US Army Corps
of Engineers
Kansas City District

DRAFT
FEASIBILITY REPORT
AND
ENVIRONMENTAL ASSESSMENT
WITH APPENDICES

TOPEKA, KANSAS
LOCAL FLOOD PROTECTION PROJECT

AUGUST 2008

HEARTLAND ENGINEERS

TOPEKA KANSAS
FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT

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Appendices as Follows (all attached in order)

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Syllabus

Flood risk in the metropolitan area of Topeka, Kansas, is managed by a Federal levee system which began construction in the late 1930's and was expanded in the mid-1960s. This system consists of six separable units. The study area includes significant industrial, commercial, and residential areas, public facilities and transportation infrastructure, and agricultural property.

While this flood risk management system is designated as a Federal project, it has long been turned over to the local sponsors for operation and maintenance. The Corps of Engineers continues to conduct regular inspections and technical review of significant modifications to the system. The non-Federal sponsors are the City of Topeka, Kansas, and the North Topeka Drainage District.

In the early 1990's, studies conducted by a consultant working for the Kansas Sate Department of Transportation as part of a new highway crossing of the river and the levee raised concern that the levees may not be high enough to provide the intended level of flood risk management. At the request of the local levee sponsors, a review of the levees was initiated in 1998 to evaluate the existing project and determine alternatives for possible improvement. Section 216 of the 1970 Flood Control Act provided the study authority.

The feasibility study evaluated various alternatives including the no-action plan using a risk-based analysis. During the analysis, it was determined that the levee height was sufficient, but that there was a risk of levee failure at less than the design flood due to structural and geotechnical concerns. The recommended plan includes improvements to the geotechnical and structural features of the existing project units. The levee alignment will remain the same. This plan will have minimal local disruption to both the populace and the environment. Potential borrow areas have been identified close to the existing levee.

The recommended plan is the National Economic Development (NED) plan which maximizes the net economic benefits of the project. The NED plan is also the locally preferred plan. There are no significant direct or cumulative environmental impacts of the NED plan primarily because it sustains the existing levee rather then encumbering additional resources for a "new" project. The long-term environmental and cultural consequences of plan implementation are positive as the increased reliability of the units act to guard the social and environmental fabric that has developed within the study area.

The total estimated implementation cost of the NED plan is $20,738,000 (Oct 2007 prices) shared between the Corps and two non-Federal levee sponsors. The average annual costs of the NED plan are $1,194,000; benefits, $14,466,000; net benefits, $13,272,000. The resulting benefit to cost ratio is 12.1 to 1. The sponsors would receive credit for any necessary lands, easements, rights-of-way, relocations or disposal areas (LERRD). The total Federal share of the plan is $13,480,000 or 65 percent of the total cost and the sponsors share is $7,258,000 or 35 percent. The sponsors will take ownership of project improvements and assume all operation, maintenance, repair, and replacement costs of the completed works.

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TOPEKA, KANSAS, LOCAL PROTECTION PROJECT
FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT

I. Introduction

The Topeka, Kansas, Local Flood Protection Project (the Project) is a part of the general comprehensive plan for flood risk management and other purposes in the Missouri River Basin. The original project plan was included in House Document 195, 73rd Congress, 2nd Session (The Kansas River "308" Report) and was authorized by the Flood Control Act approved 22 June 1936 (Public Law 738, 74th Congress). The authorized plan provided for the construction of flood risk management works for South Topeka, North Topeka, and the municipal waterworks. As detailed in the Definite Project Report of 27 October 1936, modifications were made to the authorized plan to reflect more recent studies, and a partial implementation plan was proposed for South Topeka to meet the funding limitations of the 1936 Act. Construction of the partial South Topeka plan and the Waterworks portion was completed in 1939. The North Topeka levee construction was postponed in 1940 when local interests requested modifications of the proposed levee system to include a larger area.

Additional studies undertaken in the Kansas River Basin resulted in the development of the project outlined in H. Doc. 642, 81st Congress, 2nd Session, "Kansas River and Tributaries, Colorado, Nebraska, and Kansas", published 13 July 1950. This plan proposed the expansion of the North Topeka levee to encompass a larger area and also included the cutoff and diversion of several local tributaries, including Soldier Creek. Prior to authorization of this plan, the July 1951 flood necessitated additional modifications, including the completion of those portions of the South Topeka unit not constructed in the 1930's. These proposed modifications were outlined during Committee Hearings in May 1954, and the modified plan was authorized by the Flood Control Act approved 2 September 1954 (P.L. 780, 83rd Congress).

Final construction and modification of all project units and appurtenant features was completed in 1973. The completed Project consisted of six levee units along the Kansas River and its tributaries, Soldier and Shunganunga Creeks, providing flood risk management for the City of Topeka, (see Figure 1). The Waterworks, Auburndale, South Topeka, and Oakland Units lie on the south side, or right bank, of the Kansas River, with the Oakland Unit extending up the left bank of Shunganunga Creek. The North Topeka Unit lies on the north side (left bank) of the Kansas River and connects at each end to the Soldier Creek Diversion Unit which includes levees on both banks of Soldier Creek. Local sponsorship of the existing system is provided by the City of Topeka and the North Topeka Drainage District.

In the early 1990's, a private engineering consultant working for the Kansas Department of Transportation conducted studies for the Oakland Expressway, a new highway bridge to cross the Kansas River within the project area. Concern arose from their review that the levee in the area of the new highway may no longer be providing the expected level of flood risk management. As a result of these concerns, the City of Topeka requested a Reconnaissance Study in a letter dated March 26, 1992.

A Reconnaissance Study, initiated in September 1996 and completed in September 1997, found that there was a Federal interest in one or more alternatives to improve the level of flood risk management at Topeka by raising the top of levee elevation. This Feasibility Study was initiated in August 1998 with the signing of a Feasibility Cost Sharing Agreement between the Corps and the City of Topeka. The study is financed on a cost-share basis in accordance with the Water Resources Development Act of 1986. The cost of the study is shared between the Corps (50%) and the non-Federal Sponsors (50%).

Early in the feasibility study, a delay in study activities was authorized to await completion of the Upper Mississippi River Flow Frequency Study (UMRFFS). As part of this study, updated hydraulic models were developed for the Upper Mississippi and Missouri River and several tributaries, including the Kansas River, using updated gage records and state of the art technology – the UNET model. The UMRFFS study was completed in 2003. When the feasibility study resumed with updated hydraulic data, it was determined that the hydraulic overtopping reliabilities for the existing levee units range from 94 to 99 percent for the 1-percent chance (100-year) flood and a raise in the system would not be necessary to meet the criteria for continued FEMA certification.

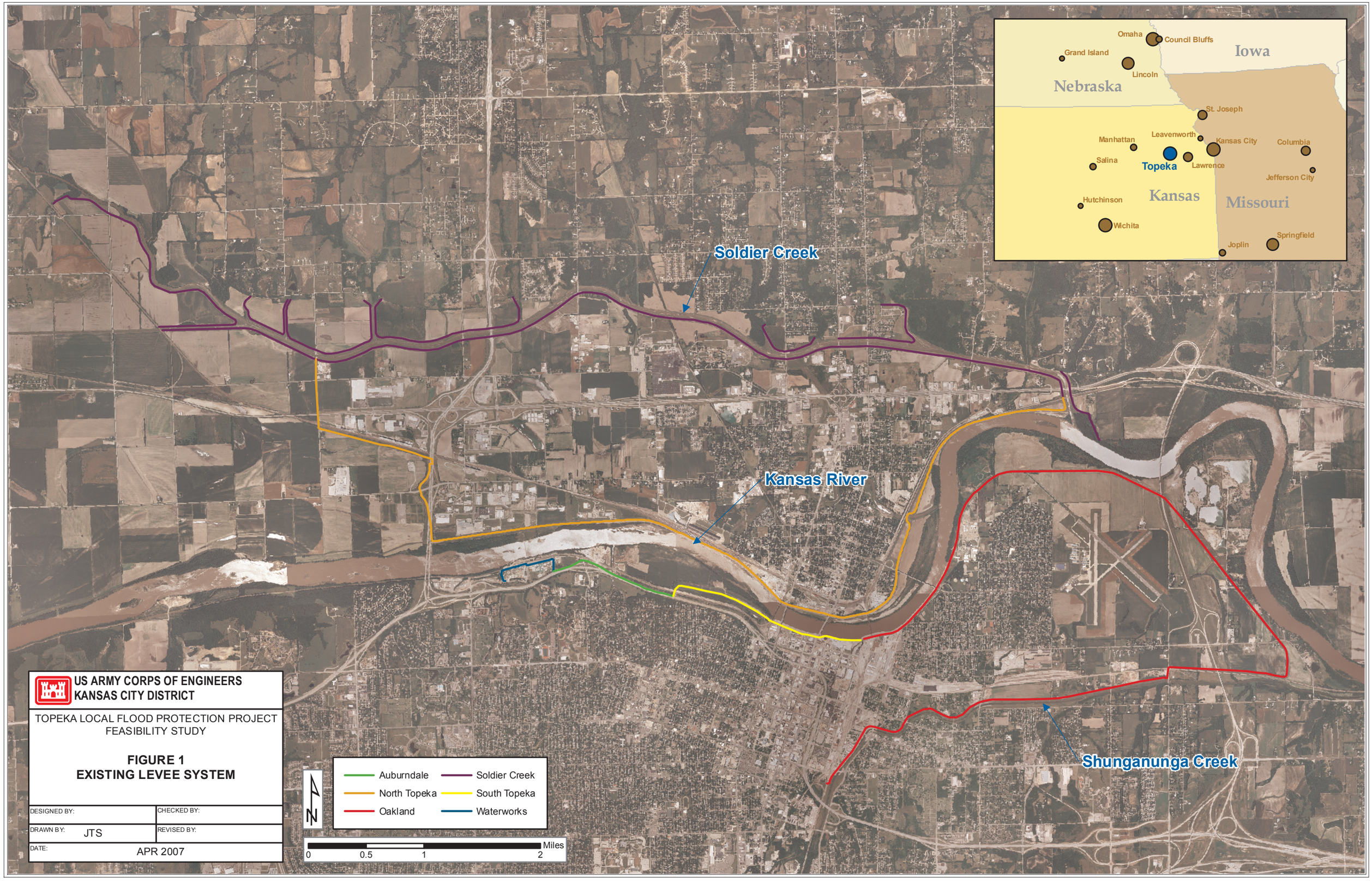
The focus of the study was then directed to examining the reliabilities of the geotechnical and structural features of the system. The reliabilities of several features within the system have been found deficient, creating potential failure locations within the levee system. Further description of these deficiencies will be presented in later sections of this document.

This study report is written using current risk and reliability analysis and flood frequency terminology that may not be familiar to all readers. The reliability of specific features is typically expressed as a percentage probability of failure as a measure of the likelihood of that feature to withstand a certain level of flooding. The frequency of a flood of a certain size is expressed both in terms of the percent chance of that flood occurring in a single year (i.e. 1% chance event) and also using the return interval designation (i.e. 100 year flood).

II. Study Authority

This report details the analysis, results, and recommendations resulting from the Topeka, Kansas, Flood Risk Management Feasibility Study (the Study). The Study was authorized under Section 216 of the 1970 Flood Control Act, which reads as follows:

> *The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects, the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to the significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying structures or their operation, and for improving the quality of the environment in the overall public interest*


Soldier Creek
Kansas River
Shunganunga Creek
Omaha
Council Bluffs
Grand Island
Lincoln
Iowa
Nebraska
St. Joseph
Manhattan
Leavenworth
Kansas City
Columbia
Salina
Topeka
Lawrence
Jefferson City
Hutchinson
Kansas
Missouri
Wichita
Springfield
Joplin
Auburndale
Soldier Creek
North Topeka
South Topeka
Oakland
Waterworks
N
Miles
0
0.5
1
2
US ARMY CORPS OF ENGINEERS
KANSAS CITY DISTRICT
TOPEKA LOCAL FLOOD PROTECTION PROJECT
FEASIBILITY STUDY
FIGURE 1
EXISTING LEVEE SYSTEM
DESIGNED BY:
CHECKED BY:
DRAWN BY: JTS
REVISED BY:
DATE: APR 2007

III. Study Purpose and Scope

The purpose of the feasibility study is twofold. First, the study serves to update and verify data on the reliability of the existing flood risk management units. Secondly, the study provides a means to examine and develop alternative plans (including a review of the "no Federal action" alternative) for reliability (performance) improvement of the units to reduce damages from potential flooding on the Kansas River in the vicinity of Topeka, with the ultimate aim of a final recommended plan for authorization and implementation. The recommended plan for increasing the reliability of the system will be selected through the basic tests of technical effectiveness and completeness, economic feasibility, and environmental acceptability.

IV. Prior Project Documents, Studies, and Reports

Several studies and reports have been completed pertaining to the study area and surrounding areas. These reports were used to gather information regarding the levee units and past flood events.

Definite Project Report, Levee System at Topeka, Kansas, 27 October 1936. This document was prepared subsequent to the Flood Control Act of 1936 and contains general discussion of the purpose, layout, and costs of the original Federal levee project at Topeka.

Design Memorandums, Volumes 1-15, Topeka, Kansas, Flood Protection Project, Kansas City District, U.S. Army Corps of Engineers, 1956 through 1967. The design memorandums are the justification documents, subsequent to the Flood Control Act of 1954, which recommend proceeding with plans and specifications for the various units within the Topeka, Kansas, Project. They include general design data, previous projects, and a general description of the authorized project.

Operation and Maintenance Manuals, Volumes 1-8, Topeka, Kansas, Flood Protection Project, Kansas City District, U.S. Army Corps of Engineers, 1961 through 1978. These document present detailed information for the use and guidance of the local interests in the operation and maintenance of the Topeka, Kansas, Project.

Flood Plain Information Report, Kansas River, Kansas, Junction City to the Mouth, Kansas City District, U.S. Army Corps of Engineers, April 1956. This report evaluated flood hazards along the Kansas River from Junction City downstream to the confluence with the Missouri River in Kansas City, Kansas. This document examines the hydrology and hydraulics of the Kansas River Valley.

Review Report on the Kansas River, Appendix IV, Hydrology, September 1960. This report examines the hydrology on the Kansas River as part of the extensive study to review the adequacy of the Kansas River and downstream flood risk management systems. Congress authorized this study in 1953.

Senate Document No. 122, 87th Congress, 2nd Session, Kansas River and Tributaries, Kansas, Nebraska and Colorado, U.S. Army Corps of Engineers, August 1962. This is the final report submitted to Congress that reviews the Kansas River and tributaries, Kansas, Nebraska, and Colorado, which was requested by resolution of the Committee on Public Works, United States Senate, adopted on August 20, 1953 and June 16, 1954.

Flood Insurance Study (FIS), City of Topeka, Kansas, Federal Emergency Management Agency, June 1981. This report published by the Federal Emergency Management Agency (FEMA) included flood discharges, water surface profiles, and flooded area and floodway maps for use in developing flood insurance rates. Since the City of Topeka, Kansas is a participating community in the Flood Insurance Program, all properties are eligible for flood insurance.

Modification to Completed Project, Soldier Creek Diversion Unit, Topeka Local Protection Project, Kansas, Kansas City District, U.S. Army Corps of Engineers, March 1987. This report describes channel degradation concerns in, and upstream of the Soldier Creek Project.

Draft Kansas River and Shunganunga Creek, Flood Plain Study, Oakland Expressway KDOT Project No. 4-89, K-3362-01, May 1992. This study examines the effects to the Kansas River and Shunganunga Creek of the proposed Oakland Expressway.

