JORDAN CREEK FLOOD RISK MANAGEMENT STUDY

SPRINGFIELD, MISSOURI

FINAL FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT

May 15, 2013

Written in Conjunction with:

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DRAFT FINDING OF NO SIGNIFICANT IMPACT (FONSI)

NAME OF PROPOSED ACTION: Jordan Creek Flood Risk Management Study, Springfield, Missouri

PURPOSE AND NEED FOR THE PROPOSED ACTION: Flash flooding, resulting from high frequency events, in the Jordan Creek watershed in Springfield, Missouri, have caused millions of dollars in property damage to residential properties and local businesses and has overtopped current channel capacity. The purpose of this study is to analyze flood risk management issues in Springfield. The City requested assistance from the US Army Corps of Engineers (USACE) to evaluate and recommend actions designed to reduce flood damages along Jordan Creek.

The Little Rock District, US Army Corps of Engineers (USACE) is conducting this environmental assessment in accordance with the Council on Environmental Quality (CEQ) guidelines pursuant to the National Environmental Policy Act (NEPA) of 1969.

ALTERNATIVES: In addition to the proposed action (Alternative J), a No Action alternative, and Plan G2 were evaluated in the Environmental Assessment.

No Action Alternative. - The "No Action" alternative includes not constructing the five upper watershed detention basins and modifying the Jordan Creek channel in Economic Reach 1 (E1), which would result in continued flood damages to be incurred by the City of Springfield.

Plan G2 – Offered protection against property damage for a 1/500 ACE in Economic Reach 1 (E1) and a 1/25 ACE in Reaches E3 and E6. This plan contained detention basins and channel improvements. This plan did not contain the Main Street or Boonville Street Bridge.

Proposed Action. – The proposed action (Alternative J) includes construction/modification of approximately 0.6 miles of channel, sized to accommodate a 1/500 ACE in the lower reach (Economic Reach 1). One new stream crossing and one modified crossing are sized to accommodate the 1/500 ACE. This proposed action will produce an estimated $1,961,100 in annual net benefits.

ANTICIPATED ENVIRONMENTAL IMPACTS: *Consideration of the effects disclosed in the EA, and a finding that they are not significant, is necessary to prepare a FONSI. This determination of significance is required by 40 CFR 1508.13. Additionally, 40 CFR 1508.27*

defines significance at it relates to consideration of environmental effects of a direct, indirect or cumulative nature.

Criteria that must be considered in making this finding are addressed below, in terms of both context and intensity. The significance of both short and long term effects must be viewed in several contexts: society as a whole (human, national); the affected region; the affected interests; and the locality. The context for this determination is primarily local. The context for this action is not highly significant geographically, nor is it controversial in any significant way. Consideration of intensity refers to the magnitude and intensity of impact, where impacts may be both beneficial and adverse. Within this context, the magnitude and intensity of impacts resulting from this decision are not significant. The determination for each impact topic is listed below.

1. The degree to which the action results in both beneficial and adverse effects. A significant effect may exist even if the Federal agency believes that on balance the effect will be beneficial. The EA indicates that there will be beneficial effects from a major reduction of flood damage that are incurred during each flood event. Temporary disruption of traffic routes during construction will be the major adverse effects.

2. The degree to which the action affects public health or safety. No adverse effects to public health or safety will result from the Proposed Action and implementation will provide increased safety for the public by keeping a major portion of flood flows in the lower economic reach within the channel and off roadways.

3. The degree to which the action affects unique characteristics of the potentially affected area, such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas. The proposed action will have minor impacts to wetlands due to filling a small isolated wetland in Economic Reach 1 (E1) resulting from required channel widening.

4. The degree to which effects on the quality of the human environment are likely to be highly controversial. The project will benefit the public through implementation of a flood risk management project. The Little Rock District, Corps of Engineers does not regard this activity as controversial.

5. The degree to which the possible effects on the human environment is highly uncertain or involves unique or unknown risks. The uncertainty of the impacts of this action is low. The City of Springfield is required to provide a clean corridor for construction activity, thus eliminating the risk of unknown HTRW issues. Any contamination areas within the project footprint will be remediated prior to channel construction.

6. The degree to which the action may establish a precedent for future actions with significant impacts The action should not establish a precedent for significant future impacts because the proposed action involves reducing existing persistent flood damages and improves public safety,

7. Whether the action is related to other actions with individually insignificant but cumulatively significant impacts. There are no other known individual actions associated within the project area, therefore there are no known cumulatively significant impacts identified with the proposed action.

8. The degree to which the action may adversely affect items listed or eligible for listing in the National Register of Historic Places, or other significant scientific, cultural or historic resources. There are no known structures eligible for National Register of Historic Places listing, or other significant scientific, cultural, or historic resource sites in the proposed construction footprint.

9. The degree to which the action may adversely affect an endangered or threatened species or its critical habitat. The proposed action will not affect any Threatened & Endangered species as none exist in the project area, as determined by a June 28, 2012 letter from USFWS.

10. Whether the action threatens a violation of Federal, state or local law or requirements imposed for the protection of the environment. No such violations will occur. All applicable Federal, state or local laws and regulations will be complied with during the implementation of the action.

CONCLUSIONS: The impacts identified in the prepared EA have been thoroughly discussed and assessed. No impacts identified in the EA would cause any significant adverse effects to the human environment. Therefore, due to the analysis presented in the EA and comments received from a 30-day public review period that began on 4 February 2013 and ended on 4 March 2013, it is my decision that the preparation of an Environmental Impact Statement (EIS) as required by the National Environmental Policy Act (NEPA) is unwarranted and a "Finding of No Significant Impact" (FONSI) is appropriate. The signing of this document indicates the Corps final decision of the proposed action as it relates to NEPA. The EA and FONSI will be held on file in the Environmental Branch, Planning and Environmental Division of the Little Rock District, Corps of Engineers for future reference. Consultation with regulatory agencies will be ongoing to ensure compliance with all federal, state, regional, and local regulations and guidelines.

_____ _____

Date

Glen A. Masset
Colonel, Corps of Engineers
District Engineer

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JORDAN CREEK FLOOD RISK MANAGEMENT STUDY

SPRINGFIELD, MISSOURI

Executive Summary

1 Study Information

The purpose of the report is to analyze flood risk management issues in Springfield, Missouri. The City of Springfield, Missouri (City), the non-Federal sponsor, requested assistance from the Corps of Engineers to study and provide recommendations for reducing significant flood damages in and around Jordan Creek.

This report was prepared as an interim response to the White River Basin, Arkansas and Missouri, Comprehensive Study Resolution passed on 11 May 1962 by the U.S. Senate Committee on Public Works.

2 Problem

The overall objective of the planning study is to improve flood risk management and improve the overall quality of life for the residents of Springfield, Missouri. The City experiences damages from flash floods because of insufficient flow capacity along Jordan Creek. The area along Jordan Creek is heavily urbanized and includes extensive infrastructure associated with both commercial and industrial areas.

Jordan Creek, Wilsons Creek, North Branch Jordan Creek and South Branch Jordan Creek are classic urban streams throughout most of their respective lengths. The upstream reaches of North and South Branches consist of grass ditches with small culverts capable of carrying only small frequent storm events through the surrounding residential neighborhoods. They flow through an industrial area and several college campuses into Jordan Creek, which includes concrete and natural channels, some regional detention and large-diameter culverts capable of conveying a 1/5 – 1/10 Annual Chance Exceedance (ACE). When large rainfall events occur, the water exceeds the channel capacity and flows through the downtown area over streets and through buildings, moving with it the debris it picks up along the way.

The downstream portion of Jordan Creek is primarily natural channel with an assortment of conveyance improvements: bridges, culverts, utility crossings and grade control structures. Jordan Creek ultimately merges with Fassnight Creek to create Wilsons Creek. Substantial damage to the area occurs at about 1/10 – 1/25 ACE.

3 Plans Considered

The planning objectives are as follows:

- Reduce overall flood damages in the project area from 2020 to 2070.
- Reduce residual risk to property by removing properties from the floodplain in the project area from 2020 to 2070.
- Reduce risk to transportation, life, health and safety by reducing flood levels in the project area from 2020 to 2070.

A wide variety of management measures were developed that would address one or more of the planning objectives. These measures were then evaluated and screened. Fifteen plans that included one or more of the management measures were developed and considered. The plans were evaluated for cost efficiency and flood risk reduction effectiveness, which resulted in an array of four plans:

- No Action – This was used as a basis to determine how the other plans perform.
- Detention Basins Only Plan– This was the smallest plan presented. It included five detention basins in the upper reaches of the watershed.
- Plan G2 – This was the plan that provided the most residual risk reduction while still being cost effective. This plan included 1/500 ACE protection at the confluence with Wilsons Creek and 1/25 ACE through the downtown industrial area and detention basins in the upper reaches of the watershed.
- Plan J – This plan included 1/500 ACE protection at the confluence with Wilsons Creek and detention basins in the upper reaches of the watershed.

4 Recommended Plan

The National Economic Development (NED) Plan and recommended plan are both Plan J. The recommended plan is the NED Plan because it provides the greatest net benefits. Plan J leaves considerably more residual risk in the floodplain than Plan G2; however, the additional increment of work in reaches 3 and 6 has negative net benefits.

In Plan J, channel improvements only occur in Reach E1 and were designed to keep structural damage from a 1/500 ACE to a minimum. On Wilsons Creek, approximately 2,100 feet of channel widening will occur. Modification to Scenic Bridge will likely be required because of channel excavation beneath the bridge. The modification may include installing piers and a mat foundation. Because the railroad bridge over Wilsons Creek at the southeast corner of the ball fields causes a restriction to stream flow, it will be replaced. No recreational improvements are planned along with the channel modification because of the real estate restrictions on either side of the creek.

A flood diversion structure will be constructed adjacent the Archimica plant to prevent water from flowing over a low point on Bennett street into the manufacturing facility. The flood diversion structure completes the Archimica plants floodwall and protects it from flood damage. Channel work will end approximately 350 feet north of the Bennett Street Bridge.

Five regional detention basins are included in the NED Plan. Those basins are B6, B7, B9B, B11 and B11C.

Due to the highly developed, urban environment of the project footprint, and the fact that channel construction activity will be confined to the highly industrialized lower reach, the resulting environmental impacts are minimal. No compensatory mitigation is required.

5 Project Impacts

Due to the highly developed, urban environment of the project footprint, the resulting environmental impacts are minimal. No compensatory mitigation is required. The lower reach has four Hazardous, Toxic or Radioactive Waste (HTRW) sites on three properties with suspected or documented environmental issues. The effective cost of the remediation is likely $32,500 - $340,000; however, the risk is low that HTRW exists in the footprint of the project. Not all of the properties are in the actual construction footprint, so actual costs may be substantially lower. The City is working with the Missouri Department of Natural Resources on the HTRW issues and is required to provide a clean corridor for channel construction. There are no known cultural resource sites in the proposed channel construction footprint.

6 Benefits and Costs

Plan J, as the recommended and NED Plan, has an investment cost of $21,063,300; an annual cost of $1,173,300 [including Operations, Maintenance, Repair, Rehabilitation and Replacement costs (OMRR&R) of $234,400 per year]; annual benefits of $3,029,400; net benefits of $1,856,100; and a benefit-to-cost ratio (BCR) of 2.6 at an interest rate of 3.75 percent. Including NED benefits upstream of the limit of Federal interest, the net benefits are $1,961,100 with a BCR of 2.7. The BCR is 1.7 at an interest rate of 7 percent.

The fully funded total project cost is estimated to be $21,873,000 with a sponsor contribution of $7,656,000 and a Federal contribution of $14,217,000. The estimated cost of Lands, Easements, Rights-of-way, Relocations and Disposal areas (LERRD) is $6,470,000. The sponsor's required cash contribution is $1,094,000, and the sponsors total cash contribution is estimated to be $1,186,000. The sponsor is responsible for 100 percent of the OMRR&R costs.

7 Timeline

Public Review of the Draft Report ended 4 March 2013. After evaluation of comments received, Final Report and Civil Works Review Board will occur on 29 May 2013. The Chief's Report is anticipated by August 2013.

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JORDAN CREEK FLOOD RISK MANAGEMENT STUDY

SPRINGFIELD, MISSOURI

Integrated Feasibility Report and Environmental Assessment

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Attachment A: Hydrology and Hydraulics Report
Attachment B: Cost Analysis, Construction Schedule and MCACES Cost Estimate
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JORDAN CREEK FRM STUDY, SPRINGFIELD MO
FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT

1 STUDY INFORMATION

The purpose of this report is to analyze flood risk management issues in Springfield, MO. The City of Springfield, MO (City) requested assistance from the U.S. Army Corps of Engineers (USACE) to study and provide recommendations for reducing significant flood damages around Jordan Creek.

1.1 PROBLEM DESCRIPTION

The overall objective of the planning study is to improve flood risk management and improve the overall quality of life for the residents of Springfield, Missouri. The City experiences damages from flash floods because of insufficient flow capacity and urbanization along Jordan Creek. The area along Jordan Creek is heavily urbanized and includes extensive infrastructure associated with both commercial and industrial development.

Jordan Creek, Wilsons Creek, North Branch Jordan Creek and South Branch Jordan Creek are classic urban streams throughout most of their respective lengths. The upstream reaches of North and South Branches consist of grass ditches with small culverts capable of carrying only small frequent storm events through the surrounding residential neighborhoods. They flow through an industrial area into Jordan Creek which includes concrete and natural channels, some regional detention and large-diameter culverts capable of conveying a 1/5 – 1/10 Annual Chance Exceedance (ACE). When large rainfall events occur, the water exceeds the capacity of the enclosed channel and flows through the downtown area over streets and through buildings, moving with it the debris it picks up along the way.

The downstream portion of Jordan Creek is primarily natural channel with an assortment of conveyance improvements, bridges, culverts, utility crossings and grade control structures. Jordan Creek ultimately merges with Fassnight Creek to create Wilsons Creek. Substantial damage to the area occurs at about 1/10 – 1/25 ACE.

1.2 STUDY AUTHORITY*

This report was prepared as an interim response to the White River Basin, Arkansas and Missouri, Comprehensive Study Resolution passed on 11 May 1962 by the U.S. Senate Committee on Public Works.

The resolution states the following:

> *Resolved by the Committee on Public Works of the United States Senate, that the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 12, 1902, be and is hereby, requested to review the reports on the White River and Tributaries, Missouri and Arkansas, printed in House Document Numbered 499, Eighty-third Congress, second session, and other reports, with a view to determining the advisability of modifying the existing project at the present time, with particular reference to developing a comprehensive plan of improvement for the basin in the interest of flood-control, navigation, hydro-electric power development, water supply, and other purposes, coordinated with related land resources.*

The Conference Report recommendation accompanying the Energy and Water Development Appropriations Act, 2002, Public Law 107-66, 12 November 2001, included $100,000 for a General Investigation for Watershed Restoration for Springfield, Missouri.

The existing project refers to the dams in the White River Basin. The Flood Control Act of 1938 approved a comprehensive plan for flood control and other purposes on the White River Basin.

In response to the study authority, the Section 905(b) analysis was initiated 18 March 2002 with a meeting between the City of Springfield officials and the Little Rock District. A Reconnaissance Report, completed on 31 October 2002, recommended a feasibility study. The approved Reconnaissance Report indicates a Federal interest in both flood risk management and aquatic ecosystem restoration. However, upon further analysis, it was determined that any aquatic ecosystem restoration benefits would be ancillary to the flood risk management benefits due to the objectives of the local sponsor.

The Federal Water Project Recreation Act of 1965 (Public Law 89-72), as amended, requires an agency to fully consider recreational features that may be associated with Federal flood risk management projects. Recreation features were considered but were eliminated due to cost.

1.3 PURPOSE AND SCOPE (PURPOSE AND NEED)*

The purpose of this report is to present the findings of a feasibility investigation that was conducted to determine if there was a Federal interest in providing flood risk management improvements along Jordan Creek in Springfield, Missouri. The City experiences damages from flash floods at high-frequency events. This report analyzes the problems and opportunities and expresses desired outcomes as planning objectives. Plans were then developed to address these objectives. These plans include a No Action Plan and various combinations of structural and nonstructural measures. The economic and environmental impacts of the plans were then evaluated and a feasible plan was tentatively selected.

*Designates a section that is traditionally found in an Environmental Assessment.

Public, agency, and peer review of the Draft Report and Environmental Assessment resulted in no change to the tentatively selected plan. The report also presents details on USACE and sponsor participation needed to implement the recommended plan. The report concludes with a recommendation for authorization.

1.4 LOCATION OF THE STUDY AREA

The study area is located within the White River Basin, extending approximately 6 miles along Jordan Creek. Jordan Creek, including North Branch and South Branch Jordan Creek, has a 13.75-square-mile drainage basin. The project area is generally centered on the Chestnut Expressway between U.S. Highway 65 to the east and U.S. Highway 160 to the west in the northern half of the City of Springfield, Missouri. The study area (shown in Figure 1-1: Study Location Map) includes Jordan Creek, North Branch Jordan Creek, South Branch Jordan Creek and the upstream portion of Wilsons Creek. Wilsons Creek is a tributary of the James River, which eventually flows into the White River.

Figure 1-1: Study Location Map

The upstream end of a project area in an urban setting starts at the limits of Federal interest, which is defined by ER 1165-2-21 paragraph 7(a) as the point on the creek at which flow of at least 800 cubic feet per second (cfs) at the 1/10 ACE occurs. USACE regulation consider this a local drainage issue; as a result benefits accrued upstream of the limit of Federal interest are not used to justify Federal involvement. The red triangles in the Figure 1-1: Study Location Map designate the limits of Federal interest.

1.5 HISTORY OF THE INVESTIGATION

In July 2000, one of the most damaging floods on record in the watershed occurred. Six inches of rainfall fell (a majority of which fell in the first two hours), which resulted in floodwaters 4 to 6 feet deep in some places, damage to at least 124 homes, and displacement of more than 100 people with an estimated $2 million in damages to public property alone. The photograph in Figure 1-2 (courtesy of the City) was taken during the 2000 flood. It was a 1/100 to 1/50 ACE flood.

Figure 1-2: July 2000 Flood: South Branch of Jordan Creek at Fremont Avenue.

In response to the flood, the City requested a reconnaissance study, which was initiated on 18 March 2002. This phase of the study confirmed a Federal interest in continuing the study into the feasibility phase. The City, as the non-Federal sponsor, and USACE initiated the feasibility phase by signing a Feasibility Cost Sharing Agreement (FCSA) on 12 May 2004.

On 18 February 2011, Jordan Creek was chosen as a pilot study to help USACE transform the Pre-Authorization Study (Planning) Process. USACE suggested that the study be a part of the pilot program to test methods to expedite the planning process and approval. The core principles of planning stay the same; however, USACE is evaluating ways to streamline the feasibility level analysis and decision making to deliver recommendations more efficiently. USACE hopes to gain lessons learned from this study to apply nationwide to other studies.

1.6 PRIOR REPORTS AND EXISTING PROJECTS

A number of prior reports and studies by USACE as well as other agencies were reviewed and utilized in this report as they relate to Jordan Creek. Information from the following documents was deemed the most significant to problem identification and plan formulation:

- Total Maximum Load, Wilsons and Jordan Creeks (MO_2375 and 3374), Christian Counties, Missouri. United States Environmental Protection Agency, Region 7. 2011.
- Annual Report July 2008- June 2009. Municipal Separate Storm Sewer System (MS4) Springfield, City of. 2009.
- Jordan Creek Baseline Water Quality Project. Missouri State University and Ozarks Environmental and Water Resource Institute, Final Report. March 2007.
- Springfield Urban Streams, Clear Creek, Jordan Creek, Wilson Creek and Galloway Creek, Greene County, Missouri. Missouri Department of Natural Resources, Biological Assessment Report. 2007.
- Biological Assessment Report – Springfield Urban Streams – Clear Creek, Jordan Creek, Wilson Creek, and Galloway Creek, Greene County. March 2007: Missouri Department of Natural

Resources. This report provided an assessment of urban stream biology, water quality and habitat to determine if the aquatic life protection designated use of Springfield urban streams was supported.

- Final Report to the City of Springfield on the Biological Assessment of Urban Streams II, Missouri State University. July 2005- June 2006.
- Jordan Creek – South Branch Sinkhole Assessment Project. SMU. Spring 2005. It is an evaluation of Sinkhole Flooding, Stability & Non-point Sources.
- Jordan Creek Baseline Water Quality Project. Ozarks Environmental and Water Resources Institute and Missouri State University, Aug 2004 – July 2005. This report provided baseline water quality trends for the upper Wilsons-Jordan Creek watershed.
- Hydrology and Hydraulics Report South Branch Jordan Creek – Box Culvert from National Avenue to Sherman Avenue. Harrington and Cortelyou. Dec 2004. This report sized an enclosed structure between National Avenue and Sherman Avenue.
- Missouri Department of Natural Resources. Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure. MDNR-FSS-030. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 24 pp. 2003.
- Stage 1, Reconnaissance Report (905(b) Analysis) for the Jordan Creek General Investigations Study. Little Rock District, Corps of Engineers. Oct 2002. This report identified potential projects within the Jordan Creek, Springfield, Missouri Watershed that have a potential Federal interest.
- Flood Insurance Study. City of Springfield, Missouri, 2002. The City revised the Federal Emergency Management Agency (FEMA) preliminary flood insurance studies. The City developed a detailed hydrologic and hydraulic model and used recent aerial photos, 2-foot contours and GIS technology to produce improved mapping.
- Brownfields Assessment Demonstration Pilot Jordan Valley Area-Wide Assessment, Springfield, Missouri. The Forrester Group. May 2002. This assessment was conducted on over 600 properties as a tool to prioritize and direct the future use of grant funds. The report included a database list search, an historical Sanborn map review, a geographical information system (GIS) and a current assessment.
- Jordan Creek Greenway Preliminary Feasibility Study. Ozark Greenways, Inc. City of Springfield. Oct 2001. The report studied the feasibility of establishing a greenway from Boonville to Scenic streets of Jordan Creek as identified by Vision 20/20. The plan defined the corridor, analyzed existing conditions, identified issues and proposed alternatives for greenway development and amenities such as a trail, facilities and landscaping. Jordan Creek is central to the proposed greenway system, which traverses Jordan Valley Park and the downtown area.
- Jordan Creek: Story of an Urban Stream, Watershed Committee of the Ozarks. Bullard, Loring Bullard. 2001. This paper provided a 200-year account of the history of Jordan Creek.
- Preliminary Report on Flood Damage Resulting From 7/12/2000 Rain Event. Wagner, Todd, P. E. 2000. This report was a summary of the rainfall and flood damage that occurred during the July 12, 2000 flood.
- Major Rainfall Events of 2000 – Springfield, Missouri. Wagner, Todd P.E. 2000. This report summarized the rainfall events and flooding from the July 2000 rains.
- Flood Insurance Study, City of Springfield, Missouri, FEMA. Michael Baker, Jr., Inc. June 2000. This study revised and updated the previous Flood Insurance Study/Flood Insurance Rate Map for Springfield, Greene and Christian counties, Missouri. The information was used to update existing floodplain regulations and further promote sound land use and floodplain development.
- Springfield-Greene County Comprehensive Plan, Parks, Open Space, and Greenways Plan Element, Vision 20/20, Creating the Future. Sept 1998. This plan was in response to traffic

congestion, rapidly diminishing natural resources and increasing urban development in Springfield, Missouri. The goal was to create a safe, accessible, comprehensive system of parks, open space and greenways with sufficient land and facilities that unite public and private areas while preserving the environment.

- James River – Wilsons Creek Study, Springfield, Missouri. U.S. Department of the Interior. June 1969. The purpose of this study was to assess pollution problems associated with fish kills, storm runoff and odorous and unsightly conditions in Wilsons Creek. The project included measurements of physical and chemical parameters, biological studies and a groundwater study.
- Floodplain Information, Wilsons Creek and Tributaries, Springfield, Missouri, Part I. U.S. Army Corps of Engineers, Little Rock District. Nov 1968. This report provided information relative to areas that are subject to flooding in and near Springfield, as well as the frequency and depths of the flooding. The flood information was based on historic and technical records for this area.
- Comprehensive Storm Water Report, Crawford Murphy Tilly. City of Springfield. 1964. This report contained analysis and proposed improvements for all of the watersheds in Springfield. Recommended criteria for detailed design of drainage facilities was also included.

1.7 PLANNING PROCESS AND REPORT ORGANIZATION

The planning process consists of six major steps: (1) Specification of water and related land resources problems and opportunities; (2) Inventory, forecast and analysis of water and related land resources conditions within the study area; (3) Formulation of alternative plans; (4) Evaluation of the effects of the alternative plans; (5) Comparison of the alternative plans; and (6) Selection of the recommended plan based upon the comparison of the alternative plans. The chapter headings and order in this report generally follow the outline of an Environmental Assessment (EA). Chapters of the report relate to the six steps of the planning process as follows:

- The second chapter of this report, Problem Description and Objectives of the Proposed Action, covers the first step in the planning process (Specification of water and related land resources problems and opportunities).
- The third chapter of this report, Plans, is the heart of the report and is therefore placed before the more detailed discussions of resources and impacts. It covers the third step in the planning process (Formulation of plans), the fifth step in the planning process (Comparison of alternative plans) and the sixth step of the planning process (Selection of the recommended plan based upon the comparison of the alternative plans).
- The fourth chapter of this report, Affected Environment, covers the second step of the planning process (Inventory, forecast and analysis of water and related land resources in the study area).
- The fifth chapter of this report, Effects on Environmental Resources, covers the fourth step of the planning process (Evaluation of the effects of the alternative plans).

This report was written as a part of a pilot program for USACE Planning modernization. Information contained in the report demonstrates the decision-making process. For more information on the detailed analysis, please refer to the appendices.

2 PROBLEM DESCRIPTION AND OBJECTIVES OF THE PROPOSED ACTION

This chapter presents the results of the first step of the planning process, the specification 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

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.

2.2 PUBLIC CONCERNS

A number of public concerns were identified during the course of the study. Initial concerns were expressed in the study authorization. Additional input was received through coordination with the sponsor and other agencies through public meetings. A discussion of public involvement is included in Chapter 6, Public Involvement, Review and Consultation. The public concerns that were related to the establishment of planning objectives and planning constraints are as follows:

- Flood damage losses to private, commercial, light industrial and public property
- Inadequate flood risk management near Jordan Valley Park
- The loss of aquatic life due to poor water quality
- Lack of recreational opportunities in the study area

2.3 PROBLEMS AND OPPORTUNITIES

This section describes the needs in the context of problems and opportunities that can be addressed through water and related land resource management. The problems and opportunities are based upon the project conditions that are described in Chapter 4, Affected Environment.

The primary problem this study addresses is flooding along the Jordan Creek corridor; however, the opportunity exists to address aquatic ecosystem degradation factors.

Jordan Creek is an urban stream that is prone to flash flooding. The time to peak flood heights for a critical 1-hour storm is 30 minutes. This means that, almost simultaneously, the water is rising in the urban areas as the rain is falling. The flooding events are quick and unpredictable, preventing the City from constructing an effective flood warning system. The water backs up along the creek and spreads throughout the floodplain rapidly. During large flood events, the City has to block busy thoroughfares, inhibiting the delivery of police, fire and street department resources to occupants. An opportunity

exists to implement a flood risk management system that uses both structural and nonstructural measures.

Multiple times, throughout the last decade, Springfield has had a flood that causes significant damage to its downtown and infrastructure every few years. From the existing conditions modeling, it is estimated that the flows through downtown are between 5 and 6 feet deep with a velocity of about 6 feet per second at the 1/100 ACE. At this velocity, it takes less than 14 inches of water to push a full-size truck off the road. There exists an opportunity to reduce damage to the existing buildings and contents as well as damage to infrastructure within the floodplain.

Another problem, directly related to channel design, is the ecological condition of Jordan Creek. There is little instream habitat in Jordan Creek because a majority of the creek is a concrete-lined channel. An opportunity exists to remove concrete in the channel and reduce total flow for frequent storm events. Removing concrete in the channel increases residence time, allows contact of storm water with sunlight and vegetation and allows the natural stream processes to improve water quality and aquatic habitat.

The existing trail system within the City does not provide the public suitable access to Jordan Creek. Additionally, the system lacks connectivity and has safety issues due to road and railroad crossings. The opportunity exists to provide ancillary benefits from the FRM study for recreation: replaced bridges can be widened to allow an area for building trails and maintenance roads can double as multi-use paths.

2.4 EXISTING FLOODING

2.4.1 Historical Flooding

In 2000, six inches of rainfall fell (a majority of which fell in the two hours), which resulted in floodwaters 4 to 6 feet deep in some places, sweeping through at least 124 homes and displacing more than 100 people with an estimated two million dollars in damages to public property alone. The storm produced a 1/50 to 1/100 ACE with a flow rate of 3,200 cfs. The storm inundated structures, trapped motorists and swept building materials from local supply yards. In 2002, a 1/5 ACE occurred when 3.5 inches of rain fell in six hours. In 2005 two short and intense rainfall events, 2.25 inches in one hour and 1.86 inches over 1.5 hours, resulted in the 1/2 to 1/5 ACE. The two events were three hours apart. Even as recent as 2008, people were rescued along the creek during intense flooding. In 2009, Chestnut Street, the main east/west thoroughfare situated about 500 feet from the channel, was closed due to flooding.

2.4.2 Flooding by Reach

The characteristics of this watershed lead to damages during the frequent flood events. The confined river channel contains numerous crossings and the watershed is prone to flash-flood events. These conditions cause water to leave the channel at frequent events and flow overland causing damage to property and posing a safety risk. See Figure 2-1 for a depiction of the reaches. The economic reaches were created by grouping the hydraulic reaches together by building types.

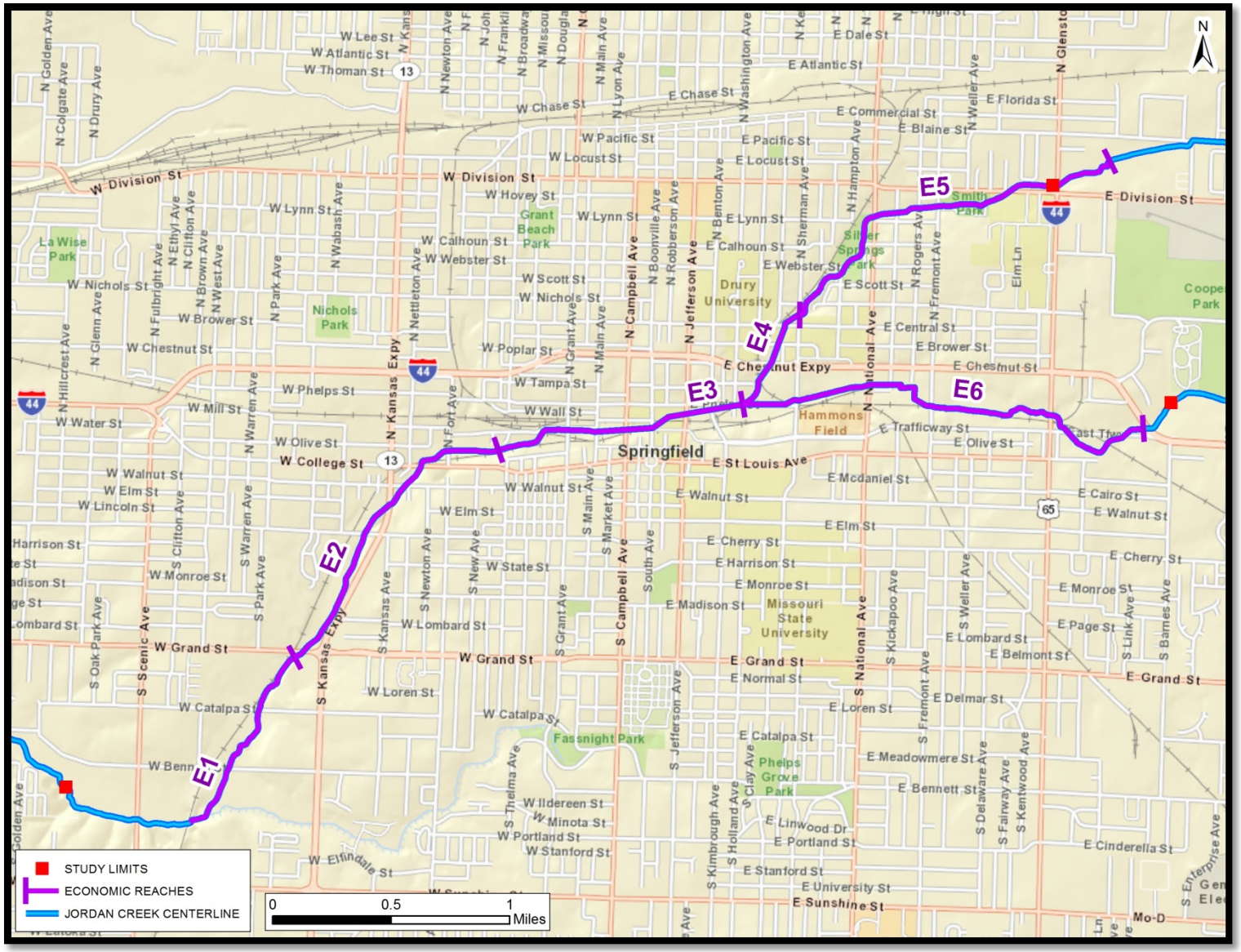

Figure 2-1: Economic Reaches of Jordan Creek

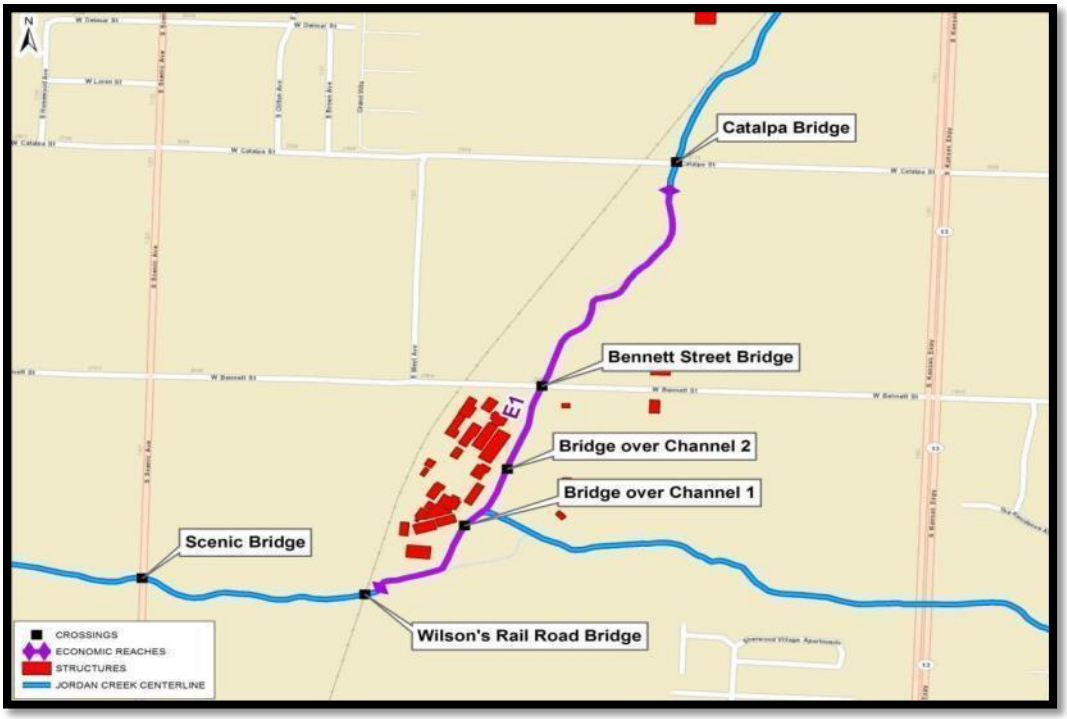

Figure 2-2: Reach E1

Reach E1 (Figure 2-2) is at the confluence of Jordan and Fassnight Creeks. This reach is industrial. The Archimica Pharmaceutical plant, Advantage Waste and an old municipal landfill sustain damages during flood events. Water flows over the Archimica floodwall between the 1/10 ACE and the 1/25 ACE. At the 1/500 ACE, there can be anywhere from 2 to 4 feet of water in the buildings. There are significant life, health and safety issues associated with this plant during flood events. During the 2000 flood, people were rescued from rooftops. There are 32 buildings within the 1/500 ACE floodplain, 22 buildings in the protected area and an additional 10 structures not protected by the floodwall. A structural analysis completed on the floodwall determined that it is structurally sound.

Downstream of the Archimica plant is Scenic Bridge. The Scenic Bridge overtops somewhere between the 1/25 and 1/50 ACE in the existing conditions. The bridge connects the fire station to neighborhoods on the south side of town. In the event of floods, the fire engines and rescue vehicles are significantly delayed and are not able to respond in their mandatory 5- to 9-minute window.

Bennett Street, located on Jordan Creek, overtops between the 1/10 and 1/25 ACE in the existing conditions modeling. The roadway adjacent to the bridge is lower and overtops between the 1/5 and 1/10 ACE posing a significant safety hazard. There is a potential for cars to be swept off the road. Bennett Street is the bridge that the emergency vehicles take to reach communities to the east of the fire station. When it is overtopping, emergency response is delayed.

There are three properties in this reach containing Hazardous, Toxic or Radioactive Wastes (HTRW). The City owns two of these properties, both sites of former municipal landfills. No radioactive waste was detected in the landfills. The largest City-owned parcel, Ewing Park, borders Wilsons Creek on the north

and is currently used as a sports complex. The Archimica Pharmaceutical Company owns the third property consisting of two parcels of land.

