PECAN CREEK, GAINESVILLE, TEXAS
DETAILED PROJECT REPORT
and
INTEGRATED ENVIRONMENTAL ASSESSMENT

APPENDIX F
FLOOD DAMAGE ANALYSIS

INTRODUCTION

Purpose. The purpose of this analysis is to examine the single event and average annual flood damages under without-project conditions within the study area. The without-project damages will be compared to damages expected to occur under with-project conditions (alternatives), the difference being the economic (monetary) benefit attributable to the alternatives.

Study Area. The study area is located in the city of Gainesville, Cooke County Texas. Pecan Creek originates approximately six miles north of the city and flows south through the central portion of the city to its confluence with Wheeler Creek, Redmond Branch, and the Elm Fork of the Trinity River. The study area is broken down into three reaches: the Upper, the Middle, and the Lower reaches. Table 1 displays a summary of the reaches with upstream and downstream limits.

Table F-1
Reach Descriptions

Reach Name	Upstream Limit	Downstream Limit
Upper	US Hwy 82	Belcher Street
Middle	Belcher Street	Pecan Street
Lower	Pecan Street	Anthony Street

Socio-Economic Overview. The economy of Cooke County is driven by varied manufacturing, which makes up 23 percent of the workforce. Trade, Transportation, and Utilities make up 21 percent of the workforce, while local government makes up 16 percent of the workforce. Leisure and hospitality and professional and business services account for ten and eight percent of the workforce respectively. Industries important to the City of Gainesville include aircraft, steel fabrication, tourism, and agribusiness. Agricultural activities include beef, dairy operations, wheat, sorghum, corn, soybeans, and horses. The city is located on Interstate I-35 and is also serviced by US Highway 82. Other amenities include North Central Texas College and the Frank Buck Zoo. Table 2 displays population data. Table 3 displays data on per capita income.

Table 2
Population

	1990	2000	2004	2009-2010
Gainesville	14,256	15,538	16,250	17,184
Cooke County	30,777	36,363	38,126	41,619
Texas	16,986,510	20,851,820	22,293,020	23,286,510

Table 3
Per Capita Income

	1990	2000	2004
Gainesville	$10,527	$15,154	$16,521
Cooke County	$11,594	$17,889	$20,296
Texas	$17,446	$27,992	$30,281

Table 4
Unemployment Rates

	1990	2000	2004
Gainesville	5.7%	4.3%	4.4%
Cooke	4.9%	4.6%	4.2%
Texas	6.3%	6.1%	5.5%

Source: for Texas and Cooke County - http://bea.gov; for City of Gainesville - http://txsdc.tamu.edu/

The population of Cooke County saw an increase of 21 percent from 1990 to 2004. This compares with a 31 percent increase in population for the State for the same period. Per capita income for Cooke County increased by 75 percent between 1990 and 2004. When adjusted for inflation, the increase in per capita income is 23 percent. By comparison, per capita in come for the State between 1990 and 2000 increased 74 percent in nominal terms with a 22 percent increase when adjusted for inflation. Unemployment in Cooke County has fallen from 1.3 percentage points from 1990 to 2004 compared to a 0.8 decrease for the state of Texas. Table 5 shows the distribution of labor between industries in Gainesville.

Table 5
Gainesville Employment by Industry

	1990	2000	2004
Business/Professional	21.5%	24.1%	24.3%
Service	22.7%	16.8%	16.8%
Sales and Office	19.0%	23.6%	23.5%
Farming/Fishing/Forestry	2.9%	1.2%	1.2%
Construction	13.7%	12.1%	12.0%
Production/Transportation	20.2%	22.2%	22.2%

With the current growth rates in population and income a continuous increase in housing and the value of housing can be assumed. An increase in the benefits from flood damage reduction can be anticipated as a result of this trend.

WITHOUT PROJECT FLOOD DAMAGES AND COSTS

Flood History. In the past, Gainesville has experienced serious flooding from the three watercourses that traverse through the city, those being Pecan Creek, Wheeler Creek, and the Elm Fork of the Trinity River.

Pecan Creek has flooded the city of Gainesville on numerous occasions. The October 1981 event was the most catastrophic flood recorded. Gainesville reached a total rainfall of 23.55 inches for the period of October 6-14, 1981 with 6.9 and 7.25 inches falling on October 12th and 13th respectively. Resultant flood depths ranged from three to five feet in the Pecan Creek watershed just west of the city and two to four feet within the city limits.

As a result of this widespread flooding, Cooke County was one of four counties in North Central Texas declared a national disaster area and received assistance under the Disaster Relief Act of 1970. The Corps conducted reconnaissance surveys of the flood-stricken area shortly after floodwater receded. Overall, 271 residential, commercial, and industrial structures throughout the city were found to have sustained damages from the storm. In addition, the Gainesville City Park, Frank Buck Zoo, and various public properties, streets, and bridges were inundated. No estimate on the losses to these public facilities is available.

Methodology. The theoretical computation of flood damages is relatively simple. It is based on the depth of flooding for various flood events (exceedence probabilities), and a relationship between the depth of flooding and the estimated damages based on a percentage of the structure and content, or vehicle value. The nomenclature used in this appendix to describe the relative risk reflects the actual probability, rather than the average recurrence interval, of flood events. For example, the commonly used term "100-year frequency flood", meaning that flood which stands a one percent chance of being equaled or exceeded in any given year period, will hereafter be known as the “1 percent annual chance exceedence (ACE) flood.” Damages to the various structures, accumulated by frequency, produce a frequency-damage function. An integration process using this frequency-damage data calculates estimates of expected annual damages. This involves aggregating the multiplication of the mean damage between each pair of flood events by the difference in exceedence probabilities. This is then repeated for the range of flood events in each damage category.

Hydrologic Engineering Center-Flood Damage Assessment (FDA) Program. The Hydrologic Engineering Center-Flood Damage Assessment (FDA) Program is used to compute Flood damages under without- and with-project conditions. The program integrates hydrologic, hydraulic, and flood plain characteristics through application of a Monte Carlo simulation, and computes single event and expected annual damages while accounting for uncertainty in the values of structures and contents. Damage susceptibility factors used by the program to estimate flood damages include the number and type of structures, structures and content values, the elevation where the structure begins to sustain measurable damages, and a flood depth-damage relationship.

