 to 2025.

6. The fiscal year 2008 discount rate of 0.04875 applies to the LACPR evaluation.

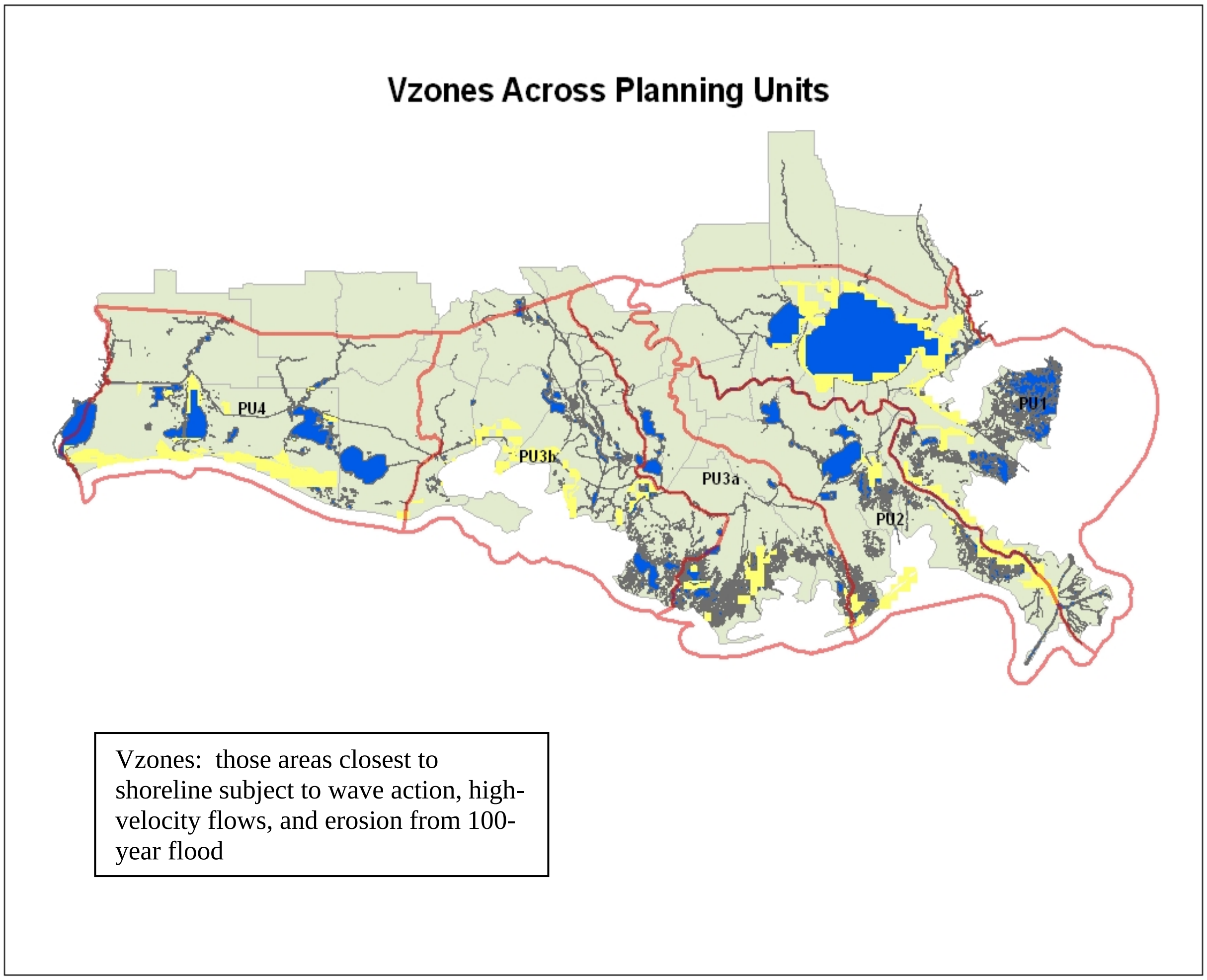
C. Applied Concepts

In order to evaluate risk with regard to storm surge, the concept of risk must be defined in a practical way so that metrics can be applied and plans be formulated in response to risk reduction. For the purposes of the nonstructural analysis, indicators of high risk from tropical events are defined as storm surge velocity and depth of flood inundation.

1. Storm Surge Velocity

Areas exposed to storm surge velocity, where the storm surge moves with great force, are defined by FEMA as those areas closest to shoreline subject to wave action, high-velocity flows, and erosion from a 100-year (1 percent annual chance) flood. The speed at which floodwaters move, i.e., velocity, is normally expressed in terms of feet per second. As floodwater velocity increases, hydrodynamic forces are added to the hydrostatic forces from the depth of still water, significantly increasing the possibility of structure failure. Greater velocities can quickly erode or scour the soil surrounding structures. These fast-moving waters can also induce failure by erosion, as their impact may move a structure from its foundation. When floodwater velocities exceed 3 feet per second and depths exceed 3 feet, it becomes difficult, if not impossible, for adults to maintain their balance while walking through a flooded area. For the purposes of this analysis, structures located in areas designated by FEMA as possessing high velocity flow characteristics with storm surge, Vzones, are subject to buyout and relocation assistance. **Figure 1** shows the location of velocity zones within the LACPR planning area.

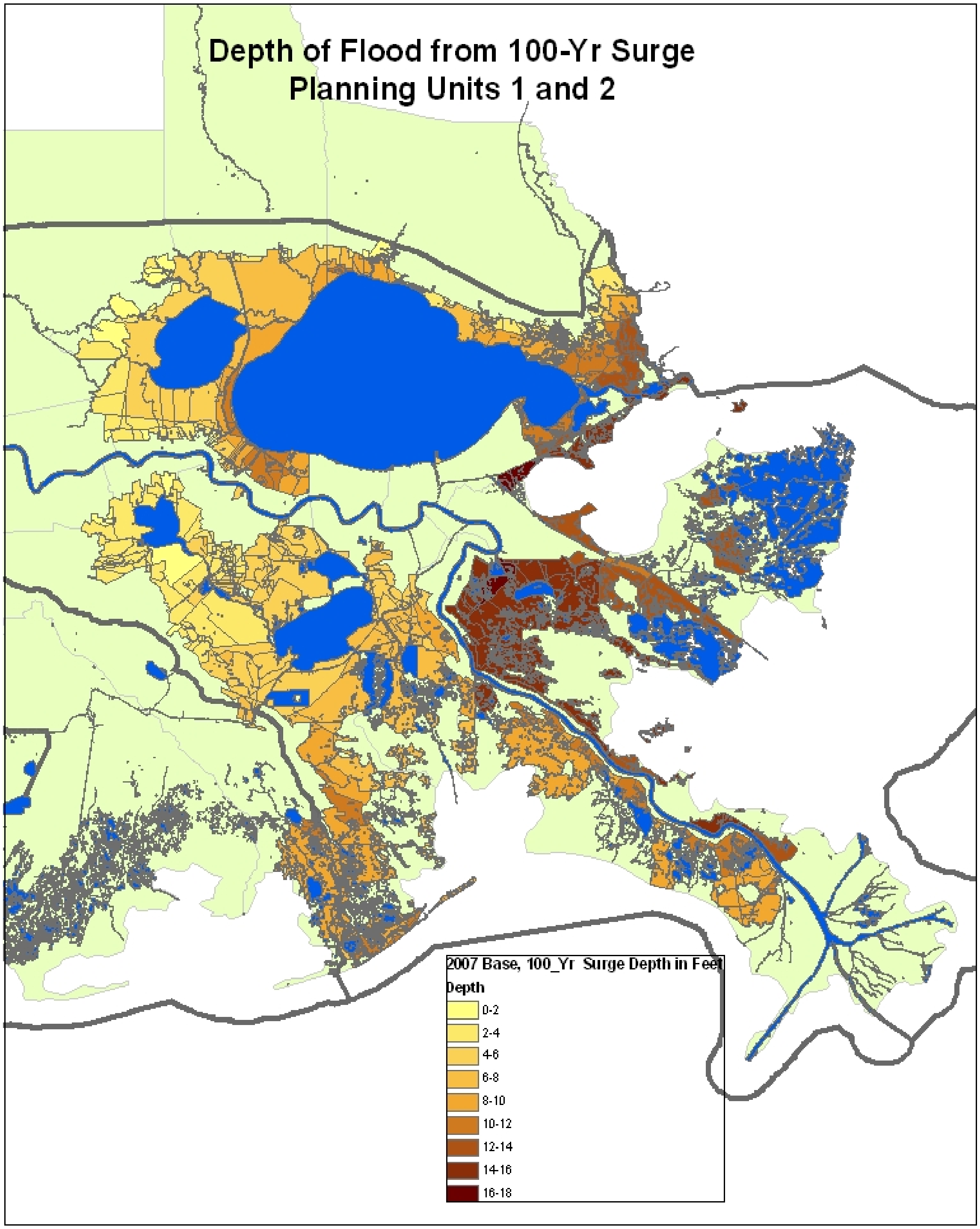
Figure 1. Location of Velocity Zones within the LACPR Planning Area



2. Depth of Flood Inundation

Areas of high risk to people and assets are also those areas where flood depths are high. The concept of risk was further defined with the determination of flood depths for the 100-year, the 400-year, and the 1000-year events. **Figure 2** shows the depth of flood inundation across Planning Units 1 and 2 of the LACPR planning area for a 100-year event. Flood stages were developed by the New Orleans District following established engineering principles and models, which are described in detail in the *Hydraulics and Hydrology Appendix*.

Figure 2. Depth of Flooding in Planning Units 1 and 2 for 100-year Event



D. Applying Decision Criteria to Plan Formulation

The formulation of nonstructural measures was based on the following decision criteria:

1. ***Storm surge velocity***: Areas noted as "high-velocity" Vzones by FEMA were investigated for population and property with the intent of reducing or eliminating exposure using buyout and permanent relocation. Velocity zones (Vzones) were spatially associated with census blocks to identify areas of high risk. Census blocks were identified and combined for processing using ESRI ArcMap software and the New Orleans District's economic spatial database. Outputs of the processing were an estimate of number of structures and the population flooded by various events as well as an estimate of damages to economic assets from those flood events. These areas were targeted for relocation/permanent evacuation based on the established decision criteria. Therefore, benefits and costs were developed for relocations to the 2010 structure inventory for the designated census blocks falling within FEMA's Vzones. A major assumption of the economic analysis is that property development will return over time to at least pre-Katrina levels by the year 2075 including those properties within the Vzones. Buyouts of these areas would eliminate risk to people and assets. In order to accomplish this, the cost of buying vacant lots projected to be developed over time was added to the cost of buying improved property as of 2010. The value of the vacant land was used as a proxy value for purchase of perpetual, restricted use easements for the vacant lots projected for development. Buyout of velocity zones is a nonstructural measure that was combined with all other nonstructural measures as a separate component.

2. ***Depth of inundation:*** Depth of inundation was applied as another indicator of risk. Areas of flood inundation were investigated for nonstructural measures such as raising-in-place for depths of inundation less than 14 feet. Where inundation depths are 14 feet or higher, buyout/permanent evacuation measures apply. FEMA publication, "Recommended Residential Construction for the Gulf Coast: Building on Strong and Safe Foundations," FEMA 550, April 2006, offers the rationale for the raising-in-place criterion decision. This manual contains closed foundation designs for elevating homes up to 8 feet above ground level and open foundation designs for elevating homes up to 15 feet above ground level. These upper limits are a function of constructability limitations and overturning and stability issues for more elevated foundations. Each census block in the planning area was assigned a hydrologic profile based on its location within a planning subunit. Planning subunits were developed to distinguish significant differences in the hydrologic condition across the projected area of inundation. Depth of inundation was calculated by census block based on the water surface of each hydrologic event when compared against the mean ground elevation of the census block. Flood depths, i.e., depth of flooding from the ground to the top of the water, from the 100-year, the 400-year, and the 1000-year events were aggregated into practical ranges of 2 feet or less, 3–6 feet, 7–13 feet, and 14 feet and higher.

Census blocks identified to be flooded 2 feet or less were removed from further consideration based on the assumption of negligible damage based on the assumption of an average 2-foot floor correction above ground. Census blocks identified as flooding 3 – 13 feet qualified for raising-in-place with the expectation that the integrity of the structures would be determined during the implementation phase of the project. Those census blocks that experienced depths of flooding of 14 feet or greater qualified for buyouts/permanent evacuation based on the decision criterion that lifting a structure above 13 feet would elevate it into an undesirable wind field and would violate the recommendations in FEMA publication 550. The nonstructural analysis used an upper limit of 14 feet for elevation because of the uncertainty of where the bottom of the lowest horizontal member of the structure frame might actually be. Using 14 feet as the upper limit was considered to be a conservative approach to the analysis but could be refined in subsequent studies. Different midpoint values for raising-in-place were used for estimating costs for elevating 3-6 and 7-13 feet.

The final two decision criteria should be considered during an implementation phase. These elements require more precise information and interagency coordination than is available during the generalized plan formulation phase.

