FEASIBILITY REPORT
TOPEKA, KANSAS, LOCAL FLOOD PROTECTION PROJECT

APPENDIX D

SOCIOECONOMIC ANALYSIS

July 2008

DEPARTMENT OF THE ARMY
Kansas City District, U.S. Army Corps of Engineers
Kansas City, Missouri

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1.0 INTRODUCTION

1.1 PURPOSE

This feasibility-level economic analysis provides an accounting of all properties protected by the units of the Topeka Federal Local Protection Project. The inventory serves as the database for a risk-based analysis which evaluates project performance by simulating a large number of possible flood events, taking into account all pertinent economic and engineering data including uncertainty factors. This analysis yields several outputs:

- Description and quantification of economic and social flood damage impacts to properties within the study area in the existing condition;

- Statistical estimates of project engineering performance or reliability under existing conditions in the context of a range of possible flood events;

- Estimated economic performance of alternatives formulated to improve project performance, in terms of residual damages, damages prevented, annualized benefits and costs;

- Statistical estimates of enhanced project engineering performance provided by each alternative;

- Economic optimization of alternatives and identification of the most economically efficient alternative;

- Characterization of the selected plan in terms of economic performance (annual benefits and costs, residual damages) and engineering performance.

1.2 STUDY GUIDANCE

Pertinent guidance governing economic analysis procedures includes:

- “Economic and Environmental Principles and Guidelines for Water and Related Resources Implementation Studies” (P&G), dated March 1983;

- Engineering Regulation (ER) 1105-2-100, “Planning Guidance Notebook,” dated 22 April 2000 (partially updated subsequently);

- Engineer Manual (EM) 1110-2-1619, “Risk-Based Analysis for Flood Damage Reduction Studies,” dated 1 August 1996;

- ER 1105-2-101, “Risk-Based Analysis for Evaluation of Hydrology/Hydraulics, Geotechnical Stability, and Economics in Flood Damage Reduction Studies," dated 1 March 1996.

1.3 STUDY AREA LOCATION

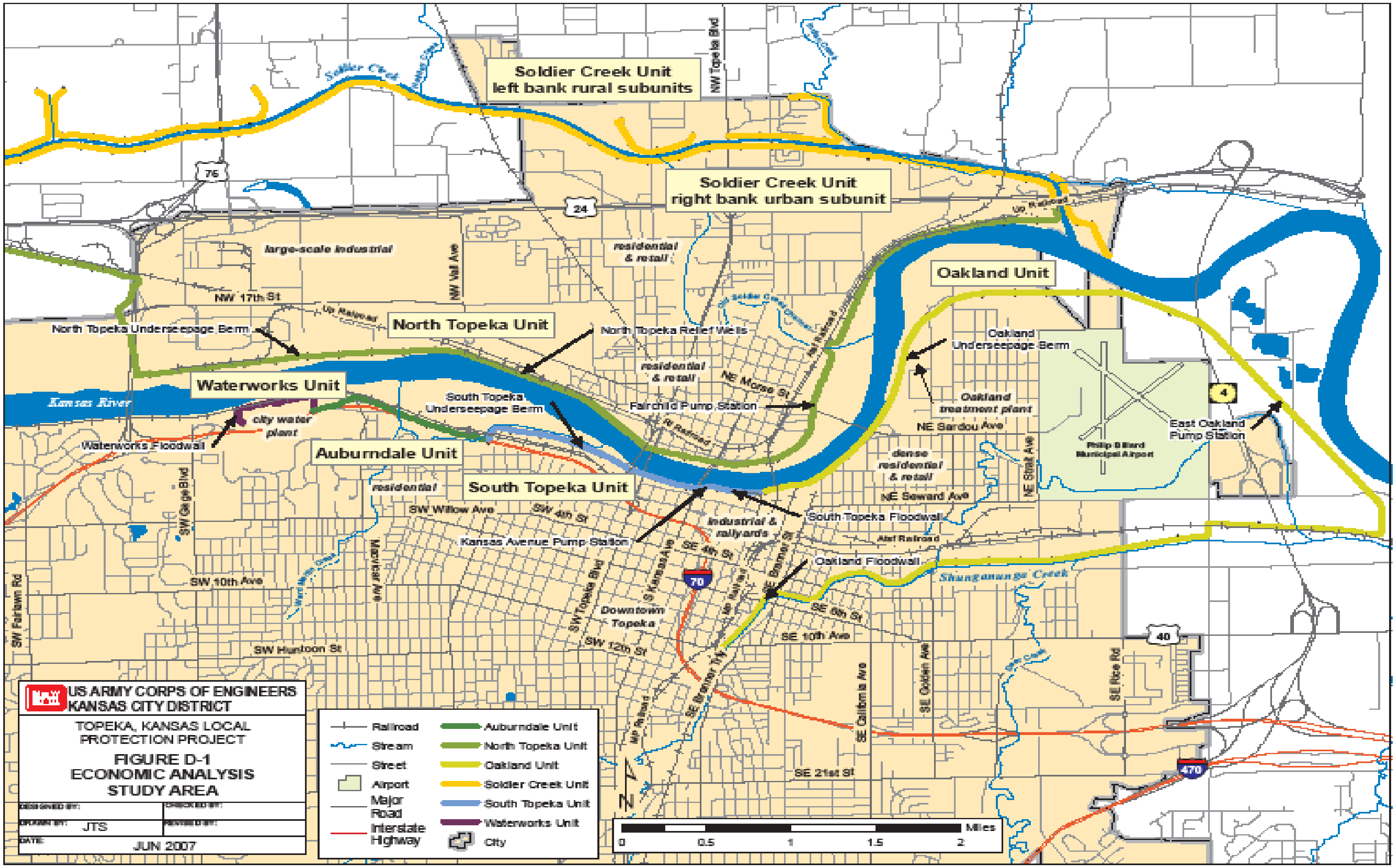
Topeka, the state capital of Kansas, is located in Shawnee County in east central Kansas, about 60 miles west of Kansas City, Missouri. It is situated on the main stem of the Kansas River, covering the area between river miles 76 and 90. The city's downtown and the capitol building are at mile 84. Within this broad area, this analysis specifically is concerned with leveed portions of the floodplains of the Kansas River, Soldier Creek and Shunganunga Creek in Topeka and adjoining areas. Adjacent unprotected areas along the right bank of Shunganunga Creek and the left bank of Soldier Creek are also considered in certain contexts. However, the term "study area," as used in this report, will refer to those portions of the metropolitan Topeka area protected by the Federal project.

1.4 FEDERAL PROJECT OVERVIEW

The Topeka Local Protection Project was originally authorized in the Flood Control Act of 1936, while subsequent modifications were authorized in the Flood Control Act of 1954. The project primarily consists of six units. Four of the six – Waterworks, Auburndale, South Topeka, and Oakland – form a continuous levee system protecting areas of central and eastern Topeka along the right or south bank of the Kansas River main stem. A fifth unit, North Topeka, protects most of the urban area on the opposite or left bank of the main stem. The sixth unit, Soldier Creek, protects the same North Topeka area from Soldier Creek and additionally protects several rural areas along the northern edge of the study area. The original project also included two additional units comprised of railroad and street bridge and approach alterations as well as channel and floodway improvements in the same areas as the levee units. This analysis is mainly concerned with the six levee units, which are shown on Figure 1 and described below.

1.4.1 Waterworks Project Description. This unit, which protects the city's water plant, is at the upstream end of the four levee units on the Kansas River's right or south bank (Kansas River miles 87.2 to 86.7). The downstream end of the unit ties into the Auburndale Unit. The levee and floodwall have a combined length of 0.8 miles. This unit was one of the first units constructed in the Topeka system, completed in 1938, and was operational during the 1951 flood. Subsequent construction to augment the project was completed in 1959.

1.4.2 Auburndale Project Description. Immediately downstream from the Waterworks unit on the Kansas River right bank, the Auburndale levee ties into the Waterworks unit at its upstream end (river mile 86.7) and the South Topeka unit at its downstream end (mile 85.5). The levee is approximately 1.5 miles long, including tieback, and is largely constituted by the I-70 highway embankment. Construction was initiated in 1959 and completed in 1962. The levee protects portions of an older neighborhood and a few businesses serving the neighborhood.


US ARMY CORPS OF ENGINEERS
KANSAS CITY DISTRICT
TOPEKA, KANSAS LOCAL
PROTECTION PROJECT
FIGURE D-1
ECONOMIC ANALYSIS
STUDY AREA
DRAWN BY: JTS
DATE: JUN 2007
Railroad
Stream
Street
Airport
Major Road
Interstate Highway
Auburndale Unit
North Topeka Unit
Oakland Unit
Soldier Creek Unit
South Topeka Unit
Waterworks Unit
City
Miles
0
0.5
1
1.5
2
Soldier Creek Unit
left bank rural subunits
Soldier Creek Unit
right bank urban subunit
Oakland Unit
North Topeka Unit
Waterworks Unit
Auburndale Unit
South Topeka Unit
large-scale industrial
residential & retail
North Topeka Underseepage Berm
North Topeka Relief Wells
South Topeka Underseepage Berm
Fairchild Pump Station
Oakland Underseepage Berm
Oakland treatment plant
East Oakland Pump Station
Philip Billard Municipal Airport
city water plant
Waterworks Floodwall
dense residential & retail
industrial & railyards
South Topeka Floodwall
Kansas Avenue Pump Station
Oakland Floodwall
Downtown Topeka
Kansas River
Soldier Creek
Shunganunga Creek
NW 17th St
NW Topeka Blvd
NE Morse St
NE Sardou Ave
NE Seward Ave
SW Willow Ave
SW 4th St
SE 4th St
SW 10th Ave
SW Huntoon St
SW 12th St
SE 6th St
SE 10th Ave
SE 21st St
SW Fairlawn Rd
SW Gage Blvd
SW Topeka Blvd
SE California Ave
SE Golden Ave
SE Rice Rd
NE Strait Ave
24
40
70
75
470

1.4.3 South Topeka Project Description. The South Topeka unit, like the Waterworks unit, is one of the older units in the system. The original levee was built in 1938 and was operational on a smaller scale during the 1951 flood, and subsequent construction was completed in 1971. The

unit, which includes about 1.8 miles of levee and floodwall, ties into the Auburndale unit at its upstream end (mile 85.5) and the Oakland unit at its downstream end (mile 83.7). This unit protects a significant industrial area and a small quantity of homes.

Although the Oakland levee and the adjoining South Topeka unit are ostensibly separate units of the Topeka system, the two units are not hydraulically independent, inasmuch as flooding in South Topeka can also enter the Oakland area. However, the reverse situation - flooding in Oakland entering South Topeka - cannot occur because of the topography. For this reason, the areas protected by these two units are treated as partially dependent in this analysis. See section 4.7.3 for a description of how this issue is modeled.

1.4.4 Oakland Project Description. The Oakland unit is at the downstream end of the four right bank Kansas River units (miles 83.7 to 76.0). The unit consists of about 10.2 miles of levee and floodwall, including a tieback preventing flooding along Shunganunga Creek. Construction was initiated in 1962 and completed in 1969. The protected area contains densely populated residential areas and retail/service hubs as well as an airport, treatment plant, and agricultural land uses.

1.4.5 North Topeka Project Description. The North Topeka area is protected from both the Kansas River on the south and Soldier Creek on the north. The North Topeka unit on the Kansas River left (or north) bank is a 9 mile-long levee protecting a large area extending from approximately mile 80.8 to 88.8. Construction started in 1962 and was completed in 1967. The protected area contains many densely populated neighborhoods and service areas as well as industrial areas and a small amount of agriculture.

1.4.6 Soldier Creek Project Description. Soldier Creek is a left bank Kansas River tributary running through North Topeka and entering the Kansas River at approximately mile 80.6. Prior to its diversion, the creek entered the river at mile 82.2. The Soldier Creek unit consists of a series of levees totaling 17.9 miles along both banks of the creek. The main Soldier Creek levee, on the creek's right or south bank from miles 0.2 to 7.2, protects the same North Topeka urban area that is protected from the Kansas River by the North Topeka unit. In addition to the large urban levee, there are seven smaller levees (six of which are on the left or north bank) protecting rural areas of either agricultural or residential land use. Federal construction of the unit was initiated in 1957 (building on much older construction by local interests) and completed in 1961.

2.0 SOCIOECONOMIC DESCRIPTION

2.1 CITY AND GENERAL STUDY AREA SOCIOECONOMIC CHARACTERISTICS

2.1.1 Study Area Land Use. The Federal project protects a total of 11,059 acres in Topeka, representing about 31% of the city's total land area. As summarized in Table D-1, the largest leveed areas are North Topeka and Oakland. The North Topeka area includes 6,076 acres that are protected by two units of the system: North Topeka and Soldier Creek. The Oakland area contains 3,208 acres. The four right bank Kansas River main stem units account for a total of 10.7 miles of leveed riverfront and protect 3,926 acres, while the left bank main stem unit accounts for 8 miles of leveed riverfront and protects 6,076 acres. In addition to the urban North Topeka area, the Soldier Creek unit protects an additional 1,057 acres in rural areas. These seven leveed areas range from 39 to 449 acres in area.

Densely populated urban neighborhoods characterize Auburndale, most of the western two-thirds of Oakland, and the eastern two-thirds of North Topeka. Industrial land uses dominate the Waterworks area, the western portion of North Topeka, almost all of South Topeka, and the southwestern and eastern portions of the Oakland area. A number of neighborhood retail and service areas are scattered throughout Oakland and North Topeka, which also has a riverfront old town area of offices, stores and services. Agricultural land uses are found primarily in the northern portions of Oakland, the western portions of North Topeka, and especially along the left bank of Soldier Creek.

TABLE D-1

PROTECTED AREA ACREAGE

Reach	Acres
Waterworks	35.8
Auburndale	308.5
South Topeka	301.0
Oakland	3,280.8
North Topeka	6,076.3
Soldier Creek left bank	1,056.5
TOTAL PROTECTED AREA	**11,058.9**

Source: KC District USACE GIS estimates

2.1.2 Study Area Population and Social Characteristics. Topeka, with a 2006 estimated population of 122,113, is the fourth largest city in Kansas, after Wichita, Kansas City, and Overland Park. The city ranks 195th among all U.S. cities in population. Population is down slightly from the 123,101 recorded in the 2000 Census, as the area's population continues to redistribute itself from the center city to the suburbs, but is up about 2% from the 1990 total of 119,883. Shawnee County grew 5.5% during the 1990-2000 period and has grown 1.5% since the 2000 Census to its current (2006) estimated population of 172,693. The Topeka Metropolitan Statistical Area (MSA), meanwhile, has seen a 1.9% increase in population from 224,551 in 2000 to 228,894 in 2006. (Note: The Topeka MSA has been redefined since the 2000 Census when it was defined as Shawnee County, and is now a much larger area.)

Table D-2 lists the Census areas defining the study area, including tracts, block groups and blocks. Census blocks, the smallest area units defined by the Census Bureau, are small areas that often correspond to a city block in urban areas but can be much larger in rural areas. Blocks usually contain somewhat more than a thousand residents. The specific blocks within the study area are noted in the table. Population and housing units data from the 2000 Census are available for Census blocks and allow a fairly accurate accounting of study area population, as summarized in Table D-3. By this reckoning, the 2000 population of the study area was 16,098, with 7,153 housing units. (1990 data are not summarized here since they are not available for all blocks.) If the adjacent unprotected areas along Shunganunga and Soldier Creeks are included, the total population was 17,535 with 7,724 housing units. The study reaches with the largest population are Oakland and North Topeka, which respectively account for 43.7% and 41.8% of the total study area population. Auburndale accounts for an additional 9.1%, the rural Soldier Creek left bank reaches account for 4.1%, and South Topeka accounts for 1.3%. The Waterworks reach has no residents. About 13.1% of the city's total population resided within the study area in 2000.

Most other socioeconomic data besides population and number of households are not readily available at the block level. Instead, Tables D-4 and D-5 summarize a range of socioeconomic indicators from the 2000 Census for the block groups comprising the study area. Block groups are subdivisions of tracts and are the smallest areas for which the Census Bureau tabulates sample data. (Tracts, in turn, are socioeconomically homogeneous subdivisions of counties that usually average about 4,000 residents.) The totals for each area are weighted averages, weighted by either the population or the number of housing units in the block group. Note that the block group data cover areas that sometimes go beyond the study area, especially in the Soldier Creek left bank area, resulting in larger (sometimes much larger) estimates of population, housing and other characteristics than a block-level accounting.

A number of conclusions can be drawn concerning the study area population and housing stock from the data in Tables D-4 and D-5. Per capita income (2000) in the study area was $17,596, which was only 90% of the Topeka per capita income ($19,555), 84% of Shawnee County ($20,904), 86% of the state ($20,506), and 82% of the national total ($21,587). Study area residents were more likely to have incomes below the poverty level (12.6% vs. 12.4% in the city and 9.6% in the county) or to be unemployed, and were somewhat less educated. The study area population was 83.6% white, slightly higher than the Shawnee County percentage (82.9%) and significantly higher than the city (78.5%) and the nation (75.1%). The percentage of whites in the overall population varies a great deal between different parts of the study area, as will be seen below. Hispanics account for 12% of the population, which is about on a par with the national average but much higher than the city, county and state totals. African Americans account for only 5.4% of study area population, slightly lower than the state total of 5.7% and much lower than the Topeka total of 11.7% and the national total of 12.3%.

In housing, the average value of owner units in the study area was $66,148, which was only 81% of the Topeka average, 70% of the county average, and 64% of the statewide average. The relatively low home values undoubtedly are related to the age of the study area housing stock, which was 46.1 years old on average compared to 39.7 for Topeka and 36.9 for the county. The statistics showed somewhat greater neighborhood stability in the study area relative to larger areas. Renter-occupied housing was less prevalent in the study area at 29.8%, compared to 32.5% in Shawnee County and 39.2% in Topeka, and a larger percentage of home owners had lived in the same home for five years prior to the 2000 Census - 53% in the study area vs. 46.7% in the city and 49.9% in the county. However, the latter statistics are somewhat skewed by the rural Soldier Creek left bank block groups, which are large areas that include numerous residents outside the study area. The study area vacancy rate of 7.9% exceeded the city rate of 7.5% and the county rate of 6.6%.

TABLE D-2

CENSUS AREAS INCLUDED IN STUDY AREA

Census tract	Block group	Blocks included	Portions of study area included
6	1	1000, 1007-1011	South Topeka (upstream portion)
7	1	all	North Topeka (central)
7	2	all	North Topeka (US 24 Highway area)
8	1	1001-1002, 1040-1046, 1050-1055	Soldier Creek left bank rural (downstream end)
8	1	1004-1006, 1009-1032, 1034-1035, 1056-1060	North Topeka (downstream end)
8	2	all	North Topeka (central)
8	3	all	North Topeka (central)
8	4	all	North Topeka (old town area)
9	1	all	Oakland (extreme NW portion)
9	2	all	Oakland (treatment plant area)
9	3	all	Oakland (west of airport)
9	4	4000-4029, 4037	Oakland (airport area)
10	1	all	Oakland (airport area)
10	2	all	Oakland (central)
10	3	all	Oakland (central)
10	4	all	Oakland (central)
11	1	1003-1004	Oakland (central)
11	2	2000-2006, 2025-2035	Oakland (central)
11	3	3005-3011	Oakland (central)
21	4	4005-4006	Auburndale (southern)
21	5	5001-5005, 5009-5012	Auburndale (southern)
22	1	1001-1019, 1021-1024, 1027, 1030-1031	Auburndale (northern potion)
22	1	1000	South Topeka (extreme southern end)
22	3	3000-3012, 3014-3017, 3020-3021	Auburndale (central)
33.01	1	1020-1023, 1025	Soldier Creek left bank rural
34	1	1029, 1033	Soldier Creek left bank rural
34	2	2056-2058	Soldier Creek left bank rural
34	2	2061-2063	North Topeka (NW portion)
35	1	1083, 1090-1091	Soldier Creek left bank rural
35	1	1117-1122, 1124-1125, 1132-1134	North Topeka (upstream end)
40	1	1000-1047, 1053-1063, 1078-1083, 1087-1088	South Topeka (RR yards)
40	2	2002-2005, 2040-2043	South Topeka (southern)
40	3	3000	South Topeka (southern end)
41	1	1014	Waterworks; Auburndale (W edge)
41	2	2000	Auburndale (SW portion)

TABLE D-3

STUDY AREA POPULATION AND HOUSING

Based on 2000 Census blocks contained in study area

	Population	Households		Population	Households
WATERWORKS			**NORTH TOPEKA**		
Tract 41, Block Group 1	0	0	Tract 7, Block Group 1	1,211	549
TOTAL WATERWORKS	0	0	Tract 7, Block Group 2	2,097	779
AUBURNDALE			Tract 8, Block Group 1	635	308
Tract 21, Block Group 4	29	14	Tract 8, Block Group 2	883	447
Tract 21, Block Group 5	260	139	Tract 8, Block Group 3	884	433
Tract 22, Block Group 1	565	273	Tract 8, Block Group 4	925	435
Tract 22, Block Group 3	584	267	Tract 34, Block Group 2	39	15
Tract 41, Block Group 1	0	0	Tract 35, Block Group 1	51	22
Tract 41, Block Group 2	30	18	**TOTAL NORTH TOPEKA**	**6,725**	**2,988**
TOTAL AUBURNDALE	**1,468**	**711**	**SOLDIER CREEK LEFT BANK**		
SOUTH TOPEKA			Tract 8, Block Group 1	135	58
Tract 6, Block Group 1	101	54	Tract 33.01, Block Group 1	211	73
Tract 22, Block Group 1	0	0	Tract 34, Block Group 1	81	37
Tract 40, Block Group 1	110	62	Tract 34, Block Group 2	146	55
TOTAL SOUTH TOPEKA	**211**	**116**	Tract 35, Block Group 1	91	33
OAKLAND			**TOTAL SOLDIER CREEK LB**	**664**	**256**
Tract 9, Block Group 1	634	239	**(UNPROTECTED) SOLDIER CREEK LEFT BANK**		
Tract 9, Block Group 2	1,110	464			
Tract 9, Block Group 3	799	374	Tract 33.01, Block Group 1	442	167
Tract 9, Block Group 4	296	100	Tract 35, Block Group 1	4	2
Tract 10, Block Group 1	863	437	**TOTAL UNPROTECTED SOLDIER**	**446**	**169**
Tract 10, Block Group 2	902	394	**(UNPROTECTED) SHUNGANUNGA CREEK RIGHT BANK**		
Tract 10, Block Group 3	616	270			
Tract 10, Block Group 4	1,105	485	Tract 9, Block Group 4	55	20
Tract 11, Block Group 1	0	0	Tract 11, Block Group 1	744	313
Tract 11, Block Group 2	444	217	Tract 11, Block Group 2	192	69
Tract 11, Block Group 3	66	25	**TOTAL SHUNGANUNGA RB**	**991**	**402**
Tract 40, Block Group 1	191	74			
Tract 40, Block Group 2	4	3	**TOTAL, PROTECTED AREAS**	**16,098**	**7,153**
Tract 40, Block Group 3	0	0	**TOTAL, UNPROTECTED**	1,437	571
TOTAL OAKLAND	**7,030**	**3,082**	**TOTAL STUDY AREA**	**17,535**	**7,724**

TABLE D-4
STUDY AREA POPULATION CHARACTERISTICS

(Data from 2000 Census)	Population									
	Population	% White	% Black or African American	% Hispanic	% Foreign Born	Median Age	% Adults over 25 with H.S. Diploma or More	Per Capita Income	% Indiv. Below Poverty Level	Unemploy. Rate (%)
U.S.	281,421,906	75.1	12.3	12.5	11.1	35.3	80.4	$21,587	12.4	5.8
Kansas	2,688,418	86.1	5.7	7.0	5.0	35.2	86.0	$20,506	9.9	4.2
Shawnee County / Topeka MSA	169,871	82.9	9.0	7.3	2.7	37.1	88.1	$20,904	9.6	4.0
Topeka city	122,377	78.5	11.7	8.9	3.3	36.3	85.9	$19,555	12.4	4.8
STUDY AREA TOTAL OR AVG.	**36,775**	**83.6**	**5.4**	**12.0**	**26.6**	**n.a.**	**81.1**	**$17,596**	**12.6**	**5.8**
AUBURNDALE										
Tract 21 BG 4	703	91.0	3.8	3.4	1.7	36.4	86.4	$22,168	1.7	3.2
Tract 21 BG 5	538	90.1	3.7	3.2	0.0	36.7	96.1	$18,002	5.8	6.7
Tract 22 BG 1	780	89.1	3.7	4.1	1.2	36.1	93.0	$18,707	10.3	4.1
Tract 22 BG 3	810	90.4	1.9	7.0	0.0	39.1	81.3	$16,263	9.6	0.0
Tract 41 BG 1	1,357	89.4	5.4	0.9	1.5	40.2	86.8	$21,438	5.7	1.9
Tract 41 BG 2	996	93.7	2.3	3.3	1.3	35.1	94.5	$18,791	3.2	0.7
Total Auburndale	**5,184**	**90.6**	**3.6**	**3.4**	**37.6**	**n.a.**	**89.3**	**$19,452**	**6.0**	**2.4**
SOUTH TOPEKA										
Tract 6 BG 1	1,140	80.5	5.1	11.6	0.4	30.6	78.0	$10,140	42.0	10.6
Tract 40 BG 1	713	62.7	8.8	34.6	18.1	32.7	61.3	$10,570	35.2	14.9
Total South Topeka	**1,853**	**73.7**	**6.5**	**20.4**	**31.4**	**n.a.**	**71.6**	**$10,305**	**39.4**	**12.3**
OAKLAND										
Tract 9 BG 1	634	82.8	1.9	16.1	1.4	31.1	83.8	$14,801	0.0	9.9
Tract 9 BG 2	1,110	85.6	1.8	13.1	0.0	32.1	83.2	$14,431	7.3	11.6
Tract 9 BG 3	799	87.3	1.5	10.4	0.0	37.4	84.0	$13,124	12.9	6.3
Tract 9 BG 4	1,048	86.4	3.1	12.3	1.5	41.4	71.8	$16,192	12.4	1.1
Tract 10 BG 1	863	84.0	2.1	22.6	4.9	43.7	67.2	$17,133	8.2	18.9
Tract 10 BG 2	902	78.0	1.9	25.9	8.7	34.4	73.3	$13,785	10.8	0.0
Tract 10 BG 3	616	66.4	0.5	52.9	4.5	38.2	79.1	$15,695	10.9	9.8
Tract 10 BG 4	1,105	68.5	2.8	40.6	2.9	36.8	68.1	$17,551	16.0	2.6
Tract 11 BG 1	1,033	52.3	23.4	28.6	11.4	30.3	62.7	$14,113	20.4	4.7
Tract 11 BG 2	995	44.0	19.0	41.5	19.1	28.4	60.1	$10,660	32.1	10.3
Tract 11 BG 3	1,148	44.3	18.9	51.1	32.3	28.6	53.3	$9,206	27.1	13.3
Tract 40 BG 2	770	58.6	28.8	16.5	5.6	33.4	80.8	$5,784	36.0	14.9
Tract 40 BG 3	792	49.2	34.8	15.3	4.2	34.8	58.4	$10,753	41.0	13.4
Total Oakland	**11,815**	**67.7**	**10.9**	**27.1**	**8.1**	**n.a.**	**70.3**	**$13,361**	**18.4**	**8.7**
NORTH TOPEKA										
Tract 7 BG 1	1,211	87.4	5.9	4.3	2.6	35.1	76.1	$13,125	12.4	7.6
Tract 7 BG 2	2,097	86.7	6.5	5.8	1.3	29.3	80.0	$13,227	15.2	7.3
Tract 8 BG 1	829	94.6	1.2	3.1	0.0	35.7	74.8	$27,109	8.6	4.7
Tract 8 BG 2	883	92.2	2.9	3.3	0.8	40.2	80.7	$15,429	17.0	5.9
Tract 8 BG 3	884	86.0	4.2	8.3	1.5	40.6	71.3	$12,738	24.3	10.9
Tract 8 BG 4	925	82.5	5.1	6.4	0.7	37.8	58.5	$12,138	27.9	11.1
Tract 35 BG 1	1,867	96.8	0.6	1.5	1.0	39.0	95.1	$23,001	2.0	1.3
Total North Topeka	**8,696**	**89.8**	**3.9**	**4.5**	**36.0**	**n.a.**	**79.1**	**$16,693**	**13.8**	**6.4**
SOLDIER CREEK LEFT BANK										
Tract 33.01 BG 1	2,240	95.2	0.8	5.0	0.0	40.9	91.5	$24,218	0.5	1.7
Tract 34 BG 1	3,953	96.9	0.3	2.6	1.3	41.7	95.0	$23,647	2.9	2.7
Tract 34 BG 2	3,034	96.2	1.0	2.2	1.1	38.7	95.7	$25,178	3.0	1.3
Total Soldier Creek rural	**9,227**	**96.3**	**0.7**	**3.1**	**40.5**	**n.a.**	**94.4**	**$24,289**	**2.4**	**2.0**

Note: This table shows the Topeka MSA (metropolitan statistical area) as being equivalent to Shawnee County. Although the Census Bureau's definition of the Topeka MSA has expanded recently, the MSA and the county are the same in the 2000 Census data.