Inventory of Flood Plain Structures. An inventory of properties lying within the limits of the 0.2% annual chance exceedence (500-yr) flood plain was conducted to determine the number and type of structures, values of structures and contents, and ground and finished floor elevations (elevation where water enters the structure). Structures were initially identified and digitized in GIS using digital orthoquads as base maps. A field survey was then conducted to determine condition and quality of the structures and to identify the first floor elevation. In addition, the survey identified the applicable flood depth-percent damage relationship for each structure type. Lastly, the privately owned vehicles susceptible to flood were estimated. Each is described in detail in the following paragraphs.

Depreciated Structure Value/Replacement Cost. Structure values were obtained from the Cooke County appraisal district and used as a base value. In compliance with ER-1105-2-101, in order to accurately reflect replacement cost less depreciation to the existing structures, values for a sample of eight commercial structures were calculated using Marshall and Swift based on the information collected during the field survey. This sample represents 11 percent of commercial structures in the study area. Residential structures were adjusted based on appraisals done by HDR, an AE firm, for nine properties identified as potential participants under a FEMA buyout plan. These nine structures represent approximately three percent of residential structures (excluding mobile residences) and include structures with both pier and beam foundations as well as concrete slab foundations. Replacement cost is the cost of physically replacing (reconstructing) the structure. Depreciation accounts for deterioration occurring prior to flooding, and variations in remaining useful life of the structure. Structure values for single family residential, multifamily, and mobile homes were adjusted by upward by 25 percent; commercial properties were adjusted upward by 27 percent. Public structures were not adjusted since values for these structures came from the controlling entities themselves in the form of insurance replacement costs. Uncertainty distributions associated with estimating the depth-damage functions, structure values, content ratios, and first flood stage are used to develop the total aggregated stage-damage uncertainty function by damage categories for each damage reach. An uncertainty factor of 10 percent was used for residential structures and 15 percent for commercial and public structures.

Content Value. Content values for residential structures were not specifically collected. Residential content values are embedded in the depth-percent relationship (the discussion on depth-percent damage relationships is described in detail below). The applicable appraisal district records provided content value data on commercial structures. Content value data for public structures were obtained from the entity involved.

Ground and First Floor Elevations. Topographic maps compiled from aerial photography, flown during the summer of 2002, served as base maps to identify flood prone properties and estimate ground elevations. First floor elevations were visually inspected for each structure. For each Monte-Carlo simulation the first floor stage with uncertainty is computed from the first floor stage, the uncertainty distribution and the uncertainty parameters. The uncertainty parameters are the same units as the first floor stage. The uncertainty in the first floor stage is modeled using the normal distribution with a standard deviation of 0.5 feet.

Depth-Percent Damage Relationships. Depth-percent relationships (curves) relate the depth of flooding relative to the structure first floor to flood damages as a percent of the estimated structure value. For residential structure types, the curves used were compiled by the USACE Institute of Water Resources (IWR) and are based on data collected from flooding events occurring in various parts of the United States between 1996 and 2001. These curves assume that contents for all residential structures are equal to the value of the structure (although content damages are maximized at 50% of their value). Damage curves for commercial and public structures also reflect the results of analyses of historical data collected from major flood events across the United States, and have been supplemented based on the findings of subsequent economic field surveys of flood plain properties in the Fort Worth District, considering such factors as the design of the structure and nature of the structure contents. The uncertainty associated with residential structures and contents is modeled using a normal distribution with a standard deviation of 10 percent. Commercial and public structures are similarly modeled with a standard deviation of 15 percent.

Privately Owned Vehicles. Damages for automobiles were estimated based on the average number of vehicles per residence characteristic of the study area, and the probability of their being present at the time of a flood. An analysis was made of registered motor vehicles per occupied housing unit for counties within Metropolitan Statistical Areas (MSA) in Texas, using data from the U.S. Census and the Texas State Department of Highways and Public Transportation. The number of registered vehicles per occupied housing unit in MSA clusters around a mean value of 2.48. Given that not all registered motor vehicles are associated with private residences, and some housing units are unoccupied, an average of 2.0 vehicles per residence is assumed for this analysis. It is anticipated that 1.5 of these would be present during non-work hours (128 hours per week) and 0.5 present during work hours (40 hours per week). The expected number of vehicles present at any given time that a flood might occur would therefore be

$$((128/168)*1.5)+((40/168)\ 0.5$$

or 1.26 expected vehicles per residence.

Field observations suggest a positive correlation between the value of a residential structure and the value of the associated vehicle. However, the relationship is not proportional, since low-valued structures can be associated with vehicles worth as much as the structure itself. Likewise, the most affluent residence can be associated with a vehicle worth a tenth of the value of the structure. A plausible average value for a vehicle results by assuming the following relationship for detached single-family residences:

$$V = (0.15*S)+1000$$

where V is the vehicle value and S is the value of the residential structure. The typical residence, with a structure value in the range of $40,000 to $60,000, would have a vehicle worth $7,000 to $10,000. An exception to this general formula results with mobile homes due to the lower structure value relative to the economic status of the residents, (which is the basic determinant of the value of their personal property, including vehicles). The assumed relationship for mobile homes is

$$V = (0.2*S)+1000.$$

Flood Profiles and Probability of Flood Events. A range of without-project water surface profiles were developed. They include the 50-, 20-, 10-, 4-, 2-, 1-, 0.4-, and 0.2-percent annual chance exceedence (ACE) flood events (or the 2-, 5-, 10-, 25-, 50- 100-, 250- and 500-year flood, respectively). The profiles were used to delineate the flood plain (and damage) limits, and determined the relationship of damageable properties to both elevation and frequency of flood occurrence. As mentioned earlier, the computation of flood damages is based on the depth of flooding for various flood events and a relationship between the depth of flooding and the estimated damages based on a percentage of the structure and content, or vehicle value.

Flood Profile Stationing. The study adopts stations along the stream denoted, in this case, as feet above the mouth of the stream. Stationing is attached to structures by assigning the structure to the closest cross section.

