GREENS BAYOU GENERAL REEVALUATION REPORT

Economic Appendix

January 2005

INTRODUCTION

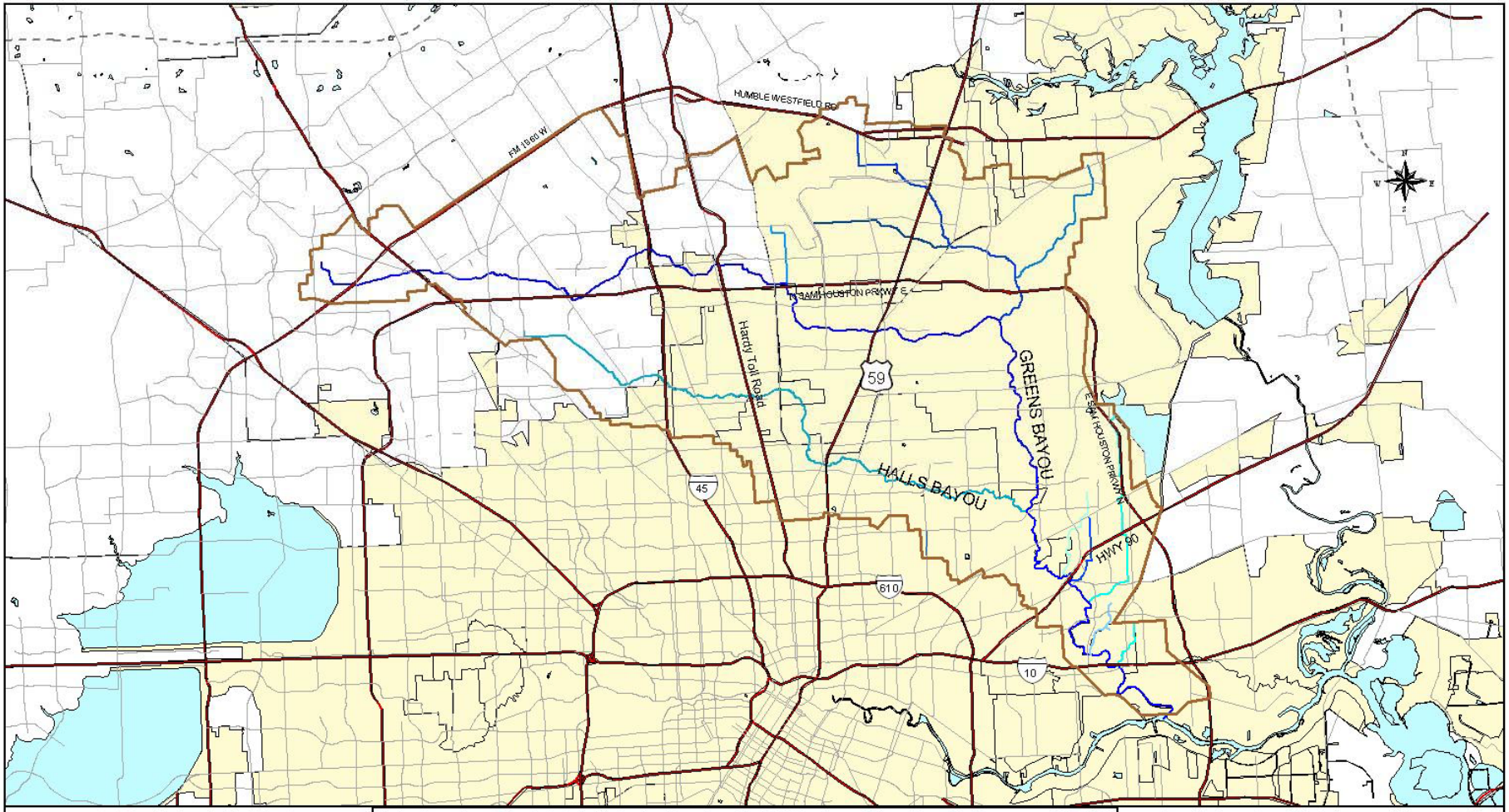
Greens Bayou is a tributary of Buffalo Bayou in Houston, Texas. This general reevaluation study originated from the feasibility study "Buffalo Bayou and Tributaries, Texas," June 1990. This study was also known as the Buffalo Bayou Comprehensive Study, and it investigated measures to reduce losses from flood damage occurring along the Buffalo Bayou watershed, which encompasses most of the Greater Houston Area. The study resulted in the congressional authorization of seven separate tributary flood damage reduction projects. The non-Federal sponsor, the Harris County Flood Control District (HCFCD), then requested that a different project be formulated for Greens Bayou, with less environmental impact, and focusing on recently damaged areas.

Study Area

Greens Bayou is located in north central Harris County, approximately 10 miles north of the central business district of the city of Houston, Texas. The Greens Bayou watershed drains an area of about 154 square miles. The topography of the area is characteristic of the Texas Gulf Coastal Plains – flat, grassy, and mostly treeless. Land elevations range from about 20 feet above sea level near the mouth of the bayou to about 135 feet near its headwaters. The slope of the land changes only about 2.7 feet per river mile. The soils of the region are mostly clay, and excess rainfall tends to run off or pond rather than percolate down through the soil. The geography of the area, rapid development, and high average annual rainfall combine to make the area prone to damaging floods.

The bayou flows across northern Harris County generally eastward from its headwaters near FM 1960 for about 23 miles, and then turns at its confluence with Garners Bayou and flows southward for about 19 miles to its out-fall into the Houston Ship Channel (Buffalo Bayou). The Harris County Flood Control District (HCFCD) has improved most of the channel. It is a grass-lined, trapezoidal channel that the HCFCD regularly mows and maintains. The portion of the stream flowing south from the Garners confluence to the out-fall into the Houston Ship Channel is predominantly riparian woodlands and wetlands. From U.S. Hwy 90 to just downstream of IH 10, the channel has not been improved, and the bayou through this reach approaches its natural state.

The study area for the economic reanalysis is the Greens Bayou watershed impacted by the estimated median 0.2 percent annual exceedance probability flood event as defined by the most likely future 2055 hydrology. This area, from river station 1500 to river station 228462, was field surveyed for development, which comprises the complete structure inventory. A map of the study area is presented in Figure 1.



Legend

Greens Bayou Watershed

2 0 2 4 Miles

Greens Bayou Watershed
General Reevaluation Report

Figure 1

Date: May 2004

THE PERIOD OF ANALYSIS, INTEREST RATE AND PRICE LEVEL

The period of analysis begins in the year 2005, the base year, and extends 50 years in the future to the year 2055, in accordance with ER 1105-2-100. The most probable future hydrologic conditions reflect anticipated growth over the period of analysis, 2005 to 2055. This assumption is consistent with current guidance.

Values presented in the screening analysis reflect 2001 prices, which were based upon 1994 prices, when the initial structure survey was made, and adjusted to 2001. A random sample of 37 properties was extracted from the structure inventory and given to the Real Estate Division for calculation of depreciated replacement cost at October, 2001 prices. These values were regressed against their 1994 values for a factor adjustment of 1.4 at the 95 percent confidence level.

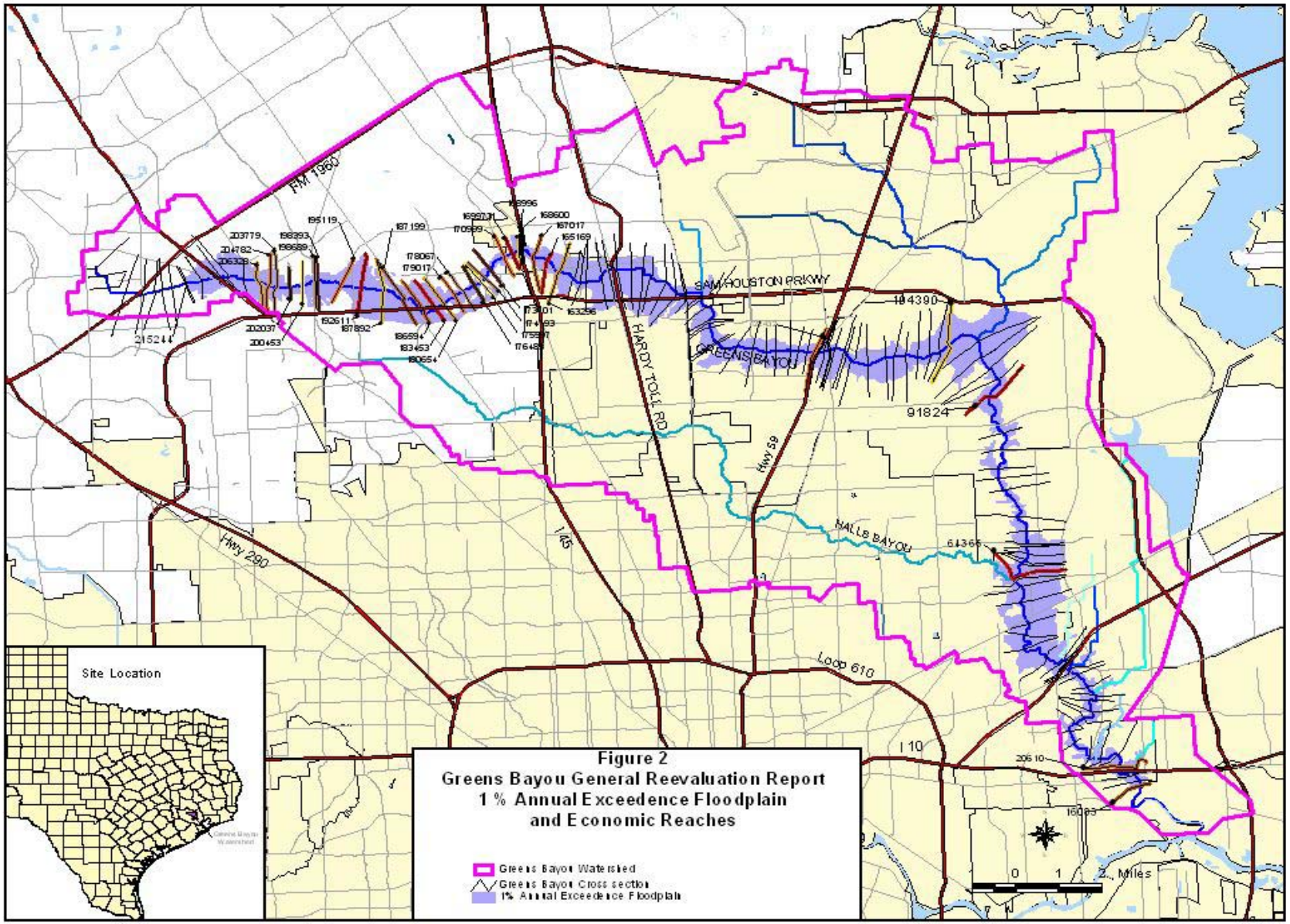
The Recommended Plan and the Authorized Plan have been updated to October 2004 prices and are displayed as such in Tables 12 and 14 of this report. Again the 1994 price level was updated to October 2004 prices using the identical methodology of updating a sample of structures for which the depreciated replacement value had been calculated by the Real Estate Division. The price adjustment was developed by regression analysis with the paired 1994 and 2004 values.

For the purpose of plan comparison, a uniform period of analysis is required for the incorporation of the time value of money. Guidance requires that all project benefits be reported as average annual equivalent (AAE) values, which involves calculating damages over the entire period of analysis, discounting them to the base year, and then amortizing them over the project life using the stated interest rate to produce AAE values. The interest rate applied is 5.625 percent for the screening exercise. The Recommended Plan and Authorized Plan are displayed at the current FY05 rate of 5.375 percent.