3. ***Structural integrity:*** Determination of whether structures possess the integrity to be lifted or retrofitted for nonstructural measures would be determined in an implementation phase. The issue of structural integrity is a structure-specific metric that will not be known until more detailed planning is required for specific nonstructural project implementation. The economic database with which nonstructural measures were formulated and evaluated assumes that the structures in existence in 2010 are habitable because they reflect the resident population expected at that time. No allowance is made in the database for unoccupied, dilapidated, abandoned, or vacant housing. The corollary to this database assumption is that all structures evaluated over time possess the integrity to be raised since they are inhabited. Benefits and costs for raising structures assume full integrity.

4. ***Other agency involvement***: Implementation priority would be given to areas where the potential to collaborate with other agencies is high and nonstructural measures are compatible with other Federal, State, or local initiatives such as ecosystem restoration, FEMA acquisitions, or local initiatives for preserving communities/living cultures.

E. Methodology and Data

The level of detail for this nonstructural analysis deviates from a traditional nonstructural analysis. Usually, nonstructural measures rely on information more specific to individual structures and are more responsive to the particular characteristics of the structure and the flood threat. A structure-by-structure inventory with explicit data elements would have been the preferred database for a nonstructural analysis but the breadth of the evaluation and the time allocated to the nonstructural effort precluded creation of such a database. As an example, the potential size of a structure inventory covering all of South Louisiana exceeds one million structures and would take several years to develop to the preferred level of detail. Rather, the nonstructural plan formulation is based on the New Orleans District database developed for the structural plan evaluation. The level of detail within the current economic database is commensurate with the conceptual level of nonstructural plan formulation deemed appropriate for the LACPR evaluation.

The LACPR structure database has its foundation based on the year 2000 U.S. Census data with structure characteristics, such as number, type, value, and elevation estimated at the block level. Census blocks are roughly equivalent to city blocks. There are approximately 72,000 census blocks covering the entire planning area. While the LACPR structure database lacks the level of specificity generally desired for nonstructural measure formulation, it is considered appropriate for purposes of this evaluation for identifying target areas for further in-depth analysis and for assessing the measures' maximum performance.

The demonstration projects are formulated and evaluated based on the traditional approach of a structure-by-structure inventory with explicit detail collected for each structure. The critical facilities information is derived from a spatially-referenced database which identifies the type and location of facility from Federal Emergency Management Agency's (FEMA's) Hazards U.S. Multi-Hazard (HAZUS-MH) database.

The format employed for the data analysis is compatible with the industry standard, ESRI ArcGIS, and data consisted of spatially referenced census block information, hydrology, and FEMA flood maps. A customized GIS spatial database similar to the one used by the Interagency Performance Evaluation Team (IPET) for the Hurricane Katrina IPET Report was used to accumulate data and assess damages to residential and non-residential structures, their contents, and vehicles in the LACPR planning area. The database was used to develop a water elevation-, or stage-, damage relationship for each census block in the LACPR planning area. Inputs to the database include elevation data, depreciated exposure values of residential and nonresidential structures, and depth-damage relationships. Hydrologic data were combined with stage-damage functions to estimate damages from various storm events.

Outputs from processing the database included damages to economic assets from various probabilistic storm events and the projected population and number of structures flooded by each event. A detailed description of the database and its attributes can be found in the *Economics Appendix*.

IV. Nonstructural Measures Identified for Evaluation

A. Stand Alone Measures

Using the decision criteria previously described, planning units were evaluated for depth of inundation based on base condition hydrology. Stand alone nonstructural plans were formulated with the following measures for all planning units.

1. Buyout of delineated FEMA velocity zones across each entire planning unit.
2. Buyout of all structures within census blocks not in velocity zones which demonstrate a depth of inundation from the ground of 14 feet or greater across each entire planning unit.
3. Raise-in-place for all structures in census blocks which demonstrate a depth of inundation between 3 and 13 feet from the ground across each entire planning unit.

Stand alone nonstructural plans with these combined measures were formulated for three levels of risk reduction from 100-year, the 400-year, and the 1000-year events. By applying this method a uniform level of risk reduction is achieved across each planning unit at three levels of risk reduction.

Table 2 demonstrates the distribution of structures evaluated for nonstructural measures based on the criteria described.

Table 2. Distribution of Structures Impacted by Stand Alone Measures

Distribution of Structures Impacted by Stand Alone Nonstructural Measure Level of Risk Reduction (LORR), Planning Unit, and Growth/Development Scenario

	100yr LORR		400yr LORR		1000yr LORR	
Planning Unit 1	count	percent	count	percent	count	percent
Compact Business as Usual	27,996	100%	160,724	100%	205,273	100%
Structures to be Bought Out	5,036	18%	8,453	5%	23,776	12%
Structures to be Raised in Place	22,960	82%	152,271	95%	181,497	88%
Dispersed High Employment	50,264	100%	219,381	100%	286,387	100%
Structures to be Bought Out	10,472	21%	15,649	7%	44,296	15%
Structures to be Raised in Place	39,792	79%	203,732	93%	242,091	85%
Planning Unit 2						
Compact Business as Usual	18,931	100%	128,761	100%	131,720	100%
Structures to be Bought Out	4,215	22%	16,621	13%	22,975	17%
Structures to be Raised in Place	14,716	78%	112,141	87%	108,745	83%
Dispersed High Employment	25,427	100%	168,124	100%	171,995	100%
Structures to be Bought Out	5,777	23%	23,085	14%	34,357	20%
Structures to be Raised in Place	19,650	77%	145,039	86%	137,638	80%
Planning Unit 3a						
Compact Business as Usual	35,485	100%	53,228	100%	59,484	100%
Structures to be Bought Out	614	2%	6,184	12%	9,748	16%
Structures to be Raised in Place	34,872	98%	47,043	88%	49,736	84%
Dispersed High Employment	43,637	100%	63,499	100%	69,579	100%
Structures to be Bought Out	738	2%	7,695	12%	12,747	18%
Structures to be Raised in Place	42,899	98%	55,804	88%	56,832	82%
Planning Unit 3b						
Compact Business as Usual	12,947	100%	22,358	100%	30,835	100%
Structures to be Bought Out	903	7%	957	4%	1,307	4%
Structures to be Raised in Place	12,044	93%	21,401	96%	29,528	96%
Dispersed High Employment	13,157	100%	24,378	100%	32,970	100%
Structures to be Bought Out	846	6%	907	4%	1,307	4%
Structures to be Raised in Place	12,311	94%	23,471	96%	31,663	96%
Planning Unit 4						
Compact Business as Usual	10,157	100%	16,957	100%	25,341	100%
Structures to be Bought Out	2,250	22%	2,509	15%	3,150	12%
Structures to be Raised in Place	7,907	78%	14,448	85%	22,191	88%
Dispersed High Employment	10,510	100%	19,387	100%	29,906	100%
Structures to be Bought Out	2,248	21%	2,547	13%	3,146	11%
Structures to be Raised in Place	8,262	79%	16,841	87%	26,760	89%
All Planning Units						
Compact Business as Usual	105,516	100%	382,028	100%	452,653	100%
Structures to be Bought Out	13,017	12%	34,724	9%	60,957	13%
Structures to be Raised in Place	92,499	88%	347,304	91%	391,696	87%
Dispersed High Employment	142,995	100%	494,768	100%	590,838	100%
Structures to be Bought Out	20,081	14%	49,882	10%	95,854	16%
Structures to be Raised in Place	122,913	86%	444,886	90%	494,984	84%

Depending upon the planning unit, growth/development scenario, and level of risk reduction, buyouts comprise at most 23% of the structures impacted (Planning Unit 2, Dispersed High Employment, 100-year level of risk reduction) and as low as 2 % of the structures impacted (Planning Unit 3a, Compact, Business as Usual, 100-year level of risk reduction).

Overall, of the 143,000 structures impacted by the stand alone nonstructural measure providing a 100-year level of risk reduction across all the planning units, 14% (20,000) are buyouts; of the 495,000 structures impacted by nonstructural measure providing a 400-year level of risk reduction, 10% (50,000) are buyouts, and of the 591,000 structures impacted by the 1000-year stand alone nonstructural measure, 16% (96,000) are buyouts. Therefore, raising-in-place is the major contributor to risk reduction for nonstructural measures with the greatest potential for protecting economic assets. Raising structures in place would also provide redundancy to the risk reduction system and would support efforts to create communities resilient to catastrophic events.

B. Combination Measures Developed in the Residual Floodplains of Structural Measures

The magnitude and distribution of nonstructural measures, that were formulated based on depth of flooding, change with the structural measure considered but generally conform to those areas lying outside or seaward of the structural alignments. As such, nonstructural measures were formulated in the residual floodplain of each structural measure to conform to the level of risk reduction provided by the structural measure. Decision criteria were applied in the same way as with the stand alone nonstructural measure formulation. As a result the nonstructural measures formulated in the residual floodplain of the structural measures share the same components of buyout of structures in velocity zones, buyout of structures in census blocks that demonstrate deep flooding of 14 feet or greater, and raising-in-place of structures in census blocks that demonstrated flooding between 3 and 13 feet. Once again, by applying this method, a uniform level of risk reduction is afforded to the entire planning unit whether structurally or nonstructurally.

C. Site Specific Measures

Levee segments that could be considered increments to the overall levee system were identified for the formulation of competing nonstructural measures for a cost effectiveness analysis. Nonstructural measures for specific sites conformed to the decision criterion of depth of inundation previously described and were formulated to the corresponding level of risk reduction provided by the levee segment. Nonstructural measures were formulated for the following sites:

Planning Unit 1

1. Slidell Ring Levee
2. Northshore Levee

3. LaPlace Levee
4. Oakville Levee
5. Plaquemines Levee

Planning Unit 2
1. Lafitte Levee
2. Golden Meadow Levee
3. Des Allemands Levee
4. Plaquemines Levee

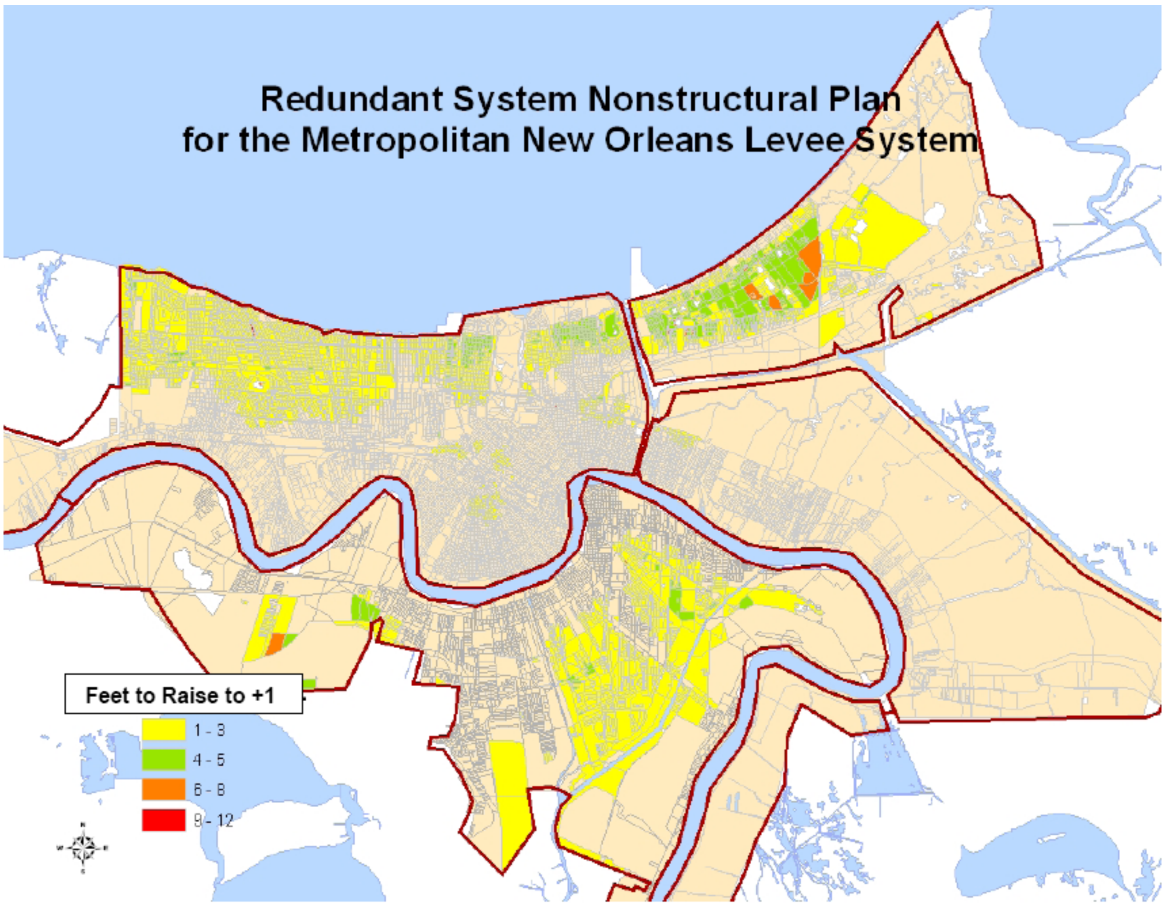
D. Redundant Measures

Redundant measures are those that would be included in a plan to provide backup risk reduction in the event that a structural component is exceeded by storm surge or has failed in some way. A single layer of hurricane risk reduction typically relies on project scale, for example the size of a levee, to protect an area and does not necessarily incorporate redundancy or system backup. The single-layer approach implies that the structural measures are fail-safe. However, fail-safe protection cannot be achieved through structural measures alone. Residual risk will always remain. To avoid the recurrence of the catastrophic consequences of Hurricane Katrina and Rita, vital economic and urban areas could receive additional risk reduction with a back-up system of nonstructural measures to support that provided by the structures measures.

