U.S. Army Corps of Engineers, Kansas City District

Final Feasibility Report

APPENDIX B

SOCIOECONOMIC ANALYSIS

Kansas Citys, Missouri and Kansas
Flood Risk Management Project
Final Feasibility Report

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Table of Contents

List of Tables

List of Acronyms and Abbreviations

AAD	Average Annual Damages
ACS	American Community Survey
AE	Architectural-engineering
AEP	Annual Exceedance Probability
BNSF	Burlington Northern & Santa Fe Railway Company
cfs	Cubic feet per second
CID	Central Industrial District
CSVR	Contents-to-structure value ratio
CWPM	Civil Works Policy Memorandum
DDF	Depth-Damage Function
EAB	Expected Annual Benefit
EAD	Expected Annual Damage
ER	Engineering Regulation
FEMA	Federal Emergency Management Agency
IWR	Institute for Water Resources
MSA	Metropolitan Statistical Area
msl	Mean sea level
NED	National Economic Development
OMRR&R	Operation, Maintenance, Repair, Rehabilitation, and Replacement
OSE	Other Social Effects
P&G	Principles and Guidelines
RED	Regional Economic Development
RM	River mile
UPRR	Union Pacific Railroad
USACE	United States Army Corps of Engineers

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1.0 Introduction

1.1 Federal Project Overview & Study Purpose

The Kansas Citys Flood Control Project was originally authorized by Section 5 of the Flood Control Act approved 22 June 1936, while subsequent modifications were authorized under Section 216 of the 1970 Flood Control Act. The system consists of seven separable units protecting much of the central industrial district of the Kansas City area. Protection of both public safety and property requires that the seven units function as an integrated and unified system during flood events.

The entire seven-levee system withstood the Missouri River Flood of 1993, but the general performance of the system was severely tested during the event. Not only were the stages extreme, but also durations were lengthy. Concerns arose about the level of protection against overtopping and seepage. Further, there was a concern that the levees may provide less than the authorized level of protection. In response to these concerns, a reconnaissance study was undertaken and completed in 2000, which produced recommendations supportive of further feasibility analysis.

The initial investigation of all seven units resulted in the identification of specific remedies and improvements that could be most readily analyzed and evaluated. In order to enable the feasibility study of the overall system to progress in an efficient manner, the study was separated into Phase 1 and Phase 2 efforts.

The Phase 1 study effort resulted in the Interim Feasibility Report (Interim Report), published in September 2006, which addressed four of the seven levee units: Argentine, North Kansas City, East Bottoms, and Fairfax-Jersey Creek. A fifth levee unit, the Birmingham unit, was determined to meet the authorized level of protection assuming continued adequate operations and maintenance efforts. Study of the two remaining units – CID and Armourdale – was deferred to a second phase. The Interim Report summarizing the Phase 1 analysis presented a series of recommendations that were subsequently authorized by the Water Resources Development Act of 2007.

The final Feasibility Report is the culmination of Phase 2 of the ongoing feasibility study. The study area of Phase 2 includes the Armourdale unit on the Kansas River at Kansas City, Kansas, and the Central Industrial District (CID) unit on the Kansas and Missouri Rivers at Kansas City, Kansas, and Kansas City, Missouri, along with all of their appurtenant features, including levees, floodwalls, pump stations, relief wells, closure structures, and berms. The Armourdale and CID units are two of three units comprising an integrated, interdependent flood risk reduction system on the Kansas River. The third unit in the Kansas River system is the Argentine unit, which was among the units evaluated in the Phase 1 interim report. In order to discuss the Kansas River units as a system, the present report will display certain data for the Argentine unit that was covered in greater detail in the Phase 1 interim report.

1.2 Study Guidance

Pertinent guidance governing economic analysis procedures includes:

- "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies" (P&G), dated March 1983;
- Engineering Regulation (ER) 1105-2-100, "Planning Guidance Notebook," dated 22 April 2000 (partially updated subsequently);
- Engineering Regulation (ER) 1105-2-101, "Risk-Based Analysis for Flood Damage Reduction Studies," dated 3 January 2006
- Engineer Manual (EM) 1110-2-1619, "Risk-Based Analysis for Flood Damage Reduction Studies," dated 1 August 1996.

1.3 Study Area Location

The Kansas Citys, Missouri and Kansas, Local Flood Protection Project consists of seven separate levee/floodwall units located along both banks of the Missouri and Kansas Rivers. The Phase 1 report evaluated the Argentine, Fairfax-Jersey Creek, North Kansas City, East Bottoms, and Birmingham units whereas the Phase 2 report will focus on the Armourdale and Central Industrial District units. The CID unit, located near the confluence of the Missouri and Kansas Rivers, can be impacted by both Missouri River flooding and Kansas River flooding. For purposes of this appendix, the total project study area will refer to all seven units while the Phase 2 study area will only refer to the Armourdale and CID reaches. Table 1 below lists the study reaches as well as their beginning and ending river mile.

Table 1: **Study Reaches**

Reach Name	Beginning Station	Ending Station	Bank
Phase 2 Units			
Kansas River:			
Armourdale	0.6	7.7	Left
CID-Kansas	0.0	3.0	Right
Missouri River:			
CID-Missouri	365.8	367.4	Right
Phase 1 Units			
Kansas River:			
Argentine	4.6	10.0	Right
Missouri River:			
Fairfax-Jersey Creek	367.5	373.9	Right
North Kansas City	362.6	370.7	Left
East Bottoms	356.6	366.0	Right
Birmingham	353.2	360.4	Left

1.4 Phase 2 Project Description

1.4.1 Armourdale Project Description

The Armourdale unit is located in Wyandotte County, Kansas, along the left bank of the Kansas River from river mile 7.0 to river mile 0.3, near the confluence of the Kansas and Missouri Rivers. The original levees and floodwalls were constructed under the jurisdiction of the Kaw Valley Drainage District (Kaw is a colloquial, regional name referring to the Kansas River) and then modified and expanded in the initial and follow-on Federal projects. The primary components of the unit consist of earthen levee, floodwalls, riprap and toe protection on riverward slope of levees, toe drains along the concrete floodwalls, sandbag gaps, stop log gaps, drainage structures, relief wells and pumping plants. Construction of the Federal project began in 1949 and was completed in 1951. More recent improvements, separately authorized under the 1962 modification, were completed in 1976. The levees and floodwalls of the Armourdale unit are currently authorized to pass a maximum Kansas River flow of 390,000 cfs coincident with a Missouri River flow of up to 220,000 cfs.

1.4.2 Central Industrial District (CID) Project Description

Although the CID unit is one levee unit, it is operated and managed as two separate and distinct sections: the CID-Kansas section, and the CID-Missouri section. The CID-Kansas section (CID-KS), is located in Wyandotte County, Kansas, and extends along the right bank of the Kansas River from mile 3.4 to the mouth, then downstream along the right bank of the Missouri River to the Missouri and Kansas State Line. The unit consists of levee sections and floodwalls, riprap and levee toe protection and a surfaced levee crown and ramps, a stop log gap, a sandbag gap, pumping plants, drainage structures, and relief wells. This section was originally developed by the Kaw Valley Drainage District, and initial Federal improvements entered construction in 1948. Most of the Federal improvements including repairs to levee unit damage from the 1951 flood were completed by 1955. The most recent improvements authorized under the 1962 modification were completed in 1979. The CID-KS section is authorized to pass a Kansas River discharge of 390,000 cfs coincident with a Missouri River flow of 220,000 cfs.

The CID-Missouri section (CID-MO) is located in Kansas City, Jackson County, Missouri. This section extends along the right bank of the Missouri River (river mile 365.7) to the Kansas-Missouri state line (river mile 367.2). The CID-MO section consists of levee, floodwalls, a levee drainage system and pumping plants, sandbag and stop log gaps, toe and bank protection, and slope protection on the riverward slope. The initial construction began in 1946. Significant improvements and repair of 1951 flood damage followed the initial construction and were completed in 1955. The CID-MO section is designed to pass a Missouri River flow of 540,000 cfs.

2.0 Socioeconomic Description

Census 2010 data and American Community Survey (ACS) 2007-2011 5-year estimates for 11 census tracts were compiled to describe the socioeconomic characteristics for both Phase 1 and Phase 2 levee units. Census and ACS data were also compiled for counties in the study area and for the Kansas City MO-KS Metropolitan Statistical Area (MSA). Although census tracts cover areas that may typically be somewhat larger than the area protected by a levee unit, the census tracts surveyed for the Kansas Citys units have similar alignments. Table 2 lists the census tracts that define the study area.

Population and housing units from the 2010 Census are available for census tracts and allow a fairly accurate accounting of study area population, as summarized in

Table 3. By this reckoning, the 2010 population of the Phase 2 study area was 4,654 and there were 1,887 households. The Phase 2 study reach with the larger population is Armourdale; however the Armourdale unit has suffered moderate decline over the last decade while the CID unit has experienced significant growth.

Table 4 and

Table 5 summarize a range of population characteristics from the 2010 Census for the Census tracts comprising the entire project area, whereas Table 6 describes the housing characteristics. If 2010 Census data were not available, American Community Survey 5-year estimates were used.

Table 2: **Census Areas Included In Study Area**

Phase 2 Units			
State	**County**	**Census Tract**	**Portions of Study Area Included**
Kansas	Wyandotte	425.01	Armourdale
Kansas	Wyandotte	425.02	Armourdale
Kansas	Wyandotte	426	Armourdale
Kansas	Wyandotte	400.02	CID
Missouri	Jackson	152	CID
Kansas	Wyandotte	430	CID (Turkey Creek)
Kansas	Wyandotte	452	CID (Turkey Creek)
Missouri	Jackson	46	CID (Turkey Creek)
Missouri	Jackson	153	CID (Turkey Creek)
Phase 1 Units			
State	**County**	**Census Tract**	**Portions of Study Area Included**
Kansas	Wyandotte	428	Argentine
Kansas	Wyandotte	438.04	Argentine
Kansas	Wyandotte	400.01	Fairfax-Jersey Creek
Missouri	Clay	221	North Kansas City
Missouri	Jackson	3	East Bottoms
Missouri	Jackson	155	East Bottoms

Table 3: **Study Area Population Trends**

Phase 2 Units	Armourdale	Central Industrial District	CID - Turkey Creek
2010 Population	2,924	1,730	8,626
2000 Population	3,212	936	10,002
% Change 2000-2010	-8.97%	84.83%	-13.76%
2010 Households	872	1,015	4,454
2000 Households	986	483	4,706
% Change 2000-2010	-11.56%	110.14%	-5.35%
Phase 1 Units	**Argentine**	**North Kansas City**	**East Bottoms**
2010 Population	3,345	4,283	2,808
2000 Population	3,480	4,883	3,276
% Change 2000-2010	-3.88%	-12.29%	-14.29%
2010 Households	1,258	2,416	1,178
2000 Households	1,282	2,669	1,282
% Change 2000-2010	-1.87%	-9.48%	-8.11%

*After the Phase 1 report, it was determined that a portion of the Turkey Creek floodplain needed to be added to capture the potential effects of river flows escaping the CID unit.

Table 4: **Selected Population Characteristics**

Phase 2 Units	Armourdale	Central Industrial District	CID - Turkey Creek
Population	2,924	1,730	9,712
Median Age	13.5 to 51.5	30.5 to 51.5	30.4 to 43.0
% 18 and under	33.1%	4.8%	47.4%
% 65 and above	7.8%	1.0%	8.5%
Racial Distribution			
% White	58.3%	77.2%	62.8%
% Black or African American	2.4%	15.4%	14.2%
% American Indian and Alaska Natvie	2.1%	0.5%	0.9%
% Asian	1.4%	1.9%	2.6%
% Native Hawaiian and Other Pacific Islander	0.0%	0.1%	0.1%
% Some Other Race	32.4%	2.0%	15.3%
% Multi Race	3.4%	2.9%	4.1%
% Hispanic	64.7%	4.9%	36.1%
Education Levels			
% High School Grads (age 25+)	57.9%	90.8%	80.2%
% College Grads (age 25+)	4.9%	50.1%	30.4%
Phase 1 Units	**Argentine**	**North Kansas City**	**East Bottoms**
Population	3,345	4,283	2,808
Median Age	29.6 to 30.5	40.3	31.2 to 36.8
% 18 and under	33.7%	15.5%	28.1%
% 65 and above	13.4%	16.5%	11.4%
Racial Distribution			
% White	55.4%	76.4%	58.7%
% Black or African American	17.8%	11.1%	17.8%
% American Indian and Alaska Natvie	1.1%	0.8%	0.8%
% Asian	1.4%	3.3%	8.0%
% Native Hawaiian and Other Pacific Islander	0.0%	0.3%	0.3%
% Some Other Race	18.1%	4.6%	10.6%
% Multi Race	6.1%	3.4%	3.8%
% Hispanic	45.6%	11.4%	20.8%
Education Levels			
% High School Grads (age 25+)	68.9%	87.6%	71.9%
% College Grads (age 25+)	10.6%	23.0%	14.3%

Table 5: **Study Area Unemployment, Poverty, and Personal Income**

Phase 2 Units	Armourdale	Central Industrial District	CID - Turkey Creek
Median Household Income	$32,559	$41,118	$32,974 to $50,121
Unemployment Rate	12.4%	7.1%	10.1%
Per Capita Income	$12,614	$37,689	$26,048
% of Individuals Living Below Poverty Level	29.9%	17.4%	25.2%
Phase 1 Units	**Argentine**	**North Kansas City**	**East Bottoms**
Median Household Income	$31,742	$42,886	$25,389 to $29,718
Unemployment Rate	19.8%	8.2%	13.3%
Per Capita Income	$15,472	$29,193	$15,310
% of Individuals Living Below Poverty Level	32.5%	6.6%	46.5%

Table 6: **Housing Characteristics for Study Area**

Phase 2 Units	Armourdale	Central Industrial District	CID - Turkey Creek
Total Housing Units	1,025	1,110	5,091
% Occupied	85.1%	91.4%	87.5%
% Vacant	14.9%	8.6%	12.5%
% Owner Occupied	57.0%	18.3%	43.3%
% Renter Occupied	43.0%	81.7%	56.7%
% Built 1939 or earlier	29.6%	58.8%	49.7%
% Moved in 2004 or earlier	42.8%	89.0%	52.6%
Average Household Size	3.28	1.41	2.11
Median Value of Owner-Occupied Housing	$47,600	$233,200	$81,000 to $200,500
Phase 1 Units	**Argentine**	**North Kansas City**	**East Bottoms**
Total Housing Units	1,373	2,744	1,467
% Occupied	91.6%	88.0%	85.8%
% Vacant	8.4%	12.0%	21.0%
% Owner Occupied	37.0%	26.7%	38.5%
% Renter Occupied	13.9%	73.3%	61.5%
% Built 1939 or earlier	14.7%	18.3%	57.0%
% Moved in 2004 or earlier	35.2%	66.7%	46.9%
Average Household Size	2.81	1.86	2.27
Median Value of Owner-Occupied Housing	$85,600 to $137,500	$119,000	$41,300 to $156,900

2.1 Armourdale Unit

2.1.1 Armourdale Land Use and Location

The Armourdale unit is located on the left bank of the Kansas River in Wyandotte County, Kansas and is encompassed by census tracts 425.01, 425.02, and 426, with a land area of 3.8 square miles. This unit protects the Armourdale area of Kansas City, Kansas, an area of mixed residential, commercial, industrial and public development There are several very large, complex manufacturing and commercial facilities (e.g., Proctor and Gamble, Colgate Palmolive), a power plant facility (Kansas City, Kansas Board of Public Utilities Kaw Power Station/Municipal Plant) and the Kansas City Southern and Union Pacific rail yards and main line tracks located in the study area. There are many small retail and commercial businesses typically found in and around residential neighborhoods, and more than 900 residential units in the area.