ECONOMIC REACHES

The new H&H produced over 468 river stations. Property surveyed within the floodplain was allocated to the nearest river station (also called cross-sections), beginning downstream at station 1500 and ending upstream at station 228462. In order to provide the most flexible analytical framework, these properties were clustered around the nearest cross-section, which functioned as a midpoint for the reach. For the lower portion of the Greens Bayou watershed, these stations were aggregated into more generalized economic reaches encompassing multiple stations. There were six reaches for the lower portion, which contained a total of 248 stations. Of the stations for the lower portion of the watershed, 75 have structures allocated to them. For the upper portion of the watershed, the stations were not aggregated into more generalized economic reaches. The upper portion contained 219 stations. Of these stations, 29 have structures allocated to them. The river stations with structures allocated to them are listed in Table 1. The six aggregated reaches for the lower portion of the watershed are designated by their aggregate reach name. Figure 2 provides a visual layout of the economic reaches.

TABLE 1			
REACH NAME	BEGINNING STATION	ENDING STATION	INDEX STATION
BLO-I10	16083	17638	16704
BLO-HALLS	20610	63860	25097
ABUVHALLS	64366	86100	68249
GARNERSCUT	91824	100307	94517
BLOHWY59	104390	121990	115212
HWY59-IMPVALLEY	122432	161049	153232
163269	163269	163269	163269
165169	165169	165169	165169
167017	167017	167017	167017
168600	168600	168600	168600
168996	168996	168996	168996
169973	169973	169973	169973
170999	170999	170999	170999
173701	173701	173701	173701
174793	174793	174793	174793
175597	175597	175597	175597
176483	176483	176483	176483
178067	178067	178067	178067
179017	179017	179017	179017
180654	180654	180654	180654
181816	181816	181816	181816
183453	183453	183453	183453
186594	186594	186594	186594
187199	187199	187199	187199
187892	187892	187892	187892
189892	189892	189892	189892
192611	192611	192611	192611
195119	195119	195119	195119
198393	198393	198393	198393
198689	198689	198689	198689
200453	200453	200453	200453
202037	202037	202037	202037
203779	203779	203779	203779
204782	204782	204782	204782
206328	206328	206328	206328


FM 1960
SAM HOUSTON PRKWY
GREENS BAYOU
HARDY TOLL RD
HWY 59
HALLS BAYOU
Hwy 290
I45
Loop 610
I 10
104390
91824
64366
20610
16093
215244
202037
200453
Site Location
Figure 2
Greens Bayou General Reevaluation Report
1 % Annual Exceedence Floodplain
and Economic Reaches
Greens Bayou Watershed
Greens Bayou Cross section
1% Annual Exceedence Floodplain
0 1 2 Miles

DATA COLLECTION AND ANALYSIS PROCEDURE

Changing conditions within the watershed and new evaluation criteria required that new information be collected for the reevaluation effort. A new structure inventory, new hydrologic conditions, and new stage-frequency curves were incorporated into the reanalysis. The methodology detailed in the following paragraphs describes the procedures used to determine project benefits in accordance with the most current guidance, ER 1105-2-100 and ER 1105-2-101.

Survey of Existing Development. Data elements required for economic evaluation of structures include the location and type of structure, its value, and its ground elevation and floor correction. In order to evaluate the impact of flooding in the study area, the District developed a GIS coverage from which a structure inventory was compiled. This coverage contained the location of each property parcel within the inundation area along Greens Bayou. A computed parcel centroid represented the location of the improvement that lay within the parcel. This methodology was believed to be acceptable because of the lack of topographic variability within individual parcels and within the study area in general. An attribute table was joined to the parcel coverage by linking the property tax identification of the parcel to the Harris County Tax Appraisal District database. The database contained information pertinent to the structure inventory such as type of improvement and improvement value. Hydrologic information was associated with the inventory of structures by overlaying the coverage of cross-sections to which an array of flood stage-frequencies was assigned. The cross-section lying most proximate to the parcel centroid was assigned to each centroid as a representation of hydrologic conditions for that location.

Ground and First-floor elevations. The initial maps for the project were USGS quad sheets obtained from Harris County Engineering Department. These maps were used to assign ground elevations to the property centroids. First-floor corrections for the majority of the single-family residential structures were obtained through field surveys between January and March 1998 and from examination of slab elevation maps obtained from Harris County Flood Control District. During the field survey, floor corrections were established for 3,273 structures. Determination of floor corrections for most of the remaining properties, primarily apartment and business complexes, was conducted in July 1997. In total, the universe from which the Greens Bayou database was extracted consisted of over 21,000 records. Not all of these properties were susceptible to damages by a most likely future 0.2 percent annual exceedance event, however. Analysis indicates that roughly 4,700 structures are vulnerable to damage by a most likely future 0.2 percent annual exceedance event. The economic input to the flood damage reduction models was developed from these 4,700 records.

Analytical Tools. Field data gathered for the structure inventory was initially analyzed using the Hydrologic Engineering Center's HEC-SID Program (Structure Inventory for Damage Analysis) and the HEC-EAD Program (Expected Annual Flood Damage Program). The HEC-SID Program was used to determine the depth-damage curves for the without project condition. The output of the HEC-SID Program was then incorporated into the HEC-EAD Program. Also placed in the HEC-EAD were stage frequencies for the twenty-one project features for the initial screening. The HEC-SID program utilizes the ground and first-floor elevations of structures, structure types and values, and content, equipment, and inventory values in computing damages by depth of inundation based on each cross-section's stage-damage frequency.

DAMAGE CATEGORIES

Damages associated with flooding are divided into the following categories: damages to structures and contents for residential, commercial, industrial and public properties; damages to vehicles, utilities and roads; and other costs associated with flooding. Intangible damages were not evaluated.

Damages to Residential Structures. Residential structure damages include inundation losses for single and multi-family dwellings including one, one-and-a-half, and two-story single family, detached dwellings, mobile homes, high-raised homes, apartments with living space on one floor, and townhouses/condominiums with living space on multiple floors. Separate depth-percent damage relationships were applied to the residential inventory based on their classification type. The depth-percent damage curves published in Economic Guidance Memorandum (EGM) 01-03 for single-family, one- or two-story structures with no basements and the contents of those structures were used in this analysis. Galveston District depth-percent damage curves for mobile homes, apartments, and condominium were used to develop damages for those structure types and the contents within those structures.

Residential Property Values. Current guidance (ER 1105-2-100) states that if percent damage functions are used in the assessment of stage-damage relationships, replacement cost less depreciation is the correct measure of structure value. In order to comply with this directive, a methodology for determining depreciated replacement value to inventoried structures was developed. Property values for the residential and commercial properties in the 0.2 annual percent exceedance probability floodplain were obtained originally from the Harris County Tax Appraisal District in 1994. In order to convert 1994 assessed values to 2001 depreciated replacement values, a random sample of 37 properties within the study area was extracted from the database and given to the District's Real Estate Division for their computation of equivalent 2001 depreciated replacement values for each structure in the sample. A regression of the 1994 assessed values and the 2001 depreciated replacement values produced a correlation coefficient of 0.81 and credence that the 1994 values should be adjusted by a factor of 1.4 to bring the structures up to current prices and appropriate values.
Prices were updated for the Recommended Plan and the Authorized Plan to 2004 levels using the established method of surveying the sample of properties to establish 2004 depreciated replacement costs which were then compared statistically to the properties' 1994 values.

Structure Contents Values. EGM 01-03 provides depth-percent damage curves for single-family, one- or two-story structures with no basements and the contents of those structures. Content flood depth-percent damage relationships are based on the value of the structure, negating the need for an estimate of the residential structure's contents. However, EGM 01-03 does not provide flood depth-percent damage relationships for the apartments, condominiums, and mobile homes that were also identified within the study area. IWR report 93-R-7, Guidelines to Estimating Existing and Future Residential Content Values, June 1993, was referenced for its Harris County, Texas survey of Cypress Creek and Greens Bayou. The mean value content-to-structure ratio was reported as 0.466 with a standard deviation of 0.327. These values were incorporated into the FDA model for use in estimating content damages to residences other than single-family detached residential structures.

Commercial and Industrial. Commercial and industrial damages include losses to all properties used in commerce, industry, business, trade, servicing, or entertainment. Separate depth-damage relationships were used to assess inundation damage to structures, equipment, and inventories. The depth damage curves for commercial and industrial properties were developed in the Southwestern Division over a period of 30 years. While they do no reflect uncertainty, they were deemed acceptable for this application since these properties represented approximately 11 percent of the overall structures in the 0.2 percent floodplain. In the commercial category, there were 899 structures identified in the field survey as commercial and classified as by type of commercial activity. For the industrial category, there were 18 structures identified as industrial and classified by type of industrial activity. Totals for these assessed damages are presented under the general commercial or industrial categories

Public. Public damages include damages to public facilities such as public buildings, parks, and other facilities, including equipment and furnishings owned or operated by Federal, State, County, or municipal entities. The depth damage curves for public properties were developed in the Southwestern Division over a period of 30 years. While they do no reflect uncertainty, they were deemed acceptable for this application since public properties represented less than 1.5percent of overall structures in the 0.2 percent floodplain. Separate depth-damage relationships were used to assess inundation damage to structures, equipment, and inventories. The total of these assessed damages is presented under the general public category.

Vehicles. Streets in Harris County are graded lower than the surrounding land to function as tertiary drainage conduits from the surrounding urban development. Because of the dual function of roadways for transportation and drainage, vehicles are especially vulnerable to flood damages. Flood damage to vehicles includes the labor and parts to dry out and replace materials, as necessary, whenever a vehicle is inundated. In reviewing flooding in Houston in 1989, the Institute for Water Resources found that, on average, each flooded household lost one vehicle to flooding, with damages exceeding $7,500 per vehicle (Stuart Davis, unpublished Houston Residential Flood Survey, Fort Belvoir, Virginia 1991). Therefore, a one-to-one vehicle-flooded-to-damaged-residential-structure relationship was established for the number of residential structures at each cross-section and at various flood elevations. The Insurance Services Offices indicated that approximately 105,000 automobiles were damaged as a result of Tropical Storm Allison in June 2001, which caused severe flooding in Harris County. Data on individual vehicle damages was incomplete, and it was not possible to establish an average damage amount. To establish a base value for vehicle damages, the average loss per vehicle of $7,500 cited in the 1991 report was adjusted to an October 2001 value of $10,860 using the Consumer Price Index (CPI).

Flooding on the flat Texas coastal plain is characterized by slow rise, low velocity, and long duration. Because of the lack of topographic relief and the predominance of thick clay soils in Harris County, floodwaters tend to pool and stand. Some limited topographic relief is created by the development practice of grading streets lower than the surrounding land, thereby allowing roads to function as tertiary drainage conduits from the surrounding urban development. Because of the dual function of roadways for transportation and drainage, vehicles are especially vulnerable to flood damages. This risk was realized with the Tropical Storm Allison event in

June 2001. That event, considered to be a 0.2 percent chance event in some parts of Harris County, flooded 73,000 structures in Harris County according to a Harris County Flood Control District report on the effects of Tropical Storm Allison ("Off the Charts, Tropical Storm Allison Public Report," Harris County Flood Control District and the Federal Emergency Management Agency, 2002). However, the Insurance Services Offices, the insurance industry's sole research enterprise reporting comprehensive vehicular damage claims, indicated that approximately 105,000 automobiles were damaged as a result of Tropical Storm Allison (Jim Welsh, Insurance Services Offices, personal communication, 2001). Many of these vehicles were inundated on the flooded freeways and roads within the metropolitan area. Data on individual vehicle damages was incomplete so it was not possible to establish sufficient information to incorporate into this analysis. However, the information gathered about Tropical Storm Allison added credence to the vulnerability of vehicles to damage. The nature of flooding is such that there is no way to escape once the roads are under water other than by wading out on foot or by evacuation by boat.