A conceptual nonstructural measure that addresses redundancy within the metropolitan New Orleans levee system was developed and is shown in Figure 3. The metropolitan New Orleans area was chosen for a demonstration of a redundant plan because a levee system is in place; therefore, the nonstructural measures would contribute the redundant component. The Redundant System Nonstructural Plan is independent of depth of inundation but is based on the mean ground elevation of census blocks. A +1 foot elevation target for raising-in-place was chosen for evaluation because it is the first whole foot increment above sea level and demonstrates what would be involved in creating a back-up system for risk reduction in the face of catastrophic failure of the levee system. The assumption in the formulation process was that, following a catastrophic failure, structures raised to +1 elevation would remain dry as the flooding equalizes at sea level within the New Orleans Metropolitan Area.

The plan would elevate all structures with first floor elevations below +1 foot elevation to +1 foot elevation inside the metropolitan levee system. The Redundant System Nonstructural Plan was developed with the assumption that a levee breach would occur with little resulting velocity after the initial break and that all pumps would fail. No specific levee failure scenario was applied to the plan development, but rather a uniform application of the nonstructural plan formulation decision and cost criteria with regard to raising-in-place were applied. While it is acknowledged that nonresidential structures would more likely be flood proofed rather than elevated, the strategy applied to this analysis allows for a gross estimate of the magnitude of investment required for implementation of such a plan, given that only 4 percent of all structures in the database are assumed to be nonresidential. Actual implementation would require more detailed information than what was available for the LACPR effort. However, this plan demonstrates conceptually the potential magnitude and cost for achieving a back-up system of risk reduction within the Metropolitan New Orleans area.

Figure 3. Redundant Plan for Metropolitan Levee System



Information upon which the analysis was based stems from data developed for the economic analysis. Topographical data obtained from the LIDAR digital elevation model using the NAVD88 (2004.65 epoch), which were used for the IPET study area, were combined with census block boundaries obtained from the 2000 Census using GIS mapping to determine the mean ground elevation for each census block in the New Orleans metropolitan area. The +1 foot value was calculated based on a difference between the mean ground elevations of census blocks, consistent with the reference datum of NAVD 88 (2004.65).

Elevating structures to +1 foot might not be sufficient to guarantee redundancy in a risk reduction system since relative sea level rise and other important considerations were not included in this particular analysis; however, this exercise was not intended to be a precise calculation of benefits and costs, in fact, no benefits were derived for this exercise at all. The derivation of cost for a redundant nonstructural concept plan for the Greater New Orleans levee system was intended to demonstrate the minimum order of magnitude of effort and resources required in creating a back-up or redundant measure for risk reduction in the face of catastrophic failure of the levee system. Actual implementation would require more detailed information than what was available for the LACPR effort; however, this plan demonstrates conceptually the potential magnitude and cost for achieving a back-up system of risk reduction with the Metropolitan New Orleans area.

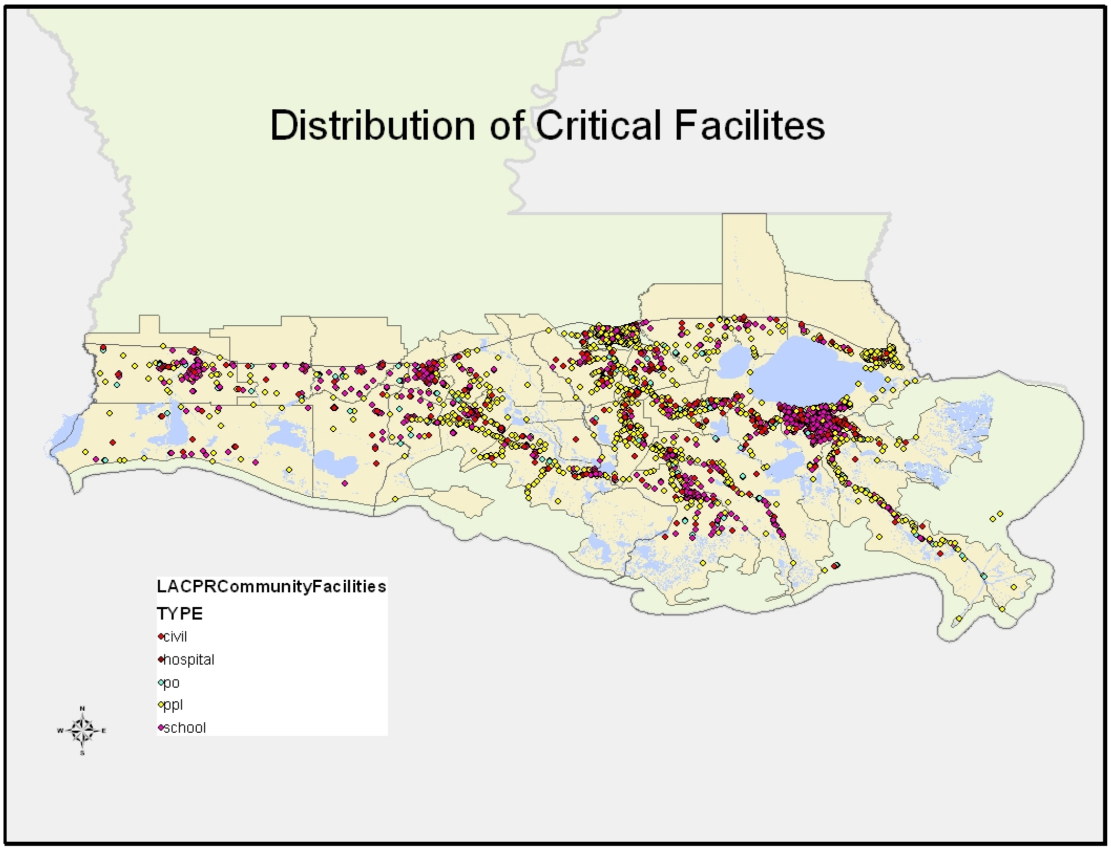
E. Measures to Protect Critical Facilities

One way to create resiliency within the South Louisiana communities is to protect those public and private facilities that are critical to the health and safety of the resident population. These facilities are defined as hospitals, police and fire protection facilities, water treatment and wastewater treatment plants, public administration buildings, and schools that provide a base for emergency response and a post-storm foothold for recovery.

Critical facilities have been identified within the spatial extent of the LACPR planning area and are shown in Figure 4. Critical facilities are defined following the guidance and definitions contained in Executive Order 11988 (EO 11988), issued on 24 May 1977. The Executive Order is the guidance for flood risk management for all Federal activities within floodplains. EO 11988 is further implemented through guidance within the Federal Register dated 10 February 1978. Critical facilities are covered under what is named as “critical actions.” The definition of a critical action is “any action for which even a slight chance of flooding would be too great.” The interpretation of this term includes the following facilities: hospitals, water treatment plants, police and fire stations, city halls, emergency operations centers, and schools that could serve as centers to accommodate people evacuated from flooded areas. A total of 1,551 facilities have been identified within the LACPR planning area as meeting the critical action definition by using FEMA’s HAZUS-MH database. These facilities are distributed into the following categories:
:

- Hospitals - 72
- Police Stations - 234
- Fire Stations – 223
- City Halls - 40
- Emergency Operations Centers - 10
- Schools that could serve as evacuation centers - 960
- Water treatment facilities – 12

Figure 4. Distribution of Critical Facilities in the LACPR Study Area.



The desired base flood elevation for these facilities as stated in Executive Order 11988 is outside the 500-year floodplain or protected to the 500-year stage. All nonstructural measures were considered to protect these facilities. Many critical facilities in South Louisiana are subject to high velocity storm surge or deep inundation, indicators of a high degree of risk. However, in order to best serve their surrounding communities, it is important that these facilities remain at their present locations. For the purposes of this evaluation, however, all structures within velocity zones are subject to buyout and/or relocation at a higher elevation. This is consistent with the decision criteria for nonstructural plan formulation.

Nonstructural measures formulation is site- and structure-specific to the individual facility being protected. Structure-specific information for every critical facility is required for the accurate formulation of appropriate nonstructural measures. These data include foundation type, use and type of building, exterior finish, size and height, condition, and other building characteristics. This type of explicit structure information was not collected for the LACPR report, but rather per square foot unit values for standard facilities were used instead.

Decision criteria based on depth of inundation and surge velocity was used in the formulation of nonstructural measures for critical facilities. Protection of critical facilities that are publicly owned such as public schools, colleges, city halls, police and fire stations, and emergency services facilities can be addressed through either standard relocation contracts of the Engineer Federal Acquisition Regulation Supplement to demolish and rebuild or can be flood proofed by the use of veneer walls or ring walls. Veneer wall flood proofing was assigned to facilities with depths of inundation ranging from 0-3 feet with ring walls assigned to facilities with depths of 3-6 feet. Any critical facility that is located within a FEMA designated high velocity, "Vzone," or extreme high hazard area, however, was subject to buyout and/or relocation. For structures that had water depths greater than 6 feet, buyout and/or relocation at a higher elevation was selected as the most likely alternative nonstructural measure. Critical facilities that are privately owned can be acquired similarly to other commercial or residential properties through the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970.

Implementation of measures to protect critical facilities would require coordination with FEMA's Public Assistance and Hazard Mitigation Grant Program and Public Assistance Program to avoid duplication of effort.

F. Demonstration Projects

Nonstructural demonstration projects are of particular interest for LACPR because they can provide almost immediate risk reduction to a small area in a manner that is consistent with local interests. Demonstration of nonstructural measures offers the opportunity for USACE to work with State and local interests to achieve risk reduction in the near-term while large structural measures are constructed over a long period. Demonstration projects are intended to identify opportunities for and challenges of collaboration across the full spectrum of government entities.

The parameters for locating demonstration projects were as follows:

1. Identify locations that span across all of the South Louisiana planning area;
2. Identify locations that allow the use of nonstructural measures that are generally applicable to reducing risk across South Louisiana;
3. Identify locations that span the cultural, social, and economic range of South Louisiana;
4. Identify locations that have local governments that are strongly supportive of implementing nonstructural measures for risk reduction;
5. Concentrate the demonstration projects into those areas that sustained substantial damage and human suffering from the hurricanes of 2005;
6. Identify locations where USACE authorization complements nonstructural programs already underway or are potentially underway by other agencies such as FEMA and the Louisiana Recovery Authority (LRA); and
7. Identify locations where demonstration projects may be used as a catalyst for future implementation of nonstructural measures as part of an overall plan.

1. Coordination

Coordination of the demonstration project effort occurred at multiple levels within USACE and across other agencies. The New Orleans District, LACPR Team, and USACE Headquarters were included in the USACE coordination. The Louisiana Recovery Authority, the Louisiana Governor's Office of Homeland Security and Emergency Preparedness, and the Louisiana Office of Community Development were primary coordinators at the State level. Local governments at the locations selected for the demonstration projects were also involved. These locations are described below.

2. Applicable Nonstructural Measures

The demonstration projects included an assessment of all nonstructural measures applicable to the particular risk characteristics of the locale. The measures applied conformed to the interests of the local community and serve to support the needs for community resiliency and economic recovery.

3. Demonstration Project Areas Identified

City of New Orleans, Planning Unit 1. Potential demonstration projects within the City of New Orleans were identified within or immediately adjacent to target recovery areas designated by the City. The demonstration projects were developed in collaboration with the Office of Recovery Management, a division of the Mayor's office at the City of New Orleans. The Office of Recovery Management has developed a recovery plan that is based upon the Unified New Orleans Plan, which has been approved by the Louisiana Recovery Authority. A major component of the City's recovery plan is to focus public funding on redevelopment at the neighborhood level in a recognizable and sustainable pattern. A total of 17 target areas have been designated throughout the City. The target areas fall into three categories – rebuild areas that experienced severe impacts and are not recovering in terms of returning population; redevelop areas that were in need of redevelopment even before the storms and flooding; and renew areas where modest public investment can result in leveraging private and non-profit investment.
The United New Orleans Plan, a comprehensive public planning process conducted during 2006, strongly endorsed the concept of a neighborhood stabilization program, or "clustering." The goal of "clustering" is to concentrate population in areas of lower risk while removing people from areas of higher risk; this concept has widespread public support. Working closely with the City, demonstration nonstructural projects were identified on the basis of the following criteria:

- Projects located in Target Recovery Areas identified by the Office of Recovery Management;
- Projects located in areas with a high or medium risk of flooding to maximize the benefit of investing in nonstructural measures;
- Projects located in areas with a high incidence of blighted properties to facilitate the creation of clustered communities and to keep neighborhoods intact; and
- Projects that exhibit a wide variety of nonstructural options.