2.1.2 Armourdale Population, Income and Employment Characteristics

Population in the Armourdale unit decreased from 3,213 in 2000 to 2,924 in 2010 (a 9.9 percent decrease). Compared to Wyandotte County and Kansas City metropolitan residents in general, Armourdale residents on average are slightly younger and less educated. The median age for residents in the census tracts is 28.7. Only 52.1 percent of residents above the age of 25 are high school graduates. High school graduation rates for Wyandotte County and the Kansas City MSA are 78.6 percent and 90.0 percent respectively. Almost 65 percent of Armourdale residents classify themselves as Hispanic or Latino, which is significantly higher than the city (8.2 percent) and county (26.4 percent) percentages.

The median household income for Armourdale households in 2010 was $32,813, much lower than Wyandotte County ($38,503) and the Kansas City MSA ($55,749) households. Moreover, 34 percent of residents find themselves living below the poverty level with a per capita income of $11,261.

2.1.3 Armourdale Housing Characteristics

The 1,025 housing units in the Armourdale unit had a vacancy rate of 15 percent, higher than the 12.5 percent vacancy rate for Wyandotte County and the 9.5 percent rate for the Kansas City MSA. The median value of owner-occupied housing units in 2010 was $40,700 compared with a median value of $97,600 for Wyandotte County and $158,000 for the Kansas City MSA. More than 33 percent of the housing units in the Armourdale Levee unit were built before 1940 versus 20.8 percent for Wyandotte County and 13.1 percent for the Kansas City MSA.

2.2 Central Industrial District Unit

2.2.1 CID Land Use and Location

The Central Industrial District unit is located on the right banks of the Missouri and Kansas Rivers near their confluence. The protected area lies on both sides of the state line between Missouri and Kansas, and includes most of the central industrial districts of both the City of Kansas City, Missouri (Jackson County portion) and the City of Kansas City, Kansas in Wyandotte County. The area encompasses census tracts 152 (Missouri) and 400.02 (Kansas), with a total land area of 1.8 square miles.

The CID contains commercial, industrial, and public type development. This is an older, historical area, that was devastated during the 1951 flood, but that has been experiencing recent development, revitalization, and renovation of existing commercial and industrial properties. There has also been high interest in recent years in developing and using some of the large older commercial/industrial buildings as residential loft space. The higher value investment is in two convention centers/entertainment venues (American Royal Building and Kemper Arena), some large warehouse facilities, several industrial sites, a few large commercial businesses, and public works facilities. The area is also the home to the world headquarters of Butler Manufacturing.

2.2.2 CID Population, Income, and Employment Characteristics

In 2010, the Central Industrial District had a population of 1,730 representing a noteworthy increase (84.8 percent) over the 2000 population of 936. CID residents appear to be slightly younger and more educated than Kansas City MSA, Wyandotte County, and Jackson County residents with a median age of 28.7 and high school graduation rate of 93.5 percent. The predominately white racial distribution of the population (77.2 percent) is similar to that of the Kansas City MSA (78.4 percent) but higher than percentages for Wyandotte County (54.6 percent) and Jackson County (66.9 percent).

The unemployment rate (6.3 percent) for CID residents is slightly lower than comparable county and city rates, while the percentage of individuals living below poverty level (11.8 percent) is analogous to the Jackson County (11.9 percent) and Kansas City MSA (11.1 percent) rates. However, the per capita income of $36,707 for area residents compares favorably to both county and city levels.

2.2.3 CID Housing Characteristics

The average owner-occupied home value of $227,400 is considerably higher than the average values for Wyandotte County, Jackson County, and the Kansas City MSA and the percentage of renter-occupied units in the area (81.7 percent) is also significantly higher than all comparable levels. These numbers are primarily due to the recent influx of new apartment and loft development in the CID area, which coincides with the appreciably lower percentages of residents living in the same unit as five years prior and smaller average household size.

2.3 Study Area Economy and Access

The Kansas City metropolitan area has a diverse and varied economic base. As a centrally located market, it is a major warehouse and distribution center and a leading agribusiness center. It ranks first in the nation as a farm distribution center and as a market for hard wheat. In addition to its agribusiness activities, the metropolitan area has major industrial activities such as auto and truck assembly, steel and metal fabrication, envelope and greeting card production, and food processing. The metropolitan area also fosters a growing non-manufacturing sector. Wholesale and retail industries and service organizations are now chief employers in the area.

The metropolitan area has a major network of interstates and major highways that provides excellent access to each of the levee units. The CID unit is accessed by means of Interstate 70 on the north, by Interstate 35 on the West, and by Interstate 670, which crosses the center portion of the protected area. U.S. Highway 69 and Interstate 35 provide access to the Argentine unit, and U.S. 69, U.S. 169, and

Interstate 70 serve the Armourdale unit. Interstate 70 and the Fairfax Bridge/U.S. 69 provide major highway access to the Fairfax-Jersey Creek unit. Missouri Highway 210, Burlington Avenue, the Bond and Heart of America Bridges, and Interstates 35 and 435 provide access to the North Kansas City unit. The East Bottoms unit is served by Interstates 29, 35, and 435, and the Birmingham unit has ready access by means of Missouri Highway 210 and Interstates 29, 35 and 435. Kansas City International Airport, less than 20 miles north of the study area, is easily accessible via the interstate system. Major rail service is available to each of the units, and the Charles B. Wheeler (Downtown) Airport is located in the North Kansas City unit. The Greater Kansas City Area is generally considered to be the nation's second largest rail center, second only to Chicago. The trunk lines serving Kansas City have main line tracks in the areas protected by the Kansas City Levees. Greater Kansas City is also among the top five trucking centers in the nation.

Table 7 summarizes the study area's industrial structure according to the percentage employed in each industry. The figures below are based on 2007-2011 American Community Survey 5-Year Estimates.

Table 7: **Study Area Employment by Industry**

Workers By Industry	Armourdale	Central Industrial District	CID - Turkey Creek	Argentine	North Kansas City	East Bottoms	% of Study Area
Civilian Employed Population (Age 16+)	1,090	1,086	5,480	1,167	2,463	1,221	12,507
Agriculture, forestry, fishing and hunting, and mining	16	0	9	19	14	0	0.5%
Construction	194	19	503	44	92	78	7.4%
Manufacturing	198	168	558	201	264	198	12.7%
Wholesale trade	19	25	95	70	214	75	4.0%
Retail trade	82	107	553	99	188	93	9.0%
Transportation and warehousing, and utilities	69	60	194	58	69	54	4.0%
Information	0	113	216	0	62	18	3.3%
Finance and insurance, and real estate and rental and leasing	17	106	421	50	202	42	6.7%
Professional, scientific, management, and administrative	136	182	812	113	273	182	13.6%
Educational services, and health care, and social assistance	129	183	953	308	536	182	18.3%
Arts, entertainment, and recreation, and accommodation, and food services	69	86	745	81	410	181	12.6%
Other services, except public administration	147	29	286	32	81	118	5.5%
Public administration	14	8	135	92	58	0	2.5%

2.4 Study Area Investment

Table 8 below shows a summary of study area investment as reported in the Phase 1 Interim Feasibility Report. The price level for the report was October 2004. Table 9 provides the study area investment totals in current dollars based on the most recent survey data for the Phase 2 units and updating the Phase 1 units to the October 2012 price level.

As indicated above in relation to Table 3, after the Phase 1 report was completed, it was determined that the area in the Turkey Creek floodplain along Southwest Boulevard needed to be added to the CID unit to capture the potential effects of river flows escaping the CID unit. The totals for this area that was not considered during Phase 1 are broken out from the remainder of the CID in Table 10.

In accordance with Section 308 of the Water Resources Development Act of 1990, the structure inventory reflected in Tables 8 through 10 includes no structures located within the 1 percent flood plain, with first-floor elevations below the 1 percent flood event that have been built new or have been substantially improved since 1999. Such structures also are not included in the benefits prepared for this economic analysis.

Table 8**: Interim Feasibility Report Investment**

October 2004 prices ($ Million)

Levee Unit	Number of Structures	Structure/ Infrastructure Investment	Cotents/Other Investment	Levee Unit Totals
Argentine	723	$ 588.0	$ 1,898.0	$ 2,486.0
Armourdale	**1,349**	**$ 628.0**	**$ 1,555.0**	**$ 2,182.0**
CID	**287**	**$ 386.0**	**$ 377.0**	**$ 763.0**
Fairfax-Jersey Creek	348	$ 656.0	$ 2,303.0	$ 2,960.0
North Kansas City	1,658	$ 1,438.0	$ 1,519.0	$ 2,957.0
East Bottoms	751	$ 1,438.0	$ 2,981.0	$ 4,561.0
Birmingham	209	$ 1,580.0	$ 126.0	$ 386.0
Study Area Totals	**5,325**	**$ 6,714.0**	**$ 10,759.0**	**$ 16,295.0**

Table 9**: 2012 Updated Investment**

October 2012 prices ($ Million)

Levee Unit	Number of Structures	Structure/ Infrastructure Investment	Cotents/Other Investment	Levee Unit Totals
Argentine	723	$ 775.3	$ 2,277.8	$ 3,053.1
Armourdale	**1,468**	**$ 1,241.4**	**$ 1,320.5**	**$ 2,561.9**
CID	**526**	**$ 1,067.7**	**$ 1,747.8**	**$ 2,815.5**
Fairfax-Jersey Creek	348	$ 864.9	$ 2,763.8	$ 3,628.8
North Kansas City	1,658	$ 1,896.0	$ 1,823.0	$ 3,719.0
East Bottoms	751	$ 2,083.2	$ 3,577.5	$ 5,660.7
Birmingham	209	$ 342.8	$ 151.2	$ 494.0
Study Area Totals	**5,683**	**$ 8,271.3**	**$ 13,661.6**	**$ 21,933.0**

The Phase 2 study area collectively protects property with an estimated value of $5.38 billion (October 2012 prices), as summarized in Table 10. This total includes 951 residential structures and 1,043 businesses and public facilities as well as 279 miles of streets and railroads that would be subject to flood damage.

Table 10**: Phase 2 Study Area Investment**

October 2012 prices ($1,000s)

	Armourdale	**Central Industrial District**	**CID - Turkey Creek**	**Phase 2 Total**
Non-Residential (businesses and public facilities)				
Quantity	538	341	164	**1,043**
Structures	$ 388,508.4	$ 547,169.7	$ 202,020.1	$ 1,137,698.2
Contents	$ 1,260,810.4	$ 1,431,042.6	$ 307,821.9	$ 2,999,674.9
Other	$ 22,700.5	$ 3,304.9	$ 0.7	$ 26,006.1
Total Value	**$ 1,672,019.3**	**$ 1,981,517.2**	**$ 509,842.7**	**$ 4,163,379.2**
Residential				
Quantity	930	0	21	**951**
Structures	$ 52,882.1	$ -	$ 8,824.7	$ 61,706.8
Contents	$ 26,396.9	$ -	$ 3,886.1	$ 30,283.0
Other	$ 10,576.4	$ -	$ 1,764.9	$ 12,341.4
Total Value	**$ 89,855.4**	**$ -**	**$ 14,475.7**	**$ 104,331.1**
Roads & Streets (railroads, highways, city streets)				
Miles	167.0	73.4	39.0	**279.4**
Total Value	$ 799,978.9	$ 243,507.6	$ 66,147.1	$ 1,109,633.6
Total Value	**$ 2,561,853.6**	**$ 2,225,024.8**	**$ 590,465.5**	**$ 5,377,343.9**

3.0 Phase 1 Economic Justification Update

3.1 Purpose and Scope of Update

Although the Phase 1 units are not the subject of the present report, we are presenting updated investment figures for these units so that they will be on the same basis as the Phase 2 units discussed in this report.

The last approved economic justification data of record for the Kansas Citys Levees project is the FY12 NWK Economic Update covering the Phase 1 units. This update was approved by CENWD in July 2012. The economic update was a Level 1 update under the current methodology for updating benefit-to-cost ratios for budget development guidance. A Level 1 update is a reaffirmation that the last approved set of published benefits, in this case the 2006 Chief's Report for the Phase 1 units, remains valid based on primarily qualitative analysis. There were no significant changes in Phase 1 assumptions concerning economic development, hydrologic/hydraulic, structural and geotechnical engineering parameters, NEPA requirements, or plan formulation. An updated cost estimate was prepared for the update and used in the benefit-cost analysis.

For the update, a field survey was completed by NWK staff in July-August 2011 noting changes in the property base throughout the study area since the feasibility study. Specifically, we noted (1) changes in occupancy for existing structures; (2) obvious changes in activity level at existing businesses; (3) changes in the type of land use; and (4) new construction. The windshield survey was supplemented by additional research on the internet concerning occupancy. In general, relatively few changes in the economic property base had occurred in the Kansas Citys Levees area since publication of the Chief's Report. None of the developments that had occurred would materially alter the assumptions that framed and supported the 2006 economic analysis. Thus, there was no compelling reason to change the estimate of annual benefits.

3.2 Phase 1 Project Benefits and Costs

3.2.1 Phase 1 Project Benefits as of 2012

Since there was no compelling reason to change the estimate of annual benefits, the previously reported benefits total of $41,336,400, reflecting a 7 percent interest rate, was maintained. At the current Federal water resources interest rate of 3.75 percent, the benefits total $41,444,700 using the same data as shown in

Table 11. These totals reflect the October 2005 price level used in the feasibility report.

3.2.2 Phase 1 Project Costs as of 2012

The current estimate of total Phase 1 project costs, in October 2012 prices, is $96,697,900. This total represents an increase of 21.7 percent over the total of $79,431,000 in the approved Chief's Report. Using CWCCIS (31 March 2012 version) index numbers from the composite account for October 2005 and October 2012, the price level increase is 23.8 percent. Thus, the Phase 1 project cost changes are generally nominal rather than real cost adjustments. Note that the first costs have been deflated to October 2005 prices so that the annual costs will be on an equivalent basis to the annual benefits.

Downward adjustments in costs to North Kansas City were the result of the need for fewer relief wells than originally proposed. An existing pump station, eliminating the need to construct a new pump station, can handle the resulting lower well flows resulting in significant cost savings. In all, the total first costs have dropped from $8.2 million to $5.5 million.

First costs for the Argentine unit have not increased more than those for the overall project, but assumptions for interest during construction and annual cost savings have changed. It is now recognized that work on the Argentine unit cannot begin until after completion of Phase II work on the CID and Armourdale units. Project completion for the Argentine unit has therefore been pushed out to 2026, with a significant increase in interest during construction. This has increased Argentine's total first costs from $52.9 million to $63.3 million.

For the Fairfax-Jersey Creek unit, the estimate for addressing the structural/geotechnical issues identified has increased. It should be noted, however, that this portion of the current cost estimate is in progress and is at a more preliminary level than the rest of the total project estimate. As it currently stands, the total first costs have risen from $16.7 million to $25.2 million.

3.2.3 Phase 1 Benefit-Cost Ratio

At the current FY 2013 Federal interest rate of 3.75 percent, the benefit-cost ratio for the Phase 1 project is 9.5, as shown in

Table 11, with net annual benefits of $37,076,400. In the approved Chief's Report, the ratio for the then-current interest rate of 5.125 percent was 8.0. The drop in interest rates since then has resulted in a higher benefit-cost ratio at the current rate.

