EXECUTIVE SUMMARY

This study estimates some of the economic costs that can be anticipated under the No-Action scenario for barrier island protection in the study area. The economic cost impacts of No-Action on storm tidal surge flooding regimes and on barrier island configurations have been compared to Current Conditions, the latter referring to a current storm in current conditions. In considering the implications of the results of this study for barrier island policy, it is important to clearly recognize the meaning of these results. Most importantly, No-Action would result in the gradual disintegration of the barrier island systems. This disintegration would lead to changes in hydrologic regimes landward of these systems. The economic implications of these hydrologic changes are the subject of this report. The Step J report will estimate the potential economic implications of proactive, alternative barrier island projects compared to the No-Action alternative.

The only storm analyzed in this study is a Category 5 storm. Expected flood damages to residential, commercial, industry and public structures, as well as to roads, were estimated. These expected damages took into consideration the probability that such a storm would occur. Damage costs for the No-Action alternative were then compared to costs of a similar storm under Current Conditions of the barrier shoreline and wetland configurations. It is emphasized that only a Category 5 storm was analyzed. Lesser storms would also yield economic implications for the different project alternatives. For this reason alone, the cost differences would be underestimated.

In addition to estimating storm damages to coastal structures, this study estimated the economic losses to commercial and recreational fishing from wetlands losses, which may or may not be related to coastal barrier island configurations (the subject of Step J). Other estimated economic costs include the reburial of barrier island and inland oil and gas pipelines. The study also estimated increased oil and gas well platform construction costs, for those fields lying landward of the barrier islands, under No-Action compared to Current Conditions. Increased highway and street maintenance costs were also estimated, as were increased costs of public water supplies. Increased costs of No-Action to agriculture appeared to be minimal, but this may be attributable to not being able to estimate costs of length or depth of inundation.

A summary of increases in costs under No-Action compared to Current Conditions is shown the table below. No-Action imposes costs that range from $68.488 to $72.172 million higher over a

30-year period than Current Conditions, using the USACE 8.25% discount rate. The annualized increase in costs over this 30-year period range from $6.209 to $6.537 million per year. Over a 100-year period, these costs range from $110.751 to $116.040 million higher under No-Action compared to Current Conditions, with annualized cost increases of $9.141 to $9.577 million per year. Lower discount rates result in higher present and annualized value estimates of these increased costs. For example, with a 3% discount rate the present value of cost increases range from $126.527 to $135.044 million for the 30-year period. These cost increases can be attributed to both barrier island loss and to wetlands losses, the latter caused by a variety of factors. The No-Action scenario confounds both barrier island and wetlands losses.

A Summary of Cost Increases to the Study Area of No Action Compared to Current Conditions ($1000's)

Discount Rate	Current Condition Compared to:	No-Action 30-years $1000's Low	No-Action 30-years $1000's High	No-Action 100-years $1000's Low	No-Action 100-years $1000's High
1	2	3	4	5	6
8.25%	Present Value	$68,488.11	$72,171.79	$110,751.40	$116,040.09
	Annualized Value	$6,209.05	$6,536.51	$9,140.71	$9,577.19
5.00%	Present Value	$98,747.55	$104,789.62	$221,030.19	$234,706.83
	Annualized Value	$6,378.70	$6,753.45	$11,136.22	$11,825.30
3.00%	Present Value	$126,527.00	$135,043.62	$428,209.72	$460,463.94
	Annualized Value	$6,379.09	$6,782.80	$13,552.17	$14,572.91

These costs may understate the full costs of No-Action. This is because storm damage costs were estimated for only one type of storm, a Category 5 storm. Lesser storms would certainly impose increased damage costs under No-Action. These lesser storms could not be analyzed in this study because the hydrologic modeling was done for only Category 5 prototype storms. It is also important to realize that these cost values are not measures of the gains that would be made from barrier island remediation and reconstruction. However, they can be interpreted as estimates of the costs at risk from No-Action. Step J will establish whether these costs are diminished by project alternatives.

1.0. INTRODUCTION

The purpose of this amendment to Step H is to quantify several major economic impacts of potential Barataria-Terrebonne Barrier Island disintegration under a No-Action alternative compared to Current Conditions. The driver of these economic impacts will be the changes in hydrologic conditions associated with barrier island and wetlands losses. The estimation procedure is to select those potential impacts that are both important and quantifiable, and are physically tied to the storm and wave related changes that would result from barrier island and wetlands losses. The procedure is to compare conditions, and their economic implications, at present, Current Conditions, with projected future conditions prevailing under a No-Action assumption.

The economic impacts analyzed in this report are limited to those which are both likely to be important in magnitude and that are quantifiable given existing data and estimation methodologies. These economic impacts are a result of changes in coastal flooding regimes, which may be altered under the No-Action alternative. These impacts are largely increases in costs associated with residing and operating businesses in flood prone coastal areas. Flooding scenarios under two types of Category 5 hurricanes will be used, along with flood damage functions, to estimate the damages of storms for the Current Conditions, and for the No-Action alternative.

A complicating factor in analyzing the economic impacts of the No-Action condition is that multiple coastal ecosystem altering processes, wetlands loss, sea level rise and subsidence, are expected to occur in the future. The impacts of authorized coastal restoration projects and their impacts to wetlands loss have been included. The hydrologic predictions, which are the basis for damage estimates in this study, are assumed to continue to occur at historic rates with adjustments being made for the inclusion of the authorized projects. The economic impact estimates for No-Action will include not only the impacts of future barrier island erosion, but also the future predicted loss of wetlands.

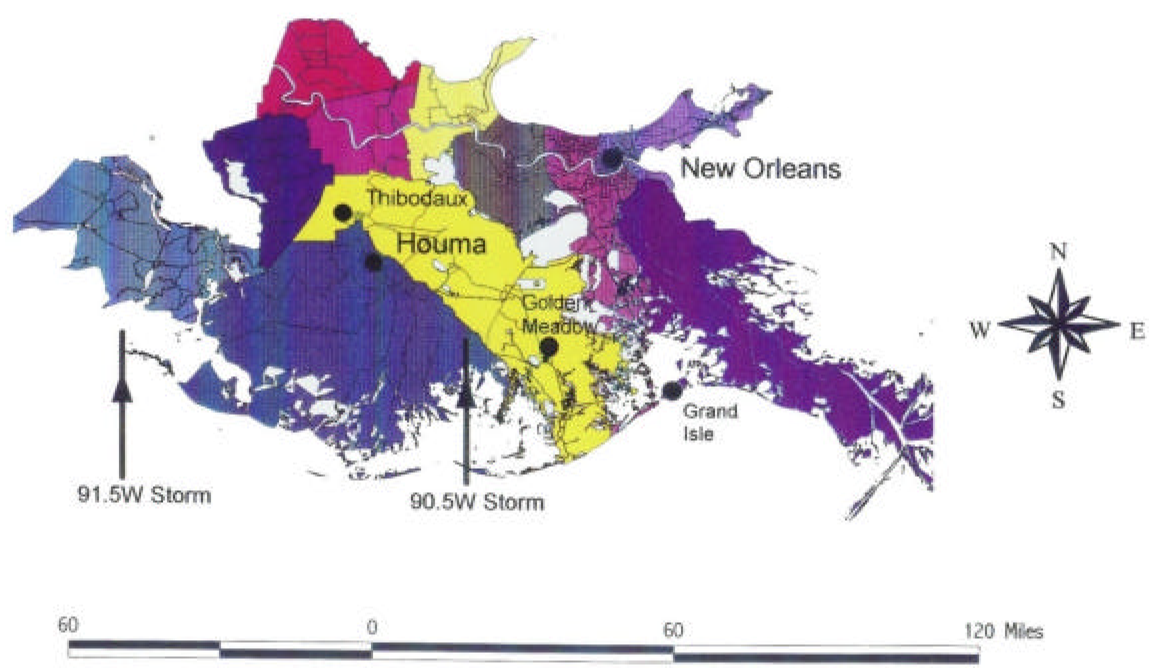
Another complicating factor in analyzing economic impacts is the possible alteration of coastal population patterns under No-Action. In principle, any increases in the likelihood or intensity of coastal flooding would adversely alter economic conditions in the coastal region.

This would result in increases in the cost of living and doing business in coastal flood prone areas. This may cause reconsideration of coastal residence and business activity. One counteracting factor to any regional decline, however, would be broader economic development conditions in the state and region as a whole. These conditions may counteract any coastal out-migration. This study assumes that coastal populations will remain fixed at current levels. This may be a reasonable assumption, as population stability has marked coastal Louisiana during the past decade (Step F Report).

This report estimates damages to the study area defined for the barrier island project analysis. This area is limited to all or parts of an eleven-parish region in coastal Louisiana. The eleven parishes are: Ascension, Assumption, Jefferson, Lafourche, Orleans, Plaquemines, St Charles, St James, St John, St Mary, and Terrebonne. These eleven parishes are shown in Figure 1. Flood damage analysis is performed at the Census Tract level. This level of resolution is dictated by the demographic and flood depth resolutions.

This study uses Arc View(Geographic Information Systems (GIS) for analyzing the location specific impacts of flooding events under No-Action and Current Conditions. Section I of this report outlines the hydrologic data used for deriving flooding conditions. Flood scenario data are coupled with US Army Corps of Engineer (USACE) estimated flood damages to residential, commercial, industrial and public structures from floods of varying depths. Section II explains these data and how they will be used in this report. Section III outlines how the flood event and damage data are combined in the GIS analysis to obtain location specific estimates of flood damages to structures. Section 4.0 presents the prototype storm related flood damage estimates and analyses how these damages are expected to differ between No-Action and Current Conditions.

Figure 1 The Eleven Parish Study Area



2.0. HYDROLOGIC REGIMES

The coastal hydrologic regimes were predicted by the LSU project team using computerized hydrologic modeling. Two types of hydrologic phenomena were modeled:

* Storm surge flood levels under two prototype storms
* Average wave heights for normal tidal processes

The procedures for modeling these two phenomena are explained in the Step G report. Preliminary analysis of the average wave height scenarios showed differences between Current Conditions and No-Action that were too small for any economic analysis. Therefore, economic analysis was limited to the storm surge flood scenarios.

Hydrologic models were used to predict storm surge elevations ranging from 0' to 20' for two worst case storms: Category 5 hurricanes reaching landfall at longitudes 90.5W and 91.5W. These longitudes are shown in Figure 1. Topographic models were used to estimate land elevations, a complex function of sea level rise, wetlands loss and coastal subsidence. The difference between predicted storm surge and topographic elevations is flood depth from storm surge. Flood depth is then the height of the water level above the land surface. All elevations are measured NGVD. The flood depth is used as the basis for flood damage estimation.

Flood depth data were created at LSU using ArcInfo(GIS software and exported in a format for use by the Spatial Analyst Extension(in ArcView(, a GIS software for personal computers. These data are in raster form, with each pixel representing a predicted flood depth. Flood depths were developed as continuous data but were reclassified into discrete classes for visual and statistical analysis. The reclassification scheme was as follows:

Original Depth	**Reclassified Depth**
> 16.5 feet (5.0 m)	17 feet (5.2 m)
15.5-16.5 feet (4.7-5.0 m)	16 feet
↓	↓
1.5-2.5 feet (0.5-0.8 m)	2 feet (0.6 m)
0.5-1.5 feet (0.2-0.5 m)	1 feet (0.3 m)
< 0.5 feet (0.2 m)	0 feet (0.0 m) - No Flooding

A baseline tidal surge estimation was made for each of the two prototype storms using the present configuration of barrier islands and coastal topography. Figure 2 shows these tidal surge flood depths for the 90.5W storm. This is a complicated map but illustrates the variation in flood depths in the study area. In order to assist the reader in understanding the resolution of the surge flood data, Figure 3 is a magnified version of Figure 2 showing the same flood data overlayed with US Bureau of the Census census tract boundaries for Terrebonne and Lafourche parishes. Census tract boundaries were obtained using Wessex(software and data, and are based on US Bureau of the Census Tiger 92 files.