Residential redevelopment areas to accomplish "clustering" are part of the demonstration projects. These vary from where the USACE and the City will identify areas for clustering that have existing infrastructure that may require purchase and clearing of blighted areas to areas that are currently somewhat open space, where infrastructure to support residential development will be placed as part of the demonstration project. Where areas will be evacuated of residential structures, the City would like the option of converting the vacated land to a use that is compatible with their associated risk (commercial or light industrial) rather than having to return the property to perpetual green space. Other demonstration projects involve the elevation of existing residential structures within or adjacent to target recovery areas.

In addition to the residential component, the demonstration program in New Orleans includes various measures to protect facilities, which are essential for improving resiliency during and after rare storm events. These measures include hospitals, a school, several groceries, and a pharmacy located in or near several target recovery areas.

City leadership views implementation of nonstructural measures as a high priority even with an enhanced Federal levee system and coastal restoration. The City realizes the mistakes of the past that allowed “slab on grade” construction to occur throughout the City, even in areas below sea level. The City firmly believes in the concept of “redundancy in flood risk reduction” especially in light of subsidence and a rising sea level.

A variety of nonstructural measures located in or near six target recovery areas have been identified. They are as follows:

1. Lower Ninth Ward—Buyout 150 residences in the low-lying high risk area. For an existing urbanized area with limited land available for development, the City desires the flexibility to redevelop the evacuated area in a manner appropriate to the risk and in conformance with target levels of risk reduction.
2. New Orleans East Plaza—Elevation of 25 existing slab on grade residential structures. In addition, the demonstration program envisions the elevation in place of an existing public school facility, dry flood proofing of a commercial facility (i.e., a pharmacy), and hardening (applying building techniques to make the structure more flood damage resistant and resilient) of two critical facilities (i.e., hospitals).
3. I-10 at Carrollton Avenue—Elevation of 40 existing residential structures.
4. Broad Street at Lafitte—Secondary levees or floodwalls to protect a large commercial facility (i.e., a supermarket).
5. South Claiborne at Toledano— Hardening (applying building techniques to make the structure more flood damage resistant and resilient) of a critical facility (i.e., a hospital).
6. St. Bernard at North Claiborne—Dry flood proofing to protect a mid-size commercial facility (i.e., a grocery store).

St Bernard Parish, Planning Unit 1. Potential demonstration projects in St. Bernard Parish were identified just to the east of Orleans Parish and north of Judge Perez Road. Two projects have been identified with approximately 100 homes in each project. These projects consist of relocation and/or buyout with removal of the structure and conversion of the evacuated floodplain into new uses compatible with the risk associated with the locale.

Delcambre, Planning Unit 3b. Delcambre is located in South Central Louisiana. Potential demonstration projects were identified along Carlin Bayou, which directly connects with Vermilion Bay and the Gulf of Mexico. Delcambre has long had an important role in regional hurricane risk reduction as Carlin Bayou has been used over the years to temporarily harbor boats for risk reduction from hurricane induced storm surge.

Two basic demonstration projects were identified at Delcambre. They are relocation/buyout of existing residential and some commercial structures and flood proofing of existing critical facilities such as schools, water treatment facilities, police and fire stations, and city halls, as well as some commercial structures in the downtown areas considered critical to the community such as grocery stores and pharmacies. Approximately 128 structures would be evaluated for relocation or buyout, and approximately 35 would be evaluated for elevation-in-place, flood proofing, or low berms and walls. In Delcambre, the location of relocation/buyout of structures is in a very low area. The City is interested in converting the evacuated floodplain to activities that are appropriate for the risk levels and that take advantage of water connections to Carlin Bayou in order to facilitate access for water related recreation and for storage of boats during hurricanes.

Calcasieu Parish, Planning Unit 4. A potential demonstration project was identified north of the City of Lake Charles, Louisiana. It is located in Calcasieu Parish along the right bank of the West Fork, Calcasieu River. The area is not only subject to hurricane induced storm surge flooding, but also to riverine flooding. The area has 78 residential structures with varied type of foundation construction ranging from slab on-grade to elevated pier and beam. The area contains structures that meet criteria for classification as repetitive loss structures under the National Flood Insurance Program, meaning that they have filed two or more claims greater than $1,000 within a ten year period. Several of the structures have also received funding for mitigation to reduce flood risk through FEMA’s hazard grant mitigation program. Approximately 30 to 40 residential structures would be considered under a demonstration program. The homes would be categorized according to depth of flooding. They would be elevated in place if indicated flood depths are less than 15 feet. Any structures subject to greater flood depths than 14 feet would be considered for relocation and/or buyout as discussed previously.

V. Evaluation Metrics

Nonstructural measures/alternatives were evaluated across 10 metrics as described in the main report. The following sections discuss a subset of those metrics related to residual damages, population impacted, regional economic impacts, and cost. Because no NED analysis is required for the LACPR evaluation, no net excess benefit calculations were made.

A. Residual Damages

Base "without project" damages were calculated using the New Orleans District's economic spatial database as were all "with project" damages for stand alone plans, for combined structural, coastal and nonstructural plans and for site-specific plans. Both "with" and "without project" conditions are described in terms of future scenarios for development and land use as well as relative sea level rise. The Economics Appendix gives a full explanation of the derivation of the metrics used in the analysis.

B. Population Impacted

A similar method as applied to calculating damages was employed to calculate the population flooded for the various "with" and "without project" conditions. Assets protected by some nonstructural measures, such as raising-in-place, may require that the resident population evacuate their homes during the storm threat, but will return to homes protected to a defined level of risk reduction. In this instance, nonstructural measures do not protect the population from inundation, only assets are protected.

C. Regional Economic Impacts

Regional economic impacts were derived by eliminating flooding to census blocks that contained commercial and industrial structures. Protecting commercial and industrial structures from flood inundation was the only defined measure of regional economic impacts. No assessment was made of the potential impact of buyouts and relocations of businesses to the regional economy from implementation of nonstructural measures. Buyouts could depress the local economies of some areas and stimulate the local economies of others. How the region would be affected by massive buyouts and relocations of populations has yet to be investigated.

D. Project Cost

1. Costing Stand Alone, Complementary, Site Specific and Redundant Nonstructural Measures

Costs were generically applied to stand alone, complementary, site specific, and redundant nonstructural measures. Cost information was developed at a level commensurate with the level of detail of other information employed for evaluation purposes. Costs for buyout and permanent relocation of property were developed by the New Orleans District Real Estate Office. Representative property values were developed at the parish level and applied to the estimated number of properties required for buyout for nonstructural measures. Unit values for relocation assistance and acquisition costs were applied on a per structure basis to comprise the real estate cost for purchasing property for risk reduction. Nonresidential structures comprise only 4 percent of the total structures assumed for the base condition under both land use/development scenarios in the near-term and the future conditions and were, therefore, analyzed as residential with no distinction for nonresidential type. **Table 3** below displays the costs applied to Planning Units 1 and 2.

Table 3. Cost for Evacuation/Buyout per Structure by Parish

PARISH	Unit Value (Land and Improvement)	Residential Value	Relocation Assistance*	Acquisition Costs	Total Real Estate Cost
Ascension	$150,000	$150,000	$100,000	$20,000	$270,000
Jefferson	$215,000	$215,000	$100,000	$20,000	$335,000
Lafourche	$100,000	$100,000	$100,000	$20,000	$220,000
Livingston	$150,000	$150,000	$100,000	$20,000	$270,000
Orleans	$150,000	$150,000	$100,000	$20,000	$270,000
Plaquemines	$100,000	$100,000	$100,000	$20,000	$220,000
St. Bernard	$110,000	$110,000	$100,000	$20,000	$230,000
St. Charles	$230,000	$230,000	$100,000	$20,000	$350,000
St. James	$150,000	$150,000	$100,000	$20,000	$270,000
St. John the Baptist	$170,000	$170,000	$100,000	$20,000	$290,000
St. Tammany	$240,000	$240,000	$100,000	$20,000	$360,000
Tangipahoa	$115,000	$115,000	$100,000	$20,000	$235,000

*As a conservative cost-estimating approach, relocation assistance costs are included in the cost of nonstructural measures for LACPR; however, P.L. 91-646 benefits may be applied differently during implementation of actual projects.

Unit values were applied to the estimated 2010 structure inventory for two land use and redevelopment scenarios developed by the New Orleans District. In order to maintain a level of risk reduction over time within the census block targeted for buyout and relocation, an assumption was made that a number of vacant lots equal to the growth projected within the block over the period of analysis would necessarily be bought to preclude future development from occurring. These costs represent a proxy value for a perpetual restricted use easement. These costs would be incurred during the construction period. The cost of vacant lots in parishes within the planning area was also provided by the New Orleans District Real Estate Office. **Table 4** below displays the unit costs applied to Planning Units 1 and 2.

Table 4. Costs for a Standard Vacant Lot by Parish

PARISH	Unit Value (Lot Only)	Residential Value	Relocation Assistance	Acquisition Costs	Total Real Estate Cost
Ascension	$40,000	$0	$0	$20,000	$60,000
Jefferson	$50,000	$0	$0	$20,000	$70,000
Lafourche	$10,000	$0	$0	$20,000	$30,000
Livingston	$40,000	$0	$0	$20,000	$60,000
Orleans	$20,000	$0	$0	$20,000	$40,000
Plaquemines	$10,000	$0	$0	$20,000	$30,000
St. Bernard	$20,000	$0	$0	$20,000	$40,000
St. Charles	$60,000	$0	$0	$20,000	$80,000
St. James	$40,000	$0	$0	$20,000	$60,000
St. John the Baptist	$30,000	$0	$0	$20,000	$50,000
St. Tammany	$60,000	$0	$0	$20,000	$80,000
Tangipahoa	$25,000	$0	$0	$20,000	$45,000

Costs for raising structures in place were developed by the Huntington District. The Huntington District provided costs for a new elevated structure where the existing structure was either destroyed or remained in a structural condition that would not support elevation and also for elevation of an existing structure. The costs employed in this analysis assumed that the structure was inhabited and was therefore an existing structure. These costs were separated into two height categories with the cost of the midpoint of each category applied to the number of structures raised between 3 feet and 6 feet and between 7 feet and 13 feet. Attachment 3 details the costs for raising-in-place as developed by the Huntington District and adjusted for the Gulf Coast region. For example, Gulfport, MS was chosen for the Marshall & Swift estimate while quotes were obtained from the New Orleans area. In certain instances, national averages were used. To these costs, Huntington District added unit values of $3,000 for temporary housing/relocation assistance and $25,000 for administration, oversight, and design.

Recovery and reconstruction are assumed to be ongoing activities throughout the project life. A basic assumption outlined in this analysis is that future growth will conform to the NFIP base flood elevation for first floor height above the 100-year flood elevation. Therefore, if a nonstructural measure proposes a level of risk reduction greater than the 100-year level, only the cost of the height increment above the 100-year was included as an economic cost of raising-in-place for future growth. Should the nonstructural measure be implemented, a requirement that future growth conform to the project's level of risk reduction, such as to the 400-year or 1000-year level, would be necessary in order to maintain the level of risk reduction throughout the 50-year period of analysis. The costs for incremental raising-in-place were derived from the cost information supplied by the Huntington District. A unit cost of $2,500 per foot of elevation above the 100-year elevation was calculated and applied to future growth, except when the raising to target exceeded the raising threshold of 13 feet. When this occurred, growth within the census block was assumed to be bought out and the vacant lot value was applied instead.

2. Costing Nonstructural Measures for Critical Facilities

Local governments provided information on the structure type, use, and depth of flooding at the structure. Numbers of students at schools were used to determine the school size. Since the building footprint size was unavailable for critical facility structures, standard public buildings sizes of 2,500 square feet (sf) and 5,000 sf were used for police and fire stations and city halls while building sizes for schools were based upon the number of students, using current national standards of square footage per student by school type. The following assumptions were made in order to develop general cost estimates for protecting critical facilities:

Hospitals

- Building condition is good.
- Building foundation will be slab on grade.
- Building type will be brick veneer.

- Building footprint will be 40,000 square feet.
- Each building will have eight door openings at 1 foot above the adjacent grade.
- Each building will have 200 feet of window located 3 feet above the adjacent grade.
- The building is four stories.
- The building must be usable during flood events.

Police Stations and City Halls
- Building condition is good.
- Building foundation is slab on grade.
- Building type will be brick veneer.
- Building foot print will be 2,500 square feet.
- Each building will have three doors at 1 foot above the adjacent grade.
- Each building will have 45 feet of window located 3 feet above the adjacent grade.
- Each building will have one story.
- Each building could be evacuated during a flood.

Fire Stations
- Use the same assumptions as police stations with the exception that three overhead doors of 10 feet in width will be present at 1 foot above the adjacent grade and window space will be reduced to 25 feet.