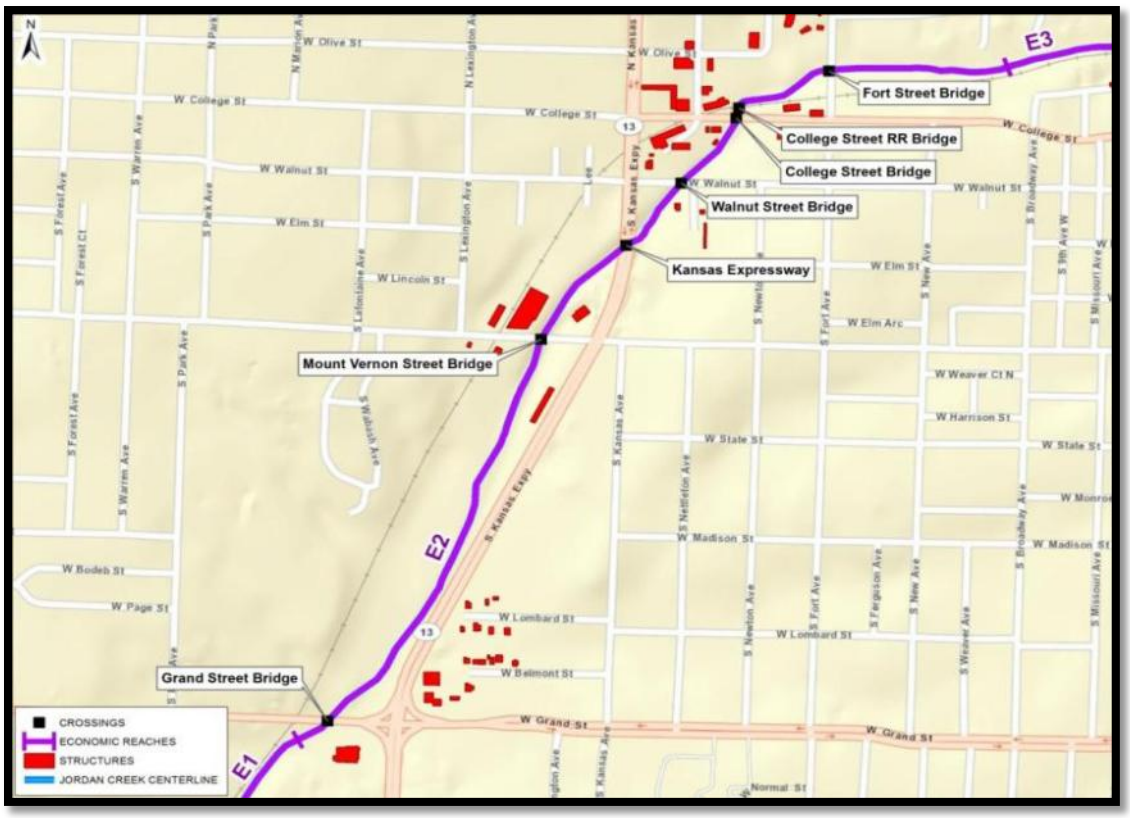

Figure 2-3: Reach E2

Reach E2 (Figure 2-3) is mainly industrial, but it includes a small neighborhood that starts to sustain damages around the 1/5 ACE. This portion of the stream is mostly natural channel with an assortment of conveyance improvements, bridges, culverts and grade control structures. The 1/10 ACE causes damages to about 15 of the 54 structures in the inventory.

There are seven crossings in this reach, all of which restrict flow. The severity depends on the storm event, flow and downstream conditions. Overtopping of bridges is a severe safety issue in this reach. As shown in Table 2-1: Bridges in Reach E2, many of the bridges overtop between the 1/2 ACE and the 1/5 ACE.

Table 2-1: Bridges in Reach E2

River Station	Crossing Name	ACE Overtops
4096	Grand Street Bridge	1/2 – 1/5
7115	Mount Vernon Street Bridge	1/2 – 1/5
8535	Walnut Street Bridge	1/2 – 1/5
9112	College Street Bridge	1/2 – 1/5
9187	Rail Road at College Street	1/5 – 1/10
9853	Fort Street Culvert	1/1 – 1/2

In the northern end of Reach E2, there are a HTRW sites. Those sites have been analyzed for cleanup. There are a few natural springs in this reach, one of which is called Diesel Spring because of the smell of the water.

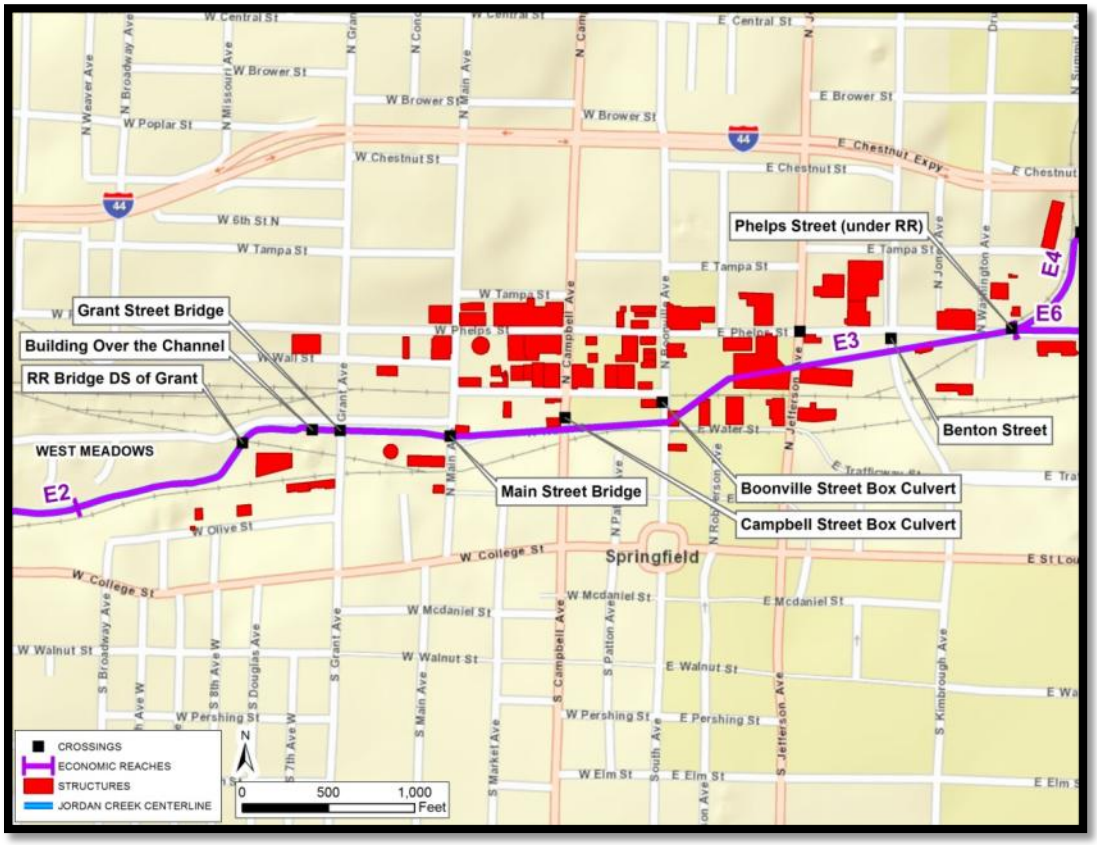

Figure 2-4: Reach E3

Reach E3 (Figure 2-4) is the downtown area of Springfield, and, until a few years ago, it primarily consisted of industrial and commercial buildings. However, local Universities are moving into the old warehouses and factories, and it is starting to become a pedestrian- and cyclist-friendly neighborhood.

The upstream end of Reach E3 is at the confluence of North and South Branches where Jordan Creek flows into a set of box culverts capable of conveying the 1/5 to 1/10 ACE. The 30-foot-wide, 10-foot-tall, dual box culverts extend 3,400 feet underneath most of the downtown area. Once the capacity of these structures has been exceeded, water flows over land, through buildings and over roads, until it reaches the areas south of downtown where it can return to the channel.

The City's industrial and commercial heart is situated in the Jordan Creek Valley. Along Jordan Creek, it is relatively flat. However, about a city block out on either side of the stream, the terrain gets substantially steeper. This topography concentrates the floodwaters through a narrow corridor. In Figure 2-5, there is a steep rise from a largely flat area in the 1/100 to 1/500 ACE floodplain. At 1/5 ACE, damages are $570,000. There are high damages at the high-frequency events.

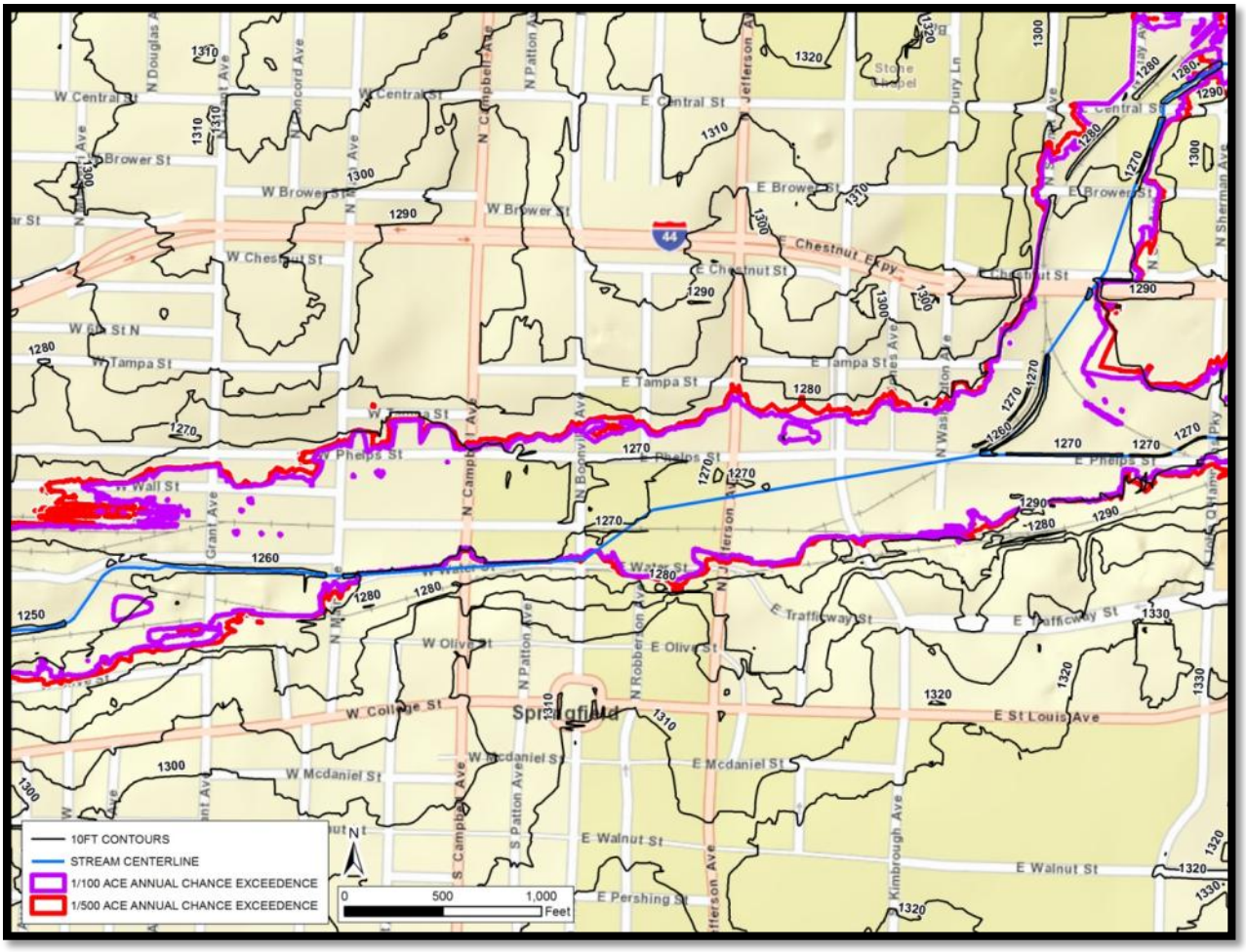

Figure 2-5: Inundation Map in the 1/100 to 1/500 ACE in Reach E3

Reach E3 includes an area called the West Meadows, which is a brownsfield site the City has been working with the Environmental Protection Agency (EPA) to clean up. The numerous HTRW sites throughout the reach are a remnant of the City's industrial past.

Reach E4 (Figure 2-6) damages are primarily to properties on a local university campus and a community college campus. Ozark Technical College has a parking lot that is subject to the 1/50 ACE in the existing conditions. Two buildings receive structure damage and one receives damage to contents at the 1/5 ACE. The City has worked to daylight some of the channel in this area to help alleviate some of the flooding. Although the channel is no longer in a box culvert, both banks of the channel are vertical walls due to real estate restrictions.

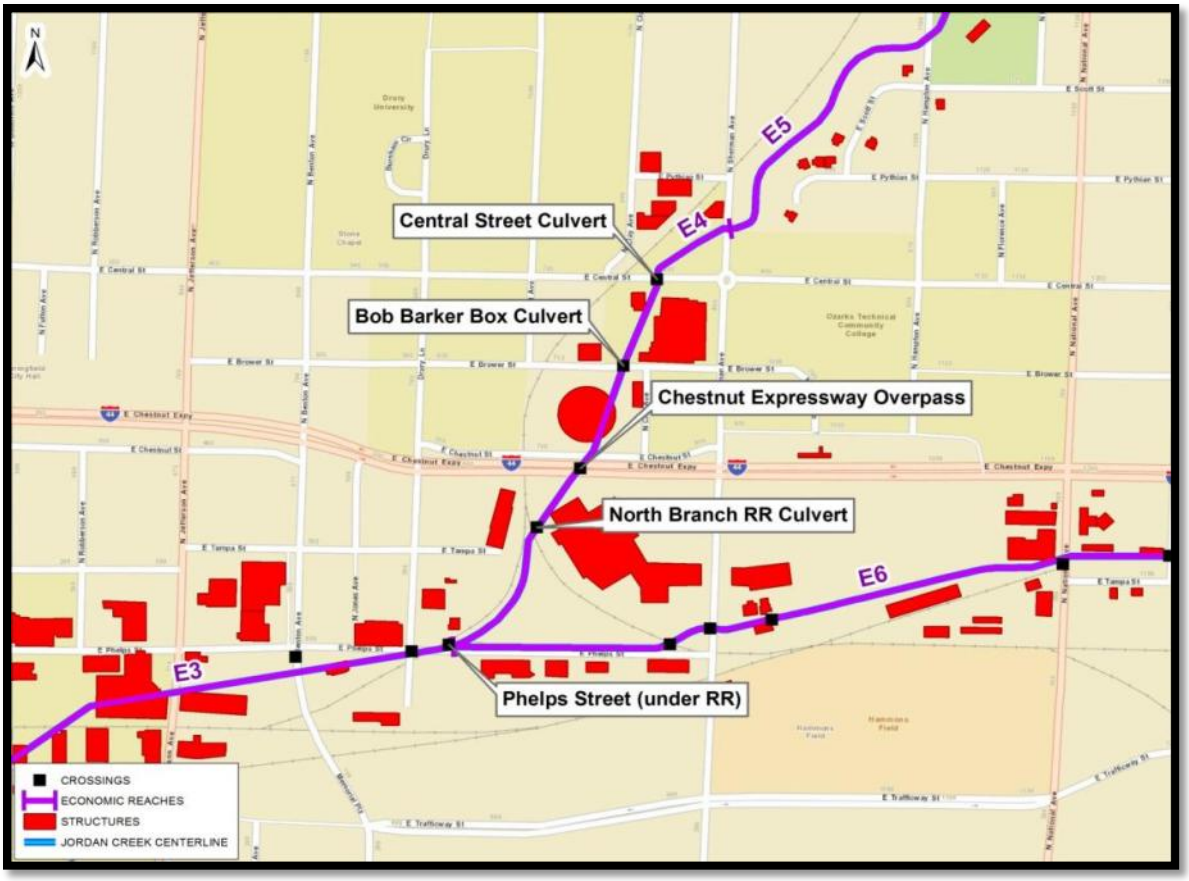

Figure 2-6: Reach E4

In Reach E5 (Figure 2-7) a park pavilion close to the channel is frequently flooded but with few damages. At the 1/100 ACE, about six houses are damaged with no single structure receiving more than $400 worth of damage. The majority of the channel in this reach runs through parkland or open space.

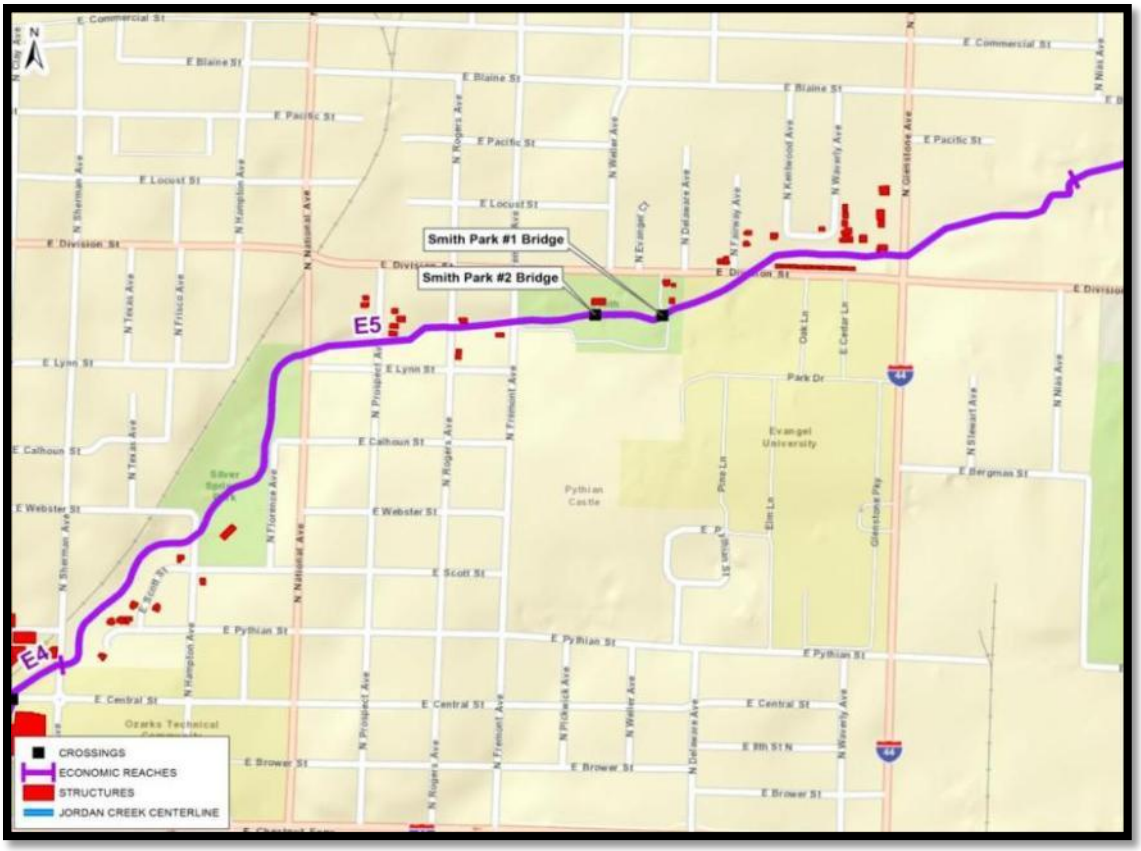

Figure 2-7: Reach E5

The upstream part of Reach E6 (Figure 2-8) is mainly residential. Once Glenstone Street is crossed, it becomes more industrial. Frequent damages occur at the Loft's parking lot and Harry Cooper Supply, a local pipe wholesaler.

The upstream reaches of South Branch of Jordan Creek consist of grass ditches with small culverts capable of carrying a storm that is expected to occur every year. Once the water is out of the ditches, it starts to flow overland. Even at frequent events, the flooding affects buildings. Mostly, the water ponds in intersections before flowing back into the creek. Approximately 80 residential properties in the upstream reaches are within the 1/100 ACE floodplain. Water surrounds many of the homes once the capacity of the channel is exceeded.

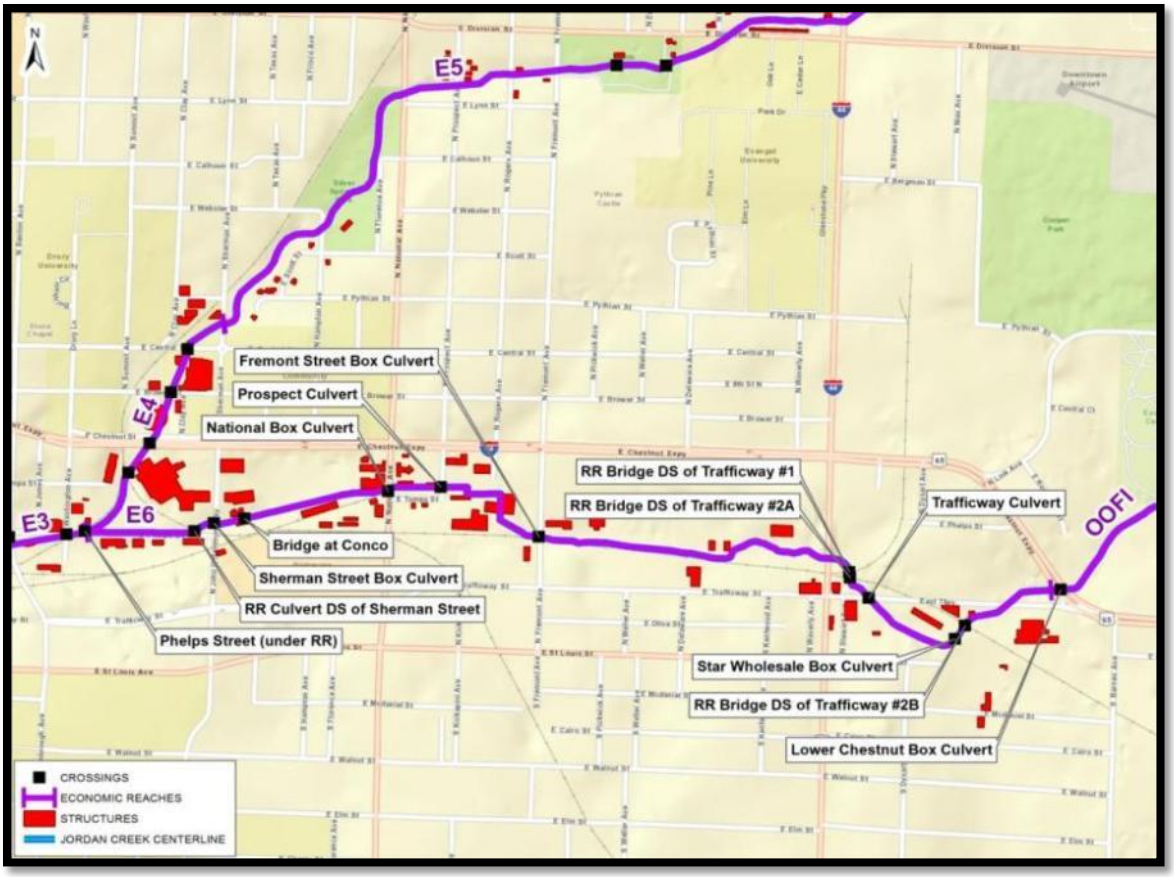

Figure 2-8: Reach E6

2.4.3 Existing Flood Risk Management

Springfield manages flood risk through its storm water protection program. The City has stringent storm water policies and is recognized statewide for its work in storm water reduction. The City has worked with the EPA on innovative programs to help the citizens become aware of where their runoff goes.

In 1989, the City entered into the National Flood Insurance Program; however, the buildings damaged during storm events were built prior to the City's inclusion into the program. Although there are stretches of floodway delineated through the downtown area, the floodway does not exist where the culvert is underground. Currently, if development is permitted within the 100-year floodplain, it has to meet two criteria:

1. The development cannot increase the water surface elevation.
2. The first-floor elevation must be 2 feet higher than the 100-year floodplain.

After the flood in 2000, FEMA offered buyouts to homeowners who would accept them. The City has offered buyouts to businesses downtown that are frequently inundated; however, the City did not have the funds available to buy all inundated properties. As buildings become available in the floodplain, the City buys them and either retrofits them to meet floodplain regulations or demolishes the structure.

The City's storm water management permit mandates that new construction buildings not increase the peak flow from a 1/5, 1/10, 1/50 or 1/100 ACE. During construction, the landowner is not allowed to induce flooding on neighboring properties.

Springfield has a large public awareness campaign on the importance of good storm water management for quality and quantity. The City has a "rain barrel" program to encourage the use of rain barrels and has removed pavement and installed pervious pavement in public areas to increase infiltration. Springfield is known statewide for its proactive storm water program.

2.4.4 Federal Interest

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, Springfield has a flood that produces significant damage every couple of years. It is within USACE and Federal interest to study the flood risk management issues with Jordan Creek because there are significant flood damages that result in residential and commercial 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.

2.5 PLANNING OBJECTIVES

The water and related land resource problems and opportunities identified in this study are stated as specific planning objectives to provide focus for the formulation of plans and development of criteria. These planning objectives represent desired positive changes in the "without project" conditions. The base year, the year the project is assumed to be fully operational is 2020, and the period of analysis is through the year 2070. The planning objectives are as follows:

- Reduce overall flood damages in the project area from 2020 to 2070.
- Reduce residual risk to property by removing properties from the floodplain in the project area from 2020 to 2070.
- Reduce risk to transportation and life, health and safety by reducing flood levels in the project area from 2020 to 2070.

2.6 PLANNING CONSTRAINTS

Unlike planning objectives that represent desired positive changes, planning constraints represent restrictions that should not be violated. The planning constraints identified in this study are as follows:

- Avoid potential contamination sites.
- Minimize disruption of community cohesion and community services.

- Avoid interruption to railroad service.
- Avoid adverse impacts to historic properties.

3 PLANS

This chapter describes the development of alternative plans that address the planning objectives, the comparison of those plans and the selection of a plan. It also describes the recommended Plan and its implementation requirements.

3.1 PLAN FORMULATION RATIONALE

A wide variety of management measures were developed that would address one or more of the planning objectives. These measures were evaluated and screened as described below. Alternative plans were then developed which included one or more of the management measures. Through the planning process, plans were formulated as a result of analysis. See Figure 3-1: Plan Formulation Process for the process used.

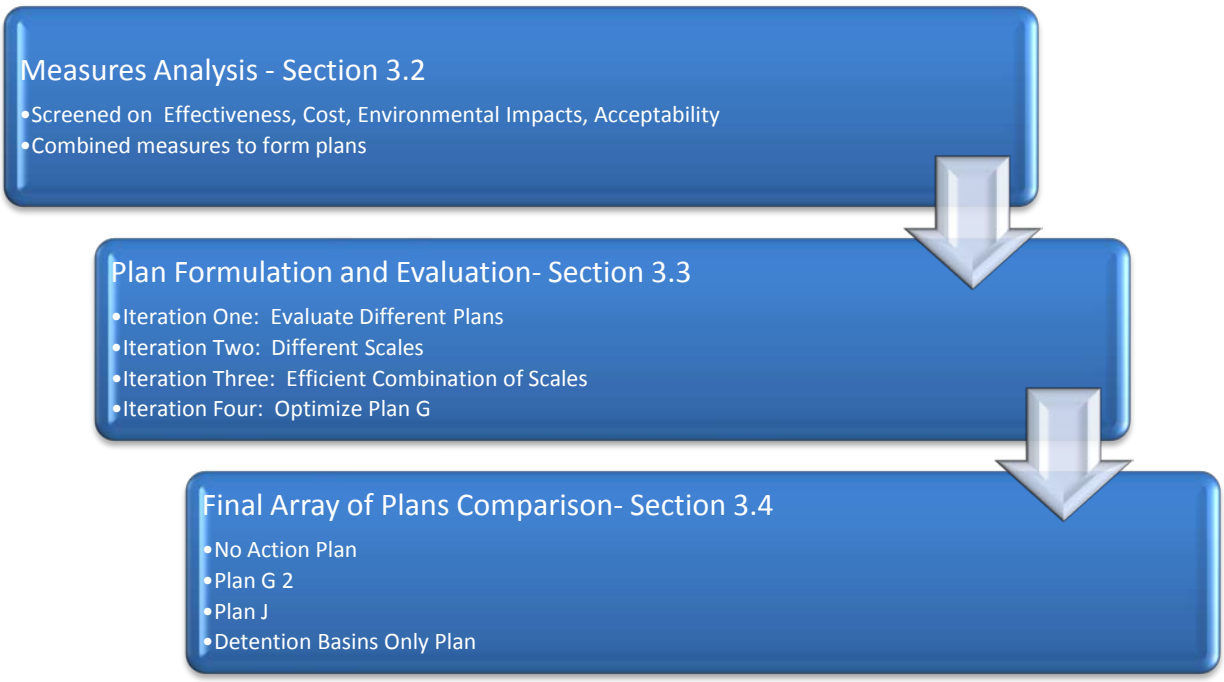

Figure 3-1: Plan Formulation Process

3.2 MANAGEMENT MEASURES TO ADDRESS IDENTIFIED PLANNING OBJECTIVES

A management measure is a feature or activity at a site that addresses one or more of the planning objectives. Measures for inclusion in the Jordan Creek study were evaluated based on their potential for flood risk reduction, relative development cost, environmental impacts and acceptability by the sponsor. No Federal Action, detention basins and channel modification underwent a thorough analysis. The descriptions and results of the evaluations of the remaining measures considered in this study are presented in Table 3-1: Measures Analyzed.

Table 3-1: Measures Analyzed

Measures	Description	Location	Analysis	Flood Risk Reduction Effectiveness	Development Cost	Positive Environmental Impacts	Acceptability	Conclusion	Risk Associated with Elimination
Elevate Structures	Elevation is the process of raising a structure so that the main living area (main floor) will be above a design flood elevation.	No real alternatives	Most of the flooding occurs in industrial areas. Generally, commercial buildings are on concrete pads. Raising the business is not practical, because it involves tearing down the building, removing the concrete pad, adding fill, recreating the concrete pad and rebuilding the building. We cannot add fill anywhere in Reaches E6 and E3 because there is no delineated floodway. FEMA will not allow fill in the floodplain unless no impacts are shown to the water-surface elevation. The buildings have to maintain a zero surcharge. If a structure goes through a major remodel, the City's regulations say it has to be 2 feet above the 100-year floodplain.	High for the individual buildings but medium overall - risk is only reduced on a per-structure basis	High	Low	Low - may cause business to shut down for a period while building is being elevated.	Removed from consideration	Low – Cost is high for the number of structures affected.
Buildings Removal From Within to Outside the Floodplain	This measure allows for moving structures out of the floodplain and buying the land upon which the structures are located.	No real alternatives	Most of the flooding occurs in industrial areas. There is limited railway access for businesses outside of the floodplain.	High for the individual buildings but medium overall - risk is only reduced on a per-structure basis	High	Low	Low - may cause business to shut down for a period while building is being relocated.	Removed from consideration	Low – Cost is high for the number of structures affected.
Floodplain Evacuation (Buy-Outs)	Floodplain Evacuation or buyout, as it is commonly known, results in the acquisition, demolition and removal of structures from the floodplain.	Throughout the watershed	The high-frequency events cause high damage. Removing the properties from the floodplain would eliminate the damages at all events as opposed to a structural measure that can be exceeded. However, the feasibility of moving people out of the downtown corridor without significant legal costs is low. Community cohesiveness may be affected because the government is moving established businesses out of the downtown corridor, which is the industrial heart of the City. There were two types of buyouts examined, voluntary and mandatory. In our examination, we focused on mandatory buyouts because voluntary buyouts created issues with community cohesiveness because they may leave individuals with low damages in the floodplain while their neighbors were offered incentives to move.	High for the individual buildings but medium overall - risk is only reduced on a per--structure basis	Medium initially but the cost would be high due to litigation	Low but potentially positive because the land through the urban core can be restored to something more natural	Some people would want to be bought out while others would fight it.	May be economical for use in formulation of alternative plans	Not removed from consideration
Flood Warning/ Flood Forecasting System	Flood warning systems warn property owners of impending floods and therefore allow, time to evacuate and relocate property subject to flood damage.	Various locations throughout the watershed	The downtown flooding occurs simultaneously with the rainfall event. The time to peak is about 30 minutes on a 1-hour critical storm.	Low - Due to short response time	High	Low	High	Removed from consideration	No risk associated with a measure that will not work.
Dry Flood Proofing Buildings	Dry Flood Proofing is the process of making any combination of structural or nonstructural changes or adjustments incorporated in the design, construction or alteration of individual buildings or properties in order to reduce flood damages. Dry flood proofing keeps the water out of the building.	Throughout the watershed	Flood proofing of buildings was ruled out early because of the nature of the floods. According to the Nonstructural Center of Expertise, dry flood proofing is not recommended due to the flashy nature of the floods. Not enough warning occurs to seal the doorways of the buildings, which leaves an opening to the floodwaters.	High for the individual building but medium overall because it is an individual building	Medium to High depending on the individual measure	N/A	High	Removed from consideration	Low - the measure is not expected to work.
Wet Flood Proofing Buildings	Wet flood proofing allows water to flow into and through buildings without causing damage to the buildings or the contents. Contents are generally elevated.	Throughout the watershed	Wet flood proofing may be a viable option for some buildings remaining in the floodplain. However, due to the industrial nature of the buildings and short response period, it is not feasible for most of the buildings. Businesses would need either to abandon the first floor of their buildings or move their tools and materials several feet off the ground. Neither one of these options is practical in an industrial setting.	High for the individual building but medium overall	Low	Low - May release some contaminants into the stream	Low - most people would not want to elevate everything in their building; however vacating the first floor of a building may be an option.	May be economical for use in formulation of alternative plans	Not removed from consideration

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Measures	Description	Location	Analysis	Flood Risk Reduction Effectiveness	Development Cost	Positive Environmental Impacts	Acceptability	Conclusion	Risk Associated with Elimination
Floodwalls	For structures that are too large to elevate, a concrete wall may be considered around the structure's property, where space and aesthetics permit.	Protection of manufacturing plant at the confluence of Wilsons and Jordan Creek	There is a levee that protects the plant that currently is overtopped at the 1/25 ACE. In the Future Without Project Conditions, that wall is overtopped in a 1/10 ACE. The team examined increasing the height of the wall. To increase the wall height, the wall had to be removed and completely rebuilt. The protection of the area is limited by the height of the road entering the site. To raise the entrance requires raising the road and increasing the bridge height. Doing some rough calculations during the Value Engineering meeting, it was found to be more economical to build a channel than rebuild the wall.	High	Medium	High	High	May be economical for use in formulation of alternative plans	Not removed from consideration
		Throughout the watershed	Adding walls around numerous structures would increase the flood heights downstream. There were no buildings where floodwalls could be added without leaving an opening that would need to be closed during a flood event.	Medium	Low	N/A	N/A	Removed from Consideration	No risk associated with a measure that will not work.
Diversions	Existing underground culverts may be used to divert high flows. Flood flows contained within the culvert would bypass the developed area and re-enter the creek downstream. Once the water reaches a critical height in the channel, the weir in the diversion channel is overtopped that allows flows into the culvert.	Lower Jordan Creek	This twin cell box culvert conveys storm water nearly 3,400 feet through the Springfield downtown area with portions of the tunnel measuring approximately 30 feet wide and 10 feet tall. The box structures were constructed in the late 1920s and early 1930s. This existing structure can be used when there are high flows.	High	Low	N/A	High	May be economical for use in formulation of alternative plans	Not removed from consideration
		North Branch of Jordan Creek	975 feet single cell box culvert tunnel located under an industrial area. This existing structure can be used when there are high flows.	High	Low	N/A	High	May be economical for use in formulation of alternative plans	Not removed from consideration
		South Branch of Jordan Creek - between National Street and Fremont	Structure is degraded and may need to be replaced. Real estate restrictions exist in this area so building a new diversion and daylighting the channel may be less expensive.	Medium	Medium	N/A	High	May be economical for use in formulation of alternative plans	Not removed from consideration
Impervious Removal from the Watershed	Remove parking lots and large areas of concrete throughout the watershed.	Throughout the watershed	There are several large parking lots in the watershed that if removed, could promote infiltration; however, there is not much reduction in flow for parking lot removal.	Low	Low	High	Medium	Removed because it was not cost effective	No risk associated with removal.
Levees	Levees provide protection against floodwaters but depending on their height may require substantial real estate.	Throughout the watershed	There are numerous real estate restrictions along Jordan Creek. It is preferable to build a larger channel to convey flow and keep the flow line at a lower elevation. In those areas where there is a real estate restriction and the channel cannot be practically enlarged, a wall is preferable to a levee because its footprint is smaller.	Medium	High	Low	Low	Removed from Consideration	Low - There are not areas where a levee is practical in an urban area.
Channel Modification	Channel modifications include widening the channel to allow more water to flow faster through an area to avoid damages. Channel modifications also create some temporary storage in the channel.	Along the North, South and Lower Branches of Jordan Creek	The channel modifications were thoroughly analyzed. Details of that analysis are described in Section 3.2.3.	High	Medium	Low	High	Retained	Not removed from consideration.
Detention Basins	Detention basins are used to reduce the peak flood flows by temporarily storing (detaining) floodwater, then releasing it slowly. This reduced peak water-surface elevations and helped to minimize flood damages downstream.	Throughout the watershed	A thorough analysis of the detention basins was conducted. It is described in Section 3.2.1.	High	Medium	High	High	May be economical for use in formulation of alternative plans	Not removed from consideration

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3.2.1 Detention Basins (Flood Storage)

Detention basins are used to reduce the peak flood flows by temporarily storing (detaining) floodwater, then releasing it slowly. This reduces peak water-surface elevations and helps minimize flood damages downstream. Initially over 24 sites were identified as potential detention basins (See Figure 3-2). The detention basins sites were chosen based on available real estate. Basin size was maximized to fit the available real estate.

