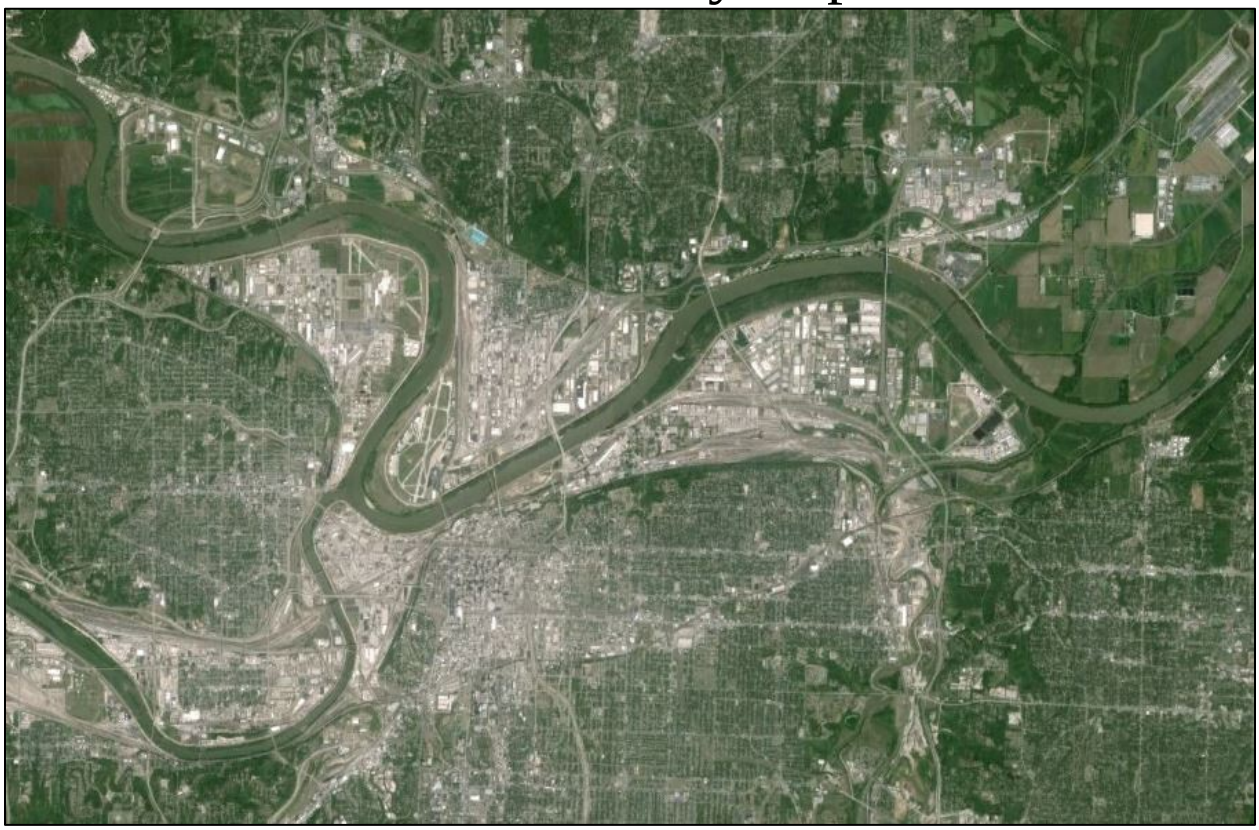
US Army Corps
of Engineers
Kansas City District
Northwestern Division

Kansas Citys, Missouri and Kansas Flood Risk Management Project

Final Feasibility Report



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Kansas Citys, Kansas and Missouri
Flood Risk Management Project

Final Feasibility Report
May 2014

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EXECUTIVE SUMMARY

The existing Kansas Citys, Missouri and Kansas, Flood Risk Management Project provides local flood risk management for the metropolitan areas of Kansas City, Missouri, and Kansas City, Kansas. The Kansas Citys project is authorized as a system of seven levee units. This project extends over the lowest 10 miles of the Kansas River (at its confluence with the Missouri River) and a 20 mile reach of the Missouri River flanking the mouth of the Kansas River. The Kansas Citys project is a unit of the Missouri River basin comprehensive plan authorized and modified by the 1936, 1944, 1946, and 1954 Flood Control Acts. The last major modification to raise some of the levee units comprising the Kansas Citys Project was authorized in 1962.

Section 216 of the 1970 Flood Control Act provides the authority to reexamine a completed civil works project and recommend modifications or improvements. An Interim Feasibility Report and an Environmental Impact Statement (EIS), published in September 2006, recommended performance improvements in four of the units: Argentine, North Kansas City, Fairfax-Jersey Creek, and East Bottoms. These recommendations were subsequently authorized by the Water Resources Development Act of 2007 and have proceeded with design and implementation. The Interim Report concluded that no improvements were needed in the Birmingham Unit.

This Final Feasibility Report addresses the remaining two levee units; the Armourdale and Central Industrial District (CID) Units. The EIS published with the Interim Report included analyses for all seven levee units, including the two units addressed in this report. The alternatives identified in this Final Report are the same scope and location as addressed in the existing EIS. A review of the current environmental conditions in the study area confirmed that no significant changes have occurred since 2006. No new NEPA documentation is required.

The Armourdale Unit is located in Wyandotte County Kansas, along the left bank of the Kansas River from mile 7 (Mattoon Creek) to mile 0.3, near the confluence of the Kansas and Missouri Rivers. The primary components of the unit consist of earthen levees, floodwalls, riprap and toe protection on riverward slopes of levees, toe drains along the concrete floodwalls, sandbag gaps, stoplog gaps, drainage structures, relief wells and pumping plants. The floodwalls, in two reaches, vary from 11 to 17 feet high and total approximately 6,200 feet. The levees, in three reaches, vary from 4 to 17 feet high and total about 5.3 miles. Existing underseepage control features include approximately 13,400 LF of riverside impervious fill cutoffs, 1,550 LF of landward underseepage berm, and 39 relief wells with collector systems in several reaches.

Although the CID Unit is one continuous levee unit, it crosses the Kansas and Missouri State Line and is subsequently operated and managed as two separate and distinct sections: the CID-Kansas section, and the CID-Missouri section. The CID-Kansas Section (CID-KS), is located in Wyandotte County, Kansas, and extends along the right bank of the Kansas River from mile 3.4 to the mouth, then downstream along the right bank of the Missouri River to the State Line. The unit consists of two levee reaches, three floodwall reaches, riprap and levee toe protection, a surfaced levee crown and ramps, a stoplog gap, a sandbag gap, eight pumping stations, drainage

structures, and relief wells. The levees total approximately 1.7 miles long and the floodwalls about 7,900 feet. The section varies from zero to 14.5 feet high. Existing underseepage control features in CID-KS includes a buried collector system, approximately 1,800 LF of area fill, and 19 relief wells with collector system.

The CID-Missouri section (CID-MO) is located in Jackson County, Missouri. This section extends along the right bank of the Missouri River from near the Kansas-Missouri state line, river mile 367.2, and ending near river mile 365.7. The CID-MO section consists of levee, floodwalls, a levee drainage system and pumping plants, sandbag and stoplog gaps, toe and bank protection, and slope protection on the riverward slope. The CID-MO section floodwalls total 1.5 miles and the levee is about 430 feet.

The feasibility study assessments provide insight into both the existing levee performance and the economic damages expected under existing conditions for an array of high water events. Much of the analysis used data and observations from recent high water events, especially those in 1993 and, to a lesser degree, 2011. Risk and uncertainty analysis results and observations of levee performance during flood events form the basis for the identification of opportunities for risk reduction measures. The critical reaches for geotechnical underseepage failure and slope stability risks were identified and analyzed in each unit. Probabilities of failure versus water surface elevation were calculated for the most critical features to determine the overall existing risk for each unit. The current existing failure risk, in terms of annual exceedance probability, is significantly high in both units: 3.5% for the Armourdale Unit and a 0.3% for the CID Unit.

Deficiencies in multiple pump stations are the major contributors to the existing condition probability geotechnical/structural failure, which would cause a breach in the Armourdale Unit. For the CID Unit, it is structural gatewells, floodwalls, and stoplog gaps that contribute to a lesser, but still significant, probability of structural/geotechnical failure, which would cause a breach. Both the Armourdale and CID units have some probability of breach under existing conditions, but the probability of breach is much greater for the Armourdale Unit. For both units, the analysis indicates that the unit will structurally fail prior to overtopping.

If all geotechnical and structural failure risks were addressed, a significant overtopping risk would still remain for the target 0.2% chance flood event. These findings for overtopping risk in the lower Kansas River show that these units do not reliably achieve the authorized 390,000 cfs conveyance target. This indicates the need for a general increase in the existing overtopping protection along the lower Kansas River.

Management measures considered to address the identified conditions of unacceptable flood risk include: no action, non-structural, and structural measures. The selection of management measures and development of alternatives focuses on achieving and maintaining a uniform level of flood risk management for the Kansas Citys system. The maximum target system performance level has been selected as the elevation three feet above the 0.2% flood event water surface profile. The management measures for structural and geotechnical components were evaluated for their feasibility and effectiveness under the hydraulic conditions expected at the

desired top of levee elevation. Alternative plans were evaluated, which included modifications to floodwalls, levees, underseepage controls, pump stations, and unit tiebacks.

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

For most reaches of the Armourdale Unit, only one alternative plan was identified as technically feasible and effective to perform the raise and address the respective impacts to appurtenant structural and geotechnical features. Additionally, multiple alternative plans for structural modifications were identified and evaluated for five reaches within the Armourdale Unit.

For the purpose of plan selection, economic analysis was conducted to develop a risk-based evaluation in terms of benefits, costs, and performance of the alternatives under the future with-project condition. The analysis encompasses all flood-prone properties within the study area. All costs include interest during construction computations which assume project completion in mid-2026. All costs reflect an October 2013 price level and the annualized totals reflect the current Federal interest rate of 3.5 percent as well as a 50-year period of analysis. OMRR&R costs were included in this analysis for those features that will incur a net cost over and above present levels.

The Final Feasibility Report Recommended Plan generates annual flood risk management benefits of $56.7 million at an annual cost of $16.8 million. Net average annual equivalent benefits are $39.9 million and the benefit to cost ratio is 3.4 to 1. Each unit is also individually justified.

With net benefits of $39.9 million, the recommended plan represents a strong contribution to national economic outputs and is shown to be an efficient project meeting the planning objectives, constraints, and criteria; limiting land disturbance and environmental impacts; and avoiding HTRW disturbances and significant real estate conflicts and relocations. Considering the urban industrial nature of both areas, it is possible that unidentified concerns are present. Additional soil sampling and testing will be conducted as part of the design phase, as well as close monitoring of material excavated during the project construction, to ensure that any HTRW uncovered is properly handled and disposed. Any and all removal of contaminated soils or other contaminated materials found will be 100% local sponsor responsibility (including cost). All removal of contaminated soils or other contaminated materials must be completed prior to construction.

The median annual exceedance probability – currently as much as 3.5 percent for Armourdale and 0.3 percent for CID in their existing conditions – would improve to 0.12 percent for both units. In other words, there would be a 0.12 percent chance of a damaging flood in any year

following project implementation. Under existing conditions, in the 1 percent annual chance flood event, both units would have between an 11 percent and 55 percent annual chance of experiencing damage due to overtopping or breach failure. These probabilities are improved to roughly 1 percent in the future-with-project condition.

The long-term with-project risk of a damaging flood in both of the units over 50-year period would be less than 1 in 10, compared to a current 50-year risk exceeding 1 in 2 in Armourdale and approximately 1 in 5 in CID.

Under the Final Feasibility Report Recommended Plan, both levee units will comply with and exceed FEMA base flood insurance certification requirements (sufficient to pass the 1% event with 90% assurance). Furthermore, both units will have approximately 65-70% assurance against the median 0.2% chance exceedance flood profile

The estimated implementation cost of the Final Feasibility Report Recommended Plan is $203,711,000 Federal and $109,691,000 Non-Federal for a total estimated cost of $313,402,000 at October 2013 price levels. Project costs will be shared with two non-federal sponsors: the Kaw Valley Drainage District of Wyandotte County, Kansas (KVDD) and the City of Kansas City, Missouri. A set of maps showing the locations of the proposed modification is provided following the main report text.

The combination of recommendations from this Final Feasibility Report and the Interim Feasibility Report, approved in 2006 and authorized in 2007, represent a complete and complementary efforts that together addresses the existing Kansas Citys Flood Risk Management System as a whole. The two phases of the study effort have maintained a consistent approach to improving performance and reliability within the system.

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

REVIEW OF COMPLETED PROJECT
KANSAS CITYS LEVEES, MISSOURI AND KANSAS
FINAL FEASIBILITY REPORT

1 Study Information

The existing Kansas Citys, Missouri and Kansas, Flood Risk Management Project provides local flood risk management for the metropolitan areas of Kansas City, Missouri, and Kansas City, Kansas. The Kansas Citys project is a unit of the Missouri River basin comprehensive plan authorized and modified by the 1936, 1944, 1946, and 1954 Flood Control Acts. The last major modification to raise some of the levee units comprising the Kansas Citys Project was authorized in 1962.

The Kansas Citys project is authorized as seven levee units. A simplified map of the system is shown in Figure 1. A more detailed system map is provided in Exhibit 1 following the report text. This project extends over the lowest 10 miles of the Kansas River (at its confluence with the Missouri River) and a 20 mile reach of the Missouri River flanking the mouth of the Kansas River. These units act in concert to manage flood risks for an area of dense industrial and commercial development and minor areas of farmland all together covering about 32 square miles. Five of the seven units protect residential development. Communities within the study area include Kansas City, Missouri; North Kansas City, Missouri; Randolph, Missouri; Birmingham, Missouri; and Kansas City, Kansas.

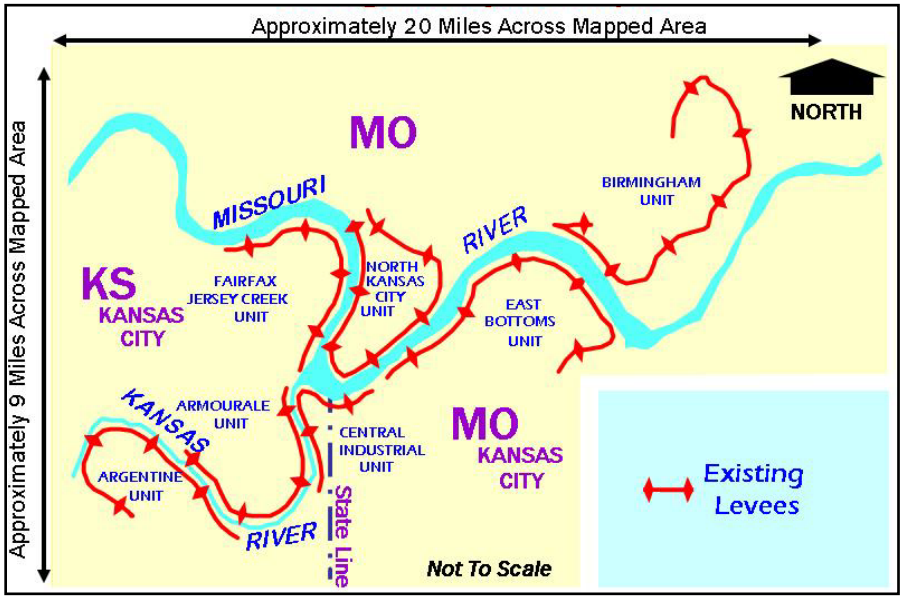

Figure 1: Simplified Kansas Citys System Map

Although the project is designed and functions as a coordinated system, its components are located on opposite banks of two major rivers within two states and various political jurisdictions. Thus, the seven levee units are operated and maintained independently by five non-federal sponsors. Most of the Federally constructed works date to the 1940's and 1950's.

Significant Federal modifications to several units were accomplished in the 1970's. While this metropolitan flood risk management system is designated as a Federal project, it has long been turned over to 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 entire metropolitan system of seven levee units withstood the Missouri River Flood of 1993, but some components were nearly overtopped or experienced underseepage issues. As a result, there was a concern that the levees may provide less than the intended design level of flood risk management. Section 216 of the 1970 Flood Control Act provides the authority to reexamine a completed civil works project and recommend modifications or improvements.

An Interim Feasibility Report, published in September 2006, recommended performance improvements in four of the units: Argentine, North Kansas City, Fairfax-Jersey Creek, and East Bottoms. The Interim Report concluded that no improvements were needed in the Birmingham Unit. This Final Feasibility Report addresses the remaining two levee units; the Armourdale and Central Industrial District (CID) Units.

This report focuses on identifying, describing, evaluating, and recommending alternatives to improve identified performance weaknesses in the Armourdale and CID Units by reducing the risk of flooding due to overtopping, underseepage, or structural failure.

This report also provides an update of the Interim Report recommendations and presents both sets of recommendations as a coordinated plan of system wide performance improvement.

1.1 Problem Description

Accordingly, this feasibility study identified the following problems within the study area:

- The existing system provides less than the level of performance for which it was authorized.
- Project failure due to overtopping, underseepage, or structural inadequacy, presents a significant life safety concern and will cause catastrophic damage to the urban development in the study area.
- The existing system includes components between forty and seventy years of age. While the system has been well maintained and is currently in good working condition, the state of the art of design, construction, and reliability analysis has changed significantly since the original construction. This concern will continue to grow as the system ages.

1.2 Study Authority

Section 216 of the 1970 Flood Control Act provides continuing authority to reexamine completed civil works and determine whether the projects are providing benefits as intended. Section 216 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.

The Feasibility Study began in September 2000 with the execution of a Feasibility Cost Sharing Agreement between the Corps of Engineers and the local non-Federal levee sponsors. The study is cost-shared 50% Federal and 50% non-Federal.

1.3 Purpose and Scope

The purpose of the feasibility study effort is to review the conditions of the existing flood risk management system, identify potential weaknesses and areas of concerns, and analyze alternatives for potential improvements to increase the project performance and reduce the risk of flooding to local communities. In order to enable the study of the overall system to progress in an efficient and orderly manner within available funding, the study was separated into Phase 1 and Phase 2 efforts in 2006. This two-step reporting process meant the complete feasibility study would generate two sets of recommendations.

At the time the phasing decision was made, hydrology and hydraulics modeling and analysis was complete for the entire system. However, structural and geotechnical analysis and calculations were not complete for all units. Those units wherein the analyses were complete were included in Phase 1 (the Argentine, North Kansas City, East Bottoms, Fairfax-Jersey Creek, and Birmingham Units). Those units for which the level of detail desired was not yet fully developed, or significant uncertainties remained, were included in Phase 2 of the study for further evaluation (the Armourdale and Central Industrial District (CID) Units).

Phase 1 and Phase 2 are complementary efforts that view the Kansas Citys project as one complete system. This Final Report documents the existing conditions, evaluation of alternatives, and improvement recommendations for the two units addressed in Phase 2 (Armourdale and CID). Additional details on the other units of the system and their recommendations are provided in the Interim Report. Historical and reference information on the entire system, and updates to information presented in previous report if applicable, are provided in this Final Report where needed for context and continuity. Additionally, this Report presents the combination of Phase 1 and Phase 2 of the study as an integrated economically justified plan for improvement to the overall system.

1.4 Study Area and Non-Federal Sponsors

The overall feasibility study effort addresses the areas within the existing seven units of the Kansas Citys system and directly affected adjacent areas. Within this Final Feasibility Report, the terms “study area” and “project area” refer only to the Armourdale and CID units, unless specifically noted otherwise.

The Phase 2 study has been conducted in conjunction with two sponsors: the Kaw Valley Drainage District of Wyandotte County, Kansas, and the City of Kansas City, Missouri. The

Kaw Valley Drainage District (KVDD) is the owner-operator of the Armourdale Unit and the Kansas Section of the CID Unit. The City of Kansas City, MO (KCMO) is the owner-operator of the Missouri Section of the CID Unit.

1.5 History of the Investigation

The entire metropolitan system withstood the Missouri River Flood of 1993, but the general performance of the system was severely tested as the flood crest reached within one foot of overtopping in at least one location. Not only were stages extreme, but durations were lengthy. Concerns arose about the reliability of the system to prevent overtopping and adequately handle underseepage. Further, there was a concern that the levees may provide less than the original authorized and intended level of performance.

The Kansas Citys metropolitan population and economy have grown significantly since the last system improvements were authorized in 1962. Much of the metropolitan economy is dependent on the areas within the levee system. Parts of the existing system are well over 60 years old. Project failure would endanger lives and create massive physical flood damages.

Both natural and man-induced geomorphologic changes have occurred since the last project authorization. Reservoirs have reduced some of the river systems' sediment load and navigation structures as well as natural river processes have contributed to the Missouri River's cross-sectional adjustments.

In response to the performance observed in 1993, both Kansas City, Kansas, and Kansas City, Missouri, wrote letters to the Kansas City District expressing concern for the adequacy of the system. A Reconnaissance Report was prepared and published in August 1999 which found that there was a Federal interest in proceeding with a Feasibility Study. The Reconnaissance Report was approved by Corps of Engineers Headquarters in July 2000.

The Phase 1 study effort resulted in the Interim Feasibility Report (Interim Report) and an Environmental Impact Statement (EIS), published in Aug 2006. These recommendations were subsequently authorized by the Water Resources Development Act of 2007 and have proceeded with design and implementation.

The EIS published with the Interim Report included analyses of the existing environmental conditions and potential impacts of project implementation in all seven levee units. This Final report covers two of the seven units addressed in the EIS. The alternatives identified and recommended in this Final Report are within the same footprint of disturbance for the tentatively recommended plan identified in the EIS. The plans recommended in this Final Report contain additional design refinements, which fall within the resources, location, and impacts addressed in the EIS.

1.6 Existing Projects and Prior Reports

The existing Kansas Citys project was created and subsequently modified by the Flood Control Acts authorized in 1936, 1944, 1946, 1954, and 1962. Following the 1936 Flood Control Act,

construction of the first Federal levees began around 1940. The original Federal construction included some incorporation of, and improvements to, previously existing local levees. Much of the authorized system was nearing completion at the time of the 1951 Kansas River Flood. In this catastrophic flood, the Argentine, Armourdale, CID, and Fairfax levees were overtopped and heavily damaged. Based on this experience, Congress later authorized the Kansas River basin reservoir system in the 1954 Flood Control Act.

The Kansas Citys system, especially along the Kansas River, was re-examined during the post-1951 period as the Kansas River basin reservoirs were being designed and constructed. This led to a major modification (raise) of the Armourdale, Argentine, and CID Units authorized by Public Law 87-874 on October 23, 1962 (the "1962 modification"). Construction of these modifications began in 1971.

The modified design of the Kansas Citys project, including the authorized design discharges for the Kansas River levee units, was predicated on construction and operation of the Kansas River Basin system of reservoirs as authorized in 1954. Most of the lakes in that system are in place and operating, but three of the smaller originally authorized lakes in the system (Woodbine, Grove and Onaga) were not built.

The existing protective works consist principally of levees, floodwalls, bridge and approach alterations, and some limited channel improvement and alteration. The project extends over the lower 10 miles of the Kansas River and on the Missouri River from 6.5 miles upstream to 12.5 miles downstream of the mouth of the Kansas River. The 32-square-mile study area includes the heavily industrialized floodplains of the two rivers. Complete effectiveness of the overall project is contingent upon adequate reservoir control in the upper Missouri and Kansas River basins.

The existing levee system and its components were authorized by specific legislation, as documented in multiple reports of Congress, and have been implemented through a series of definite project reports (DPR's), design memorandums (DM's), and operations and maintenance (O&M) manuals. Following original project implementation, multiple reports and studies have been prepared and published at various times including reservoir regulations, post-flood assessments, river hydrology updates, and flood plain hazard evaluations. The Interim Feasibility Report and the associated EIS (both August 2006), reviewed and incorporated information from the multitude of prior reports and are both directly referenced in this Final Feasibility Report.

<u>Review of Completed Project, Kansas Citys Levees, Missouri and Kansas, Interim Feasibility Report, USACE Kansas City District, August 2006</u>
The Interim Feasibility Report recommended improvements to four units of the system: the Fairfax-Jersey Creek, North Kansas City, and East Bottoms Units on the Missouri River, and the Argentine Unit on the Kansas River. The Missouri River Units were determined to have adequate height to resist overtopping at the design flood level, but require significant underseepage and structural modifications to maintain acceptable overall system reliability. In addition to similar geotechnical and structural reliability concerns, the entire Kansas River portion of the system was determined to be of insufficient height to provide adequate overtopping protection. The Interim Report included the detailed analysis of alternatives for the

Argentine Unit. The Argentine NED plan was identified as a unit raise to provide improved reliability to pass the 0.2% annual chance (500-year) plus 3 feet water surface profile. This level of flood risk management benefit is consistent with the Missouri River units, and meets economic project justification criteria.

The Armourdale and CID Units are located immediately downstream of the Argentine Unit. In order to achieve the desired condition of a uniform system level of flood risk management benefit, and to reduce the potential for induced damages between units within the system, it was determined that the development of alternatives for these two units would not consider measures providing a level of risk management or reliability greater than the authorized plan for the upstream unit.

Final Environmental Impact Statement, Kansas Citys, Missouri and Kansas Flood Damage Reduction Study, Missouri and Kansas Rivers, USACE Kansas City District and U. S. Environmental Protection Agency Region VII, August 2006
The seven levee units addressed in the Final Environmental Impact Statement (FEIS) include North Kansas City; Northeast Industrial District (East Bottoms) and Birmingham units in Missouri and the Argentine, Armourdale, and Fairfax-Jersey creek units in Kansas. The Central Industrial District (CID) levee unit, which protects land in both Kansas and Missouri, was also addressed in the FEIS.

Engineering, economic, and environmental analyses were conducted for the North Kansas City, East Bottoms, Argentine, and Fairfax-Jersey City levee units. The results of these analyses and recommendations to increase levee unit reliability are included in the Interim Feasibility Report and the FEIS. Analysis of the Birmingham unit found no geotechnical or structural deficiencies. Therefore no reliability improvements were proposed for this unit.

Preliminary engineering, economic, and environmental analyses were conducted for the CID and Armourdale units for the FEIS. Findings for overtopping risk and geotechnical/structural risk indicated the need to pursue reliability improvements for the Armourdale and CID levee units. Projected improvements, which were assessed in the FEIS, included earthen levee raises, floodwall raises, and underseepage improvements. Tentative preferred alternatives for these units were recommended, and their environmental effects assessed, within the FEIS. The final preferred alternatives identified in this Final Feasibility Report were developed from the tentative preferred alternatives assessed in the FEIS.

1.7 Planning Process and Report Organization

The Corps of Engineers uses a six step planning process to guide project studies, as detailed in Engineering Regulation (ER) 1105-2-100 “Planning Guidance Notebook”. This process is a structured approach to problem solving which provides a rational framework for sound decision making. The six steps are:

1. Identifying problems and opportunities

2. Inventorying and forecasting conditions
3. Formulating alternative plans
4. Evaluating alternative plans
5. Comparing alternative plans
6. Selecting a plan

It should be stressed that the six step process is iterative. As more information was developed throughout the study it was necessary to review and update previous steps to reach the final conclusions and analyses presented herein.

This report is generally organized to follow these six steps. The results of Steps 1 and 2 are discussed in Sections 2 and 3, respectively. Steps 4, 5, and 6 are closely related and their discussion is combined into Section 4 of the report.

2 Problem Description and Planning Objectives

This chapter presents the results of the first step of the planning process, the identification of water and related land resources problems and opportunities in the study area. The chapter concludes with the establishment of planning objectives and planning constraints, which is the basis for the formulation of alternative plans.

2.1 National Objectives and the Federal Interest

The national, or Federal, objective of water and related land resources planning is to contribute to national economic development. In addition, it must be consistent with protecting the nation's environment, pursuant to national environmental statutes, with applicable executive orders and with other Federal planning requirements. Contributions to National Economic Development (NED) are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and in the rest of the nation.

The Federal Government investigates prospective projects from a national point of view. When determining the need for Federal investment in a project, the primary analysis centers on significance of the problem and the benefits of possible solutions. In the case of this study, the focus is primarily on flood risk management benefits. It is also in the Federal and non-Federal sponsor's interest to select a cost-efficient plan, specifically one in which the benefits exceed costs. It is important to note that benefits can include non-monetary benefits such as reducing life-safety issues and improving the environmental quality. Federal interest in the project is identified when both requirements are satisfied.

Based on historical records, the study area has a high risk of flooding capable of producing significant damages and loss of life. It is within USACE and Federal interest to study the flood risk management issues within the Missouri and Kansas River Basins because there are significant risks of residential, commercial, and industrial property loss. Impacts from frequent flooding in the past include significant economic costs. Developing a project that will reduce the

frequency of these damages and protect human life is within the Federal interest and a primary mission of USACE.

2.2 Public Concerns

In addition to the review of the existing project for technical or performance concerns, public input is very valuable to help define problems and opportunities. Discussion of public input and review process used in this study is included in Section 7 and Appendix G of this report.

Previous comments received with responses are documented in the Interim Report and FEIS. Comments pertinent to Phase 2 of the study were incorporated into the analysis and documented in this report. Additional comments received from the public review of this report are documented in Appendix G. The recommendation, or incorporation, of recreation features into the existing levee system is not within the Federal study authority and is left to the discretion of the non-Federal levee sponsors, so long as any such features do not hinder or conflict with the flood risk management benefits provided by the existing project. Some limited recreational features have been implemented within the Kansas Citys system.

2.3 Problems and Opportunities

Step 1 of the Planning Process seeks not only to identify the problems and opportunities within the study area, but also to establish planning objectives and constraints that will guide efforts to solve the problems and achieve the desired opportunities.

Past flood experience raised concerns that the existing system may provide less than the level of performance for which it was designed and constructed. Following the Flood of 1993, several local sponsors wrote letters to the Kansas City District expressing concern for the adequacy of parts of the flood risk management system and requesting Corps of Engineers assistance in conducting a study of the system.

In response to these local concerns, a Reconnaissance Study was undertaken through Section 216 authority. The reconnaissance study examined readily available information, data, and flood performance results, and produced recommendations supportive of a Federal Interest in proceeding with further feasibility examination. Accordingly, this feasibility study identified the following problems within the study area:

- The existing system provides less than the level of performance for which it was designed.
- Project failure due to overtopping, underseepage, or structural inadequacy, presents a significant life safety concern and will cause catastrophic damage to the urban development in the study area.
- The existing system includes components between forty and seventy years of age. While the system has been well maintained and is currently in good working condition, the state of the art of design, construction, and reliability analysis has changed significantly since the original construction. This concern will continue to grow as the system ages.

Following the problem definition, the following opportunities were identified in the study area:

- Verify current performance of the existing system versus the original design intent and project authorizations.
- Apply current understanding of large river dynamics and design criteria to assess the reliability of the existing system.
- Identify and present recommendations for designing and implementing viable measures to reduce the risk of flooding and improve the overall safety and performance of the system

2.4 Planning Objectives

Planning objectives are statements that describe the desired results of the planning process by solving the problems and taking advantage of the opportunities identified. The planning objectives will be used for the formulation and evaluation of alternative plans. They should be clearly defined and provide information on the effect desired, the subject of the objective (what will be changed, the location where the expected result will occur, the timing of the effect, and the duration of the effect. Planning objectives are listed below as they relate to each of the identified project opportunities.

- Verify current performance of the existing system.
    - Gather all available data and historical observations to develop updated engineering analysis, and combine with the economic existing conditions to establish a complete approach to estimating the existing risks and uncertainties of flood performance, reliability, and potential consequences of failure. Comparing this analysis to the authorized design and intent of the existing system will increase the knowledge and understanding of current system reliability and performance and allow the identification of areas of concern needing to be addressed by alternative measures.

- Identify and present recommendations for reducing the risk of flooding
    - Identify measures to address the identified reliability and performance inadequacies in the existing system, including hydrologic, geotechnical, and structural concerns.
    - Develop and evaluate alternatives and recommend a plan to increase the overall reliability of the existing system and reduce flood future risk and damages over the 50 year period of analysis.

- Consider the study area as a whole and thereby provide a uniform level of risk management across the system, as directed by guidance. The authorized Phase 1 project for the Argentine Unit established the formulation goal for the Kansas River units.

2.5 Planning Constraints

The Feasibility Study examination of measures to increase the performance and reliability of the system are guided by an overarching principle that seeks to achieve a relatively consistent level of performance throughout the seven unit metropolitan system. This essentially means that the study avoids recommending:

- Any measures or plans which would directly or indirectly exacerbate any performance weaknesses (or relative weaknesses) within the system, including any measure or plan that would allow one or more units of the system to provide higher or lower risk management or reliability than the rest of the overall system, and
- Any measures or plans that would contribute to increasing the level of performance of strong components of the system without a commensurate strengthening of weaker components.

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.

3 Existing and Future Conditions

This chapter presents the results of the second step of the planning process, inventorying and forecasting conditions. Inventorying of existing conditions is more than just describing the features of the existing project; it requires a review of the original authorization and design intent, the past performance of the system during flood events, and an assessment of the integrity of the existing system relative to current design standards. The forecasting of conditions establishes the Future Without Project scenario, to which all formulated alternative plans will be compared when assessing expected plan performance. It is important to note that the Future Without Project scenario is not the same as the existing condition, as the performance of the existing system would be expected to decline in the future if no action were taken.