Each pixel (small square) of the raster flood data in Figure 3 has a surge flood depth associated with it. It was necessary to obtain a statistic representing flood depth for each census tract in the study area. The mean and median of the raster flood depth data were obtained for each census tract using the "Summary Zone" feature of the ArcView Spatial Analyst Extension(. The mean and median flood depths can differ substantially within a census tract and there is no general rule whether one will be greater than the other in a particular tract. As explained below, damage estimates were made using each of these statistics.

For example, census tract 221090002 in Terrebonne parish is shown in Figure 3 as the tract with the dot representing Houma. This tract contains 29 pixels of flood depth data. The mean flood depth for this tract is 0.3448 feet under Current Conditions and the 90.5W storm; and the median depth is 0 feet. Census tract 220570216 is in Lafourche parish directly to the east of Houma in Figure 3. This tract contains 278 pixels, with a mean flood depth of 1.5863 feet and a median depth of 1 foot. Similar mean and median flood depth statistics were obtained for all census tracts in the study area, for each of the two prototype storms, and for the No-Action and Current Conditions (the basis for Figures 2 and 3).

The LSU project team modeled flood depths under the three project conditions for 30-years from the present and for 100-years from the present. The economic impact methodology is not so highly developed that it can directly analyze minor changes likely to occur over a 30-year period. Therefore, the procedure used in this report was to analyze economic impacts for the conditions 100-years from the present and to presume that impacts 30-years from the present would be only thirty percent of the full 100-year impact; i.e., economic impacts occur linearly over time. This may or may not be the case. Only the 100-year analyses and maps are presented in this section.

The effects of the different project assumptions on flood depths can be analyzed using the GIS system employed in this study. It is illustrative to show how one can use the flood depth data to estimate flood depth impacts of the project assumptions. For example, we can compare flood depths of a 90.5W storm occurring at present, Current Conditions, with depths of the identical storm 100-years from the present under a No-Action assumption; i.e., barrier islands and wetlands are allowed to disintegrate. Figure 4 shows the pixel-by-pixel expected increases in depths under this No-Action assumption for the census tracts in Terrebonne and Lafourche parishes. Census tract 221090002 in Terrebonne Parish is expected to have flood depths increase from a mean of 0.3448 feet under Current Conditions to 0.5517 feet in 100-years under the No-Action assumption; i.e., an increase of 0.2069 feet. Similarly, tract 220570216 in Lafourche Parish is expected to have an increase in mean depth from 1.5863 feet under Current Conditions to 2.8633 feet in 100-years under the No-Action assumption; i.e., an increase of 1.2770 feet.

Figure 5 shows flood depth implications of the 91.5W prototype storm under No-Action compared to flood depths expected for the same storm under Current Conditions. Increased flooding under the No-Action case impacts the entire study area, the majority of these increases being between 0' and 2'.

Some types of economic impacts of flooding are more dependent upon whether the area is flooded at all, rather than upon the elevation of the flooding. For example, road damages would be more related to whether the road is flooded than to the elevation of the water above the road surface. For this reason, Figures 6 and 7 illustrate those areas where locations not likely to be flooded under Current Conditions would likely be flooded in 100-years under No-Action. These are the flooding "margins." Figure 6 shows these margins for the 90.5W storm. Bands of newly flooded areas run across the center of the study area below Houma, and run in a band between Thibodaux and Houma. Figure 7 shows the 91.5W storm margins, consisting primarily of two bands: one southeast of New Orleans and another running along Grand Isle and Grande Terre.

The LSU project team also modeled average tidal wave heights for normal tides. As noted above, the difference in these elevations was too small to perform any meaningful economic analysis. This is not to say there were not differences; only that the resolution of the economic data were not high enough to perform any analysis of these wave heights.

Figure 2 Tidal Surge Flood Depths Under Present Barrier Configuration With 90.5W Storm, (0-15 foot flood elevations only)

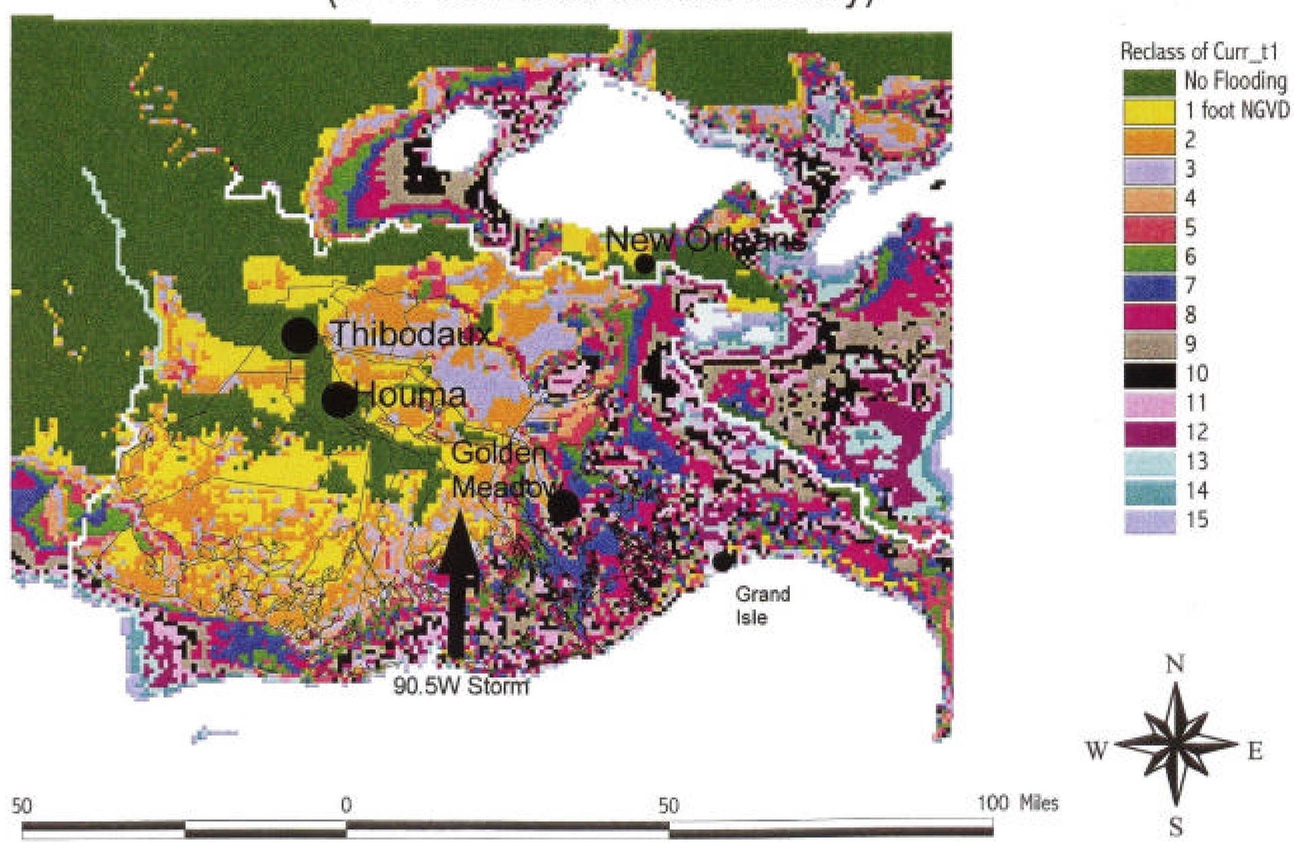


Figure 3 Zoom of Tidal Surge Flood Depths Under Present Barrier Configuration With 90.5W Storm, Showing Terrebonne and Lafourche Parish Census Tracts (0-10 foot flood elevations only)

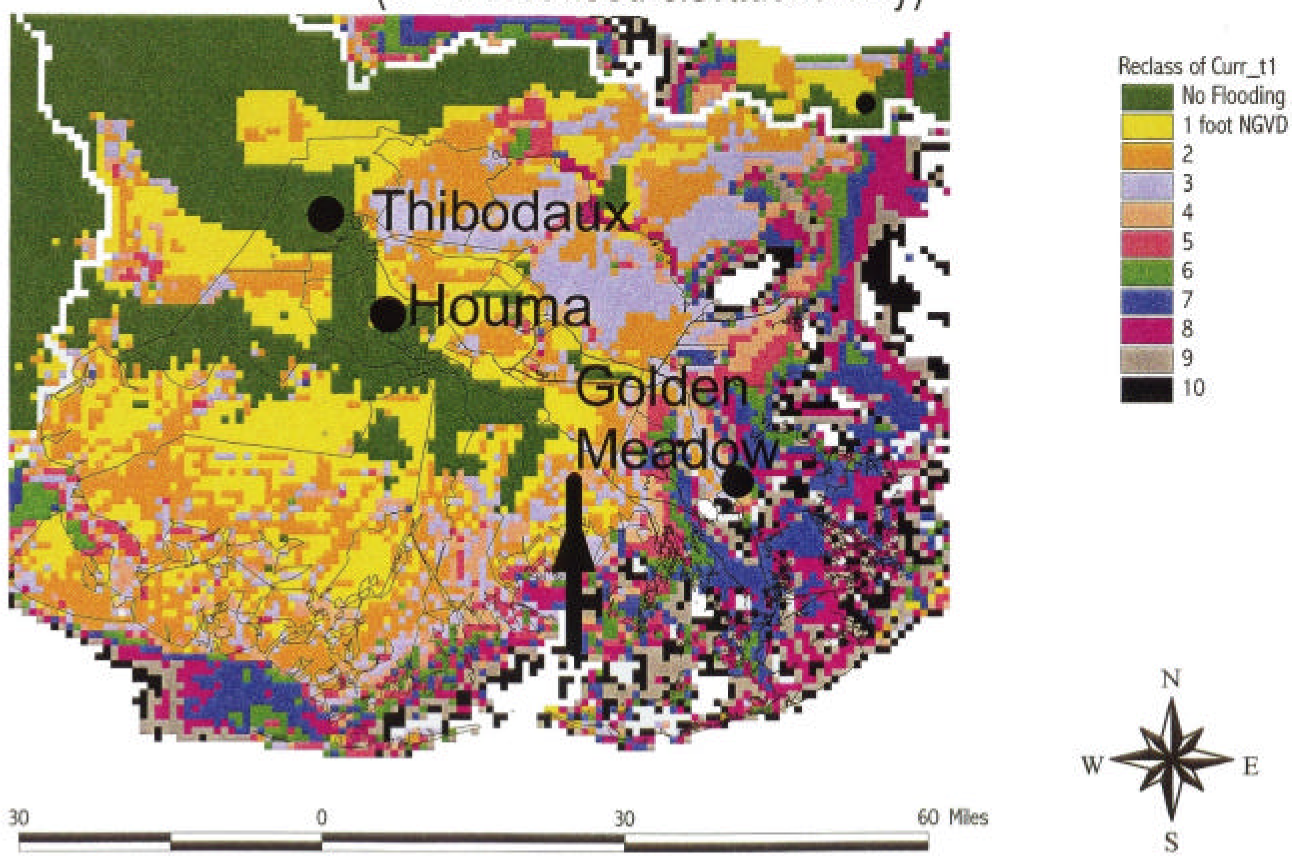


Figure 4 Increases in Flood Depth in 100 Years Under No Action Compared to Current Flood Depths for 90.5W Storm, Showing Terrebonne and Lafourche Parish Census Tracts