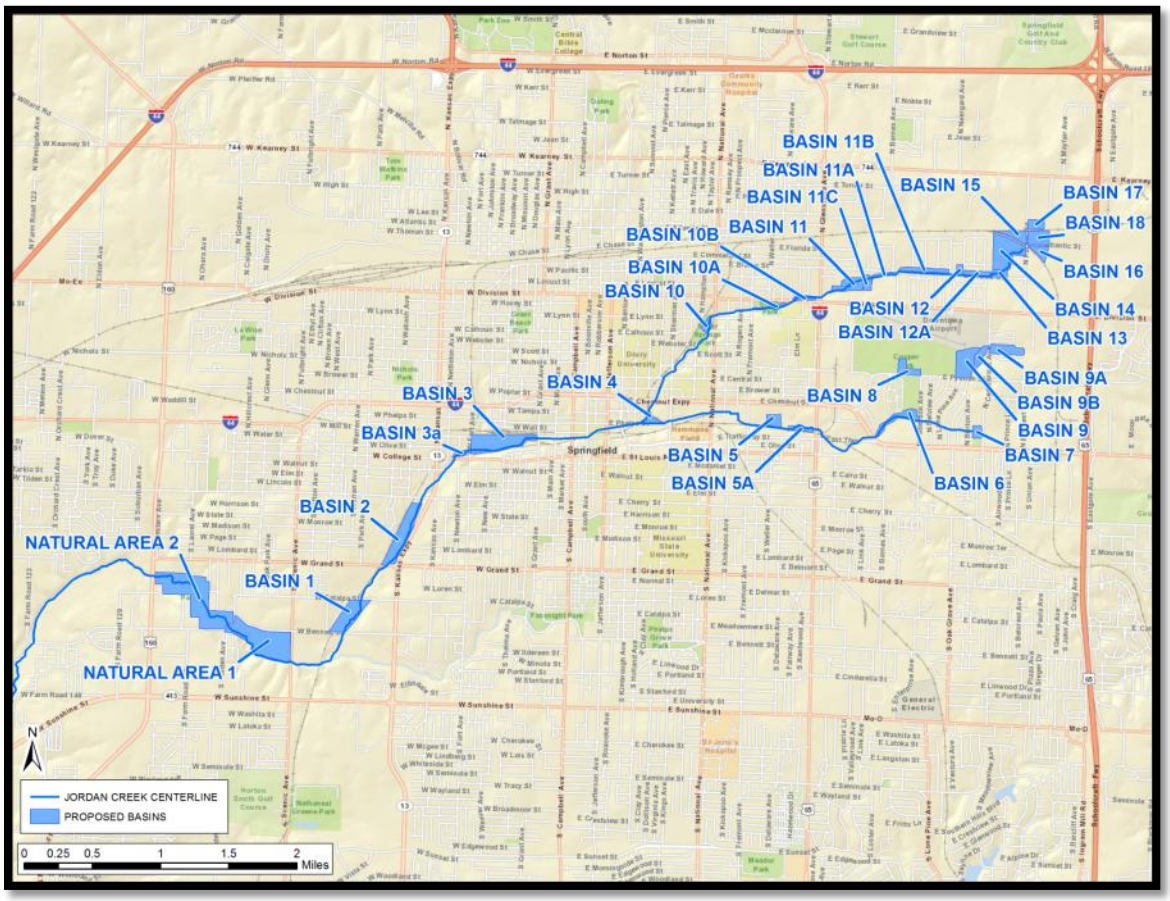

Figure 3-2: Preliminary Regional Detention Basins

The detention basins were designed to maximize flow reduction while maintaining reasonable vertical and horizontal limitations. They were initially analyzed and screened by routing water through the basins, both individually and in a series with other basins. Only the basins that provided a significant flow reduction (greater than 20 percent) at their outlet and through the downtown area were retained for further analysis, the others were screened out as ineffectiveness. Many of these basins were not large enough to have a significant impact on peak flows. This was especially true as the contributing watershed increased. Basin 9A was ruled out prior to in the preliminary analysis. Basins B9B and B9C, which were analyzed in series, produced comparable or better results than Basin 9A with less excavation and destruction of recreational facilities.

From this analysis, it was determined that nine basins reduce peak flows under both current and ultimate development conditions: B15, B14, B12, B11 and B11A, located on the North Branch of Jordan Creek and B9B, B9C, B6 and B7, located on the South Branch. Detailed information on the basin outputs is found in Appendix B: Attachment A: Hydrology and Hydraulics Report Appendix HH-K – Proposed Regional Detention – Preliminary Basin Summary (document page 294).

Simplified analysis of each basin determined each basin's impact on peak flows throughout the watershed. This analysis included an examination of the 2-hour 1/100 ACE peak flow immediately downstream of each basin (at the next downstream hydrograph combination) as well as at six other places along the stream alignment. Again, the basins were analyzed both individually and in series. No set criteria were used to evaluate the basins; rather, overall performance throughout the system was evaluated. If a number of basins performed roughly equal to one another, the amount of excavation, a rough estimate of construction cost and the environmental consequences were used as screening tools. Detailed information on the basin outputs is found in Appendix B: Attachment A: Hydrology and Hydraulics Report Appendix HH-L – Summary Table of Regional Detention Analysis (document page 298).

The analysis identified five basins that provided a significant reduction in water surface elevation, two on the North Branch (B11 and B11C) and three on the South Branch (B6, B7, and B9B). Figure 3-2: Preliminary Regional Detention Basins depicts the basins that were retained. More information on the output from the detention basin analysis is found in Appendix B: Attachment A: Hydrology and Hydraulics Report.

The basins were also analyzed for economic efficiency. North Branch basins alone, South Branch basins alone and the North and South Branch basins combined were analyzed to determine which grouping of basins provided the maximum net benefits in the study area. The results indicated that all five basins working together provided the most benefits. See Table 3-2 for the results of that analysis.

Table 3-2: Economic Benefits by Segment for the Detention Basins

Plan	Net Benefits	BCR
North Branch Only	$ 301,900	3.7
South Branch Only	$ 112,500	1.4
All Basins (North and South)	$ 334,700	1.8

The results from the basin analysis showed a 7 to 8 percent drop in flows through the downtown area resulting in an $800,000 reduction in annual damages downstream of the basins both in the project area as well as outside the project area. The detention basins measure was carried forward as an efficient component of a recommended plan. The selected basins are pictured below in Figure 3-3: Regional Detention Basins (Refined Analysis).

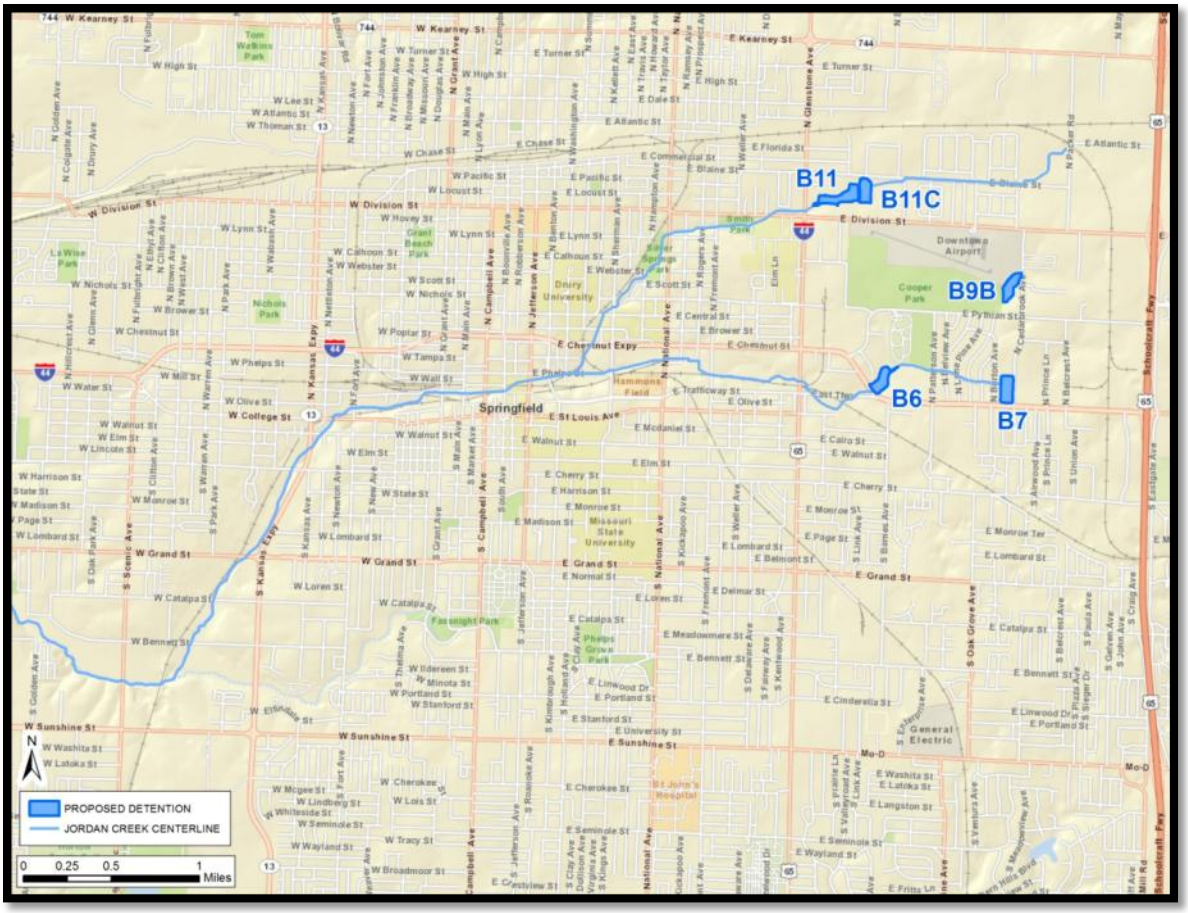

Figure 3-3: Regional Detention Basins (Refined Analysis)

3.2.2 No Action Measure

USACE is required to consider the measure of "No Action" to comply with the requirements of the National Environmental Policy Act (NEPA) and planning policy. With the No Action measure, which is synonymous with the Future Without Project Condition, it is assumed that no measure would be implemented by the Federal Government to achieve the planning objectives. Any reasonable activities to be pursued by state and local interests in the absence of a Federal project are assumed to be undertaken.

3.2.3 Channel Modifications

Channel modifications provide an effective way to move large amounts of water through the City. Routing of the stream was determined by following the existing stream whenever possible. For those areas that were currently in a box culvert, an open channel was preferred over replacing the box culvert. The goal was to remove the impervious surfaces from the stream corridor to give the stream natural characteristics.

Through the downtown area, it was not possible to follow the existing alignment because buildings and railroads were built over the box culverts containing the stream. Six alignments were analyzed based on real estate restrictions and engineering feasibility. Two final alignments were analyzed which included

creating a large box culvert under Phelp's street. The two alignments were compared in Plans A and B. The alignment with the shorter tunnel under Phelp's street cost less to construct; however, it involved more realignment of the railroad tracks.

The preferred cross section was a grass-lined channel with flat slopes because it is lower maintenance, provides more habitat and is aesthetically more pleasing than other cross sections like concrete or rock-lined channels. The cross section size was determined by adjusting the existing cross section until the water surface elevation dropped below the finished floor elevation of the surrounding buildings. A standard cross section with a low-flow channel that included a bench with a maintenance road was selected to improve both habitat and recreation in the area. The operation and maintenance road could double as a recreation trail, but it was designed to accommodate a large truck. In some areas, there is a real estate restriction limiting the width of the channel. In those areas, the slopes were steepened to provide sufficient cross-sectional area. Those slopes were protected with a concrete block wall, selected because it is easy to install and readily available.

The design of the modified channel will reduce damages to buildings. Channel design modification brings the water surface elevation to just below the finished floor of the buildings for a particular flood event.

3.2.4 Conclusions from Screening the Measures

From the preliminary analysis, it was determined that channel modifications and detention basins will make up the bulk of the plans. Channels are an efficient way of moving water through the downtown area and removing a large amount of damages. The basins were added to the channel improvement plans to reduce the size of the channels needed. Even a small channel offered protection in the high-intensity events. Due to infrastructure and real estate constraints, the channel alignments were limited. Formulation of specific plans was based on channel effectiveness (benefit outputs) and river reaches. Measures remaining from the preliminary screening were combined to form different plans.

3.3 PLAN FORMULATION AND EVALUATION

Four different iterations of formulation occurred before selection of the final plans for analysis as shown in Figure 3-4.

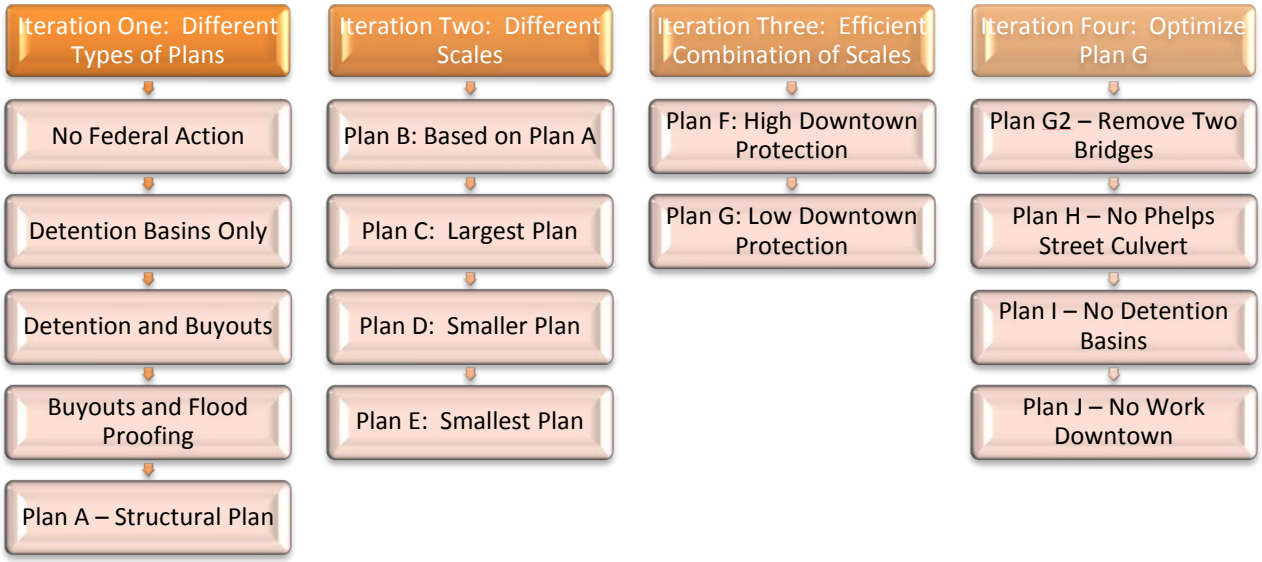

Figure 3-4: Iterations of Plan Formulation

The alternative plans were screened by formulation criteria established in the Principles and Guidelines for Water Resources Projects (P&G): completeness, effectiveness, efficiency and acceptability.

- Completeness - Completeness is a determination of whether or not the plan includes all elements necessary to achieve the objectives of the plan. For a project to be successful in this area, it must meet all of the objectives for the project listed in Section 2.5.
- Effectiveness - Effectiveness is a measure of the extent to which a plan achieves its objectives. All of the plans in the final array provided some contribution to the planning objectives.
- Efficiency - The cost effectiveness of a plan is expressed in net benefits and is a measure of its efficiency. All of the plans in the final array provided positive net benefits. Plans removed from consideration produced the same level of protection with fewer net benefits than other plans.
- Acceptability - Acceptability is acceptance of the plan by the local sponsor and the concerned public. All of the plans in the final array were in accordance with Federal law and policy.

Fifteen plans were analyzed, but only four plans were included in the final array of plans. The benefits categories used to compare the plans included flood damages reduced (structure, content and auto) and infrastructure damages reduced (road, bridge and utility). Other benefit categories, such as emergency costs and transportation delays, were investigated but determined to yield low additional benefits; therefore, they were excluded from the calculation and had no bearing on the choice of a selected plan. For further discussion on benefit categories, see the Economic Analysis Appendix (A).

A description of each of the plans follows. Table 3-12: Comparison of Plans displays how each plan met the P&G criteria.

3.3.1 Iteration One: Different Types of Plans

The purpose of Iteration 1 was to determine which plans to investigate further. The initial plans were formed at the Value Engineering (VE) meeting. Copies of the VE Report, written in accordance with ER 11-1-321, are available upon request. The following alternative plans were considered:

- No Action (Future Without Project Condition)
- Detention Basins Only
- Nonstructural (Buyouts) – Consisted of buying out structures that sustained high damage and removing them from the floodplain.
- Detention Basins and Buyouts
- Detention Basins and Channels (Plan A) – Provided property protection against the 1/100 ACE storm.

3.3.1.1 No Action (Future Without Project Condition)*

The No Action Plan assumed the conditions that would occur in the absence of a Federal project. USACE is required to consider "No Action" as one of the plans in order to comply with the requirements of the National Environmental Policy Act (NEPA) and planning policy (Engineering Regulation 1105-2-100). With the No Action Plan, which is synonymous with the Future Without Project Condition, it is assumed that no project would be implemented by the Federal Government to achieve the planning objectives. The No Action Plan forms the basis against which all other alternative plans are measured.

The planning period for both the economic and environmental analysis is 50 years. Assuming a minimum of 7 years for planning and implementation, projections for socioeconomic and environmental resource conditions were based on the year 2020. The period of analysis would extend through the year 2070. The future conditions were assumed over the period of analysis. Using GIS, it was determined that the watershed is currently closer to the future conditions than the existing conditions that was developed using data from 2003. Using data from the existing conditions as the base year would grossly underestimate the damages currently occurring in the watershed. Documentation of the determination is in the Economic Appendix.

When examining the No Action Plan, it was necessary to project what course of action local entities might take given the lack of Federal involvement. Due to budgetary concerns, the major funding requirements associated with the Jordan Creek FRM Project would not likely be accomplished under a local initiative. Significant long-term risk of flooding would remain over the period of analysis.

The No Action Plan assumptions consisted mainly of future development and improvements in the watershed. The following critical assumptions were used in defining the No Action Plan:

- Topography, physiography and soils would remain relatively unchanged (as described in Section 4.3.3) for the near future.
- The current zoning map for the City of Springfield would be followed, and all areas marked would develop. Few open lots exist for development within the watershed. Development in the remainder of the watershed would occur according to current zoning.

*Designates a section that is traditionally found in an Environmental Assessment.

It is reasonable to assume the City would continue to follow its zoning map. There is a possibility that the zoning map may modified to include higher density development, but there is also a possibility that it would include lower density development. There is a risk that the areas on the zoning map may not be completely constructed by the base year. However, the increase in flows from this assumption is relatively small (5 percent) and within the margin of error for a hydrology and hydraulics (H&H) analysis. To mitigate that risk, the selected plan was tested against the existing conditions as described in Section 3.6.7.

The City has an ordinance requiring detention on all new developments. In an effort to simulate the effects of future detention on future development, 38 regional detention ponds were modeled throughout the watershed at locations downstream of developable areas.

These detention basins were designed to reduce the peak flow to the predevelopment peaks. However, the total volume of water entering the system increases because of the addition of impervious cover. (Peak flow is the same, but the total volume of water increases).

- Currently developed areas would redevelop. It is assumed that all pervious areas, including those that are fully developed, would see a 15 percent increase in curve number (CN), a measure of the perviousness of the groundcover. An industry standard when using the CN method is to increase infiltration one "letter grade" when the land is redeveloped (B soils go to a C soil, etc.), which is approximately 15 percent. It is important to note that many different factors increase the imperviousness of soil. Parking on grass would increase the imperviousness. It is a reasonable assumption to assume that there would be areas that redevelop more than other areas, but the soils in general would become more compacted during the period of evaluation.
- Improvements would be made on the existing water conveyance system. In an effort to simulate the effects of future storm water conveyance on the watershed's time of concentration, roughness factors for many of the channelized flow elements were reduced. The rationale being that, as a parcel of land develops, pipes and channels would be constructed that decrease the time it takes for water to move off-site. A systematic procedure was used such that all channel roughness coefficients greater than 0.035 were reduced by 20 percent. In effect, this assumed that any "improved" channels would remain improved and any "rough channels" (n > 0.035) would be improved in the future. A value of .35 indicates that the channel is natural with stones and weeds. A natural channel in good condition is a .25, (a 28 percent difference). It is very unlikely all unimproved channels would be improved. Factors such as widening of the channels and concreting the sides of the channels would increase the flow. They were not specifically modeled in the H&H model. This assumption serves as a "catch all" for improvements in the system. System improvements would occur and the flow through the system would increase due to those improvements. Total increase in peak flow for this and the previous assumption was approximately 4 to 5 percent more.
- Development within the floodplain would comply with FEMA regulations. Development would comply with FEMA regulations, but there could be instances in which new buildings are

constructed in the FEMA SFHA, assuming they show no-rise or were constructed in an area with a delineated floodway.

There was reasonable risk associated with the project assumptions. Predictions of damages were based on 20 years of rainfall data and did not take into account global climate change, which had the potential to increase the intensity of rainfall events in Missouri. For each of the project assumptions, there was uncertainty for both under and over estimating the future flow. When all of the assumptions were modeled, the flow increase was relatively small and seemed reasonable given the characteristics of the watershed.

The Jordan Creek Valley was very sensitive to economic damages with increased flows induced by the Future Without Project Condition assumptions. From the hydrologic models, these base assumptions increased the flow through the Jordan Creek Valley by 10 percent over the existing conditions, but they caused an increase in damages of between 50 and 60 percent. The Jordan Creek Valley was constrained by development and was prone to flash flooding. The relatively small increase in flow caused water surface elevations to increase dramatically sooner at areas where the flow was blocked by a bridge or culvert. For example, the large culvert under the downtown section reaches capacity at the 1/5 ACE in the existing conditions. In the future conditions, the same culvert would overtop in the 1/2 ACE; instead of staying in the culvert, the water would spill into the streets of downtown Springfield causing damage in its wake. In the future conditions, damage would occur sooner.

Table 3-3: Without Project Single-Event Damages presents the damages by occurrence in the Future Without Project Condition. There is a large jump in damages between the 1/5 ACE and the 1/10 ACE. At the 1/10 ACE the pharmaceutical plant in Reach 1 starts to flood as well as the downtown industrial area (Reaches 3 and 6) resulting in a significant increase in damages. The Future Without Project Condition would have 193 structures subject to flooding in the 1/500 ACE floodplain with an estimated value of between $70 and $80 million. The average annual damages would be between $4 and $5 million. It was clear that, without a Federal investment, flood risk would increase over the next 50 years.

Table 3-3: Without Project Single-Event Damages

Annual Chance Exceedance (Recurrence Interval) Damages								
ACE	**1/1**	**1/2**	**1/5**	**1/10**	**1/25**	**1/50**	**1/100**	**1/500**
Reach E1								
Damage ($)	-	-	-	10,496,600	21,249,000	24,974,800	27,322,100	29,779,400
Structures (#)	0	0	0	25	29	30	30	30
Reach E2								
Damage ($)	5,600	96,600	419,100	644,800	1,062,600	1,435,600	1,961,000	2,859,400
Structures (#)	2	4	13	15	21	26	28	36
Reach E3								
Damage ($)	-	100,000	786,600	2,813,400	4,261,300	5,666,700	8,745,400	19,234,000
Structures (#)	0	10	21	29	40	41	45	50
Reach E4								
Damage ($)	-	6,300	35,800	150,700	335,500	532,900	848,000	1,657,600
Structures (#)	0	3	3	5	6	6	8	9
Reach E5								
Damage ($)	100	2,800	11,500	23,600	35,500	42,900	58,400	106,300
Structures (#)	1	2	5	6	8	12	15	24
Reach E6								
Damage ($)	-	192,400	714,700	1,495,700	4,087,500	6,175,300	8,725,000	14,741,300
Structures (#)	0	10	18	22	31	33	36	44
Total								
Damage ($)	5,700	398,200	1,967,700	15,624,800	31,031,500	38,828,200	47,660,000	68,378,100
Total								
Structures (#)	3	29	60	102	135	148	162	193
Damages per								
Structure ($)	1,894	13,732	32,795	153,184	229,863	262,353	294,198	354,291

3.3.1.2 Detention Basins Only Plan

This plan consisted of five detention basins that were deemed efficient in the preliminary analysis. There were no channel improvements with this plan. See Paragraph 3.2.1 for location and analysis.

This plan decreased the peak flows through downtown by about 7 to 8 percent. They were reduced from about 6000 cubic feet per second (cfs) to about 5600 cfs 1/100 ACE. However, the reduction was not sufficient to prevent damage in downstream reaches.

This plan was brought into the final array to provide a low-cost solution.

The total cost for this plan was $11.5 million. It provided $805,900 in benefits per year yielding $106,900 in net benefits.

3.3.1.3 Nonstructural Plan (Buyouts)

Buyouts were the only nonstructural measure remaining because of the flashy nature of the flooding and the real estate restriction.

The high-frequency events contribute most of the damages to the EAD calculations. Four mandatory buyout plans were examined that targeted the high-frequency events. Included in the plans were those properties that sustained more than $500 worth of damages for a 1/2, 1/5, 1/10 or 1/25 ACE. It was assumed that damages less than $500 dollars were insignificant and may have resulted from a modeling

error. Each property was examined using an EAD spreadsheet designed by USACE. The output of the spreadsheet was the EAD per building summed to create a total for the plan.

The cost to buy and move a property was roughly estimated by the Corps real estate appraisers to be 2.5 times the appraised value of the structure only. This estimate included the cost to buy the structure and property, to relocate the property and for administrative and legal fees. That cost was then annualized.

The EAD and cost were used to create a BCR for each plan. If the BCR was greater than 0.8, the plans were considered viable. A ratio that assumed a higher cost than benefits was chosen as the screening criteria to reduce the chance of inadvertently screening out viable plans. See Table 3-4 for outputs of the first round of analysis.

Table 3-4: Outputs from Initial Evaluation

ACE	Structure Count	EAD	Average Annual Cost	BCR	Net Benefits
1/2	26	$938,835	$2,055,391	0.46	($1,116,556)
1/5	55	$1,560,445	$2,667,778	0.58	($1,107,332)
1/10	98	$4,285,810	$4,140,341	1.04	$145,468
1/25	129	$4,427,333	$5,914,661	0.75	($1,487,328)

The damages were determined on a per structure basis. For the initial evaluation, only the structures that sustained damages were included in the buyout plan.

The 1/10 ACE plan was the only buy-plan determined to be viable after initial evaluation. To further refine the analysis, on the 1/10 ACE plan, all of the structures needed to operate the business were included in the cost of the buyout. The structures included in the analysis may not be flooded at the 1/10 ACE. The assumption was that the government would not purchase only one building on the property, it would purchase them all. Again, a 2.5 multiplier was used to estimate the cost of buying the property. The additional structures were run through the same EAD spreadsheet for only the 1/10 ACE plan. The results are presented below in Table 3-5. The total structure count went up because more structures were added.

Table 3-5: Output from Second Round of Buyout Analysis

ACE	Structure Count	EAD	Average Annual Cost	BCR	Net Benefits
1/10	113	$4,304,836	$4,904,585	0.88	($599,749)

The 1/10 ACE plan remained above the cutoff of 0.8, so a Hydrologic Engineering Center- Flood Damage Analysis (HEC-FDA) model was created to calculate the actual EAD of the buildings to refine the benefits. HEC-FDA is the model that USACE uses to determine benefits in a project. From HEC-FDA, the EAD was $4,202,339, which is close to the spreadsheet-estimated value. The 1/10 ACE plan was eliminated from consideration because it did not have a BCR greater than 1.

Eliminated from Consideration - Buyouts as a stand-alone plan were determined to be neither efficient nor economically feasible; the costs exceeded the benefits. They were also unacceptable because they would negatively affect the downtown community cohesiveness. For these reasons work on formulating stand-alone buyout plans ceased.

3.3.1.4 Detention Basins and Buyouts

This plan consisted of five regional detention basins in combination with buyouts or flood proofing selected structures in the higher-frequency floodplain. General plan components included the following:

- Detention Basins (same number of basins as in the Detention Basin Only Plan).
- Buying key properties under different flood inundation levels to remove them from the floodplain. (same as the buyout plan)

Eliminated from Consideration - Both detention basins and buyouts are effective for high-frequency events. The buyouts remove the high-frequency properties from the floodplain, which is what the detention basin plan targets. Combined, detention basin and buyouts reduced the benefits of the stand-alone plans while increasing the cost. This plan was eliminated from consideration because it was not economically efficient.

3.3.1.5 Plan A

Plan A consisted of detention basins and a channel sized to protect a majority of the structures from the 1/100 ACE storm. By design, water would inundate the streets and parking lots. General plan measures included the following:

- Five regional detention basins were located in the upper watershed. These are the same detention basins in the stand-alone detention plan.
- There were about 4 miles of channel improvements. Channel improvements on the North Branch started 2,000 feet upstream of the junction of North and South Branches. On the South Branch, channel improvements started about 4,600 feet upstream of the junction. Channel widths varied from 10 feet on South Branch to about 37 feet on the lower end of Jordan Creek and on Wilsons Creek. Side slopes varied from 3:1 to 5:1 depending on real estate restrictions. In one area, the channel width extended to 100 feet and the walls were vertical.
- The original path of the stream was followed whenever possible.
- There were 34 existing crossings in the project area. Six of those crossings would be removed and five crossings would not require a change. Modifications or replacements would occur to 20 of the structures. Due to channel modifications, six new bridges were added. There were 26 crossings modified or built.
- A 10-foot-wide Operation and Maintenance road was included along most of the daylighted or improved channel. The road would double as a recreation trail. The new stream crossings were wide enough to allow pedestrian or bicycle traffic to cross safely under them. There was no trail near the Archimica Plant in the southern part of the project nor was there a trail along the Phelp's Street box culvert.

- This plan contained channel modifications in all of the reaches.

Eliminated from Consideration - This plan was eliminated in the next iteration because it provided the same protection as Plan B (Section 3.3.2.1) but at a higher cost. Table 3-6 displays the output from Plan A using preliminary economics.

Table 3-6: Plan A Results Using Preliminary Economics

Plan	Net Benefits							BCR
	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Total	
A	$1,826,000	($334,000)	($946,000)	($585,300)	($70,200)	$1,852,700	$1,743,100	1.3

3.3.1.6 Results of Iteration One

Plan A and the Detention Basins Only Plan were complete and economically efficient plans. In an effort to formulate an equally effective but more cost-efficient plan, Plan A underwent value-engineering. HEC-FDA model and a preliminary cost estimate were created for Plan A. The following modifications to Plan A (displayed in Figure 3-5: Difference between Plan A and Plan B) resulted in the creation of Plan B:

- 880 linear feet of Phelp's Street culvert were converted to open channel in Plan B. The project saved significant money by moving adjacent railroad tracks and daylighting the channel. In Plan A, the underground portion ran 1,800 feet from Robberson to the junction of North and South Branches. In Plan B, the underground portion was 550 feet and ran between Robberson and Jefferson Street. Open channel replaced the portion from Jefferson Street to Washington Street, but beyond that, the channel remained covered (370 linear feet).
- Two railroad bridge replacements were eliminated in Plan B. The damage prevented by replacing those bridges and reducing backwater effects was minimal.
- Two bridge replacements in Smith Park were eliminated in Plan B. The original bridges caused water to back up and damage a pavilion, but the cost of replacing the bridges was more than the cost of the damage the replacements prevented.
- Grand Street Bridge improvements were removed from further examination because they did not prevent enough damage to warrant replacement.

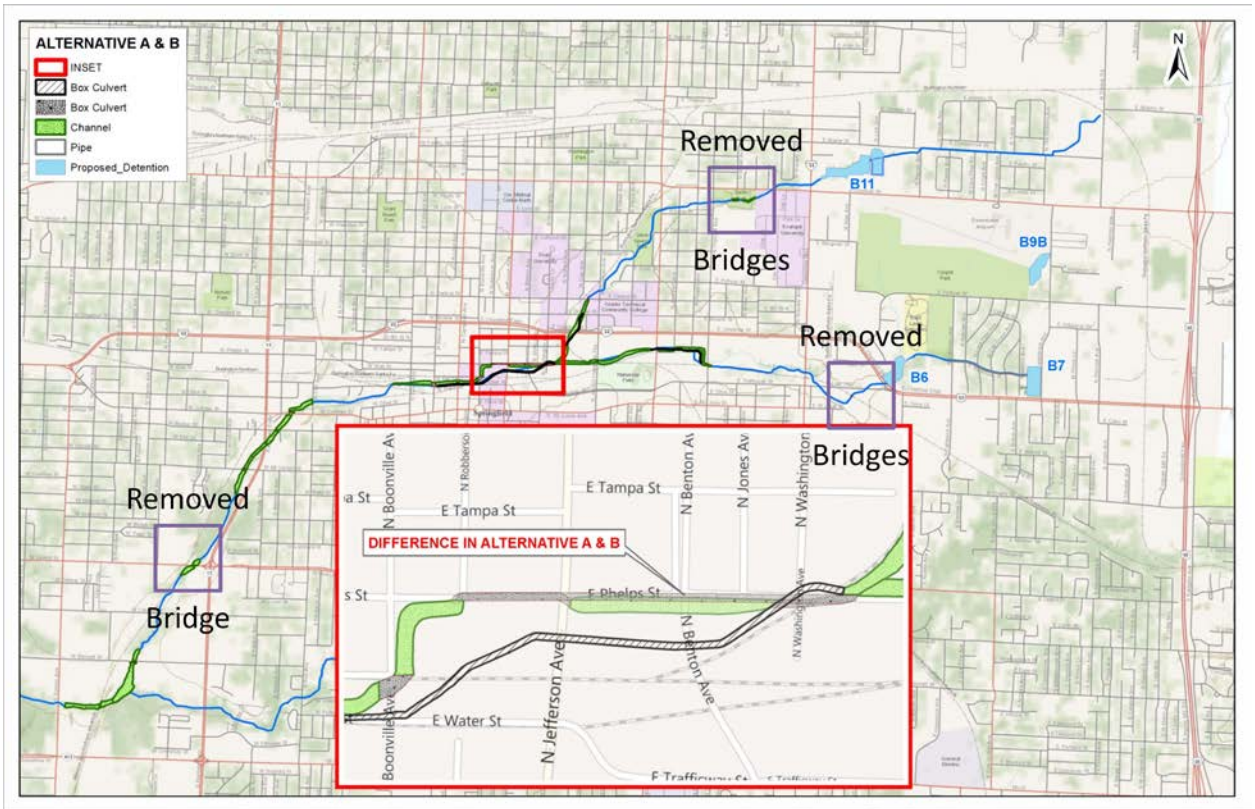

Figure 3-5: Difference between Plan A and Plan B

Detentions Basins and the No Action Plan were used in the final array. Plan A, the Nonstructural Plan, and Detention Basins and Buyouts were eliminated from consideration.

3.3.2 Iteration Two: Different Scales

The purpose of Iteration Two was to determine an efficient scale for a plan. Plan B protected structures to approximately the 1/100 ACE. Three more scales of Plan B were created to examine how different sizes of channels and bridges affected the efficiency. A HEC-FDA model and an MII cost estimate were created to compare the plans.

- Plan B – Offered protection against the 1/100 ACE storm. This plan included detention basins and channels.
- Plan C – Offered protection against the 1/50 ACE storm. This plan included detention basins and smaller channels than Plan B.
- Plan D – Offered protection against the 1/500 ACE storm. This plan included detention basins and larger channels than Plan B.
- Plan E – Offered protection against the 1/25 ACE storm. This plan included detention basins and the smallest channels of all the plans.

3.3.2.1 Plan B

This plan provided the minimum improvements necessary to keep the 1/100 ACE below the first-floor elevation of buildings. Plan B measures for construction included the following:

- Five regional detention basins were located in the upper watershed. These were the same detention basins in the stand-alone detention plan.
- Channel improvements were similar to those in Plan A. There were about 3.5 miles of channel improvements. Channel improvements on the North Branch started 2,000 feet upstream of the junction of North and South Branches. On the South Branch, channel improvements started about 4,600 feet upstream of the junction. Channel bottom widths varied from 10 feet on South Branch to about 37 feet on the lower end of Jordan Creek and on Wilsons Creek. Side slopes varied from 3:1 to 5:1 depending on real estate restrictions. For the Mount Vernon bridge transition, there was an area where the channel width extended to 100 feet and the walls were vertical.
- This plan contained channel modifications in Reaches E1, E2, E3, E4 and E6.
- As part of the channel rerouting through the downtown area, the new alignment followed Phelp's Street underground. The underground portion of Phelp's Street was approximately 30 feet wide and 920 feet long.
- There were six new stream crossings and twelve replaced crossings. These replaced crossings were either bridges or box culverts. Three bridge foundations were modified to reinforce the piers in the channel. Six crossings in the stream would be removed and not replaced. Thirteen structures in the watershed would remain unchanged.
- There were approximately 2.5 miles of concrete maintenance road added along the side slope of the channel where it was feasible. A concrete road in the channel would require significantly less maintenance over time than other materials. The road would double as a recreation trail. The new and replaced stream crossings were wide enough to allow pedestrian or bicycle traffic to cross safely under them. There was no trail near the Archimica Plant in the southern part of the project nor was there a trail along the Phelp's Street box culvert.