Flood Insurance Study (FIS), Shawnee County, Kansas, Federal Emergency Management Agency, May 1993. This report published by the Federal Emergency Management Agency (FEMA) included flood discharges, water surface profiles, and flooded area and floodway maps for use in developing flood insurance rates. Since Shawnee County, Kansas is a participating community in the Flood Insurance Program, all properties are eligible for flood insurance.

The Great Flood of 1993 Post-Flood Report, Lower Missouri River Basin, Kansas City District, U.S. Army Corps of Engineers, September 1994. The report presents a picture of the Great Flood of 1993 to be used in the analysis of the flood risk management system on the lower Missouri River and tributaries.

V. Existing Projects

Additional Federal levee units are located along the Kansas River at several locations, both upstream and downstream of Topeka. Downstream units are located at Lawrence, Kansas, approximately 25 river miles below Topeka, and at the river mouth at Kansas City. Upstream units are located at the cities of Manhattan and Abilene.

There are sixteen Federal reservoirs in the Kansas River basin above Topeka, five managed by the Corps and eleven managed by the Bureau of Reclamation. The five Corps reservoirs and the waterways on which they are located, in order of increasing distance from Topeka, are: Tuttle Creek (Big Blue River), Milford (Republican River), Kanopolis (Smoky Hill River), Wilson (Saline River), and Harlan County (Republican River).

VI. Problem Identification

A. Existing Conditions and Flood History

1.0 Study Area

The Study Area includes those portions of the Kansas River, Soldier Creek, and Shunganunga Creek drainage basins that are located within the City of Topeka. It is important to examine how the areas of these basins outside the city may affect the flood conditions at Topeka.

The Kansas River flows through the center of the City and is leveed between approximately river miles 77 and 88.5. The Kansas River drainage basin above Topeka includes 56,720 square miles of contributing and non-contributing surface area. Of this drainage, approximately 42,000 square miles are modified by sixteen existing Federal reservoirs located on tributaries of the Kansas River. The Kansas River basin and tributaries are predominately in a wide valley of well-developed agricultural lands used for general farming. This basin typically produces floods at Topeka that are slow to develop and slow to recede. The basin has shown, as in the 1951 flood of record, that relatively rapid flooding can occur and is also a serious threat.

The study area includes the confluence of Soldier Creek and the Kansas River. Soldier Creek flows through north Topeka and enters the Kansas River at river mile 80.6. The Soldier Creek basin is 331 square miles located to the north of the Kansas River. The predominant use of the basin is for general farming. The general basin shape is quite narrow (2.5 to 3 miles) near the headwaters and increases in width as it approaches the confluence with the Kansas River to a maximum width of 12 miles. This basin produces floods that are quite sudden and recede quickly.

Shunganunga Creek flows through southeast Topeka and enters the Kansas River at river mile 76.4. The total drainage area of the basin is 75.7 square miles of which 22.5 square miles lay within the city limits of Topeka. The basin is about 20 miles long and 7 miles wide at its widest point. The land is flat in the lower part of the basin and hilly in the headwater areas. There are four detention dams within the basin. In 1935, Lake Shawnee on Deer Creek, a tributary within the Shunganunga basin, was constructed. However, no provision was made for floodwater storage in this lake. After the flood of 1951, two more detention basins were constructed; Burnett Dam on Shunganunga Creek in 1952 and South Branch Dam on South Branch Shunganunga Creek in 1953. In 1962, Sherwood Lake was constructed upstream from Burnett Dam.

2.0 Description of Existing Overall Project

The existing project includes approximately 40 miles of main and 2.91 miles of tieback levees, 0.7 miles of floodwall, 9.2 miles of improved channel on Soldier Creek, 5.5 miles of improved channel on Shunganunga Creek, and 2.6 miles of improved and enlarged channel along the

Kansas River. The project also includes pumping plants, gated outlets for drainage structures, sandbag and stoplog gaps, and ponding areas. Each of the six flood risk management units was designed and constructed in coordination with the other, but each is operationally independent.

Existing Conditions of the Six Flood Risk Management Units

Waterworks Unit. The Waterworks Unit is located on the right bank of the Kansas River in the western portion of the City of Topeka and forms a "U" shape with Interstate 70 serving as the southern boundary. This unit encloses the City of Topeka's municipal water treatment plant. The location of the unit is shown in Figure 1.

The unit consists of 1,998 feet of levee and 1,662 feet of floodwall. The crest of the levee is 10 feet wide and varies from 10 feet to 14 feet in height above the ground surface. The spread footing floodwall has an average exposed wall height of between eight and twelve feet. A sheetpile cutoff wall is embedded in the heel of the floodwall. The unit also includes a system of nine individually pumped relief wells with header, four stoplog gaps, one sandbag gap, four gated drainage structures, and intake lines from the Kansas River for the treatment facility. The floodwall was constructed in 1938 and the rest of the unit was completed in June 1959.

Auburndale Unit. The Auburndale Unit connects the Waterworks and South Topeka Units and is primarily the Interstate 70 highway embankment. The location of the unit is shown in Figure 1. The unit consists of approximately 1.3 miles of zoned highway fill and some separate levee embankment fill. Also included in the unit is the Waite Street Levee, an 850-foot sub-levee which is the upstream boundary for a ponding area.

The Auburndale Unit also has fifteen relief wells, one sandbag closure gap structure, two pumping plants (Waite Street and Ward-Martin), four gated interior drainage structures and sewers through the levee, and a ponding area to protect a residential area. The area landside of the Interstate 70 embankment was re-graded to provide the ponding area for collection of interior drainage. This ponding area is bound by the Interstate 70 embankment to the north, high ground to the east and south, and the Waite Street tieback levee to the west. The relief wells are located on a rock fill berm at the landside toe of the Interstate 70 embankment. The unit was constructed under three separate contracts with the latest being completed in October 1962.

South Topeka Unit. The South Topeka Unit is located in the central portion of the City of Topeka, on the right bank of the Kansas River. The unit begins at the east end of the Auburndale Unit and extends to approximately 500 feet upstream of the Burlington, Northern, & Santa Fe (formerly the Atchison, Topeka & Santa Fe) Railroad bridge, which is the west end of the Oakland Unit. The location of the unit is shown in Figure 1.

The levee portion of the unit is approximately 1.4 miles long with a 10-foot crest that ranges from three to 16 feet above the natural ground surface. The levee generally follows the alignment of a concrete floodwall constructed in 1908 by local interests. Where the original wall and levee location coincided, portions of the wall were left in place within the new levee

embankment. The levee is founded on an impervious blanket varying in thickness between 5 and 24 feet, with an average of 15.5 feet. The blanket, consisting of silty clays and silty sands, overlays a sand deposit more than 80 feet thick. Fill placed on the top of the natural blanket between station 50+00 and 74+30 contains debris, rock, rubble, and sand requiring the construction of riverside cut-off trenches to reduce seepage. The levee was originally constructed in 1938 and a raise was completed in 1971.

At Station 74+41, the levee portion of the unit abuts downstream with a 1,945 linear foot concrete timber-pile founded floodwall that rises ten to twelve feet above the natural ground surface. A steel sheet pile cutoff wall is embedded in the heel of the levee. The floodwall was also originally constructed in 1938. Because of the nature of the blanket materials, and the effects of underseepage observed during the 1951 flood, an elaborate underseepage control system consisting of approximately twenty manholes and drop inlets, 27 relief wells with headers, and a new pump station (Kansas Ave.), was installed landward of the floodwall at the same time as the upstream levee raise. The blanket beneath this fill averages only a few feet in thickness and appears to be entirely missing between stations 77+50 and 80+50.

The Morrell, Madison Street, and City Park pump stations were constructed by the City of Topeka in 1931, 1946, and 1956, respectively, for the discharge of storm water to the Kansas River. The Morrell and City Park stations still exist as originally constructed. A new Madison Street pump station was constructed in 1970 by the City of Topeka with cost-share assistance from the Corps.

The unit contains fifteen drainage structures and was originally constructed with two sandbag railroad closure structures. The closure structure at the Chicago, Rock Island, and Pacific RR bridge was converted to a stoplog structure in 1964 and the nine-track closure at the upstream end of the unit was converted in 1973.

Oakland Unit. The Oakland Unit is located in the eastern portion of the City of Topeka and is bound by the Kansas River on the north and Shunganunga Creek on the south. It begins approximately 500 feet upstream of the Burlington Northern Santa Fe (formerly the Atchison, Topeka & Santa Fe) Railroad bridge. The unit creates the right bank levee of the Kansas River and becomes the left bank levee of Shunganunga Creek until its termination just north of Interstate Highway 70. The location of the unit is shown in Figure 1.

The unit consists of 10 miles of levee, 515 feet of concrete floodwall on Shunganunga Creek, and 5.5 miles of channel modification. The crest of the levee is 10 feet wide and varies from five feet to greater than fifteen feet in height above the ground surface. The floodwall height varies from seven to nine feet above existing ground surface. The Oakland Unit includes 22 relief wells, one sandbag gap closure structure, two pump stations, and 48 drainage structures. The unit was constructed under four separate contracts with the latest being completed in April 1969.

North Topeka Unit. The North Topeka Unit was constructed under two contracts and completed

in January of 1967. The unit encompasses the portion of the city that lies north of the Kansas River. The unit provides damage reduction from U.S. Highway 4 to Chester Avenue. On the west, the unit begins at the Soldier Creek Diversion Unit along Menoken Road. The levee then runs southeast and parallels the left bank of the Kansas River to just above the mouth of Soldier Creek. At this point the North Topeka Unit connects again with the Soldier Creek Diversion Unit on the east end. The location of the unit is shown in Figure 1.

The unit consists of nine miles of levee with crest heights varying from 3 feet to 17 feet above the natural ground elevation. The natural blanket for the entire levee unit, consisting predominantly of silt, varies in thickness from 1 to 23 feet, with an average thickness of 12 feet. Underseepage is controlled by landside underseepage berms between stations 83+00 and 220+00. Cut-off trenches are present between stations 205+00 and 462+50 at locations where the blanket is overlain by a sand layer or by existing pervious fill. Three (3) relief wells were placed at station 392+05 where the natural impervious blanket had been excavated for the basement of a warehouse building.

The North Topeka Unit includes three pump stations, Quincy Street, Fairchild, and Soldier Creek, fifteen drainage structures, and one sandbag and stoplog closure each. In 2003, the City redirected the sanitary and storm sewers that were connected to the Fairchild pump station as part of local infrastructure improvement. This action removed the majority of the flow for which the station was originally designed. The Fairchild station still provides removal of interior drainage from a two to three block residential neighborhood.

Soldier Creek Diversion Unit. Soldier Creek is located on the north side of the City of Topeka. It is a left bank tributary of, and flows generally parallel, to the Kansas River. Soldier Creek drains into the Kansas River at approximately river mile 80.6, but originally its mouth was located approximately 1.6 miles further upstream. The Soldier Creek channel was relocated to the north to intersect and follow the previous Indian Creek channel.

The Soldier Creek Diversion Unit consists of 9.2 miles of new or modified channel and 17.9 miles of levee on both banks. There are short tieback levees on several small tributaries and 35 drainage structures. The unit was constructed under eight separate contracts with the latest completed in 1961.

3.0 Existing Flood Threat

Prior to the construction of the levee units, this reach of the Kansas River routinely flooded river bottomland in the vicinity of Topeka. Also, without the levees, flood stages in excess of 15 feet caused significant flood damage. For this study, a detailed update of the hydraulics was completed with current state-of-the-art hydraulic modeling, utilizing calibration to the 1993 flood event. The discharge-frequency data for this study were taken from regulated and unregulated flow data for the Kansas River developed for the Upper Mississippi River Flow Frequency Study (UMRFFS), completed in 2003. UMRFFS was a major reevaluation of regulated and

unregulated flows in the subject basin, including the Missouri River and its Kansas River tributary. The UMRFFS currently estimates the 1-percent event discharge at Topeka to be 217,000 cfs. The authorized design discharge from the project Design Memorandum, published in 1956, is 314,000 cfs with freeboard, which is approximately a 0.29-percent annual occurrence event (approximately a 350-yr flood). Further detail of the hydraulic analysis and the design discharge is presented in later sections of this report.

4.0 Historic Floods and Damages

Kansas River. Major floods on the Kansas River are usually caused by a series of short-duration, high intensity storms following a prolonged period of general rains. Table 1 lists the five largest annual peaks at the United States Geological Survey (USGS) gage on the Kansas River at Topeka, Kansas. The period of record for this gage is from 1904 to the present. The USGS gage (06889000) is located on the Sardou Bridge, river mile 83.1, 2.3 miles upstream of Soldier Creek.

Table 1. Kansas River - Five Largest Recorded Annual Peaks at Topeka

Year	Discharge (cfs)
July 1951	469,000
May 1903	253,000 (estimated)
August 1908	200,000
July 1993	170,000
June 1935	154,000

It is also known that a great flood occurred on the Kansas River in June of 1844, for which records do not exist. Various estimations and accounts of the flood indicate that this event may have been the largest ever to occur on the Kansas River.

In addition to the large historical events noted in Table 1, smaller floods occurred in 1904, 1919, and 1928; all of which contributed to the inclusion of Topeka in the Flood Control Act of 1936. However, the cycle of flooding continued through the Forties with notable events in 1941, 1943, 1944, 1945, and 1949, reaching a peak with the flood of July 1951.

The Flood of Record of 1951 was a catastrophic event that impacted the entire Kansas River. The damages caused by the event in Topeka were estimated at over $34 million (1951 price level), over $350 million in FY 2007 prices. As a result, Federal involvement in Topeka, as well as other cities in the basin, significantly increased with the passage of the Flood Control Act of 1954. The modifications and additional work implemented in the 1960's and 70's were the result. However, it should be noted that the South Topeka Unit was not fully tested during this flood event. Historical records indicate that the interior of the unit flooded prior to any levee overtopping or structural failure due to flow through a railroad sandbag gap that was not closed.

Of the discharges shown in Table 1, only the 1993 flood was influenced by full reservoir control of the upstream basin. Of the sixteen Federal reservoirs, the two most influential lakes that affect

the Kansas River flows at Topeka are Tuttle Creek Lake and Milford Lake. Tuttle Creek Lake is located on the Big Blue River above Manhattan, Kansas, and began operation in March 1962. The Big Blue enters the Kansas near river mile 145. Milford Lake is located on the Republican River above Junction City, Kansas, and began operation in January 1967. The confluence of the Republican and the Smoky Hill River creates the Kansas River at approximately river mile 171. Studies indicate that without this upstream flow regulation, the peak discharge of the 1993 flood at Topeka would have been approximately 192,000 cfs. Additionally, it is estimated that the 1951 flood would have been about 288,000 with full regulation.

Soldier Creek. Floods on Soldier Creek are caused by short duration storms that quickly develop and recede. Table 2 lists the five largest annual peaks at the USGS gage located approximately one-third of a mile upstream of the U.S. Highway 75 bridge over Soldier Creek. The period of record for this gage is from 1929 to the present. There are no upstream reservoirs that impact the flows of Soldier Creek in Topeka.

Table 2. Soldier Creek - Five Largest Recorded Annual Peaks at Topeka

Year	Discharge (cfs)
October 2005	47,800
June 1982	30,400
July 1981	25,000
June 1999	24,000
September 1977	21,900

Other floods of interest: the July 1993 flood of 18,900 cfs, approximately the 6th largest, and the June 1951 flood of 11,400 cfs, approximately the 9th highest.

Shunganunga Creek. USGS gage record data is only available for the years 1980-81. Historic peak discharges are unavailable.

5.0 Floodplain Conditions

The City of Topeka, Kansas, participates in the National Flood Insurance Program (NFIP). Property owners in a participating community within the 1 percent chance flood zone, and other specially designated zones, can obtain flood insurance. Any proposed construction in the 1 percent chance floodplain must generally be elevated above the 1 percent chance flood elevation, or in compliance with local ordinances. The floodway is an area hydraulically defined that must be reserved in an unobstructed condition in order to pass the base (1 percent chance) flood without increasing flood levels more than one foot. Existing floodplain ordinances generally prohibit construction or development within the floodway.