Flood damage to vehicles includes the labor and parts to dry out and replace materials, as necessary, whenever a vehicle is inundated. In reviewing flooding in Houston in 1989, the Institute for Water Resources found that, on average, each flooded household lost one vehicle to flooding, with damages exceeding $7,500 per vehicle (Stuart Davis, unpublished Houston Residential Flood Survey, Fort Belvoir, Virginia 1991). Therefore, a one-to-one vehicle-flooded-to-damaged-residential-structure relationship was established for the number of residential structures at each cross-section and at various flood elevations. To establish a base value for vehicle damages, the average loss per vehicle of $7,500 cited in the 1991 report was adjusted to an October 2001 value of $10,860 using the Consumer Price Index (CPI).

Utilities. Utility damages include losses to electrical transformers and transmission lines, telephone company lines and switch boxes, and water and gas pipelines. Stage-damage relationship estimates were revised to reflect the current value of damages from Tropical Storm Allison. The current value of utility damages is estimated to be approximately $315 per structure per flood event.

Roads. Road damages include repair costs for roads, bridges, street signals, and street lighting. Damage data from Tropical Storm Allison was gathered from the Federal Emergency Management Administration (FEMA), the Texas Department of Transportation, Harris County, and the City of Houston. The data showed over $9,608,000 in damages for this category. However, the data did not contain sufficient information on the miles of road damaged, and it was not possible to calculate an average cost per mile of road damaged.

Because more recent information could not be utilized for purposes of estimating damages, stage-damage relationships for roads are based on the April 1979 Montgomery County and Tropical Storm Claudette flood data collected from FEMA, which was applied in the 1994 Cypress Creek General Reevaluation Report. These were updated to October 2001 price levels using the CPI. From the FEMA data, an average repair cost per mile of inundated asphalt, concrete, and dirt road was developed. Miles of road within the 0.2 percent annual exceedance floodplain were measured on the Geographic Information System (GIS) base maps. A stage-damage relationship was developed based on the relative distribution of structures to roads

within the various exceedance probability floodplains, with damages to roads assessed at $11,109 per mile at October 2001 prices.

Other Costs Associated With Flooding. IWR's 1990 survey of flood victims within the Cypress Creek and Greens Bayou watersheds in Harris County revealed other associated costs of flooding that lacked prior quantification. These costs include lodging and travel costs, food costs, costs of cleanup, costs of moving and storing furniture, emergency costs, vandalism and looting costs, and medical costs which are all associated directly with the flood experience (Stuart Davis, unpublished Houston Residential Flood Survey, Fort Belvoir, Virginia, Institute for Water Resources, 1991). On average, each surveyed household reported costs exceeding $5,700 based on the costs iterated. Therefore, a stage-damage relationship was developed based on the number of damaged residential structures within each frequency floodplain, with each structure accruing damages of $8,500 based on October 2001 price levels.

WITHOUT PROJECT CONDITION

Capital Investment within the Various Flood Plains. Table 2 shows the distribution of capital investment within the various flood plains along the main stem of Greens Bayou. Over 87 percent of the structures within the existing median 0.2 percent annual exceedance probability floodplain are residential. In total the 0.2 percent annual exceedance probability floodplain contains over 4,300 structures valued at $400 million dollars, at 2004 prices.

Table 2

All Structures

Distribution of Capital Investment Within Annual Exceeedance Probability Floodplains

Cumulative Totals Based on First Floor Elevations and Existing (2005) Hydrology

Dollar Values in $1,000, October 2004 Price Level

	Bank to 50% Floodplain	Bank to 20% Floodplain	Bank to 10% Floodplain	Bank to 4% Floodplain	Bank to 2% Floodplain	Bank to 1% Floodplain	Bank to 0.40% Floodplain	Bank to 0.20% Floodplain	Distribution within 1% Floodplain	Distribution within 0.2% Floodplain
Residential Property										
no.	62	366	867	1705	2110	2503	3546	3788	87.2%	87.3%
value	$4,278	$23,198	$53,441	$102,889	$125,211	$152,253	$208,344	$220,773		
Commercial Property										
no.	5	30	70	177	253	316	449	485	11.0%	11.2%
value	$5,808	$12,746	$25,321	$44,083	$61,950	$75,641	$109,299	$122,831		
Public Property										
no.	3	9	14	22	30	42	58	59	1.5%	1.4%
value	$540	$1,542	$3,484	$13,802	$17,636	$26,858	$41,838	$45,538		
Industrial Property										
no.	1	2	3	6	8	8	9	9	0.3%	0.2%
value	$379	$389	$445	$592	$702	$702	$747	$747		
Total Value										
no.	71	407	954	1910	2401	2869	4062	4341	100.0%	100.0%
value	$11,005	$37,875	$82,691	$161,366	$205,499	$255,454	$360,228	$389,889		

Value: Structure value only, no land, no contents

Single-Occurrence Damages. Damages expected to occur from various annual exceedance probability events are displayed in Table 3 and are based on 2005 without project conditions. Determination of flood damages to existing development were estimated for all property within the Harris County portion of the estimated 2055 median 0.2 percent annual exceedance probability floodplain of Greens Bayou. Single-occurrence damages estimated in Table 3 include damages to structures and contents of various types of physical properties classified as residential, commercial, public, or industrial.

Table 3

Single Occurrence Damages by Event

Without Project Condition, 2005

Values in thousands of October 2004 dollars

Annual Exceedance Probability Event	50%	20%	10%	4%	2%	1%	0.40%	0.20%
Damage Category								
Residential	$2,963.3	$12,627.6	$22,565.7	$42,114.6	$57,074.2	$68,279.2	$91,123.9	$102,494.6
Public	$178.9	$330.8	$480.1	$1,928.4	$3,363.2	$4,447.4	$7,923.3	$10,042.0
Commercial	$2,273.8	$9,634.2	$14,231.6	$23,448.8	$28,308.3	$32,754.9	$43,901.7	$50,407.3
Industrial	$2.8	$24.1	$47.5	$150.6	$218.5	$265.3	$363.0	$401.7
Damages to Structures, Contents	$5,418.8	$22,616.7	$37,324.8	$67,642.4	$88,964.2	$105,746.7	$143,311.9	$163,345.6
Post Emergency Costs	$527.0	$3,111.0	$7,369.5	$14,492.5	$17,935.0	$21,275.5	$30,141.0	$32,198.0
Vehicles	$673.3	$3,974.8	$9,415.6	$18,516.3	$22,914.6	$27,182.6	$38,509.6	$41,137.7
Roads	$200.1	$943.1	$1,949.4	$3,022.1	$4,172.8	$5,141.4	$6,281.0	$7,217.7
Utilities	$22.4	$128.2	$300.5	$601.7	$756.3	$903.7	$1,279.5	$1,367.4
Total Damages by Event	**$6,841.6**	**$30,773.8**	**$56,359.9**	**$104,274.9**	**$134,742.9**	**$160,249.9**	**$219,523.0**	**$245,266.4**
Percent Distribution								
Residential	43.3%	41.0%	40.0%	40.4%	42.4%	42.6%	41.5%	41.8%
Public	2.6%	1.1%	0.9%	1.8%	2.5%	2.8%	3.6%	4.1%
Commercial	33.2%	31.3%	25.3%	22.5%	21.0%	20.4%	20.0%	20.6%
Industrial	0.0%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%
Post Emergency Costs	7.7%	10.1%	13.1%	13.9%	13.3%	13.3%	13.7%	13.1%
Vehicles	9.8%	12.9%	16.7%	17.8%	17.0%	17.0%	17.5%	16.8%
Roads	2.9%	3.1%	3.5%	2.9%	3.1%	3.2%	2.9%	2.9%
Utilities	0.3%	0.4%	0.5%	0.6%	0.6%	0.6%	0.6%	0.6%
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Damages in the Without Project Condition. Average annual equivalent damages expected to occur to the structure inventory over the fifty-year project life under existing, without project conditions are shown in Table 4 by economic reach. Damages from inundation are based on data obtained from the previously described field surveys of existing development.

TABLE 4
Average Annual Equivalent Damages
Without Project Condition
Greens Bayou
(in thousands of dollars)

Reach	AAE Damages 5.625% 2001 prices	Percent Distribution	AAE Damages 5.375% 2004 prices	Percent Distribution
BLO-I10	$5,225.1	23.9%	$5,536.3	23.8%
BLO-HALLS	$2,768.1	12.6%	$2,931.4	12.6%
ABUVHALLS	$228.3	1.0%	$241.7	1.0%
GARNERSCUT	$75.9	0.3%	$80.5	0.3%
BLOHWY 59	$398.0	1.8%	$422.7	1.8%
HWY 59-IMPVALLEY	$4,923.6	22.5%	$5,233.7	22.5%
163269	$366.7	1.7%	$390.1	1.7%
165169	$400.6	1.8%	$426.2	1.8%
167017	$501.9	2.3%	$534.2	2.3%
168600	$15.6	0.1%	$16.6	0.1%
168996	$77.3	0.4%	$82.4	0.4%
169973	$9.8	0.0%	$10.5	0.0%
170999	$82.3	0.4%	$87.6	0.4%
173701	$37.1	0.2%	$39.5	0.2%
174793	$0.0	0.0%	$0.0	0.0%
175597	$0.6	0.0%	$0.6	0.0%
176483	$130.9	0.6%	$139.4	0.6%
178067	$187.3	0.9%	$199.5	0.9%
179017	$150.3	0.7%	$159.5	0.7%
180654	$66.6	0.3%	$70.8	0.3%
181816	$0.0	0.0%	$0.0	0.0%
183453	$133.8	0.6%	$142.4	0.6%
186594	$576.5	2.6%	$613.3	2.6%
187199	$1,265.3	5.8%	$1,345.1	5.8%
187892	$802.1	3.7%	$854.1	3.7%
189892	$3.6	0.0%	$3.8	0.0%
192611	$628.9	2.9%	$669.6	2.9%
195119	$1,272.2	5.8%	$1,348.0	5.8%
198393	$342.5	1.6%	$363.1	1.6%
198689	$46.4	0.2%	$49.2	0.2%
200453	$326.5	1.5%	$346.5	1.5%
202037	$0.0	0.0%	$0.0	0.0%
203779	$121.6	0.6%	$129.2	0.6%
204782	$518.4	2.4%	$550.4	2.4%
206328	$218.7	1.0%	$232.3	1.0%
TOTAL DAMAGES	$21,902.3	100.0%	$23,249.9	100.0%

INITIAL SCREENING OF ALTERNATIVES

The Greens Bayou project was developed as part of the comprehensive flood control plan for Buffalo Bayou. In June 1989, a feasibility report on the Buffalo Bayou Comprehensive Study underwent Washington-level review and was approved by the Board of Engineers for Rivers and Harbors. This report included an authorized project on Greens Bayou, which extends the entire length of the bayou and includes 14 miles of stream clearing, 25.2 miles of channel enlargement, and four detention basins. Recreation features include trails, picnic facilities, canoe-launching ramps, comfort stations, and parking areas.

In response to the study authority, the Harris County Flood Control District (HCFCD) requested a separable element analysis of the Greens Bayou project to improve the feasibility of financing their share of the project costs in 1991. A Limited Reevaluation Report (LRR) for Separable Elements was submitted to HQUSACE in October 1993. In April 1994, HQUSACE agreed with the Galveston District assessment that separable elements existed; however, they maintained that phased construction would be more appropriate.