Plan B cost $99 million to construct. See Plate 2 for a map of the area.

Eliminated from Consideration - This plan was eliminated because plans F (Section 3.3.3.1) and G (3.3.3.2) were more efficient. In plan A, reaches E2, E3 and E4 were not economically justified; however, parts of Plan B were used to formulate Plans F and G.

3.3.2.2 Plan C

This plan identified the minimum improvements necessary to keep the 1/50 ACE below the first-floor elevation of buildings. General plan components included the following:

- Five regional detention basins were located in the upper watershed. These were the same detention basins in the stand-alone detention plan.
- Channel modifications included narrowing the channel and decreasing linear feet of modified channel to accommodate a lower level of protection than Plan B. Channel improvement occurred along about 3 miles of channel. Channel widths varied from 10 feet on South Branch to about 37 feet on the lower end of Jordan Creek and on Wilsons Creek. Side slopes varied from 3:1 to 5:1 depending on real estate restrictions. The 920-foot-long box culvert under Phelp's was reduced in size. It was 20 feet wide.

- This plan contained channel modifications in Reaches E1, E2, E3, E4 and E6.
- There were six new stream crossings and twelve replaced crossings. The replaced crossings were either bridges or box culverts. Four bridge foundations were modified to reinforce the piers in the channel. Six crossings in the stream would be removed. Fifteen structures in the watershed would remain unchanged.
- Where feasible, there were approximately 2.2 miles of concrete maintenance road added along the side slope of the channel. A concrete road in the channel would require significantly less maintenance over time than other materials. The road would double as a recreation trail. The new and replaced stream crossings were wide enough to allow pedestrian or bicycle traffic to cross safely under them. There was no trail near the Archimica Plant in the southern part of the project nor was there a trail along the Phelp's Street box culvert.

Plan C cost $88 million. See Plate 3 for a map of the area.

Eliminated from Consideration - This plan was eliminated because plans F (Section 3.3.3.1) and G (3.3.3.2) were more efficient. Reaches E2, E3 and E4 were not economically justified. It was also not effective because there were too many residual damages in the lower reaches.

3.3.2.3 Plan D

This plan provided the minimum improvements necessary to keep the 1/500 ACE below the first-floor elevation of buildings. General plan components included the following:

- Five regional detention basins were located in the upper watershed. These were the same detention basins in the stand-alone detention plan.
- Channel modifications included increasing the channel size creating the highest level of protection of all of the plans. Approximately 3.5 miles of channel improvements were included in the plan. Channel bottom widths varied from 10 feet on South Branch to about 48 to 84 feet on the lower end of Jordan Creek and on Wilsons Creek. Side slopes varied from 3:1 to 5:1 depending on real estate restrictions.
- This plan contained channel modifications in Reaches E1, E2, E3, E4 and E6.
- As part of the channel rerouting through the downtown area, the new alignment followed Phelp's Street underground. The Phelp's Street culvert was 920 feet long and 45 feet wide with vertical walls. Additional channel improvements were added in Wilsons Creek to improve conveyance.
- There were six new stream crossings and twelve replaced crossings. These replaced crossings were either bridges or box culverts. Four bridge foundations were modified to reinforce the piers in the channel. Six crossings in the stream would be removed. Twelve structures in the watershed would remain unchanged.
- Where feasible, there were approximately 2.5 miles of concrete maintenance road added along the side slope of the channel. A concrete road in the channel would require significantly less maintenance over time than other materials. The road would double as a recreation trail. The new and replaced stream crossings were wide enough to allow pedestrian or bicycle traffic to

cross safely under them. There was no trail near the Archimica Plant in the southern part of the project nor was there a trail along the Phelp's Street box culvert.

Plan D cost $112 million. See Plate 4 for a map of the area.

Eliminated from Consideration - This plan was eliminated because plans F (Section 3.3.3.1) and G (3.3.3.2) were more efficient. Reaches E2, E3 and E4 were not economically justified; however, parts of Plan D were used to formulate Plans F and G.

3.3.2.4 Plan E

This plan identified the minimum improvements necessary to keep the 1/25 ACE below the first-floor elevation of buildings. General plan components included the following:

- Five regional detention basins were located in the upper watershed. These were the same detention basins in the stand-alone detention plan.
- Channel modifications included narrowing the channel and decreasing linear feet of modified channel to accommodate a lower level of protection than Plan C. Channel improvements occurred along about 2.5 miles of channel. Channel widths varied from 5 feet on South Branch to about 37 feet on the lower end of Jordan Creek and on Wilsons Creek. Side slopes varied from 3:1 to 5:1 depending on real estate restrictions. The box culvert under Phelp's Street was 15 feet wide and 920 feet long. Overall, Plan E had about a 50 percent reduction in bottom width compared with Plans A and B.
- This plan contained channel modifications in Reaches E1, E2, E3, E4 and E6.
- There were six new stream crossing and eight replaced crossings. These crossings were either bridges or box culverts. Three bridge foundations were modified to reinforce the piers in the channel. Six crossings in the stream would be removed. Seventeen structures in the watershed would remain unchanged.
- Where feasible, there were approximately 2.0 miles of concrete maintenance road added along the side slope of the channel. A concrete road in the channel would require significantly less maintenance over time than other materials. The road would double as a recreation trail. The new and replaced stream crossings were wide enough to allow pedestrian or bicycle traffic to cross safely under them. There was no trail near the Archimica Plant in the southern part of the project nor was there a trail along the Phelp's Street box culvert.

Plan E cost $74 million. See Plate 5 for a map of the area.

Eliminated from Consideration - This plan was eliminated because plans F (Section 3.3.3.1) and G (3.3.3.2) were more efficient. This plan was eliminated because reaches E2, E3 and E4 were not economically justified. It was also not effective because there are too many residual damages in the lower reaches. Parts of this plan were used to formulate Plan G.

3.3.2.5 Results of Iteration Two

The plans formulated in Iteration Two were removed from consideration because Plans F and G produced more net benefits using the initial economics. Reaches of these plans were included in the plans formed in Iteration 3.

Reaches of the plans for Iteration Two were combined to form Plans F and G. All of the plans from Iteration Two were eliminated because Plans F and G produced more net benefits. See Table 3-7 for the economic output of Iteration Two using the preliminary economics.

Table 3-7: Economic Results of Iteration 2 Using Preliminary Economics

Plan	Net Benefits							BCR
	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Total	
B	$1,922,800	($255,700)	($511,900)	($73,700)	($9,300)	$1,636,300	$2,708,400	1.6
C	$1,651,500	($5,800)	($393,100)	($31,800)	($9,300)	$1,674,800	$2,886,300	1.7
D	$1,960,300	($244,100)	($821,500)	($104,500)	($9,300)	$1,510,500	$2,291,500	1.4
E	$1,451,400	$86,800	($304,100)	($19,000)	($9,300)	$1,856,100	$3,062,000	1.9

3.3.3 Iteration Three: Efficient Combination of Scales

To create additional high-performance plans, a reach-by-reach analysis was completed with the varying levels of protection. A HEC-FDA model and an MII cost estimate were created to compare the plans. Plans F and G were created by combining the reaches from Plans B through E to optimize for both performance and efficiency. The remaining risk to people, roads and structures, incidental flooding, resiliency and the frequency of high damages for any given event were considered. Those plans are listed below:

- Plan F – Offered protection against property damage for a 1/500 ACE in Reach E1 and a 1/100 ACE in Reaches E3 and E6. This plan contained detention basins and channel improvements.
- Plan G – Offered protection against property damage for a 1/500 ACE in Reach E1 and a 1/25 ACE in Reaches E3 and E6. This plan contained detention basins and channel improvements. This combination of reaches gave the highest combination of net benefits prior to the economics being updated.

3.3.3.1 Plan F

Plan F provided varying performance outputs. It focused on the reaches of Plans B through E that provided the most effective benefits.

- Five regional detention basins were located in the upper watershed. These were the same detention basins in the stand-alone detention plan.
- Channel modifications included modifications in lower Jordan Creek and Wilsons Creek (Reach E1) to accommodate a 1/500 ACE. Channel improvements occurred along about 2.4 miles of channel. Channel improvements also occurred along Reaches E3 and E6 to accommodate about a 1/100 ACE. Channel widths varied from 5 feet on South Branch to about 37 feet on the lower end of Jordan Creek and on Wilsons Creek. Side slopes varied from 3:1 to 5:1 depending on real

estate restrictions. The underground portion of Phelp's Street was approximately 30 feet wide and 920 feet long.

- This plan contained channel modifications in Reaches E1, E3 and E6. Channel improvements were not planned for Reaches E2, E4 and E5.
- There were six new stream crossings and eight replaced crossings. These crossing are either bridges or box culverts. Three bridge foundations were modified to reinforce the piers in the channel. Six crossings in the stream would be removed. Seventeen structures in the watershed would remain unchanged.
- The trail was not included in the Federal project, but the cross section was created so the City could add the trail later. The new and replaced stream crossings were wide enough to allow pedestrian or bicycle traffic to cross safely under them. There was no trail near the Archimica Plant in the southern part of the project nor was there a trail along the Phelp's Street box culvert.

The plan cost about $77 million. See Plate 6 for a map of the plan.

Eliminated from Consideration - This plan was eliminated because it was not efficient when the economics were refined.

3.3.3.2 Plan G

Plan G provided varying levels of protection. It was built by combining the most efficient reaches into a new plan.

- Five regional detention basins were located in the upper watershed. These were the same detention basins in the stand-alone detention plan.
- Channel improvements occurred along about 2.2 miles of channel. This plan offered protection at around a 1/500 ACE for Reach E1. Channel widths varied from 5 feet on South Branch to about 37 feet on the lower end of Jordan Creek and on Wilsons Creek. Side slopes varied from 3:1 to 5:1 depending on real estate restrictions. Work through the downtown reaches (Reaches E3 and E6) provided substantial protection against a 1/25 ACE.
- This plan contained channel modifications in Reaches E1, E3 and E6. Channel improvements were not planned for Reaches E2, E4 and E5.
- There were five new stream crossings and six replaced crossings. These crossing were either bridges or box culverts. One bridge foundation was modified to reinforce the piers that are in the channel. Five crossings in the stream would be removed. Twenty-three structures in the watershed would remain unchanged.
- The maintenance road was not included in the Federal project, but the cross section was created so the City could add it later. The new and replaced stream crossings were wide enough to allow pedestrian or bicycle traffic to cross safely under them. There was no trail near the Archimica Plant in the southern part of the project nor was there a trail along the Phelp's Street box culvert.

This plan cost approximately $65 million. It provided $4 million in benefits per year, which was slightly over the annual cost of the project. See Plate 7 for a map of the plan.

Eliminated from Consideration - Minor improvements to this plan were added to create Plan G2, which provided the same level of protection but with lower cost. This plan was eliminated because it was not as efficient as other plans.

3.3.3.3 Results of Iteration Three

Both Plans F and G were more efficient than any other plans examined previously as shown in Table 3-8: Output of Plans F and G Using Preliminary Economics. The combined reaches in Plan G gave the greatest net benefits.

Table 3-8: Output of Plans F and G Using Preliminary Economics

Plan	Net Benefits							BCR
	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Total	
F	$1,920,100	$318,000	($549,000)	$56,500	($7,000)	$1,512,500	$3,251,000	1.8
G	$1,919,500	$318,200	($277,700)	$61,800	($8,600)	$1,834,700	$3,847,800	2.1

The preliminary economics were refined to incorporate updated properties values, update costs and correct some previous assumptions using newly collected data. The results of that updated analysis is included in Table 3-9: Output of Plans F and G using Refined Economics. Plan F was removed from consideration because it had more cost per year than the benefits it provided. Plan G was efficient, and it served as a basis for formulation in Iteration 4. Plan G was eventually eliminated from consideration because other plans were more efficient and provided approximately the same level of protection.

Table 3-9: Output of Plans F and G using Refined Economics

Plan	Net Benefits							BCR
	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Total	
F	$1,750,900	$7,400	($1,691,500)	$10,600	$1,100	($693,000)	($614,500)	0.87
G	$1,775,000	$8,600	($953,300)	$12,400	$1,100	($335,500)	$508,300	1.14

3.3.4 Iteration Four: Optimize Plan G

One last iteration of analysis occurred on Plan G. Plans G2 through J were variations of Plan G. The analysis in Iteration Four created a better understanding of how the different components in Plan G performed. A HEC-FDA model and an MII cost estimate were generated to compare the plans. Those plans are listed below:

- Plan G2 – Offered protection against property damage for a 1/500 ACE in Reach E1 and a 1/25 ACE in Reaches E3 and E6. This plan contained detention basins and channel improvements. Unlike Plan G, this plan did not contain the Main Street or Boonville Street Bridge.
- Plan H – Similar to Plan G, but it did not contain the Phelp's Street culvert, which is costly.
- Plan I – Similar to Plan G, but it did not contain the detention basins.

- Plan J – Contained only the detention basins and the 1/500 ACE protection for Reach E1.

3.3.4.1 Plan G2

Plan G2 was similar to Plan G except that in the downtown area, two bridge replacements were eliminated. The current bridges would be removed to allow flow through the channel. These bridges had low traffic counts, but they contributed greatly to the annual cost of the project. The bridge replacements removed from Plan G were the Main Street Bridge and the box culvert under Boonville. The box culvert for railroad crossing near Boonville would remain. Table 3-10 shows costs and benefits by reach. The construction cost for the detention basins was distributed amongst the reaches in proportion to the benefits they received from the detention basins.

Table 3-10: Plan G2 Net Benefits and Costs

Reach	E1	E2	E3	E4	E5	E6	Total
ACE	1/500		1/25			1/25	
Net Benefits per year ($)	1,827,000	3,200	(580,200)	9,200	700	(338,400)	921,400
Total Cost ($)	8,245,600	569,300	29,402,300	339,100	51,200	23,291,800	61,899,300

Plan G2 consisted of the following:

- Five regional detention basins were located in the upper watershed. These were the same detention basins in the stand-alone detention plan.
- Channel improvements occur along about 2.2 miles of channel. This plan offered substantial protection against a 1/500 ACE for Reach E1. Channel widths varied from 5 feet on South Branch to about 37 feet on the lower end of Jordan Creek and on Wilsons Creek. Side slopes varied from 3:1 to 5:1 depending on real estate restrictions. Work through the downtown reaches (Reaches E3 and E6) provided substantial protection against a 1/25 ACE.
- This plan contained channel modifications in Reaches E1, E3 and E6. Channel improvements were not planned for Reaches E2, E4 and E5.
- There were five new stream crossings and four replaced crossings. These crossings were either bridges or box culverts. One bridge foundation was modified to reinforce the piers in the channel. Five crossings in the stream would be removed. Twenty-three structures in the watershed would remain unchanged.
- The maintenance road was not included in the Federal project, but the cross section was created so the City could add it later. The new and replaced stream crossings were wide enough to allow pedestrian or bicycle traffic to cross safely under them. There was no trail near the Archimica Plant in the southern part of the project nor was there a trail along the Phelp's Street box culvert.

The total cost for this plan was $56 million. It provided $4.2 million in benefits per year yielding $921,400 in net benefits. See Plate 8 for a map of the plan. This plan was not eliminated from consideration. It was the sponsor's preferred plan.

3.3.4.2 Plan H

Plan H targeted the areas of high economic damages while removing the more expensive Phelp's Street Culvert. Plan H was based on Plan G and consisted of the following:

- Five regional detention basins were located in the upper watershed. These were the same detention basins in the stand-alone detention plan.
- Channel improvements occur along about 2.2 miles of channel. This plan offers substantial protection against a 1/500 ACE for Reach E1. Channel widths varied from 5 feet on South Branch to about 37 feet on the lower end of Jordan Creek and on Wilsons Creek. Side slopes varied from 3:1 to 5:1 depending on real estate restrictions. Work through the downtown reaches (Reaches E3 and E6) provided substantial protection against a 1/25 ACE; however, the Phelp's Street culvert was not included in this plan. In the model, water flowed over the streets through the downtown area and was collected near Boonville Street.
- This plan contained channel modifications in Reaches E1, E3, and E6. Channel improvements were not planned for Reaches E2, E4, and E5.
- There are five new stream crossings and six replaced crossings. These crossing were either bridges or box culverts. One bridge foundation was modified to reinforce the piers that are in the channel. Five crossings in the stream would be removed. Twenty-three structures in the watershed would remain unchanged.
- The maintenance road was not included in the Federal project, but the cross section was created so the City could add it later. The new and replaced stream crossings were wide enough to allow pedestrian or bicycle traffic to cross safely under them. There was no trail near the Archimica Plant in the southern part of the project.

This plan cost $41 million to construct. It provided $3.7 million in annual benefits, which was $1.4 million over the annual cost of the project. See Plate 9 for a map of the plan.

Eliminated from Consideration - Eliminating the Phelp's Street culvert was engineeringly feasible, but it had the potential to induce damages in the downtown area. Removing the culvert did not provide substantial economic efficiency over Plan G. The plan was removed from consideration because it induced damages and was inefficient in Reach E3 and Reach E6.

3.3.4.3 Plan I

Plan I was similar to Plan G except it did not contain detention ponds.:

- There was no regional detention
- Channel improvements occur along about 2.2 miles of channel. This plan offers protection at around a 1/500 ACE for Reach E1. Channel widths varied from 5 feet on South Branch to about 37 feet on the lower end of Jordan Creek and on Wilsons Creek. Side slopes varied from 3:1 to 5:1 depending on real estate restrictions. Work through the downtown reaches (Reaches E3 and E6) provided substantial protection against a 1/25 ACE.
- This plan contained channel modifications in Reaches E1, E3 and E6. Channel improvements were not planned for Reaches E2, E4 and E5.

- There were five new stream crossings and six replaced crossings. These crossing are either bridges or box culverts. One bridge foundation was modified to reinforce the piers that are in the channel. Five crossings in the stream would be removed. Twenty-three structures in the watershed would remain unchanged.
- The maintenance road was not included in the Federal project, but the cross section was created so the City could add it later. The new and replaced stream crossings were wide enough to allow pedestrian or bicycle traffic to cross safely under them. There was no trail near the Archimica Plant in the southern part of the project nor was there a trail along the Phelp's Street box culvert.

The cost to construct the project was approximately $53 million. It provided $3.8 million in benefits per year, which was $830,000 more than the annual cost. See Plate 10 for a map of the plan.

Eliminated from Consideration - This plan was eliminated from consideration because it did not contain detention basins, which provide many benefits to upstream residential housing. This plan was inefficient in Reach E3 and Reach E6; therefore, it did not move into the final array. Plan J was more efficient.

3.3.4.4 Plan J

Plan J was the most economically efficient plan. It included only the increments that produced the most net benefits. Table 3-11: Plan J Net Benefits and Cost details the benefits and cost for Plan J. The construction cost for the detention basins was distributed amongst the reaches in proportion to the benefits they received from the detention basins.

Table 3-11: Plan J Net Benefits and Cost

Reach	E1	E2	E3	E4	E5	E6	Total
ACE	1/500						
Net Benefits per year ($)	1,752,300	4,800	39,800	3,000	500	55,700	1,856,100
Total Cost ($)	9,918,300	569,300	4,781,300	339,100	51,200	5,404,100	21,063,300

Plan J consisted of the following:

- Five regional detention basins were located in the upper watershed. These were the same detention basins in the stand-alone detention plan.
- Channel modifications occurred only in the first reach to protect against the 1/500 ACE.
- This plan contained channel modifications in Reaches E1. Channel improvements were not planned for Reaches E2, E3, E4, E5 and E6.
- One stream crossing was replaced for the railroad. Another stream crossing was modified to accommodate a wider channel.
- There was no trail near the Archimica Plant in the southern part of the project.

The total cost for this plan was $20 million. It provided $3.0 million in benefits per year yielding $1.9 million in net benefits. See Plate 11 for a map of the plan. This plan was not eliminated from consideration, and it was included in the final array.

3.3.4.5 Results of Iteration Four

All of the plans were efficient and effective. Plans I and H were both eliminated from consideration. Plans G2 and J proceeded into the final array.

3.3.5 Formulation Criteria

The alternative plans were screened by four formulation criteria established in the P&G: completeness, effectiveness, efficiency and acceptability. Table 3-12: Comparison of describes how each of the plans meet the criteria.

Table 3-12: Comparison of Plans

Plan	Completeness	Effectiveness	Efficiency	Acceptability
No Federal Project (No Action)	No - Did not completely meet any of the Planning objectives.	No - Served as baseline of effectiveness against which all other plans were measured.	Yes - Yielded zero net benefits.	No - Not acceptable to continue incurring damages.
Detention Basins Only	No - Reduced some risk to property and lives but did not meet the minimum requirement of the 1/25 ACE. Also did not provide recreation nor increase environmental benefits.	No - Removed some risks from flooding but not effectively.	Yes	Yes - Took up little room but significantly reduced flows in the project area and beyond the limits of Federal interest.
Detention and Buyouts	No - Reduced some risk to property and lives but did not meet the minimum requirement of the 1/25 ACE. Some buyout areas could be used for recreation and environmental restoration.	Yes	No - Buying properties to the 1/25 ACE yielded negative net benefits.	No - Not acceptable to the public to buy large portions of downtown and move them further out of the City.
Buyouts (Nonstructural Plan)	Yes - A plan could be formulated that provides a minimum of 1/25 ACE.	Yes	No - Analysis proved that a number of buyout plans cost more on a yearly basis than they provide in benefits.	No - Buyouts through the downtown area would affect community cohesiveness.
Plan A	Yes	Yes	No - Improved upon to create plan B which provided significant cost reduction but approximately the same benefits.	Yes

Plan	Completeness	Effectiveness	Efficiency	Acceptability
Plan B	Yes	Yes	No - Yielded negative net benefits.	Yes
Plan C	Yes	No - Left substantial flooding in lower reaches of the watershed.	No - Yielded negative net benefits.	Yes
Plan D	Yes	Yes	No - Yielded negative net benefits.	Yes
Plan E	Yes	No - Left substantial flooding in lower reaches of the watershed.	No - Yielded negative net benefits in Reaches E2, E3 and E4.	Yes
Plan F	Yes	Yes	No - Yielded negative net benefits.	Yes
Plan G	Yes	Yes	No - Plan G2 was more efficient, providing the same level of protection at a lower cost.	Yes
Plan G2	Yes	Yes	Yes	Yes
Plan H	Yes	Yes	Yes	No - Removing the work through the downtown area causes concern about induced flooding, even though the model predicts minimal flooding.
Plan I	Yes	No - Left considerable flooding in the upstream reaches of the North and South Branches.	Yes	Yes
Plan J	Yes	Yes – Was effective for high-frequency but not low-frequency events.	Yes	Yes

3.3.6 Results of Plan Formulation and Evaluation

The results of the analysis determined the following plans would be included in the final array:

- No Action Plan
- Detention Basins Only
- Plan G2
- Plan J

3.4 FINAL ARRAY OF PLANS COMPARISON

Comparison is the fifth step in the planning process. It is based on the evaluation of the impacts of the plans, the fourth step in the planning process. The more detailed evaluations of the impacts of the plans are presented in Chapter 5, Environmental Consequences.

3.4.1 Planning Objective Matrix

Table 3-13: Matrix of How Plans Met Objectives shows how the No Action Plan, Plan J, Plan G2 and the Detention Basins Only Plan met the original planning objectives. See Section 2.5 for a discussion on how the planning objectives were determined. The plans were compared for their ability to fulfill the objectives of the project. A thorough discussion of each objective follows the matrix.

Table 3-13: Matrix of How Plans Met Objectives

Objective	No Action Plan	Plan J	Plan G2	Detention Basins Only Plan
Reduce overall flood damages in the project area from 2020 to 2070.	Increased flooding over time. $4.6 million in EAD.	Reduced 65 percent of the damages, but started to incur significant damages at 1/5 ACE. $1.9 million in EAD.	Reduced 89 percent of the damages, but still incurred considerable damages before 1/25 ACE. $900,000 in EAD.	Reduced 15 percent of the damages. Not effective. $3.9 million in EAD.
Reduce residual risk to property by removing properties from the floodplain.	Increased risk over time. Flooded 162 buildings at 1/100 ACE.	Removed 25 percent (41 buildings) from 1/100 ACE. Better than detention alone, but not as good as Plan G2.	Removed 50 percent (81 buildings) from 1/100 ACE floodplain.	Removed 10 percent (16 buildings). Did not meet this objective.
Reduce risk to transportation and life, health and safety by reducing flood levels.	Began inundating city streets at 1/2 ACE. Incurred downstream damages at 1/10 ACE.	Began inundating city streets at 1/5 ACE. Virtually eliminated Reach E1 damages.	Began inundating city streets at 1/25 ACE. Virtually eliminated Reach E1 damages.	Began inundating city streets at 1/5 ACE. Incurred Reach E1 damages at 1/10 ACE.

Reduce Overall Flood Damages in the Project Area - Plan J reduced 65 percent of the average annual damages, and plan G2 reduced 89 percent of the average annual damages. Plan J more efficiently reduced damages than Plan G2, because Plan J reduced the high-frequency damages at a third of the cost of Plan G2. Detention basins only provided a 15 percent reduction in average annual damages, much lower than either Plan J or Plan G2.

Reduce Residual Risk to Properties by Removing Properties from the Floodplain - Removing properties from the floodplain reduced risk to the people who, during flood events, transverse the floodplain to other destinations. While 50 percent (81) of the buildings were removed from the 1 percent ACE floodplain in Plan G2, only 25 percent (41) of the buildings were removed with the Plan J. With the Detention Basin Only Plan, 10 percent of the properties were removed, which was dramatically less than Plan J or Plan G2.

Reduced Risk to Transportation and Life, Health and Safety - The channel plans were designed to protect building contents from specific flood events while allowing roadways and parking lots to flood. Road inundation increases the probability of loss of life. Residual flooding was significantly less with Plan G2 than with Plans J and the Detention Basin Only. Using the hydrology from 2003, at the 1/100 ACE, there was 2- to 3- foot drop from Plan J to Plan G2 in the downtown area, but at the 1/10 ACE, it could be anywhere from 3 to 6 feet. There was a large reduction at the 1/10 ACE because most of the water was carried by the channel. With Plan G2 there was no flooding of the streets until about the 1/25 ACE, but with Plan J, there was flooding at about the 1/2 ACE. Plan J and the detention basins performed similarly through the downtown area. Plan J and Plan G2 performed the same in the lower reaches of the watershed and far outperformed the Detention Basins Only Plan.

The Detention Basins Only Plan did not sufficiently remove risk; therefore, it was removed from consideration.

3.4.2 Economic Viability of the Plans

The costs of the plans are presented in Table 3-14: Final Array of Costs. These costs include only benefits achieved within the limits of Federal interest.

Table 3-14: Final Array of Costs

	Plan G2	Plan J
Total Project Cost	$ 55,717,000	$ 21,873,000
Annual OMRR&R Costs	$ 927,000	$ 234,400
Annualized Cost	$ 3,231,200	$ 1,173,300
Annualized Benefits	$ 4,152,600	$ 3,029,400
BC Calculation	1.3	2.6
Net Benefits	$ 921,400	$ 1,856,100

The total project costs were significantly lower with Plan J. It would deliver 2.5 dollars of return for every dollar spent. The addition of channelization through downtown (the difference between Plans J and G2) would yield a 60-cent return for every dollar spent.

The net benefits for Plan J far exceeded those of Plan G2 because the channels through the downtown area were not incrementally justified. The net benefits for Plan G2 were $921,400. The net benefits for

Plan J were $1,856,100 per year. Plan J provided almost $1 million net benefits a year more than Plan G2.

3.4.3 Action Versus No Action

There was a high risk that continual flooding in Jordan Creek would result in adverse impacts to the community. Without Federal involvement in the modification to the existing flood risk management system, the study area would continue to be at risk from large flooding events and the affected community would be faced with continued economic development concerns, potential loss of life and physical, as well as environmental, damage to the study area. The problem would worsen with time with no action taken because natural growth and redevelopment in the watershed would increase flows and flood damages.

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

The economic implications of the No Action Plan were broadly negative. The investment at risk was so large that no Federal action would subject the study area to the possibility of an overall long-term adverse impact on the local economy. 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 occurs, the long-term effects were likely to include diminished economic stability, business interruptions that could jeopardize workers' jobs and wages, potential losses in population and employment, reductions in the tax base and generally diminished property values.

Without Federal intervention, there was significant risk that the aquatic ecosystem would remain stagnant or decline in Jordan Creek. Total flows would increase, even with added regional detention, which would exacerbate the decline in habitat quality. General channel improvements would occur over the period of analysis to increase flow, but, because of cost factors and real estate restrictions, the improvements would be minor. The likely improvement was a grass-lined channel that would be mowed or a concrete channel that would provide no habitat.

3.4.4 Risk and Uncertainty

The Plan J would remove 65 percent of the average annual damages in the study area; however, it would provide minimal protection to the downtown area that contained both industrial and educational facilities. Two college campuses that include both a technology center and a pharmacy school have renovated buildings. Although the cost of channel modification was greater than the property damages reduced in Plan G2, the residual risk was high with Plan J because these structures were population concentrations. Varieties of nonstructural and structural plans were analyzed, but flash flooding and requirements for infrastructure in the Jordan Creek Valley rendered channelization the only effective alternative to managing the flood risk through the downtown area.

Risk reduction to people and property were the focus of this project. The three project objectives focus on reducing risk. With Plan G2, flooding would still occur in the downtown area, but fewer people and less property were affected. With Plan G2, the elevation of the water through the downtown area

would drop to 3 to 4 feet as opposed to 3 to 6 inches with Plan J. See Table 3-15: Summary of Residual Risks for a breakdown of how the plans would perform.

Table 3-15: Summary of Residual Risks

	No Action	Plan G2	Plan J
Residual Annual Damages	$4.6 million	$ 498,700	$1.62 million
Damages Prevented		$4.15 million	$3.03 million
Reduction in Damages		89%	65%
Acres Removed from the 1/100 ACE	657 (in the floodplain)	118	92
Buildings Remaining in the 1/100 ACE	162	80	121
Buildings Removed from the 1/100 ACE	0	82	41
Depth Reduction Through Downtown During 1/100 ACE (Future Hydrology)	5 to 6 feet of flooding (no reduction)	3 to 4 feet	3 to 6 inches
Duration of Flooding for the 1/100 ACE in Reach E1 (Archimica Plant)	4 hrs	1 hr	1 hr
Duration of Flooding for the 1/100 ACE in Reach E3 (confluence of North and South Branch)	4 hrs	3 hrs	4 hrs

What follows is a list of the residual risks and their performance under each of the plans.

1. **Project Performance -** There would be minimal performance of Plan J through the downtown area for events greater than the 1/10 ACE. The only protection offered to the downtown area would be the detention basins. Damage reduction in the downtown reaches (E3, E4 and E6) with a 1/10 ACE would be 44 percent. However, the damage reduced with a 1/25 ACE would be only 27 percent. Detention basins reduce high-frequency-event flood damages, but they provide less protection for storms greater than the 1/10 ACE. With Plan J, once the detention basins were overwhelmed, there would be significantly less protection provided to the downtown area. With the downtown channel in Plan G2, the 1/25 ACE would yield an 89 percent reduction in damages. Project exceedance for the No Action, Detention Ponds, Plan G2, and Plan J are all presented in Section 4.7 of the Economic Analysis Appendix (A).
2. **Residual Flooding -** The channel plans were designed to protect building contents from specific flood events while allowing roadways and parking lots to flood; however, road inundation increases the probability of loss of life. The residual flooding was significantly less with Plan G2 than with the Plan J. Using the hydrology from 2003, at the 1/100 ACE, there was a 2- to 3-foot drop from Plan J to Plan G2, but at the 1/10 ACE, it could be anywhere from 3 to 6 feet. There was a large reduction at the 1/10 ACE because most of the water was carried by the channel. Even during the high-frequency events, there was significant conveyance of the water and reduction of residual flooding. With Plan G2 there was no flooding of the streets until about the 1/25 ACE, but with Plan J, there was flooding at about the 1/2 ACE. Single-event residual damage tables can be found in Section 4.2 of the Economic Analysis Appendix (A).

3. **Long-Term Risk to the Project Area -** Long-term risk reduction was greater with Plan G2 as opposed to Plan J. With Plan G2, there was a 65 percent chance of exceeding the capacity in 10 years. With Plan J, which would start to show damages at the 1/2 ACE, the chances of exceeding the capacity of the project in the next 10 years was greater than 99 percent. The effectiveness of Plan J was dramatically reduced after the 1/10 ACE. Plan J would not provide complete protection to the industrial and education centers. Long-term risk tables can be found in Section 4.7 of the Economic Analysis Appendix (A).
4. **Population at Risk -** Removing properties from the floodplain reduced risk to the people who, during flood events, transverse the floodplain to other destinations. While 50 percent (82) of the buildings were removed from the 1 percent ACE floodplain in Plan G2, only 25 percent (41) of the buildings were removed with the Plan J. With the Detention Basin Only Plan, 10 percent of the properties were removed, which was dramatically less than Plan J or Plan G2.
5. **Flooding in Recent History -** Twenty years of data was used to determine how the watershed would perform. With Plan J, little protection would be offered to the downtown area during the high-intensity events, because between a 1/10 and 1/25 ACE, the detention ponds exceed their capacity. In the last 15 years, the City has encountered two 1/25 ACE events, a 1/50 ACE, and a 1/100 ACE. Plan G2 would offer Reach E3, the downtown area, 13 times more protection from a 1/100 ACE than would Plan J. The City would not have been protected against large damages in the large floods of recent memory with Plan J.
6. **Climate Change -** Climate change became an area of concern due to the potential for effects on numerous aspects of the environment, especially those related to water resources. The U.S. Global Change Research Program (USGCRP) summarized information regarding climate change and its potential effects in regional assessments (http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts). In the Midwest, which extends from Minnesota to Missouri, extreme events such as heat waves, droughts and heavy rainfall events were projected to occur more frequently. There may be a 31 percent increase in precipitation at the 1/100 ACE in the region in the year 2099. Climate change was not specifically modeled in the Jordan Creek watershed; however, uncertainty was built into both the hydrologic and economic models. Should the dramatic increase in precipitation per event happen, both plans will be exceeded with higher water depths than they are now. Both plans reduce the risk at the lower-frequency events; however, they were both plans that target high-frequency risks.

Uncertainty in the Analysis – Risk and uncertainty are intrinsic in water resources planning and design. All measured or estimated values in project planning and design are best estimates of key variables, factors, parameters and data components. These estimates are the “most likely” values. The true values of planning and design variables and parameters are not certain and could take on a range of values. Those in the current study were based on short periods of record, small sample sizes and measurements that were subject to error. However, uncertainty was shared across the plans equally, making the likelihood of a wrong decision low.

The likelihood of a parameter taking on a particular value by a probability distribution could be described. In the hydrologic and hydraulic analysis, there is uncertainty in the rain gage data and historical stream gage data. See Section 4.5 in the Hydrology and Hydraulics Report (Appendix C-Attachment A) for information on the risk and uncertainty analysis in the hydrology and hydraulic analysis. In the economic analysis, areas of uncertainty in the analysis included first-floor elevations from surveys, structure values, content values, vehicle values, H&H exceedance probabilities, stage-discharge function and the depth-percent damage functions. Ranges of uncertainty for all of these functions were entered into the HEC-FDA program. Values for EAD were calculated with uncertainty as described in the Economic Analysis Appendix (A) Section 4.6.

3.4.5 Loss of Life

A HEC-FIA model was run on the preliminary array of plans. The calculated loss of life was negligible in the Future Without Project Conditions. As a result, there was no calculated loss of life reduction with any of the plans evaluated.

The HEC-FIA analysis may understate the flood risk on Jordan Creek. The HEC-FIA model associated people with a particular building type. Historical flooding shows high velocities were present during high-water events near the stream's centerline. High velocities did not affect most structures in the floodplain, as there are very few structures directly in the high-velocity areas. However, high velocities did occur perpendicular to the roadway. HEC-FIA does not account for people attempting to cross inundated roads, potentially underestimating the risk of loss of life due to flooding. In previous floods, numerous water rescues occurred when people tried to cross flooded roads and bridges.

3.4.6 Environmental Considerations

The Environmental Impacts of the No Action Plan, Plan G2 and Plan J are discussed in Section 5 Effects on Significant Resources.

3.4.7 System of Accounts

A method of displaying the positive and negative effects of various plans was to use the System of Accounts as suggested by the U.S. Water Resources Council. The accounts are categories of long-term impacts, defined in such a manner that each proposed plan can be easily compared to one another. The four accounts used to compare proposed water resource development plans were the national economic development (NED), environmental quality (EQ), regional economic development (RED) and other social effects (OSE) accounts.

3.4.7.1 National Economic Development (NED)

The intent of comparing alternative flood control plans in terms of national economic development was to identify the beneficial and adverse effects that the plans may have on the national economy. Beneficial effects were considered to be increases in the economic value of the national output of goods and services attributable to a plan. Increases in NED were expressed as the plans' economic benefits, and the adverse NED effects were the investment opportunities lost by committing funds to the implementation of a plan. The NED benefits for Plans G2 and J were described in Section 3.4.2. Plan J had the most net benefits.

3.4.7.2 Environmental Quality (EQ)

The environmental quality account was another means of evaluating the plans to assist in making recommendation. The EQ account was intended to display the long-term effects that the alternative plans may have on significant environmental resources. The Water Resources Council defined significant environmental resources as those components of the ecological, cultural and aesthetic environments that, if affected by the alternative plans, could have a material bearing on the decision-making process. The EQ account is described in Section 5. Plans G2 and J had similar effects and benefits. The No Action Plan had negative impact to HTRW and biological resources.

