US Army Corps of Engineers®
Little Rock District

JORDAN CREEK FLOOD RISK MANAGEMENT STUDY

SPRINGFIELD, MISSOURI

FINAL FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT

May 2013

(Revised December 2013)

Written in Conjunction with:

CITY of SPRINGFIELD

Page intentionally left blank

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.

4 Sep 2013
Date

Courtney W. Paul
Colonel, Corps of Engineers
District Engineer

This page was intentionally left blank.

Addendum 1 to Jordan Creek Flood Risk Management Study, Springfield, Missouri, dated May 2013

Compliance with Executive Order 11988 – Floodplain Management

1. Purpose. This addendum summarizes the information from the Jordan Creek Flood Risk Management Study Report that demonstrates compliance with EO 11988 and adequate evaluation of public safety. The only revision to the May 2013 Feasibility Report is this addendum.

2. References.

a. Executive Order (EO) 11988, Floodplain Management, May 24, 1977.

b. Water Resources Council, Floodplain Management Guidelines for Implementing E.O. 11988, February 10, 1978 (43 FR 6030).

c. ER 1165-2-26, Implementation of Executive Order 11988 on Flood Plain Management, March 30, 1984.

3. Compliance

The US Army Corps of Engineers in cooperation with the City of Springfield Missouri conducted a study to determine the feasibility of reducing flood risk along Jordan Creek in Springfield, Missouri. The Jordan Creek Flood Risk Management Study, Springfield, Missouri dated May 2013, documents the results of that analysis. To comply with EO 11988, the policy of USACE is to formulate projects that, to the extent possible, avoid or minimize adverse effects associated with use of the flood plain and avoid inducing development in the flood plain unless there is no practicable alternative. As a flood damage risk reduction project, modification of the flood plain cannot be avoided while achieving project objectives. A number of non-structural measures were evaluated during the feasibility phase of this study, which would have reduced flood damages; however, these measures either did not satisfactorily meet planning criteria or were cost prohibitive.

The Jordan Creek study team recognized the objectives of EO 11988 and used the principles from ER 1165-2-26 in plan formulation for alternatives to reduce flood risks in the Jordan Creek flood plain. Executive Order 11988, Flood Plain Management, signed 24 May 1977, has an objective to avoid long- and short-term adverse impacts associated with the occupancy and modification of the base flood plain and the avoidance of direct and indirect support of development in the base flood plain wherever there is a practicable alternative. Under the Order, the Corps is required to provide leadership and take action to:

- Avoid development in the base flood plain unless it is the only practicable alternative;
- Reduce the hazard and risk associated with floods;
- Minimize the impact of floods on human safety, health and welfare; and
- Restore and preserve the natural and beneficial values of the base flood plain.

According to ER 1165-2-26, there are general procedures that must be followed to assure the project is in compliance with EO 11988. The recommended plan for Jordan Creek, does involve work within the flood plain, but all practical alternatives to avoid impacts to flood plain were evaluated and compared against the recommended plan. The creation of detention ponds will improve the groundwater recharge, a flood plain value. Section 3.2 discusses the management measures evaluated to reduce flooding. Measures such as removing structures from the flood plain would improve natural flood plain values and return the flood plain to a more natural condition. Unfortunately, this alternative did not have net positive benefits, see 3.3.1.3. It is important to note, that the City of Springfield has programs already in place to remove structures from the flood plain and improve flood plain values such as water quality maintenance with vegetation along the floodway and returning the natural meanders.

Additionally, through implementation of the NEPA process the report documents consideration of measures which would avoid adverse impacts to flood plain, minimization of impacts on the human environment resulting from flooding, and restoration of flood plain functions where possible. The Proposed Action is in compliance with EO 11988, Flood Plain Management.

A. Executive Order 11988

EO 11988 requires Federal agencies to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of flood plain development wherever there is a practicable alternative. In accomplishing this objective, "each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities." The Water Resources Council Flood plain Management Guidelines for implementation of EO 11988, as referenced in USACE ER

1165-2-26, require an eight-step process that agencies should carry out as part of their decision-making on projects that have potential impacts to or within the flood plain. The eight steps reflect the decision-making process required in Section 2(a) of the EO. The eight steps and responses to them are summarized below.

1. Determine if the proposed action is in the base flood plain.

Flooding along Jordan Creek is flashy. The six mile stretch of the creek investigated starts at North and South Branch of Jordan Creek in the upstream end of the floodplain. The branches come together to form Jordan Creek. At the downstream limit of the study area, Jordan Creek converges with Fassnight Creek to form Wilson's Creek. All the reaches have a moderate slope, from upstream to downstream and towards the creek bottom. Thus, maximum flood depths can be reached within hours of an event starting. Time to peak flood height for a critical 1-hour storm is 30 minutes. The channel is confined with numerous crossings that during flood events cause the channel capacity to be frequently exceeded. The resulting overland flows damage property and cause a safety risk. The city developed along its creeks so there is considerable infrastructure subject to flooding to include industries, commercial enterprises, railroads, and even colleges. During the flood of July 2000 (a 2% to 1% ACE event) floodwaters were 4 to 6 feet deep in some places and swept through structures.

Chestnut Expressway, a major east-west thoroughfare, was underwater and vehicles were trapped in the floodwater (including a City truck). However, the loss of life from a capacity exceedance or a structural failure is very low because the floodplain width is narrow with many evacuation routes. At Fort Street, the 500-yr water surface elevation of Jordan Creek is approximately 6.5 feet greater than the 2-yr water surface elevation. There is little difference in width between the 1/100 and 1/500 ACE floodplains; although at Fort Street the difference in flood heights for these two events is approximately 2 feet. See Figure 3-6 for the inundation map and Section 3.6.3 regarding failure of the project.

The project is entirely located in the 100-year flood plain. The proposed project consists of detention ponds upstream on the North and South Branches of Jordan Creek and a channel widening in the downstream Reach 1 on Wilsons Creek. The detention ponds should alleviate some of the flood damages, but most crossings over the channel and adjacent roads will continue to be flooded. The detention ponds will reduce flood heights along Jordan Creek for all the reaches but they will not significantly change the frequency or start of damage or reduce the total number of structures flooded during the 500-yr event. The measures constructed in Reach 1 will virtually eliminate flood damages for the 500-yr event. All of the project effects are located in the flood plain.

The majority of the structures in the floodplain were constructed prior to 1989 when the city of Springfield entered into the NFIP. The City manages flood risk through its stringent storm water protection plan. Development in the flood plain cannot increase the water surface elevation, and first floor elevations must be 2-feet higher than the 100-yr flood plain. When funding and properties become available, the city will purchase to demolish or retrofit properties to meet flood plain regulations. The City also works with EPA on innovative programs to help citizens become aware of where the runoff goes.

The only critical action identified within the 1/500 ACE flood plain is the evacuation route connecting the fire station via Scenic Bridge to the neighborhoods south of Bennett Street in Reach 1. See next item for a fuller description of this action.

2. If the action is in the base flood plain, identify and evaluate practicable alternatives to the action or to location of the action in the base flood plain.

Chapter 3. Plans contains the alternatives analysis. Because of a lack of warning time, buying out and demolishing structures in the flood plain or relocating structures from the flood plain were the only two nonstructural options considered that would not have located the project in the flood plain. Neither option was economically justified; thus there was no practical alternative to locating the activity in the flood plain to meet the federal objective of reducing flood risk.

The recommended NED Plan for Jordan Creek provides protection to critical infrastructure in the 0.2-percent annual chance exceedance (500 year) flood plain. In Reach 1, Bennett St. (located in front of the Archimica plant) and S. Scenic Ave. are currently flooded as described in the report section 2.4.2. The Scenic Bridge is overtopped by the 1/50 ACE and Bennett St. is overtopped by the 1/10 ACE. Scenic Bridge connects the fire station to neighborhoods to the south and Bennett Street to communities to the east. The NED plan will remove S. Scenic Ave. and Bennett St. from the 1/500 ACE flood plain. The NED would also remove the Archemica plant, a chemical processing plant, from the 1/500 ACE flood plain. It produces the chemicals used in the production of Tamiflu. There are numerous roads and bridges that cross the flood plain upstream of Reach 1, but most will continue to be flooded.

The Recommended Plan was evaluated in accordance with Section 308 of WRDA 1990, which requires that structures built in the 100-year flood plain with a first floor elevation less than the 100-year flood elevation not be included in the in the benefit base for justifying Federal flood damage reduction projects. The Recommended Plan does not include the value of structures built in the base flood plain after 1991.

3. If the action must be in the flood plain, advise the general public in the affected area and obtain their views and comments.

Public involvement activities are described in Chapter 6, Public Involvement, Review and Consultation. Public meetings were held at the start of the feasibility study in 2004. The Draft and Final Report were sent out for 30 day reviews with the public, state and federal agencies. There were no comments received from the public on the proposed action.

4. Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial flood plain values. Where actions proposed to be located outside the base flood plain will affect the base flood plain, impacts resulting from these actions should also be identified.

Potential impacts associated with the Recommended Plan are summarized in Chapter 5 of this report. The NED Plan is expected to have no significant adverse impact to the natural and beneficial flood plain values. The flood plain is highly urbanized with numerous concrete channels. In the planning study, the team evaluated opportunities to return natural flow to the flood plain, improve water quality maintenance, and groundwater recharge. In Reach 1, with the channel widening, a low flow channel will be considered in final design to provide sufficient depth of water for fish habitat. Also, work would be on one side of the channel to allow the tree cover to remain on one bank. The NED plan includes detention ponds in the upper reaches that will improve groundwater recharge, a floodplain value. There are no anticipated impacts from the proposed action outside the floodplain. The team and the sponsor also recognize the cultural and forestry resource values of a flood plain. The City's ongoing 'Renew Jordan Creek Project' seeks to return natural and beneficial flood plain values to the system. Over time, as the watershed redevelops, modernized storm water management practices may ease some of the flood peaks, particularly for more frequent storm events. Alternative plans to the proposed action included returning the downtown reaches of the floodplain to a more natural channel design. This alternative was not cost effective.

5. If the action is likely to induce development in the base flood plain, determine if a practicable non-flood plain alternative for the development exists.

The Recommended Plan is not likely to induce development in the base flood plain. Section 3.3.1.1. describes the future without project assumptions. The watershed, based on GIS and ground analysis, is determined to be virtually fully developed under existing conditions. Therefore there is almost no land available for induced growth due to the Recommended Plan. For new development and significant redevelopment, the city has stringent flood plain management regulations. Any new construction must prove that they have zero impact on their neighbors or landowners downstream at any flood event. The city of Springfield has a "Renew Jordan Creek" campaign, in which they are buying businesses within the flood plain and removing them. That land will be used to give the constrained channel of Jordan Creek a more natural appearance, restore flood plain values, and provide recreation benefits. Although this is not part of the federal project, it is part of the comprehensive plan for the Jordan Creek watershed. The City of Springfield also has zoning and land use regulations to further manage growth and prevent further encroachment on the flood plain. However, there are no actions which would occur outside of the flood plain that meaningfully achieve the Federal objective of flood risk reduction.

6. As part of the planning process under the Principles and Guidelines, determine viable methods to minimize any adverse impacts of the action including any likely induced development for which there is no practicable alternative and methods to restore and preserve the natural and beneficial flood plain values. This should include reevaluation of the "no action" alternative.

As stated previously, there is no anticipated induced flooding from the proposed action. The proposed action should slightly improve flood plain values with the addition of detention ponds, widening the channel in Reach 1, and designing to increase flow. Additional measures to minimize adverse impacts include the City's long-term flood plain management plan which will seek to remove additional structures from the flood plain.

7. If the final determination is made that no practicable alternative exists to locating the action in the flood plain, advise the general public in the affected area of the findings.

The Draft Feasibility Report and EA was released for public review between February 4 and March 4, 2013. The Final Feasibility Report and EA were released for public review, along with State and Agency Review in July 2013. There were no comments received from the public.

8. Recommend the plan most responsive to the planning objectives established by the study and consistent with the requirements of the Executive Order.

The objective of the project is to reduce the probability and consequences of flood risk and associated damages in the study area. The project is responsive to the EO 11988 objective of "avoidance, to the extent possible, of long- and short-term adverse impacts associated with the occupancy and modification of the base flood plain, and the avoidance of direct and indirect support of development in the base flood plain wherever there is a practicable alternative" because the proposed features focus on reducing the threat of flooding to the existing urban area, altering a very small footprint within the flood plain. These features would reduce the hazard and risk associated with floods, thereby minimizing both the probability and the consequences of flooding within the urban area, and would preserve the natural and beneficial values of the base flood plain.

B. Residual Risk

1. Vulnerabilities.

Jordan Creek is an urban stream prone to flash flooding with peak flood heights for a critical 1-hour storm occurring within 30 minutes. Existing condition models estimate that flows through the downtown are between 5 to 6 deep with a velocity of about 6 feet per second during the 1/100 annual chance exceedance flood event. Flooding events are quick and unpredictable preventing the City from constructing an effective flood warning system. Road crossings along the creek are inundated during 1/2 ACE flood events. The only critical action identified within the 1/500 ACE flood plain is the evacuation route using Scenic Bridge from the fire station to the neighborhoods south of Bennett Street in Reach 1.

During flood events the city blocks thoroughfares that overpass Jordan Creek. Evacuation can still occur away from the creek, but traffic is limited over the creek. Springfield is located in Greene County, Missouri. The County population in 2010 was approximately 275,000. The population at risk from flooding along Jordan Creek is approximately 1,200. The life loss estimates are zero in the critical action flood plain and throughout the study area (See Section 3.4.5 Loss of Life). The proposed plan reduces the number of affected structures from 162 to 121. These are primarily industrial and commercial structures; only 22% of the structures are residential. As the majority of the floodplain is in commercial and industrial use, it is expected that the majority of the population at risk would be working age. (A flood event could affect their commute or hinder their mobility once at their work place.) The demographic data is in Appendix A: Economic Analysis, Section 2.

Although the proposed alternative reduces 65% of the damages, there is still approximately $30 million in residual damage in a 1/500 ACE event. Residual damages occur due to short warning times and high depths. As previously stated, there is only one critical infrastructure or function within the 1/500 ACE flood plain.

2. Residual Risk.

The Recommended Plan reduces the risk of flooding within the city of Springfield along Jordan Creek. The recommended plan will remove 92 acres from the one- percent annual chance exceedance flood plain. Those acres are concentrated in the industrial area of Reach 1, a completely developed industrial complex. Forty-one of the 162 buildings in the flood plain are removed from the one percent annual chance exceedance flood plain. Again, a large majority of these buildings are in the lower reaches of the watershed. Detention basins in the upper reaches of the Jordan Creek watershed reduce the flood heights along the creek for all storm events.

The majority of the residual risk is in the downtown Springfield area where the recommended plan reduces flood depths by 3 to 6 inches. The effectiveness of the recommended plan is drastically reduced beyond the 1/10 ACE, and the plan does not provide complete protection to the industrial and education centers. High velocities across roadways still exist as residual risk that poses a life loss threat to those who try to cross the inundated roadways. (However, as mentioned previously, the city quickly monitors the road ways and closes roads over the creek to minimize traffic flow into the impassable areas.) The plan does reduce the chance for life loss by removing population from the flood area by reducing the number of structures affected. Section 3.4.4 of the report addresses Risk and Uncertainty.

3. Managing Residual Risk.

In parallel to this joint flood risk management study, the City of Springfield's 'Renew Jordan Creek Project' and the public awareness process associated with it, improved the public's knowledge of function and values of flood plains. The recommended plan reduces flood risk along Jordan Creek. But this report acknowledges residual risk, which will help to prevent further development in the flood plain. See Table 3-15, page 51. Additionally, the City of Springfield has regulations in place to prevent encroachment of development within their flood plain. See Section 2.4.3. For new development and significant redevelopment, the city has stringent flood plain management regulations. Any new construction must prove that they have zero impact on their neighbors or landowners downstream at any flood event.

Springfield's "Renew Jordan Creek" campaign, includes buying businesses within the flood plain and removing them. That land will be used to give the constrained channel of Jordan Creek a more natural appearance, restore flood plain values, and provide recreation benefits. Although this is not part of the federal project, it will be part of the comprehensive plan for the Jordan Creek watershed.

The evacuation route between Scenic Bridge Fire Department and the neighborhoods to the south and communities east of Bennett Street are impacted within the 0.02 percent Exceedance flood plain. The project would allow fire and rescue vehicles to cross the bridge/roadway within the mandatory 5-9 minute response time before the creek rises out of the bank and over the roadway. Half of the structures within the downtown reaches of the Jordan Creek flood plain (R-3 & R-4) would remain within the 0.1 annual chance exceedance flood plain. There were no economically justified alternatives to provide full protection to these routes. There are outbound roads in most locations along the channel such that the channel flooding would not disrupt evacuations. See Section 2.4.2, Flooding by Reach, second paragraph that describes location of fire department and the impacts of the flooding to the community, but it is not described specifically as an evacuation route.

C. Conclusion

The project is in compliance with EO 11988. The Jordan Creek Flood Risk Management Feasibility Report documents the measures and alternatives evaluated during project planning. With a small footprint in the urban flood plain of Jordan Creek, the proposed plan reduces flood risk. The proposed plan does have some improvements to the flood plain values by adding detention in the upper reach and widening channel in the lower reach of the flood plain. There are no anticipated induced flooding impacts. The proposed action minimizes adverse impacts to the flood plain and, where possible, has minor flood plain value improvements. Due to the urban nature of the stream and riparian corridor ecosystem restoration was dropped as a planning objective early in the study, since cost effective habitat restoration was unlikely. Numerous non–structural alternatives were evaluated and channel modification in Plan J and Plan G2 initially identified the use of natural sloped grassed line channels. Although those design considerations proved to be cost prohibitive, the team agreed to coordinate with Missouri Department of Natural Resources and the US Fish and Wildlife Service during post authorization design to create low flow channels and riparian habitat facets more representative of the historic flood plain and stream, where possible. See Section 3.2.3 and response letters to State and Agency Review.

This page was intentionally left blank.

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 at October 2012 price levels of $21,063,000; an annual cost of $1,173,000 [including Operations, Maintenance, Repair, Rehabilitation and Replacement costs (OMRR&R) of $234,000 per year]; annual benefits of $3,029,000; net benefits of $1,856,000; 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.

This page was intentionally left blank.