TABLE D-5 STUDY AREA HOUSING CHARACTERISTICS						
(Data from 2000 Census)	Housing					
	# Housing Units	Average Value of Owner Units	Average Age of Units	Vacancy Rate (%)	% Renter Occupied Units	% Lived in Same House 5 Yrs Ago
U.S.	115,904,614	$158,934	34.2	9.0	33.8	51.2
Kansas	1,131,200	$103,669	37.9	8.2	30.7	50.4
Shawnee County / Topeka MSA	73,768	$93,969	36.9	6.6	32.5	49.9
Topeka city	56,435	$81,283	39.7	7.5	39.2	46.7
STUDY AREA TOTAL OR AVG.	**15,131**	**$66,148**	**46.1**	**7.9**	**29.8**	**53.0**
AUBURNDALE						
Tract 21 BG 4	360	$60,066	59.0	3.8	17.1	39.0
Tract 21 BG 5	272	$54,112	56.7	0.0	27.6	46.0
Tract 22 BG 1	369	$62,746	57.9	6.4	24.0	55.4
Tract 22 BG 3	404	$53,750	57.3	8.2	40.7	43.8
Tract 41 BG 1	764	$61,614	31.7	5.0	69.1	36.3
Tract 41 BG 2	489	$64,894	58.2	3.3	11.7	62.8
Total Auburndale	**2,658**	**$60,202**	**50.4**	**4.7**	**36.7**	**46.3**
SOUTH TOPEKA						
Tract 6 BG 1	500	$41,932	59.1	20.9	44.1	42.6
Tract 40 BG 1	380	$40,132	66.8	24.1	58.6	29.7
Total South Topeka	**880**	**$41,155**	**62.4**	**22.3**	**50.4**	**37.0**
OAKLAND						
Tract 9 BG 1	239	$48,140	51.8	3.7	21.5	37.8
Tract 9 BG 2	464	$49,542	56.3	6.4	26.7	66.5
Tract 9 BG 3	374	$87,302	49.1	5.5	27.0	53.4
Tract 9 BG 4	424	$56,067	44.3	6.0	18.3	71.3
Tract 10 BG 1	437	$53,251	41.3	5.5	36.5	62.5
Tract 10 BG 2	394	$42,561	61.3	8.0	29.4	56.9
Tract 10 BG 3	270	$47,031	60.4	8.2	12.5	69.5
Tract 10 BG 4	485	$42,248	66.0	7.1	20.9	60.8
Tract 11 BG 1	395	$35,442	42.0	16.7	46.4	52.4
Tract 11 BG 2	430	$34,563	44.9	10.5	64.9	33.4
Tract 11 BG 3	434	$27,198	57.8	13.3	38.6	48.8
Tract 40 BG 2	188	$57,639	64.5	0.0	80.5	33.7
Tract 40 BG 3	435	$47,384	66.7	22.5	73.6	36.8
Total Oakland	**4,969**	**$47,546**	**54.0**	**9.3**	**37.5**	**53.7**
NORTH TOPEKA						
Tract 7 BG 1	596	$48,291	47.2	9.7	43.3	46.5
Tract 7 BG 2	732	$59,622	35.2	3.7	10.2	47.8
Tract 8 BG 1	423	$82,694	31.0	16.8	27.6	34.9
Tract 8 BG 2	441	$45,971	46.7	7.7	23.3	48.2
Tract 8 BG 3	433	$36,336	52.2	12.1	43.5	51.9
Tract 8 BG 4	435	$25,079	61.1	13.0	50.9	36.6
Tract 35 BG 1	685	$133,340	29.6	4.3	9.7	71.0
Total North Topeka	**3,745**	**$65,596**	**41.9**	**8.8**	**27.5**	**49.6**
SOLDIER CREEK LEFT BANK						
Tract 33.01 BG 1	835	$99,675	33.1	2.3	5.8	77.7
Tract 34 BG 1	938	$106,089	33.5	2.3	7.0	66.2
Tract 34 BG 2	1,106	$126,583	21.6	3.4	7.3	60.7
Total Soldier Creek rural	**2,879**	**$112,102**	**28.8**	**2.7**	**6.8**	**67.4**

2.1.3 Study Area Economy.

2.1.3.1 Historical Development. Topeka originally developed in the mid-19th century at a point on the Kansas River long known for its fords. A ferry service developed to facilitate traffic along the Oregon Trail. Soon the town became an important rail center, which it remains today as home to one of the largest railroad shop operations in the world. It was also well situated as an agricultural hub since it lies at a juncture where southwestern cattle ranches meet the Corn Belt. Rail traffic, meat packing, and agriculture dominated the city's economy well into the 20th century as the Kansas River continued to play an enormous role in the city's development.

Nearly one-third of Topeka's land area is in the Kansas River floodplain, and much of the city's earlier industrial and commercial base was alongside the river. A major flood in 1903 caused enough devastation to spark initial efforts to protect the town with levees. During World War II, the city's economic base turned toward military spending and manufacturing with the establishment of Forbes Air Force Base and the Goodyear Tire Company plant. The 1951 Kansas River flood of record destroyed much of the older economic base in North and East Topeka. The 1974 closing of Forbes Air Force Base was an enormous blow to the regional economy, resulting in a population loss of about 10,000 that hobbled the city for years afterward.

2.1.3.2. Industrial Structure. According to the Topeka Chamber of Commerce, the largest individual employers in the Topeka metropolitan area are the state of Kansas (8,400 employees), Stormont-Vail Health Care (3,100 employees), and the Topeka School District (2,540 employees). Other major area employers with between 1,000 and 2,000 employees include Blue Cross and Blue Shield insurance (1,800+); St. Francis Health Center (1,800+); Payless Shoe Source (1,600); City of Topeka (1,400); Goodyear Tire Manufacturing (1,600); Washburn University (1,650); Federal government (1,250); Shawnee County (1,100); Burlington Northern Santa Fe Railroad (1,100); and Jostens Printing (1,000). In addition, the Target Corporation has built a major and growing distribution facility in Topeka employing about 650. Several major employers have substantial presences in the study area floodplain, including Goodyear Tire, Payless Shoe Source, and Burlington Northern Santa Fe Railroad. BNSF Railroad continues to maintain an important railroad shop operation in the South Topeka area. Goodyear Tire Company's plant in North Topeka is being revitalized at present with over $100 million in new investment. Other large private employers situated in the study area floodplain include Hill's Pet Nutrition (840 employees), which is headquartered in South Topeka; Hallmark Cards (725); Del Monte Pet Products (260); and Southwest Publishing (177).

Table D-6 summarizes Topeka's industrial structure according to the percentage employed in each industry. The figures are U.S. Bureau of Labor Statistics (BLS) 2005 annual averages. In general, the public sector continues to have a powerful presence in the city's industrial structure, employing 25.5% of the work force, which is much higher than the state total of 18.9% or the national total of 16.3%. Manufacturing has a smaller share of Topeka area jobs than in the state and nation, but unlike most other communities, Topeka continues to experience modest growth in the manufacturing sector, particularly food manufacturing. The financial services industry also continues to lead job growth in the area.

TABLE D-6 **TOPEKA EMPLOYMENT BY INDUSTRY**			
Industry	Topeka %	Kansas %	U.S. %
Construction	5.3	4.7	5.5
Manufacturing	7.7	13.5	10.7
Wholesale Trade	3.2	4.5	4.3
Retail Trade	10.4	11.2	11.4
Transportation & warehousing	4.5	3.9	3.3
Information	2.5	3.0	2.3
Finance	6.7	5.3	6.1
Professional & business services	7.4	9.9	12.6
Private educational & health services	15.1	12.4	13.0
Leisure & hospitality	6.9	8.3	9.6
Other services	4.7	4.0	4.9
Government	25.5	18.9	16.3
Source: Bureau of Labor Statistics, 2005 annual averages			

A further breakdown of industrial activity is provided by the count of businesses provided by the 2005 County Business Patterns (U.S. Census Bureau). There were 4,711 businesses in Shawnee County in 2005, which were distributed among the following major industries: retail trade, 15.6%; health care and social assistance, 10.7%; construction, 10.5%; professional, scientific and technical services, 10.3%; finance and insurance, 8.2%; accommodation and food services, 7.8%; real estate and rental/leasing, 5.2%; administration, management and waste remediation services, 4.8%; wholesale trade, 4.1%; manufacturing, 2.5%; transportation and warehousing, 2.5%. Other industries comprised less than 2% of Shawnee County businesses.

2.1.3.3 Income and Employment. Per capita personal income (PCPI) in the Topeka MSA, as defined by the Bureau of Economic Analysis (BEA), was $31,074 in 2005. This total ranked the Topeka MSA 155th among MSAs in the U.S. The total amounted to 90% of the national average and a 3.4% increase over the 2004 figure compared to the 4.2% national increase in the same period. Over the 1995-2005 period, PCPI grew at an average annual rate of 3.9%, a little less than the national average of 4.1%. Total personal income (TPI) for the MSA in 2005 was $7,092,816, which was 182nd in the U.S. TPI increased 4.3% over the 2004-2005 period, and the average annual growth rate over the 1995-2005 period also was 4.3%. The comparable national increases for TPI were 5.2% in each case. Earnings by Topeka employees increased 3.5% from 2004 to 2005 and 4.1% from 1995 to 2005, according to the BEA. National increases over the same periods were stronger: 5.6% for 2004-2005 and 5.5% for 1995-2005.

BEA also publishes data for the 18-county Topeka EA (Economic Area). The PCPI for the EA was $30,483, which was 88% of the national average. The 4.9% increase over 2004 exceeded the national increase of 4.2% over the same period. The average annual growth rate since 1995 for the Topeka EA was 4.7%, which was more than the national rate of 4.1%. TPI as of 2005 was $13,768,609. TPI had increased 4.6% over 2004 and had averaged 4.5% annually since

1995. The comparable national increase for each period was 5.2%. Increases in earnings in the EA were 4.1% since 2004 and an annual average of 4.6% since 1995. Both of these rates were well below the national increases of 5.6% and 5.5%.

Unemployment for the Topeka MSA in June 2007 was 5.0%, according to the BLS, up slightly from 4.8% a year earlier. (The Topeka MSA, or metropolitan statistical area, is a 5-county area that also includes the counties of Jackson, Jefferson, Osage and Wabaunsee in addition to Shawnee.) The median hourly wage for all occupations in Topeka as of May 2006 was $14.13, according to BLS.

2.1.3.4 Transportation and Access. Access generally has been a strength for Topeka throughout its existence. Topeka's rich, sandy loam Kansas River bottomlands were long used by Indians, who also favored the superior fords available here. Later settlers established ferry services for crossing the river, facilitating the rise of the future town site as a significant post on the Oregon Trail which crossed the river here. Incorporated in 1857, the early city was strongly influenced by railroads. Rail continues to have a strong role in today's city. Topeka is a shipping and distribution hub linking the corn and wheat production region of northeastern Kansas, as well as cattle producing Southwestern states, with markets nationwide. The city is well-positioned on the Chicago-to-Los Angeles Transcon route that has boomed in recent years. Topeka has successfully retained a large and important maintenance and testing facility for the Burlington Northern Santa Fe Railroad, which has been a major employer in the city for many years. The BNSF rail yards are a dominating physical feature in the South Topeka/Oakland area, while the Union Pacific Railroad serves the North Topeka area with its grain elevators and is considering adding a third track in the area. As for the Kansas River, it is not today navigable for freight transport.

East-west highway access through the city is provided by Interstate Highway 70, which roughly parallels the Kansas River, while U.S. Highway 24 provides a secondary east-west route on the northern side of the area. The main north-south access route is U.S. Highway 75. Kansas Route 4, completed in the past few years, also is also a key component of the freeway loop on the east side of Topeka. Interstate Highway 335 runs from Topeka to the southwest, eventually joining Interstate Highway 35 which runs from the Canadian to the Mexican borders. The trucking industry benefits from this transportation network, with 300 motor carriers employing more than 7,000 workers locally. The city's transportation network of roads and streets has until recently been more than adequate in accommodating growth in the region, but growing pains are now perceived in the city and a long-term transportation plan has been developed in the past few years to plan for expansion and improvement of the transportation system.

Forbes Field, a former military base that is now the city's main airport, is on the south side of Topeka outside the study area. Billard Airport, a secondary facility rated as a Basic Transport Class General Aviation Airport that is located in the center of the Oakland area, emphasizes industrial usage but is still one of the busiest airports in the state. Both airports have significant capacity beyond their current usage, the demand for which is limited by easy access to Kansas City International Airport about an hour away.

2.1.3.5 Economic Development and Redevelopment. A fair and accurate overview of Topeka's relative economic position is given in a recent report advocating an economic development strategy for the city: "The area's basic economic trends have been positive, and closely match state trends, but generally lag U.S. and similar city trends. It is better off than many Midwest cities in that it continues to gain population, but the growth is below the national average." ("Creating Excellence in Economic Development: A Comprehensive Economic Development Strategy for Topeka and Shawnee County, Kansas," prepared by Competitive Strategies Group for the Topeka Chamber of Commerce, February 2007.)

The Topeka area has several advantages in attracting economic development. In addition to the relatively good access options described above, the work force has a fairly high percentage of high school graduates. Although the percentage of college graduates is not as high, the city does host Washburn University and is situated between the University of Kansas 20 miles to the east and Kansas State University about an hour to the west. The city has a strong manufacturing corridor, and attracting new manufacturers often is influenced by the presence of an existing work force with manufacturing skills. Construction employment has increased in the past few years, which often is a harbinger of future development. On the other hand, the city lacks sufficient office space to support major new development in the short term and tends to have an unfocused pattern of commercial development with no real center of gravity. In addition, much of the commercial growth in Topeka in the past 20 years has been on the south side of the area and along the Wannamaker corridor on the west side of the city, and continued growth on the southern edge of town is running up against sewer and water capacity constraints as well as the disincentives associated with the need to use a toll road.

The 2002 Economic Development Plan for Topeka/Shawnee County identified several areas that are targeted for economic development and redevelopment in the study area. Plans include commercial office and industrial park development. At least four major development sites are within or adjacent to areas protected by the Federal project: the Kanza Business and Technology Park (west edge of Auburndale); the Oakland Expressway area; the Northwest Topeka area; and the U.S. Highway 24 area in North Topeka. These areas are discussed below in connection with the individual protected areas.

For the year to date in August 2007, the Topeka public works department listed 122 residential permits accounting for $33,958,000 of new construction as well as 30 commercial permits for new buildings accounting for $24,489,000 and 35 alteration permits accounting for $4,998,000.

2.1.4 Study Area Investment. The Topeka Federal Levee system collectively protects property with an estimated value of $2.53 billion, as summarized in Table D-7. This total - based on a field survey and subsequent data development described in section 4 of this appendix - includes 6,487 homes and 790 businesses and public facilities as well as 164 miles of roads and streets and over 800 acres of crops. About 55.1% of total investment is in the North Topeka area, while Oakland accounts for 21.6%, South Topeka 15.2%, Auburndale 4.5%, Waterworks 2.4%, and rural Soldier Creek 1.1%.

TABLE D-7								
STUDY AREA INVESTMENT								
	WW	**AUB**	**S TOP**	**OAK**	**N TOP**	**SOLD CK RURAL**	**TOTAL STUDY AREA**	**% OF TOTAL**
Non-residential (businesses and public facilities)								
Quantity	1	18	142	89	539	1	790	
Structures	$25,500.0	$10,610.4	$143,047.5	$51,338.1	$236,891.3	$79.2	$467,466.5	
(equipment/inventories)	$33,711.0	$10,430.8	$212,120.1	$143,374.1	$839,081.9	$101.4	$468,256.5	
Total Value	$59,211.0	$21,041.2	$355,167.6	$194,712.2	$1,075,973.2	$180.6	$1,706,285.8	67.3%
Residential								
# Homes	0	616	80	2,942	2,752	97	6,487	
Structures	$0.0	$45,126.3	$2,192.1	$176,796.6	$122,639.1	$13,744.8	$360,498.9	
autos and landscaping)	$0.0	$31,588.4	$1,534.5	$123,757.6	$85,847.4	$9,621.4	$366,985.9	
Total Value	$0.0	$76,714.7	$3,726.6	$300,554.2	$208,486.5	$23,366.2	$612,848.1	24.2%
Roads & Streets (railroads, highways, city streets & county roads)								
Miles	0.6	11.2	20.0	45.9	82.9	3.32	163.9	
Total Value	$1,287.4	$15,657.4	$27,466.8	$53,189.0	$112,762.3	$3,480.3	$213,843.2	8.4%
Agriculture								
Cropped Acres	0	0	0	90	15	700	805	
Total Value	$0.0	$0.0	$0.0	$135.0	$22.5	$1,050.0	$1,207.5	0.0%
Total Value	**$60,498.4**	**$113,413.3**	**$386,361.0**	**$548,590.4**	**$1,397,244.5**	**$28,077.1**	**$2,534,184.6**	100.0%
% of total	2.4%	4.5%	15.2%	21.6%	55.1%	1.1%		
October 2007 prices; all structure and content values reflect depreciated replacement values								

2.2 WATERWORKS SOCIOECONOMIC CHARACTERISTICS

2.2.1 Waterworks Land Use. The protected area totals only 36 acres, and the sole property in the protected area is the massive Topeka water treatment plant. This plant supplies drinking water to 160,000 people throughout Topeka as well as outlying areas of Shawnee County. The plant has a treatment capacity of 63 mgd (million gallons per day) with an average daily use of 25 mgd.

2.2.2 Waterworks Population and Social Characteristics. The Waterworks area is wholly industrial and has no population or housing

2.2.3 Waterworks Investment. Total investment in the Waterworks unit, in depreciated replacement value terms, is approximately $60.5 million. The treatment plant is the sole property, apart from a small amount of city streets. The investment total is 2.4% of total investment in the study area.

2.2.4 Waterworks Economic Development. The Topeka Water Division recently has crafted a master plan called Water for Growth intended to guide updating and expansion of the water distribution system in the city for the next 30 years. The project will involve some replacement of older infrastructure, but mainly aims to expand the current 800-mile water distribution system's capacity in areas of the city where growth is expected to occur.

2.3 AUBURNDALE SOCIOECONOMIC CHARACTERISTCS

2.3.1 Auburndale Land Use. The protected area is a portion of an older urban neighborhood clustered around the Ward-Martin Diversion. The area, which totals a little over 300 acres, is largely single-family homes. Most homes are older, but many have been rehabilitated in recent years. Also included in the Auburndale area is a small commercial strip at the south edge of the area and a few public facilities, notably a large state printing plant near the river which is the largest property (in terms of economic value) in the area.

2.3.2 Auburndale Population and Social Characteristics. The 2000 population of Auburndale was 1,468, which accounted for about 9% of the total study area population. The Census block groups containing the Auburndale area had a total population of 5,184. Compared to Topeka and Shawnee County residents in general, Auburndale residents on average are slightly older and somewhat better educated. Auburndale per capita income as a weighted average of the Census blocks included in the study area was $19,452 in 2000, which was comparable to the overall Topeka total of $19,555. The poverty rate of 6% was well below the city's 12.4% rate and the county's 9.6%, and the 2.4% unemployment rate was only half that of Topeka. Only 1.1% of Auburndale residents are foreign-born, which is significantly fewer than in the city and county. Whites account for 90.6% of the Auburndale population, much higher than comparable percentages for the study area, city, county, state or nation.

The average home value of $60,202 was about 64% of the Shawnee County average and 74% of the Topeka average. The lower Auburndale housing values probably are due chiefly to the older housing stock: Auburndale homes are on average about 50 years old, compared to the citywide and countywide average ages of 37 to 40 years. The home ownership rate of 63.3% is about midway between the Topeka rate of 60.8% and the Shawnee County rate of 67.5%, and vacancy rates in this stable, older neighborhood were lower than in the city and county.

2.3.3 Auburndale Investment. Total current investment (October 2007) in the Auburndale area is an estimated $113.4 million. The property base includes 616 homes valued at $76.7 million including contents. The neighborhood also had 18 businesses and public facilities valued at $21 million, and 11.2 miles of streets and highway valued at $15.66 million. The total investment for Auburndale represents 4.5% of the total for the study area.

2.3.4 Auburndale Economic Development. The main redevelopment project in this area of Topeka involves the old State Mental Hospital campus at the west edge of the area (and directly south of Waterworks). This 550-acre area has largely been bought up in anticipation of planned retail and office development, and MacVicar Street and 6th Street, which respectively run along the east and south sides of the campus, have recently been widened. The biggest player in the redevelopment is the St. Francis Health Center, one of the most dominant forces in the local and regional economy and already the tenant of a facility on the south edge of the Auburndale area. St. Francis plans to build a 250-bed hospital anchoring a state-of-the-art health park and incorporating the historic clock Tower Building. This project figures to involve large-scale investment; the hospital alone probably would cost on the order of $250 million, using the industry rule of thumb of $1 million in costs for every bed in a new hospital. Only a small portion of the redevelopment area is in the Kansas River floodplain. However, the scale of development could have future implications for the floodplain. The project should augur well for the continued health of the Auburndale neighborhood as well.

2.4 SOUTH TOPEKA SOCIOECONOMIC CHARACTERISTICS

2.4.1 South Topeka Land Use. The South Topeka protected area is a 300-acre area just north of downtown Topeka which includes some of the oldest riverfront blocks in the city. (South Topeka is "south" due to its location on the south bank of the Kansas River, not in the sense of being the southern portion of today's city.) It is primarily given over to industrial and office uses. Some of the area's largest employers are located in South Topeka, Hallmark Cards, Hill's Pet Nutrition, and a portion of the Burlington Northern Santa Fe Railroad maintenance shops and offices. A secondary use in the area is residential: South Topeka is not a large neighborhood but does have a number of homes.

2.4.2 South Topeka Population and Social Characteristics. The 2000 population of South Topeka, based on the block group statistics, stood at 211. For the larger area defined by block groups, the population was 1,853. The area contained 880 housing units with an average value of $41,155 and an average age of 62 years. The average value is about half that of Topeka and less than half the comparable figures for the county and state. Renters occupy 50.4% of housing units, a higher percentage than the 39.2% for the city or the 32.5% for Shawnee County. South Topeka also has a lower percentage (37%) of residents who lived in the same home in 1995; the city and county percentages are 46.7% and 49.9%. The vacancy rate of 22.3% is about triple the city and county vacancy rates of 7.5% and 6.6%.

Per capita income in South Topeka is $10,305, the lowest total in the study area, only about half of the city and county per capita incomes and less than half of the national figure. The poverty rate of 39.4% was more than triple that of Topeka (12.4%) and was four times that of Shawnee County (9.6%). The poverty rate in some South Topeka block groups is as high as 42%. The 12.3% unemployment rate was much higher than the city and county rates of 4.8% and 4.0%. South Topeka residents generally were much more likely to be foreign born and less likely to have high school diplomas than the area averages. Whites account for a smaller percentage of the population in South Topeka (73.7%) than in the study area as a whole, and the 20.4% of the population that is Hispanic is higher than the national figure of 12.5% and much higher than the city and state figures of 7.0% and 8.9%.

2.4.3 South Topeka Investment. The South Topeka area currently has 80 homes valued at $3.7 million including contents, 142 businesses and facilities valued at $355.2 million including equipment and inventories, and 20 miles of roads and streets valued at $27.5 million. Total investment is $386.4 million. This total is 15.2% of the investment for the entire study area.

2.4.4 South Topeka Economic Development. South Topeka has several of the Topeka area's largest employers, including the Burlington Northern Santa Fe Railroad (about 1,100 employees), Hill's Pet Nutrition (800 employees), and Hallmark Cards (725 employees). No significant future development plans are known to exist for this area apart from the city's riverfront development, which may include a hiking and biking trail.

2.5 OAKLAND SOCIOECONOMIC CHARACTERISTICS

2.5.1 Oakland Land Use. The Oakland protected area accounts for nearly 3,300 acres in east Topeka. The Oakland levee protects the city's main sewage treatment plant and Billard Airport as well as several older residential areas, retail service areas and a moderate amount of farmland.

2.5.2 Oakland Population and Social Characteristics. Based on the Census blocks accounting, Oakland had 7,030 residents in 2000, which was 44% of the study area total. There were 11,815 residents in the block groups containing the area. Oakland's 2000 per capita income of $13,361 was only 68.3% of Topeka's, 65.2% of the state and 61.9% of the nation. It was also well below the study area total of $17,596. However, some block groups in Oakland have per capita incomes that are less than 30% of the city, state and national figures. The poverty rate of 18.4% for Oakland was 48% higher than the rate for Topeka and 46% higher than the study area's rate. Four block groups in the area have poverty rates ranging from 27% to 41%. The unemployment rate of 8.7% was about twice those of Topeka and Shawnee County (4.8% and 4.0%). The percentage of the population that was foreign born amounted to 8.1%, which was triple the rate for Shawnee County and about two and a half time that of the city.

Of the 4,969 housing units in Oakland in 2000, the average value of owner units was $47,546, a total which was about 50%-60% of the average city and county values and about 72% of the study area average. Like the other components of the study area, Oakland has an older housing stock. The average age of homes was 54 years, compared to Shawnee County's 36.9% and Topeka's 39.7%. The vacancy rate of 9.3% and the 53.7% of residents who lived in the same house in 1995 were somewhat above comparable city and county totals.

2.5.3 Oakland Investment. Total investment in Oakland currently is estimated at $548.6 million, about 21.6% of total study area investment. Included in this total are 2,942 homes valued at $300.6 million, 89 businesses and facilities valued at $194.7 million, 46 miles of roads and streets valued at $53.2 million, and 90 acres of crops.

2.5.4 Oakland Economic Development. In the South Topeka/Oakland area the Kansas Department of Transportation has completed work on the Oakland Expressway along the city's eastern boundary. The Expressway connects I-70 to the south with U.S. Highway 24 to the north. This new corridor presents extensive long-term opportunities for economic development. Billard Airport lies at the northern end of the corridor. The airport possesses up to 100 acres of land that could be developed for commercial and industrial uses. Sewer and water lines are available to these sites. An additional 270 acres of undeveloped land, zoned for industrial purposes, lies immediately north and east of the airport. This land could be attractive for development by a large firm since there are available parcels that are large and near downtown. Additional sites that seem likely to develop include a potential node at the Oakland Expressway's intersection with Seward Avenue, where approximately 300 acres of industrial-zoned land await development. Just south of this area and north of Shunganunga Creek is another area of about 200 industrial-zoned acres. This land, however, lacks sewer and water connections at present. South of Shunganunga Creek and adjacent to the U.S. Highway 40 interchange with the Expressway, along both sides of the Expressway down to the I-70 interchange, is an area encompassing about 500 acres that is currently zoned for residential use but that could be developed for commercial or industrial uses. Since much of the residential and commercial building stock in Oakland is relatively old, there is a high likelihood that some or all of these sites will be developed during the 50-year period of analysis, adding to any damage potential associated with the existing levee system's condition.

2.6 NORTH TOPEKA SOCIOECONOMIC CHARACTERISTICS

2.6.1 North Topeka Land Use. The North Topeka protected area is a huge area of more than 6,000 acres accounting for the great majority of the portion of Topeka lying north of the Kansas River. North Topeka once was a separate community called Eugene with its own riverfront downtown. This old town area and many surrounding neighborhoods and service areas are protected by the levee, along with a number of large businesses, including a Goodyear Tire plant, the largest industrial concern in the city, and the world headquarters of Payless Shoe Source, Del Monte Pet Products, Cargill, and U.S. Foods. A large new sewage treatment plant is also located in the area.

2.6.2 North Topeka Population and Social Characteristics. The 2000 population of the North Topeka area was 6,725, which was 42% of the total study area population. The block groups comprising this reach had a population of 8,696. The per capita income for North Topeka, $16,693, was 95% of the study area total, 85% of the Topeka total, and 80% of the county total. Residents of this area were more likely to be unemployed (6.4%) than in the overall study area, city, county or state, and the poverty rate of 13.8% was higher than in those areas. North Topeka residents also were more likely to be white (89.8%) and less likely to be foreign born (1.2%).

The 2000 housing units total was 3,745. The housing vacancy rate of 8.8% was higher than the Topeka rate of 7.5% and the statewide rate of 8.2%. The average value of owner units was $65,596, which was only slightly lower than the average for the study area but was 81% of Topeka's, 70% of Shawnee County's and 63% of the Kansas average. Homes were 41.9 years old on average, somewhat older than in Topeka or Shawnee County but not as old as the study area average of 46.1.

2.6.3 North Topeka Investment. The North Topeka area contains 2,752 homes valued at $208.5 million, 539 businesses and facilities valued at $1.075 billion, and 83 miles of roads and streets valued at $112.6 million. The total estimated value of protected property is almost $1.4 billion, which is 55% of study area total investment.

2.6.4 North Topeka Economic Development. New development is slowly taking shape around the western and northern edges of the North Topeka area. The biggest development on the horizon at present is a $200 million ethanol plant that seems poised to be built on a parcel just west of the study area. Within the protected area, the northwest Topeka area, situated around the cloverleaf intersection of U.S. Highways 24 and 75 and the area northwest of the Lower Silver Lake Road intersection with Highway 75, is a prime focus of interest. About 80% of the area is zoned for industrial uses, but only about a quarter of the more than 2,000 acres in the area is currently used for industrial or commercial purposes. About 44% of the land is considered vacant, although some of it is farmed. The area has certain drawbacks, including inadequate infrastructure and fragmentation of parcels. Most of the land is divided into over 200 small parcels of generally 30 acres or less, requiring developers to consolidate developable parcels from several small property owners. In addition, much of this land is either just outside the corporate limits of the city of Topeka, or unplatted, or both. On the other hand, a recently constructed sewage treatment plant allows plenty of capacity for new development, and portions of the area have rail service.