Value of Flood Plain Inventory. The 0.2% ACE contains 491 structures with a total structures and contents value of $32,498,800. Residential structures make up 55 percent of the structures and 51 percent of the structure and contents value. Commercial structures make up 15 percent of the structures and 27 percent of the structure and contents value. Public structures make up three percent of the structures and 22 percent of the structure and contents value. Other residential structures make up 27 percent of the structures but less than one percent of structure and contents value.

The Upper reach has 72 structures; one commercial, 41 residential, and 30 other residential making up 15 percent of the structures and five percent of the structure and contents value in the 0.2% ACE. The average value for residential structures with contents is $36,900.

The Middle reach has 294 structures in the 0.2% ACE, consisting of 63 commercial, 12 public, 151 residential structures, and 68 other residential structures. These make up 60 percent of the structures and 75 percent of the structures and contents value in the 0.2% ACE. Average value for residential structures and contents is $62,700. Commercial structures average $127,600 with contents and public structures with contents average $564,300 in value.

The Lower reach has 125 structures; 10 commercial, two public, 80 residential, and 33 other residential making up 25 percent of the structures in the 0.2% ACE as well as 20 percent of the structure and contents value. Residential structures with contents average $68,300 with commercial structures with contents averaging $63,900.

Table 6 displays a summary of the number and value of flood plain properties. Table 7 displays a summary of the number and value of privately owned vehicles. Chart 1 graphically displays total investment values of the reaches.

Table 6

Number and Value of Flood Plain Properties
($000; August 2003 price level)

	50% ACE		20% ACE		10% ACE		4% ACE		2% ACE		1% ACE		0.4% ACE		0.2% ACE	
Upper	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
Commercial	0	0.0	1	88.5	1	88.5	1	88.5	1	88.5	1	88.5	1	88.5	1	88.5
Residential	2	67.8	26	797.5	28	857.3	32	1097.7	33	1141.3	35	1224.8	39	1385.0	41	1511.3
Other	10	18.0	24	25.9	25	26.3	28	27.8	28	27.8	30	28.9	30	28.9	30	28.9
Total	12	85.8	51	911.8	54	972.1	61	1214.0	62	1257.6	66	1342.2	70	1502.4	72	1628.7

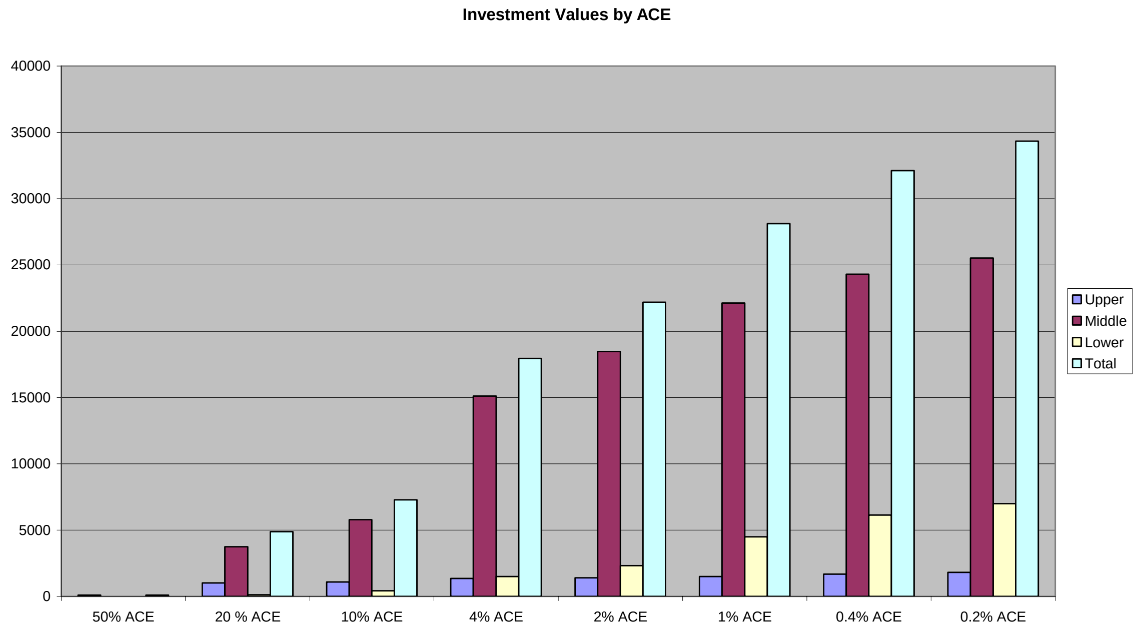
	50% ACE		20% ACE		10% ACE		4% ACE		2% ACE		1% ACE		0.4% ACE		0.2% ACE	
Middle	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
Commercial	0	0.0	13	1014.0	28	1668.7	49	7236.7	54	7463.8	59	7782.0	63	8037.6	63	8037.6
Public	0	0.0	0	0.0	0	0.0	4	2752.9	5	2833.8	7	5377.0	11	6718.6	12	6771.8
Residential	0	0.0	53	2326.7	83	3577.8	101	4476.4	110	7126.1	126	7840.2	135	8357.0	151	9461.5
Other	0	0.0	39	120.3	47	124.9	58	150.2	60	152.7	65	195.7	67	197.0	68	197.5
Total	0	0.0	105	3461.0	158	5371.4	212	14616.2	228	17576.4	257	21194.8	276	23310.2	294	24468.4

	50% ACE		20% ACE		10% ACE		4% ACE		2% ACE		1% ACE		0.4% ACE		0.2% ACE	
Lower	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
Commercial	0	0.0	1	9.1	1	9.1	2	56.1	3	56.6	10	638.8	10	638.8	10	638.8
Public	0	0.0	0	0.0	0	0.0	1	4.7	1	4.7	1	4.7	2	226.7	2	226.7
Residential	0	0.0	4	105.5	10	333.1	25	1306.3	36	2016.6	54	3483.2	72	4739.7	80	5465.7
Other	0	0.0	4	7.7	12	25.5	18	34.1	20	39.4	29	67.1	32	70.0	33	70.6
Total	0	0.0	9	122.3	23	367.7	46	1401.2	60	2117.3	94	4193.8	116	5675.1	125	6401.8
Grand Total	12	85.8	165	4495.1	235	6711.1	319	17231.4	350	20951.2	417	26730.8	462	30487.6	491	32498.8