JORDAN CREEK FLOOD RISK MANAGEMENT STUDY

SPRINGFIELD, MISSOURI

Integrated Feasibility Report and Environmental Assessment

Table of Contents

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

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

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

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

Plates

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

Figures

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

Tables

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

Appendices

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

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.

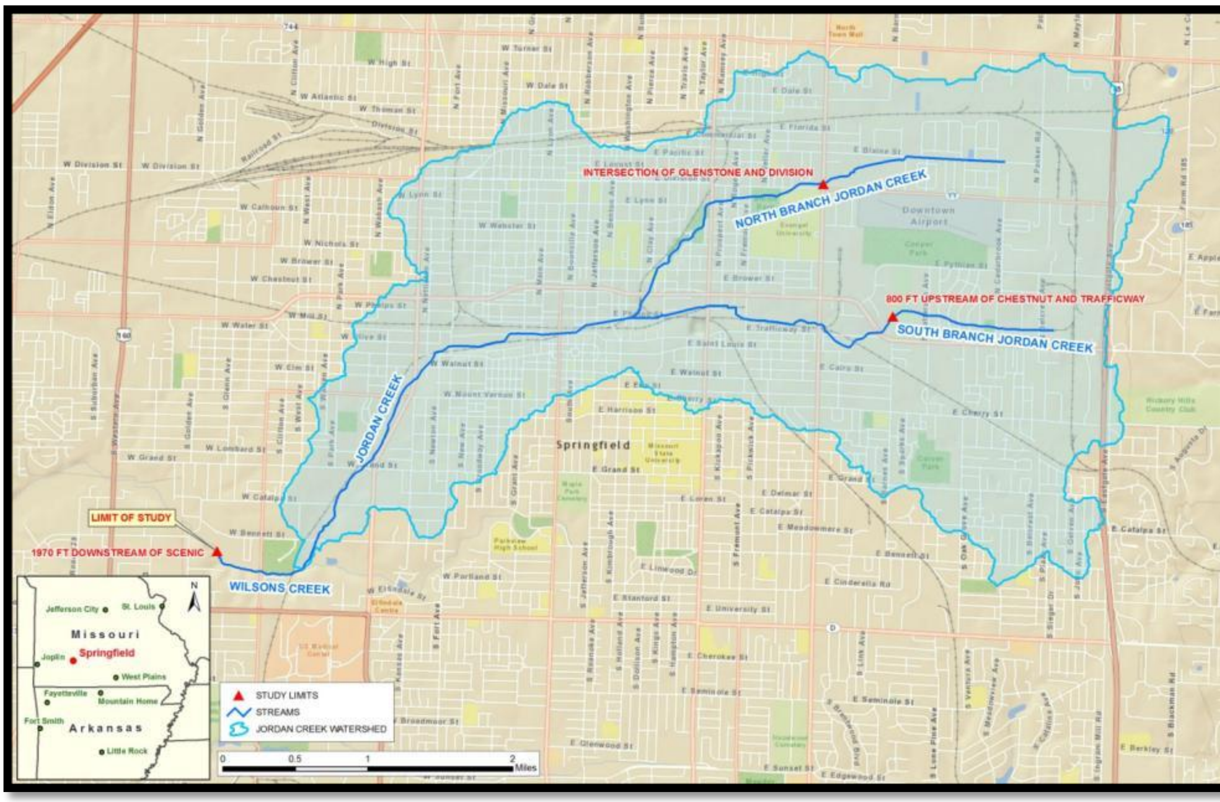


Figure 1-1: Study Location Map

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.

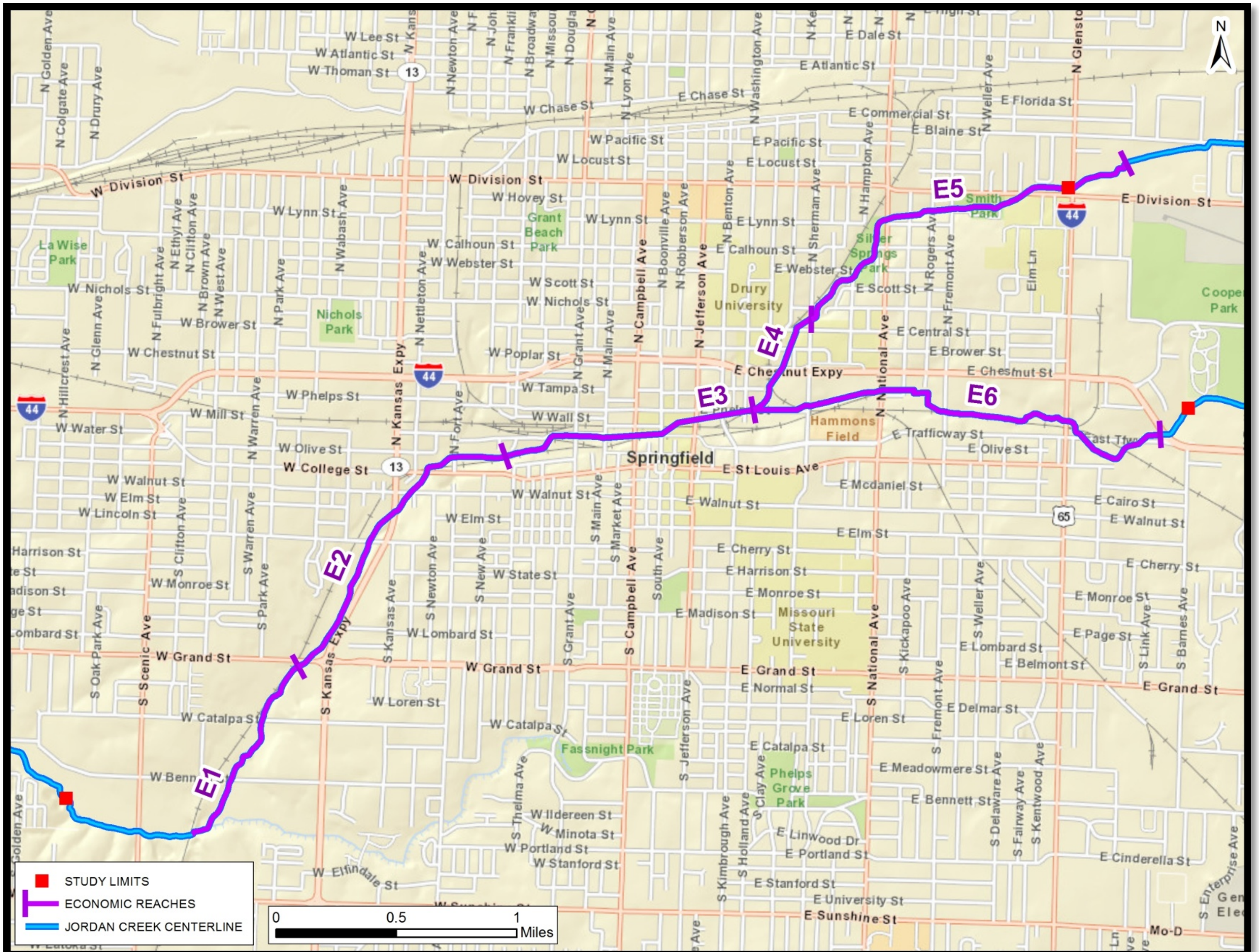


Figure 2-1: Economic Reaches of Jordan Creek

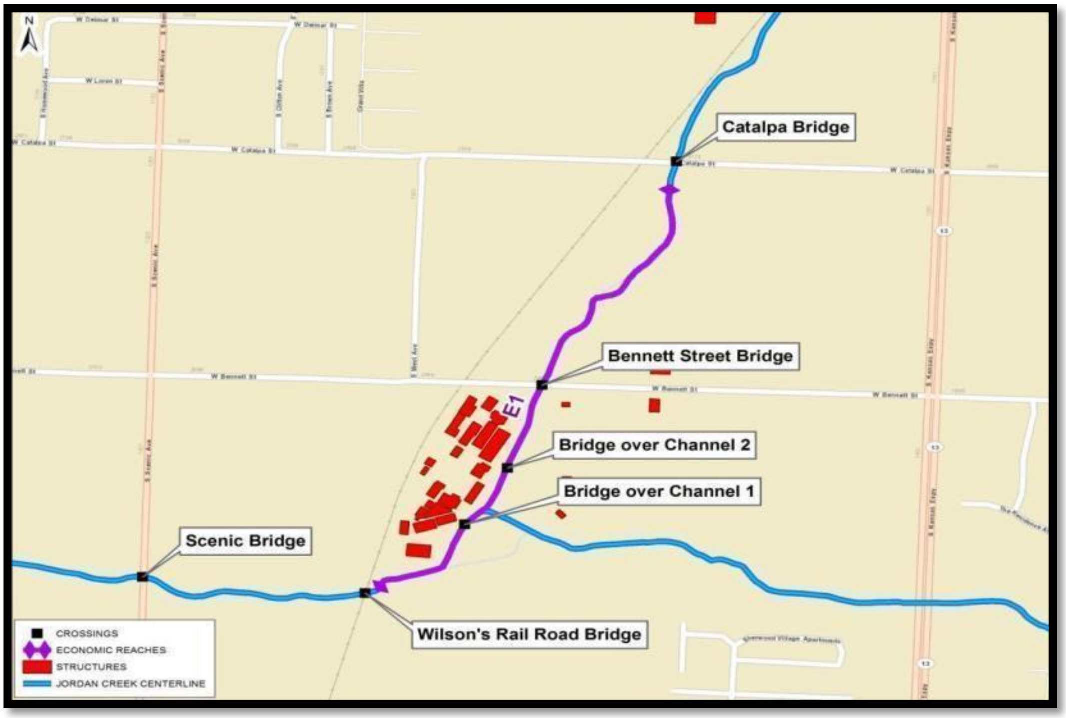


Figure 2-2: Reach E1

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.

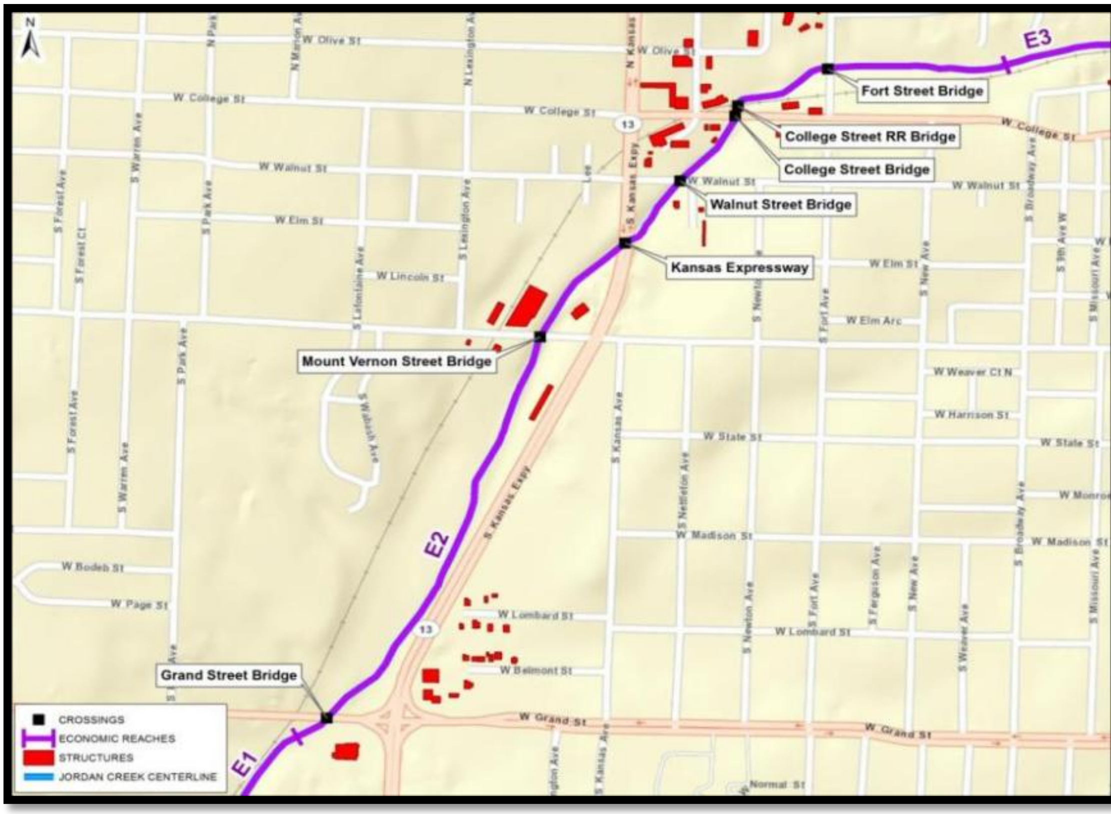


Figure 2-3: Reach E2

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.

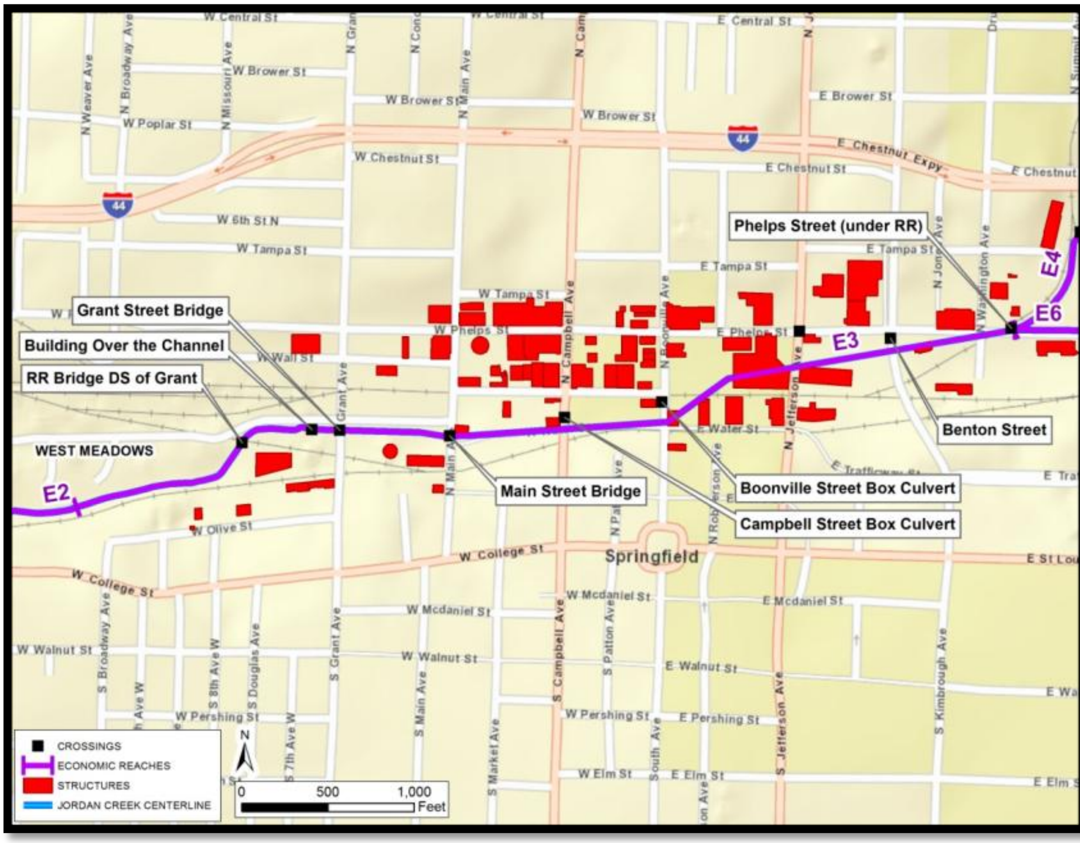


Figure 2-4: Reach E3

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.

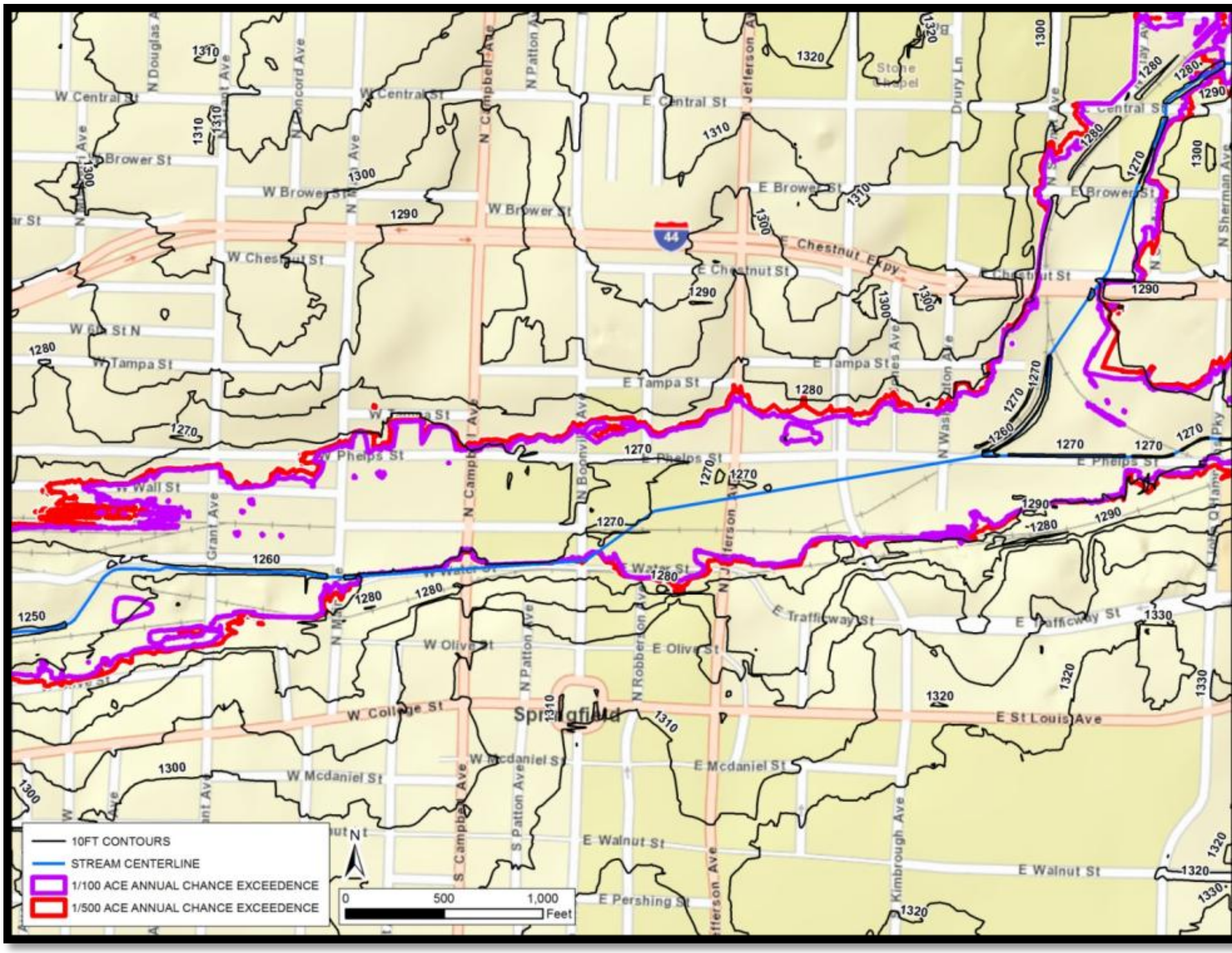


Figure 2-5: Inundation Map in the 1/100 to 1/500 ACE in Reach E3

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.