In a partnering meeting between Galveston District and HCFCD in May, 1994, the non-Federal sponsor requested that a smaller project be reformulated with less environmental impact, focusing on recently damaged areas. A partnering meeting was held in April 1995, during which specific locations where recent flood damages occurred were identified. Flood damage reduction alternatives were also identified to be included in reformulation analyses. The Harris County Flood Control District, as the non-Federal sponsor, and the Galveston District initiated the General Reevaluation Report feasibility phase of the study on 1 March 1995**.**

During the partnering meetings held prior to the start of the study, tasks accomplished were identification of study reaches; identification of damage areas from recent floods; and possible structural and nonstructural remedies for flood damage reduction were discussed. Changes had occurred within the watershed since project authorization that included improvements to the channel by the non-Federal sponsor for flood damage reduction and increased development in the study area, which necessitated a review and revision of the base data.

Structural measures were formulated for the portion of the stream flowing east from its headwaters upstream of FM 1960 to its confluence at Garners Bayou. A ring levee was considered for the Forest Acres subdivision, southwest of the confluence at Garners Bayou. No structural alternatives were formulated for the portion of the stream running south from the confluence with Garners Bayou to the outfall at the Houston Ship Channel, due to the environmental sensitivity of the area. There have been few channel improvements in the downstream reach of Greens Bayou since it is heavily vegetated and there are wetlands adjacent to the stream. Nonstructural plans (i.e., buyouts by flood plain) were also considered for the entire length of the bayou.

Results of Initial Screening Activities. There were no structural solutions for flood damage reduction proposed for the portion of the bayou extending from the ship channel to the Garner's Bayou confluence. The bayou has not been channelized to any great extent through this reach as it contains wetlands and riparian areas that are environmentally sensitive. A ring levee around the Forest Acres Subdivision and a nonstructural buyout of the floodplains were considered for this planning reach. The levee crest elevations were evaluated for the 4 percent, 2 percent, and the 1 percent annual exceedance probability floodplain levels of protection. The average annual

construction cost was significantly higher than the average annual damages reduced producing a negative benefit-to-cost ratio (BCR). Therefore, the ring levee was not economically justified.

The first impact reach was defined from the Garner's Bayou confluence to the John F. Kennedy Boulevard (JFK) Bridge. Three alternatives were analyzed for this reach: (1) detention only at the upstream end of the reach by JFK; (2) A channel from the confluence with Garners Bayou to the JFK Bridge with mitigating detention at the downstream end; and, (3) A channel from the confluence with Garners Bayou to the JFK Bridge with linear detention.

The second impact reach extended from the Greens Parkway Bridge to the bridge at Aldine Westfield Road. Two alternatives were analyzed for this reach: (1) an upstream detention basin near Greens Parkway and (2) A channel from Greens Parkway to Aldine Westfield, with a mitigating detention basin at the downstream end of the reach.

The third impact reach was defined from the Greens Parkway Bridge to the bridge at Cutten Road. Two alternatives were analyzed: (1) a channel from Greens Parkway to Cutten Road, with a mitigating detention basin at the downstream end of the reach and (2) A channel from Greens Parkway to Cutten Road with a linear detention. Stand-alone detention basins were analyzed but not found to be economically feasible.

To facilitate the screening process, channel analyses were conducted as discussed below. Using engineering judgment, three channel bottom-widths were designated for each channel configuration for each reach. Hydraulic models were run on the variously sized channels, and the results were used to conduct economic analyses. No risk and uncertainty analyses were conducted for the initial screening. For Garner's Bayou to JFK and Greens Parkway to Cutten Road, two channel configurations were analyzed: a channel with downstream mitigating detention, and the same channel with linear, adjacent detention. Equal hydraulic performance was assumed for each configuration, since the volume of the downstream mitigating detention basin was equal to the volume of the linear detention excavation. Therefore both channel configurations were presumed to have equal benefits, but different costs. A tabulation of the average annual benefits and costs for this first iteration of alternatives was computed. Quantity and cost estimates were completed for the channel designs, and net excess benefits were computed. Only the major cost items were quantified. Only one plan of the initial 21 produced a positive benefit-to-cost ratio (BCR) with positive net excess benefits. That plan was an earthen channel, 55 feet wide, extending from the bridge at Greens Parkway to the bridge at Cutten Road, with a downstream mitigating detention basin. This plan was optimized in a subsequent plan formulation iteration. Table 5 shows the economic outcome of the initial screening phase.

Table 5. Benefits And Costs ($1000)					
FIRST SCREENING - FY97 (Cost in 2001)					
REACH	**PLAN NAME***	**AVERAGE ANNUAL BENEFITS****	**FIRST COSTS**	**AVERAGE ANNUAL COSTS**	**NET EXCESS BENEFITS*****
Garner's Bayou to JFK	JFK-DET1	$991.44	$62,028.5	$3,866.86	($2,875.41)
Reaches100307---130061	JFK-DET2	$1,321.34	$69,270.5	$4,318.33	($2,996.98)
	JFK-DET3	$1,679.34	$99,552.4	$6,206.09	($4,526.75)
	JFK-CHD1	$1,078.03	$22,193.2	$1,383.52	($305.50)
	JFK-CHD2	$1,202.41	$30,075.5	$1,874.91	($672.50)
	JFK-CHD3	$1,274.40	$37,994.6	$2,368.58	($1,094.18)
	JFK-CHL1	$1,078.03	$27,404.9	$1,708.42	($630.39)
	JFK-CHL2	$1,202.41	$37,782.2	$2,355.34	($1,152.94)
	JFK-CHL3	$1,274.40	$46,734.3	$2,913.42	($1,639.02)
Aldine-Westfield to Greens	GP-DET1	$1,184.76	$35,304.5	$2,200.88	($1,016.12)
Parkway	GP-DET2	$1,176.81	$42,841.5	$2,670.74	($1,493.93)
Reaches 144415--169973	GP-DET3	$1,386.80	$59,567.2	$3,713.42	($2,326.62)
	GP-CHD1	$1,090.77	$28,381.8	$1,769.32	($678.55)
	GP-CHD2	$1,290.85	$39,922.7	$2,488.78	($1,197.94)
	GP-CHD3	$1,452.47	$51,425.9	$3,205.89	($1,753.42)
Green's Parkway to	CUT-CHD1	$1,061.69	$19,296.0	$1,202.91	($141.22)
Cutten Road	CUT-CHD2	$1,510.53	$23,855.0	$1,487.12	$23.40
Reaches 169973--206328	**CUT-CHD3**	**$2,009.02**	**$27,236.7**	**$1,697.93**	**$311.09**
	CUT-CHL1	$1,061.69	$20,520.8	$1,279.27	($217.58)
	CUT-CHL2	$1,510.53	$27,169.1	$1,693.72	($183.20)
	CUT-CHL3	$2,009.02	$32,136.8	$2,003.4	$5.6
*JFK-DET1-3 = Upstream detention only - 25% depth, 50% depth, and 100% depth					
JFK-CHD1-3 = Channel with downstream mitigating detention - 75-ft bottom width, 105-ft bottom width, and 135-ft bottom width					
JFK-CHL1-3 = Channel with adjacent linear detention - 110-ft bottom width, 160-ft bottom width, and 200-ft bottom width					
GP-DET1-3 = Upstream detention only - 25% depth, 50% depth, and 100% depth					
GPCHD1-3 = Channel with downstream mitigating detention - 75-ft bottom width, 90-ft bottom width, and 105-ft bottom width					
CUT-CHD1-3 = Channel with downstream mitigating detention - 25-ft bottom width, 40-ft bottom width, and 55-ft bottom width					
CUT-CHL1-3 = Channel with adjacent linear detention - 100-ft bottom width, 150-ft bottom width, and 188-ft bottom width					
This one is updated. First costs have been reduced by $3,060.00 (charges prior to GRR). Benefits have been computed using					
adjusted median stage frequencies. This chart reflects the most optimistic BCRs possible.					
** Average annual benefits based on 0-ft floor correction					
***Figures in bold reflect net excess benefits of anchor component					

SECOND SCREENING WITH REFINEMENT OF HYDROLOGY AND ANALYTICAL TOOLS

Use of revised without project hydrology. Before the optimization of the channel segment was conducted, a review of the hydrology used in the screening exercise revealed an error that was corrected with a revision of the without project condition water surface profiles. These revisions produced slightly lower flood stages in the channel reach but a more pronounced lowering of profiles in the downstream reaches of the Bayou. Overall, the without project average annual equivalent damages to structures and contents declined about 12.5 percent with the adoption of the revised hydrology holding the October, 2001 price level and 5.625 percent discount rate constant. Table 6 provides a display of average annual equivalent damages expected to occur to structures and their contents during the project life in the revised without project condition.

TABLE 6
Average Annual Equivalent Damages
Revised Without Project Condition
Greens Bayou
(in thousands of dollars)

REACH LIMITS		without project revised condition 5.625% 2001 prices	percent distribution	without project revised condition 5.375% 2004 prices	percent distribution
LOWER	UPPER				
16083	17638	$4,172	21.8%	$4,420	21.7%
20610	63860	$2,289	11.9%	$2,424	11.9%
64366	86100	$184	1.0%	$195	1.0%
91824	100307	$71	0.4%	$76	0.4%
104390	121990	$343	1.8%	$364	1.8%
122432	161049	$4,333	22.6%	$4,606	22.6%
	subtotal	$11,392	59.4%	$12,085	59.4%
REACH	163269	$327	1.7%	$348	1.7%
	165169	$360	1.9%	$383	1.9%
	167017	$483	2.5%	$514	2.5%
	168600	$14	0.1%	$15	0.1%
	168996	$73	0.4%	$77	0.4%
	169973	$10	0.1%	$11	0.1%
	170999	$75	0.4%	$80	0.4%
	173701	$34	0.2%	$36	0.2%
	174793	$0	0.0%	$0	0.0%
	175597	$1	0.0%	$1	0.0%
	176483	$120	0.6%	$128	0.6%
	178067	$172	0.9%	$183	0.9%
	179017	$145	0.8%	$153	0.8%
	180654	$63	0.3%	$67	0.3%
	181816	$0	0.0%	$0	0.0%
	183453	$125	0.7%	$133	0.7%
	186594	$540	2.8%	$574	2.8%
	187199	$1,191	6.2%	$1,267	6.2%
	187892	$744	3.9%	$792	3.9%
	189892	$3	0.0%	$4	0.0%
	192611	$584	3.0%	$622	3.1%
	195119	$1,219	6.4%	$1,292	6.3%
	198393	$330	1.7%	$350	1.7%
	198689	$44	0.2%	$47	0.2%
	200453	$311	1.6%	$330	1.6%
	202037	$0	0.0%	$0	0.0%
	203779	$115	0.6%	$123	0.6%
	204782	$493	2.6%	$523	2.6%
	206328	$208	1.1%	$220	1.1%
	subtotal	$7,783	40.6%	$8,273	40.6%
	av ann equiv total	$19,175		$20,357	100.0%
	present worth equivalents	$318,790		$351,108	

Use of HEC-FDA. While the hydrology was undergoing review, the evaluation framework for the economic analysis was updated from the Hydrologic Engineering Center's (HEC) Structural Inventory for Damage Analysis (SID) and the HEC's Expected Annual Flood Damage Computation (EAD) to HEC's Flood Damage Analysis (FDA) model, incorporating the opportunity for risk-based calculations in keeping with ER 1105-2-101 (1 Mar 96). Also Economic Guidance Memorandum (EGM) 01-03, Generic Depth-Damage Relationships, (4 Dec 2000) was incorporated into the stochastic model. These depth-percent damage functions for single-family residential, one- or two-story, no basement structures apply to about 80 percent of the structure inventory within the "most likely future" 0.2 percent median expected probability floodplain of Greens Bayou. Uncertainty parameters were incorporated into the HEC-FDA with regard to first-floor stage, structure value, and content-to-structure value ratios for residential structures not covered by EGM 01-03.