At 7 percent, the benefit-cost ratio in the Chief's Report was 6.0, while the 7 percent benefit cost-ratio is 5.4 in this update. Since benefits are unchanged, the growth in annual costs has accounted for the drop in the benefit-cost ratio, which nevertheless remains strong. Net benefits total $33,724,000.

It should be emphasized, once more, that the discussion provided here in section 3 is primarily in reference to the economic survey and analysis supporting the previously completed study and authorized project for Phase 1, as well as the economic update of the Phase 1 project approved in 2012, and the newly-added inventory for the Turkey Creek portion of the CID unit. The primary relevance of this discussion to the Phase 2 units is to portray the surveyed investment for all portions of the Kansas Citys project (both Phase 1 and 2) on an equivalent price level basis.

Table 11: **Phase 1 Economic Justification**

October 2005 prices (First Costs October 2012); $1,000's				
	Interest Rate = 3.75%		**Interest Rate = 7%**	
	Total	Remaining	Total	Remaining
Argentine				
First Costs	$ 63,293.7	$ 63,293.7	$ 63,293.7	$ 63,293.7
Annual Benefits	$ 18,177.6	$ 18,177.6	$ 18,148.8	$ 18,148.8
Annual Costs	$ 3,066.2	$ 3,066.2	$ 5,483.1	$ 5,483.1
Benefit-Cost Ratio	5.9	5.6	3.3	3.3
Net Benefits	$ 15,111.4	$ 14,957.3	$ 12,665.7	$ 12,665.7
Fairfax-Jersey Creek				
First Costs	$ 25,228.8	$ 18,761.6	$ 25,228.8	$ 18,761.6
Annual Benefits	$ 12,023.6	$ 12,023.6	$ 11,991.0	$ 11,991.0
Annual Costs	$ 960.0	$ 725.7	$ 1,616.7	$ 1,235.8
Benefit-Cost Ratio	12.5	16.6	7.4	9.7
Net Benefits	$ 11,063.6	$ 11,297.9	$ 10,374.3	$ 10,755.2
East Bottoms				
First Costs	$ 2,001.1	$ 1,786.6	$ 2,001.1	$ 1,786.6
Annual Benefits	$ 4,363.2	$ 4,363.2	$ 4,344.2	$ 4,344.2
Annual Costs	$ 104.0	$ 96.3	$ 153.8	$ 141.2
Benefit-Cost Ratio	41.9	45.3	28.2	30.8
Net Benefits	$ 4,259.2	$ 4,266.9	$ 4,190.4	$ 4,203.0
North Kansas City				
First Costs	$ 5,544.2	$ 2,793.5	$ 5,544.2	$ 2,793.5
Annual Benefits	$ 6,880.3	$ 6,880.3	$ 6,852.4	$ 6,852.4
Annual Costs	$ 238.1	$ 138.4	$ 358.6	$ 196.6
Benefit-Cost Ratio	28.9	49.7	19.1	34.9
Net Benefits	$ 6,642.2	$ 6,741.9	$ 6,493.8	$ 6,655.8
Phase 1 Project Total				
First Costs	$ 96,697.9	$ 87,265.4	$ 96,697.9	$ 87,265.4
Annual Benefits	$ 41,444.7	$ 41,444.7	$ 41,336.4	$ 41,336.4
Annual Costs	$ 4,368.3	$ 4,026.6	$ 7,612.4	$ 7,056.8
Benefit-Cost Ratio	9.5	10.3	5.4	5.9
Net Benefits	$ 37,076.4	$ 37,418.1	$ 33,724.0	$ 34,279.6

4.0 Previous Flood Events

4.1 Pre-1929 Flooding

Floods in the Missouri and Kansas River Basin carry great quantities of silt and debris, and are of comparatively low velocity and of several days duration. Flow data at the USGS gauge on the Hannibal Bridge in Kansas City is available for the period 1929 to present. Before 1929 the major flood events in the Kansas Citys area occurred in 1844 (believed to have been approximately 17.0 feet above flood stage), 1881 (6.8 feet above), 1903 (14.0 feet above), and 1908 (9.3 feet above). Although the 1844 event is considered the greatest known event in the lower Missouri Basin, there was little development in the area. However, the wharves at nearby Independence, Missouri were destroyed, and Westport Landing (early downtown Kansas City area) thus gained most of the Santa Fe Trail trade. In the 1903 flood, 19 lives were lost in the Kansas Citys area, and an estimated $23,000,000 in property damages (1903 prices) was sustained. The flood of 1903 had an estimated discharge of 543,000 cubic feet per second (cfs).

4.2 The 1951 Flood

The 1951 flood, with a Missouri River discharge of 573,000 cfs, and 469,000 cfs on the Kansas River, exceeded the other previous events except for the flood of 1844. A two-month period of above-normal precipitation followed by unprecedented intense rains over a 72-hour period in early July caused the flooding. In the early morning hours of Friday, July 13, 1951, the Kansas River poured over the dikes in the Argentine District and about 2,000 residents fled to nearby bluffs. Early that morning, too, after more than 9,100 people were evacuated from the Armourdale district, water began to overtop a 4-mile stretch of the levee and inundated the Armourdale area with depths of 15 to 30 feet. On Kansas Avenue, the floodwater was reported to be “waist-high on top of a two story building”. About 400-800 people who had decided to stay had to be rescued by boats, out of trees, and from ledges and rooftops. Intense sandbagging efforts to save the West Bottoms failed and later that morning, the Central Industrial District was flooded. In the East and West Bottoms areas, manufacturing and wholesale districts, railroad yards and the Kansas City stockyards were devastated. Packing plants were flooded, and the floodwaters swept away thousands of hogs and cattle. Railroad transportation was halted due to the flooding with severe damage to tracks, rail cars, and rail yards. The American Royal building was inundated by 15 feet of water. Only two highway bridges remained in operation in the area, and runaway barges were a threat to these remaining bridges.

The flood threat moved on to the Municipal Airport (now the Charles B. Wheeler (Downtown) Airport), the Fairfax District and North Kansas City by Friday night. Planes were evacuated, and about 4,000 North Kansas City residents were ordered to evacuate. Although work to support the dike using bulldozers and trucks continued through the night, the Jersey Creek dike collapsed early on Saturday July 15, and water poured into the Fairfax District. In an effort to protect the downtown airport and Municipal Air terminal, junked cars were dumped onto levees. Of the five industrial districts, only North Kansas City was completely saved (the Municipal Air Terminal escaped the worst of the damage). Emergency operations also prevented flooding of the Northeast (East Bottoms) and Birmingham Industrial Districts. Water stood for several days in the flooded units and the Kansas River stretched from the Armourdale bluff to the Argentine bluff, with very little to be seen above the floodwater. About 11 square miles were flooded in the Kansas Citys area. Although at least 5 persons died in the Kansas Citys area, about 15,000 people were evacuated. Many of these residents were left homeless and were relocated to trailers and other temporary housing, some for nearly two years. According to the Kansas City District’s post-flood report for the Kansas Citys 7 levees area, the flood caused an estimated $461 million in damage (roughly $8 billion in 2013 prices). In addition to at least 5 deaths and 17,500 evacuations, more than 5,700 homes and nearly 1,500 businesses were flooded in the 7 levees area alone. Consequently, July 13, 1951 became known as “Black Friday”.

4.3 The 1993 Flood

The 1993 flood event crested at 48.9 feet on July 27, 1993, with a Missouri River discharge of 543,000 cfs. Despite the discharge being less than for the 1951 flood, the 1993 crest of 48.9 feet exceeded the 1951 crest stage of 46.2 feet. All the levees in the Kansas Citys project held, although water levels on several units were encroaching in established freeboard. Every one of the levees sustained some damage. An estimated $4.57 billion in damages were prevented by the Kansas Citys Federal levee system (The Great Flood of 1993, Post-Flood Report, U.S. Army Corps of Engineers, Sept. 1994). Main stem reservoirs on the Missouri above Kansas City prevented an estimated $3.8 billion in damages, much of that in the Kansas Citys area. Just outside the study area in Kansas City, Kansas, several low-lying trailer courts and other homes near Kansas River mile 10 were damaged or destroyed. An estimated 600 mobile homes and 200 other homes were affected. Damages to Kansas City, Kansas utilities reached several million dollars. Kansas City, Missouri reported more than $15 million in damage to public infrastructure. Kemper Arena and the American Royal Building suffered about $2.5 million in water damage to flooring and electrical circuits. The downtown airport sustained damages of nearly $3 million, and pollution control and public works facilities sustained an estimated $8 million in damage. Since the levees in the Kansas Citys project did not overtop or breach, these reported damages sustained were due to underseepage, interior drainage, and possibly Turkey Creek overbank flows.

5.0 Damage Analysis Database Preparation

5.1 Data Collection Methodology

The data collection effort for Phase 1 carried out primarily in 2002-2004, included data for all seven of the Kansas Citys project leveed areas, including the Phase 2 units. The Phase 2 data collection involved three steps: (1) evaluation of the data obtained during Phase 1 of the feasibility study; (2) obtaining structure characteristics from relevant county and state tax records, and GIS data and available mapping from the city and/or county; and (3) design and execution of a structure-by-structure field survey.

It is important to note that the data collection methodology for Phase 2 represented as few changes as possible over the Phase 1 methodology. The Phase 1 project was approved by ASA (CW) and was subsequently authorized; various portions of the project are now in design or construction. It would be inappropriate to produce a Phase 2 economic analysis that is methodologically inconsistent with the Phase 1 analysis. Apart from correcting a handful of minor errors found in the Phase 1 analysis and using the vehicles depth-damage function released in EGM 09-04 in 2009, the data collection and development methodology for Phase 2 are identical to Phase 1.

5.1.1 Phase 1 Survey

Due to the massive extent of the investment in the study area, intense efforts were required to prepare for, closely manage, and coordinate, conduct, and complete the economic field survey for the Kansas Citys feasibility study to determine study area investment and its damage potential. For Phase I of the survey, the data collection efforts for the commercial, industrial, and public facilities were accomplished by architectural-engineering (AE) contract. Corps in-house economics staff members completed the data collection for residential investment, public investment in streets and highways, and commercial investment in railroad tracks, with contract assistance for research and data input. These surveys were detailed in the socioeconomics appendix to the 2006 feasibility report, but the information is repeated here for reference.

5.1.1.1 Phase 1 Commercial, Industrial, and Public Facility Economic Data Collection

Economic data collection efforts for the commercial, industrial, and public facilities were based on a mix of direct interviews of large, high value businesses, direct interviews of a representative sample of other typical businesses in the study area, visual field observation, estimates based on similar investment and damages for comparable types of businesses, and visual observation and estimates using Marshall and Swift commercial valuation software. Business specific data obtained during the reconnaissance phase were also evaluated for use in the feasibility study.

For Phase 1 of the survey, the survey team leader (an experienced former Corps economist) conducted an initial windshield survey of all development in each levee unit, with extensive identification of individual major businesses. Based on several factors, including his visual observation, the lists of major businesses identified by the study sponsor representatives, available reconnaissance phase data, and the color-coded parcel valuation maps prepared by the GIS staff, the survey team leader identified the largest and/or highest value businesses in each levee unit and a mix of other businesses that would comprise a representative sample of typical businesses in the study area. These businesses were compiled as a "master list" of commercial, industrial and public properties that would be given priority for data acquisition. From the master list, the survey team leader determined an initial subset of these master list businesses that either would specifically need to be interviewed due to their size and complex nature, or would be included in order to develop and interview a representative sample of the typical business types found in the study area. Survey team members were then sent out with survey forms for face-to-face interviews with the specifically identified master list businesses.

Survey forms completed and returned provided detailed information about property values, location of damageable investment, and damageability of the investment at various depths of flooding in relation to the first floor. Data included the type of business, depreciated structure investment value, investment values by physical location (basement, first floor, second floor) for inventory, office equipment, production equipment, and other contents. Survey data also included estimates of potential damage to structure, inventory, equipment and other contents with various potential depths of flooding in relation to first floors. Information on historical flood events and historical damages were obtained in some cases.

The AE contractor developed descriptive and location data for each master list business by visual observation during a windshield survey, review of the aerial survey maps, and available Phase 1 field notes. The data items developed included the following: levee unit location and river mile location of structure, structure number, name and address of business occupant as available, number of buildings, ground elevation and first floor above ground height, type of construction material, estimated effective age and condition of the building. Ground elevation for each structure was determined based on the aerial maps with either 2-foot contours and spot elevations (Kansas) or 4-foot contours and spot elevations (Missouri).

The investment values for structure and contents for the master list businesses were completed using the methodologies proposed and described above. For other businesses, the estimated valuations were based either on a unit cost per square foot from similar business types that had returned survey forms or by using the Marshall and Swift Commercial Estimator 7 computer program. The required data input included zip code, stories in building, total building area, occupancy group, occupancy type, occupancy code number, occupancy percentage, story height, construction class, and quality.

Descriptive and location data for the remaining businesses and public entities (not on the master list) in the rest of the study area were obtained by windshield survey and from available mapping. Each structure or group of structures was assigned a structure number corresponding to the aerial map structure number for identification purposes. Square footage estimates were calculated by scaling the structure footprint outline shown on the map, combined with descriptive data from the visual survey. Quality control review of such calculations was conducted by comparing square footages for a sample of the structures to available GIS data on square footage. First floor heights above ground, structure ground elevations, and low entry elevations were identified using the aerial maps and visual inspections. Valuation estimates were developed either by using Marshall and Swift estimation software or by estimating based on locally-obtained data for similar structures/investment types.

5.1.1.2 Phase 1 Residential Data Collection

Corps of Engineers Economics staff conducted a field survey of residential structures in the study area. Local realtors in both Kansas and Missouri who sell homes in the levee unit areas were contacted to obtain the typical sales prices for residences by type of residential structure (one-story with basement, two-story without basement, etc.). Realtors also provided typical market values for residential lots in the individual market areas. For comparison purposes, Multiple Listing Service data was also obtained from a real estate appraiser about recent comparable sales for residential units in the levee units. To verify that the realtor provided market values were reasonable and representative of depreciated replacement values, Marshall & Swift depreciated replacement values were developed for a random sample of residential structures. The realtor-provided market values were determined to reasonably reflect depreciated replacement value. Based on the values provided by the local realtors, typical residential structure market values (not including the typical market land value) were developed by structure type and by levee unit area.

Elevations of the lowest openings and first floors relative to the ground were noted by visual observation of structures during the field survey. Ground elevations for residential structures were determined from the available mapping.

5.1.2 Tax Data

Property parcels within the 0.2 percent-chance floodplain were identified and looked up in their respective county appraiser's property database. The Wyandotte County Appraiser's property database provided assessment values along the necessary structure details to calculate replacement costs. This data included structure characteristics such as occupancy, age, construction quality/class, area (square feet), number of stories, exterior wall type, basement type, garage type, and condition. The Jackson

County, Missouri Appraiser's property database also provided structure assessment values but no supporting data. Values from the tax data were updated as the study progressed.

5.1.3 Phase 2 Field Survey

Kansas City District economics staff carried out a structure-by-structure field survey of all buildings in the seven levee areas (both Phase 1 and Phase 2 units) over several days in July-August 2011. The purpose of the survey was to build on the data from the Phase 1 survey and county tax records and obtain a generalized reality check on the usefulness of the appraised values by assessing whether obvious mismatches between data and reality occurred. Specifically we looked for any obvious discrepancies in existing data, changes in structure occupancies, or changes in activity level at existing businesses. Finally, the nature of the activity was not always obvious from the tax data or business name, so properties were inspected for additional clues, as well as for the presence of significant outside inventory or equipment. The windshield survey was supplemented by additional research on the Internet concerning occupancy. Notes from the completed field survey were subsequently integrated with the tax data to form an adjusted initial structure inventory for the study area.