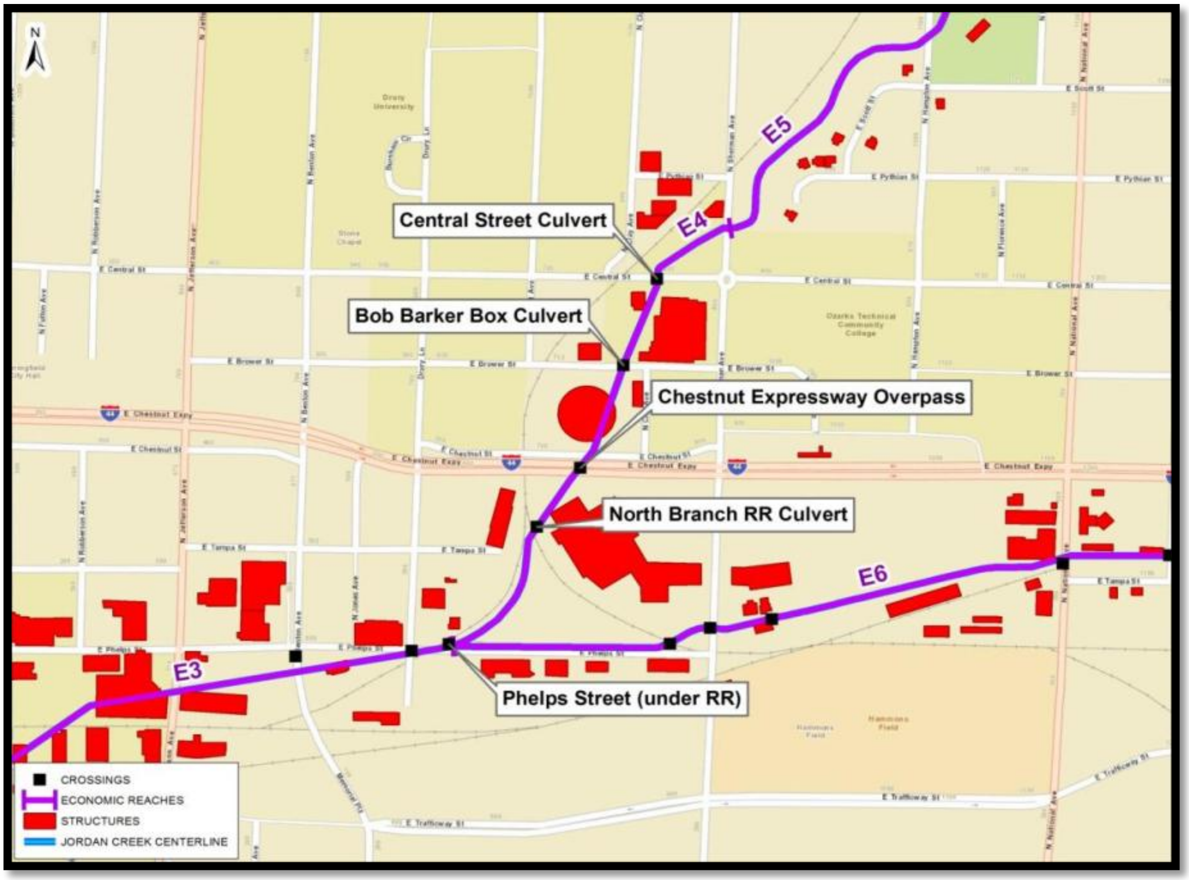


Figure 2-6: Reach E4

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.

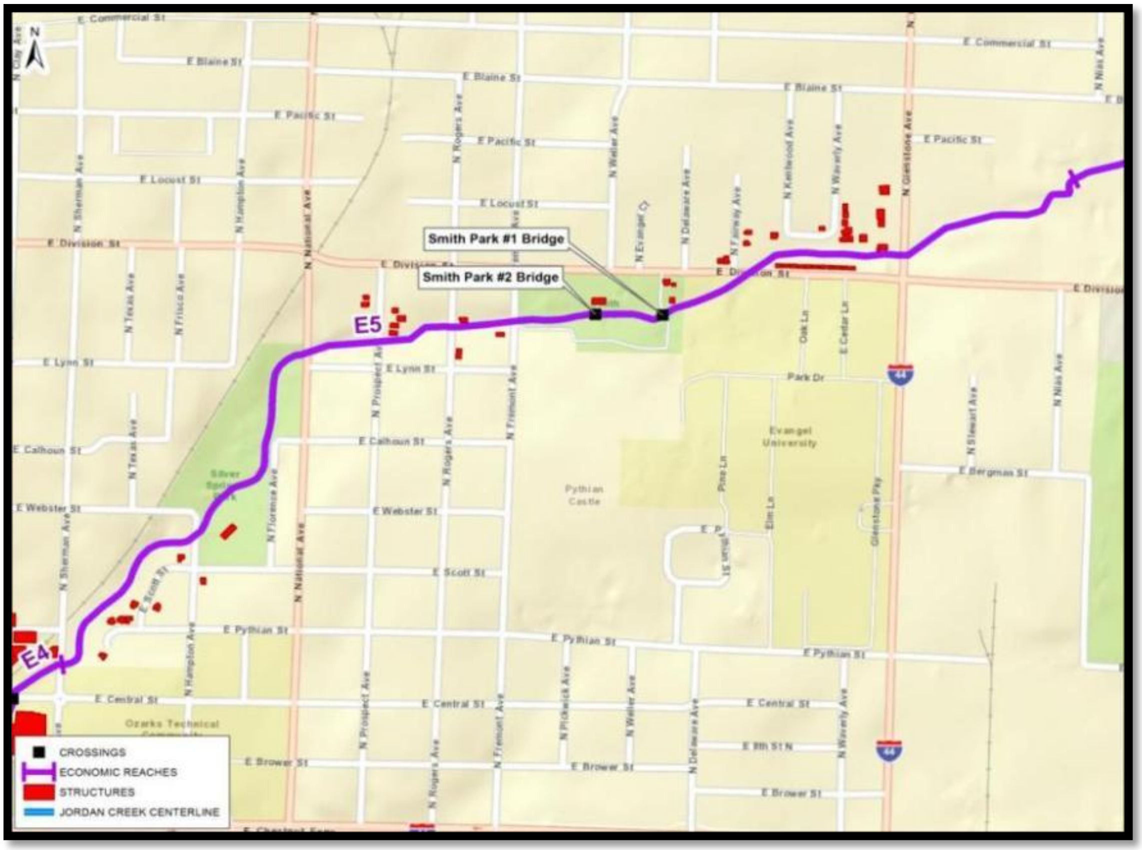


Figure 2-7: Reach E5

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.

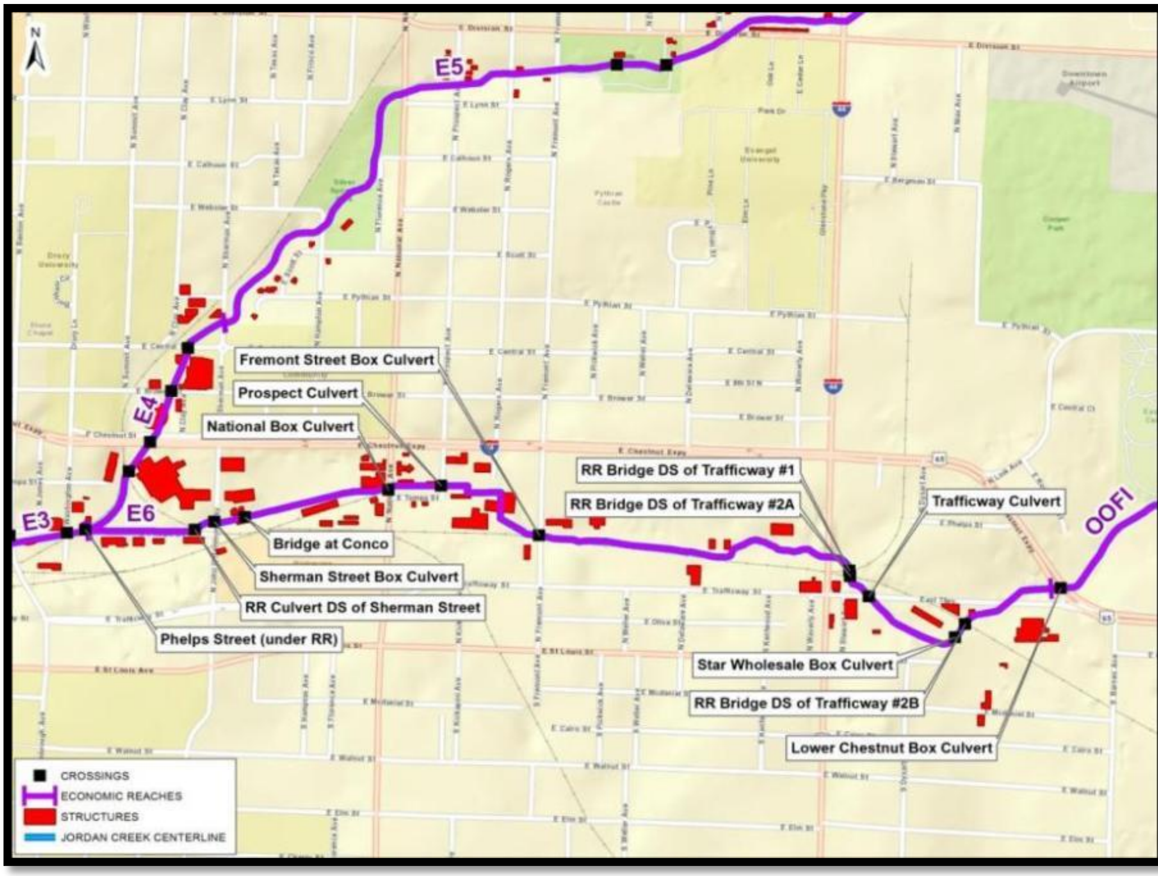


Figure 2-8: Reach E6

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.

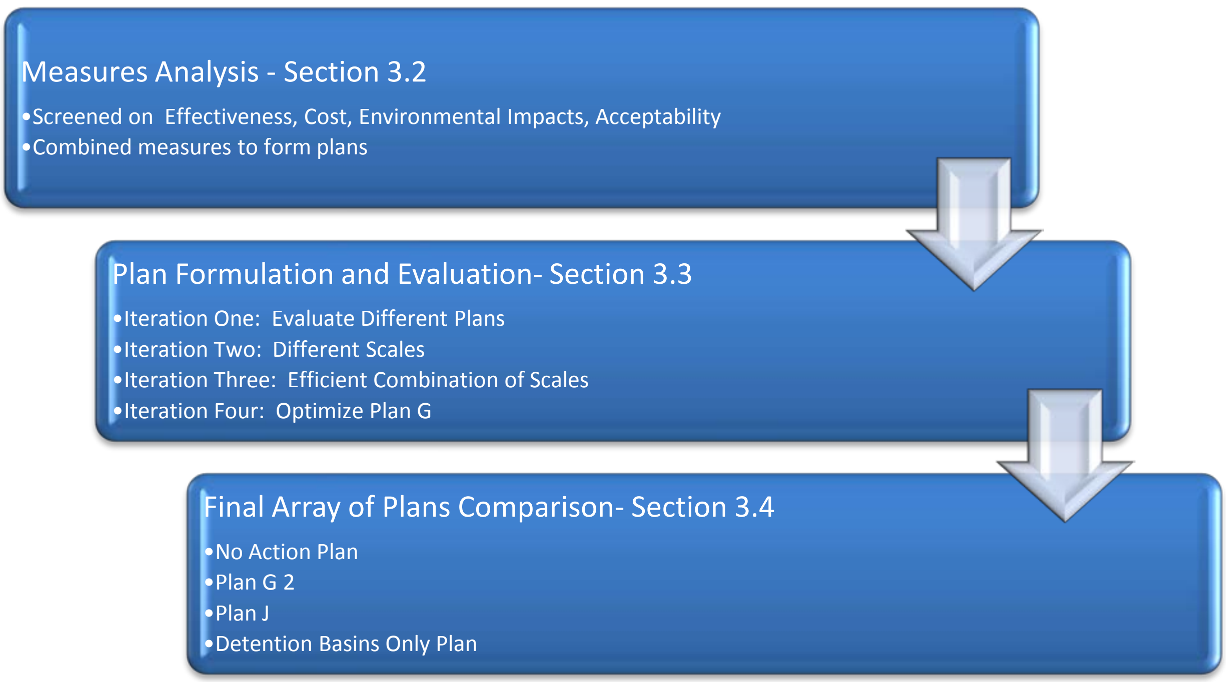


Figure 3-1: Plan Formulation Process

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

This page intentionally left blank

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

This page intentionally left blank

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.

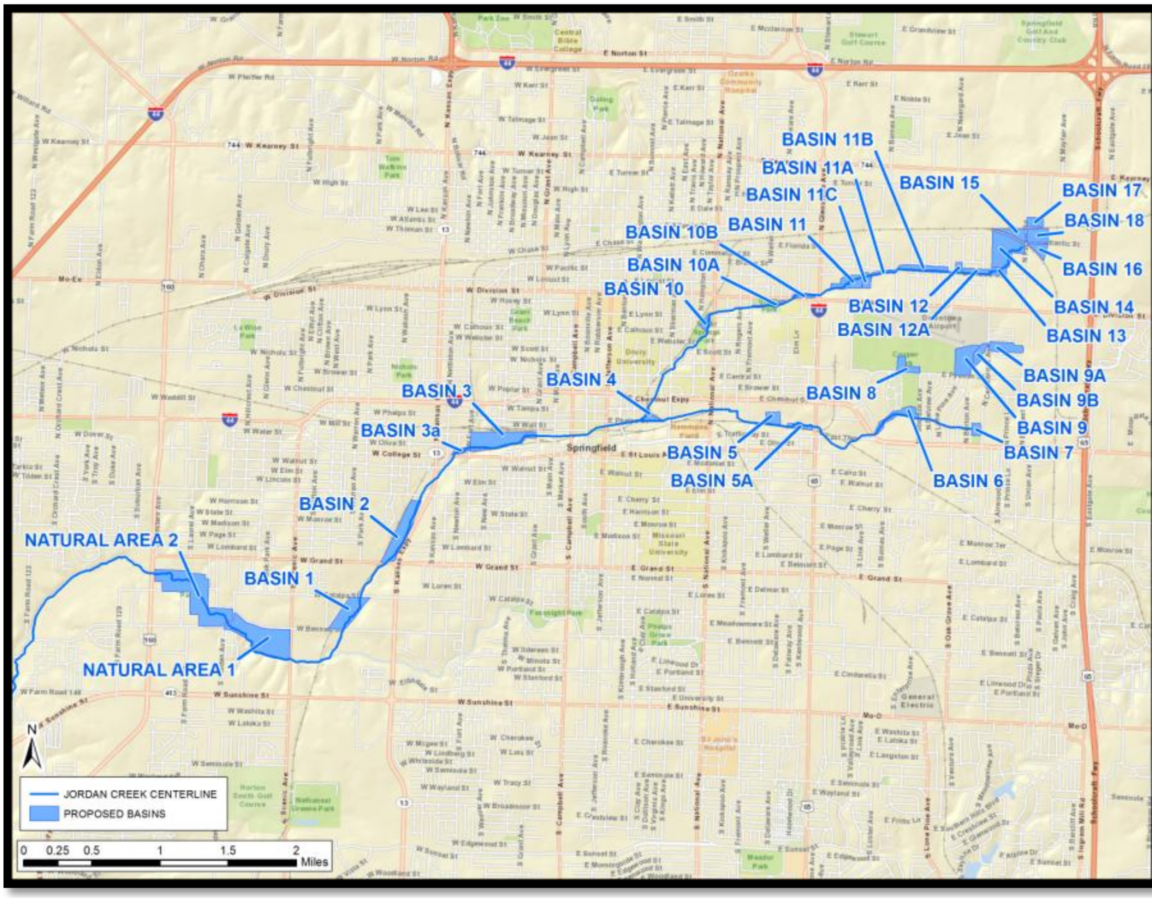


Figure 3-2: Preliminary Regional Detention Basins

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).