Another corridor for new development is along U.S. Highway 24 and the nearby Soldier Creek. and the city recently announced a corridor study for U.S. Highway 24. One other development that may be on the horizon is the proposed Kaw Reserve Trail. This trail would follow the Kansas River from Highway 75 east to Happy Hollow Road near Soldier Creek at the downstream end of the North Topeka unit, turning the levee maintenance road into a hiking and biking trail.

2.7 SOLDIER CREEK SOCIOECONOMIC CHARACTERISTICS

The large area protected by the right bank portion of the Soldier Creek unit is essentially the same as the area protected by the North Topeka unit. Therefore, the discussion of land use, population and social characteristics for North Topeka in the preceding section also applies to the Soldier Creek unit. This section will cover the left bank area of Soldier Creek.

2.7.1 Soldier Creek Land Use. The small rural areas protected by the seven smaller portions of the Soldier Creek unit are along the northern edge of Topeka. These areas total 1,057 acres and range from 39 to 449 acres. Several of the units protect residential areas, but only one, the left bank area around Kansas Avenue, contains a significant amount of property, including more than three-quarters of the 97 homes in the rural floodplain. Only one business is found in these areas. Other land uses are primarily agricultural.

2.7.2 Soldier Creek Population and Social Characteristics. The 2000 population of the protected left bank portions of the Soldier Creek unit was 664. Other left bank areas that are unprotected and interspersed with the protected areas accounted for an additional 446 residents. The block groups that include these areas extend well beyond the floodplain, with the result that the population of the block groups was 9,227. Thus, the discussion of social characteristics based on the block groups data should be prefaced with the caveat that these totals are largely based on residents outside the study area.

The 2000 per capita income of $24,289 was 138% of the study area per capita income, 124% of the city total and 116% of the Shawnee County total. The 2.0% unemployment rate and 2.4%

poverty rate were significantly less than the comparable figures for overall study area, city, county and state. Residents of this area were 96.3% white and only 0.9% were foreign born. The 94.4% of residents with high school diplomas or better was significantly higher than the study area total of 81.1% or the Topeka total of 85.9%.

The 2,879 housing units in 2000 were, on average, only 28.8 years old, making them much newer than in the overall study area or the city and county. The average owner unit value of $112,102 was 169% of the study area average and 119% of Shawnee County's average. Only 6.8% of residential units were occupied by renters, compared to 29.8% in the study area, 39.2% in Topeka, and 30.7% in the state. The vacancy rate of 2.7% was very low in comparison to city, county and state rates. The percentage of residents who lived in the same home in 1995 was 67.4% compared to 46.7% in Topeka and 53.0% in the study area.

2.7.3 Soldier Creek Investment. The rural subunits of the Soldier Creek unit protect a total property value of $28.1 million, including 97 homes, 1 business, 3.3 miles of roads and streets, and about 700 crop acres.

2.7.4 Soldier Creek Economic Development. This area has acquired a new Wal-Mart store within the past few years that has quickened the overall pace of development. Woodland Park at Soldier Creek, a $25 million affordable housing project that will include 236 units, was recently announced for an area just north of the study area. It will be one of the few new apartment complexes built in Topeka in the past 25 years. Similar projects are being discussed for other points along the left bank of Soldier Creek, although there are no definite details yet.

3.0 HISTORICAL FLOODS IN TOPEKA

3.1 EARLY KANSAS RIVER FLOODS AT TOPEKA

3.1.1 The 1844 Flood. The earliest known Kansas River flood event affecting the Topeka town site occurred in 1844. A legendary Kansas River flood event that year reportedly inundated the entire floodplain in eastern Kansas from bluff to bluff. The flood occurred before river stages and high water marks were recorded systematically, but legendary high water marks suggest a peak stage that exceeded any flood that has occurred since 1844, with the possible exception of 1951. However, the impact at Topeka was presumably slight since little of the future city existed then.

3.1.2 The 1903 Flood. The first flood event that seriously affected the city was in May 1903, and this flood proved to be one of the three worst flood events that have ever occurred in Topeka. The Kansas River reached a stage of 37.7 at Topeka on Memorial Day, a stage exceeded only two other times in Topeka history (including the 1844 event and its legendary high water marks), and the Corps has estimated that the discharge was about 253,000 cfs. (However, it should be noted that the National Weather Service estimates that the discharge was about 300,000 cfs.) Flood depths reached around 12 feet in North Topeka. The 1903 flood occurred after westward expansion had increased the city's population, resulting in urbanization of the riverfront, but long before Federal flood risk management measures were implemented along the river. As a result, the flood resulted in 38 deaths and 8,000 homeless persons, almost all in North Topeka. Damage estimates are very sketchy, but urban damage above Kansas City – much of which presumably would have occurred in Topeka - was estimated at $2.7 million by S.D. Flora of the National Weather Service in a 1948 review.

Other flood events affected the city in 1908 and 1935, but the 1903 event remained the benchmark for Topeka floods for the first half of the twentieth century.

3.2 MODERN KANSAS RIVER FLOODS AT TOPEKA

3.2.1 The 1951 Flood. In terms of damage, the 1951 Kansas River flood was the record flood event in Topeka history up to the present day. The peak flow was 469,000 cfs, and the Kansas River stage reached 40.8 on July 13th, a stage exceeded before 1951 only in 1844 (if then) and never exceeded since 1951. More than 23,000 Topeka residents were evacuated during the event. A degree of Federal flood damage protection had been implemented by 1951 in South Topeka and Waterworks on a limited scale, but the South Topeka levee failed, and Oakland and North Topeka had no significant protection. Depths reached 15 to 20 feet in these areas. Only two deaths were attributed to the flood. The relatively small number of deaths probably was due to two factors: a much more effective flood warning system than existed in the 1903 event, and another flood event 16 years before that was recent enough to have remained in the city's consciousness. But more than 6,600 homes and 500 businesses and facilities were affected by the flood. More than 15,000 people were homeless. Extensive post-flood surveys carried out by the Corps of Engineers estimated total damage at $34.12 million, of which about $18.9 million occurred in North Topeka as well as $6.1 million in Oakland/South Topeka and $600,000 in Auburndale. North Topeka's residential and commercial areas, while strong today, never completely recovered from the 1951 devastation.

A rare bright spot during the event was the desperate flood fight at Waterworks involving more than 4,500 residents that shored up the limited Federal project which then existed and saved the city's water supply.

The peak flow of the 1951 event was 469,000 cfs. This flow would exceed a 0.001-chance (1000-year) event flow, according to current data. However, only one of the five upstream Kansas River reservoirs - and neither of the two largest ones - was in operation at that time. It has been estimated that, had all five upstream reservoirs been in operation in 1951, the peak flow would have been about 288,000 cfs, which would be in the range of a 0.04% to 0.033%-chance (250 to 300 year) flood.

Following the 1951 event, the design of the Federal flood risk management project at Topeka was reconceptualized and augmented. The existing levees and other elements of the project were completed during the 1960s and 1970s and were therefore fully operational for the next major flood event in 1993.

3.2.2 The 1993 Flood. A record Missouri River basin flood event occurred during that summer. The event gathered momentum along the Kansas River above its mouth at Kansas City, but did not reach the extremes that were recorded along the Missouri River main stem. A peak stage of 34.9 along with a discharge of 170,000 cfs was recorded at Topeka on July 25th. Both the stage and the discharge were the fourth-highest ever recorded, but the river was held in place by the Federal project. Only very minor damage occurred in Topeka during the 1993 flood, in contrast to the devastation downstream in portions of the greater Kansas City area and other locations along the main stem of the Missouri River. The peak discharge amounted to almost a 2%-chance (50 year) flood event, while the peak stage was equal to just over a 2%-chance event.

Apart from a May 1995 event when the stage at Topeka reached 29.5, no other major Kansas River events have occurred since 1993.

3.3 SOLDIER CREEK FLOODS

Little is known about Soldier Creek floods prior to the 1940s, and very little economic data is available concerning damage estimates. Records at the Soldier Creek gauge (at RM 6.0 near the upstream end of the Federal project) go back to 1929. An April 1929 flood had produced a stage of 28.25 which stood as the highest on record for many years, but this flood event is not well documented. The 1951 flood event, which was the flood of record on the Kansas River main stem, produced a flow of 11,400 cfs and a stage of 28.15 on June 22, virtually equaling the 1929 peak. It should be noted that pre-1961 Soldier Creek flood events are not directly comparable to subsequent ones since the Federal project constructed at that time deepened the stream bed by 5 feet and also widened it.

An October 1973 flood produced a peak stage of 23.9, a record up to that time for the post-Federal project years. The flow was 20,800 cfs. Damages of $120,000 in and near Topeka were cited for the 1973 event in Corps records; in 2007 prices, this total would amount to about a half million dollars. The damages primarily occurred in relatively rural areas. Another flow exceeding 20,000 cfs was produced by a September 1977 event.

Two larger events occurred in the early 1980s. A July 25, 1981 flood reached a peak stage of 25.9 with a peak flow of 25,000, both records up to that time for the post-1962 period. The following year, a flood of June 9, 1982 produced a new record flow of 30,400 cfs and also a new record stage of 27.4. According to current flow data, the 1982 event would have fallen in the range between a 2% (50-year) and 1%-chance (100-year) event, while the 1981 event would have fallen between a 5% (20-year) and 2%-chance event. In the period from 1982 through 2004, only two additional flood events produced flows exceeding the 5%-chance event discharge of 21,500 cfs: the July 1993 event (23,400 cfs) and the June 1999 event (25,200 cfs). All of the flood events of the 1980s and 1990s appear to have been contained more or less successfully by the Federal project with little or no damage in Topeka.

On Oct. 2, 2005, Soldier Creek reached a new record stage of 34.5. The flow was 47,800 cfs, which would be rated as approximately a 0.4%-chance (250-year) event given current flow data. The flow resulted in damage to the levee exceeding $10 million. Limited overtopping occurred in North Topeka, where the Payless distribution center on Highway 24 was evacuated and closed for 14 hours, though it did not sustain damage. A small number of homes and businesses on both sides of the creek, especially the unprotected left bank areas, were damaged by up to six feet of water. But in general, the levee held, and known damage from the event was modest in light of the historic flow and stage.

4.0 DAMAGE ANALYSIS DATABASE PREPARATION

4.1 STUDY CONFIGURATION

4.1.1 Analysis Years and Period of Analysis. In addition to the existing conditions of 2007, 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 2013. The future condition year is 2038.

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. Some of these potential projects are touched on in the economic development portions of section 2 of this appendix, but none could be added to the economic analysis at this time. (Given the nature of the alternatives formulated for the feasibility study, the addition of any future development to the analysis would have affected estimates for the future without-project condition but would have had no effect on economic screening of alternatives. This is because the alternatives within each study reach accomplish the same purposes and have the same benefits. See section 6 of this appendix.)

Therefore, the economic database used in the existing conditions analysis is carried through to the base and future conditions without change. In addition, engineering data used in the risk-based analysis for hydraulic, hydrologic, structural and geotechnical conditions is also identical in all three conditions.

4.1.2 Interest Rate and Price Level. Annualized estimates of damages, benefits and costs in this analysis assume the FY 2008 Federal interest rate of 4.875% and a period of analysis of 50 years based on official guidance for evaluation of Federal levees. All estimates are expressed in October 2007 prices unless otherwise noted.

4.1.3 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 elevations 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 a river or creek.

The reaches used in this study are summarized in Table D-8, which indicates the beginning and ending river mile or station for each reach as well as the index point. In this analysis of areas protected by existing projects, the study reaches coincide with the areas protected by each unit or subunit. There are five units located along the Kansas River. Right bank units include (from upstream to downstream) Waterworks, Auburndale, South Topeka, and Oakland. The Oakland unit also includes a tieback running along Shunganunga Creek. North Topeka is the sole left bank Kansas River unit. The North Topeka area is protected from the Kansas River along its southern edge and is also protected along its northern edge by the main portion of the Soldier Creek unit. Soldier Creek has only one existing project unit, but it includes a number of discrete sections. Besides the main segment of the levee that protects North Topeka, other discrete portions of the Soldier Creek unit, primarily on the left bank, are very small rural areas with minimal property bases and very slight damage potential.

TABLE D-8

ECONOMIC STUDY REACHES

Name	Bank	Beg. Station	End Station	Index Station
KANSAS RIVER				
Waterworks	Right	86.7	87.2	87.0
Auburndale	Right	85.5	86.7	86.1
South Topeka	Right	83.7	85.5	84.8
Oakland	Right	76.0	83.7	82.3
North Topeka	Left	80.8	88.8	85.6
SOLDIER CREEK				
Right bank urban (North Topeka)	Right	0.2	7.2	4.2
Right bank rural @ Silver Creek ditch	Right	8.1	10.0	8.7
Left bank rural 1 @ Hwy 24	Left	0.2	0.6	0.4
Left bank rural 2 @ Kansas Ave.	Left	1.9	2.3	2.2
Left bank rural 3 @ Rochester Rd.	Left	2.7	3.1	3.0
Left bank rural 4 @ Brickyard Rd.	Left	5.5	6.7	6.2
Left bank rural 5 @ Menoken Rd.	Left	6.8	7.5	7.3
Left bank rural 6 @ NW 33rd St.	Left	7.6	8.0	7.9

4.1.4 Economic Categories. The economic structure inventory in this study is categorized in terms of four basic land uses: residential, non-residential (including businesses, non-profit institutions such as churches and schools, public facilities and utilities), roads and streets, and agriculture (i.e., crops – farm sets are categorized in residential). Two categories of non-physical costs of flooding, disaster relief and emergency costs, also are included in the analysis.

4.2 DATA COLLECTION METHODOLOGY

Data collection, the first phase of the economic database development, involved three steps: (1) obtaining relevant county and state tax records, GIS data and available mapping from the city and/or county; (2) design and execution of a structure-by-structure field survey; and (3) discussions of investment and damage potential with a series of owner/operators at selected critical businesses and facilities.

4.2.1 Tax Data. The Shawnee County Appraiser's property database provided structural values for businesses and homes in the study area. Protected areas of the city within the 0.1%-chance (1000-year) floodplain were identified and furnished to city GIS staff, who worked with the appraiser's office to sort county tax records and delineate the property records for the protected areas. Land values were separated from structure values for each property. The resulting records included not only structure values for each address but also such useful supporting data as area (square feet), condition, land use type, year in service, and number of stories. Values from the tax data were updated as the study progressed.

Most public buildings also had been assigned values in the county tax data. However, the appraiser's office cautions users that estimates for these properties are not done to the same level of detail as with residential and commercial properties, and most of the supporting data for the estimates are not readily available. Not included at all in the tax data are values for most utilities, telecommunications, or railroads. Railroads in particular are an important part of the economic base in the South Topeka/Oakland area, where the Burlington Northern Santa Fe (BNSF) Railroad has large rail yards and maintenance shops.

4.2.2 Mapping. The city GIS staff provided Kansas River mapping with 1-foot contours and spot elevations based on a 2002 survey. Real estate parcels and structure footprints were included in the GIS layers. This city mapping was further developed for purposes of the economic analysis by Kansas City District Corps of Engineers GIS staff. A floodplain map was developed based partially on existing mapping of the extent of the 1951 flood and partly on identification of a 0.1%-chance (1000-year) flood. This map was used to guide the field survey tasks. Ground elevations were also assigned to all floodplain structures based on the contours and spot elevations from the mapping.

4.2.3 Field Survey. Kansas City District economics staff carried out a structure-by-structure field survey of all buildings in the study area over 12 days in May-July 2003. The purpose of the survey was to build on the initial data from the county tax records in four areas. First, current occupancy as shown in the tax records was confirmed or updated for each building. Second, first-floor elevations relative to the ground were estimated by visual inspection, and the presence of basements also was noted. Third, other information from the tax data were verified or corrected. In particular, appraised values included in the tax data were evaluated for each structure in light of condition, make, age, area in square feet, and other qualities. The purpose was to obtain a generalized reality check on the usefulness of the appraised values by assessing whether obvious mismatches between data and reality occurred on a regular basis. Finally, where businesses and public facilities were concerned, the nature of the activity was not always obvious from the tax data or the business name, so properties were inspected for additional clues, as well as for the presence of significant outside inventory or equipment. Notes from the completed field survey were subsequently integrated with the tax data to form an adjusted initial structure inventory for the study area.

4.2.4 Key Businesses and Public Facilities. Discussions with business owners, managers, and plant foremen at selected businesses and facilities (on-site in some cases, by telephone in other cases) also yielded detailed information on values, types of inventory and equipment, elevations, and effects of inundation. The purpose was to develop a more accurate estimation of damage potential for businesses or facilities that are critical to the results of the damage analysis. Usually they are critical because they account for a significant portion of total property value in their area. Estimated damage potential developed based on these discussions also can be applied to similar businesses. The information provided by company representatives facilitated the subsequent preparation of detailed value estimates and depth-damage estimates for the company.

In selecting a series of key businesses and facilities for more detailed evaluation, the goal was to account for as much as possible of the investment, and therefore damage potential, in each protected area by emphasizing those firms controlling a disproportionately large percentage of the investment. Early in the feasibility process, the reconnaissance economics database from 1997 was utilized for an initial screening in which firms with the largest structure value in each area were identified. (Neither an organized feasibility-level database nor any reliable estimate of business contents was yet available at that time.) The list subsequently was refined based on other discussions with city and county officials and on observations during the field survey.

Ultimately, we spoke with representatives of 34 businesses and facilities. Based on the final estimates of non-residential structure and content values used in this analysis, these 34 firms and facilities account for 56% of non-residential investment (i.e., businesses and public facilities) in the study area. Of the 34, 22 were firms in North Topeka, an area with most of the larger companies in the study area and about half the property value, and the 22 firms accounted for 55% of the total non-residential value in that area. In Oakland and South Topeka, the other largest components of the study area, data from discussions with representatives of 10 companies and facilities accounted for 55% of non-residential value in that area. In Auburndale, we spoke with representatives of the only large facility in the floodplain. Other Auburndale businesses are few in number, small, and generally at the edge of the floodplain, minimizing their contribution to expected annual damage potential.

4.3 DATA DEVELOPMENT - ELEVATIONS

In the second phase of the database preparation for the economic analysis, the raw data obtained from the county and city tax and GIS data and from the field survey and discussions with businesses 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 (M.S.L.) ground elevation. This includes crop acreage and roads 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 1-foot contour maps. Because of the large number of structures in the study area (about 6,500 homes and 800 businesses), elevations for homes and smaller businesses were assigned on a block-by-block basis in densely populated neighborhoods with very flat topography and structural homogeneity. In areas with more dispersed development, each structure was evaluated individually, particularly large business or public structures. Each structure also was assigned a station or stream 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 also was 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 0.1%-chance event, we evaluated all city streets and county roads in the floodplain 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 segment.

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. According to EM 1110-2-1619, Table 6-5, the uncertainty associated with mapping based on an aerial survey with 2-foot contours would be characterized by a standard deviation of 0.3 feet. The table does not give the error associated with 1-foot contour maps, which by inference might have a standard deviation of 0.15 feet (or something less than 0.3 feet, in any case). However, at least three factors increased the uncertainty beyond this rule of thumb: (1) the generalized block-by-block method for assigning ground elevations in some areas; (2) the difficulty of estimating the correct ground elevation for properties where the structure footprint is traversed by multiple elevation contours; and (3) the uncertainty inherent in brief and somewhat distant visual observation and estimation of foundation heights in the field during surveys. These factors are bigger issues with some properties and areas than others, and the exact uncertainty associated with each limitation is unknown. But in order to accommodate the known uncertainty factors involved in estimating elevations for this study, all structures in the database, as well as all road segments, were assigned a standard deviation of 0.8 feet.

4.4 DATA DEVELOPMENT - VALUATION

Guidance for Corps of Engineers economic analyses defines asset value in terms 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 finished 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, so that the most likely value estimate is accompanied by a maximum and minimum value.

4.4.1 Residential Structures Valuation. For this analysis, appraised values of homes were initially taken from the 2003 Shawnee County property tax data as an approximation of depreciated replacement values. (The appraised values ultimately were updated to 2006 values for use in the alternatives analysis.) The appraised values are based on sales data for comparable properties, and sale prices generally provide a fair approximation of depreciated replacement value, with two provisos: overall property value must be stripped of land value (which had been done by the county prior to receipt of the data by the Corps), and appraisals must be updated regularly. Kansas state law, enforced by audits, requires county appraisers to keep statistics indicating how well appraised values reflect actual sales prices data, and appraised values are required to be within 10% of actual sale prices. The Shawnee County appraiser's office, based on data for the most recent 12-month period, estimated that residential property appraisals have been within 3% of actual sales. The field survey also allowed a reality check on the reasonableness of appraised values since each property could be visually inspected in light of its appraised value, and severe mismatches between estimated value and reality could be identified. Generally, however, the field survey confirmed the reasonableness of the appraised values for Topeka homes.

The appraised values were only used as a starting point, however. A detailed Marshall and Swift analysis of depreciated replacement value was performed on a sample of homes, with the intention of ultimately using the results to adjust the appraised values of the entire population of residences. The sample size was selected by calculating mean values and a standard deviation for the entire population of appraised values and then entering them into a standard statistical formula along with specified confidence factors and deviations from the mean. The sample was stratified by study reaches and included only single family, non-manufactured homes. (Mobile homes and apartments, which form much smaller groups within the population, were dealt with separately but using a parallel methodology.) Given our specification of a 90% confidence factor and an allowable deviation of 10% from the mean value, the minimum sample size was estimated to be 31 for Auburndale, 62 for Oakland/South Topeka, and 214 for North Topeka, for a total of 307 homes.

We obtained detailed data from the county tax database on each of the homes in the sample, including square footage, construction type, number of stories, wall type, basements, garages, porches, heating and air conditioning types, floor coverings and interior walls, and lump sum adjustments such as fireplaces. The Marshall and Swift 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 Marshall and Swift material to estimate depreciation and calculate a depreciated replacement value. Upon completion of the sample, the resulting depreciated replacement values for each of the 307 homes was compared to the 2007 appraised value to determine the percentage change. Finally, the percentage changes for the sample were averaged and the average increase of 21.8% was applied to the remainder of the population.

Structure value uncertainty in this analysis generally is related to uncertainty in either the assessment of residential construction quality or depreciation estimates. The standard deviation for residential structure value in this analysis is assumed to be normally distributed and is characterized by a standard deviation of 0.19. This standard deviation is based on the typical differences in value between successive categories of construction quality in the Marshall and Swift residential data.

4.4.2 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 and described further in section 4.4.1 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. Content damage is computed as a percentage of structure value. However, use of the IWR functions eliminates the need to establish content to structure value ratios. For purely informational purposes of estimating investment values in the study area, residential contents value is assumed to equal 50% of structure value.

The IWR functions are used for all 1, 1 1/2, and 2-story homes, with or without basement. Mobile homes and apartments are not included in the IWR functions, and CSVRs are used to value contents for these two residential categories. For apartments, a CSVR of 0.23 was used, based on New Orleans District data summarized in the next section below. For mobile homes, a CSVR of .636 was used, based on Table 6-4 in EM 1110-2-1619, “Risk Based Analysis for Flood Damage Reduction Studies,” 1 August 1996.

Autos are included in the residential data by assuming that there are two vehicles associated with each home, based on data from the Bureau of Labor Statistics indicating an average of 2.2 cars per household in this region. We assume that in the event of evacuation, one vehicle would be left behind and would be subject to damage. In order to account for autos, as well as landscaping and other outdoor features nor included in the contents category, all residences are assumed to have an "other"-to-structure value ratio of 20%. In support of this ratio, we determined that the average used car sale value in 2007 is approximately $8,500 (Maryland Motor Vehicle Administration, 2007). The $8,500 would be slightly more than 15% of the average home value in this study of $55,600, and since the $8,500 does not account for those who have new cars (triple the cost of used vehicles, on average) and does not include landscaping, 20% of structure value appears to be a reasonable assumption for this category of damages.

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 mobile homes, the source for the CSVR (EM 1110-2-1619, Table 6-4) also specifies a standard deviation of 0.378. The New Orleans data which includes the CSVR for apartments also specifies a standard deviation of 0.13. For the "other" category, which includes autos, a standard deviation of 0.05 is assumed.

4.4.3 Commercial and Public Structures Valuation. The values of commercial and public structures in this analysis are estimated using information from the county tax database in conjunction with Marshall and Swift's commercial valuation reference products. Characteristics for each building taken from the tax database included occupancy type (e.g., garage, church, retail store, office building, etc.), construction class, construction quality, and square footage. These characteristics were the basis for calculation of replacement values for each structure using the Marshall and Swift 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 an effective age and a corresponding depreciation factor. Application of the depreciation factor to the replacement value resulted in a depreciated replacement value for each building. These methods are similar to the process used for residential structure valuation, but unlike the residential computations which used a sample to adjust a large population of residences, all non-residential building values were evaluated individually without a sample.

Uncertainty in the valuation of commercial and public structures is assumed to be normally distributed and is characterized in this analysis by a standard deviation of 0.21 for all properties. Like the structure value uncertainty for residential properties, this standard deviation assumes that assessment of construction types and qualities is a key source of value uncertainty and reflects the typical differences between successive categories of construction types in Marshall and Swift commercial data.

4.4.4 Commercial and Public 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 a contents-to-structure-value ratio (CSVR). For firms and facilities that provided more detailed data to us via discussions, 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, 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.

The first-hand, company-specific data yielded CSVRs ranging from 0.28 for a railroad company to 80.17 for a food warehouse. Since the companies and facilities providing these data accounted for about 65% of the estimated total study area non-residential contents value, it can be seen that non-residential contents valuation in this analysis is primarily based on first-hand information from the companies. Since obtaining first-hand data from all 800 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. This source was recommended by Corps subject experts for use in NWK flood risk management economic analyses. 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 - characteristics that transfer well to the Topeka context of flooding. The owner/operators interviewed represented many of the same types of businesses and facilities as are found in the Topeka 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 business within each broad category.

Additional CSVRs for churches and service stations were taken from IWR Report 96-R-12, "Analysis of Nonresidential Content Value and Depth-Damage Data for Flood Damage Reduction Studies," May 1996. This report evaluated post-flood data from the Wyoming Valley area of the Susquehanna River basin in northeastern Pennsylvania. The context of the data is again long-term, freshwater, main stem river flooding in an urbanized area, which is similar to the flooding context of the present analysis. Finally, non-residential properties for which available information was insufficient to determine an occupancy type were assigned a CSVR of 1.0. Vacant properties were assigned a CSVR of 0.05, since many vacant properties have minor contents or are used for storage; moreover, properties that are currently vacant would not necessarily remain vacant over the 50-year period of analysis. Table D-9 summarizes the CSVRs used in this analysis.

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 business structure values.

Uncertainty in contents valuation for firms we did not contact and speak to 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 D-9. To take an example using the second category listed, a grocery store with a structure value of $100,000 would have contents valued at $128,000 ($100,000 X 1.28). The data indicate a standard deviation of 0.76, which would amount to $97,280 ($128,000 X 0.76) for one standard deviation and $194,560 for two standard deviations. Consequently, the sampled contents value could range from $0 on the low end ($128,000 - $194,560 < $0; negative values would not be sampled) to $322,560 at the high end ($128,000 + $194,560).

TABLE D-9

CONTENT TO STRUCTURE VALUE RATIOS

Category	CSVR	Standard deviation
1. Eating & recreation places	3.06	1.62
2. Groceries & gas stations	1.28	0.76
3. Professional businesses	0.78	0.58
4. Repairs & home use businesses	2.51	0.86
5. Retail & personal service businesses	1.48	0.79
6. Warehouses & contractor services	3.72	1.45
7. Public & semi-public enterprises	0.82	1.39
8. Churches	0.34	0.82
9. Service stations	1.22	1.57
10. Multi-family housing	0.23	0.13
11. Mobile homes	0.64	0.38

Sources: "Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVR) in Support of the Lower Atchafalaya Reevaluation and Morganza to the Gulf, Louisiana Feasibility Stuides," Gulf Engineers & Consultants, May 1997, prepared for New Orleans District COE (#1-7, 10); IWR Report 96-R-12, "Analysis of Nonresidential Content Value and Depth-Damage Data for Flood Damage Reduction Studies," Planning and Management Consultants Ltd., May 1996, prepared for the Institute for Water Resouces (#8-9); EM 1110-2-1619, Table 6-4 (#11).

4.4.5 Roads and Streets Valuation. Length in miles of city streets, highways, and railroad track was computed for each protected area based on GIS data provided by the city. Identification of construction costs for each segment of each street or road, along with appropriate depreciation factors, is not practical for an analysis of this nature. For this reason, the valuation of roads and streets is based on typical construction costs per mile, which are applied to the length in miles for each type of road. Typical construction costs are based on data from various sources, including several state departments of transportation, cities in the Kansas City District, railroad companies, the USACE Transportation Systems Center in Omaha, and previous Corps studies. Values for the urban railroad tracks include switching. For conversion of these replacement values per mile to depreciated replacement values, the costs were discounted by 35% as an average life-cycle rate of depreciation. The resulting depreciated replacement values per mile for various road categories are listed below:

Railroad track	$1,300,000
Highways	$2,266,300
City arterials	$2,723,400
City secondary streets	$1,486,200
City residential streets	$1,114,700
County roads	$743,100

Uncertainty in valuation of roads and streets was computed as a triangular distribution. Low and high values around the median were computed by changing assumptions for replacement cost per mile (based on the different sources listed above) and depreciation percentage. Based on these hypothetical adjustments in data, railroad values are allowed to range from 19.2% to 182.7% of the most likely value. For streets, roads and highways, the allowable range in values is from 34.6% to 182.7%.