3.1 Existing Unit Descriptions

3.1.1 Armourdale Levee Unit

The Armourdale Unit is located in Wyandotte County, Kansas, along the left bank of the Kansas River from mile 7 (Mattoon Creek) to mile 0.3, near the confluence of the Kansas and Missouri Rivers. Prior to the Federal project, levees and floodwalls were constructed by the Kaw Valley Drainage District. These original works were modified and expanded in the initial Federal projects. Construction of the Federal project began in 1949 and was completed in 1951. More recent improvements, separately authorized under the 1962 Modification, were completed in 1976. The levees and floodwalls of the Armourdale Unit are currently authorized to pass a

maximum Kansas River flow of 390,000 cubic feet per second (cfs) coincident with a Missouri River flow of up to 220,000 cfs.

The primary components of the unit consist of earthen levees, floodwalls, riprap and toe protection on riverward slopes of levees, toe drains along the concrete floodwalls, sandbag and stoplog closures, drainage structures, relief wells and pumping plants. The floodwalls, in two reaches, vary from 11 to 17 feet high and total approximately 6,200 feet. The levees, in three reaches, vary from 4 to 17 feet high and total about 5.3 miles.

Existing underseepage control features include approximately 13,400 linear feet LF of riverside impervious fill cutoffs, 1,550 LF of landward underseepage berm, and 39 relief wells with collector systems in several reaches. Additional detail of these features is provided in Appendix A, Chapter 4. The unit begins with a stoplog closure across the Union Pacific (UP) Railroad which creates a tieback from high ground west of Mattoon Creek. The first levee section continues downstream approximately 1.28 miles along the left bank of the Kansas River, incorporating a portion of the UP embankment near the mouth of Mattoon Creek, and ends just north of the West Kansas Avenue Bridge. The first section of floodwall then extends downstream approximately 1,740 feet, ending just south of the Osage Pump Station. The second section of levee continues downstream approximately 3.3 miles to a point downstream (north) of the Chicago, Rock Island and Pacific (CRI&P) railroad bridge. This section contains one stoplog closure at the Kansas City Terminal (KCT) railroad bridge, five pumping stations, and a short reach of floodwall at the East Kansas Avenue Bridge. The second major reach of floodwall continues downstream another 4,493 feet to connect with the final levee section downstream of the Central Avenue Bridge. This section contains two sandbag closures at the UP and Missouri Pacific (MO Pac) railroad bridges, and two pumping stations. The final levee section extends another 4,156 feet and ties back into high ground at the embankment of the Lewis and Clark Viaduct.

3.1.2 Central Industrial District (CID) Levee Unit

Although the CID Unit is one continuous levee unit, it crosses the Kansas and Missouri State Line and is subsequently operated and managed as two separate and distinct sections: the CID-Kansas section, and the CID-Missouri section.

The CID-Kansas Section (CID-KS), is located in Wyandotte County, Kansas, and extends along the right bank of the Kansas River from mile 3.4 to the mouth, then downstream along the right bank of the Missouri River to the State Line. This section was originally developed by the Kaw Valley Drainage District, and initial Federal improvements began construction in 1948. Most of the Federal improvements, including repairs to damages from the 1951 Flood, were completed by 1955. The most recent improvements authorized under the 1962 Modification were completed in 1979. The CID-KS section is authorized to pass a Kansas River discharge of 390,000 cfs coincident with a Missouri River flow of 220,000 cfs.

The unit consists of two levee reaches, three floodwall reaches, riprap and levee toe protection, a surfaced levee crown and ramps, stoplog and sandbag closures, eight pumping stations, drainage

structures, and relief wells. The levees total approximately 1.7 miles in length and the floodwalls about 7,900 feet. The section varies from zero to 14.5 feet high.

Existing underseepage control features in CID-KS includes a buried collector system, approximately 1,800 linear feet of area fill, and 19 relief wells with collector system. Additional details of these features are provided in Appendix A, Chapter 4.

The CID-Missouri section (CID-MO) is located in Kansas City, Jackson County, Missouri. This section extends along the right bank of the Missouri River (river mile 365.7) to the Kansas-Missouri state line (river mile 367.2). The initial construction began in 1946. Significant improvements and repair of 1951 Flood damage followed the initial construction and were completed in 1955. The CID-MO section is designed to pass a Missouri River flow of 540,000 cfs.

The CID-MO section consists of levee, floodwalls, a levee drainage system and pumping plants, sandbag and stoplog gaps, toe and bank protection, and slope protection on the riverward slope. The floodwalls total 1.5 miles and the levee is about 430 feet in length.

3.1.3 Socioeconomic Resources

The overall existing project protects highly developed urban portions of the Kansas City metropolitan area. The protected areas encompass a major segment of the Kansas Citys' economy. Flood disruptions to this area would strongly impact the local, regional, and national economy. The Kansas City metropolitan area has a diverse and varied economic base. As a centrally located market, it is a major warehouse and distribution center and a leading agribusiness center. It ranks first in the nation as a farm distribution center and as a market for hard wheat. In addition to its agribusiness activities, the metropolitan area has major industrial activities such as auto and truck assembly, steel and metal fabrication, and food processing. The metropolitan area also fosters a growing non-manufacturing sector. Wholesale and retail industries and service organizations are now chief employers in the area.

The metropolitan area has a network of interstates and major highways that provides excellent access to each of the levee units.

- The CID Unit is accessed by means of I-70, I-35, and by I-670 which crosses over the middle of the protected area.
- The Armourdale Unit is served by U.S. 69, U.S. 169, and I-70.
- Major rail service infrastructure is present in each of the units.

Census 2010 data for 111 census tracts were compiled to describe the socioeconomic characteristics of each levee unit area as well as for the overall study area. Census 2010 data were also compiled for counties in the study area and for the Kansas City (Missouri and Kansas) Metropolitan Statistical Area (KC MSA). Although census tracts cover areas that may typically be somewhat larger than the area protected by a levee unit, the census tract data is considered to be generally representative of the protected area.

Table 3-1 displays estimates of population, employment and housing for the census tracts covering each levee unit and the study area as a whole.

Table 3-1: Estimates of Population, Employment and Housing

Unit	Population	Employment	Housing Units
Armourdale Unit	2,924	6,700	1,025
CID Unit	1,730	7,494	1,110
Study Area Total	**4,654**	**14,194**	**2,135**

Source: Census 2010

Census data, 1970 to 2000, and Mid-America Regional Council (MARC) forecasts, 2010 to 2030, for the census tracts in the study area were used to describe general trends in population, households and employment. MARC is the metropolitan planning organization for the bi-state Kansas City region. In 1970 the areas within the metropolitan flood risk management system had total population of 23,124 persons and 7,952 households. Between 1970 and 1990, the total population and number of households in the study area declined. This trend in the study area was reflective of the national trend that occurred in the 1970's and 1980's when there were population shifts to areas outside of central city areas. After 1990 the population and number of households began to stabilize and by 2000 had increased to 19,818 persons and 8,180 households in the overall system study area.

Fluctuations also occurred in the system-wide study area employment, with an overall decline from a 1970 level of 96,069 to 85,949 by 1990 and then increasing by the year 2000 to a level of 94,035. Based on MARC forecast data for the period 2000 to 2030, total employment in the system-wide study area is expected to increase steadily. Population and number of households in the area are expected to experience steady but modest growth. Figure 2 displays the general trends in population, households and employment 1970 to 2030 for the entire study area.

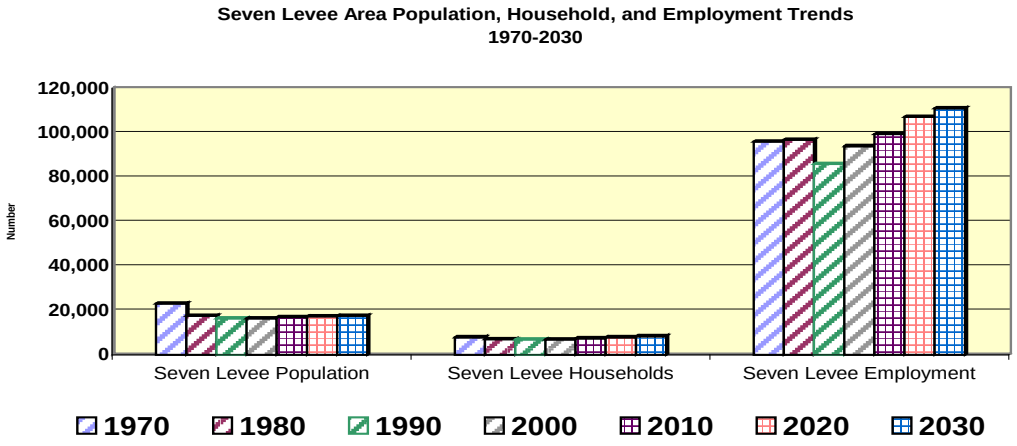

Figure 2: Kansas Citys System Study Area Population, Households, and Employment Trends

Total investment within the metropolitan system estimated at $21.9 Billion dollars (Oct 2012 price levels) and includes investment in structures, contents and equipment for commercial, industrial, residential, transportation, and public categories of investment. Depreciated replacement value for buildings and infrastructure in the study area is estimated at $8.3 billion. Businesses and residences have roughly a $13.7 billion investment in contents. Business contents include inventory, office equipment, computers, production equipment and machinery, and other miscellaneous contents. Table 3-2 shows both the Final and Interim Report study area values for comparison. Table 3-3 presents the investment breakdown for the Kansas River portion of the overall metropolitan system.

Table 3-2: Overall Investment Summary

Levee Units – Basis for Totals	Total Investment	Total Value of Structures	Total Value of Contents
Units Addressed by Final Study (Armourdale and CID)	$5,377,340,000	$2,309,040,000	$3,068,300,000
Units Addressed by Interim Study (Argentine, E Bottoms, NKC, Birmingham, Fairfax-Jersey Creek)	$16,555,600,000	$5,962,300,000	$10,593,300,000
Total System	**$21,932,940,000**	**$8,271,340,000**	**$13,661,600,000**

Note: Oct 2012 prices, rounded and shown without uncertainties

Table 3-3: Kansas River Study Area Investment for Structure and Content

Levee Unit	Number of Structures	Total Investment	Total Value of Structures	Total Value of Contents
Argentine	723	$3,053,000,000	$775,000,000	$2,278,000,000
Armourdale	1,468	$2,561,850,000	$1,241,370,000	$1,320,480,000
CID	526	$2,815,490,000	$1,067,670,000	$1,747,820,000
Total	**2,717**	**$8,430,340,000**	**$3,084,040,000**	**$5,346,300,000**

Note: Oct 2012 prices, rounded

3.2 Flood History

3.2.1 Kansas River Flood Events

Major floods on the Kansas River are usually caused by a series of short duration, high intensity storms following a prolonged period of general widespread precipitation. Table 3-4 lists the five largest annual discharges and associated stage peaks at the United States Geological Survey (USGS) gage (06889000) located on the Sardou Bridge over the Kansas River at Topeka, Kansas, river mile 83.1. The period of record for this gage is from 1904 to the present, though intermittent and anecdotal information is available from 1869. There are several gages on the Kansas River closer to Kansas City (Lawrence, Turner Bridge, 23rd Street); however, historical discharge data is not available for all locations.

Table 3-4: Flood History - Kansas River at Topeka

Year	Discharge (cfs)	Stage (ft)
July 1951	469,000	40.80
May 1903	300,000 (est.)	NA
August 1908	200,000	33.0
July 1993	170,000	34.97
June 1935	154,000	32.7

Note: Flood Stage at Topeka is 26 feet

3.2.2 Missouri River Flood Events

Floods on the Missouri River are caused by widespread storm systems over several days or weeks, sometimes combined with runoff of spring snowmelt in Wyoming, Montana, and both North and South Dakota. Table 3-5 lists the five largest annual discharges and associated stage peaks at the USGS gage on the Hannibal Bridge, just downstream of the Kansas/Missouri confluence. The period of record for stage data at this gage is from 1873 to the present; and for flow data is from 1929 to present. The highest discharge was recorded in 1951, while the highest stage peak was seen in 1993. This reflects the dynamic nature of differing flood events and the river's response to natural and man-made alterations over time.

Table 3-5: Flood History - Missouri River at Kansas City

Year	Discharge (cfs)	Stage (ft)
1951	573,000	46.2
1903	543,000 (est.)	45.0
1993	541,000	48.87
1908	402,000 (est.)	40.3
1952	400,000	40.6

Note: Flood Stage at Kansas City is 32 ft

3.2.3 Historical Flood Damages

Floods in the Missouri and Kansas River Basins are of comparatively low velocity and of several days duration. Flow data at the USGS gage on the Hannibal Bridge is available for the period 1929 to present. Before 1929 the major flood events in the Kansas Citys area occurred in 1844 (17.0 feet above flood stage), 1881 (6.8 feet above), 1903 (14.0 feet above), and 1908 (9.3 feet above). While no recorded flow information is available, the 1844 event is considered the greatest known event in the lower Missouri Basin.

In the 1903 Flood, 19 lives were lost in the Kansas Citys area, and an estimated $23,000,000 (1903 prices) in property damages was sustained. The flood of 1903 had an estimated Missouri River discharge of 543,000 cfs. The 1903 Flood gave rise to the first well-organized local efforts at major flood risk management works in the Kansas Citys area. These very old local works

provided some initial line of protection layouts and features that were subsequently adapted, added to, strengthened and raised under the subsequent Federal project.

3.2.3.1 ***The 1951 Flood***

The 1951 Flood of the Kansas River exceeds all other recorded flood events at Kansas City with a discharge of 469,000 cfs on the Kansas River and 573,000 cfs on the Missouri River (measured downstream of the confluence). A two-month period of above-normal precipitation followed by intense rains over a 72-hour period in early July caused the flooding.

Beginning on Friday, July 13, 1951, a sequence of catastrophic overtopping events played out across several of the units existing at that time. Kansas River floodwaters first overtopped the Argentine Unit, then Armourdale and CID. Floodwaters eventually poured through the West Bottoms area and exited into the Missouri River by overtopping and breaching the CID-Missouri segment of levee near the old Kansas City, Missouri, Municipal Wharf. Packing plants were flooded and railroad transportation was halted due to the flooding with severe damage to tracks, rail cars, and rail yards. The flood filled the units with water depths of 15 to 30 feet. Exhibit 2 shows a photograph of the 1951 Flood along the Kansas River in Kansas City.

After devastating the three Kansas River units, the floods then threatened the intact levees located opposite and upstream of the Kansas and Missouri River confluence area. Floodwaters eventually breached a section of the Fairfax-Jersey Creek Unit near the Kansas City, Kansas, municipal wharf and flowed into the Fairfax Business District the following morning. At the peak of the flood, the Kansas River stretched from the Armourdale bluff to the Argentine bluff, with very few structures reaching above the floodwater. Of the five levee districts near the Kansas and Missouri Rivers confluence, only North Kansas City was completely saved.

Altogether about 11 square miles were flooded in the metropolitan Kansas Citys area. At least 5 persons died, and about 15,000 people were evacuated. Many residents were left homeless and five deaths in the Kansas City area are attributed to the flood. The flood caused a reported $870 million in damages throughout the Kansas River basin, and $462 million just in the Kansas City urban area (1951 price level); in 2014 prices $12.3 billion and $8.4 billion, respectively. This event is the current Kansas River flood of record for the Kansas City area.

3.2.3.2 ***The 1993 Flood***

The 1993 Missouri River flood event crested at 48.9 feet (Hannibal Bridge gage reading) on July 27, 1993, with a Missouri River discharge of 543,000 cfs. Although this discharge was less than the 1951 flood (peak 573,000 cfs), the 1993 crest of 48.9 feet exceeded the 1951 crest stage of 46.2 feet. This is likely due to changes in the river channel in the intervening years and different dynamics of Kansas vs. Missouri river flooding, upstream levee breaches, etc. All the levees in the Kansas Citys project held, although some units saw floodwaters near the top of levees, and underseepage problems were evident in several units. Several of the levees sustained some damages (erosion, etc.) and were subsequently repaired.

This event was a Missouri River event with no coincident flooding on the Kansas River. However, there was still loading on the Kansas River Units caused by backwater effects from the Missouri River, starting near full height at the confluence and decreasing upstream. In two reaches of the CID Unit near the confluence, sand boils and seeps were observed in two locations areas where floodwaters were measured at two and three feet below the top of the levee. At the upstream end of the CID Unit, floodwaters were measured at seven feet below the top of the floodwall, and one sand boil was observed. In the Argentine Unit, the furthest upstream unit from the confluence, flood waters reached within nine feet of the top of the levee and several sand boils were observed. At one point during the event, the very downstream end of the Armourdale Unit was forecasted for overtopping. Sandbags, concrete barriers, and steel beams were used to raise the levee and floodwall in this reach of the unit approximately two feet, but the peak stage stabilized at 1.5 feet below the top of the existing levee at this location and did not reach into the additions. By comparison, at the upstream end of the Armourdale Unit floodwaters remained approximately ten feet below the top of the levee. Despite these issues, and the flood fight efforts that were required, the 1993 event is not considered a full capacity test of the Kansas River units. Had floodwaters been higher in the more upstream reaches of these units and the loading more evenly distributed long the length of these units, as would be expected to occur in a Kansas River flood event, the observed underseepage concerns would have been worse and the potential for structural failures much greater.

An estimated $4.57 billion (1993-1994 price level) in damages were prevented by the Kansas Citys flood risk management project (The Great Flood of 1993, Post-Flood Report, U.S. Army Corps of Engineers, September 1994). Even though none of the levees in the Kansas Citys project experienced overtopping, and observed underseepage was effectively managed, the combination of relief well flows, pump stations operating near or at capacity, and local tributary flooding, resulted in interior flood damages within the protected area.. Damages to Kansas City, Kansas, utilities reached several million dollars. Kansas City, Missouri, reported more than $15 million in damage to public infrastructure. Kemper Arena and the American Royal Buildings within the CID Unit suffered about $2.5 million in water damage to flooring and electrical circuits. The downtown airport sustained damages of nearly $3 million, and pollution control and public works facilities sustained an estimated $8 million in damage. The 1993 Flood is the Missouri River flood of record for the Kansas City area. Exhibit 3 shows a photo of the Missouri and Kansas Rivers confluence during the 1993 flood and the flood event hydrograph for the Kansas City gauge on the Missouri River.

3.2.3.3 ***Recent Flood Events***

Several flood events occurred during the course of this study that were significant to the Missouri River Basin, even though they did not directly impact the Kansas Citys System. Events in 2007, 2010, and 2011 loaded levee systems and caused overtopping breaches both up and downstream of Kansas City, but did not create significant concern locally. The peak discharges for these three Missouri River events at Kansas City were 286,000 cfs, 212,000 cfs, and 245,000 cfs, respectively. The 2011 event is particularly notable due to the prolonged duration of the event, 145 days; a result of record discharges from the upstream basin reservoir system. It should be noted that the upstream levee breaches that occurred during these events most likely

lowered the river stages at Kansas City and contributed to these events not directly impacting the local system. The 2011 Flood is currently the flood of record in the Upper Missouri basin.

3.3 Authorized Flood Risk Management

Multiple reports were prepared by various entities during the 1930's proposing different plans for projects at Kansas City. The authorized discharges of the Kansas River Units, pursuant to the Flood Control Act of 1936, are contained in the October 31, 1936 report titled "Missouri & Kansas Rivers, Kansas Citys, Flood Control Project, Project Report." This report states that the project should accommodate a probable maximum flow in the Kansas River of 370,000 cfs, and a combined flow of the Missouri and Kansas Rivers of 630,000 cfs.

The determination design discharges depended greatly on assumptions about the center of storm events. The following excerpt is taken from House Document No. 342 (78th Congress; June 9, 1943): "With an excessive storm centered principally over the Kansas River basin, the design-flood discharge at the Kansas Citys would be 170,000 cfs from the Kansas River and 330,000 cfs from the upper Missouri River, or a total of 500,000 cfs. Conversely, with an excessive storm centered principally over the Missouri River basin, the design flood discharges would be 80,000 cfs from the Kansas River and 460,000 cfs from the upper Missouri River, or a total of 540,000 cfs."

The available construction plans for the levee units indicate 540,000 cfs as the design discharge for units downstream of the confluence, 460,000 cfs for Missouri River units upstream of the confluence, and 390,000 cfs for Kansas River units. The larger combined design discharge of 630,000 cfs contained in the 1936 report was apparently never adopted into the units' construction history.

Each unit was designed and constructed to successfully pass a specified river discharge with adequate freeboard, or levee height, above the estimated water surface elevation. Discharge and level of performance is a complex issue for this system due to the confluence of the Kansas River with the Missouri River occurring within the study area, and given that each river has an independent runoff basin. Additional details relating to design hydraulics are provided later in this report.

Another complicating issue when discussing flood discharges and probabilities is changes to the preferred terminology. Expressing discharge probability in percent chance exceedance (occurrence) is currently preferred by the Corps of Engineers in lieu of a flood return interval expressed in years. The terms "flood return interval" and "level of protection" have been in use for many years and are familiar to the general public. However, over the years it is apparent that misconceptions have developed around the return interval nomenclature, such as, the expectation that the 100-year flood can only occur once in a period of 100-years. Percent chance exceedance is a more statistically accurate expression of the probability of a specific flood discharge occurring in any given year. For example, the flood magnitude with a 1 in 100 probability of occurrence in any given year is designated as the 1%-chance flood event.

The phrase "level of protection" can also be misunderstood to indicate that only floods above a certain magnitude are capable of causing levee failure or damages, when in fact the dynamic and differing conditions of separate flood events will impact the existing levee in different ways. From one flood to the next, the same measured discharge flow will rarely produce the same water surface elevation. It is now more common to express water surface elevations in terms of probability, or confidence limits, to establish a range within the flood elevation can be expected to occur for a given discharge. This, in turn, allows for the inclusion of risk and uncertainty in the evaluation and expression of probable levee performance under different conditions.
To account for the uncertainties inherent in calculations of flood probabilities, Corps of Engineers risk and uncertainty (R&U) analytical tools and procedures were used in this feasibility analysis, as per ER 1105-2-101 "Risk Analysis for Flood Damage Reduction Studies". It should be noted that the risk analysis and evaluations resulting from this type of analysis are not directly comparable to the discharge-plus-freeboard performance criteria used for the original authorized levee design. The use of level of protection is maintained when referencing and quoting historical documents and sources that relied on these terms.

3.4 Construction History and Design Discharge

Table 3-6 provides a summary of the major periods of construction and the current design discharge conveyance targets for each of the units in the project.

Table 3-6: Summary of Levee Unit Construction History and Design Discharge

Levee Unit	Initial Federal Project Completed (year)	Last Federal Modification (year)	River	Design Discharge (cfs)
Armourdale	1951	1976	Kansas	370,000[1]
CID, Kansas	1948	1979	Kansas	370,000[1]
CID, Missouri	1947	1955	Missouri	540,000[2]

[1]1936 Project Report
[2] 1943 Congressional Documentation

After the catastrophic 1951 Flood, the Kansas River levee units were reauthorized to pass higher design discharges. Table 3-7 shows the increased design discharges along with coincident Missouri River discharges. However, the Missouri River levees downstream of the confluence were not improved as a result of the 1951 Flood event, even though the 1951 Flood discharge exceeded the original design discharge of these units.

Table 3-7: Revised Design Discharges for the Kansas River Levees ("1962 Mod")

Levee Unit	Kansas River Authorized Design Discharge (cfs)	Missouri River Coincident Discharge (cfs) Upstream of Kansas River	Missouri River Coincident Discharge (cfs) Downstream of Kansas River
Armourdale	390,000	220,000	610,000
CID (Kansas)	390,000	220,000	610,000
Argentine	390,000	220,000	610,000

In general, the "1962 Mod" discharges were used to develop higher design water surface profiles for levee raises in the affected units. The final elevation of the levee was determined by taking the design water surface profile and adding freeboard. The levee units were authorized to pass specified discharges on the Kansas and Missouri Rivers with either 2 or 3 feet of freeboard. The other units along the Missouri River have a design level of performance as authorized in 1944. Subsequently, the Liberty Bend Cutoff was constructed along the Missouri River in the 1950's and aided in overall conveyance of flood discharges through the Kansas Citys reach.

3.5 Current O&M Requirements

The individual units of the Kansas Citys flood risk management system were turned over to the levee unit sponsors following each construction effort. Operation, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R) of the units and features is accomplished by the respective sponsors and annually inspected by the Kansas City District. The primary responsibilities for sponsors of Federal flood risk management projects are detailed in the Code of Federal Regulations (CFR) Title 33 - Navigation and Navigable Waters, Chapter II - Corps of Engineers, Department of the Army, Part 208 - Flood Control Regulations, Maintenance and Operation of Flood Control Works. Also providing guidelines regarding operations and maintenance requirements is Engineering Regulation (ER) 1130-2-530 (Project Operation).The Operation and Maintenance Manual for each levee unit addresses project specific sponsor responsibilities and contains the full text of Title 33. The sponsors all have operating staff that are familiar with the details of effective maintenance practices. Each sponsor maintains their own office and legal records, and operation and maintenance records to the extent they determine useful. The Corps of Engineers does not normally inspect nor duplicate these records.

Each unit is inspected annually and a more in-depth Periodic Inspection is conducted every five years. The sponsors of each unit have continued to adequately and effectively fulfill their O&M responsibilities since project construction, as documented by Kansas City District inspection records. Any deficiencies or encroachments on the units identified in inspection reports have generally been minor in nature, not significantly impacting project operations or readiness, and are being addressed by the sponsor in a timely manner. Sponsor operations and maintenance is an important and indispensible component of ensuring the existing system provides the intended risk management benefits.

3.6 Existing Reservoir System Effects

3.6.1 Effects of Kansas River Basin Reservoir System

A multi-purpose system of reservoirs in the Kansas River basin was authorized in the Flood Control Act of 1944. Eighteen (18) Federal lakes/reservoirs now exist in the Kansas River basin; seven managed by the Corps of Engineers and eleven by the Bureau of Reclamation. The seven Corps lakes are large enough and close enough to the Kansas City area to have a major effect on flows passing through the Kansas City system.

This system was authorized, in part, to act in concert with the system of Federal levees in Kansas City and other areas to reduce flood damages in the areas protected by the levees (the levees in

the Kansas City area had been previously authorized). Modifications to this original 1944 lakes authorization have appeared in subsequent Flood Control Acts, but the basic objective of providing a coordinated flood risk management system on the Kansas River, as outlined in the 1944 Act, has been preserved. The Kansas City District operates these reservoirs in compliance with the original intent of that Act.

The upstream reservoirs in the Kansas Basin are operated with consideration of Kansas and Missouri River flows. Depending on the amount of water stored in their flood control zones, each reservoir restricts releases based on downstream conditions. Reservoir releases will not increase downstream flow more than the limits presented in Table 3-8 at the Desoto gage on the Kansas River, the Kansas City gage on the Missouri River, or the Waverly gage on the Missouri River.

Table 3-8 Kansas River Basin Reservoirs Releases: Downstream Flow Limits

	Desoto Gage Kansas River	Kansas City Gage Missouri River	Waverly Gage Missouri River
Phase 1: Lower zone of flood control pool	66,000 cfs	176,000 cfs	90,000 cfs
Phase 2: Middle zone of flood control pool	110,000 cfs	220,000 cfs	130,000 cfs
Phase 3: Upper zone of flood control pool	130,000 cfs	240,000 cfs	180,000 cfs

Cfs = cubic feet per second

3.6.2 Effects of Missouri River Basin Reservoir System

There are six major Federal lakes/reservoirs on the main stem of the Missouri River in the Dakotas and Montana. The reservoir furthest downstream is Gavins Point in southern South Dakota, which is about 440 river miles upstream of the Kansas City area. This system of reservoirs provides flood risk management benefits all along the Missouri River, but the system does not operate specifically for the Kansas City area. Any release at Gavins Point undergoes a five day travel lag before arrival of that water at Kansas City. The Kansas River levee units can be indirectly impacted by Missouri River reservoir operations when considering Missouri River backwater effects and the possibility of coincident flooding scenarios.

3.7 Recent Evaluations of River Flow Frequency

Following the flood of July 1993, the Corps of Engineers undertook a major reevaluation of the flow frequency of the upper Mississippi, Missouri and lower Illinois Rivers. The resulting Upper Mississippi River System Flow Frequency Study (UMRFFS) constituted an update of the previous flow frequency estimates then in use for these rivers. On the Missouri River, the previous flow estimates were completed and published in 1962. The UMRFFS study provided revised flow frequency estimates and flood profiles.

To fully evaluate the operations of the Kansas River basin reservoir system as part of the UMRFFS study, updated flow information and flow frequency estimates were also generated for the Kansas River from its mouth to Manhattan, Kansas. Table 3-9 summarizes the regulated

flow frequency estimates as applicable to the Kansas Citys study[1]. The Kansas River data from Table 3-9 is presented graphically in Figure 3.

Using the data and information from the UMRFFS study, and other studies, the Corps of Engineers conducted a complete hydraulic and hydrologic analysis, including development of an existing conditions HEC-RAS (River Analysis System) model calibrated to the flood event of 1993 for use in studying this system. This analysis also addressed the effects of potential improvements for all seven units of the existing system and is the basis for the system EIS. The results and findings of this system wide hydraulic analysis were completed and published in the Engineering Appendix to the 2006 Interim Feasibility Report. The hydraulic information detailed herein is taken from the previously completed analysis; no new analysis was conducted for the purposes of this Final Feasibility Report as the previous data was determined not to have changed. For reference, the previous Hydrology and Hydraulics chapter is repeated in the Engineering Appendix accompanying this report.

Table 3-9: Study Area Flow Frequency Data

Annual Percent Chance of Exceedance	Missouri River Downstream of Blue River (cfs)	Missouri River Downstream of Kansas River (cfs)	Missouri River Upstream of Kansas River (cfs)	Kansas River at Mouth (cfs)
0.2	537,000	530,000	358,000	341,000
0.5	459,000	454,000	316,000	283,000
1	405,000	401,000	287,000	241,000
2	354,000	351,000	257,000	202,000
5	292,000	289,000	220,000	150,000
10	247,000	245,000	192,000	121,000
20	203,000	201,000	162,000	90,700
50	143,000	142,000	120,000	51,200
80	104,000	103,000	89,500	26,400
90	89,100	88,300	77,200	18,700
95	78,800	78,100	68,500	14,000
99	63,400	62,900	55,100	8,200

[1] Sources: Upper Mississippi River System Flow Frequency Study, 2001; and the Kansas River Hydrology Report, 2002

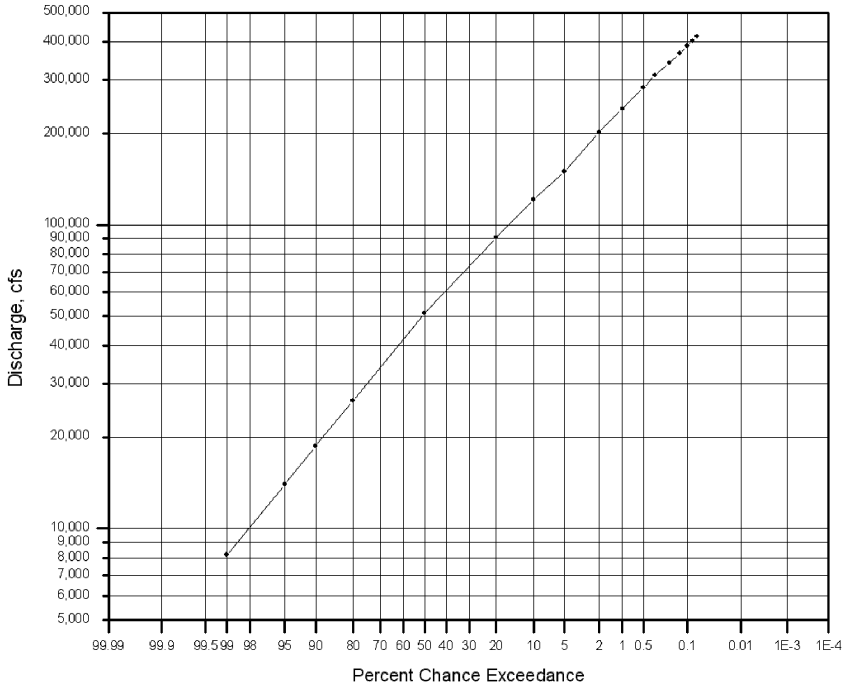

Figure 3: Discharge-Frequency Curve – Kansas River at Mouth

Since flood events above the 0.2% chance of exceedance (500-year) event needed to be considered in this study, the discharge-frequency curves were extended up to the 0.067% chance of exceedance (1,500-year) flood event. Table 3-10 summarizes all of the discharges developed for use in this study.