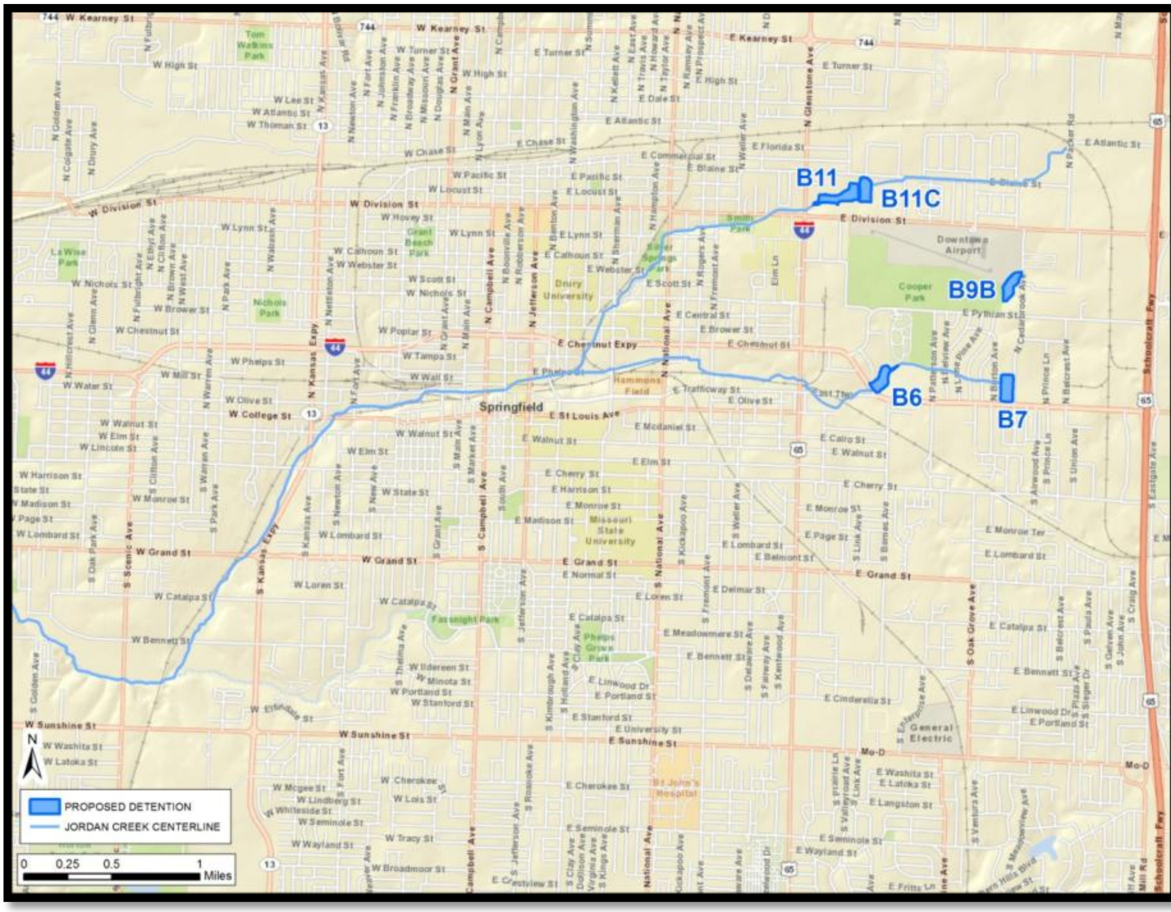


Figure 3-3: Regional Detention Basins (Refined Analysis)

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.

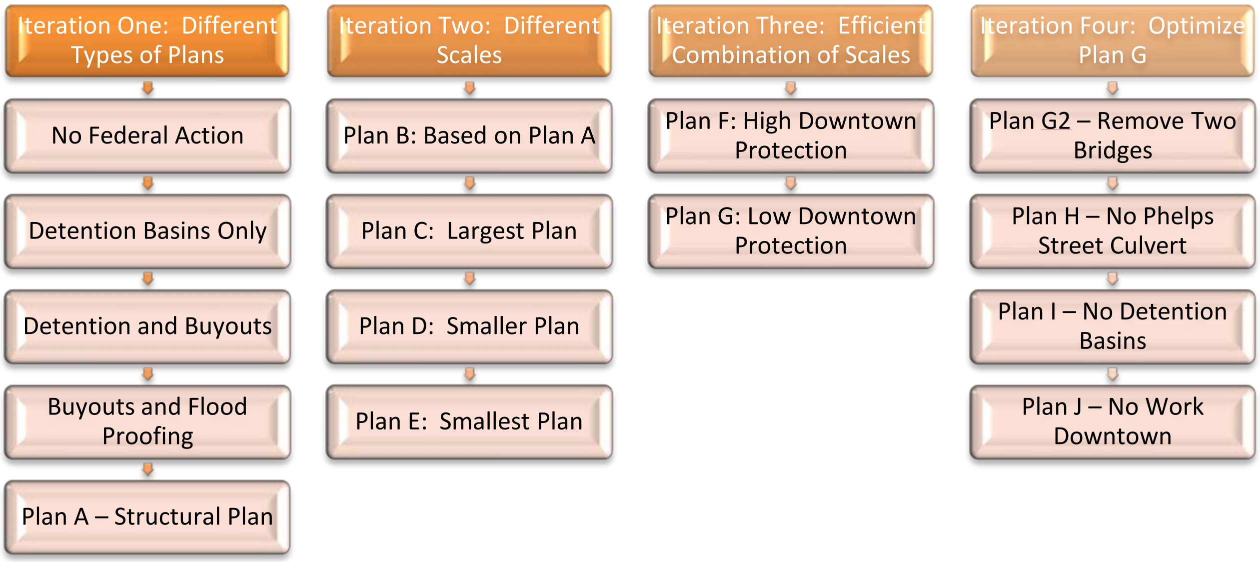


Figure 3-4: Iterations of Plan Formulation

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).

- <u>Currently developed areas would redevelop.</u> 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.
- <u>Improvements would be made on the existing water conveyance system.</u> 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.
- <u>Development within the floodplain would comply with FEMA regulations.</u> 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.

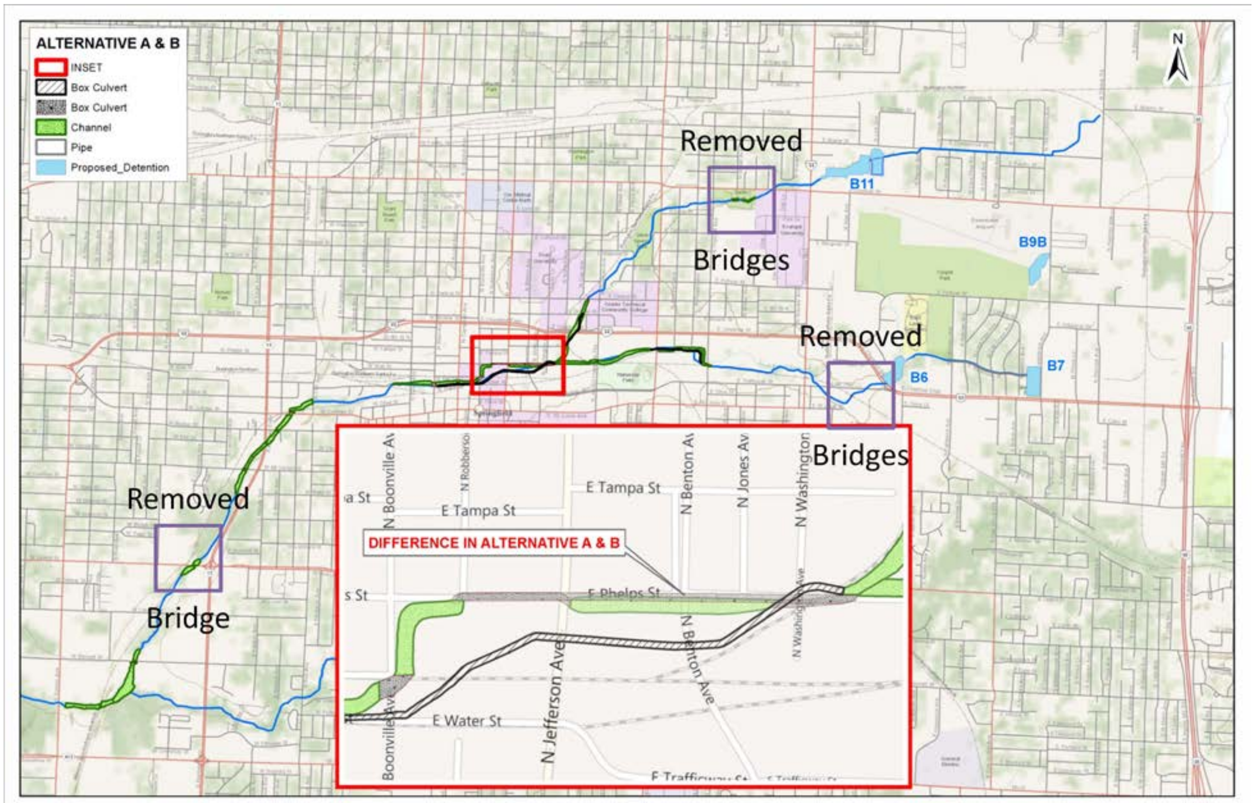


Figure 3-5: Difference between Plan A and Plan B

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 ($)	1,827,000	3,200	(580,200)	9,200	700	(338,400)	921,400
Preliminary First Cost ($)	8,245,600	569,300	25,576,000	339,100	51,200	23,291,800	58,073,000

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 project cost for this plan was $58 million after the costs were updated. 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 ($)	1,752,300	4,800	39,800	3,000	500	55,700	1,856,100
First Cost ($)	9,918,300	569,300	4,781,300	339,100	51,200	5,404,100	21,063,000

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 project cost for this plan was $22 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 at October 2012 price levels 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	$ 234,000
Annualized Cost	$ 3,231,000	$ 1,173,000
Annualized Benefits	$ 4,153,000	$ 3,029,000
BC Calculation	1.3	2.6
Net Benefits	$ 921,000	$ 1,856,000

The total project costs were significantly lower with Plan J. It would deliver 2.6 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 $1,856,000 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	$4.65 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.

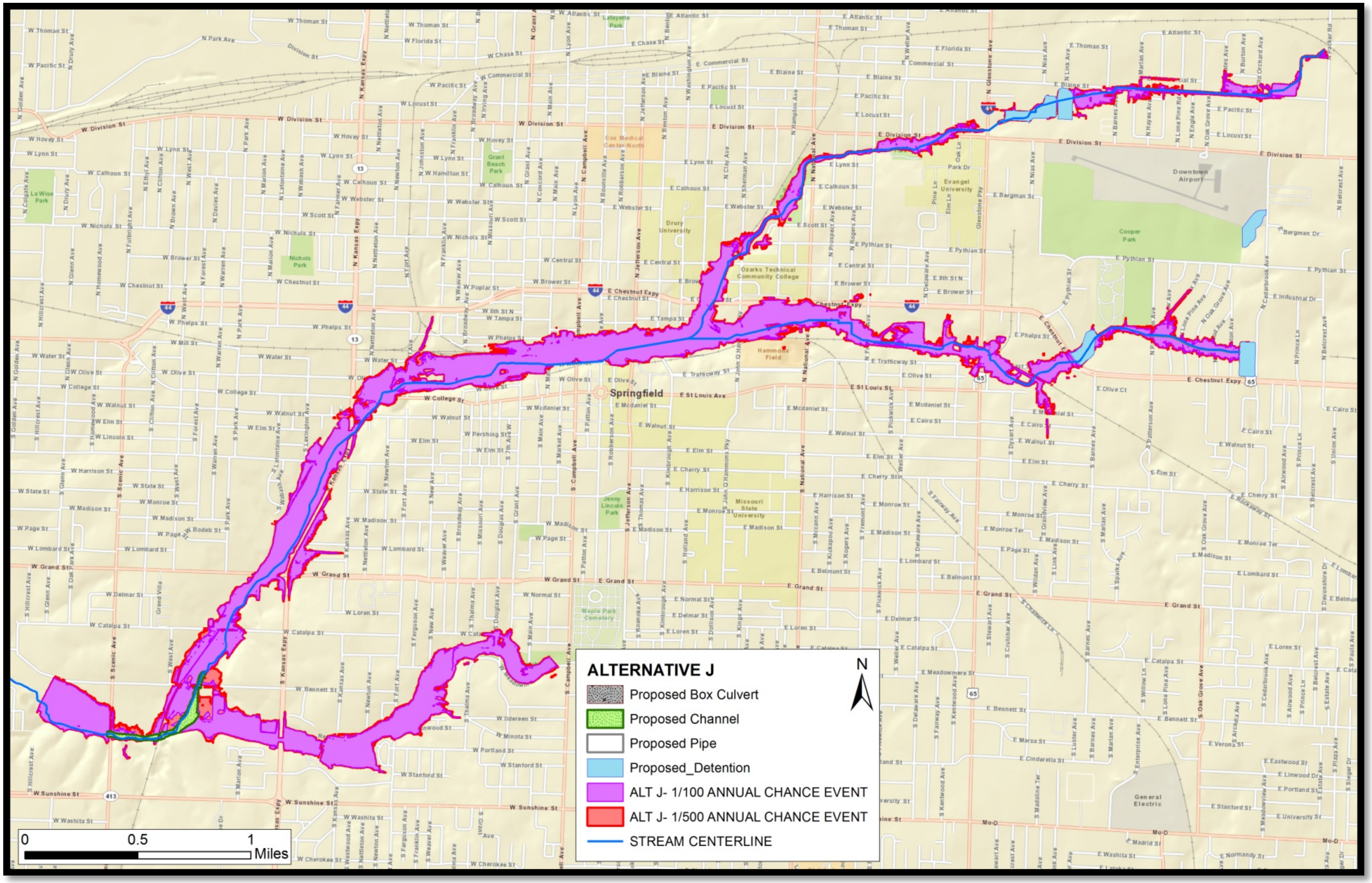


Figure 3-6: Inundation from a 1/100 ACE and a 1/500 ACE with Plan J

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 Plan J's boundary for expected inundation for the 1/100 ACE and the 1/500 ACE. 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 $21,063,000; 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	$584,000	$584,000
Investment Cost	$21,063,000	$21,063,000
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 $735,800 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 using October 2012 price levels. This cost included the contingency from the Cost Schedule Risk Analysis.

Table 3-20: Cost Apportionment

		Non-Federal Sponsor Contribution (Total Project Cost)	Federal Contribution (Total Project Cost)	Non-Federal Sponsor Contribution (Project First Cost)	Federal Contribution (Project First Cost)
LERRD		$ 6,470,000		$6,220,000	
	Lands	$4,517,000		$4,360,000	
	Relocations	$1,953,000		$1,860,000	
Cash		$1,186,000		$1,024,000	
	Min 5%	$1,094,000		$1,024,000	
	Additional Cash Required.	$92,000		$0	
Total		$ 7,656,000	$14,217,450	$7,240,000	$13,239,000
Cost Share		35%	65%	35.4%	64.6%

3.7.3 Fully Funded Cost Estimate

Table 3-21 is the fully funded cost estimate using October 2012 price levels 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.

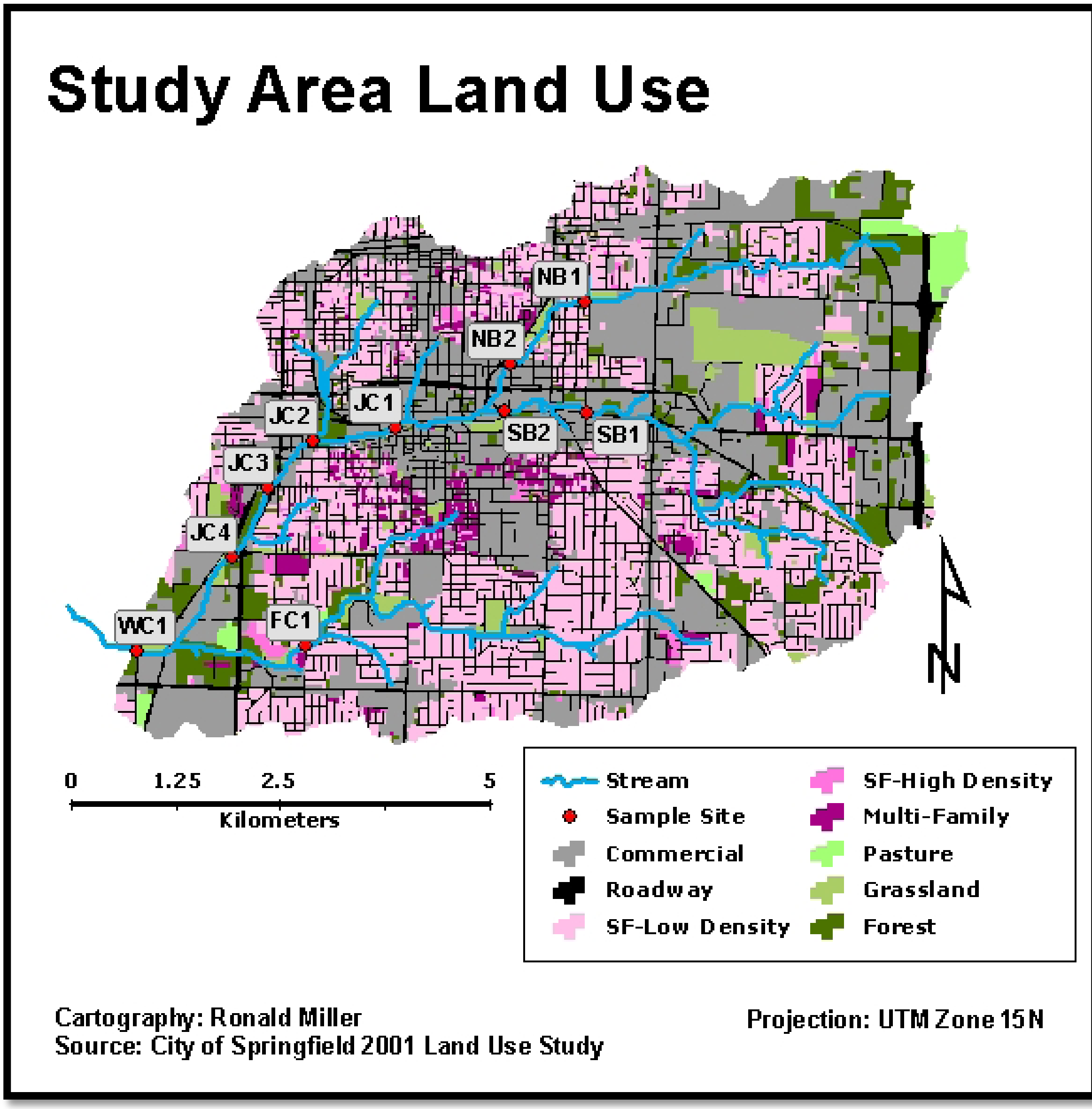


Figure 4-2: Land Use Map

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.