Also included in this category is damage to rail cars sitting idle in the rail yards of South Topeka, Oakland and North Topeka. Locomotives would likely be evacuated in the event of a flood warning, but most boxcars could not be removed on short notice due to lack of sufficient locomotive power. For those boxcars stranded in the floodplain, damage would mainly consist of damage to wheel assemblies, along with more minor damage to the cars themselves. But any commodities stored on the cars would be subject to total loss, although the containers would incur little damage. Based on information obtained from railroad representatives interviewed for the Kansas Cities Seven Levees study, we assumed a cost of $80,000 per car for replacement of wheel assemblies, plus an average cost per car of $22,000 in commodities based on the types of commodities commonly routed through Topeka. We estimated that on average, at least 3,000 rail cars would be found in study area rail yards on any given day. Of these, we assumed that a flood warning would lead to the evacuation of all locomotives and 25% of boxcars. Of the remaining boxcars stranded in the area, many would be located at the BNSF shops in South Topeka, where cars are sent for repair, and most of these cars presumably would not be carrying commodities. Therefore, we assumed that only one-third of the 3,000 cars would carry commodities.

4.4.6 Agricultural Valuation. Crop damages in the analysis are expressed as a value per representative acre. A value per acre was prepared for Shawnee County using a weighted average that accounts for a number of factors. Initially, a typical crop pattern or distribution is established for river bottoms in the relevant area. Standard, widely available county and district crop data are not useful for this purpose since they reflect all farms, not just those in river bottom areas, and crop patterns and yields in river bottom areas usually differ significantly from other farms. Instead, Farm Service Agency county staff and Natural Resource Conservation Service state staffs are consulted for their estimates of local crop patterns and yields in floodplain areas. Virtually all river bottom farming in the study area involves corn and soybeans, with a very small amount of wheat and bean double-cropping in Kansas counties. Crop budgets available from state university extension offices are used to determine annual production costs per acre for each crop, including planting costs per input and harvest costs. Crop calendars for each crop are used to determine the typical monthly schedule for planting, growing and harvesting. Yields per acre for each crop are obtained from the FSA and NRCS sources. For prices per bushel, Corps economic analyses are required to use normalized prices updated each year by the U.S. Department of Agriculture for all basic crops.

These data inputs are integrated to determine on a monthly basis the extent to which each crop is in the ground, mature, and harvested. These calculations in turn determine the value per acre that can be lost to flooding at any given time during the year. Potential monthly losses for each crop are then integrated with monthly flooding probabilities to determine actual losses. Finally, the losses for each crop are combined with crop distribution data to determine the overall crop value lost per acre in a flood. The damage per acre assumed in this analysis is $149.

To determine an uncertainty factor for these values, the FSA staff consulted on local crop distribution and yields were asked to estimate yields per acre in an average year, a very good year, and a poor year. The value per acre computations that had been done using the yields per average year were repeated for the very good and poor years. These computations established a maximum and minimum value. The maximum was 14 to 16% greater than the average, while the minimum was 14 to 17% less than the average. The value uncertainty for crops is therefore expressed using a triangular distribution, with a minimum of 85% and a maximum of 116%.

4.4.7 Emergency and Disaster Relief Costs Valuation. In addition to the tangible damages to businesses, homes, and other physical property items caused by flood inundation or exposure, the costs of flooding include emergency costs and disaster relief costs. Emergency cost savings can encompass savings related to a wide range of flooding impacts, including emergency personnel costs, flood fighting costs (sandbagging, for example), avoidance costs (raising or evacuation of property), temporary food and housing, debris cleanup, and damage to infrastructure items not otherwise included in the damage analysis such as sewer lines. The city of Topeka was contacted to obtain available historical data on emergency costs incurred during previous flood events. However, no serious Kansas River events have occurred since 1951, with the result that there is a dearth of empirical data, and we were unable to obtain enough reliable data to estimate this category of impacts based on direct or first-hand data. Yet emergency flood fighting costs are a recognized and significant category of economic impacts from flooding, and accuracy is not served by their absence from the economic analysis.

As an alternative, we consulted several reports published by the Corps pertaining to the 1993 Missouri River basin flood in order to estimate typical emergency costs for a large flood in an urban setting. (The 1993 event was rated as equal to or approximating a 0.2%-chance event in most locations along the Missouri.) These reports included the 1993 Interagency Floodplain Management Review Committee Report (Galloway Report); Impacts of the Great Flood of 1993 (CELMV, May 1996); and the Flood Plain Management Assessment of the Upper Mississippi River and Lower Missouri Rivers and Tributaries (USACE, June 1995). We compared 1993 flood damage estimates for damage centers detailed in these reports with 1993 agency emergency costs as reported in these documents. Based on these data, emergency costs as a percentage of total physical flood damages ranged from a low of 12.4% to a high of 15%, with an average of 13.4% for all states impacted by the 1993 flood. In addition, we also consulted a white paper by a former HQUSACE reviewer who surveyed planning reports submitted to HQUSACE by Corps districts across the nation in recent years. This analysis found that emergency costs claimed in approved Corps reports averaged about 9% of total EAD reduced. Based on the information contained in these sources, we assumed that emergency costs are equivalent to a maximum of 9% of physical flood damages in the largest events and to smaller percentages in lesser events. Preliminary HEC-FDA runs were executed to obtain estimates of total physical damages for the 0.2%-chance event in each study reach, and these totals were entered into HEC-FDA.

Also included in the data we reviewed from prior studies were estimates of disaster relief costs. However, these costs appeared to overlap with the emergency cost estimates in the same studies, presenting a potential for double-counting damages, and we instead elected to obtain data from the Region VII FEMA office. Their data included typical costs for disaster housing assistance and grant assistance to individuals and families following recent Missouri floods, including the 1993 Missouri River flood. Relocation and reoccupation costs for non-residential occupants were not estimated and were not included in the analysis. The data indicated that residential emergency assistance averaged about $7,500 per home. We multiplied this average household amount by the estimated number of homes damaged in a 0.2%-chance flood, again using preliminary HEC-FDA runs. This total was entered into the HEC-FDA study file for each levee unit area as the maximum emergency costs that could be incurred.

4.5 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% 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. A selection of depth-damage functions used in this analysis is presented in Table D-10 and discussed below.

4.5.1 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. Of the eight residential occupancy types selected for this analysis, the IWR functions pertain to six: 1-story with and without basement, 1 1/2-story with and without basement, and 2-story with and without basement. Although the IWR functions begin as low as 8 feet below the first floor for homes with basements, all homes in this analysis have been assigned beginning damage stages of minus 2 feet. This prevents the software from beginning to read the functions until a depth of minus 2 feet is attained, and then only for homes with basements.

The other two residential occupancy types, mobile homes and apartments/multi-family housing, are not included in the IWR data. However, the IWR function for 1-story homes with no basement was chosen to compute damages for apartments without basements. For mobile homes, a depth-damage relationship from the New Orleans District data was used.

4.5.2 Commercial and Public 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 plant (usually the floor of the main building). Companies with more than one building were asked to split their overall estimates of investment into values per building and to identify types of equipment and inventory in each building. Often, Corps personnel made these determinations during on-site inspections of each building. Ultimately, a spreadsheet program was used to develop a single contents depth-damage function for the company based on a weighted average of all the individual item depth-damage functions, with each item weighted by its value as a percentage of total contents value for the company. For example, if office equipment was valued at $10,000 for a given facility, and total equipment and inventory for the facility were valued at $200,000, the depth-damage relationship for office equipment would get 5% of the weight in determining the total contents depth-damage function.

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 4.4.4. 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. The New Orleans owner/operator estimates used for Topeka were based on post-flood surveys conducted in the aftermath of an urban, freshwater, main stem (long duration) flooding event in Louisiana. The owner/operators interviewed represented many of the same types of businesses and facilities as those included in the Topeka structure inventory. These are the factors making the data relevant for Topeka. Depth-damage functions are included in the New Orleans District report for each of 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. Additional depth-damage functions for churches and service stations came from a published IWR report evaluating data from the Wyoming Valley in Pennsylvania. These depth-damage curves included only median values and had to be augmented by assumed uncertainty bounds. In cases where no generalized depth-damage function for similar businesses was available or not enough information existed concerning the nature of the business, one of three generalized functions was used based on high, medium or low damage potential (see #26-28 in Table D-10).

It will 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 good 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 in the floor. Another reason is that 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.

The availability of flood avoidance measures such as evacuation, raising, or flood proofing was taken into consideration in formulating depth-damage relationships where appropriate. The company-specific information we obtained, covering key facilities throughout the study area accounting for a large portion of total investment, included discussion of avoidance measures and emergency plans that could be employed in a major flood event. However, most of the large plants or warehouses evaluated in this study would be unable to relocate more than a small portion of their massive inventories in the warning time provided, and most of the facilities would be unable to move or raise their equipment regardless of warning time. One exception is aircraft, which are assumed to be evacuated from the airport in advance of a flood event.

4.5.3 Road and Street Depth-Damages. Depth-damage functions used for roads in this analysis were formulated by obtaining typical costs per mile for minor maintenance such as regrading and resurfacing as well as for more major reconstruction to compare against the costs of new construction. In general, it is assumed that lower levels of inundation will result in relatively minor damage requiring repairs amounting to regrading and/or resurfacing, while more severe inundation levels will require much more expensive repairs that would be comparable to reconstruction. The resurfacing and reconstruction costs per mile obtained were divided by the new construction costs per mile to produce the depth-damage percentages.

4.5.4 Agricultural Depth-Damages. Based on our interviews with farmers following many previous flood events, the depth-damage function used for crop damages simply assumes that one foot of water ruins a crop. A surface flow is assumed to result in about 5% of total damage, based primarily on contamination rather than physical crop destruction.

4.5.5 Emergency Cost and Disaster Relief Depth-Damages. The depth-damage functions constructed for these categories of non-physical costs were developed in conjunction with preliminary runs of the HEC-FDA program that estimated single-event damages for the 0.2%-chance event and other large events. The emergency costs function was structured so that a 0.2%-chance flood would result in damages for this category equal to about 9% of total physical damages. Percentages for smaller events were estimated as proportions of the 9% damage based on comparing typical flood depths in each event.

For the disaster relief category, we estimated total costs in the 1%, 0.4%, and 0.2%-chance events based on the estimated number of homes flooded in each event and the per home cost of $7,500. The depth-damage function was then structured so that it produced nominal damages at each flood event roughly approximate to these amounts.

4.6 COSTS OF FLOODING NOT INCLUDED IN ANALYSIS

Although the accounting of flood losses for this analysis is fairly comprehensive, certain costs of flooding are not included in this economic analysis. Usually this is because of one or a combination 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 utilities - Damages to sewer systems and underground utility lines would occur in each reach, with damages likely in the millions of dollars, and cleanup costs would add to the total. But much of this damage probably would still occur in any large flood event, even with a stronger or higher levee.

- Damage to levee units - The levee units that are the subjects of this study would themselves sustain at least minor damages in large flood events, and damages easily could reach the tens of millions of dollars. But here again, much of this damage might still occur even with augmented levees.

- Traffic interruption costs - Flood-related detours result in extra vehicular operating expenses as well as the opportunity costs of lost time, and the costs can be substantial when busy routes or lengthy detours are involved. But most of these traffic interruptions would occur whenever there is a serious flood threat, even if no flooding actually occurs, so Federal project improvements probably would not prevent most of these losses

- Lost production - Business shutdowns can last for weeks in large floods, causing sizable and even ruinous production losses. Usually, production can be replaced by other locations of the company or companies in the same industry, so costs of business interruptions are generally considered economic transfers rather than losses to total output

TABLE D-10

SELECTED DEPTH-DAMAGE FUNCTIONS

Abbreviations: NB = no basement; WB = with basement; std dev = standard deviation

RESIDENTIAL

TYPES	DEPTH IN FEET	0	1	2	3	4	6	8	10	12	16
1. 1 story no basement homes	Struc damage %	13.4	23.3	32.1	40.1	47.1	58.6	67.2	73.2	77.2	80.7
	Struc damage % std dev	2.0	1.6	1.6	1.8	1.9	2.1	2.3	2.7	3.3	4.9
	Cont damage %	8.1	13.3	17.9	22.0	25.7	31.5	35.7	38.4	39.7	40.0
	Cont damage % std dev	1.5	1.2	1.2	1.4	1.5	1.6	1.8	2.1	2.6	3.8
2. 1 1/2 story no basement homes	Struc damage %	11.4	19.3	26.5	33.2	39.3	49.7	58.0	64.5	69.3	75.0
	Struc damage % std dev	2.7	2.3	2.2	2.4	2.6	2.9	3.2	3.5	3.8	5.0
	Cont damage %	6.6	11.0	15.1	18.8	22.1	27.7	32.1	35.2	37.2	38.6
	Cont damage % std dev	2.2	1.9	1.9	2.0	2.1	2.4	2.6	2.8	3.1	4.0
3. 2 story no basement homes	Struc damage %	9.3	15.2	20.9	26.3	31.4	40.7	48.8	55.7	61.4	69.2
	Struc damage % std dev	3.4	3.0	2.8	2.9	3.2	3.7	4.0	4.2	4.2	5.0
	Cont damage %	5.0	8.7	12.2	15.5	18.5	23.9	28.4	32.0	34.7	37.2
	Cont damage % std dev	2.9	2.6	2.5	2.5	2.7	3.2	3.4	3.5	3.5	4.2
4. 1 story with basement homes	Struc damage %	25.5	32.0	38.7	45.5	52.2	64.5	74.2	80.1	81.1	81.1
	Struc damage % std dev	0.9	1.0	1.1	1.4	1.6	2.1	2.5	2.8	2.9	2.9
	Cont damage %	16.0	18.9	21.8	24.7	27.4	32.4	36.3	38.6	39.1	39.1
	Cont damage % std dev	0.7	0.8	1.0	1.2	1.4	1.8	2.1	2.4	2.5	2.5
5. 1 1/2 story with basement homes	Struc damage %	21.7	27.2	32.9	38.7	44.6	55.7	65.3	72.5	76.3	78.8
	Struc damage % std dev	1.1	1.2	1.3	1.6	1.8	2.4	2.8	3.2	4.0	7.6
	Cont damage %	14.0	16.4	18.8	21.2	23.6	28.4	32.7	36.5	39.6	45.9
	Cont damage % std dev	0.9	1.0	1.1	1.3	1.5	2.0	2.3	2.7	3.3	6.3
6. 2 story with basement homes	Struc damage %	17.9	22.3	27.0	31.9	36.9	46.9	56.4	64.8	71.4	76.4
	Struc damage % std dev	1.3	1.4	1.5	1.8	2.0	2.6	3.1	3.7	5.0	12.4
	Cont damage %	11.9	13.8	15.7	17.7	19.8	24.3	29.1	34.4	40.0	52.6
	Cont damage % std dev	1.1	1.1	1.2	1.4	1.7	2.2	2.6	3.0	4.1	10.2
7. Apartments & multi-family	Struc damage %	13.4	23.3	32.1	40.1	47.1	58.6	67.2	73.2	77.2	80.7
	Struc damage % std dev	2.0	1.6	1.6	1.8	1.9	2.1	2.3	2.7	3.3	4.9
	Cont damage %	8.1	13.3	17.9	22.0	25.7	31.5	35.7	38.4	39.7	40.0
	Cont damage % std dev	1.5	1.2	1.2	1.4	1.5	1.6	1.8	2.1	2.6	3.8
8. Mobile homes	Struc damage %	9.9	44.7	45.7	96.5	96.5	96.5	96.5	96.5	96.5	96.5
	Struc damage % min	9.4	42.5	43.4	91.6	91.6	91.6	91.6	91.6	91.6	91.6
	Struc damage % max	12.9	58.1	59.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Cont damage %	0.0	85.0	95.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0
	Cont damage % min	0.0	80.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0
	Cont damage % max	0.0	95.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
9. Automobiles	Damage %	0.0	3.7	46.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Damage min %	0.0	2.3	44.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Damage max %	0.0	4.7	46.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0

NON-RESIDENTIAL

TYPES	DEPTH IN FEET	0	1	2	3	4	6	8	10	12	16
10. Structure - masonry	Damage %	0.0	13.7	25.9	33.4	40.5	53.4	64.8	72.4	75.7	78.1
	Damage % min	0.0	0.0	0.0	0.0	2.0	2.0	2.0	2.0	2.0	2.0
	Damage % max	0.0	35.0	75.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
11. Structure - metal	Damage %	0.0	10.1	18.6	21.0	27.4	47.1	53.1	58.9	60.4	61.6
	Damage % min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Damage % max	0.0	50.0	50.0	50.0	90.0	100.0	100.0	100.0	100.0	100.0
12. Structure - wood	Damage %	0.0	18.3	31.0	38.1	43.1	57.0	69.2	75.5	83.7	91.3
	Damage % min	0.0	4.0	5.0	6.0	10.0	15.0	15.0	15.0	50.0	50.0
	Damage % max	0.0	85.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
13. Contents - warehouse	Damage %	0.0	27.5	45.3	54.6	62.3	77.5	87.0	93.0	95.5	95.5
	Damage % min	0.0	0.0	20.0	25.0	25.0	55.0	55.0	55.0	55.0	55.0
	Damage % max	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
14. Contents - retail & services	Damage %	0.0	29.6	54.9	64.5	77.0	95.5	96.5	96.5	96.5	100.0
	Damage % min	0.0	10.0	19.0	25.0	50.0	65.0	65.0	65.0	65.0	100.0
	Damage % max	0.0	65.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
15. Contents - repair & home supply	Damage %	0.0	30.0	40.9	51.6	65.3	90.6	93.3	99.0	100.0	100.0
	Damage % min	0.0	1.0	3.0	8.0	28.0	43.0	43.0	90.0	100.0	100.0
	Damage % max	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE D-10 -- SELECTED DEPTH-DAMAGE RELATIONSHIPS (continued)											
TYPES	**DEPTH IN FEET**	0	1	2	3	4	6	8	10	12	16
16. Contents - grocers	Damage %	0.0	39.0	54.0	65.9	78.5	97.0	99.5	99.5	100.0	100.0
	Damage % min	0.0	0.0	0.0	29.0	50.0	80.0	95.0	95.0	100.0	100.0
	Damage % max	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
17. Contents - professional offices	Damage %	0.0	31.2	52.4	65.2	72.7	82.0	85.9	89.4	91.5	97.5
	Damage % min	0.0	0.0	10.0	15.0	20.0	30.0	34.0	34.0	50.0	75.0
	Damage % max	0.0	79.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
18. Contents - public facilities	Damage %	0.0	25.1	55.0	69.0	79.0	84.5	85.0	89.7	90.2	94.0
	Damage % min	0.0	0.0	5.0	15.0	35.0	50.0	50.0	50.0	50.0	50.0
	Damage % max	0.0	92.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
19. Contents - restaurants	Damage %	0.0	26.0	54.0	67.5	83.0	95.0	98.0	99.0	100.0	100.0
	Damage % min	0.0	0.0	0.0	20.0	30.0	80.0	90.0	90.0	100.0	100.0
	Damage % max	50.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20. Contents - service stations & auto dealers	Damage %	0.0	14.4	25.6	34.2	40.9	50.0	55.5	58.8	60.8	62.6
	Damage % min	0.0	5.0	15.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
	Damage % max	0.0	20.0	40.0	60.0	80.0	100.0	100.0	100.0	100.0	100.0
21. Contents - churches, 1 story with basement	Damage %	8.6	31.5	47.5	58.7	66.5	75.8	80.4	82.6	83.6	84.4
	Damage % min	5.0	20.0	35.0	45.0	50.0	60.0	65.0	70.0	70.0	70.0
	Damage % max	15.0	40.0	65.0	75.0	80.0	90.0	95.0	100.0	100.0	100.0
22. Contents - churches, 2 story with basement	Damage %	6.6	44.9	64.7	75.0	80.2	84.4	85.5	85.8	85.9	85.9
	Damage % min	3.0	20.0	40.0	50.0	55.0	65.0	65.0	65.0	65.0	65.0
	Damage % max	15.0	60.0	80.0	90.0	100.0	100.0	100.0	100.0	100.0	100.0
23. Contents - churches, 1 story no basement	Damage %	0.0	25.5	43.3	55.8	64.5	74.8	79.9	82.3	83.5	84.4
	Damage % min	0.0	15.0	30.0	40.0	50.0	55.0	65.0	70.0	70.0	70.0
	Damage % max	5.0	35.0	55.0	65.0	75.0	100.0	100.0	100.0	100.0	100.0
24. Contents - churches, 2 story no basement	Damage %	0.0	41.5	63.0	74.0	79.8	84.3	85.5	85.8	85.9	85.9
	Damage % min	0.0	25.0	35.0	45.0	55.0	70.0	70.0	70.0	70.0	70.0
	Damage % max	5.0	50.0	70.0	80.0	80.0	100.0	100.0	100.0	100.0	100.0
25 . Contents - motels	Damage %	8.1	13.3	17.9	22.0	25.7	31.5	35.7	38.4	40.0	40.0
	Damage % std dev	1.5	1.2	1.2	1.4	1.5	1.6	1.8	2.1	3.2	3.8
26. Contents - miscellaneous - medium damage	Damage %	1.0	10.0	20.0	30.0	40.0	60.0	80.0	100.0	100.0	100.0
	Damage % min	0.0	5.0	10.0	15.0	25.0	40.0	60.0	80.0	80.0	80.0
	Damage % max	5.0	25.0	50.0	65.0	85.0	100.0	100.0	100.0	100.0	100.0
27. Contents - miscellaneous - light damage	Damage %	0.0	3.0	7.0	11.0	15.0	23.0	25.0	25.0	25.0	25.0
	Damage % min	0.0	1.0	3.0	5.0	7.0	11.0	15.0	15.0	15.0	15.0
	Damage % max	1.0	5.0	15.0	20.0	25.0	35.0	40.0	40.0	40.0	40.0
28. Contents - miscellaneous - heavy damage	Damage %	3.0	25.0	50.0	80.0	100.0	100.0	100.0	100.0	100.0	100.0
	Damage % min	1.0	15.0	30.0	45.0	60.0	95.0	100.0	100.0	100.0	100.0
	Damage % max	5.0	35.0	65.0	95.0	100.0	100.0	100.0	100.0	100.0	100.0
29. Contents - vacancy	Damage %	4.0	26.9	42.4	52.3	58.9	66.5	70.3	72.3	73.4	74.3
	Damage % min	8.5	13.3	12.9	12.1	11.4	10.4	10.0	10.0	10.1	10.3
	Damage % max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30. General structure & contents	Struc dmg %	5.6	13.6	21.3	28.1	34.1	44.3	52.6	59.3	64.9	73.4
	Struc dmg % std dev	9.5	9.3	9.1	9.1	9.1	8.7	8.0	7.3	6.9	6.9
	Cont dmg %	4.0	26.9	42.4	52.3	58.9	66.5	70.3	72.3	73.4	74.3
	Cont dmg % std dev	8.5	13.3	12.9	12.1	11.4	10.4	10.0	10.0	10.1	10.3
ROADS											
31. Streets & roads	Damage %	0.6	2.0	4.0	6.0	8.0	15.0	22.5	32.5	42.5	62.5
	Damage % std dev	0.6	1.4	1.4	1.4	1.4	2.8	3.5	3.5	3.5	3.5
32. Railroad track	Damage %	1.0	3.1	7.0	10.0	15.0	22.0	26.0	30.0	34.0	42.0
	Damage % std dev	1.0	1.0	2.0	2.0	4.0	6.0	6.0	6.0	7.0	12.0
CROPS											
TYPES	**DEPTH IN FEET**	0	1	2	3	4	6	8	10	12	16
33. Crops	Damage %	5.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Damage % min	0.0	35.0	80.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Damage % max	50.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: IWR residential functions (#1-7, 25); New Orleans District (#8-20); IWR Wyoming Valley data (#21-24); Kansas City District file data (#26-31) and are not counted as NED damages. But certain Topeka companies such as Goodyear (specialized tires), Hallmark (greeting cards), and the Kansas Lottery, produce products or services that only they or a few such companies provide and that could not be replaced elsewhere in the short term. These localized production losses in a long shutdown could also represent losses to the national economy. Quantification of such losses requires detailed and sensitive sales data and has not been accomplished for this analysis.

4.7 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 control 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 range of 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 damage, 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. 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% chance event (i.e., the event magnitude with a 1% chance of occurring in any year).

4.7.1 Hydrologic and Hydraulic Data. Water surface profiles relating Kansas River and Soldier Creek stages to frequencies or probabilities of occurrence throughout the study area were provided for each of eight events, including the 10%, 2%, 1%, 0.5%, 0.2%, 0.133%, 0.1% and 0.4% chance events. The profiles are referenced to 2004 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. Table D-11 displays the elevations and discharges associated with each of eight selected flood events on the Kansas River. The table also includes major historical flood events placed in the context of the current stage-discharge-frequency relationships. The data are relative to the index points of each of the Kansas River reaches and also include the official USGS gauge. Table D-12 displays similar data for Soldier Creek.

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 (82 years) for the stream. For Soldier Creek, the exceedance-probability relationship was based on the analytic method, which computes synthetic statistics given discharges associated with the 50%, 10% and 1% chance events along with the equivalent record length of 70 years. A stage-discharge relationship also was entered for each reach along with the associated standard deviations of 0.85 feet for Kansas River stages and 1.68 feet for Soldier Creek stages.

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 necessarily be the same as the actual top of levee elevation at the index point.

4.7.2 Geotechnical and Structural Data. Geotechnical and structural evaluations of each levee unit were carried out, resulting in identification of the locations with the most critical deficiencies. For each unit with deficiencies, a probability of failure function was developed for each critical section or location. The functions were developed in accordance with the procedures for evaluating reliability of existing levees prescribed in Appendix E of ER 1105-2-100 as well as guidance in other geotechnical engineering regulations. Each function extends from the elevation at which probability of failure begins to the top of levee elevation at that location. Among other points specified in each function are the probable failure point (PFP), the stage associated with an 85% chance of failure, and the probable non-failure point (PNP), the stage associated with an 85% chance of non-failure. The elevations specified in the function at each location were then adjusted to the appropriate index points.

A potential problem in modeling some reaches was presented by a HEC-FDA limitation. HEC-FDA allows the specification of only one probability of failure function for each reach, yet several reaches have more than one location with geotechnical or structural concerns. This limitation in modeling was dealt with by devising combined probability of failure functions for each reach with more than one deficiency. For any elevation at the index point where x_1, x_2, and x_3 represent the probabilities of failure at each of three locations within the same reach, the combined probability of failure at each elevation is given by the formula

$$1-((1-x_1)*(1-x_2)*(1-x_3))$$

Combined probability of failure functions were entered into HEC-FDA for North Topeka, South Topeka, and Oakland.

TABLE D-11

ELEVATIONS AND DISCHARGES FOR SELECTED KANSAS RIVER FLOOD EVENTS

event	event frequency	discharge (thousands of cfs)	elevations						
			USGS GAUGE (RM 83.1)		WW	AUB	N TOP	S TOP	OAK
			stage	elevation	RM 87.0	RM 86.1	RM 85.6	RM 84.8	RM 82.3
10 year	10.00%	93.6	28.6	875.3	879.2	878.1	877.4	876.8	874.6
1993 flood discharge >	2.30%	170.0	---	---	---	---	---	---	---
50 year	2.00%	173.0	34.5	881.2	886.6	885.3	884.4	883.5	880.4
1993 flood stage >	1.85%	n.a.	34.9	881.6	---	---	---	---	---
100 year	1.00%	217.0	37.0	883.7	889.7	888.4	887.5	886.3	882.7
1903 flood (est. cfs) >	0.60%	253.0	37.7	884.4	n.a.	n.a.	n.a.	n.a.	n.a.
250 year	0.40%	268.0	39.3	886.0	892.8	891.4	890.4	889.0	885.0
1951 flood discharge (est.with full regulation) >	0.35%	288.0	40.1	---	---	---	---	---	---
1951 flood stage >	0.31%	---	40.8	887.5	---	---	---	---	---
Design discharge >	0.29%	314.0	41.2	---	---	---	---	---	---
500 year	0.20%	348.0	42.6	889.3	900.4	899.5	898.7	897.3	888.1
750 year	0.13%	387.0	44.0	890.7	901.1	900.1	899.2	897.5	889.5
1000 year	0.10%	410.0	44.8	891.5	902.6	901.5	900.6	898.9	890.3
1951 flood discharge (actual) >	0.06%	469.0	---	---	---	---	---	---	---
2500 year	0.04%	500.0	47.8	894.5	907.7	906.7	905.8	903.8	893.1

Note on historical floods: The 469,000 cfs discharge was the actual discharge of the 1951 event. However, only one of today's five upstream reservoirs - and neither of the two biggest lakes - was in operation in 1951, so the historical discharge does not fit smoothly into the current regulated rating curve. It is estimated that if the conditions that produced the 1951 peak occurred today with much greater upstream regulation, the discharge would instead be about 288,000 cfs. Stages cannot be identified for 1951 in the context of this table since the stage-discharge relationship has changed since 1951. The same considerations apply to the 1903 event.