Emergency Operations Centers/Civil Defense
- Use the same assumptions as police stations with the exception that this facility must be in operation during floods.
- Use the same assumptions as hospitals except the building is one story.

Schools
- Base cost on student enrollment and other external sources.

Water Treatment Facilities
- The building condition is good.
- Building foundation is slab on grade.
- Building construction is masonry block.
- Building foot print is 20,000 square feet.
- Each building will have four door openings located 1 foot above the adjacent grade.
- Each building will have two overhead doors located 1 foot above the adjacent grade.
- Each building will be two stories.
- Each building will have 50 feet of window located 3 feet above the adjacent grade.
- Each building will be usable during floods.

The characteristics assumed and noted above were used for determining costs of implementation. These costs were calculated using cost versus depth versus type of nonstructural measure and were developed by Huntington District, USACE for use in both the LACPR and the Mississippi Coastal Improvement Program (MsCIP) reports.

VI. Evaluation of Nonstructural Measures

A. Stand Alone, Combination, and Site Specific Measures

Nonstructural measures/alternatives were evaluated against the same metrics as the structural measures/alternatives—residual damages, population impacted, regional economic impacts, costs, etc. The assessment of residual damages, population impacted and regional economic impacts to stand alone and nonstructural complements to structural measures was made by applying queries to a spatially referenced database described in the Methodology and Data section of this appendix. Outputs of these queries are reported in the *Evaluation Results Appendix*. Costs associated with site specific measures are included in the files.

B. Redundant Measures

The Redundant System Nonstructural Plan entailed raising-in-place of all eligible existing and projected future structures within the New Orleans metropolitan levee system under the two land use/population growth scenarios used in the evaluation of all LACPR plans. Existing structures were assumed to be built with a 2-foot floor correction above the mean ground elevation of the census block in which they are located. This is a consistent assumption made for all existing development. Structures projected for future growth were assumed to be built at the NFIP-required base flood elevation. However, for the purpose of redundancy, future development was raised to +1 foot elevation and the cost to elevate between the base flood stage and +1 foot elevation was added to the Redundant System Nonstructural Plan cost. The mean ground elevation for all census blocks showed no elevations within the range of eligibility for buyouts and relocations. The difference between the target +1 foot elevation and all estimated first floor elevations allowed for raising-in-place as the preferred nonstructural measure.

In total a plan for elevating all structures below +1 foot elevation within the metropolitan levee system to +1 foot elevation would cost between $19 and $21 billion. This plan would impact between 160,000 to 230,000 structures and an associated population between 320,000 and 460,000 residents. The levee system and coastal features would provide risk reduction from storm surge. The Redundant System Nonstructural Plan would provide back-up security to the City's economic assets from any flooding source by raising all eligible structures above sea level.

C. Measures to Protect Critical Facilities

Protecting critical facilities addresses the need for community resiliency, the ability of a community to rebound from rare and catastrophic natural events. As such, benefits calculated for the stand alone and complementary nonstructural measures were not computed for the critical facilities measures. Costs were computed based on generalized assumptions noted previously. The results of the analysis are displayed in **Tables 5 through 9** below. In total 539 structures would be eligible for flood proofing or buyout and/or relocation based on depth of flooding at an estimated total cost of $2.7 billion.

Table 5. Costs for Nonstructural Measures Applied to Protect Critical Facilities, Planning Unit 1

	Veneer Wall 0-3 feet	**Ring Wall 3-6 feet flood depth**	**Relocation greater than 6 feet**
Critical Facility			
Schools			
Count	58	57	31
Average Cost	$479,000	$5,490,000	$12,149,000
Total Cost	$27,761,000	$312,927,000	$376,623,000
Hospitals			
Count	2	5	4
Unit Cost	$510,000	$5,905,000	$22,717,000
Total Cost	$1,020,000	$29,525,000	$90,868,000
Police Stations			
Count	3	1	6
Unit Cost	$90,000	$1,646,000	$870,000
Total Cost	$270,000	$1,646,000	$5,220,000
Fire Stations			
Count	3	4	9
Unit Cost	$127,000	$2,025,000	$608,000
Total Cost	$381,000	$8,100,000	$5,472,000
Civil Defense			
Count	0	0	0
Unit Cost	$90,000	$1,646,000	$870,000
Total Cost	$0	$0	$0
Total by Flood Depth	$29,432,000	$352,198,000	$478,183,000
Grand Total			
$859,813,000			

Table 6. Costs for Nonstructural Measures Applied to Protect Critical Facilities, Planning Unit 2

	Veneer Wall 0-3 feet	Ring Wall 3-6 feet flood depth	Relocation greater than 6 feet
Critical Facility			
Schools			
Count	2	22	68
Average Cost	$297,000	$5,370,000	$12,437,000
Total Cost	$593,000	$118,143,000	$845,686,000
Hospitals			
Count	0	0	3
Unit Cost	$510,000	$5,905,000	$22,717,000
Total Cost	$0	$0	$68,151,000
Police Stations			
Count	2	7	15
Unit Cost	$90,000	$1,646,000	$870,000
Total Cost	$180,000	$11,522,000	$13,050,000
Fire Stations			
Count	1	4	25
Unit Cost	$127,000	$2,025,000	$608,000
Total Cost	$127,000	$8,100,000	$15,200,000
Civil Defense			
Count	0	0	0
Unit Cost	$90,000	$1,646,000	$870,000
Total Cost	$0	$0	$0
Total by Flood Depth	$900,000	$137,765,000	$942,087,000
Grand Total			
$1,080,752,000			

Table 7. Costs for Nonstructural Measures Applied to Protect Critical Facilities, Planning Unit 3a

	Veneer Wall 0-3 feet	**Ring Wall 3-6 feet flood depth**	**Relocation greater than 6 feet**
Critical Facility			
Schools			
Count	16	21	30
Average Cost	$354,000	$4,971,000	$8,175,000
Total Cost	$5,669,000	$104,389,000	$245,237,000
Hospitals			
Count	0	2	2
Unit Cost	$510,000	$5,905,000	$22,717,000
Total Cost	$0	$11,810,000	$45,434,000
Police Stations			
Count	6	3	2
Unit Cost	$90,000	$1,646,000	$870,000
Total Cost	$540,000	$4,938,000	$1,740,000
Fire Stations			
Count	2	9	14
Unit Cost	$127,000	$2,025,000	$608,000
Total Cost	$254,000	$18,225,000	$8,512,000
Civil Defense			
Count	0	0	0
Unit Cost	$90,000	$1,646,000	$870,000
Total Cost	$0	$0	$0
Total by Flood Depth	$6,463,000	$139,362,000	$300,923,000
Grand Total			
$446,748,000			

Table 8. Costs for Nonstructural Measures Applied to Protect Critical Facilities, Planning Unit 3b

	Veneer Wall 0-3 feet	**Ring Wall 3-6 feet flood depth**	**Relocation greater than 6 feet**
Critical Facility			
Schools			
Count	7	7	17
Average Cost	$338,000	$4,944,000	$9,102,000
Total Cost	$2,368,000	$34,609,000	$154,729,000
Hospitals			
Count	1	0	0
Unit Cost	$510,000	$5,905,000	$22,717,000
Total Cost	$510,000	$0	$0
Police Stations			
Count	1	2	5
Unit Cost	$90,000	$1,646,000	$870,000
Total Cost	$90,000	$3,292,000	$4,350,000
Fire Stations			
Count	0	2	10
Unit Cost	$127,000	$2,025,000	$608,000
Total Cost	$0	$4,050,000	$6,080,000
Civil Defense			
Count	0	1	0
Unit Cost	$90,000	$1,646,000	$870,000
Total Cost	$0	$1,646,000	$0
Total by Flood Depth	$2,968,000	$43,597,000	$165,159,000
Grand Total			
$211,724,000			

Table 9. Costs for Nonstructural Measures Applied to Protect Critical Facilities, Planning Unit 4

	Veneer Wall 0-3 feet	Ring Wall 3-6 feet flood depth	Relocation greater than 6 feet
Critical Facility			
Schools			
Count	2	6	6
Average Cost	$299,000	$4,429,000	$5,554,000
Total Cost	$597,000	$26,572,000	$33,325,000
Hospitals			
Count	0	1	1
Unit Cost	$510,000	$5,905,000	$22,717,000
Total Cost	$0	$5,905,000	$22,717,000
Police Stations			
Count	4	2	6
Unit Cost	$90,000	$1,646,000	$870,000
Total Cost	$360,000	$3,292,000	$5,220,000
Fire Stations			
Count	1	7	10
Unit Cost	$127,000	$2,025,000	$608,000
Total Cost	$127,000	$14,175,000	$6,080,000
Civil Defense			
Count	0	0	1
Unit Cost	$90,000	$1,646,000	$870,000
Total Cost	$0	$0	$870,000
Total by Flood Depth	$1,084,000	$49,944,000	$68,212,000
Grand Total **$119,240,000**			

D. Demonstration Projects

City of New Orleans

1. Lower Ninth Ward

Buyout of 150 residential structures. Metrics for the buyout of 150 residential structures with assistance with relocation include average annual equivalent damages reduced equaling $560,000; population protected of 300 persons, and costs approximating $22.5 million.

2. New Orleans East Plaza

Raise-in-place 25 residential structures. Metrics for the raising-in-place 25 residential structures to an elevation of 8 feet above grade include average annual equivalent

damages reduced equaling $1.8 million; 50 persons protected, and cost approximating $3.7 million.
Demolish and rebuild a public school: Cost of $21.3 million.
Dry flood proof a commercial building: Cost of $2.1 million
Flood proof a hospital: Cost of $4.4 million.

3. I-10 at Carrollton Ave.
Raise-in-place 40 residential structures. Metrics for the raising-in-place 40 residential structures to an elevation of 8 feet above grade include average annual equivalent damages reduced equaling $4.9 million; 90 persons protected, and cost approximating $5.9 million.

4. Broad St. at Lafitte Ave.
Dry flood proof a commercial structure. Cost to construct ring wall of $3.3 million.

5. South Claiborne at Toledano Ave.
Flood proof a hospital. Cost to construct at $4.4 million.

6. North Claiborne at St. Bernard.
Dry flood proof a commercial structure. Cost to construct impermeable veneer wall of $140,000.

St. Bernard Parish
Metrics for buyout of 200 residential structures with relocation assistance include average annual equivalent damages reduced equaling $8.4 million; 450 persons protected, and cost approximating $40.3 million.

E. Benefits and Costs Captured by Other Agency Actions

Following Hurricanes Katrina and Rita, the Federal government made available billions of dollars to assist with disaster recovery. *The Road Home* program, created by Louisiana Governor Blanco, the Louisiana Recovery Authority, and the Office of Community Development and funded by the U.S. Department of Housing and Urban Development, is the largest single housing recovery program in U.S. history. The program's objective is to help Louisiana residents get back into homes or apartments as quickly and fairly as possible.

These Federal investments are being made with the expectation that recovery complies with the National Flood Insurance Program's (NFIP) adjusted base flood elevations (ABFEs) and that this level of risk reduction provides a tolerable level of risk to the population. Conformance with NFIP building requirements for future growth is a basic assumption of LACPR's nonstructural measures formulation and evaluation.

However, the extent to which disaster recovery has influenced risk reduction has yet to be determined. For the purposes of the nonstructural measures analysis, any Federal contribution already made to risk reduction over and above the NFIP criteria cannot be ascertained without more detailed analysis. Some of the costs and some of the benefits for risk reduction are captured by these existing recovery programs but the extent of their influence cannot be determined until the implementation phase of the authorized Federal project.

VII. Implementation

A strategy has been developed for a programmatic authorization for nonstructural measures implementation throughout southern Louisiana. The rationale and strategy for the program is described in Attachment 1.

VIII. Findings and Conclusions

Nonstructural measures were formulated with the primary goal of reducing risk to the population and assets of South Louisiana. The development of applicable measures was based on two primary sources of risk: storm surge velocity and inundation. Findings support that nonstructural measures perform well across all the metrics considered for the LACPR evaluation. They are efficient and effective in reducing risk from storm surge, as well as from other sources of flooding. Nonstructural measures bear few operational and maintenance costs and have little or no environmental mitigation requirement.

Overall, the raising-in-place component of any nonstructural plan contributes most to risk reduction due specifically to the magnitude of the application. Of the half million structures impacted by a 400-year stand alone nonstructural measure, over 90 percent would be raised-in-place thereby preserving neighborhoods, communities, and the local economy while contributing significantly to risk reduction.

These findings demonstrate the potential of the nonstructural measures; however, the evaluation assumed full participation in the program. The actual benefits and costs are dependent on local participation rates. The successful implementation of a coast wide program of nonstructural measures would require full agency endorsement as well as intense stakeholder and non-Federal sponsor involvement to address outstanding issues such as preserving living cultures and the social fabric of communities in addition to potential impacts to the regional economy.