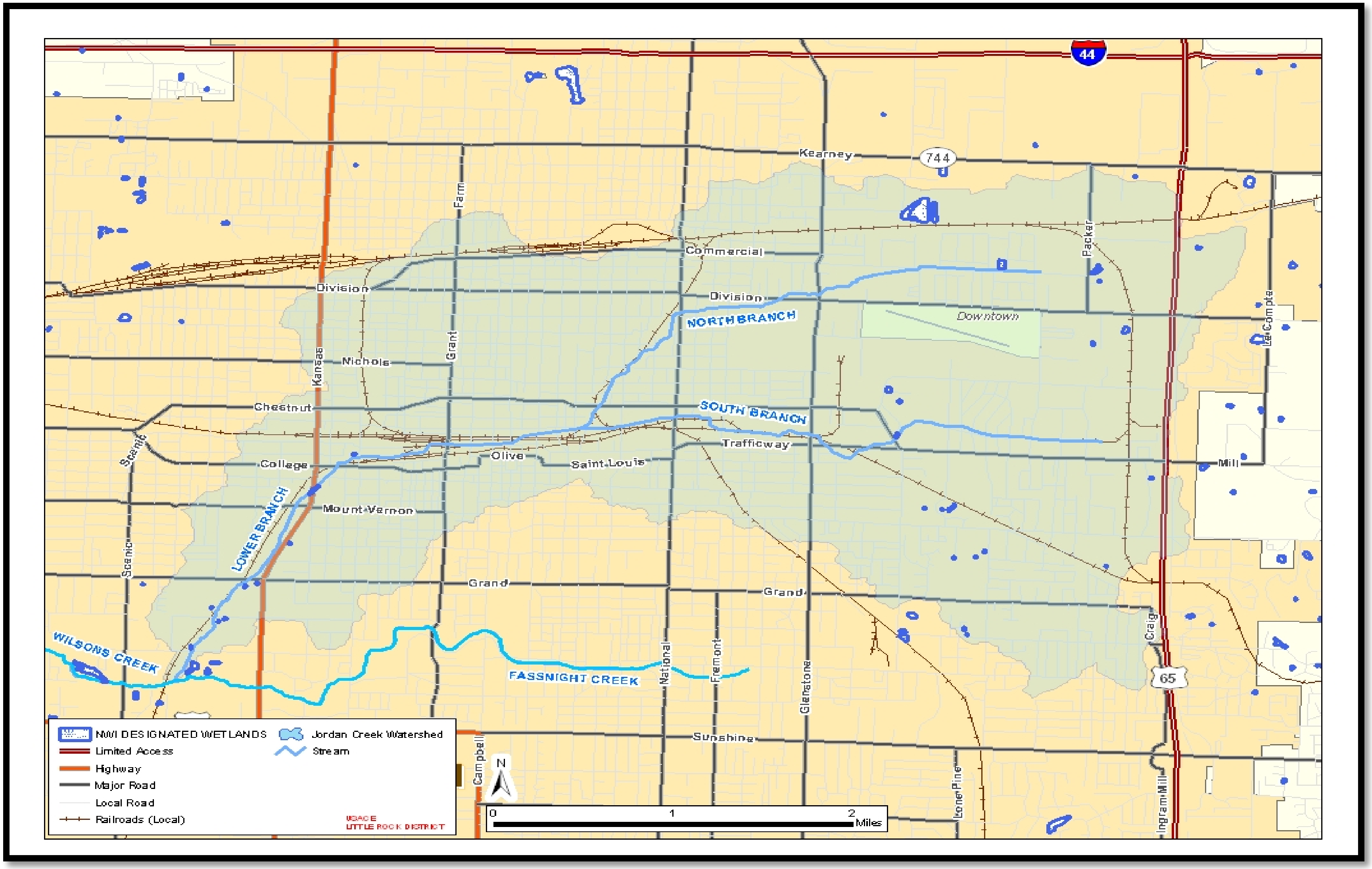


Figure 4-3: National Wetland Inventory Wetland Distribution

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.

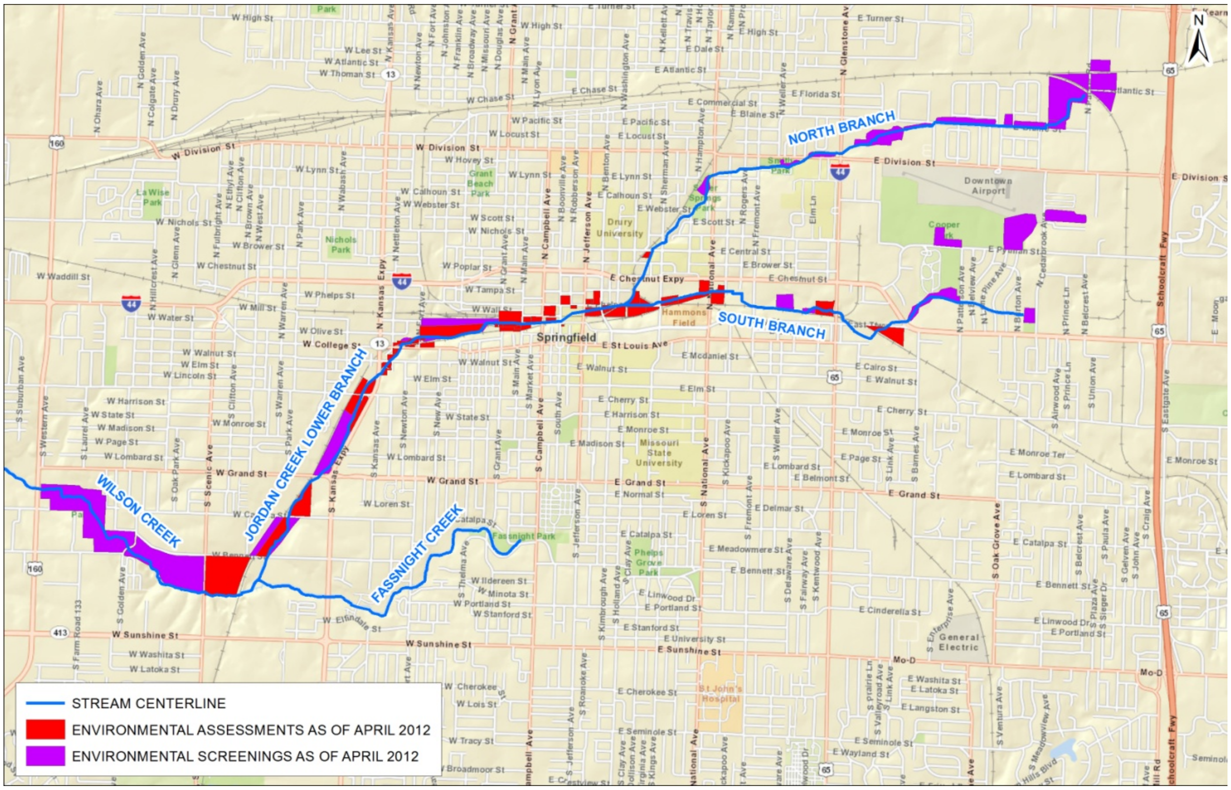


Figure 4-4: HTRW Assessment Areas

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.

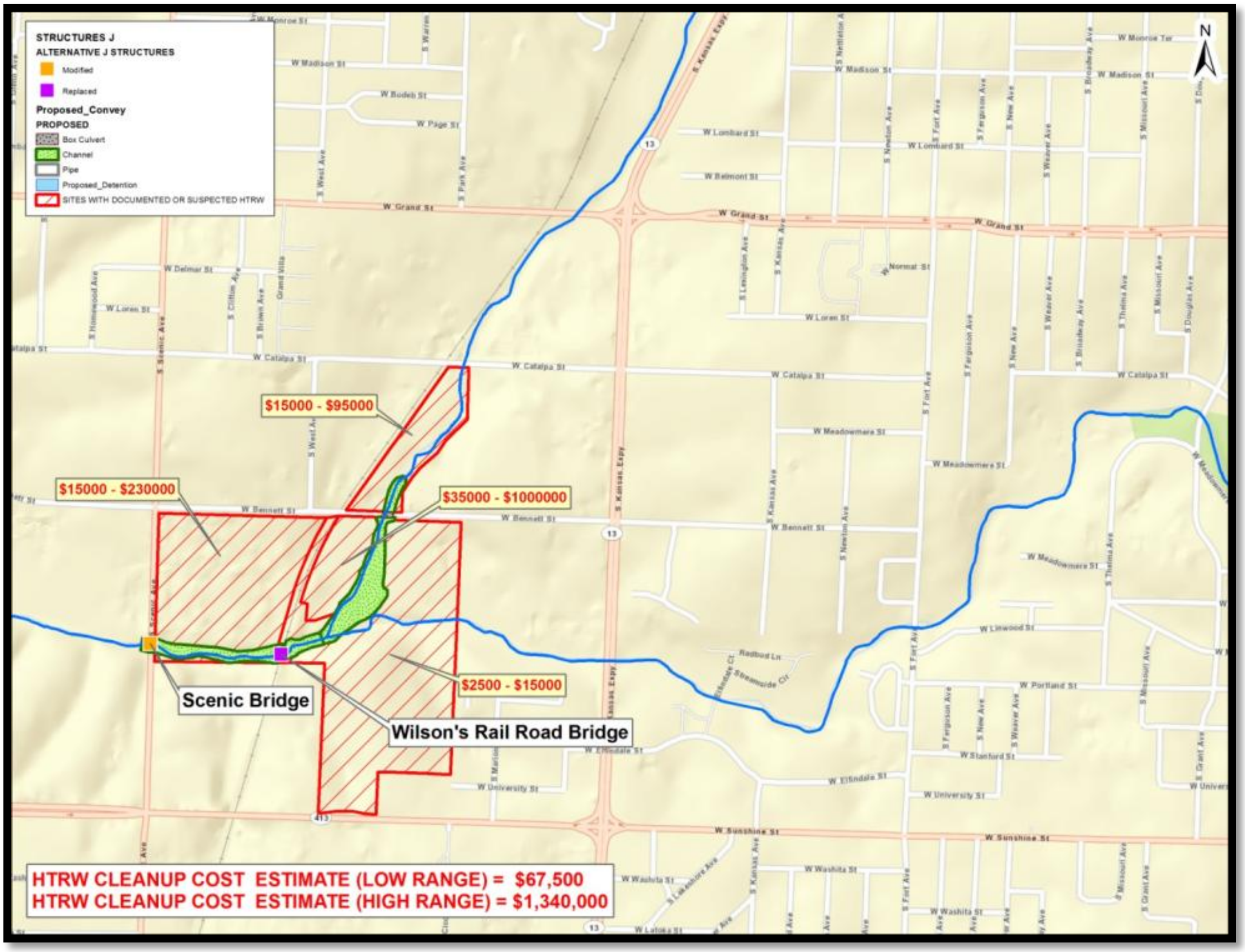


Figure 5-1: Plan J Cost Ranges for HTRW Remediation

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.

.

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 at October 2012 price levels 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 the required non-Federal share 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 construction, a contribution of funds equal to 5 percent of total flood risk management costs;

(3) 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;

(4) Provide, during construction, any additional funds necessary to make its total contribution for flood risk management equal to at least 35 percent of total flood risk management costs;