3.4.7.3 Regional Economic Development (RED)

The regional economic development account was intended to illustrate the effects that the proposed plans would have on regional economic activity, specifically, regional income and regional employment. RED benefits were similar across both plans. Plan G2 had more construction in the downtown reaches which had a short-term multiplier effect on the regional economy.

3.4.7.4 Other Social Effects (OSE)

The other social effects (OSE) account typically includes long-term community impacts in the areas of public facilities and services, recreational opportunities, transportation and traffic and man-made and natural resources. Plan G2 has more health safety features and potential for trails than Plan J.

3.5 PLAN SELECTION

3.5.1 Rationale for Designation of NED Plan

Federal policy requires that the feasibility study identify the plan that reasonably maximizes net NED benefits consistent with protecting the environment. This NED Plan must be recommended for implementation unless there are overriding reasons for recommending another plan.

The NED Plan was determined by evaluating the net economic benefits for each individual reach. The NED Plan is Plan J.

3.5.2 Rationale for Recommended Plan

The recommended plan is the NED Plan because it provides the greatest net benefits. Plan J leaves considerably more residual risk in the floodplain than Plan G2; however, the additional increment of work in reaches 3 and 6 has negative net benefits.

3.6 DESCRIPTION OF RECOMMENDED PLAN

3.6.1 Plan J Components

Channel improvements: Channel improvements only occur in Reach E1 and were designed to keep structural damage from a 1/500 ACE to a minimum. On Wilsons Creek, approximately 2,100 feet of channel widening will occur. The widening will start at the confluence of Wilsons and Jordan Creeks and will end approximately at station 310+00, 100 feet west of the Scenic Bridge. The channel top width varies from 100 feet to 360 feet and runs mostly through City-owned property. Modification to Scenic Bridge will likely be required because of channel excavation beneath the bridge. The modification may

include reinforcement the piers and adding a mat foundation. Because the railroad bridge over Wilsons Creek at the southeast corner of the ball fields causes a restriction to stream flow, it will be replaced. No recreational improvements are planned along with the channel modification because of the real estate restrictions on either side of the creek.

The sponsor will remove two pedestrian walkways on Jordan Creek to increase the channel width from approximately 45 to 100 feet. A flood diversion structure will be constructed adjacent the Archimica plant to prevent water from flowing over a low point on Bennett street into the manufacturing facility. The flood diversion structure completes the Archimica plants floodwall and protects it from flood damage. Channel work will end approximately 350 feet north of the Bennett Street Bridge.

The Archimica plant is located at the confluence of Fassnight and Jordan Creeks. Raising the floodwall would require substantial excavation and rebuilding; as a result, no work is planned to raise the floodwall.

Reach E1 contains three HTRW areas, two of which are City-owned sites of former municipal landfills. The largest City-owned parcel, Ewing Park, borders Wilsons Creek on the north and is currently used as a sports complex. The completed Phase I study of this 35.5-acre parcel recommended further assessment. The other City-owned property is an eleven-acre parcel along Bennett Street. The remaining HTRW property consists of two parcels of land owned by the Archimica Pharmaceutical Company. While, there is no toxic or radioactive waste known in the project area, estimated remediation costs for cleanup of these properties range from $67,500 to $1,340,000. There is a low risk that HTRW is within the project footprint. The sponsor is responsible for cleaning the site to a level suitable for channel widening. USACE will continue to work with the City and the Missouri Department of Natural Resources (MDNR) to discuss HTRW issues on theses site.

Detention Basins: Five regional detention basins are included in the NED Plan. Those basins are B6, B7, B9B, B11 and B11C. Refer to Paragraph Number 3.2.1 for a description of the basins.

Due to the highly developed, urban environment of the project footprint, and the fact that channel construction activity will be confined to the highly industrialized lower reach, the resulting environmental impacts are minimal. No compensatory mitigation is required.

3.6.2 Design and Construction Considerations

Construction of the proposed channel will occur within the existing, operating channel and some of the detention basins. This will present a challenge to the construction contractor regarding the movement of equipment, personnel and supplies within the construction areas. Erosion will be minimized during the construction process.

The railroad bridge over Wilsons Creek will be replaced using a “Saddlecap” method; that is, the new bridge will be constructed underneath the existing bridge. This will eliminate the need to construct an alternate railway, commonly called a shoofly. Once the new structure is in place, the rails from the old bridge can be installed on the new structure within an allowable downtime.

There will be several required utility relocations along Rockhurst Street, which is downstream of Basin B7. The flow line of the basin will be lowered to provide additional storage capacity. This change in grade will require two 48”-diameter reinforced concrete pipes to be placed along Rockhurst Street to convey the storm water downstream. Affected utilities likely include water, sanitary sewer, natural gas, communication and electrical. Because the drainage and utility construction occur underneath the existing street, reconstruction of the street will be required. During design and construction, special consideration will be given to unknown site conditions such as unidentified utilities, rock formations and other artificial subsurface obstructions.

Jordan Creek is a steep flashy stream with many of the upstream reaches lined with concrete. Traditionally, it is a relatively stable stream with minimal head cutting or gravel bars. Meandering does not occur in the stream. Given the flow velocities, proposed channel side slopes (1:4), use of turf-reinforcement mats and historical performance of the stream; sedimentation within the channel should be minimal and should not affect the flow capacity of the channel over time. There may be some maintenance gravel removed from the system, but it is minor and accounted for in the maintenance costs. A low-flow channel will be considered in the final design to provide an increased depth of flow during frequent events, which aids in both habitat improvement and channel maintenance. The geomorphology will be considered in the final design to produce a stable stream environment.

A Cost Schedule Risk Analysis (CSRA) was conducted on the project to determine the contingencies to add to the cost estimate. Based on unknowns in construction, contracting, real estate and funding sources, the team assigned a 22 percent contingency to the construction items in the project and a 23 percent contingency on labor. The real estate was assigned a 20 percent contingency.

3.6.3 Failure of the Project

The project will consist of detention basins, channel modifications and widening of bridge openings. Because of the static nature of the system, the only probable failure would be that of a detention pond levee. Should that happen, the water flowing through that pond would reach points further downstream faster, causing a slight rise in water level that could damage buildings. Failure of the system in this way will not worsen the existing conditions because the channel conveyance and bridge openings would allow more water to flow through them at any given time.

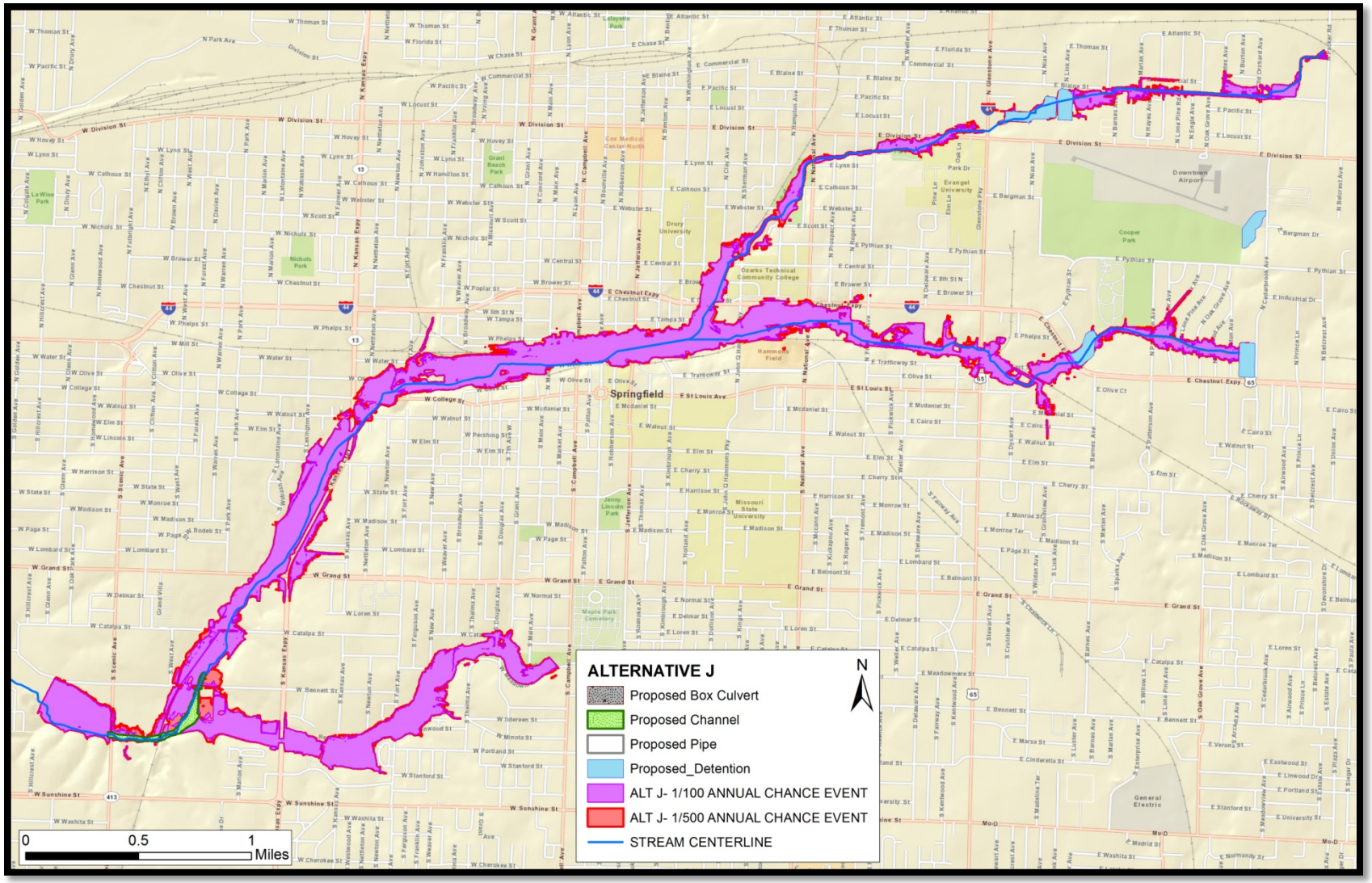

Figure 3-6: Inundation from a 1/100 ACE and a 1/500 ACE with Plan J

Should the system encounter a rainfall event that exceeds design capacity, bridges could be overtopped and roadways flooded. The scales of both the project and the rainfall event would determine the scale of the safety risk posed. A floodplain management plan will be developed for the project constructed, and it will include advising the public of the residual risk.

The probability that Plan J's capacity is exceeded in the 10 years following its construction is greater than 99 percent. The capacity of the project will be exceeded and damages will occur. Plan J targets the high-frequency events. For the low-frequency events (1/100 ACE and 1/500 ACE), the project will perform similarly to the without project conditions. Figure 3-6 shows the boundary for expected inundation for the subject events. The boundary is similar to the Future Without Project Condition.

Jordan Creek is an urban stream that is prone to flash flooding. The time to peak flood heights for a critical 1-hour storm is 30 minutes. The depth of flooding in the downtown streets will be from 5 to 6 feet. This means that, almost simultaneously, the water rises in the urban areas as the rain falls. The flooding events are quick and unpredictable, preventing the City from constructing a flood warning system. The water backs up along the creek and spreads throughout the floodplain rapidly. During large flood events, the City has to block busy thoroughfares inhibiting the delivery of police, fire and street department resources to occupants. However, the loss of life from a structural failure or from a capacity exceedance is expected to be very low because the floodplain width is narrow with many evacuation routes.

3.6.4 Real Estate Requirements

Real estate requirements include the acquisition of an approximate 10-acre channel improvement easement and an approximate 1-acre temporary construction easement for Reach E1. Five detention basins are part of this study. Approximately a 2-acre utility/pipeline easement connecting with detention basin B7 will be acquired. An easement or fee-simple acquisition of detention basin 9B will also be needed. The City has drainage easements on detention basins B6, B7, B11 and B11C. Depending on the conditions or provisions for each of the easements, the non-Federal sponsor may need to acquire a fee-simple interest in detention basins B6, B11 and B11C. The land area for the proposed detention basin B7 is under the administration of the City Parks Department. An interdepartmental land transfer of authority over this basin area may be required. The City will provide rights-of-way free of HTRW to the government.

3.6.5 Local Betterments

There are no betterments.

3.6.6 Operations, Maintenance, Repair, Rehabilitation and Replacement Considerations

A summary of the OMRR&R cost estimate appears in Table 3-16: Summary of OMRR&R Costs for Plan J. This estimate was calculated to account for the net increase in project costs to operate and maintain the project features and to recognize costs for the repair, replacement and rehabilitation of, primarily, bridges and culverts. This cost will be a required minimum in the future to maintain the improved project for its expected life. The basis of the OMRR&R is a visual inspection of the project area via aerial

photography. Woody growth along the creek banks indicated a lack of regular maintenance. Regular mowing and clearing is assumed in the estimate. The difference in maintenance of bridges and culverts is due to the change in physical size of the structure.

Table 3-16: Summary of OMRR&R Costs for Plan J

Item Description		Annual Cost
Wilsons Creek and South Branch 0+00 to 37+92		$48,300
Detention Ponds on North Branch of Jordan Creek		$63,000
Detention Ponds on South Branch of Jordan Creek		$123,100
	Total	**$234,400**

3.6.7 Economic Summary

The 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 3-17: Economic Analysis for Plan J. These values are based on October 2012 price levels, an interest rate of 3.75 percent, a 50-year period of analysis and a 3-year construction period.

Detention basins provide flood damage reduction benefits to all economic reaches. The benefits provided by the detention basins were summed across all of the reaches to justify the inclusion of the basins into the recommended plan. During the formulation of an alternative, USACE computes benefits within the limits of Federal interest to compare the plans to one another. If the plan has a positive net benefits, the plan can remain in the array of plans to be considered. As Plan J has positive net benefits within the limits of Federal interest, the benefits upstream of Federal interest can be included in the final benefits calculation. The detention basins are located upstream of the limits of Federal interest. Immediately downstream of the detention basins is a housing development that is also outside of the limit of Federal interest. The detention basins protect the housing development during frequent events. Some of the houses flood as frequently as the 1/1 ACE. The NED benefits accrued by the detention basins protecting the houses were included in the final analysis. For further discussion on this, please see Economic Analysis Appendix (A) Section 7: Benefits Outside of Federal Interest. The NED benefits that accrue upstream of the limit of Federal interest in this project were calculated, included in the final analysis and reported in Table 3-17.

Therefore, the selected plan, Plan J, has an investment cost of $21,621,000; an annual cost of $1,173,000; annual benefits of $3,134,000; excess net benefits of $1,961,000 and a BCR of 2.7, which becomes the Federal BCR.

Table 3-17: Economic Analysis for Plan J

Item	Benefits within the Federal Interest	Benefits Including Upstream of the Limit of Federal Interest
Interest Rate,%	3.750%	3.750%
Interest Rate, Monthly	0.307%	0.307%
Construction Period, Years	3.0	3.0
Period of Analysis, Years	50	50
Project First Cost	$20,479,000	$20,479,000
Interest During Construction	$1,142,000	$1,142,000
Investment Cost	$21,621,000	$21,621,000
Annual Cost		
Amortized Cost	$939,000	$939,000
OMRR&R	$234,000	$234,000
Total Annual Cost	$1,173,000	$1,173,000
Annual Benefits		
Structures, Contents, Other	$2,968,000	$3,065,000
Infrastructure	61,000	69,000
Total Annual Benefits	$3,029,000	$3,134,000
Benefit-to-Cost Ratio	2.6	2.7
Net Benefits	$1,856,000	$1,961,000

3.6.8 Sensitivity of Recommended Plan to the Future Conditions

The benefits are based on assumptions about the future; however, there is a possibility that the future conditions may never occur. There is a large increase in the estimated damage from the existing conditions to the Future Without Project Conditions. It is important to note that data gathered for the existing conditions was collected in 2003. Since then development has occurred, and it is as projected in our future without project conditions. However, a sensitivity analysis, conducted on the NED Plan, validated that it is not solely justified on the Future Without Project Conditions assumptions. The NED Plan is justified in the existing conditions. It provides S735,800 in annual net benefits and a BCR of 1.6.

3.6.9 Environmental Compliance

No significant environmental impacts have been detected to date. See Table 3-18 for the status of compliance.

Table 3-18: Status of Project with Applicable Laws and Statutes

Item	Compliance
Federal Statutes 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
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*

Note: The compliance categories used in this table were assigned based on the following definitions:

Full Compliance (Full): Having 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, E.O. 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.

3.6.10 Environmental Operating Principles

The selected plan **strived to achieve environmental sustainability** by working to reduce the velocity through the channel to improve habitat quality in the channel. The feasibility study team coordinated with the appropriate environmental agencies in order **to proactively consider environmental consequences**. The project **created mutually supporting economic and environmentally sustainable solutions** by reducing risk of flooding to the downtown area of Springfield, Missouri, and creating areas for groundwater recharge in the detention basins. The plan was consistent with all applicable laws and policies, and the Corps and its non-Federal sponsors **continued to meet corporate responsibility and accountability** for the project in accordance with those laws and policies. The study team used appropriate ways and means to assess cumulative impacts to the environment through the National Environmental Policy Act and the use of engineering models, environmental surveys and coordination with natural resource agencies. As a result of **employing a risk management and systems approach throughout the life cycle of the project,** the project design evolved to address as many concerns as possible with no mitigation required to address adverse impacts**.** Study activities, including hydrologic, hydraulic, economic, cultural resource and HTRW surveys, **increased the integrated scientific knowledge base** for the Jordan Creek Valley and the **understanding of the environmental context and effects of Corps actions**. The feasibility study process included a public and agency scoping meeting to interact with **individuals and groups interested in the study activities**. Through those meetings and written interactions, the study team **listened actively and respectfully** to project proponents and opponents alike in an effort to find innovative solutions to the flooding problems in the study area.

3.6.11 Actions for Change

- **Theme 1: Comprehensive Systems Approach**
  The team looked at Jordan Creek as a hydraulic, environmental and economic system. The team evaluated damages and benefits upstream of the limit of Federal interest while ensuring those areas downstream of the project area did not incur damages.
  Initially, the evaluation of the Jordan Creek project included environmental criteria. As the plans evolved, those criteria were removed from consideration because they did not help to distinguish between the plans.
- **Theme 2: Risk-Informed Decision Making**
  A Cost Schedule Risk Analysis was completed on the project. A risk register was developed during the plan formulation phase to capture risks to the decision process. Residual risks were thoroughly discussed in the report. Although the team selected the NED Plan, the team evaluated other factors and explicitly stated the residual risks in accordance with ER 1105-2-101.
- **Theme 3: Communication of Risk to the Public**

A flood risk management plan will be developed. The City has a public awareness campaign centered around the issues of environmental degradation and flood risk on Jordan Creek. They actively engage the media with special events to raise awareness of those issues. USACE has engaged citizens groups and helped the City develop information for public distribution.

- **Theme 4: Professional and Technical Expertise**
  The team is piloting a number of new review processes for USACE. The project has had full vertical team coordination throughout the plan formulation process and quality control for both technical and policy reviews.

3.7 IMPLEMENTATION REQUIREMENTS

3.7.1 Institutional Requirements

All USACE projects must comply with all applicable environmental statutes and policies. Table 3-18: Status of Project with Applicable Laws and Statutes illustrates this project's status of compliance.

The schedule for project implementation assumes authorization in the proposed Water Resources Development Act of 2014. After project authorization, the project will be eligible for construction funding. It will be considered for inclusion in the President's budget based on national priorities, magnitude of the Federal commitment, economic and environmental feasibility, level of local support, willingness of the non-Federal sponsor to find its share of the project cost and the budget constraints that may exist at the time of funding.

Once Congress appropriates Federal construction funds, USACE and the non-Federal sponsor would enter into a Project Partnership Agreement (PPA). This PPA would define the Federal and non-Federal responsibilities for implementing, operating and maintaining the project.

Following the signing of the PPA and the design approval, USACE would officially request the sponsor to acquire the necessary real estate. The advertisement of the construction contract would follow the certification of the real estate acquisition and right-of-entry. The final acceptance and transfer of the project to the non-Federal sponsor will follow the delivery of an operation and maintenance manual and as-built drawings.

Assuming full funding, the project will be fully constructed by the year 2020 as displayed in Table 3-19: Project Schedule.

Table 3-19: Project Schedule

Task	Date
Release Draft Report	31 January 2013
Independent External Peer Review	4 February – 4 March 2013
Agency Technical Review	4 February – 4 March 2013
Headquarter Review	4 February – 4 March 2013
Decision Point 3 (Civil Works Review Board)	May 2013
Decision Point 4 (Chief's Report)	August 2013
Water Resources Development Act	2014
Planning, Engineering and Design	2014-2015
Construction	2016-2020

3.7.2 Cost Apportionment

The sponsor is responsible for the LERRD which is included in the sponsor's share of the construction cost. Items included in the LERRD total include the land to construct the project and the relocation of utilities. Costs for HTRW cleanup is not a Federal responsibility and is not included in the total project costs. Plan J has no identified HTRW in the construction footprint. Table 3-20: Cost Apportionment

shows the cost breakdown for both Federal and non-Federal sponsors cost share. This cost included the contingency from the Cost Schedule Risk Analysis and inflation.

Table 3-20: Cost Apportionment

	Non-Federal Sponsor Contribution	Federal Contribution
LERRD	$ 6,470,000	
Lands	$4,517,000	
Relocations	$1,953,000	
Cash	$1,186,000	
Min 5%	$1,094,000	
Additional Cash Required.	$92,000	
Total	$ 7,656,000	$14,217,450
Cost Share	35%	65%

3.7.3 Fully Funded Cost Estimate

Table 3-21 is the cost estimate by Feature Code. The cost estimator assigns the codes. This cost estimate includes contingency and inflation.

Table 3-21: Cost Estimate by Feature Code

Feature Code	LERRD	Cost Shared	Subtotal
01 – Lands and Damages	$4,517,018	$44,982	$4,562,000
02 - Relocations Channels	$1,953,000		$1,953,000
09- Channels and Canals		$7,708,000	$7,708,000
15 – Floodway Control and Diversion Structures		$5,139,000	$5,139,000
30- Planning Engineering and Design		$1,249,000	$1,249,000
31 – Corps Contract Supervision and Administration		$1,262,000	$1,262,000
Total			$21,873,000

3.7.4 Permits

Requirements for Section 404 of the Clean Water Act of 1972, as amended, will be met prior to any construction activity, as will any permit requirements of MDNR for the construction activity in the stream channel. The completed 404 (b) (1) guidelines form is included in Appendix E.

3.7.5 Views of Non-Federal Sponsor

The non-Federal sponsor fully supports the recommended plan and is willing and financially capable of cost sharing it.

4 AFFECTED ENVIRONMENT*

4.1 ENVIRONMENTAL SETTING OF THE STUDY AREA

The major characteristics of the study area's natural and human resources are provided to promote a general understanding of the area. The Jordan Creek drainage basin is within the City limits of Springfield, in south-central Missouri. The City has experienced numerous floods because of insufficient flow capacity and urbanization along the reaches of Jordan Creek. The study area includes Jordan Creek, North Branch Jordan Creek, South Branch Jordan Creek and a portion of Wilsons Creek.

Jordan Creek, including North Branch and South Branch Jordan Creek, at its confluence with Wilsons Creek, has a 13.75-square-mile drainage basin. The total drainage area of the project area is 19.3 square miles and includes Fassnight Creek, which is not included in the Jordan Creek study area. The Jordan Creek watershed study area encompasses approximately 6 miles along Jordan Creek, generally centered on the Chestnut Expressway between U.S. Highway 65 to the east and U.S. Highway 160 to the west in the northern half of the City.

The study corridor is a heavily urbanized environment and has an extensive infrastructure associated with areas of high-density housing, low-density housing, commercial areas, industrial areas and some open spaces. The City is currently developing a civic park, Jordan Valley Park, in the central portion of the area.

*Designates a section that is traditionally found in an Environmental Assessment.

Several railroad tracks, serving the Burlington Northern Santa Fe, Missouri & Northern Arkansas, Union Pacific, Arkansas-Missouri and Kansas City Southern railroads, are in current operation and traverse the project area.

4.2 FLOODING

The flood of 1909 inspired thoughts of engineering the creek to control floodwaters, and between 1933 and 1935 thoughts turned to action. Most infrastructure development in this study area occurred in the 1930s–1940s. Typically, natural drainage channels were placed in pipes or narrowed through fill placement, and there was little recognition of the space that floodwaters would occupy (i.e., the floodplain). Jordan Creek was channelized through downtown, from Main Street to Washington (3,520 feet), with two parallel boxes 11 feet wide and 10 feet tall. These enclosed channel culverts are not large enough to convey flood flows. As a result, water spills out of the channel culverts and moves through the neighborhoods via streets, alleys and yards, frequently inundating crawl spaces and basements.

In an effort to reduce flood damages, large-scale channelization of the central portion of Jordan Creek began with a funding measure in 1927. Large storm drains were installed with viaducts for vehicular traffic. Funding from a bond measure and subsequent Public Works Administration money obtained during the Depression provided the central part of Jordan Creek with a concrete tunnel nearly two-thirds of a mile long, conveying floodwaters directly under downtown streets and buildings. Many of these channelization projects were completed in the 1930s.

Figure 4-1: Flooding on Sherman Street

Historically, the Jordan Creek area has experienced numerous floods because of insufficient drainage capacity and urbanization. Prior to 1900, major flood events occurred in 1844, 1859, 1866, 1868, 1871 and 1876. Since 1900, recorded major flood events have occurred in 1909, 1932, 1951, 1993, 2000, 2002, 2005, 2008, 2009 and 2011.

Within the past 10 years, one of the most damaging floods of record in the watershed occurred on 12 July 2000. The photograph in Figure 4-1 (courtesy of the City) was taken during the 2000 flood near the

corner of East Chestnut Expressway and Sherman Street. Floodwaters were 4 to 6 feet deep in some places, sweeping through at least 124 homes and displacing more than 100 people. The City has grown accustomed to dealing with flooding, but, due to the flashy, unpredictable nature of the flooding, there is usually insufficient time to prepare for flood fighting. As a result, the City cannot construct an effective emergency flood warning systems.

Significant costs are incurred during emergency flood fighting efforts. Businesses, residents, Federal agencies and local and state governments all contribute to the flood fight, rescue and clean-up efforts. A description of the flooding problem is covered in Section 2.3: Problems and Opportunities.

4.3 PHYSICAL ENVIRONMENT

4.3.1 Land Use

The North, South and main Branch channels of Jordan Creek run through a mix of residential and industrial areas. The North Branch runs through two parks and a residential area. The South Branch is mostly an industrial setting following railroad lines. Most of the channel is lined with either concrete or natural stone. Reaches of the channel are walled with flat stone thought to be the work of the Civilian Conservation Corps (CCC).

The City's 2001 land use classification was used to create a land use map for the study area. The study area contains the highly urbanized core of the City so the resulting classification is highly skewed towards commercial and residential uses (Table 4-1: Land Use Tables for Sub-Watersheds, Figure 4-2: Land Use Map). Pasture and forest exist only in the far eastern headwaters area of the study area and in the riparian zone near the watershed outlet along Fassnight Creek. Land use for the study area and each sub-watershed was calculated using the City's 2001 land use map. The watershed polygons created in Arc Hydro, a geographic information systems tool used for water resources, were used to clip portions of the land use map and to calculate land use areas. Land uses among the watersheds were quite similar and were highly skewed toward urban types such as residential and commercial. The land use map did not classify roadways; however, the area difference between classified land use and total watershed area for each watershed was classified as "Roadway area" (MSU 2007).

Table 4-1: Land Use Tables for Sub-Watersheds

	[1]NB1		NB2		[2]SB1		SB2		[3]JC1	
Roadway	219.7	12.4%	316.8	14.9%	462.1	15.5%	591.3	16.7%	1073.2	17.0%
Commercial	733.9	41.5%	788.0	37.1%	997.6	33.6%	1216.0	34.3%	2366.0	37.5%
Multi-Family Res	1.2	0.1%	16.1	0.8%	53.6	1.8%	95.9	2.7%	134.7	2.1%
SF High-Density	17.1	1.0%	26.7	1.3%	36.3	1.2%	48.7	1.4%	92.9	1.5%
SF Low-Density	392.2	22.2%	538.4	25.4%	870.5	29.3%	1012.4	28.6%	1597.3	25.3%
Forest	265.4	15.0%	273.5	12.9%	322.7	10.9%	345.0	9.7%	639.8	10.1%
Grass	33.9	1.9%	58.3	2.7%	226.6	7.6%	228.3	6.5%	305.4	4.8%
Pasture	104.0	5.9%	104.0	4.9%	3.0	0.1%	3.0	0.1%	107.0	1.7%
Total Area (acre)	1767.0		2122.1		2972.2		3540.8		6316.5	
Total Area (square miles)	2.8		3.3		4.6		5.5		9.9	

	JC2		JC3		[5]JC4		[4]WC1	
Roadway	1371.2	18.6%	1445.6	18.9%	1582.5	19.0%	1783.4	14.4%
Commercial	2673.9	36.3%	2800.9	36.6%	2873.1	34.5%	4593.2	37.1%
Multi-Family Res	153.7	2.1%	154.7	2.0%	214.5	2.6%	358.3	2.9%
SF High-Density	113.7	1.5%	117.1	1.5%	150.0	1.8%	163.8	1.3%
SF Low-Density	1937.3	26.3%	2009.7	26.2%	2309.2	27.7%	3815.5	30.8%
Forest	696.3	9.4%	703.0	9.2%	754.2	9.0%	1049.2	8.5%
Grass	321.5	4.4%	321.5	4.2%	347.7	4.2%	479.1	3.9%
Pasture	107.0	1.4%	107.0	1.4%	107.0	1.3%	152.2	1.2%
Total Area (acre)	7374.6		7659.5		8338.3		12394.5	
Total Area (square miles)	11.5		12.0		13.0		19.4	

[1]North Branch Jordan Creek

[2]South Branch Jordan Creek

[3]Main Fork Jordan Creek

[4]Wilsons Creek

[5] JC4 Total area (square miles) does not include a small portion of the watershed area between JC4 and the Wilsons Creek confluence and may not correspond exactly with other sections of this document.

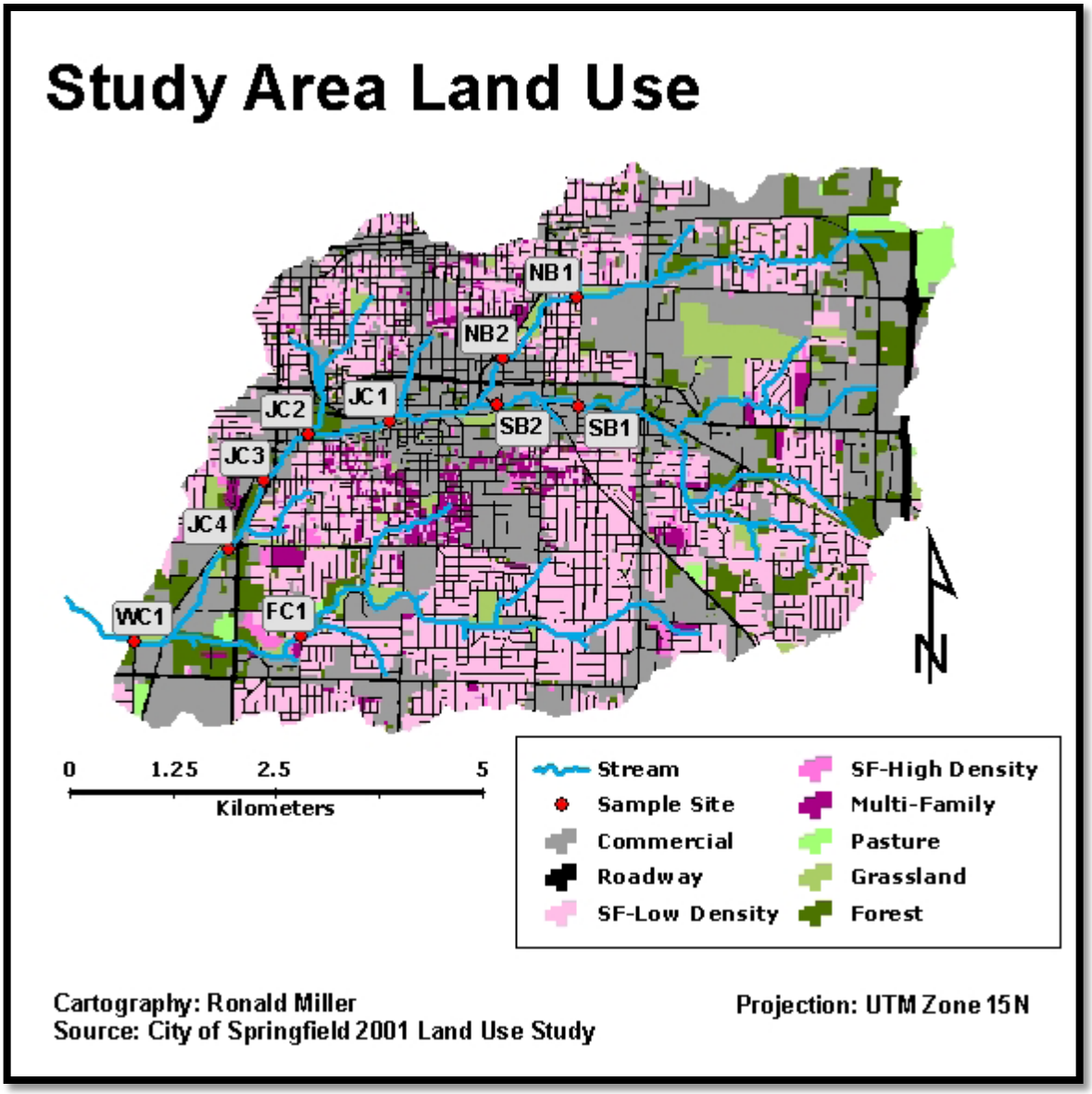

Figure 4-2: Land Use Map

4.3.2 Climate and Climate Change

The study area is generally hot in summer, especially at low elevations, and moderately cool in winter, especially at high elevations. Rainfall is moderate and well distributed throughout the year. Snow falls nearly every winter, but snow cover lasts only a few days. Two active weather stations are located near Wilsons and Jordan Creeks in Greene County. The Springfield Weather Station and the Springfield Regional Airport Weather Station are west of the City and approximately 10 miles from Wilsons Creek. Both stations record daily precipitation, maximum and minimum temperature and snowfall and snow depth. The annual average precipitation and temperature over the most recent 30-year period is 44.97 inches and 56.2 degrees Fahrenheit, respectively. These two weather stations provide useful

information for understanding when critical conditions occur and establishing a general understanding of the hydrology of the watershed (EPA 2011).

Climate change became an area of concern due to the potential for effects on numerous aspects of the environment, especially those related to water resources. The U.S. Global Change Research Program (USGCRP) summarized information regarding climate change and its potential effects in regional assessments (http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts). In the Midwest, which extended from Minnesota to Missouri, extreme events such as heat waves, droughts, and heavy rainfall events were projected to occur more frequently. There may be a 31 percent increase in precipitation at the 1/100 ACE in the region in the year 2099. Climate change was not specifically modeled in the Jordan Creek watershed; however, there was uncertainty built into both the hydrologic and economic models. Should the dramatic increase in precipitation per event happen, both plans will be exceeded with higher water depths than they are now. Both plans reduce the risk at the lower frequency events; however, they were both plans that target high frequency risks.

4.3.3 Topography, Physiography and Soils

The City area is located on the Springfield Plateau of the Ozarks physiographic region. The area is underlain by Mississippian Age limestone, which is highly susceptible to solutional weathering. This geology is commonly referred to as “karst” and is characterized by numerous sinkholes, losing streams, springs, caves and other related features. As a result, a complex and often-fragile interaction exists between surface and groundwater, requiring special consideration and protection. Karst geology can present certain hazards to urban development, such as unstable soil foundation for structures, flood hazards, groundwater contamination and public safety hazards related to collapses.

The Springfield Plateau consists of undulating to rolling plains. Elevation ranges from about 900 to 1,500 feet above sea level. The area around the City is within Missouri’s primary karst area. Sinkholes are common and are known to convey storm water to streams. Slope ranges from 2 to 20 percent (EPA 2011). Bedrock is present at varying depths and consists of sedimentary rock: mostly limestone, dolomite, sandstone and shale. Limestone, some of which is cherty, is predominant. Faults are common. Unconsolidated surficial deposits include residuum, loess, colluvium and alluvium. Soil, an important natural resource, is formed in these deposits. Residuum and colluvium are dominant in the survey area except for relatively small areas that have a loess cap or alluvium. The consolidated bedrock exposed in the survey area is conspicuous but significant in area only in some localities.

Upland soils consist primarily of the Wilderness-Viraton association and comprise approximately two-thirds of the watershed. This association consists of broad upland ridges, narrow floodplains and terraces. Slope of the major soils ranges from 2 to 9 percent. These soils are formed from cherty limestone and the surface layer is from two to 7 inches thick. This association has a fragipan or hardpan layer that restricts root growth in the subsoil. These soils are mostly used for grasses and legumes with some areas suitable for growing small grain crops (EPA 2011).

Soils within the study area are primarily developed from the red clay residuum that results from the weathering of the underlying limestone bedrock, although some glacial loess does occur as a parent material in some upland area soils. The study area however, is south of the primary area of loess deposition (MSU 2006).

Urban soils undergo progressive cycles of development and redevelopment involving wholesale earthmoving, erosion or removal of topsoil, compaction of subsoils and the filling of depressions, wetlands and natural rainfall storage areas. Consequently, the soils of urban pervious areas often lack the fertility, tilth and recharge characteristics of their non-urban counterparts. From a practical standpoint, the hydrology of many urban pervious areas is more similar to impervious areas than natural ones (Schueler 2005). For a list of the characteristics of the soils in the watershed, refer to Table 4-2.