Uncertainty in first-floor stage. Uncertainty in first floor stage is represented by a standard deviation of 1.5 feet. This uncertainty is a combination of uncertainty in the ground elevation coupled with uncertainty in the first-floor correction. Ground elevations were derived from digitized USGS contour maps. Windshield surveys of first-floor corrections were employed to develop the first-floor elevation. In some cases, surveyed first-floor or slab elevations were recorded on Lambert sheets for structures within the 1 percent annual exceedance probability floodplain of the study area.

Uncertainty in structure value. The Galveston District Real Estate Division provided an estimate of the accuracy of the structure values used in the stochastic damage estimation procedure. According to the professional judgment of a Master Appraiser, the values could vary 10 percent higher or lower than listed.

Uncertainty in content-to-structure value ratios. The EGM 01-03 provides uncertainty parameters for single-family, one- or two-story structures with no basements and the contents of those structures. Content flood depth-percent damage relationships are based on the value of the structure negating the need for content-to-structure ratios for these types of structures. However, EGM 01-03 does not provide flood depth-percent damage relationships for the apartments and mobile homes that were also identified within the study area. Their elevation-damage computation using the HEC-FDA model requires that uncertainty in content-to-structure value be expressed. IWR report 93-R-7, Guidelines to Estimating Existing and Future Residential Content Values, June 1993, was referenced for its Harris County, Texas survey of Cypress Creek and Greens Bayou. The mean value content-to-structure ratio was reported as 0.466 with a standard deviation of 0.327. These values were incorporated into the FDA model for use in estimating uncertainty in content damages to apartment units and mobile homes.

CHANNEL OPTIMIZATION

The screening level analysis produced a channel segment in the upstream reaches of Greens Bayou as the component with the greatest net excess benefits. This channel segment was optimized to refine its economic efficiency. Toward that end, channel widths were varied in 30-foot increments for a channel segment that ran from Veteran's Memorial Drive, cross-section 187199, to Cutten Road at cross-section 206328.

A fundamental assumption made with the optimization process was that all downstream rises in water surface profiles induced by the channel modification would be mitigated by a detention basin located within the downstream portion of the channel reach. This operational assumption was consistent with the Non-Federal Sponsor's desire to induce no increase in the downstream water surface profile above that which would be expected in the "most likely future" without project condition. By following this assumption, no hydrology was developed downstream of the impact reach. However, a fully mitigating detention basin was designed for each of the 30-, 60-, and 90-foot-width channels analyzed. While this method does not expressly identify induced damages, the fully mitigating basins represent the costs of those disbenefits by proxy by including the costs of the basin along with the cost of the channel for comparison against benefits produced within the channel reach.

This optimization process demonstrated that the 60-foot-wide channel segment maximized net excess benefits and, so, was identified as the structural anchor component for further damage reduction opportunities. The 60-foot channel and mitigating basin produced net excess benefits of $19.5 million in present worth equivalents or $1.175 million in average annual equivalents, discounted at 5.625 percent. The benefit-cost ratio was 2.0 and is shown in Table 7.

In effect, the economic damages prevented within the channel segment reach justified not only the channel but also a mitigating detention basin, the cost of which functioned as a proxy value for induced damages. The channel segment was optimized by incorporating the cost of the mitigating basin as well as the channel into the project cost. Economists realized, however, that the assumption made with regard to mitigating downstream runoff from the structural plan deviated from published USACE guidance. ER 1105-2-100, E-18, (f) states that "mitigation of induced damages is appropriate when economically justified or there are other reasons of safety, economic or social concerns, or a determination of a real estate taking… has been made." Therefore, the economic justification for mitigation must be derived from an analysis of the damages prevented in the downstream impact area.

Table 7

Channel Optimization of Channel Reach between Veteran's Memorial and Cutten Road with Downstream Mitigating Detention

Average Annual Equivalent Damages, 05625%, 50 yrs

(in thousands of Oct. 2001 $'s)

Cross-section	without project revised	30ft channel width	damages reduced	60ft channel width	damages reduced	90ft channel width	damages reduced
187199	$1,191	$1,263	-$72	$1,168	$23	$1,223	-$32
187892	$744	$742	$1	$668	$75	$654	$90
189892	$3	$3	$0	$3	$0	$3	$1
192611	$584	$571	$13	$422	$162	$306	$278
195119	$1,219	$433	$787	$277	$943	$174	$1,046
198393	$330	$182	$148	$130	$200	$74	$256
198689	$44	$23	$21	$15	$29	$7	$37
200453	$311	$162	$148	$96	$214	$40	$270
202037	$0	$0	$0	$0	$0	$0	$0
203779	$115	$27	$88	$9	$107	$2	$113
204782	$493	$123	$370	$37	$455	$9	$484
206328	$208	$53	$154	$14	$194	$3	$205
benefits for channel reach			$1,659		$2,403		$2,746
pwe			$27,582		$39,947		$45,658
first cost, 10/1/01, channel and mitigating basin			**$18,779**		**$20,410**		**$27,657**
first cost, 10/1/01, channel only			**$7,617**		**$8,879**		**$15,337**
net excess benefits, channel and mitigating basin							
present worth equivalents			**$8,803**		**$19,537**		**$18,001**
average annual equivalents			**$530**		**$1,175**		**$1,083**
benefit:cost ratio			**1.5**		**2.0**		**1.7**

(EGM 01-03, 4 Dec 00 curves)

amortization factor, .05625 0.060148

BASIN OPTIMIZATION

Mitigation had been prematurely applied to the optimized structural channel segment since opportunities for further flood damage reduction had not yet been exhausted. This realization spurred optimization of what had once functioned as the mitigating detention basin. This process began with the development of 5 differing basin sizes and 2 weir structures for evaluation. Table 8 displays the results of basin sizing and shows that, with the 60-foot channel in place, the 108-acre basin with weir size 2 produces the greatest net excess benefits. Table 8A summarizes the information presented in Table 8. As can be seen in Table 8A of the Economic Appendix, all induced economic damages from the 60-foot channel segment are mitigated with a 65-acre detention basin, weir 2 configuration. At that basin size, induced damages reach zero dollars. The 65-acre, weir 2 basin adds an incremental benefit over the 60-foot channel without basin of $3,974,000 average annual equivalent dollars at an incremental cost of $727,000 average annual equivalent dollars. The net excess benefits for the 65-acre basin mitigating to the 0.2 percent chance event is $3,248,000 and produces a benefit-cost ratio of 4.6.

The NED plan has been identified as the 60-foot channel with the 108-acre detention basin with a weir 2 configuration. The 108-acre, weir 2 basin adds an additional $1,875,000 benefits over and above the 65-acre, weir 2 basin for an incremental cost difference of $471,000, on an average annual equivalent basis. The net excess benefits from the incremental difference are $1,403,000 with a benefit-cost ratio of 4.0. The 108-acre basin produced the greatest net excess benefits of any basin modeled. The optimization curve was not broken, but the Non-Federal Sponsor opted to halt the process by invoking its prerogative under PGL 97-10. The paucity of additional land required for continued basin enlargement suggested a highly probable negative outcome from additional analyses.

Table 8
Optimization of Downstream Detention Basin
Average Annual Equivalent Damages, 05625%, 50 yrs
Damages Reduced to Structures and Contents Only
(in thousands of Oct. 2001 $'s)