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

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

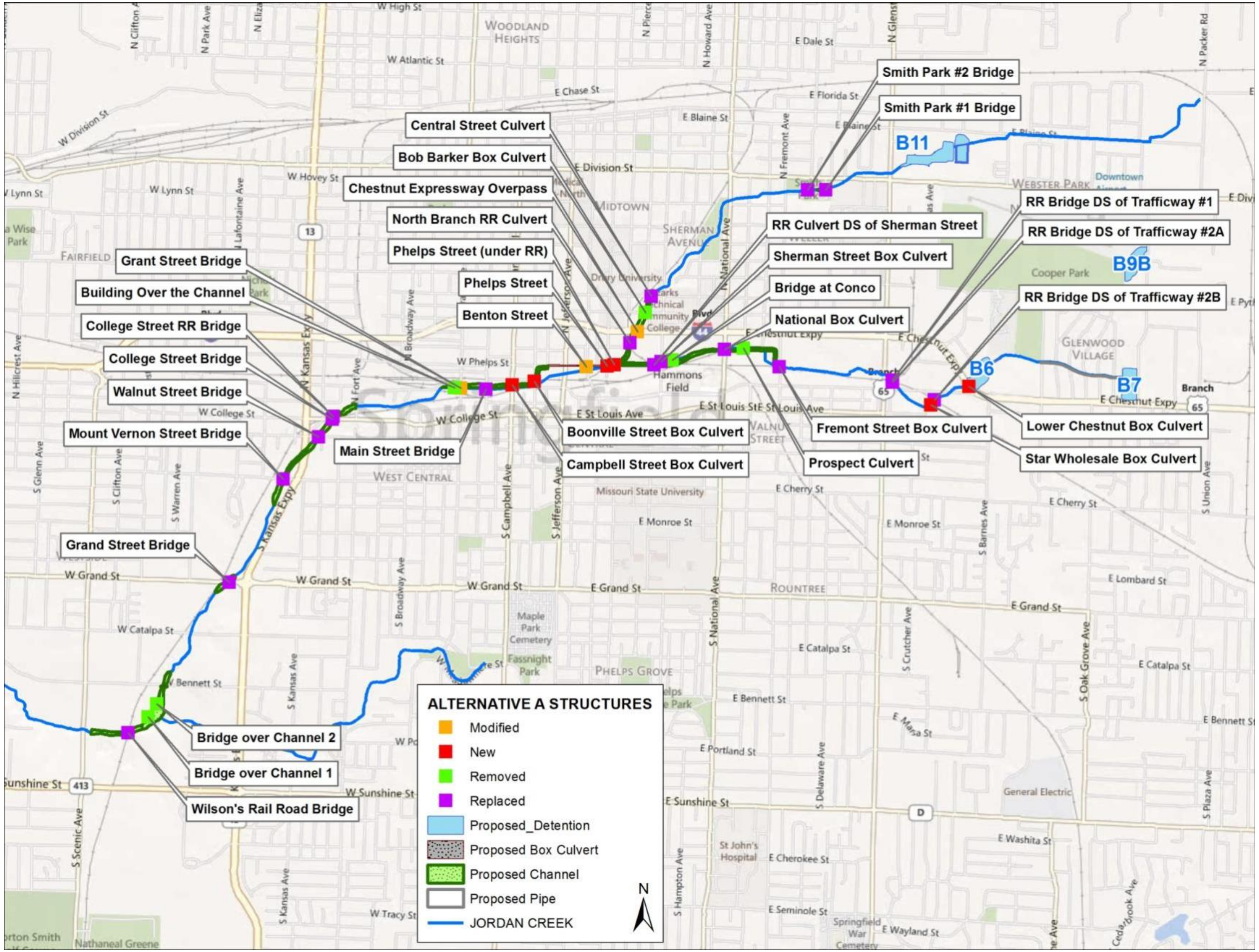


Plate 1: Plan A

Plate 1: Plan A

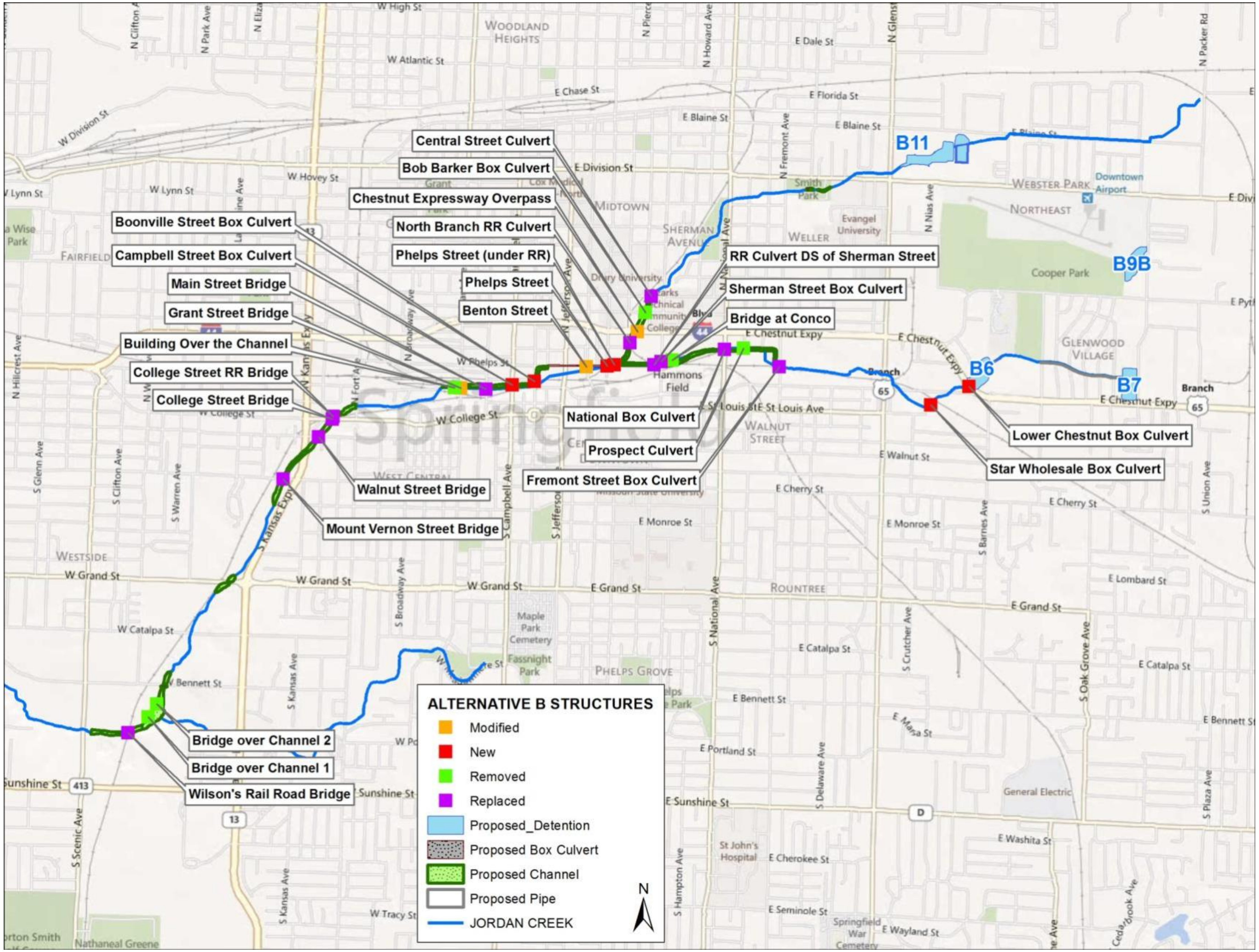


Plate 2: Plan B

Plate 2: Plan B

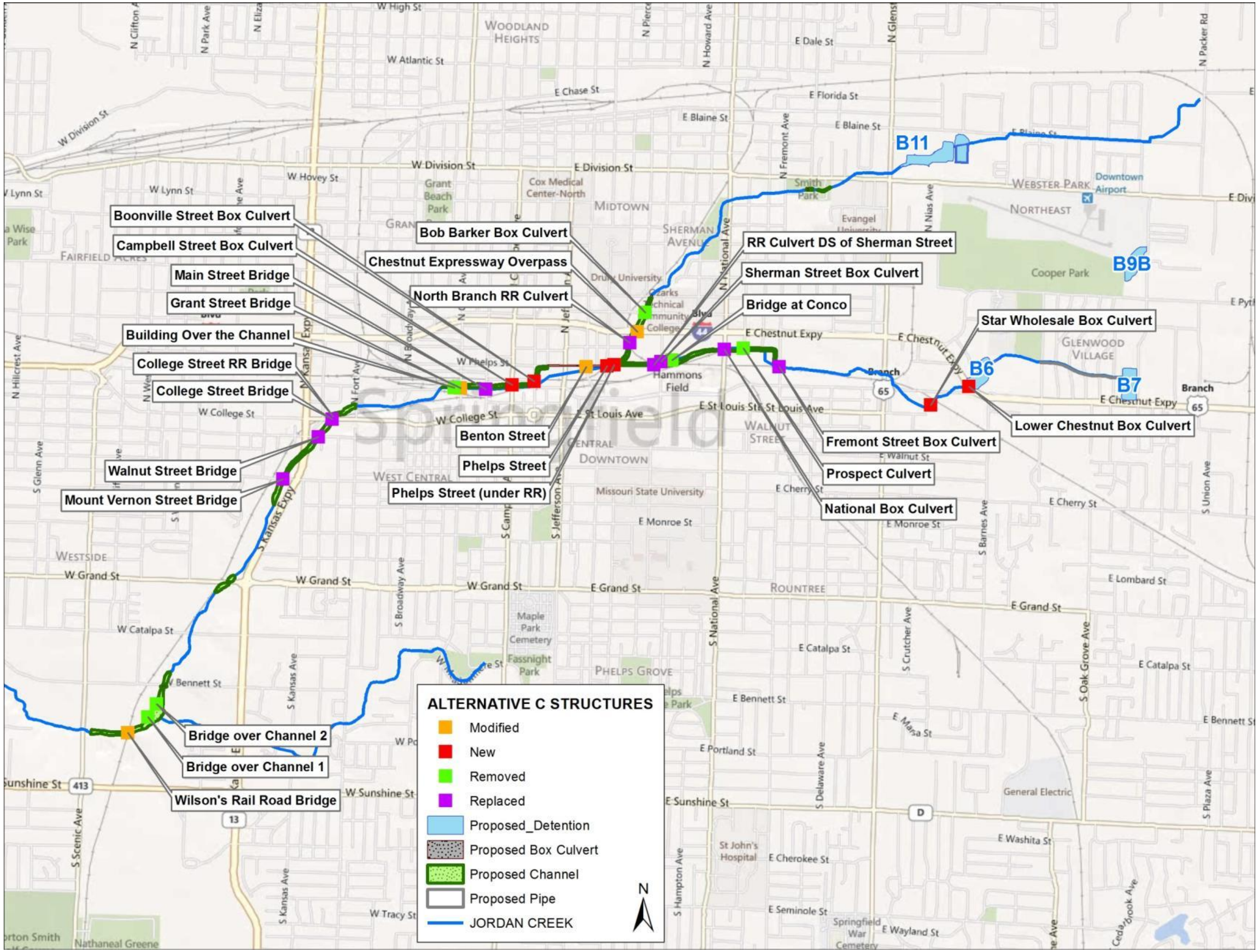


Plate 3: Plan C

Plate 3: Plan C

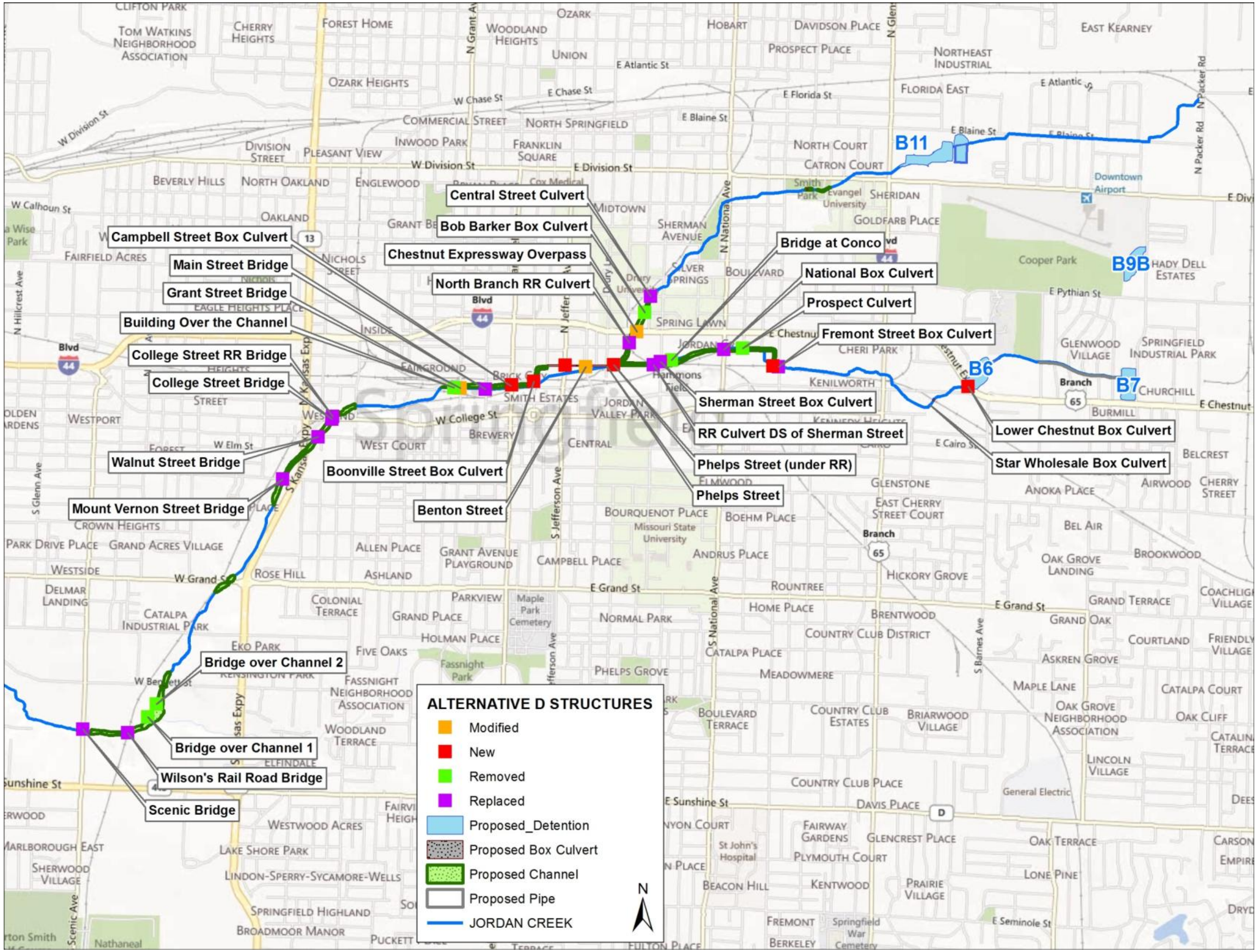


Plate 4: Plan D

Plate 4: Plan D

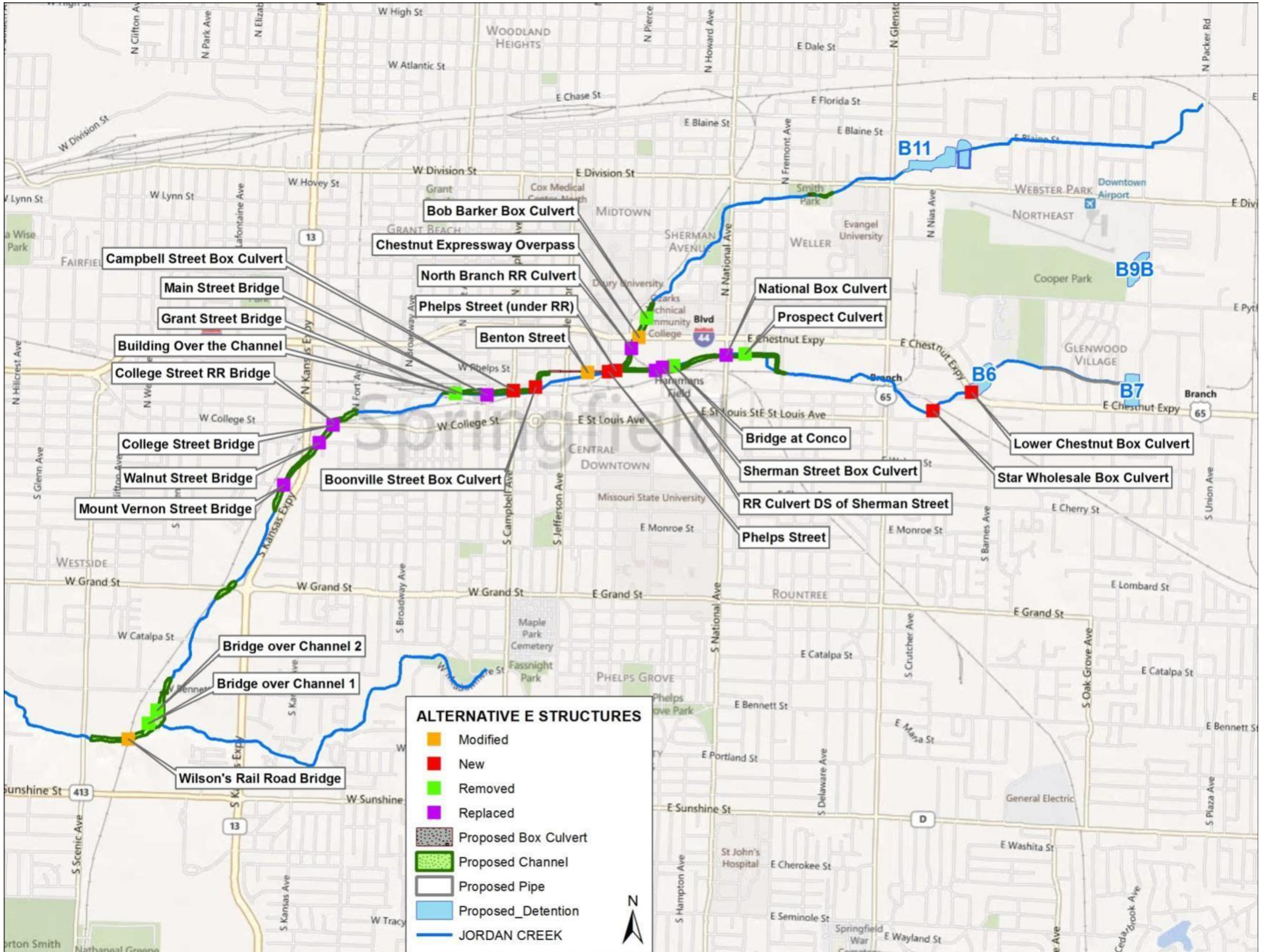


Plate 5: Plan E

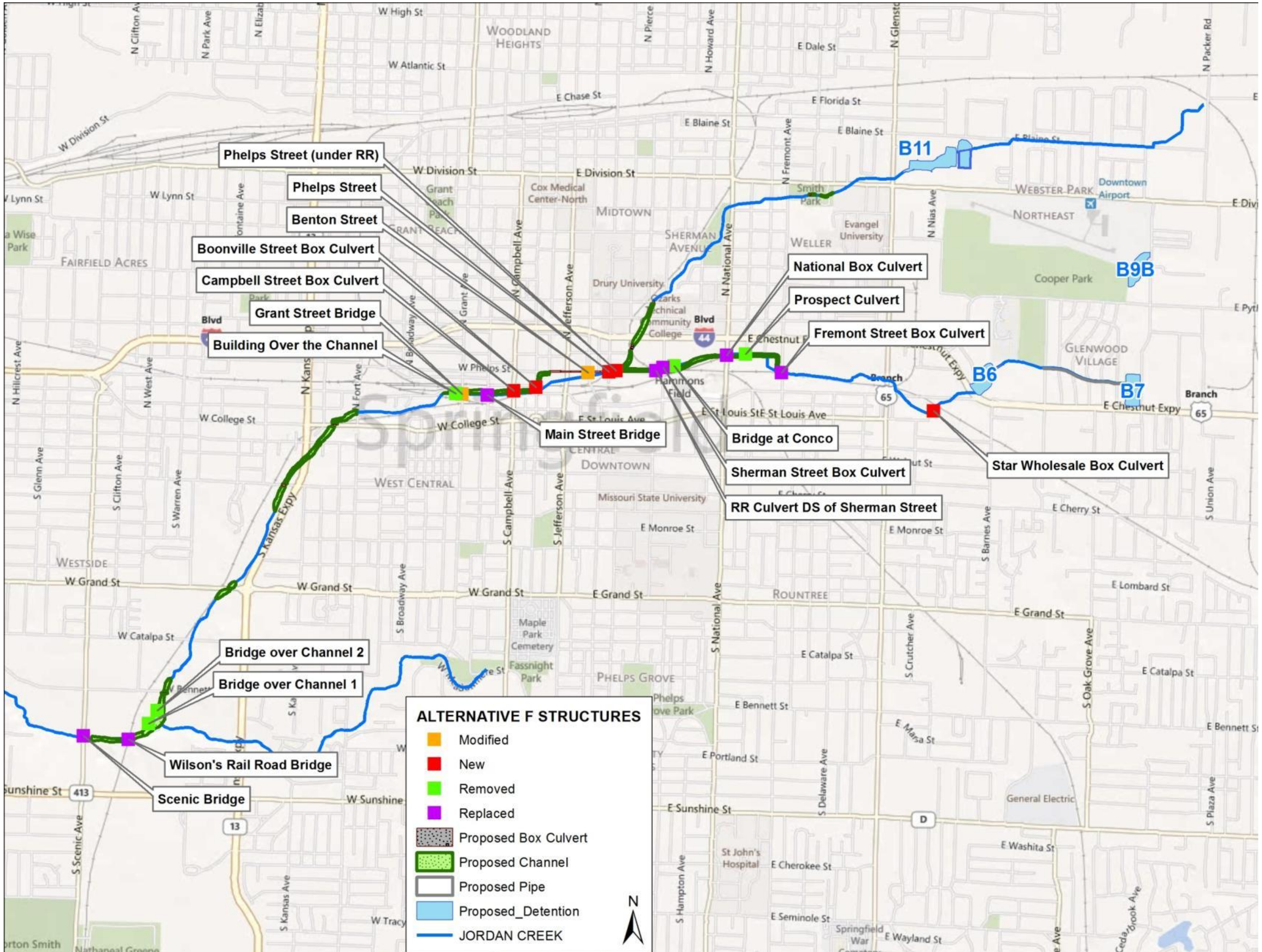


Plate 6: Plan F

Plate 6: Plan F

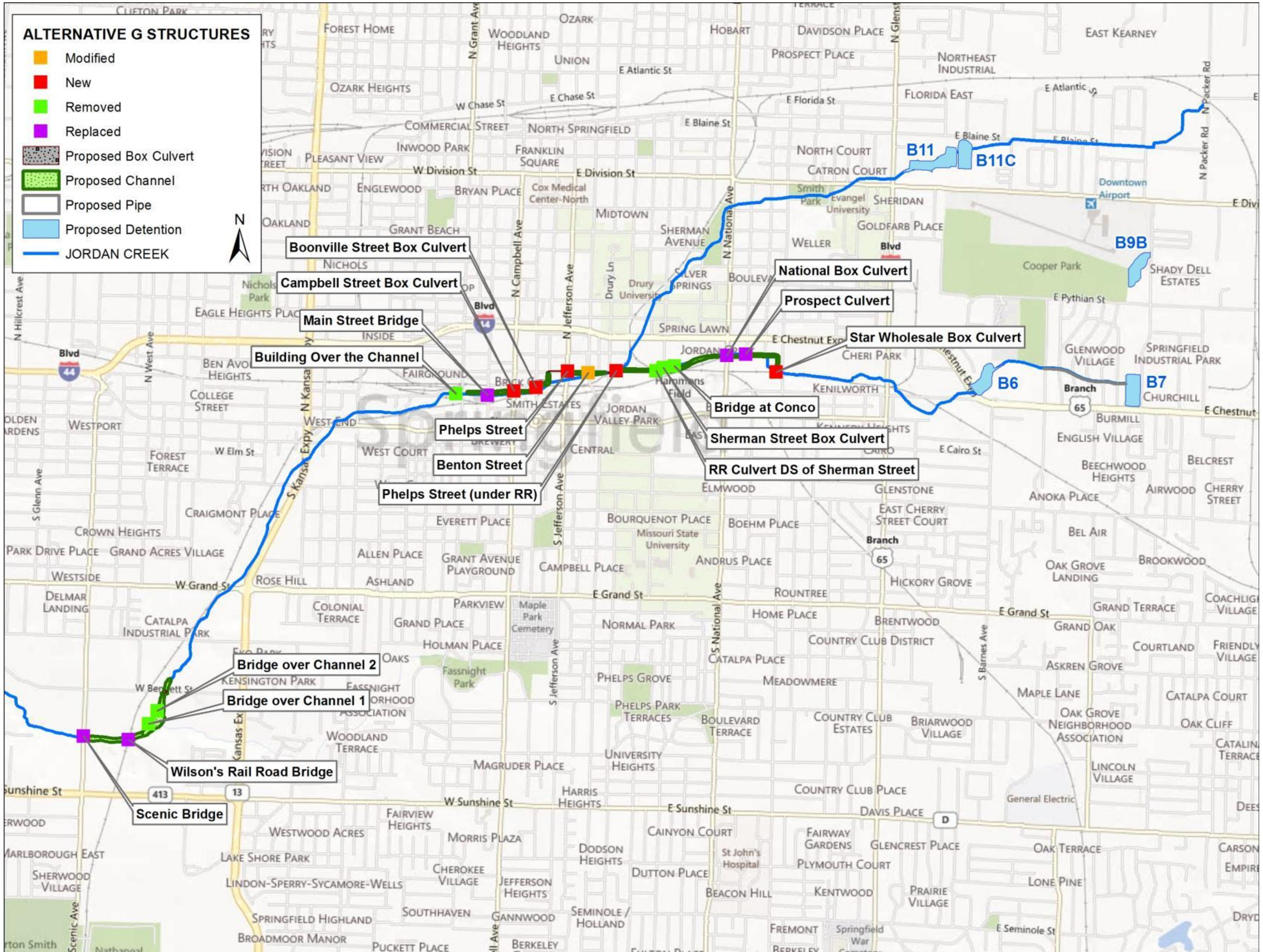


Plate 7: Plan G

Plate 7: Plan G

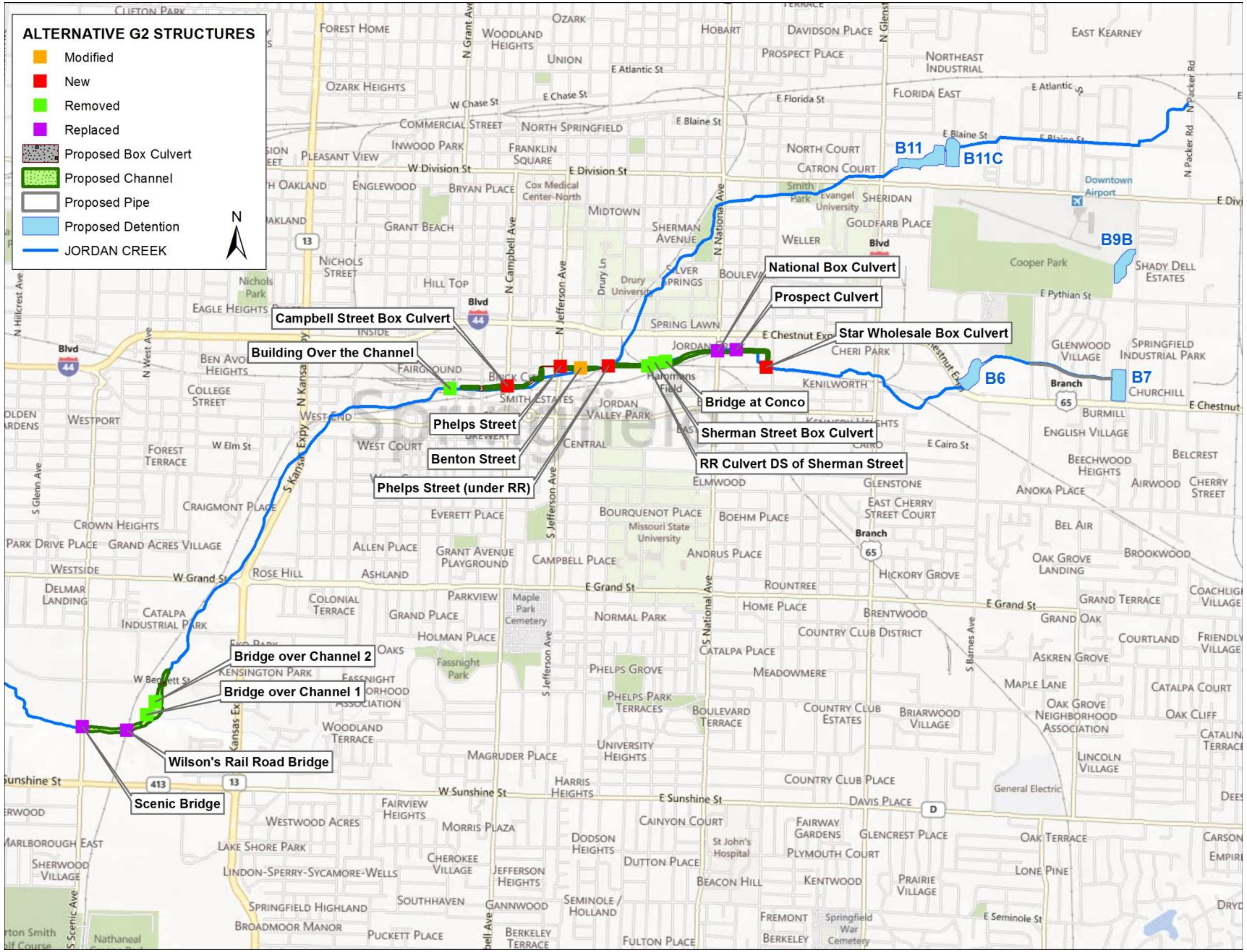


Plate 8: Plan G2

Plate 8: Plan G2

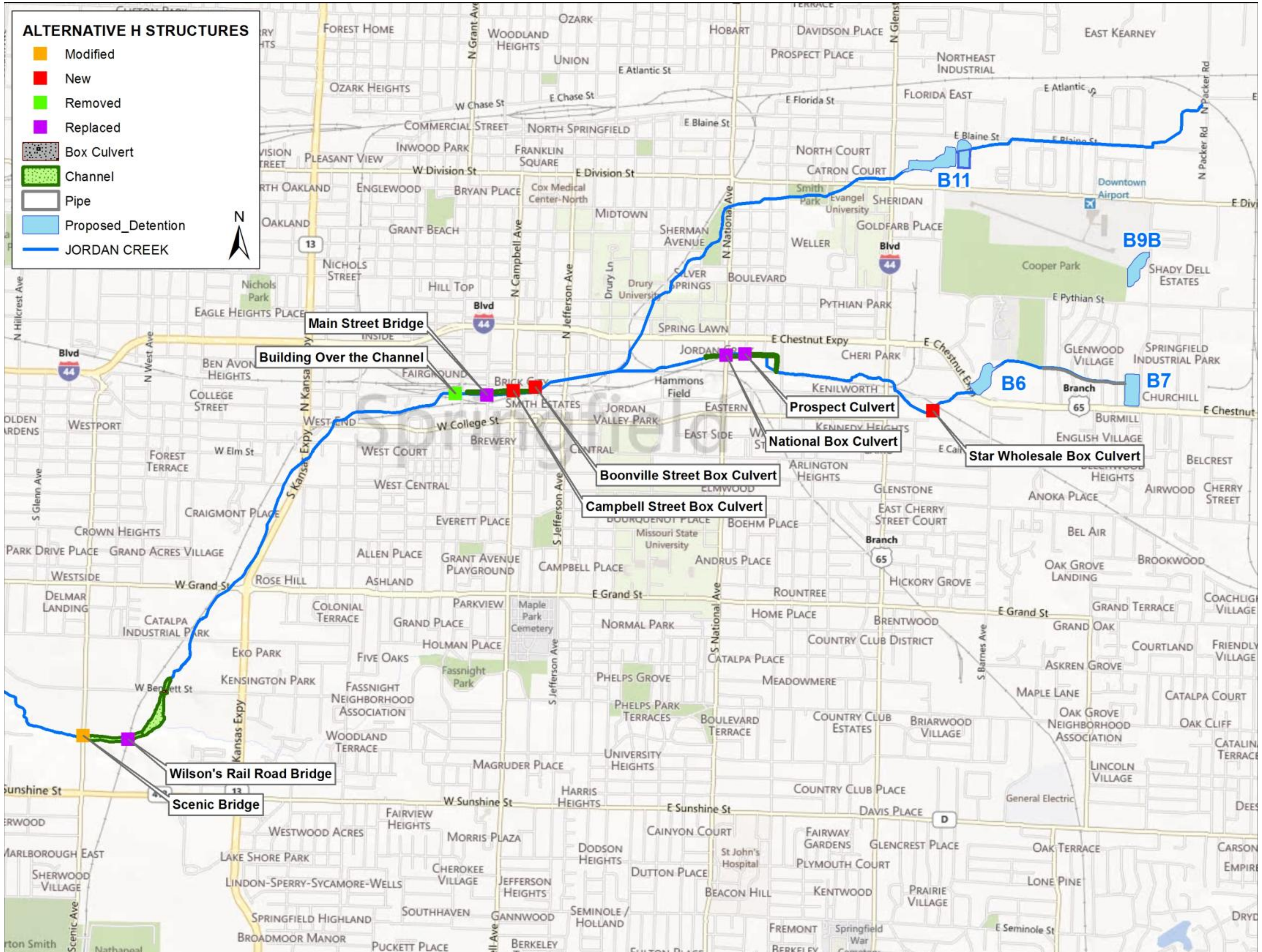


Plate 9: Plan H

Plate 9: Plan H

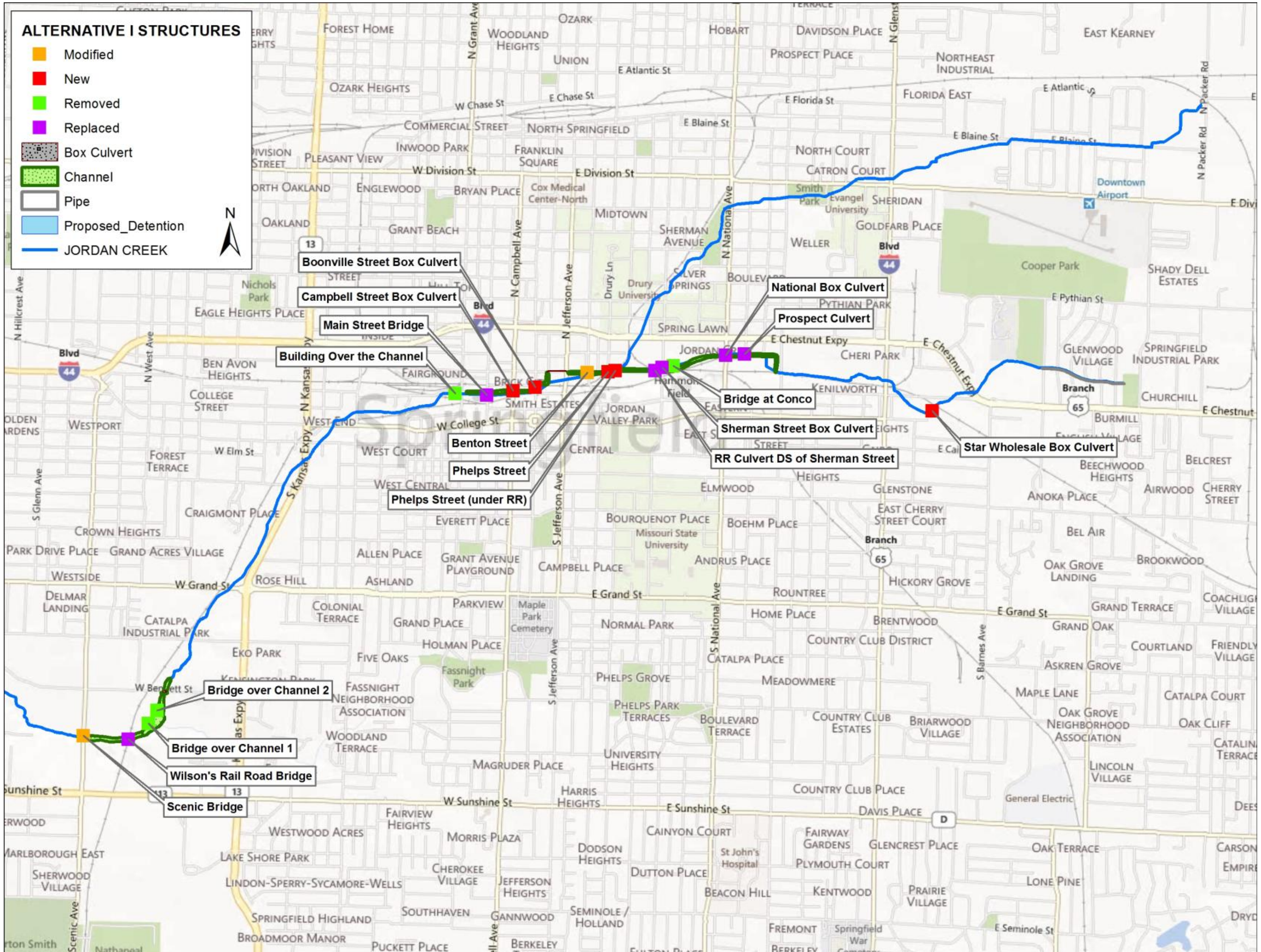


Plate 10: Plan I

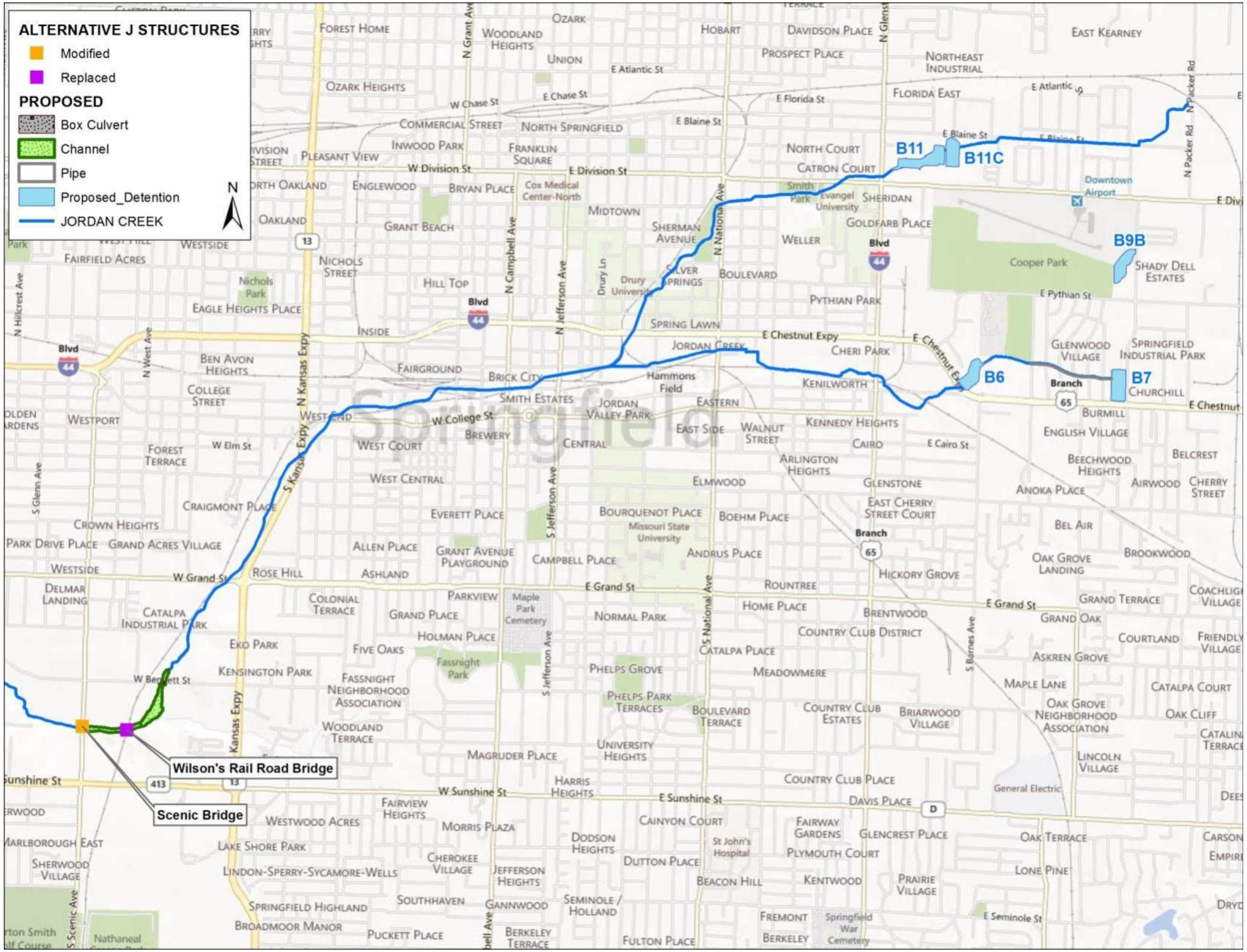


Plate 11: Plan J

Plate 11: Plan J

Appendix A
Economic Analysis Appendix

Table of Contents

Figures

Tables

1 INTRODUCTION

The Economic Analysis Appendix provides information on the methodologies and details of the economic analysis conducted for the Jordan Creek Flood Risk Management (FRM) Study, Springfield, Missouri (Study). Additional information regarding the Study can be found in the main report and appendices of the Study.

1.1 PURPOSE OF THE STUDY

This appendix describes the economic analysis of project alternatives for providing flood risk management measures for the city of Springfield, Missouri. The purpose is to provide a comprehensive review of the methodology applied and results of the economic analysis performed on the FRM alternatives for the Study.

1.2 STUDY AREA