Table 7
Number and Value of Privately Owned Vehicles
($000; August 2003 price level)

	50% ACE		20% ACE		10% ACE		4% ACE		2% ACE		1% ACE		0.4% ACE		0.2% ACE	
	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
Upper	1	3.9	21	94.4	24	113.7	29	137.4	31	145.4	34	157.8	38	178.6	40	187.8
Middle	0	0.0	53	284.1	76	413.7	91	493.2	111	889.0	121	941.3	128	992.6	136	1053.0
Lower	0	0.0	2	3.7	16	52.3	22	93.3	29	199.7	49	299.8	62	452.1	75	589.2
Total	1	3.9	76	382.1	116	579.7	142	723.8	171	1234.2	204	1398.9	228	1623.2	251	1830.0

Chart 1
Total Investment Value by ACE



Single Event Damages. Damages begin at the 50% ACE (2-yr event) in the Upper reach. At the 0.2% ACE (500-yr event) the study area experiences an estimated $7,900,700 in damages. The Upper reach contributes four percent to the damages, the Middle contributes 86 percent, and the Lower accounts for 11 percent of the damages.

Table 8 displays a summary of the number and value of single event flood plain damages. Table 9 displays a summary of the number and damage of privately owned vehicles. Chart 2 graphically displays total single event damages of the reaches.

Table 8
Single Event Damages by ACE, Reach, and Damage Category
Structures and Contents
($000; August 2003 price level)

	50% ACE		20% ACE		10% ACE		4% ACE		2% ACE		1% ACE		0.4% ACE		0.2% ACE	
Upper	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
Commercial	0	0.0	1	7.8	1	9.0	1	10.2	1	10.6	1	11.4	1	12.4	1	13.3
Residential	2	8.5	26	81.9	28	110.1	32	151.2	33	171.3	35	206.1	39	241.6	41	273.2
Other	10	0.7	24	2.1	25	2.5	28	3.1	28	3.4	30	3.9	30	4.4	30	4.7
Total	12	9.2	51	91.8	54	121.6	61	164.5	62	185.3	66	221.4	70	258.3	72	291.2

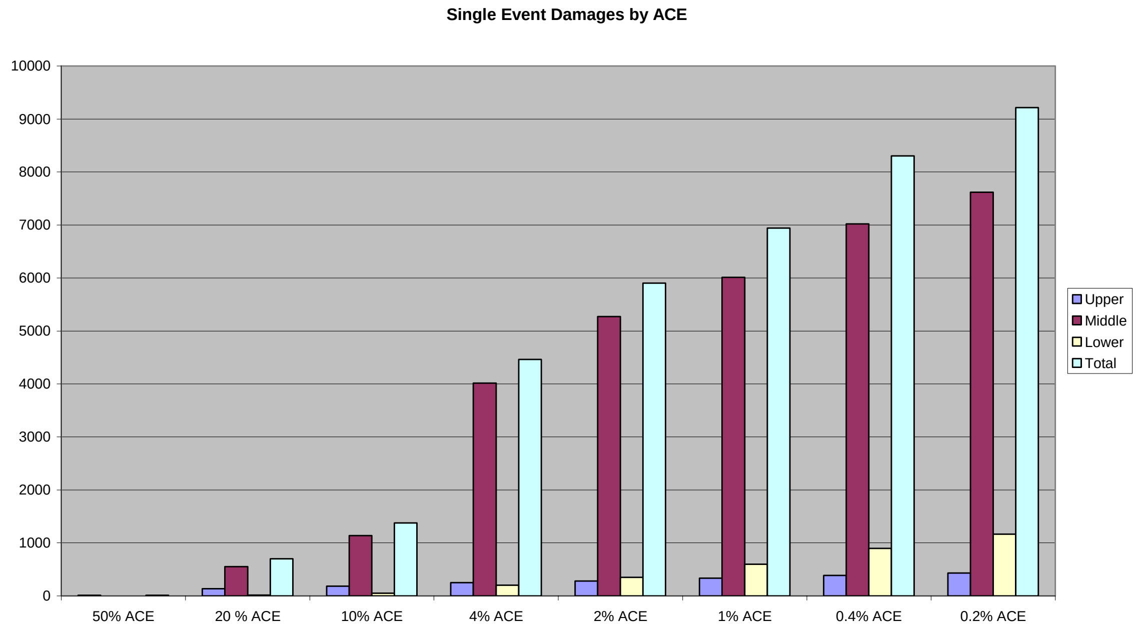
	50% ACE		20% ACE		10% ACE		4% ACE		2% ACE		1% ACE		0.4% ACE		0.2% ACE	
Middle	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
Commercial	0	0.0	13	187.6	28	483.2	49	2794.0	54	3270.8	59	3567.5	63	3864.4	63	3981.9
Public	0	0.0	0	0.0	0	0.0	4	252.3	4	393.5	7	501.6	11	833.6	12	1012.7
Residential	0	0.0	53	241.1	83	432.5	101	643.0	110	1061.4	126	1281.9	135	1533.2	151	1749.7
Other	0	0.0	39	8.3	47	11.3	58	14.6	60	17.3	65	22.0	67	24.9	68	27.6
Total	0	0.0	105	437.1	158	926.9	212	3703.9	228	4743.0	257	5372.9	276	6256.1	294	6772.0

	50% ACE		20% ACE		10% ACE		4% ACE		2% ACE		1% ACE		0.4% ACE		0.2% ACE	
Lower	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
Commercial	0	0.0	1	0.7	1	1.0	2	2.4	3	7.4	10	47.0	10	62.6	10	76.4
Public	0	0.0	0	0.0	0	0.0	1	0.1	1	0.5	1	0.9	2	6.4	2	17.1
Residential	0	0.0	4	13.5	10	34.3	25	154.1	36	252.6	54	391.0	72	578.7	80	736.9
Other	0	0.0	4	0.2	12	0.8	18	2.1	20	3.1	29	4.5	32	6.0	33	7.1
Total	0	0.0	9	14.5	23	36.1	46	158.7	60	263.6	94	443.3	116	653.8	125	837.4
Grand Total	12	9.2	165	543.3	235	1084.6	319	4027.0	350	5191.9	417	6037.7	462	7168.1	491	7900.7