REACH LIMITS LOWER	UPPER	without project revised	60ft chan without basin	damages reduced	60ft chan with 50-ac basin weir 1	damages reduced	60ft chan with 50-ac basin weir 2	damages reduced	60ft chan with 65-ac basin weir 1	damages reduced	60ft chan with 65-ac basin weir 2	damages reduced	60ft chan with 80-ac basin weir 1	damages reduced	60ft chan with 80-ac basin weir 2	damages reduced	60ft chan with 93-ac basin weir 1	damages reduced	60ft chan with 93-ac basin weir 2	damages reduced	60ft chan with 108-ac basin weir 2	damages reduced	Project w/ Cutten weir 1	damages reduced	Project w/ Cutten weir 2	damages reduced
16083	**17638**	$4,172	$4,186	($15)	$4,161	$11	$4,172	$0	$4,161	$11	$4,148	$24	$4,172	$0	$4,172	$0	$4,172	$0	$4,172	$0	$4,172	$0	$4,172	$0	$4,172	$0
20610	**63860**	$2,289	$2,294	($5)	$2,283	$6	$2,289	$0	$2,283	$6	$2,278	$11	$2,289	$0	$2,289	$0	$2,289	$0	$2,289	$0	$2,281	$8	$2,289	$0	$2,289	$0
64366	**86100**	$184	$181	$3	$182	$2	$183	$1	$182	$2	$182	$2	$183	$1	$183	$0	$183	$1	$184	$0	$184	$0	$184	$0	$184	$0
91824	**100307**	$71	$71	$0	$70	$1	$70	$1	$70	$1	$70	$2	$71	$1	$69	$2	$71	$1	$69	$2	$69	$2	$69	$3	$69	$2
104390	**121990**	$343	$378	($35)	$347	($4)	$342	$1	$347	($4)	$335	$8	$347	($4)	$317	$26	$347	($4)	$313	$30	$311	$32	$301	$42	$325	$18
122432	**161049**	$4,333	$5,309	($976)	$4,557	($224)	$4,392	($58)	$4,533	($200)	$4,217	$116	$4,544	($211)	$3,936	$397	$4,540	($207)	$3,780	$553	$3,749	$584	$3,502	$831	$3,677	$656
	subtotal	$11,392	$12,420	($1,028)	$11,601	($209)	$11,448	($56)	$11,575	($183)	$11,230	$162	$11,605	($213)	$10,966	$426	$11,601	($210)	$10,806	$586	$10,766	$626	$10,516	$876	$10,715	$677
	REACH																									
	163269	$327	$425	($98)	$338	($11)	$322	$5	$336	($9)	$309	$17	$337	($10)	$281	$46	$337	($10)	$267	$59	$264	$63	$235	$92	$251	$75
	165169	$360	$482	($122)	$383	($23)	$364	($4)	$382	($22)	$350	$10	$382	($22)	$316	$44	$382	($22)	$300	$60	$298	$62	$267	$93	$286	$74
	167017	$483	$640	($157)	$523	($40)	$498	($14)	$522	($38)	$479	$5	$525	($42)	$439	$44	$525	($41)	$420	$63	$416	$67	$379	$104	$404	$79
	168600	$14	$19	($5)	$14	$0	$13	$1	$13	$0	$12	$1	$13	$1	$11	$3	$13	$1	$10	$3	$10	$3	$9	$5	$9	$5
	168996	$73	$97	($25)	$75	($3)	$71	$1	$75	($2)	$66	$7	$75	($2)	$57	$16	$75	($2)	$54	$19	$53	$20	$47	$25	$50	$23
	169973	$10	$14	($4)	$10	$0	$10	$0	$10	$0	$9	$1	$10	$1	$8	$3	$10	$1	$7	$3	$7	$3	$6	$4	$6	$4
	170999	$75	$104	($29)	$76	($1)	$71	$4	$75	($0)	$66	$9	$75	$0	$55	$20	$75	$0	$51	$24	$50	$25	$43	$32	$45	$30
	173701	$34	$50	($16)	$33	$0	$31	$3	$33	$1	$29	$5	$33	$1	$24	$10	$33	$1	$22	$12	$21	$13	$17	$16	$18	$15
	174793	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	175597	$1	$1	($0)	$1	$0	$1	$0	$1	$0	$0	$0	$1	$0	$0	$0	$1	$0	$0	$0	$0	$0	$0	$0	$0	$0
	176483	$120	$181	($61)	$118	$2	$109	$12	$117	$3	$100	$20	$117	$3	$80	$40	$117	$3	$73	$47	$70	$50	$56	$64	$61	$59
	178067	$172	$276	($104)	$166	$6	$154	$18	$164	$8	$140	$32	$163	$9	$112	$60	$162	$10	$102	$70	$95	$77	$74	$98	$78	$94
	179017	$145	$188	($43)	$142	$3	$137	$7	$140	$5	$131	$13	$140	$5	$122	$23	$139	$5	$118	$27	$114	$30	$107	$38	$108	$37
	180654	$63	$97	($34)	$65	($2)	$62	$1	$64	($1)	$58	$5	$65	($2)	$51	$12	$64	($1)	$48	$15	$46	$17	$41	$22	$42	$21
	181816	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	183453	$125	$188	($63)	$115	$11	$104	$21	$113	$12	$94	$31	$113	$12	$73	$52	$113	$12	$66	$59	$61	$64	$47	$79	$52	$74
	186594	$540	$799	($260)	$479	$61	$436	$103	$470	$70	$394	$146	$471	$69	$305	$234	$469	$70	$275	$265	$252	$288	$195	$345	$213	$327
channel reach	**187199**	$1,191	$1,619	($427)	$1,112	$80	$1,021	$170	$1,103	$88	$952	$239	$1,111	$80	$639	$552	$1,109	$82	$575	$616	$536	$656	$411	$780	$457	$734
channel reach	**187892**	$744	$1,078	($335)	$658	$86	$602	$141	$644	$100	$551	$193	$641	$102	$347	$396	$638	$105	$314	$429	$296	$447	$218	$526	$212	$532
channel reach	**189892**	$3	$4	($1)	$3	$0	$3	$1	$3	$1	$3	$1	$3	$0	$2	$2	$3	$1	$1	$2	$1	$2	$1	$2	$1	$2
channel reach	**192611**	$584	$528	$56	$386	$199	$371	$213	$375	$210	$349	$235	$374	$210	$230	$354	$373	$211	$214	$370	$189	$396	$151	$434	$143	$442
channel reach	**195119**	$1,219	$313	$907	$261	$958	$255	$965	$257	$962	$246	$973	$259	$960	$194	$1,026	$259	$961	$185	$1,034	$176	$1,044	$124	$1,096	$129	$1,091
channel reach	**198393**	$330	$136	$194	$128	$202	$126	$204	$127	$202	$125	$205	$128	$202	$113	$217	$128	$202	$111	$218	$110	$220	$76	$254	$89	$241
channel reach	**198689**	$44	$16	$28	$15	$29	$14	$30	$15	$30	$14	$30	$14	$30	$12	$32	$14	$30	$12	$32	$12	$32	$8	$36	$9	$36
channel reach	**200453**	$311	$94	$216	$91	$220	$90	$220	$91	$220	$90	$221	$90	$220	$82	$228	$90	$220	$81	$229	$80	$230	$52	$259	$56	$255
channel reach	**202037**	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
channel reach	**203779**	$115	$8	$108	$7	$108	$7	$108	$7	$108	$7	$108	$8	$108	$7	$108	$8	$108	$7	$108	$7	$108	$5	$110	$4	$111
channel reach	**204782**	$493	$32	$461	$32	$461	$32	$461	$32	$461	$32	$461	$32	$461	$31	$462	$32	$461	$30	$463	$30	$463	$23	$470	$21	$471
channel reach	**206328**	$208	$11	$197	$11	$196	$11	$197	$11	$197	$11	$196	$11	$196	$11	$197	$11	$196	$11	$197	$11	$197	$9	$199	$7	$201
	subtotal	$7,783	$7,399	$384	$5,240	$2,542	$4,915	$2,868	$5,179	$2,603	$4,616	$3,166	$5,191	$2,592	$3,602	$4,180	$5,180	$2,603	$3,358	$4,425	$3,206	$4,577	$2,601	$5,182	$2,749	$5,033
	total	$19,175	$19,818	($644)	$16,841	$2,333	$16,363	$2,811	$16,754	$2,420	$15,847	$3,328	$16,796	$2,379	$14,568	$4,606	$16,781	$2,393	$14,164	$5,011	$13,972	$5,203	$13,117	$6,058	$13,464	$5,711
	pwe	$318,790																								
damages induced				($2,814)		($308)		($77)		($276)		$0		($293)		$0		($288)		$0		$0		$0		$0
pwe																										
damages reduced				$2,167		$2,641		$2,888		$2,696		$3,328		$2,672		$4,606		$2,681		$5,011		$5,203		$6,058		$5,711
pwe																				$83,306		$86,496		$100,716		$94,943
benefits (damages reduced+induced)				($646)		$2,333		$2,811		$2,420		$3,328		$2,379		$4,606		$2,393		$5,011		$5,203		$6,058		$5,711
pwe				($10,748)		$38,793		$46,740		$40,236		$55,327		$39,545		$76,580		$39,790		$83,306		$86,496		$100,716		$94,943
subtotal benefits for channel reach				$1,404		$2,539		$2,709		$2,577		$2,863		$2,570		$3,574		$2,576		$3,700		$3,794		$4,165		$4,116
pwe				$23,342		$42,211		$45,036		$42,849		$47,592		$42,732		$59,423		$42,829		$61,510		$63,086		$69,250		$68,424
pwe benefits				($10,748)		$38,793		$46,740		$40,236		$55,327		$39,545		$76,580		$39,790		$83,306		$86,496		$100,716		$94,943
first cost						$13,135		$13,006		$15,270		$15,274		$17,898		$18,044		$20,056		$20,127		$23,112				
channel						$3,181		$3,191		$3,191		$3,191		$3,190		$3,190		$3,190		$3,190		$3,280				
basin						$9,954		$9,815		$12,079		$12,083		$14,708		$14,854		$16,866		$16,937		$19,832				
pwe net excess benefits						$25,658		$33,734		$24,966		$40,053		$21,647		$58,536		$19,734		$63,179		$63,384				
average annual equivalents						$1,543		$2,029		$1,502		$2,409		$1,302		$3,521		$1,187		$3,800		**$3,812**				
bcr						3.0		3.6		2.6		3.6		2.2		4.2		2.0		4.1		3.7				
(EGM 01-03, 4 Dec 00 curves)																										
amortization, .05625	0.060148																									

Table 8A
Incremental Justification
Mitigation Component and Flood Damage Reduction Component
of the 108-Acre Basin
values in $1,000's

	60ft chan without basin damages reduced	60ft chan with 65-ac basin weir 2 damages reduced	Difference from 60ft chan without basin	60ft chan with 80-ac basin weir 2 damages reduced	Difference from 65-ac basin weir 2	60ft chan with 93-ac basin weir 2 damages reduced	Difference from 65-ac basin weir 2	60ft chan with 108-ac basin weir 2 damages reduced	Difference from 65-ac basin weir 2
damages induced	($2,814)	$0	$2,814	$0	$0	$0	$0	$0	$0
pwe									
damages reduced	$2,167	$3,328	$1,161	$4,606	$1,278	$5,011	$1,683	$5,203	$1,875
pwe						$83,306	$27,978.65	$86,496	$31,168.62
benefits (damages reduced+induced)	($646)	$3,328	$3,974	$4,606	$1,278	$5,011	$1,683	$5,203	$1,875
pwe	($10,748)	$55,327	$66,075	$76,580	$21,252	$83,306	$27,979	$86,496	$31,169
first cost		$15,274		$18,044	$2,770	$20,127	$4,853	$23,112	$7,838
channel		$3,191		$3,190		$3,190		$3,280	
basin		$12,083	$12,083	$14,854		$16,937		$19,832	
average annual equivalent cost		$919	$727	$1,085	$167	$1,211	$292	$1,390	$471
pwe net excess benefits		$40,053	$53,992	$58,536	$18,482	$63,179	$23,126	$63,384	$23,331
average annual equivalents net excess		$2,409	$3,248	$3,521	$1,112	$3,800	$1,391	**$3,812**	**$1,403**
bcr		3.6	4.6	4.2	7.7	4.1	5.8	3.7	4.0

Note: Damages reduced are based on comparison with revised without project condition unless stated otherwise.

Note: Costs are simplistic and deemed sufficient for preliminary plan formulation.

amortization, .05625 0.060148

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NONSTRUCTURAL SOLUTIONS

Section 73 of WRDA 74 requires consideration of nonstructural alternatives in flood damage reduction studies. Nonstructural solutions can be considered independently or in combination with structural measures. Furthermore, Section 219 of WRDA 99 directs the Secretary of the Army to calculate benefits for nonstructural flood damage reduction projects using methods similar to those used in calculating the benefits of structural projects and further directs the Secretary to avoid double-counting of benefits in the projects. Implementation guidance for Section 219 was published 22 January 2001.

STAND-ALONE NONSTRUCTURAL SOLUTIONS

During the plan formulation for solutions to flooding on Greens Bayou, plans were developed both as stand-alone remedies and as complements to the structural components in keeping with Section 73 WRDA 74. The stand-alone measures would evacuate the floodplains of the 50-, 20-, and 10-percent annual exceedance probability events. These plans extended the full length of the bayou and were distinguished by buyout of residential only or both residential and nonresidential properties within each respective floodplain considered.

Table 9 presents results that comply with Section 219 guidance. In doing so, the total present worth equivalent damages expected to accrue to structures and contents over the period of analysis are compared with the first cost of purchasing those properties as though they were located outside the 1-percent annual exceedance probability floodplain. The analysis was accomplished with the assistance of the Appraisal Branch of the Galveston District's Real Estate Division who provided proxy "flood-free" values for NED cost analysis.

Table 9 reveals that, of the nonstructural plans considered, the buyout of structures lying within the 20-percent annual exceedance probability floodplain produced the greatest net excess benefits amounting to $22.2 million in present worth equivalents at a October 2001 price levels, or $1.3 million in average annual equivalents, discounted at 5.625 percent.

These nonstructural plans were compared with the optimized channel and basin plan to identify the most economically efficient alternative. The structural plan with a 60-foot-wide channel segment and 108-acre detention basin produced the greatest net excess benefits with $3.8 million in average annual equivalents and, was therefore carried forward as the most economically efficient plan.

Table 9
Greens Bayou , Texas GRR
Economic Evaluation of Section 219 Compliant Nonstructural Buyouts
Stand-Alone Measures
(in thousands of Oct. 2001 $'s)

	50% Annual Exceedance Fldplain		20% Annual Exceedance Fldplain		10% Annual Exceedance Fldplain	
	Residential	Res & Com	Residential	Res & Com	Residential	Res & Com
Units	(14)	(20)	(249)	(270)	(405)	(444)
Non-Federal Costs						
01 Lands & Damages	$ 1,489	$ 7,237	$ 27,369	$ 58,314	$ 69,613	$ 137,746
TOTAL	$ 1,489	$ 7,237	$ 27,369	$ 58,314	$ 69,613	$ 137,746
Federal Costs						
01 Lands & Damages	$ 44	$ 62	$ 800	$ 880	$ 2,029	$ 2,227
09 Channels & Canals	87	130	1,491	3,459	3,770	7,767
30 Eng & Design	16	24	295	359	399	666
31 Const Mngt	10	16	197	287	299	500
TOTAL	$ 157	$ 232	$ 2,783	$ 4,985	$ 6,497	$ 11,160
INCREMENTAL PROJECT COST	$ 1,646	$ 7,469	$ 30,152	$ 63,299	$ 76,110	$ 148,906
CUMULATIVE PROJECT COST	$1,646	$7,469	$31,798	$70,768	$107,908	$219,674
Cumulative AAEV Benefits	$323	$680	$2,516	$5,593	$4,726	$8,716
Cumulative PWE Benefits	$5,370	$11,309	$41,836	$92,980	$78,576	$144,916
CUMULATIVE NET EXCESS						
AAEV BENEFITS, $1,000'S	$224	$231	$604	**$1,336**	-$1,764	-$4,497
PWE BENEFITS, $1,000's	$3,724	$3,840	$10,038	$22,212	-$29,332	-$74,758
CUMULATIVE BCR	3.3	1.5	1.3	1.3	0.7	0.7

BUYOUT OF RESIDUAL FLOODPLAIN

With the implementation of the 60-foot channel and the 108-acre detention basin, average annual equivalent damages within the 0.2 percent annual exceedance floodplain will be reduced by 24 percent. There remain residual damages with which to formulate additional components. However, environmental constraints in the downstream reaches of Greens Bayou dictated a nonstructural approach to subsequent damage reduction. An evacuation/buyout analysis was performed within the residual floodplains of the 50-, 20-, and 10-percent annual exceedance probability events. As with the stand-alone nonstructural measures analysis, buyouts of residential only and residential and nonresidential structures combined were evaluated. Only those residential structures considered for buyout were those not already purchased by FEMA under the Hazard Mitigation Grant Program (HMGP) following Tropical Storm Allison in June 2001. The analysis also followed USACE guidance put forth in Section 219 WRDA 99. The Real Estate Division, Galveston District, provided both project and economic costs for evacuation of properties in compliance with Section 219. The economic costs and benefits of each buyout option are displayed in Table 10. The results of this analysis indicated that no nonstructural component in the residual floodplain was economically justified. Benefits from buyouts were not augmented with economic benefits that might be derived from new uses of the evacuated floodplain, i.e., recreation, because of the patchwork effect that the target properties would produce if vacated.