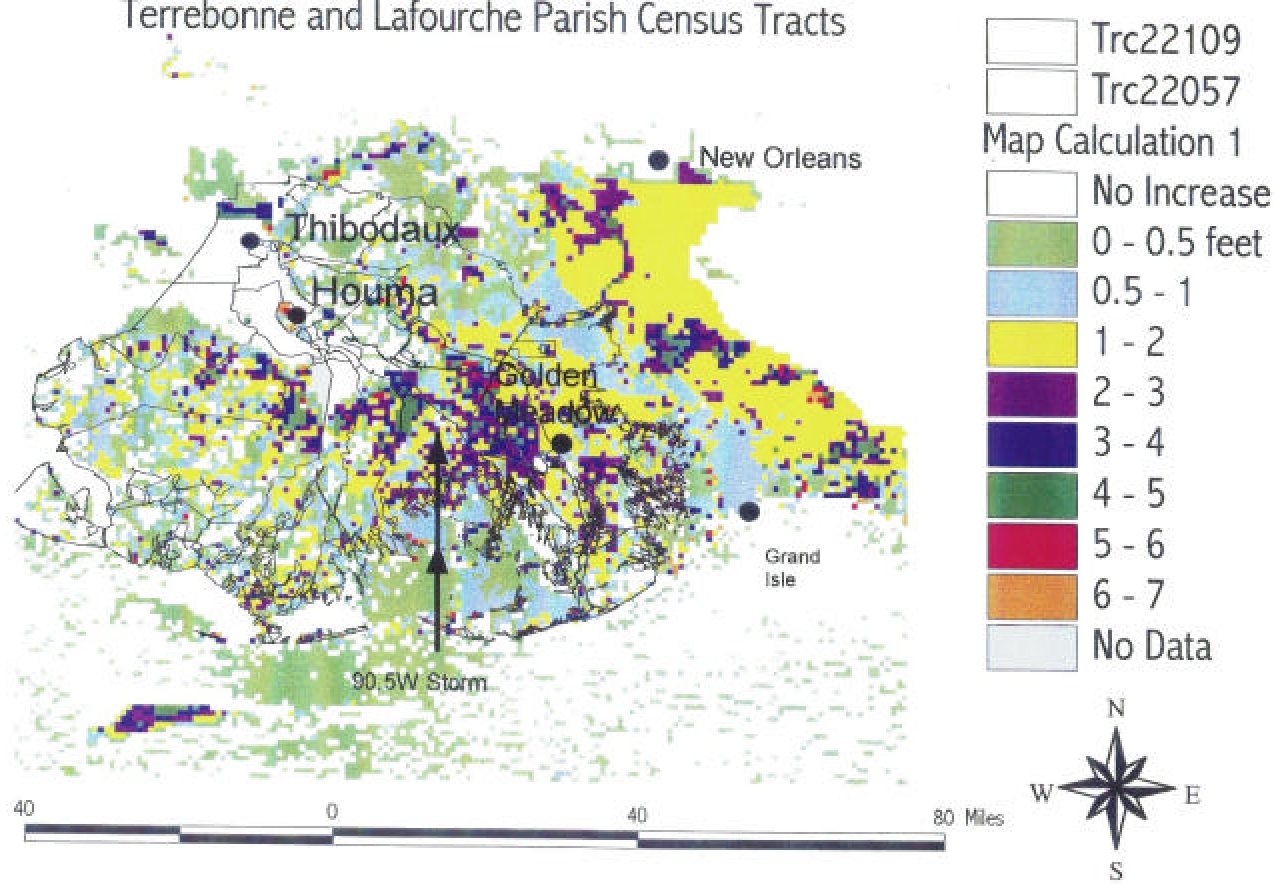


Figure 5 Increases in Flood Depth in 100 Years Under No Action Compared to Current Flood Depths for 91.5W Storm

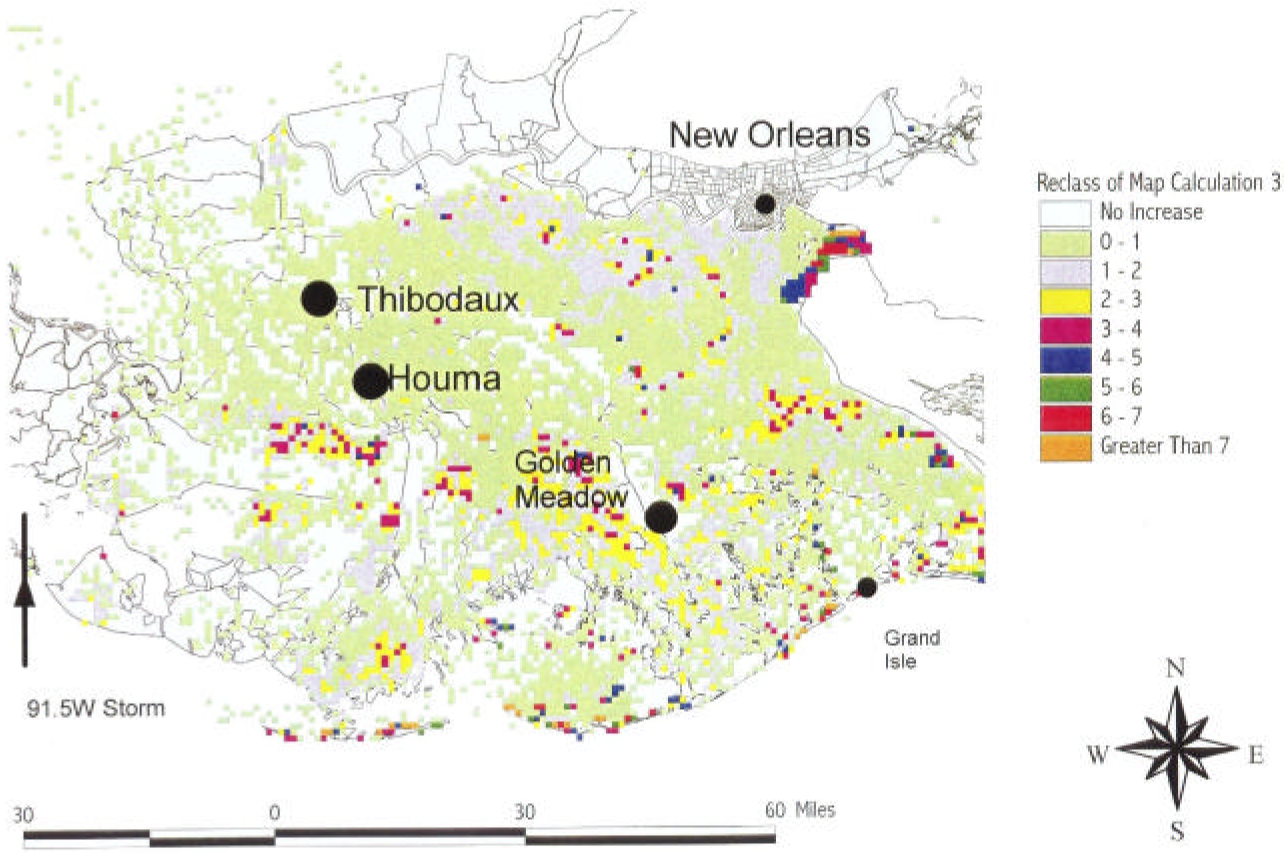


Figure 6 Areas Newly Flooded By 90.5W Storm in 100 Years Under No Action, But Not Currently Flooded in 90.5W Storm

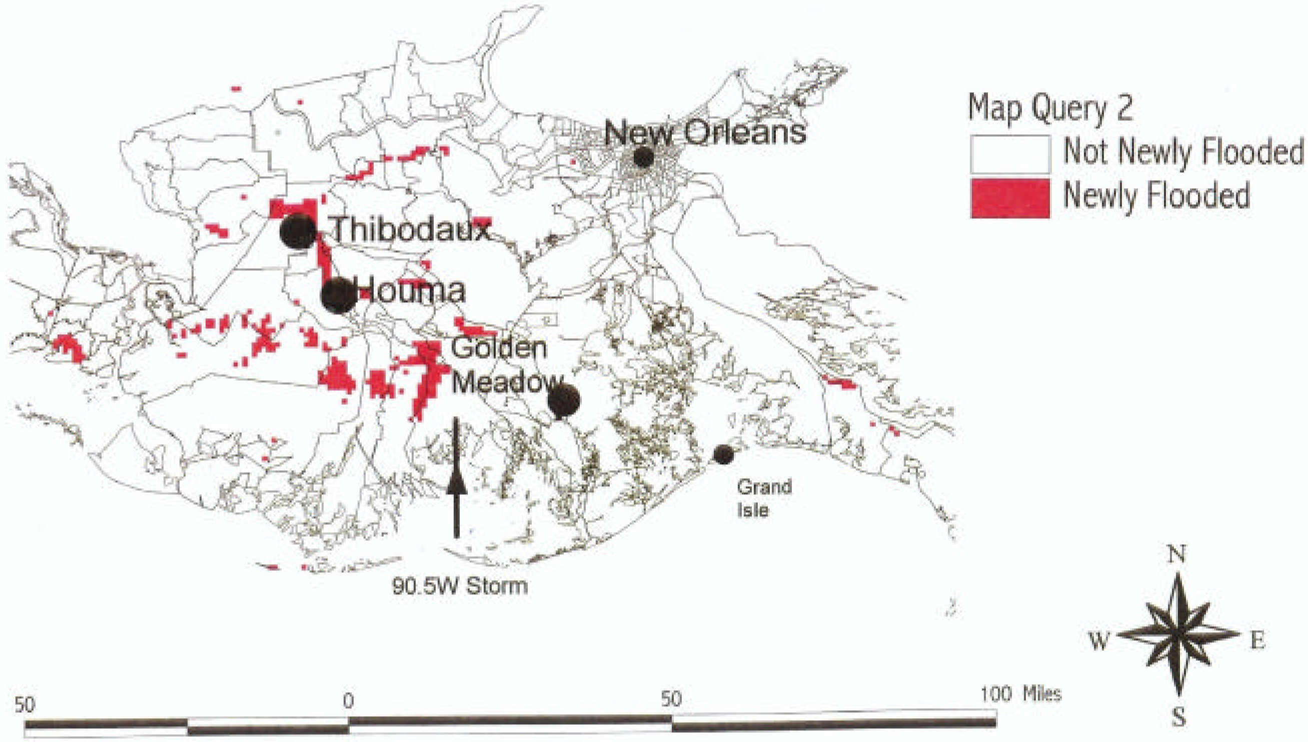
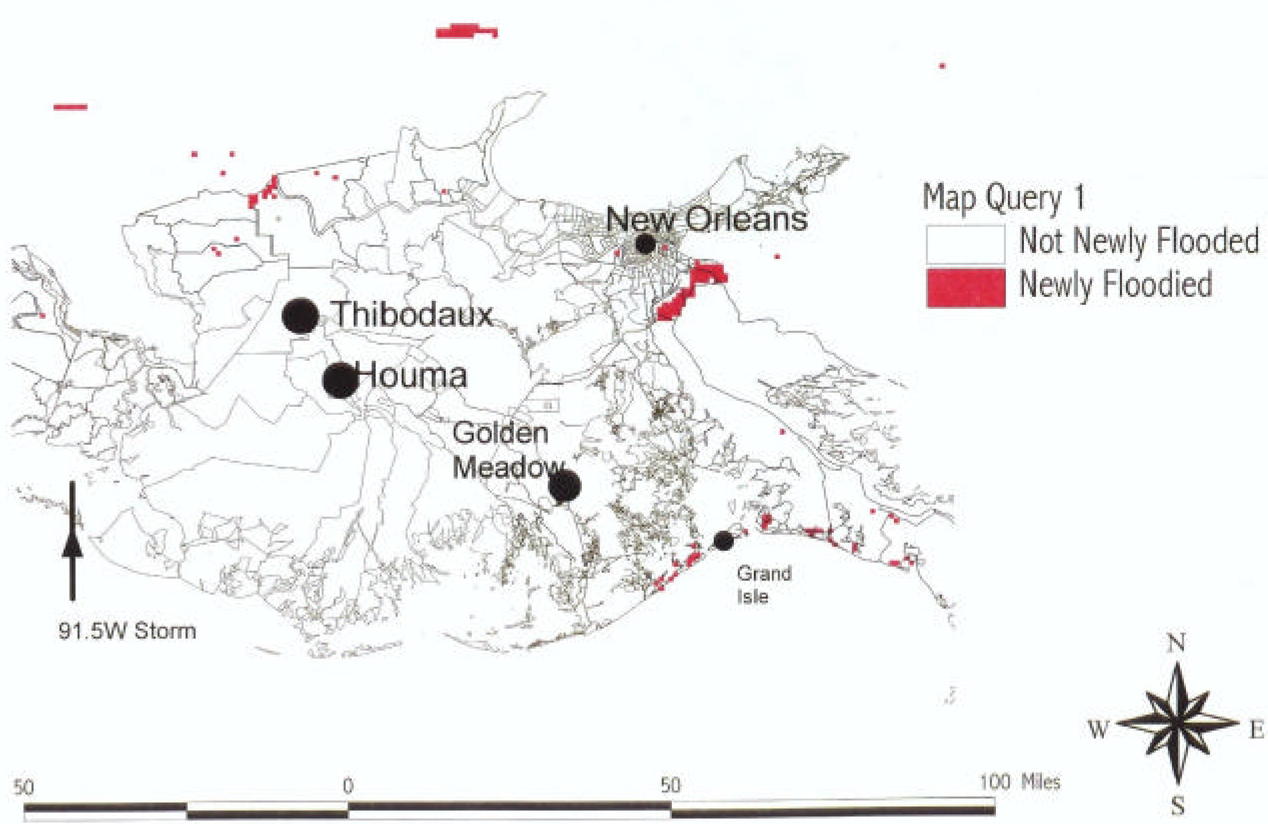