6.0 Geotechnical Conditions

The Engineering Appendix presents the results of the geotechnical evaluation of the existing conditions performed as part of the feasibility flood study. The flood risk management project

within the study area was designed by the Kansas City District U. S. Army Corps of Engineers and was constructed under its supervision.

The primary goal of this phase of the geotechnical evaluation was to gather and review all available data and develop an assessment of the existing conditions of each levee unit by identifying the critical reaches for each unit and their probability of failure for different river stages. Additionally, the past performance of the levee system was evaluated. This information is to assist in an assessment of the future performance of the levee during flood events. In particular, the following tasks were performed for this study:

- Review of existing sources of information,
- Description of each existing levee unit including design features and subsurface conditions.
- Reliability analyses of each unit and identification of critical reaches of each unit

The evaluation of the existing condition was based on the original subsurface investigation performed for the design of the project. This was supplemented with additional investigations, such as cone penetrometer tests and laboratory testing performed on selected samples collected from borings drilled in areas considered critical.

7.0 Economic Setting

The City of Topeka, Kansas, the State Capital, is centrally located in Shawnee County, in west central Kansas, near the geographic center of the continental United States. The city covers 57.6 square miles surrounded by unincorporated areas of Shawnee County. The development in Topeka represents all the features of a mid-sized urban area including transportation by road, rail, and air, and social and cultural infrastructure including a wide variety of public and private educational facilities and a particularly diverse selection of health care providers. In addition to the State government administration, Topeka hosts a wide variety of industries including preparation of packaged foods, printing and publishing, warehousing and distribution, and transportation.

Topeka, with a 2006 estimated population of 122,113, is the fourth largest city in Kansas, after Wichita, Kansas City, and Overland Park, and 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.

The study area, or the areas within the Federal levee project, had an estimated 2000 population of 16,098 (about 13.1% of the total Topeka population) and a total of 7,153 housing units. These totals are based on data from the Census blocks comprising the study area.

Per capita income in the study area (i.e., the Census block groups comprising the protected areas) was $17,596 in 2000, which was only 90% of the Topeka per capita income, 84% of Shawnee County, 86% of the state, and 82% of the national total. Study area residents were more likely than city and county residents in general to have sub-poverty level incomes or to be unemployed, and they were somewhat less educated. 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 probably resulted in part from 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 study area vacancy rate of 7.9% exceeded the city rate of 7.5% and the county rate of 6.6%. Refer to Appendix D, Section 2 for further discussion of area demographics.

Commercial, industrial, and residential developments are located in the floodplain of the study area behind the different levee units. Numerous city streets, county roadways, state and Federal highways, and railroads cross the floodplain. The Philip Billard Airport, one water treatment plant, two wastewater treatment plants, and other public utilities are located in the floodplain. In addition, open land already protected by the levees could be developed for commercial and industrial uses. Pressures for additional development of the floodplain within the existing levee system will continue to intensify during the period of analysis due to the concentration in Oakland and North Topeka of several sites amenable to large-scale commercial or industrial development. Topeka has only a few other sites available outside of these areas.

The Federal project protects a total of 11,059 acres in Topeka, representing about 31% of the city's total area. The largest leveed areas are the North Topeka area (6,076 acres – protected by two units of the system: North Topeka and Soldier Creek) and the combined Oakland/South Topeka area (3,582 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 right 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 and western portions of North Topeka.

The left bank area protected by the North Topeka unit contains significant heavy industry, including a Goodyear Tire plant, as well as residences and farm acreage on the east and west ends of the area. Properties in the North Topeka area include 2,752 residences and 539 businesses and public facilities which, together with highways, roads, and rail, have a total

estimated investment of almost $1.4 billion. Rural sections of the Soldier Creek unit along the north edge of North Topeka protect a few dozen homes as well as several areas planted in crops, with a total estimated value of about $28.1 million. The main section of the Soldier Creek unit protects the same urban North Topeka area that is also protected from the Kansas River by the North Topeka unit.

On the right bank, the Waterworks unit's sole protected property is a water treatment plant. The Auburndale unit protects an estimated investment of $113.4 million, including 616 residences and 18 businesses. The South Topeka Unit contains investment valued at $386.4 million, including 142 businesses and facilities and 80 homes. The Oakland area contains 2,942 residences and 89 businesses and facilities comprising an estimated investment of $548.6 million. In total, the Topeka federal levee system protects an estimated $2.53 billion in investment, including 6,487 residences and 790 businesses and public facilities.

8.0 Environmental Setting

The study area is an urban wildlife setting characterized by industrial, residential, and commercial development. The small areas of natural habitat available are generally confined to riparian woodland strips along the river corridor. Portions of the Kansas River have been channelized and, in some locations, the levees are almost right at the riverbank, constraining the extent of riverine habitat.

Vegetation types present in the study area include: floodplain habitat of cottonwood and willow trees, oak-hickory forest, and bluestem prairie. Additional detail of the vegetation, climate, and soil characteristics of the study area is presented in Section 9.0 of the attached Environmental Assessment.

9.0 Fish and Wildlife

Typical fish species found in the Kansas River include various species of bass, shiner, catfish, chub, and others. The fisheries resources in this reach of the Kansas River are greatly influenced by releases from Tuttle Creek Lake. The spring spawning season is a particularly sensitive period when releases from the lake provide high flows which are critical for spawning success.

Many species of mammals, birds, reptiles and amphibians utilize the riparian woodlands and grasslands adjacent to the banks of the Kansas River. This riparian corridor, although severely reduced in much of the study area, continues to represent a significant amount of important wildlife habitat.

There are three Federally-listed species that may occur within the project area: bald eagle, piping plover, and least tern.

State listed endangered species in Shawnee County include the American burying beetle, Eskimo curlew, least tern, peregrine falcon, silver chub, and whooping crane. State listed threatened species include the bald eagle, eastern spotted skunk, piping plover, smooth earth snake, snowy

plover, sturgeon chub, and Topeka shiner.

More detailed information on fish and wildlife resources, and threatened and endangered species, is provided in Sections 10 of the attached Environmental Assessment. Lists of typical fish and wildlife species found in the project area are included in the 2007 USFWS Coordination Act Report (EA, appendix C).

10.0 Wetlands

Based on a review of National Wetland Inventory mapping and site investigations by Corps of Engineers personnel, there are no wetlands currently present within the project study area.

11.0 Cultural Resources

The Corps conducted a review of the National Register of Historic Places (NHRP), an appropriate records search at the Kansas State Historical Society, and a field reconnaissance of the project area. No NRHP properties are recorded in the study area. Also, the records search found no other archeological sites, historic structures, or shipwrecks recorded within any of these areas. For additional information see the attached Environmental Assessment, Section 10.6.

12.0 Hazardous, Toxic, and Radioactive Waste

A Hazardous, Toxic, and Radioactive Waste (HTRW) assessment was completed as part of the Topeka, Kansas, Reconnaissance Report (USACE, 1997), and a more recent assessment (USACE, 2007) of potential HTRW resources was completed.

Overall, the assessment found very little risk associated with HTRW contamination in the study area; however, there were three areas of potential HTRW or solid waste impact. Former city dump sites were identified in parts of the South Topeka and Oakland Units that will need to be avoided. The description from the Scotch Cleaners site, located in the southeast portion of the South Topeka Unit, indicates a groundwater plume of chlorinated solvents is emanating from this site and extends north-northeast to the Kansas River. This plume may be present below the existing floodwall.

The conclusions of the 2007 HTRW assessment are summarized in the attached Environmental Assessment, Section 11.0, and the complete investigation report is included with the EA as Appendix H.

B. Future Conditions Without Project

1.0 Future Flooding

The existing conditions of each unit described earlier were analyzed using current methods and criteria for factor of safety and reliability. Each unit was systematically analyzed to determine if

any critical reaches for geotechnical and structural concern were evident. For those reaches that did not meet current factor of safety criteria, an additional reliability analysis was conducted to calculate the probability of failure. Table 3 presents the current estimates of the reliability of passing the 1-percent annual chance event for each unit.

As stated earlier, the overtopping reliabilities of the Kansas River units are all above 93%. The values in Table 3 indicate the significance of the geotechnical and structural weaknesses identified for each unit.

Table 3. Existing Conditions Reliability of Kansas River Units

Levee Unit	Reliability Against the 1% event
Waterworks	92.8%
Auburndale	96.8%
South Topeka	84.2%
Oakland	2.9%
North Topeka	14.1%

Supporting detail for the geotechnical and structural analyses is found in Appendix A (Engineering). Additional detail supporting exceedance probabilities and the consequences of failure in each unit are presented in Appendix D (Socioeconomics).

Large areas of existing residential, business, and industrial development are now in a zone that is vulnerable to flood damage due to unacceptable reliability. If a project is not authorized and implemented, it is expected that FEMA could eventually enact a major zoning change that will greatly increase flood insurance requirements, potentially causing the area to enter into an economic decline with less viability for improvement or enhancement. Modifications or improvements to existing businesses, and any new investment within the area, would be constrained due to flood insurance requirements. If the project recommended by this study is not implemented by the Federal government, then the non-Federal sponsors will be faced with a significant financial burden of trying to implement the project themselves, or they will have to rely on temporary flood-fighting to protect the area from future floods.

The primary goal of evaluating these areas of concern was to identify potential failure modes and impacts on the ability of the project to continue to perform as intended. Knowing how the system can be expected to react provides the basis for identifying the types of alternatives that will be most effective in restoring project performance. The specific areas of concern for each unit and their expected failure modes area discussed in the following paragraphs.

Waterworks

Floodwall Stability. Six analyzed floodwall cross sections failed to meet sliding stability criteria. Sliding factors of safety calculated vary from 0.78 to 1.15; the minimum requirement is 1.3. Additionally, the four stoplog closure structures within the floodwall were analyzed with water

to the top of the wall. Each closure showed a factor of safety of less than 1.3 for sliding stability (values ranged from 0.75 to 1.04). Sliding failure of the wall could lead to separation of the wall sections, water infiltration through opened wall joints, scour around the openings, and rapid wall failure.

South Topeka Unit

Underseepage. The critical geotechnical reach for the unit with respect to underseepage was identified within the earth levee section between stations 22+00 and 48+00. The Probable Failure Point (PFP), being the water surface elevation corresponding to an 85-percent probability of failure, occurs 0.2 feet below the top of the protection at that section. This is an excessively high probability at the top of the levee and indicates that the existing underseepage control fill in this area is inadequate. Excessive underseepage underneath the levee could cause internal erosion, undermining the foundation and resulting in collapse of the levee.

Structural Uplift. Uplift concerns are created when the hydraulic pressures in the ground pushing up on a structure during high flow events are greater than the weight of the structure itself. Calculations assumed fifty percent efficiency in existing pressure relief wells and up to three feet of water in the existing underseepage collector system to meet uplift requirements. Four manhole boxes failed to meet uplift criteria under these conditions (Sta. 16+07, 84+10, 84+10a, and 85+57). The existing factors of safety range from 0.84 to 0.96; 1.1 is the required uplift factor of safety. Uplift failure of a manhole could result in a path for floodwaters to enter the unit, causing a failure mode similar to the underseepage failure discussed in the previous paragraph. Furthermore, three of these manholes are part of the floodwall underseepage control system. Loss of one manhole could cause loss of the entire underseepage collector system.

Floodwall Stability. The original 1936 construction drawings for the floodwall are available, but accompanying specifications and design calculations are not. The construction drawings were employed along with other incomplete records of design and construction, memoranda of investigations and activities related to 1960's era modifications to the drainage systems, inspection reports, and site visit information collected during the feasibility study to conduct a preliminary stability and strength analysis of the wall.

From the information available, the structural analysis initially found that the loads on the timber piles supporting the wall exceeded the allowable shear stress. By exceeding the allowable stresses, the piles did not meet the factor of safety included in the allowable loads which suggested a reliability concern. However, a reliability analysis showed that the combined axial and bending stresses in the timber piles were less than the allowable stresses, indicating an acceptable reliability in resistance to shear loads.

A geotechnical analysis was also performed to determine the axial capacity of the existing piles. Two locations were selected. The first is a reach between station 83+00 and 87+00, where the foundation conditions were found to be the least desirable. The second is at station 89+00, which is more representative of the majority of the floodwall foundation conditions. A

deterministic analysis of the axial pile capacity was initially performed for the design loading condition with water to the top of the wall. The piles at station 89+00 were found to meet the required factor of safety; however the piles at station 83+75 did not. A reliability analysis was subsequently performed for station 83+75 starting with water at the top of the floodwall and lowering the water level in one foot intervals to determine the water surface at which the probability of failure approaches zero. The probability of failure for the design loading condition was found to be 45%. A foundation failure could result in excessive floodwall deflections and rapidly lead to a wall failure.

Pump Station Strength. At the Kansas Avenue pump station, an interior foundation wall exhibits a factor of safety of 0.97, failing to meet the required 1.5 strength factor. A failure of the steel within the wall will lead to cracking of the wall and possible loss of the foundation of the pump station, leading to water infiltration and the inability of the station to operate as intended. As this pump station is an important part of the floodwall underseepage control system, loss of the station could contribute to failure of the wall itself.

Oakland Unit

Underseepage. The critical geotechnical section for underseepage was identified between stations 64+00 and 80+00. The PFP for this section occurs 7.3 feet below the top of levee at this section. Flood flow elevations higher than the PFP could cause excessive underseepage, resulting in undermining of the levee foundation and possible loss of the levee. This reach is immediately adjacent to the Oakland Wastewater Treatment Plant.

Structural Uplift. The 5.5 ft. by 4.5 ft. drop inlet, 6.5 ft. deep, at station 75+50 fails to meet uplift criteria. The existing structure shows a factor of safety of 0.93. Almost 4 ft of water would be necessary to meet the minimum required 1.1 uplift factor of safety. An uplift failure of the manhole would provide a path of floodwaters to enter the unit and potentially undermine the levee.

The East Oakland Pump station exhibits an uplift factor of safety of 0.76, failing to meet the minimum of 1.1. An uplift failure would create a path for floodwaters to enter the protected area. Additionally, a pump station failure would prevent interior drainage from being evacuated to the river, contributing to interior flood damages.

Floodwall Stability. Two cross-sections analyzed of the floodwall on Shunganunga Creek failed to meet sliding stability, exhibiting factors of safety of 0.76 and 0.85, compared to the minimum requirement of 1.3. Sliding failure can lead to separation of the floodwall sections, infiltration of water, scour around the openings, and possible rapid loss of the wall. The wall is adjacent to an industrial business area.

North Topeka.

Underseepage. Analysis identified the areas between stations 165+00 and 180+00 and stations

246+00 to 250+00 as having piping safety factors less than 1.0 and were considered critical for reliability evaluation. The existing underseepage berm between 165+00 and 180+00 is inadequate and the reach from 246+00 to 250+00 does not have any existing underseepage control measures. The PFP for the section between stations 165+00 and 180+00 occurs 7.5 feet below the top of levee at that section. For the reach between stations 246+00 and 250+00, the PFP occurs 5.8 feet below the top of levee at that location. Flood flow elevations higher than the PFP could cause excessive underseepage, resulting in undermining of the levee foundation and possible loss of the levee These reaches are located adjacent to agricultural and industrial areas, including such facilities as the North Topeka Wastewater Treatment Plant, grain elevators, and a railroad switching yard.