A full collaboration among Federal agencies, State and local governments and the population at risk is necessary for any successful Federal action; however, the nonstructural measures developed through plan formulation can be implemented under existing USACE policy and local sponsor cooperation. Some incentives to encourage public participation may be required and creative options to direct property acquisition may require changes to public law and policies. It is the intention of the nonstructural program outlined in the following Attachment 1 to explore these opportunities for and obstacles to success by utilizing resources made available through a programmatic authority that may establish and maintain a continuous and adaptive implementation process.

Attachment 1
An Implementation Program for Flood Risk Reduction Using Nonstructural Measures

Purpose

This paper presents a rationale and potential strategy that may be used to create a program to implement nonstructural measures in support of LACPR objectives if further development is requested by the Administration or Congress. A United States Army Corps of Engineers (USACE) program for nonstructural risk reduction could strengthen the long term recovery of southern Louisiana. In concert with structural measures and coastal restoration, nonstructural measures could be the key component to reducing long-term risks and supporting sustainable redevelopment. Adaptive management practices are critical to insure success of the program because many of the ideas presented here, while based on precedence, have never been applied on such a large scale as the region affected by Hurricanes Katrina and Rita.

Introduction

The Louisiana Coastal Protection and Restoration (LACPR) plans should be based on a collaborative approach to flood risk management in southern Louisiana. The LACPR Technical Report outlines a multiple lines of defense strategy, and nonstructural measures are an integral part of that defense network. Nonstructural measures include elevated structures, residential buyouts, hardened structures, evacuation planning and flood warning systems, maintained evacuation routes, flood risk communication and education, and flood insurance programs. The nonstructural plans presented in this report include measures specifically related to protecting structures and assets – elevating, relocating, hardening (applying building techniques to make the structure more flood damage resistant and resilient), and protecting homes, businesses and critical facilities. The State Master Plan specifically addresses evacuation routes in the FY08 annual plan, and State, local and Federal emergency planners have already evaluated and updated regional evacuation plans. The Governor's Office of Homeland Security and Emergency Preparedness (GOHSEP) has enabled the Integrated Public Alert and Warning System (IPAWS) to create a comprehensive and modern public alert and warning system. All of these efforts would be incorporated into risk communication and education programs, which are a vital component of risk management.

Background

Louisiana is a working coast. People and assets are there for many good reasons; however, the people and assets are at risk from coastal storms. Residents need to balance risk against the desirable benefits of the region. This balancing act amounts to making risk-benefit (or risk-cost) tradeoff decisions. Nonstructural measures are particularly dependent upon successful collaboration with the public, across programs, and across levels of government as these trade-off decisions are made. Individual property owners and local governments have responsibility for local land-use decisions and building patterns and the success of many Federal programs depends upon the fulfillment of these responsibilities.

Over time flood damages across the nation have risen rather than declined, even after billions of dollars of investment have been made in protection and mitigation programs. Adopting an innovative and integrated program of nonstructural measures that augments structural structures can further reduce potential flood damage across southern Louisiana.

Need for a Sustainable Recovery

Federal agencies such as the Department of Housing and Urban Development (HUD) and the Federal Emergency Management Agency (FEMA) support Louisiana's economic recovery with billions of Federal dollars in rebuilding grants and payments to local communities and individual homeowners. As the recovery continues, compliance with the National Flood Insurance Program's (NFIP) base flood elevations remains the sole risk reducing criterion for reconstruction. Little local attention is paid to the storm risk that lead to the catastrophic event itself. With the exception of work to rebuild the hurricane risk reduction system for the Metropolitan New Orleans area, the population and economic assets of South Louisiana remain as vulnerable as they were pre-Hurricanes Katrina and Rita. While floodwalls, levees and pumps are being improved so that the areas within existing structures will have reduced risk levels, areas within the system continue to possess residual risk because existing structures are authorized to the 100-year level and can be exceeded by larger storms while threats from other interim flooding sources remain.

While recovery is the immediate goal, attention should be paid to opportunities to meet long-term goals for resilient, sustainable communities. Nonstructural measures not only reduce risk to people and assets, they also contribute to the sustainability and resiliency of the region. Resilience is defined here as the ability to bounce back from a catastrophic storm event. Homes and businesses can be flood proofed; relocated, or elevated and critical facilities can be designed and constructed with hardened features. Critical facilities can be modified to maintain the necessary operational requirements and the structural integrity to quickly return to operations in the storm's aftermath. Critical facilities are the base of operations for health, safety, public protection, and governance operations so that services can be restored to the impacted area. These are the operations that will ensure that roads, sewers, water, power, healthcare and other essential services will be available to people and their homes, businesses, schools, and churches, in effect, the community, as quickly as possible so that residents can begin the recovery process. With these measures, the region would improve its ability to recover from these natural events in a timely manner.

Program Overview

Need for Programmatic Authority

Establishing a programmatic authority could create and maintain a continuous and adaptive implementation process. By establishing and funding at the program level rather than at the project level, efficiencies could be attained with regard to project execution. But most importantly, a programmatic approach could allow for the critical development and maintenance of collaboration among Federal agencies, State and local governments and the population at risk. Adaptive management practices should be an integral part of the program as described in the creation of any general LACPR implementation plan.

Precedence

Louisiana's Road Home program and USACE's Section 202 program could be administrative models for a nonstructural measures program. The prototype for nonstructural measures implementation for southern Louisiana is based on the USACE, Huntington District's experience with implementation of Public Law 96-367, Title II, Section 202(a) of the Energy and Water Development Appropriations Act of 1981. Section 202 and subsequent legislation noted below have created a program within which nonstructural measures can be effectively implemented. Aspects of the Section 202 program are worthy of consideration for application in the State of Louisiana.

> *Section 202* directed the Secretary of the Army, acting through the Chief of Engineers, to design and construct, at full Federal expense, flood damage reduction measures in those areas impacted by the flood of April, 1977, most notably along the Kanawha, Guyandotte, Big Sandy, Kentucky, Cumberland, and Tennessee Rivers. Benefits exceed the cost of the flood control measures authorized. This legislation established a level of protection commensurate with a historic event; introduced full Federal expense, and forgave the requirement for justification based on a benefit-cost analysis.
>
> *House Joint Resolution 492 (Public Law 98-332, 3 July 1984)* directed expeditious implementation of nonstructural features "such as relocation sites, flood proofing, and floodplain acquisition and evacuation" of the Section 202 General Plan for Project Implementation, dated 28 April 1982. This legislation emphasized the application of nonstructural measures.

Section 103b of Public Law 99-662 (Water Resources Development Act ((WRDA)) of 1986) states that "the non-Federal share of the cost of nonstructural flood control measures shall be 25 percent of the cost of such measures. The non-Federal interests for any such measures shall be required to provide all lands, easements, rights-of-way, dredged material disposal areas, and relocations necessary for the project, but shall not be required to contribute any amount in cash during construction of the project." This legislation changed the non-Federal sponsor's traditional cash contribution and reduced to 25 percent the cost-share by the non-Federal sponsor.

Section 336 of Public Law 106-541, WRDA 2000, directed the Secretary (of the Army) to determine the ability to pay by the non-Federal sponsor based on the criterion specified in Section 103(m)(3)(A)(i) of WRDA 86. The non-Federal cost share was to be based on the benefits test and county per capita income, omitting the state per capita income in the formula.

Applicable nonstructural measures

Nonstructural measures considered for application in the program could include acquisition and buyout, relocations of property improvements to higher ground, raising-in-place of improvements on existing property, wet flood proofing and dry flood proofing. For the purpose of this program, actions would be affected to individual properties in the interest of reducing risk to the resident population and economic assets by removing the population from the source of storm risk or by elevating assets above the flood risk. Facilities that cannot be elevated or moved away from risk because of their critical contribution to the local community could be assessed for elevation, and dry or wet flood proofing. Nonstructural measures could be applied based on the decision criteria established for LACPR which incorporate an assessment of risk and structural integrity.

Level of risk reduction

The level of risk reduction achieved by implementation of a nonstructural program could be at the levels of risk reduction described in the LACPR report (100-year, 400-year, or 1000-year).

Spatial scope

The area eligible for program participation could be the planning area of the LACPR report.

Nonstructural projects defined

The technical report identifies nonstructural measures at the gross planning unit level. Smaller geographical boundaries could be considered during an implementation phase, and nonstructural projects could be identified according to these smaller boundaries. For example, a nonstructural project may be defined at the parish, city or neighborhood level. Project boundaries would be influenced by the nature and extent of the flood risks, the complexity of the measures, available resources, sponsor's capability and similar issues that influence project evaluation and implementation.

Nonstructural project evaluation

Nonstructural projects could be evaluated using the same or similar metrics that have been used in the LACPR technical report. Risk reduced and residual risk could be explicitly considered using population and damage metrics. However, additional metrics would be necessary to characterize social effects and impacts to community cohesion. Coherence with recovery planning, and local land use planning efforts, could also be considered in the evaluation. Finally, the ability to leverage other public and private investment should be included in the metrics.

Need for collaboration with other agencies, local communities

Coordination and collaboration across Federal, State, and local agencies involved in the economic recovery of Louisiana is necessary to achieve risk reduction in a comprehensive and systematic manner. This approach may require collaboration among multiple agencies with each providing funding in order to achieve both objectives of risk reduction and disaster recovery within a comprehensive framework.

As part of the recovery process, the Road Home program offers compensation grants to homeowners who want to rebuild or repair their homes, move to another home within the State, or sell their property and move out of state. For those homeowners who want to repair, rebuild, or sell and move to another property in Louisiana, Road Home offers grants for rebuilding and repair and additional funding to elevate property. Any previously received FEMA or insurance, including NFIP, proceeds are subtracted from the total grant awarded. These Federal investments are being made with the expectation that recovery complies with the National Flood Insurance Program’s (NFIP) adjusted base flood elevations (ABFEs). The Road Home requirement to elevate to the ABFE, however, is limited to new structures or those where the assessed flood damage was substantial, i.e. more than 50 percent of the structure value. Another Federal program being utilized to reduce risk in the planning area is FEMA’s Hazard Mitigation Grant Program (HMGP). This program, however, has funding and eligibility limitations that constrain its effectiveness in reducing residual risk.

A USACE program for nonstructural implementation with a primary goal of risk reduction is needed to integrate that priority into the ongoing economic recovery. A USACE program could supplement existing Road Home and HMGP programs in which requirements other than identified risk must be met for program eligibility. In other words, the USACE program would be intended to allow for a more systematic nonstructural implementation by providing funding for risk reduction while other Federal monies are committed to economic recovery. Additionally, in order to provide resiliency to the area and redundancy to the flood risk reduction system, the USACE's nonstructural measures program would provide a level of risk reduction that corresponds to at least that contained in the plans presented in the LACPR report. Should the level of risk reduction exceed the ABFE target elevations, that increment of elevation above the ABFE target would be considered part of the nonstructural project.

It is further noted that the Federal government forbids two or more Federal agencies from providing compensation to cover the same loss. Coordination across Federal agencies would also be required to avoid duplication of funding.

General Procedures

The USACE would develop a Procedures Manual upon receiving authorization and appropriation to create a program for implementation of nonstructural measures for southern Louisiana. This Procedures Manual would contain necessary elements for implementing the nonstructural program and would be patterned after the Huntington District's administration of its Section 202 program. Except for noted differences, all USACE standard operating procedures would be maintained. All environmental compliance, hazard and toxic waste abatement, and historic and cultural preservation laws and policies that apply to Federal civil works projects would apply to the implementation of the nonstructural measures program.

Elements to be addressed by the Procedures Manual could include but not be limited the topics discussed below.

Local community involvement in the planning process

Local community involvement is a requisite for program success. In order to achieve sustainable storm risk reduction, difficult decisions would be required, thereby necessitating intense stakeholder involvement. Program participation would stem from application by local or State governments that possess the authority to enter into cost-sharing agreements with the Federal government.

Individual participation and application

Individual participation in the program would evolve from the non-Federal sponsor. Owners of eligible properties would be required to apply to participate. The Huntington District has developed the process and forms for program application that have utility to a nonstructural program for Louisiana.

Ranking of participants would most likely be necessary for the disbursement of available funding. Applicants could be screened and ranked for participation with regard to storm risk associated with their property. The LACPR evaluation has produced indicators of risk based on storm velocity and depth of flood inundation. These criteria could be applied to screening and ranking of applicants. Additional ranking criteria may be needed to possibly include social effects, community cohesion, local or state recovery priorities, as well as any leveraging of funds from other programs.

Design, construction, inspection, operation and maintenance of nonstructural measures

The design, construction, and inspection of nonstructural measures could be the responsibility of the Federal government. Operation and maintenance activities could be responsibility of the non-Federal sponsor and the individual property owner.

Real estate and legal considerations

Interests in real property could be acquired by negotiated direct purchases and by negotiated flood proofing agreements. Interests acquired by direct purchase and by flood proofing agreements could be acquired directly in the name of the non-Federal sponsor.

Real estate procedures for property appraisals, land surveys, property acquisition, demolition, disposal and other requirements could be established in the Procedures Manual and could reflect standard methods employed by the Federal government. Acquisitions and flood proofing procedures could be established to conform to standard procedures. All legal agreements, covenants, and documents could be endorsed by the USACE with regard to Federal interests. The Huntington District has established procedures and forms which can be used as examples to address these procedural elements.