Figure 7 Areas Newly Flooded By 91.5W Storm in 100 Years Under No Action, But Not Currently Flooded in 91.5W Storm



3.0. WETLANDS LOSSES

Wetlands losses in the study area were estimated by the LSU project team using historic loss rates projected to 30 and 100-years. The procedure is explained in the Step G Report and the results used here come from the Step H Report. The total acres of fresh, intermediate, brackish and saline marsh in the study area in 1990 was estimated to be 366113 hectares (ha). The projected marsh area in 30-years under No-Action at historic loss rates was estimated to be 307,482 ha; and in 100-years 231,373 ha. These represent losses of 58,630 ha of marsh (16% of 1990 acres) over the first 30-years under No-Action, or 1,954 hectares per year; and an additional loss of 76,109 ha, or 1,087 hectares per year, over the remaining 70 years. The estimated total loss over the 100-year period represents roughly 37% of the 1990 area.

It is important to note that these wetlands loss estimates are based on historic loss rates provided by the CWPPRA agencies. These may or may not be reasonable estimates under a No-Action alternative; the loss of barrier islands may increase or decrease these loss rates. Consequently, it is problematic to use these historic-based loss rates to appraise wetlands related impacts of No-Action. However, this information was used to make an estimate of the economic value of these losses.

Wetlands losses will result in reduced catch to commercial and recreational fishing due to reductions in habitat and nutrient sources. Reduced commercial catch will lower profits, and reduced recreational catch will lower fishing enjoyment. The economic implications of these two effects can be measured. Effects of wetlands habitat and nutrient losses will alter fish species composition. Step H suggests possible effects, although these effects are not quantified in a manner useful for estimation of economic losses. Wetlands loss effects on fisheries are complicated by the possible initial increase in "edge," which may increase fishery stock carrying capacity. However, this positive effect on fisheries may turn negative with more significant wetlands losses.

In order to estimate the impact on commercial fishing incomes, we make the simplistic assumption that fishing effort will remain constant in spite of reduced stock. (While effort would likely diminish, there is no way of estimating that.) The loss of catch is then the result of reduced catch for the same effort, and can be estimated using the marginal product of wetlands for commercial fishery harvest. Farber and Costanza (1987) have made such estimates for coastal Louisiana, and Bell (1989) has made estimates for coastal Florida. These studies estimate the present value of the marginal product of wetlands for commercial catch to be approximately $91 to $128 per hectare in 1990 dollars. Inflating this estimate to 1995 dollars using the Consumer Price Index results in a present value of $102.55 to $144.06 per hectare. This means, for example, that losing one acre of wetlands today would result in future fisheries losses, the present value today being between $91 and $128 per hectare. Furthermore, losing one acre of wetlands ten years from today will also result in a present value loss at that time of $91 to $128 per hectare. However, the present value today of that $91 to $128 loss occurring in ten years requires discounting that $91 or $128 back to today; i.e., a ten year discounting.

Recall that annual wetlands losses under No-Action will be 1,954 ha per year for the first 30-years, and 1,087 ha per year for the remaining 70 years. The economic value of these losses is obtained by first calculating the value of wetlands losses in each of the 100-years, using the different loss rates for the 30 and 70 year period. This stream of economic losses is then discounted using the various discount rates employed in this study. The present values of these commercial fisheries losses over the 30 and 100-year periods are shown Table 1. For example, 100-year losses are shown in Columns 5 and 6. Using the 8.25% discount rate mandated for US Army Corps of Engineers water projects (US Army Corps of Engineers, 1994, p. B-1), these losses range from $2.319 million to $3.258 million. Annualized losses are $0.191 and $0.269 million per year, respectively. Losses over the 30-year period range from a present value of $2.204 to $3.096 million. The 5% and 3% discount rates generate present value loss estimates over the 100-year period ranging from $3.556 million to $7.343 million.

Recreation will be adversely impacted by barrier island loss due to reductions in wetlands habitat and nutrient flows to fisheries. Farber and Costanza (1987) have estimated the recreational value per acre of coastal Louisiana wetlands using measures of losses in enjoyment from fishing and hunting. The argument is that users place a value on current conditions would place a lower value if catch or bag conditions were less desirable. Using a study of Louisiana recreationists by Bergstrom and Stoll (1990), recreationists would presumably value a 50% reduction in catch or bag at $66 per year per user ($1986), or $92 in $1995. Estimated wetlands loss over the 100-year period are 37% of the 1990 wetlands area. We assume that a 37% reduction in catch or bag would be valued at 37/50=0.74 times $92, or $68.08 per year per user.

Table 1. Present Value of Commercial Fishery Losses Due to Wetlands Loss Under No-Action ($1,000's)

Discount Rate	Current Condition Compared to:	No-Action 30-years $1000's Low	No-Action 30-years $1000's High	No-Action 100-years $1000's Low	No-Action 100-years $1000's High
1	2	3	4	5	6
8.25%	Present Value	$2204.04	$3096.28	$2319.34	$3258.26
	Annualized Value	$181.89	$255.53	$191.41	$268.90
5.00%	Present Value	$3080.88	$4328.08	$3556.11	$4995.69
	Annualized Value	$155.22	$218.06	$179.16	$251.69
3.00%	Present Value	$3928.24	$5518.46	$5227.03	$7343.03
	Annualized Value	$124.31	$174.64	$165.41	$232.38

In order to convert wetlands losses into recreational valuations, we must make some assumption relating wetlands to catch. A variety of studies have shown a direct and roughly proportional relation between area of marsh or marsh-water interface of coastal wetlands and commercial fishery production (Mitsch and Gosselink, 1993). This relation has held for Louisiana fish and shrimp harvests (Turner, 1982; Farber and Costanza, 1987), for blue crab production in Florida (Lynn et al., 1981), and oyster production in Virginia (Batie and Wilson, 1978). In addition, Turner (1977, 1982) has show a direct linear relation between fish harvest and wetland area for a number of fisheries around the world. Therefore, we assume that catch or bag would fall proportionally with wetlands loss over time, so the $68.08 annual loss noted above would increase linearly from $0 at present to $68.08 in 100-years.

The Bergstrom and Stoll (1990) study estimated a total of 76,000 recreational users (not total visits) annually in 1986 within the seven parish regions surrounding Terrebonne-Barataria Bays. If this number of users remained constant, the annual loss in recreational enjoyment would total $5.23 million in 100-years. On the other hand, if recreational use falls proportionately with wetlands loss, usage would be only 47,880 users annually in 100-years, resulting in a loss of enjoyment equal to $3.26 million by that time. The present values of these annual losses over the 30 and 100-year periods are shown in Table 2. For example, losses over the 100-year period are shown in columns 5 and 6. Using the 8.25% discount rate, the present value of these recreational losses range from $7.78 million to $8.20 million. Using 5% and 3% discount rates, these losses range from $18.02 million to $47.42 million. The present value of losses over the 30-year period range from $5.530 to $14.143 million, depending on the low/high estimates and discount rates.

Table 2. Present Value of Recreational Fishery Losses Due to Wetlands Loss Under No-Action ($1,000's)

Discount Rate	Current Condition Compared to:	No-Action 30-years $1000's	No-Action 30-years $1000's	No-Action 100-years $1000's	No-Action 100-years $1000's
		Low	High	Low	High
1	2	3	4	5	6
8.25%	Present Value	$5530.01	$5858.36	$7476.53	$8204.52
	Annualized Value	$502.85	$532.70	$617.03	$677.11
5.00%	Present Value	$9248.27	$9872.54	$18,020.46	$20,815.59
	Annualized Value	$601.61	$642.22	$907.92	$1048.75
3.00%	Present Value	$13,185.98	$14,142.71	$39,044.87	$47,421.37
	Annualized Value	$672.73	$721.55	$1235.64	$1500.72

This is a measure of the welfare losses to recreationists from reduced recreational enjoyment. It does not measure income losses to the recreational industry, nor does it truly estimate the reduction in recreational usage; it simply makes an ad hoc proportional presumption. It has been estimated that recreational activities result in regional (Lafourche, Jefferson, Plaquemines and Terrebonne Parishes) spending of $956.2 million annually, and employment of 18,696 persons if we include direct and indirect economic impacts (Industrial Economics, 1996). If it is reasonable to presume that recreational visitation and spending will decline proportionately with wetlands losses over the next 100-years, annual spending and employment will fall by $353.8 million and 6918 persons, respectively, during this period. However, these are very ad hoc assumptions given the complex factors behind the dependence of recreational activity on wetlands quality.

4.0. FLOOD DAMAGES TO STRUCTURES

This section of the report estimates the impact of No-Action on flood damages to structures from the two prototype storms. These estimates use a damage function developed from data provided by the US Army Corps of Engineers (USACE) and from the US Bureau of the Census. The damage function is then applied to the storm surge flood depths obtained from the hydrologic modeling outlined in Section 2.0.

4.1. Flood Damage Data

The USACE has developed flood stage-damage functions for Water Resource Units (WRU) in some regions of coastal Louisiana (US Army Corps of Engineers, 1994). These stage-damage functions show structural damages to properties under varying flood stages. Structural damage categories include:

* Residential (including mobile homes)
* Commercial
* Industrial
* Public
* Farm Buildings
* Automobiles

Damages to public structures would include damages to schools and other public buildings, but not to public infrastructure, such as roads and piers. These damages are presented in 1993 price levels and are used directly for purposes of this report. For example, WRU 148A (near Morgan City) has 5863 1 or 2 story residential structures, 610 commercial and industrial structures, and an estimated 5863 automobiles at risk (it was assumed that each household would leave one vehicle at their residence when evacuating). Total structural damages from various flood stages in this WRU were estimated to be:

Stage Elevation Damages	($1000's)
4.0 ft (1.2 m)	$0.0
5.0 ft (1.5 m)	$847.5
6.0 ft (1.8 m)	$4,377.0
7.0 ft (2.1 m)	$25,589.7

Flood damages do not begin until elevations reach 1.2 m; and they increase more than proportional to elevation.