5.2 Data Development – Elevations

In the second phase of the database preparation for the economic analysis, the raw data obtained from the county tax records, GIS maps, field surveys and business surveys were further developed, refined, and organized to produce the three key variables for each property to be used in the damage analysis: beginning damage elevations, property values, and depth-damage relationships. The risk analysis program used for the damage analysis also requires specification of uncertainty factors for each of these variables.

Each property in a flood risk management analysis is assigned a mean sea level (msl) ground elevation. This includes streets and railroads as well as buildings. Buildings additionally are assigned a first-floor elevation expressed as a foundation height above the ground elevation. Damage computations take into account ground elevation, first-floor elevation, and lowest-opening elevation if it is different from the other two elevations. Property elevations help determine depths of flooding for each flood event evaluated.

Each structure in the study area was assigned a ground elevation using the contour maps. All structures were also assigned a station or river mile for the purpose of allowing the stage-damage relationship for the structure to be transferred to the index point of the reach in the damage analysis.

In addition to the ground elevations and stations, each structure was also assigned a foundation height relative to the ground elevation. The foundation heights were estimated in half-foot intervals by visual observation during the field survey. The first-floor elevation (which is usually the beginning damage elevation) in the economic analysis model was determined by adding the foundation height to the ground elevation.

Using a flooded area map based on a 0.2 percent chance event, all city streets in the floodplain were evaluated on a block-by-block basis, assigning an average elevation for each block. Highways and railroad track were similarly divided into short segments and assigned an average elevation for each section.

The first-floor elevation for each type of structure is characterized by an uncertainty factor, usually expressed as a standard deviation around a normally distributed variable. Ground elevations were assigned in accordance with EM 1110-2-1619 dated 1 August 1996. Based on contour interval mapping for each levee unit, the recommended standard deviations and normal distributions were assigned (0.3 feet for Kansas units and 0.6 feet for Missouri units).

5.3 Data Development – Valuation

Guidance for Corps of Engineers economic analyses defines asset value of depreciated replacement value, which is defined as the cost of replacing an item today with an item of identical effective age (i.e., not a brand new item, unless the item being replaced is brand new). As the term implies, the concept is to identify the replacement cost of the item and then depreciate this value according to the item's condition and age. This concept of value is applied to values for all structures, whether residential or non-residential, as well as major production or office equipment and vehicles. Inventories of businesses, including raw materials, work in progress, and furnished goods, are valued in terms of replacement value.

The economic expression of values for each property category also must include uncertainty factors to be used in the risk analysis. Most economic variables in flood risk management studies are believed to be distributed normally, so the uncertainty around a median value is expressed as a standard deviation. In cases where the samples available for estimating variables are very small and the distribution of the variable is unknown, uncertainty may instead be expressed as a triangular distribution with most likely, maximum, and minimum value estimates.

5.3.1 Residential Structures Valuation

For this analysis, a detailed RS Means analysis of depreciated replacement value was performed on all homes in the Armourdale and CID floodplain. The detailed data obtained from the county tax database on each of the homes included square footage, construction type, number of stories, wall type, basements, garages, porches, heating and air conditioning, floor coverings and interior walls, and lump sum adjustments such as number of bathrooms and fireplaces. The RS Means database provides values associated with each of these characteristics and allows computation of detailed replacement values for each home. Additional data from the tax database on age and condition were then used in conjunction with the RS Means material to estimate depreciation and calculate a depreciated replacement value.

Structure value uncertainty in this analysis generally is related to uncertainty in either the assessment of residential construction quality or depreciation estimates. Uncertainties were determined from the range of values provided by local realtors contacted for the different structure types and levee unit areas.

5.3.2 Residential Contents Valuation

Residential content values are normally expressed in terms of a contents-to-structure value ratio (CSVR). For example, if a home appraised at $100,000 has a CSVR of 0.5, the home is assumed to have contents valued at $50,000. The CSVR is a standard technique used in the insurance industry for estimating contents values in the absence of detailed data. Due to the nature of the residential depth-damage relationships (developed by the Institute for Water Resources described further below) used in this analysis, a nominal residential CSVR of 1.0 is used in the risk analysis, following the guidance accompanying the IWR functions. The IWR functions are formulated so that no CSVR is actually used to compute content values in the analysis (the function of the nominal CSVR of 1.0 is only to ensure that the depth-damage functions result in correct calculations in the risk analysis). For purely informational purposes of estimating investment values in the study area, residential contents value is assumed to equal 50 percent of structure value. The IWR functions are used for all 1, 1 ½, and 2-story homes, with or without basement.

Uncertainties in residential contents valuation are not specified in this analysis for those homes affected by the IWR functions, following the guidance for the functions warning against the use of any uncertainty factors because of how the functions are constructed and used in the risk analysis. That approach has been followed in this analysis.

For the residential other category in HEC-FDA, each residential unit was assumed to have a vehicle of typical average value and typical landscape investment subject to damage. Most families today own more than one vehicle, and with imminent threat of flooding, it is likely that a family would load belongings into one of the vehicles and evacuate the area. Thus, for purposes of the study, vehicles subject to flood damage were limited to one per residential structure. Most homes in the protected areas have typical shrub plantings, lawns, and gardens that would also be damaged by flooding. The vehicle and typical landscaping investment value in the Residential Other category was assumed to be about 20 percent of structure value, with 5 percent as one standard deviation of error for uncertainty. In support of this ratio, we determined that the average used vehicle sale value in 2012 was approximately $9,300 (Automotive Dealer Exchange Services of America, September 2012). The $9,300 would be slightly more than 18 percent of the average home value in the Phase 2 study area of $51,100, and since the $9,300 does not account for those who have new cars and does not include landscaping, 20 percent of structure value appears to be a reasonable assumption for this category of damages.

5.3.3 Commercial Structures Valuation

The values of all commercial and public structures in Wyandotte County, Kansas inventoried for this analysis are estimated using information from the county tax database in conjunction with RSMeans commercial valuation reference products. Characteristics for each building taken from the tax database included occupancy type (e.g., warehouse, church, retail store, office building, etc.), construction quality, exterior wall, and square footage. These characteristics were the basis for calculation of replacement values for each structure using the RS Means reference data. The next step involved obtaining data on age, typical building life, and condition for each structure from the tax database and using these characteristics to develop effective age and corresponding depreciation factor. Application of the depreciation factor to the replacement value resulted in a depreciated replacement value for each building.

The values obtained from the Phase I survey for Jackson County, Missouri commercial and public structures were updated using CCI update factors and were then compared against the appraised values, field survey notes, and other sources such as internet, newspaper articles, and personal interviews with adjustments being made where necessary.

Structure value uncertainties were determined in Phase 1 by completing a set of Marshall & Swift valuations for a representative sample of master list businesses/properties that had returned completed survey forms. The Marshall & Swift valuations were compared to the survey values and a standard deviation was computed. The 30 businesses sampled for the uncertainty determinations were selected to be representative of the various types of structures located within the study area, and the process considered such factors as construction material, size, location, and building effective age. Based on statistical analysis of the sampled data set, a normal distribution was selected with a standard deviation of 41.3 percent. This standard deviation was used as the depreciated structure value uncertainty for all commercial structures within the study area that did not provide survey data.

5.3.4 Commercial Contents Valuation

Commercial and public contents include assets such as office equipment, major production equipment, and rolling stock, as well as inventories items including raw materials, work in progress, and finished goods. All properties in this analysis were assigned content values in terms of contents-to-structure-value ratio (CSVR). For firms and facilities that provided more detailed data to us via interviews and survey forms, this ratio was developed indirectly from data on asset and inventory values obtained from the companies. It should be stressed that in these cases, the structure and content values were developed first, and then the CSVRs were derived from those values. Although computation of CSVRs was an additional step not required for valuation of these businesses and facilities, the CSVRs were developed in order to treat all data in the database consistently (the majority of businesses derive content values from CSVRs) and facilitate simpler data handling for the risk analysis.

Since obtaining first-hand data from all companies in the study area would not be realistic, content values for the majority of businesses and facilities must be derived from something other than company-specific data. For contents valuation of these firms, this analysis primarily utilizes CSVRs developed by the New Orleans District Corps of Engineers, which has accomplished a great deal of analysis over several major studies concerning typical content values and depth-damage functions for both structures and contents in a broad range of industries. The data used in this analysis were published in the report “Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios in Support of the Lower Atchafalaya Reevaluation and Morganza to the Gulf, Louisiana, Feasibility Studies,” dated May 1997. During the Phase I Interim Feasibility Report, this source was recommended by Corps subject experts from HQUSACE and other districts for use. The New Orleans report, which includes two sets of CSVRs for various business types, is probably the most methodical available attempt to develop CSVRs. One set of CSVRs was based on estimates by expert panels, while the other set was based on interviews with business owners or operators in the Baton Rouge area. The informative expert panel data from the report is limited somewhat by its use of only one prototypical business as a basis for estimating CSVRs in each broad industry category. We instead chose to use CSVRs from the New Orleans owner/operator data. These data were based on post-flood surveys conducted in the aftermath of an urban, freshwater, main stem (long duration) flood event in Louisiana. These flooding characteristics transfer well to the Kansas City context of flooding. The owner/operators interviewed represented many of the same types of businesses and facilities as are found in the Kansas City structure inventory. Seven broad business categories are included: restaurants, grocers, retail and services, professional offices, repairs and home use businesses, warehouses and contractors, and public facilities. Development of the owner/operator data for each of these categories included interviews with 10 businesses, usually representing several specific types of businesses within each broad category. Table 12 summarizes these ratios.

In contrast to residential valuation, values were not added to commercial and public contents as an "other" category to account for vehicles and landscaping. Each home is assumed to have vehicles, and many residents of the study area also work there. Therefore, the addition of vehicles at places of business would entail considerable double counting. Landscaping is not included since no generalized data are available relating to typical ratios of landscaping costs to business structure values.

Uncertainty in contents valuation for firms not contacted is assumed to be subject to a normal distribution and is characterized by standard deviations accompanying the CSVRs in the New Orleans data, as seen in Table 12.

Table 12: **Commercial Content-to-Structure Value Ratios**

Category	CSVR	Standard Deviation
Eating and Recreation	3.06	1.62
Groceries and Gas Stations	1.28	0.76
Professional Businesses	0.78	0.58
Public and Semi-Public	0.82	1.39
Repairs and Home Use	2.51	0.86
Retail and Personal Services	1.48	1.23
Warehouse and Contractor Services	3.72	1.45
Source: "Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios in Support of the Lower Atchafalaya Reevaluation and Morganza to the Gulf, Louisiana, Feasibility Studies," dated May 1997.		

5.3.5 Streets and Railroads Valuation

Roads are perhaps the most commonly damaged infrastructure facility in a flood event. Damage to roads and other paved surfaces may be caused by floodwaters overtopping, eroding and scouring road surfaces, shoulders, and embankment slopes. In addition to obvious washout areas, as the ground begins to dry out after flooding, pavement buckling and other problem areas can become apparent. Curbs, gutters and sidewalks along the streets and roads can be damaged by uprooted trees and by heavy equipment during cleanup. Also associated with road damage would be damage to traffic signs and stoplights. For purposes of this study, damages to roads and paved parking lots were estimated for the Armourdale and CID units. Damages to traffic signs and traffic signals were not included. Miles of roads by type and elevation for each levee unit were determined during the reconnaissance phase of the study. Estimates of the average investment per mile for the various types of roads were developed from road construction cost estimates obtained from the Missouri Department of Transportation and from representatives of Kansas City highway engineering firms, and were applied to the estimated miles of roadways by type in each levee unit area subject to flooding. Uncertainties in investment value were determined based on the ranges of values provided for the different types of roads. The analysis uses a 20 percent maximum or minimum variation for interstates and heavy-duty concrete roads, and 35 percent variation for arterial and local/collector streets.

Data for railroad tracks were developed in a similar manner. Miles of track were determined by elevation and by levee unit area during the reconnaissance phase of the study. Estimates of investment value per mile for different types of track were obtained during interviews with study area railroad representatives. Investment per mile was estimated to range from $1 million to more than $2.5 million, depending on the number of electric time locking switches in the track. Since the study area encompasses heavily urbanized areas and major rail yards, it is reasonable to assume that track with electronic switching would be more prevalent than track without electronic switching. Based on values per mile and the miles of track with the different levels of electronic switching provided by railroad representatives interviewed, an average value per mile of $1.75 million (October 2004 price level) was developed and applied to the total miles of railroad tracks in the levee unit areas. This value has been updated to $2.25 million based on CWCCIS index numbers for Roads, Railroads, and Bridge. On average, approximately 42 percent of this value represents the value of main line tracks, and about 57 percent represents the value of electronic switching and other equipment. Uncertainties were based on the range of values obtained from the railroad representatives interviewed.

The Kansas Citys study area also contains significant rail yards and main line track. For Kansas River flooding, there is not much advance warning. Therefore, if a call went out to evacuate the study area, railroad representatives from different rail companies stated independently that it would be nearly impossible to move the boxcars out of the study area rail yards because there is not enough locomotive power available to move them in a short timeframe. The majority of cars and their commodities would be left on the track and thus subject to damage. For purposes of this analysis we estimated that approximately 25 percent of the boxcars would be moved out of harm’s way, and that all locomotives would be moved out, except for locomotives in the repair facilities. Railroad car damage would mainly be damage to wheel assemblies once they get wet, along with some other minor damage to the cars themselves. The railroad representatives interviewed estimated the cost for replacement of flooded wheel assemblies at $80,000 ($96,000 in October 2012 prices) per car. Estimated numbers of rail cars in each yard were determined from examination of aerial photos and comparison with the information obtained from the Argentine rail yard. Boxcar commodities would also be damaged in a major flood event. To estimate boxcar commodities damage, the top inbound and outbound commodities by rail carload were researched for the Kansas City area, and a weighted value per rail car of $21,700 ($26,000 in October 2012 prices) was developed. The top commodities included motor vehicles and motor vehicle parts, grain and grain products, bituminous coal, miscellaneous coal and petroleum, and mineral products. The Kansas City rail yards are also major containerized shipping centers. Containers waiting processing were estimated by field observation, examining aerial photos, and counting stacks of containers. It was also assumed that approximately 25 percent of these containers would be moved in a major flood event. Container unit damage in a major flood event was estimated at about 5 percent of total investment in containers for purposes of the analysis. Container commodity damage was assumed to be similar to boxcar damage; container content values and damages are for finished goods and would likely be much higher for raw materials.