Negotiation procedures

The Huntington District example contains established procedures which outline negotiations procedures between the Federal government and the property owner.

Procedural support for applicants

Support could be provided to individual property owners with regard to the procedural details of program participation. This could include the proper completion and execution of necessary documents, counseling with regard to program eligibility and other concerns that may arise.

Property Acquisitions and Relocation Assistance

Property buyouts are an important nonstructural measure for risk reduction. Acquisitions entail owners selling property to the non-Federal sponsor so that improvements can be cleared and the parcels left vacant or converted to a use that is compatible with their associated risk.

In addition to receiving fair market value for the property acquired, owners of real property acquired for Federal projects are entitled to receive relocation assistance under Public Law 91-646, the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (PL91-646). Such assistance generally consists of a replacement housing payment and payment for moving expenses. A displaced homeowner may receive up to $22,500 to acquire a comparable replacement dwelling. This amount can be increased if comparable homes are not available in the market. Generally the replacement housing payment is the difference between the fair market value of the home acquired and the cost to acquire a comparable home at a site with reduced flood risk, typically outside the 100-year floodplain. The displaced homeowner is entitled to decent, safe, and sanitary accommodations as part of relocation assistance.

Of specific interest to the LACPR effort is the situation in which the property targeted for buyout for risk reduction has lost its improvements or its improvements are uninhabitable as a result of the storm event. Generally, in order for a homeowner to be eligible for relocation assistance, that homeowner must occupy the property for 180 days prior to acquisition. But because many of the persons displaced by Hurricanes Katrina and Rita may not occupy the property when an acquisition phase would be commenced, there is some question regarding their eligibility for relocation assistance.

Some guidance on this question with respect to residential properties is provided by the Robert T. Stafford Disaster Relief and Emergency Assistance Act as amended, 42 USC § 5121 (Stafford Act) and PL91-646 regulations. Section 414 of the Stafford Act does not deny eligibility for relocation benefits to displaced persons whose property is uninhabitable because of a major disaster as determined by the President to meet the occupancy requirements set forth by PL91-646. In 49 CFR § 24.403(d) (additional rules governing replacement housing payments) reflects this § 414 requirement. That section provides that “No person is denied eligibility for a replacement housing payment solely because the person is unable to meet the occupancy requirements...for a reason beyond his or her control, including: (1) A disaster, an emergency, or an imminent threat to the public health or welfare, as determined by the President, the Federal Agency funding the project, or the displacing Agency.”

Extending these provisions to implementation of nonstructural measures for risk reduction within South Louisiana and applying relocation assistance to all Federal project acquisitions in support of a nonstructural program in Louisiana could significantly influence the success of the nonstructural program. This aspect of the program could support local initiatives for redevelopment and population concentration to areas that are less risk-prone as is the goal of the City of New Orleans’ Recovery Plan while also meeting the LACPR objective of overall risk reduction to the population. This application of relocation assistance would allow for both risk reduction and resilient economic recovery.

Alternatives to Direct Property Acquisitions

Other possible mechanisms for acquiring real property in support of risk reduction could require Congressional authorization but are worthy of consideration. Many local governments resist nonstructural buyouts for fear of losing their tax base along with the social fabric of their communities. Given the fact that many households have been reestablished since the devastation of 2005, a funding program could be established whereby options to purchase properties could be extended to homeowners in high risk areas. This would constitute a form of property lien to be exercised at the time that the property is vacated either by attrition or in the event of another catastrophe. Other real estate mechanisms for property acquisition that are available in the market such as reverse mortgages could be investigated for application in situations where property owners desire to live in their homes for the remainder of their lives. These mechanisms would not produce risk reduction immediately, but would allow for a gradual and permanent risk reduction without the overt disruption that many communities fear. These types of creative solutions could be explored in collaboration with local governments when determining the trade-offs between risk reduction and other societal concerns.

Relocations and Raising-in-place

The structural integrity of property improvements may allow for relocation of that structure by lifting and moving to a site having a target elevation for risk reduction or allow for lifting the structure in place to a target elevation. Temporary relocation assistance could be offered to participants in a manner that is consistent with normal USACE procedures.

Project justification, cost-sharing and ability-to-pay provisions

Section 202 of the Energy and Water Development Appropriations Act of 1981 was the first of a series of laws that set precedent for risk reduction in areas of West Virginia and Kentucky that had historically failed to compete for Federal assistance using traditional economic justification methodology. The social and economic plight within the State of Louisiana brought about by Hurricanes Katrina and Rita is very similar to that experienced in West Virginia and Kentucky, presenting another case whereby the results of catastrophic events are insufficiently captured in traditional expected annual damage calculations. As a result, the LACPR study has not been limited by “normal policy considerations” as directed by the Congressional authority for LACPR. To that end, a nonstructural measures program would seek to manage residual risk in a cost effective manner.

In order to achieve both objectives of economic recovery and storm risk reduction, special consideration could be granted for program participation. Non-Federal sponsors, strapped for funds with which to participate in the program, might have their traditional cost-sharing obligation reduced based on the shared interest of supporting economic recovery in a timely and risk-responsible manner. Ability to pay provisions could reflect the financial condition of the non-Federal sponsor.

Program Administration

The general implementation plan in the LACPR Technical Report outlines a new organizational framework. In that program management framework, the governing Decision Board and the Integration Support Team would be responsible for all LACPR project implementation, including the program for nonstructural measures implementation. The proposed new LACPR program management structure with its collaborative adaptive management focus incorporates both objectives of recovery and storm risk reduction. However, due to the need for extensive coordination with local and State government and communities, implementation of the LACPR nonstructural program would likely require a “nonstructural support team” that includes professional staff not normally involved in USACE projects. This staff could include urban planners, community outreach specialists, and residential construction experts.

Next Steps to Implementation

The next phase of work could be a transition from the high-level analysis performed thus far to a community-based collaboration and evaluation process. The nonstructural appendix describes the formulation and evaluation of nonstructural measures. The appendix also describes plans that could complement the levees and floodwall systems and plans that could substitute for levees and walls in some locations. The scale of these evaluations demonstrates the potential performance of these measures; however a number of analytical and procedural issues need to be resolved in order to transition to implementation.

Further analysis would be needed to refine the assessment of risks drawn from the storm modeling and flood risk mapping as well as to refine individual plan’s effects and costs. In the nonstructural appendix, plan formulation criteria were based upon depth and velocity of flooding. The plans were then evaluated for their potential to reduce flood damages and to remove population from the floodplain as well as for their costs. During program implementation, these plans could be further evaluated in collaboration with local communities and other partners for a more explicit accounting of project impacts and a customized application of nonstructural measures. An appropriate mix of flood proofing, elevating-in-place, and buyouts could be determined for each participating community. The nonstructural program could continue to apply the risk-informed decision framework, relying heavily on collaboration with stakeholders to formulate and evaluate plans and to prioritize investments according to the risk reduction goals of the program.

The demonstration projects developed for LACPR apply a variety of nonstructural measures to the particular needs of communities. These demonstration projects would be an excellent opportunity to “kick start” a nonstructural program and could represent the initial phase of the nonstructural implementation program.

Summary

This paper presents the rationale and a proposed strategy for the creation of a programmatic approach to implementing nonstructural measures as part of LACPR. The nonstructural program would identify, evaluate and prioritize nonstructural projects according to their contributions towards achieving the risk reduction goals of LACPR. The program would continue to use the risk-informed decision framework that has been developed during the completion of the technical report. The decision framework emphasizes the importance of collaborative planning between the USACE team, partners and the community. The personal nature of nonstructural measures increases the importance of this collaborative approach. The program would rely upon adaptive management practices to assure that new knowledge is incorporated into program decisions to deliver nonstructural measures as efficiently and effectively as possible.

Attachment 2
Examples of Cost Determination

The following information is provided to show actual costs as provided by Huntington District for implementation of several nonstructural measures.
Costs shown in 2007 dollars.
All costs include E&D and S&A
Elevation of residential buildings with slab on grade attached

Elevate 0' – 6' above adjacent grade, existing structure = $85 per sq ft of building footprint

Elevate 7'- 15' above adjacent grade, existing structure = $95 per sq ft of building footprint

Nonstructural flood wall around to protect a school
2300 linear feet of flood wall
7' wall height
12' roller gate for vehicles
12' pedestrian gate
34' access ramp over wall
2 – 268 gpm pump stations for
Interior drainage
Cost--$5,100,000

Combination Town Hall [TH] & Fire Station [FS]

Demolish existing building and reconstruct new building at a relocation site
T.H. – 1800 sq ft (offices, conference room and rest room)
F.S. – 2400 sq ft (office, BR/showers, bays to house 2 – 28' pumper trucks and 1 20' rescue truck)

$80,000 to demolish old structure
$950,000 construction

Dry Flood Proofing a Commercial Building

Dry flood proof an existing commercial building that is slab on grade, good condition, brick veneer type construction, building footprint of 4000 square feet, three door openings elevated 1 foot above the adjacent grade, 80 feet of window elevated 3 feet above the adjacent grade, single story.
$72,000 to dry flood proof 3 feet above the adjacent grade and add another layer of brick veneer.

School Relocation

57,500 sq ft pre-K thru 8. Old building demolished and new building constructed at new development site

Total cost construction, E&D and S&A = $10,698,531

$186 per sq ft

Acquisition

3,000 sf Brick Rancher with basement, garage & carport; .36 acre city lot

Acquisition: $133,000
Relocation: $ 26,000
Demolition: $_71,000 (includes asbestos & underground kerosene tank removal)
TOTAL: $230,000

4,200 sf 1.5 story brick with basement, in ground pool, two car garage, .37 acre city lot

Acquisition: $250,000
Relocation: $ 38,000 (estimated Housing Differential)
Demolition: $_60,000
TOTAL: $348,000

2,350 sf 2 story frame/brick no basement, .27 acre rural lot

Acquisition: $105,000
Relocation: $ 23,000
Demolition: $_30,000_
TOTAL: $158,000

Before

New facility by relocations contract

Attachment 3
Costs for Raising in Place

Prepared by:
Huntington District
USACE

Print Date Tue 24 July 2007
Eff. Date 10/1/2007

U.S. Army Corps of Engineers
Project : Gulf Coast Flood Proofing

Time 15:01:09

Summary Report

Title Page

Estimated by CELRH-ECT
Designed by CELRH-PD, CELRH-ECD
Prepared by Donald Whitmore, P.E.
Preparation Date 7/18/2007
Effective Date of Pricing 10/1/2007
Estimated Construction Time Days

Date **Author** **Note**

7/18/2007

SCOPE

This cost estimate is comprised of 4 model estimates:

1. New house construction on pier foundation at a finished first floor of 6 FT above low ground. Costs included herein have been developed to represent requirements associated with constructing a new structure on an elevated pier foundation ranging from 0' - 6' above low ground.

2. New house construction on pier foundation at a finished first floor of 15 FT above low ground. Costs included herein have been developed to represent requirements associated with constructing a new structure on an elevated pier foundation ranging from 6.1' - 15' above low ground.

3. Raise of existing house on slab foundation to a finished first floor of 6 Ft above low ground. Costs included herein have been developed to represent requirements associated with elevating an existing structure on an elevated pier foundation ranging from 0' – 6' above low ground.

4. Raise of existing house on slab foundation to a finished first floor of 15 Ft above low ground. Costs included herein have been developed to represent requirements associated with elevating an existing structure on an elevated pier foundation ranging from 6.1' - 15' above low ground.

In each case, the structure is assumed to have a living area 1,600 SF. For the purposes of this estimate, the cost engineer assumed a simple rectangular house with outside dimensions of 25' x 64'. This yields an area of 1600 SF and a perimeter of 178 LF.

LEVEL OF EFFORT

This estimate is considered to be preliminary in nature and is to be used as such. The scopes provided to the cost engineer were very general. Indeed, the level of effort put forth by the cost engineer is commensurate to the general nature of the design.

PRICE LEVEL

The costs contained within this estimate have been prepared at a Price Level equivalent to 1 October 2007. Contingency has been included generally at 25%. However, this may have varied on an item by item basis as deemed appropriate by the engineer.