Table 3-10: Summary of Flood Discharges Used in this Study

Frequency in Percent Chance of Exceedance	Missouri River Downstream of Blue River (cfs)	Missouri River Downstream of Kansas River (cfs)	Missouri River Upstream of Kansas River (cfs)	Kansas River at Mouth (cfs)
0.067%	637,000	625,000	414,000	417,000
0.080%	621,000	610,000	403,000	403,000
0.100%	600,000	590,000	390,000	388,000
0.133%	573,000	565,000	377,000	367,000
0.200%	537,000	530,000	358,000	341,000
0.500%	459,000	454,000	316,000	283,000
1.000%	405,000	401,000	287,000	241,000
10.000%	247,000	245,000	192,000	121,200

The Discharge-Frequency relationships summarized in Table 3-10 indicate that the authorized design discharge of 390,000 cfs has an annual exceedance probability of less than 0.1%. Given

the very low chance of occurrence of a flood of this magnitude it was determined to be neither practical nor economical to evaluate existing performance, or develop modification alternatives, for the authorized discharge profile. For consistency with the desired benefits and uniformity of risk management within the levee system, evaluations of current and future project performance conducted for this study focused on the 0.2% chance flood.

It is of interest to explore and understand the possible reasons why the existing units are unable to perform at the discharge for which they were originally designed and constructed. The Kansas River Unit raises of the 1970's were based on hydraulics utilizing 1951 cross-sections. These cross-sections were taken after the July 1951 flood event and they show that in the lower reach of the Kansa River major channel scour occurred during the flood event. The major assumption for using the 1951 cross-sections for hydraulic analyses and levee design profile is taken from General Design Memorandum #1 and is as follows: "It was determined that for design conditions, the cross-sections that existed on the Kansas River shortly after the 1951 flood would represent the channel cross-section during passage of the design discharge."

The Kansas River Unit raises of the 1970's were also based on hydraulics utilizing roughness coefficients (Manning's n-values) of 0.025 and 0.05 for the channel and overbank areas, respectively. Aerial photos of the lower Kansas River shortly after the 1951 flood event indicate very little obstructive vegetation in the overbank areas. This is more evident from about river mile 4 upstream to river mile 10. From levee to levee, a relatively clean conveyance area for carrying flood flows existed after the 1951 event.

The hydraulic model developed for this Kansas Citys Levees Feasibility Study is based on mapping and aerial photography obtained between 1995 and 1999 (most currently available data at the time of model development). In the last 40-50 years since the 1951 flood, the lower reach has accreted with sediment and the composite roughness values across the entire cross-section have increased dramatically. These factors have lead to higher water surface elevations than those calculated for the 1970's Kansas River Unit raises. It should be noted, that accretion has significantly slowed and vegetation growth appears to have reached its maximum density, therefore these factors are unlikely to significantly affect flood stages in the future.

3.8 Assessment of Existing Levee Integrity

During early portions of the existing conditions assessment, the O&M Manuals and Record Drawings were reviewed and were followed by field visits with sponsor representatives to compare available survey information with actual field conditions.

In 2001, a centerline survey of the top of levee was conducted for verification of the O&M Manual elevations and was used in conjunction with the hydrologic and hydraulic analyses. A review of the centerline survey indicated that some areas along the levee were slightly lower than shown in the O&M Manual. Based on this, a resurvey of portions of the centerline was conducted in late 2003. The results of the resurvey confirmed that some areas were slightly lower. Review of the levee condition found no indicators that these low spots were due to post

construction settlement or geotechnical foundation concerns. This information led to discussions with sponsors and additional emphasis on preparations for emergency flood fighting (sandbagging) or local maintenance and repair of the low spots.

The study assessments provide insight into both the existing levee performance and the economic damages expected under existing conditions for an array of high water events. Risk and uncertainty analysis results and observations of levee performance during flood events form the basis for the identification of opportunities for risk reduction measures. The critical reaches for geotechnical underseepage failure and slope stability risks were identified and analyzed in each unit. Critical reaches for geotechnical risk are determined by several factors including levee height, slope, and soil type, and are the locations where underseepage or stability risks are expected to be the highest. The structural components of each unit were analyzed and compared to the current minimum factor of safety (FS) for hydraulic uplift, strength, and stability. Features that did not meet the minimum required factor of safety were further evaluated to determine probability of failure (PoF) with water at the top of the levee (TOL). .

Probability of failure curves (probability vs. water surface elevation) were prepared for the most critical features and combined in the economic analysis to determine an overall probability of failure for each unit. The details of this analysis, which are based on evaluations using the HEC-FDA program, are presented in Appendix B. The overall existing condition engineering performance is shown in Table 3-11. The locations and features not meeting the factor of safety and showing the highest probabilities of failure in each unit are summarized in Table 3-12.

In Table 3-11, the “Conditional Exceedance Probability – Overtop or Breach” represents the probability of levee unit failure from all possible failure modes (overtopping, geotechnical, and structural). As shown, the current existing failure risk is significantly high in both units: 3.5% annual probability for the Armourdale Unit and 0.3% for the CID Unit. The “Conditional Exceedance Probability – Overtopping Only” represents that portion of the existing failure probability attributable to overtopping failure only.

Table 3-11: Engineering Performance (Existing Conditions)

	Armourdale	CID
Annual Exceedance Probability* (median)	3.5%	0.33%
Annual Exceedance Probability* (expected)	3.7%	0.47%
Long Term Risk (chance of exceedance during indicated period)		
over 10 years	31.4%	4.6%
over 30 years	67.7%	13.2%
over 50 years	84.8%	21.0%
Conditional Exceedance Probability - Overtop or Breach**		
10.0% event	16.4%	0.0%
4.0% event	22.2%	0.0%
2.0% event	31.7%	1.4%
1.0% event	54.5%	11.3%
0.4% event	81.4%	42.4%
0.2% event	91.9%	66.6%
Conditional Exceedance Probability - Overtopping Only		
10.0% event	0.0%	0.03%
4.0% event	0.0%	0.03%
2.0% event	0.6%	0.5%
1.0% event	7.9%	6.6%
0.4% event	36.7%	33.5%
0.2% event	61.4%	58.8%

*Annual exceedance probability is the chance of experiencing any flood event - of whatever magnitude - within any year. Expected values include Monte Carlo risk and uncertainty modeling.
**Conditional exceedance probability is the probability that specified flood event would overtop or breach the levee.

Table 3-12 Summary of Existing Conditions in Areas of Concern

ARMOURDALE UNIT				
LOCATION	**DESCRIPTION**	**FS NOT MET**	**PoF**	**CONSEQUENCE**
Sta. 185+70	5th Street Pump Station	Uplift	100%	Unit will flood
Sta. 129+20	12st Street Pump Station	Uplift/Strength	100%	Uplift: Unit will flood
Sta. 156+75	Mill Street Pump Station	Uplift/Strength	100%	Strength: Post-flood repair
Sta. 222+00	Slope Stability Critical Location	Slope Stability	24%	Unit will flood
Sta. 276+00	Underseepage Critical Location	Underseepage	8%	Unit will flood
CENTRAL INDUSTRIAL DISTRICT UNIT - KANSAS SECTION				
LOCATION	**DESCRIPTION**	**FS NOT MET**	**PoF**	**CONSEQUENCE**
Sta. 83+52	Ohio Street Pump Station	Strength	100%	Post-flood repair
Sta. 132+20	Closure Structure	Strength	99%	Unit will flood
Sta. 166+31	Closure Structure	Stability	20%	Unit will flood
Sta. 104+51	Closure Structure	Stability	6%	Unit will flood
Sta. 85+00	Underseepage Critical Location	Underseepage	4.5%	Unit will flood
CENTRAL INDUSTRIAL DISTRICT UNIT - MISSOURI SECTION				
LOCATION	**DESCRIPTION**	**FS NOT MET**	**PoF**	**CONSEQUENCE**
Sta. 19+39 to 22+31	Floodwall	Sliding Stability	100%	Unit will flood
Sta. 63+15	Closure Structure	Foundation Stability	64%	Unit will flood
Sta. 0+00 to 3+49	Floodwall	Strength	14%	Unit will flood

Both the Armourdale and CID units have some probability of breach under existing conditions, but the probability of breach is much greater for the Armourdale Unit. For both units, the analysis indicates that the unit will structurally fail before overtopping. Deficiencies in the Mill St. Pump Station, the 12th St Pump Station, and the 5th Ave Pump Station are the major contributors to the existing condition probability of geotechnical/structural failure, which could cause a breach in the Armourdale Unit at flood levels below TOL. For the CID Unit, it is structural gatewells, floodwalls, and stoplog gaps that contribute to a lesser, but still significant, probability of structural/geotechnical failure and breach for events below TOL.

If all geotechnical and structural failure risks listed in Table 3-12 were addressed, a significant overtopping risk would still remain for the target 0.2% chance flood event. These findings for overtopping risk in the lower Kansas River show that these units do not reliably achieve the authorized 390,000 cfs conveyance target. Similar information was presented in the Interim Report on the Argentine Unit. This indicates the need for a general increase in the existing overtopping protection along the lower Kansas River.

The details of the engineering performance analyses of geotechnical and structural features of the Armourdale and CID Units, including floodwalls, drainage structures, closure structures, and pump stations, are provided within the appropriate chapters of Appendix A to this report.

3.9 Future Without Project Scenario

The without condition scenario is a narrative description of the significant water and related land resources conditions and their impacts that could exist if the planning partnership takes no action. In best practice all scenarios are developed after careful consideration of what is reasonably known and not known about the future. When most of the alternative futures are relatively similar, differing only in the details, some of which may be significant, it is both possible and desirable to use a single most likely without condition scenario. Uncertainties in such a scenario can be explored using sensitivity analysis and other risk-based analytical techniques within the framework of that scenario. When uncertainties are so great as to produce significantly different future scenarios it is not reasonable to single out one scenario as most likely. In these instances scenario planning with multiple without condition scenarios may be necessary.

3.9.1 Socioeconomic Considerations

The Armourdale and Central Industrial District Units last experienced catastrophic flooding in July of 1951. Following this devastating flood these areas struggled for years, even decades, to return to their pre-flood economic vitality. The meat packing industry that thrived in these areas never fully recovered (the Armourdale area took its name from the Armour & Co. plant). One plant did not reopen and the rest were gone within twenty years. The impact of the flood was not the only factor to affect the meat packing industry, but certainly it was a significant one. The famous Kansas City stockyards began a slow decline with the departure of the meat packing industry, finally closing down for good in 1991. The residential populations within these areas also dropped significantly in the years after the flood as jobs left and people moved out of the

flood prone areas. These are just a few examples of the impacts that severe flooding has on affected areas, and ones that could easily be repeated in the future.

Since the 1951 flood, the industries that remained have recovered and new industries have arrived. Convention facilities, restaurants, artist studios, commercial offices, and other uses have slowly moved into the study area. In keeping with this trend, only gradual, minor changes in population, employment, and land use are expected within the study area. The population of the Kansas City metropolitan area has been relatively stable according to the 1980 through 2010 census. Significant changes in population and land use in relation to existing conditions are not expected. However, several important planned commercial and residential developments have been identified in certain areas during discussions with sponsors and occupants of the study area. In addition, several road and highway improvement projects have been proposed, or are being implemented currently, that will increase access and traffic flow to, and within, the study area. These developments are expected to add to the general overall economic activity.

Opportunities for new development in the future are limited by the dense urbanization already existing and the scarcity of available open ground. Redevelopment efforts, or other changes from the current land use, may be restricted by floodplain zoning and flood insurance requirements. Most of this area would be within the base flood plain if not for the current flood risk management project. Any development along the river outside the line of protection would be precluded by the regulatory floodway which covers the entire span between the left- and right-bank levees.

While the identified trends and assumptions indicate that the existing socioeconomic fabric of the study area will remain relatively the same, and may improve some, the relative risk of a damaging flood increases into the future. Should another catastrophic flood occur with the study area, economic stability would be severely impacted, as has been seen before. It is reasonable to assume that some businesses and residents impacted by such a flood would not return to, or rebuild within, the study area. Large regional and national businesses currently in the study area may choose to relocate jobs completely outside of the Kansas City area, causing significant regional economic impacts.

3.9.2 Hydrologic and Hydraulic Considerations

3.9.2.1 ***General***

The Hydrologic Engineering Center River Analysis System (HEC-RAS) computer model is used to calculate the probable stage-discharge relationship at a selected future date based on the best available current data, the incorporation of any known projects planned to be completed within the study area, and any long term natural river processes that may affect future stages. In the development of the future without scenario, it is important to adequately detail and validate the current data and future assumptions that are input into the model.

3.9.2.2 ***Expected Future Condition Changes***

A critical assumption in the future conditions analysis is that hydrologic conditions along the Missouri River and the Kansas River are relatively static and that flows used in the existing conditions study generally apply to the future conditions analysis. This assumption was also used in the development of the *Upper Mississippi River System Flow Frequency Study* (UMRFFS), 2003, which was based on the study of 100 years of gage records along the Mississippi River and tributaries, including the Missouri and Kansas Rivers. The UMRFFS superseded the previous Missouri River hydrology published in 1962 in the report titled *Missouri River Agricultural Levee Restudy Program*. The newly published flows in the UMRFFS were used in this study for both present and future conditions.

The future condition scenario does not anticipate the construction of any major Federal or local projects along the Kansas River that will have the capacity to affect the water surface elevations in the future. However, some of the natural processes occurring on the Kansas River are similar to processes occurring on the Missouri River.

Examination of aerial photography sequences show significant tree growth on certain lower Kansas River foreshore areas during the years from 1955 to the 1990's, especially on the left and right foreshores from the upper limits of the studied reach to approximately Kansas River mile 3.5, a distance of approximately 6.5 miles. Downstream of river mile 3.5, very little vegetation exists on the foreshore. Some accretion is noted along the studied reach, but not to the extent of the Missouri River. This difference may be due to the absence of navigation structures in the Kansas River.

The future without scenario assumes that because the upper reach is heavily vegetated for the existing conditions, the future conditions will not be worsened by further maturity of these growths. Based on a review of the vegetation patterns from 1955 to the present, it is also assumed that the amount and extent of vegetation on the lower reach from river mile 3.5 to the mouth will remain relatively stable. Therefore, the future natural condition along the Kansas River does not change from the existing condition.

3.9.2.3 ***Missouri River Degradation***

The Missouri River between miles 340 and 400 in the Kansas City reach has exhibited down cutting of the river bed. This phenomenon has been observed by evaluation of Missouri River gage data collected over a long period of time. As the bed of the Missouri lowers, degradation begins to travel upstream many of its tributaries, including the Kansas River. Bed degradation can have many negative impacts to infrastructure such and bridges and water supply intakes, and can impact the riverward stability of existing flood risk management features.

The potential causes of degradation, documentation of its effects, and potential alternatives for management or mitigation are currently being evaluated under separate study efforts. This Kansas Citys feasibility study is directed only towards the analysis of levee unit performance under flood conditions. Channel degradation has been considered where it has demonstrable potential effects on flood risk management performance. However it was determined

unnecessary to project future degradation changes into future without project for the Kansas Citys study. The results and recommendations of the separate degradation study efforts will be reviewed when available and incorporated into future project design efforts where deemed necessary.

3.9.3 Period of Analysis and Related Assumptions

Both the future with and without condition scenarios are evaluated over a 50 year period of analysis to allow a consistent and appropriate comparison of alternatives. The period of analysis is the time horizon for which project benefits and project operation, maintenance, repair, rehabilitation and replacement (OMRR&R) costs are evaluated. The period of analysis begins with the base year condition (considering resources in the study area and economic and engineering factors) thought to exist in the first year a project alternative is expected to become operational. Engineering and economic data is also developed (projected) for a future year about 20 to 30 years out from the base year. The analysis years used in this Final feasibility study are 2026 for the base year and 2049 for the future year, with the total 50 year period of analysis ending in 2076.

In this study, certain assumptions related to the period of analysis were made:

- River stage uncertainty values were increased from 1.5 ft. to 1.8 ft. in the future year 2049; this reflects the increased difficulty in predicting stages far in the future.
- No significant increase in economic development is projected for the 50 year period of analysis as much of the protected area is essentially built-out.
- Beyond the future condition year of 2049, the expected annual damage is assumed to be constant in the remaining years of the period of analysis.

These assumptions provide the framework of the future without scenario in which the analysis of future flooding impacts is conducted. The expected annual damage for each year in the period of analysis is then computed, discounted back to present value and annualized to determine the equivalent annual damage for any year during the analysis period.

3.9.4 Without Project Scenario Conclusion

If modifications and improvements to the existing flood risk management system are not implemented through a Federal cost-shared project, the non-Federal Sponsors will be faced with either a significant financial burden of trying to implement the project themselves, or they will have to rely on flood-fighting to protect the study area from future floods. Neither option alleviates the existing flood risks or the increasing risks as the exiting project continues to age.

The trends and assumptions discussed in this section establish a future scenario in which the without-project and with-project conditions and flooding impacts can be analyzed and compared. The specific details and results of these analyses are discussed later in this report.

4 Development of Alternatives

This chapter presents the results of steps three through six of the planning process, the formulation, evaluation, and comparing of alternative plans leading to plan selection. These steps are difficult to separate into discrete activities as the evaluation and comparison of management measures and alternative plans often leads to reformulation, additional evaluation, and continued refinement, before a final recommendation is reached.

Early problem definition efforts required that the study establish the existing performance condition and future without project condition scenario for the individual units in the study area. The primary means of quantification of these baseline conditions was through the development of risk and reliability metrics (for flood condition performance) by using risk and uncertainty (R&U) principles and the Corps of Engineers HEC-FDA program. This is significant due to the numerous elements and features of the units which required the identification and quantification of performance weaknesses.

Much of the analysis used data and observations from recent high water events, especially those in 1993 and, to a lesser degree, 2011. This updated engineering analysis, along with the economic existing conditions analysis, establishes a complete R&U approach to estimating existing conditions flood damages. The engineering and economic evaluations were taken together with a summary baseline environmental review and an HTRW review to develop the existing conditions.

The initial broad feasibility evaluations of existing conditions undertaken during the first two to three years of this study allowed subsequent formulation efforts more focus. The development of measures to increase reliability was narrowed to the candidate sites which offered the best opportunity for significant reliability improvements and potential economic return on investment. These candidates were also reviewed for compatibility with the basic planning objective which emphasized the desirability of a relatively uniform level of flood risk management across the metropolitan system.

As feasibility progressed, the development of reliability improvements were thus focused on those specific areas identified as having relatively low reliability; areas where low reliability significantly compromised the projects 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.

Alternative plans shall be formulated to identify specific ways to achieve planning objectives within constraints so as to solve problems and realize the opportunities identified. An alternative plan consists of a system of structural and/or nonstructural measures, strategies, or programs that meets, fully or partially, the planning objectives. The first phase in plan formulation is the identification of management measures, followed by combing the measures into plans as appropriate.

The results of the existing conditions analysis, and observations and effects from historic and recent flood events, were used to identify and formulate potential solutions aimed at lowering the risk of flooding for units under study.

At times additional measures and alternatives surfaced leading to formulation of new plans or plan reformulation. As the alternatives passed through subsequent evaluation and screening processes, the economic analysis of each alternative was used as a primary 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 plan.

Note regarding Price Level: Throughout the planning and alternative development process, cost estimates and economic analyses were prepared at various times to assist in decision making regarding the efficiency and performance of measures and alternatives. Due to inflation and interest rate changes, cost estimates and economic benefits calculated in different years are not comparable. Cost and economic information presented in this report is shown as calculated at the time it was used for decision making, and is labeled with the appropriate Price Level. Price Level is designated by the first month of the Fiscal Year in which the prices were effective, for example an October 2005 Price Level is Fiscal Year 2006, and so on. The final Recommendation of this report presents the recommended project costs and benefits in the appropriate Price Level for the Fiscal Year in which this report is published and approved.

4.1 Plan Formulation Rationale

Planning studies are required to examine and address the Federal criteria of completeness, efficiency, effectiveness, and acceptability. Alternatives and recommendations are also closely examined for their potential to impact the environment. To adequately address these criteria, the development and screening of alternatives should consider of a number of evaluation factors. Primary among those factors are the following:

- Engineering adequacy of the proposed solutions (effectiveness)
- Contribution to planning objectives (completeness of the solution)
- Consistency with planning constraints and authorities
- Environmental, cultural, and public acceptability
- Early cost indicators (early efficiency indicators for screening purposes)
- Induced damages considerations (where applicable)
- 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 various Engineering Appendices.

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: Any cultural resources present were considered as the areas likely to be affected by a solution were determined. 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.

Induced Damages: While this consideration is similar in some respects to the floodway conveyance factor, the analysis actually goes one step further and addresses the possibility of induced impacts during extremely rare events in which the order of overtopping may be altered by levee raise proposals.

4.2 Key Uncertainties

A number of preliminary uncertainties were identified and investigated as thoroughly as possible during the study. These uncertainties were important considerations in selection and evaluation of effective management measures. These included the following:

- Impact of Missouri River bed degradation on the Kansas River. A separate Corps of Engineers study is currently underway examining bed degradation in the Missouri River. As the Missouri river bed scours itself lower, there is potential for this degradation to begin travelling up tributary streams, such as the Kansas, and alter future water surface profiles, undercut river bank slopes, etc. At this time, the study has not reached any firm conclusions or recommendations to slow or reverse the degradation, but that is part of the study's goals and objectives. For the purposes of evaluating future flood risk management on the Kansas River, it is assumed that some future measures will be in place to address degradation, and that the future water surface profile models used for establishing new levee heights will not be significantly impacted. The future findings and results of the degradation study will need to be monitored and incorporated into actual design of future levee modifications as needed. Any risks and costs associated with degradation study recommendations, including any related to bridge scour, will be evaluated and addressed as part of that separate study effort.

- Impact of raised water surface profiles on Kansas River bridges. A large number of bridges cross the Kansas River within the current study area. Raising the system on either side of the river increases the future water surfaces, leading to higher lateral loads on these bridges, more potential for debris impacts, etc. A qualitative assessment was conducted using all known and available bridge inspection reports and information to identify the most highly impacted bridges and rank their potential for failure under multiple scenarios. Of critical concern to this study was the possibility that a bridge failure might directly cause a failure of the flood risk management system leading to inundation of the study area. The results of this assessment determined that if any of the affected bridges were to fail during a flood, there would be no direct failure impact to the adjacent flood risk system. Furthermore, the probability of a flood high enough to impact the bridges is small, and, even at that flood level, the probability of an actual bridge failure is small, making the overall scenario a remote and rare occurrence that does not justify the formulation of specific measures or alternatives. Additional detail of the bridge assessment is provided in Appendix A.

- Condition of existing CID floodwall foundations. At the beginning of the study there was significant uncertainty regarding the existing condition of the original timber pile foundations supporting the floodwalls in the CID unit. It was assumed they would be inadequate to support a raise of the walls. The walls would therefore need a large number of new adjacent piles to support buttressing of a raise, or the walls and foundations would need complete replacement. After several iterations of plan formulation and cost screening with this constraint in place, the team decided there was value in conducting excavation and testing of the foundation piles to address this uncertainty. Two locations were excavated and the piles were visually inspected and samples were laboratory tested. The resulting data reduced the uncertainty concern, and the subsequent structural analysis concluded that the existing piles were still capable of providing support of a raise, eliminating the need to consider wall replacement, and reducing the number of additional piles needed.

4.3 Management Measures

The following management measures were identified and studied for the applicability to each feature of the exiting unit and their ability to meet the project objectives.

4.3.1 No Action

In accordance with current policy it is necessary to fully evaluate the No Federal Action alternative for purposes of comparison to other alternative and future with-project conditions. Evaluation of the No Action plan is closely related to the future without project scenario and requires the projection of 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 would likely to be focused on the engineering reliability measures which are the least costly of the recommendations offered herein, such as underseepage improvements. However, full implementation of the measures as described may not be possible with local budgets alone. The major requirements associated with structural feature reinforcements, and increased overtopping protection, are just as likely not to be accomplished under a local initiative. This would mean a significant long-term remaining risk.

The No Federal Action alternative does not address any of the project's objectives and 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.

Economic Impacts of the No Action Alternative. 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 the protected areas) and generally diminished property values.

The No Federal Action alternative would leave several of the busiest rail yards in the nation at significant risk. 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.

Environmental Impacts of the No Action Alternative. 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 could result in direct and indirect impacts through inundation of habitat of terrestrial populations. Direct impacts during flood events would be the displacement of mobile organisms and the loss of organisms unable to escape inundated areas. Indirect impacts would be the temporary or permanent loss of the already limited existing habitat preventing organisms from returning to the area.

Direct and indirect impacts could also result from the introduction of contaminants currently controlled or contained by businesses and industries in interior of the levee systems. While a complete inventory of chemicals and chemical classes is not available, the primary sources of contaminants within the Armourdale and CID levee units include auto salvage, railroad operations, electrical power generation, chemical plating, producers of starch and other household chemicals, a wastewater treatment facility, and additional sources of contaminants. Catastrophic levee failure and flooding within these units could result in the release of volatile

organic compounds such as benzene, ethylbenzene, toluene, xylene, TCE (trichloroethene), and PCE (tetrachloroethene). Organic compounds released would minimally include fuels, grease, oil, plastic, and rubber. Inorganic compounds released would include metals such as chromium, copper, iron, lead, nickel, and zinc.

Contaminants in water can be transported within the water, transported into the atmosphere, absorbed into the soil/sediment or solid matter within the water, dissolved, degraded, and/or transformed. The release of contaminants from behind the levees due to catastrophic failure and flooding would cause significant immediate and long-term surface water, ground water, soil, and air contamination and result in carcinogenic and non-carcinogenic toxic effects to the human and natural environment. Flood response and recovery efforts would be hindered by the presence of released chemicals. The inhalation, ingestion, and contact with these materials would irritate the eyes, nose and throat. Prolonged exposure would lead to nausea, vomiting, headaches, dizziness, drowsiness and confusion. Relatively high concentrations would lead to respiratory failure, cardiac arrest, unconsciousness and death.

Impacts from the No Federal Action alternative could range from no significant impact under non-flood events, to minor or significant impact during flood events, depending on the location of levee failure and the resulting duration of inundation.

4.3.2 Non-Structural Measures

Floodfighting. This measure attempts to address all objectives through temporary means implemented during a flood event aimed at preventing or minimizing flood damages.

Relocation or flood-proofing of individual structures. This measure aims to reduce or prevent damages in the study area by removing structures or preventing floodwaters from entering them. It does not address any of the objectives specific to the existing system (i.e. overtopping or structural and geotechnical reliability of the existing features).

4.3.3 Structural Measures

Tree clearing and/or channel modification. The related objective addressed is inadequate reliability against overtopping. Channel modification would be aimed at attempting to establish a more efficient cross-sectional flow area along substantial lengths of the levee foreshore to allow a greater discharge capacity, and lower the water surface profile of the design flood.

Modify or replace existing pump stations. The related objective addressed is inadequate reliability against structural failure. All pump stations will be initially evaluated using current criteria and required factors of safety for uplift, strength, and hydraulic capacity. Those found not meeting criteria for any of these failure modes will be proposed for modification or replacement. If evaluation shows that the original purpose of the pump station is no longer required for operation of the project, the pump station will be recommended for abandonment.

Modify or replace existing floodwalls. The related objective addressed is inadequate reliability against structural failure. All existing floodwalls will be initially evaluated for strength, stability,

overturning, and foundation reliability. Any floodwall not meeting criteria for any of these failure modes will be proposed for modification or replacement.

Replace or expand underseepage control features. The related objective addressed is inadequate reliability against geotechnical underseepage failure. Each unit will be initially evaluated using current criteria and required factors of safety for underseepage. Areas showing low reliability for this failure mode will be proposed for replacement or expansion of existing underseepage control features, or if no existing features are present, new installations. Underseepage control is typically achieved through the use of area fill, impervious berms, underground slurry cut-off walls, buried collectors, or relief wells.

Unit Raise. The related objective addressed is inadequate reliability against failure due to unit overtopping.

- Raises of earthen levees typically maintain the existing side-slope profile, resulting in a widening of the levee footprint, often to one side or the other (landside or riverside), or possibly in both directions. If levee width increases are not possible, other methods available include adding retaining walls to limit width increase, adding floodwalls on top of the levee, or replacing the levee with a floodwall.
- Concrete floodwall raises are typically achieved through structural modification, as long as the existing wall base and foundation can provide sufficient support. If modification is not possible, the wall can be removed and replaced with a higher wall on a new foundation.

New CID floodwall tieback. This measure was added for consideration in the CID Unit after the first iteration of screening and alternative formulation. The related objective addressed is to economically achieve reliability against all potential failure modes. The floodwall at the upstream end of the CID Unit has been raised previously and would require very expensive modifications for additional raise, or possibly a complete replacement. A higher floodwall also requires a large number of new underseepage relief wells. The proposed measure consists of constructing a new wall to tie the existing unit into the bluff at a different location, thus eliminating the cost of modification or replacement of a long reach of the existing unit. This would result in a portion of the study area where the current flooding risk would remain; however, this area contains only railroad tracks and no businesses or residences, ensuring no continued life safety risk.

4.3.4 Conclusions from Initial Screening of Measures

4.3.4.1 *Floodfighting*

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. Nor is flood fighting a reliable option for substantially raising the elevation of a large levee unit.

4.3.4.2 ***Non-Structural Measures***

Nonstructural approaches have merit when the site characteristics and the flooding threat are compatible with the nonstructural capabilities. The intent of non-structural measures is not to prevent the flooding from occurring, but to reduce the damages and consequences caused by the flooding. Typical methods include structure removal or relocation, structure elevation, or flood-proofing, either wet or dry. Wet flood proofing allows water to enter the structure but focuses on reducing the damages caused, while dry flood proofing aims at keeping floodwaters outside the structure.

Structure Removal or Relocation. Within the Armourdale and CID Units there are 951 residential structures and 1,043 businesses and public facilities with a total value of approximately $4.27B (October 2012 prices). Due to the large number, density, and value of homes and businesses within these levee units, structure acquisition for removal or relocations is not efficient or acceptable.

Structure Elevation. Structure elevation may provide some protection from moderate floodwaters, but would be inefficient at preventing significant flood damages such as those associated with catastrophic levee failure. The cost of elevating existing buildings is higher than the cost associated with implementing higher building standards for new construction. The estimated cost to elevate an existing home (FEMA 2009), in 2009 dollars, ranges from $30 to $100 per square foot, depending on the type of home and the amount of raise, up to eight feet. Assuming an average home size of 1,000 square feet results in a preliminary cost range of $29M to $95M. The cost to elevate commercial or industrial buildings (if feasible) would be higher.

Structure Flood Proofing. Flood proofing measures generally have limited application where a large number of homes and businesses are located within the flood prone area; and flood proofing of areas below the 100-year flood or base flood elevation (BFE) in residential buildings is not permitted under the National Flood Insurance Program (NFIP), except in communities that have been granted an exception to permit flood-proofed basements. NFIP allows new or substantially improved non-residential buildings in the 100-year floodplain to have a lowest floor below the BFE, provided the design and methods of construction have been certified by a registered professional engineer or architect as being dry flood proofed in accordance with established criteria.

The costs associated with flood proofing existing buildings are also higher than the cost associated with implementing higher building standards for new construction, and the feasibility of flood proofing existing buildings varies based on site and structure constraints. The estimated cost for wet flood proofing an existing home (FEMA 2009) in 2009 dollars, can range from $2 to $17 per square foot depending on the type of structure and the height of flood proofing effort, up

to eight feet. Assuming an average home size of 1000 sq ft. results in a preliminary estimate of $1.9M to $16M for residential structures only. Dry flood proofing costs for commercial structures can vary widely depending on structure type, and is generally considered to only be effective up to three feet. The expected flood depths in the Armourdale and CID units would significantly exceed three feet. Due to the large number of older existing homes and businesses within these levee units and the significant depth of flooding expected by levee failure, flood proofing is not considered efficient or effective.

Other Measures. There are other types of non-structural measures focused on informing and warning the public, removing the public from harm's way, and preventing further development within the area of risk. These include flood-warning systems, floodplain management planning, including emergency action and evacuation plans, and municipal ordinances prohibiting or limiting development. The Kansas and Missouri Rivers are heavily monitored by both the Corps of Engineers and the United States Geological Survey and forecasts of expected river conditions are regularly issued by the National Weather Service. These activities minimize the effectiveness of typical flood-warning systems using gauges and sirens. The local non-Federal sponsors and municipalities in the project area have existing floodplain, emergency, and evacuation plans of varying levels of detail. The multiple sponsors with the assistance of the Kansas City District, are currently engaged in an effort to coordinate these various plans and identify those areas were additional detail and plan development may be necessary. The Corps of Engineers will continue to provide public information, technical, and financial assistance to these efforts beyond this Feasibility Study, as allowed by current authorities and programs. Floodplain ordinances and building codes are recommended, however their implementation is the responsibility of the local municipal governments.

Non-Structural Conclusion. There is already an extensive existing structural flood risk management system providing benefits to the study area. The nature of damages expected from levee failure under the existing condition, and the need and desire for large-scale future risk reduction within the study area, especially from system overtopping, far exceeds the normal performance parameters of typical nonstructural measures. The value of the dense urban development in the study area precludes consideration of large scale relocation, elevation, or flood-proofing of structures. For these reasons, it was concluded that without structural modification of the existing levee system these methods alone would not provide the desired performance improvements and they were not carried forward for further analysis. It is recognized that there may be possibilities and uses for nonstructural measures in addition to, and coordination with, structural alternatives, especially in limited locations for the prevention of damages due to localized interior flooding or for the protection of infrastructure of local importance. These potential limited applications would be best identified and pursued independently by the project sponsors.