5.3.6 Emergency and Disaster Relief Costs Valuation

These other costs of flooding are much more difficult to determine and estimate than physical flood damages. In the Kansas Citys study area, actual study area historical data about these types of costs are neither readily available nor easily estimated because the last damaging flood event in any of the study area units was in 1951. However, we estimated emergency costs for the study area units based on an evaluation of actual data collected about the 1993 flood along the Missouri and Mississippi Rivers. Several Corps published reports about the 1993 flood were consulted to obtain estimates of typical emergency costs in Missouri. These reports included the *1993 Interagency Floodplain Management Review Committee Report* (Galloway Report); *Impacts of the Great Flood of 1993*, U.S. Army Corps of Engineers Lower Mississippi Valley Division, May 1996; and the *Flood Plain Management Assessment of the Upper Mississippi River and Lower Missouri Rivers and Tributaries,* U. S. Army Corps of Engineers, June 1995. We specifically compared 1993 flood damages with 1993 agency emergency costs as reported in these documents. The 1993 emergency cost category data included the following: Federal Emergency Management Agency disaster administrative costs (costs of temporary disaster field offices and temporary hires, but not including costs for permanent administrative staff or permanent office and equipment costs), Department of Health and Human Services 1993 flood disaster costs, Corps flood emergency and emergency operations costs, and Environmental Protection Agency 1993 flood costs relative to underground storage tanks, oil spill response, and Abatement, Control, Compliance program operations. Based on the data provided in the reports, emergency costs, as a percent of total physical flood damages, ranged from a low of 12.4 percent to a high of 15 percent, with an average of 13.4 percent for all states impacted by the 1993 flood. We assumed that the 1993 flood data were typical for a flood event of that magnitude (approximately a 0.2 percent probability event) and that the data provided an historical basis for estimating these types of costs that could be incurred in the Kansas Citys highly developed urban study area for a flood event of similar magnitude. For the Kansas Citys feasibility study, emergency costs were estimated at 13 percent of primary damages for a 0.2 percent event. This percentage is similar to the average percentage described above for all states impacted in the 1993 flood and is also similar to the percentage used to estimate these costs in the Pearl River Study (USACE Mobile District). We did not obtain or include data about emergency costs for local police and emergency services. Estimated emergency costs for a 0.2 percent event were entered into the HEC-FDA study file for each levee unit area as the maximum emergency costs that could be incurred, and a depth percent damage relationship was applied in the HEC-FDA model to estimate emergency costs for other probability events. The equivalent annual emergency costs incurred over the period of analysis were computed in HEC-FDA.

5.3.7 Cleanup Costs

Based on data obtained from studies and approved reports by other Corps Districts, cleanup costs, with levee overtopping and approximately a 0.2 percent event in each of the Kansas Citys levee units, were estimated at 2 percent of total investment in structures and contents. Estimated cleanup costs for each levee unit were entered into the HEC-FDA study file, along with an appropriate depth-damage relationship, for integration with the hydrologic data and to determine annual cleanup costs incurred in each unit over the period of analysis.

5.3.8 Floodplain Relocation/Reoccupation Costs

Based on our research, the 1993 emergency costs described above included hazardous and toxic waste type cleanup costs, but in our opinion, did not include normal business and residential cleanup costs or relocation and reoccupation costs for floodplain residents. Relocation and reoccupation costs (and cleanup costs to a certain extent) were included in a different category identified as "disaster relief" in the 1993 flood data published in the three reports cited above. This disaster relief category reported all government human resource disaster relief payments. However, in our evaluation of the 1993 data, we determined that the 1993 disaster relief category data overlapped somewhat with actual physical flood damages and use of that data would result in the potential for double counting. Thus, estimates of costs for relocation and reoccupation of floodplains were instead obtained from extensive interviews with Federal Emergency Management Agency (FEMA) officials and published FEMA data for recent Missouri declared disasters, including the 1993 flood in Missouri. FEMA estimates were based on monies provided for disaster housing assistance and individual and family grant assistance. Estimated FEMA assistance per disaster per housing unit ranged from a low of $5,500 to a high of nearly $16,000, and an estimated average of $7,500 per housing unit. The average cost per housing unit was applied to the number of housing units in each of the Kansas Citys levee unit areas for use in this study as an estimate of relocation and reoccupation of floodplain costs that occur with floods of the magnitude of the 1993 event. This average value per housing unit was also comparable to a value computed per vulnerable residence in the floodplain based on information and data for Missouri counties provided in the *1993 Interagency Floodplain Management Review Committee Report* noted above. Relocation and reoccupation costs for non-residential occupants (commercial, industrial, public) were not estimated and were not included in the analysis.

5.3.9 Traffic Disruption Costs

Flooding or even the threat of flooding and public safety concerns may cause road closures and detouring of traffic. Traffic detours can last for the duration of actual flooding plus the time required for road cleanup and road repairs. As described in *National Economic Development Procedures Manual-Urban Flood Damage*, IWR Report 88-R-2, March 1988, the costs of traffic disruption are based on the vehicle operating costs for the additional miles traveled because of the detour, and on traffic delay costs per passenger. Lowest point elevations for major routes in each unit were compared with levee unit overtopping elevations and flood event interior stages with overtopping to determine which roads would be closed and by which flood events. Kansas City District Hydrology and Hydraulics Section staff made estimates of flood durations for various events, and further durations of potential road closures were estimated for cleanup and repair activities. Daily traffic counts for major roads and highways that would likely be closed in the event of levee failure/overtopping were obtained from Missouri and Kansas state transportation departments, together with estimates of the number of trucks versus cars in the count. The average number of passengers per vehicle was determined based on an urban weighted average (1.42 persons) provided in a Kansas Department of Transportation study. Detour routes were measured and compared with mileage for the non-disrupted route to determine the additional miles that would be traveled with the detour. Additional operating costs per mile were estimated at $0.375 for cars and $0.625 for trucks. Additional time to travel the detour was computed based on an estimated detour route speed limit and distance compared with the non-disrupted route speed limit and distance. The published average local wage rate for the metropolitan area of $16.56 was used for truck drivers and one-third of the average local wage rate was used for adult car passengers. Estimated traffic disruption costs for each unit were entered into the HEC-FDA study file, and integrated with the hydrologic data, to determine estimated annual traffic disruption costs during the period of analysis.

5.4 Data Development – Depth-Damage Functions

The goal of this portion of the analysis is the production of depth-damage relationships or functions for each type of item susceptible to inundation. An item that has experienced prolonged submersion might be a total loss, or badly damaged but salvageable, or even relatively unaffected in some cases. Depth-damage functions give estimated percentages of value affected by each foot of flooding; e.g., 2 feet of inundation might be associated with damage amounting to 20 percent of total property value. The relationships are developed for each type of occupancy within each economic category and are usually broken down by structure and contents. Uncertainty in the depth-damage percentages must also be specified in terms of either a standard deviation or minimum and maximum values for each foot of flooding.

5.4.1 Residential Depth-Damages

Residential damages for most homes in this analysis are based on depth-damage percentages released in Economic Guidance Memorandum 04-01, “Generic Depth-Damage Relationships for Residential Structures with Basements,” dated 10 October 2003. This EGM summarized data developed by the Institute for Water Resources (IWR) using post-flood residential damage claim records provided by the Federal Emergency Management Agency (FEMA). The functions account for both structural and content damage to homes. Based as they are on post-flood damage claims data, the functions should also account for any emergency flood avoidance actions taken by residents such as evacuation or flood proofing. The IWR functions pertain to all six residential occupancy types selected for this analysis: 1-story with and without basement, 1 1/2-stories with and without basement, and 2 stories with and without basement.

For the residential other category, depth-damage percentages are based on a weighted average from the damage functions produced for the Economic Guidance Memorandum 09-04, “Generic Depth-Damage Relationships for Vehicles,” dated 22 June 2009. The EGM summarized data provided by the Flood Damage Data Collection Program from residential post-flood damage surveys that included data collected for vehicles kept at residences in ten communities that experienced major flooding.

5.4.2 Commercial Depth-Damages

A customized individual occupancy type for use in the risk analysis was developed for companies and facilities that provided specific information on values, elevations and damage potential in our discussions with them. Each major asset or inventory item was valued and assigned a depth-damage function with uncertainty (usually expressed as a triangular distribution with minimum and maximum values) indexed to a given elevation within the structure. However, most businesses and facilities in a large urban floodplain inventory cannot be characterized by company-specific data, and the treatment of depth-damage relationships for these businesses is similar to the contents valuation process for the same businesses described above in section 5.3.4. The New Orleans District report discussed there is also the source for many of the depth-damage functions used in this analysis and is considered relevant to the study area for the same reasons. The functions are based on a wide range of expertise, including panels made up of experienced subject experts on construction and post-flood cleanup, owner/operators of businesses, and FEMA post-flood depth-damage functions for the same region. It was determined that the New Orleans owner/operator curves were appropriate because flooding characteristics (urban, freshwater, and long duration) were similar. The owner/operators interviewed also represented many of the same types of businesses and facilities as those included in the Kansas Citys structure inventory. Depth-damage functions are included for each of the three types of non-residential structure (masonry, steel, and wood) and seven types of non-residential contents (restaurants, grocers, retail and services, professional offices, warehouses and contractors, repair and home use establishments, and public facilities). The New Orleans functions include median, maximum, and minimum values that serve as the basis for triangular damage uncertainty distributions in the risk analysis. To account for the high depths of flooding in the Kansas Citys study area, depth-damage relationships were extended by means of extrapolation and professional judgment.

It should be noted that some of the functions assume that damage occurs at an elevation of zero. One reason for this is that surface flows do, in fact, damage some items. Examples include finished goods inventories stored on the floor (particularly items such as food or drugs), inventories that are very sensitive to humidity even if not directly touching the water, or equipment with electrical wiring on the floor. Another reason is that the depth-damage functions typically are structured in depth increments of a half-foot, if not a foot. If damage occurs with depths of only two or three inches (as it usually would), these depths would more readily round to zero than to one foot or one half foot. Damage percentages paired with an elevation of zero, therefore, might in actuality be accounting for very shallow flows of greater than zero depth.

5.4.3 Streets and Railroads Depth-Damages

Depth-percent damage relationships for roads in the study area were based on previously developed Kansas City District curves used in other approved studies. Omaha District curves were obtained for comparison and to develop estimated uncertainties in the depth-damage relationship. Large paved parking lots associated with commercial and industrial structures in the study area were measured from aerial maps to determine square footage, and a value per square foot representing the cost to resurface the lot (obtained from Kansas City District Cost Engineering staff) was applied to the square footage to determine investment value. Road depth percent damage relationships were used for the large paved parking lots identified. Damages to roads and parking lots in each levee unit area are included in the public category of damage.

For railroads, previously developed Kansas City District depth-percent damage curves were used, and compared with Omaha District curves to determine estimated uncertainties. Separate depth damage relationships for railroad tracks and electronic equipment were used. Estimated damages to railroad tracks are also included in the public category of damage in each levee unit area.

5.4.4 Emergency and Disaster Relief Depth-Damages

The depth percent damage relationship for emergency and disaster relief was developed as follows. First, study area primary damages resulting from various probability events were computed as a percentage of the estimated 0.2 percent probability event primary damages in the study area. Each resulting percentage was then paired with the average flood depth in the study area flooded units for each probability event in order to develop a depth-percent damage relationship. Thus, emergency costs estimated to be incurred for any exceedance probability event would be approximately 13 percent of the primary physical damages for that specific exceedance probability event.

5.5 Costs of Flooding Not Included in the Analysis

Although the accounting of flood losses for this analysis is quite comprehensive, certain costs of flooding are not included in this economic analysis. Usually this is because of one or more of the following reasons: (a) difficulty of monetizing the damages; (b) difficulty of estimating the scale of damage and relating it to specific flood events for use in a function; or (c) uncertainty that improvements in the Federal project would significantly affect the costs involved. Costs not included in the analysis include:

- Damages to some utilities – Damages to sewer systems and underground utility lines would occur in each reach, with damages likely in the millions of dollars with additional cleanup costs. Much of this damage would likely occur in a large flood event anyhow, even with a stronger or higher levee.
- Damage to levee units – The levee units that are the focus of this study would themselves be subject to damages in large flood events, and damage could easily reach the tens of millions of dollars. But again, much of this damage might still occur even with augmented levees.

6.0 Model Configuration

6.1 Study Configuration

6.1.1 Analysis Years and Period of Analysis

In addition to the existing conditions of 2012, we also analyze a base condition and a future condition. The base year for the economic analysis – i.e., the year when the project would be completed and operational – is 2030. The future condition year (selected to be 2049 in this study) is normally used to project changes in hydrologic/hydraulic conditions and economic development for a specific future year, usually about 20 to 30 years out from the base year.

In this analysis, the economic database for the existing condition is also used to characterize the base and future conditions. These conditions initially were defined separately in order to allow the addition of planned development late in the study completion period based on the most current information about future development. Since economic development plans potentially affecting the future without-project condition tend to be fluid and speculative, we establish our assumptions in this area as late in the study as possible. Ultimately, however, while there were many possible projects on the horizon as we completed this study, none met our criteria for inclusion: (a) high likelihood of implementation, (b) firm identification of a location, and (c) availability of information on industrial classification and estimated investment. Therefore, the economic database used in the existing conditions analysis is carried through to the base and future conditions without change. However, in the future condition there are changes in the engineering data used in the risk-based analysis for structural and geotechnical conditions caused by the continuing neglect of the deficiencies in the CID levee reach. Moreover, there is also a minor change in the hydraulic and hydrologic conditions due to the increase in uncertainties regarding river stages.

6.1.2 Interest Rate and Price Level

Annualized estimates of damages, benefits and costs in this analysis assume the FY 2013 Federal interest rate of 3.75 percent and a period of analysis of 50 years. The selection of a 50-year period of analysis is based on the period over which hydrologic/hydraulic conditions can be projected as well as on official guidance for evaluation of Federal levees, which specifies a maximum period of 50 years. All estimates are expressed in October 2012 prices unless otherwise noted.

6.1.3 Study Streams and Reaches

Study reaches serve the basic purpose of allowing the aggregation of stage-damage data for all properties located in a particular portion of the stream's floodplain. Each reach is assigned an index point, and all property evaluations in that reach are adjusted to the elevations at the index point. These adjustments in elevation compensate for variations in the lay of the land along the stream and particularly the gradual drop in ground elevations typically encountered when going downstream.

The Phase 2 study damage streams and their reaches used in this study are summarized in Table 13, which indicates the beginning and ending river mile or station for each reach as well as the index point.

Table 13: **Study Damage Reaches**

Damage Reach Name	Beginning Station	Ending Station	Bank	Index Location
Kansas River:				
Armourdale	0.6	7.7	Left	5.2
Missouri River:				
Central Industrial District	365.8	370.7	Both	368.8

6.1.4 Economic Categories

The economic structure inventory in this study is categorized in terms of three basic land uses: residential, commercial (including businesses, non-profit institutions such as churches and schools, public facilities and utilities), and public (notably, streets and railroads). Four categories of non-physical costs of flooding, cleanup, emergency, floodplain evacuation and reoccupation, and traffic disruption, are also included in the analysis.

6.2 Risk Analysis Preparation

The comprehensive structure inventory for the study area – including elevations, values, and depth-damage functions for each property – was entered into the HEC-FDA risk analysis program for damage computations. HEC-FDA refers to the Flood Damage Analysis software developed by the Hydrologic Engineering Center for use by the Corps of Engineers. The basic assumption underlying use of a risk analysis program is that the field data in flood risk studies are based on imperfect knowledge and that key variables for which median or most likely values are specified could, in reality, take on a range of values above and below the specified values. The economic structure inventory is loaded into HEC-FDA and integrated with hydraulic and hydrologic data characterizing flood potential as well as geotechnical and structural data characterizing the levee units. All engineering and economic data are entered into the program in terms of median or most likely values and accompanied by appropriate uncertainty parameters specifying the assumed range of theoretically possible values for each variable. The subsequent risk analysis simulates tens of thousands of theoretical flood events, synthetically extending the period of record to thousands of years and thereby producing results that embody uncertainties in assumptions and the dynamic interaction of variables over time. For each event, the program samples the range of possible values for each variable and determines (a) whether the flood event results in damages, and (b) how much damage occurs.