TABLE D-12 ELEVATIONS AND DISCHARGES FOR SELECTED SOLDIER CREEK EVENTS						
event	**frequency**	**USGS GAUGE (RM 6.0)**			**URBAN RIGHT BANK (RM 4.2)**	
		discharge (thousands of cfs)	**stage**	**elevation**	**discharge (thousands of cfs)**	**elevation**
2 year	50.00%	6.5	13.2	876.2	7.1	871.8
5 year	20.00%	11.8	18.5	881.5	12.9	877.4
10 year	10.00%	16.3	22.0	885.0	17.8	881.0
20 year	5.00%	21.5	25.1	888.1	23.4	884.0
1981 flood >	3.67%	25.0	25.9	888.9	---	---
1982 flood stage >	---	---	27.4	890.4	---	---
50 year	2.00%	29.4	28.6	891.6	32.0	887.4
1982 flood discharge >	1.86%	30.4	---	---	---	---
100 year	1.00%	36.4	31.1	894.1	39.7	890.2
200 year	0.50%	44.3	33.7	896.7	48.3	892.8
2005 flood >	0.41%	47.8	34.5	--	--	--
500 year	0.20%	56.4	40.2	903.2	61.5	897.2

4.7.3 Modeling of South Topeka and Oakland Damages.

4.7.3.1 The Analytical Challenge: Determination of Discrete Performance Outputs. A complicating factor in the economic analysis for the Oakland and South Topeka units is presented by the issue of hydraulic independence. Despite the longstanding practice in older reports of treating the two units as separate and independent, we have determined upon further inspection that they are instead "partially dependent." Overland flows from any flood event not contained by the South Topeka levee can also enter and flood the Oakland area immediately downstream. Flooding originating in Oakland, on the other hand, cannot overcome the rising land elevations as it tries to back up into the South Topeka area.

It is apparent from the nature of this relationship that any evaluation of damages or benefits of proposed alternatives properly attributable to the South Topeka levee unit must account for damages in Oakland as well as in South Topeka. Damages in the Oakland area in any flood event could be due to either or both of these units to some extent. At the same time, computational methods must head off the potential for double-counting Oakland damages since they can be attributed to either the Oakland levee or the South Topeka levee.

A further complication is that in modeling the combined potential from all sources of damage in Oakland, the performance of the South Topeka unit is almost completely obscured by the performance of the Oakland unit. Yet the South Topeka unit has three critical sections associated with a moderate risk of failure that could result in catastrophic damage in both South Topeka and Oakland. To properly evaluate and sort out the partial dependence issue, we must start by combining all critical sections within these two units (five total) into a single probability of failure function to determine the maximum damage potential in Oakland, regardless of source.

But while the South Topeka unit has very significant issues that require addressing, the Oakland unit's condition is even worse. The combined probability of failure function for the two Oakland sections shows chances of failure much farther below top of levee than the comparable function for the South Topeka unit's three critical sections, and consequently the Oakland unit's performance completely dominates the results of the risk-based analysis, as will be discussed further in section 5.2.3.

4.7.3.2. Modeling Partial Dependence. Within the main HEC-FDA study file, the damage analysis for South Topeka is based on the lowest overtopping elevation for the South Topeka levee (adjusted to the index point) as well as a combined probability of failure function reflecting the two South Topeka sites with deficiencies (also adjusted to a common index point). Similarly, the Oakland damage analysis is based on the lowest overtopping elevation for the Oakland levee and the combined probability of failure function for the two Oakland sections, with all levee data adjusted to the Oakland index point. The main study file thus produced performance outputs for South Topeka and Oakland that essentially assumed the two units to be independent.

The partial dependence relationship was then introduced in a second HEC-FDA study file, which was constructed to isolate the damages in Oakland that would be attributable to the performance of the South Topeka levee. The second study file used the same economic and engineering data inputs as the first file, except that the levee parameters applied to Oakland properties are instead based on the performance of the South Topeka unit. The South Topeka initial overtopping point was determined and then adjusted to the Oakland index point, and the probability of failure functions for the three South Topeka critical sections with structural or geotechnical deficiencies were individually adjusted to the Oakland index point and then combined into a single function. Probability of failure functions for the two Oakland sections, on the other hand, were zeroed out in the second study file in order to prevent the performance of the Oakland levee from being included in the calculation. Thus, the second study file attempts to isolate damages occurring in Oakland that are due to overtopping or failure of the South Topeka levee.

The first two study files, however, did not completely capture the damage potential in Oakland. The combined effects of the three South Topeka sections were included in one file, and the combined effects of the two Oakland sections were included in the other file. But the combined effects in Oakland of all five critical sections theoretically should produce an even greater effect than the individual sums of the sections for the two units. Therefore, a third HEC-FDA study file was constructed to calculate the combined effects in Oakland of all five critical sections on both levee units. The lowest overtopping point for the Oakland unit, adjusted to the Oakland index point, was entered as top of levee elevation. The five critical sections were aggregated into a combined function adjusted to the Oakland index point. This portion of the analysis produced a maximum total for damages occurring in Oakland (the total ultimately proved to be only marginally greater than the Oakland total from the first study file) and also was used to calculate the damage reduction from repair of the two Oakland sections (without repair of South Topeka).

The estimates of existing condition damages in Oakland summarized in section 5.2.4 below are based on the third study file. The screening analysis of alternatives, summarized in section 6, bases benefits for Oakland on the third file, while benefits for South Topeka alternatives are based on the first file for the South Topeka component and on the second file for Oakland damages. Finally, the benefits of the selected plan in section 7 use results from all three study files in incremental first and second-added calculations described more thoroughly in section 7.3.

4.7.4 Treatment of North Topeka and Soldier Creek Damages. The North Topeka Kansas River unit and the main section of the Soldier Creek unit each protect essentially the same urban area of North Topeka. Separate analyses evaluate the damages attributable to each unit - i.e., the model contains no assumptions or data linking stages and discharges on Soldier Creek with corresponding data for the Kansas River. The economic structure inventory used is identical for both streams. Damages for the two units are therefore not additive. Double counting would result from any summation of North Topeka and Soldier Creek urban damages. Damage totals for the North Topeka area cited in this analysis will reflect damages attributable to the Kansas River unit unless otherwise stated.

The foregoing discussion applies only to the Soldier Creek urban subunit. The other six subunits, collectively identified in this appendix as "Soldier Creek rural," protect small rural areas, primarily on the left bank, that are distinct from the urban area and are therefore additive.

5.0 DAMAGE ANALYSIS RESULTS

Preliminarily, it should be emphasized that the damages summarized in this section are risk-based, and the results obtained in the risk analysis can appear to be at odds with nominal data that do not reflect the uncertainties involved. As an example, it might be stated that a given Kansas River unit in existing conditions would successfully contain a 1%-chance flood, inasmuch as the current top of levee elevation for that unit exceeds the nominal or most likely 1%-chance flood elevation by one foot. It might also be stated elsewhere that a 1%-chance flood event would result in damages of $5 million within that same unit. These two statements are not contradictory. Although the nominal 1%-chance flood elevation might be lower than the top of levee, a Monte Carlo-based risk analysis would produce a number of possible estimates for the 1%-chance flood event elevation. Within the risk analysis, the standard-deviation of 0.85 feet for the Kansas River stage-frequency relationship under existing conditions means that the elevation attained by a 1%-chance event could be 1.7 feet above or below the nominal 1% elevation at two standard deviations from the mean. The 1%-chance flood elevation, in other words, could assume a value anywhere within a range of about 3.4 feet. As such, although the top of levee might exceed the nominal 1%-chance flood elevation by a foot, with uncertainty thrown into the mix the risk-based 1%-chance flood elevation could reach a height that would overtop the levee by as much as 0.7 feet. The levee that is said to contain a 1%-chance event therefore would also show substantial damages for a 1%-chance event.

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 by far the main existing issues with units of the Topeka levee system.

5.1 KEY FLOOD EVENTS

Two flood events of particular interest in defining an area's flood damage potential are the 1% and 0.2%-chance events. Among other things, these events are particularly relevant in defining floodplains for purposes of determining flood insurance requirements. The HEC-FDA results for these events take into account the effects of existing flood protection measures, but are not annualized. The estimated damage potential of these events, as well as the 0.4%-chance event, is summarized in Table D-13.

5.1.1 The 1%-Chance Flood. A 1%-chance flood event in the existing condition would cause catastrophic damage in Topeka. The main points are summarized below:

- Estimated total damages of $730.6 million would be expected in Topeka. North Topeka and Oakland would be the affected areas; the other units would not flood.

- A total of 5,046 homes and 571 businesses and facilities would be damaged, along with about 50 acres of crops. Average damage per home would amount to about $38,000. For businesses and facilities, damages would average about $811,000.

- North Topeka estimated damages would total $556.7 million, accounting for 76% of the total. Depths would average 5 feet and would reach depths of 20 feet in some places.

- Oakland damages would be an estimated $173.8 million. Water depths would average 1 foot and reach 13 feet.

The centrality of geotechnical and structural issues is clear from the perspective of this flood event. All levees in the study area are at least three feet higher than the 1%-chance flood elevation, and all units except Oakland are at least six feet higher. Yet two units do not contain the 1%-chance event due to their geotechnical/structural deficiencies and suffer serious flooding.

5.1.2 The 0.4%-Chance Flood. Effects of a 0.4%-chance (250-year) flood event in Topeka would include the following:

- Total damages would be nearly $1.35 billion. All study reaches except Auburndale would be flooded.

- A total of 5,637 homes and 697 businesses and facilities would be damaged, along with about 740 acres of crops. Average losses per home would amount to $56,700, while damage to businesses and facilities would average $1.28 million.

- North Topeka again would suffer the worst impact with an estimated $893.7 million in damages, 66% of the total. Depths in North Topeka would average 7.5 feet and would reach 22 feet in some areas.

- Oakland damages would be an estimated $291.8 million, about 22% of the total. Depths would average 2 feet and would reach as much as 11.5 feet.

- South Topeka would account for most of the remaining damage, an estimated $130.7 million, with average depths of 2 feet and maximum depths of about 11.5 feet.

- Waterworks damages would reach an estimated $30.7 million, and the average depth would be about 3 feet. Water supply operations for the entire city of Topeka and surrounding communities would be interrupted for several days.

- Soldier Creek rural reaches would suffer about $1.8 million in damage from a 0.4%-chance flood on Soldier Creek. The urban Soldier Creek subunit also would flood in such an event, resulting in $202.1 million in estimated damages in North Topeka.

TABLE D-13															
DAMAGES FOR KEY EVENTS (EXISTING CONDITIONS)															
October 2007 prices; $1,000s															
1% CHANCE EVENT - EXISTING CONDITIONS															
UNITS	**Total Damage**	**% of Total**	**Residential**			**Non-Residential**			**Crops**		**Streets & Roads**	**Disaster**	**Emergency**	**Depths (feet) ****	
			Homes	**Damage**	**Avg Dmg**	**Businesses**	**Damage**	**Avg Dmg**	**Acres**	**Damage**	**Damage**	**Relief**	**Costs**	**Avg**	**Max**
WW	$0.0	0.0%	0	$0.0	$0.0	0	$0.0	$0.0	0	$0.0	$0.0	$0.0	$0.0	0.0	0.0
AUB	$0.0	0.0%	0	$0.0	$0.0	0	$0.0	$0.0	0	$0.0	$0.0	$0.0	$0.0	0.0	0.0
S TOP	$0.0	0.0%	0	$0.0	$0.0	0	$0.0	$0.0	0	$0.0	$0.0	$0.0	$0.0	0.0	0.0
OAK	$173,847.2	23.8%	2,535	$93,911.6	$37.0	69	$55,750.2	$808.0	44	$1.8	$5,632.7	$8,322.5	$10,228.4	1.0	13.0
N TOP	$556,725.3	76.2%	2,511	$99,434.2	$39.6	502	$407,052.0	$810.9	7	$1.6	$17,501.2	$5,378.8	$27,357.5	5.0	20.0
SOLD CK RURAL	$0.0	0.0%	0	$0.0	$0.0	0	$0.0	$0.0	0	$0.0	$0.0	$0.0	$0.0	0.0	0.0
SOLD CK URBAN*	$0.0	--	0	$0.0	$0.0	0	$0.0	$0.0	0	$0.0	$0.0	$0.0	$0.0	0.0	0.0
TOTAL	**$730,572.5**	100.0%	5,046	$193,345.8	$38.3	571	$462,802.2	$810.5	51	$3.4	$23,133.9	$13,701.3	$37,585.9		
0.4% CHANCE EVENT - EXISTING CONDITIONS															
UNITS	**Total Damage**	**% of Total**	**Residential**			**Non-Residential**			**Crops**		**Streets & Roads**	**Disaster**	**Emergency**	**Depths (feet) ****	
			Homes	**Damage**	**Avg Dmg**	**Businesses**	**Damage**	**Avg Dmg**	**Acres**	**Damage**	**Damage**	**Relief**	**Costs**	**Avg**	**Max**
WW	$30,711.2	2.3%	0	$0.0	$0.0	1	$26,645.5	$0.0	0	$0.0	$36.4	$0.0	$4,029.3	3.0	3.0
AUB	$0.0	0.0%	0	$0.0	$0.0	0	$0.0	$0.0	0	$0.0	$0.0	$0.0	$0.0	0.0	0.0
S TOP	$130,713.6	9.7%	52	$1,166.6	$22.4	86	$113,140.5	$0.0	0	$0.0	$3,227.1	$424.1	$12,755.2	2.0	11.5
OAK	$291,804.8	21.6%	2,776	$157,631.7	$56.8	82	$93,577.5	$1,141.2	74	$3.0	$9,454.6	$13,969.4	$17,168.5	3.0	14.5
N TOP	$893,668.9	66.3%	2,748	$159,614.1	$58.1	528	$653,409.8	$1,237.5	11	$2.6	$28,093.3	$8,634.2	$43,914.9	7.5	22.0
SOLD CK RURAL	$1,789.8	0.1%	61	$1,339.3	$22.0	0	$0.0	$0.0	652	$105.1	$108.4	$107.0	$130.0	0.5	23.5
SOLD CK URBAN*	$202,066.5	--	2,745	$25,661.4	$9.3	369	$158,118.1	$0.0	11	$0.1	$2,536.5	$6,712.9	$9,037.6	8.5	23.5
TOTAL	**$1,348,688.2**	100.0%	5,637	$319,751.8	$56.7	697	$886,773.3	$1,272.3	737	$110.6	$40,919.9	$23,134.7	$77,997.9		
0.2% CHANCE EVENT - EXISTING CONDITIONS															
UNITS	**Total Damage**	**% of Total**	**Residential**			**Non-Residential**			**Crops**		**Streets & Roads**	**Disaster**	**Emergency**	**Depths (feet) ****	
			Homes	**Damage**	**Avg Dmg**	**Businesses**	**Damage**	**Avg Dmg**	**Acres**	**Damage**	**Damage**	**Relief**	**Costs**	**Avg**	**Max**
WW	$51,958.1	2.8%	0	$0.0	$0.0	1	$45,079.6	$0.0	0	$0.0	$61.6	$0.0	$6,816.8	10.5	10.5
AUB	$52,622.4	2.8%	529	$32,206.8	$60.9	11	$10,216.5	$0.0	0	$0.0	$2,475.0	$3,943.9	$3,780.2	3.0	19.5
S TOP	$210,827.5	11.4%	71	$1,881.6	$26.5	115	$182,484.0	$0.0	0	$0.0	$5,205.0	$684.0	$20,572.9	5.0	16.5
OAK	$356,694.7	19.2%	2,917	$192,685.0	$66.1	88	$114,386.7	$1,299.8	90	$3.7	$11,557.1	$17,075.9	$20,986.3	5.5	17.5
N TOP	$1,170,529.6	63.1%	2,752	$209,063.0	$76.0	538	$855,837.6	$1,590.8	15	$3.4	$36,796.7	$11,309.1	$57,519.9	13.5	28.0
SOLD CK RURAL	$11,221.4	0.6%	95	$9,222.6	$97.1	1	$46.1	$0.0	700	$112.7	$253.3	$714.9	$871.8	3.5	27.0
SOLD CK URBAN*	$238,242.5	--	2,747	$30,255.6	$11.0	373	$186,425.9	$0.0	15	$0.2	$2,990.6	$7,914.7	$10,655.5	12.5	26.5
TOTAL	**$1,853,853.6**	100.0%	6,364	$445,059.0	$69.9	754	$1,208,050.6	$1,602.2	805	$119.8	$56,348.6	$33,727.8	$110,547.9		

* Soldier Creek urban damages are not included in total since they are for the same area as the North Topeka levee.
** Depths cited refer to average and maximum depths affecting those homes and businesses in the study reach that flood in that event.

5.1.3 The 0.2%-Chance Flood. A 0.2%-chance or 500-year flood event would result in catastrophic damage throughout the entire study area.

- Damages would total over $1.85 billon in the study area, and all protected areas would flood.

- A total of 6,364 homes, 754 businesses and facilities, and over 800 acres of crops would be damaged. Businesses and facilities would suffer an average of $1.6 million in damages, and the average residential damages would be about $70,000.

- North Topeka damages would reach an estimated $1.17 billion, about 63% of the total, with depths averaging 13.5 feet and maximum depths of about 28 feet.

- Oakland's damage total of $356.7 million would comprise about 19% of total study area damages. Depths would average 5.5 feet, and depths would reach 17.5 feet in some locations.

- South Topeka damages would total an estimated $210.8 million, 11% of the total, with average depths of 5 feet and maximum depths of about 16.5 feet.

- Waterworks and Auburndale each would suffer estimated damages of $52 million, less than 3% of the total in each case. Depths at Waterworks would be about 10.5 feet. Auburndale depths would average about 3 feet but would be nearly 20 feet in some areas.

- A Soldier Creek flood of 0.2%-chance magnitude would result in estimated damages of $238.2 million in North Topeka and $11.2 million in the rural areas.

5.2 RESULTS BY REACH - EXISTING CONDITIONS

As computed in the HEC-FDA risk analysis model, equivalent annual damages (EAD) total $21,450,300 for the study area. The distribution of EAD among the individual protected areas is summarized in Table D-15. Table D-14 gives the benefits of the levees in their existing conditions - how much damage hypothetically would occur annually if the levees did not exist. These benefits are compared to the EAD totals in Table D-15. For example, the table indicates that North Topeka's annualized damages amount to $15.1 million in the context of that levee's currently less-than-optimal condition (see section 5.3.5 below), but would be expected to reach $25.1 million if the levee did not exist at all. D-16 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 Topeka levee system:

- Hydraulically, all of the Kansas River units at Topeka are sufficiently high to offer protection against all but the most extreme events.

- However, significant geotechnical and structural concerns are compromising the performance of the three largest units - North Topeka, Oakland, and South Topeka. There also are significant but lesser concerns at Waterworks, while Auburndale and Soldier Creek have no identified problem areas.

TABLE D-14			
BENEFITS OF EXISTING LEVEES			
Oct 2007 prices, 4.875% interest rate; $1,000s			
Levee Unit	**EAD without existing levees**	**EAD with existing levees**	**Benefits**
KANSAS RIVER			
Waterworks	$597.0	$211.0	$386.0
Auburndale	$515.0	$194.3	$320.7
South Topeka	$2,818.1	$1,017.8	$1,800.3
Oakland	$5,384.0	$4,852.0	$532.0
North Topeka	$25,069.1	$15,126.6	$9,942.5
Kansas River total	$34,383.2	$21,401.7	$12,981.5
SOLDIER CREEK			
Urban (North Topeka)	$22,858.4	$1,521.1	$21,337.3
Rural	$731.8	$48.7	$683.1
Soldier Creek total	$23,590.2	$1,443.6	$22,146.7
TOTAL	**$35,115.1**	**$21,450.4**	**$13,664.6**

TABLE D-15								
EQUIVALENT ANNUAL DAMAGES - EXISTING CONDITIONS								
Oct 2007 prices, 4.875% interest rate; $1,000s								
Levee Unit	**Non-Residential**	**Residential**	**Roads**	**Ag**	**Emergency**	**Disaster Relief**	**Total**	**% of Total**
KANSAS RIVER								
WATERWORKS	$182.6	$0.0	$0.3	$0.0	$28.1	$0.0	$211.0	1.0%
AUBURNDALE	$37.7	$118.9	$9.1	$0.0	$14.0	$14.6	$194.3	0.9%
SOUTH TOPEKA	$881.0	$9.1	$25.1	$0.0	$99.3	$3.3	$1,017.8	4.7%
OAKLAND	$1,555.9	$2,621.3	$157.2	$0.1	$285.4	$232.2	$4,852.0	22.6%
NORTH TOPEKA	$11,059.9	$2,701.7	$475.5	$0.0	$743.3	$146.2	$15,126.6	70.5%
TOTAL KANSAS RIVER	$13,717.1	$5,450.9	$667.3	$0.1	$1,170.1	$396.2	$21,401.6	99.8%
SOLDIER CREEK								
Urban (North Topeka)	$1,190.3	$193.2	$19.1	$0.0	$68.0	$50.5	$1,521.1	
Rural	$0.2	$40.0	$1.2	$0.8	$3.5	$2.9	$48.7	0.2%
TOTAL SOLDIER CREEK	$1,190.5	$233.2	$20.3	$0.8	$71.6	$53.4	$1,569.8	
TOTAL	**$13,717.3**	**$5,490.9**	**$668.5**	**$0.9**	**$1,173.6**	**$399.1**	**$21,450.3**	100.0%

Soldier Creek urban damages are for the same area covered by the North Topeka unit and are not counted in the study area total.

Oakland totals reflect combined probabilities of failure for both Oakland and South Topeka. The Oakland totals represent all damage that would occur in Oakland without regard to the source of the flooding, which can be either the Oakland unit or the South Topeka unit. South Topeka totals include only damage occurring in South Topeka and do not include damages in Oakland attributable to the South Topeka unit.

TABLE D-16						
ENGINEERING PERFORMANCE - EXISTING CONDITIONS						
	WW	**AUB**	**S TOP**	**OAK**	**N TOP**	**SOLD CRK URBAN**
ANNUAL EXCEEDANCE PROBABILITY (median)	0.003	0.003	0.004	0.057	0.024	0.006
Return interval (years)	333	333	250	18	42	167
LONG-TERM RISK (chance of exceedance during indicated period)						
over 10 years	1 in 25	1 in 32	1 in 23	1 in 2	1 in 4	1 in 13
over 25 years	1 in 10	1 in 13	1 in 9	1 in 1.3	1 in 2	1 in 5
over 50 years	1 in 5	1 in 7	1 in 5	1 in 1	1 in 1.4	1 in 3
PERFORMANCE VS. 1% FLOOD						
Initial overtopping elevation margin (feet) over nominal 1% flood elevation	5.9	8.2	6.5	3.7	6.6	1.7
Conditional exceedance probabilty - overtopping or failure	0.072	0.032	0.158	0.971	0.860	0.332
Conditional exceedance probabilty - overtopping only	0.067	0.032	0.054	0.058	0.054	0.332
OTHER FLOOD EVENTS - EXCEEDANCE						
10.0%	0.000	0.000	0.000	0.165	0.004	0.000
4.0%	0.000	0.000	0.003	0.589	0.180	0.002
2.0%	0.003	0.032	0.031	0.857	0.554	0.094
0.4%	0.331	0.213	0.436	0.995	0.970	0.661
0.2%	0.758	0.644	0.806	1.000	0.998	0.817
Annual exceedance probability is the chance of experiencing any flood event - of whatever magnitude - within any year.						
Conditional exceedance probability is the probability that a specified flood event would overtop or breach the levee.						

5.2.1 Waterworks Unit

5.2.1.1 Waterworks Economic Performance Without Project. Equivalent annual damages total $211,000 for Waterworks, about 1% of the total study area EAD. Over 99% of this total is accounted for by the water plant, while roads account for a tiny percentage. The risk-based outputs from the model show that a 0.4%-chance event would be required to cause damage (whether overtopping or failure) in Waterworks.

5.2.1.2 Waterworks Engineering Performance Without Project. At the economic index point, RM 87.0, the adjusted top of levee elevation of 895.6 exceeds the nominal 1%-chance event elevation of 889.7 by 5.9 feet. There is an overtopping exceedance probability of 0.045 in a 1%-chance flood, and this would be the overall 1%-chance event exceedance probability for the levee if there were no were no geotechnical or structural issues. The median annual exceedance probability is 0.003; this is the percentage chance in any year that a flood event will occur that is of a large enough magnitude to result in economic damages.

But even in the context of geotechnical and structural deficiencies, the overall exceedance probability for Waterworks in the context of any 1%-chance event is 0.07. The levee's only significant deficiency is a floodwall sliding threat at about RM 87.3. This threat occurs only in large flood events when water approaches the top of the floodwall. At this location, the PNP (probable non-failure point) at which there is an 85% chance of nonexceedance is 2.4 feet

TABLE D-17

WATERWORKS UNIT

PROBABILITY OF FAILURE FUNCTION - EXISTING CONDITIONS

p(F) = probability of failure; WSE = water surface elevation; TOL = top of levee

FLOODWALL SLIDING THREAT

sta. 0+78 to 7+00 & 10+00 to 16+50

Kansas River mile 87.3

WSE @ index point RM 87.0		p(F)	key elevations
900.4			
897.5	0.0	0.8960	TOL
895.6	1.9	0.2763	Initial overtopping point at index point
895.1	2.4	0.1500	PNP
893.9	3.6	0.0000	
892.8	4.7		0.5% chance (200 year) flood
889.7	7.8		1% chance (100 year) flood
886.6	10.9		2% chance (50 year) flood

below the top of levee, and probability of failure reaches 89.6% at the top of the wall. However, the levee would overtop at its lowest point before water reaches the top of levee at the location of the floodwall concern. Probability of failure reaches only 27.6% at the initial overtopping elevation. Table D-17 summarizes the probability of failure function used in the HEC-FDA analysis for the Waterworks unit.

5.2.2 Auburndale Unit

5.2.2.1 Auburndale Economic Performance Without Project. Equivalent annual damages in Auburndale total $194,300, which is less than 1% of the total study area EAD. About 61% of this total is residential damages and 19% is business and public facilities. The remaining 20% is roads and streets, disaster relief and emergency costs. As with the Waterworks unit immediately upstream, a flood event of greater than a 0.004 magnitude is required to result in economic damage in Auburndale.

5.2.2.2 Auburndale Engineering Performance Without Project. The Auburndale top of levee elevation of 896.6 exceeds the 1%-chance event elevation of 888.4 by 8.2 feet at the index point (RM 82.1). This levee unit has no significant geotechnical or structural deficiencies, so the PFP would be equal to the top of levee as specified in Corps guidance. The overall nonexceedance probability is the same as the overtopping nonexceedance probability. The Auburndale unit has an exceedance probability of 0.032 in a 1%-chance flood event. The median annual exceedance probability is 0.003.

5.2.3 South Topeka Unit

5.2.3.1 South Topeka Economic Performance Without Project. As was explained in section 4.4.3, damages attributable to the South Topeka unit include downstream damages in Oakland due to flooding from South Topeka as well as flooding within South Topeka itself. However, the totals in this section for existing conditions reflect only damages occurring within South Topeka. The total equivalent annual damages for the South Topeka unit are $1,017,800. This is 4.7% of the total EAD for the study area. Of the South Topeka total, businesses and public facilities account for 87%, residential properties and streets account for 3%, and non-physical costs account for the remaining 10%. Floods large enough to cause economic damages in South Topeka would need to exceed a 0.075%-chance (133-year) event.

5.2.3.2 South Topeka Engineering Performance Without Project. The South Topeka unit has three sections with identified deficiencies. Site 1, near RM 84.4, has been identified as a potential underseepage problem area. The PFP (probable failure point), at which probability of failure reaches 85%, occurs at this site only 0.2 feet below top of levee, although the levee would overtop elsewhere before this elevation is reached by water. But the PNP (probable non-failure point) at which the probability of failure reaches 15%, is 8.8 feet below the top of levee at that location. Site 2, near the downstream end of the unit at RM 83.9, is a critical floodwall foundational weakness. Probability of failure at top of levee reaches only 44.7%, so the PFP essentially occurs at or just below top of levee, but the PNP at this site is 4.9 feet below adjusted top of levee. Also in the same area is a third critical site at the Kansas Avenue pumping plant, where there is a strength deficiency issue. The probability of failure at this site reaches 31% at top of levee, and the PNP is located 4.1 feet below top of levee. The pump station section is less critical to the combined probability of failure section for the levee than the floodwall and underseepage problem areas.

The same set of probability of failure functions also serves as the basis for the separate computation of damages in Oakland resulting from performance of the South Topeka levee. However, for that set of calculations, the reference elevations shown in Table D-18 which had been adjusted to the South Topeka river mile of 84.8 are instead adjusted to the Oakland index point of mile 82.3. The reference PFP and PNP points retain the same position relative to levee height. The initial overtopping elevation also is adjusted to the Oakland index point.

Table D-18 and Figure D-2 summarize the probability of failure functions for South Topeka. Figure 2 is a bar chart showing the three individual probability of failure functions and the combined function for the reach. Each function is portrayed as a bar with a clear section from the ground up to the PNP elevation, a hatched area between the PNP and the PFP, and a blacked-out area above the PFP. The chart is not to scale and is not a substitute for the numerical functions detailed in Table D-18, but it is intended to complement the rather complex functions with a starker view of the unit's geotechnical/structural deficiencies in terms of the positioning of key reference points (PFP and PNP) relative to top of levee and ground elevations. The combined PNP of -8.9 feet indicates that a significant probability of failure begins well before water approaches the top of the South Topeka levee.