The stage-damage data presented in the USACE study were used to establish a statistical damage function. The functional form presumed a logistic function, whereby damages first increase more than proportional to flood depth then eventually less than proportional to flood depth, reaching a maximum ceiling damage level. This is reasonable as location patterns would suggest more properties at risk as flood levels rise, but only a maximum amount of damage can be done. The functional form also presumed that damages would be proportional to residential structures in a WRU. This implies that commercial, industrial and public structures at risk are assumed to be proportional to residential structures. While this residential proportion-logistic function is reasonable theoretically, other functional forms were tested.

Data for the six WRU's published in the USACE (1994) study were used to estimate the logistic function. The best-fit regression, using SAS(, resulted in the following estimation:

log(Damages)=1.443852 - 2.710987*(1/Flood Depth) + 1.11726*log(Residences)
(t=1.346) (t=-7.493) (t=6.746)
Adjusted R-sq = 0.50; N=92

Damages were total damages to structures in a WRU; and Residences were the number of 1 or 2 story residential units in the WRU, published in the same USACE report. Flood Depth was flood stage elevation minus the elevation at which damages became positive. So this variable represents depth of water above land; i.e., not flood elevation. Use of this variable was necessary in order to use the LSU modeled depth of flood data, which were not flood elevations but depth of flood above land. This estimating model explained one-half of the variance in the data. The coefficient for log(Residences) was not significantly different from 1, implying damages are proportional to residential units. Other function forms did not have as high R-sq values as this logistic function.

4.2. Flood Damage Estimates

Flood damages were estimated for all storm and project scenarios using the damage function presented above. Damages were estimated by census tract. The census tract data for the variable, Residences, in the damage function equation was the total number of unattached (non-mobile home) residential structures in a tract. This is the census statistic most like the 1 and 2 story structures used to estimate the damage function. This statistic was obtained from the Wessex(US Bureau of the Census database. It is important to note that mobile home damages are included in the variable, Damages, in the damage function; so damages to these structures are included in the estimates.

The flood variable, Flood Depth, in the damage function was estimated for each census tract. The average flood depth for a tract was obtained by applying the ArcView(procedure, Summarize Zones, to the flood scenarios modeled by the LSU project team. Both mean and median flood depths were estimated for each census tract in the study area. They were estimated for both prototype storms, and for Current Conditions and No-Action.

Table 3 shows predicted flood damages in each study area parish from the 90.5W storm. These include damages to residential (including mobile homes and automobiles), commercial, industrial and public structures. For example, the predicted flood damage, using mean flood depths, to Ascension parish if there is such a storm under Current Conditions is shown in Column 1, $15.588 million. Expected damages, using median flood depths, are $6.116 million. The estimate using median depths is substantially lower than the estimate using mean depths in this case. In other instances, such as the estimate for Plaquemines parish, the estimate using the median is slightly higher than the estimate using the mean flood depths. The bottom row of Columns 1 and 2 show estimated total damages in the study area from a current 90.5W prototype storm to be between $862.360 and $928.386 million.

Columns 3 and 4 of Table 3 shows estimated damages from a 90.5W prototype storm in 100-years under No-Action. This estimate presumes a constant coastal population distribution and number of residential structures over this time period; i.e., a fixed number of residences in the same census tracts (the basis of this assumption was provided in the Introduction). Column 3 shows that a the prototype Category 5 storm would result in an estimated $15.589 million in structural damages to Ascension parish in 100-years under a No-Action plan, when mean flood depths are used as the basis for estimation. This is roughly equivalent to the damages to Ascension parish for an identical storm under Current Conditions, shown in Column 1. However, Column 3 shows that damages to Jefferson, Lafourche and Terrebonne parishes would be substantially higher for a storm which occurs in 100-years under the No-Action plan than an identical storm occurring under Current Conditions.

Table 3. Predicted Flood Damage Costs to Structures from 90.5W Storm, Under Current Conditions and No-Action

	Current Condition	Current Condition	No-Action	No-Action
Date:	Present	Present	100-years	100-years
Parish	Mean $1000's 1	Median $1000's 2	Mean $1000's 3	Median $1000's 4
Ascension	$15,589	$6,117	$15,589	$6,117
Assumption	$602	$495	$506	$495
Jefferson	$379,403	$346,814	$401,756	$387,280
Lafourche	$55,779	$53,211	$74,870	$71,901
Orleans	$255,108	$253,488	$257,786	$256,995
Plaquemines	$34,725	$35,165	$35,754	$36,195
St Charles	$59,043	$52,246	$60,616	$54,153
St James	$18,145	$17,870	$18,715	$17,870
St John	$66,951	$64,403	$67,270	$64,403
St Mary	$22,711	$12,017	$22,687	$12,017
Terrebonne	$20,332	$20,535	$32,055	$31,746
TOTAL	$928,386	$862,361	$987,604	$939,173

The predicted total damages from the 90.5W prototype Category 5 storm occurring in 100-years under the No-Action plan, using mean depths, are $987.604 million, as shown in Column 3. This can be compared to the $928.386 million in damages for an identical storm under Current Conditions, shown in Column 1. In other words, a No-Action plan would result in $59.218 million more damages from a storm in 100-years than the same storm occurring currently. This increase in damages is attributable to the fact that the hydrologic modeling, which is the basis for this estimate, takes into consideration the deterioration of the barrier islands and wetlands over this 100-year period. Therefore, the increased storm damages are due to these two factors jointly; i.e., not simply to the natural reconfiguration of the barrier islands.

Median depths of flooding can also be used as a basis for estimating flood damages. The median may be a superior statistic to represent the depth. This is because the mean can be highly skewed by a few extremely large or small values. This type of situation is typical of many of the census tracts in the study area. Therefore, the median based damage estimates are likely to be more appropriate than the mean based estimates.

Median based damage estimates for the 90.5W storm, $862.361 million, are shown for Current Conditions in Column 2 of Table 1. The corresponding 100-year No-Action damage estimates, $939.173 million, are shown in Column 4. The difference between the two estimates, $76.812 million, is the median based estimate of increases over the next 100-years in storm damages from No-Action compared to damages from the 90.5W storm occurring currently. Recalling the discussion above, this increase is due to both inaction in maintaining the barrier islands as well as the naturally occurring subsidence, wetlands loss and sea level rise over the next 100-years.

Table 4 shows flood damage estimates under Current Conditions and No-Action using the prototype Category 5 storm reaching landfall at 91.5W. Damage estimates for this storm are slightly lower than for the 90.5W storm shown in Table 3. For example, the mean and median total damages from a storm occurring currently (Columns 1 and 2) are $876.670 and $787.636 million, respectively, compared to $928.386 and $862.361 million, respectively, from the 90.5W storm in Table 1. Using median based estimates, a comparison of Columns 2 and 4 of Table 4 shows that No-Action (accompanied by naturally occurring subsidence, wetlands loss and seal level rise) will result in $91.226 million greater damages from a 91.5W storm in 100-years compared to a current storm.

Table 4. Predicted Flood Damage Costs to Structures from 91.5W Storm, Under Current Conditions and No-Action

	Current Condition	Current Condition	No-Action	No-Action
Date:	Present	Present	100-years	100-years
Parish	Mean $1000's 1	Median $1000's 2	Mean $1000's 3	Median $1000's 4
Ascension	$25,978	$17,670	$26,136	$18,187
Assumption	$25,737	$22,061	$27,238	$24,287
Jefferson	$249,478	$235,284	$290,690	$282,847
Lafourche	$123,345	$119,266	$134,935	$131,458
Orleans	$111,680	$91,402	$115,327	$95,779
Plaquemines	$26,014	$20,102	$31,138	$31,318
St Charles	$54,344	$33,006	$59,233	$38,766
St James	$10,682	$8,100	$11,829	$8,951
St John	$31,478	$29,226	$31,806	$29,716
St Mary	$51,649	$46,403	$51,425	$46,403
Terrebonne	$166,285	$165,116	$172,611	$171,149
TOTAL	$876,670	$787,636	$952,369	$878,862

4.3. Using Flood Damage Estimates for Evaluating Increased Costs Under No-Action

The flood damage predictions presented in Section 4.2 can be used to estimate the expected damage costs of No-Action compared to Current Conditions. However, using them is not straightforward. First, these comparisons are based on damage estimates for storms occurring 100-years from the present. Project evaluation procedures require annual comparisons of costs over a 30-year period rather than a snapshot comparison for an event in 100-years. A 30-year comparison requires some method of interpolating results from a 100-year analysis to an annual 30-year period. Second, costs of barrier island scenarios are expected costs. These expected costs are based both on the expectations of the effects of hydrologic changes, modeled for use in this study, as well as expectations that the events modeled will occur. Expected costs are probabilistic, based on probabilities that the events analyzed will occur. Third, the storms analyzed are Category 5 hurricanes. Analysis was not performed for a wide variety of storms of varying intensities. The estimated comparisons are only valid for this one type of storm, so could not be used to represent other storms.

The reason this study bases its analysis on a storm event in 100-years is that changes in flooding regimes over a 30-year period were anticipated to be small relative to the statistical procedures that would have to be used. For example, it was anticipated that mean values could not be used as reasonable bases for estimation and that median values were a better basis. Also, continuous flood depth data had to be grouped into integer (1', 2', 3', etc.) categories for analysis by the GIS. This meant that depth changes less than 0.2 m (0.5 ft) would become lost in the statistical procedures. We can interpolate to 30-years by assuming that hydrologic related damages increase linearly over time. This means that if No-Action compared to Current Conditions would increase damage costs by $76.812 million (Table 3) if the prototype storm event occurred in 100-years, it would increase costs by thirty percent of that amount, $23.04 million, if the storm event occurred in 30-years. Similarly, it would increase costs by fifteen percent of that amount, $11.52 million, if it occurred in 15 years. Of course, the linearity assumption underestimates cost increases at 30-years if most of the hydrologic changes were to occur early in the 100-year period; and, conversely, overestimates cost increases for the opposite case.

From Tables 3 and 4, the damage cost increase from Current Conditions to No-Action in 100-years for a 90.5W Storm was **$76.812 million** and for a 91.5W storm, **$91.226 million**. Using linear interpolation, this implies the expected damage cost increases from a Category 5 storm for no-action in 30-years would be thirty-percent of this amount. Therefore, given the assumptions used in this study, expected damage cost increases from a Category 5 storm will increase in 30-years by $23.044 million for a 90.5W storm and $27.368 million for a 91.5W storm. Again, these losses are due to combined loss of barrier islands and interior wetlands.

Table 5 uses the 30-year damage cost increase to estimate the present values of thoses cost increses using three discount rates: 8.25%, 5%, and 3%. The US Army Corps of Engineers was using a discount rate of 8.25% in 1993 (US Army Corps of Engineers, 1994), the base year used for this study. It is always useful to do a sensitivity analysis of effects of discount rate assumptions on present values, since there is considerable controversy surrounding appropriate discount rates.

Using the 8.25% discount rate, the increases in damage costs are $2.137 million for the 90.5W storm and $2.537 million for the 91.5W storm. The 90.5W storm is predicted to cause the larger flood damage than the 91.5W track for current conditions and no-action. However, the estimated increase in damage for no-action compared to current conditions is larger for the 91.5W track. This implies that future losses of the barrier shoreline and wetlands along the western portion of the Phase 1 Study Area will have slighly more flood damage impact than those in the eastern section of the study area.