Structural Uplift. The Fairchild pump station uplift calculations are based on field measurements of exterior footprint dimensions, interior sump dimensions, and assumptions for floor member thickness. Using these dimensions and varying hydraulic gradelines (based on possible variations in blanket thickness, blanket permeability, and foundation permeability) the uplift factor of safety was determined to be 0.72. The required minimum is 1.1. Uplift failure of the pump station could result in a pathway for flood water to enter the unit. The pump station is located near a small residential neighborhood.

2.0 Socioeconomic Considerations

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 4. 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. The probabilities of failure indicate a serious safety risk due to the fact that some features of the system, such as the South Topeka floodwall, may catastrophically with little or no warning. 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 enumerated below.

Table 4. Future Without Project Condition Summary

	Equiv. annual damages	Expected damages in 1% flood	Expected damages in 0.2%-chance	Affected population	Affected homes	Affected businesses and facilities	Annual exceedance probability	1% event nonexceedance probability	Chance of failure 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			

Costs in 1000’s. Solider Creek urban damages are not included in overall total because North Topeka damages covering the same area are included.

NED (National Economic Development) 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, to include: (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 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 to residents forced from their homes by flooding would be required for thousands of residents at an average of $7,500 per home.

- 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.

RED (Regional Economic Development) 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.

- 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 scale backs; (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 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.

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 large

daytime populations of workers 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. Public safety impacts would take the form of drowning, electrocution, and illness from exposure to contaminated flood waters.

- 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).

3.0 Environmental Considerations

The future without project condition of the natural environment in the study area is discussed in the attached Environmental Assessment. Generally, the remaining habitat within the study area is confined to the riparian corridor and this area is not expected to be subject to impact or change from future development. However, as development of the City of Topeka increases outside the current study area, the importance of the existing riparian corridor within the larger environmental context is expected to increase.

C. Planning Problems and Opportunities

The primary study area problem is that the existing levee system does not reliably provide the design level of flood risk management. This is supported by the research of design and authorizing documents, engineering analysis performed using current criteria, and mathematical modeling. The specific problem areas of the system that cause low reliability include floodwalls, pump stations, manholes, and areas of underseepage concern. The low reliabilities exhibited in this system pose a public safety risk to a significant population and sizeable area of economic investment.

This study presents the opportunity to restore the reliability of the local flood risk management system and thereby minimize damages from future flood events. By doing so, there is the opportunity to provide the affected community the confidence to continue with future economic development. Opportunities for protection or enhancement of the natural and cultural resources of the area also exist and may be addressed by the study or by other related activities taking place or proposed in the study area.

VII. Hydrologic and Hydraulic Analysis

As part of the feasibility study, hydraulic investigations were conducted on the Kansas River, Soldier Creek, and Shunganunga Creek using the HEC-RAS computer software developed by the Hydrologic Engineering Center, U.S. Army Corps of Engineers. Hydraulic models were developed using 1997 survey data supplemented with 1995 four-foot aerial contour maps supplied by the City of Topeka and calibrated using high water marks from the 1993 Flood. Water surface profiles were then generated for eight different discharge events. These include the 10, 2, 1, 0.5, 0.2, 0.133, 0.1, and 0.04-percent chance (10, 50, 100, 200, 500, 750, 1000, and 2500-year) flood events. The discharge uncertainty results are detailed in Chapter 2 of Appendix A for a range of frequencies.

A. Kansas River

The area of hydraulic investigation extends from Kansas River mile 73.0 through mile 96.5. A HEC-RAS hydraulic model was developed to determine the expected flood discharge based on

statistical analysis of the Topeka Gage located on the Sardou Avenue Bridge. The uncertainty in both stage and discharge were calculated. The standard deviation of stage is 0.85 feet.

The Kansas River discharges and associated flood frequencies, up to the 0.2% (500-year) event, are shown in Table 5. Model results for larger events and the associated discharge-frequency curve are provided in Chapter 2 of Appendix A.

Table 5. Kansas River Discharge-Frequency Relationship

Annual Percent Chance of Exceedance	Flow at Topeka Gage (cfs)
0.2	348,000
0.5	268,000
1	217,000
2	173,000
5	123,000
10	93,600
20	67,200
50	36,600

The current authorized design discharge is 314,000 cfs, which corresponds to an approximate annual percent chance of exceedance of 0.33% (300-year flood). The currently authorized discharge is less than the discharge of 340,000 cfs originally authorized in 1936. The discharge was lowered due to the influence of the upstream reservoir control system that was under development at the time of the 1954 Flood Control Act. However, two of the proposed upstream reservoirs considered in the discharge determination were later deauthorized and not constructed.

Today's methods of hydraulic analyses are based on risk and uncertainty calculation (reliability) instead of the freeboard concept used in the past. Current practice is to establish the water surface elevation at which the intended river flow can be contained by the levee with 90% reliability. Using the current hydraulic model, the 90% reliable elevations for the design flow are higher than the top of the existing project in each of the four units where improvements are proposed; overtopping margins range from 0.3 to 1.47 feet.

According to the current hydraulic model, the North and South Topeka units will begin overtopping at 300,000 cfs, and the Oakland unit at 305,000 cfs. The average difference in water surface elevation between 300,000 cfs and the authorized discharge of 314,000 cfs is only 0.4 feet and the standard deviation of the model itself is 0.85 feet, thus making these differences statistically insignificant.

While an understanding of the hydraulic performance of the levee system at high Kansas River flows is important, it is secondary to the fact that many of the geotechnical and structural issues discussed in other sections of this report occur at elevations at, or below, the top of the existing project, causing a significant risk of project failure before overtopping. Furthermore, the

formulation of alternatives to address a small stage discrepancy at a high flood level is not considered practical or cost-effective. The potential for increased benefits stemming from such a raise would be very limited since incremental damage prevention benefits would be associated with only the most extreme flood events. Thus, no further consideration was given to a levee raise in this study.

B. Soldier Creek

The hydraulic investigation was completed on the first ten miles of Soldier Creek. The hydrologic analysis was completed to determine the expected discharges at the flood risk management works based upon statistical analyses of four stream flow gages in the watershed.

The model shows that the existing Soldier Creek levees are not overtopped until the 0.5% chance exceedance (200-year) flood event. The uncertainty in both stage and discharge were calculated. The standard deviation of stage is 1.68 feet.

C. Shunganunga Creek

The hydraulic investigation was completed to calculate water surface profiles on approximately the first five miles of Shunganunga Creek adjacent to the Oakland Levee Unit, from the mouth of Shunganunga Creek to the 10th Street Bridge. To determine the expected discharges within the Oakland Levee Unit, a watershed analysis was completed using the Storm Water Management Model (SWMM) computer software developed by the U.S. Environmental Protection Agency. The model was calibrated using data from a U.S.G.S. gage that was located at the upstream face of Rice Bridge from May 1980 to September 1981.

The model shows that the existing Shunganunga Creek levees are not overtopped until the 0.04% chance exceedance (2500-year) flood event (with a 50% chance of non-exceedance).

VIII. Flood Damage Estimates

A. Economic Damage Analysis Methodology

This section provides a summary of the data and methods used to perform the economic risk analysis of the study area. A detailed discussion is provided in Appendix D of this report. The study area was divided into reaches for the economic analysis, as summarized in Table 6.

Table 6. Economic Study Reaches

Name	Stream	Bank	Reach Description	Beg. Station	End Station	Index Station
WW	Kansas River	Right	Waterworks unit	86.7	87.2	87.0
AUB	Kansas River	Right	Auburndale unit	85.5	86.7	86.1
ST	Kansas River	Right	South Topeka unit	83.7	85.5	84.8
OAK	Kansas River	Right	Oakland unit	76.0	83.7	82.3
NT	Kansas River	Left	North Topeka unit	80.8	88.8	85.6
SC-RB1	Soldier Creek	Right	Urban subunit - North Topeka	0.2	7.2	4.2
SC-RB2	Soldier Creek	Right	Rural subunit @ Silver Creek ditch	8.1	10.0	8.7
SC-LB1	Soldier Creek	Left	Rural subunit @ Hwy. 24	0.2	0.6	0.4
SC-LB2	Soldier Creek	Left	Rural subunit @ Kansas Ave.	1.9	2.3	2.2
SC-LB3	Soldier Creek	Left	Rural subunit @ Rochester Rd.	2.7	3.1	3.0
SC-LB4	Soldier Creek	Left	Rural subunit @ Brickyard Rd	5.5	6.7	6.2
SC-LB5	Soldier Creek	Left	Rural subunit @ Menoken Rd	6.8	7.5	7.3
SC-LB6	Soldier Creek	Left	Rural subunit @ NW 33rd St. west end	7.6	8.0	7.9

Kansas City District economics staff carried out a structure-by-structure field survey of all buildings in the study area. The economic structure inventory is categorized in terms of four basic land uses: residential (including farm sets), non-residential (including businesses, non-profit institutions such as churches and schools, public facilities and utilities), roads and streets, and agriculture (crops).

Data obtained from county and city tax and GIS data, 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.

The comprehensive structure inventory for the study area – including elevations, values, and depth-damage functions for each property – was entered into the HEC-FDA software (Hydrologic Engineering Center's Flood Damage Analysis program), a risk analysis software product that is standard for Corps of Engineers flood risk management analyses. 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.

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, further inspection determined 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 upstream 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 can be attributed to 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. For a discussion of how this complex problem is modeled in the economic analysis, see Appendix D, section 4.7.3.

The North Topeka unit along the Kansas River and the main subunit 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, and the economic structure inventory used is identical for both streams. For this reason, the damages for the two units are 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 North Topeka unit on the Kansas River unless otherwise stated. It also should be noted that the foregoing discussion applies only to the main urban subunit of the Soldier Creek unit. The other subunits protect small rural areas primarily on the left bank of Soldier Creek that are distinct from the urban North Topeka area. These properties are protected only by the Soldier Creek unit. Damages identified as “Soldier Creek rural” are distinct from North Topeka area damages and are additive with North Topeka damages, unlike the “Soldier Creek urban” damages.

The base year for the economic analysis - i.e., the year when the project would be completed and operational - is 2014. The base year condition also is used to describe the existing condition in this analysis. Existing conditions data would not differ from base year data in any respect, including economic structure inventory, hydraulic and hydrologic conditions, or structural and geotechnical estimates. A future condition also is defined for 2038, but it again is based on exactly the same data sets as the 2014 condition. All available information on prospective economic development in the floodplain areas was obtained in mid-2007 as this study was being completed. Of the possible projects on the horizon, most were not yet definite, while others that were definite were not far enough along to identify specific locations and estimate investment and damage potential. Ultimately, expected future development was not included in any of the conditions used - existing, base, or future.

B. Study Area Investment

The Topeka Federal Levee system collectively protects property valued at $2.53 billion, as summarized in Table 7. The study area includes 6,487 homes and 790 businesses and public facilities as well as 164 miles of roads and streets (including 28 miles of railroad) and more than 800 crop acres. North Topeka accounts for more than half of total investment (55.1%), while South Topeka and Oakland combined account for about 36.8%. The other units of the system - Waterworks, Auburndale, and the Soldier Creek rural areas - have much smaller property bases that collectively account for about 8% of total investment.

Table 7. Study Area Investment

	WATER WRKS	**AUB**	**SOUTH TOP.**	**OAKLAND**	**NORTH TOP.**	**SOLDIER CRK RUR**	**TOTAL**	**% OF TOT.**
October 2007 prices. All structure and content values reflect depreciated replacement values.								
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	
Contents (equip & inventory)	$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	
Contents (incl. auto & 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	0.63	11.2	20.01	45.86	82.89	3.32	163.91	
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	0.05%
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%		

C. Damage Results

This section summarizes the results of the without-project economic analysis as they pertain to beginning damage points and selected flood events. Table 8 presents the Equivalent Annual Damages (EAD) expected and Table 9 details the expected engineering performance of the system. A more detailed analysis and discussion of the without-project condition damages is presented in Appendix D.

Table 8. Equivalent Annual Damages (Without Project)

Oct 2007 prices, 4.875% interest rate; $1,000s

Levee Unit	Non-Residential	Residential	Roads	Ag	Emergency	Disaster Relief	Total	% of Total
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 South Topeka.

Table 9. Engineering Performance (Without Project)

	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 over nominal 1% flood elevation (feet)	5.9	8.2	6.5	3.7	6.6	1.7
Conditional exceedance probability - overtopping or failure	0.072	0.032	0.158	0.971	0.860	0.332
Conditional exceedance probability - overtopping only	0.067	0.032	0.054	0.058	0.054	0.332
OTHER FLOOD EVENTS - EXCEEDANCE PROBABILITIES						
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.

In general, the analysis produces two conclusions regarding engineering performance:

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

(2) Significant geotechnical and structural concerns are compromising the reliability 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.

IX. Plan Formulation

A. Planning Constraints

The following planning constraints affect many decisions related to study execution:

- The study shall be conducted in accordance with the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*, as approved by President Ronald Reagan, February 3, 1983 and accepted by the United States Water Resources Council on February 22, 1983. These guidelines are contained in the U.S. Army Corps of Engineers Engineering Regulation (ER) 1105-2-100, *Policy and Planning, Guidance for Conducting Civil Works Planning Studies.*

- Feasible projects will comply with the principles of Executive Order 11988 which addresses floodplain management and Section 404 of the Clean Water Act concerning the protection of wetlands. Project planning must be accomplished to minimize project effects on floodplains in general, and wetlands and other environmental features. Mitigation must be considered where applicable

- Project formulation will adhere to FEMA guidelines adopted by the State of Kansas regarding the regulatory floodway. These guidelines require that construction in the base floodplain be accomplished in such a manner as to limit any resulting increase in the 1.0-percent-chance flood elevation to less than one foot.

- Project Design alternatives recognize the provisions of Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act and the Hazard Mitigation Grant Program administered by FEMA and the Kansas State Emergency Management Agency.

- Relationships between the levee units will be maintained. For this feasibility study, the examination of measures to increase the performance of the system will be guided by an overarching principle that seeks to achieve a relatively consistent level of performance throughout the system. This essentially means that the study should <u>avoid</u> recommending:
    - Any measures which would directly or indirectly exacerbate any performance weaknesses (or relative weaknesses) of another unit.
    - Any measures that would contribute to increasing the level of performance of one unit without a commensurate increase or at the expense another unit.

- Project alternative screening will consider the financial capability of the local sponsor. Feasibility phase financial constraints play a very significant role in the execution of this

study. Sponsor affordability and associated financial constraints demand that feasibility analysis, scoping, and planning decisions must first focus on those areas, measures and solutions which address pressing needs or significant performance weaknesses within the overall system as these will provide the greatest relative opportunity for reliability improvements.

- All other items of the study will be in accordance with the standards of the U.S. Army Corps of Engineers.

B. Planning Objectives

A primary objective of Corps feasibility studies is to comply with the national objective of water and related land resources planning. This includes contributing to the National Economic Development (NED) consistent with protecting the Nation's environment. Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units. The NED Plan is that alternative that maximizes net benefits over the period of analysis.

Other planning objectives for the Feasibility Study include:

- Update and verify data on the reliability of the existing project performance under flood conditions.

- Formulate measures/components (to include the "no Federal action" alternative) that provide each levee unit a complete plan to restore unit reliability to acceptable levels as needed.

- Identify the National Economic Development (NED) Plan that maximizes net economic benefits for each unit.

- Develop a comprehensive plan that provides for acceptable reliability of the entire existing system and increases economic flood risk management benefits.

- Provide a complete final recommended plan for implementation that is technically sound, economically feasible, and environmentally acceptable.

- Reduce the potential for loss of life and human suffering caused by flooding within the project area.

- Integrate the Environmental Operating Principles into the project plan by minimizing the impact of the proposed project, maintaining or improving the current environmental conditions, and preserving the cultural and historical resources within the project area.