(Note that the PFPs and PNPs in Figure D-2 appear to differ from those in Table D-18. For example, the PNP for the floodwall at site 2, is shown as -1.1 feet in the table and as -3.3 feet in the figure. The difference is explained by different reference points. Figure 2 portrays the PNP relative to the top of levee at that location, while Table D-18 adjusts the elevations at the three sites to a common index point for the reach and uses the lowest overtopping point in the reach, adjusted to the index point, as the top of levee elevation. This adjusted initial overtopping elevation generally will not be the same as the top of levee elevation at most locations along the levee. The key elevations need to be understood in both contexts to fully understand the problem, and sections 5.2.4 and 5.2.5 below also will present the critical points in both contexts.)

Hydraulically, the South Topeka levee's overtopping elevation exceeds the 1%-chance event elevation of 886.3 by 6.5 feet at the index point. The levee would have an exceedance probability in overtopping 1%-chance events of 0.054. But the overall exceedance probability from either overtopping or failure in a 1%-chance flood is 0.158. The median annual exceedance probability is 0.004, and the associated return interval is 250 years.

TABLE D-18

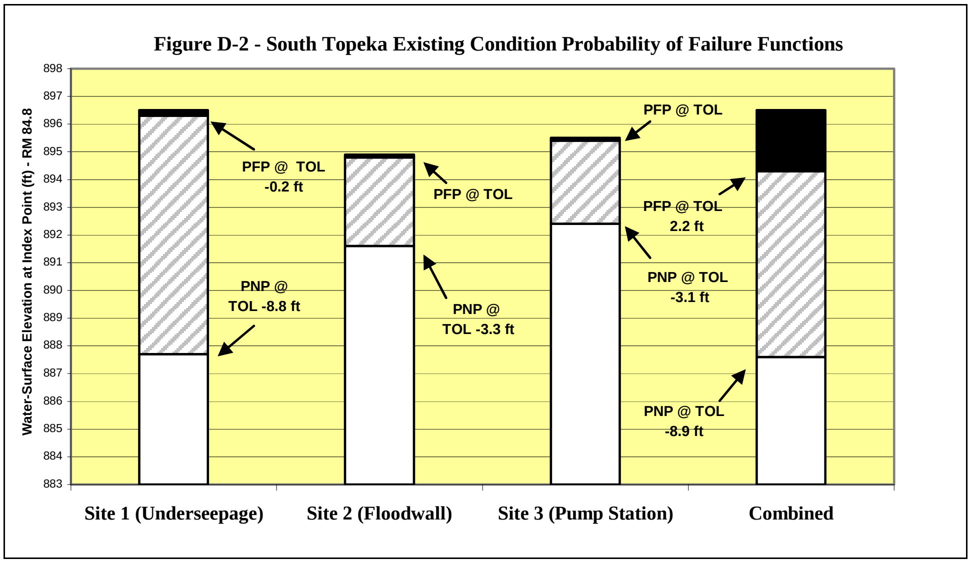
SOUTH TOPEKA UNIT

PROBABILITY OF FAILURE FUNCTIONS - EXISTING CONDITIONS

WSE ** @ index point	p(F) site 1 UNDERSEEPAGE	p(F) site 2 FLOODWALL FOUNDATION WEAKNESS	p(F) site 3 KANSAS AVENUE PUMP STATION	p(F) combined	key elevations (adjusted to index point)	
	sta. 22+00 to 48+00	sta. 74+41 to 93+86	sta. 75+84			
RM 84.8	RM 84.4	RM 84.0	RM 83.9			
897.3					4.6	0.2% chance (500 year) event
896.5	0.8569	0.4467	0.3100	0.9454	3.7	TOL underseepage site
896.3	0.8500	0.4467	0.3100	0.9427	3.5	PFP underseepage site
895.5	0.7785	0.4467	0.3100	0.9154	2.7	TOL pump station site
894.9	0.7348	0.4467	0.2840	0.8949	2.2	TOL floodwall site
894.8	0.7238	0.4344	0.2775	0.8872	2.0	
894.3				0.8500	1.6	approximate combined PFP
893.3	0.5827	0.2880	0.2000	0.7623	0.5	
892.8	0.5370	0.2460	0.1755	0.7122	**0.0**	**Initial overtopping***
892.5	0.5079	0.2195	0.1600	0.6774	-0.3	
892.4	0.5033	0.2152	0.1500	0.6692	-0.4	PNP pump station
891.6	0.4321	0.1500	0.0236	0.5287	-1.1	PNP floodwall site
889.9	0.3048	0.0498	0.0000	0.3394	-2.9	
889.0					-3.8	0.5% chance (200 year) event
887.7	0.1500	0.0065	0.0000	0.1555	-5.1	PNP underseepage site; approximate combined PNP
886.3					-6.5	1% chance (100 year) event
883.5					-9.3	2% chance (50 year) event
883.4	0.0009	0.0000	0.0000	0.0009	-9.4	
881.3	0.0000	0.0000	0.0000	0.0000	-11.5	

* Initial overtopping point is the lowest point on the top of levee profile within the reach, adjusted to the index point. It is not necessarily located at any of the sites listed.

** p(F) = probability of failure; WSE = water surface elevation; TOL = top of levee; PFP = probable failure point (elevation at which there is an 85% chance of failure); PNP = probable non-failure point (elevation at which there is an 85% chance of non-failure)



5.2.4 Oakland Unit

5.2.4.1 Oakland Economic Performance Without Project. Oakland's EAD of $4,852,000 represents 22.6% of the total study area EAD. The damage total is comprised of 54% residential damages, 32% business and public facilities, and 3% roads and streets, with the remaining 11% accounted for by crop acreage, emergency costs and disaster relief costs. A relatively small flood event of approximately a 5%-chance (20-year) magnitude would result in economic damages at Oakland, according to the HEC-FDA results.

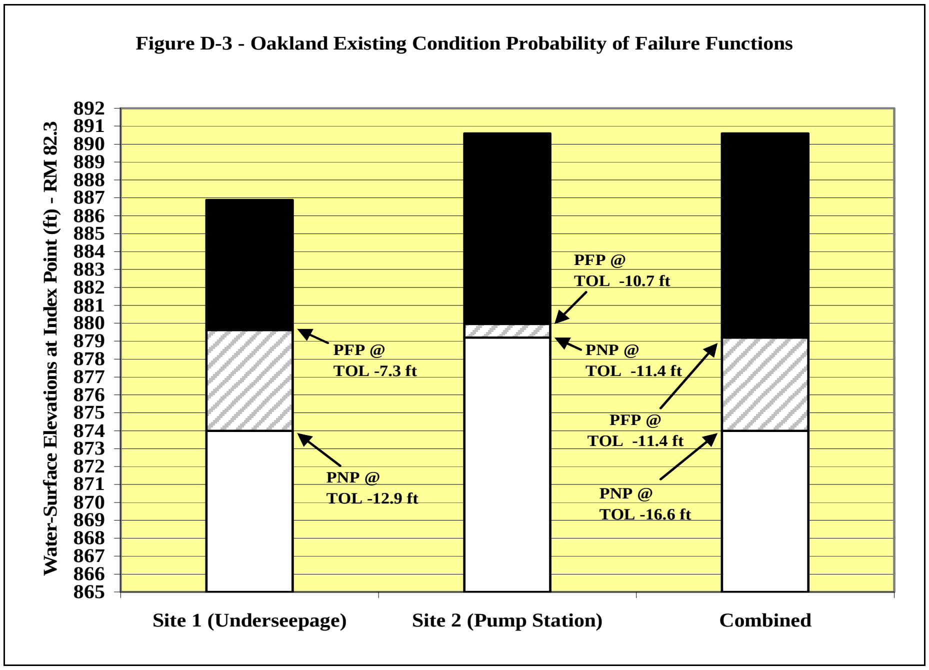
5.2.4.2 Oakland Engineering Performance Without Project. The Oakland levee has two critical sections with deficiencies, one structural and one geotechnical. Site 1, at RM 82.3, is a potential underseepage location. The PFP and PNP at site 1 are 7.3 and 12.9 feet below top of levee at that location. Site 2 is the East Oakland pump station, several miles downstream at RM 77.3, where the potential for uplift has resulted in a PFP and PNP of 10.7 and 11.4 feet below top of levee. The individual and combined probability of failure functions are summarized in Table 19 and Figure 3, which show significant probabilities of failure at both locations long before water reaches the top of the levee. The combined PFP and PNP for the levee occurs 11.4 and 16.6 feet below top of levee. (Top of levee in this example is relative to site 2, which, at the index point, is somewhat higher than site 1.)

The Oakland levee's initial overtopping elevation at the index point of RM 82.3 is 886.4, which is 3.7 feet above the 1%-chance event elevation. If all 1%-chance events were overtopping events, Oakland's exceedance probability would be 0.057. But in the context of all possible 1%-chance events, the exceedance probability is 0.971. Even when the frame of reference is switched to smaller events, the levee has an exceedance probability of 0.857 in a 2%-chance event and 0.589 in a 4%-chance event.

TABLE D-19					
OAKLAND UNIT					
PROBABILITY OF FAILURE FUNCTIONS - EXISTING CONDITIONS					
WSE @ index point RM 82.3	**p(F) site 1 UNDERSEEPAGE sta. 64+00 to 80+00 RM 82.3**	**p(F) site 2 EAST OAKLAND PUMP STATION UPLIFT sta. 220+00 RM 77.3**	**p(F) combined**	**key elevations (adjusted to index point)**	
890.6	1.0000	1.0000	1.0000	4.2	TOL East Oakland pump station
888.1				1.7	0.2% chance (500 year) event
887.6	1.0000	1.0000	1.0000	1.2	
886.9	1.0000	1.0000	1.0000	0.4	TOL underseepage site
886.4	1.0000	1.0000	1.0000	**0.0**	**initial overtopping point**
885.0				-1.4	0.5% chance (200 year) event
882.7	0.9999	1.0000	1.0000	-3.7	1% chance (100 year) event
881.5	0.9882	1.0000	1.0000	-5.0	
880.7	0.9813	0.9886	0.9998	-5.7	
880.4				-6.1	2% chance (50 year) event
880.0	0.8854	0.8500	0.9828	-6.5	PFP East Oakland pump station
879.6	0.8500	0.5513	0.9327	-6.8	PFP underseepage site
879.3			0.8500	-7.2	approximate combined PFP
879.2	0.8007	0.1500	0.8306	-7.2	PNP East Oakland pump station
878.7	0.7479	0.0000	0.7479	-7.7	
875.8	0.2639	0.0000	0.2639	-10.7	
874.0	0.1500	0.0000	0.1500	-12.4	PNP underseepage site / approximate combined PFP
871.8	0.0065	0.0000	0.0065	-14.7	
871.5	0.0000	0.0000	0.0000	-14.9	

* Initial overtopping point is the lowest point on the top of levee profile within the reach, adjusted to the index point. It is not necessarily located at any of the sites listed.

** p(F) = probability of failure; WSE = water surface elevation; TOL = top of levee; PFP = probable failure point (elevation at which there is an 85% chance of failure); PNP = probable non-failure point (elevation at which there is an 85% chance of non-failure)



5.2.5 North Topeka Unit

5.2.5.1 North Topeka Economic Performance Without Project. North Topeka EAD is an estimated $15,126,600, accounting for 70.5% of the total study area EAD. Businesses and facilities account for 73% of EAD, while residential comprises 18% and roads 3%. The remaining 6% comes from crop acreage, emergency costs, and disaster relief costs. A moderate flood event of about a 2.5%-chance (40-year) magnitude would cause damages at North Topeka.

5.2.5.2 North Topeka Engineering Performance Without Project. North Topeka has three sites with significant deficiencies. The probability of failure functions for the three sites and the combined function for the reach are summarized in Table D-20 and Figure D-4. Site 1 is a levee section with underseepage potential at RM 86.9 near the North Topeka treatment plant. The probability of failure function at this site includes a PFP that is 7.1 feet below the top of levee, and the PNP is 13.9 feet below top of levee. Site 2 is an additional underseepage threat near Buchanan Street at RM 85.6. Here, the PFP and PNP are 5.8 and 10.6 feet below top of levee. Site 3 is the Fairchild pump station at RM 83.1, where there are potential uplift issues. The PFP and PNP here are 7.1 and 7.8 feet below top of levee.

The 1%-chance flood elevation of 887.5 at the index point, RM 85.6, is 6.6 feet below the initial overtopping elevation of 894.1. As with other Kansas River units in the Topeka system, the height of the North Topeka levee is more than adequate in preventing 1%-chance overtopping floods, and the exceedance probability in such events is 0.054. But geotechnical and structural issues increase the overall exceedance probability in a 1%-chance event to 0.86. Exceedance probability in a smaller 2%-chance event would be 0.554. The median annual exceedance probability is 0.024.

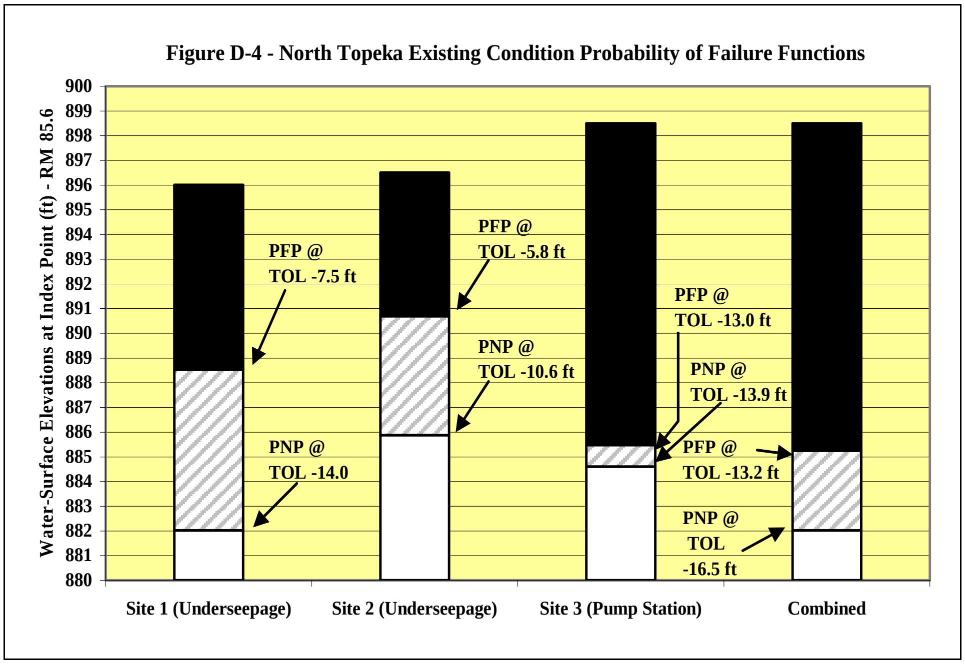


Figure D-4 - North Topeka Existing Condition Probability of Failure Functions
Water-Surface Elevations at Index Point (ft) - RM 85.6
900
899
898
897
896
895
894
893
892
891
890
889
888
887
886
885
884
883
882
881
880
PFP @
TOL -7.5 ft
PNP @
TOL -14.0
PFP @
TOL -5.8 ft
PNP @
TOL -10.6 ft
PFP @
TOL -13.0 ft
PNP @
TOL -13.9 ft
PFP @
TOL -13.2 ft
PNP @
TOL
-16.5 ft
Site 1 (Underseepage)
Site 2 (Underseepage)
Site 3 (Pump Station)
Combined

TABLE D-20 NORTH TOPEKA UNIT PROBABILITY OF FAILURE FUNCTIONS - EXISTING CONDITIONS						
WSE @ index point RM 85.6	p(F) site 1 UNDERSEEPAGE sta. 165+00 to 189+00 RM 86.9	p(F) site 2 UNDERSEEPAGE sta. 246+00 to 250+00 RM 85.6	p(F) site 3 FAIRCHILD PUMP STATION sta. 364+40 RM 83.1	p(F) combined	key elevations (adjusted to index point)	
898.7						0.2% chance (500 year) event
898.5	0.9919	0.9952	1.0000	1.0000	4.4	TOL Fairchild pump station
896.5	0.9919	0.9952	1.0000	1.0000	2.4	TOL underseepage site 2
896.0	0.9919	0.9952	1.0000	1.0000	1.9	TOL underseepage site 1
895.5	0.9886	0.9893	1.0000	1.0000	1.4	
894.1	0.9795	0.9726	1.0000	1.0000	**0.0**	**Initial overtopping point**
893.0	0.9724	0.9597	1.0000	1.0000	-1.1	
891.0	0.9407	0.8787	1.0000	1.0000	-3.1	
890.7	0.9355	0.8500	1.0000	1.0000	-3.4	Underseepage site 2 PFP
890.5	0.9327	0.8328	1.0000	1.0000	-3.6	
890.4					-3.7	0.5% chance (200 year) event
888.6	0.8506	0.5855	1.0000	1.0000	-5.5	
888.5	0.8500	0.5779	1.0000	1.0000	-5.6	Underseepage site 1 PFP
887.5					-6.6	1% chance (100 year) event
886.9	0.7235	0.2752	1.0000	1.0000	-7.2	
885.9	0.6118	0.1500	0.9835	0.9946	-8.2	Underseepage site 2 PNP
885.5	0.5650	0.1009	0.8500	0.9413	-8.6	Fairchild pump station PFP
885.3				0.8500	-8.8	approximate combined PFP
885.0	0.5089	0.0419	0.4682	0.7497	-9.1	
884.6	0.4588	0.0336	0.1500	0.5554	-9.5	Fairchild pump station PNP
884.4	0.4319	0.0294	0.0000	0.4486	-9.7	2% chance (50 year) event
882.0	0.1500	0.0000	0.0000	0.1500	-12.1	Underseepage site 1 PNP / approximate combined PNP
877.1	0.0000	0.0000	0.0000	0.0000	-17.0	

* Initial overtopping point is the lowest point on the top of levee profile within the reach, adjusted to the index point. It is not necessarily located at any of the sites listed.

** p(F) = probability of failure; WSE = water surface elevation; TOL = top of levee; PFP = probable failure point (elevation at which there is an 85% chance of failure); PNP = probable non-failure point (elevation at which there is an 85% chance of non-failure)

5.2.6 Soldier Creek Unit Performance

5.2.6.1 Soldier Creek Economic Performance Without Project. The Soldier Creek Unit's urban North Topeka subunit is charged with equivalent annual damages of $1,521,100. This total is not included in the overall study area total because the same area is the basis for the North Topeka unit's totals. Approximately 78% of the EAD is non-residential and 18% is residential, while roads make up 3% of the total. Floods of a magnitude of at least 0.075%-chance (133- year) are required to produce economic damages from Soldier Creek in North Topeka.

The rural reaches of Soldier Creek account for $48,700 in EAD. Of this total, 82% is residential, and the remainder is streets, crops, emergency costs and disaster relief costs. A flood of at least 0.075%-chance scale is also required to produce flood damage in these rural reaches.

5.2.6.2 Soldier Creek Engineering Performance Without Project. The Soldier Creek Unit's urban North Topeka subunit has an initial overtopping elevation of 892.0 at the index point of RM 4.4. This is higher than the 1%-chance flood elevation of 890.8 at the same location by 1.7 feet. The unit's exceedance probability in a 1%-chance flood is 0.332. There are no significant structural or geotechnical concerns related to this unit and no probability of failure functions, so the nonexceedance probability is based solely on hydraulics. The median annual exceedance probability is 0.006.

5.3. FUTURE WITHOUT-PROJECT CONDITION - SUMMARY OF EVALUATION ACCOUNTS

Continuing neglect of the deficiencies in the Topeka levee system eventually would result in catastrophic flood losses affecting large urban neighborhoods and industrial areas, as can be seen from the summary in Table D-21. There is at least a 1 in 2 chance that the two largest units, Oakland and North Topeka, will experience at least one flood in the next 25 years. A "no action" condition would have negative impacts on the national economic development (NED), regional economic development (RED), and other social effects (OSE) accounts, as discussed below.

5.3.1 NED Effects of No Action. Losses to national economic output can be quantified to a considerable extent by reference to the equivalent annual damages (EAD) estimated for this study. EAD is the average damage expected annually over the long term if existing conditions are maintained - i.e., if the levee system remains in its current condition. EAD totals an estimated $21.45 million in the study area. This is only an average annual total; little or no damage might occur in some years, while other years would bring flood events causing as much as $2 billion in damages. Listed below are several aspects of these losses.

- **Residential** - Many residents in the study area would sustain heavy personal losses from flooding. A 0.2%-chance flood would be expected to damage more than 6,300 homes in Topeka. Even a smaller 1%-chance flood would damage more than 5,000 homes.

- **Businesses** - Many businesses and public facilities, large and small, would be seriously damaged by flooding and possibly driven out of business. A 0.2%-chance flood could damage more than 750 businesses in the city, and a smaller 1%-chance flood could damage nearly 600 businesses.

- **Public sector** - Public sector losses would be catastrophic: (a) sewage treatment facilities in the North Topeka and Oakland areas would be subject to relatively frequent damage and their operations would be interrupted periodically; (b) the Waterworks plant supplying the city's water also would face marginally greater periodic damage to its facilities; (c) highways and streets would require very costly repairs. (d) police and fire-fighting services employed in flood fights, along with other emergency personnel and their equipment and temporary offices, would cost the city millions of dollars in significant floods; (e) relocation and reoccupation assistance would be required for thousands of residents at an average of $7,500 per home.

Additional effects that are likely NED losses, but are not included in the EAD cited above because they were not calculated for this study (see section 4.6), include the following:

- **Water supply** - The Topeka region's water supply plant behind the Waterworks levee unit would suffer periodic operational interruptions or damage, affecting water supply delivery to 160,000 people and likely resulting in net income losses due to the need to implement alternative water supply arrangements.

- **Traffic interruptions** - Periodic closures during flooding (threatened flooding as well as actual) would interrupt traffic and commerce along key transportation arteries such as U.S. Highways 24 and 75, Kansas Route 4, and the two railroad lines in the area. Lengthy closures could lead to long detours and time-consuming delays on these routes.

- **Business income losses from shutdowns** - Production losses at some study area companies probably could not be made up by other companies or other branches of the same company, at least not quickly enough to meet consumer needs. Some production losses probably would represent unquantified NED losses at the Goodyear tire plant, Hallmark, and the Kansas Lottery.

5.3.2 RED Effects of No Action. Regional economic development considerations are factors affecting the Topeka regional economy while not necessarily affecting national economic outputs. Several such effects in this study would be in connection with the danger that one or more Federal levee units in the Topeka system could be decertified. This action would loom large in the area's business climate. RED effects resulting from this and other factors would include the following:

- **Residential flood insurance premium costs** *(probable adverse income impact*) - Residents would face onerous new flood insurance requirements in the event of levee decertification.

FUTURE WITHOUT-PROJECT CONDITION SUMMARY									
	Equiv. annual damages	Expected damages in 1%-chance flood	Expected damages in 0.2%-chance flood	Affected population	Affected homes	Affected businesses and facilities	Annual exceedance probability	1%-chance event nonexceedance probability	Chance of failure or overtopping over 25 years
Waterworks	$211.0	$0.0	$51,958.1	0	0	1	0.003	0.928	1 in 10
Auburndale	$194.3	$0.0	$52,622.4	1,468	616	18	0.003	0.968	1 in 13
South Topeka	$1,017.8	$0.0	$210,827.5	211	80	142	0.004	0.842	1 in 9
Oakland	$4,852.0	$173,847.2	$356,694.7	7,030	2,942	89	0.057	0.029	1 in 1.3
North Topeka	$15,126.6	$556,725.3	$1,170,529.6	6,725	2,752	539	0.024	0.141	1 in 2
Soldier Creek							0.006	0.668	1 in 5
Urban	$1,521.1	$0.0	$238,242.5	(6,725)	(2,752)	(539)			
Rural	$48.7	$0.0	$11,221.4	664	97	1			
Total	$21,450.3	$730,572.5	$1,853,853.6	16,098	6,487	790			
Soldier Creek urban damages are not included in overall total because North Topeka damages covering the same area are included.									

- **Threats to existing local/regional businesses** *(probable adverse income and jobs impacts)* - Topeka businesses in and around the study area would be threatened by multiple factors related to flood risk, including (a) catastrophic periodic flood damage; (b) frequent business closures or scalebacks; (c) employee safety during flood events; (d) the cost of new flood insurance requirements in the event of levee decertification; (e) stiffer building codes, also in the event of levee decertification, that would work against firms needing to expand in the floodplain. Large employers in the study area such as BNSF Railroad, Goodyear, Hallmark, Del Monte, Hill's and others could decide to relocate from the city and region. Particularly affected would be manufacturing jobs which are declining nationally but have been a strong part of the Topeka jobs base, and which are concentrated in floodplain locations.

- **Threats to economic development prospects** *(probable adverse income and jobs impacts)* - The same considerations listed just above that would affect existing jobs in the city also would discourage new development and growth in the form of businesses migrating into the city or region or the development of new areas. Large companies considering moving into the study area, bringing job concentrations with them, probably would not do so in a flood-prone area with a decertified levee and the attendant regulatory environment. In addition, many of the city's most attractive developable parcels are located in Oakland and North Topeka, which are the two units with by far the highest flood risk. Land uses would in many cases be downgraded from higher valued commercial and residential uses to greenways and possibly agriculture, resulting in income losses.

- **Threats to riverfront redevelopment** *(possible adverse income impacts)* - Topeka's emerging strategy to rehabilitate and revive its riverfront, which has resulted in the recent redevelopment of the old Union Pacific depot in North Topeka and is likely to spawn hiking and biking trails and other amenities in the future, could be stymied by periodic flood damage, resulting in impacts to recreation and tourism revenues.

5.3.3 Other Social Effects of No Action

- **Public safety** *(probable adverse impacts on human life)* - The chance of a major flood in the next 10 years is 1 in 4 in North Topeka and 1 in 2 in Oakland. At risk are more than 13,700 residents and more than 5,700 homes in these two areas, in addition to daytime populations of workers in the thousands in North Topeka. Warning times would be expected to be relatively short, since the overwhelmingly likely failure mode would be structural or geotechnical failure rather than overtopping. Danger would take the form of drownings, electrocution, and illness from exposure to contaminated flood waters. South Topeka is also a potential concern; although the chance of failure is only 1 in 23 over the next 10 years, any failure that did occur due to rupture of the floodwall would leave very little chance for residents and workers to escape inundation.

- **Low income residents suffer greatest flood risk** *(probable adverse socioeconomic impacts)* - The South Topeka, Oakland, and North Topeka neighborhoods collectively had a 2000 poverty rate of 18.4%. This rate was 48% greater than the Topeka city and national rates of 12.4% and was 92% greater than the Shawnee County rate of 9.6%. In some portions of these areas, poverty rates exceeded 40%. The 2000 unemployment rate of 8.1% in these three areas was 69% greater than the city rate, 93% greater than the Kansas rate, and 103% greater than the county rate, and some block groups reached rates as high as 19%. Per capita income for these areas in 2000 was $14,403, which was only three-quarters of the Topeka per capita income, about seven-tenths of Shawnee County, and two-thirds of the national figure. (See sections 2.1.2, 2.4.2, 2.5.2, and 2.6.2 as well as Table D-4.)

- **Minority residents suffer greater flood risk** *(probable adverse socioeconomic impacts)* - Hispanics account for 20.4% of South Topeka's population and 27.1% of Oakland's residents. These percentages are approximately twice the national percentage of 12.5%, two to three times the Topeka percentage of 8.9%, and three to four times the state percentage of 7.0%. In about half of the Oakland and South Topeka block groups, Hispanics account for more than 25% of the population, and a few areas have majority Hispanic populations. (Again, see sections 2.1.2, 2.4.2, and 2.5.2 as well as Table D-4.)

- **Threats to center city redevelopment** *(probable adverse cultural impacts)* - Topeka's long-term efforts to maintain and rebuild center city areas would be dealt a crippling blow. The floodplain areas of North Topeka, Oakland and South Topeka comprise a substantial portion of the center city. Population losses from the center city would occur as residents flee the likelihood of flood damage and react to the shrinkage in area job opportunities. High vacancy rates would characterize commercial properties and the housing stock.

- **Threats to riverfront redevelopment** *(possible adverse cultural, historical and aesthetic impacts)* - Also touched on above under R.E.D. impacts; if redevelopment is indeed hampered, it would negatively affect aesthetic values (removal of blight followed by orderly, planned redevelopment) and historical values (the riverfront is where the city began).

- **Untreated sewage releases** *(adverse health and environmental impacts)* - The city sewage treatment plants in Oakland and North Topeka would likely be subject to frequent short-term operational interruptions, and the interruptions would be much longer term in flood events causing physical damages at the facilities. Service interruptions would result in large releases of unprocessed sewage into the Kansas River, adversely affecting public health (potentially) and environmental values (certainly).

6.0 ALTERNATIVES SCREENING

(Preliminary note on price levels: The screening damages, benefits, and costs in this section reflect a price level of October 2005, unlike either the existing condition damage computations in section 5 or the NED plan benefits and costs in section 7, both of which are in October 2007 prices. The screening cost estimates were completed late in FY 2006 (October 2005 price level) and were subsequently revisited only for the selected plan. In order to put the screening-level economic costs on the same basis as the benefits, the benefits were deflated to October 2005 prices using the ENR Building Cost Index. The price level issue has no effect on the screening-level evaluation and plan selection since all alternatives reflect the same price level. But the economic screening data summarized below in Tables D-22 and D-26 cannot be compared directly with the existing condition damages in Table D-14 or the NED plan benefits and costs in Tables D-29 through D-32 without taking account of the different price levels, and there are also other differences touched on below.)

6.1 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 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.