Springfield is the county seat of Greene County and the third largest city in Missouri. The study area is located within the White River Basin, extending approximately six miles along Jordan 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 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. The study area includes Jordan Creek, North Branch Jordan Creek, South Branch Jordan Creek and the upstream portion of Wilsons Creek.

Substantial residential, commercial, and industrial development has occurred on the floodplain, with continuing development primarily in the south part of the city. The principal flood problem is insufficient channel size, whether vertical wall culverts, open channels, or narrow bridges. The increase in flood heights resulting from development and the absence of a storm system is also significant. Flood runoff from the headwaters of the North and South Branches of Jordan creek affects flood heights along Jordan Creek, as well as its outfall, Wilsons Creek.

Typically, area rainfall is fairly heavy and well distributed throughout the year. Historical flood events indicate that flooding along the basin is flashy in nature with the water rising to maximum flows in about an hour and then receding over the next few hours. Flooding will continue along the entire length of the study area, causing additional economic damages to residential, commercial, light industrial, and public property.

Jordan Creek runs through the downtown business district, residential neighborhoods, city parks, and commercial and industrial areas. For analysis purposes, the Study area was delineated into “reaches,” all of which exhibit fairly dense urban land use. Figure 1 illustrates the delineation of the reaches and Table 1 lists the reaches by title, description, and river stationing.