Table 4-2: Relative Abundance and Some Characteristics of Soil Types Found in the Study Area

Soil Name	Percent Area	Slope (%)	Landform	Parent Material	Infiltration rate (in/hr)	Depth to Impervious Layer (in)
Creldon silt loam	31.4	1 to 3	uplands	loess/residuum	0.6 – 2.0	24
Viraton silt loam	19.1	2 to 5	upland/ terrace	loess/residuum	0.6 – 2.0	22
Pembroke silt loam	12.9	1 to 5	upland/ terrace	loess/residuum	0.6 – 2.0	72+
Wilderness cherty silt loam	6.9	2 to 9	uplands	residuum	2.0 – 6.0	10
Keeno and Eldon chert silt loams	5.1	2 to 14	uplands	residuum	2.0 – 6.0	19-28
Peridge silt loam	3.8	2 to 5	upland/ terrace	loess/residuum	0.6 – 2.0	72+
Newtonia silt loam	3.8	1 to 3	uplands	loess/residuum	0.6 – 2.0	72+
Goss cherty silt loam	3.4	2 to 20	uplands	residuum	2.0 – 6.0	20
Hepler silt loam	2.9	0 to 2	upland/ terrace	alluvium	0.6 – 2.0	30
Lanton silt loam	2.7	0 to 2	floodplain	alluvium	0.6 – 2.0	10
Wilderness & Goss chert silt loam	2.6	2 to 9	uplands	residuum	2.0 – 6.0	24
Sampsel silty clay loam	2.3	1 to 5	uplands	residuum	2.0 – 6.0	13

4.4 WATER RESOURCES

4.4.1 Watershed Description

The study area is primarily urban and includes approximately 13.75 square miles of watershed area, which includes Jordan Creek, North Branch Jordan Creek, South Branch Jordan Creek and the upstream portion of Wilsons Creek. Jordan Creek, including the lower reach and South and North Branches, includes 9.6 miles of existing channel. The North Branch of Jordan Creek drains 3.59 square miles and is the smallest major sub-watershed in the study. North Branch has moderate stream slopes (although the highest in the study) and a high degree of urbanization. Most of the development in the sub-watershed is evenly divided between industrial/commercial in the upper portions of the sub-watershed and residential in the lower portions. The stream travels in a pair of roadside ditches for the first 4,000 feet and passes through a regional detention basin on its way through the sub-watershed. Just before the joining South Branch, the stream passes through a 1,000-foot tunnel located under an industrial area. One unique characteristic of this sub-watershed is the railroad line that crosses through the northeast portion. The culverts under this rail line are relatively small. The railroad embankment provides detention of runoff from the uppermost 0.5 square mile (14 percent) of the sub-watershed, thereby reducing peak flow. The North Branch sub-watershed includes approximately 14 additional storm water detention basins that were specifically constructed for that purpose.

The South Branch of Jordan Creek is a moderately sloped reach. The sub-watershed has a high degree of urbanization divided between industrial/commercial and residential development. South Branch drains 5.95 square miles and is the largest major sub-watershed in the study. However, due to a number of sinkholes, much of the sub-watershed contributes little storm runoff. The South Branch sub-watershed includes 16 constructed storm water detention basins.

The North and South Branches converge to form the Lower Branch of Jordan Creek, which carries runoff from 4.21 square mile in addition to that contributed by the North and South Branch sub-watersheds. The stream has a moderate slope similar to the South Branch. The sub-watershed is highly urbanized with a high number of industrial/commercial developments on the upstream side of the sub-watershed and a large percentage of residential development on the downstream end. Just downstream of the confluence of the North and South Branches, the stream enters a large tunnel, which conveys storm water nearly 3,400 feet through the City's downtown area. Different portions of this tunnel, which measures approximately 30 feet wide and 10 feet tall, were constructed around the 1930s. The Lower Branch sub-watershed includes three constructed detention basins.

Jordan Creek and Fassnight Creek converge to form Wilsons Creek approximately 2,000 feet upstream of Scenic Avenue, with Fassnight Creek adding runoff from 5.52 square miles of drainage area.

Wilsons Creek flows to the west at the confluence of Jordan Creek and Fassnight Creek. Due to limited floodplain development, only a short reach of Wilsons Creek has been included in the study. U.S. Highway 160 establishes the downstream study limits for Wilsons Creek. Wilsons Creek is a natural channel and a tributary to the James River, which drains into Table Rock Lake.

4.4.2 Groundwater and Public Water Sources

Deep wells provide groundwater for some homes, farms, towns, industries and part of the water supply for the City. Adequate water of good quality for home and farm use can be obtained from the Roubidoux Formation; however, the largest yields of water come from wells in Greene County that tap the entire Potosi Formation. Many of these wells are at a depth of 1,400 feet or more. The yield varies from 500 to 1,385 gallons per minute with an average of 700 gallons per minute.

The carbonate nature of the bedrock produces many karst features such as caves, sinkholes and springs, which are common within the study area and throughout the state of Missouri. These features complicate surface drainage by producing “losing” and gaining” sections of streams in which water either enters the stream from springs or leaves the stream at karst fissures.

In some cases, sinkholes function as storm water conduits. The recharge areas for many of these springs include past and present industrial sites with the potential to contaminate streams. Karst features and springs have been known to contribute pollutants to Jordan Creek in some locations and to facilitate the loss of water in other areas. This hydrology involves a high level of interaction between surface water and groundwater. The Missouri Department of Natural Resources (MDNR) identified the North Branch and South Branch Jordan Creek as losing stream segments, while the main channel below the confluence of the branches was characterized as a gaining stream segment.

Fellows and McDaniel Lakes are located on the Little Sac River (north of the Jordan Creek project) area and provide part of the public water supply for the City. Water from Lake Springfield is used by the City for industrial purposes, and a limited supply of water is stored in shallow lakes or pumped from the larger streams to be used for irrigation. Groundwater from springs sustains the flow of perennial streams.

4.4.3 Water Quality

As an urban stream, Jordan Creek has a long history of anthropogenic impacts. Once a source of water for early settlers' livestock, the creek became a flood-prone liability in the early 1900s, serving as a conduit for all kinds of trash and pollutants produced in the City's original Industrial area. The creek was considered such a liability that by the late 1920s, City leaders had it confined to concrete channels and tunnels as it flowed through downtown. Now, Jordan Creek is at the heart of an effort to redevelop the Jordan Creek Valley with parks and rehabilitated buildings.

The United States Environmental Protection Agency (EPA) is establishing the Wilsons Creek and Jordan Creek Total Maximum Daily Loads (TMDLs) in accordance with Section 303(d) of the Clean Water Act (CWA) to meet applicable water quality standards (WQS) and to allocate loads to the pollutant sources. Typically, the purpose of a TMDL is to determine the maximum amount of a pollutant (the load) that a water body can assimilate without exceeding the WQS for that pollutant. The water quality limited segments are included on the EPA approved 2008 Missouri 303(d) List. They are listed as impaired by multiple point sources and urban nonpoint sources. Here, the pollutant causing the impairment is listed as unknown; however, toxicity from multiple pollutants and changes in hydrology from increased

impervious surfaces are the suspected cause of the impairment. It is appropriate to characterize these TMDLs as phased TMDLs. In the first phase of the Wilsons Creek and Jordan Creek TMDLs, EPA recommends that monitoring be conducted to assess the effect of implementation of the TMDL on the water quality of the watersheds. The phased TMDL approach recognizes that additional data and information may be necessary to validate the assumptions of the TMDL and to provide greater certainty that the TMDL will achieve the WQS (EPA 2011). This USACE Flood Risk Management study for the Jordan Creek watershed is not designed to address directly the issues identified in the TMDL although measures implemented in this study are likely to aid in water quality improvement. Water quality is not an authority of USACE; however, quality is tied to aquatic habitat and ecosystem function through the TMDL.

4.4.4 Wetlands

The U.S. Fish and Wildlife Service spearheads the National Wetland Inventory and has completed a draft inventory of wetlands in Greene County. For the most part, these are small and isolated wetland areas. Local representatives of state and Federal agencies indicate that wetlands in Greene County are located primarily in the floodplains of rivers and streams but could also be present in the floors of sinkholes and other depression areas. See Figure 4-3: National Wetland Inventory Wetland Distribution for locations.

Wetland evaluations were conducted by USACE Regulatory personnel from the Table Rock Project Office to verify the presence/absence of wetlands within the project footprint on the Jordan Creek corridor. It was determined that no wetland areas, other than those described in Section 5.2.2, will be impacted by the construction of this project.

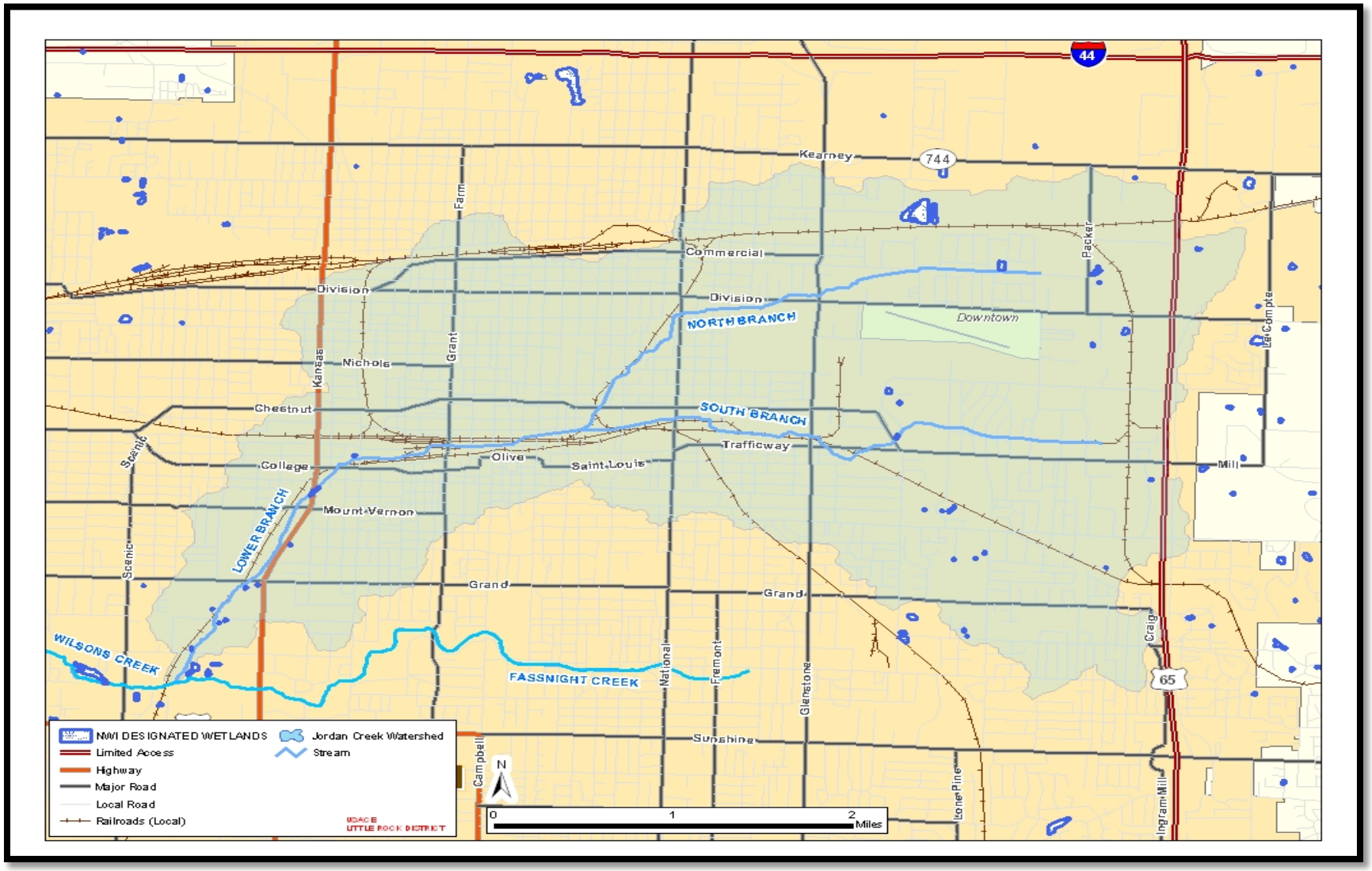

Figure 4-3: National Wetland Inventory Wetland Distribution

4.5 BIOLOGICAL RESOURCES

The biological resources of the Jordan Creek Watershed are indicative of urban watersheds and generally consist of moderate-to low-value habitat. The biological resources specifically listed in this Integrated Feasibility Report and Environmental Assessment (EA) include vegetation, fish and wildlife, threatened and endangered species and wetlands.

4.5.1 Vegetation

Vegetation within the study area consists of small areas of riparian corridors along rip rapped banks and intermittent shrubs and grasses along the creek bank. In general the stream is lined with a variety of invasive species with little of the tree cover in a good quality condition. Lack of structured pruning, impacts from wind and ice damage and the harsh ground conditions of the area have allowed for a rather degenerated condition of the current tree cover. A large percentage of the tree cover is growing into or out of the bank retaining structure. The south side of the creek contains a thin tree corridor, with a large degree of the tree cover being invasive species of trees, vines and weeds. Normally the creek contains only a sparse vegetated corridor dominated by invasive species of trees, vines and weeds.

4.5.2 Fish and Wildlife

Due to its urban setting, the Jordan Creek watershed provides minimal habitat for terrestrial wildlife species; however, some wooded areas along the southern portion and the minimal riparian habitat of the watershed provide terrestrial habitat for songbirds and small mammals.

Jordan Creek is managed by the MDNR as a warm-water fisheries habitat and for livestock and wildlife watering. Jordan Creek is on the EPA 303(d) list of impaired streams. It flows directly into Wilsons Creek, which is also a listed impaired stream. To improve and protect the quality and biological integrity of these streams, urban stream best management practices are recommended. Further monitoring could provide insight into the impairment of these streams. This would include sediment analysis, particularly for metals, pesticides, polycyclic aromatic hydrocarbons, and toxicity (MDNR 2007). Sediment studies are not part of this USACE feasibility study.

Urban streams in the City are exposed to a number of stressors that affect the health of the organisms living in them. With growth and urbanization of the City, the amount of impervious surfaces (such as roads, parking lots and rooftops) has increased. These changes increase runoff volume and rate into the streams, increasing the physical disturbances from rain events. The streams also potentially receive more organic and inorganic pollutants from point and non-point sources than a stream in a rural area. Still, many organisms in Jordan and Wilsons Creeks survive and flourish despite the anthropogenic stressors on their environment. The organisms that live in a stream provide information about the health of the stream; biological communities reflect overall ecological integrity. One tool used to explain and quantify the health of a stream, as indicated by the biota collected, is the Index of Biotic Integrity (IBI). The IBI is based on categories or metrics and can be adapted for different eco-regions. Metrics reflect aspects of the community such as diversity, sensitive species richness and percentage of tolerant individuals. The metrics provide a score similar to a report card; the score signifies the level of impairment in comparison to a reference condition. For this study, the fish and benthic

macroinvertebrate communities were sampled to evaluate ecological integrity with established, regionally-modified IBIs. Higher scores indicate greater biotic integrity and stream health (MSU 2006).

4.5.2.1 Fisheries

In a study completed by Missouri State University (MSU) from samples collected from July 2005 – June 2006, the results suggest that the biotic communities are impaired in Jordan and Wilsons Creek. IBI values for Jordan and Wilsons Creek remained relatively stable from fall to spring. A *moderately impaired* classification typically indicates that the most sensitive fishes are absent and that the trophic structure is highly skewed towards omnivores, herbivores and tolerant species. Species classified as sensitive included the Striped Shiner and Longear Sunfish, neither of which were found in the study area. Invertivores included the Duskystripe Shiner, Blackspotted Topminnow and Longear Sunfish. See Table 4-3 and Table 4-4 for the results of MSU's collections.

Table 4-3: Jordan Creek Seasonal Fish Collections 2005-2006

Common Name	Species	10/26/2005	5/12/2006
MINNOWS	**CYPRINIDAE**		
Stoneroller	Campostoma spp.	283	200
Duskystripe Shiner	Luxilus pilsbryi	4	0
Southern Redbelly Dace	Phoxinus erythrogaster	135	190
Creek Chub	Semotilus atromaculatus	52	65
Bluntnose Minnow	Pimphales notatus	0	5
SUCKERS	**CATOSTOMIDAE**		
White Sucker	Catostomus commersoni	14	35
CATFISHES	**ICTALURIDAE**		
Yellow Bullhead	Ameiurus natalis	5	8
KILLIFISHES	**FUNDULIDAE**		
Blackspotted Topminnow	Fundulus olivaceous	20	23
LIVEBEARERS	**POECILIIDAE**		
Mosquitofish	Gambusia affinis	45	11
SUNFISHES	**CENTRARCHIDAE**		
Bluegill	Lepomis macrochirus	4	2
Green Sunfish	Lepomis cyanellus	31	54
Hybrid Sunfish		0	1
	Total Individuals	**593**	**594**

Table 4-4: Wilsons Creek Seasonal Fish Collections 2005-2006

Common Name	Species	10/13/2005	4/21/2006
MINNOWS	**CYPRINIDAE**		
Duskystripe Shiner	Luxilus pilsbryi	27	23
Southern Redbelly Dace	Phoxinus erythrogaster	102	218
Creek Chub	Semotilus atromaculatus	46	82
Goldfish	Carassius auratus	1	0
Common Carp	Cyprinus carpio	11	4
SUCKERS	**CATOSTOMIDAE**		
Golden Redhorse	Moxostoma erythrurum	0	16
CATFISHES	**ICTALURIDAE**		
Yellow Bullhead	Ameiurus natalis	7	17
KILLIFISHES	**FUNDULIDAE**		
Blackspotted Topminnow	Fundulus olivaceous	56	10
LIVEBEARERS	**POECILIIDAE**		
Mosquitofish	Gambusia affinis	48	13
SCULPINS	**COTTIDAE**		
Banded Sculpin	Cottus carolinae	0	2
SUNFISHES	**CENTRARCHIDAE**		
Bluegill	Lepomis macrochirus	4	3
Green Sunfish	Lepomis cyanellus	41	21
Largemouth Bass	Micropterus salmoides	0	1
	Total Individuals	**639**	**605**

4.5.2.2 Benthic Macro Invertebrates

In 2007, MDNR completed a study following a standardized habitat procedure for Riffle/Pool stream types as described in the Stream Habitat Assessment Project Procedure (SHAPP) (MDNR 2003b). For comparison, a habitat assessment at the Pomme de Terre River biological criteria reference (BIOREF) station at Highway 65 was conducted during the sample period.

A standardized sample analysis procedure was followed as described in the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP), which provides details on the calculation of metrics and scoring of the multimetric Macroinvertebrate Stream Condition Index (MSCI). The following four metrics were used: 1) Taxa Richness (TR); 2) total number of taxa in the orders Ephemeroptera, Plecoptera and Trichoptera (EPTT); 3) Biotic Index (BI); and 4) Shannon Diversity Index (SDI).

The instream habitat assessment score for Jordan Creek and other urban streams within the City exceeded the minimal 75 percent total score of the habitat assessment of the BIOREF (Pomme de Terre) criteria used for comparison. It is therefore inferred that, based on habitat score, Jordan Creek should support biological communities comparable to those found in the reference site (MDNR 2007). The EPA established the Wilsons Creek and Jordan Creek TMDLs in accordance with Section 303(d) of the Clean

Water Act (CWA) to meet applicable WQS and to allocate loads to the pollutant sources. The water quality limited segments are included on the EPA approved 2008 Missouri 303(d) List. They are listed as impaired by multiple point sources and urban nonpoint sources. Here, the pollutant causing the impairment is listed as unknown; however, toxicity from multiple pollutants and changes in hydrology from increased impervious surfaces are the suspected cause of the impairment.

Macroinvertebrate Stream Condition Indices (MSCI) were calculated for each stream. MSCI sustainability scores of 20-16 qualify as fully sustaining, 14-10 as partially sustaining and 8-4 as non-sustaining of aquatic life. The four metrics, total scores and MSCI sustainability rankings during Spring 2007 are presented in Table 4-5: . The non-sustainability of aquatic life, as noted in the table, is likely due to instream toxicity and should show improvement upon implementation of the TMDL.

Table 4-5: Metric Values for Stream Condition Indices

Stream	TR	EPTT	BI	SDI	MSCI	Sustainability
Jordan Creek	41	4	7.51	2.34	6	Non
Wilsons Creek	41	6	6.55	2.33	8	Non

4.5.2.3 Threatened and Endangered Species

Coordination with the Missouri Department of Conservation (MDC) indicates that their database does not include any records of any threatened or endangered species or state-listed species of concern within the study area. However, due to the area's karst geology, an approximately two-mile side buffer around the designated drainage led to the following listings by the MDC (Table 4-6). Coordination with the U.S. Fish and Wildlife Service (FWS) is consistent with the MDC information.

Table 4-6: Species/Habitats with Federal restrictions within two-mile buffer of project area

Scientific Name	Common Name	Federal/State Status	State Rank	Ownership	Section	Township/Range
Amblyopsis Rosae	Ozark Cavefish	E	S2	Private	04	28n022w
Amblyopsis Rosae	Ozark Cavefish	E	S2	Private	05	28n022w
Amblyopsis Rosae	Ozark Cavefish	E	S2	Private	32	29n022w
Species/Habitats With State Restrictions						
Scientific Name	**Common Name**	**State Status**	**State Rank**	**Ownership**	**Section**	**Township/Range**
Lepus Californicus	Black-Tailed Jackrabbit	E	S1	Private	16	29n022w
Tyto Alba	Barn Owl	E	S2	Private	31	29n021w
Accipiter Cooperii	Cooper's Hawk		S3	Private	31	29n021w
Agalinis Purpurea	Purple False Foxglove		S2	Private	09	29n021w
Amb. Rosae Recharge Area	Ozark Cavefish Recharge Area		S2	Private	17	29n022w
Buteo Swainsoni	Swainson's Hawk		S2	Private	34	29n021w
Cambarus Setosus	Bristly Cave Crayfish		S3	Private	27	29n021w
Cambarus Setosus	Bristly Cave Crayfish		S3	Private	11	29n021w
Cambarus Setosus	Bristly Cave Crayfish		S3	Private	32	29n022w
S1 = Critically Imperiled; S2 = Imperiled; or S3 = Rare and uncommon in the state.						

4.6 HAZARDOUS, TOXIC AND RADIOACTIVE WASTES (HTRW)

In 1999, the City received an EPA Brownfields Assessment Demonstration Pilot grant for a 0.8 square mile area surrounding Jordan Creek Valley in the historic downtown area of the City. Since then, the City has expanded its assessment area and conducted initial HTRW screenings on 70 properties along the Jordan Creek corridor. Through the EPA Brownfields Program and other state-related programs, the City has received $3,960,000 from Federal and state partners towards assessment and cleanup of properties within Springfield. Large portions of these funds have been used in the assessment and cleanup of properties along the Jordan Creek corridor.

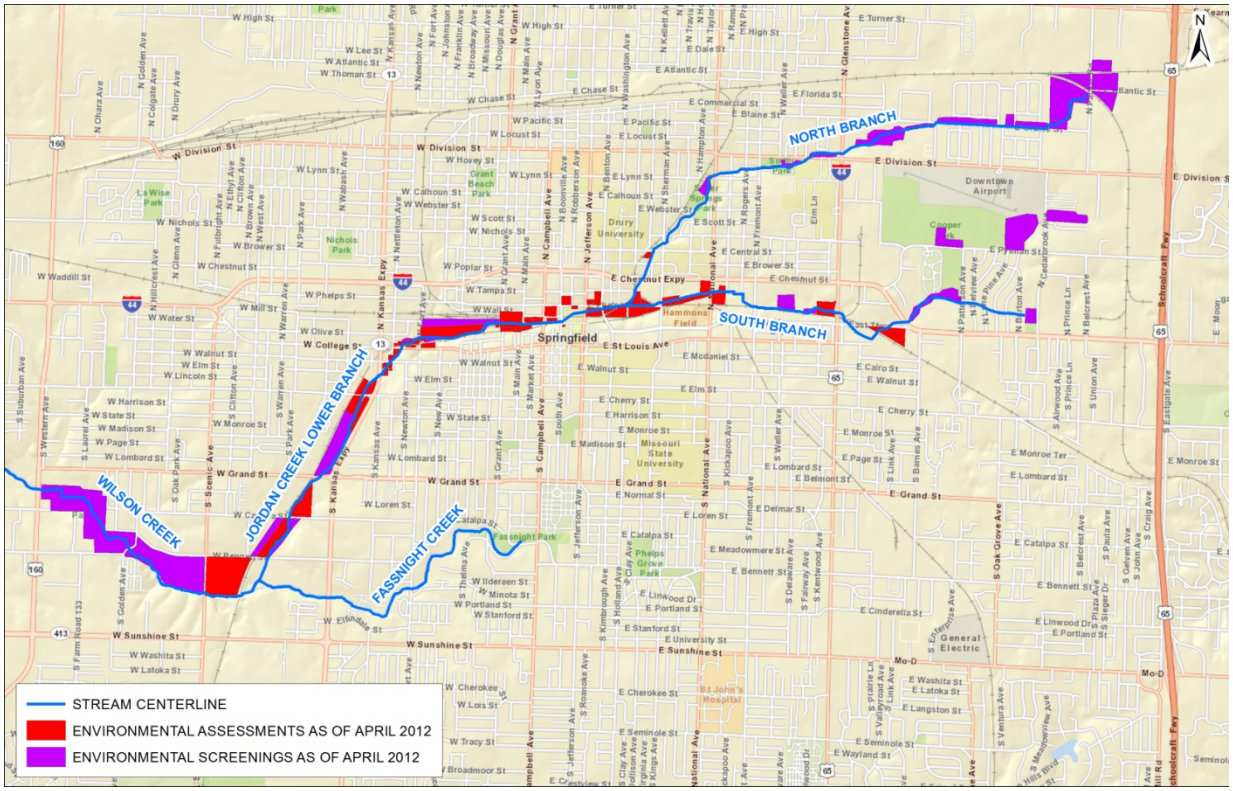

Figure 4-4: HTRW Assessment Areas

The MDNR is currently reviewing site assessments and other documentation on the 70 properties to determine if, or where, additional action is needed. Five additional properties along the corridor have been identified as needing further assessments. Refer to Figure 4-4: HTRW Assessment Areas for a list of the HTRW areas.

USACE conducted one HTRW assessment on a former City landfill and 23 HTRW screenings on potential basin areas. Based on the available information about historical land use, the results of the screenings of the potential basin areas showed a low potential for contaminants; no further environmental assessments were recommended for the five selected basins. However, further assessment has been recommended for the landfill site in Reach E1. The City is working with MDNR in the evaluation of HTRW issues in this area and is aware they are required to provide a clean corridor prior to any construction activity related to this study.

4.7 AIR QUALITY

The Springfield-Greene County Health Department maintains air-monitoring sites at five locations: Hillcrest High School, James River South on East Evans Road near the Battlefield Fire Station, 5012 South Charleston, 1555 South Glenstone and Southwest Missouri State University. Site placement is dictated under the guidance and monitoring objectives of the EPA. Air quality monitoring stations are strategically placed in areas believed to have higher concentrations of pollutants. The Springfield-

Greene County area does not exceed any of the National Ambient Air Monitoring Standards set by the EPA.

4.8 NOISE

Noise levels in this area are indicative of an urban setting and arise primarily from sources such as vehicular traffic and industrial manufacturing. Any residential or industrial construction activity typically elevates current City noise levels to a level commonly produced by equipment such as backhoes, bulldozers and gravel and cement trucks. Section 78-113(a)(6) of the City of Springfield, Missouri, Code of Ordinances, Construction in Residential Districts, states that the erection (including excavation), demolition, alteration or repair of any building and the excavation of streets and highways in any residential district or section, may be allowed through the City permitting process. No decibel noise levels are listed for this type activity.

4.9 CULTURAL RESOURCES

The project parcel lies within the West White Drainage Basin of the James River Watershed. A thorough review of the cultural history of this area can be found in *The Prehistory of Missouri* (O'Brien and Wood 1998), *The Archaeology of Missouri I and II* (Chapman 1975 and Chapman 1980) and the project report resulting from a cultural resource survey of the project area, *Jordan Creek: History, Architectural History, and Archaeology* (Jones, et al. 2007) and needs not be repeated here. The general area in which this project is located has a rich history of historic settlement and Civil War activities as well as prehistoric land use. Wilsons Creek National Battlefield, the site of a major Civil War battle in Missouri, is just south of the project area. The rolling terrain made the area an ideal spot for historic settlement; ready sources of water and chert provided a good location for prehistoric settlement. The prehistory of southwest Missouri goes back to the earliest periods of human occupation in North America. That said, the historic and modern development of the City has destroyed much of the prehistory left behind by Native Americans, and only a small prehistoric component at two historic sites was recorded during the archeological survey conducted for this project. There have been 153 archaeological surveys carried out within Greene County, 30 of which have been conducted within one mile of the project area. One of the more recent surveys studied the potential impact of this project on cultural resources. The report resulting from this survey, *Jordan Creek: History, Architectural History, and Archaeology* (Jones, et al. 2007), outlines two multicomponent sites (23GR2023 and 23GR2024) and one historic site (23GR2026) located within or near the project area. The report states that further investigations are needed in order to determine spatial extent and integrity with respect to their eligibility for listing on the National Register of Historic Places (NRHP). That said, the report states that the two multicomponent sites are located in an area where contaminants are present and that further testing would require special safety measures, so "it may be imprudent to implement further excavations at these sites" (Jones, et al. 2007:88). Depending on the impacts of the plan chosen, all three sites may require further testing. The historic significance and the prehistoric context will be determined for two sites rarely found within the City limits of Springfield. If significant impacts to any of these sites in unavoidable, the determination on what level of testing is reasonable (given the data that is currently available and the safety concerns involved) will be made in coordination with external stakeholders such as the Missouri State Historic

Preservation Office (SHPO) and Federally recognized Native American tribes. Currently there are no known sites within any of the detention basins, and the Phase I survey in these areas appears to be sufficient.

The City also has a significant historic structure component. During the cultural resources survey, 53 structures near the project area were evaluated to determine eligibility for listing on the NRHP. Of those 53 structures, 10 were recommended eligible. Seven structures had previously been listed on the NRHP; the abovementioned report (Jones, et al. 2007) suggests that they be either avoided or mitigated prior to ground-disturbing activities that could affect their historic integrity. Table 4-7 describes the listed and eligible properties. One of the seven previously listed structures/districts (Woods-Evertz Stove Company National Register Historic District) is currently in the process of being removed from the NRHP and will not require mitigation if delisted by the project start date. There are also multiple bridges that may be affected by various plans associated with this project. If modifications or demolition is proposed for any bridge, further analysis will be required to determine whether the structure is historically significant and eligible for listing on the NRHP. All of these structures will be considered during the evaluation of plans as well as during the design of the actual project to avoid adverse impacts where feasible. If adverse impacts are unavoidable, consultation with the State Historic Preservation Office (SHPO) and interested historical groups will be carried out in order to identify appropriate mitigation procedures.

The SHPO has reviewed the cultural resources report for this project (Jones, et al. 2007) and has provided comments that were incorporated into the final document.

Table 4-7: Structures within the project area eligible for listing or listed in the National Register of Historic Places. Adapted from Jones et al. 2007

Property Name	Address	Criterion	Significance
Tindle Mills	701 E. Chestnut	C	Strongly embodies the setting and feel of a 1930s or 1940s mill.
The Edge Video Bar (vacated)	414 N. Boonville	C	This building is a good example of a turn-of-the-century retail commercial block with a high level of integrity.
MFA Grain Elevators	S. Marlan	C	This mill structure appears to be essentially asit was when built.
Cooper Maintenance /Receiving	2709 E. Pythian	C	Buildings 2 (barn), 4 (house) and 5 (garage) are good examples of Ozark rock masonry.
Quinn Hotel Supply Company	222 E. Water	C	Original structure retains integrity and is a good example of arcaded block, Victorian, functional.
Springfield Furniture Company	601 N. National	A and C	Strongly retains the setting and feel of an 1890s factory, good example of arcaded block.
Unknown	1432 W. College	A and C	Good example of a Route 66 filling station.

Unknown	1420 W. College	A and C	Good example of a Route 66 filling station.
Wholesale Lumber and Materials Company	404 N. Jefferson	C	Good example of Art Deco style with high integrity.
United Iron Works Crescent Plant	SE corner of Tampa and Prospect	C	Good example of Neo-Romanesque details
National Audio, Inc.	309 E. Water		On NRHP
Country Corner	351 N. Boonville		On NRHP
Harry Cooper Supply Company	211 and 223 E. Water		On NRHP
Unknown	338 N. Boonville		On NRHP
Unknown	215 W. Mill		On NRHP
Ozarks Technical Community College	815 N. Sherman		On NRHP
Stove Works Lofts	505 N. Jefferson		On NRHP (submitted for removal from NRHP)

4.10 SOCIOECONOMIC

The City economy is based upon education, healthcare, retail, tourism and manufacturing. The City is the third-largest city in Missouri and is home to nine colleges and universities. Being the largest city in its area, it attracts shoppers from throughout the region. There is little to no agricultural production in the City as it is a highly developed area. This results in a stable workforce that is not influenced by seasonal agricultural labor demands.

As Table 4-8 shows, the population in the study area is primarily white and is significantly younger than the United States population on average. Although the median per capita income in the City is only 70 percent of the national median, the population is not as poor as these numbers suggest. The median housing value is 66 percent of the national median. If housing values are used as a rough measure of cost of living, lower per capita income is offset by a reduction in the cost of living. The number of families in the City below the poverty level is only slightly higher than the national rate. In September 2012, Springfield had an unemployment rate of 5.5 percent compared to 6.9 percent for the national rate.

The City has a higher rate of those completing high school than the national rate. Of those aged 25 and higher, the rate of earning a bachelor's degree or above is slightly lower than the national rate.

Table 4-8: 2010 Population Characteristics of Springfield, MO

	Estimate	Percent	U.S.
Total Population	159,498	-	-
Race			
White	141,526	88.7%	72.4%
Black or African American	6,524	4.1%	12.6%
American Indian or Alaska Native	1,233	0.8%	0.9%
Asian	3,015	1.9%	4.8%
Native Hawaiian and Other Pacific Islander	267	0.2%	0.2%
Some other race	1,889	1.2%	6.2%
Two or more races	5,044	3.2%	2.9%
Age			
Under 18 years	24,176	18.3%	24%
between 18 and 64 years	112,201	67.2%	63%
65 years and over	23,121	14.5%	13%
Income (2010 Dollars)*			
Median per capita income	20,793	-	27,334
Median housing value	103,800	-	188,400
Families below poverty level	-	21.7%	13.8%
Unemployment rate***		5.5 %	7.8%
Education level for those over 25 years old*		-	-
High school graduate and over	-	86.6%	85%
Bachelor's degree or higher	-	25.6%	27.9%

Data source: US Census 2010 estimates
*Data source: U.S. Census 2010 American Community Survey, Selected Social Characteristics, 5-year estimates: 2006 – 2010

Table 4-9 shows that Greene County's population grew over 14 percent while Missouri grew 7 percent. The national population grew just over 9 percent along the same period. The City's population is expected to continue to grow.

Table 4-9: Population Change 2000-2010

Location	Population 2000	Population 2010	Population Change 2000-2010
Greene County	240,391	275,174	14.47%
Missouri	5,595,211	5,988,927	7.04%
United States	281,421,906	307,006,550	9.09%
Data source: 2000 and 2010 U.S. Census			

5 EFFECTS ON SIGNIFICANT RESOURCES*

Table 5-1: Summary of the Potential Effects provides a summary of the potential effects of Plans G2, J and No Action. Following this table is a narrative description of the anticipated impacts to the physical, biological, cultural and socioeconomic environment of the area.

Table 5-1: Summary of the Potential Effects of Plans G2, J and No Action

Resource	Plan G2	Plan J (NED)	No Action Plan
Land Use	Minimal impact-primarily parking lots and bridges in Reaches E1, E3 and E6	Minimal impact-primarily parking lots and bridges in Reach E1	No impact
Water Resources	Positive impact due to water retention in basins and stream, improved water quality from greater nutrient cycling; temporary increase in turbidity due to basins and channel construction	Positive impact due to water retention in basins and stream, improved water quality from greater nutrient cycling; temporary increase in turbidity due to basins and channel construction	No impact
Cultural Resources	Impact to two sites in Springfield Warehouse District and Industrial Historic District	No cultural resources impact	No impact
Biological Resources	Positive impact from flow retention and velocity reduction; possible negative impacts due to temporary construction related turbidity increase	Positive impact from flow retention and velocity reduction; possible negative impacts due to temporary construction related turbidity increase	Negative impact to biological resources continue to be degraded due to undersized channel, resulting in excessive scour and turbidity increases during storm events
HTRW	Positive impact due to expedited evaluation/cleanup of 30 sites in project footprint	Positive impact due to expedited evaluation/cleanup of 3 sites	Negative impact to HTRW issues dealt with as deemed necessary and/or when funds become available to the City
Air Quality	Minimal temporary impact due to construction activity consisting of fugitive dust and exhaust emissions from construction equipment	Minimal temporary impact due to construction activity consisting of fugitive dust and exhaust emissions from construction equipment	No impact
Noise	Minimal impact, temporary increased levels typically associated with construction equipment	Minimal impact, temporary increased levels typically associated with construction equipment	No impact
Socioeconomic	Minimal temporary impact due to construction activity	Minimal temporary impact due to construction activity	No impact

*Designates a section that is traditionally found in an Environmental Assessment.