4.3.4.3 ***Non-Raise Structural Alternatives***

The management measures discussed previously would be combined to improve the levee system reliability by implementing modifications to structural features (pump stations, gatewells, closures, floodwalls, etc.) and improvements to the underseepage control system, without raising

the existing height of the levee units. The different available methods for structural modification and underseepage control allow for the development of multiple alternative plans under a no-raise scenario.

Channel modification was also evaluated as a separate non-raise alternative plan. Channel modification was modeled for both sides of the Kansas River through the study area and the results indicated some additional conveyance capacity under modified conditions. However, the conveyance gains are very limited (not totally effective and complete) and do not fully serve to establish the desired design discharge.

Furthermore, it is expected that channel modification would have a limited life much less than the 50-year period of analysis. The natural process of meandering and foreshore building would require repeated dredging cycles to maintain the expanded floodway. The overall prospect of massive environmental disruption, extensive maintenance dredging adjacent to the existing levees, the potential creation of new underseepage paths, and the general risk associated with effective timing of dredge cycles and potential floods make the channel-modification measure undesirable.

4.3.4.4 ***Unit Raise Structural Alternatives***

This group of alternatives would improve levee system reliability by implementing the modifications to structures and underseepage control necessary to address identified weaknesses in combination with raising the height of both units. These plans address all potential failure modes. The different available methods for structural modification and underseepage control allow for development of multiple alternative plans for screening under a unit raise scenario. As the unit height is increased, there are many dependencies and conflicts created among the various types of management measures identified. The alternative plans under this scenario must consider all of the following concerns:

- As the levee height is increased, stress on the adjacent structural and geotechnical features also increases, causing associated changes in the scope and viability of the different management measures.
- Measures considered for one feature may cause impacts, either positive or negative, to other features.
- Some existing features which can be modified with no raise, or even a short raise, may need replacement at a higher raise. Similarly, different underseepage control methods will perform differently, and may lose effectiveness, when a raise is considered.
- The raise of an earthen levee requires an expansion of the levee footprint and the need for additional permanent right-of-way on one or both sides of the levee. Considering the urban development of the study area, this is not possible in all levee reaches. Levee raises may need to be constructed with retaining walls to limit footprint expansion, installation of floodwalls on top of the levee, or completely replacing the levee with a new floodwall.

4.4 Plan Formulation and Evaluation

The Interim Feasibility Report recommended improvements to four units of the system: the Fairfax-Jersey Creek, North Kansas City, and East Bottoms Units on the Missouri River, and the Argentine Unit on the Kansas River. The Missouri River Units were determined to have adequate height to resist overtopping at the design flood level, but require significant underseepage and structural modifications to maintain acceptable overall system reliability. In addition to similar geotechnical and structural reliability concerns, the entire Kansas River portion of the system was determined to be of insufficient height to provide adequate overtopping protection. The Interim Report included the detailed analysis of alternatives for the Argentine Unit. The Argentine NED plan was identified as a unit raise that provided a 64% reliability to pass the 0.2% event. This level of flood risk management is consistent with the Missouri River units, and meets economic project justification criteria.

The Armourdale and CID Units are located immediately downstream of the Argentine Unit. In accordance with the planning objective of desiring to achieve a uniform system level of flood risk management and to reduce the potential for induced damages between units within the system, the evaluation of raise alternatives sought a plan that provided at least the same reliability as the Argentine Unit project at the 0.2%-chance water surface profile.

4.4.1 Non-Raise Structural Alternative Plans

While a non-raise structural alternative plan would provide improvements to the structural and geotechnical reliability of the units at their current height, they would not achieve a uniform system level of flood risk management benefit, and reduce the potential for induced damages between units within the system. A no-raise plan would not be consistent with the authorized plan for the upstream unit in the system, or the desired conveyance target.

4.4.2 Unit-Raise Structural Alternatives

Based on the stated study objectives and evaluation criteria, the highest priority was placed on evaluation and screening of the unit-raise structural alternatives. To provide the desired reliability at the 0.2% event results in an actual physical raise above the existing height of between 1.2 to 5.2 feet in the Armourdale Unit, and 0.2 to 3.9 feet in the CID Unit.

The management measures for structural and geotechnical components were evaluated for their feasibility and effectiveness under the future expected hydraulic conditions. The alternative plans combining the most effective measures were retained for further cost-estimating and economic analysis. By focusing first on the required raise, the study team was able to quickly evaluate whether the desired levee height was technically feasible before evaluating lower elevation alternatives. Discussion and results of these evaluations specific to each unit are presented in the following sections.

4.4.2.1 ***Central Industrial District Unit***

Floodwalls. Investigation and engineering analysis confirmed that the floodwall sections can be modified to support the additional increase in height without need for replacement.

Levees. Sufficient real estate is available in the levee reaches for the expansion of width associated with an earthen levee raise.

Underseepage. To control underseepage at the new levee height, area fill to raise the landside ground elevation is proposed for reaches with sufficient real estate availability. In more congested reaches, both relief wells and slurry cut-off walls were feasible at the selected raise. A preliminary estimate of the relative cost of these two measures was calculated for comparison. The overall life-cycle cost of the relief wells was found to be less than the construction of a slurry cutoff wall. The slurry cut-off wall measure was eliminated and only relief wells were included in the final alternative plans.

Existing Pump Stations. The existing pump stations were evaluated for their ability to withstand increased hydraulic uplift pressures and handle flows from additional relief wells. Several stations were found to need strength and capacity modifications, and two smaller stations were determined to be no longer needed and are proposed for abandonment. Since these modifications are primarily driven by the new levee height, they are necessary in any final alternative plan.

Unit Tieback. The inclusion of a new tie-back connection between the existing unit and the river bluff was determined feasible on several different alignments. Where the tieback connection is located along the existing alignment impacts the resulting number of new relief wells needed, whether or not a new pump station is required to handle the relief well flows, and the number and locations of new railroad crossings and closure structures. These options allow for several alternative plans to be considered for the final analysis.

4.4.2.2 ***Armourdale Unit***

Due to the varying existing conditions and characteristics of the study area, it was necessary to separately evaluate alternative plans for discreet reaches of the overall unit. For underseepage evaluation, the unit was divided into reaches of similar geotechnical conditions (unit height, impervious soil blanket thickness, aquifer thickness, seepage entrance condition, etc.). Evaluation of the different raise measures in each reach considered existing protection (levee vs. floodwall), adjacent development, the potential for real estate conflicts, and potential encroachment into known areas of Hazardous, Toxic, and Radioactive Waste (HTRW) contamination.

Floodwalls. Each reach of existing floodwall was evaluated to determine if the existing wall and foundation were adequate, or could be modified successfully, to support additional height. Analysis indicated that the existing floodwall from stations 60+40 to 70+80 cannot be modified to support a raise leaving only replacement as a viable measure. The existing floodwall from stations 257+65 to 302+58 can be modified to support the raise, except for the section from 274+36 to 277+21 that must be realigned to avoid conflicts between new closure structures and the Missouri Pacific and Union Pacific Railroad Bridges. A new section of raised floodwall incorporating new closures to replace the existing wall is the most feasible alternative at this location.

Levees. Where possible, earthen levee raises are the preferred, and typically least cost, alternative. As discussed previously, earthen levee raises create a wider levee footprint, either landside or riverside of the existing levee. In almost all reaches of this unit, the levee is immediately adjacent, or integral, to the Kansas River bank slope, eliminating the possibility of a riverside raise. Landside levee width increases are significantly complicated by the potential for real estate conflicts with adjacent businesses, railroads, utilities, pump stations, and areas of environmental concerns. Additionally, in some reaches, certain measures would create limitations to unit access needed for maintenance, inspection, and operation.

In the initial evaluation of alternatives in each reach, the PDT decided to eliminate all levee raise alternatives that caused encroachment on adjacent buildings, infrastructure, and known areas of environmental contamination. In the reaches where earthen levee raise would not fit this constraint, the evaluation next considered levee raises with retaining walls to limit width increase, then floodwalls on top of the existing levee, and finally replacing the levee entirely with a new floodwall. The evaluation of alternatives thus focused on the avoidance of real estate relocation costs. If the conflicts were strictly concerns of real estate easements or project access, the alternatives were retained for the final evaluation.

Those levee reaches with no HTRW or real estate concerns were only evaluated to be raised by typical earthen levee methods. All other alternatives in these reaches were eliminated from further consideration.

The existing unit ends at Station 61+00LE. Downstream of Station 42+00LE the required levee height increase to match the desired reliability is less than 1.2 feet. While a landside levee raise is technically feasible in this reach, the implementation of this raise will conflict with the adjacent active railroad track. This single track is the only existing infrastructure receiving benefits in this reach. On the opposite side of the track is the high ground embankment of an existing city street (James Street). It is feasible to tie into this existing high-ground with a sand bag closure structure across the railroad track at Station 42+00, this shortening the unit by almost 2,000 linear feet. The existing levee would remain in place providing benefits to the lower reach up to its current elevation. If this reach is overtopped, the sand bag gap would prevent floodwaters from backing up into the rest of the study area. This alternative would eliminate the railroad impacts of a raise. Both alternatives for this reach are retained for the final evaluation.

Underseepage. Three reaches of the unit were identified as potentially not meeting required underseepage factors of safety under the proposed future raise. In all identified reaches, the proximity of urban development eliminated consideration of additional or expanded berms. The evaluation next considered the use of pressure relief wells or a slurry cut-off wall at each location. However, similar to the CID-KS evaluation discussed previously, the cost of a slurry wall installation was found to be greater than the life-cycle cost of relief wells, making the use of wells the preferred alternative. In the reach from Station 295+00 to 313+00, thirty-five new relief wells are needed to address increased hydraulic pressures. In the reach from station 62+00 to 82+00 adjacent railroad tracks and facilities would need to be relocated for relief well installation. Additionally, this reach overlaps with an identified groundwater contamination concern between stations 45+00 and 75+00. A slurry cut-off wall constructed to bedrock is the

only remaining option. In the reach from 257+65 to 295+50,which includes the railroad "slot", the existing ground surface is significantly lower than surrounding areas. Placement of area fill in this low area was deemed sufficient to improve underseepage safety.

Pump Stations. Six pump stations require modifications due to either insufficient strength, potential for flotation, or inadequate capacity to handle relief well flows. Two additional pump stations are no longer needed as the facilities they were built to service are no longer in existence. These pump station modifications are necessary regardless of how the unit is raised and are common to all final alternative plans.

4.4.3 Initial Economic Analysis

Preliminary economic analyses were prepared in 2006 to assist in the screening of the initial array of alternatives. As stated previously, the selection of management measures and development of alternatives was limited by the Planning Objective of achieving and maintaining a uniform level of flood risk management for the Kansas Citys system. The Argentine NED plan recommended in the Interim Feasibility Report was applied as the desired target for system performance in the Kansas River units. Costs and benefit estimates were prepared for two other scales of levee raises and associated modifications leading up to this target. Although these lower raise alternative plans do not meet all of the study objectives they were necessary for comparison to ensure the identification of the plan, or plans, that meet economic criteria within each levee unit and the overall system. The economic analysis of the three Kansas River raise alternatives evaluated are shown in Table 4-1 with Kansas River Plan 3 (KR3) representing the plan consistent with the Argentine Unit NED plan. Cost estimates for the Argentine Unit were included to allow for comparison of the Kansas River three-unit system total.

Table 4-1: Screening Analysis of Alternative Raise Profiles

Unit	First Cost	Total Annual Cost	Total Annual Benefits	B/C	Net Benefits
Kansas River Plan 1 (KR1)					
Argentine	$33,042,548	$2,093,795	$16,322,473	7.80	$14,228,678
Armourdale	$51,723,299	$3,371,286	$5,234,014	1.55	$1,862,728
CID-KS	$39,959,191	$2,563,797	$3,266,651	1.27	$702,854
TOTAL	$124,725,038	$8,028,878	$24,823,138	3.09	$16,794,260
Kansas River Plan 2 (KR2)					
Unit	**First Cost**	**Total Annual Cost**	**Total Annual Benefits**	**B/C**	**Net Benefits**
Argentine	$33,945,404	$2,150,335	$16,560,871	7.70	$14,410,536
Armourdale	$61,233,118	$3,984,373	$5,553,332	1.39	$1,568,959
CID-KS	$40,482,623	$2,597,032	$3,454,202	1.33	$857,170
TOTAL	$135,661,145	$8,731,740	$25,568,405	2.93	$16,836,665
Kansas River Plan 3 (KR3)					
Unit	**First Cost**	**Total Annual Cost**	**Total Annual Benefits**	**B/C**	**Net Benefits**
Argentine	$35,313,745	$2,278,318	$17,081,997	7.50	$14,803,679
Armourdale	$63,411,583	$4,138,267	$5,744,664	1.39	$1,606,397
CID-KS	$41,759,697	$2,686,581	$3,608,586	1.34	$922,005
TOTAL	$140,485,025	$9,103,166	$26,435,247	2.90	$17,332,081

Note: Oct 2005 prices; 5.125% interest rate (Prepared Feb 2006)

The 2006 screening results indicated that the total net benefits of the three-unit Kansas River system were continuing to rise at the KR3 plan. Traditional economic analysis requires the identification of the plan that maximizes the net economic benefits, defined as the National Economic Development (NED) Plan, which usually means analyzing progressively larger plans until it is shown that net benefits have begun to decrease. The screening results indicated that the NED plan for these units would be somewhere above the plan identified as the preferred maximum, which also meant that it would be inconsistent with uniform system performance. In consultation with the project sponsors it was agreed that it was not desired to continue the analysis of larger plans to identify the NED, as allowed by the Categorical Exemption to NED Plan stipulated by ER 1105-2-100, Section 3-3.b.(11), which states:

> *For flood damage reduction studies, where the non-Federal sponsor has identified a desired maximum level of protection, where the with-project residual risk is not unreasonably high, and where the plan desired by the sponsor has greater net benefits than smaller scale plans, it is not required to analyze project plans providing higher levels of protection than the plan desired by the sponsor*.

The results of the initial economic analysis and application of the Categorical Exemption supported the selection of the KR3 plan as the system levee height for alternative formulation. Further alternative evaluations and comparisons for the Armourdale and CID units focused on the development and refinement of plans to implement this selected raise plan and address the associated underseepage and stability concerns.

4.4.4 Efficient Combinations of Measures and Scales

4.4.4.1 *Central Industrial District Unit Alternative Plan Development*

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

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

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

Note that Alternative Three and Alternative Six are identical in terms of floodwall tieback location and height, number of closure structures, and number of relief wells. The thirty relief wells will be designed to surface discharge and thus will provide the same degree of underseepage control in the future-with-project-condition, with or without a pump station. At the time the alternatives were first developed and screened it was unknown if a pump station would be needed in order to prevent interior flooding damages as a result of the relief well flows. The pump station analysis is summarized in Section 4.4.4.3.

Similarly, Alternative Two and Alternative Five are identical with the exception of the header pipe included in Alternative Five. Alternative One and Alternative Four each stop at Station 130+00 and turn to the bluff and each include four additional stop log gaps. Alternative One also includes 15 new relief wells, whereas Alternative Four includes a smaller pump station but no new relief wells.

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

<u>Tieback at Sta. 130+00</u>: Alternatives One and Four assume that a tieback is constructed to the bluff starting at Sta. 130+00, immediately downstream of the Kansas City Terminal Bridge. The existing floodwall upstream of Sta. 130+00, including the existing stop log closure at the KC Terminal Bridge, would not be raised. The tieback would require four new stop log closure structures and 15 new relief wells. Alternative Four assumes that a new small pump station would be needed to handle additional relief well flows. Alternative One does not include a pump station. Both alternatives have the same future with and without project conditions. Implementation of either alternative will provide reliable flood risk management up to the recommended plan top of levee elevation along the existing unit alignment downstream of Station 130+00. Upstream of this location, the existing floodwall would remain in place and continue to provide benefits up to its current elevation. If a flood exceeded this height, this reach

would overtop causing inundation of the railroad tracks. The new tieback would prevent these floodwaters from entering the rest of the study area.

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

4.4.4.2 *CID Cost Screening Evaluation*

In July 2008, screening level cost estimates were prepared for the six final alternatives. The results are presented in the following Table 4-2.

Table 4-2: CID-KS Screening Cost Estimates

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

Note: October 2008 Prices

4.4.4.3 *CID New Pump Station Analysis*

Following the initial plan evaluation and cost estimates, further analysis was conducted to determine the technical necessity of a new pump station to handle relief well flows. A review of the existing interior storm drainage system showed that if all proposed new relief wells were installed as surface discharging, there was adequate capacity to carry the expected flows to existing sewer outlets and pumping facilities. Removing the new pump station from the proposed alternative plans eliminates Alternatives Four, Five, and Six from consideration (they are now identical to Alternatives One, Two, and Three, respectively). Furthermore, with no pump station the estimated cost of Alternative Two is reduced by approximately $8.9 million, for a new estimate of $121.l million. The estimates for Alternatives One and Three are not affected by this pump station evaluation.

4.4.4.4 ***CID Floodwall Foundation Investigation***

In December of 2010, an investigation was conducted of the existing condition of the timber pile floodwall foundations. The intent of this investigation was to address one of the Key Uncertainties previously identified. In each reach of existing floodwall, an excavation was made on the landside of the wall to expose the existing timber foundation for inspection and analysis. The excavations were at approximately Stations 30+00 and 114+00. At each location the piles were inspected and their condition documented. Sonic Echo Methods/Impulse Response (SE/IR) was used to estimate the length and soundness of the piles. Ultrasonic Pulse Velocity (UPV) testing was attempted at one location with no useful results, and Sonic Pulse Velocity (SPV) testing was used at both locations. Wood cores were obtained from Stations 114+00 for laboratory testing to determine specific gravity, moisture, creosote penetration, and fungal testing.

The results of the inspection and analysis indicated that the existing foundation was in good condition. This led to a revised assumption by the study team concerning the ability of the existing foundation to provide support for floodwall modifications. The previous assumption had been that the foundation would not be able to provide support for modifications and that the existing walls would need complete replacement.

The change from floodwall replacement to modification decreased the cost of all three remaining alternative, but did not alter their relative ranking. Alternative Three is still the lowest cost alternative plan, there by maximizing the net economic benefits. Alternative Three was retained as the Recommended Plan for the Central Industrial District Unit.

4.4.4.5 ***Armourdale Unit Alternative Plan Development***

Alternative evaluation determined that, in most of the reaches of the unit, only one alternative plan was identified as technically feasible and effective to perform the desired raise and address the respective impacts to appurtenant structural and geotechnical features. These individual reach alternatives are thus common to all final alternative plans for the overall unit. Similarly, structural and hydraulic pump station modifications are necessary based on the new unit height and are common to the final array of plans.

The final evaluation of alternatives thus focused only on those unit reaches where more than one feasible alternative was identified and carried forward. In five separate reaches of the unit, multiple raise alternatives were identified as feasible. These reaches and their alternatives are shown in Table 4-3.

Table 4-3: Armourdale Reaches for Further Evaluation

Start Station	End Station	Remaining Alternatives
		1. Landside levee raise.
		2. Riverside levee raise.
10+00UE	16+48UE	**3. Replace levee with floodwall.**
		1. Landside levee raise
		2. T-wall on levee.
77+80	81+00	3. **Replace levee with floodwall.**
		1. Landside levee raise.
95+00	105+00	**2. T-Wall on levee**
		1. Landside levee raise
120+00		**2. Landside levee rise with retaining wall**
		1. Landside levee raise
230+00		**2. T-Wall on levee**
		1. Landside levee raise.
		2. T-Wall on Levee.
240+00	257+66	**3. Replace levee sections with floodwall.**
		1. Landside levee raise.
42+50LE	61+00LE	**2. New sandbag gap closure at Sta. 42+50LE.**

Note: **Bold font** indicates selected alternative.

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

Sta. 10+00UE to 16+48UE. A landside levee raise would require relocation of railroad tracks and a riverside levee raise would require modification of two large outfall structures. Replacement of the existing levee with a floodwall eliminates all real estate conflicts. Alternative Three is recommended.

Sta. 77+80 to 81+00. A landside levee raise would require relocation of railroad tracks. A T-wall on the levee limits top of levee road accessibility to this area of the unit. The access cannot be rerouted to the landside due to the railroad tracks. Replacement of the levee with a new floodwall eliminates the real estate conflicts and maintains access. Alternative Three is recommended.

Sta. 95+00 to 105+00. A landside levee raise would encroach upon an area needed for access to an adjacent business, Kansas City Hardwoods. A T-Wall on top of the levee limits top of levee road access, but access could be rerouted on the landside in the same area as the business access. Alternative Two is recommended.

Station 120+00. A landside levee raise would encroach upon an adjacent business, KC Railcar. The use of a retaining wall at the landside two would limit the increase in levee width and avoid this conflict. Alternative Two is recommended.

Station 230+00. A landside levee raise would encroach upon an adjacent business, Sambol Meat Packing. A T-wall on top of the levee would eliminate the increase in levee width and avoid this conflict. Alternative Two is recommended.

Sta. 240+00 to 257+66. This reach contains two existing levee sections separated by an existing floodwall section. The floodwall has already been identified for replacement as its foundation cannot support modification for a raise. A landside raise of the levee sections would encroach upon areas used by adjacent businesses for storage and access. A T-Wall on top of the levee would limit top of levee access. Landside access in this reach is already difficult due to the operations of multiple adjacent businesses and the Kansas Ave. bridge approach. Replacement of the levee sections with new floodwall eliminates the real estate conflicts, creates additional area for landside access, and provides for a uniform raise measure for the entire reach. Alternative Three is recommended.

Sta. 42+50LE to 61+00LE. Even though a landside levee raise would be a very short increase in height, access and implementation of the project would conflict with the adjacent railroad track. A new sandbag gap closure at Sta. 42+50 eliminates this minor unit modification and potentially costly real estate conflict. Alternative Two is recommended.

The evaluation of the technical alternatives in each discrete reach of the Armourdale Unit resulted in only one feasible method of achieving the levee height increase and address associated structural and geotechnical impacts. The combination of alternatives in each reach results in one complete alternative plan for the Armourdale Unit to meet the study objectives and constraints. Thus, there are no other plans for a cost screening evaluation. The remaining Alternative Plan is the Recommended Plan for the Armourdale Unit.

4.4.5 Formulation Criteria

Planning objectives and early economic analysis led to the determination of the KR3 levee raise plan as the desired level of flood risk management. All subsequent alternatives formulated provide the same level of future economic benefit to the study area. The evaluation and comparison of the final array of alternatives focused on those alternative measures and plans that maximized the cost effectiveness of the project, thereby increasing the net economic benefit. Economic screening and evaluation was conducted in 2008 and used the prices and interest rates current at the time.

Screening level cost estimates and estimated construction periods for each of the alternatives were developed in accordance standard Corps of Engineers estimating practice. Interest during construction (IDC) for each alternative was calculated based on the total first cost for each alternative, the starting and completion dates for each phase, assumed equal monthly expenditures during each phase, and the Federal interest rate of 5.375%. Potential Federal

funding constraints were not considered in the starting and completion dates of the implementation phases; appropriate funding was assumed available for each phase.

The total first cost for each alternative includes the estimated construction cost, cost for lands, easements and rights of way, preliminary engineering and design cost, supervision and administration cost, and contingencies. Interest during construction calculated for each alternative was then added to the total first cost to derive the economic cost of each alternative. The economic cost was then annualized for a 50-year period of analysis and a 5.375% interest rate. Other direct costs of project implementation (such as potential induced damages) were determined and included in the total annual project implementation cost.

4.5 Results of Plan Formulation and Evaluation

4.5.1 Costs for Operation, Maintenance, Repair, Rehabilitation, and Replacement

Operation, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R) costs were estimated for each alternative and are based on a life cycle cost analysis. The analyses include only the additional OMRR&R costs that the sponsors would be expected to incur based on the proposed unit modifications. The analyses considered and accounted for the additional OMRR&R in each year of occurrence, and then computed a present worth value of the future OMRR&R costs. The present worth value was then annualized using a Federal Interest Rate of 3.5% and a 50 year period of analysis. Following are the major assumptions used in determining the additional OMRR&R costs that the local sponsors would incur with each alternative.

- New Relief Wells: Each new well is assumed to be maintained every four years at an estimated cost of $5,000 per well. New wells are assumed to be replaced after 40 years at a cost equal to the current construction cost; the replacement cost includes 10% E&D and 7% S&A. The sponsor would continue to incur costs for any existing relief wells but these costs are ongoing for the existing project and are not included in the analysis of the proposed project.

- The levee units in the Kansas Citys project are well-maintained and the sponsors comply with annual inspection requirements. It is assumed that the sponsor's current OMRR&R costs for the existing project will continue.

4.5.2 Other Economic Benefits Not Quantified

The Corps of Engineers benefit evaluation process involves analysis of the economic losses to the subject study area from flooding, and the potential gains to the study area from the successful prevention of flooding. Some of the economic impacts that are likely to occur in the “without project” condition may be of major significance to a metropolitan area or community, but may not have any net impact on the national economy. For example, if a flood interrupts production at a given business in one community, that community suffers a loss. However, if the lost production is replaced by production at another plant elsewhere in the country, the loss to the local community does not represent a net loss to the national economy. These regional (RED)

impacts are not included in determining the NED benefits and costs, but should receive consideration in the overall decision-making process.

In the Kansas Citys study area, some major production facilities are either a sole producer of a specific product or are one of just a very few in the nation that produces that product. Proctor and Gamble is a prime example in the Armourdale Unit. Loss of production capability in these instances could be an economic loss to the nation unless consumers were able to find a similar product and made the choice to purchase the substitute product. However, these potential NED losses were not quantified for purposes of this study.

4.6 Plan Selection

4.6.1 Verification of the Systems Analysis

As previously presented in Table 4-1, a comparison of costs and benefits of different system raise alternatives was conducted in 2006 and identified the KR3 plan as the preferred raise maximizing the net economic benefit for the system within the Planning Objectives and Constraints and the desires of the Non-Federal sponsor.

During the economic analysis of the Recommended Plan it was recognized that the current annual costs and benefits are significantly higher than in the 2006 screening, especially in the Armourdale Unit, even after adjustment for inflation. The earlier calculation of economic benefits was derived from overtopping failure impacts only. Potential geotechnical and structural failure modes identified and evaluated since that time can lead to flooding risks and impacts at lower elevations than overtopping, thus increasing the benefits. Similarly, the relative project costs are greater due to the measures required to address these additional project concerns. The addition of new potential failure modes, and the plan formulation to address them, represents a change in the Future With Project condition upon which the initial economic analysis was based. A new comparison of the costs and benefits of the different levee height alternatives was required to verify the optimization of net benefits.

Updated economic benefits were determined for the KR1 and KR2 raises. A review of the Recommended Plan cost estimate was conducted to determine costs for the lower raise alternatives. As the different alternatives are in the same locations, requiring essentially the same easements, equipment, contracting, design effort, etc., there is only a relatively small cost savings of building a levee one or two feet lower. The primary cost differences are related to material quantities of earth and concrete for the levee and floodwall raises and underseepage berms, and the number of required relief wells. An update to Table 4-1 is presented in Table 4-4. As shown in the table, each individual unit, and the three-unit Kansas River system collectively, continue to show rising net benefits at the KR3 raise alternative.

Table 4-4: Updated Screening Analysis of Alternative Raise Profiles

Kansas River Plan 1 (KR1)					
Unit	**First Cost**	**Total Annual Cost**	**Total Annual Benefits**	**B/C Ratio**	**Net Benefits**
Argentine	$59,812.5	$3,279.3	$17,367.1	5.30	$14,087.8
Armourdale	$219,948.0	$12,428.9	$47,685.6	3.84	$35,256.6
CID-KS	$74,135.0	$4,190.1	$5,430.4	1.30	$1,240.3
Total	$353,895.5	$19,898.3	$70,483.1	3.54	$50,584.8
Kansas River Plan 2 (KR2)					
Unit	**First Cost**	**Total Annual Cost**	**Total Annual Benefits**	**B/C Ratio**	**Net Benefits**
Argentine	$61,446.8	$3,368.5	$17,620.7	5.23	$14,252.2
Armourdale	$223,814.0	$12,640.0	$48,465.7	3.83	$35,825.7
CID-KS	$81,157.0	$4,573.5	$6,532.1	1.43	$1,958.7
Total	$366,417.8	$20,582.0	$72,618.6	3.53	$52,036.5
Kansas River Plan 3 (KR3)					
Unit	**First Cost**	**Total Annual Cost**	**Total Annual Benefits**	**B/C Ratio**	**Net Benefits**
Argentine	$63,923.7	$3,503.8	$18,175.2	5.19	$14,671.4
Armourdale	$232,984.0	$13,140.8	$50,006.8	3.81	$36,866.1
CID-KS	$83,682.0	$4,711.4	$7,389.0	1.57	$2,677.7
Total	$380,589.7	$21,355.9	$75,571.1	3.54	$54,215.2

Notes: Oct 2012 prices; 3.75% interest rate; $000s

4.6.2 Recommended Plan Cost Estimate and Cost Risk

Project costs are summarized in Table 4-5. For additional detail of the cost estimates and cost risk analysis, see the Cost Estimating Appendix. Costs were prepared by cost engineering for each of the alternatives. All costs include interest during construction computations which assume project completion in mid-2026. All costs reflect an October 2013 price level and the annualized totals reflect the current Federal interest rate of 3.5 percent and a 50-year period of analysis. OMRR&R costs were included in this analysis for those features that will incur a net cost over and above present levels. The additional OMRR&R is due to net increases of twenty relief wells in the CID unit and fifty-nine in the Armourdale unit.

Table 4-5: Project Cost Summary

Category	**Cost ($1,000's)**			
	Armourdale	**CID-KS**	**CID-MO**	**Total**
Lands & Damages	$ 2,024	$ 1,730	$ 0	$ 3,754
Construction Elements				
Relocations	$ 1,389	$ 246	$ 0	$ 1,635
Floodwalls and Levees	$ 145,867	$ 49,451	$ 380	$ 195,698
Pumping Plants	$ 5,943	$ 1,971	$ 0	$ 7,914
Subtotal	$ 153,199	$ 51,668	$ 380	$ 205,247
Preconstruction, Engineering, and Design (PED)	$ 11,934	$ 4,156	$ 32	$ 16,122
Construction Management	$ 10,724	$ 3,616	$ 27	$ 14,367
Contingencies	$ 54,769	$ 19,006	$ 136	$ 73,912
Total First Cost	$ 232,650	$ 80,177	$ 575	$ 313,402
Interest During Construction (IDC)	$ 52,388.5	$18,361.2	$127.3	$ 70,877.0
OMRR&R	$ 191.6	$ 144.9	$ 0	$ 336.5
Total Annual Costs	**$ 12,343.80**	**$ 4,345.90**	**$ 29.90**	**$ 16,719.70**

Total first costs = PED + LERRD + construction + S&A
Annual costs = ((Total first costs + IDC) x I&A factor of 0.004457) + OMRR&R
Annual OMRR&R costs include only additional costs over and above existing costs

For each unit a cost and schedule risk analysis was conducted that identified possible risks, their likelihood of occurrence, and the significance of their impact. A Monte Carlo computer model then calculated multiple iterations and combinations of the possible risks and resulted in the appropriate contingency percentage applied to each estimate to ensure an 80% confidence that the recommended plan will not exceed the estimated cost. The majority of the risks driving the contingency are unrelated to the technical issues of the study and thus much more difficult to control. The risks showing the highest impact to the contingency are:

- Market/Bidding Conditions. The economy is in a downturn. Contractors looking for work will compete aggressively for large jobs.

- Adequacy of Project Funding. Estimate and project schedule assumes optimal availability of funds. Risk considers both incremental congressional appropriations and the Sponsors ability to cost share. Slow funding extends project schedule resulting in higher costs for future inflation.

- Undefined Acquisition Strategy. Project estimate assumes full and open competitive bidding for contract acquisition. Changes in acquisition strategy may affect competition costs.

- Contract Modifications. Unknown or unforeseen site conditions or changes not currently captured in the cost that will require contract modifications.

- Prime/Subcontractor Structure. Estimate assumes large business competitive bids. More subcontracting increases overhead and markups.

- Confidence in Scope. In some cases plan formulation was made on limited information, leading to assumptions by the designers. Risk factors were assigned to specific pieces of the Recommend Plan scope.

    - CID. Risk factor assumes possible change from floodwall modification to partial floodwall replacement and possibility of one additional pump station required

    - Armourdale. Risk factor assumes an increase in relief wells required, changes in the cost of gatewell modifications, and a possible change in the length of floodwalls needing replacement.

4.6.3 Recommended Plan Economic Analysis

Economic analysis discussed previously identified the expected economic impact of future flooding with the existing project. To aid in comparison of the alternatives, additional economic analysis was conducted to develop a risk-based evaluation in terms of benefits, costs, and performance of the alternatives under the with-project condition. The analysis encompasses all flood-prone properties within the study area.