6.2 GENERAL DESCRIPTION OF ALTERNATIVES

While a number of alternatives were evaluated at some level of detail, there were seven alternatives showing enough promise to justify preparation of costs and benefits. None of the alternatives involve levee raises; all are related to the structural and geotechnical probability of failure characterizing the existing levees. The Waterworks unit has one alternative while the North Topeka, Oakland and South Topeka units each have a similar pair of alternatives. The pair of alternatives for each of the latter three units includes a fix for the structural deficiency affecting that unit (floodwall or pump station) along with a geotechnical fix. In each pair of alternatives, the geotechnical fix is an underseepage berm in the first alternative and a relief wells system (with or without collector system) in the second alternative.

The alternatives are listed below:

- Waterworks 1 - Stability berm.

- South Topeka 1 - Underseepage berm at site 1, floodwall replacement at site 2, wall stiffener at pump plant, miscellaneous heel extensions.

- South Topeka 2 - Same as South Topeka 1 except substitute relief wells for underseepage berm.

- Oakland 1 - Underseepage berm, East Oakland pump station heel extension, small stability berm on Shunganunga Creek tieback, miscellaneous heel extensions.

- Oakland 2 - Same as Oakland 1 except substitute relief wells for underseepage berm.

- North Topeka 1 - Underseepage berm at site 1, relief wells and collector system at site 2, abandonment of Fairchild pump station.

- North Topeka 2 - Same as North Topeka 1 except substitute relief wells at site 1 for underseepage berm.

6.3 SCREENING BENEFITS DETERMINATION

6.3.1. Benefits Computation. To determine the economic justification of the array of alternatives, each alternative was entered into the HEC-FDA risk analysis model. The Monte Carlo analysis in HEC-FDA was then employed to determine 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 for the alternative. The Topeka alternatives analysis involved no modifications to the existing condition economic structure inventory and occupancy type data.

Screening benefits in this analysis were based on physical inundation reduction to homes, businesses, public facilities, roads, and crops, as well as emergency costs and relocation/ reoccupation costs. Not included were induced damages, which should be insignificant if not nonexistent in any case since no levee raises are being considered.

6.3.2 Engineering Data Considerations. Like the economic data, top of levee elevations and hydraulic and hydrologic data also were unchanged from the existing conditions. Given the structural and geotechnical character of all identified deficiencies in the Topeka levee system, the most important variable in determining the performance of alternatives in this analysis was the probability of failure function. As described above in section 4.4.2, 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 analysis, the probability of failure function for the existing condition at each problem site is modified to reflect the repair by specifying a probability of failure of 0.002 at top of levee and a zero probability of failure at three feet below top of levee and all points below. (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).

6.3.3 Treatment of South Topeka and Oakland. The evaluation of the South Topeka and Oakland units involves certain complexities as discussed above in section 4.7.3. The screening-level benefits total for the South Topeka alternatives is comprised of two components: damage reduction in the South Topeka area, based on results from the first HEC-FDA study file, and damage reduction in Oakland, based on the second HEC-FDA file which isolates the damages in Oakland due to the performance of the South Topeka unit. For the Oakland unit, damages are based on the combined effects of all five critical sections of both the South Topeka and Oakland units as computed in the third HEC-FDA study file, while the benefits are based on repair of the two Oakland sections from the same study file.

6.4 SCREENING COST ESTIMATES

Screening-level costs are summarized in Table D-22. Costs were prepared by cost engineering staff for each of the seven alternatives. All costs include interest during construction computations which assume project completion in mid-2013. All screening costs reflect an October 2005 price level, and the annualized totals reflect the current Federal interest rate of 4.875% as well as a 50-year period of analysis.

Annual costs for operations and maintenance were included only for the alternatives that would produce additional O&M costs over and above current without-project levels. The three alternatives with net additional O&M costs are the alternatives that include relief wells. For these alternatives, the life-cycle cost analysis for each alternative assumed that each pump would require servicing every four years at $5,000 per pump. There are 22 wells for the Oakland relief wells alternative, 35 for South Topeka, and 38 for North Topeka. Complete replacement of the wells was assumed to be required after 40 years at a cost equal to the current construction cost for the wells in each alternative plus 17% to account for E&D and S&A. In addition to the relief wells, the North Topeka alternative also includes underground collector systems and a temporary pumping component. O&M costs for the collector systems assume that flushing and cleaning would be required every 25 years and would cost $10,900 in each instance. This total includes 3 days of labor by a 2-man crew as well as equipment costs. The temporary pumping plan would be needed when the water surface elevation comes within 3 feet of top of levee, which would require an event of about a 0.5% magnitude. We assumed that the pumping capability would be needed three times over the 50-year period of analysis. Each event would require one pump rental for one week costing $700, which includes installation, use, removal and return.

TABLE D-22 SCREENING COSTS SUMMARY								
October 2005 prices; 4.875% interest rate; 50 year period of analysis; $1,000s								
ITEM	**PED**	**LERRD**	**CONSTR**	**S&A**	**TOTAL FIRST COST**	**IDC**	**O&M**	**TOTAL ANNUAL COSTS**
WATERWORKS ALT 1								
Stability berm	$3.7	$1.5	$37.1	$2.4	$44.7	$2.6	$0.0	$2.5
SOUTH TOPEKA ALT 1								
Underseepage berm	$81.7	$849.0	$457.5	$53.1	$1,441.3	$82.9	$0.0	$81.9
Floodwall replacement	$1,001.6	$27.5	$10,015.7	$650.0	$11,694.8	$672.4	$0.0	$664.4
Kansas Avenue pump plant wall stiffener	$0.5	$0.0	$5.5	$0.4	$6.4	$0.4	$0.0	$0.4
Miscellaneous heel extensions	$39.0	$0.0	$390.3	$25.3	$454.6	$26.1	$0.0	$25.8
Total	$1,122.9	$876.5	$10,868.9	$728.8	**$13,597.0**	$781.8	$0.0	**$772.5**
SOUTH TOPEKA ALT 2								
Relief wells	$115.6	$0.0	$1,155.6	$75.0	$1,346.2	$77.4	$51.0	$127.5
Floodwall replacement	$1,001.6	$27.5	$10,015.7	$650.0	$11,694.8	$672.4	$0.0	$664.4
Kansas Avenue pump plant wall stiffener	$0.5	$0.0	$5.5	$0.4	$6.4	$0.4	$0.0	$0.4
Miscellaneous heel extensions	$39.0	$0.0	$390.3	$25.3	$454.6	$26.1	$0.0	$25.8
Total	$1,156.7	$27.5	$11,567.1	$750.7	**$13,502.0**	$776.4	$51.0	**$818.1**
OAKLAND ALT 1								
Underseepage berm	$94.2	$215.3	$942.3	$61.2	$1,313.1	$75.5	$0.0	$74.6
East Oakland pump station heel extension	$19.0	$0.0	$189.9	$12.3	$221.2	$12.7	$0.0	$12.6
Stability berm on Shunganunga tieback	$2.0	$14.8	$19.6	$1.3	$37.6	$2.2	$0.0	$2.1
Miscellaneous heel extensions	$1.1	$0.0	$11.3	$0.7	$13.2	$0.8	$0.0	$0.8
Total	$116.3	$230.2	$1,163.2	$75.5	**$1,585.1**	$91.1	$0.0	**$90.1**
OAKLAND ALT 2								
Relief wells	$73.4	$0.0	$733.8	$47.6	$854.8	$49.1	$31.3	$79.9
East Oakland pump station heel extension	$19.0	$0.0	$189.9	$12.3	$221.2	$12.7	$0.0	$12.6
Stability berm on Shunganunga tieback	$2.0	$14.8	$19.6	$1.3	$37.6	$2.2	$0.0	$2.1
Miscellaneous heel extensions	$1.1	$0.0	$11.3	$0.7	$13.2	$0.8	$0.0	$0.8
Total	$95.5	$14.8	$954.6	$62.0	**$1,126.8**	$64.8	$31.3	**$95.3**
NORTH TOPEKA ALT 1								
Underseepage berm (site 1)	$153.5	$181.2	$1,534.5	$99.6	$1,968.8	$113.2	$0.0	$111.8
Relief wells & collector system (site 2)	$39.8	$0.0	$398.1	$25.8	$463.7	$26.7	$10.7	$37.0
Fairchild pump station abandonment	$4.0	$0.0	$40.2	$2.6	$46.8	$2.7	$0.0	$2.7
Total	$197.3	$181.2	$1,972.8	$128.0	**$2,479.3**	$142.6	$10.7	**$151.6**
NORTH TOPEKA ALT 2								
Relief wells (site 1)	$105.8	$110.3	$1,057.6	$68.6	$1,342.3	$77.2	$46.7	$122.9
Relief wells & collector system (site 2)	$39.8	$0.0	$398.1	$25.8	$463.7	$26.7	$10.7	$37.0
Fairchild pump station abandonment	$4.0	$0.0	$40.2	$2.6	$46.8	$2.7	$0.0	$2.7
Total	$149.6	$110.3	$1,495.8	$97.1	**$1,852.8**	$106.5	$57.4	**$162.6**

Interest during construction (IDC) assumes following project schedule: PED, Jan 08 thru Jan 11; LERRD, Jan 11 thru Oct 11; construction, Oct 11 thru Jul 13.

Total first costs = PED + LERRD + construction + S&A
Annual costs = ((Total first costs + IDC) X interest & amortization factor of 0.053722) + O&M
Annual O&M costs include only additional or net costs over and above comparable existing costs.

6.5 SCREENING RESULTS BY REACH

Economic and engineering performance results for each of the alternatives screened are detailed in Table D-26 and D-27 at the end of this section and in the discussions of each reach below.

6.5.1 Waterworks Alternative. To address the floodwall sliding threat, a stability berm was evaluated as the most likely cost-effective solution. Replacement of the floodwall section or modification of the wall's foundation probably would be much more expensive than the berm, which would require less than 1,000 cubic yards of material. The first cost for the stability berm is $44,700, and the annualized total cost is $2,500. Annual benefits total $4,900, and the benefit-cost ratio is 1.9 with net benefits of $2,400. The benefits total is based solely on physical flood risk management and does not include benefits related to preventing interruptions of the city's water supply, so these benefits are very conservative. Residual damages associated with this alternative are $193,500, meaning that 98% of the equivalent annual damages at Waterworks would continue to occur even with the project in place, but the residual damages would be associated with very large and infrequent events. Project implementation would marginally improve the levee's exceedance probability in a 1%-chance event from 0.072 to 0.067.

6.5.2 South Topeka Alternatives

6.5.2.1 South Topeka Alternatives - Economic Performance. Alternative 1 at South Topeka includes an underseepage berm at site 1 (first cost of $1,441,300) and a floodwall replacement at site 2 ($11,694,800). Also included are two smaller features at or near the floodwall site: a wall stiffener at the Kansas Avenue pump plant ($6,400), and small heel extensions at several manholes ($454,600). A separate probability of failure function was not developed for the heel extensions. Their proximity to the deficient floodwall section, which is the major deficiency at that section of the levee, would make it difficult or impossible to accurately determine a separate probability of failure for each feature, and the costs are minor in the context of the overall alternative (about 3% of total costs for alternative 1). Alternative 1 has first costs of $13,597,000. No net annual O&M costs are included in the annualized total cost of $772,500.

Alternative 2 at South Topeka is the same as Alternative 1, except that the site 1 fix is a system of 35 relief wells rather than the underseepage berm. As discussed above in section 6.3, annual operation and maintenance costs for relief well systems are significant. Alternative 2 has first costs of $13,502,000. Net annual O&M costs are $51,000, and the total annual cost is $818,100.

Annual benefits, which account for damage reduction in both South Topeka and Oakland, total $932,300 for both alternatives (October 2005 prices). Alternative 1 annual costs are $772,500, resulting in a benefit-cost ratio of 1.2 and net benefits of $159,800. Alternative 2 annual costs are $818,100, which yields a benefit-cost ratio of 1.1 and net benefits of $114,200. Both South Topeka alternatives are economically justified, and Alternative 1, which includes the underseepage berm at site 1, is the NED alternative with the greatest net benefits.

Significant annual residual damages of $1,834,000 would continue to occur in the with-project condition. The overall damage reduction relative to the existing condition EAD of $2,766,300 would be 34%. However, the 66% of EAD that remains in the with-product condition would occur primarily in large and infrequent flood events.

6.5.2.2 South Topeka Alternatives - Engineering Performance. Implementation of either South Topeka alternative would improve the unit's exceedance probability in a 1%-chance flood event from 0.158 to 0.054. The median annual exceedance probability, which is 0.004 (or a return interval of 250-year) under existing conditions, would increase to 0.003 (333-year). The chance of flooding over a 50-year period would be 1 in 6, improved from the existing conditions chance of 1 in 4. (Refer to Table D-24 for additional statistics.)

Table D-23 shows the combined probability of failure function for existing conditions, fixing each of the three sites separately, fixing any two of the three sites, and fixing all three sites as in the formulated alternatives. It will be seen that all of the partial repairs fail to reduce probability of failure to an acceptable minimum. Only by repairing all three sites can probability of failure for the unit be reduced to a level appropriate to public safety in a densely populated urban area.

TABLE D-23

SOUTH TOPEKA - PROBABILITY OF FAILURE FUNCTIONS

WITH-PROJECT

p(F) = probability of failure

Elevation @ index point	Existing condition	Fix of underseepage only	Fix of floodwall only	Fix of pump station only	Fix underseepage & floodwall, not pump station	Fix underseepage & pump station, not floodwall	Fix floodwall & pump station, not underseepage	Combined fix of all 3 sections
892.8	0.7122	0.3784	0.6182	0.6509	0.1755	0.2460	0.5370	0.0020
892.6	0.6923	0.3587	0.6000	0.6308	0.1665	0.2306	0.5201	0.0011
891.6	0.5141	0.1542	0.4323	0.5083	0.5141	0.1441	0.4255	0.0007
889.9	0.3394	0.0498	0.3048	0.3394	0.0000	0.0498	0.3048	0.0000
888.2	0.1974	0.0127	0.1871	0.1974	0.0000	0.0127	0.1871	0.0000
887.7	0.1555	0.0065	0.1500	0.1555	0.0000	0.0065	0.1500	0.0000
885.4	0.0277	0.0000	0.0275	0.0277	0.0000	0.0002	0.0275	0.0000
883.4	0.0009	0.0000	0.0009	0.0009	0.0000	0.0000	0.0009	0.0000
881.3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

6.5.3 Oakland Alternatives

6.5.3.1 Oakland Alternatives - Economic Performance. Alternative 1 for Oakland includes an underseepage berm at the Oakland wastewater plant (first cost of $1,313,100) and a heel extension at the East Oakland pump station ($221,200). Also included are two smaller, inexpensive repairs that are not separately evaluated in this analysis: a small stability berm on the unit’s Shunganunga Creek tieback ($37,600) and heel extensions at several manholes ($13,200). The total first cost for alternative 1 is $1,585,100. The annualized total cost, which does not include any net annual O&M costs, is $90,100.

Alternative 2 includes the same features as alternative 1, except that a system of 22 relief wells ($854,800) is substituted for the underseepage berm at the treatment plant. The first cost of $1,126,800 is lower than the first cost for alternative 1, but alternative 2 also has significant annual O&M costs of $31,300 that result in a higher annualized cost. The annual cost for alternative 2 is $95,300.

Both alternatives have annual benefits of $2,558,500, and the difference in net benefits is quite small. The NED plan is alternative 1, with a benefit-cost ratio of 28.4 and net benefits of $2,468,400. Alternative 2 also would have strong economic justification with a benefit-cost ratio of 26.8 and net benefits of $2,463,100. The project would reduce 56% of existing condition EAD, leaving residual damages of $2,005,300.

6.5.3.2 Oakland Alternatives - Engineering Performance. Table D-24 presents the probability of failure functions for existing conditions, as well as the combined with-project reliabilities for

TABLE D-24

OAKLAND - PROBABILITY OF FAILURE FUNCTIONS WITH-PROJECT

Elevation @ index point	Existing condition	Underseepage fix	Pump station fix	Combined fix of both sections
887.5	1.0000	1.0000	1.0000	0.0020
886.9	1.0000	1.0000	1.0000	0.0016
886.4	1.0000	1.0000	1.0000	0.0014
883.7	1.0000	1.0000	1.0000	0.0000
882.7	1.0000	1.0000	0.9999	0.0000
881.5	1.0000	1.0000	0.9882	0.0000
880.7	0.9998	0.9886	0.9813	0.0000
880.0	0.9828	0.8500	0.8854	0.0000
879.6	0.9327	0.5513	0.8500	0.0000
879.2	0.8306	0.1500	0.8007	0.0000
878.7	0.7479	0.0000	0.7479	0.0000
875.8	0.2639	0.0000	0.2639	0.0000
874.0	0.1500	0.0000	0.1500	0.0000
871.8	0.0000	0.0000	0.0000	0.0000

separate underseepage berm or relief wells system, separate heel extension at the East Oakland pump station, and the two repairs combined. The functions for the two separate with-project conditions once again show very little significant improvement over the existing condition; only the combined repair creates the conditions for regaining an acceptable level of engineering performance. The extremely high exceedance probability of 0.97 in a 1%-chance event that currently characterizes the Oakland unit would be improved only marginally by fixing only the underseepage section (0.903 with project) or only the pump station (0.958 with project). But implementation of either of the formulated alternatives which include improvements at both critical sections would reduce the 1%-chance event exceedance probability to 0.058. The chance of a damaging flood over a 50-year period would be reduced from 1 in 1.05 to 1 in 6, and the median annual exceedance probability with the project in place would be 0.003, compared to the current probability of 0.057.

6.5.4 North Topeka Alternatives

6.5.4.1 North Topeka Alternatives - Economic Performance. Alternative 1 for North Topeka includes an underseepage berm at site 1 ($1,968,800), a relief wells and collector system at site 2

($463,700), and abandonment of the old Fairchild pump station ($46,800). The total first cost of the alternative is $2,479,300. The total annual costs of $151,600 also include $10,700 of O&M costs associated with the site 2 relief wells & collector system.

Alternative 2 is identical to alternative 1 except that the underseepage berm at site 1 is replaced by a system of 32 relief wells ($1,342,300). The total alternative cost is $1,852,800. Annual O&M costs are $57,400, including $46,700 for the relief wells at site 1 and $10,700 for the relief wells and collector system at site 2. The total annual cost for alternative 2 is $162,600.

Benefits are $10,118,000 for both alternatives. The NED plan for North Topeka is alternative 1, which has a benefit-cost ratio of 66.8 and net benefits of $9,966,500. Alternative 2 also has strong economic justification with a benefit-cost ratio of 62.2 and net benefits of $9,955,400. Either alternative would reduce existing condition EAD by 71%, but would also be characterized by significant residual damages of $4,110,100.

6.5.4.2 North Topeka Alternatives - Engineering Performance. Probability of failure functions are shown in Table D-25 for the three North Topeka critical sections, individually and combined, under existing conditions. Also shown are the with-project functions that result from repairing each section separately, as well as the functions associated with the repair of any two sites out of three. The last column shows the function that results from repairing all three sites. Only the latter function displays any significant improvement over the existing condition. Even the functions for repair of two out of three sites continue to show PFPs several feet below top of levee and PNPs near the bottom of the levee. The existing condition exceedance probability of 0.859 against a 1%-chance flood event improves to 0.054 with implementation of improvements at all three deficient sections. The chance of a damaging flood over 50 years drops from 1 in 1.4 in the existing condition to 1 in 6 with implementation of either formulated alternative. The median annual exceedance probability improves from 0.024 to 0.003.

TABLE D-25								
NORTH TOPEKA - PROBABILITY OF FAILURE FUNCTIONS								
WITH-PROJECT								
p(F) = probability of failure								
Elevation @ index point	Existing condition	Fix underseepage site 1	Fix underseepage site 2	Fix pump station (site 3)	Fix sites 1 & 2	Fix sites 1 & 3	Fix sites 2 & 3	Combined p(F) for repair of all 3 sections
894.1	1.0000	1.0000	1.0000	0.9999	1.0000	0.9893	0.9886	0.0020
893.5	1.0000	1.0000	1.0000	0.9992	1.0000	0.9655	0.9756	0.0005
893.0	1.0000	1.0000	1.0000	0.9989	1.0000	0.9597	0.9724	0.0002
892.7	1.0000	1.0000	1.0000	0.9985	1.0000	0.9480	0.9705	0.0000
890.7	1.0000	1.0000	1.0000	0.9903	1.0000	0.8500	0.9355	0.0000
889.0	1.0000	1.0000	1.0000	0.9566	1.0000	0.6671	0.8697	0.0000
887.0	1.0000	1.0000	1.0000	0.8086	1.0000	0.2875	0.7313	0.0000
886.7	0.9993	0.9977	0.9991	0.7822	0.9969	0.2519	0.7088	0.0000
885.5	0.9413	0.8651	0.9347	0.6089	0.8500	0.1009	0.5650	0.0000
885.3	0.8500	0.8500	0.8500	0.5294	0.4682	0.0419	0.5089	0.0000
885.0	0.7497	0.4905	0.7388	0.5037	0.3011	0.0375	0.4843	0.0000
884.8	0.6531	0.3274	0.6396	0.4769	0.1500	0.0336	0.4588	0.0000
884.6	0.5554	0.1785	0.5400	0.4486	0.0000	0.0294	0.4319	0.0000
884.4	0.4486	0.0294	0.4319	0.2438	0.0000	0.0003	0.2436	0.0000
883.0	0.2438	0.0003	0.2436	0.2275	0.0000	0.0000	0.2275	0.0000
882.0	0.1500	0.0000	0.1500	0.0512	0.0000	0.0000	0.0512	0.0000
879.1	0.0024	0.0000	0.0024	0.0000	0.0000	0.0000	0.0000	0.0000
877.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

6.6 SELECTION OF NED PLAN

Based on the screening data summarized above, the NED plan consists of the single Waterworks alternative along with Alternative 1 (berm rather than relief wells) in South Topeka, Oakland and North Topeka. All alternatives exhibit economic feasibility (i.e., net benefits), but these alternatives have the highest net benefits, as can be seen in Table D-26. Engineering performance statistics for the alternatives can be found in Table D-27. The next section will fully describe the NED plan.

While the Waterworks unit does not have serious engineering deficiencies at present and already has a high level of reliability, the stability berm is very inexpensive and is economically justified even without consideration of the substantial benefits of preventing interruption of water supply to a relatively large urban area. Additionally, existing deficiencies in a levee, even if small at present, probably will only become worse with time, threatening the city water supply.

TABLE D-26									
SCREENING ALTERNATIVES - BENEFITS & COSTS SUMMARY									
October 2005 prices; 50 year period of analysis; 4.875% interest rate									
Unit	**WATERWORKS**	**SOUTH TOPEKA**				**OAKLAND**		**NORTH TOPEKA**	
Alternative	**Alt 1**	**EAD in S Top**	**EAD in Oak**	**Alt 1**	**Alt 2**	**Alt 1**	**Alt 2**	**Alt 1**	**Alt 2**
DAMAGES & BENEFITS									
EAD without project	$198.4	$957.3	$1,809.0	$2,766.3		$4,563.8		$14,228.1	
EAD residual	$193.5	$775.3	$1,058.7	$1,834.0		$2,005.3		$4,110.1	
Residual as % of without project	97.5%	81.0%	58.5%	66.3%		43.9%		28.9%	
EAD reduction									
Mean	$4.9	$182.0	$750.3	$932.3		$2,558.5		$10,118.0	
Probabilistic estimates*									
0.75	$3.9	$81.6	$395.2	$476.8		$1,516.9		$5,829.4	
0.5	$4.6	$139.1	$612.2	$751.3		$2,379.9		$9,070.0	
0.25	$6.1	$270.6	$1,164.0	$1,434.6		$3,362.3		$13,635.0	
Annual benefits - screening level	**$4.9**	$182.0	$750.3	**$932.3**		**$2,558.5**		**$10,118.0**	
COSTS									
First costs	$44.7	--	--	$13,597.0	$13,502.0	$1,585.1	$1,126.8	$2,479.3	$1,852.8
Annual costs - screening level	**$2.5**	--	--	**$772.5**	**$818.1**	**$90.1**	**$95.3**	**$151.6**	**$162.6**
BENEFIT-COST RATIO	**1.9**			**1.2**	**1.1**	**28.4**	**26.8**	**66.8**	**62.2**
NET BENEFITS	**$2.4**			**$159.8**	**$114.2**	**$2,468.4**	**$2,463.1**	**$9,966.5**	**$9,955.4**

* Probabilistic EAD reduction shows the minimum level of benefits expected at the indicated probability, resulting in a range of possible benefit values rather than a single value. For example, North Topeka benefits, expressed as a mean value, equal $10,118.0, but there is 75% confidence that benefits are at least $5,829,4 and 25% confidence that they exceed $13,635.0..

Alternatives within each reach have identical benefits since they accomplish the same project purposes. The economic performance of the alternatives differs only in costs.

Screening BCR data will not match the BCR data for the selected plan in Table D-26. This table includes a portion of Oakland damages and damages reduced that is double-counted in both Oakland and South Topeka benefits for screening purposes. For the NED plan benefits in Table D-26, the Oakland benefits are accounted incrementally and the double-counting is eliminated. The NED plan benefits also include additional categories of benefits not considered in the screening analysis.

TABLE D-27								
SCREENING ALTERNATIVES - ENGINEERING PERFORMANCE								
Alternative	**Annual exceedance probability (median)**		**Long-term risk (chance of exceedance during indicated period)**			**Exceedance probability per flood event**		
	Probability	Return interval (years)	10 years	25 years	50 years	2.0%	1.0%	0.2%
WATERWORKS - ALT 1								
Without project	0.003	333	1 in 25	1 in 10	1 in 5	0.003	0.072	0.758
With project	0.003	333	1 in 26	1 in 11	1 in 6	0.003	0.067	0.750
SOUTH TOPEKA - ALT 1 OR 2								
Without project	0.004	250	1 in 23	1 in 9	1 in 5	0.031	0.158	0.806
With project	0.003	333	1 in 27	1 in 11	1 in 6	0.002	0.054	0.721
OAKLAND - ALT 1 OR 2								
Without project	0.057	18	1 in 2	1 in 1.3	1 in 1.05	0.856	0.971	1.000
With project	0.003	333	1 in 27	1 in 11	1 in 6	0.003	0.058	0.700
NORTH TOPEKA - ALT 1 OR 2								
Without project	0.024	42	1 in 4	1 in 2	1 in 1.4	0.180	0.860	0.998
With project	0.003	333	1 in 27	1 in 11	1 in 6	0.002	0.054	0.715

7.0 THE NED PLAN

7.1 DESCRIPTION OF THE NED PLAN

The plan emerging from the screening analysis consists of the single Waterworks alternative, South Topeka alternative 1, Oakland alternative 1, and North Topeka alternative 1. These are the NED alternatives in each unit. Specifically, the plan for the Topeka levee system consists of the following elements:

1. At Waterworks, a stability berm would be constructed to eliminate the sliding threat between stations 0+00 and 16+50. Only 958 cubic yards of fill would be required for the berm.

2. At South Topeka's underseepage section (stations 22+00 to 48+00), an underseepage berm would be built using 48,150 cubic yards of fill.

3. At South Topeka's weakened floodwall section (stations 74+41 to 93+86), the deficient sections of the floodwall would be replaced.

4. In the same area, a strength deficiency at the Kansas Avenue pump station (station 75+84) would be remedied by wall stiffener, and uplift concerns at several nearby sites would be dealt with by small heel extensions.

5. At Oakland's underseepage section (stations 64+00 to 80+00, near the Oakland treatment plant), an underseepage berm would be constructed, using 84,500 cubic yards of fill. A small heel extension would be done in the same area at a manhole where uplift concerns exist.

6. At Oakland's East Oakland pump station (station 220+00), a heel extension would be built to alleviate uplift concerns.

7. On the Shunganunga Creek tieback of the Oakland unit (stations 485+86 to 491+01), a sliding threat would be addressed by a small stability berm. 388 cubic yards of fill would be required.

8. At the upstream North Topeka underseepage site (stations 165+00 to 189+00), an underseepage berm would be constructed, using 122,250 cubic yards of fill.

9. At the downstream North Topeka underseepage section (sections 246+00 to 250+00), a system of 6 relief wells and an underground collector system would be built. A temporary pumping plan also would need to be implemented periodically.

10. Near the downstream end of the North Topeka unit, the old Fairchild pump station would be abandoned in order to end the uplift threat at that location. (It is no longer an active portion of the Topeka local protection system and would not need to be replaced functionally.)

7.2 ENGINEERING PERFORMANCE OF NED PLAN

Table D-28 compares without and with-project condition reliability statistics for the NED plan. The key results of implementing the NED plan would be as follows:

- The median annual exceedance probability would increase to 0.003 (333-year) for the system. In other words, there would be a 0.3% chance of a damaging flood in any year. Currently, it is as much as 0.057 (18-year) for Oakland, 0.024 (42-year) for North Topeka, and 0.004 (250-year) for South Topeka.

- In a 1%-chance flood event, all Kansas River units would have between a 5% and 7% chance of experiencing damage. Currently, Oakland has a 97.1% chance of a damaging flood in an event of that magnitude, North Topeka an 85.9% chance, and South Topeka a 15.8% chance. For Waterworks, the nonexceedance probability would increase marginally to 0.933, but the performance of other Kansas River units would be substantially improved.

- The long-term risk of a damaging flood in any of the Kansas River units over a 50-year period would be approximately 1 in 6. The risk over 25 years would be 1 in 11. Over 10 years, it would be 1 in 27.

- Probability of failure (PFP) elevations, defined as the elevation at which the probability of failure reaches 85%, would not occur until the top of levee elevation is almost reached.