Damages are initially expressed as a stage-damage relationship; i.e., each foot of potential flooding at an index point is associated with an estimated amount of “primary damage.” But the ultimate goal is expression of damages in an annualized equivalent form. The calculation of average annual damages conceptually involves a weighted average in which the primary damages for each event are multiplied by the incremental probability of that event and the product is summed and averaged over 100 years. This total represents an estimate of the average damages that could be expected in any given year over the long term. The average annual damage total can then be compared on an equal basis to an annualized cost for the planned project to obtain a benefit-cost ratio.

An additional result of the risk analysis is a set of statistics characterizing project performance in terms of reliability or non-exceedance probability. The program estimates the probability that a levee unit will successfully contain certain specified flood events of interest such as the 1 percent chance event (i.e., the event magnitude with a 1 percent chance of occurring in any year).

6.2.1 Hydrologic and Hydraulic Data

Water surface profiles relating Kansas River stages to frequencies or probabilities of occurrence throughout the study area were provided for each of eight events, including the 0.10, 0.01, 0.005, 0.002, 0.0013, 0.001, 0.0008 and 0.0007 probability events. The profiles are referenced to 2008 conditions, although it should be noted that no increases in these stages are forecasted through the period of analysis and the same profiles are used for existing, base year, and future conditions.

The exceedance-probability relationship for the Kansas River was evaluated using the graphical method, which involves specifying a discharge-probability relationship (including a discharge for the 0.999 probability event) for each index point along with the equivalent record length for the stream.

The risk-based economic analysis is based on each levee's lowest point. The low point for each unit is identified by developing a water surface profile that corresponds to the overtopping discharge and then comparing the water surface profile to the top of levee elevation profile to find the location at which the top of levee falls below the water surface profile. The initial overtopping elevation in each area is adjusted to the economic index point for that reach. The resulting adjusted initial overtopping elevation at the index point essentially serves as the top of levee elevation for that reach, although it will not be necessarily be the same as the actual top of levee elevation at the index point or other sections of the levee.

6.2.2 Geotechnical and Structural Data

In addition to the top of levee elevation, geotechnical and structural probabilities of failure below the top of levee/floodwall elevations must also be considered. Existing older levees and floodwalls may have deteriorated and can no longer be assumed to hold water to the stage initially designed for. Geotechnical and structural engineers determined the most likely expected modes and sites of failure prior to overtopping in each unit. A full range of conditional probabilities of failure versus river stage elevation were determined by geotechnical and structural engineer PDT members for each site/mode of failure in each unit, in accordance with existing guidance. The probability of failure versus exterior stage relationships developed for major features and/or sites that were considered to have high probability of failure were then translated to the index point of each reach, and each individual potential failure site/mode was determined to be independent. The probabilities of failure for each site/mode were then combined using a formula contained in ETL-1110-2-556, Risk-Based Analyses for Geotechnical Engineering for Support of Planning Studies, to derive a single combined probability of failure versus river stage curve that accounted for all sites or modes of potential failure (Formula: Pr(f)=1-(1-p1)(1-p2) . . .(1-pn)). The resulting combined probability of failure versus river stage curve was entered into the HEC-FDA study file in the "Levee Features" section.

Table 14: **Armourdale Probability of Failure Functions – Existing Conditions**

WSE	p(F) site 1	p(F) site 2	p(F) site 3	p(F) site 4	p(F) site 5	p(f) combined
@ index point (RM 5.2)	Underseepage Station 276+00	Stability Station 222+00	Mill St Pump Station 156+75	12th St Pump Station 129+20	5th Ave Pump Station 185+70	
748.06	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
764.37	0.0000	0.0000	0.2408	0.2486	0.0000	0.4300
766.37	0.0027	0.0000	0.4022	0.4518	0.0250	0.6800
766.87	0.0038	0.0000	0.4574	0.5046	0.4732	0.9800
767.37	0.0050	0.0005	0.5125	0.5574	0.9390	0.9900
768.37	0.0075	0.0025	0.6228	0.6630	0.9990	1.0000
770.56	0.0110	0.0515	0.8643	0.8944	0.9990	1.0000
771.70	0.0310	0.2500	0.9901	1.0000	0.9990	1.0000

Table 15: **CID Probability of Failure Functions – Existing Conditions**

WSE	p(F) site 1	p(F) site 2	p(F) site 3	p(F) site 4	p(F) site 5	p(f) combined
@ index point (RM 368.8)	Structural Gatewell 67+65	Structural Floodwall 162+65	Structural Stoplog Gap 104+51.5	Structural Stoplog Gap 132+20	Structural Stoplog Gap 166+31	
756.80	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
757.30	0.0000	0.0779	0.0000	0.0000	0.0000	0.0779
757.71	0.0000	0.1437	0.0000	0.0000	0.0239	0.1641
758.00	0.0000	0.1927	0.0000	0.0000	0.0277	0.2151
758.45	0.0450	0.2800	0.0000	0.0000	0.0456	0.3437
758.68	0.0680	0.3341	0.0000	0.0000	0.0583	0.4156
759.03	0.1032	0.4150	0.0000	0.0000	0.0800	0.5173
759.30	0.1300	0.4710	0.0000	0.1692	0.0989	0.6555
759.49	0.1491	0.5110	0.0000	0.3232	0.1123	0.7500
759.67	0.1670	0.5471	0.0000	0.4672	0.1278	0.8247
759.92	0.1920	0.5912	0.0000	0.6436	0.1556	0.9006
760.30	0.3000	0.6582	0.0074	0.8630	0.1978	0.9739

7.0 Damage Analysis Results

It should be emphasized that the damages summarized in this section are risk-based, and the results obtained in the risk analysis can appear at odds with nominal data that do not reflect the uncertainties involved. An additional factor distinguishing damage potential in the risk context from data based on nominal top of levee and flood event elevations is that the risk model assumes that a flood can occur from geotechnical or structural failure as well as by overtopping. Geotechnical and structural deficiencies are important existing issues in both the Armourdale and CID units.

7.1 Existing Condition Results

As computed in the HEC-FDA risk analysis model, equivalent annual damages (EAD) total $63,728,700 for the Phase 2 study area. The distribution of EAD among the damage categories for both Phase 2 units is summarized in Table 16. Table 17 summarizes the engineering performance statistics emerging from the risk analysis. Both aspects of the results are discussed below for each study reach.

In general, the analysis produces two conclusions regarding the engineering performance of the Armourdale and CID units:

- Hydraulically, both units are high enough to offer moderate protection against all but the most extreme events.
- However, significant geotechnical and structural concerns are compromising the performance of the units.

Table 16: **Equivalent Annual Damages – Existing Conditions**

Oct 2012 prices, 3.75% interest rate; $1000s			
Damage Category	**Armourdale**	**Central Industrial District**	**Phase 2 Study Area**
Commercial	$ 37,629.39	$ 8,421.21	$ 46,050.60
Residential	$ 1,880.75	$ 0.99	$ 1,881.74
Public	$ 6,203.73	$ 635.62	$ 6,839.35
Emergency	$ 6,336.04	$ 774.50	$ 7,110.54
Cleanup	$ 1,383.94	$ 190.58	$ 1,574.52
Evacuation	$ 178.82	$ 2.62	$ 181.44
Traffic	$ 89.92	$ 0.58	$ 90.50
Total	**$ 53,702.59**	**$ 10,026.10**	**$ 63,728.69**

Table 17: **Engineering Performance – Existing Conditions**

	Armourdale	Central Industrial District	Argentine
Annual Exceedance Probability* (median)	0.0350	0.0040	0.0110
Return interval (years)	29	250	91
Long Term Risk (chance of exceedance during indicated period)			
over 10 years	0.3138	0.0539	0.1250
over 30 years	0.6099	0.1294	0.2838
over 50 years	0.8478	0.2421	0.4871
Conditional Exceedance Probability - Overtopping or Breach**			
10.0% event	0.1641	0.0003	0.0000
4.0% event	0.2220	0.0007	0.0320
2.0% event	0.3165	0.0247	0.2140
1.0% event	0.5453	0.1566	0.5121
0.4% event	0.8139	0.4887	0.8057
0.2% event	0.9194	0.7169	0.9132
Conditional Exceedance Probability - Overtopping Only**			
10.0% event	0.0000	0.0003	
4.0% event	0.0000	0.0003	
2.0% event	0.0062	0.0054	
1.0% event	0.0794	0.0663	
0.4% event	0.3670	0.3346	
0.2% event	0.6141	0.5875	

*Annual exceedance probability is the chance of experiencing any flood event - of whatever magnitude - within any year

**Conditional exceedance probability is the probability that specified flood event would overtop or breach the levee

7.1.1 Armourdale Economic Performance Without-Project

Equivalent annual damages total $53,702,590 for Armourdale. Over 70 percent of this total is accounted for by commercial structures. Public structures (including streets and railroads) make up nearly 12 percent of damages, while homes only account for 3.5 percent.

7.1.2 Armourdale Engineering Performance Without-Project

The median annual exceedance probability for Armourdale is currently 0.035. In other words, there is a 3.5 percent chance of a damaging flood in any year given the levee's existing state. In the 1 percent-chance flood event, the probability of only overtopping is 7.9 percent. However, the levee has five critical sections with deficiencies. Given these deficiencies, the probably of overtopping or breaching the levee for that event rises to 54.53 percent. The long-term risk of a damaging flood over 30-year period currently exceeds 1 in 2.

7.1.3 Central Industrial District Economic Performance Without-Project

The total equivalent annual damages for the Central Industrial District reach are $10,026,100. Again commercial structures make up the vast majority of the total with 84 percent of damages. Emergency costs and public structures account for another 8 percent and 6 percent, respectively. All other damage categories combine to total less than 2 percent.

7.1.4 Central Industrial District Engineering Performance Without-Project

The median annual exceedance probability for CID is currently 0.004. In the 1 percent-chance flood event, the probability of only overtopping is 6.6 percent. However, there are five critical sections with structural deficiencies. Given these deficiencies, the probably of overtopping or breaching the levee for that event rises to 15.66 percent. The long-term risk of a damaging flood over 50-year period is currently roughly 1 in 4.

7.2 Future Without-Project Condition

7.2.1 Hydraulic Changes from the Existing Condition

Future condition profiles were determined to be the same as existing condition profiles, with the exception of any impacts from the recently completed Missouri River Levee System L-385 Federal Levee. The L-385 project, on the opposite bank of the Missouri River and just upstream of the Fairfax-Jersey Creek unit, was determined to have minimal effect on future condition profiles in the Kansas Citys study area. Some very slight variations in profiles occurred in the far upstream portion of the Kansas Citys study area, and these were accounted for in the future condition profiles. It should be noted that uncertainties about river stage, however, were increased from 1.5 feet in the existing condition to 1.8 feet in the future condition. This was based on calculation procedures outlined in EM 1110-2-1619 and further described in the Hydrology and Hydraulics Engineering Appendix.

7.2.2 Geotechnical/Structural Changes from the Existing Condition

Continuing neglect of the deficiencies in the CID levee reach would result in a higher probability of levee failure in the future without-project condition, as can be seen in

Table 18.

Table 18: **CID Probability of Failure Functions – Future Without-Project Condition**

WSE	p(F) site 1	p(F) site 2	p(F) site 3	p(F) site 4	p(F) site 5	p(f) combined
@ index point (RM 368.8)	Structural Gatewell 67+65	Structural Floodwall 162+65	Structural Stoplog Gap 104+51.5	Structural Stoplog Gap 132+20	Structural Stoplog Gap 166+31	
756.80	0.0000	0.1400	0.0000	0.0000	0.0000	0.1400
757.30	0.0000	0.2309	0.0000	0.0000	0.0000	0.2309
757.71	0.0000	0.3115	0.0000	0.0000	0.0239	0.3280
758.00	0.0000	0.3769	0.0000	0.0000	0.0277	0.3942
758.45	0.0450	0.4775	0.0000	0.0000	0.0456	0.5237
758.68	0.0680	0.5282	0.0000	0.0000	0.0583	0.5860
759.03	0.1032	0.6018	0.0000	0.0000	0.0800	0.6714
759.30	0.1300	0.6458	0.0000	0.1692	0.0989	0.7693
759.49	0.1491	0.6772	0.0000	0.3232	0.1123	0.8350
759.67	0.1670	0.7047	0.0000	0.4672	0.1278	0.8857
759.92	0.1920	0.7341	0.0000	0.6436	0.1556	0.9353
760.30	0.3000	0.7788	0.0074	0.8630	0.1978	0.9831

7.2.3 Future Without-Project Condition Annual Damages

No changes in economic development are assumed for these estimates of future without-project condition damages. The property base assumed for the future condition is identical to the one used for the existing condition.

Table 19: **Future Without-Project Condition Annual Damages**

Oct 2012 prices, 3.75% interest rate; $1000s			
Damage Category	**Armourdale**	**Central Industrial District**	**Phase 2 Study Area**
Commercial	$ 37,786.16	$ 9,653.11	$ 47,739.27
Residential	$ 1,888.59	$ 1.13	$ 1,889.72
Public	$ 6,229.68	$ 726.76	$ 6,956.44
Emergency	$ 6,362.43	$ 883.85	$ 7,246.28
Cleanup	$ 1,389.70	$ 217.08	$ 1,606.78
Evacuation	$ 179.57	$ 3.00	$ 182.57
Traffic	$ 90.29	$ 0.66	$ 90.95
Total	**$ 53,926.43**	**$ 11,485.60**	**$ 65,412.03**

7.2.4 Future Without-Project Condition Engineering Performance

Engineering performance estimates for the future without-project condition are similar to, but slightly different from corresponding estimates for the existing condition.

Table 20: **Future Without-Project Condition Engineering Performance**

Engineering Performance - Future Without Project

	Armourdale	Central Industrial District	Argentine
Annual Exceedance Probability* (median)	0.0350	0.0047	0.0110
Return interval (years)	29	213	91
Long Term Risk (chance of exceedance during indicated period)			
over 10 years	0.3148	0.0619	0.1264
over 30 years	0.6114	0.1477	0.2867
over 50 years	0.8490	0.2736	0.4912
Conditional Exceedance Probability - Overtopping or Breach**			
10.0% event	0.1631	0.0000	0.0001
4.0% event	0.2236	0.0015	0.0359
2.0% event	0.3207	0.0395	0.2186
1.0% event	0.5457	0.2004	0.5116
0.4% event	0.8114	0.5415	0.8025
0.2% event	0.9174	0.7543	0.9107
Conditional Exceedance Probability - Overtopping Only**			
10.0% event	0.0000	0.0003	
4.0% event	0.0000	0.0003	
2.0% event	0.0073	0.0054	
1.0% event	0.0831	0.0663	
0.4% event	0.3701	0.3346	
0.2% event	0.6150	0.5875	
*Annual exceedance probability is the chance of experiencing any flood event - of whatever magnitude - within any year			
**Conditional exceedance probability is the probability that specified flood event would overtop or breach the levee			

8.0 Alternatives Screening

8.1 Overview of Evaluation Procedures

Economic costs and benefits resulting from a project are evaluated in terms of their impacts on national wealth, without regard to where in the United States the impacts may occur. National Economic Development (NED) benefits must result directly from a project and must represent net increases in the economic value of goods and services to the national economy, not simply to a locality. For example, if a flood interrupts auto production at a plant in one community, that community suffers a loss. But if the affected company replaces the interrupted production at another plant in another city, the community's loss does not represent a net loss to the national economy, and the prevention of such a loss cannot be claimed as a NED benefit.