Extensive economic surveys of the whole Kansas Citys Levees study area were completed in 2002. Economic data developed for this analysis includes values, elevations and depth-damage relationships for homes, businesses, public facilities, roads, and railroads in the study area. Furthermore, a follow up survey was conducted in early FY2012 to update the economic field data. Conditions are evaluated in terms of a base year of 2026 when the project would be operational and a future without-project conditions year of 2049. The same data set was used for both 2026 and 2049 conditions.

A risk-based economic damage analysis was performed using the HEC-FDA software that is standard in the Corps for flood damage reduction analyses. Water surface profiles with stages and discharges were obtained for eight probability events: 0.10, 0.01, 0.005, 0.002, 0.0013, .0001, 0.0008, and 0.0007. The profiles are referenced to 2008 conditions, although it should be noted that no increases in these stages are forecasted through the period of analysis and the same profiles are used for existing, base year, and future conditions. The exceedance-probability relationship for the Kansas River was evaluated using the graphical method, which involves specifying a discharge-probability relationship (including a discharge for the 0.999 probability event) for each index point along with the equivalent record length for the stream. Top of levee stages based on the critical levee low point were translated to each index point, as were exterior-interior stage relationships. Geotechnical and structural probability of failure curves were developed for critical sections on each levee, adjusted to the appropriate index points, and a combined probability of failure was computed using a formula from ETL 1110-2-556, *Risk Based Analysis for Geotechnical Engineering for Support of Planning Studies* (Formula: Pr(f) = 1-(1-p1)(1-p2),,,(1-pn)). The resulting combined probability of failure versus river stage curve was entered into the HEC-FDA study file in the "Levee Features" section.

It can be seen in Table 4-6 that in addition to the strong benefit-cost ratio for the Kansas River system-wide project, each unit is also individually justified. The combined Phase 2 portion of the total project has a benefit-cost ratio of 3.4, while Armourdale unit's benefit-cost ratio is 4.1 and the CID portion stands at 1.2. With Phase 2 net benefits of $39.5 million, the project represents a strong contribution to national economic outputs.

Table 4-6: Economic Analysis Summary

Oct 2013 prices; 3.5% interest rate; 50 year period of analysis; $1000s

Levee Unit Alternative	Annual Costs	Annual Benefits	Benefit-Cost Ratio	Net Benefits
Armourdale				
KR3 Plan	$ 12,343.8	$ 51,457.1	4.2	$ 39,113.2
Central Industrial District				
KR3 Plan	$ 4,375.9	$ 5,229.6	1.2	$ 853.7
Total Phase 2 Study Area	**$ 16,719.7**	**$ 56,686.6**	**3.4**	**$ 39,966.9**
Authorized Argentine Plan	$ 3,821.5	$ 18,180.0	4.8	$ 14,358.5
Kansas River System	**$ 20,541.2**	**$ 74,866.6**	**3.6**	**$ 54,325.4**

The primary benefits of the Recommended Plan are the reductions in the potential for flood damage. Because much of the protected area is already industrial, implementation of the Recommended Plan will provide continuity to the current employment base of the area. In the long-term, business volume, personal income, employment, and taxes are not expected to change significantly as a result of implementing the Recommended Plan. However, with improved flood risk management, new business and investment would be more easily attracted to the protected area if vacancies were to occur.

During the short-term, construction of the Recommended Plan can be expected to temporarily increase employment. The temporary presence of construction workers is likely to being a temporary increase in the demand for local area goods and services. Taken together, this is likely to result in a temporary increase in retail business and associated profits, and increased sales tax receipts at the local level.

4.6.4 Principles of Flood Risk Management Planning and Associated Analysis

The Corps of Engineers functions and operates in accordance with laws established by Congress. The Corps develops policy and guidance for implementation of the laws under which it operates. The laws, and Corps policy and guidance, provide for the use of prescribed methodologies and nationwide uniformity in the Corps planning process. Corps planning products are reviewed locally, independently, and by three levels of Washington review, i.e., Corps Headquarters, Assistant Secretary of the Army for Civil Works, and Office of Management and Budget. Reviews not only ensure consistency and accuracy in the application of the prescribed methodologies, but determine and confirm that the work was completed with adherence to guidance, policy and the law.

The structured and uniform planning process implemented and followed by the Corps of Engineers is documented in Engineering Regulation 1105-2-100, Planning Guidance Notebook. This regulation is grounded in the laws which apply to the Civil Works Program and to the Corps of Engineers missions, and is particularly based on the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) (March 10, 1983). The P&G were established pursuant to Section 103 of the Water Resources Planning Act (Public Law 89-80) and Executive Order 11747.

Corps policy and guidance provide for proper and consistent planning in the formulation of reasonable plans responsive to National, State, and local concerns. The resulting plans recommended for implementation are economically and environmentally sound and in general reasonably maximize net national economic development benefits, consistent with protecting the Nation's environment (NED plan). Contributions to national economic development (NED) are increases in the net value of the national output of goods and services, and are the direct net benefits that accrue in the planning area and in the rest of the nation as a result of project implementation.

The Corps uniform planning process includes certain fundamental principles in the analysis of flood risk management alternatives. These principles include, among others:

- With and Without-Project Analysis. The without-project condition is the most likely condition expected to exist in the future in the absence of a proposed water resources project. The future without project condition constitutes the benchmark against which plans are evaluated.

- Benefit-Cost Analysis and Cost Effectiveness Analysis. This is a framework used in evaluating government investments. All pertinent costs and effects of a proposed project are systematically identified and tallied. The stream of monetized benefits that occur through time with project implementation are accumulated and are discounted to a base year in order to express a single total benefit figure. Similarly on the cost side the same accumulating and discounting process is conducted so the costs are also expressed as a single value in the base year. This process allows direct comparison of benefits and costs on a common basis. If the benefits exceed the costs the project is considered economically justified. Allowable benefits categories and required cost categories to be used in analysis of Corps water resource projects are standardized across the nation. Cost effectiveness analysis seeks to answer the question: given an adequately described objective, what is the least-costly way of attaining that objective.

- Net Benefits, Optimization Analysis. Benefits can be monetary or non-monetary. The scale of flood risk management alternative that reasonably maximizes expected net benefits (returns the greatest excess of benefits over costs) is the National Economic Development (NED) Plan.

- Risk and Uncertainty. Risk-based analysis is defined as an approach to evaluation and decision making that explicitly, and to the extent practical, analytically, incorporates considerations of risk and uncertainty in a flood risk management study. In water resources planning, risk-based analysis is used to compare plans in terms of the likelihood and variability of their physical performance, economic success, and residual risks. It captures and quantifies the extent of risk and uncertainty in the various planning and design components of an investment project.

4.6.5 Risk Based Analysis of Flood Risk Management Alternatives

Flood risk management projects can significantly reduce risk of flooding, but 100% absolute protection from flooding is not an achievable goal. A zero residual risk does not exist because no project can completely eliminate natural hazards. Flooding may occur less frequently but there is always some residual risk of flooding after implementation of any flood risk management project.

Historically, many flood control projects were planned, designed, and constructed on the Standard Project Flood (SPF). The SPF was generated using modeling techniques to determine a single target design discharge. In later years, the SPF may have been associated with a return interval to describe an expected level of protection for a given flood control project. In the context of risk analysis guidance, the SPF is no longer used for a “target design”. Instead, a

range of floods, including those that exceed the SPF, are to be used in formulation and evaluation of alternatives. The historic SPF method relied on safety factors and freeboard, estimates of worst case scenarios, and other indirect methods to compensate for uncertainty. These indirect methods were necessitated due to the mathematical complexities involved in computing the interaction of uncertainties in hydrologic, hydraulic, and economic functions. However, with computational advances it is now possible to describe these uncertainties explicitly and calculate that interaction.

For risk and uncertainty analysis, the Corps of Engineers uses risk-based analysis procedures for formulating and evaluating flood risk management measures according to guidance in Engineering Manual 1110-2-1619, Engineering and Design Risk Based Analysis for Flood Damage Reduction Studies; and in Engineering Regulation 1105-2-101, Planning Risk Analysis for Flood Damage Reduction Studies. Risk and uncertainty arise from measurement errors and from the underlying variability of complex natural, social, and economic situations. Flooding is random in nature and flood problems are multi-dimensional making it difficult to fully understand, document, and model the physical nature of flooding, its magnitude, its probability of occurrence, and its consequences. Risk is defined as the probability an area will be flooded, resulting in undesirable consequences. Uncertainty is a measure of imprecision of knowledge of parameters and functions used to describe the hydraulic, hydrologic, geotechnical, structural, and economic aspects of a project plan.

In water resource planning for flood risk management, uncertainties in the hydrologic and hydraulic data about discharges and flood stages, uncertainties in economic data about investment values, beginning damage elevations, and damages with various flood depths, and uncertainties about the potential for geotechnical or structural failure of features in an existing flood control project can have significant impact on the residual damages, benefits, costs, planning, design, and reliabilities of a proposed flood control project.

To develop a risk based analysis as required by regulation, the Corps uses the HEC (Hydrologic Engineering Center) Flood Damage Analysis (HEC-FDA) model. The HEC-FDA model combines the engineering and economic study data to determine economic performance (flood damages) and engineering performance (probability of design exceedance) with and without a flood control project. The HEC-FDA model uses the Monte Carlo simulation process which incorporates the risk and uncertainties associated with the required HEC-FDA input values.

Planners cannot know with full certainty the exact value of a variable that may ultimately be important to the selection and implementation of a plan. The analysis instead considers a best estimate of the value, and recognizes the uncertainty inherent in that value by also using other possible values (often in terms of input curve). The range of outcomes in some areas of risk and uncertainty can be reasonably described or characterized by a probability distribution. Certain future demographic, economic, hydrologic, and meteorological events are essentially unpredictable because they are subject to random influences; however the randomness can sometimes be described by a probability distribution based on historical data. If there is no historical database, the probability distribution of random future events can be described subjectively, based on insight and judgment.

Key variables explicitly incorporated into the risk based analyses used in the Kansas Citys feasibility study included the following:

Hydraulic uncertainty. A stage-exceedance probability function was developed from the water surface profiles and a normal probability distribution was selected. Conveyance roughness and cross-section geometry were evaluated to determine a standard deviation of 1.5 feet in the base year and 1.8 feet in future years for uncertainty in river elevation, given a certain discharge.

Hydrologic uncertainty. A graphical discharge-frequency exceedance probability function was developed in the HEC-FDA model for each reach based on a 70 year period of record. The distribution of errors is assumed to be a non-central t-distribution about the specified function.

Investment value uncertainty. Interview data about most likely structure and content values, and the minimum and maximum range of values for each were obtained from business owners and representatives and entered into HEC-FDA. For structures that did not have specific data obtained by surveys and interviews, expected values for structures and contents were estimated using Marshall & Swift professional valuation software or from locally obtained study area data for similar businesses. The uncertainty was defined using a normal or triangular probability distribution, depending on the type of structure and category of damage, and any other specific data available.

Structure and beginning damage elevation uncertainty. Uncertainties about ground and first floor elevations (beginning damage elevations) were determined based on two and four foot contours on study area mapping. Uncertainties were determined per guidance in Engineering Manual 1110-2-1619, Risk Based Analysis for Flood Damage Reduction Studies.

Depth-damage relationship uncertainty. Structure occupancy types were defined for each type of structure and category of damage. The structure occupancy code defines the depth-percent damage function and its uncertainties. Normal and triangular probability distributions were used based on the category of damage, type of structure, and type of use.

Uncertainty about geotechnical or structural failure. Probabilities of geotechnical and structural failure in each unit were developed using engineering analysis. Geotechnical and structural engineers determined the most likely expected modes and sites of failure prior to overtopping in each unit. A range of conditional probabilities of failure versus river stage elevation encompassing the probable failure point and non failure point were determined for each site/mode of failure. The river elevation versus probability of failure relationship developed by the geotechnical and structural engineers for each potential failure site/mode was then translated to the index point of the reach (levee unit) and each individual potential failure site/mode was determined to be independent. The

probabilities of failure for each site/mode were then combined using a formula contained in ETL 1110-2-556 to derive a single combined probability of failure versus river stage curve that accounted for all the sites or modes of potential failure. The resulting combined probability of failure curve was then entered into the HECFDA study file.

4.6.6 Other Considerations Related to Risk and Reliability

It is important to bear in mind the variability and uncertainty associated with the inputs to a risk and uncertainty analysis.

- Care must be taken to consider the entire output of the analysis rather than placing undue reliance on any one statistic.
- Such simulations are sensitive to assumptions about correlations between parameters, the likelihood that a particular specification is correct, any omitted factors, and assumptions about the appropriate distribution for parameters, etc.
- Generally, the quality of the overall analysis is reflective of the quality (or accuracy) of its input components.

This final feasibility study is, in many respects, a groundbreaking effort with regard to the scale and scope of effort. In the past, many Corps studies have been performed using risk and uncertainty principles for planning smaller levee systems limited to flood events at or about the 1% event. The target conveyance in the original authorizations places this system in the upper echelon of U.S. levee systems. This makes it difficult for direct comparisons to other levee systems of the results and reliabilities produced by this analysis. The possibility for better characterization and comparison for residual risk is expected as the number of larger levee systems analyzed using risk and uncertainty principles increases over time.

In general, water resource development and planning continues to be a field where judgment and context plays a vital role. There can never be one exact solution to all conceivable issues. The feasibility process undertaken in this study allows for a reasoned and systematic approach to formulating plans. However, natural environments and especially the dynamic characteristics inherent in river systems, remain subject to re-interpretation and refinements as the knowledge base and experience with those systems grow over time.

4.6.7 Selection of the Recommended Plan

When evaluating alternative levee raises, incremental economic analysis strongly affects the optimization and selection process. Levee raise costs typically increase as the levee height increases. These cost increases arise from the various components of cost that increase along with levee height: additional material and construction requirements, additional real estate costs, and a longer construction period (Interest During Construction). Other life cycle costs (such as operation and maintenance costs over the period of analysis) are included in the analysis. The optimal raise is the one with the greatest net economic benefits (essentially damages reduced less project economic costs) as computed for an array of flood events. As the evaluation progressed, Kansas River Plan 3 (KR3) was shown to be an efficient raise meeting the planning objectives, constraints, and criteria; maximizing the net economic benefits; limiting land disturbance and

environmental impacts; and avoiding HTRW disturbances and significant real estate conflicts and relocations. Plan KR3 is the Recommended Plan.

All features of the individual Recommended Plans identified for CID and Armourdale were retained and combined to constitute the Recommended Plan for the Phase 2 study area. The plan grows from an assembly of the most technically feasible and cost effective measures to achieve the desired unit height in each reach and/or area of concern in each unit. The economic analysis shows that it is economically viable and furthers national economic development in manner consistent with Corps of Engineers economic regulations and Administration economic policies.

It should be made clear that while this Recommended Plan addresses existing concerns and improves the risk management benefits provided by the existing units, consistent with the rest of the Kansas Citys Levee System, it does not provide a system capable of passing the authorized Kansas River discharge. Modifications to comply with the authorized discharge for the Armourdale and CID Units, given the results and findings of the current engineering analysis, would very likely be uneconomical or unaffordable, and would be inconsistent with the rest of the system, causing induced damages or risks to other units of the metropolitan system if implemented.

The tax bases within both of the levee units are relatively stable as the protected areas are essentially built-out. This limitation on tax base essentially places an upper limit on the potential for totally local initiatives. The Recommended Plan leverages local funding through the Federal cost share process. It is likely that several of the major recommendations herein would remain un-built if not for the Federal cost sharing opportunity provided by the Recommended Plan. The Recommended Plan also provides many lower income residents with additional flood risk management benefits which might not otherwise be available through local processes.

4.7 Description of the Recommended Plan

4.7.1 Components of the Recommended Plan

The major components of the Recommended Plan are summarized in Table 4-7. A comparison of the current and recommended features by levee station is provided in Exhibits 5 and 6. Maps of the Recommended Plan are provided following the main report text.

Table 4-7: Recommended Plan Components

Overtopping/Structural Measures	**CID**	**Armourdale**	**Total**
Levee Raise (LF)	6,495	13,223	19,718
Floodwall Modification(LF)	4,649	4,208	8,857
Floodwall Replacement (LF)	152	2,105	2,257
New Floodwall (LF)	600	5,392	5,992
New T-Wall on Levee (LF)	-	7,715	7,715
Closure Structure Measures			
New Sandbag Closure	2	3	5
Convert Sandbag to Stop log	1	2	3
Replace Stop log Closure	1	2	3
New Stop log Closure	2	-	2
Underseepage Control Measures			
New Relief Wells	57	74	131
Area Fill (LF)	3,448	-	3,448
Slurry Cutoff Wall (LF)	-	2,000	2,000
Drainage Control Measures			
Pump Station Removal	2	2	4
Pump Station Modification	5	7	12

4.7.2 Summary of Recommended Plan Performance

The with-project (residual) flood risks and damages are shown in Table 4-8. The residual risk results address all three major aspects of the levee performance analysis: overtopping (hydraulic), geotechnical, and structural. The with-project performance provides a very significant decrease in the flood risk for each of the respective units.

Table 4-8: Engineering Performance - With Project Conditions

	Armourdale	**CID**
Annual Exceedance Probability* (median)	0.12%	0.12%
Annual Exceedance Probability* (expected)	0.14%	0.19%
Long Term Risk (chance of exceedance during indicated period)		
over 10 years	1.39%	1.84%
over 30 years	4.10%	5.43%
over 50 years	6.74%	8.88%
Conditional Exceedance Probability** - Overtop or Breach		
10.0% event	0.00%	0.03%
4.0% event	0.00%	0.03%
2.0% event	0.04%	0.03%
1.0% event	1.39%	0.73%
0.4% event	14.51%	10.17%
0.2% event	34.79%	28.88%

Notes:
*Annual exceedance probability is the chance of experiencing any flood event - of whatever magnitude - within any year.
**Conditional exceedance probability is the probability that specified flood event would overtop or breach the levee.

Through implementation of the Recommended Plan, both levee units will be designed and constructed to meet current USACE requirements for a positive levee evaluation. Furthermore, each unit will comply with FEMA base flood insurance certification and accreditation requirements, including passing the 1% event with at least 90% assurance. Both units will have approximately 65-70% assurance against the median 0.2% chance exceedance flood profile. Other performance aspects of the with-project condition are described in additional detail below.

4.7.3 Future With-and Without-Project Condition Economic Performance

Implementation of the Recommended Plan in each of the units addressed in the final feasibility report will provide significant reduction in physical flood damages and other costs that result from flooding. The damages reduced represent the benefits provided by the recommended plan and are typically characterized in terms of annualized equivalent values as computed in the HEC-FDA program.

Table 4-9 summarizes the equivalent annual damages that would be expected to occur with and without the recommended plan. The uncertainties in evaluation of project benefits are characterized in the far right three columns of the table.

Table 4-9: Equivalent Annual Damages and Damages Reduced
(Oct 2013 Prices, 3.5% Inter Rate, 50 Yr Period of Analysis, $000)

Plan	Top of Levee Elev. (ft)	Expected and Probabilistic Values of EAD and EAD Reduced					
		Equivalent Annual Damage			Probability Damage Reduced Exceeds Indicated Values		
		Total Without Project	Total With Project	Damage Reduced	.75	.50	.25
ARMOURDALE UNIT							
Future **WITHOUT** Project	771.70	$55,392.04	$55,392.04	$0.00	$0.00	$0.00	$0.00
Future **WITH** Project	776.41	$55,392.04	$3,395.04	$51,457.05	$36,287.34	$49,899.39	$63,998.28
CENTRAL INDUSTRIAL DISTRICT							
Future **WITHOUT** Project	760.30	$8,867.90	$8,867.90	$0.00	$0.00	$0.00	$0.00
Future **WITH** Project	763.45	$8,867.90	$3,638.32	$5,229.58	$1,583.39	$3,769.20	$7,442.57

4.7.4 Future With- and Without-Project Condition Engineering Performance

4.7.4.1 *Conditional Probability of Design Non-Exceedance.*

One of the many metrics that can be used to characterize the performance of a flood risk management project is overall project reliability against the 1% event. Project reliability is characterized in the HEC-FDA model by the probability of the project design containing a specified event or the probability of design non-exceedance. Overall reliability against the 1% event and other engineering performance data include consideration of both the probability of overtopping and also the probability of geotechnical and structural failure.

Table 4-10 displays for each unit addressed in the Final Feasibility Report the with- and without-project condition overall project reliability against the 1% probability event, and shows the top of levee margins above the 1% and 0.2% event water surface profile.

4.7.4.2 ***Levee Performance in Any Given Year and Equivalent Long-term Risk***

Long-term risk indicates how successfully a flood control project would protect against floods given the uncertainties and over a long period of time. Annual Exceedance Probability is the probability that flooding will occur in any given year considering the full range of possible annual floods. The terms "exceeded" or "exceedance" when used herein with regard to engineering performance data include consideration of both geotechnical and structural failure potential and consideration of the potential for levee overtopping.

Table 4-11 shows the expected probability of the levee design being exceeded (occurrence of flooding) in any given year and the long-term risk or probability of the project being exceeded in a 10-, 30-, and 50-year period, with and without the recommended plan for each unit.

Table 4-10: Future Condition Overtopping Margins and Overall Reliability Against the 1% Chance Event

	Top of Levee Elev. at Index Point (ft, msl)	**Overtopping Margin (ft) Above 1.0% Chance Event**	**Overtopping Margin (ft) Above 0.2% Chance Event**	**Overall Reliability Against 1% Chance Event (includes geotechnical and structural risk considerations)**
ARMOURDALE UNIT				
Future **WITHOUT** Project	771.70	6.89	-1.92	.4547
Future **WITH** Project	776.41	11.66	3.17	.9861
Net Change in Margins and Overall Reliability	+4.71	+4.78	+5.10	+.5314
CENTRAL INDUSTRIAL DISTRICT UNIT				
Future **WITHOUT** Project	760.30	5.06	-0.87	.8866
Future **WITH** Project	763.45	8.21	2.28	.9927
Net Change in Margins and Overall Reliability	+3.15	+3.15	+3.15	+.1061

*Any discrepancies due to rounding

Table 4-11: Recommended Plan Engineering Performance and Equivalent Long-Term Risk

	Top of Levee Elevation at Index Point (ft, msl)	Annual Exceedance Probability	Equivalent Long-Term Risk Probability of Exceedance Over the Indicated Time Period		
			10 Years	30 Years	50 Years
ARMOURDALE UNIT					
Future **WITHOUT** Project	771.70	.0350	.3148	.6784	.8490
Future **WITH** Project	776.41	.0014	.0139	.0410	.0674
Net Change in Probability of Exceedance (Flooding)	+4.71	-.0366	-.3009	-.6374	-.7816
CENTRAL INDUSTRIAL DISTRICT UNIT					
Future **WITHOUT** Project	760.30	.0047	.0461	.1321	.2103
Future **WITH** Project	763.45	.0019	.0184	.0543	.0888
Net Change in Probability of Exceedance (Flooding)	+3.15	-.0028	-.0277	-.0778	-.1215

Note: Any discrepancies due to rounding

As shown in Table 4-12, long term risk can be alternatively described in terms of chance of flooding in any one year or in a specified time period.

Table 4-12: Alternative Display of Recommended Plan Engineering Performance and Equivalent Long Term Risk

	Top of Levee Elevation at Index Point (ft msl)	Chance of Exceedance in any Given Year	Equivalent Long-Term Risk Chance of Exceedance Over the Indicated Time Period		
			10 Years	30 Years	50 Years
ARMOURDALE UNIT					
Future **WITHOUT** Project	771.70	1 in 28.6	1 in 3.2	1 in 1.6	1 in 1.2
Future **WITH** Project	776.41	1 in 833.3	1 in 71.9	1 in 24.4	1 in 14.8
CENTRAL INDUSTRIAL DISTRICT UNIT					
Future **WITHOUT** Project	760.30	1 in 303.0	1 in 21.7	1 in 9.0	1 in 4.8
Future **WITH** Project	763.45	1 in 833.3	1 in 54.3	1 in 18.4	1 in 11.3

Note: Any discrepancies due to rounding

4.7.5 Induced Damages

The Interim Feasibility Report included the following discussion of induced damages: *Minor induced damages from the Argentine levee unit raise, which can occur under certain rare and somewhat extraordinary conditions. If one of these rare flood events occurs, then minor induced damages could possibly occur in the following areas:*

- *Areas downstream of the Argentine Unit (areas within the existing Armourdale and CID Units)*
- *In a small unprotected area opposite the Armourdale Unit and located below the bluff line.*

The flood events for which these induced damages can be calculated to possibly occur are more rare than the 250 year (or 0.4%) event and approaching the 300 year (0.33%) event. In these situations the induced flooding is very small (about 6 inches deep in most cases). Given this, the induced damages amount on each structure is essentially inconsequential compared to the existing damages from normal river flooding. The predominant threat of flooding in these areas remains essentially the same as the without-raise conditions. While the events that may trigger these induced damages are rare, in accordance with economic policy the costs associated with induced damages are recognized in the study economics.

These relatively small induced damages discussed would occur only if the Argentine Unit was raised and the downstream units, Armourdale and CID, were not. The Recommended plan for raising the Armourdale and CID Units eliminates these induced damages. The Recommended Plan causes no new induced damages on other areas.

4.7.6 Residual Risk

Although floodplain users and occupants may desire total protection from flooding, it cannot be overemphasized that this is an unachievable goal. Residual Risk will remain after completion of the Recommended Plan. The primary source of residual flood risk will be from infrequent large flood events that overtop the levees. A number of factors can influence the nature of flood inducing storm events and the performance of flood risk management systems, such that an event of historical magnitude is not necessarily required to overwhelm the project and cause catastrophic damage. However, the implementation of project improvements may lead many floodplain users and occupants to feel that they have near-total protection against flooding. Therefore, it is important to emphasize and communicate the level of flood risk that remains even after project implementation such that floodplain occupants are aware of the nature of the flood threats and are able to make informed decisions about acceptable levels of risk.

The tables presented in this report show that the recommended plan for the units addressed by this final feasibility report provides a significant increase in reliability against flooding. Flooding will be less frequent; however, the analyses show there is still residual risk of flooding. For the Corps, determining an acceptable level of risk is in most cases a function of the NED process. The goal is to manage the risk of flooding within limited budget and funding constraints, and yet implement a cost effective and efficient flood risk management plan that reasonably maximizes net economic benefits (flood risk management benefits) consistent with protecting the Nation's environment.

From the Federal perspective, selection of the recommended alternative is a determination of an acceptable level of residual risk based on trade-offs between potential benefits and the associated level of residual risk versus the cost of a larger and more risk-adverse flood risk management project. Increases in project reliability above what is recommended can sometimes be achieved

with much larger projects. However, in most instances, costs for larger projects increase dramatically faster than project benefits. The Recommended Plan reasonably maximizes net benefits consistent with study objectives and constraints as measured by the difference between annual benefits and annual costs.

From the local perspective, a community or sponsor may desire less residual risk of flooding than that provided by the Recommended Plan. Many persons in a community might express the desire for zero residual risk and no chance of damage from a recurrence of flooding, even though this is an economically unattainable goal. The level of risk a community (or sponsor) is willing to bear can be indicated by their willingness to pay for each additional increment of flood risk reduction.

4.7.6.1 ***With-Project Damages and Impacts***

The selected plan has substantial economic benefits and reduces the overall study area equivalent annual damages in the existing condition by nearly 88% (93% in Armourdale and 59% in the CID). The probability and occurrence of flooding will be greatly diminished. There would remain a significant total of residual equivalent annual damages of $7.57 million ($3.93 million in Armourdale and $3.64 million in CID).

Tables 3-11 and 4-8 compare the existing and future-with-project assurance statistics for the two levee units. Comparing the expected annual exceedance probabilities there remains a 0.14 and 0.19 percent chance of a damaging flood in Armourdale and CID, respectively, in any year following project implementation. In the 1 percent-chance flood event, both Phase 2 units currently have between an 11 and 55 percent chance of experiencing damage due to overtopping or breach failure. These probabilities would be reduced to roughly 1 percent in the with-project condition. The remaining risk of incurring damage at the 0.2 percent-chance flood event over the same time period is approximately 32%. The long-term risk of a damaging flood in both of the Phase 2 units over 50-year period would be less than 1 in 10, compared to a current 50-year risk exceeding 1 in 2 in Armourdale and approximately 1 in 5 in CID. While the improvements proposed are substantial, it can be seen that residual risks remain.

If the capacity of the Federal levee system is exceeded in a particular event, most of the areas and properties inside the levees would be affected due to the flat floodplain topography in these areas. The Armourdale and CID areas are generally small volumetrically in relationship to the Kansas River hydrograph. Analysis has shown that the areas would fill quickly on the rising limb of the hydrograph by the time maximum overtopping depth is reached. In general, if the amount of water that gets through or over the levees is sufficient to produce severe flood depths, event specific damages in the study area would reach $2 billion or more. Prohibitive depths of water would likely remain inside the levees for several weeks. Large-scale evacuations of urban neighborhoods would be necessary in advance, followed by humanitarian assistance. A number of highly-traveled highways and streets as well as railroad tracks would be closed and in some cases inundated. Public utilities including power generation and wastewater treatment would be interrupted, perhaps for a few weeks.

4.7.6.2 ***Life Safety Risk Assessment***

The Corps of Engineers Levee Safety Program evaluates a number of safety criteria using the Levee Screening Tool. The LST provides a common basis on which to rate the condition and failure consequences for levees across the Nation. The LST also provides an analysis of the loss of life that could occur due to a project breach prior to overtopping (PTOT) and due to an overtopping (OT) breach. The existing condition life safety assessment evaluation for the Armourdale and CID Units is shown in Table 4-13.

Table 4-13 – Existing Condition Life Safety Assessment

	Population at Risk		Threatened Population		Loss of Life	
	Day	Night	Day	Night	Breach PTOT	OT Breach
Armourdale	6,700	2,924	1,817	681	19	9
CID	7,274	813	2,503	252	22	14
Total	13,974	3,737	4,320	933	41	23

Population at Risk (PAR) is representative of the occupants and users within the levee units. The Recommended Plan will not cause any changes (upwards or downwards) in the Population at Risk. The study area is already fully developed, and improvements to the levee systems will not promote additional development nor does the Recommended Plan change the area limits. Threatened population is an estimate of that portion of the PAR that would still be remaining in the floodplain at the time of project failure. The resulting estimate of Loss of Life is heavily influenced by the determination of threatened population; however, both are influenced by other factors including:

1. Probability of overtopping failure
2. Project reliability at events below top of levee
3. Unit geometry and inundation characteristics
4. Quality of emergency planning and risk communication prior to project failure

The Recommended Plan directly addresses the first two of these factors by increasing reliability of project features and reducing overtopping probability. This will allow the occupants of the floodplain more time to implement emergency procedures and evacuations, if needed, potentially decreasing the threatened population and loss of life.

The Recommended Plan also affects unit geometry and inundation characteristics. Raising the height of the existing unit reduces the likelihood and frequency of inundation and can lower the total loss of life expected during the life of the project. However, a higher levee unit will cause increased inundation depths during an actual project failure, which could increase the potential for loss of life during that event. This is a lesser concern in the CID Unit, where floodwaters entering from the Kansas River would be expected to exit over or through the Missouri River section of the unit, which is not being raised.

Emergency planning and communication is the biggest driver of threatened population and loss of life analysis. If the occupants of the floodplain are well informed of the risks and emergency procedures in advance, and are able and willing to implement those actions when directed, including compliance with evacuation orders, the loss of life can be significantly reduced. The Feasibility Study process included public information and involvement, which helped to inform the public of the risks, but the Recommended Plan contains no components specific to emergency planning or communication.

Because of the different factors that can affect loss of life estimates, and the dependency of life safety concerns on actions beyond those addressed by the Recommended Plan, no attempt has been made to correlate plan implementation to a reduction in loss of life.

4.7.6.3 ***Residual Risk Management***

Informed risk management and emergency preparedness, by both the sponsor and the Corps of Engineers, **i**s the manner in which residual risks and potential exceedance of the system will be addressed. Based on the hydraulic analysis of the Kansas River units it is expected that overtopping would begin at or near the upstream end of each individual unit during a Kansas River flood. Conversely, these units would likely overtop near the downstream end during a Missouri River flood, as was the threat in 1993. There is no advantage or evident solution in managed overtopping, i.e. designing for a specific overtopping location, in an interrelated system of levees with intensive development throughout each protected area. Effective emergency planning in advance is the best way to protect communities and minimize the damage from these rare flood events.

Each of the five sponsors within the existing system operates their unit(s) according to unit specific Operations and Maintenance Manuals originally prepared by the Corps of Engineers. Each manual contains a list of specific actions to be taken by that sponsor during emergency flood operations. The emergency actions detailed within all of the manuals are triggered by the Missouri River stage as reported on the official USGS Missouri River at Kansas City gauge. The gauge is attached to the Hannibal Railroad Bridge downstream of the confluence of the two rivers. By using a single control point, the group of manuals, and the actions of each individual sponsor, is tied together into a complete system emergency operations plan. Forecasts and warnings for the Kansas City gauge, and other gauge locations on both rivers upstream of Kansas City, are issued regularly by the National Weather Service. These forecasts include projected river flows and stages several days in advance. During normal operations these forecasts are issued daily and during flood emergencies, three times a day.