Table 5. Increased Median Flood Damages for Current Conditions and No-action Damages ($1000's)

Discount Rate	Current Condition Compared to:	No-Action 30-years ($1000's) 90.5W	91.5W
	Increased Damages (30-years)	**$23,044**	**$27,368**
8.25%	Present Value	$2,137	$2,537
5.00%	Present Value	$5,332	$6,332
3.00%	Present Value	$9,494	$11,275

These cost increases must be interpreted as minimum cost increases since lesser storms would also result in higher damage costs under No-Action. Of course, the assumptions and procedures necessary to achieve these estimates (the damage function used, USACE flood stage damage estimates, hydrologic modeling, statistical averaging of flood depths by census tract, temporal linearity, etc.) may have problems of their own, but they are not inherently biased upward or downward. Considering only a Category 5 storm does bias damage cost increases downward because it is only one of five types of storms that could impact the coast.

5.0. OTHER COST IMPACTS OF NO-ACTION COMPARED TO CURRENT CONDITIONS

Increased storm damage costs are likely the most significant effects of barrier island disintegration. There may also be some attendant wetlands losses attributable to barrier island disintegration. Some of these impacts were estimated in Sections 3.0 and 4.0. However, there may be other storm related economic costs associated with No-Action compared to Current Conditions. These would include:

* Oil and gas infrastructure cost savings
* Highway and street maintenance cost savings
* Water supply cost savings
* Agricultural crop flood damage cost savings

These costs are more difficult to estimate than structural damage costs due to data availability problems as well as conceptual measurement problems. Very ad hoc assumptions may have to be made to make estimates of these costs. This section attempts to address estimation of several of these costs. However, it should be noted that these estimates do not possess the same degree of theoretical and statistical validity as the flood damages in Section 4.0.

5.1. Oil And Gas Infrastructure

Oil and Gas infrastructure (wells, pipelines, processing plants, compressor and metering stations, etc.) face increased storm risk as the barrier islands deteriorate. When barrier island loss exposes platforms to open seas that were once protected behind barrier islands, platform construction costs can double or triple (personal communication with Steve Champagne, Chet Morrison Contractors, Feb. 19, 1997; Jules Ledet, Dolphin Services, Feb 19, 1997; and Kerry Guidry, Maw Welders, Feb. 20, 1997). The loss of barrier islands would diminish the usefulness of these islands as anchors for pipelines and would require pipeline reburial. This could be a substantial cost (Brent Duet, Koch Gateway Pipeline Co, Feb 19, 1997; Frank Mariah, Koch Gateway Pipeline Co, Feb 20, 1997). Pipelines traversing wetlands may have to be reburied if protected marshland areas convert to open water. Storm impacts from increased tidal surge elevations could require some redesign of well structures in open water.

Barrier island stabilization has the straightforward benefit of providing an anchor point for offshore oil and gas pipelines; barrier island loss would require more expensive engineering of these pipelines. This cost is estimated below. Current and future oil and gas wells located in open waters landward of the barrier islands benefit from barrier island stabilization insofar as tidal surge heights are moderated by the islands, as Figures 4 and 7 illustrate. These figures show that surge height elevations directly landward of the barrier islands in the study area will increase up to one foot for both prototype Category 5 storms. A cost for reengineering at-risk well platforms is estimated below.

5.1.1. Barrier Island Pipeline Reburial Costs

Barrier islands are anchoring structures for some offshore pipelines. There are currently nearly sixty 6" or larger pipelines coming onshore in the study area comprising the Terrebonne-Timbalier Bay and the Barataria Bay complexes (DTC, Incorporated, 1990). They range in size from 6" to 36", with an average size of 16". These are the pipelines most vulnerable to the projected barrier island losses in these complexes. Pipeline reburial occurs regularly as lines rise and washovers remove line cover. However, this reburial rate would increase as barrier islands disintegrate. We cannot predict how much more frequently and how much more severe reburial will be. We cannot estimate the costs for pipelines not shown on the DTC map.

Loss of the barrier island anchoring system will require the construction of underwater trenches and reburial of these and future pipelines. Lowering a pipeline costs approximately $3500 per day. A 3000' segment of a 16" pipeline in Timbalier Bay was lowered in 1992 at a cost of $20,000 (communication with Brent Duet, Koch Gateway Pipeline Co, Feb. 19, 1997). We assume that the barrier island loss will require such length of burial at roughly similar costs for a 16" line, the average of lines coming onshore in the study area. We also assume that same number of roughly 60 lines will cross the islands during the next 30 and 100-year periods. While some will become unnecessary, others will be needed for further offshore field production. We also have to make some assumption about when the reburial will be necessary. According to Step G projected barrier island scenarios, there will be sufficient loss within 30 to 50 years to require reburial; so we assume reburial of all 60 lines in 30-years, again in 60 years and again in 90 years. This reburial cost would be $1.2 million each time it occurs. The present values and annualized values of these costs for the 30 and 100-year periods of analysis are shown in Table 6. These reburial costs are small compared to other costs of No-Action.

Table 6. Expected Barrier Island Pipeline Reburial Costs for No-Action Compared to Current Conditions ($1000's)

Discount Rate	Current Condition Compared to:	No-Action 30-years $1000's	No-Action 100-years $1000's
1	2	3	4
8.25%	Present Value	$111	$123
	Annualized Value	$10	$10
5.00%	Present Value	$278	$357
	Annualized Value	$18	$18
3.00%	Present Value	$494	$782
	Annualized Value	$25	$25

5.1.2. Wetlands Pipeline Reburial Costs

Many miles of pipeline also run through the coastal wetlands. For example, there are roughly 750 miles of pipelines, ranging from 5" to 36" lines, running through the wetlands region adjacent to the Terrebonne-Timbalier and Barataria Bays (DTC, Incorporated, 1990). These estimates were calculated from pipeline maps and include all pipelines within approximately five miles of these bays . These wetlands provide some protection against wave action and storms. Loss of wetlands may require the repositioning of vulnerable lines, including reburial. Lowering a line in marsh canals or protected waters typically costs approximately $5000 per day (communication with Frank Mariah, Koch Gateway Pipeline Co, Feb 20, 1997). We can assume all miles of lines will have to be reburied, but gradually over the next 100-years. If it costs $20,000 to bury a 3000' segment of line in open water, and roughly 40% more for inland burial, this suggests it would cost $28,000 to bury the 3000' line; i.e., $49,280 per mile. Assuming 750 miles must be replaced over the next 100-years as wetlands convert from marsh to open water, this means 7.5 miles per year, or $369,600 reburial cost per year. Table 7 shows, for example, that these reburial costs in the adjacent wetlands over the 30-year period will have a present value of $4.064 million under No-Action, using the USACE discount rate of 8.25%. No-Action costs over the 100-year period have a present value of $4.478 million using this discount rate.

Table 7. Expected Wetlands Pipeline Reburial Costs for No-Action Compared to Current Conditions ($1000's)

Discount Rate	Current Condition Compared to:	No-Action 30-years $1000's	No-Action 100-years $1000's
1	2	3	4
8.25%	Present Value	$4064	$4478
	Annualized Value	$370	$370
5.00%	Present Value	$5682	$7336
	Annualized Value	$370	$370
3.00%	Present Value	$7244	$11,679
	Annualized Value	$370	$370

5.1.3. Oil and Gas Wells and Related Structures

There are roughly 340 oil and gas fields and nearly 19,000 wells in the study area, with 270 fields and over 17,000 wells located in the five parishes adjacent to the barrier islands (Step F Report). The associated well structures may be subject to greater washover intensities from storms in the absence of protective barrier islands. If these inland structures are typically built to withstand washovers there will be no increased engineering and maintenance costs to these inland well structures from increased tidal surge elevations. Figures 4 and 5 suggest these increased tidal elevations would typically range up to 1' in the regions immediately adjacent to the barrier island complexes.

Wells and associated structures in open waters lying landward of the barrier islands may be subject to substantial increased storm risk in the absence of those protective islands. Table 8 shows those fields located in open waters in Terrebonne-Timbalier and Barataria Bays. Column 2 shows there are 4166 such wells. While these are the wells at risk, estimating increased costs to these wells under alternative project scenarios is problematic.

Well platforms located gulfside of the barrier islands have more costly engineering specifications than those located bayside of the islands. While equipment costs are the same, costs of platform fabrication and installation differ. Typical gulfside costs are $210,000 versus bayside costs of $105,000; i.e., gulfside structural costs are roughly twice as high. A platform will typically service several wells (communication with Steve Champagne, Chet Morrison Contractors, Inc., Feb 19, 1997). These increased engineering costs are likely to apply to newly developed wells bayside of the islands. Of course, the critical question is how many new at-risk wells will there be in the next 30-years.

An analysis of wells operating in the study area shows roughly 20 new wells developed during the 1980's. If we assume the same rate of development for the open water areas of the two bays and that one platform can service 10 wells (Walk, Haydel, 1989), there will be an estimated 2 well platforms constructed each decade; or one platform every five years. If the cost differential between gulfside and bayside platforms is $105,000 per platform, increased costs each five years will be $105,000, assuming oil and gas developers anticipate the eventual need for more storm worthy structures. The present and annualized values of these increased costs are shown in Table 8. Using the
USACE 8.25% discount rate, the present value of these increased costs is $0.269 million and annualized values are $0.024 million per year over the 30-year period. The present value of these increased costs is $0.436 using the 3% discount rate, and annualized costs rise to $0.022 million per year.

Table 8. Expected Well Platform Construction Cost Increases for Anticipated Bayside Wells Under No-Action Compared to Current Conditions ($1000's)

Discount Rate	Current Condition Compared to:	No-Action 30-years $1000's	No-Action 100-years $1000's
1	2	3	4
8.25%	Present Value	$269	$296
	Annualized Value	$24	$24
5.00%	Present Value	$355	$458
	Annualized Value	$23	$23
3.00%	Present Value	$436	$703
	Annualized Value	$22	$22

5.1.4. Oil and Gas Refineries and Processing Plants

There are five active refineries and twenty-three gas processing plants in the study area (Step F Report). Only five of the gas processing plants are likely to be vulnerable to increased coastal tidal surges under the No-Action scenario. These facilities are:

Company	Location	MMcfd Capacity
Mobile Oil	Golden Meadow	125
Placid Oil	Chauvin	100
Shell Oil	Chauvin	100
Superior Oil	Dulac	50
Texaco	Cocodrie	11

Some of the oil and gas refineries may be subject to increased flooding risks under No-Action compared to current conditions. The five refineries in the study area are:

Company	Location	BBL/day Capacity	Increased Flood Depth 90.5W Storm	Increased Flood Depth 91.5W Storm
BP Oil	Belle Chase	223,000	1 - 2 feet	4 - 6 feet
Marathon Oil	Garyville	255,000	none	none
St Rose Refining	St. Rose	32,000	none	none
Shell Oil	Norco	215,000	none	1 - 2
Star Enterprise	Convent	225,000	none	none

Figures 2 and 5 show the increased flood depths under No-Action compared to current flood depths for the 90.5W and 91.5W storms, respectively. Locating these refineries on these figures shows the increased flood depths likely to occur at these facilities. These increased depths are shown above.

Estimation of potential flood damage costs to these structures is problematic. On the one hand, the flood damage estimation methodology used in Section IV included damages to industrial structures insofar as these structures were included in the USACE estimates. However, there is reason to believe that costs to refineries and processing plants are likely to be omitted using that methodology. The reason is that damages were tied to residential units in the WRU's (Water Resource Units) studied by the USACE. Refineries and processing plants in coastal Louisiana are likely to be isolated from residences so the residential based methodology used in Section III may omit, or undervalue, damages to these industrial structures. Damages to these unique structures would have to be estimated using a typical refinery and processing plant. We do not

know of any study that has made such an estimate. While there may be effects of No-Action on flood damage costs to these structures, we are not able to estimate them.