C. Development and Screening of Alternatives

The results of the existing conditions analysis and observations and effects from historic and recent flood events were used to formulate potential engineered solutions aimed at lowering the risk of flooding for units under study. Often these alternatives needed to address problems with specific segments or locations within a unit (the problem areas are termed "areas of interest", or AOI in this report).

An initial set of alternative measures was developed using experience from other levee system studies and investigation of current engineering practices. These alternatives were screened and refined for their application at each AOI. As the process continued, additional alternatives surfaced and were examined. Alternatives were examined and compared considering the Federal criteria of completeness, efficiency, effectiveness, and acceptability. Alternatives were closely examined for their potential to impact the environment. As the alternatives passed through this evaluation and screening process, the economic analysis of each alternative's incremental cost was used as a ranking factor in the final selection. Having passed review for engineering adequacy, environmental and public acceptability, and other evaluation criteria as described below, the remaining alternative with the highest net benefits to the national economy was identified as a component of the overall recommended NED plan.

The development and screening of alternatives involved the consideration of a number of evaluation factors or criteria. Primary among those factors were the following:

- Engineering adequacy of the proposed solutions (effectiveness)
- Contribution to planning objectives (related to completeness of solution)
- Consistency with planning constraints and authorities
- Environmental, cultural, and public acceptability
- Early cost indicators (early efficiency indicators for screening purposes)
- Floodway conveyance considerations
- Hazardous and regulated waste site constraints (where applicable)
- Constructability (are construction techniques and quality difficult to attain at reasonable price)
- Construction site constraints (given existing features and development)

Engineering Adequacy: The engineering adequacy of alternatives was analyzed and reviewed during the initial screening process. Any alternatives which could not meet the minimum technical criteria for the expected flood conditions were eliminated from further review. This is a key effectiveness criterion and normally must be met. The amount of engineering analysis necessary to perform the engineering review was generally considerable and is contained in the Engineering Appendix.

Environmental Acceptability: Environmental acceptability of alternatives was reviewed in concert with appropriate resource agency guidance. Any alternative which had major disruptive

effects on the environment was normally screened out. A typical formulation exercise would involve adjusting some of the alternative measures so as to minimize any environmental impacts when such impacts could not reasonably be avoided.

Cultural Acceptability: As the alternatives were developed, the areas likely to be affected by implementation were reviewed for the presence of any known cultural and historical resources. Steps were taken during the alternatives screening and refinement process to generally avoid any impacts to culturally significant sites.

Early Cost Indicators (efficiency): Early approximate cost indicators related to the various alternatives were used to determine if an alternative was prudent for further examination. As the evaluation process continued, cost estimates and economics were refined. The detailed cost estimating and economic analysis normally focused only on those alternatives that remained viable solutions after early screening criteria were passed.

Floodway Conveyance Considerations: Very early in the plan formulation process, a general guiding rule was adopted: any measures which negatively impacted the established floodway conveyance should be avoided. This was deemed essential as in most cases levees lie along both banks of the river reaches within the study area, and are often located either upstream or downstream of another unit. This principle is consistent with floodway "no rise" criteria as promulgated under FEMA regulations. This criterion was maintained during feasibility and the final alternatives are essentially benign in respect to any adverse floodway impact.

The following sections describe the specific measures considered and the results of the screening and evaluation process.

D. Measures Considered for Plan Formulation

Traditional Corps analyses for identification of the NED plan (the plan with the highest net benefits) involve identifying an array of measures (structural and non-structural) to achieve the stated objectives and then determining the most cost-effective combination of those measures that fully addresses the identified problems.

The initial plan formulation concepts which guided early portions of the feasibility study were based on producing a plan and report which addressed all units within the six levee system. This approach had its genesis in the abbreviated studies conducted during the reconnaissance phase which indicated the possibility of system-wide levee raises. While no feasibility level plans were developed along these lines, it was the original guiding expectation.

The initial broad feasibility evaluations of existing conditions undertaken during the first several years of this study allowed subsequent formulation efforts more focus. The development of measures to increase reliability was narrowed to the candidate sites which indicated significant risk, offered the best opportunity for significant reliability improvements, and had the greatest potential for economic return on investment. These candidates were also reviewed for

compatibility with the basic planning objectives and constraints which emphasized the desirability of a relatively uniform level of flood risk management across the system.

As feasibility progressed, the development of reliability improvements were thus focused on those areas of interest (AOI) with relatively low reliability; i.e. areas where low reliability significantly compromised the project's original intended level of performance. Engineered reliability remedies and improvements were developed considering both the improvements to individual unit performance and the performance of the whole system.

1.0 Non-Structural Measures

Beginning with the Flood Control Act of 1936, the Federal government has led the nation's flood risk management efforts, and as a result, also led the nation's floodplain management activity. Historically, structural programs such as levees, floodwalls, channelization, and dam and reservoir projects played the lead role in preventing flood damages. In more recent years, the Federal government has endeavored to support nonstructural approaches (such as flood warning systems, flood-proofing of structures, floodplain management, etc.).

Nonstructural approaches have merit when the site characteristics and the flooding threat are compatible with the nonstructural capabilities. In the case of the existing Topeka flood risk management system, nonstructural methods were eliminated early as potential solutions due to:

- Planning objectives for this study (which address existing structural flood risk management systems) cannot be met through the use of nonstructural measures.
- The need for large-scale risk reduction within the extensive protected areas is best accomplished through performance improvements to the existing Topeka structural flood risk management system.
- The performance of the existing Topeka flood risk management system far exceeds the normal performance parameters of nonstructural measures.

No opportunity for large-scale application of nonstructural measures is foreseen within this study other than continuing to effectively manage the floodplain using FEMA NFIP guidelines. It may be possible to find some limited use for nonstructural measures along the fringe of the protected area and for the prevention of damages due to localized interior flooding. These potential limited applications are outside the scope of this study and doe not warrant Federal involvement.

Flood Fighting Alternative

The flood fight alternative normally requires a stockpile of sandbags to be stored near areas subject to high underseepage pressures or overtopping. Sandbags are then deployed to strategic locations and placed (or stacked) in accordance with proven flood fighting techniques. These stacks of sandbags serve to add mass or height in an attempt to temporarily reinforce the permanent features already in place. When working with major levee systems, flood fighting is generally best thought of as an aid to manage unpredictable and unforeseen problems during

flood events.

For large levee units where substantial investment is protected, some flood fighting can be planned and implemented for limited low-risk situations. But, in general, when exposed to massive flood events, flood fighting measures will often prove unreliable. For the levee units and problems under examination in this study, flood fighting is generally not an acceptable planning alternative when compared to engineered solutions. Flood fighting generally will not prevent underseepage failures when dealing with very high pressures, nor can flood fighting reliably prevent structural floodwall failures under extreme load conditions.

2.0 Structural Measures

Underseepage Measures

- Landside Seepage Berm. Constructing a seepage berm of pervious fill to control underseepage during a flood event is considered an effective and relatively reliable alternative. Direct construction costs associated with this alternative are typically moderate. Indirect costs such as extending the right-of-way and conducting subsurface investigations can add additional costs. If sufficient real estate is not available, structural demolition and relocating of utilities, residences and businesses will greatly increase the total cost and logistics problems associated with this alternative.

- Buried Collector System. A buried collector is constructed using perforated pipe placed within an excavated trench adjacent to the levee on the landside. Typically, buried collectors include a drainage pipe or ditch, which collects and removes seep water. Buried collectors require greater maintenance than underseepage berms but are effective in areas with restricted construction space.

- Pressure Relief Wells**.** This alternative consists of installing a series of pressure relief wells along the landside toe of the levee. Wells can normally discharge directly to ground or if needed a header system may serve to transfer seep-water from the wells to a selected discharge area or to a pump station. Relief wells are a highly effective apparatus used to control underseepage. However, pressure relief well performance is very dependent upon the quality of construction, and the long-term maintenance costs associated with this alternative are greater than installing a buried collector system.

Uplift Measures

- Structure Abandonment. If a structure is determined to no longer be a necessary component of the flood risk management system, it can be removed and/or properly abandoned in place. This should not be confused with the No Action alternative as proper abandonment of a deficient structure removes a potential avenue of levee failure and contributes to lowering the risk of flooding.

- Pump Station Operational Change Alternative. In the case of a pump station, it may be possible to change the operations plan to keep more water in the wet well and thereby increase the weight of the station and counteract the uplift pressures. Leaving more water in the well may require changes in the pumps themselves.

- Heel Extension Alternative. A heel extension is another method of increasing the weight of a structure to counteract uplift pressures. The area around the structure (pump station or manhole) is excavated to expose the foundation base, or heel, of the structure. The heel is extended using additional concrete to increase the weight and size of the structure.

- Remove and Replace Alternative. The most expensive alternative for correcting an uplift concern is to remove the existing structure and replace with a new structure designed to counteract the hydraulic pressures. However, for structures where required factors of safety cannot be obtained by other alternatives, replacement is the preferred alternative.

Floodwall Sliding Stability Measures

- Wall Replacement. Replacement of the affected wall sections with new sections designed to better withstand the sliding forces can be complex and construction intensive, requiring the provision of temporary flood protection during construction, and protection of the integrity of the existing sections not being replaced.

- Foundation Modification. Foundation modifications may increase the factor of safety against sliding, but would require excavation of the existing foundation which may place increased stress on the existing wall during construction. Foundation modifications under an existing wall are technically complex and the quality of installation can be difficult to maintain. These factors increase the cost of this alternative comparative to other available alternatives.

- Landside Stability Berm. The placement of an earthen stability berm along the landside of the wall would provide the needed additional stability with minimal impact to the integrity of the existing wall and foundation. A stability berm typically consists of compacted soil extending from the wall landward and then tapering to the existing ground surface. Berm dimensions will depend on the degree of stability required. Comparison of the stability berm alternative to wall replacement or foundation modification indicates that a berm is typically more cost effective by orders of magnitude and can provides the same benefits. However, as the need for stability support increases, the size of the berm can become excessive, requiring additional easement space and the provision of large quantities of soil material. For floodwalls exhibiting high degrees of instability, a stability berm may not be as effective as other alternatives.

Pump Station Strength Measures

- Reinforcement. Interior reinforcement of a pump station can be achieved by installation

of a wall stiffener. A wall stiffener is a steel beam or plate attached to the inside of the station wall that shortens the effective length of the existing steel reinforcement, increasing its ability to resist bending.

- Remove and Replace. The removal and replacement of a pump station with a new structure designed to withstand hydraulic pressures is a much greater cost than reinforcement.

Floodwall Foundation Measures

- Construct a new floodwall on same alignment or landward of the existing wall. A new floodwall designed and constructed with current standards and methods would provide the risk management benefits intended by the existing wall. By constructing a new wall landward of the existing wall, costs of removal of the old wall are minimized. However, sufficient right-of-way would be required for the new structure. If sufficient right-of-way and clearances are not available the original wall and foundation would require complete removal.

- Earthen fill against landside of existing floodwall, temporary or permanent. Similar to a stability berm, the placement of earthen fill, essentially the same as earth levee construction, might help the wall to resist deflection during high flows.

- Structural modification of the existing floodwall and foundation. Structural reinforcement to resist wall deflection could be installed.

- Foundation soil strengthening by jet grouting. Soil strengthening may increase the capacity of the soil to resist pile movement during high flows.

E. Screening of Measures

The measures presented in the previous section were examined to address their ability to adequately address the deficiencies and potential failure modes described earlier in this document. Those found lacking sufficient validity were screened-out. Table 10 lists the initial array of measures for each AOI, the results of the screening review, and indicates whether the measure was carried forward for more detailed analysis. The rest of this section presents more detailed discussions of the screening.

1.0 North Topeka Unit

Geotechnical Concerns

Geotechnical analysis of the North Topeka Unit revealed two areas of underseepage risk at approximately Stations 165+00 to 189+00 and Stations 246+00 to 250+00. The area from station 165+00 to 189+00 has a sufficient amount of open space to construct an underseepage berm. A berm in this location would need to be seven feet thick at the levee toe, sloping down to

Table 10
Topeka, Kansas, Feasibility Study
Alternatives Matrix

Description of Problem by Levee Unit and Location	Possible Alternative Corrective Measures					Discussion
	1	2	3	4	5	
North Topeka Unit, Station 364+60 Fairchild Pump Station Problem: Uplift	Operational changes	Heel Extension	Remove and replace	Abandon		Fairchild Pump Station out-dated and no longer used or maintained by sponsor. Recommend measure 4.
North Topeka Unit, Station 246+00 to 250+00 Problem: Underseepage	Underseepage berm.	Burried collector system.	Relief wells discharging to ground.	Relief wells discharging to manhole w/ temporary pumping.	Relief wells discharging to permanent pump station.	Insufficient area is available to install measure 1. Uplift pressures are not high enough to allow for ground discharge. Pumping only required at times of high flow. Permanent pump station would increase construction cost and future O&M. Recommend measure 4.
North Topeka Unit, Station 165+00 to 189+00 Problem: Underseepage	Underseepage berm.	Burried collector system.	Relief wells discharging to ground.	Relief wells discharging to manhole w/ temporary pumping.	Relief wells discharging to permanent pump station.	Sufficient open land is available to install measure 1. Recommend berm 7 feet thick and 220 feet wide consisting of 140,000 cy of random fill material.
Oakland Unit, Station 220+00 East Oakland Pump Station Problem: Uplift	Operational changes	Heel Extension	Remove and Replace	Abandon		Measure 1 will not provide sufficient uplift factor of safety. Recommend measure 2.
Oakland Unit, Station 75+50 - Manhole Problem: Uplift	Heel Extension	Remove and Replace				Measure 1 will provide minimum uplift factor of safety.
Oakland Unit, Station 485+86 to 491+01 Problem: Sliding Stability	Stability berm	Foundation Mod				Measure 1 will provide minimum sliding stability factor of safety.
Oakland Unit, Station 64+00 to 80+00 Problem: Underseepage	Underseepage berm.	Burried collector system.	Relief wells discharging to ground.	Relief wells discharging to manhole w/ temporary pumping.	Relief wells discharging to permanent pump station.	Sufficient open land is available to install measure 1. Recommend berm 6.5 feet thick and 240 feet wide consisting of 70,000 cy of random fill material.
South Topeka Unit, Station 75+84 Kansas Avenue Pump Station Problem: Strength	Wall Stiffener	Remove and Replace	Abandon			Measure 1 will provide minimum strength factor of safety.
South Topeka Unit, Station 86+00 Madison St. Pump Station Problem: Uplift	Operational changes	Heel Extension	Remove and Replace	Abandon		Measures 1 will not provide required minimum uplift factor of safety. Insufficient area is available for excavation to install measure 2. Recommend measure 3.
South Topeka Unit, Station 16+07 - Manhole Problem: Uplift	Heel Extension	Remove and Replace				Measure 1 will provide minimum uplift factor of safety.
South Topeka Unit, Station 84+10 - Manhole Problem: Uplift	Heel Extension	Remove and Replace				Measure 1 will provide minimum uplift factor of safety.
South Topeka Unit, Station 84+10a - Manhole Problem: Uplift	Heel Extension	Remove and Replace				Measure 1 will provide minimum uplift factor of safety.
South Topeka Unit, Station 85+57 - Manhole Problem: Uplift	Heel Extension	Remove and Replace				Measure 1 will provide minimum uplift factor of safety.
South Topeka Unit. Station 74+41 to 93+86 Problem: Floodwall foundation weakness	New wall on offset alignment	New wall on existing alignment	Earthen Levee behind existing wall	Modify existing wall		Insufficient area is available to implement measure 1. Recommend measure 2.
South Topeka Unit, Station 22+00 to 48+00 Problem: Underseepage	Underseepage berm.	Burried collector system.	Relief wells discharging to ground.	Relief wells discharging to manhole w/ temporary pumping.	Relief wells discharging to permanent pump station.	Sufficient open land is available to install measure 1. Recommend berm 5 feet thick and 100 feet wide consisting of 71,000 cy of random fill material.
Waterworks Unit, Station 0+78 to 7+00, 10+00 to 16+50 Problem: Sliding Stability	Stability berm	Foundation Mod	Wall replacement			Measure 1 will provide minimum sliding stability factor of safety.
Waterworks Unit, Station 13+07 to 15+95 Problem: Sliding Stability	Stability berm	Foundation Mod	Wall replacement			Measure 1 will provide minimum sliding stability factor of safety.

three feet thick at a distance of 220 feet landward of the levee. This will require the acquisition of 122,250 cubic yards of fill material and temporary easements for borrow excavation and construction activities.