The Corps of Engineers employs a very proactive approach to monitoring and inspecting the system units, provides training for flood preparedness and flood fighting, and activates a comprehensive Emergency Operations Center (EOC), including liaison and technical assistance as needed to assist local entities in their flood response and operation of the system. During flood operations the EOC conducts a daily conference call with sponsors and stakeholders throughout the impacted area, whether in Kansas City or beyond, to disseminate and communicate all available flood status and risk information. The Kansas City Water

Management Branch and the Northwestern Division Reservoir Control Center in Omaha, NE, are regular participants in these calls and provide updates on upstream reservoir conditions and operations, and their potential impact to expected flows.

Similarly, the sponsors have monitoring, emergency response, and evacuation plans that are coordinated between the Kaw Valley Drainage District, the Kansas City, Kansas, Emergency Management Office, the City of Kansas City, Missouri flood / emergency response elements, and the business and residential areas protected by the levees. These tie together in a proactive and coordinated flood response and risk management framework with the Corps of Engineers, both in preparation and training activities as well as during flood response. Further, as assisted through this study, the Sponsors are in development of a system-wide Floodplain Management Plan that will make recommendations in an improved framework for local cooperation and risk management.

Following implementation of the Recommended Plan in each unit, the Corps of Engineers will update each O&M Manual to reflect the new with-project conditions and features, including any changes to the emergency actions list that may be needed. Each sponsor and local municipality within the study will need to modify any other emergency action, evacuation, or floodplain plans they currently have, or design new plans, to further manage and minimize the residual risks remaining after Recommended Plan implementation.

During this feasibility study effort, all sponsors in the system began an effort to develop a coordinated system-wide floodplain management plan as a combination and expansion of their existing individual plans. Sponsors will continue to this effort as this project enters PED. Those efforts will reduce potential loss of life by resulting in improvements to: evacuation planning, flood warning effectiveness, and community awareness.

4.7.7 Real Estate Requirements

Project purposes would require the expansion of the current Kaw Valley Drainage District and City of Kansas City, Missouri, easements. Required estates include temporary easements, permanent easements and borrow easements. It is estimated that roughly 33 acres will be needed for Armourdale levee raises and roughly 62 acres will be needed for CID levee raises. There are three utilities requiring relocations that have been identified as eligible for compensation on the Armourdale portion, and six on the CID portion. The estimated total amount for all creditable Lands, Easements, Rights-of-Way, Relocations, and Disposal Areas (LERRD) costs, including contingencies, for the Armourdale Unit is $4,463,000, and for the CID Unit is $2,591,000. Important aspects of the LERRD's required for the Recommended Plan are highlighted below. See the Real Estate Appendix for additional detailed information.

4.7.7.1 *Lands and Damages Costs*

For both units in the Recommended Plan, this LERRD category includes the costs for Non-Federal sponsor acquisition of lands in fee title, permanent right-of-way, temporary right-of-way; and associated and incidental costs for legal work, title work, tract appraisals, and land surveys. The recommended plan does not include any costs to address encroachments into the existing

project right of way. Addressing these encroachments is the responsibility of the non-Federal sponsor.

Land acquisition anticipated for the Recommended Plan primarily consists of limited permanent and temporary easements on private and public lands. Fee acquisition is not expressly required for levee rights-of-way (r-o-w) on either of the units. Estates to be acquired by the sponsors include permanent levee and floodwall easements necessary for the levee raise (berm placement) and floodwall work.

A permanent easement will be used for a borrow area and temporary easements will be used for equipment storage, site access for construction vehicles and staging areas. Temporary access road easements will vary in width along the different work areas but are generally 15 to 30 feet wide. Duration of the temporary easements will also vary for each of the individual work areas, generally running from 1 year to 3 years. The Recommended Plan does not require acquisition of an off-site disposal area.

4.7.7.2 ***Borrow Area Considerations***

The area of proposed borrow for the Armourdale and CID Unit raises is the same as previously proposed for the Argentine Unit and discussed in the Real Estate Plan included as Appendix to the Interim Feasibility Report. The borrow area was described in Section 1.2.8 of the FEIS as follows:

> The proposed borrow area measures approximately 276 acres and is owned by Water District Number One (WaterOne) of Johnson County, Kansas. The proposed borrow area is located adjacent to the right descending bank between Kansas River miles 11 and 13, Wyandotte County, Kansas. The borrow area is accessed from south 74th Street via Holliday Drive and Interstate 435. Levee access from the proposed borrow area would route from Inland Drive to South 59th Street.

The primary uses of the land are lime residual storage from the water treatment process and active row-cropping under a lease agreement, thus, existing disturbances within the proposed borrow area includes excavating, hauling, grading, and disk harrowing. WaterOne treats water from the Kansas River and occasionally the Missouri River. Because these two water sources are hard waters, WaterOne uses lime to “soften” the water by removing the carbonate hardness in the water. The by-product of this process is a lime residual that is removed from the treatment process and stored in large lagoons on this site and allowed to dry. After the drying process, which may take a few years, the dried material is excavated and removed for disposal, and the lagoons are cleared for future use. Excavated material used for the levee raises will not contain the lime residual, but the activity to obtain levee fill material from clean areas of the site will be beneficial to WaterOne in the creation of new lagoons for future lime residual storage.

Material from the borrow area will be necessary for levee raises, area fill, underseepage berms, and stability berms. The amount of fill material needed to implement the proposed levee raises in all three levee units on the Kansas River units is shown in Table 4-14.

Table 4-14: Borrow Area Requirements

Unit	Borrow Amount (*cubic yards*)
Central Industrial District	175,088
Armourdale	459,162
Argentine	261,955
Total	896,205

4.7.7.3 *Facility/Utility Relocations*

A number of existing utilities are deemed necessary to be relocated for implementation of the Recommended Plan. Utility relocations include relocations of utility crossings (crossing the raised levee) and relocations of utilities within the critical levee zone affected by increased uplift pressures. This category is further divided into: a) public utility relocation costs which are deemed compensable and are included within project LERRD, and b) those utility relocations which were deemed not compensable and are the responsibility of the utility owners (relocation of non-compensable utilities are considered an associated cost but not a project cost).

PL 91-646 relocation assistance applies to the removal and relocation costs for private business structures (less than 10,000 sf total). No costs are included for PL 91-646 assistance to business owners as no impacts of this type are expected. No residential housing is affected in any unit by the Recommended Plan.

4.7.7.4 *Transportation Facilities Impacts*

No active railroad tracks or railroad facilities require permanent relocation. Temporary adjustments to trackage or schedules are likely needed during some periods of construction. No public roads or bridge crossings require modification.

4.7.8 Design and Construction Considerations

As this study deals with an existing levee system, the site constraints arising from adjacent infrastructure must be considered during design and construction. During alternatives development and refinement, the study examined design and construction considerations important to an efficient implementation of the Recommended Plan.

In particular, work alongside rivers must consider the somewhat unpredictable nature of flood hazards. High water conditions may occur while construction is in progress. If the high water conditions were to occur while the line of protection is temporarily down or compromised by construction (such as when a floodwall is being removed), then serious inadvertent flooding could result. This situation is normally handled through the development of specific high-water contingency measures. Requirements for these contingency measures are included within the plans and specifications (construction contract) package. The construction package must address high-water contingencies for all sites in the Recommended Plan.

Such contingencies must aim to provide for at least the 1%-chance annual event as the most basic requirement. Beyond this, an additional level of preparation should be planned to bring the protection back to the preconstruction (design) level if needed under severe flood conditions.

Common site measures for water control include dewatering, construction of ring levees, and emergency backfilling of open excavations. Sandbags and pumping can also be used to supplement the effort. It is preferable to schedule work within the levee critical zone for typically dry seasons. Excavation in the levee critical zone must be avoided during periods of ground saturation.

For all sites, the project coordination team (composed of sponsors, Corps of Engineers staff, and other stakeholders deemed appropriate to the work) will take the Recommended Plan and develop the design detail and contracting documents necessary for successful construction efforts. The project management plan (PMP) will address project scope, quality, schedule, communications, safety, and project team roles as the project develops. The requirements of ER 1110-2-1150 will guide the overall design effort. The Project Partnership Agreement (PPA) will contain specific requirements regarding responsibilities, funding and coordination of construction activities. Additionally, an implementation phase Review Plan (RP) will be developed detailing the level of review each design and construction package will receive prior to award. This RP will detail the need for IEPR Type II, or Safety Assurance Review, which will include a review of all life safety concerns including emergency action planning.

The Non-Federal Sponsor will conduct specific utilities relocation coordination and design planning prior to levee raise construction contract award. Even though sponsors and utility owners are responsible for utility relocations, the Kansas City District must be kept aware of relocation designs and schedules to ensure coordination of the overall implementation effort. Detailed planning for utility relocations is fully developed in the latter stages of the PED phase in coordination with the construction plans. All parties (sponsor, utility owner, and Corps of Engineers) should prepare for a highly coordinated utility relocation effort as the levee raise begins.

In general, the following two factors will affect design and construction along several areas of the levee raise.

- Several areas along the Armourdale levee were identified as Hazardous, Toxic, or Radiological Waste (HTRW) sites. A section within the main feasibility report describes HTRW considerations of the Recommended Plan. Design and construction procedures need to recognize these sites and adapt accordingly. Construction cannot normally occur on top of contaminated soil.

- The Recommended Plan for the Armourdale and CID raises involves <u>no</u> permanent impact to existing railroad tracks, but the design and construction in for all areas with adjacent railroad tracks does require coordination with the railroads. Trains may need to be temporarily re-scheduled so as to allow movement of construction equipment into and out of the construction area.

<u>Armourdale T-wall on Levee Construction.</u> The pre-construction coordination should include careful planning sessions where the T-wall procedures are sequenced and scheduled to avoid undue delays with an open levee crown. During T-wall construction, the levee crown is removed

along with any rip rap cover. The T-wall installation proceeds and then the levee crown is rebuilt as soon as practical.

Utility Crossings. Utilities crossing the Units were studied to estimate the costs for relocation or removal of (functioning or abandoned) utilities, and for the real estate implications related to preliminary compensability determinations. As a general rule, pressure pipelines passing through or under the levee are generally relocated over the raised levee. An additional amount of earth cover tops off the utility lines and the resulting "mound" is sloped on each side to allow vehicular transverse. Normally these utility lines are hot-tapped thus maintaining service to customers during construction.

Bridges and Roadways. The Recommended Plan does not require any bridge superstructure modifications, nor does the Recommended Plan require any road realignments. Transportation of levee raise materials may at times increase traffic along nearby roadways but this area is industrial and truck traffic is common.

The final grade and slope on the raised top-of-levee access road needs close coordination with the sponsor. The raised top-of-levee road incorporates up-and-over utility crossings under the Recommended Plan. The design for these crossings points and the amount of roadway cover should allow vehicular traffic (such as passenger cars and trucks) to traverse the crossings with relative ease. The design of the top-of-levee road may need some realignment to maintain required minimum clearance under the I-635 bridge structure.

4.7.9 Operations and Maintenance Considerations

4.7.9.1 *OMRR&R Costs*

Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) of the project will remain the responsibility of the non-Federal sponsors. Operation and Maintenance (O&M) manuals will be prepared (or updated as appropriate) by the Corps of Engineers and provided to the sponsors following each implementation contract or phase. Proper and timely non-Federal Sponsor operation is required to ensure the integrity and performance of the levee system as designed. Non-Federal sponsor requirements for coordination, operations, maintenance, and training, are established and governed by the existing Operations and Maintenance Manuals of each levee unit, as well as multiple existing national and local regulations and policies, and are monitored through established Corps of Engineers inspection and oversight programs.

The majority of the sponsor O&M concerns and costs will remain the same as the current condition. There will be some savings in costs related to pump station removals, although most of the stations slated for removal are already essentially abandoned and not being fully operated maintained or upgraded currently. There will be an overall net increase in the number of relief wells in the system, requiring periodic testing and rehabilitation, repairs as needed, and eventual replacements. While these relief well costs are the driver in overall changes to the O&M costs, evaluation of their impact on an annual basis indicates little overall change as shown in Table 4-15.

Table 4-15: Annual Operation & Maintenance Cost for Phase 2 Recommended Plan

Levee Sponsor	Average Annual O&M Costs	Incremental Annual O&M Cost for Recommended Plan
Kaw Valley Drainage District	$1,700,000	+$336,500
Kansas City Missouri	$875,000	+$0

Several closure structures are being converted from sandbags to stoplogs and new structures of both types are being added to the system. The necessary coordination and operational considerations of closure structures are already well understood by the sponsor and the affected stakeholders from past experience. Any changes in the recommended closure plans, i.e. notifications, timing, river elevation action levels, etc., will be documented in revisions to the Operations and Maintenance Manuals. For locations where new stoplog gaps are being placed, stoplog storage locations will be identified and the necessary easements or property requirements coordinated through the LERRD process.

4.7.9.2 *System Operations Risk*

While project Residual Risk is often expressed and understood in terms of the remaining statistical probabilities of failure after project implementation, there are factors other than the chances of flood occurrence that can contribute to the risks of poor levee system performance.

It is recognized that the five non-Federal sponsors that own, operate, and maintain the individual units within the existing system have a long history of diligent and effective management and performance. In fact, the cooperation of the sponsors in local flood risk management efforts pre-dates the involvement of the Corps of Engineers and the presently existing system. However, the separation of system operational responsibilities among multiple independent entities creates dependencies and risks unique to this system. There are several aspects to this system operations risk, including:

- If maintenance, operations, or improvement activities are not performed by all Sponsors at a level consistent with the others, the system as a whole does not perform as intended.

- The actions, or non-actions, of one entity could potentially cause increases in risks and/or damages to another.

- The multiple political boundaries (City, State, County, and Congressional) within the system create differing authorities and abilities regarding taxation, financial bonding, budget support, control of floodplain development, and the issuance and coordination of flood warnings and evacuations when needed.

The Project Sponsors are aware of these system-wide concerns and realize it is in their collective self interest to mitigate their risk by coordinating their activities whenever possible. The Sponsors conduct regular meetings and discussions among their organizations and stakeholders,

and, most recently, have initiated an effort to coordinate and combine their individual floodplain management and emergency planning efforts into a single system-wide approach. The individual Sponsors are supported in many of these collaboration efforts by local municipalities and regional stakeholder groups, including the Missouri and Associated Rivers Coalition, the Mid-America Regional Council, and the Kansas City Industrial Council.

An Operation and Maintenance Manual for each levee unit addresses project specific sponsor responsibilities. Each manual spells out the specific actions necessary by the sponsor for maintenance of project features and operations of the project during normal and emergency situations (i.e. at what river levels to activate pump stations or close openings in the levee, etc.). Although each manual addresses only one specific unit, they were originally written by the Corps following initial construction of the system, and have been updated by the Corps following all major modifications. In this way the separate manuals, collectively, represent a total system operations plan. By operating their respective elements of the system according to their individual manuals, each Sponsor, insures that the system will operate as a whole, as originally intended. The manuals will be updated again by the Corps following implementation of each element of the Recommended Plan.

The responsibilities for sponsors of Federal flood risk management projects are detailed in the Code of Federal Regulations (CFR) Title 33, Part 208, as well as ER 1130-2-530 (Project Operation). It is the corresponding responsibility of the Corps to take an active role in overseeing the activities of the Sponsors and ensuring that they execute their requirements according to these policies. This enables the Corps to monitor the system as a whole, thus attenuating some of the system operational risks. For example, each levee unit is annually inspected in cooperation with each Sponsor, for compliance with maintenance requirements; all proposed construction within the vicinity of the levee system is reviewed to ensure adherence to current guidelines; and the Corps' Levee Safety Program evaluates the risk of each unit based on current condition and potential consequence. While each of these activities are conducted on a unit-by-unit basis, the same criteria, standards, and guidelines are applied to all, allowing the District to establish an overall view of the system and identify where additional assistance or emphasis may be necessary. Finally, the District's Emergency Management Branch provides periodic training and assistance on flood fighting and preparedness and provides engaged and proactive liaison, monitoring, technical, and material assistance when required during flood stage operations. This coordinated system based flood response was well tested in 1993, and greatly improved and validated as very effective during the flooding years of 2007 through 2011.

4.7.10 Economic Summary

Project benefits (Table 4-16) are the reduction in projected future damages, which would result from project implementation. The probabilistic values of equivalent annual damage (EAD) and EAD reduced show the impact of uncertainty in evaluation of project benefits. The damages reduced (*i.e.*, project benefits) are shown in terms of annualized equivalent values as computed in the HEC-FDA program.

Table 4-16: Recommended Plan Economic Benefits

	Equivalent Annual Damages			Probability EAD Reduced		
Plan	**Without Plan**	**With Plan**	**Damages Reduced**	**0.75**	**0.50**	**0.25**
Armourdale						
KR3 Plan	$55,392.04	$ 3,935.00	$51,457.05	$36,287.34	$49,899.39	$63,998.28
Central Industrial District						
KR3 Plan	$ 8,867.90	$ 3,638.32	$ 5,229.58	$ 1,583.39	$ 3,769.20	$ 7,442.57
Total	**$64,259.94**	**$7,573.32**	**$56,686.63**	**$37,870.73**	**$53,668.59**	**$71,440.85**

Note: October 2013 price level; 3.5% discount rate; 50-year period of analysis; $1,000's

Estimated project construction costs and OMRR&R costs were developed using the MII cost estimating system. These costs, along with annualized costs, annualized benefits, net economic benefits and the benefit-to-cost ratios are shown in Table 4-17: Recommended Plan Economic Summary. These values are based on October 2013 price levels, an interest rate of 3.5 percent, 50-year period of analysis and a 10-year construction period.

In the Kansas Citys study area, some major production facilities are either a sole producer of a specific product or are one of just a very few in the nation that produces that product. Proctor and Gamble is a prime example in the Armourdale Unit. Loss of production capability in these instances could be an economic loss to the nation unless consumers were able to find a similar product and made the choice to purchase the substitute product. However, these potential NED losses were not quantified for purposes of this study.

Induced damages would occur only if the Argentine Unit was raised and the downstream units, Armourdale and CID, were not. The Recommended Plan for raising the Armourdale and CID Units eliminates these induced damages. The Recommended Plan causes no new induced damages on other areas.

Table 4-17: Recommended Plan Economic Summary

Item	Recommended Plan
Interest Rate	3.5%
Construction period, years	10
Period of Analysis, years	50
Project First Cost	$313,402,000
Interest During Construction	$70,877,000
Investment Cost	$384,279,000
Annual Cost	
Amortized Cost	$16,383,200
OMRR&R	$336,500
Total Annual Cost	$16,719,700
Annual Benefits	$56,686,600
Benefit to Cost Ratio	3.4
Net Benefits	$39,966,900

4.7.11 Sensitivity of the Recommended Plan to Future Conditions

Both the future with and without condition scenarios are evaluated over a 50 year period of analysis to allow a consistent and appropriate comparison of alternatives. The period of analysis is the time horizon for which project benefits and project operation, maintenance, repair, rehabilitation and replacement (OMRR&R) costs are evaluated. The period of analysis begins with the base year condition (considering resources in the study area and economic and engineering factors) thought to exist in the first year a project alternative is expected to become operational. Extensive economic surveys of the whole Kansas Citys Levees study area were completed in 2002. Economic data developed for this analysis includes values, elevations and depth-damage relationships for homes, businesses, public facilities, roads, and railroads in the study area. Furthermore, a follow up survey was conducted in early FY2012 to update the economic field data. Engineering and economic data is also developed (projected) for a future year about 20 to 30 years out from the base year. The analysis years used in this Final feasibility study are 2026 for the base year and 2049 for the future year, with the total 50 year period of analysis ending in 2076.

In this study, certain assumptions related to the period of analysis were made:

- River stage uncertainty values were increased from 1.5 ft. to 1.8 ft. in the future year 2049; this reflects the increased difficulty in predicting stages far in the future.
- No significant increase in economic development is projected for the 50 year period of analysis as much of the protected area is essentially built-out.
- Beyond the future condition year of 2049, the expected annual damage is assumed to be constant in the remaining years of the period of analysis.

These assumptions provide a future without project scenario in which there are no substantial growth assumptions, which would influence project benefits.

4.7.12 Environmental Compliance

No significant environmental impacts have been detected to date. See Table 4-18 for the environmental compliance status.

Table 4-18: Environmental Compliance

Federal Law	
Archaeological and Historic Preservation Act, as amended, 16 U.S.C. 469, et seq.	Full
Clean Air Act of 1977, as amended, 42 U.S.C. 7609, et seq.	Full
Clean Water Act, as amended, (Federal Water Pollution Control Act), 33 U.S.C. 1251, et seq.	Full*
Coastal Zone Management Act, 16 U.S.C. 1451, et seq.	N/A
Endangered Species Act, 16 U.S.C. 1531, et seq.	Full
Estuary Protection Act, 16 U.S.C. 1221, et seq.	N/A
Federal Water Project Recreation Act, 16 U.S.C. 460-12, et seq.	Full
Fish and Wildlife Coordination Act, 16 U.S.C. 661, et seq.	Full
Land and Water Conservation Fund Act, 16 U.S.C. 460/ -460/-11, et seq.	N/A
Marine Protection, Research and Sanctuary Act, 33 U.S.C. 1401, et seq.	N/A
National Environmental Policy Act, 42 U.S.C. 4321, et seq.	Full

Table 4-18: Environmental Compliance

National Historic Preservation Act, 16 U.S.C. 470a, et seq.	Full
Rivers and Harbor Act, 33 U.S.C. 401, et seq.	N/A
Watershed Protection and Flood Prevention Act, 16 U.S.C. 1001, et seq.	N/A
Wild and Scenic Rivers Act, 16 U.S.C. 1271, et seq.	Full
Executive Orders, Memorandums, etc.	
Executive Order 11988, Floodplain Management, May 24, 1977 (42 CFR 26951; May 25, 1977)	Full
Executive Order 11990, Protection of Wetlands, May 24, 1977 (42 CFR 26961; May 25, 1977)	Full
Council on Environmental Quality Memorandum of August 11, 1980: Analysis of Impacts on Prime or Unique Agricultural Lands in Implementing the National Environmental Policy Act.	Full
Executive Order 12114, Environmental Effects Abroad of Major Federal Actions.	N/A
Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, February 11, 1994.	Full
State and Local Policies	
Missouri Water Quality Standards	Full*

The compliance categories used in this table were assigned based on the following definitions:
Full Compliance (Full): Has met all requirements of the statute, Environmental Order (EO) or other environmental requirements for the current stage of planning.
Ongoing: Coordination ongoing, and should be completed prior to signature of FONSI.
Not Applicable (N/A): No statute, EO or other environmental requirement for the current stage of planning.
Full*: All necessary permits/certifications will be acquired prior to project implementation and/or construction.

4.7.13 System of Accounts Evaluation

The Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) establish a system of four accounts for evaluation of alternative plans. The first of these accounts, National Economic Development (NED), evaluates the changes in the economic value of the national output of goods and services and is measured by the economic benefit, or reduced damages, resulting from the alternative plan, discussed previously. The remaining three accounts are:

- Environmental Quality (EQ). The non-monetary effects on significant natural and cultural resources.
- Regional Economic Development (RED). Changes in the distribution of regional economic activity that result from the plan.
- Other Social Effects (OSE). Plan effects from perspectives relevant to the planning process that are reflected in the other accounts.

An evaluation of the Recommended Plan for all four accounts is presented in Table 4-19.

Table 4-19 Evaluation of P&G System of Accounts

National Economic Development (NED)

	Armourdale		Central Industrial District	
	No Action	**Recommended Plan**	**No Action**	**Recommended Plan**
Project Cost	NA	$232,650,000	NA	$80,752,000
Annual Cost	NA	$12,343,800	NA	$4,375,900
Annual Benefits	NA	$51,457,100	NA	$5,229,600
Annual Net Benefits	NA	$39,113,200	NA	$853,700
BCR	NA	4.2	NA	1.2

Environmental Quality (EQ)

	Armourdale		Central Industrial District	
	No Action	**Recommended Plan**	**No Action**	**Recommended Plan**
Flooding	Expected Annual Flood Damage of $55.3 million.	Expected Annual Damage reduced by $51.5 million.	Expected Annual Flood Damage of $8.9 million.	Expected Annual Damage reduced by $5.2 million.
Air Quality	No immediate impact. Possible adverse future impacts	Temporary impacts during construction	No immediate impact	Temporary impacts during construction
Water Quality	No immediate impact. Possible adverse future impacts	Essentially no impact	No immediate impact. Possible adverse future impacts	Essentially no impact
Erosion and Sedimentation	No immediate impact. Possible adverse future impacts	Essentially no impact	No immediate impact. Possible adverse future impacts	Essentially no impact
Water Quantity	No impact	No impact	No impact	No impact
Ground Water	No immediate impact. Possible adverse future impacts	Essentially no impact	No immediate impact. Possible adverse future impacts	Essentially no impact
Aquifers	No impact	No impact	No immediate impact	No impact
Aquatic Habitat	No immediate impact. Possible adverse future impacts	Essentially no impact	No immediate impact. Possible adverse future impacts	Essentially no impact
Riparian Habitat	No immediate impact. Possible adverse future impacts	No impact	No immediate impact. Possible adverse future impacts	No impact
Upland Habitat	No immediate impact. Possible adverse future impacts	No impact	No immediate impact. Possible adverse future impacts	No impact
Floodplains (E.O. 11988)	No impact	No expected impact	No impact	No expected impact
Cultural Resources	No immediate impact	No impact	No immediate impact	No impact
Prime and Unique Farmland	No immediate impact. Possible adverse future impacts	No impact	No immediate impact	No impact
Economic Resources	Continued potential for property damage and business losses due to damaging flood events.	Significant reduction in property damage and lost business.	Continued potential for property damage and business losses due to damaging flood events.	Significant reduction in property damage and lost business.

Table 4-19 (continued)

Other Social Effects (OSE)

	Armourdale		Central Industrial District	
	No Action	**Recommended Plan**	**No Action**	**Recommended Plan**
Health and Safety	High level of flood risk in entire region with associated stress and anxiety, risk to regional health care system, and impacts to emergency access during floods. High potential for loss of life during flood fights.	Project would significantly reduce risk to public health and safety.	High level of flood risk in entire region with associated stress and anxiety, risk to regional health care system, and impacts to emergency access during floods. High potential for loss of life during flood fights.	Project would significantly reduce risk to public health and safety.
Economic Vitality	Current economy is strong. If catastrophic flood occurs, economic impacts would be extensive and long-lasting.	Project would significantly benefit the regional economy.	Current economy is strong. If catastrophic flood occurs, economic impacts would be extensive and long-lasting.	Project would significantly benefit the regional economy.
Social Connectedness	High levels of instrumental social support will continue throughout the region.	Armourdale area would see less frequent disruptions due to flood fights.	High levels of instrumental social support will continue throughout the region.	The Central Industrial District would see less frequent disruptions due to flood fights.
Identity	Strong Hispanic heritage	Project would not likely affect cultural and community identity significantly	Strong European heritage with growing minority population.	Project would not likely affect cultural and community identity significantly
Social Vulnerability and Resilience	Armourdale highly vulnerable to catastrophic flood damage. Resilience of community may be lower due to lack of temporary housing options. Low income residents more vulnerable to short-term impacts of floodfighting.	Project would significantly reduce the Armourdale area vulnerability to floods, allowing focus on other social needs.	The Central Industrial District is vulnerable to catastrophic flood damage. Resilience of community may be lower due to lack of temporary housing options. Low income residents more vulnerable to short-term impacts of floodfighting.	Project would significantly reduce the Central Industrial District vulnerability to floods allowing focus on other social needs.
Participation	Residents in the study area exhibit a normal rate of participation in civic activities like flood fights, elections, and public meetings	Project would have little to no effect on civic participation.	Residents in the study area exhibit a normal rate of participation in civic activities like flood fights, elections, and public meetings	Project would have little to no effect on civic participation.
Leisure and Recreation	Residents of the area are active. Recreational facilities would continue to be provided as currently planned.	Project would have little to no effect on recreational opportunities.	Residents of the area are active. Recreational facilities would continue to be provided as currently planned.	Project would have little to no effect on recreational opportunities.

Table 4-19 (continued)

Regional Economic Development (RED)			
Armourdale		**Central Industrial District**	
No Action	**Recommended Plan**	**No Action**	**Recommended Plan**
Continued potential for property damage and business losses due to damaging flood events.		Reduced flooding would enhance stability in employment in the Unit with potential for additional permanent employment opportunities; project construction would provide minor, short-term increase in construction employment; temporary increase in sales tax revenues during construction; property values would remain stable or improve, thereby increasing the local tax base; reductions in income attributable to flood damages, wage losses, traffic disruption costs, floodfight emergency expenditures.	Continued potential for property damage and business losses due to damaging flood events	Reduced flooding would enhance stability in employment in the Unit with potential for additional permanent employment opportunities; project construction would provide minor, short-term increase in construction employment; temporary increase in sales tax revenues during construction; property values would remain stable or improve, thereby increasing the local tax base; reductions in income attributable to flood damages, wage losses, traffic disruption costs, floodfight emergency expenditures.

4.7.14 Environmental Operating Principles

Under the seven Environmental Operating Principles (EOPs), 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 Kansas City, with permanent structural features dating back several decades, has inherent limitations to the inclusion of viable environmental improvements. During the feasibility study, various candidate environmental measures were reviewed in recognition of the EOPs. In addition, flood risk management engineering measures were developed in a manner which sought to preserve, improve and sustain the environment. After review of the options and consideration of the conditions in this project area, it was generally determined that the best way to comply with the EOPs for this project, would be preservation of the continuity and value of habitat along and adjacent to the Kansas River bank line areas within the metropolitan area. The Recommended Plan has minimal impacts on existing habitat and wetlands and serves to protect the environmental and community fabric that has developed behind the existing levee system.

It is important to note the other Corps of Engineers projects underway in the general area that have substantial environmental benefits. The Missouri River Fish and Wildlife Mitigation Program provides for a long-term major restoration of areas along the Missouri River. The Riverfront Ecosystem Restoration Section 1135 project in the Kansas City reach of the Missouri River (near river mile 365.7) provides numerous environmental benefits along levee and floodwall areas and is a part of a larger effort to restore habitat and increase recreational opportunities along the Kansas City Missouri riverfront area. The Blue River project in the

eastern sections of Kansas City and Jackson County also provides for a number of important environmental benefits in an urban setting. The benefits from all these other projects include: a) improvement of aquatic habitat by measures to improve water quality, bottom diversity, aquatic species spawning and rearing habitat; b) wetland restoration and natural vegetation development to improve habitat function and diversity; and c) improving the hydraulic connection and habitat continuity between riverine habitat areas, tributaries, and the Missouri River.

4.7.15 USACE Campaign Plan

USACE Campaign Plan. The USACE Campaign Plan contains four goals: Support the Warfighter. Transform Civil Works, Reduce Disaster Risks, and Prepare for the Future. Project formulation and alternative development furthered three of these four goals

Transform Civil Works: This study effort employed the current strategies in place for delivering enduring and essential water resource solutions. Review processes incorporated in this study included District Quality Control (DQC), Agency Technical Review (ATR), and Independent External Peer Review (IEPR). The ATR was conducted by an interdisciplinary team across several Corps Districts and coordinated with both the Flood Risk Management Center of Expertise and the Cost Estimating Directory of Expertise. The IEPR was managed by an outside organization employing independent technical experts. Customer and stakeholder engagement was encouraged throughout the planning process.

Reduce Disaster Risks: The overall study and recommendations as presented in the Interim Feasibility Report and this Final Feasibility Report present an integrated analysis of seven levee units to ensure overall system reliability and performance. Risk and uncertainty based models and methods were employed to examine the existing system and identify reliability deficiencies. The study team provided early and often communication of risk assessments, finding, and recommendations with the project sponsors and stakeholders using currently accepted terminology and concepts. Alternatives were chosen to reduce the flood risk to existing infrastructure and investment, and improve future system reliability. The Recommended Plan considers interactions and dependencies between units and sponsors and provides a complete plan for a safe, reliable, and resilient flood risk management system that mitigates disaster impacts to local community and the Nation.

Prepare for Tomorrow: The study effort employed the best available technical expertise and experience, and project management and leadership, to establish a dedicated, competent, and capable team to produce a quality project recommendation. The lessons learned by the team in the execution of this study will contribute to sustaining a culture of collaboration and innovation for delivering future solutions.

4.8 Implementation Requirements

Implementation responsibilities refer to actions and financial arrangements of Federal and non-Federal interests directed toward implementation of the Recommended Plan.