Table 9
Single Event Damages by ACE and Reach
Privately Owned Vehicles
($000; August 2003 price level)

	50% ACE		20% ACE		10% ACE		4% ACE		2% ACE		1% ACE		0.4% ACE		0.2% ACE	
	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
Upper	1	1.2	21	45.6	24	62.1	29	83.6	31	95.3	34	111.0	38	127.9	40	141.4
Middle	0	0.0	53	113.2	76	211.5	91	310.6	111	528.7	121	639.6	128	766.2	136	846.8
Lower	0	0.0	2	0.8	16	16.3	22	40.8	29	87.2	49	152.9	62	241.7	75	326.9
Total	1	1.2	76	159.5	116	289.8	142	435.0	171	711.2	204	903.6	228	1135.7	251	1315.1

Chart 2
Single Event Damages by ACE

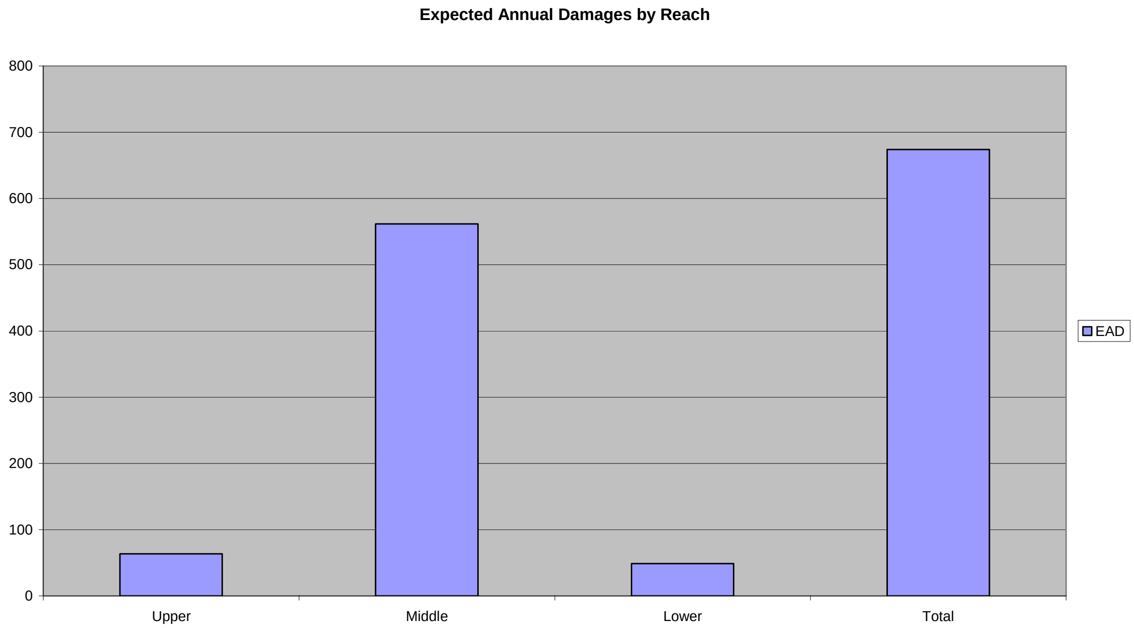


Expected Annual Damages. The expected annual damages for the area total $673,870. The Upper reach accounts for nine percent of the EAD. The Middle reach contributes 83 percent to EAD while the Lower reach contributes the remaining seven percent. Table 10 summarizes the annual expected flood damages. Chart 3 graphically displays total expected annual damages by reach.

Table 10
Expected Annual Flood Damages
($000; August 2003 price level; 5.375 percent @ 50-yr period of analysis)

	Structures and Contents				
	Residential	Commercial	Public	Vehicles	Total
Upper	40.48	3.36	0.00	19.68	63.52
Middle	152.95	301.69	41.10	65.97	561.71
Lower	34.93	2.32	0.34	11.05	48.64
Grand Total	228.36	307.37	41.44	96.70	673.87

Chart 3
Expected Annual Damages by Reach



WITH PROJECT FLOOD DAMAGES

Permanent Evacuation. Benefits and costs were developed for permanent evacuation of the 50-, 20-, 10-, and 4--percent ACE flood plain. Only residential structures were identified for a permanent evacuation. A number of commercial structures would remain in the floodplain – four within the 50-percent ACE flood plain, 40 within the 20-percent ACE flood plain, and 49 within the 10-percent ACE flood plain. Table 11 displays a summary of the single occurrence and average annual flood damages with permanent evacuation. Chart 4 displays the reduction in expected annual damages for the non-structural alternatives.

Table 11
With-Project Expected Annual Flood Damages
Permanent Evacuation
($000; August 2003 price level; 5.375% @ 50-yr period of analysis)

ACE	Without-Project Expected Annual Damages	Number of Structures Removed	With-Project Expected Annual Damages	Annual Damages Reduced
50%	673.9	6	663.3	10.6
20%	673.9	225	428.3	245.5
10%	673.9	299	395.0	278.8
4%	673.9	342	359.3	314.6

Chart 4
Permanent Evacuation Alternatives
Percent Reduction in Expected Annual Damages