Table 10
Nonstructural Buyout of Floodplains Residual to the 60-Foot Channel and 108-Acre Basin
Economic Evaluation
Greens Bayou , Texas GRR
October 2001, Price Level

CUMULATIVE FLOODPLAINS	*50% Annual Exceedance Fldplain*		*20% Annual Exceedance Fldplain*		*10% Annual Exceedance Fldplain*	
	Residential	*Res & Comm.*	*Residential*	*Res & Comm.*	*Residential*	*Res & Comm.*
Non-Federal Costs						
01 Lands & Damages	$ 2,090,000	$ 10,880,100	$ 15,055,000	$ 35,216,500	$ 31,937,100	$ 117,293,600
TOTAL	$ 2,090,000	$ 10,880,100	$ 15,055,000	$ 35,216,500	$ 31,937,100	$ 117,293,600
Federal Costs						
01 Lands & Damages	$ 24,400	$ 32,500	$ 240,500	$ 266,500	$ 524,900	$ 593,100
09 Channels & Canals	118,100	168,000	1,149,700	2,311,000	2,484,400	5,947,000
30 Eng & Design	24,000	32,000	69,000	139,200	150,000	359,000
31 Const Mngt	16,800	28,000	52,000	104,400	113,000	269,000
TOTAL	$ 183,300	$ 260,500	$ 1,511,200	$ 2,821,100	$ 3,272,300	$ 7,168,100
TOTAL PROJECT COST	**$ 2,273,300**	**$ 11,140,600**	**$ 16,566,200**	**$ 38,037,600**	**$ 35,209,400**	**$ 124,461,700**
AAEV PROJECT COST	**$ 136,735**	**$ 670,089**	**$ 996,431**	**$ 2,287,901**	**$ 2,117,790**	**$ 7,486,174**
These costs reflect compliance with Sect 219 in that land costs are valued as though they lie outside the 1% annual exceedance floodplain.						
BENEFITS TO STRUCTURES AND CONTENTS ONLY						
AAEV Benefits	$125,002	$329,948	$897,955	$2,217,112	$1,813,285	$3,404,132
PWE Benefits	$2,078,228	$5,485,570	$14,928,982	$36,860,696	$30,146,847	$56,595,537
AAEV NET EXCESS BENEFITS	-$11,733	-$340,141	-$98,476	-$70,789	-$304,505	-$4,082,042
NET EXCESS BENEFITS, PWE	-$195,072	-$5,655,030	-$1,637,218	-$1,176,904	-$5,062,553	-$67,866,163
BENEFIT-COST RATIO	0.91	0.49	0.90	0.97	0.86	0.45
number of structures to buyout economic analysis	15	20	148	164	338	388
Add Associated Benefits						
Reduction in FIA admin cost @$133/Policy	$1,995					
Reduction in Other Costs Assoc with Flooding @$8,500/Struct	$127,500					
Total Net Excess Benefits, PWE	-$65,577					
BCR	0.97					
AAEV= AVERAGE ANNUAL EQUIVALENT VALUE						
Discount Rate	0.05625					
Amortization Factor, 50 yrs.	0.060148415					

IDENTIFICATION OF NED PLAN

The NED Plan is identified as the 60-foot-wide channel segment from Veteran's Memorial Drive, cross-section 187199, to Cutten Road at cross-section 206328, coupled with a 108-acre detention basin located in the downstream part of the channel reach at West Greens Road. Average annual equivalent damages reduced by reach over the 50-year project life are presented in Table 11. This table reflects benefits accruing to all categories. Of the five categories structure and contents represent approximately 52 percent of the benefits accrued.

Table 11

Recommended Plan

Average Annual Equivalent Damages and Damages Reduced

Without Project, Revised		With Project		Benefits	
Damage Category	Damages	Damage Category	Damages	Damage Category	Damages Reduced
Structure & Contents	$20,357.43	Structure & Contents	$14,821.32	Structure & Contents	$5,536.11
Roads	$1,294.26	Roads	$275.60	Roads	$1,018.66
Utilities	$155.82	Utilities	$36.04	Utilities	$119.78
Vehicles	$5,261.84	Vehicles	$1,407.68	Vehicles	$3,854.16
Other Costs	$2,109.40	Other Costs	$1,883.62	Other Costs	$225.78
Total	$29,178.75	Total	$18,424.26	Total	$10,754.49

interest rate= .05375

price levels=October 2004

amortization factor, 50yrs @5.375=.0579806

Economic costs are comprised of project implementation costs including PED costs; construction costs including operation and maintenance costs, interest during construction (IDC), and mitigation costs, if any. The IDC is calculated on the PED study cost, implementation costs as they occur, and land as it is consumed for the project. Table 12 displays the Recommended Plan's costs. The net excess economic benefits are computed as the difference of the economic benefits and the economic costs. The benefit-to-cost ratio (BCR) is the quotient of the benefits divided by the costs. The resulting computations are shown in Tables 12.

Table 12

Comparison of the Recommended Plan and the Authorized Plan

	Recommended Plan	Recommended Plan Updated	Recommended Plan Updated	Authorized Plan 1988 [1]	Last Presented to Congress [2]	Last Presented to Congress Price Updated to Oct 01 Updated Interest Rate	Last Presented to Congress Price Updated to Oct 04	Last Presented to Congress Price Updated to Oct 04 Updated Interest Rate
Price Level	Oct-01	Oct-04	**Oct-04**	Jan-88	Oct-00	Oct-01	Oct-04	**Oct-04**
Interest Rate	0.05625	0.05625	**0.05375**	0.08625	0.08625	0.05625	0.05625	**0.05375**
Project Life, years	50	50	50	100	50	50	50	50
Flood Control (includes Mitigation) First Cost								
PED	$5,470,000	$5,470,000	$5,470,000					
Construction	$26,431,000	$32,308,000	$32,308,000					
Const. Contingency	$4,587,000	(includes contin)	(includes contin)					
Total First Cost	$36,488,000	$37,778,000	$37,778,000	$118,035,000	$274,320,000	$279,806,400	$296,594,784	$296,594,784
IDC	$3,885,083	$4,001,551	$3,813,593					
O&M (PV of $289,300 annually)	$4,810,000 (PV of $289,300 ann)	$4,710,049 (PV of $283,300 ann)	$4,710,049 (PV of $283,300 ann)					
Recreation First Cost	$0	$0	$0	$3,065,000	(incl. in total first cost)	(incl. in total first cost)	(incl. in total first cost)	(incl. in total first cost)
Total NED Cost	$45,183,083	$46,489,600	$46,301,642	$121,100,000	$274,320,000	$279,806,400	$296,594,784	$296,594,784
AAEV Total NED Cost					$24,044,269	$16,829,795	$17,839,583	$17,196,748
Flood Control	$2,717,672	$2,796,256	$2,684,598	$11,986,000				
Recreation	$0	$0	$0	$406,000				
AAEV O&M								
Flood Control				$463,200				
Recreation				$98,000				
AAEV Total NED Benefits					$63,623,900 [3]	$44,533,574	$47,205,588	$45,504,143
Flood Control	$10,126,000	$10,733,560	$10,754,490	$32,205,000	$61,722,100	$43,202,408	$45,794,552	$44,143,966
Recreation	$0	$0	$0	$1,901,800	$1,901,800	$1,331,166	$1,411,036	$1,360,177
BCR					2.65	2.65	2.65	2.65
Flood Control	3.73	3.84	4.01	2.69				
Recreation	n/a	n/a	n/a	4.68				
AAEV Net Excess Benefits								
Flood Control	$7,408,328	$7,937,304	$8,069,892	$20,219,000	$39,579,631	$27,703,778	$29,366,005	$28,307,395
Recreation	$0	$0	$0	$1,495,800				

1/ The authorized data is taken from Buffalo Bayou and Tributaries, Texas Feasibility Report (Flood Damage Prevention), Volume 1 Main Report, May 1988.

2/ The authorized plan last presented to Congress: Justification Sheet, 2 Feb 2004

3/ The benefits presented to Congress were taken from the Limited Reevaluation Report on Separable Element Analyses, Greens Bayou and Houston, Texas, Preconstruction Engineering and Design, U.S. Army Corps of Engineers, Southwestern Division, Galveston Division, October 1993

Uncertainty of Project Outputs. ER 1105-2-101 requires that uncertainty of outputs be expressed for damages reduced; net excess benefits, and the benefit-to-cost ratio. Table 13 displays these outputs with uncertainty.

Table 13
Uncertainty Associated with Outputs of the NED Plan

	AAEV Damages		AAEV Damages Reduced to Structures and Contents Only		
	Mean	St. Dev.	Mean	St. Dev.	
Without Project Condition, Revised	$20,357	$14,022			
60-ft Channel, 108-Acre Basin Plan	$14,821	$11,002	**$5,536**	**$3,020**	
Exceedance Probability	**0.95**	**0.75**	**0.50**	**0.25**	**0.05**
Probability Damages Reduced Exceed Indicated Values	$569	$3,500	$5,536	$7,573	$10,504

	AAEV Benefits All Benefit Categories		AAEV Costs	AAEV Net Excess Benefits	
	Mean	St. Dev.	Constant	Mean	St. Dev.
60-ft Channel, 108-Acre Basin Plan	$10,754	$3,020	$3,228	$7,526	$3,020
Exceedance Probability	**0.95**	**0.75**	**0.50**	**0.25**	**0.05**
Probability Net Excess Benefits Exceed Indicated Values	$2,559	$5,490	$7,526	$9,563	$12,494

	AAEV Benefits All Benefit Categories		AAEV Costs	Benefit:Cost	
	Mean	St. Dev.	Constant	Ratio	
60-ft Channel, 108-Acre Basin Plan	$10,754	$3,020	$2,685	4.0	
Exceedance Probability	**0.95**	**0.75**	**0.50**	**0.25**	**0.05**
Probability Benefit:Cost Ratio Exceeds Indicated Values	2.0	3.0	4.0	4.6	5.7
Percent Probablity BCR > 1	100				

Values in Thousands of Oct. 2004 Dollars
AAEV= Average Annual Equivalent Value

COMPARISON OF THE AUTHORIZED PLAN WITH THE RECOMMENDED PLAN

The Authorized Project consisted of 14 miles of vegetative clearing in the lower reach, 25 miles of channel enlargement, four detention basins, tree and shrub plantings, and recreation features. The Recommended Plan is identified as the 60-foot-wide channel segment from Veteran's Memorial Drive to Cutten Road, coupled with a 108-acre detention basin located downstream of the channel segment at West Greens Road. Average annual cost for the Recommended Plan declined to approximately $3 million from the Authorized Plan's cost of approximately $18 million, at an interest rate of 5.625 percent and at October, 2004 prices. Average annual benefits for the Recommended Plan declined when compared with the benefits attributed to the Authorized Plan due to the reduction in the size of the project. However, the BCR for the Recommended Plan increased to 3.84 percent as compared with the 2.65 BCR of the Authorized Plan. Benefits and costs for the authorized design and the recommended plan are shown in Table 12.