A relief well system installed in this same area would require a series of thirty-two wells installed at an average spacing of 75 feet. Installation of a relief well system would not require the impacts caused by borrow site excavation and would likely require less easement acquisition. Both the underseepage berm and relief well measures at this location were carried forward for additional study.

The area from station 246+00 to 250+00 is constrained by existing railroad tracks and does not provide enough area to construct a seepage berm without substantial and expensive relocations. Furthermore, uplift pressures are not high enough to allow ground discharge through a buried collector system or relief wells.

A pumped relief well and collector system would address the underseepage concern in this area. Specifically, seven evenly spaced relief wells connected to a header are needed, with temporary or permanent pumping during high flow events. Temporary pumping does create an added requirement on the local sponsor during flood fighting and will increase the cost of operation. A permanent pump station would eliminate the potential logistical issues of providing a temporary pump during a flood event, but would also substantially increase construction and future operation and maintenance costs.

The pumped well system measure was carried forward for additional consideration.

Structural Concerns: Uplift

Structural analysis identified uplift concerns at the Fairchild Pump Station (station 364+40). The Fairchild Pump Station is no longer used or maintained as an active part of the levee system. Whereas flood risk management benefits could be gained by correction of the structural deficiency and a lowering of the probability of failure, the same benefits could be gained by removal of the station without the need for future operation and maintenance costs. Removal of the pump station was carried forward as the preferred measure.

2.0 Oakland Unit

Geotechnical Concerns

Geotechnical analysis of the Oakland Unit identified one area prone to underseepage, from station 64+00 to station 80+00. Sufficient open land is available adjacent to the levee at this location to construct an underseepage berm six and one-half feet thick at the levee toe sloping to three feet thick at a distance of 240 feet landward of the levee. This installation would require 84,500 cubic yards of material and associated material borrow areas and easements.

A relief well system in this same reach would require the installation of 22 wells at an average spacing of 75 feet. Installation of a relief well system would not require the impacts caused by borrow site excavation and would likely require less construction easement acquisition.

Both measures were carried forward for additional detailed evaluation.

Structural Concerns: Floodwall Stability

Structural analysis found that the concrete floodwall section of the Oakland Unit tieback on Shunganunga Creek is at risk of a sliding failure when loaded with water near the top of the wall. Potential weaknesses were found the entire length of the wall from Station 485+86 to 491+01. A landside stability berm approximately 2 feet thick, extending 5 feet landward, and then sloping at a 1:3 slope will address the instability. Approximately 388 cubic yards of material would be required to construct this berm. This measure was carried forward for additional evaluation.

Structural Concerns: Uplift

Structural analysis identified uplift concerns at the East Oakland Pump Station at station 220+00 and one utility manhole at station 75+50. Sufficient area is available around each structure for the installation of a heel extension, which will improve the necessary factors of safety to an acceptable value. This measure was carried forward for additional evaluation.

3.0 South Topeka Unit

Geotechnical Concerns: Underseepage

Geotechnical analysis of the south Topeka unit identified one area of underseepage concern, from station 22+00 to station 48+00.

Sufficient open land is available adjacent to the levee to construct an underseepage berm five feet thick at the levee toe sloping to three feet thick at a distance of 100 feet landward. This installation would require 48,150 cubic yards of material and associated material borrow areas and easements.

A relief well system in this reach would require the installation of 35 wells at an average spacing of 75 feet. Installation of a relief well system would not require the impacts caused by borrow site excavation and would likely require less construction easement acquisition.

Both measures were carried forward for additional detailed evaluation.

Structural Concerns: Uplift on Utility Manholes

Structural analysis identified uplift concerns with several utility manholes on the landside of the levee. Heel extensions will be sufficient to achieve the required uplift factor of safety of the

utility manholes adjacent to the South Topeka unit. This measure was carried forward for additional evaluation.

Structural Concerns: Strength

The Kansas Avenue Pump Station was analyzed and an interior foundation wall was found deficient for meeting the required strength factor of safety. A wall stiffener installed inside the Kansas Avenue Pump Station will redistribute the pressure loads and allow the structure to achieve the required factor of safety for structural strength without the added expense of removal and replacement of the existing structure. This measure was carried forward for additional evaluation.

Geotechnical Concerns: Floodwall Foundation

A risk and reliability analysis of the South Topeka floodwall axial pile capacity was conducted using the original construction drawings, on-site inspections, assumptions based on typical 1930's construction methods from other similar facilities studied by the Kansas City District, and research on the design limitations of this type of construction. The axial pile capacity of the foundation of the South Topeka floodwall for wall type B between station 83+00 and 87+00 was found not to meet the required minimum factor of safety for the extreme loading condition of water to the top of the wall. Pile overloading could result in excessive floodwall deflections, water infiltration through opened wall joints, scour around the openings, and rapid wall failure. A lateral deformation analysis, however, was not performed due to the limited knowledge of the piles and the foundation conditions.

There is very little foreshore on the riverside of the floodwall, preventing any improvement measures from being installed on that side. On the landside, several large operating industrial facilities are located along the entire length of the floodwall, some as close as 40 feet. The area between the existing floodwall and these facilities is congested with underground and overhead utilities, two flood pump stations and associated collector wells, several railroad spurs used by the industrial facilities, and other assorted obstacles. These physical site characteristics and the potential cost and complexity of relocations place severe limitations on the practicality and feasibility of constructing an additional floodwall or earthen levee landward of the existing wall.

Temporarily placing earthen fill against the landside of the floodwall as flood waters rise, and removing it when high water recedes, is essentially a time intensive flood fighting measure with little or no long-term reliability impact and could be excessively costly over the course of several flood events. Whereas the placement of fill material could counteract the pressures exerted on the wall by high flood waters, if the temporary fill material is not removed coincident with the receding of high water, the weight of the fill could excessively stress the existing wall and foundation and may cause the wall damage similar to that which it is attempting to prevent.

Piles could be added to improve the identified reliability concern. However, doing so would be very costly due to the new piles and the required stem and footing modifications to tie those piles

into the wall. Additionally, the existing, aging timber piles would still need to be relied on while their remaining useful life is in question.

Jet grouting or pressure grouting is used in a variety of construction applications to modify soil properties, but it is not considered a long-term viable solution for floodwall strengthening. Within the Kansas City District, jet grouting was attempted on some levee features after the 1993 flood with very limited success. Due to the limited capacity of the existing soils, the entire floodwall foundation (approx. 1,900 feet) would require grout injection. Ensuring the quality of grout installation sufficient to stabilize the foundation soils over the full distance of the wall would be difficult and controlling injection pressures to simultaneously achieve sufficient grouting without damaging existing adjacent utilities is problematic. Furthermore, installation would be complicated and construction quality difficult to maintain with the existing wall remaining in place.

Due to technical infeasibility and low confidence in the long-term results, wall and foundation modification measures were eliminated from further consideration.

A new floodwall on the existing alignment would accommodate the physical limitations of the work site and would include a higher capacity pile foundation system and stronger structural elements consistent with current construction criteria. New floodwall installation would include such factors as excavation, raw materials transport, and general construction activity that can disrupt activities on the adjacent properties, but would overcome space limitations of the area and may potentially avoid many of the utility relocations and extra excavation needs of other alternatives. However, the other factors listed previously remain with the addition that temporary flood risk management capability must be maintained during demolition of the existing wall. This additional factor could be minimized by maintaining a separation of no more than three wall sections between demolition activities and new construction activities. Additionally, an earthen work platform would need to be constructed on the riverside of the existing wall to allow movement of construction equipment.

Replacing the existing floodwall with a new wall was carried forward for additional detailed evaluation.

4.0 Waterworks Unit

<u>Structural Concerns: Floodwall Stability</u>

Structural analysis found that some sections of the concrete floodwall portion of the Waterworks Unit are at risk of a sliding failure when loaded with water near the top of the wall. Potential weaknesses were found from Station 0+78 to 7+00 and station 10+00 to 16+50. Sufficient area is available behind the floodwall to construct a stability berm two feet high extending from the wall five feet and then tapering at a one on three slope to the existing ground surface. Comparison of this measure to wall replacement or foundation modification indicates that a berm is more cost effective by orders of magnitude; therefore it was retained for further analysis.

Approximately 958 cubic yards of material would be required to construct this berm. This measure was carried forward for additional analysis.

F. Borrow Areas

Borrow material sources are required for underseepage and stability berm construction in three units of the Topeka Levee system. Two potential borrow sites have been chosen, each on the riverside of the levee and in close proximity to the areas of work to limit the distance that material must be hauled. Each site has been reviewed for environmental and cultural resources. Easements and rights-of-way for entrance and removal of material from each site will be obtained by the non-Federal sponsor during the Pre-Construction Engineering and Design Phase (PED).

The sites are currently in agricultural production. As possible, steps will be taken to allow these areas to return to agricultural use after borrow operations have ceased. The top one foot of topsoil will be removed, stockpiled, and returned to the site after completion of excavation. Excavation depths in agricultural areas will be kept to a minimum to reduce impacts to the drainage of fields. Encroachment into adjacent trees and environmental habitat areas is prevented by the implementation of a minimum separation of 50 feet, although greater distances are applied in this preliminary plan where allowable.

Preliminary layouts of borrow cells were prepared to determine the availability of the required quantities of material within the confines of each site and in accordance with the borrow area guidelines contained in EM 1110-2-1913, “Design and Construction of Levees”. The calculations used to determine borrow cell sizes, excavation depths, and excavation quantities are preliminary and subject to change. Borings and surveys will be conducted early in PED to ensure adequate depth of suitable material and ensure that the proposed excavations will not adversely affect existing underseepage conditions, foreshore stability, or river bank stability.

To account for shrinkage of material during compaction and losses during excavation and hauling, all material quantities for the planned levee features are increased by 25%. Table 11 provides the quantities for each feature and the corresponding quantity of borrow needed.

Table 11. Borrow Quantities Required

Unit	Feature	Fill Quantity (cy)	Borrow Quantity (cy)
South Topeka	Underseepage Berm	38,520	48,150
Waterworks	Stability Berm	766	958
North Topeka	Underseepage Berm	97,800	122,250
Oakland	Underseepage Berm	67,600	84,500
Oakland	Stability Berm	310	388
Total		204,996	256,246

South Topeka Borrow Site

The South Topeka Borrow Site is located on the riverside of the Auburndale and South Topeka Levee Units. This site will be used to provide borrow material for the South Topeka underseepage berm, the Waterworks floodwall stability berm, and the North Topeka underseepage berm on the opposite side of the Kansas River.

A cell measuring 1000 ft by 400 ft can provide an estimated 59,259 cubic yards of fill material when excavated to a depth of four (4.0) feet. At these dimensions, three cells are required. The cell layout maintains a 100 foot separation between pits for the movement of equipment and to maintain foreshore stability. The preliminary plan utilizes a minimum 200 foot buffer between the borrow cells and adjacent treed areas although this could be reduced to increase borrow efficiency and minimize overall impact to the property. All cells are located over 500 feet from the existing levee and at least 300 feet from the Kansas River. These distances should suffice to prevent adverse underseepage impacts and to maintain bank stabilization.

Oakland Borrow Site

The Oakland Borrow Site is located on the riverside of the Oakland Unit, between levee stations 100+00 and 110+00. This site will be used to provide material for the underseepage and stability berms in the Oakland Unit.

A cell measuring 1400 ft by 300 ft can provide 46,667 cubic yards of fill material when excavated to a depth of three (3.0) feet. At these dimensions, a total of 2 cells are required. The cell layout maintains a 100 foot separation between cells for the movement of equipment and foreshore stability and provides a 50 foot buffer from adjacent treed areas. All cells are located over 100 feet from the existing levee and more than 400 feet from the Kansas River.

Effect of Relief Well Alternatives on Borrow Needs

Alternatives utilizing relief wells instead of underseepage berms have also been formulated. If relief wells prove to be economical and are selected as the preferred alternative, the need for borrow material will be greatly reduced. Borrow material would only be required for the Waterworks and Oakland unit stability berms, in the quantities detailed above. This would significantly decrease the impacts to the designated borrow areas in those units. The Waterworks stability berm could be supplied by a single borrow cell 175 ft. by 150 ft. by 1 ft. deep. The Oakland stability berm could be supplied by a single borrow cell 105 ft. by 100 ft. by 1 ft. deep.

Alternatives to Land Based Borrow

Several sand dredging and excavation companies operate in the Topeka area and may be able to

provide material without disturbance to existing lands and property owners. This could possibly provide a cost savings and minimize the environmental impact of borrow operations. There is concern that these operators may not be able to provide the quantities necessary in addition to satisfying their existing commercial demands. Furthermore, conditions on the Kansas River have recently caused the Corps of Engineers to restrict the regulatory permits of those operators dredging from the river. The future possibility of sand dredging in the river is unknown. The availability of these alternative sources will be reevaluated nearer to the time of construction.

G. Initial Plan Formulation and Screening Results

1.0 No Federal Action Alternative

For each AOI, the No Federal Action alternative was considered. When examining the No Federal Action alternative, it is necessary to project what course of action local entities may take given the lack of Federal involvement. It is possible that some of the recommended measures may be undertaken by the local sponsors. These local initiatives are likely to be focused on the underseepage measures which are the least costly of the recommendations offered herein. However, the major requirements associated with the South Topeka floodwall and the Madison St. pump station replacement are just as likely not to be accomplished under a local initiative. This would mean significant long-term risk remaining for at least one of the units analyzed in this report.

The No Federal Action alternative does nothing to alleviate risks to public health and safety. While some local emergency preparedness plans can be updated and general awareness of the risks can be increased, this could be considered an inappropriate small scale response to significant life and safety risks.

The economic implications of the No Federal Action alternative are broadly negative. The investment at risk within each unit is so large that No Federal Action will subject the study area to the possibility of an overall long-term adverse impact on the local economy, and dislocations of industry may even result. In the short term, with an absence of flooding, the current trends in-place for the local economy, tax base, population, and employment may remain intact. However, if major flooding occurred and one or more of the levee units failed, the long term effects are likely to include: diminished economic stability, business interruptions that could jeopardize workers jobs and wages, potential losses in population and employment, and reductions in the tax base (given net movement out of the protected areas) and generally diminished property values.

Levee failure(s) would halt or at least significantly impede the nationwide movement of goods by rail, and major interstate highways could also shut down. During any such failure, it is also expected that production centers, wholesale distribution, and containerized shipping centers would close. Following the flood, subsequent restoration periods could be months or years depending on the damage involved.

The No Federal Action alternative also raises the possibility of permanent loss of local manufacturing employment through industrial relocation to developing countries. Certain industries may see moving outside the United States as a more viable option in lieu of industrial re-investment and rebuilding after any widespread flood damage. Were this to occur, it could severely degrade the industrial base of the metropolitan area for decades.