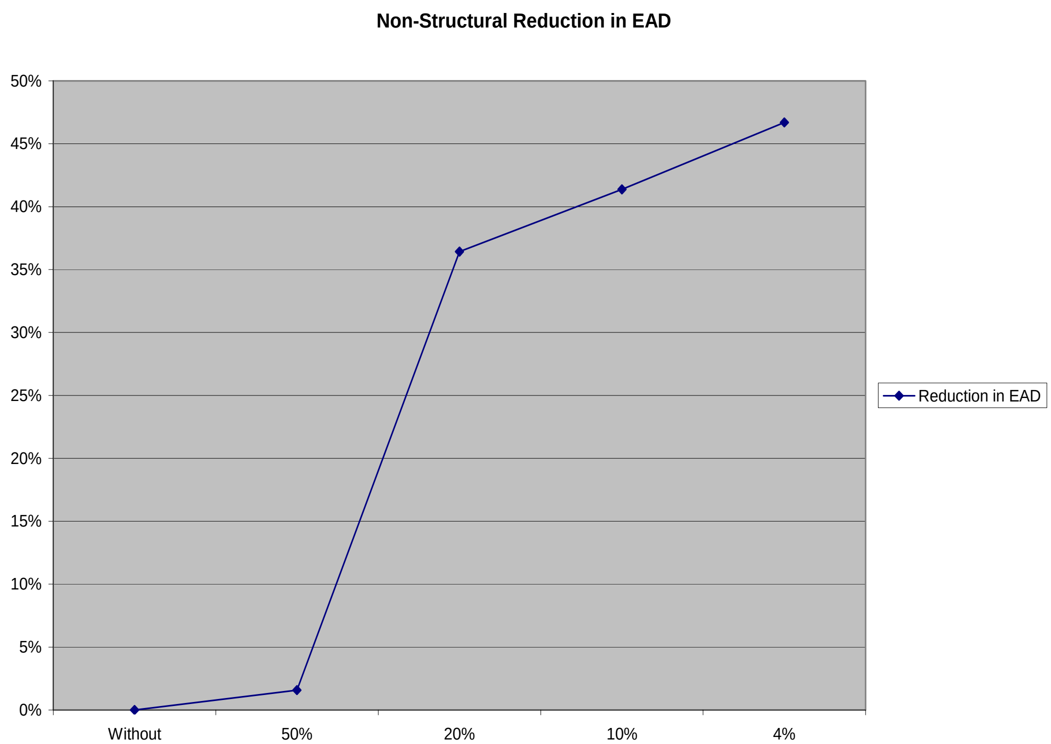


Table 12
Permanent Evacuation Benefit-Cost Summary
($000; August 2003 price level; 5.375% @ 50-yr period of analysis)

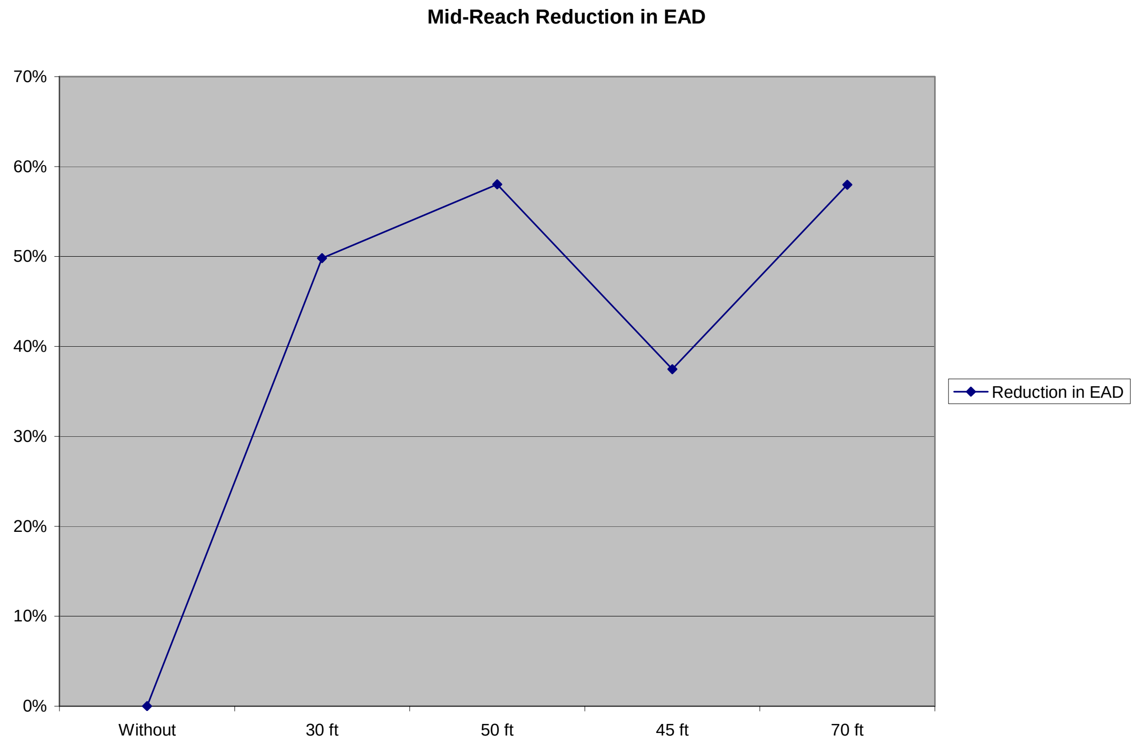
	Permanent Evacuation (ACE floodplain)			
	50%	20%	10%	4%
Investment Cost:				
Estimated First Cost	470.4	23,242.50	30,886.70	35,328.60
Interest During Construction	9.3	1,906.40	2,979.30	3,928.70
Total Investment Cost	**479.7**	**25,148.90**	**33,866.00**	**39,257.30**
Annual Cost:				
Interest	25.8	1,351.80	1,820.30	2,110.10
Amortization	2	106.4	143.3	166.1
Operations and Maintenance	5	15	20	25
Total Annual Cost	**32.6**	**1,473.20**	**1,983.60**	**2,301.20**
Total Annual Benefits	**10.6**	**245.6**	**327.7**	**314.6**
Benefit Cost Ratio	**0.32**	**0.17**	**0.17**	**0.14**
Net Benefits	**-22.2**	**-1,227.60**	**-1,655.90**	**-1,986.60**
Residual Damages	**663.3**	**428.3**	**395.0**	**359.3**

Pecan Creek and/or Bridge Modifications. Based on the location of the flood damage and hydraulic analyses, the initial channel modification investigation was located between from Broadway Street, extending 4,400-feet upstream to 600-feet upstream of Moss Street. A grass-lined channel with 1 vertical on 3.5 horizontal side slopes (1V:3.5H) with nominal bottom widths varying between 30- and 20-feet. A second grass-lined channel with 1V:3.5H side slopes had a nominal bottom widths varying between 65- and 50-feet. The third modification was a grass-lined channel with 1V:3.5H side slopes, and bottom width of 50-feet, except between Garnett and Moss Street where the channel was gabion-lined with 1V:1.5V side slopes with a bottom width of 45-feet. The fourth channel modification had an 80-foot bottom width for the grass-lined and 70-foot bottom width for the gabion-lined portion. Table 13 displays a summary of the average annual flood damages for without and with project conditions. Chart 5 displays the percentage reduction of each project scenario. Table 15 summarizes the benefit-cost ratios for the four channel alternatives.