4.8.1 Institutional Requirements

The overall project schedule for the areas of interest in the Final Feasibility Report analysis is based upon the assumption that a positive Chief of Engineers' Report will be forwarded through the Assistant Secretary of the Army for Civil Works and the Office of Management and Budget to Congress for inclusion in authorizing legislation. Funding is assumed available at the earliest practical opportunity for new PED starts. Lack of initial PED funding will shift the schedule out accordingly until such time as the funding is made available. Additional refinements to the project schedule will be made as authorization and program guidance is received.
The project schedule provides for almost immediate start of design remedies beginning in FY2016, followed by award of construction contracts for the remedies, pending authorization, in FY20 through FY30. Several factors have been considered when projecting the sequence of future work:

- Construction contracts for different features can be undertaken simultaneously for increased efficiency.
- Improvements to the reliability of existing features will be implemented prior to increasing the levee height.
- Federal and Non-Federal construction funding is available in the years required
- Real estate actions are completed on schedule.

The project schedule (Table 4-20) reflects the information currently available and the current departmental policies governing execution of projects. It does not reflect program and budgeting priorities inherent in either the formulation of a national civil works construction program or the perspective of higher review levels within the Executive Branch. Consequently, the proposed schedule may be modified before it is transmitted to higher authority for authorization and/or implementation funding.

In meeting the area's needs for flood risk management, the Federal Government will be responsible for providing the Federal share of project costs and for implementing the Recommended Plan. The Kansas City District will develop the Project Management Plan sections needed for guiding the PED (design) and construction of the project.
The non-Federal sponsors are fully aware of and able to comply with all non-Federal sponsor responsibilities as described within the Recommendation section of this report.

Table 4-20: Project Schedule

Date	Task
April 2014	Feasibility Report Approval by the Civil Works Review Board
July 2014	Approval of the Report of the Chief of Engineers recommending the project to Congress for authorization
October 2015	Execution of Project Design Agreement with Local Sponsor; initiation of Pre-Construction Engineering and Design Phase (pending availability of design funding)
October 2018	Execution of the Project Partnership Agreement with the Local Sponsor (pending construction authorization and availability of construction funding); Initiation of Land and Easement Acquisition by the Local Sponsor
October 2019	Initiation of Construction
October 2029	Completion of Project Construction

4.8.2 Fully Funded Cost Estimate

The fully funded cost estimate accounts for all costs through construction completion including inflation based on the current project schedule. The current and fully funded project costs are presented in Table 4-21.

Table 4-21: Cost Summary by Levee Unit – Recommended Plan

Levee Unit	Total	Federal (65%)	Sponsor (35%)	PED	LERRD	FRM
OCT 2013 PRICE LEVEL ESTIMATE						
Armourdale Unit	$232,650	$151,222.5	$81,427.5	$15,611	$4,463	$212,576
CID Unit						
Kansas Section	$80,177	$52,115.1	$28,062.0	$5,450	$2,591	$72,136
Missouri Section	$575	$373.8	$201.3	$41	$0	$534
Totals	**$313,402**	**$203,711.3**	**$109.690.7**	**$21,102**	**$7,054**	**$285,246**
FULLY FUNDED ESTIMATE						
Armourdale Unit	$296,660	$192,829	$103,831	$19,117	$5,253	$272,290
CID Unit						
Kansas Section	$102,000	$66,300	$35,700	$6,659	$2,945	$92,396
Missouri Section	$735	$478	$257	$51	$0	$684
Totals	**$399,395**	**$254,279**	**$145,116**	**$25,827**	**$8,198**	**$365,370**

Notes: All costs in $1,000's; Amounts include the estimated contingencies for each site; Totals in this table are rounded.

4.8.3 Cost Apportionment

This discussion of individual non-Federal sponsor amounts is based on the fully funded project costs in Table 4-16. Of the two non-Federal sponsors, the Kaw Valley Drainage District of Wyandotte County, Kansas (KVDD), is responsible for the largest non-Federal share. KVDD will be responsible for the non-Federal share of work on the Armourdale Unit and the Kansas Section of the Central Industrial District Unit. Total costs for these two project components are expected to total $312,827,000. The 35 percent non-Federal share is $109,489,500. KVDD will continue to be responsible for annual operation and maintenance costs including the approximately $336,500 in annual costs added by this project. In a letter to the Kansas City District Corps of Engineers dated April 12, 2006, KVDD asserted their capability and intent to fund non-Federal costs for design, construction, operation and maintenance functions related to

these two project components. KVDD support for the recommended plan of this report was expressed by letter dated March 4, 2014. KVDD currently funds their operations through a tax levy on properties within their district and they have authority under state statutes to issue general obligation bonds to raise funds. Additional possible funding alternatives include increases to their tax levy, expansion of their statutory bonding authority, and identification of local funding partners. It is expected that the proposed projects will be implemented in phases spread over a number of years to lessen the annual impact to KVDD's annual budgets and operations.

The City of Kansas City, Missouri, is responsible for non-Federal cost sharing of the recommended plan in the Missouri Section of the Central Industrial District Unit, with an estimated total cost of $575,000. The non-Federal cost share responsibility would be $201,300. The City will continue to provide annual budgets for levee operations and maintenance in accordance with current practice. This project is not expected to create additional operations and maintenance costs. The City expressed its intent and capability to provide the required non-Federal share in a letter to the Kansas City District dated June 16, 2006. The City expressed support for the recommended plan of this report by letter dated February 27, 2014. The City anticipates providing the non-Federal share from the Public Improvements Advisory Committee (PIAC) Capital Improvement Funds; the same as they are currently funding such projects. The Kansas City District is of the opinion, based on the current financial standing and past performance of these sponsors, that their financing plans are reasonable and that they will be capable of meeting their financial obligations for implementation of the Recommended Plan.

4.8.4 Updated Survey Datum Requirements

Current Corps of Engineers policy stipulates that the vertical survey datum of all projects must be based on the North American Vertical Datum of 1988 (NAVD 88). This feasibility study analysis relied heavily on existing information including original levee record drawings and prior reports, many of which were based on the National Geodetic Vertical Datum of 1929 (NGVD 29). Recent design and construction projects undertaken by the Kansas City District, including implementation resulting from the Interim Feasibility Report, have shown a difference of between two and four inches in the vertical elevations when converting from NGVD 29 to NAVD 88. This was determined not to be a significant difference for the purposes of this feasibility report analysis and recommendations. Future design phase efforts for implementation of the Recommended Plan will require updated survey data using NAVD 88. For additional detail and discussion of survey information refer to the Survey and Mapping Chapter to the Engineering Appendix.

4.8.5 Permits

Requirements for Section 404 of the Clean Water Act of 1972, as amended, will be met prior to any construction activity, as well as any permit requirements of the Missouri Department of Natural Resources and/or the Kansas Department of Health and the Environment for any construction activity near the stream channel. The completed 404 (b) (1) guidelines form is included in Appendix J of the 2006 EIS.

4.8.6 Views of the Non-Federal Sponsors

The non-Federal sponsors strongly support the Recommended Plan. On a daily basis, each of the sponsors accomplish the numerous actions necessary for keeping 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 obligations associated with the Recommended Plan.

The sponsors are fully aware of and in agreement with the requirements of the model Project Partnership Agreement. Both sponsors have previous experience on similar projects with Kansas City District that have utilized the model agreement with no requests for special conditions. It is anticipated that no special requirements will be requested or required for implementation of the Recommended Plan.

5 Environmental Considerations

5.1 Review of Previous Documentation and Current Conditions

The FEIS published in August 2006 (USACE, 2006b) included discussion of tentative alternatives, including environmental and cultural conditions and impact assessments, for the levee units and study areas discussed in this Final Feasibility Report. In accordance with the Council on Environmental Quality regulations for implementing NEPA, 40 CFR Part 1502.9(c)(1), Federal agencies "shall prepare supplements to either draft or final environmental impact statements if: (i) the agency makes substantial changes in the proposed action that are relevant to environmental concerns; or, (ii) There are significant new circumstances or information relevant to environmental concerns or bearing on the proposed action or its impacts." Due to the Armourdale and CID levee units schedule for construction initiation in 2018, and a seven year timeframe since completion of the 2006 FEIS, NEPA compliance review for these units was conducted to document any change in the scope of work and/or impacts to resources that occur within these levee units, and any potential changes to existing resources that may have occurred since the 2006 FEIS was finalized.

The Recommended Plan presented herein is within the project alternatives and geographic areas previously proposed and assessed; no substantial change has been made to the proposed action. Review of the project areas has shown no changes in the environmental conditions of the project area since publication of the FEIS, nor have there been changes in status, standards, or other factors that would affect the conclusions of the FEIS. Based on this review a new or supplemental EIS has not been prepared for the recommendations of this report. The FEIS is incorporated by reference and is currently available on the Kansas City District website, http://www.nwk.usace.army.mil/Missions/CivilWorks/ CivilWorksProgramsandProjects/KansasCitys,FloodRiskManagement.aspx. Federal and State resource agencies with jurisdiction over environmental resources reviewed this report and its findings during the Public Review period. No significant comments were received, as detailed in Appendix G.

The Armourdale and CID levee units are located within highly industrialized areas. As a result of industrialization, the resources within and adjacent to these levee units are severely disturbed. Impacts to resources due to the implementation of the recommended plan are documented in Section 4 of the FEIS. No significant impacts were documented to occur. Impacts primarily include a long-term, adverse visual impact due to the recommended landside levee raise, and minor, short-term, adverse construction related impacts. A review of current conditions and potential impacts of the Recommended Plan are presented in the following sections.

5.1.1 Affected Environment

Feasibility analysis and field reconnaissance was conducted for the 2006 FEIS to document the affected environment within each respective levee unit including water resources and water quality, geology and minerals, air quality, noise, visual quality, soils and prime farmland, hazardous, toxic and radioactive waste, cultural resources, floodplain terrestrial habitat, wetlands, fisheries, wildlife, threatened and endangered species, and the socioeconomic environment including recreation and environmental justice. The affected environment is addressed within section 3 of the FEIS. The FEIS addressed the impacts of the no action alternative, action alternatives that were not selected for implementation, as well as the recommended plan on the affected environment within each of the seven levee units. Impacts to resources are addressed in section 4 of the FEIS.

Throughout the study effort, Corps staff has maintained contact with the project sponsors, the Kaw Valley Drainage District and the City of Kansas City, MO, regarding ongoing property management and access to the levee units. No change in the property, or maintenance of the property, has been reported by the levee unit sponsors.

In July, 2013, Corps staff conducted field reconnaissance within the Armourdale and CID levee units, and the Water District Number One of Johnson County, Kansas (WaterOne) property that was identified in the FEIS as the proposed borrow location. Field reconnaissance was conducted by both driving and walking through the borrow area and levee units.

5.1.1.1 ***Borrow Area***

WaterOne employees provided borrow area access and confirmed that WaterOne still owned the same property including the proposed borrow area addressed in the FEIS. WaterOne employees stayed on site and observed while CENWK conducted field reconnaissance of the WaterOne property.

The land use and land cover of the proposed borrow area has not changed compared to the land use and land cover observed and documented in 2006. The farmed wetland and associated vegetation, tree cover and crop field still exist in the same locations. The crop field was observed to be planted in soybeans. WaterOne employees reiterated that WaterOne has future plans to excavate monofills for lime storage. No new monofills were observed excavated since

2006. WaterOne employees were unsure when the next monofill would be excavated, but felt that the location would be adjacent to existing excavated monofills. No new borrow areas are proposed for use in addition to WaterOne property.

5.1.1.2 ***Armourdale Levee Unit***

The Armourdale levee unit was observed by driving the entire length of the levee and periodically walking through vegetated areas. The land use and land cover of the Armourdale Levee Unit has not changed compared to the land use and land cover observed and documented in 2006. The Armourdale unit still primarily consists of earthen levee and floodwall.

5.1.1.3 ***CID Levee Unit***

The CID Levee Unit was observed by driving along the entire length of the levee and walking through railroad property and fields. The CID unit still primarily consists of earthen levee and floodwall. No changes in land cover were observed. A minor change in land use was observed compared to the land use observed and documented in 2006. A large warehouse in the rail yard area at the upstream end of CID has been torn down and removed. The warehouse was observed in 2006 as being abandoned and in poor condition.

5.1.2 Threatened and Endangered Species

State and Federal listed threatened and endangered species for Wyandotte County, Kansas and Jackson County, Missouri were reviewed for changes in status since the 2006 FEIS. Additions to the Wyandotte County, KS list include the Federally endangered shoal chub, which inhabits the Kansas River. No work will be conducted within the Kansas River. Therefore, this species will not be impacted by the proposed project.

Additions to the Jackson County, MO list include the following terrestrial species: American badger, bald eagle, eastern collared lizard, Franklin's ground squirrel, thirteen lined ground squirrel, and tufted loosestrife. These species require specific habitats that are not available within the proposed project areas as the project areas are urbanized, industrialized, and severely disturbed. Riparian vegetation is available for the bald eagle. However, this species is not known to inhabit any riparian areas within the vicinity of the project area. No trees suitable for bald eagle roosting or nesting will be impacted by the proposed project.

Aquatic species include the lake sturgeon, longtail tadpole shrimp, plains minnow, sturgeon chub, and western silvery minnow. No work will be conducted within the Missouri River. Therefore, these species will not be impacted by the proposed project. One listed semi-aquatic species includes the northern crawfish frog. There is no northern crawfish frog habitat within the vicinity of the proposed work. Therefore, this species will not be impacted by the proposed project.

In response to the Final Feasibility Report (FFR) 30-day public comment period, neither the U.S. Fish and Wildlife Service, the Kansas Department of Wildlife and Parks, nor the Missouri Department of Conservation had comments concerning threatened and/or endangered species or their respective habitats. (See Appendix G.)

5.1.3 Hazardous, Toxic, and Radioactive Waste

The August 2006 Review of Completed Project, Kansas City Levees, Missouri and Kansas Interim Feasibility Report stated that "*The Interim Feasibility Report examines* (*and makes recommendations regarding*) *five of the seven levee units (Argentine, Fairfax-Jersey Creek, East Bottoms, North Kansas City, Birmingham). The Final Feasibility Report will address the remaining two units (Armourdale and CID). In accordance with 40 CFR 1500, the EIS addresses all seven levee units using projections of the tentatively preferred alternatives in the Armourdale and CID Units where firm detailed conclusions are not yet available. A supplement to the EIS will be developed to support the Final Feasibility Report.*" The Interim Feasibility Report recognized that there could potentially be a need for additional NEPA reporting, such as a Supplemental EIS (SEIS) if new information arose during the HTRW, geotechnical, and structural analyses to confirm the tentatively preferred alternatives for the Armourdale and CID Units and complete the feasibility study. The need for additional HTRW for Armourdale and CID was reiterated by the U.S. Environmental Protection Agency (USEPA) in the Lack of Objections rating for the 2006 DEIS (July 17, 2006). The USEPA as a cooperating agency for the study provided air quality, environmental justice, and HTRW information. Additionally, early in the feasibility study records and files were obtained from, and personal interviews conducted with, the Kansas Department of Health and Environment and the Missouri Department of Natural Resources. The USEPA DEIS review recognized that both Armourdale and the CID needed additional HTRW investigation. Table 2-1 of the EIS lists the tentatively preferred alternatives for Armourdale and CID as the nominal 0.2% event +3 ft. levee raise (KR3 plan) with underseepage controls. Sections 4.8.7 and 4.8.8 of these documents state that additional hazardous waste investigations for these units are needed and the FEIS states that the results of additional HTRW investigations will be used in selecting the preferred alternative for Armourdale and CID.

Despite the recognized potential, the tentative alternatives remained the selected alternative through the remaining analysis and no new substantive information arose. Additional HTRW investigation for Armourdale and CID levee units was completed in 2007 and is documented within Appendix D. A summary of the HTRW sites is provided below.

5.1.3.1 ***Armourdale Levee Unit***

HTRW sites addressed within Appendix D of this FFR within the Armourdale levee unit that were not addressed within the DEIS or FEIS, as the analyses had not been fully conducted, include: Inland Container Corporation, Kaw Power Station, KC Hardwood Corporation (a.k.a. American Walnut), Kansas City Railcar Services, Auto Salvage Yard (formerly A to Z Production Plating), Sambol Packing Company, SELCO (formerly Chromium, Inc.), APAC –

Wilkerson and Union Pacific Railroad. The results of the additional HTRW documentation, annotated by section within Appendix D, include:

4.1.2 Inland Container Corporation: "*Based on information evaluated, no impacts to levee improvements resulting from HTRW concerns were identified. No further investigation is necessary*."

4.1.3 Kaw Power Station: "*There is no longer evidence of contamination associated with this property. The property would only be encroached on if there was a need for a temporary easement. Therefore, no further investigation is needed*."

4.1.4 KC Hardwood Corporation (a.k.a. American Walnut): "*There is no longer evidence of contamination associated with this property. The property would only be encroached on if there was a need for a temporary easement. Therefore, no further investigation is needed*."

4.1.6 Kansas City Railcar Services: "*Due to the past use as a salvage yard, the property which falls into the limits of disturbance for the selected alternative should be more fully investigated during the Design Stage to ensure that the surface and subsurface soil are not contaminated and to determine how to dispose of any contaminated soil*."

4.1.7 Auto Salvage Yard, Formerly A to Z Production Plating: "*Due to past use as a salvage yard, the property which falls into the limits of disturbance for the selected alternative should be more fully investigated during the Design Stage to ensure that the surface and subsurface soil are not contaminated and to determine how to dispose of any contaminated soil*."

4.1.10 Schock Truck & Leasing: "*During the site visit, two AST's were seen from the levee road. The tanks were in good condition. A pile of debris lies between the tanks and jersey barriers that denote the edge of the property. It appears to be random construction debris. No other soil or groundwater contamination appears to be present at the site; therefore no further investigation is planned*." The "*site visit*" as described in FFR Appendix D does not include the date that a "*site visit*" was conducted. The "*site visit*" is the last bullet in Section 3.0 HTRW SITE ASSESSMENT and is bulleted as "*Performed a site visit to the Armourdale Levee Unit*."

4.1.11 Sambol Packing Co.: "*According to KDHE, Sambol was listed as having two UST's removed after the previous investigations were published. These were removed in 2000. KDHE found no evidence of contamination and considered the site closed. During the site visit, no contamination issues were seen. No HTRW concerns exist for this site; therefore, no further investigation is required*."

4.1.12 SELCO (formerly Chromium, Inc.): "*The aerial photographs show the site was industrialize"* (the author did not state "industrialized") "*before 1951, as KDHE records had said. The current building for SELCO was in existence by 1983. The site visit did*

not indicate any current hazardous waste issues occurring at the site. As only very low concentrations of metals and VOCs below KDHE action levels at the site, no further investigation is required at this location. The previous buried construction debris, if excavated, may be taken to a solid waste landfill."

4.1.14 APAC – Wilkerson: "*During the site visit, APAC was still using the properties as a storage yard for their construction equipment. No contamination is known to be present at this site. Based on information evaluated, no impacts to levee improvements resulting from HTRW concerns were identified. Therefore, no investigation is necessary*."

4.1.15 Union Pacific Railroad: "*During a review of EPA documents, a permit for discharging wastewater and sludges was requested by UPRR. A 1982 document states that test results of the wastewater classified it as non-hazardous. The UPRR withdrew its permit application. While a potential exists for previous contamination resulting from spills along the railroad lines, all known contamination has been remediated from various UPRR sites. Therefore, no further investigation is warranted for the railroad yards*."

5.1.3.2 ***CID Levee Unit***

One potential HTRW site is addressed by Appendix D of this FFR within the CID Levee Unit: River View Properties Inc. The summary of the results, annotated by section within Appendix D, states:

4.2.1 River View Properties Inc.: "*Potential HTRW concerns have been identified within the study area between station 40+31 and 51+00. Potential encroachment into this area associated with the levee raise is proposed to be avoided by steepening the landside levee slope rather than extending the landside toe. No other locations of HTRW concerns have been identified at this time*."

The HTRW investigation conducted to complete the HTRW analysis for this FFR revealed no new substantive information that changes the conclusions of the original EIS or warrants additional NEPA. HTRW investigation has been conducted to the practicable extent within both the Armourdale and CID unit.

5.1.3.3 ***Remaining Areas of Concern***

Considering the urban industrial nature of both areas, it is recognized that there is a residual risk that unidentified concerns are present and HTRW may be encountered during project implementation. Additional soil sampling and testing will be conducted as part of the design phase to verify the limits of known contamination, as well as close monitoring of material excavated during the project construction to ensure that any previously unknown HTRW uncovered is properly handled and disposed. Identified concerns and proposed actions at each of the known HTRW locations are listed in Table 5-1. Any and all removal of contaminated soils

or other contaminated materials will be 100% local sponsor responsibility (including cost). All removal of known contaminated soils or other materials must be completed prior to construction.

Table 5-1: Armourdale Unit Areas of HTRW Concern

Location	Proposed Action
43+00 to 63+00 Proctor & Gamble Manufacturing	Levee raise methods proposed in this reach include T-wall on the existing levee, levee replacement with new floodwall, and floodwall replacement with floodwall, all of which avoid expansion of the levee toe into the area of concern. A slurry cutoff wall will be installed to avoid discharge of contaminated groundwater that may occur with relief wells. Any construction debris encountered near the former Fire Training Area should be removed, sampled, and properly disposed.
110+00 to 130+00 Auto Salvage Yards KC Railcar Services	Levee raise methods proposed in this reach include T-wall on the existing levee and a landside levee raise, which would encroach upon the area of concern. The property will be more fully investigated during the design phase to ensure that surface and subsurface soils are not contaminated and to determine how to dispose of any contaminated soils.
130+00 to 157+00 Trimodal	The levee raise method proposed in this reach is a T-wall on the existing levee. Intrusive activity is limited to areas outside the area of concern. Construction of any haul roads outside the existing right-of-way must be coordinated the Kansas Department of Health and Environment.
278+00 to 293+00 PBI Gordon Corporation	The levee raise method proposed in this reach is a modification of the existing floodwall. No HTRW concern is expected as no invasive activity is planned within the area.

5.1.4 Wetland Delineation and Potential Impact Assessment

In accordance with the statements made in sections 4.11.7 and 4.11.8 of the FEIS, wetland delineation and impact assessment was conducted for the Armourdale and CID levee units to complete the feasibility study. Review of NWI mapped wetlands revealed two NWI-mapped wetlands within the CID unit and seven NWI-mapped wetlands within the Armourdale unit. Wetland delineation was conducted by walking through all of the NWI-mapped features and adjacent land.

Only mapped feature #4 within the Armourdale unit was determined to be a wetland based on the presence of wetland vegetation and wetland hydrology. No soil samples were needed as this feature consists of open water with a wetland fringe. All other areas were riparian forest/riparian scrub-shrub or old field with 10YR3/2 silty clay, silty clay loam, no mottles. Descriptions of enumerated features and associated work include:

> Area 1 is a NWI-mapped feature that does not exist. The area west of the bridge was dominated by cottonwoods (*Populus deltoides*). No depressions or potential wetlands were observed. Work proposed in this area includes replacing existing levee with a floodwall (station 58+00 to 60+40), which would impact the existing levee. No work will occur riverside of the levee.

Area 2 was dominated by riparian vegetation including cottonwoods, box elder (*Acer negundo*), and silver maple (*Acer saccharinum*). Occasional grapevine (*Vitis riparia*) was also observed. The topography of this area is very irregular with depressions. No primary or secondary wetland hydrology indicators were observed. Work proposed includes installing a T-wall on the existing levee. No impacts to this area would occur due to construction as no work is proposed riverside of the levee and levee work would occur at a distance of approximately 230 ft.

Area 3 was very similar to Area 2 as the topography was highly variable with depressions and the landscape was dominated by scrub-shrub box elder with a silver maple fringe. Occasional grapevine was also observed. No direct hydraulic connection with the Kansas River was observed. No primary or secondary wetland hydrology indicators were observed. Work proposed includes installing a T-wall on the existing levee. No impacts to this area would occur due to construction as no work is proposed riverside of the levee and levee work would occur at a distance of approximately 230 ft.

Area 4 consisted of an open water feature (pond) with an emergent wetland fringe dominated by barnyard grass (*Echinochloa crusgalli*) and millet (*Panicum dichotomiflorum*) with some areas of vegetation dominated by reed canarygrass (*Phalaris arundinacea*). Forested wetland fringe comprised of silver maple and box elder was observed on the western side of the pond. The area of wetland fringe varied, but measured a maximum of approximately 30’ in width. Hydrology to this area is provided by a 42” inch storm sewer. No impacts to this feature would occur due to construction as the work proposed is a landside levee raise.

Area 5 consisted of old field vegetation including vetch, goldenrod, and fescue with a fringe of eastern red cedar. No impacts to this feature would occur due to construction as the work proposed is a landside levee raise.

Areas 6 and 7 are additional NWI-mapped features located to the west. These features are storm sewers that drain into the Kansas River. Riparian vegetation including box elder and cottonwood dominates within the vicinity of these drainages. No wetlands were observed within the vicinity of these storm sewers. No impacts would occur within the area of these features as proposed work consists of replacing the existing levee with floodwall.

NWI-mapped wetlands within CID include two features located down gradient of the existing levee located between the James Street Bridge and I-70 Eastbound Bridge. One linear depression was observed about 40 ft riverward of the levee toe. The depression consisted of downed cottonwoods presumably cut down by the Kaw Valley Drainage District for maintenance purposes. This area receives direct precipitation and runoff from the adjacent levee slope. No soil samples could be taken within the depression due to multiple downed cottonwoods and no indicators of wetland hydrology could be observed. Soils are mapped as Eudora-Urban Land Complex. No impacts are anticipated to occur in this area as the proposed work consists of a landside levee raise.

The assessment of the proposed project in both units determined that these wetlands are not expected to be impacted by implementation of the Recommended Plan.

5.1.5 Incorporation of Previous USFWS Recommendations

Recommendations from the USFWS received during the 2006 review of the IFR were reviewed for their applicability to the recommended plan of this Final Report. The previous comments are enumerated below and are followed by the manner in which the Corps is addressing these recommendations in both Phases of the project:

1. Riparian and wetland habitats should be avoided to the maximum extent practicable when selecting borrow sites for the proposed levee raises and compensatory mitigation should be undertaken for unavoidable impacts.

    Impacts to natural resources including wetlands, islands, snags, riparian and upland trees were avoided during plan formulation and design and are being avoided during construction to the extent practicable. An example of avoidance is the removal of clearing the Argentine riparian foreshore from the alternatives for that levee unit. The Phase 1 project implementation will include compensatory mitigation for significant unavoidable resource impacts as needed. No impacts are expected from the Phase 2 recommendations.

2. Levees should be seeded with warm season grasses such as switch grass.

    Levee seeding is conducted in accordance with the information provided in the operation and maintenance section within *the·"Guidance For The Design and Construction Within The Critical Area Of Constructed Flood Control Projects"* (http://www.nwk.usace.army.mil.localprotection/guidance.html), MAINTENANCE Chapter, paragraph 2.2 to 2.2.10. The seeding requirements meet 33 CFR 208.10 Part B section, Levee Maintenance. This requirement assures that levee slopes are mowed on a regular basis for close inspection of the slopes. Close inspection is required to detect settlement, sloughing, slope instability, erosion, the presence of burrowing animals, the presence of debris, encroachments that tend to weaken levees, rutting, depressions or other effects. Regular mowing also assures that deep-rooted vegetation will not become established on levee slopes. Levees will not be seeded with warm season grasses such as switch grass as warm season grasses are not amenable for use on levee slopes meeting the above requirements.

3. Removal of mature cottonwoods, and other native vegetation should be avoided where possible, and if they are removed, replace woody vegetation by establishing 2 acres of native vegetation for every acre impacted.

The removal of woody vegetation has been avoided to the extent practicable. There are trees within the area of construction area of the Phase 1 Fairfax-Jersey Creek sheetpile wall site that will be removed and mitigated at a 2:1 ratio. No other levee unit work, including the Phase 2 recommended plan, is anticipated to result in impacts to woody vegetation.

4. The Corps should create wetland mitigation habitat to compensate for the loss of wetland acreage from the construction of the project. Because an, as yet, unknown number of acres of farmed wetland may be directly impacted, it may be necessary to restore non-wetland habitat to wetland habitat. Farmed wetlands should be mitigated at a 1.0 to 1.0 ratio.

As evaluated in the 2006 EIS, a farmed wetland measuring 0.17 acres is located within the proposed borrow area property owned by Johnson County Water District #1 (WaterOne). This borrow area will provide the material needed for both Phase 1 and 2 levees raises. This farmed wetland will be mitigated at a 1.0 to 1.0 ratio if it is impacted by borrow activities It is unknown at this point in time if the farmed wetland will be impacted as the exact location of borrow within the site is currently unknown..The location of borrow will be at the location of WaterOne's next monofill excavation, which is currently unknown per personal communication with WaterOne on January 9, 2014.

5. Since channelization and levee construction have already resulted in dramatic loss of riparian and wetland habitats in the Missouri and Kansas River basins, the alternative to remove riparian vegetation to increase discharge capacity of the lower Kansas River should be dropped from further consideration.

The alternative to removed riparian vegetation to increase discharge capacity of the lower Kansas River was dropped from further consideration.

6. Encourage wetland development and hydrological re-connection to the river at existing borrow areas landward of the levee units.

Opportunities for environmental measures within the system are being considered in combination with potential mitigation requirements planned under the Phase 1 recommendations. The Phase 2 recommended plan does not include mitigation potential nor any environmental development measures.

7. Provide river access at the Argentine Levee segment.

Providing river access at the Argentine levee segment or the construction of an access road over the Argentine unit is not within the scope of work for this project.

8. Establish native vegetation (trees and shrubs) riverward of levee segments where riparian woodlands are sparse or nonexistent.

The feasibility of woody vegetation establishment is being considered in locations where impacts to woody vegetation occur due to construction, currently only expected at the Fairfax Jersey-Creek Unit Sheetpile Wall project site of Phase 1. Establishment of additional trees and shrubs in areas where no impact is expected to occur is not proposed.

9. Potential for aquatic and wetland restoration at Liberty Bend Cut-off just downstream of Kansas City should be explored.

No aquatic or wetland impacts are currently anticipated for the Phase 2 recommended plan. The Phase 1 recommendations do not anticipate a need for aquatic restoration and have proposed wetland restoration at the site of impact. If, during implementation, previously unforeseen impacts result requiring mitigation for fish and wildlife, the Liberty Bend cut-off site will be considered.

10. Consult with State wildlife agencies in regards to state-listed threatened and endangered species.

Coordination was conducted and completed with the Kansas Department of Wildlife and Parks and the Missouri Department of Conservation. Impacts to state-listed threatened and endangered species will be avoided to the extent practicable.

11. Conduct surveys for the presence of nesting birds in areas slated for clearing and grubbing.

A CENWK biologist is conducting surveys for the presence of nesting birds within all levee units prior to construction.

12. Best Management Practices should be included within the project specifications to avoid and minimize erosion and petrochemical spills within construction areas.

Erosion control measures are included in the project specifications where applicable and include silt fences, straw bales, and other suitable mechanisms. Measures being used to prevent the loss of petrochemicals into waters of the U.S. include the designation of staging areas for chemical storage away from streams, fueling heavy equipment away from streams, and the proper disposal of contractor generated waste. Contractors are also required to submit an environmental protection plan prior to initiating construction activities.

13. Invasive species have been identified as a major factor in the decline of native flora and fauna and their ecosystems. Nearly half of the species currently listed as Threatened

or Endangered under the U.S. Federal-Endangered Species Act are considered to be at risk primarily because of competition with and predation non-indigenous species (Nature Conservancy 19915; Wilcove et al. 1998). Human actions are the primary means of invasive species introductions. Prevention of introductions is the first and most cost-effective option for dealing with invasive species (Global Invasive Species Program Toolkit). Executive order 13112 Section2 (3) directs Federal agencies to not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere and to ensure that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions. Therefore, we recommend that the following Best Management Practice (BMP) be implemented during construction of the levees.

All equipment brought on site will be thoroughly washed to remove dirt, seeds and plant parts. Any equipment that has been in any body of water within the past 30 days will be thoroughly cleaned with hot water (hotter than 40° C or 104° F) and dried for a minimum of five days before being used at this project site. In addition, before transporting equipment from the project site all visible mud, plants, and fish/animals will be removed, all water will be eliminated, and the equipment will be thoroughly cleaned. Anything that came in contact with the water will be cleaned and dried following the above procedure.

Levee unit construction is not anticipated to cause or promote the introduction or spread of invasive species in the United States or elsewhere. Best Management Practices are always included within project specifications and include a requirement for heavy equipment washing and drying prior to and following construction.

5.1.6 Cultural Resources

The cultural resource evaluation of the project area found no archaeological sites or historic structures listed on or eligible for listing on the National Register of Historic Places (NRHP). The project area, heavily disturbed by past levee and urban related construction, was found unlikely to contain previously unidentified archaeological sites eligible for inclusion in the NRHP. Cultural resource findings were coordinated with both the Kansas and Missouri State Historic Preservation Officers who concurred with Corps of Engineers recommendations for no further investigations unless an unanticipated discovery is encountered during construction. See also the 2006 FEIS (USACE, 2006b) section 4.2.7 Armourdale Levee Unit Raise Alternatives and section 4.2.8 CID Levee Unit Raise Alternatives.