The No Federal Action alternative results in no changes to the existing environment in and around the levee units unless catastrophic levee failure occurs. Levee failure at specific locations or across the system could result in direct and indirect impacts through inundation of habitat of terrestrial populations and through release of contaminants to the river systems or floodplain environment. Direct impacts during flood events would be the displacement of mobile organisms and the loss of organisms unable to escape inundated areas. Direct and indirect impacts could also result from the introduction of contaminants currently controlled or contained by businesses and industries landward of the levee system. Levee failure and inundation of stored chemicals, and the variety of chemicals released within the protected community, would allow introduction of these contaminants into the Kansas River impacting water quality and contaminant loading of the rivers during these events. Potential impact to aquatic populations (fish and benthic communities) from the degradation of water quality and contaminant loading would result from chemical release during flood events. Subsidence of flood waters could also result in the introduction or redistribution of chemical contaminants across the foreshore floodplain and impact terrestrial communities (plants and animals) utilizing the foreshore habitat. Impacts from the No Federal Action alternative could range from no significant impact under non-flood events, to minor to significant impact depending on location of levee failure and the resulting duration of inundation.

2.0 Structural Alternatives

Those measures identified in Table 10 as being carried forward for further analysis were labeled and combined into alternative plans for each levee unit. In some cases only one measure was carried forward for a particular area of interest. Measures within a unit that are consistent among different alternative plans were combined for simplicity. Measures from the same area of interest cannot be combined. The implementation of corrective measures at each area of interest was evaluated for its impact on the overall system reliability. It was determined that each alternative plan must include a measure from each area of interest in order to provide a complete plan for obtaining the desired overall system reliability.

H. Detailed Plan Formulation – Final Array of Plans

1.0 No Federal Action

No additional flood risk management would be provided under the “No Action” Alternative. Without modification to the existing flood risk management system, the study area would continue to be at risk from large flooding events and the affected community would be faced with continued economic development concerns. The problem would worsen with time if no

action is taken because flood-insurance rates could rise and prevent new development and may force existing development out of the study area.

2.0 Structural Plans

The structural plans consist of reliability improvements to each unit in the system. These plans are confined to modification or replacement of existing unit features on the existing unit alignment. Two alternative plans each have been prepared for the North Topeka, South Topeka, and Oakland Units, and one plan for the Waterworks Unit. Each plan includes a measure for addressing the reliability concern at each area of interest. Multiple plans for the same unit differ only in their treatment of underseepage concerns (berms versus relief wells).

I. Economic Analysis and Screening of Plans

The economic analysis identifies the extent of the economic impact from flooding with the existing project and, on a comparable basis, evaluates the range of plans to increase project performance considered in the study. The analysis first requires a risk-based analysis of the flood problem under the existing condition (existing levees and floodwalls). The future without project condition is then determined, and finally a risk-based evaluation in terms of benefits, costs, and performance of the various alternatives under the with-project condition is completed. The analysis encompasses all flood-prone properties within the study area.

Screening-level costs were prepared by cost engineering staff for each of the seven alternatives and are summarized in Table 12. Discussion of the screening results for each unit can be found in Appendix D. Economic performance results for each of the alternatives screened are shown in Table 13. Screening costs were completed in 2006 based on October 2005 prices. Only the NED plan elements were subsequently updated. Therefore, the data shown in Tables 12 and 13 are in October 2005 prices.

Annual costs for operations and maintenance (O&M) are included only for the alternatives that 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 assumes that each pump will 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 is assumed after 40 years at a cost equal to the current construction cost plus 17% to account for E&D and S&A.

Table 12. 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 ANN. 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
Misc. 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
Misc. 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
Shunganunga tieback stability berm	$2.0	$14.8	$19.6	$1.3	$37.6	$2.2	$0.0	$2.1
Misc. 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
Shunganunga tieback stability berm	$2.0	$14.8	$19.6	$1.3	$37.6	$2.2	$0.0	$2.1
Misc. 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 project schedule of: PED-Oct 2008 to Sept 2011; LERRD-Oct 2011 to Jun 2012; Construction-Jul 2012 to Apr 2014.

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.

Table 13. Screening Alternatives - Benefits & Costs Summary

October 2005 prices; 50 year period of analysis; 4.875% interest rate

Unit	WW	SOUTH TOPEKA				OAKLAND		NORTH TOPEKA	
Alternative	**Alt 1**	**EAD South Top**	**EAD Oakland**	**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.

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 three days of labor by a two-man crew as well as equipment costs. The temporary pumping plan would be needed when the water surface elevation comes within three feet of top of levee, which would require an event of about a 0.5% magnitude. It is assumed that the pumping capability will 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.

Results of the Risk-Based Screening

Waterworks – Only one alternative was carried forward from initial screening. This alternative maximizes the net benefits over the No Action alternative and is recommended as the NED Plan.

South Topeka – Two alternatives were carried forward from the initial screening. Alternative 1 maximizes the net benefits and is recommended as the NED Plan.

Oakland – Two alternatives were carried forward from the initial screening. Alternative 1 maximizes the net benefits and is recommended as the NED Plan.

North Topeka – Two alternative were carried forward from the initial screening. Alternative 1 maximizes the net benefits and is recommended as the NED Plan.

The combination of the individual unit NED plans will constitute the overall NED plan for the Topeka levee system.

J. Environmental Considerations

1.0 No Federal Action

In the absence of any Federal action addressing levee improvements, a high water event should cause failure of the levee resulting in the release of a variety of industrial chemicals and substantially adversely impact the natural and human environment.

2.0 Structural Alternatives

The reliability measures proposed will impact a small amount of existing riparian wildlife habitat. Specifically, the installation of the South Topeka underseepage berm will require the removal of seven and one-half acres of trees. These impacts will be mitigated on available riparian area riverward of the North Topeka levee between stations 165+00 and 184+00. A detailed description of proposed mitigation efforts is found in the attached Environmental Assessment. The North Topeka underseepage berm and the proposed borrow areas will impact agricultural properties that are already cleared for crop use. The remaining measures will have no impact on environmental resources.

K. Hydraulic and Floodplain Considerations

Implementation of the proposed reliability measures will not change the height of the levee nor otherwise impact the floodway conveyance. Water surface profiles will not be changed from the current existing condition.

L. HTRW Considerations

As presented previously in the discussion of existing conditions, an HTRW site assessment of the study area was conducted. All proposed plans will stay within the previously assessed corridor, precluding the need for additional study. Borrow areas have been reviewed and selected to avoid impacting former solid waste dumping sites. Proposed work in the South Topeka floodwall area will be reviewed during the project design phase to determine the potential for encountering contaminated groundwater during construction.

M. Engineering Considerations

There are no engineering features associated with the No Action plan. The proposed structural plans have primarily the same engineering characteristics with only minor variations. Each plan addresses the same reliability risks with a similar level of complexity. There are no special or unique construction methods required by any of the plans. The only difference of note is the added future operation and maintenance procedures required by the relief well alternatives.

N. Plan Selection

Based upon consideration of all pertinent factors, Alternative 1 was selected as the recommended plan for implementation in each levee unit. For each unit, Alternative 1 is the NED plan, meeting the planning objectives and the National Economic objectives of maximizing net project benefits while providing the lowest cost. The combination of each individual unit NED plan is selected and recommended as the NED plan for the overall Topeka levee system.

Implementation of the project will improve the reliability of the system to provide flood risk management benefits to the local community. Negative impacts from the project would be minimal. Some disruption during construction could be expected, affecting traffic and agricultural activities. No relocation of homes or businesses is required.

The evaluation results show strong economic justification for the project in the Topeka areas. The existing project would be improved to provide greater than 90% reliability against damages from the base flood.

Plans Considered and Eliminated

Other combinations of reliability improvements were considered and eliminated since they produce lower levels of net benefits over the period of analysis. The “No Action” alternative would not resolve the continuing risk to which the area is subject. The no action plan would have detrimental long term effects to the business and home owners in the area and to the economy of the local community.

X. Description of the Selected Plan

The NED Plan consists of a combination of remedial measures and improvements for multiple sites as summarized in the descriptions below. The NED plan essentially grows from an assembly of the recommended alternatives from each of the four levee units addressed in the Feasibility Report. If examined on a unit by unit basis, each unit's recommendations are also the NED measures for the unit. The NED Plan assembles these individual recommendations into one complete set of recommendations (one plan). The economic analysis of the NED plan shows that it is economically viable and furthers national economic development in manner consistent with Corps of Engineers economic regulations and Administration economic polices.

Plate 1, located at the end of this report, provides a map of the Topeka levees system showing the location of the sites included in the Recommended Plan for this Feasibility Report

A. Recommended Plan - Work Components

Major components of the Recommended Plan are discussed in the following paragraphs.

North Topeka Unit

Station 165+00 to 189+00 (Plate 2): Recommended Plan provides for controlling underseepage at the interior toe of the existing levee by installing an underseepage control berm 220 feet wide, seven feet thick at the levee toe, and sloping to three feet thick at the end of the berm. This will require the acquisition of 122,250 cubic yards of fill material and temporary easements for borrow excavation and construction activities.

Station 246+00 to 250+00 (Plate 9): Recommended Plan provides for controlling underseepage at the interior toe of the existing levee by installing a series of six stainless steel pressure relief wells located along the thin blanket zone from station 246+00 to station 250+00. Adequate pressure control at this site requires removal of seep-water through below grade header piping. This header piping discharges into a cast-in-place concrete pump pit which collects the seep water and then allows pumping to discharge the seep water to the river in a controlled manner.

Station 364+60 (Plate 10): Recommended plan provides for controlling uplift at the Fairchild Pump Station by proper in-place abandonment of the structure. The above-grade structure will be removed and properly disposed of while the below-grade structure and outlet lines will be filled with flowable fill or other suitable material and buried in-place.

South Topeka Unit

Station 22+00 to 48+00 (Plate 4): Recommended Plan provides for controlling underseepage at the interior toe of the existing levee by installing an underseepage control berm 100 feet wide, five feet thick at the levee toe, and sloping to three feet thick at the end of the berm. This will require 48,150 cubic yards of material and temporary easements for borrow excavation and construction activities.

Kansas Avenue Pump Station (Plate 3): Recommended Plan provides for increasing the strength factor of safety by installation of a wall stiffener on the interior foundation of the pump station.

Manholes (Plates 3 and 4): Recommended Plan provides for increasing the uplift factor of safety of several manholes by installation of heel extensions.

Floodwall (Plate 3): Recommended Plan provides for construction of a new concrete wall on concrete foundation piles following the existing wall alignment to the same length and height

dimensions. Approximately 3,685 cubic yards of concrete will be needed to construct the new wall. The following construction sequence is recommended:

- Stockpile sufficient fill material (approximately 5,000 CY) on site or within easy access for emergency closure in the event of a flood event during construction.
- Remove one monolith section (~84ft) to allow ease of riverside access. This monolith will be rebuilt at the completion of the project.
- Construct riverside construction and haul road to serve as working platform.
- Remove three additional floodwall monoliths.
- Drive foundation piles, form and place the two monolith pile caps.
- The following five sequential construction steps will be repeated until the length of the wall has been replaced.

    1. Construct floodwall stem (completing monolith)
    2. Remove next floodwall monolith. (No more than four monoliths will be open at any one time, one for construction access and three for separation between existing wall removal and new wall construction).
    3. Drive pile foundation system. (There is always a separation of at least one monolith (~84 ft) between piles being driven and freshly poured "green" concrete.)
    4. Pour monolith pile cap.
    5. Repeat Steps 1-4

As noted, a river side construction and work road will be constructed as a working platform. This will consist of material placed on the riverside slope adjacent to the existing wall to provide an area wide enough for the movement of construction equipment. This platform is not anticipated to extend into or otherwise impact the river itself. Access to this area for construction of the platform will be from the landside through the first removed section of the existing wall. After completion of the access/working area on the riverside of the existing wall, removal of the remaining existing wall, and construction of the new wall, will be conducted from both sides of the wall alignment.

Waterworks Unit

<u>Stations 0+78 to 7+00 and 10+00 to 16+50 (Plate 5)</u>: Recommended Plan provides for increasing the stability factor of safety by installation of stability berms on the landside of the affected wall sections. Berms in these locations would consist of compacted soil approximately two feet high extending from the wall five feet and then tapering at a one on three slope to the existing ground surface. Approximately 958 cubic yards of material would be required as well as temporary easements for borrow excavation and construction activities.

Oakland Unit

<u>64+00 to station 80+00 (Plate 6)</u>: Recommended Plan provides for controlling underseepage at the interior toe of the existing levee by installing an underseepage control berm 240 feet wide,

six and one-half feet thick at the levee toe, sloping to three feet thick at the end of the berm. This will require the acquisition of 84,500 cubic yards of fill material and temporary easements for borrow excavation and construction activities.

485+86 to 491+01(Plate 7): Recommended Plan provides for increasing the stability factor of safety by installation of a stability berm two feet high extending from the wall five feet and then tapering at a one on three slope to the existing ground surface. Approximately 382 cubic yards of material would be required as well as temporary easements for borrow excavation and construction activities.

East Oakland Pump Station (Plate 8): Recommended Plan provides for increasing the uplift factor of safety of the station by installation of a heel extension.

Manhole at station 75+50 (Plate 6): Recommended Plan provides for increasing the uplift factor of safety of the manhole by installation of a heel extension.

B. Economic Performance of the Selected Plan

1.0 Economic Performance

Table 14 summarizes the economic performance of the selected plan. For further elaboration of the NED plan benefits and how they were calculated, please refer to Tables D-31 and D-32, as well as section 7.4, of Appendix D.

Table 14. 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**

2.0 Engineering Performance

Table 15 compares with and without-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 overall levee 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 (See Table 9 – Engineering Performance Without Project).

Table 15. Engineering Performance for NED Plan, With vs. Without-Project Conditions

	WATERWORKS		AUBURNDALE		SOUTH TOPEKA		OAKLAND		NORTH TOPEKA		SOLDIER CREEK URBAN	
	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 probability	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	0.001	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).

- 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 86.0% chance, and South Topeka a 15.8% chance. For Waterworks, the nonexceedance probability would increase marginally to 93.3%, 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.

3.0 Induced Damages

The NED Plan does not affect water surface profiles of the Kansas River or its tributaries and will not results in the creation of induced damages. 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.

4.0 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. A flood risk management project designed relative to a 1%-chance flood event (the event critical to levee certification) can be especially misleading. 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 project implementation.

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. There would remain a significant total of residual equivalent annual damages of approximately $7 million. There still would be a 1 in 6 chance of exceedance over a 50-year period (see Appendix D 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. 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 would reach $2 billion or more. Prohibitive depths of water would remain inside the levees for at least two weeks. 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 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.

5.0 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 later sections and the attached Environmental Assessment, while this section discusses some of the major economic and social considerations.

NED Effects of NED Plan - The overall NED contribution to the national economy is $13.3 million, which are 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 $6.98 million in residual EAD. The chances of experiencing floods that could result in major inundation would be greatly reduced (although not eliminated completely). Most of the adverse impacts described previously under the future without-project condition 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.

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 incomes 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.

Other Social Effects of the NED Plan

- Public safety (*probable positive impacts to human life)* - Serious public safety concerns, particularly in Oakland 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 discussion of demographics in these neighborhoods in section 5.4.3 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

C. Environmental and Cultural Considerations

Detailed discussion of the environmental and cultural considerations of the recommended plan is included in the attached Environmental Assessment. Included here is a summary of the key environmental factors with references to the location of additional information.

1.0 Fish and Wildlife Resources

Construction of the NED plan requires excavations in several areas for modifications of existing structural features and the installation of relief wells and berms along portions of the levees. The construction of the South Topeka underseepage berm will result in the permanent removal of approximately 7.5 acres of woodland habitat landward of the levee. Compensatory mitigation is proposed for this impact (see Plate 13 for mitigation area location). Temporary impacts to wildlife will result from noise and traffic associated with the construction efforts.