5.2. Highway And Street Maintenance

Increased flooding may impact road and street maintenance expenses. However, the manner in which this may occur is not obvious. The depth of flooding of roads is not as important in determining road damages as whether the road is flooded at all and whether the flow rate of water across the road is high. Figures 6 and 7 show those portions of the study area, called flood risk margins, that are more likely to be flooded from one of the prototype storms under No-Action in 100-years than would be the case for a current storm. Figure 8 reproduces these areas of increased flooding likelihood and adds a data layer of highways and streets from the Wessex(database of Tiger 92 street files. The streets in these areas are at risk from greater flooding. Figure 8 shows the four major areas, labeled A-D, for which total road miles were estimated. Total miles at risk in each of the three impacted parishes of the study are shown below:

Parish		Miles
Terrebonne		150.5
Plaquemines		74.9
Lafourche		145.6
	Total	371.0

A total of 371.0 miles are at greater risk of flood related damages from the prototype storms under No-Action than under Current Conditions.

In order to estimate the damage costs to at-risk roads there must be some cost if damage occurs, and some estimate of the temporal distribution of likely storm events over the 30 and 100-year periods of analysis. Figure 8 illustrates what these flood risk margins would look like in 100-years. Is is assumed these margins, and the associated road mileage at risk, increase linearly over time. So while 371 road miles are ultimately at risk in 100-years, only thirty percent of those miles, 111.3 miles, would be at risk in 30-years, etc.

The per mile cost of road damage from a flood event is difficult to estimate. However, a range of estimates can be used. For example, the per mile cost of resurfacing rural two lane asphalt roads is \$100,000 per mile; and the cost of simply resealing two lanes is only \$40,000 per mile (Step F Report, p. 123).

Table 9. Expected Increases in Highway and Street Maintenance Costs from Flooding Under Category 5 Storm, No-Action Compared to Current Conditions ($1000's)

Discount Rate	Current Condition Compared to:	No-Action 30-years $1000's Low	No-Action 30-years $1000's High	No-Action 100-years $1000's Low	No-Action 100-years $1000's High
1	2	3	4	5	6
8.25%	Present Value	$1,642.06	$4,105.15	$2,414.53	$6,036.31
	Annualized Value	$149.31	$373.28	$199.27	$498.18
5.00%	Present Value	$2,780.40	$6,951.00	$6,294.62	$15,736.55
	Annualized Value	$180.87	$452.17	$317.14	$792.86
3.00%	Present Value	$3,979.78	$9,949.45	$14,507.82	$36,269.54
	Annualized Value	$203.05	$507.61	$459.12	$1,147.81

The expected annual road damage costs in the flood margin areas are given by the following formula:

Expected Road Damage = Miles At Risk x Cost per Mile.

Miles at risk increase linearly over the period from zero to 371 in 100-years. Cost per mile is assumed to be either $40,000 or $100,000 per mile.

Figure 8 Streets Likely to be Newly Flooded by 90.5W or 91.5W Storm Under No Action but Not Flooded Under Current Storm

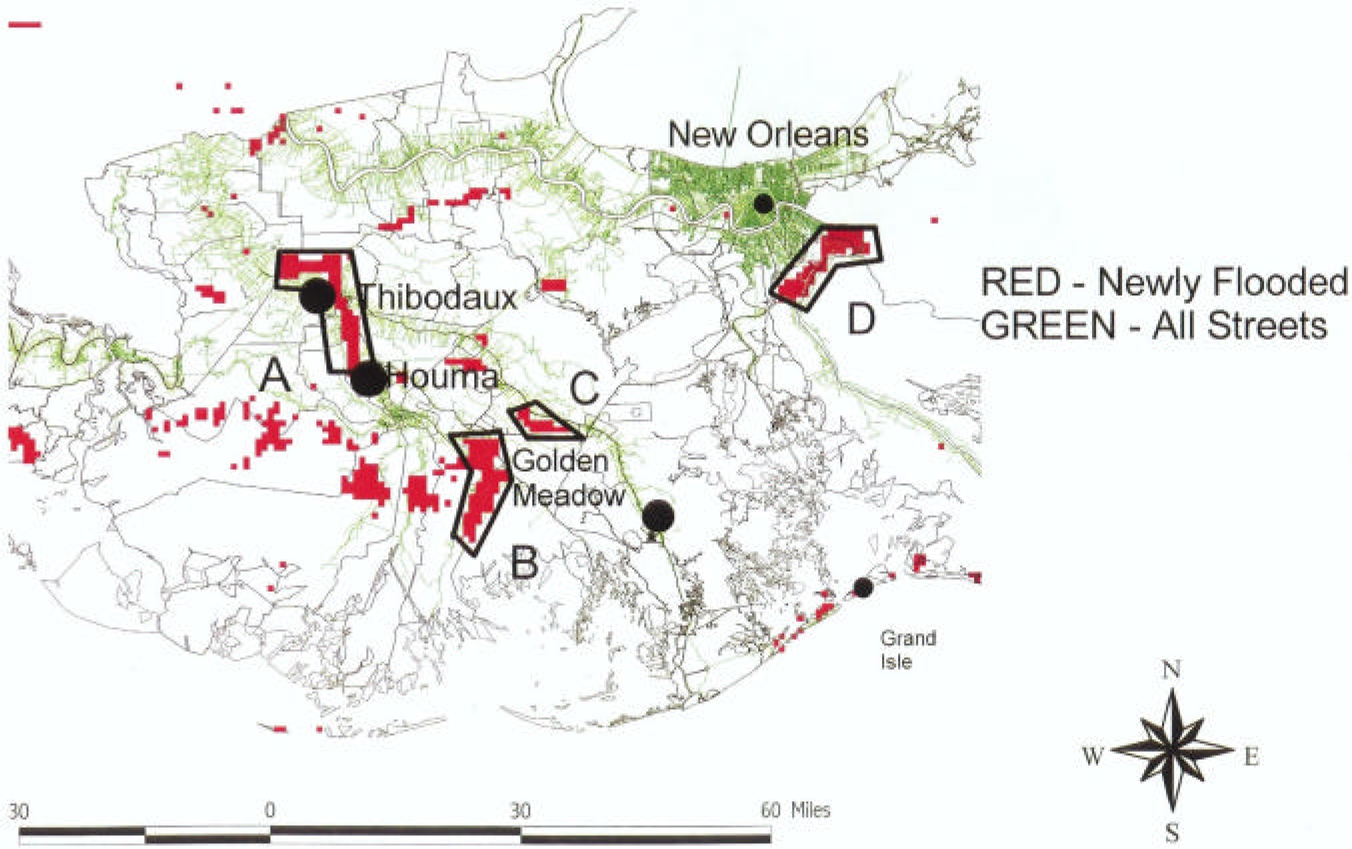


Table 9 summarizes the present values and annualized values of the estimated increases in road damage costs under the No-Action alternative compared to a current storm. Using the USACE discount rate of 8.25%, column 3 shows an estimated present value of No-Action equal to $1.642 million when per mile repair costs are assumed to be low, $40,000 per mile (resealing). This present value increases to $4.105 million if repair costs are assumed to be high, $100,000 per mile (asphalt overlay). The present value of No-Action costs over the 100-year period range from $2.415 to $6.036 million. The corresponding annualized equivalents over 30-years of these present values are $0.149 million and $0.373 million per year, respectively. Present and annualized values using 5% and 3% discount rates are also shown in Table 8. For example, using a 3% discount rate increases the present value for $40,000 per mile costs to $3.980 million, and for $100,000 per mile costs to $9.949 million.

5.3. Water Supply

Public water supplies in the study area rely on both groundwater and surface waters (Step F Report). Nearly 98% of ground and surface water withdrawals from the Barataria-Terrebonne Basins are surface water (U.S. Army Corps of Engineers, 1997). Alterations of the barrier islands and marshes may change salinity regimes of surface waters and make some surface water supplies unreliable. Furthermore, permanent changes in salinity levels and movement of salinity isoclines landward may alter salinity levels of groundwater supplies. These are possible impacts of No-Action.

A USACE (1977) study notes that:

> "Worsening salinity conditions will...require modifications to the water treatment infrastructure in Lafourche Parish, in addition to the recommended plant consolidation in Terrebonne Parish. The without-project condition presumes that indeterminate levels of saltwater intrusion in the future will **alone** (emphasis added) require new investment in water treatment plant and equipment in Terrebonne and Lafourche Parishes." (p. 25)

We assume these upgrades will be required under No-Action while they would not be required under Current Conditions. The construction costs of these upgrades would equal $98 million (USACE, 1997, p. 26). The timing of the need would depend upon the rate of increased salinity intrusion into the study area. The USACE study cited the 1996 Terrebonne Parish Master Plan predicted that existing facilities would not meet demands by 2003. Therefore, we assume the upgrade will be necessary in 10 years from the base year, 1993, resulting in the present and annualized costs shown in Table 10. For example, using the USACE 8.25% discount rate, the present value of upgrade costs will equal $44.355 million, with annualized costs over the 30-year period of $4.033 million per year and annualized costs over the 100-year period of $3.661 million per year. We assume a one time replacement cost, so the present value of costs over the 30-year period are the same as costs over the 100-year period, although the annualized costs will differ.

Table 10. Increased Water Supply Costs Under No-Action Compared to Current Conditions ($1000's)

Discount Rate	Current Condition Compared to:	No-Action 30-years $1000's	No-Action 100-years $1000's
1	2	3	4
8.25%	Present Value	$44,355	$44,355
	Annualized Value	($4,033)	($3,661)
5.00%	Present Value	$60,163	$60,163
	Annualized Value	($3,914)	($3,031)
3.00%	Present Value	$72,921	$72,921
	Annualized Value	($3,720)	($2,308)

5.4. Agricultural Crop Flood Damages

Flooding effects on agriculture will come directly from water damage due to submersion and flow, and, in the long run, to increased soil salinities from saltwater flooding. We can only address the former in this study. Increased flood damages to agricultural crops could be due to two effects: inundation of previously unflooded lands, and longer inundation periods. These are two separate effects. We have no data on length of flooding under the various project alternatives, so this effect cannot be estimated. However, Figures 10 and 11 show newly flooded areas under No-Action compared to Current Conditions for Category 5 storms. If any of these areas are agricultural lands, they may face increased expected flood damages to crops. Figure 9 shows these newly flooded lands and associated streets. The six areas, A-F, are primarily agricultural, according to the USGS Land Use-Land Cover GIS data. They comprise a total of

148 acres, which would become vulnerable from the Category 5 storm in 100-years under No-Action compared to a current storm.