5.1 PHYSICAL ENVIRONMENT

5.1.1 Land Use

Plan G2: This plan will have minimal impact on current land use along the Jordan Creek corridor. With the construction footprint primarily impacting a highly commercialized area along the creek and being limited to Reaches E1, E3 and E6; primary impacts will be to parking lots and urbanized stream corridor and these will involve modification/replacement of bridges and culverts. Detention basin construction will require removal of riparian vegetation along the creek channel in four of the five basins. A grassy swale will be leveed for creation of the fifth basin.

Plan J: This plan will have minimal impact on current land use along the Jordan Creek corridor. With the construction footprint affecting only the sparsely vegetated, urbanized stream corridor in Reach E1, primary impact will involve the modification/replacement of only two bridges, as well as the detention basin construction impacts noted in Plan G2.

No Action Plan: Under this plan, land use will develop according to the floodplain management plan, with the continued flooding of businesses and residences due to the inability of the undersized channel, bridges and culverts to convey floodwaters.

5.1.2 Climate

None of the plans will have an effect on the climate in this area.

5.1.3 Topography, Physiography and Soils

No plan will have any significant effect on the topography or physiography of the area. Channel alterations from Plan G2 will result in minor changes to the slopes of the stream channels, but these will not result in any significant change. Even less change will take place with the implementation of Plan J. North Branch Jordan Creek and South Branch Jordan Creek have been characterized as losing stream segments by MDNR, meaning a portion of the stream flow becomes subsurface through stream bed fractures. No sinkholes have been identified in these stream branches. The main channel of Jordan Creek, downstream of the confluence of the two branches, has been characterized as a gaining stream segment. The Plan J project footprint is within the downstream portion of the main channel. Proposed detention basin construction in the upper losing stream branches will involve stream excavation and widening for two of the five basins. Best management practices will be utilized during construction to minimize potential negative impacts to the aquatic environment.

Soils should benefit from the two construction actions by reducing the scouring affect of future flooding events. Under the No Action Plan, flood scour will continue as is, and will likely increase in the future due to increased impervious surfaces constructed in the watershed.

5.1.4 Water Resources

Plan G2: This plan will result in positive impacts on the Jordan Creek water resources by retaining more in-stream quantity following storm events. This will be accomplished by widening portions of the existing channel, constructing an overflow channel running adjacent to existing sections of enclosed channel and

reducing velocity effects by constructing five detention basins in the upper watershed of the stream. Water quality benefits will result from longer detention time from the basins as well as wider channel dimensions in the construction footprint. This will aid in complying with the storm water TMDL that the EPA has established for Wilsons and Jordan Creeks. The water quality limited segments on these stream are listed as impaired by multiple point sources and urban non-point sources, with the source of the impairments listed as unknown. Implementation of this plan will help reduce the flashy, high-velocity flows that scour the increased impervious landscape created by continued development, thereby reducing in-stream toxicity by increasing both the in-channel volume and retention time as the flow moves downstream. There will be a temporary construction-related increase in turbidity during this phase of the project due to the excavation of the detention basins and channel creation/modifications in Reaches E1, E3 and E6.

Plan J: This plan will also result in positive impacts on the Jordan Creek water resources by retaining more in-stream quantity following storm events. This will be accomplished by widening the channel in Reach E1 and reducing velocity effects by constructing five detention basins in the upper watershed of the stream. Water quality benefits will result from longer detention time from the basins as well as wider channel dimensions in the lower-reach construction footprint. This plan will result in a smaller amount of increased turbidity in the construction phase since channel modification will be confined to the detention basins and the E1 Reach.

No Action Plan: This plan will result in continued flash flood flows due to the existing undersized channel and the continued floodwater scour of impervious surfaces in this primarily urbanized watershed. Current stream bank integrity may be jeopardized by the inability of the current drainage system to adequately contain and slow the discharge of storm flows, resulting in increased bank scour and erosion.

5.2 BIOLOGICAL RESOURCES

Plan G2: Biological resources will improve under this plan. Benefits will include larger areas of wetted perimeters in the constructed detention basins, which will provide some groundwater replenishment, allow limited wetland vegetation to develop and reduce the velocity and extend transport time of storm flows downstream. This reduction will allow the existing stream and constructed channel to retain greater volume after storm flows pass downstream. Daylighting portions of the existing box culvert system and constructing overflow channels will also increase the linear footage open to sunlight, allowing greater nutrient cycling activity along the stream corridor, as well as providing additional habitat and forage area for fishes and macroinvertebrates.

Plan J: Biological resources will improve from this plan. Benefits will include larger areas of wetted perimeters in the constructed detention basins, which will provide temporary, storm related water storage, in addition to velocity reduction and extended transport time of storm flows downstream. This reduction will allow the existing stream and constructed channel to retain greater volume after storm flows pass downstream. The widening of the downstream reach will allow more of the storm flow volume to remain in the channel, which will aid in nutrient cycling activity and provides additional habitat and forage area for fishes and macroinvertebrates.

No Action Plan: Biological resources under this plan will continue to degrade due to stream-bank, high-velocity floodwater scour and poor water quality from excessive watershed pollutants. The lack of constructed detention basins and widened stream channel will result in the existing flashy nature of storm flow movement and impede the channel water retention needed for aquatic life community improvement.

5.2.1 Vegetation

Plan G2: This plan includes widening the channel in Reaches E1, E3 and E6. Riparian corridor vegetation will be removed to accommodate the expanded channel, equipment access and staging areas for materials. In Reach E1, approximately 7.3 acres of woody vegetation and 0.75 acres of brush will be removed in order to facilitate a total of 3,236 feet of channel modification. Due to the degree of development in Reach E3, only 3.4 acres of brush, with no measurable woody vegetation, will be removed over a distance of 4,747 linear feet of channel modification. In Reach E6, which is a highly commercialized/industrial area, a total of 2 acres of woody vegetation and 3.2 acres of brush will be removed over a distance of 4,723 linear feet of channel construction/modification. Wherever available area exists, constructed stream banks will be revegetated with grasses and other herbaceous plants and possibly native tree species.

Plan J: Riparian corridor vegetation will be removed to accommodate the expanded channel, equipment access and staging areas for materials. This plan modifies the stream channel only in Reach E1. Approximately 7.3 acres of woody vegetation and 0.75 acres of brush will be removed in order to facilitate a total of 3,236 feet of channel modification.

No Action Plan: Under this plan, the existing riparian vegetation will remain in place. Although sparse and degraded in some reaches, the woody species will continue to provide some measure of stream bank stability and shading. Continued high-velocity floodwaters will eventually undercut adjacent streamside vegetation, causing woody debris stream blockage and stream bank scour.

5.2.2 Wetlands

Plan G2: This plan will result in filling a 0.4 acre isolated wetland in Reach E1, just above the Jordan Creek confluence with Wilsons Creek. The side slope on the 1/500 ACE channel will necessitate this fill.

A small wetland area in the channel of South Branch Jordan Creek is included in detention basin B6. The constructed basin will have 8.25 surface acres and will likely exhibit wetland characteristics after post-construction rainfall events. Although excavation is planned for detention basin B11 (8.7 acres), the wetland at the mouth of this basin will not be disturbed.

Plan J: Since this plan proposes stream modification only in Reach E1 and the construction of the five detention basins upstream (as in Plan G2), the wetland impacts will be the same as noted in Plan G2.

No Action Plan: No existing wetlands in the Jordan Creek drainage basin will be impacted with the No Action Plan.

5.2.3 Fish and Wildlife

Plan G2: Under this plan the greatest benefit to fish and wildlife will be the construction of approximately 36 surface acres of detention basins in the upper watersheds of North Branch Jordan and South Branch

Jordan Creeks. These four basins (two in each creek) are in-channel construction, which will allow all upstream flow to accumulate and create a large wetted perimeter prior to discharge downstream during flood events. These basins will serve to reduce the stream velocity, as well as retain more of the storm flow in the basins and in the stream channel downstream. In a small watershed urban stream environment, flow retention is a critical component of aquatic life community development. A fifth detention basin, in an upland area between the north and south branches of this creek, is designed to temporarily retain storm flow and reduce overland velocity. This basin will be approximately 5.7 surface acres will drain into the South Branch Jordan Creek. While designed to temporarily retain storm flows and reduce downstream velocities, these basins may retain some water, allowing hydrophytic vegetation to develop. The basins, as well as the widened downstream constructed areas, will retain more volume following storm flow transport downstream. The increased stream volume will enhance aquatic community health in the stream reaches not targeted for channel modification. Channel construction/modification in Reaches E1, E3, and E6 will provide additional habitat and forage area for fishes and macroinvertebrates. Associated with construction will be a temporary increase in turbidity in, and downstream of the detention basins and modified channels.

Plan J: This plan will provide similar benefits to fish and wildlife as Plan G2, along with the corresponding construction related temporary increases in turbidity.

No Action: Under this plan the current stream corridor will remain as is, and the impacts of local storm flows will be exacerbated by continued watershed development. Increased stream velocities, excessive scour and bank erosion will continue to affect negatively the wildlife resources that currently exist in this stream.

5.2.4 Threatened and Endangered Species

Plan G2: According to a planning assistance letter received from the USFWS on 28 June 2012, the Service has made a preliminary determination that no Federally listed species are known to occur within the proposed project site on Jordan Creek. However, the USFWS does list the Indiana Bat as occurring in Greene County, Missouri. While this species is known to use stream riparian corridors as foraging areas, life history information that indicates these bats tend to forage near their summer roost areas, which typically consist of dead or dying trees or those with exfoliating bark such as shag bark hickory and oaks. Two of the five planned detention basins for the project will involve clearing riparian vegetation for basin creation. Streamside vegetation in these areas typically consist of poor quality hardwoods and invasive species, which are not suited to roosting habitat. As a result, this project has little likelihood of impact to the Indiana Bat.

Due to the Jordan Creek area's karst geology, an approximately 2-mile side buffer around the designated drainage led to the listing of the Ozark cavefish by the MDC (Table 4-6). Coordination with the USFWS is consistent with the MDC information. Potential impacts to the Ozark cavefish will be minimized by confining construction to the area of Jordan Creek that has been determined by MDNR as a gaining stream segment. Two of the five planned detention basins in the upper branches areas will involve an excavation and widening of existing stream channels, so a possibility of potential impact may exist during basin construction.

USFWS stated that detention basin construction for storm water mediation would provide habitat for amphibians and shore and wading birds. Several general recommendations were included for consideration by the City during project construction. Some suggestions, such as converting existing box culverts to more natural openings, improving all existing stream channels to more appropriate width and depth ratios, opening currently piped stream sections, and removing one side of concrete lined stream segments to incorporate 3:1 side slopes, are pertinent to the Plan G2 proposal.

Plan J: This plan, by being confined to Reach E1 and upstream detention basins, will incorporate the USFWS recommendations of replanting disturbed areas with native vegetation, and planting native tree and shrub species along the project corridor where space is available.

No Action Plan: This plan will not cause any impacts to threatened and endangered species.

5.3 HAZARDOUS, TOXIC AND RADIOACTIVE WASTE

Plan G2: This plan will have a construction footprint in only three of the six economic reaches identified in the Jordan Creek drainage basin: E1, E3 and E6. Since 1999, the City has had an ongoing program of assessment and cleanup of HTRW sites within its boundaries. A major portion of funds have been expended in the Jordan Creek corridor. Figure 4.4: HTRW Environmental Assessment Areas in Section 4 (AFFECTED ENVIRONMENT) provides a depiction of the environmental assessments and screenings completed as of April 2012.

Within Reaches E1, E3 and E6 impacted by this plan, there are 30 properties with suspected or documented HTRW issues. In April 2012, Seagull Environmental Technologies prepared an environmental review for the City. This review evaluated available information on 70 properties along the Jordan Creek corridor, along with a recommendation of additional assessment activities where needed. This review also provided a range of cost estimates for remedial activities. For properties without completed assessments, environmental conditions for surrounding properties, along with available historical documents were used to determine potential site conditions and remedial costs. The range of costs associated with remediation for these 30 sites is approximately $287,500 to $2,385,250.

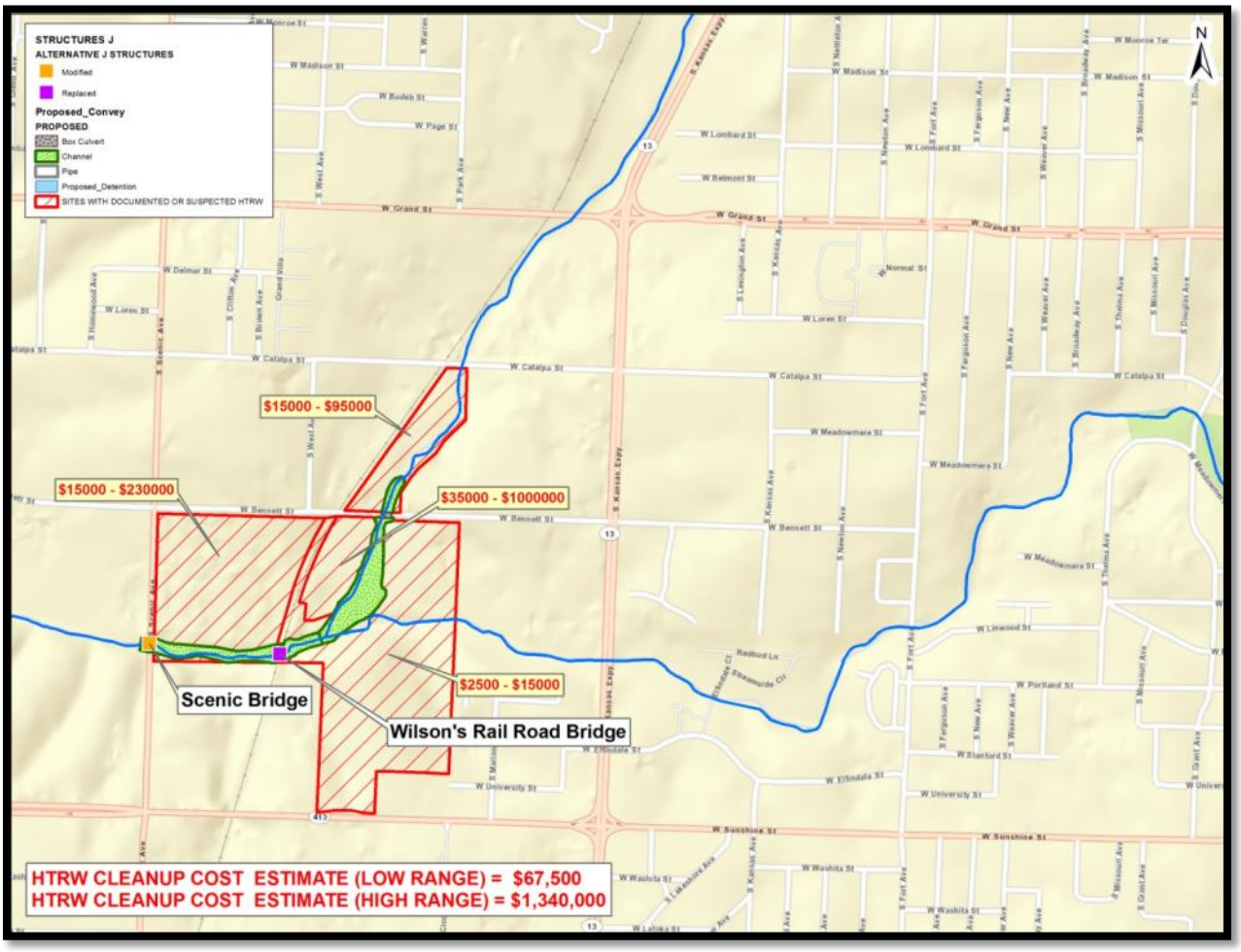

Figure 5-1: Plan J Cost Ranges for HTRW Remediation

Plan J: This plan will have a construction footprint in Reach E 1. Only three properties are listed in this reach, significantly reducing the potential cleanup costs. In Figure 5-1 the range for potential cleanup for Reach E1 is $67,500-$1,340,000; however, actual costs may be significantly lower since the stream runs along the border of these properties. The Archimica property west of Jordan Creek has the highest range associated with remediation ($35,000-$1,000,000), but this facility, which is currently involved in post-closure and corrective action activities under two hazardous waste permits (MDNR and EPA), is protected by an existing flood wall along the west bank of the creek. The effective cost of the remediation is likely $32,500 - $340,000; however, the risk is low that HTRW exists in the footprint of the project. Plan J is designed to provide protection to approximately the 1/500 ACE, which will result in no overtopping of this wall during this storm event. Refer to the HTRW section of the Engineering Appendix (C) Plate H-4 for a depiction of contaminated areas within this property. The other properties in this reach are former City landfills with unknown potential contaminants. HTRW risks for the project are considered to be minimal since the City is required to provide a clean corridor for channel construction.

No Action Plan: The MDNR is currently reviewing completed environmental assessments and other documentation for the 70 properties identified along the Jordan Creek corridor. MDNR will determine where additional action is required. Under the No Action Plan, there will be continual cleanup of these properties as funding is available.

5.4 AIR QUALITY

Plan G2: This plan will have only a temporary minimal impact on existing air quality in the Jordan Creek watershed. The primary impacts will be fugitive dust from construction equipment as well as exhaust emissions from construction equipment for the duration of the project.

Plan J: This plan will impact existing air quality even less than Plan G2 in the watershed since the construction footprint on the stream channel will be confined to Reach E1 and the construction of the detention ponds.

No Action Plan: This plan will have no impact to existing air quality in the Jordan Creek stream corridor.

5.5 NOISE

Plan G2: This plan will temporarily increase noise in the immediate project area over the normal existing industrial processes and vehicular traffic noise level due to construction equipment and materials transport vehicle usage. Any residential or industrial construction activity will typically elevate current city noise levels to a level commonly produced by equipment such as backhoes, bulldozer as well as gravel and cement trucks. Section 78-113(a)(6) of the City of Springfield, Missouri Code of Ordinances, Construction in residential districts, states that the erection (including excavating), demolition, alteration or repair of any building and the excavation of streets and highways in any residential district or section, may be allowed through the City permitting process. No noise limits in decibels are listed for this type activity.

Plan J: This plan will increase noise in the immediate project area over the normal existing industrial processes and vehicular traffic noise level, but to a lesser extent than Plan G2, based on a smaller and more localized construction footprint.

No Action Plan: This plan will have no impact on existing noise levels along the Jordan Creek corridor.

5.6 CULTURAL RESOURCES

Plan G2: Under this plan, the primary impacts to any cultural resources from channel construction will occur in the Springfield Warehouse and Industrial Historic District where the Missouri State University Center for Archaeological Research identified two multi component prehistoric and historic sites, listed as 23GR2023 and 23GR2024. These sites are located in the proposed channel construction footprint and may require further testing and documentation prior to construction. Other potential impacts under this plan occur as a result of the detention basins construction. Testing of the proposed excavation may be required to ascertain the presence/absence of cultural artifacts in the five proposed basins. Documentation of any modified or removed bridges/culverts having historical significance will also be required prior to channel construction.

Plan J: Potential impacts to cultural resources under this plan may occur as a result of detention basin construction. Testing of the proposed excavation may be required to ascertain the presence/absence of cultural artifacts in the five proposed basins. Documentation of any modified or removed bridges/culverts having historical significance will also be required prior to channel construction.

No Action Plan: This plan will have no impact on existing cultural resources in the Jordan Creek basin.

5.7 SOCIOECONOMIC RESOURCES

Plan G2: Under this plan, only temporary socioeconomic impacts are expected to occur from the proposed construction activity in the Jordan Creek corridor.

Plan J: Under this plan, only temporary socioeconomic impacts are expected to occur from the proposed construction activity in the Jordan Creek corridor.

No Action Plan: This plan will have no impact on socioeconomic conditions along the Jordan Creek corridor.

Jordan Creek was once a naturally meandering stream. During the twentieth century, stream modifications to mitigate flooding impacts have severely impacted the environmental quality and habitat of this stream. Currently the watershed is approximately 95 percent developed, therefore additional cumulative environmental impacts from development are considered to be insignificant.

Plan G2: This plan includes channel improvements in reaches E1, E3, and E6. Sections of currently enclosed channel in reaches 3 and 6 would be converted to an open channel. This improvement would result in a small environmental enhancement due to daylighting this portion of the stream channel. Temporary negative impacts due to construction activity, which include instream turbidity increases and elevated stream temperature, would occur. This detrimental effect could be minimized by completing construction during the summer months when water levels tend to be low.

Plan J: The plan includes channel improvements in Reach E1. While there will be temporary impacts associated with construction to the stream environment as noted above, there will be no significant enduring adverse impacts due to the implementation of this project. The construction footprint is confined to the detention basins and Reach E1, which will result in a smaller water quality impact than that identified in Plan G2.

No Action Plan: If the proposed project is not constructed in Jordan Creek, the continued impact to the stream environment will be a function of watershed land use patterns, as well as flood frequency and intensity.

5.8 CUMULATIVE IMPACTS

Jordan Creek was once a naturally meandering stream. During the twentieth century, stream modifications to mitigate flooding impacts have severely impacted the environmental quality and habitat of this stream. Currently the watershed is approximately 95 percent developed; therefore, additional cumulative environmental impacts from development are considered to be insignificant.

Plan G2: This plan includes channel improvements in reaches E1, E3, and E6. Sections of currently enclosed channel in reaches 3 and 6 would be converted to an open channel. This improvement would result in a small environmental enhancement due to daylighting this portion of the stream channel. Temporary negative impacts due to construction activity, which include instream turbidity increases and elevated stream temperature, will occur. This detrimental effect can be minimized by completing construction during the summer months when water levels tend to be low.

Plan J: This plan includes channel improvements in Reach E1. While there will be temporary impacts associated with construction to the stream environment as noted above, there will be no significant enduring adverse impacts due to the implementation of this project. The construction footprint is confined to the detention basins and Reach E1, which will result in a smaller water quality impact than that identified in Plan G2.

No Action Plan: If the proposed project is not constructed in Jordan Creek, the continued impact to the stream environment will be a function of watershed land use patterns, as well as flood frequency and intensity.

5.9 CONCLUSIONS OF ANALYSIS

Jordan Creek is primarily an ephemeral/intermittent highly urbanized stream draining a 13.75 square miles watershed in downtown Springfield, Missouri. North Branch Jordan Creek and South Branch Jordan Creek join to form Jordan Creek, which connects to Wilsons Creek at the lower end of the proposed project area. Due to extensive development in the watershed, including low-density housing, high-density housing, commercial areas, and industrial areas, and severe modifications to the existing stream channel, the aquatic habitat has become increasingly more degraded over the years. Several miles of the stream exist as an enclosed box culvert, traversing under downtown streets and businesses.

While the selected plan (Plan J) will result in modification of 3,236 feet of channel in Jordan and Wilson Creeks in Reach E1, the overall habitat quality in this stream corridor will remain in poor condition. Riparian corridor woody vegetation removal for channel construction activity will remove most of the limited shading that currently exists in the reach in the construction footprint. The constructed channel will be sized to convey a 1/500 ACE in this reach, so eventual low-flow meander scour may be achieved over time in this reach. This will constrict available flow, creating more water depth, which will reduce water temperature. The USFWS has recommended that this low-flow channel be created in this reach during the construction phase of the project. Replanting woody vegetation where possible along the constructed channel will enhance the aquatic environment.

Likely, the greatest environmental benefit from the proposed project will be the construction of five detention basins in the upper portions of the North and South Branches of this creek. Approximately 36 surface acres of basins will be constructed. They will detain storm flows and slow stream velocity. This will allow the retention of a larger volume of water in the stream channel as the storm flow moves downstream.

6 PUBLIC INVOLVEMENT, REVIEW AND CONSULTATION*

6.1 PUBLIC INVOLVEMENT PROGRAM

To announce the start of the feasibility phase, a public notice was issued to: residents, interested groups as well as Federal, state and local agencies. The recipients were invited to comment on the results of the completed reconnaissance study and to provide input to the feasibility study, including the scoping of the environmental issues that should be address throughout the study. The notice announced a public workshop, which was held on 26 October 2004 at the Ozarks Technical Community College in Springfield, Missouri, where the public was given the opportunity to comment. Forty-one people attended the scoping meeting, of which eight were USACE personnel. Three comments were received from private citizens during the meeting, with two of the three regarding neighborhood opposition to the unnecessary removal of 20 homes and a street closing. The third comment was regarding the 1/100 ACE delineation. These issues have been addressed in the integrated report.

During the public comment period from 4 February 2013 until 4 March 2013, no public comments were received. During that public comment period, a press release was sent to all of the local newspapers in the area surrounding Jordan Creek. Hard copies of the report were mailed to all of the public libraries and to the City Hall. The Little Rock District website also contained a digital copy of the report. No public comments were received.

6.2 INSTITUTIONAL INVOLVEMENT

6.2.1 Study Team

Staff from the City participated directly in the feasibility study effort. The City's H&H engineer and others assisted with HTRW, cultural resources and plan formulation.

6.2.2 Agency Coordination

During the feasibility study, coordination with the USFWS is being conducted in accordance with the Fish and Wildlife Coordination Act (FWCA). Several telephone calls were held between the USFWS representatives and USACE personnel to continue coordination and discussion of the proposed project plan. USFWS verbally concurred with the design and saw no significant impacts. In an email dated 1 April 2013, the USFWS stated the Planning Aide Letter,provided to USACE on 28 June 2012, fulfilled the requirements for Fish and Wildlife coordination for this phase of the project. They did request a low-flow channel be added into the final design and verbiage for the low-flow channel was added into Section 3.6.2 because of these discussions. They requested to review final designs during PED.

MDNR participated with the HTRW evaluations; however, no comments were received from MDNR during the draft report/draft EA public comment period held from 4 February 2013 through 4 March 2013. Pending review of final project design during PED, MDNR will issue state water quality certification prior to project implementation.

The Missouri SHPO and South Missouri University Center for Archeology Research participated in the Cultural Resources coordination. A project concurrence letter was received from SHPO on 7 February 2013.

Missouri Department of Conservation (MDC) submitted a 4 March 2013 letter indicating support of the project.

The City has a close relationship with FEMA Region 7 and is a Cooperating Technical Partner (CTP). This means that the City has the technical, financial and staffing capabilities to map for FEMA. The City has discussed the potential for remapping with FEMA at the Region level. The City will be responsible for map revisions.

The following agencies and agency representatives were coordinated with in the EA development:

Mr. Mark Miles, Missouri Department of Natural Resources, State Historic Preservation Office, P.O. Box 176, Jefferson City, MO 65102

Mr. Stephen Mahfood, Director, Missouri Department of Natural Resources, Division of Environmental Resources, P.O. Box 176,Jefferson City, MO 65102

Mr. John Hoskins, Director, Missouri Department of Conservation, Policy Coordination Section, P.O. Box 180,Jefferson City, MO 65102-0180

Mr. David Skaer, Area Resource Soil Scientist, U.S. Department of Agriculture, Natural Resource Conservation Service,1215 Fern Ridge Parkway, Suite 212,St. Louis, MO 63141

Mr. Earnest Quintana, Regional Director, National Park Service, Midwest Regional Office, 1709 Jackson St, Omaha, NE 68102

Missouri Department of Conservation, Southwest Regional Office, 2630 N. Mayfair, Springfield, MO 65803

Mr. Mark Green, District Conservationist, U.S. Natural Resources Conservation Service, Greene County Field Office, 688 S. State Hwy. B, Suite 200, Springfield, MO 65802

Ms. Linda Chorice, Manager, Missouri Department of Conservation, Nature Center, 4600 S. Chrisman, Springfield, MO 65804

Mr. Bob Schulz, Stream Team Coordinator, Missouri Stream Teams Ozark Unit, P.O. Box 180, Jefferson City, MO 65102

Mr. A.J. Lehman, Haz/Mat Coordinator, State Emergency Management Agency, Hazardous Materials Planning, P.O. Box 116, Jefferson City, MO 65102

Mr. Clay Goddard, Env/Community Health Planner, Springfield/Greene County EAB, 227 E. Chestnut Expressway, Springfield, MO 65802

Mr. Harold Bengsch, Director of Health, Springfield/Greene County Health Dept., 227 E. Chestnut Expressway, Springfield, MO 65802

Ms. Loring Bullard, Director, Watershed Committee of the Ozarks, 320 N. Main Springfield, MO 65806

The agency response letters are in Appendix E: Response Letters.

6.3 ADDITIONAL REQUIRED COORDINATION

The Integrated Feasibility Report and Environmental Assessment will undergo State and Agency Review.

6.3.1 Public Views and Responses

No public comments were received in the public review period that was held from 4 February 2013 through 4 March 2013.

6.3.2 Federal

USFWS concurred with the design and saw no significant impacts. They did request a low-flow channel be added into the final design. Verbiage for the low-flow channel was added into Section 3.6.2.

The Integrated Feasibility Report and Environmental Assessment will undergo State and Agency Review.

6.3.3 State and Local Agencies

A project concurrence letter was received from SHPO on 7 February 2013.

Missouri Department of Conservation (MDC) submitted a 4 March 2013 letter indicating support of the project.

The Integrated Feasibility Report and Environmental Assessment will undergo State and Agency Review.

7 LIST OF PREPARERS

The following individuals were primarily responsible for the preparation of this report.

Laura Cameron, P.E. – Plan formulation and Technical Lead

Todd Wagner, P.E. – Local Sponsor

Cherilyn Gibbs – Economics

Tyler Herriman – Economics

Nick Barner, P. E. – Civil Engineering and Engineering Lead

George Losak, P. E. – Cost Engineering

Errin Kemper, P.E. – Local Sponsor and Hydrology and Hydraulics

Robert Singleton – NEPA coordinator and NEPA lead

Rodney Parker – Archeology

Ronald Bridges – Real Estate

8 REFERENCES

http://www.springfieldmo.gov/jvp/index.html

EPA, 2011. Total Maximum Load, Wilson and Jordan Creeks (MO_2375 and 3374) Christian Counties, Missouri. United States Environmental Protection Agency, Region 7.

MDNR 2003. Missouri Department of Natural Resources. 2003. Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure. MDNR-FSS-030. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 24 pp.

MDNR, 2007., Springfield Urban Streams, Clear Creek, Jordan Creek, Wilson Creek and Galloway Creek, Greene County, Missouri. Missouri Department of Natural Resources, Biological Assessment Report.

MSU, 2007. Jordan Creek Baseline Water Quality Project. Missouri State University and Ozarks Environmental and Water Resource Institute, Final Report/ March 2007.

MSU, 2006. Final Report to the City of Springfield and the Biological Assessment of Urban Streams II, July 2005- June 2006. Missouri State University. .

Springfield, City of. 2009. Annual Report July 2008- June 2009. Municipal Separate Storm Sewer System (MS4)

Springfield, City of. 2010. Annual Report July 2009- June 2010. City of Springfield. Municipal Separate Storm Sewer System (MS4)

Chapman, C. H. 1980 The Archaeology of Missouri, II. University of Missouri Press, Columbia.

Chapman, C. H. 1975 The Archaeology of Missouri, I. University of Missouri Press, Columbia.

Jones, A. J., G. S. Powell, D. A. Thompson and D. Quick. 2007 Jordan Creek: History, Architectural History, and Archaeology. Center for Archaeological Research, Report No. 1277. Missouri State University, Springfield, Missouri.

O'Brien, M. J. and W. R. Wood. 1998 The Prehistory of Missouri. University of Missouri Press, Columbia.

Springfield News-Leader, July 14, 2000.

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9 RECOMMENDATIONS

As District Engineer, I have considered the environmental, social, and economic effects, the engineering feasibility, and comments received from the other resource agencies, the non-Federal sponsors, and the public, and have determined that the recommended plan presented in this report is in the overall public interest and is technically sound, environmentally acceptable, and economically feasible with a BCR of 2.7. I recommend that the recommended plan and associated features described in this report be authorized for implementation as a Federal project.

The recommended plan is the National Economic Development Plan, which is Plan J, as generally described in this report. The plan includes flood risk management features including but not limited to five regional detention basins, channel modifications on Wilsons and Jordan Creeks and a railroad bridge replacement. All new railroad bridges, modifications to existing railroad bridges, track modification and associated features will be cost-shared as part of the project construction costs. The fully funded cost estimate is $21,873,000, with the Federal and non-Federal shares of the total estimated at $14,217,000 and $7,656,000, respectively.

These recommendations are made with the provision that, prior to implementation, the non-Federal sponsors will agree to comply with the following requirements:

Federal implementation of the recommended plan would be subject to the non-Federal sponsors 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 flood risk management costs as further specified below:

    1. Provide 25 percent of design costs allocated by the Government to flood risk management in accordance with the terms of a design agreement entered into prior to commencement of design work for the flood risk management features;
    2. Provide, during the first year of construction, any additional funds necessary to pay the full non-Federal share of design costs allocated by the Government to flood risk management;
    3. Provide, during construction, a contribution of funds equal to 5 percent of total FCP flood risk management 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 flood risk management features;
    5. Provide, during construction, any additional funds necessary to make its total contribution for flood risk management equal to at least 35 percent of total FCP flood risk management costs;
    6. Provide 100 percent of all incremental costs of the Locally Preferred Plan.

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

c. Not less than once each year, inform affected interests of the extent of protection afforded by the flood risk management features;

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 flood risk management features;

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 flood risk management features;

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 flood risk management features afford, 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 sponsors with prior specific written direction, in which case the non-Federal sponsors shall perform such investigations in accordance with such written direction;

o. Assume, as between the Federal Government and the non-Federal sponsors, 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 sponsors, that the non-Federal sponsors 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 plan is being recommended with such modifications thereof as in the discretion of the Commander, HQUSACE, may be advisable.

The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It does 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 before it is transmitted to the Congress as a proposal for authorization and implementation funding. However, prior to transmittal to Congress, the non-Federal sponsors, the State of Missouri, interested Federal agencies, and other parties will be advised of any modifications and will be afforded the opportunity to comment further.