SECTION 575 ANALYSIS

Section 575 of WRDA 96 provides that "during any evaluation of economic benefits and costs for projects… that occurs after the date of the enactment of this Act, the Secretary shall not consider flood control works constructed by non-Federal interests within the drainage area of such projects prior to the date of such evaluation in the determination of conditions existing prior to construction of the project." Section 354 of WRDA 99 amended Section 575 to remove nonstructural actions from considerations. The WRDA 99, Section 575(b) provides that:

> (b) SPECIFIC PROJECTS. —The projects to which subsection (a) apply are—
> (1) the project for flood control, Buffalo Bayou Basin, Texas, authorized by Section 203 of the Flood Control Act of 1954 (68 Stat. 1258);
> (2) the project for flood control, Buffalo Bayou and tributaries, Texas, authorized by section 101(a) of the Water Resources Development Act of 1990 (104 Stat. 4610); and
> (3) the project for flood control, Cypress Creek, Texas, authorized by section 3(a)(13) of the Water Resources Development Act of 1988 (102 Stat. 4014).

Greens Bayou, being a tributary of Buffalo Bayou, Texas, is affected by the analytical requirements of Section 575.

To meet the intent of the legislation, the without-project condition for Greens Bayou was formulated without consideration of ongoing construction and property relocations within the study area. Only after the Federal NED plan was developed and fully evaluated was additional analysis performed, testing the effect of activities by non-Federal interests. Two activities had the potential for altering either the hydrologic or economic profile of the study area—the construction of the Cutten Road Basin upstream of cross-section 206328 and the purchase and demolition of 119 properties along the main stem of Greens Bayou following Tropical Storm Allison, which occurred June, 2001. FEMA's Hazard Mitigation Grant Program (HMGP) and the Harris County Flood Control District funded the buyouts. Table 15 displays the distribution of the properties purchased under the HGMP within the floodplains of Greens Bayou. Table 16 displays of the results of the effect of either and both the Cutten Road Basin and the buyouts. As can be seen from the table, the Cutten Road Basin with Weir Configuration 1 further reduces

flood damage along the main stem on an average annual basis of $855,000 over the 50-year life of the project or $14.2 million in present worth equivalent values.

The removal of 119 damageable properties from the 0.2 percent annual exceedance floodplain of the main stem of Greens Bayou reduced overall damages in the with-project condition by $315,000 on an average annual basis and reduced the benefits attributable to the Federal project by 0.3 percent. By reducing the benefits attributable to the Federal project, the benefit-cost ratio of the NED plan did not alter. Neither of these actions compromises the benefits derived from the Federal project. The Cutten Road Basin actually augments the performance of the Federal project by further reducing damages.

Table 14
Distribution of FEMA-Purchased Structures by Floodplain
Post Tropical Storm Allison, June, 2001

Percent Annual Exceedance Probability Floodplain	Number	Percent	Cumulative Percent
50	0	0%	0%
20	16	13%	13%
10	13	11%	24%
4	22	18%	43%
2	30	25%	68%
1	9	8%	76%
0.4	13	11%	87%
0.2	16	13%	100%
Total	119	100%	

Table 15
Section 575 Analysis
Average Annual Equivalent Damages to Structures and Contents Only, 05625%, 50 yrs
(in thousands of Oct. 2001 $'s)

		(a)	(b)		©		(d)		(c-b)	(d-b)	(e)	(f)	(g)	(h)	(i) (a-e)	(j) (b-f)	(i-j)	(k) (c-g)	(i-k)	(l) (d-h)	(i-l)
REACH LIMITS LOWER	UPPER	without project revised	NED PROJECT 60ft chan with 108-ac basin weir 2	damages reduced	60ft chan with 108-ac basin weir 2 w/Cutten Road weir 1	damages reduced	60ft chan with 108-ac basin weir 2 w/Cutten Road weir 2	damages reduced	Effect of Cutten Road Basin Weir 1 in NED project Condition	Effect of Cutten Road Basin Weir 2 in NED project Condition	DAMAGES TO FEMA STRUCTURES IN PROJECT CONDITIONS without project revised	NED PROJECT 60ft chan with 108-ac basin weir 2	60ft chan with 108-ac basin weir 2 w/Cutten Road weir 1	60ft chan with 108-ac basin weir 2 w/Cutten Road weir 2	EFFECT OF REMOVING FEMA STRUCTURES FROM INVENTORY ON PROJECT CONDITONS without project revised	NED PROJECT 60ft chan with 108-ac basin weir 2	damages reduced	60ft chan with 108-ac basin weir 2 w/Cutten Road weir 1	damages reduced	60ft chan with 108-ac basin weir 2 w/Cutten Road weir 2	damages reduced
									damages reduced	damages reduced											
16083	**17638**	$4,172	$4,172	$0	$4,172	$0	$4,172	$0	$0	$0	$0	$0	$0	$0	$4,172	$4,172	$0	$4,172	$0	$4,172	$0
20610	**63860**	$2,289	$2,281	$8	$2,289	$0	$2,289	$0	-$8	-$8	$0	$0	$0	$0	$2,289	$2,281	$8	$2,289	$0	$2,289	$0
64366	**86100**	$184	$184	$0	$184	$0	$184	$0	$0	$0	$0	$0	$0	$0	$184	$184	$0	$184	$0	$184	$0
91824	**100307**	$71	$69	$2	$69	$3	$69	$2	$0	$0	$0	$0	$0	$0	$71	$69	$2	$69	$3	$69	$2
104390	**121990**	$343	$311	$32	$301	$42	$325	$18	$10	-$14	$196	$193	$192	$193	$147	$118	$29	$109	$38	$132	$15
112432	**161049**	$4,333	$3,749	$584	$3,502	$831	$3,677	$656	$248	$73	$126	$114	$108	$113	$4,207	$3,636	$571	$3,393	$813	$3,564	$643
	subtotal	11,392	$10,766	$626	$10,516	$876	$10,715	$677	$250	$52	$322	$307	$300	$306	$11,070	$10,459	$610	$10,216	$854	$10,409	$661
	REACH																				
	163269	$327	$264	$63	$235	$92	$251	$75	$29	$12	$0	$0	$0	$0	$327	$264	$63	$235	$92	$251	$75
	165169	$360	$298	$62	$267	$93	$286	$74	$31	$12	$4	$3	$3	$3	$356	$295	$61	$264	$92	$283	$73
	167017	$483	$416	$67	$379	$104	$404	$79	$37	$13	$6	$5	$4	$4	$478	$412	$66	$375	$102	$399	$78
	168600	$14	$10	$3	$9	$5	$9	$5	$2	$2	$0	$0	$0	$0	$14	$10	$3	$9	$5	$9	$5
	168996	$73	$53	$20	$47	$25	$50	$23	$6	$4	$0	$0	$0	$0	$73	$53	$20	$47	$25	$50	$23
	169973	$10	$7	$3	$6	$4	$6	$4	$1	$1	$0	$0	$0	$0	$10	$7	$3	$6	$4	$6	$4
	170999	$75	$50	$25	$43	$32	$45	$30	$7	$5	$0	$0	$0	$0	$75	$50	$25	$43	$32	$45	$30
	173701	$34	$21	$13	$17	$16	$18	$15	$4	$3	$0	$0	$0	$0	$34	$21	$13	$17	$16	$18	$15
	174793	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	175597	$1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1	$0	$0	$0	$0	$0	$0
	176483	$120	$70	$50	$56	$64	$61	$59	$14	$9	$0	$0	$0	$0	$120	$70	$50	$56	$64	$61	$59
	178067	$172	$95	$77	$74	$98	$78	$94	$20	$17	$0	$0	$0	$0	$172	$95	$77	$74	$98	$78	$94
	179017	$145	$114	$30	$107	$38	$108	$37	$8	$6	$0	$0	$0	$0	$145	$114	$30	$107	$38	$108	$37
	180654	$63	$46	$17	$41	$22	$42	$21	$5	$4	$0	$0	$0	$0	$63	$46	$17	$41	$22	$42	$21
	181816	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	183453	$125	$61	$64	$47	$79	$52	$74	$15	$10	$0	$0	$0	$0	$125	$61	$64	$47	$79	$52	$74
	186594	$540	$252	$288	$195	$345	$213	$327	$57	$39	$0	$0	$0	$0	$540	$252	$288	$195	$345	$213	$327
channel reach	**187199**	$1,191	$536	$656	$411	$780	$457	$734	$125	$78	$0	$0	$0	$0	$1,191	$536	$656	$411	$780	$457	$734
channel reach	**187892**	$744	$296	$447	$218	$526	$212	$532	$78	$85	$0	$0	$0	$0	$744	$296	$447	$218	$526	$212	$532
channel reach	**189892**	$3	$1	$2	$1	$2	$1	$2	$0	$0	$0	$0	$0	$0	$3	$1	$2	$1	$2	$1	$2
channel reach	**192611**	$584	$189	$396	$151	$434	$143	$442	$38	$46	$0	$0	$0	$0	$584	$189	$396	$151	$434	$143	$442
channel reach	**195119**	$1,219	$176	$1,044	$124	$1,096	$129	$1,091	$52	$47	$0	$0	$0	$0	$1,219	$176	$1,044	$124	$1,096	$129	$1,091
channel reach	**198393**	$330	$110	$220	$76	$254	$89	$241	$34	$21	$0	$0	$0	$0	$330	$110	$220	$76	$254	$89	$241
channel reach	**198689**	$44	$12	$32	$8	$36	$9	$36	$4	$3	$0	$0	$0	$0	$44	$12	$32	$8	$36	$9	$36
channel reach	**200453**	$311	$80	$230	$52	$259	$56	$255	$28	$25	$0	$0	$0	$0	$311	$80	$230	$52	$259	$56	$255
channel reach	**202037**	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
channel reach	**203779**	$115	$7	$108	$5	$110	$4	$111	$2	$2	$0	$0	$0	$0	$115	$7	$108	$5	$110	$4	$111
channel reach	**204782**	$493	$30	$463	$23	$470	$21	$471	$7	$8	$0	$0	$0	$0	$493	$30	$463	$23	$470	$21	$471
channel reach	**206328**	$208	$11	$197	$9	$199	$7	$201	$2	$4	$0	$0	$0	$0	$208	$11	$197	$9	$199	$7	$201
	subtotal	$7,783	$3,206	$4,577	$2,601	$5,182	$2,749	$5,033	$605	$457	$10	$8	$7	$8	$7,773	$3,198	$4,575	$2,593	$5,179	$2,742	$5,031
	total	$19,175	$13,972	$5,203	$13,117	$6,058	$13,464	$5,711	$855	$508	$332	$315	$307	$314	$18,843	$13,657	$5,185	$12,809	$6,033	$13,150	$5,692
	pwe								$14,220	$8,447											

first cost	$53,680		$53,680
aaev,first cost	$3,229		$3,229
net excess benefits	**$1,974**		$1,957
bcr	**1.61**		**1.61**
amotization factor, .05625%	0.060148		
(EGM 01-03, 4 Dec 00 curves)			