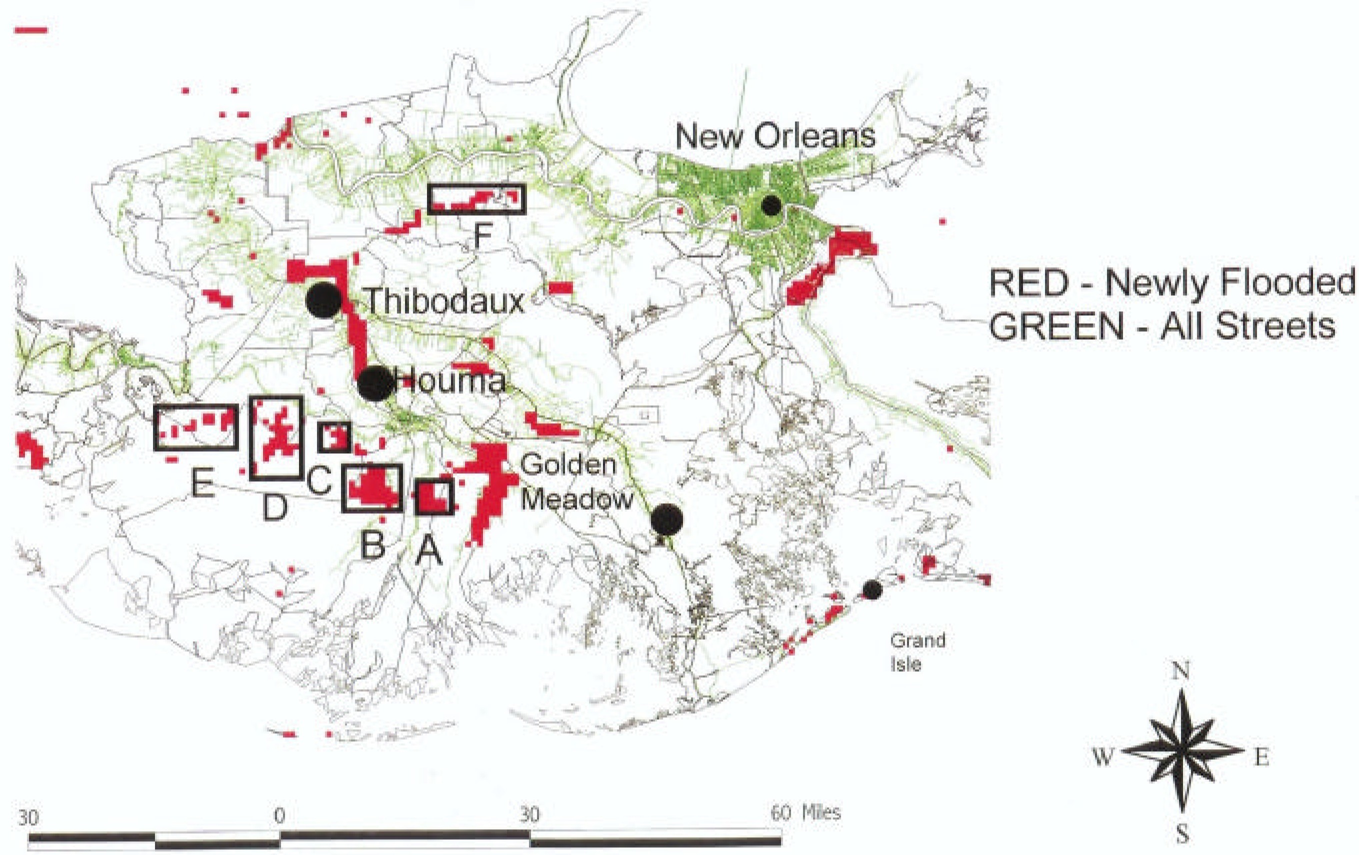
In order to establish costs of this increased crop vulnerability we must make some assumptions. First, we assume, as we did above, that these marginal risk lands increase linearly from zero currently to 148 acres in 100-years, implying that thirty percent of this acreage, 44.4 acres will be vulnerable after 30-years. Second, we assume, as we did above, that the risk of a Category 5 storm in the study area is 0.11.

The costs of flood damage to agriculture depend upon when that damage occurs. For example, if flooding forecloses a farmer from planting a crop, the loss is the net cash returns that would have been obtained from the planned crop. However, if the flooding destroys already planted crops, the loss is the sum of net cash returns plus planting and growing costs. It is most likely that flooding will occur at the end of the growing seasons in South Louisiana, so crop losses from flooding would equal the latter value.

Attachment B shows financial information for agricultural lands in Lafourche and Terrebonne parishes. Net Cash Returns were only $41.07 per acre for these two parishes combined. However, the average market value of crops and livestock per acre in these two parishes was $200 per acre. This would be the loss per acre from flooding after the growing season. If land is vulnerable to flooding from a Category 5 storm it faces a 0.11 probability of flooding each year, and an expected loss of $22 per acre ($22 x 0.11). This means that the expected annual loss from increased vulnerability to these storms will increase from zero currently to $3256 in 100-years ($22 x 148 acres). This is an insignificant amount, and the present values of these increasing annual expected losses would also be insignificant compared to the other cost impacts estimated above. We estimate that agricultural crop loss effects of No-Action will be insignificant.

The insignificance of newly flood lands to agricultural crop losses does not imply that more intense flooding for longer periods of time would be insignificant also. Duration related flooding effects could be very significant in the study area. However, this study has no means to estimate these duration effects.

Figure 9 Agricultural Areas Likely to be Newly Flooded by 90.5W or 91.5W Storm Under No Action but Not Flooded Under Current Storm



6.0. SUMMARY OF COST DIFFERENCES BETWEEN CURRENT CONDITIONS AND NO-ACTION

This study has estimated some of the increases in economic costs from No-Action compared to Current Conditions. There are three related pathways for these cost increases: alterations of hydrologic regimes, alterations of barrier island configurations, and alterations of wetlands configurations. After considering the maps showing changes in normal wave conditions under No-Action, the study concluded that economic impacts of these changes would be small.

The study has focused primarily on wetlands changes and storm flooding related damages under No-Action compared to Current Conditions. We have used flood scenarios for Category 5 storms developed under Step G to estimate damage costs to residential, commercial, industrial and public structures; and damages to roads and agricultural crops in newly flooded areas. Structural damage costs were estimated using US Army Corps of Engineers flood stage-damage data to establish a damage function applicable to census tracts in the study area. Expected damages under Current Conditions and No-Action were estimated for two prototype Category 5 storms.

Wetlands losses under No-Action will be attributable to a variety of factors, including subsidence, sea level rise, altered hydrology and barrier island disintegration. These losses will result in reduced profitability of commercial fisheries and reduced recreational enjoyments. The present values of these losses were estimated for the 100 and 30-year periods of analysis, and were shown in Tables 1 and 2 in the text. For example, using the USACE discount rate, 8.25%, these losses ranged from $2.204 to $3.096 million for commercial fisheries over the 30-year period; and from $5.530 to $5.858 million for recreation over this period.

The present values of flood damages to structures were estimated using several discount rates, and the present values of damages under Current Conditions and No-Action were compared for the 30 and 100-year time horizons. A No-Action plan would increase annual expected storm related structural damages over these periods compared to the expected damages from Current Conditions. Annual expected damages are equal to the damage if a storm occurs times the probability a storm will occur in any one year. These expected cost increases are shown in Table 5. The present value of these increased annual damages using the USACE discount rate, 8.25%, was $10.313 million over the 30-year period; which has an annualized equivalent over this 30-year period of $0.938 million per year. This means that if nothing is done to alter wetland and barrier island losses, over the next 30-years there will be increased annual expected Category 5 storm related damages compared to a storm occurring currently, and the present value of these expected increased damages is $10.313 million. The present value of these increased flooding costs over the 100-year period is $49.289 million, with an annualized value of $4.068 million per year. Using lower discount rates, such as 5% and 3% increase these present and annualized values. For example, a 3% discount rate results in a present value of increased flooding costs from No-Action over the 100-year period of $283.345 million. There are very valid arguments for using lower discount rates than those mandated for USACE projects.

These present value structural damage costs provide some insight into the minimum value of cost increases under No-Action. These cost increases are only for expected Category 5 storms. If we had scenarios for other types of storms, we could add their damage costs to these Category 5 estimates. So the estimates provided by this study are certainly underestimates of storm related damage costs of No-Action.

This study attempted to estimate cost savings to oil and gas infrastructure of project alternatives. The focus of estimation was on structural costs directly related to the barrier islands themselves. These include reburial of pipelines crossing disappearing barrier islands, and increased structural costs of future well platforms lying bayside of the islands. Barrier island pipeline reburial costs increases under No-Action are shown in Table 6. The present value of pipeline reburial costs were estimated to be $0.11 million, using the 8.25% discount rate, for the 30-year period; and $0.12 million for the 100-year period. The present value of increased oil and gas platform structural costs were estimated to be $0.20 million, using the 8.25% discount rate, and $0.69 million using a 3% discount rate. The expected pipeline reburial costs for lines in the wetlands are shown in Table 7. The present values of these costs, using the USACE 8.25% discount rate, were $4.064 million and $4.478 million for the 30 and 100-year periods, respectively. Increased well platform construction costs are shown in Table 8. Using the 8.25% discount rate, these increased costs are $0.269 and $0.296 million for the 30 and 100-year periods, respectively.

The study has also estimated expected road damage cost impacts of the No-Action scenario compared to Current Conditions. A total of 111 miles of highways and streets in newly flooded areas under No-Action and a Category 5 storm in 30-years were designated and road repair costs estimated for road miles in those areas. Both high and low repair costs were used as bases for estimates. Expected damages were equal to repair costs if a storm were to occur times the probability of a storm. These cost increases are shown in Table 9. The present value of expected road damage costs ranged from $1.668 million to $4.106 million, using the 8.25% discount rate over this 30-year period; and annualized damages ranged from $0.149 to $0.373 million per year. Using a 3% discount rate increased the present value of these damages to a range of $3.980 to $9.949 million.

Agricultural crop loss increases in newly flooded areas under the No-Action scenario compared to a current storm were insignificant. There were 18 hectares of agricultural lands flooded under a Category 5 storm in 30-years and No-Action that would not be flooded in a current storm. The assumption was that there would be total crop loss after the planting season, and resulting loss of market value of crops in a newly flooded area. Differences in newly flooded areas between project alternatives were insignificant. We were unable to estimate agricultural crop damage impacts from increased flood depths under the various project alternatives. Crop losses may be much greater for a 30 cm flood than for a 15 cm flood, particularly if flood depth and duration are related. We had no means of making these estimates. They may constitute a substantial portion of damage cost savings under the various project alternatives.

Finally, the study estimated the increased costs of public water supplies in the study area due to increased salinities of surface water supplies. These costs are shown in Table 10. The present value of a one-time cost of obtaining alternate water supply sources was $44.355 million, using the USACE 8.25% discount rate. A 3% discount rate resulted in present values of $72.921 million.

A summary of increases in costs under No-Action compared to Current Conditions is shown in Table 11. No-Action imposes costs that range from $68.488 to $72.172 million higher over a 30-year period than Current Conditions, using the USACE 8.25% discount rate. The annualized increase in costs over this 30-year period range from $6.209 to $6.537 million per year. Over a 100-year period, these costs range from $110.751 to $116.040 million higher under No-Action compared to Current Conditions, with annualized cost increases of $9.141 to $9.577 million per year. Lower discount rates result in higher present and annualized value estimates of these increased costs. For example, with a 3% discount rate the present value of cost increases range from $126.527 to $135.044 million for the 30-year period. These cost increases can be attributed to both barrier island loss and to wetlands losses, the latter caused by a variety of factors. The No-Action scenario includes both barrier island and wetlands losses.

Table 11. A Summary of Cost Increases to the Study Area of No-Action Compared to Current Conditions ($1000's)

Discount Rate	Current Condition Compared to:	No-Action 30-years $1000's Low	No-Action 30-years $1000's High	No-Action 100-years $1000's Low	No-Action 100-years $1000's High
1	2	3	4	5	6
8.25%	Present Value	$68,488.11	$72,171.79	$110,751.40	$116,040.09
	Annualized Value	$6,209.05	$6,536.51	$9,140.71	$9,577.19
5.00%	Present Value	$98,747.55	$104,789.62	$221,030.19	$234,706.83
	Annualized Value	$6,378.70	$6,753.45	$11,136.22	$11,825.30
3.00%	Present Value	$126,527.00	$135,043.62	$428,209.72	$460,463.94
	Annualized Value	$6,379.09	$6,782.80	$13,552.17	$14,572.91

It is extremely important to recognize that cost increases under No-Action are likely to be minimum savings. First, we could only analyze flood damage costs of Category 5 storms. Second, we could not estimate agricultural crop losses from higher flood depths and duration. These deficiencies must be kept in mind when considering the estimates provided in this study. It is also important to recognize that economic cost estimates include costs of wetlands loss, which may or may not be related to barrier island losses.

7.0. REFERENCES

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