5.1.7 Environmental Justice

The Executive Order on Environmental Justice (12898) requires consideration of social equity issues, particularly any potential disproportionate impacts to minority or low-income groups. This is to ensure that issues such as culture and dietary differences are taken into consideration to

ensure that adequate risk is evaluated (USEPA, 2003). To determine potential impacts to minority or low-income groups, the racial and income composition of the individual census tracts within, and adjacent to the study area, were examined using 2000 census data. The focus of Executive Order 12898 provides for the protection of both minority and low-income groups. The results of the Environmental Justice evaluation show that a significant minority population (>25%) is present within the Armourdale and CID levee units. A significant number of persons living at below the national poverty level also reside within the Armourdale Unit. There exists a minor potential for the Recommended Plan to have limited impacts on the Armourdale and CID populations and community cohesion.

Implementation of a levee raise of the Argentine Unit as recommended and approved in the Interim Feasibility Report, prior to any raise in the Armourdale and CID Units, may induce flood damages on the downstream units under extremely rare flood events until such time as equal levels of protection are attained at all three levee units. These potential induced damages are considered temporary and would only occur in the event of a major flood (more rare then the nominal "250 year" event). Impacts to the Armourdale and CID populations are limited by the rarity of coincident circumstances which must occur in order to produce the induced damages. Because significant populations of low income families and cultural and racial minorities reside and work within all the Kansas River Units, there would be no significant difference between implementation of the one unit prior to another. The project would meet the intent of protection of minority and low income populations under Executive Order 12898.

5.1.8 Secondary and Cumulative Impacts

Potential cumulative impacts relating to past, present, and projects within the foreseeable future were evaluated along with the preferred plan to determine the level, if any, of impacts upon the physical and natural environment along the Kansas and Missouri Rivers. The Recommended Plan involves a combination of levee raises and appurtenances that lies primarily within the footprint of the existing levee system. As a result of project implementation, impacts to the existing river systems are relatively minor and not considered significant. Compared to past activities and current operations within these reaches of the rivers, the additional minor impacts created by the increased levels of protection do not create significant additional or cumulative impacts to the environment. Induced damages are discussed in section 3.6.4 Induced Damages.

Executive Order 11988 requires federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. The guidelines address an eight-step process that agencies should carry out as part of their decision-making on projects that have potential impacts to or within the floodplain.

1. Determine if a proposed action is in the base floodplain (that area which has a one percent or greater chance of flooding in any given year).

Per FEMA mapping, the areas currently protected by the Kansas Citys Levees are outside of the 1% event floodplain. However, the existing levees themselves which are proposed to be modified are part of the 1% floodplain.

2. Conduct early public review, including public notice.

The Corps' Notice of Intent to prepare an EIS was published in the Federal Register on January 10, 2001. The initial scoping process was conducted during the summer/fall of 2003 and included meetings with local, state and Federal agencies, organizations and the general public. On August 20, 2003, the Corps held a public information/scoping meeting to present information on the study and to receive input from the public on resources in the affected area, alternatives and potential impacts.

A notice of availability for the Draft Environmental Impact Statement (DEIS) was published in the Federal Register on June 2, 2006. A public meeting was held in Kansas City, Kansas on July 13, 2006. Comments on the Draft Interim Feasibility Report and the DEIS were received during a 45-day comment period via email, the public meeting, and letters. The comment period ended July 17, 2006.

A notice of availability for the Draft Final Feasibility Report was mailed on November 22, 2013. Comments on the report were received during a 30-day comment period via email and letters. The comment period ended December 21, 2013.

3. Identify and evaluate practicable alternatives to locating in the base floodplain, including alterative sites outside of the floodplain.

The proposed project is for modification and improvement of an existing levee system and is generally limited to the current location and features of that system.

4. Identify impacts of the proposed action.

No floodplain impacts are expected from the proposed action. These protected areas are heavily urbanized and intense development has already been in place for many years. Significant development is not anticipated to be induced by the proposed levee project because very little open space remains and recent development has primarily consisted of improving old structures, or razing old structures and replacing with new structures.

5. If impacts cannot be avoided, develop measures to minimize the impacts and restore and preserve the floodplain, as appropriate.

No impacts are expected.

6. Reevaluate alternatives.

As stated in the response to Question 3, the proposed project is for modification and improvement of an existing levee system and is generally limited to the current location and features of that system.

7. Present the findings and a public explanation.

Study findings and recommendations as documented in this feasibility report were published for public review and comment in November 2013. Comments received are included in Appendix G.

8. Implement the action.

The proposed plan detailed in the report is recommended for approval and authorization.

5.1.9 Environmental Mitigation

After considering the environmental features of the project area, there is little potential for impacts to the existing environment from project area construction activities. The project area is primarily within urban industrial areas with little or no environmental features, or is contained with the existing project easements and rights-of-way which are already clear of trees in accordance with current O&M guidelines. Construction activities may include the clearing of grasses, weeds, and incidental immature plants and shrubs, but impacts to mature trees and wetlands are not anticipated. Therefore, mitigation funding has not been included within the Recommended Plan estimated costs.

5.1.10 Climate Change Considerations

Corps of Engineers guidance on climate change adaptation inputs for inland hydrology is at the draft final stage of production, and has not yet been officially released for use. As such, there was no guidance in place when the hydrologic analysis was conducted (finalized 2006) for the Kansas City Levees Feasibility Study. The proposed USACE guidance will initially recommend a qualitative approach. A summary of the qualitative approach as would be applied to the Kansas City Levees is provided below.

The climate of northeast Kansas trends toward a continental weather pattern of cold winters and hot, humid summers. The average temperature in 2013 at Topeka, KS (which represents the northeast portion of Kansas) was 60 degrees. The average high temperature was 73 and average low temperature was 47. The average yearly precipitation was about 37 inches of moisture.

A model of future conditions for the central plains of the United States was created by the National Oceanographic and Atmospheric Administration's (NOAA) National Environmental Satellite, Data and Information Service in a report issued in January 2013. This report is an

assessment of Climate Trends and Scenarios into the next 50 to 100 years. The report cites that over the past period of record for the Kansas River basin, both temperature and precipitation has trended above normal, especially over the last 50 years. To account for climate change in the meteorological conditions, the future forecast of conditions in the region takes into consideration the past temperature and precipitation records, and then considers future modeled conditions in the area through 2070. According to the NESDIS report, a warming trend of about 3-5 degrees F and a precipitation trend very slightly toward wetter conditions can be expected through the next 50 years although significant uncertainty is expected with these estimates. Based on this slight trend toward wetter conditions frequency flows over the study basin may increase, but these increases are being treated in this evaluation to be retained within the bands of uncertainty in the Existing Condition Feasibility hydrologic analysis.

5.2 Determination of Need for Additional NEPA Documentation

The final geotechnical and structural evaluations were required to narrow the array of measures considered for implementing the projected alternative plans, and to determine the material quantities needed for cost estimating and subsequent economic analysis. The information gathered and analyzed confirmed the initially projected alternatives as feasible and cost-effective recommended plans for each unit. No changes to the initially projected project scope or location were made and no new substantive information was found that changed the affected environment or project impacts. With the inclusion of this information within the FFR, there is no need for additional NEPA compliance documentation, including an SEIS. The tentatively preferred alternatives for the Armourdale and CID units as described in the IFR, DEIS, and FEIS as the nominal 0.2% event-year+3 levee raise (KR3 plan) with underseepage controls is still the preferred alternatives for these units and all feasibility analysis is complete.

The record of decision (ROD) for the Kansas Citys Levees Project signed November 21, 2007 by the Assistant Secretary of the Army for Civil Works recognized that "*the public interest will best be served by implementing the improvements identified and described in the interim feasibility report and the Final Environmental Impact Statement*". The improvements as described in the FEIS is documented as levee raises and underseepage improvements for the Armourdale, CID, Argentine, East Bottoms, Fairfax-Jersey Creek, and North Kansas City Levee Units, and the no action alternative for the Birmingham Levee Unit. Therefore, although the ROD omitted to mention the Armourdale and CID units by name, these units are addressed within the FEIS and included within the aforementioned quote from the ROD.

5.3 Environmental Considerations Conclusion

The 2006 scope of work for both the Armourdale and the CID Levee Units, documented as "tentative" in the DEIS, FEIS, IFR, and confirmed as the preferred alternatives (KR3) with the completion of HTRW and engineering analyses as documented in this FFR, consists of landside levee raises with underseepage control improvements to provide equal levels of protection among the Kansas River Levee Units. The preferred alternatives, locations, and scope of work for these levee units have not changed. There was no observed change in the affected

environment of these levee units during the July 15, 2013, field reconnaissance with the exception of the aforementioned removal of a large, degraded warehouse formerly located within the CID. Similarly, there were no substantial changes in environmental consequences associated with the project, including the results of additional HTRW, geotechnical, and structural analysis conducted for the FFR. The risk of residual HTRW is recognized as a project risk during construction. Therefore, the impacts to resources as a result of the implementation of the recommended plan within the Armourdale and the CID Levee Units remain unchanged as reported within the 2006 FEIS, with no additional short- or long-term adverse impacts identified or anticipated.

The IFR, DEIS and FEIS all recognized that the only additional information needed to complete feasibility was limited to minor HTRW investigation within the Armourdale and CID levee units. The DEIS, FEIS, IFR, and FFR all address the seven levee units that comprise the Kansas City Levees, including Armourdale and CID. All remaining HTRW investigation was completed and is documented in Appendix D. NEPA compliance is complete. There is no need for additional NEPA documentation.

Based on review of the FEIS and the evaluations in this FFR, environmental impacts of the Recommended Plan are limited within the project area. Environmental impacts to the project area are considered minor or not significant with many impacts temporary in nature during construction activities. Cultural resource assessment of the project area showed no significant archaeological sites or historic structures impacted by the Recommended Plan; thereby resulting in no significant impacts. However, if significant archaeological or cultural materials are discovered as the project progresses, then appropriate measures for coordination, documentation, and preservation, if needed, would be undertaken. No significant long term socio-economic impacts were identified for the populations within the project areas. Temporary impacts associated with construction activities would occur but are considered not significant. Based on the environmental analysis, implementation of the Recommended Plan would result in no significant impacts to the environment. As the formal decision document, a new ROD that states the alternatives considered and describes the selected alterative for the Armourdale and CID levee units will be prepared for review and approval by the Major Subordinate Command.

6 Public Involvement, Review, and Consultation

Review of the Environmental Impact Statement (EIS) supporting these project recommendations was conducted during the Phase 1 Feasibility Study in accordance with the National Environmental Policy Act (NEPA), and Corps of Engineers policies. The NEPA and EIS processes require full disclosure of present, future and cumulative, economic, environmental and social impacts that might occur as a result of implementing the preferred plan examined within this study. Following is a general description of the public involvement process applicable to the final feasibility study.

Public involvement provides for general public and Agency input and review within the overall NEPA process. The Corps actively solicited input from numerous Federal, State and local agencies, businesses, and organizations. Subsequent to Corps Headquarters (HQ-USACE)

approval for public release of the draft Final Feasibility Report a Notice of Availability appeared in the Federal Register. Notice of the report availability was sent to the study sponsors, elected officials, tribal governments, Federal agencies, state, county, city and local governments, environmental groups, businesses, individuals, news media, libraries, and neighborhood groups and other individuals and organizations on the project mailing list. A press release was made and the project website updated to include the released information. The Draft Report was made available for public review on the website, at area public libraries and at the Kansas City District Corps of Engineers office. The comment period on the draft documents ran for 30 days after the Notice of Availability appeared in the Federal Register. All substantive comments received during this period are included in Appendix G with responses.

6.1 Public Scoping Meetings

Scoping meetings for the feasibility study and Environmental Impact Statement were held during Phase 1 of the Feasibility Study. Invitations and announcements for the scoping meetings were sent to the study sponsors, elected officials, tribal governments, Federal agencies, state, county, city and local governments, environmental groups, businesses, individuals, news media, libraries, and neighborhood groups.

Issues and concerns identified by Agencies regarded potential impacts to downstream areas resulting from implementing any flood risk management measures, economic development of the riverfront area, transportation impacts on bridges, highways, barge traffic, channelization of the Kansas and Missouri Rivers, the potential loss of natural resources, impacts on historic trails and sites, and opportunities for Missouri River recreation and levee trails related to the Metro Green Trail System.

The public recognized the need for effective flood risk management; however they also recognized other needs. The priority needs voiced by the public were related to Missouri River recreational opportunities. Many public comments related to incorporating walking and bicycling trails into the Kansas Citys levees system. Comments also related to the interest and need for parks along the rivers and/or levees. The public also voiced concern over the lack of public access to the Missouri River and Kansas Rivers due to the continuous linear nature of the levees. There were some questions concerning peak flows, scouring, and the water resource models that would be used when addressing urban flood risk management issues.

6.2 Views of Other Agencies

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

- Kansas Department of Health and Environment
- Kansas Department of Wildlife and Parks
- Kansas State Historic Preservation Office
- Missouri Department of Conservation
- Missouri State Historic Preservation Office

- US Environmental Protection Agency
- US Fish and Wildlife Service
- US National Parks Service

Agency views or concerns expressed during the scoping process or through ongoing study coordination, focused on:

- potential or actual contamination within the industrialized areas of the levee units,
- environmental justice for local communities during the formulation of alternatives,
- potential channelization of the Kansas and Missouri Rivers
- quality of the foreshore riparian habitat along the rivers,
- wetlands within the project area,
- threatened and endangered species,
- cultural resources or historic properties that may be encountered.

Agencies have provided concerns or comments through the public scoping process, through a Planning Aid Letter, through coordination and submittal of the draft Fish and Wildlife Coordination Act Report, through coordination letters to the State Historic Preservation Officer, and through day to day contact with appropriate agencies as the formulation process and EIS developed. As a cooperating agency, the EPA has provided specific input and review on contaminant issues, air quality information, and an Environmental Justice evaluation pursuant to Executive Order 12898.

6.3 Status of Corps of Engineers Review Process

6.3.1 Policy Compliance Review

The Alternative Formulation Briefing (AFB) to HQ-USACE occurred on April 24, 2013. The Project Guidance Memorandum (PGM) was submitted to HQ-USACE on July 23, 2013, detailing the AFB comments and issues and the Kansas City District plan for resolution prior to public review of the Draft Final Report. The Draft Feasibility Report was submitted to HQ-USACE in September 2013 for policy compliance review and backcheck of the responses and actions taken per the PGM. Additional comments on the DFR were issued by HQ-USACE in November 2013 and have been incorporated into this Final Feasibility Report.

6.3.2 Agency Technical Review

An Agency Technical Review (ATR) has been completed, led by the Louisville District and including reviewers from several other Corps District offices. The ATR was conducted as defined in the project's Review Plan to comply with the requirements of EC 1165-2-214. During the ATR, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of: assumptions, methods, procedures, and material used in analyses, alternatives evaluated, the appropriateness of data used and level obtained, and reasonableness of the results, including whether the product meets the customer's

needs consistent with law and existing US Army Corps of Engineers policy. The ATR also assessed the District Quality Control (DQC) documentation and made the determination that the DQC activities employed appear to be appropriate and effective. All comments resulting from the ATR have been resolved and the comments have been closed in the Corps' DrChecks review tracking system.

Significant concerns and the explanation of the resolution are as follows: Comments were raised regarding: capacity of the current pumping system to remove interior drainage from the protected area after implementation of the recommended improvements to the existing levees; and constructability of some subsurface cutoff walls on the Armourdale unit when given the constraints of nearby utilities, existing overhead bridges, and potential HTRW concerns. Provision of additional detailed materials in the report and appendices resolved these issues with no impact on basic project formulation. No concerns remain. All ATR comments have been answered, back checked, and closed.

A separate ATR Certification Report has been prepared by the ATR Team Lead and reviewed and approved by the Flood Risk Management Planning Center of Expertise (FRM-PCX)

6.3.3 Independent External Peer Review

An Independent External Peer Review (IEPR) panel was established and managed by Battelle Institute under contract to the Corps' Flood Risk Management Planning Center of Expertise (FRM-PCX). Draft engineering and plan formulation documentation were reviewed by the panel prior to the Alternative Formulation Briefing (AFB). A second phase of review was conducted on the DFR. Seven comments were received from the panel on the DFR and were subsequently responded to by the Kansas City District and edits to this FFR made accordingly. All IEPR panel comments were successfully resolved. The IEPR panel produced a separate final report detailing the process, comments, and issue resolutions.

7 System Implementation Risk and Management

The separate Phase 1 and Phase 2 recommendations, as detailed and presented in the Interim Feasibility Report and this Final Feasibility Report, are complementary efforts that together address the existing Kansas Citys Flood Risk Management Project as a whole. The separate study efforts have maintained a consistent approach to improving performance and reliability within the system. The Interim Report recommendations have previously been authorized and are currently being implemented. It is important to recognize the overarching systems approach to metropolitan flood risk management within this Final Feasibility Report by providing an update on the current status of Phase 1 implementation and addressing any risks or management concerns that may arise from the integration of Phase 2 implementation into the current effort.

7.1 Implementation Status of Phase 1 Recommendations

Design phase investigations in several of the Phase 1 projects provided new information that served to refine the original Interim Feasibility Report assumptions and recommendations. This led to necessary changes in the technical scopes to implement the projects and achieve the

intended purpose and performance improvement. The original and revised scope, and the current status, of each of the Phase 1 projects, is shown in Table 7-1.

Table 7-1: Status of Phase 1 Project Recommendations

Project	Original Recommendation	Current Recommendation	Status
North Kansas City Unit - Harlem Site	Buried collector system for underseepage control	Underseepage relief wells with temporary pumping capability	Construction complete
North Kansas City Unit – National Starch Site	Twenty underseepage relief wells and new pump station	Seven relief wells connecting to existing pump station	Construction complete
Fairfax-Jersey Creek Unit – BPU Floodwall	Structural wall reinforcement	Reduced structural wall reinforcement with underseepage relief wells and pump station modification	Wall modification contract awarded. Relief well and pump station contract in design phase.
Fairfax-Jersey Creek Unit – Jersey Creek Sheetpile Wall	Sheetpile wall replacement	Sheetpile wall stabilization and partial municipal wharf removal.	Design phase underway
East Bottoms Unit	Seventeen underseepage relief wells and collector piping	No change	Design phase underway
Argentine Unit	Full unit raise	No change	Design phase pending

Cost impacts of the changes in project implementation were offset by value engineering analysis where possible. Throughout the process of incorporating new information and updated methods, careful consideration has been given to maintaining the original purpose and intent of the Phase 1 recommendations, and preserving the desired economic and engineering outputs. The following discussions provide additional details of each project.

North Kansas City Unit - Harlem. Additional soil investigations and analysis during the design phase determined that the buried collector system was not a viable alternative for the Harlem reach. To provide the same level of intended reliability improvement, twenty-four pressure relief wells were required. To prevent the well discharge from impacting local homes and businesses, collection piping was installed with the wells. The well flows are directed to two manhole structures from which the flows can be pumped over the levee when necessary using portable pumps. The construction of this system was completed in 2012.

North Kansas City – National Starch. Additional soil investigations and analysis during the design phase determined that fewer relief wells were required than originally

recommended. The lower flows resulting from reducing the well system are within the available capacity of an existing pump station in the area, eliminating the need for a new pump station. The construction of this system was completed in 2013.

Fairfax-Jersey Creek – BPU Floodwall. Subsurface investigations and analysis during the design phase determined that the existing foundation piles were of a different material than previously thought, and, in general, the condition of the existing foundation was better than assumed. A revised review of the existing conditions found that in addition to structural modifications, underseepage control is required to ensure the stability of the existing wall foundation. Adding underseepage control to the project scope reduces, but does not eliminate, the need for structural wall modification. To capture and handle flows from the relief wells an existing pump station within the BPU facility requires modification. Construction of the structural modifications was initiated in 2013. Initiation of the relief well and pump station construction is planned for 2014.

Fairfax-Jersey Creek – Sheetpile Wall. Design analysis determined that the original sheetpile wall replacement recommendation did not have the robustness required to ensure slope stability and reliability in the event of failure of the municipal wharf structure located within the project area. Revision of the design and construction methods accordingly resulted in significant project cost increases. Input from the City of Kansas City, KS, the owner of the wharf structure, revised the previous feasibility assumption regarding the need to maintain future operability of the wharf. Both of these factors led to a Value Engineering study that identified a revised project alternative to stabilize the sheetpile wall in place, in lieu of full replacement. This resulted in a cost savings versus the replacement alternative and provides the same desired degree of slope stability. Construction of these improvements is scheduled to begin in 2014.

East Bottoms Unit. Design efforts are underway for the recommended relief well alternative. At present, the recommended alternative has not changed. Construction initiation is planned for 2014.

Argentine Unit. Design efforts have not yet been initiated.

Efforts have been made to minimize unnecessary cost increases wherever possible, and will continue as design and construction efforts proceed; however, the changes in technical scopes summarized in the previous section have resulted in changes to the estimated project costs. Table 7-2 below the project costs as presented in the Interim Feasibility Report and the updated project cost estimates incorporating the current design information and construction status. In addition to technical changes, these estimates also reflect the inflation that has accrued between Fiscal Years 2006 and 2014.

Table 7-2: Updated Phase 1 Cost Estimates

Project	Interim Report *Oct 2005*	Current Cost Estimate *Oct 2013*
Design Deficiency		
North Kansas City	$ 8,200	$ 4030
FF-JC BPU	$ 7,900	$ 8014
Sub-Total	*$ 16,100*	*$ 12,044*
Reconstruction		
FF-JC Sheetpile	$ 8,800	$ 9,471
East Bottoms	$ 1,700	$ 4,492
Argentine	$ 52,900	$ 74,393
Sub-Total	*$ 63,400*	*$ 88,356*
Total Phase 1	$ 79,500	$ 100,401

Economic benefits within the Phase 1 levee units have been updated and compared to the cost estimates from Table 7-2. Table 7-3 presents the updated economic analysis for the Phase 1 recommendations.

Table 7-3: Updated Phase 1 Economic Analysis

Interim Feasibility Report Recommendations	First Cost	Annual Costs	Annual Benefits	Benefit/ Cost Ratio	Net Benefits
New Work/Reconstruction	$ 88,356	$ 4,487	$ 33,278	7.4	$ 28,792
Design Deficiency	$ 12,044	$ 560	$ 8,175	14.6	$ 7,616
Total Phase 1	$100,401	$ 5,046	$41,454	8.2	$ 36,408

$1000's, Oct 2013 Price Level, 3.5% Interest Rate

7.2 Integration of Phase 1 and 2 Implementation

The balance of flood risk management among these three Kansas River units is an important aspect of the system approach and must be maintained throughout the implementation efforts. Only one element of the Phase 1 project authorization is affected by the authorization and implementation of Phase 2, the Argentine Unit raise on the Kansas River. All other components of the Phase 1 recommended plan comprise specific reliability improvements in the Missouri River units of the overall system.

As discussed previously in Section 4.7.3 of this report, during large flood events (approaching the 0.33% event, or 300-year flood, and above), the proposed Argentine Unit raise would begin to induce damages downstream onto the Armourdale and CID Units, if they remain in their existing condition. These induced damages would be addressed and eliminated by implementation of the Phase 2 recommended plan. Without a Phase 2 approval and authorization, the implementation of the Argentine Units raise would either be delayed or

eliminated to prevent these induced damages. Conversely, if the Phase 2 recommended plan were approved, authorized, and implemented, and the Argentine Unit raise were in some way delayed, there would be a potential upstream induced damage as well.

To manage the potential for induced damages within the system during construction, it is expected that the design and construction of the recommended plans from both phases will proceed on a parallel and coordinated schedule. Potential management risks in coordinating the implementation schedules of both phases are reduced by the fact that all three units are owned and operated by a single non-Federal sponsor, the Kaw Valley Drainage District.

7.3 Implementation Schedule and Cost Risks

Based on current evaluations, each of the three Kansas River units shows unacceptable reliability for the existing condition. Modifications to improve the existing condition reliability in each unit will have no impact on the other units, and are expected to be implemented prior to levee raise measures. This aspect of the implementation schedules and the realization of these benefits in each phase are fully independent. Only when the proposed levee raises in each phase are implemented is there an increased risk of induced damages among the units.

The current implementation schedule for each of the three units is indicated graphically in Figure 4. These implementation schedules were used as the basis of the current cost estimates for each unit.

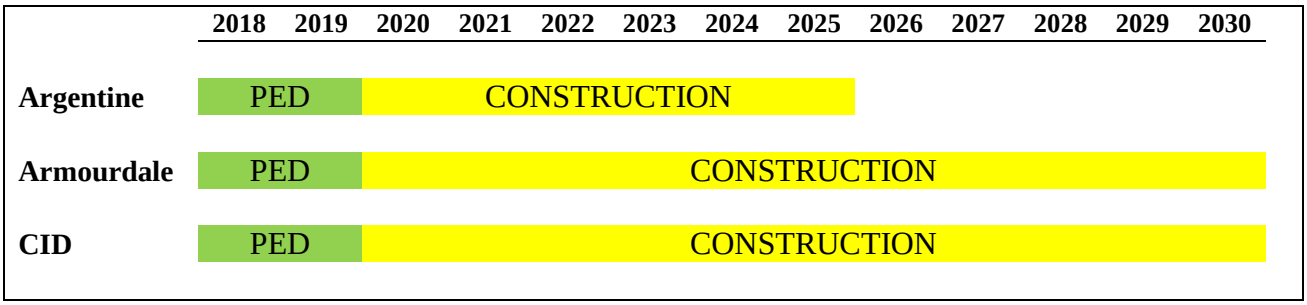

Figure 4 - Estimated Kansas River Unit Implementation Schedules

As shown, the Argentine improvements, including levee raises, are projected to be completed approximately five years before completion of the recommended Phase 2 plan. This would leave an interim period of five years in which the risk management within the system would not be balanced. If the Phase 2 implementation were delayed such that the current estimated schedule and the interim flood risk were increased, it is likely that the initiation of the Argentine levee raise would be delayed accordingly.

Changes in the schedule of levee raises in any one unit, and the effect on other units' schedules, can lead directly to cost changes due to delayed construction, increased material prices, inflation, etc. In each unit a schedule delay risk of up to ten years was identified in the cost and schedule risk analysis as very likely to occur and causing a significant impact to project cost. Such a schedule delay can occur for various reasons including availability of funds and resources, but

also due to any decisions that may be made during implementation to maintain coordinated schedules between Phase 1 and 2. Any cost risk resulting from changed to either the Phase 1 or Phase 2 implementation schedule is thus captured by the individual unit estimate contingencies.

7.4 Management of Implementation Risks

Close coordination between the Non-Federal sponsor and the Kansas City District will take place throughout the implementation phase to maintain the integrated implementation schedule and identify key milestones and decision points at which schedule review and adjustments, if needed, would take place.

Based on the current schedules as presented, there is a five year period in which there is a risk of a large flood event being passed by Argentine and adversely impacting the other two units. These induced impacts occur near and above the 0.33% annual chance exceedance flood, which results in an overall 1.6% chance of occurring in the five years. While this is a relatively small risk of a large flood event, schedule changes in either phase can increase this interim risk, and may call for offsetting schedule changes in other parts of the project. Careful schedule coordination and management with the Non-Federal sponsor will ultimately determine if this type of interim risk is acceptable, and for how long.

Interim risks during construction are expected to be small and will be managed by increased risk communication and expanded emergency action planning and flood fight preparedness.

7.5 System Performance Evaluation Summary

When the study of this existing levee system began in 2000, the general thinking at the time was that all seven units in the existing system may need to be raised. Guidance resulting from the previous Reconnaissance Phase, quoted earlier in this report, directed that the study approach be based on providing a "uniform level of protection" for the system in lieu of incremental unit analyses. This was interpreted to direct the study efforts towards establishing a uniform hydraulic overtopping profile for all unit raises based upon a common design discharge for each river, and not allowing one unit to be higher or lower in height. There was also a desire by the project sponsors to have reliable 0.2%-event (500-year) protection and to address specific areas of concern observed in the 1993 flood related to underseepage, stability, or near-overtopping issues. This section provides a summary of how this system approach process was implemented throughout the formulation of recommendations, and how decisions were made throughout this study to ensure compliance with this guidance.

Missouri River Units. Initial hydraulic modeling of the existing system conditions showed that the four Missouri River units all provided acceptable overtopping margins relative to the 0.2% (500-year) event profile. Since they provided the desired level of hydraulic performance, the team and sponsor chose not to investigate raises on the Missouri River units, as and it would be illogical under the systems approach. Subsequent technical evaluations showed that even with acceptable hydraulic performance, two of these units, Fairfax-Jersey Creek and North Kansas City, had annual exceedance probabilities (AEP) less than 0.2% due to geotechnical and structural reliability deficiencies. The formulation and recommendation of alternatives for these

two units focused on addressing these concerns according to applicable design criteria. The Birmingham Unit was determined fully acceptable and no further study was conducted in this unit. Statistically, the East Bottoms Unit exhibited acceptable reliability against Missouri River flooding, but underseepage issues had been observed during the 1993 flood in the Blue River tieback portion of the unit where floodwaters had peaked at 3.5 ft. below the top of levee. It was determined prudent to address a known concern that could be worse under higher loading conditions, so underseepage control alternatives were evaluated and recommended.

Kansas River Units. The initial hydraulic modeling indicated that all three Kansas River units did not pass their authorized discharge and would be overtopped by the 0.2% event, thus indicating a general need for formulation of raise alternatives in these units to improve reliability and also to be consistent with the Missouri River portion of the system. First, Argentine Unit alternatives were evaluated providing zero, three, or five feet of overtopping margin above the 0.2% event profile and addressing appurtenant geotechnical and structural modifications required at those heights. Economic benefit analysis determined that the plan based on the 0.2% event plus three feet was the NED Plan. The with-project performance of this plan was consistent with the Missouri portion of the system. Prior to publishing the Interim Feasibility Report recommending the Argentine and Missouri River unit recommendations, initial economic screening showed that plans based on the same profile also exhibited increasing net benefits for the Armourdale and CID Units over lower raise plans, and it was reasonable to expect similar performance results.

Interim and Final Reports. It was mutually agreed by HQ-USACE, Northwestern Division, the Kansas City District, and the non-Federal Sponsors to publish an Interim (or Phase 1) Report including the Missouri River unit recommendations along with the Argentine Unit on the Kansas River prior to completion of the final features and economic analyses for Armourdale and CID. Thus these two remaining units are included in this Final (or Phase 2) Report. The initial findings of Phase 1 have been subsequently confirmed by the technical and economic analyses presented in this Final Feasibility Report. The NED plan for Armourdale and CID was not determined as it would have been greater than the target established by the systems approach and the desires of the sponsors.

System Performance Conclusion. By establishing a common hydraulic profile and performance for formulation of plans in all units of the existing system, the study successfully implements the guidance directive for “uniform level of protection”. As a total measure of future system performance, the Annual Exceedance Probabilities encompassing all hydraulic and engineering reliabilities are shown for each Unit in Table 7-4.

Table 7-4: System Annual Exceedance Probabilities

Unit	Existing Conditions		Future With Project	
	Median %	**Expected %**	**Median %**	**Expected %**
Armourdale	**3.50**	**3.69**	**0.12**	**0.14**
CID	**0.33**	**0.47**	**0.12**	**0.19**
Argentine	**1.10**	**1.34**	**0.12**	**0.17**
East Bottoms	**1.40**	**0.19**	**0.10**	**0.10**
North Kansas City	**0.40**	**0.54**	**0.14**	**0.19**
Fairfax-Jersey Creek	**0.57**	**0.71**	**0.10**	**0.12**
Birmingham	**0.10**	**0.13**	**NA**	**NA**

7.6 System Implementation Conclusion

Each phase of this feasibility study has produced recommendations for improvement within the existing system that are technically complete and effective, acceptable to the Non-Federal sponsors and the public, economically justified, and that minimize adverse impacts to the natural environmental and the existing community infrastructure. Together the Interim Feasibility Report and this Final Feasibility Report represent a comprehensive and coordinated approach to the improvement of the reliability and performance of the overall metropolitan system. While there are inherent residual risks in any flood risk management project, the specific risks unique to this project have been addressed and will be managed through the on-going partnership between the Corps of Engineers and the local project sponsors.

8 References

USACE, 2006a. Review of Completed Project, Kansas Citys Levees, Missouri and Kansas, Interim Feasibility Report, USACE Kansas City District, August 2006

USACE, 2006b. Final Environmental Impact Statement, Kansas Citys, Missouri and Kansas Flood Damage Reduction Study, Missouri and Kansas Rivers, USACE Kansas City District and U. S. Environmental Protection Agency Region VII, August 2006

Both documents above can be found at: http://www.nwk.usace.army.mil/Missions/CivilWorks/CivilWorksProgramsandProjects/KansasCitys,FloodRiskManagement.aspx

9 Recommendation

Upon considering the economic, environmental, social, and engineering aspects of making improvements to the existing Kansas Citys Project, Armourdale and Central Industrial District Units, 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 Final Feasibility Report Recommended Plan is $203,711,300 Federal and $109,690,700 Non-Federal for a total estimated cost of $313,402,000

at October 2013 price levels. The net benefits of the Recommended Plan are $39,966,900, 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 3.4 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 the required non-Federal share 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 funds verifies in writing that such funds are authorized to be used to carry out the Project;

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.

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Andrew D. Sexton (date)
Colonel, Corps of Engineers
District Commander