7.3 COSTS OF NED PLAN

Costs for the NED plan are summarized in Table D-29. The first cost of the NED plan is $20,738,000. The South Topeka unit accounts for about 76% of the total, North Topeka 15%, Oakland 9%, and Waterworks less than 1%. The total annual cost is $1,194,000. Annual costs include $12,000 in net O&M costs associated with the North Topeka relief walls/collector system and temporary pumping plan. (Total annual O&M costs in the existing condition are estimated at $299,000, including $199,000 for North Topeka and $100,000 for the right bank levees. The total annual O&M cost with implementation of the NED plan would become $311,000.)

An interest rate of 4.875% is used in the computations with a 50-year period of analysis. The price level is October 2007. A completion date of April 2014 is assumed for the entire project.

The City of Topeka would be the non-Federal sponsor for the Kansas River right bank improvements. These improvements affect Waterworks, South Topeka and Oakland and consist of the first seven elements of the NED plan listed above. The total cost for this portion of the NED plan sponsored by the City of Topeka would be $17,859,000, which is 86% of the total NED plan costs. The city’s non-Federal share currently is estimated at $6,251,000. North

TABLE D-28

ENGINEERING PERFORMANCE FOR NED PLAN

WITH VS. WITHOUT-PROJECT CONDITIONS FOR THE NED PLAN

	WATERWORKS		AUBURNDALE		SOUTH TOPEKA		OAKLAND		NORTH TOPEKA		SOLDIER CREEK	
	WITHOUT	WITH	WITHOUT	WITH	WITHOUT	WITH	WITHOUT	WITH	WITHOUT	WITH	WITHOUT	WITH
ANNUAL EXCEEDANCE PROBABILITY*												
Median	0.003	0.003	0.003	no change	0.004	0.003	0.057	0.003	0.024	0.003	0.006	no change
Return interval (years)	333	333	333		250	333	18	333	42	333	167	
LONG-TERM RISK (chance of flooding during period)												
over 10 years	1 in 25	1 in 26	1 in 32	no change	1 in 23	1 in 27	1 in 2	1 in 27	1 in 4	1 in 27	1 in 13	no change
over 25 years	1 in 10	1 in 11	1 in 13		1 in 9	1 in 11	1 in 1.3	1 in 11	1 in 2	1 in 11	1 in 5	
over 50 years	1 in 5	1 in 6	1 in 7		1 in 5	1 in 6	1 in 1	1 in 6	1 in 1.4	1 in 6	1 in 3	
PERFORMANCE VS. 1%-CHANCE FLOOD												
Top of levee margin (feet) over flood elevation**	5.9		8.2	no change	6.5		3.7		6.6		1.7	no change
Conditional nonexceedance probability	0.928	0.933	0.968		0.842	0.946	0.029	0.942	0.141	0.946	0.668	
Conditional exceedance probabilty	0.072	0.067	0.032		0.205	0.054	0.971	0.058	0.860	0.054	0.332	
OTHER FLOOD EVENTS - EXCEEDANCE PROBABILITY												
10.0%	0.000	0.000	0.000	no change	0.000	0.000	0.165	0.000	0.004	0.000	0.000	no change
4.0%	0.000	0.000	0.000		0.003	0.000	0.589	0.000	0.180	0.000	0.002	
1951 flood (3.5%)***	0.001	0.015	0.008		0.010	0.001	0.656	0.001	0.273	0.001	0.025	
2.0%	0.003	0.003	0.032		0.031	0.002	0.857	0.003	0.554	0.002	0.094	
0.4%	0.331	0.321	0.213		0.436	0.285	0.995	0.280	0.970	0.285	0.661	
0.2%	0.758	0.750	0.644		0.806	0.721	1.000	0.700	0.998	0.721	0.817	

* Annual exceedance probability is the chance of a damaging flood in any year. The statistic implies nothing about the magnitude of the flood except that it would be large enough to exceed the system's capacity.

** Top of levee here means initial overtopping margin, i.e., the low point on the levee profile in the reach. The 1%-chance flood elevation refers to the nominal value of the elevation and is not risk-based.

*** 1951 flood statistics are interpolated between the nearest events evaluated in HEC-FDA (the 4% and 2% events).

TABLE D-29 NED PLAN COST SUMMARY									
Oct. 2007 prices; 4.875% interest rate; 50 year period of analysis; $1,000s									
ITEM	**PED**	**LERRD**	**CONSTR**	**S&A**	**TOTAL FIRST COST**	**IDC**	**O&M**	**TOTAL ANNUAL COSTS**	**% of TOTAL**
WATERWORKS ALT 1									
(Sponsor: City of Topeka)									
Stability berm	$4.0	$6.0	$36.0	$3.0	**$49.0**	$3.0	$0.0	**$3.0**	0.3%
SOUTH TOPEKA ALT 1									
(Sponsor: City of Topeka)									
Underseepage berm	$141.0	$849.0	$536.0	$59.0	$1,585.0	$96.0	$0.0	$90.0	
Floodwall replacement	$1,088.0	$27.0	$10,876.0	$706.0	$12,697.0	$766.0	$0.0	$723.0	
New gatewells	$100.0	$0.0	$1,003.0	$65.0	$1,168.0	$70.0	$0.0	$66.0	
Kansas Avenue pump plant wall stiffener	$1.0	$0.0	$7.0	$1.0	$9.0	$1.0	$0.0	$1.0	
Miscellaneous heel extensions	$45.0	$0.0	$446.0	$29.0	$520.0	$31.0	$0.0	$30.0	
Total South Topeka	$1,375.0	$876.0	$12,868.0	$860.0	**$15,979.0**	$964.0	$0.0	**$910.0**	76.2%
OAKLAND ALT 1									
(Sponsor: City of Topeka)									
Underseepage berm	$132.0	$213.0	$1,095.0	$71.0	$1,511.0	$97.0	$0.0	$87.0	
East Oakland pump station heel extension	$22.0	$0.0	$225.0	$15.0	$262.0	$17.0	$0.0	$15.0	
Stability berm on Shunganunga tieback	$2.0	$15.0	$22.0	$1.0	$40.0	$3.0	$0.0	$2.0	
Miscellaneous heel extensions	$2.0	$0.0	$15.0	$1.0	$18.0	$1.0	$0.0	$1.0	
Total Oakland	$158.0	$228.0	$1,357.0	$88.0	**$1,831.0**	$118.0	$0.0	**$105.0**	8.8%
NORTH TOPEKA ALT 1									
(Sponsor: North Topeka Drainage District)									
Underseepage berm	$195.0	$181.0	$1,770.0	$115.0	$2,261.0	$137.0	$0.0	$129.0	
Relief wells & collector system	$47.0	$0.0	$473.0	$31.0	$551.0	$34.0	$12.0	$43.0	
Fairchild pump station abandonment	$6.0	$0.0	$57.0	$4.0	$67.0	$4.0	$0.0	$4.0	
Total North Topeka	$248.0	$181.0	$2,300.0	$150.0	**$2,879.0**	$175.0	$12.0	**$176.0**	14.7%
TOTAL NED PLAN	$1,785.0	$1,291.0	$16,561.0	$1,101.0	**$20,738.0**	$1,260.0	$12.0	**$1,194.0**	100.0%
Total Federal share					**$13,480.0**				
Total Non-Federal share					**$7,259.0**				
City of Topeka projects					*$6,251.0*				
North Topeka D.D. projects					*$1,008.0*				
Interest during construction (IDC) assumes following project schedule: PED, Oct 2008 thru Sep 2011; LERRD, Oct 2011 thru Jun 2012; construction, Jul 2012 thru Apr 2014.									
Annual O&M costs include only additional or net costs over and above comparable existing costs.									

Topeka improvements, consisting of NED plan elements 8 through 10 above, would cost $2,879,000 and would be sponsored by the North Topeka Drainage District, which would be charged with a non-Federal cost share of $1,008,000. The total non-Federal share for the project would be $7,259,000.

7.4 ECONOMIC PERFORMANCE AND JUSTIFICATION OF NED PLAN

7.4.1 Benefit-Cost Ratio And Net Benefits. The NED plan has total annual benefits of $14,466,000 for the system and annual costs of $1,194,000. The plan exhibits very strong economic justification with a benefit-cost ratio of 12.1. With net benefits of $13,272,000, the project represents a strong contribution to national economic outputs.

Benefits and costs reflect a price level of October 2007 and the current Federal interest rate of 4.875%. The data for each unit of the Topeka system as well as for the overall system are summarized in Table D-30. It will be seen that each individual unit of the Topeka system also is economically justified. The South Topeka and Oakland portions of the total project have benefit-cost ratios of 1.1 and 25.8 respectively. The North Topeka unit's benefit-cost ratio is 61.1, and the Waterworks portion stands at 1.7.

TABLE D-30					
TOTAL NED PROJECT BENEFITS & COSTS					
October 2007 prices; 4.875% interest rate; $1,000s					
Unit	Annual Benefits	First Costs	Annual Costs	**BCR**	**Net Benefits**
NORTH TOPEKA UNIT	$10,757.0	$2,879.0	$176.0	**61.1**	**$10,581.0**
WATERWORKS UNIT	$5.0	$49.0	$3.0	**1.7**	**$2.0**
SOUTH TOPEKA UNIT	$991.0	$15,979.0	$910.0	**1.1**	**$81.0**
OAKLAND UNIT	$2,713.0	$1,831.0	$105.0	**25.8**	**$2,608.0**
TOTAL	**$14,466.0**	**$20,738.0**	**$1,194.0**	**12.1**	**$13,272.0**

7.4.2 Benefits Breakdowns. The total project benefits of $14,466,000 and the individual unit totals are broken down by category in Table D-31, which also includes probabilistic outputs. North Topeka accounts for 74% of total benefits, Oakland 19%, and South Topeka 7%, while Waterworks benefits make up less than 1% of the total.

Almost two-thirds of the total benefits, or 64.2%, is due to reduction of damages to businesses and facilities. Another 27.4% of the benefits comes from residential damage prevention. Roads and streets account for 2.6%, emergency costs for 4.3%, and disaster relief costs 1.5%. No additional crop benefits are provided by the project.

TABLE D-31								
NED PLAN BENEFITS SUMMARY								
October 2007 prices; 4.875% interest rate; $1,000s								
Totals below are carried out to hundreds of dollars except for the "Total benefits, rounded" row, in which totals are rounded to thousands of dollars to correspond to other report references.								
	NORTH TOPEKA UNIT	WATERWORKS UNIT	AUBURNDALE UNIT	SOUTH TOPEKA UNIT	OAKLAND UNIT	SOLDIER CREEK (RURAL)	TOTAL	
Total EAD (equivalent annual damages)								**% of EAD**
Without project damages	$15,126.6	$211.0	$194.3	$1,017.8	$4,852.0	$48.7	$21,450.4	
Residual damages (with project)	$4,369.6	$205.7	$194.3	$824.3	$1,341.0	$48.7	$6,983.6	32.6%
Damages reduced	$10,757.0	$5.2	$0.0	$193.5	$3,511.0	$0.0	$14,466.8	67.4%
Incremental benefits from Oakland	n.a.	n.a.	n.a.	$797.6	$2,713.4	$0.0	n.a.	
Total benefits	$10,757.0	$5.2	$0.0	$991.2	$2,713.4	$0.0	$14,466.8	
Total benefits, rounded	**$10,757.0**	**$5.0**	**$0.0**	**$991.0**	**$2,713.0**	**$0.0**	**$14,466.0**	
Unit benefits as % of total	74.4%	0.0%	0.0%	6.9%	18.8%	0.0%	100.0%	
Benefits by category								**% of total**
Non-Residential	$7,949.9	$4.2	$0.0	$404.1	$931.4	$0.0	$9,289.6	64.2%
Residential	$2,071.1	$0.0	$0.0	$422.4	$1,464.3	$0.0	$3,957.8	27.4%
Roads & Streets	$281.5	$0.0	$0.0	$26.6	$69.4	$0.0	$377.6	2.6%
Crops	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.1	0.0%
Disaster Relief	$64.7	$0.0	$0.0	$51.4	$102.6	$0.0	$218.7	1.5%
Emergency Costs	$389.6	$1.1	$0.0	$86.7	$145.7	$0.0	$623.1	4.3%
Total	$10,757.0	$5.2	$0.0	$991.2	$2,713.4	$0.0	$14,466.8	100.0%
Probabilistic benefit estimates - value that benefits exceed with indicated probability								
0.75	$6,197.6	$4.1	$0.0	$506.9	$1,527.2	$0.0	$8,235.9	
0.50	$9,642.8	$4.9	$0.0	$798.7	$2,455.9	$0.0	$12,902.2	
0.25	$14,496.0	$6.5	$0.0	$1,525.2	$3,550.3	$0.0	$19,578.0	
Mean	$10,757.0	$5.2	$0.0	$991.2	$2,713.4	$0.0	$14,466.8	

A more probabilistic assessment of damage reduction by the NED plan also is shown in Table D-31. The mean value of damages reduced as produced by the risk analysis is $14,466,800. (This total is rounded to thousands of dollars for use in the benefit-cost calculations.) The table shows that there is a 75% probability that the true benefits exceed $8,235,900, a 50% probability that they exceed $12,902,200, and a 25% probability that they exceed $19,578,000.

7.4.3 Incremental Benefit Computations for South Topeka and Oakland Units. As was discussed previously in section 4.7.3, there were nearly insurmountable difficulties in determining the economic performance of the South Topeka unit relative to Oakland since the damage computations were overwhelmingly dominated by the even more problematical performance of the Oakland unit. In order to reflect the economic performance of both units in a more balanced fashion while avoiding double-counting of damages and benefits in Oakland, we ultimately determined that the benefits for the South Topeka and Oakland units would need to be calculated incrementally.

The incremental calculations assume the positioning of the South Topeka unit as the first-added unit. This assumption reflected the strong consensus of the entire product development team that, of the two units in question, South Topeka would be repaired first. The main reason for this priority is that flooding in South Topeka can run downhill into Oakland, while flooding in Oakland cannot back up into South Topeka. Since Oakland flooding has dual sources, it would make little sense to fix the Oakland levee first while leaving the area vulnerable to flooding via the unrepaired South Topeka unit, rendering the Oakland repair useless and a waste of money. In addition, the design overtopping discharge for South Topeka is marginally less than for Oakland.

The incremental calculations are summarized by means of a flowchart approach in Table D-32 and are discussed step by step below:

1. First, damages in Oakland were computed relative to all sources of flooding in the third HEC-FDA study file. The probability of failure function used in this set of computations combined the five individual functions - both Oakland critical sections and all three South Topeka critical sections. The total EAD for Oakland from all sources was estimated to be $4,852,000. This total was considered to be the baseline for Oakland damages.

2. A with-project condition which assumed the repair of all five critical sections was analyzed in the third study file. Based on this run, we determined that $1,341,000 of the $4,852,000 represented residual damages that would continue to occur even after implementation of the entire NED plan. Total damage reduction in Oakland due to the complete project was therefore $3,511,000. This was the total Oakland damage reduction to be allocated to the Oakland and South Topeka units in the first and second-added computations.

3. First-added benefits to the South Topeka unit were determined from the results of the second HEC-FDA study file. The second file evaluated Oakland damages relative to the South Topeka unit by using the low overtopping point for the South Topeka unit and the combined probability of failure function for the three South Topeka critical sections, all adjusted to the Oakland index point. Oakland damages attributable to the South Topeka unit were thereby determined to be $1,923,200. Residual damages totaled $1,125,600, and the total damage reduction - the first-added benefits to South Topeka - was $797,600.

4. Total benefits for the South Topeka unit were determined to be $991,200. This total is the sum of the $193,500 in damage reduction in the South Topeka area and the first-added benefits of $797,600 from the Oakland area credited to the South Topeka unit.

5. Deducting the $797,600 in first-added benefits from the baseline Oakland damage total of $4,852,000, the residual damages following the first-added calculations are $4,054,400.

6. It was previously determined that the total damage reduction in Oakland resulting from implementation of the entire project was $3,511,000 (see step 2 above). Deducting the $797,600 in first-added benefits, the second-added benefits total of $2,713,400 is credited to the Oakland unit.

7. Residual damages following the second-added calculations are $1,341,000 ($4,054,400 in

residual damages following the first-added calculations minus the $2,713,400 in Oakland second-added benefits). Therefore, $1,341,000 in residual damages would remain after implementation of the entire project - the same total calculated in the third study file in step 2.

8. Total benefits for the two units are therefore as follows: South Topeka unit, $991,200; Oakland unit, $2,713,400. Note that these incrementally-based benefit totals for the two units differ from those in Table D-26 summarizing results of the screening analysis.

TABLE D-32

COMPUTATION OF NED PLAN INCREMENTAL BENEFITS FOR SOUTH TOPEKA AND OAKLAND UNITS

	1. OVERALL OAKLAND DAMAGES	2. 1ST-ADDED BENEFITS TO SOUTH TOPEKA UNIT FROM OAKLAND *	3. RESIDUAL / REMAINING OAKLAND DAMAGES AFTER 1ST-ADDED SOUTH TOPEKA UNIT FIX	4. 2ND-ADDED BENEFITS FOR OAKLAND	5. RESIDUAL OR REMAINING OAKLAND DAMAGES AFTER 2ND-ADDED OAKLAND UNIT PROJECT	6. TOTAL SOUTH TOPEKA BENEFITS	7. TOTAL OAKLAND & SOUTH TOPEKA INCREMENTAL BENEFITS
TOTAL DAMAGES IN OAKLAND resulting from combined performance of existing Oakland and South Topeka units **	**$4,852.0**		$4,852.0				
RESIDUAL DAMAGES continuing after implementation of Oakland fix	**$1,341.0**				**$1,341.0**		
TOTAL DAMAGE REDUCTION IN OAKLAND from entire project	**$3,511.0**			$3,511.0			
DAMAGES IN OAKLAND charged to SOUTH TOPEKA UNIT PERFORMANCE ***		**$1,923.2**					
RESIDUAL DAMAGES IN OAKLAND (charged to South Topeka unit) that continue after SOUTH TOPEKA PROJECT IMPLEMENTATION		**$1,125.6**					
DAMAGE REDUCTION from Oakland area CREDITED TO SOUTH TOPEKA UNIT		**$797.6**	$797.6	$797.6		$797.6	
RESIDUAL OAKLAND DAMAGES FROM ALL SOURCES continuing after South Topeka fix			**$4,054.4**		$4,054.4		
OAKLAND UNIT BENEFITS				**$2,713.4**	$2,713.4		**$2,713.4**
DAMAGE REDUCTION FROM SOUTH TOPEKA AREA						$193.5	
TOTAL SOUTH TOPEKA UNIT BENEFITS						**$991.2**	**$991.2**

* Incremental analysis assumes South Topeka unit would be fixed first, Oakland unit second. For reasoning supporting this assumption, see section 7.4.1.

** These totals represent damages in the Oakland area from the combined performance of both sources of flooding - the Oakland unit and the South Topeka unit. Project performance is based on the combined performance of both levees, considering all five problem sites in Oakland and South Topeka, and on the initial overtopping elevation for the Oakland levee.

*** Assumes South Topeka unit controls all damage in Oakland area (as though there were no problems related to the Oakland levee) and that it would be fixed first, prior to the Oakland unit. Project performance is based on probabilities of failure for the 3 South Topeka problem sites and on the initial overtopping elevation for the South Topeka levee translated to the Oakland index point.

7.4.4 Induced Damages. The proposed project would not be expected to cause additional damages upstream, downstream or across the river from the study area. No new levees would be constructed and no existing levees would be raised. All project elements involve only strengthening of the existing levee system to meet expected design levels of performance rather than enhancement of performance to new levels.

7.5 FUTURE WITH-PROJECT CONDITION SUMMARY

A recently reinvigorated emphasis on collaborative planning within the Corps of Engineers has set the stage for greater consideration of the full range of Federal interest in water resources projects. This includes not only tangible NED effects of the project, but also non-NED economic impacts, social impacts, and environmental impacts on the city and region. Environmental aspects are discussed in Appendix E, while this section discusses some of the major economic and social considerations.

7.5.1 NED Effects of NED Plan. The overall NED contribution to the national economy is about $13.27 million, which is the total net benefits of the project. The project would reduce the existing condition EAD of $21.45 million by more than two-thirds to $7 million in residual EAD. The chances of experiencing floods that could result in losses of up to $2 billion would be greatly reduced (although not eliminated completely). Most of the adverse impacts described in section 5.3 would be headed off, including the following:

- **Residential** - Residents would be spared most of the heavy personal losses they would face from flood damage if no action was taken.

- **Businesses** - Business owners likewise would be spared most of their potential flood losses in buildings, equipment and inventories. This includes physical flood damages as well as income losses from shutdowns.

- **Public sector** - Public sector repair costs would be greatly reduced at public facilities such as parks, community centers, Billard Airport, the Oakland and North Topeka sewage treatment plants, related to damage at public facilities such as parks, Billard Airport, and community centers would be greatly reduced. City streets and roads would

- **Water supply** - Water supply delivery to 160,000 customers in and around Topeka would be favorably affected by reducing the chances of operational disruptions from flooding at the Waterworks plant. The city's major sewage treatment plants in North Topeka and Oakland, both of which would have been subject to frequent flood damage or operational interruptions in the without-project condition, would be subject to relatively frequent damage and their operations would be interrupted periodically.

- **Transportation networks** - The risk of frequent flood-related closings and detours on heavily traveled routes would be greatly reduced along highways, city streets and railroads. Drivers would be favorably affected in avoiding lost time opportunity costs and increased vehicular operating costs. Costly flood-related physical damages to roads and railroad track also would be greatly reduced.

- **Flood control works operation and maintenance costs** *(probable minor adverse impact on income)* - The project would add net annual O&M costs of about $10,700 to the North Topeka unit.

7.5.2 RED Effects of NED Plan. Regional economic development factors associated with project implementation - mostly positive - include the following:

- **Existing local jobs, income and tax base** *(probable positive impacts on income and jobs)* - The planning horizon for existing companies in and around the study area would include a much reduced degree of flood risk. Discouraging factors in the business climate such as the potential of ruinous flood damage and income losses from shutdowns would be reduced, while the potential for flood insurance requirements and stiffer building codes would be removed. The risk of relocation from the city and region by large regional employers such as BNSF Railroad, Goodyear, Hallmark, Del Monte, Hill's and others would be sharply reduced. Population losses, likely to occur in the context of a serious and ongoing flood risk, would be far less likely. The threat of large-scale job losses from relocations as well as reductions of the city's tax base would be sharply reduced.

- **Economic growth** *(probable positive impacts on income and jobs)* - The project would greatly alleviate potential obstacles presented by high flood risk for attracting new businesses with new jobs. Certification of the Federal levees would not be called into question, meaning that the looming threats of new costs for flood insurance and stiffer construction codes could be removed from the planning horizon. This would at the very least forestall adverse impacts to local jobs and income by improving the regulatory climate for those businesses wishing to expand, build, or move into the market from the outside. Key areas targeted for future business growth in North Topeka and Oakland - among the few significant sites the city has available for significant business development - would gain a high enough degree of protection to minimize flood damage impacts and remove flood-related regulatory burdens. Commercial operations at Billard Airport would not face the prospect of frequent shutdowns and flood damage.

- **Riverfront redevelopment** *(possible positive impact on income)* - Topeka's planned redevelopment of the riverfront in the center city could proceed absent the likelihood of increasing blight from frequent flood damage. Successful redevelopment would be expected to bring tourism and recreation revenues into the city and the study area.

- **Project construction impacts** *(miscellaneous possible minor impacts, both positive and adverse, to jobs and income)* - (a) No businesses or homes are slated for acquisition or relocation due to the project. (b) The region would temporarily gain some jobs during construction of the project. (c) The temporary presence of construction workers may bring a temporary increase in demand for some local services, but also a temporary increase in volume, profits, and sales tax receipts at local retail and service businesses. (d) Modest transitory population increases could occur in the study area in connection with project construction. (e) Minor traffic disruption near the levees could occur during construction, although based on the best available information at this time, no roads are anticipated to be blocked or closed for extended periods. Most of the project area would be accessed from the levee road and should not interfere with the normal flow of traffic.

7.5.3 Other Social Effects of NED Plan

- **Public safety** (p*robable positive impacts to human life)* - Serious public safety concerns, particularly in Oakland, South Topeka, and North Topeka, would be minimized by a large reduction in flood risk. The chance of project exceedance (i.e., a damaging flood event) over a 25-year period, which currently is no more than 1 in 2 for Oakland and North Topeka, would increase to 1 in 11 (see Table D-28). Moreover, any floods that did occur in extreme circumstances likely would be overtopping rather than breaching events, which would imply a greater warning time.

- **Effects on minority and low-income residents** *(probable positive socioeconomic impacts)* Topeka residents in lower-income areas and minority neighborhoods would be disproportionately affected by ongoing flood risk; refer to the detailed demographics in section 5.3.3 as well as section 2.2. Thus, the same groups in South Topeka, Oakland and North Topeka also would benefit disproportionately from the project.

- **Threats to center city redevelopment** *(probable positive cultural impacts)* - Local efforts to revitalize center city areas would avoid a substantial obstacle if flood risk is significantly reduced in the floodplain areas of North Topeka, Oakland and South Topeka. It bears repeating that much of the "center city" of Topeka is also floodplain terrain inside the Federal levees, and it would otherwise be subject to catastrophic flood damage in the future. Flood risk reduction would be a significant stabilizing influence for these neighborhoods.

- **Threats to riverfront redevelopment** *(possible positive cultural, historical and aesthetic impacts)* - The possibility that periodic flooding would blight the riverfront and interfere with successful redevelopment would be greatly reduced.

- **Treatment plant operations** *(positive health and environmental impacts)* - The likelihood of periodic service interruptions at the Oakland and North Topeka sewage treatment plants, resulting in large releases of untreated sewage into the Kansas River, would be greatly reduced.

7.6 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. It has been said that a flood risk management project designed relative to a 1%-chance flood event (the event that is critical to certification criteria) is an especially dangerous project. The reasoning is that an event of historical magnitude is not necessarily required to overwhelm the project and cause catastrophic damage, yet many floodplain tenants will feel that they have near-total protection against 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 recommended project.

The selected plan has substantial economic benefits and reduces study area equivalent annual damages in the existing condition by more than two-thirds. The probability and occurrence of flooding will be greatly diminished. But there remains a significant total of residual equivalent annual damages of almost $7 million. There still would be a 1 in 6 chance of exceedance over a 50-year period (see Table 28). The median annual exceedance probability of 0.003 indicates that there is a 0.3% chance of a damaging flood event in any given year.

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. Here is a summary of what city leaders and residents could expect in each area in terms of flood depths:

North Topeka - Average depths of at least 10 feet would prevail, and in virtually all of central North Topeka, hundreds of structures would be flooded to 15 feet or more. Depths in some areas would be up to 25 feet or more. The wastewater plant on Button Road and the Cargill plants on N.W. Gordon and N.W. Lower Silver Lake Road are significant industrial properties that would be affected by extreme depths of flooding. Depths at other key businesses include Goodyear, 9 feet; Del Monte, 8 feet; Payless, 5 feet.

Auburndale - Average depths of about 2 feet or more would affect Auburndale, with depths up to 20 feet or more in some areas. The hardest hit locations would include: MacVicar, N.W. 200-400 blocks (including the state printing plant); and Waite, N.W. 200-400 blocks (including several manufactured homes).

South Topeka - Average depths of 3 to 4 feet would flood South Topeka, and maximum depths of at least 14 feet would be found in some areas. Particularly low areas include: Crane, N.E. 400 block to N.W. 400 block, including the Hill's Pet Nutrition plant, where depths would be at least 16 feet, and the city transit garage; Jackson, N.E. 100 block to N.W. 100 block; Van Buren, N.W. 100 block to N.W. 100 block. The Hallmark plant would see depths of 7 feet or more, while the BNSF railroad shops would have at least 5 feet of water.

Oakland - Oakland would see average depths of about 4 feet as well as maximum depths of 16 feet or more. Hard hit areas would include: Forest, N.E. 400-500 blocks; Seward, N.E. 3500 and 4100-4200 blocks; Michigan, N.E. 1100-1300 blocks. The Oakland sewage treatment plant would have 9 feet of flooding and Billard Airport would have about 5 feet of water.

In general, 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 $2 billion or more. Prohibitive depths of water would remain inside the levees for at least two weeks and probably more. Large-scale evacuations of urban neighborhoods would be necessary in advance, followed by relocation assistance. A number of highly-traveled highways and streets as well as railroad track would be closed and in some cases inundated. Water supply delivery to the entire city probably would be interrupted, perhaps for a few weeks.

Local leadership and emergency operations staff will need to design plans for these extreme flood events, which may be infrequent, but would hold the potential for catastrophe if they occurred. Effective emergency planning in advance is the best way to protect communities and minimize the damage from these rare flood events. Meanwhile, those who currently hold flood insurance policies might very well find it advantageous to keep their policies, which usually are fairly inexpensive in areas with certified levees.

7.7 CONCLUSION

The feasibility-level socioeconomics analysis of the Topeka Federal flood protection system has found that a strong Federal interest exists in the NED plan. The plan exhibits very strong economic justification with a benefit-cost ratio of 12.1. With net benefits of $13,272,000, the project represents a strong contribution to national economic outputs. The plan also would make important contributions to public safety and regional economic considerations.

Annual benefits	**$14,466.0**
First costs	**$20,738.0**
Annual costs	**$ 1,194.0**
Benefit-cost ratio	**12.1**
Net benefits	**$13,272.0**