COST SOURCES

A variety of cost were used in preparing this estimate. The primary sources were:

-Marshall & Swift Residential Estimator 7
-LRH's Section 202 Implementation Floodproofing Cost Model
-MEANS Heavy Construction, 2005

Description	Quantity	UOM	ContractCost	Contingency	ProjectCost
Summary			**630,464.15**	**157,616.04**	**788,080.19**
			115.57		*144.47*
New Structure - 6 feet off low ground	**1,600.00**	**SF**	**184,915.53**	**46,228.88**	**231,144.41**
			125.62		*157.03*
New Structure - 15 feet off low ground	**1,600.00**	**SF**	**200,996.71**	**50,249.18**	**251,245.89**
			70.00		*87.50*
Existing Structure - 6 feet off low ground	**1,600.00**	**SF**	**112,000.00**	**28,000.00**	**140,000.00**
			82.84		*103.56*
Existing Structure - 15 feet off low ground	**1,600.00**	**SF**	**132,551.91**	**33,137.98**	**165,689.89**

Description			Quantity	UOM	ContractCost	Contingency	ProjectCost
Detail			**536,504.06**	**93,960.09**	**630,464.15**	**157,616.04**	**788,080.19**
			87.70		*115.57*		*144.47*
New Structure - 6 feet off low ground	**1,600.00**	**SF**	**140,326.56**	**44,588.97**	**184,915.53**	**46,228.88**	**231,144.41**
			41,585.06		*54,947.78*		*68,684.73*
Foundation & Structure Below Sill Plate	**1.00**	**EA**	**41,585.06**	**13,362.72**	**54,947.78**	**13,736.95**	**68,684.73**
			617.30		*815.66*		*1,019.58*
Timber Piles	**60.00**	**EA**	**37,038.06**	**11,901.61**	**48,939.67**	**12,234.92**	**61,174.59**
(Note: Assume a 6' grid for a house that is 25' x 64' (i.e., a 1600 SF house).)							
			13.72		*18.13*	*25.00*	*22.66*
Timber Piles	2,700.00	VLF	37,038.06	11,901.61	48,939.67	12,234.92	61,174.59
(Note: Material price taken from MEANS. Piles are assumed to be 12" diameter at the head and are to be embedded 40' into the ground.)							
			4,547.00		*6,008.11*		*7,510.14*
Pressure Treated Lumber	**1.00**	**EA**	**4,547.00**	**1,461.11**	**6,008.11**	**1,502.03**	**7,510.14**
(Note: Assume 2 9' braces per span. A 6x6 grid for a 25 x 64 house yields 60 piles with 55 spans. Therefore, total bracing = 2 x 9 x 55 = 990 LF of 4x4 bracing<---)							
			3.30		*4.36*	*25.00*	*5.45*
4x4 Cross Bracing	990.00	LF	3,267.00	1,049.80	4,316.80	1,079.20	5,396.00
(Note: Reference LRH's 202 floodproofing implementation model.)							
			2.00		*2.64*	*25.00*	*3.30*
Pressure Treated Lumber, 2x10	640.00	LF	1,280.00	411.31	1,691.31	422.83	2,114.14
(Note: Reference LRH's 202 floodproofing implementation model.)							
			53.19		*70.28*		*87.85*
Structure Above Sill Plate	**1,600.00**	**SF**	**85,104.00**	**27,346.85**	**112,450.85**	**28,112.71**	**140,563.57**
			53.19		*70.28*	*25.00*	*87.85*
New Structure - Above Sill Plate	1,600.00	SF	85,104.00	27,346.85	112,450.85	28,112.71	140,563.57
(Note: Cost estimated by Marshall-Swift for an average quality 1600 SF structure in the Gulfport, MS area. See backup sheet from Marshall Swift. Estimated unit price is $68.35/SF including O&P. Since the pier foundation is estimated elsewhere in this estimate, the standard CIP wall foundation should be deleted from this Marshall-Swift estimate. Also, the overhead and profit should be deleted here. MII will add O&P to the direct cost unit price under the Project Item tab. O&P is estimated to be 14.5% in the Marshall-Swift program. The foundation is estimated to cost $67/LF of perimeter (MEANS), including O&P. $67/LF x (25x2 + 64x2) = $11,926. Now, $11,926 / 1600 SF = $7.45/SF that is to be deducted from the estimated unit price for new construction. So, $68.35/SF - $7.45/SF = $60.90/SF (w/ O&P) Subtracting O&P, $60.90/SF / 1.145 = $53.19/SF<---)							
Misc	**1.00**	**LS**	**13,637.49**	**3,879.40**	**17,516.89**	**4,379.22**	**21,896.11**
Misc	1.00	LS	9,673.49	2,751.78	12,425.27	3,106.32	15,531.58
(Note: This item of work covers the cost of site work concrete, porches, as well as other items such as landscaping, exterminating, and construction cleanup for a structure whose first floor is 6' off low ground. Price estimated by LRH's 202 floodproofing implementation model.)							
			3,964.00		*5,091.63*	*25.00*	*6,364.53*
Utility Hookups	1.00	EA	3,964.00	1,127.62	5,091.63	1,272.91	6,364.53
(Note: This is an allowance to cover the costs of installing (or having installed) the water, electric, and gas meters.)							
			95.40		*125.62*		*157.03*
New Structure - 15 feet off low ground	**1,600.00**	**SF**	**152,633.68**	**48,363.03**	**200,996.71**	**50,249.18**	**251,245.89**
			48,992.68		*64,735.72*		*80,919.65*

Description			Quantity	UOM	ContractCost	Contingency	ProjectCost
Foundation & Structure Below Sill Plate	**1.00**	**EA**	**48,992.68**	**15,743.04**	**64,735.72**	**16,183.93**	**80,919.65**
			740.76		*978.79*		*1,223.49*
Timber Piles	**60.00**	**EA**	**44,445.68**	**14,281.93**	**58,727.61**	**14,681.90**	**73,409.51**
(Note: Assume a 6' grid for a house that is 25' x 64' (i.e., a 1600 SF house).)							
			13.72		*18.13*	*25.00*	*22.66*
Timber Piles	3,240.00	VLF	44,445.68	14,281.93	58,727.61	14,681.90	73,409.51
(Note: Material price taken from MEANS. Piles are assumed to be 12" diameter at the head and are to be embedded 40' into the ground. Q*54)							
			4,547.00		*6,008.11*		*7,510.14*
Pressure Treated Lumber	**1.00**	**EA**	**4,547.00**	**1,461.11**	**6,008.11**	**1,502.03**	**7,510.14**
(Note: Assume 2 9' braces per span. A 6x6 grid for a 25 x 64 house yields 60 piles with 55 spans. Therefore, total bracing = 2 x 9 x 55 = 990 LF of 4x4 bracing<---)							
			3.30		*4.36*	*25.00*	*5.45*
4x4 Cross Bracing	990.00	LF	3,267.00	1,049.80	4,316.80	1,079.20	5,396.00
(Note: Reference LRH's 202 floodproofing implementation model. Assume 2 9' braces per span. A 6x6 grid for a 25 x 64 house yields 60 piles with 55 spans. Therefore, total bracing = 2 x 9 x 55 = 990 LF of 4x4 bracing<---)							
			2.00		*2.64*	*25.00*	*3.30*
Pressure Treated Lumber, 2x10	640.00	LF	1,280.00	411.31	1,691.31	422.83	2,114.14
(Note: Reference LRH's 202 floodproofing implementation model.)							
			53.19		*70.28*		*87.85*
Structure Above Sill Plate	**1,600.00**	**SF**	**85,104.00**	**27,346.85**	**112,450.85**	**28,112.71**	**140,563.57**
			53.19		*70.28*	*25.00*	*87.85*
New Structure - Above Sill Plate	1,600.00	SF	85,104.00	27,346.85	112,450.85	28,112.71	140,563.57
(Note: Cost estimated by Marshall-Swift for an average quality 1600 SF structure in the Gulfport, MS area. See backup sheet from Marshall Swift. Estimated unit price is $68.35/SF including O&P. Since the pier foundation is estimated elsewhere in this estimate, the standard CIP wall foundation should be deleted from this Marshall-Swift estimate. Also, the overhead and profit should be deleted here. MII will add O&P to the direct cost unit price under the Project Item tab. O&P is estimated to be 14.5% in the Marshall-Swift program. The foundation is estimated to cost $67/LF of perimeter (MEANS), including O&P. $67/LF x (25x2 + 64x2) = $11,926. Now, $11,926 / 1600 SF = $7.45/SF that is to be deducted from the estimated unit price for new construction. So, $68.35/SF - $7.45/SF = $60.90/SF (w/ O&P) Subtracting O&P, $60.90/SF / 1.145 = $53.19/SF<---)							
Misc	**1.00**	**LS**	**18,537.00**	**5,273.14**	**23,810.14**	**5,952.54**	**29,762.68**
Misc - 15' off low ground	1.00	LS	11,029.18	3,137.42	14,166.60	3,541.65	17,708.25
(Note: This item of work covers the cost of site work concrete, porches, as well as other items such as landscaping, exterminating, and construction cleanupfor a structure whose first floor is 6' off low ground. Price estimated by LRH's 202 floodproofing implementation model.)							
			3,964.00		*5,091.63*	*25.00*	*6,364.53*
Utility Hookups	1.00	EA	3,964.00	1,127.62	5,091.63	1,272.91	6,364.53
(Note: This is an allowance to cover the costs of installing (or having installed) the water, electric, and gas meters.)							
			11.81		*15.17*		*18.97*
300 SF Stoarge Area	**300.00**	**SF**	**3,543.82**	**1,008.09**	**4,551.91**	**1,137.98**	**5,689.89**
(Note: This would only apply to structures that area greater than 6 FT above low ground. In this estimate, that means that it only applies to the 8' - 15' raise category.)							
			6.53		*8.38*	*25.00*	*10.48*
4" Concrete Pad	300.00	SF	1,958.22	557.05	2,515.26	628.82	3,144.08
(Note: Price from LRH's floodproofing model for 4" concrete = $370/CY, direct cost. SAY = $400/CY for the gulf coast. Now, $400/CY x (4in/36in/yd) = $44.44/SY. So, $44.44/SY / 9 SF/SY = $4.94/SF<---)							

Description			Quantity	UOM	ContractCost	Contingency	ProjectCost
			13.21		*16.97*	*25.00*	*21.22*
Siding	80.00	EA	1,057.07	300.70	1,357.77	339.44	1,697.21
(Note: = 10 x 2 + 30 x 2 = 80 SF)							
			264.27		*339.44*	*25.00*	*424.30*
Door	1.00	EA	264.27	75.17	339.44	84.86	424.30
Electrical Allowance	1.00	LS	264.27	75.17	339.44	84.86	424.30
			70.00		*70.00*		*87.50*
Existing Structure - 6 feet off low ground	**1,600.00**	**SF**	**112,000.00**	**0.00**	**112,000.00**	**28,000.00**	**140,000.00**
(Note: This price already includes all contractor markups. Therefore, none have been added here.)							
			70.00		*70.00*	*25.00*	*87.50*
Raise Structure on Segmented Piles to 6' off low ground	1,600.00	SF	112,000.00	0.00	112,000.00	28,000.00	140,000.00
(Note: Reference Pat Davie of Davie Shoring. Pat said that costs for a turnkey job would normally run about $70/SF to raise a slab foundation house. This price would be for a slab foundation struture whose finished first floor would be greater than 4' above low ground. It is suspected that Pat pays significantly less than Davis-Bacon wages. PD was consulted on this issue. PD recommended that since this project is to be formulated on the basis that Davis-Bacon is not a requirement, the pricing info provided by Mr. Davie is acceptable.)							
			82.21		*82.84*		*103.56*
Existing Structure - 15 feet off low ground	**1,600.00**	**SF**	**131,543.82**	**1,008.09**	**132,551.91**	**33,137.98**	**165,689.89**
(Note: This price already includes all contractor markups. Therefore, none have been added here.)							
			80.00		*80.00*	*25.00*	*100.00*
Raise Structure on Segmented Piles to 15' off low ground	1,600.00	SF	128,000.00	0.00	128,000.00	32,000.00	160,000.00
(Note: Reference Pat Davie of Davie Shoring. Pat said that costs for a turnkey job would normally run about $70/SF to raise a slab foundation house. He said that costs would likely be higher than this for a raise as high as 15' off low ground. Therefore, add $10/SF to cover this higher raise. This price would be for a slab foundation struture whose finished first floor would be greater than 15' above low ground. PD was consulted on this issue. PD recommended that since this project is to be formulated on the basis that Davis-Bacon is not a requirement, the pricing info provided by Mr. Davie is acceptable.)							
			11.81		*15.17*		*18.97*
300 SF Stoarge Area	**300.00**	**SF**	**3,543.82**	**1,008.09**	**4,551.91**	**1,137.98**	**5,689.89**
(Note: This would only apply to structures that area greater than 6 FT above low ground. In this estimate, that means that it only applies to the 8' - 15' raise category.)							
			6.53		*8.38*	*25.00*	*10.48*
4" Concrete Pad	300.00	SF	1,958.22	557.05	2,515.26	628.82	3,144.08
(Note: Price from LRH's floodproofing model for 4" concrete = $370/CY, direct cost. SAY = $400/CY for the gulf coast. Now, $400/CY x (4in/36in/yd) = $44.44/SY. So, $44.44/SY / 9 SF/SY = $4.94/SF<---)							
			13.21		*16.97*	*25.00*	*21.22*
Siding	80.00	EA	1,057.07	300.70	1,357.77	339.44	1,697.21
(Note: = 10 x 2 + 30 x 2 = 80 SF)							
			264.27		*339.44*	*25.00*	*424.30*
Door	1.00	EA	264.27	75.17	339.44	84.86	424.30
Electrical Allowance	1.00	LS	264.27	75.17	339.44	84.86	424.30