NED costs represent the costs of diverting resources from other uses in implementing or operating and maintaining the project, as well as the costs of uncompensated economic losses resulting from detrimental effects of the project. NED benefits, the benefit-cost ratio, and the net NED benefits are calculated during the evaluation process. Net benefits represent the amount by which the NED benefits exceed NED costs, thereby defining the plan's contribution to the nation's economic output. The plan with the highest net benefits is considered the recommended plan, assuming technical feasibility, environmental soundness, and public acceptability. Note that the plan with highest net benefits is not necessarily the plan with the highest benefit-cost ratio. The benefit-cost ratio helps identify which plans have likely economic feasibility and can be carried forward for further analysis, but is not decisive in identifying the NED plan from among those plans that are economically feasible.

8.2 Alternatives Formulation Process – Economic Background

8.2.1 System Approach to Formulation

Following completion of the Reconnaissance Study in 2000, initial guidance received for the conduct of this feasibility study from HQUSACE strongly emphasized the need for use of a holistic system approach in subsequent analysis. The guidance noted the "intense development behind the levees" and "the complex interaction between individual levee units," and stated that the seven units of the Kansas Citys system "are so closely related and dependent upon each other for effectiveness that the project can only be analyzed by considering the area as a whole."

The guidance further noted that "given the location of the seven levee units relative to the confluences of the two rivers, formulation based on reaches upstream and downstream of the confluence of the Kansas and Missouri rivers is not technically feasible. The levee units in this study are either at the confluence of the rivers, or within the zone of influence of the confluence. Therefore, all units are interrelated and function as a system in providing flood protection to the area. This is the same challenge that was faced by the Corps when designing the existing levee system."

The HQUSACE guidance recognized the undesirability of a fragmented approach to plan formulation focused on individual units rather than the system, noting that "there are conditions under which failure or flooding of certain levee units may adversely affect adjacent levee units." A fragmented approach could leave different units within the system with varying and inconsistent degrees of protection, potentially posing a threat to public safety as well as property. For these reasons, the guidance ultimately concluded by stating that "we are supportive of limiting the alternatives to be investigated during the feasibility phase to those alternatives that provide a uniform level of protection" and that alternatives formulation "can proceed on the basis of providing a uniform level of protection, in lieu of doing an incremental analysis for the left and right bank levees."

Thus, alternatives formulation for the feasibility analysis was from the outset intentionally constrained and relatively narrowly focused in the manner directed by the guidance.

8.2.2 Phase 1 Approach and Results

This section will summarize several aspects of the Phase 1 analysis, as published in the 2006 Interim Report, that are germane to the alternatives formulation and evaluation process for the present Phase 2 report. Due to the constraint of working within available funding, the feasibility study was broken up into two phases. Phase 1 tasks included economic survey and database development for all seven units of the Kansas Citys system, but analysis of existing and future without-project conditions and alternatives dealt only with the four Missouri River units (Fairfax-Jersey Creek, North Kansas City, East Bottoms, and Birmingham) and the Argentine unit on the Kansas River. From a large number of possible measures, the PDT sought to concentrate on those addressing significant needs or weaknesses in the system. The ultimate goal was to arrive at an alternative providing a degree of protection that would be uniform across the system as well as economically optimal.

The Phase 1 analysis established that the Missouri River units were built high enough to provide protection consistent with the design level; i.e., the top of levee elevations for these units are approximately 3 feet above the elevation associated with the design discharge of 540,000. (This discharge is the approximate 0.2 percent event discharge on the Missouri River in the study area.) Consequently, no levee raise alternatives were considered for the Missouri River units. The analysis also indicated that various structural and geotechnical shortcomings needed to be addressed in order to provide adequate strength in these units. The NED analysis (detailed in sections 4 and 5 of Appendix C – Economics to the 2006 Interim Report) for the Missouri River units therefore concentrated on alternatives addressing these issues rather than levee raises.

The Kansas River units were another matter, however. While extensive analysis of the CID and Armourdale units was deferred to Phase 2, preliminary examination of existing conditions for the Kansas River units indicated that their overtopping exceedance probabilities were higher than the Missouri River units. The PDT decided early on that the Kansas River units would require raises in order to attain a uniform degree of protection for the seven units in the system. They also decided that engineering solutions for any levee sections with a significant probability of failure due to geotechnical or structural shortcomings would be integrated into the raise alternatives.

Of the Phase 2 units, only the Argentine unit was analyzed in detail for the Phase 1 analysis, but the NED analysis for this unit examined four major alternatives: (a) a no raise alternative addressing only earthwork and pump stations; (b) a small raise to the 0.2 percent (500-year) flood elevation; (c) a raise to three feet above the 0.2 percent elevation; and (d) a raise to five feet above the 0.2 percent elevation. Results of the Argentine NED analysis (see Table 35 of Appendix C to the 2006 interim report) indicated that net benefits increased as project scale increased across this array of alternatives. With reference to the alternatives nomenclature used in the above paragraph, estimated net benefits totaled $12,479,000 for alternative (a), the no raise; $13,508,000 for alternative (b); $14,026,000 for alternative (c); and $14,124,000 for alternative (d). Although alternative (d), the largest-scale alternative, was technically the NED plan, it was almost $1 million more expensive than alternative (c) while offering only an insignificant margin of superiority in net benefits. Therefore, the raise of the Argentine unit to three feet above the 0.2 percent elevation was selected.

The selected Argentine alternative maximized economic outputs in comparison to smaller-scale alternatives. In addition, it offered a degree of protection for this Kansas River unit that would, if implemented, be consistent with the Missouri River units analyzed in Phase 1 – thus contributing to a uniform system-wide level of protection. The Phase 1 plan was ultimately approved by HQUSACE and was authorized by Congress.

8.2.3 Phase 2 Alternatives Analysis

Phase 2 formulation began with the original study constraint of a uniform level of protection that governed Phase 1 analysis, but added an additional constraint in the form of an authorized Phase 1 project. Attainment of a uniform, system-wide level of protection would now be relative not only to the existing height of the Missouri River units, but also to the authorized plan for the Argentine unit on the Kansas River. It should also be noted that the Phase 2 units – Armourdale and CID – are situated in between the Argentine unit and the Missouri River units, leaving them potentially vulnerable if the units surrounding them offered more robust protection than they do. These constraints left only a narrow opening for formulation of alternatives for the CID and Armourdale units. Any alternative not providing a level of protection equivalent to the other five units would be unacceptable according to planning objectives. Phase 2 alternatives formulation therefore focused on measures that would bring Armourdale and CID to the same level of protection as the other units, with a top of levee elevation approximating three feet above the 0.2 percent flood event.

While this approach was satisfactory from the technical and public safety perspectives, it complicated the NED alternatives analysis process. Essentially, only one scale of alternative would be consistent with the study constraints. Economic analysis of the alternatives therefore amounted to a cost-effectiveness analysis of various measures meeting that constraint – all of the same scale - rather than a true, traditional NED analysis. However, the PDT took steps to ensure that the alternatives selection process was consistent with economic optimization. Early in the Phase 2 process, a preliminary analysis evaluated several different project scales for the three Kansas River units. In other words, the study constraints discussed above were temporarily ignored in order to investigate economic efficiency. This preliminary analysis was based on a somewhat abbreviated level of detail, but cost estimates were developed for the different project scales to complement the benefit computations. Three alternatives were investigated, each involving a raise of the Argentine, Armourdale, and CID units to the same level of protection. The alternatives evaluated were raises to one, two, and three feet above the 0.2 percent flood elevation. The HEC-FDA evaluation of these alternatives indicated that estimated net benefits for the raise of the three Kansas River units to three feet above the nominal 0.2 percent elevation (the project scale that dominates Phase 2 formulation due to study constraints) would total $17,332,000, while the smaller raises to two feet and one foot above the 0.2 percent elevation would produce net benefits of $16,837,000 and $16,794,000 respectively. On this basis, the raise of the three units in the Kansas River system to three feet above the 0.2 percent flood elevation would be the NED plan resulting from the analysis.

These preliminary results confirmed that the selection of the project scale for the Phase 2 units, while locked in by the study constraints, was nevertheless consistent with economic principles of NED analysis. Formulation of alternatives consistent with this system-wide level of protection is summarized in the next section.

8.3 General Description of Alternatives

8.3.1 Armourdale

In most of the levee sections of the unit initially evaluated, only one alternative plan was identified as technically feasible and effective to perform the raise and address the respective impacts to appurtenant structural and geotechnical features. These individual section measures are thus common to all final alternative plans for the overall unit. Similarly, structural and hydraulic pump station modifications are necessary based on the new unit height and are common to the final array of measures.

The final evaluation of measures focused only on those unit sections where more than one set of measures was identified and carried forward. In five separate sections of the unit, multiple raise alternatives were identified as feasible. These reaches and their alternatives are shown in the table below.

Table 21: **Armourdale Alternatives**

Start Station	End Station	Remaining Alternatives
10+00 UE	16+48 UE	1. Landside levee raise 2. Riverside levee raise 3. Replace levee with floodwall
77+80	81+00	1. Landside levee raise 2. T-wall on levee 3. Replace levee with floodwall
95+00	105+00	1. Landside levee raise 2. T-wall on levee
240+00	257+66	1. Landside levee raise 2. T-wall on levee 3. Replace levee sections with floodwall
42+50 LE	61+00 LE	1. Landside levee raise 2. New sandbag gap closure at Sta 42+50 LE

In the majority of these remaining sections, the feasible alternatives create access limitations and real estate related conflicts that could involve potentially costly relocations. Experience on similar projects in the Kansas City area, and other locations, has shown that real estate access and relocations involving railroads are both very costly and time consuming. This is an important consideration in the final alternative evaluation and selection. Following is a brief discussion of the alternatives in the Armourdale unit.

Sta. 10+00UE to 16+48UE

A landside levee raise would require relocation of railroad tracks and a riverside levee raise would require modification of two large outfall structures. Replacement of the existing levee with a floodwall eliminates all real estate conflicts. Alternative 3 was carried forward.

Sta. 77+80 to 81+00

A landside levee raise would require relocation of railroad tracks. A T-wall on the levee limits top of levee road accessibility to this area of the unit. The access cannot be rerouted to the landside due to the railroad tracks. Replacement of the levee with a new floodwall eliminates the real estate conflicts and maintains access. Again, Alternative 3 was carried forward.

Sta. 95+00 to 105+00

A landside levee raise would encroach upon an area needed for access to an adjacent business. A T-Wall on top of the levee limits top of levee road access, but access could be rerouted on the landside in the same area as the business access. Thus, Alternative 2 was carried forward.

Sta. 240+00 to 257+66

This section contains two existing levee sections separated by an existing floodwall section. The floodwall has already been identified for replacement as it cannot be structurally modified for raise. A landside raise of the levee sections would encroach upon areas used by adjacent businesses for storage and access. A T-Wall on top of the levee would limit top of levee access. Landside access in this section is already difficult due to the operations of multiple adjacent businesses and the Kansas Avenue bridge approach. Replacement of the levee sections with new floodwall eliminates the real estate conflicts, creates additional area for landside access, and provides for a uniform raise measure for the entire section. Alternative 3 was therefore carried forward.

Sta. 42+50LE to 61+00LE

Even though a landside levee raise would be a very short increase in height, access and implementation of the project would conflict with the adjacent railroad track. A new sandbag gap closure at Sta. 42+50 eliminates this minor unit modification and potentially costly real estate conflict. Alternative 2 was carried forward.

8.3.2 Central Industrial District

Six alternative plans were analyzed in the final evaluation. Each plan includes the same raises of the earthen levee and floodwall sections, the same area fill locations, and the same pump station modification and abandonments. The differences among the plans are related to the new tieback measure; whether or not this measure is included, where the tieback connection is located along the existing alignment, the effect of the new tieback on the proposed relief well system, and what alignment tieback is constructed on between the existing unit and the bluff. The six alternatives are described as follows:

1. Unit stops at Sta. 130+00 and turns to bluff (adds 4 stop log gaps and 15 new relief wells)
2. Unit continues to Sta. 166+80 (adds 83 relief wells/new pump plant/1 stop log gap)
3. Unit stops at Sta. 138+95 and turns to bluff (adds 2 stop log gaps and 30 new relief wells)
4. Unit stops at Sta. 130+00 and turns to bluff (adds 4 stop log gaps/smaller pump station)
5. Unit continues to Sta. 166+80 (adds 83 relief wells/new pump plant/1 stop log gap/header pipe)
6. Unit stops at Sta. 138+95 and turns to bluff (adds 2 stop log gaps and 30 new relief wells with a new pump plant)

The primary differences between the six plans in the final array is whether or not to modify and raise the existing floodwall upstream of station 130+00, or to essentially shorten the unit by constructing a new tieback to the bluff along the eastern edge of the study area. The existing floodwall in this section has already been modified and raised in the past. Although the foundation analysis determined that additional raise could be supported, the actual implementation would be technically very complex. The area inside the unit along this section contains multiple railroad tracks and one abandoned and dilapidated railroad storage warehouse which provide limited economic benefits. Following is a brief discussion of the alternatives in the CID unit.

No Tieback

Alternatives 2 and 5 assume that the existing wall is raised and no tieback is constructed. Each plan includes a new pump station to handle the flow from the additional 83 relief wells and a new stop log closure structure constructed upstream of the existing closure at the end of the unit. Alternative 5 has a different configuration of header piping to collect flows from the relief wells. Both alternatives have the same future with and without-project conditions. Implementation of either alternative will provide reliable flood risk management up to three feet above the 0.2 percent elevation along the full extent of the existing unit alignment. Without project implementation, the reliability of the unit does not meet current criteria and the entire CID study area is subject to inundation from flood events less than the authorized system design event. These alternatives meet all project objectives and are within the project constraints.

Tieback at Sta. 130+00

Alternatives 1 and 4 assume that a tieback is constructed to the bluff starting at Sta. 130+00, immediately downstream of the Kansas City Terminal Bridge. The existing floodwall upstream of Sta. 130+00, including the existing stop log closure at the KC Terminal Bridge, would not be raised. The tieback would require 4 new stop log closure structures and 15 new relief wells. Alternative 4 assumes that a new small pump station would be needed to handle additional relief well flows. Alternative 1 does not include a pump station. Both alternatives have the same future with and without-project conditions. Implementation of either alternative will provide reliable flood risk management up to three feet above the 0.2 percent flood elevation along the existing unit alignment downstream of Station 130+00. Upstream of this location, the existing floodwall would remain in place and continue to provide benefits up to its current elevation. If a flood exceeded this height, this section would overtop causing inundation of the railroad tracks. The new tieback would prevent these floodwaters from entering the rest of the study area up to three feet above the 0.2 percent elevation.

Tieback at Sta. 138+95

Alternatives 3 and 6 assume that a tieback is constructed to the bluff starting at Sta. 138+95. The existing floodwall upstream of this location would not be raised. Under both alternatives, the existing stop log closure at the Kansas City Terminal Bridge would be raised. The tieback itself would be shorter than in other alternatives, and require only two new stop log closure structures. However, an additional 30 new relief wells are needed. Alternative 6 assumes that a new pump station would be needed to handle additional relief well flows. Alternative 3 does not include a pump station. Both alternatives have the same future with and without-project conditions. Implementation of either alternative will provide reliable flood risk management up to three feet above the 0.2 percent flood elevation along the existing unit alignment downstream of Station 138+95. Upstream of this location, the existing floodwall would remain in place and continue to provide protection up to its current elevation. If a flood exceeded this height, this section would overtop causing inundation of the railroad tracks. The new tieback would prevent these floodwaters from entering the rest of the study area up to three feet above the 0.2 percent elevation. Without project implementation, the reliability of the unit does not meet current criteria and the entire CID study area is subject to inundation from flood events less than the authorized system design event. These alternatives meet all project objectives and are within the project constraints.