Table 13
Channel Modification Alternatives
Moss Street to Broadway Street
Flood Damages
($000; August 2003 price level; 5-3/8 % @ 50-yr period of analysis)

Description	Without-Project Expected Annual Damages	With-Project Expected Annual Damages	Annual Damages Reduced
Grass-Lined Channel 30-/20-ft bottom width	673.9	338.2	335.6
Grass-Lined Channel 65-/50-ft bottom width	673.9	283.0	390.9
Grass- and Gabion-Lined Channel 50-/45-ft bottom width	673.9	421.4	252.5
Grass- and Gabion-Lined Channel 80-/70-ft bottom width	673.9	283.2	390.6

Chart 5
Channel Modification Alternatives
Moss Street to Broadway Street
Percent Reduction in Expected Annual Damages



As displayed in Chart 5, damages are reduced by 48 percent for the 30 foot channel, 55 percent for the 50 foot, 36 percent for the 45 foot grass and gabion channel, and 55 percent for the 70 foot grass and gabion channel.

Table 14
Moss Street to Broadway Street Channel Modifications
Benefit-Cost Summary
($000; August 2003 price level: 5.375 @ 50-yr period of analysis)

	Channel Modifications			
	From Moss Street to Broadway Street [1]			
	Grass Lined [2]	Grass Lined [3]	Grass & Gabion [4]	Grass & Gabion [5]
Investment Cost:				
Estimated First Cost	5,176.50	6,959.40	7,733.50	11,087.00
Interest During Construction	149.5	242.2	317.6	527.4
Total Investment Cost	**5,326.00**	**7,201.60**	**8,051.10**	**11,614.40**
Annual Cost:				
Interest	286.3	387.1	432.7	624.3
Amortization	22.5	30.5	34.1	49.1
Operations and Maintenance	15	25	25	30
Total Annual Cost	**323.8**	**442.6**	**491.8**	**703.4**
Total Annual Benefits	**335.7**	**390.9**	**252.5**	**390.7**
Benefit Cost Ratio	**1.04**	**0.88**	**0.51**	**0.56**
Net Benefits	**11.9**	**-51.6**	**-239.3**	**-312.7**
Residual Damages	**338.2**	**283**	**421.4**	**283.2**

[1] Station 205+00 (600-feet upstream of Moss Street) to 248+00 (Broadway Street)
[2] Bottom widths varying between 30- and 20-feet with 1V:3.5H side slopes
[3] Bottom widths varying between 65- and 50-feet with 1V:3.5H side slopes
[4] Grass-lined portion has bottom width of 50-feet with 1V:3.5H side slopes, gabion lining between Garnett and Moss Streets with 45-foot bottom width and 1V:1.5H side slopes
[5] Grass-lined portion has bottom width of 80-feet with 1V:3.5H side slopes, gabion lining between Garnett and Moss Streets with 70-foot bottom width and 1V:1.5H side slopes

A subsequent round of analyses examined three variations of grass-lined channels that would extend from US Highway 82 in the upper reach, down through the middle reach, and ending near Gordon Street in the lower reach. The channel bottom widths alternatives examined were 30 feet, 50 feet, and 65 feet. Table 15 displays with- and without project condition for the three channel alternatives and their respective reduction in expected annual damages. Chart 6 displays the percentage reduction of the three channel alternatives. Table 16 summarizes the benefit-cost ratios for the additional three channel alternatives. As displayed in Chart 6, damages are reduced by 86 percent for the 30 foot channel, 93 percent for the 50 foot, and 95 percent for the 65 foot grass-lined channel.

Table 15
Channel Modification Alternatives
Olive Street to Gordon Street
Flood Damages
($000; August 2003 price level; 5.375 % @ 50-yr period of analysis))

Description	Without-Project Expected Annual Damages	With-Project Expected Annual Damages	Annual Damages Reduced
Grass-Lined Channel 30 ft bottom width	673.9	90.1	583.8
Grass-Lined Channel 50 ft bottom width	673.9	42.6	631.3
Grass-Lined Channel 65 ft bottom width	673.9	28.9	645.0

Chart 6
Channel Modification Alternatives
Olive Street to Gordon Street
Percent Reduction in Expected Annual Damages