Borrow excavation is needed within approximately 27.3 acres riverward of the South Topeka Unit and approximately 19.3 acres riverward of the Oakland Unit (see Plates 11 and 12 for potential borrow locations). Impacts within these agricultural borrow sites is considered temporary in nature and are expected to be less than significant. Standard construction site erosion and sediment control practices will be employed to prevent erosion and sediment deposition into adjacent waterways. The riverward borrow areas impacted will likely revert back to agricultural use after construction, unless the creation of ecosystem habitat is preferred by the non-Federal sponsor and the land owner. More information is available in the Environmental Assessment.

A detailed ecosystem mitigation plan is described in Appendix F of the attached Environmental Assessment. This plan has been coordinated with local and federal agencies including the U.S. Fish & Wildlife Service and the Kansas Department of Wildlife and Parks.

2.0 Cultural Resources

Record searches and field reconnaissance were performed for the project area. No NRHP properties or archeological sites are recorded in the proposed project locations or borrow areas. All cultural reviews in the project area determined that there are no cultural, historic, or archeological sites of any significance that would be affected by the proposed project. The Kansas State Historic Preservation Office concurred with the findings and recommended no further action. The potential extent of project features is the same at this time as presented to the agencies prior to the findings, and no changes in formulation of the project have occurred subsequently to affect these findings.

3.0 Cumulative Impacts

Section 14.0 of the Environmental Assessment, entitled "Cumulative Impacts", provides a detailed assessment of potential cumulative impacts of the levee modifications associated with the selected plan. Based on the analysis conducted, the recommended plan of flood risk management reliability improvements within the Topeka metropolitan area will not result in substantial adverse cumulative impacts.

4.0 Environmental Justice

Executive Order 12898 on Environmental Justice requires consideration of social equity issues, particularly any potential disproportionate impacts to minority or low-income groups. The study evaluated demographic and census data for the project area and analyzed the potential effects of the proposed project on minority and low-income groups. Although the project area does contain EJ populations such as minority and low-income groups, they would not be disproportionately impacted in a negative way; rather these groups would equally benefit from increased public safety and a reduced risk of flooding if this project is implemented. The proposed levee modifications would be primarily constructed adjacent to and/or within industrial and agricultural areas, and are not anticipated to cause any disproportionate impacts to sensitive populations, but are anticipated to uniformly provide increased economic benefit and a safer living environment to populations living and working behind the levee systems on both sides of the Kansas River. Further, there are no induced impacts to the levee systems located upstream and downstream of the project area that would result from the proposed plan. Public involvement processes will continue to reach out and provide information to the communities and populace affected by the proposed plan as implementation proceeds. Based upon the analysis, the proposed plan meets the intent of Executive Order 12898 and does not provide any imbalance or disproportionate affects to minority or low-income populations within the project area. More information is available in Section 12.0 of the Environmental Assessment.

5.0 Environmental Operating Principles

Under the seven Environmental Operating Principles (EOP), the Corps of Engineers is mandated to proactively seek and consider ways to improve and sustain the environment. An existing project in an urban area such as Topeka, with permanent structural features dating back several decades, has inherent limitations to the inclusion of viable environmental improvements. EOP #1 "Strive to achieve Environmental Sustainability" is the most applicable to this project. The direct affects of the proposed levee modifications will be minimized and mitigated in order to sustain as much of the existing environmental resources as possible. The specific methods chosen to perform this mitigation will adhere to EOP #5, "Seek way and means to asses and mitigate cumulative impacts to the environment."

The data collection and analysis efforts of this Feasibility Report have helped satisfy EOP #6, which reads "Build and share an integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and impacts of our work." Application of

Environmental Operating Principle #7, “Respect the views of individuals and groups interested in Corps activities,” is evidenced by past and future public involvement activities to include public review of this document and presentation of the Recommended Plan at a public meeting.

While the potential for environmental improvements under associated with the existing levees is limited, the partnership between the Corps and the City Topeka has allowed for the identification of potential projects under other available authorities. Upstream of the current project study area, but still within the city limits of Topeka, a separate wetland restoration and creation project has been proposed under the Aquatic Ecosystem Restoration authority of Section 206 of the Water Resources Development Act (WRDA) of 1996. For several years now, the Kansas City District has been a partner with the City of Topeka and the Topeka Riverfront Authority in developing a master plan for the Topeka riverfront. The Corps has participated in cost-share studies of potential riverfront redevelopment efforts through the Planning Assistance to States program, authorized by Section 22 of the WRDA of 1974. This effort will assist the sponsors and other stakeholders in bringing additional compatible recreation opportunities to the area, and providing a linkage to comprehensive recreation master plans of other communities on the Kansas River.

D. Hydraulic and Floodplain Considerations

The recommended plan addresses only reliability improvements to the existing system and will not affect water surface profiles within the Kansas River for any flood event.

E. HTRW Considerations

HTRW considerations associated with the selected plan are the same as previously described.

F. Engineering and Construction Considerations

There are no unusual engineering/design or construction issues associated with this project. Conventional construction methods will be used, and space is sufficient on site to provide for contractor mobilization and staging of construction.

G. Real Estate Considerations

The non-Federal Sponsors currently hold permanent easements sufficient for the existing levees and these are available for implementation of the selected alternative. Temporary easements will be acquired and used for installation of the underseepage and stability berms, borrow areas, equipment storage, access roads, construction vehicles, and staging areas. The width of the work area easements will vary depending on the project site, as additional lands are required.

A detailed description of the Lands, Easements, Relocations, Rights-of-Way, and Disposal (LERRD) requirements is outlined in the Real Estate Plan (Appendix C). This includes acreage, estate required, estimated land values, borrow areas, non-federal incidental costs, and in-house

government cost. The proposed borrow areas will be further refined as the project moves into Pre-Construction Engineering and Design (PED).

H. Operations and Maintenance Considerations

Operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) considerations are the responsibility of the local sponsor. The Corps is responsible for inspections. Future OMRR&R practices would remain the same as current operations for inspection and monitoring, levee mowing, vegetation control, outfall cleaning, maintenance of wells, etc. Additional cost will be added by the project with respect to maintenance of six new relief wells and temporary pumping of the well header during high flood events. The appropriate Operation and Maintenance manuals will be updated accordingly at the conclusion of the project.

XI. Plan Implementation

A. Cost Sharing Requirements

The project cost allocation is 100% Flood Risk Management. The non-Federal cost share is determined according to the cost sharing procedures prescribed in the Water Resources Development Act of 1986 (WRDA 86), as amended. It is not the intent of the Local Sponsors to seek any exception to these cost-sharing requirements. In accordance with the typical allocation, the Federal government will be responsible for 65% of implementation costs and the Non-Federal sponsors for the remaining 35%. The local sponsor share for the Waterworks, South Topeka, and Oakland Units will be the responsibility of the City of Topeka. The share for the North Topeka Unit will be the responsibility of the North Topeka Drainage District.

Table 16 presents the estimated project costs and cost sharing portions divided by unit. Costs are presented in current (Oct 2007) dollars and as a fully funded estimate. The fully funded estimate includes inflation from Oct 2007 to the expected mid-point of the construction period. Additional detailed cost estimates are provided in Appendix E.

Table 16. Project Cost Sharing

Oct 2007 prices, 1000's of Dollars					
NED Plan Feature Summary	**Water Works**	**South Topeka**	**Oakland**	**North Topeka**	**Total**
Planning, Engineering, and Design (PED)	$ 4	$ 1,374	$ 158	$ 248	$ 1,785
Construction	$ 36	$ 12,868	$ 1,357	$ 2,300	$ 16,561
Construction Management	$ 3	$ 860	$ 88	$ 150	$ 1,100
LERRD	$ 6	$ 876	$ 228	$ 181	$ 1,291
Total NED Project Cost	$ 50	$ 15,979	$ 1,831	$ 2,879	$ 20,738
NED Project Cost Sharing and Credit					
Non-Federal Share:					
Cash Contribution	$ 11	$ 4,717	$ 413	$ 827	$ 5,697
LERRD	$ 6	$ 876	$ 228	$ 181	$ 1,291
Total Non-Federal Share (35%)	$ 17	$ 5,593	$ 641	$ 1,008	$ 7,258
Total Federal Share (65%)	$ 33	$ 10,386	$ 1,190	$ 1,871	$ 13,480

Table 16. Project Cost Sharing (continued)

Fully Funded, 1000's of Dollars					
NED Plan Feature Summary	**Water Works**	**South Topeka**	**Oakland**	**North Topeka**	**Total**
Planning, Engineering, and Design (PED)	$ 5	$ 1,546	$ 178	$ 279	$ 2,008
Construction	$ 40	$ 14,532	$ 1,532	$ 2,598	$ 18,702
Construction Management	$ 4	$ 1,110	$ 113	$ 193	$ 1,420
LERRD	$ 7	$ 981	$ 253	$ 203	$ 1,444
Total NED Project Cost	$ 56	$ 18,169	$ 2,076	$ 3,273	$ 23,574
NED Project Cost Sharing and Credit					
Non-Federal Share:					
Cash Contribution	$ 13	$ 5,378	$ 474	$ 943	$ 6,807
LERRD	$ 7	$ 981	$ 253	$ 203	$ 1,444
Total Non-Federal Share (35%)	$ 20	$ 6,359	$ 727	$ 1,146	$ 8,251
Total Federal Share (65%)	$ 36	$ 11,810	$ 1,349	$ 2,127	$ 15,323

B. Sponsor's Intent

The sponsor's intent to participate in the feasibility study was originally stated in letters received in 1992 requesting the initiation of the study. The sponsors committed to the study financially by signing the original Feasibility Cost Sharing Agreement (FCSA) in 1998. Several schedule and cost changes have been enacted during the study, each with the written approval of the local sponsor. The sponsors have shown every indication that they fully intend to progress into the design and construction phase of the project with the same support given to this Feasibility Study.

C. Project Financing and Sponsor Capability

The project and local cost sharing requirements have been discussed with the sponsors during the study. They are legally constituted bodies under State statutes with taxing authority, and the Corps' assessment indicates that they have the necessary financial basis to cost share a project of this magnitude. The districts have expressed their intent to fund the non-Federal share and are expected to issue general obligation bonds under authority granted them by the State or implement other financing option that may involve a levy on property owners and/or additional contributions by selected large facilities in the protected area. The sponsors have continually expressed very strong support for the project.

D. Summary of Coordination and Public Views

1.0 Study Coordination

The non-Federal sponsors strongly support the Recommended Plan. Each of the sponsors continues to keep the project in good condition as evidenced by recent annual inspection reports and by the evaluations undertaken in the feasibility study. The sponsors will continue to provide

full cooperation and are prepared to meet the necessary financial obligation associated with the recommendations contained in the Feasibility Report.

Extensive coordination with several State and Federal agencies took place during development and evaluation of the Recommended Plan and the Environmental Assessment. The following agencies were coordinated with and in some cases have provided comments or participated in the review of this project:

- Federal Emergency Management Agency
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service
- Natural Resources Conservation Service
- Kansas Department of Wildlife & Parks
- Kansas Department of Health and Environment
- Kansas State Historic Preservation Office

2.0 Public Involvement

Public involvement and coordination is discussed in Appendix B.

E. Future Project Schedule

The project designs, cost estimates and economic analyses presented in this report are based on a future project milestone schedule as follows:

DEC 2008	Feasibility Report Approval
APR 2009	Execution of Project Design Agreement with Local Sponsor and initiation of Pre-Construction Engineering and Design Phase
OCT 2011	Initiation of Land and Easement Acquisition by the Local Sponsor
MAR 2012	Execution of the Project Cooperation Agreement with the Local Sponsor
APR 2012	Initiation of Construction Phase
OCT 2014	Completion of Project Construction

Cost estimates were prepared on the basis of one construction contract per levee unit, for a total of four separate contracts. These contracts are anticipated to be scheduled simultaneously.

Costs and economic analyses are periodically reviewed during future project phases and reevaluated as needed based on actual project progress and status.

XII. Conclusions

The Recommended Plan (NED Plan) reduces the risk of flooding through project improvements and remedies planned within the existing flood risk management system examined in this Feasibility Report. In general, the Recommended Plan would implement several geotechnical and structural reliability improvements at different areas of interest within the system.

This plan helps to restore a uniform level of flood risk management for the study area. The NED plan will provide a project that functions in a safe, viable, and reliable manner, as was initially intended by its designers. It is not required as a result of changed conditions or inadequate maintenance, is generally limited to the existing features and does not change the scope or function of the authorized project. It is also economically justified.

There are no significant long-term social or environmental impacts. Design considerations of the plan include avoidance of environmental resources, cultural resources, and HTRW where possible. The long-term environmental and cultural consequences of plan implementation are positive as the increased reliability of the units act to guard the social and environmental fabric that has developed within the protected areas for the last 50 years. A minimal amount of tree and shrub habitat would be lost and mitigation is planned accordingly.

The Recommended Plan carries a small increase in OMRR&R. The sponsors have sufficiency to provide all real estate requirements.

XIII. Recommendation

Upon considering the economic, environmental, social, and engineering aspects of making improvements to the existing Topeka, Kansas, Local Flood Protection Project, it has been determined that a project to reduce the risk of flooding is in the public interest. Accordingly, the Corps of Engineers recommends that the Recommended Plan, as described in this report, be submitted to Congress for implementation with such modifications as the Chief of Engineers may find advisable, and in accordance with existing cost sharing and financing requirements.

The estimated implementation cost of the Recommended Plan is $13,480,000 Federal and $7,258,000 Non-Federal for a total estimated cost of $20,738,000 at October 2007 price levels. The net benefits of the Recommended Plan are nearly $13.3 million, indicating a very strong contribution to the nation's economic output by the project. The average annual flood risk management benefits of the Recommended Plan exceed the average annual cost by a ratio of 12.1 to 1.

All items included in the Recommended Plan are necessary to continue providing the flood risk management benefits as intended by Congress.

Federal implementation of the recommended project would be subject to the non-Federal sponsor agreeing to comply with applicable Federal laws and policies, including but not limited to:

a. Provide a minimum of 35 percent, but not to exceed 50 percent of total project costs as further specified below:

    1. Provide 25 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

    2. Provide, during the first year of construction, any additional funds necessary to pay the full non-Federal share of design costs;

    3. Provide, during construction, a contribution of funds equal to 5 percent of total project costs;

    4. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the project;

    5. Provide, during construction, any additional funds necessary to make its total contribution equal to at least 35 percent of total project costs;

b. Shall not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefore, to meet any of the non-Federal obligations for the project unless the Federal agency providing the Federal portion of such funds verifies in writing that expenditure of such funds for such purpose is authorized;

c. Not less than once each year, inform affected interests of the extent of protection afforded by the project;

d. Agree to participate in and comply with applicable Federal floodplain management and flood insurance programs;

e. Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), which requires a non-Federal interest to prepare a floodplain management plan within one year after the date of signing a project cooperation agreement, and to implement such plan not later than one year after completion of construction of the project;

f. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection

levels provided by the project;

g. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the level of protection the project affords, hinder operation and maintenance of the project, or interfere with the project's proper function;

h. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

i. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation features, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government;

j. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

k. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

l. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;

m. Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable

Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701 – 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a *et seq.*), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 *et seq.*) and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c *et seq.*);

n. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;

o. Assume, as between the Federal Government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project;

p. Agree, as between the Federal Government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA; and

q. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-Federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

This recommendation is contingent upon such discretionary modifications as deemed necessary by the Chief of Engineers and funding requirements satisfactory to the Administration and Congress. The recommendations contained herein reflect the information available at the time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendation may be modified prior to implementation. However, the project partner, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

_____DRAFT_____
Roger A. Wilson, Jr. (date)
Colonel, Corps of Engineers
District Commander