Cost Screening Evaluation

In July 2008, screening level cost estimates were prepared for the six final alternatives. The results are presented in the following table (October 2008 price level).

Table 22: **CID Preliminary Cost Screening Evaluation**

Alternative	Preliminary Cost ($1000s)
1	$98,624
2	$130,026
3	$89,918
4	$102,580
5	$130,834
6	$96,136

New Pump Station Analysis

Following the initial plan evaluation and cost estimates, further analysis was conducted to determine the technical necessity of a new pump station to handle relief well flows. A review of the existing interior storm drainage system showed that if all proposed new relief wells were installed as surface discharging, there would be adequate capacity to carry the expected flows to existing sewer outlets and pumping facilities. Removing the new pump station from the proposed alternative plans eliminates Alternatives 4, 5, and 6 from further consideration as they are otherwise identical to Alternatives 1, 2, and 3, respectively. Furthermore, with no pump station the estimated cost of Alternative 2 is reduced by approximately $8.9 million, for a new estimate of $121.1 million.

8.4 Screening Benefits Comparison

8.4.1 Benefits Computation

To determine the economic justification of the alternatives, each alternative was entered into the HEC-FDA risk analysis model. The Monte Carlo analysis in HEC-FDA was then run to determine damage reduction and residual damages – i.e., damages that would continue to occur in the with-project condition even with implementation of that alternative. The residual damages that would continue to occur in the with-project condition were expressed as equivalent annual damages that account for both the base year condition and the discounted present-worth of the future year condition. The difference between the without-condition EAD and the residual EAD for each alternative represents the damages reduced or benefits of the alternative.

Screening benefits in this analysis were based on physical inundation reduction to homes, businesses, public facilities, railroads, and streets, as well as emergency costs and relocation/reoccupation costs.

8.4.2 Engineering Data Considerations

Like the economic data, top of levee elevations and hydraulic and hydrologic data also were unchanged from the without-project condition. Given the structural and geotechnical character of all identified deficiencies in the Armourdale and CID units of the Kansas Citys levee system, the most important variable in determining the performance of alternatives in this analysis was the probability of failure function. Each reach has a single probability of failure function accounting for the multiple locations of concern within the reach by combining them at the index point. For the alternatives in this analysis, the probability of failure function for the existing condition at each problem site is modified, consistent with Corps guidance, to reflect the repair by specifying a probability of failure of 0.002 at top of levee and a zero probability of failure at all points below three feet top of levee. The risk program interpolates probabilities between these two points. The modified individual functions then go into a revised combined probability of failure function at the index point, and the risk simulation is repeated to determine residual damages with the project in place and damages reduced (i.e., benefits).

8.5 Screening Cost Estimates

Screening-level costs are summarized in Table 23. Costs were prepared by cost engineering staff for each of the alternatives. All costs include interest during construction computations, which assume project completion in 2030. All screening costs reflect an October 2012 price level, and the annualized totals reflect the current Federal interest rate of 3.75 percent as well as a 50-year period of analysis.

The costs for operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) were estimated for each alternative and are based on life cycle cost analysis. The analyses only include the net additional OMRR&R costs the sponsors would be expected to incur based on the new proposed unit modifications. The analyses considered and accounted for the new additional OMRR&R in each year of occurrence, and then computed a present worth value of the future OMRR&R costs. The present worth value was then annualized using the current federal interest rate of 3.75 percent and a 50 year period of analysis.

The new additional (net) OMRR&R costs that the sponsors would be responsible for are due to the new additional relief wells required for each alternative. Each new well is assumed to be maintained every 4 years at an estimated cost of $5,000 per well and replaced after 40 years at a replacement cost of $45,000. Replacement costs include 10 percent E&D and 7 percent S&A. The sponsor would continue to incur costs for any existing relief wells but these costs are ongoing for the existing project and are not included in the analysis of the proposed project.

Table 23: **Screening Cost Estimates**

Oct 2012 prices; 3.75% interest rate; 50 year period of analysis; $1000s

	Armourdale	Central Industrial District
Construction	$ 150,810.0	$ 51,150.0
Lands and Damages (LERRD)	$ 10,640.0	$ 5,218.0
Planning, Engineering & Design (PED)	$ 11,410.0	$ 3,895.0
Construction Management (S&A)	$ 10,592.0	$ 3,616.0
Contingencies	$ 49,532.0	$ 19,803.0
Total First Cost	**$ 232,984.0**	**$ 83,682.0**
Interest During Construction (IDC)	$ 60,898.6	$ 23,447.0
OMRR&R	$ 419.0	$ 142.0
Total Annual Costs	**$ 13,518.6**	**$ 4,917.2**
Total first costs - PED + LERRD + construction + S&A		
Annual costs = ((Total first costs + IDC) x I&A factor of 0.004457) + OMRR&R		
Annual OMRR&R costs include only additional or net costs over and above existing costs		

8.6 Summary of Economic Screening of Alternatives

Table 24 displays a summary of total annual costs (including increases in OMRR&R costs), annual benefits, benefit-cost ratios, and net benefits for each of the Phase 2 alternatives evaluated. The Phase 1 Argentine unit benefits and costs from the 2012 Kansas Citys economic update are included in the table for the purpose of showing a Kansas River system benefit-cost ratio.

Table 24: **Economic Screening Summary**

Oct 2012 prices; 3.75% interest rate; 50 year period of analysis; $1000s

Levee Unit Alternative	Annual Costs	Annual Benefits	Benefit-Cost Ratio	Net Benefits
Armourdale				
Nominal 500+3 Raise	$ 13,518.6	$ 50,006.8	3.7	$36,488.2
Central Industrial District				
Nominal 500+3 Raise	$ 4,917.2	$ 7,389.0	1.5	$ 2,471.8
Total Phase 2 Study Area	**$ 18,435.8**	**$ 57,395.9**	**3.1**	**$38,960.0**
Argentine 500+3 Raise*	$ 3,350.0	$ 18,175.2	5.4	$14,825.2
Kansas River System	**$ 21,785.8**	**$ 75,571.1**	**3.5**	**$53,785.3**
*From approved FY12 NWK Economic Update - Kansas Citys Levees				

8.7 Economic Performance of Screening Alternatives Considered

The economic performance and effectiveness of the final array of alternatives in each unit are compared in Table 25 below. The table displays the probabilistic values of equivalent annual damage (EAD) and EAD reduced, thus showing the impact of uncertainty in evaluation of project benefits. The damages reduced represent the project benefits, and are shown in terms of annualized equivalent values as computed in the HEC-FDA program.

Table 25**: Economic Performance of Alternatives**

Oct 2012 prices; 3.75% interest rate; 50 year period of analysis; S1000s

	Equivalent Annual Damages			Probability EAD Reduced		
Plan	Without Plan	With Plan	Damage Reduced	0.75	0.50	0.25
Armourdale						
Nominal 500+3 Raise	$53,836.52	$3,829.69	$50,006.83	$35,270.21	$48,487.64	$62,214.96
Central Industrial District						
Nominal 500+3 Raise	$10,899.63	$3,510.61	$ 7,389.03	$ 2,463.68	$ 5,533.37	$10,449.73
Total	**$64,736.15**	**$7,340.30**	**$57,395.86**	**$37,733.89**	**$54,021.01**	**$72,664.69**

8.8 Engineering Performance of Screening Alternatives Considered

As shown in Table 24, implementation of the NED plan would improve the engineering performance for both units, with annual exceedance probability of 0.035 reduced to 0.0012 for Armourdale and a corresponding reduction from 0.0047 to 0.0012 for CID. Conditional exceedance probability in a 1 percent event would be reduced from 0.5457 and 0.2004 for Armourdale and CID in the future without-project condition to 0.0126 and 0.0117 respectively.

Table 26: **Engineering Performance of Alternatives**

Engineering Performance - Future With Project

	Armourdale	Central Industrial District	Argentine
Annual Exceedance Probability* (median)	0.0012	0.0012	0.0020
Return interval (years)	833	833	500
Long Term Risk (chance of exceedance during indicated period)			
over 10 years	0.0162	0.0194	0.0194
over 30 years	0.0400	0.0478	0.0478
over 50 years	0.0785	0.0934	0.0933
Conditional Exceedance Probability - Overtopping or Breach**			
10.0% event	0.0000	0.0003	0.0000
4.0% event	0.0000	0.0003	0.0000
2.0% event	0.0003	0.0003	0.0005
1.0% event	0.0126	0.0117	0.0147
0.4% event	0.1429	0.1206	0.1517
0.2% event	0.3454	0.3026	0.3586
*Annual exceedance probability is the chance of experiencing any flood event - of whatever magnitude - within any year			
**Conditional exceedance probability is the probability that specified flood event would overtop or breach the levee			

8.9 Future With-Project Condition Summary

8.9.1 NED Effects of Selected Plan

The overall NED contribution to the national economy is about $39.0 million, which are the total net benefits of the Phase 2 project. The project would reduce the existing condition EAD of $64.8 million to $7.3 million in residual EAD.

8.9.2 RED Effects of Selected Plan

Construction of the alternatives considered would contribute to the long term stability of both the Armourdale and CID units. Plans considered do not require acquisition or relocation of residents or businesses and there would be no impacts to the local tax bases due to demolition or removal of structures. With increased levee unit reliability and performance, existing businesses would be expected to continue their existing occupancy in each unit and new businesses and investment would be more easily attracted to the units in the future, resulting in a stronger tax base. With continued industrial and commercial stability enhanced by the increased reliability against flooding, existing neighborhoods and populations would also be expected to remain relatively stable, barring impacts from other sources. Temporary increases in employment would be expected during construction and the temporary presence of construction workers for the project may bring a temporary increase in demand for some services in the local area, but also a temporary increase in business volume, profits, and sales tax receipts at the local retail and service establishments.

8.10 Residual Risk

Although floodplain users and occupants may desire total protection from flooding, it cannot be overemphasized that this is an unachievable goal. No flood risk management project can guarantee total elimination of flooding. Therefore, it is important for floodplain users and occupants to be aware of the level of flood risk that remains even after implementation of a recommend project.

The selected plan has substantial economic benefits and reduces study area damages in the existing conditions by more than 88 percent. The probability and occurrence of flooding will be greatly diminished. But significant residual equivalent annual damages remain totaling $7.3 million. There would be a 1 in 11 chance of exceedance for CID and Argentine and 1 in 13 chance of exceedance for Armourdale over a 50-year period. For comparison purposes the future without-project condition indicates a 1 in 2 chance of exceedance for Armourdale and Argentine and 1 in 3 chance of exceedance for CID.

The median annual exceedance probability of 0.0012 for both Phase 2 units and .0010 for Argentine indicates that there is a 0.12 and 0.10 percent chance of a damaging flood event in any given year for those respective units.

If the capacity of the federal levee system is exceeded in a particular event, most of the areas inside the levees would be affected due to the flat floodplain topography in these areas. If the amount of water that gets through or over the levees is sufficient to produce severe flood depths, damages in the study area probably would reach $60 million or more. Large-scale evacuations of neighborhoods would be necessary, followed by relocation assistance. A number of important sections of streets and railroad would be closed and in some cases inundated. Inundation depths can range from in excess of 6 to 10 feet in CID and 10 to 15 feet in Armourdale.

Effective emergency planning in advance is the best way to protect communities and minimize the damage from these rare flood events.

9.0 Conclusion

It can be seen in Table 24 that in addition to the strong benefit-cost ratio for the Kansas River system-wide project, each unit is also individually justified. The combined Phase 2 portion of the total project has a benefit-cost ratio of 3.1, while Armourdale unit's benefit-cost ratio is 3.7 and the CID portion stands at 1.5. With Phase 2 net benefits of $39.0 million, the project represents a strong contribution to national economic outputs.

10.0 Economic Update Plan

ER 1105-2-100, paragraph D-4, requires a plan for conducting updates of the project economic justification. Economic updates, revisiting estimated damages, benefits, and costs, will be required every three years. Updates are not intended to involve major economic analyses or extensive reworking of the feasibility study analysis. They are intended to verify the continuing validity of important assumptions on which the economic justification is founded as well as to convert data to current price levels. It is currently expected that the first economic update would be required in FY 2017.

Project economic justification updates will include the following tasks:

1. Data gathering -- Information supporting the floodplain inventory will be updated as follows:
   - Windshield survey of study area – A windshield survey including all major portions of the study area will be carried out to initially identify major changes in the scale or condition of residential and nonresidential properties and transportation networks.
   - Discussions with local leaders and research – City and/or Chamber of Commerce staff will be consulted to further help indentify major changes of the previous three years pertaining to the economic structure inventory and particularly to major nonresidential properties. Discussions will encompass verification of continuing operations at major properties, identification of significant changes in operational scale at major businesses and facilities, and identification of significant new development including major new businesses, public facilities, residential developments, and roads and streets. Business owner/operators may also be consulted briefly for general information on operational scale.
   - Additional research – Available information on the internet will be consulted, including totals for new construction permits.

2. Economic structure inventory revisions – Completion of the first task may lead to the conclusion that there have been no changes since the feasibility report that would affect the overall economic justification of the project, in which case a Level 1 update will be prepared that will reaffirm the feasibility study benefits, the economic database will be revised based on the first task, as follows:
   - Major existing businesses and public facilities – For the enterprises accounting for a large share of damages and project benefits, structure values will be updated using RSMeans square foot cost values and depreciation factors. Contents will be adjusted as appropriate based on information gathered from the first task.
   - Other existing nonresidential properties – Structure values of the remaining businesses and public facilities will be updated using CCI (Construction Cost Index, Engineering News Record) factors to bring replacement costs up to current price levels. An average depreciation factor for the three-year increment based on RSMeans data will then be applied to produce updated depreciated replacement structure values.
   - Residential values – Residential updating will be based on the sample of 301 properties used to determine depreciated replacement structure values in the feasibility analysis. Depreciated replacement structure values of the sample properties will be updated individually using RSMeans cost per square foot values and appropriate individual depreciation rates. The average sample change in replacement value versus the feasibility or previous update will be applied to replacement values for the remainder of the residential database. An average depreciation factor will be applied to produce updated depreciated replacement values.

- Transportation network – Use of generalized indices such as CWCCIS will be used for specific infrastructure benefit categories such as roads and rail lines provided these benefit categories do not constitute a major portion of overall project benefits.
- New development – For significant new additions to or reductions in the property base, including large businesses and facilities, major new roads and streets, and significant new residential projects, appropriate adjustments will be made to the property inventory when properties could account for a disproportionately large share of benefits in view of their structure and content values as well as their damage susceptibility.
- Other categories of benefits – For disaster relief costs, the average percentage change in value will be computed for the residential category and applied to the relief costs. For production losses, the average percentage change in value for the nonresidential category will be computed and applied. Emergency costs will be updated using an average encompassing both the residential and nonresidential percentage changes.

3. Benefit-cost data computation
    - HEC-FDA analysis – The HEC-FDA program will be loaded with the updated property database and new damage and benefit estimates will be produced.
    - Costs and benefit-cost ratios – An updated cost estimate will be prepared by engineering staff and annualized (this will be true whether or not the benefits need to be revised rather than reaffirmed). Benefit-cost ratios and net benefits will be calculated based on the updated benefits and costs.

4. Population – Estimates of affected population and population at risk will be updated if significant new Census data are available.