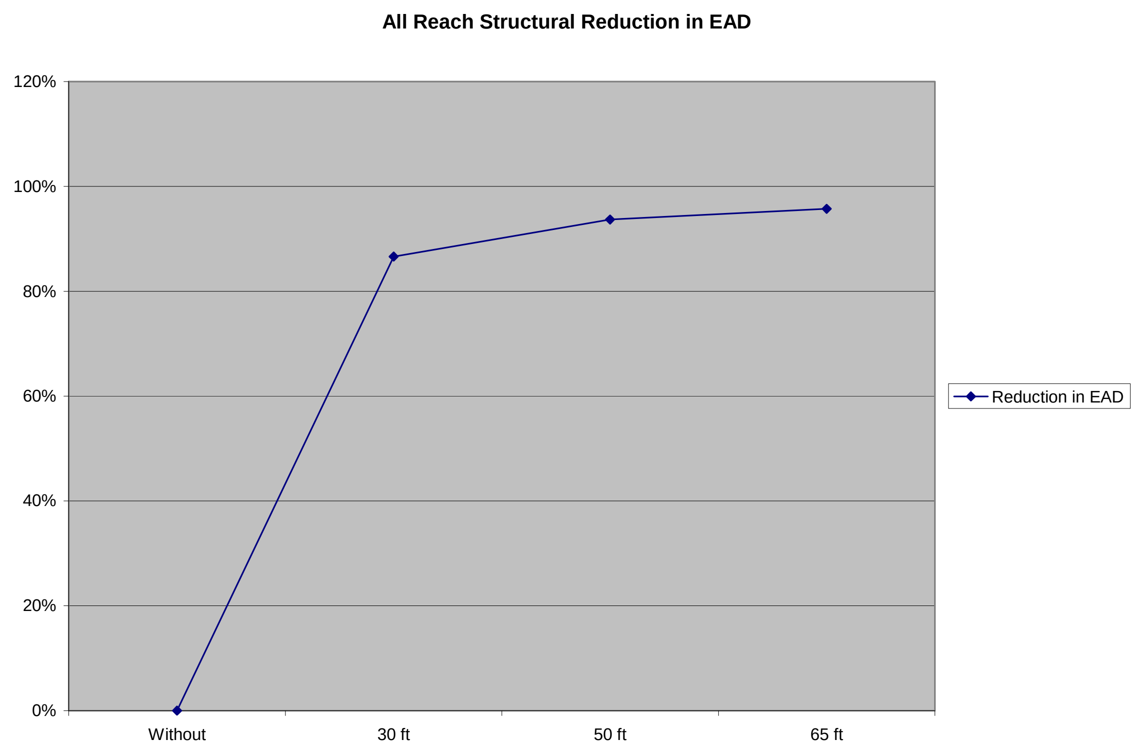


Table 16
Olive Street to Gordon Street Channel Modifications
Benefit-Cost Summary
($000; August 2003 price level: 5.375 % @ 50-yr period of analysis)

	Olive Street to Gordon Street		
	30-feet	50-feet	65-feet
Total Project Cost:			
Plans and Specifications [(1)]	599.4	787.8	1,051.70
Lands, Easements, Rights-of-Way, Relocations, and Disposal Areas	4,226.30	5,029.60	5,637.10
Construction	2,750.40	3,969.30	6,206.40
Supervision and Administration [(1)]	479.5	630.3	841.4
Total Project Cost	**8,055.60**	**10,417.00**	**13,736.60**
Investment Cost:			
Estimated First Cost	8,055.60	10,417.00	13,736.60
Interest During Construction	269.4	419.9	459.4
Total Investment Cost	**8,325.10**	**10,836.90**	**14,196.00**
Annual Cost:			
Interest	447.5	582.4	763
Amortization	35.2	45.8	60.1
Operations and Maintenance	20	20	20
Total Annual Cost	**502.7**	**648.3**	**843.1**
Total Annual Benefits	**583.8**	**631.3**	**645**
Benefit Cost Ratio	**1.16**	**0.97**	**0.77**
Net Benefits	**81.1**	**-17**	**-198.1**
Residual Damages	**90.1**	**42.6**	**28.9**

NATIONAL ECONOMIC DEVELOPMENT PLAN

The National Economic Development (NED) Plan is the plan that reasonably maximizes net benefits while protecting and preserving the environment. The NED plan is identified as the channel modification consisting of a grass-lined trapezoidal channel, beginning approximately 400-feet below Olive Street and continues downstream, ending just 360-feet below Gordon Street. The total project has an aggregate length of 7,800-feet, has a 30-foot bottom width, and 1 vertical on 3.5 horizontal side slopes. The recommended plan requires seven existing bridges replacement (Garnett, Main, Broadway, California, Scott and Belcher Streets, and a foot-bridge). Water, gas, electric, telephone, and sewer utility lines will be relocated.

RECOMMENDED PLAN

The NED plan is the recommended plan. A final economic evaluation of flood damages was completed to reflect changes in the depreciated value of structures and an accurate comparison with the recommended plan estimate total project cost. Both benefits and costs are expressed in July 2005 price levels. Table 17 displays a summary of the increase in single event damages. Table 18 displays a summary of the increase in expected annual damage. Table 19 displays the final benefit-cost ratio for the recommended plan.

Table 17
Single Event Flood Damages by ACE
($000; July 2005 price level)

	50% ACE	**20% ACE**	**10% ACE**	**4% ACE**	**2% ACE**	**1% ACE**	**0.4% ACE**	**0.2% ACE**
	Damage	Damage	Damage	Damage	Damage	Damage	Damage	Damage
August 2003	7.6	543.3	1115.1	4139.6	5191.9	6037.7	7168.1	7900.7
July 2005	10.4	604.6	1203.4	4409.1	5699.8	6637.9	7894.6	8713.8
% change	37.6%	11.3%	7.9%	6.5%	9.8%	9.9%	10.1%	10.3%

Table 18
Expected Annual Flood Damage
Recommended Plan
($000; July 2005 price level; 5.375% @ 50-year period of analysis)

	Structures and Contents				
	Residential	Commercial	Public	POV	Total
Upper	8.96	0.59	0.00	5.92	15.47
Middle	12.77	39.05	4.80	7.27	63.89
Lower	16.73	0.22	0.08	10.59	27.62
Grand Total	38.46	39.86	4.88	23.78	106.98

Table 19
Benefit-Cost Summary
Recommended Plan
(October 2005 price level; 5.125% @ 50-year period of analysis)

Annual Without Project Flood Damages	$ 783,300
Annual Residual Damages	$ 107,000
Annual Flood Damage Reduction Benefit	$ 676,300
Annual Disbenefit	$ (2,400)
Total Annual Flood Damage Reduction Benefit	$ 673,900
Total Implementation First Cost [1]	$ 8,219,400
Interest During Construction	$ 424,800
Total Investment Cost	$ 8,644,200
Interest	$ 443,300
Amortization	$ 39,700
Annual Cost	$ 482,700
OMRR&R	$ 20,000
Total Annual Cost	$ 502,700
Benefit Cost Ratio	1.3 to 1.0
Net Benefits	$ 171,200

(1) Does not include $105,000 in relocation assistance.