Glen A. Masset
Colonel, Corps of Engineers
District Engineer

10 PLATES

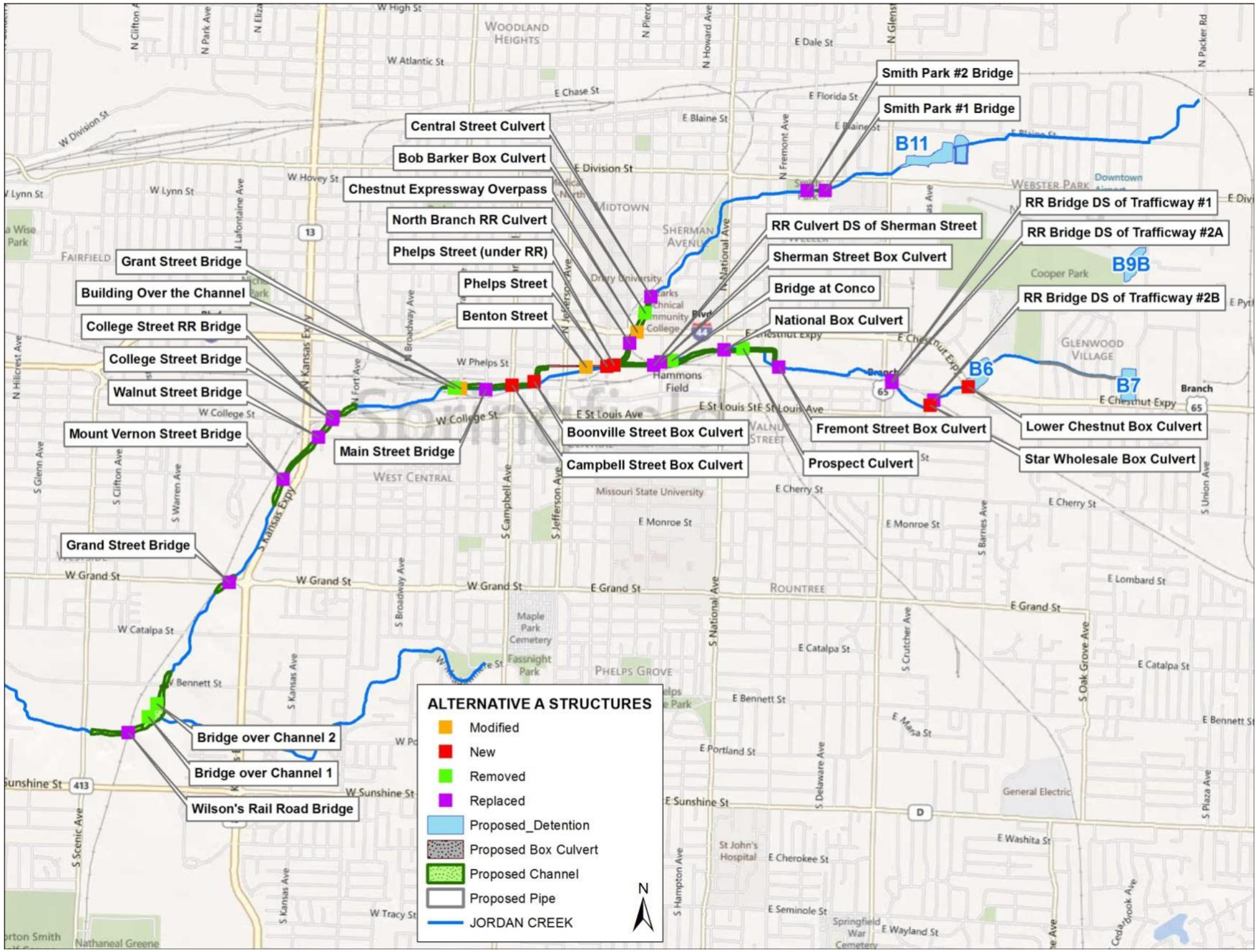

Plate 1: Plan A

Plate 1: Plan A

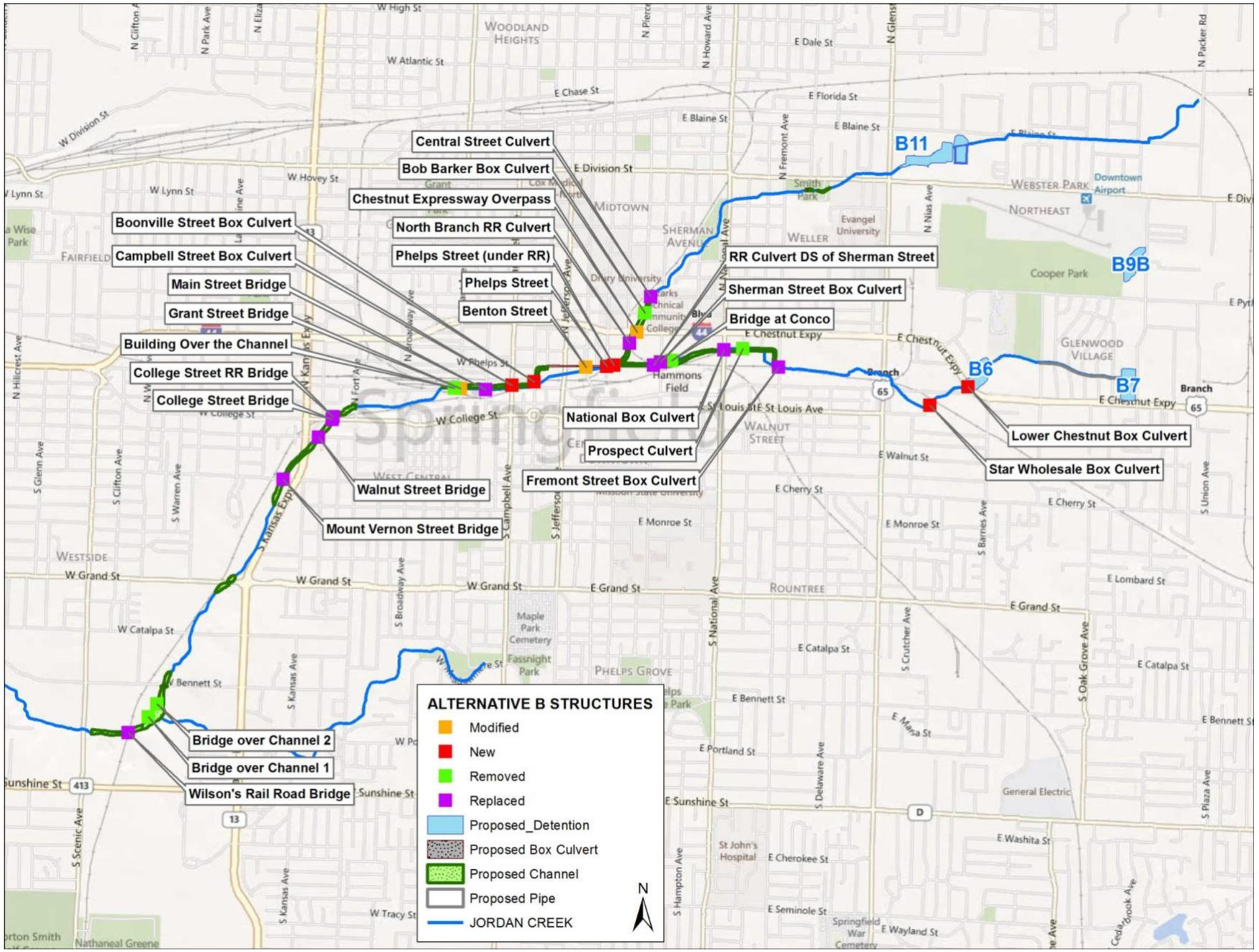

Plate 2: Plan B

Plate 2: Plan B

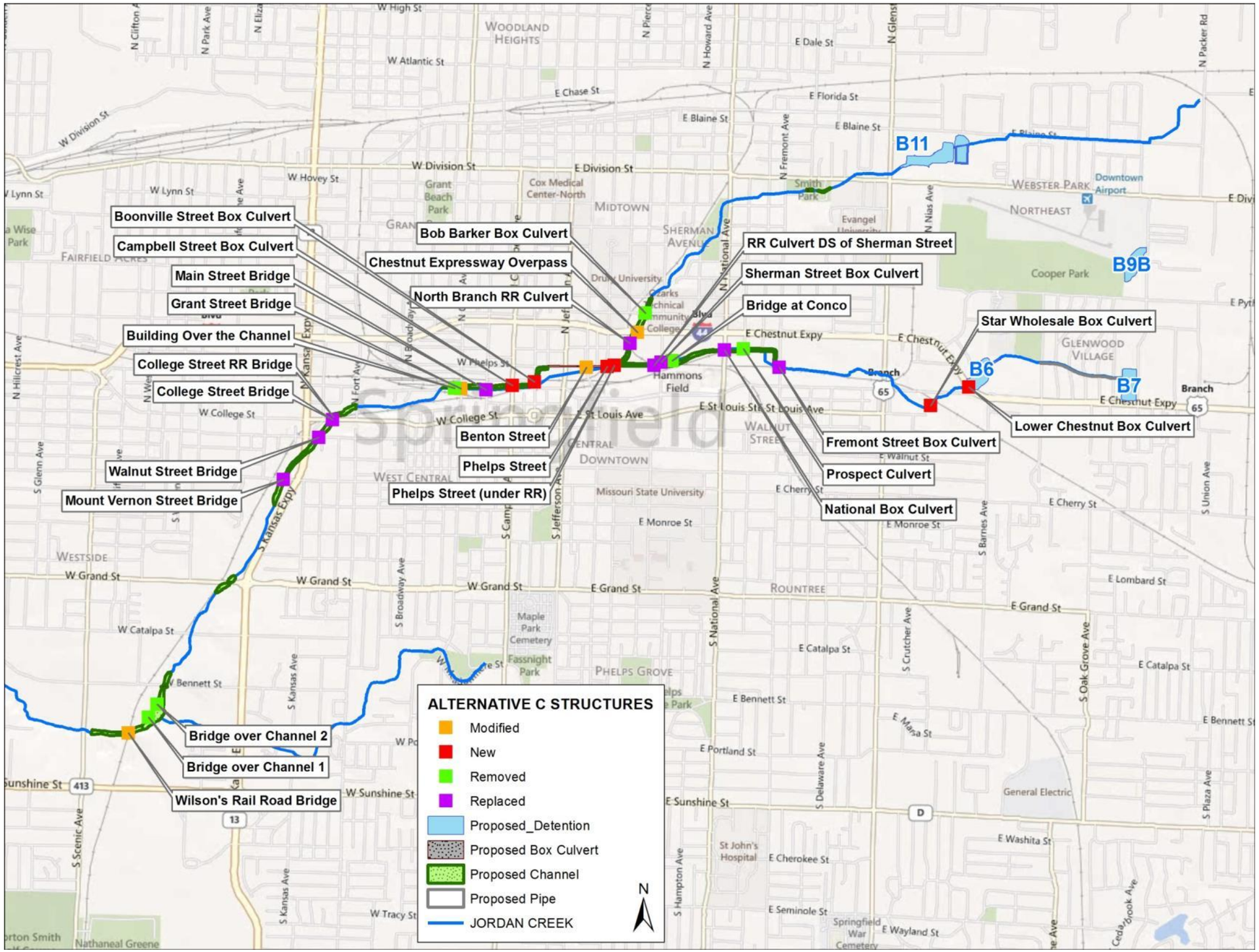

Plate 3: Plan C

Plate 3: Plan C

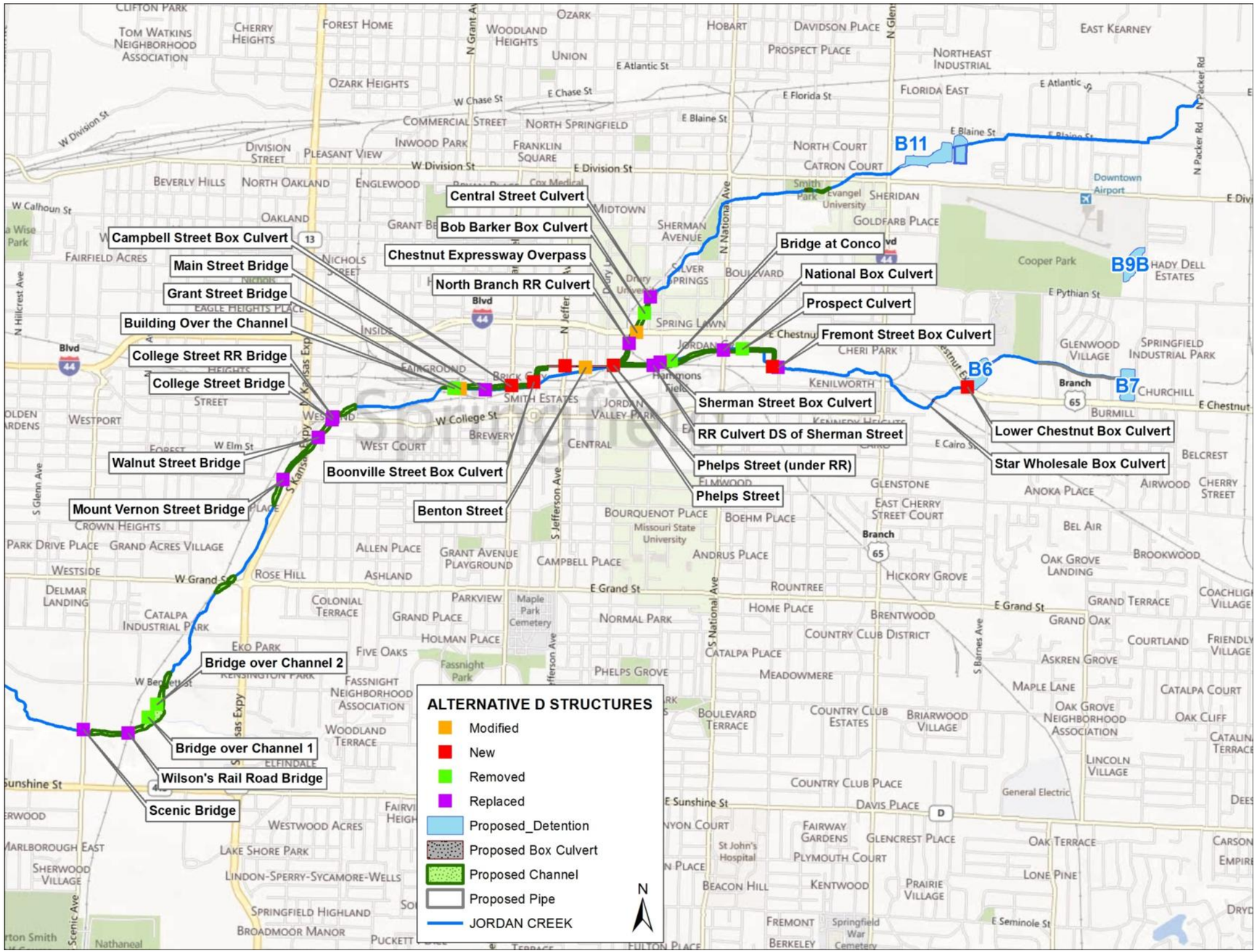

Plate 4: Plan D

Plate 4: Plan D

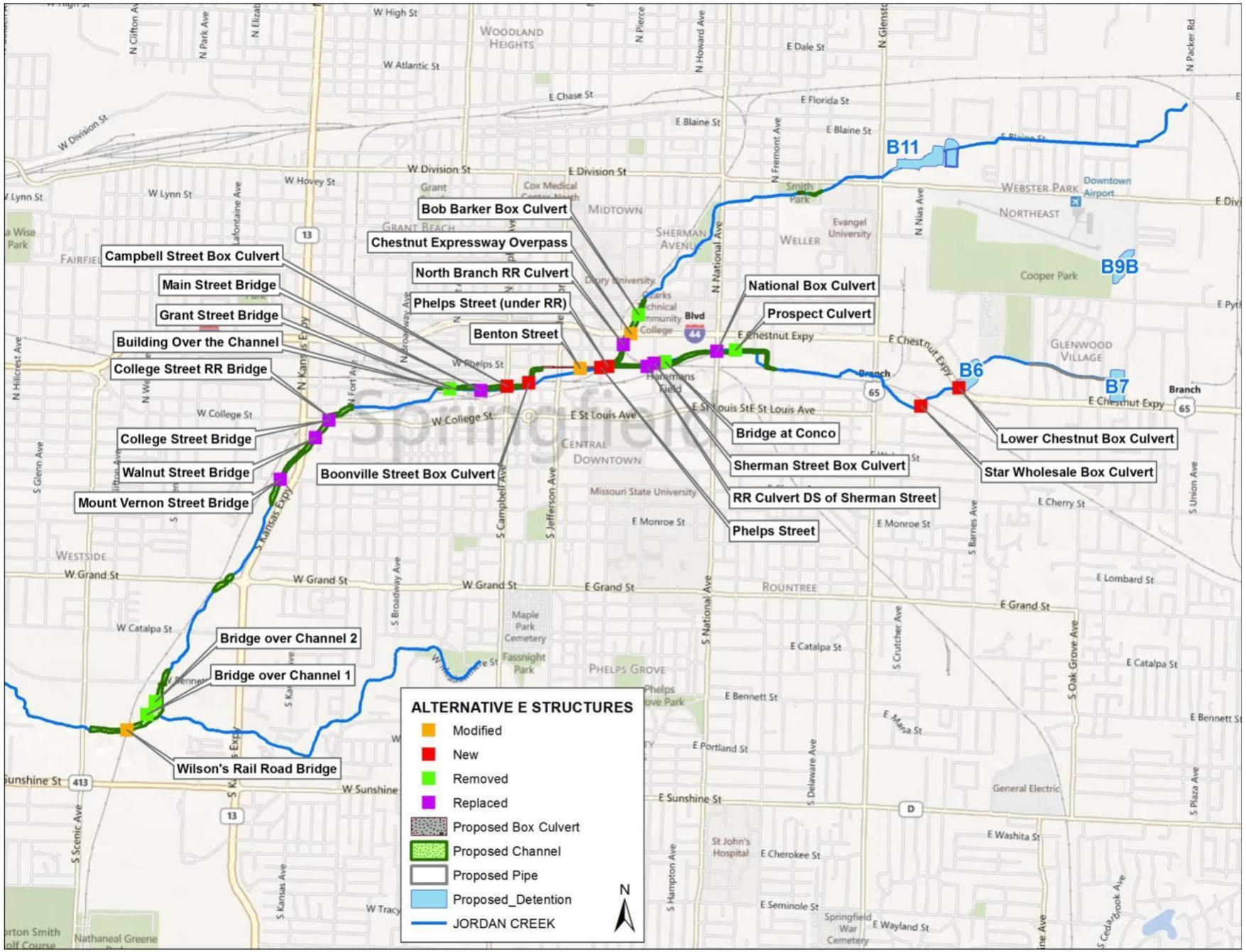

Plate 5: Plan E

Plate 5: Plan E

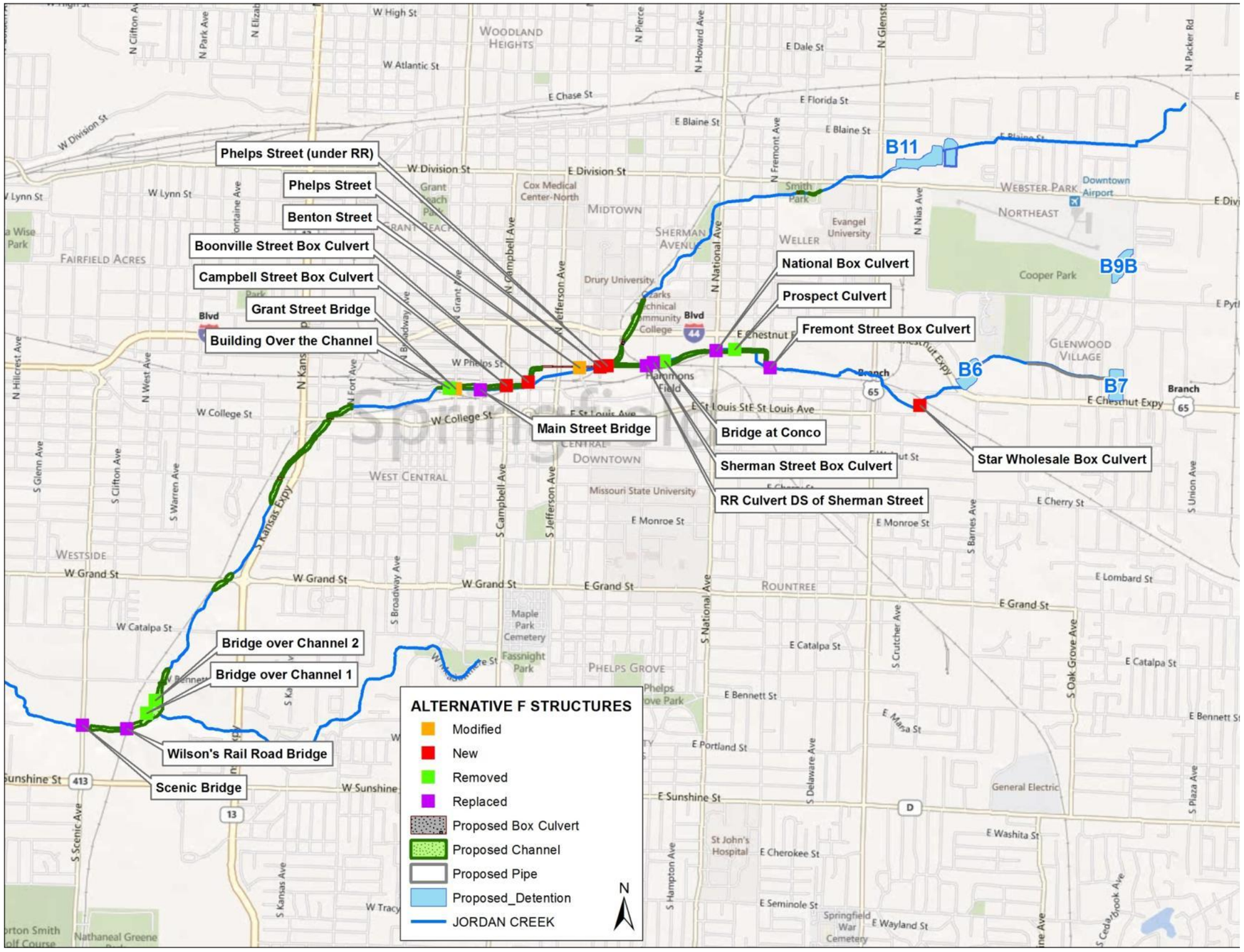

Plate 6: Plan F

Plate 6: Plan F

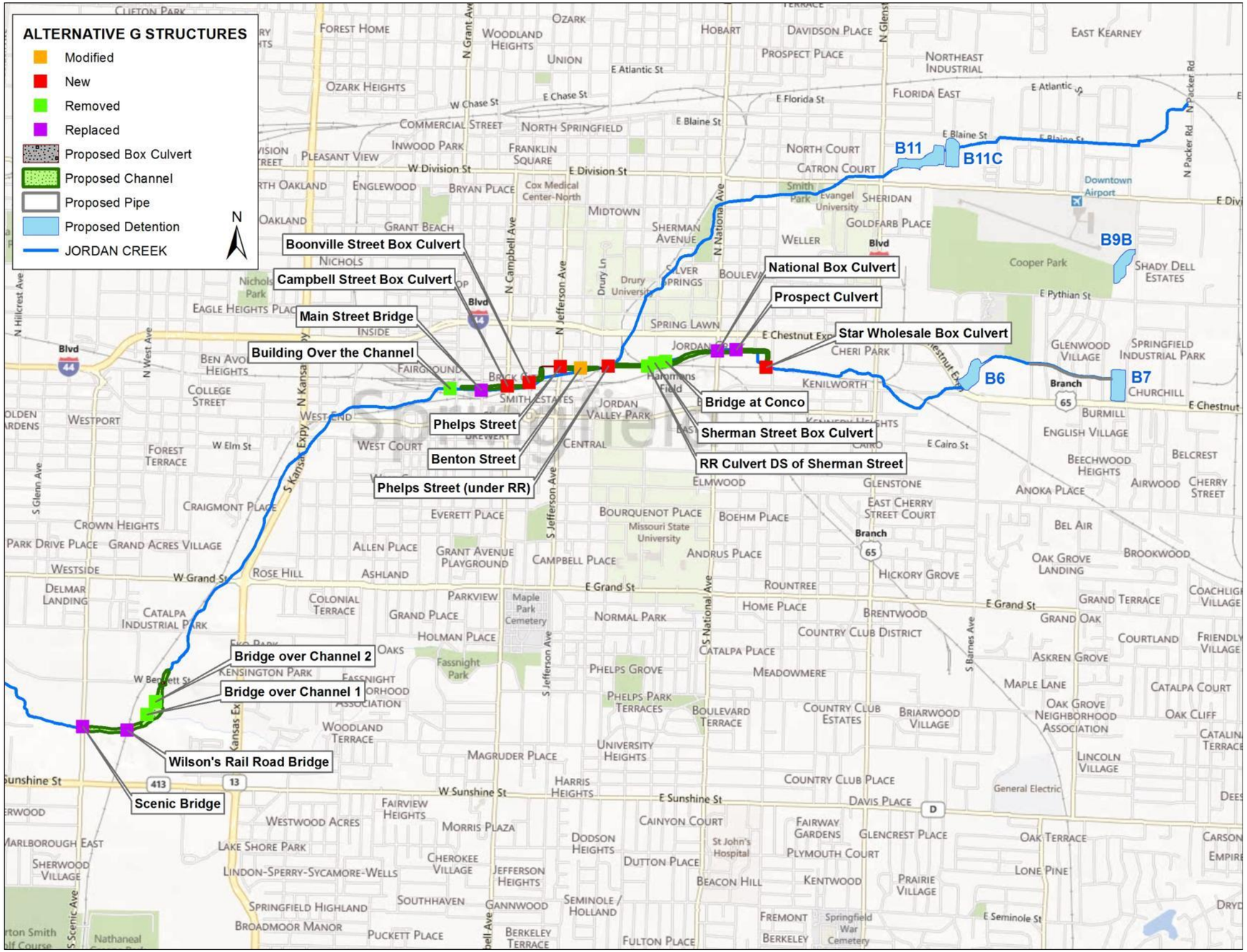

Plate 7: Plan G

Plate 7: Plan G

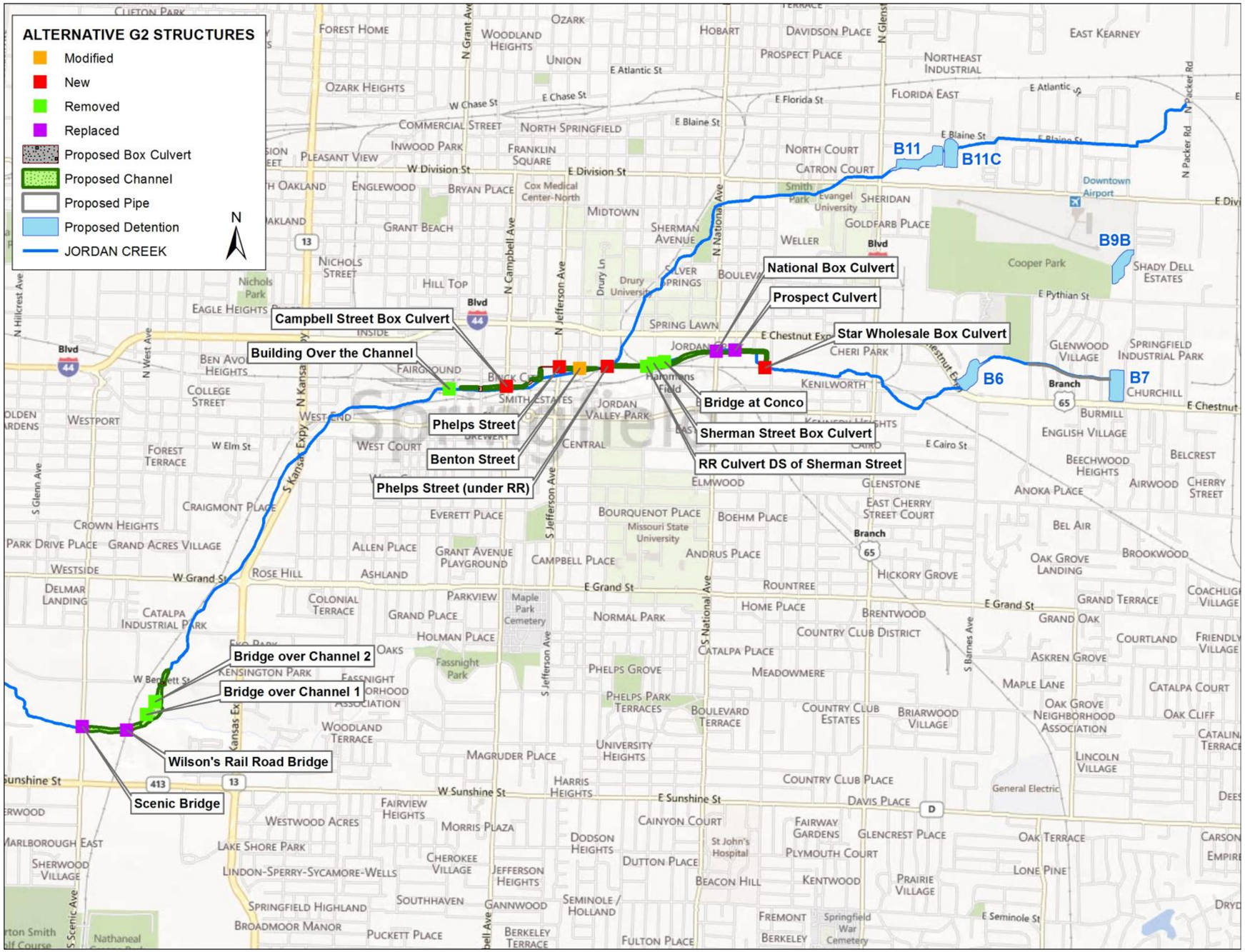

Plate 8: Plan G2

Plate 8: Plan G2

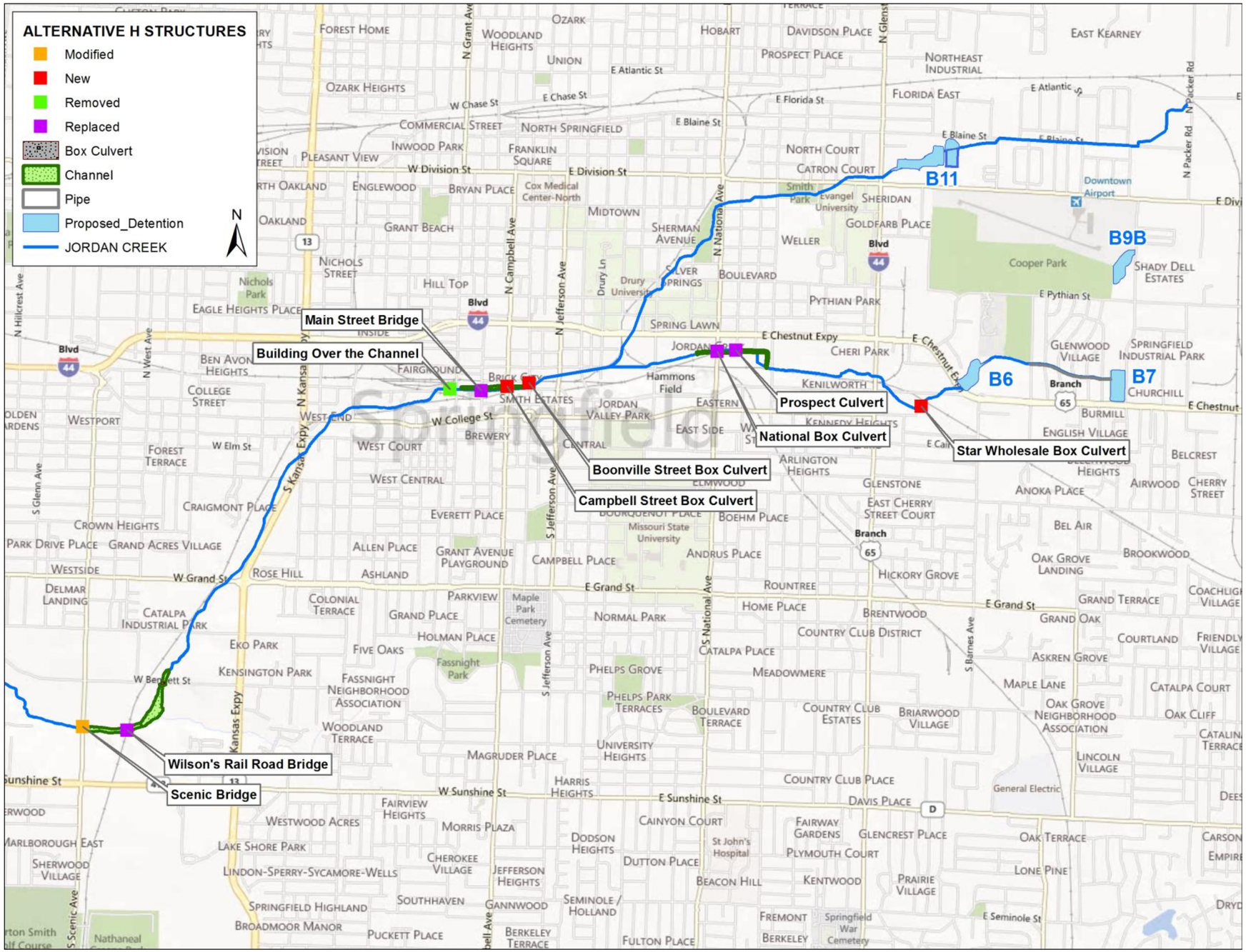

Plate 9: Plan H

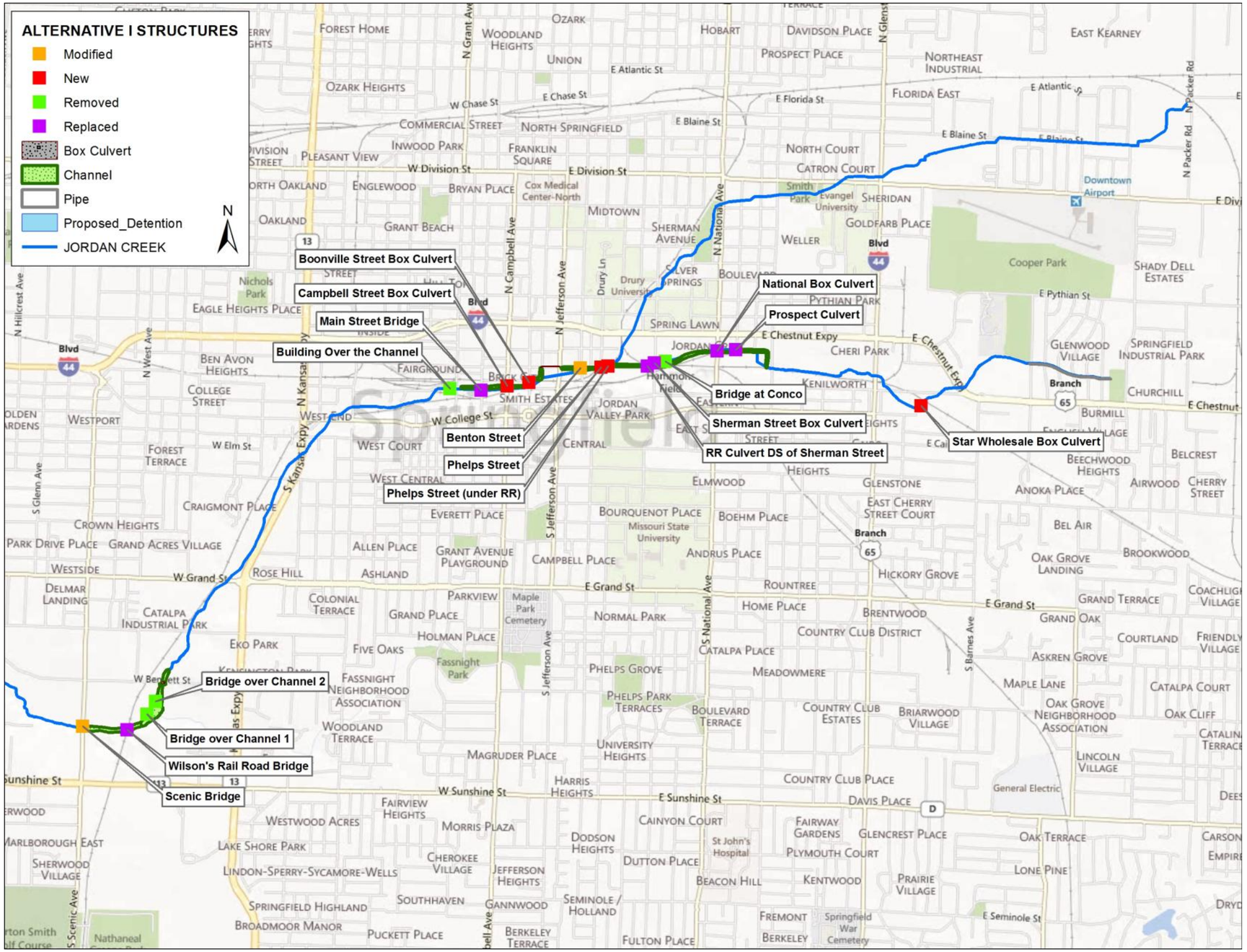

Plate 10: Plan I

Plate 10: Plan I

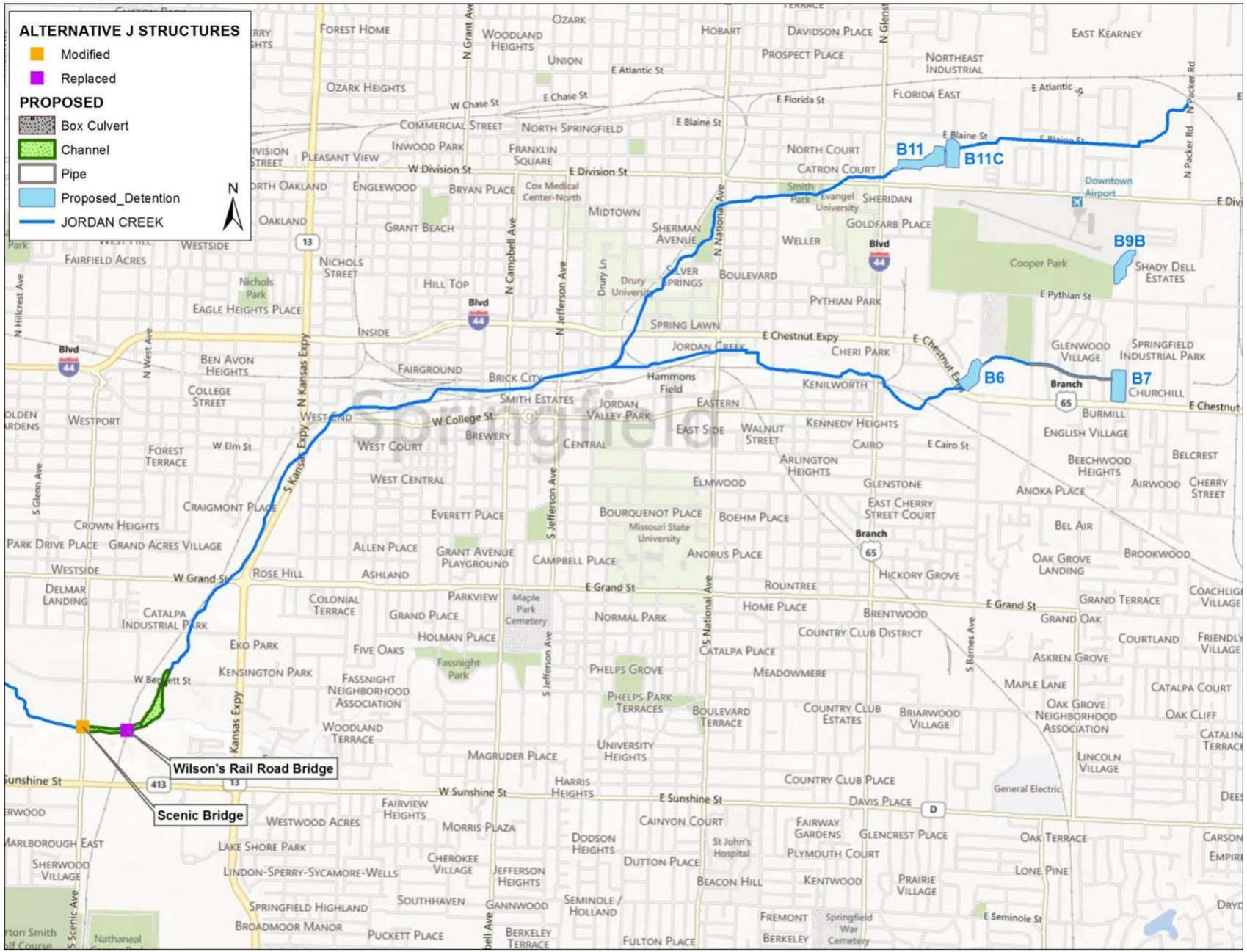

Plate 11: Plan J

Plate 11: Plan J