Figure 1: Economic Reaches

Table 1: Streams and Reaches Included in the Springfield Study Area

Reach Name	Description	Beginning Station
E1	Industrial area on the most downstream end of the Lower Branch (including a large pharmaceutical manufacturer with a floodwall protecting up to the 1/10 Annual Chance Exceedance event)	29,145.00 on Wilsons Creek
E2	Mixed industrial and residential area in the center of the Lower Branch	3,859.00 on Lower Branch of Jordan Creek
E3	Downtown Springfield on the upstream end of the Lower Branch	11,000.00 on Lower Branch of Jordan Creek
E4	Industrial area on the downstream end of the North Branch	0.00 on North Branch of Jordan Creek
E5	Residential area on the upper end of the North Branch	2,476.00 on North Branch of Jordan Creek
E6	Heavily Industrial area on the South Branch. Only reach on South Branch	0.00 on South Branch of Jordan Creek

2 CHARACTERISTICS OF THE STUDY AREA

2.1 DEMOGRAPHIC DATA

Population is one parameter of community change. As the population in an area increases or decreases, so does the demand for infrastructure. Population estimates from the 2010 US Census shows growth in Missouri and significant growth in Greene County. This data is shown in Table 2.

Table 2: 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 US Census			

As shown in Table 2, from 2000-2010, Greene County's population grew over 14 percent while Missouri grew about 7 percent. The national population grew just over 9 percent along the same period of time. Such rapid growth in population greatly increases the demand for public services and infrastructure such as schools, roads, medical care facilities, etc.

More detailed Springfield population characteristics are listed in Table 3.

Table 3: Population Characteristics of Springfield, MO

	Estimate	Percent	U.S.
Total Population	159,498	-	-
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 money income (last 12 months)	20,793	-	27,334
Median housing value (owner occupied)	103,800	-	188,400
Persons 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: US Census 2010 American Community Survey, Selected Social Characteristics, 5-year estimates: 2006 - 2010

As Table 3 shows, the population in the study area is primarily white and slightly older than the United States population on average. Although, the median per capita income in Springfield is only 76 percent of the national median, the population is not as poor as these numbers suggest. The median housing value is 55 percent of the national median. If housing values are used as a rough measure of cost of living, then although the per capita income is lower than the nation as a whole, it is offset by a reduction in the cost of living. The percentage of persons in Springfield below the poverty level is significantly higher than the national rate. In September 2012, Springfield had an unemployment rate of 5.5 percent compared to 6.9 percent for Missouri and 7.8 percent nationally.

Although Springfield has a slightly higher rate of those completing high school than the national rate, of those aged 25 and older, the rate of earning a bachelor's degree or higher is slightly lower than the national rate.

2.2 HOUSING AND FAMILIES

2.2.1 Housing

Springfield has approximately the same percentage of occupied housing units as the nation as a whole, but significantly fewer of the housing units are owner-occupied. The average household size for both owner-occupied and renter-occupied housing units is smaller than the national average. Housing data is presented in Table 4.

Table 4: Housing and Vehicles

	Springfield Estimate	%	U.S. Estimate
Total Housing Units*	**76,851**	**-**	**131,704,730**
Occupied housing units	70,167	89.9	88.6%
Owner occupied housing units	35,701	50.9	66.6%
Average household size of owner-occupied	2.2	-	2.67
Average household size of renter-occupied	1.97	-	2.42
Vehicles Available in Occupied Housing Units*			
No Vehicle	6,127	8.7	8.9%
1 vehicles	30,997	44.2	33.3%
2 vehicles	25,046	35.7	37.9%
3 or more vehicles	7,997	11.4	20%
Data source: US Census Quick Facts, American Community Survey, October 2012			
*Data source: US Census American Community Survey, Selected Housing Characteristics, 5 year estimates: 2006-2010			

2.2.2 Families

The city of Springfield has fewer households residing as families than the nation as a whole, with fewer households with individuals under 18 years old and fewer houses with individuals over 65 years old. Springfield has a smaller average household size than the nation as a whole. Family data is in Table 5.

Table 5: Family Data

	Springfield Estimate	%	U.S. Estimate
Total Households	69,754	-	116,716,292
Family Households	35,453	50.8	66.4%
Households with individuals under 18 years	16,312	23.4	33.4%
Households with individuals 65 years and over	16,688	23.9	24.9%
Average household size	2.13		2.58
Data Source: US Census Quick Facts, American Community Survey, October 2012			

2.3 EMPLOYMENT AND LABOR FORCE

2.3.1 Employment

The distribution of employment in Springfield is representative of the nation as a whole, except for lower percentages in manufacturing and construction and greater percentages in service related industries, as shown in Table 6.

Table 6: Total and Part-Time Employment by Major Industry Sector by Place of Work, 2010

Employment	Springfield Estimate	U.S. Estimate
Total Employment	77,689	141,833,331
Percent Distribution of Employment by Industry Sector		
Farming, Forestry, Mining	0.5	1.9
Construction	5.6	7.1
Manufacturing	7.8	11.0
Wholesale Trade	3.1	3.1
Retail Trade	14.1	11.5
Transportation, Communication, Utilities	4.2	5.1
Information	2.2	2.4
Finance, Insurance, Real Estate	6.7	7.0
Professional, Scientific, Management, Administrative Services	9.3	10.4
Educational, Health Care, Social Services	24.6	22.1
Arts, Entertainment, Recreation, Accommodation and Food Services	13.1	8.9
Other Services	6.2	4.9
Public Administration	2.7	4.8
Data Source: US Census Bureau, American Community Survey, Selected Economic Characteristics, 5 year estimates: 2006-2010.		

2.3.2 Labor Force

General employment statistics for Springfield are similar to the nation as a whole, as seen in Table 7.

Table 7: Employment Status

	Springfield Estimate	%	U.S. Estimate
Population 16 years and over	**133,308**		**238,733,844**
In labor force	84,652	63.5	65.0%
Employed	77,689	58.3	59.4%
Unemployed	6,852	5.1	5.1%
Not in labor force	48,656	36.5	35%
Data Source: US Census Bureau, American Community Survey, Selected Economic Characteristics, 5 year estimates: 2006-2010.			

2.4 DEMOGRAPHIC AND ECONOMIC PROJECTIONS

Population and employment projections provided by the Missouri Department of Natural Resources show an almost doubling of population and employment in the period of analysis as displayed in Table 8.

Table 8: Greene County Population and Employment Forecast

Year	Population	Employment
2010	275,174	141,359
2020	331,340	158,946
2030	389,303	171,960
2040	445,680	201,541
2050	507,100	233,627
2060	574,630	269,335
Data Source: Missouri Department of Natural Resources, Medium Growth Scenario		

3 ECONOMIC EVALUATION PROCEDURES, ASSUMPTIONS, AND METHODOLOGIES

The economic analysis evaluated the alternatives on the basis of flood-related costs and damages avoided. Flood damages and costs considered in the economic analysis included flood damages to residential and nonresidential structures and contents, damages to vehicles, and public damages (infrastructure and emergency response expenditures).

The economic justification of an alternative was determined by comparing the expected annual benefits to the expected annual costs. If the annual benefits for an alternative exceed the annual costs, then the alternative was considered economically justified. In such cases, the benefit-to-cost ratio (BCR) was greater than 1.0. For this analysis, the expected annual cost of an alternative was determined by considering a number of factors, including construction cost, timing of construction period, interest during construction, and operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) costs. The costs were based on an October 2012 price level, a period of analysis of 50 years, and were annualized to an annual equivalent cost using the FY 2013 Federal Discount Rate of 3.75 percent. The expected annual cost for an alternative was subtracted from the expected annual benefit to compute the net annual benefit.

The following sections discuss the types of evaluations and methods used in the economic analysis.

3.1 HYDROLOGIC AND HYDRAULIC MODELING FOR ECONOMIC EVALUATIONS

Refer to Hydrology and Hydraulics (H&H) Appendix for information on the hydrologic and hydraulic input into the Flood Damage Analysis (FDA) model.

3.1.1 Determining the H&H Conditions for Base and Future Economic Modeling

As stated in the H&H Appendix: "Two separate models were created in order to simulate runoff for current land use conditions and expected ultimate development land use conditions. The *current* land use model reflects development in the watershed as of about 2003. This includes current impervious areas and all significant storm-water improvements and detention basins. The *ultimate development* model is a variation of the current model with land uses projected to 2053 based on current zoning. " Given the model reflecting development in 2003, some GIS analysis was conducted to determine how accurate the model would be for a base year of 2020 and to project the fulfillment of ultimate development.

3.1.1.1 General Assumptions

1. Aerial photography was available for the study area for 1996, 2001, 2005, and 2010. Google earth aerial photography was available for 2011.
2. The ultimate development expected within Jordan Creek watershed included North Branch watershed, South Branch watershed, and Jordan Creek watershed.
3. Real estate parcel geospatial data was available for the study area from 2008.
4. Redevelopment of existing property exists within the watershed. As properties are redeveloped, the city's storm-water management practices are enforced. Over time, gravel driveways and parking lots are upgraded with growth of employment and industry, decreasing the infiltration and increasing runoff.
5. Development of industry and residential areas in undeveloped property exists within the watershed. As undeveloped properties are developed, the city's storm-water management practices are enforced, particularly for development greater than one acre.

3.1.1.2 Determination of Open Land for New Development

A team of an economist and a GIS specialist analyzed the approximately 8,700 acres of Jordan Creek watershed aerial photography using ArcMap 10.0. The GIS specialist compared 1996 photography with 2010 photography to identify areas of development and created a shapefile named "Changes_1996_2010". The economist created a shapefile named "Open" to identify open land which could be developed. Several assumptions were used in the creation of the "Open" shapefile.

1. The horizon of development occurs over multiple generations, such that a constant owner is not assumed unless the property is held in trust.
2. Per city floodplain development rules, no structures will develop within the 1/100 Annual Chance Event (ACE) floodplain.
3. Property owned by the city for recreation (parks) or as part of the storm-water management plan will not be developed.
4. Property owned by the Springfield School District, Greene County, the State of Missouri, or the US Government will be developed. Between 1999 and 2011, these entities developed approximately 5 acres of land.
5. The Springfield airport, with land not owned by a government entity, will not be developed.
6. Land which is surrounded on all sides with other development (such as residential land in the center of a block of other residential buildings with no feasible access to roads) will not be developed.
7. Current land use zoning will be maintained. Open area will be developed according to the zoning of surrounding property. Polygons in residential areas were drawn to complement residences nearby. Polygons in commercial and industrial areas were drawn to complement the businesses nearby.
8. Polygons were no greater than 2/3 of available parcel space, given city storm-water management detention basins.

3.1.1.3 Calculating Land Development Rates

Using the "Changes_1996_2010" shapefile, and the aerial photography from 2001, 2005, and 2010, the "Open" shapefile polygons were categorized as development occurring between 1996 and 2001, development occurring between 2001 and 2005, development occurring between 2005 and 2010, or as empty land still to be developed. The acres of development for each category are presented in Table 9.

Table 9: Land Development for 1996 to Future Period

Time Period	"Open" Acres Developed (incremental)	Total "Open" Acres Developed	Remaining "Open" Acres
1996-2001	104	104	305
2001-2005	41	145	264
2005-2010	52	197	212
Future	212	409	--

Next, the average rate of development over time was calculated as shown in Table 10.

Table 10: Land Development, Average Acres per Time Period

Time Period	"Open" Acres Developed (incremental)	Years	Average acres per year
1996-2001	104	5	20.8
2001-2005	41	4	10.25
2005-2010	52	5	10.4

3.1.1.4 Projecting Future Development

To determine a date at which the Jordan Creek watershed is fully developed, a panel of economists examined the time periods' average developed acres per year, considered the employment during the time periods as seen in Table 11, considered the projected growth of population and employment in Greene County (previously presented in Table 8) over the next 50 years.

Table 11: Business Establishments and Employment in Springfield, Missouri 1998-2011

Year	Business Establishments*	Employment**
1998	9,299	Unavailable
1999	9,361	148,680
2000	9,480	160,690
2001	9,566	160,130
2002	9,748	162,350
2003	10,742	163,270
2004	11,087	165,070
2005	11,336	182,640
2006	11,440	188,800
2007	11,518	192,730
2008	11,508	194,860
2009	11,255	187,600
2010	11,219	181,890
2011	unavailable	181,010
* Data Source: US Census, County Business Profiles, Springfield, MO Metro		
** Data Source: Bureau of Labor Statistics, Springfield, MO Metro		

It appeared that the average acres per year development in the watershed remained relatively constant during the economic expansion between 2002 and 2005 and the economic recession between 2008 and 2010. Given that the watershed is over 8,700 acres, and an analysis showing only 200 acres remaining as “Open” for development in 2010, the study team (with coordination of the vertical team) used professional judgment to determine that by 2020 the watershed would be developed to Ultimate Development condition.

3.1.2 Base and Most Likely Future Year Economic Modeling

For Jordan Creek study, the year the proposed project is expected to be in operation (the base year) was set at 2020. The most likely future year was set at 2030. Given constant ultimate conditions hydrology over the period of analysis, any other most likely future year would produce identical results in FDA modeling. A separate FDA model with 2003 hydrology in the base year and the most likely future year was used as a sensitivity test for the plan formulation. The result of the sensitivity testing is located in Section 8.1.

3.2 FIRST FLOOR ELEVATIONS

To identify the structures to include in the study, digital maximum floodplain maps were used. A windshield survey was performed to assign the structures with a “Corps ID” number which was retained throughout the study. The first floor elevations (FFE) for each structure indentified from the maps, as well as structures requested to be examined by the City of Springfield, were obtained by a professional survey team. FFE, as defined by the surveyors, is the lowest point of the lowest, non-basement floor.

3.3 STRUCTURE AND CONTENT VALUES

Knowledge of existing residential and nonresidential development located in a floodplain is critical to evaluating an FRM project. Potential flood damages to residential and nonresidential structures in the study area were evaluated through a structure inventory and mailed surveys.

3.3.1 General Assumptions for Most Likely Future Conditions

1. No buildings were added or removed from the floodplain during the period of analysis. After the 2000 flood event, the City of Springfield executed a voluntary buyout of properties in the Wilsons Creek watershed, beyond the southern end of Lower Jordan Creek. In the last 10 years the City of Springfield has continued purchasing properties within the Jordan Creek watershed from willing owners as a part of its floodplain management program. It is unlikely that other owners within the floodplain will be willing to leave.
2. The structure value, content value and type of use remains constant during the period of analysis. Historically, structures which were damaged by flood events within the Jordan Creek floodplain remain in use in the floodplain. These structures have had multiple owners or renters, but continue to exist.
3. Each building’s condition will remain constant. Historically, some businesses within the Jordan Creek floodplain have remodeled and renovated over time. Any deterioration of condition to some of the buildings is offset by renovation of other buildings, such that the overall condition and structure valuation remains constant.
4. In the future, the floodplain will increase and additional existing buildings will be flooded. Per the H&H modeling assumptions (current zoning will be followed, storm-water management practices with enforceable inspection and maintenance processes will be followed, all pervious areas will have decreased infiltration when land is redeveloped, existing channels will have higher conveyance with storm-water infrastructure improvements), there is increased runoff and higher stages.

3.3.2 Structure and Contents

The purpose of the structure inventory was to collect data on residential and nonresidential structures located in the Study area. Structures were numbered starting downstream and moving upstream. Structures which were added after the original survey were numbered as they were added, irrelevant of their positioning on a stream.

3.3.2.1 Data Collection

Most commercial, industrial, and residential property values were obtained from the Greene County Tax Assessor whose estimates are updated every 2 years and can be accessed online. The assessor's estimates, confirmed by the assessor's office, are derived by taking the structure's replacement cost less its depreciation.

There were 16 structures (mostly public) for which there was no assessment. The values of these structures were obtained by doing a price per square foot estimate based on the type of the structure using RSMeans. RSMeans allowed us to estimate the replacement cost minus depreciation using a building's type of construction, age, and other construction specifications.

3.3.2.1.1 Residential Structures

Structure values for residential properties were retrieved from the county tax assessor's office. The 2009 assessments were used as a base value and then updated to Oct 2012 prices using the Marshall and Swift index for Central District (including the state of Missouri) for Class D Wood Frame structures. Residential properties were classified first by whether they are a single or multi family home then by the number of stories and if they have a basement or not. Structure counts are listed in Table 12.

Table 12: Residential Structures

Structure type	Structure Count	Structure values ($)
Single Family - 1 Story	43	1,815,300
Single Family - 1 Story w/ Basement	11	488,800
Single Family - 2 Story	1	157,100
Multi-Family - 1 Story	2	112,500
Multi-Family - 2 Story	3	2,901,500
Total	**60**	**5,475,200**

Content values of residential structures were calculated based on US Army Corps of Engineers Economic Guidance Memorandum #04-01.

3.3.2.1.2 Commercial and Industrial Structures

Commercial and industrial structure values were retrieved from the Greene County tax assessor's office and are from the 2009 assessment. Values were updated to Oct2012 price levels using the Marshall and Swift index for Central District (including the state of Missouri) for Class C Masonry Bearing Walls structures.

Structures were categorized by the type of business and the number of stories. The counts of commercial and industrial structures that fall within the maximum projected floodplain are included in Table 13.

Table 13: Commercial and Industrial Structures

Structure type	Structure Count	Structure values ($)
Commercial	**92**	**45,828,700**
Food Store - 1 Story	3	511,400
Restaurant - 1 Story	3	191,500
Restaurant - 2 Story	1	96,200
Fast Food Restaurant - 1 Story	1	223,400
Medical - 1 Story	1	10,000,000
Office - 1 Story	20	3,343,500
Office - 2 Story	4	19,824,700
Retail - 1 Story	14	2,532,900
Retail - 2 Story	2	229,800
Service Store - 1 Story	14	1,066,100
Shopping - 1 Story	2	585,900
Vacant	27	7,221,500
Industrial	**114**	**23,596,000**
Specialized Manufacturing	22	4,280,000
Warehouse - 1 Story	66	9,399,100
Warehouse - 2 Story	12	4,507,200
Light Manufacturing - 1 Story	12	2,521,400
Light Manufacturing - 2 Story	2	2,888,400
Total	**206**	**69,424,800**

Content values and depth-damage curves for non-residential properties were estimated using US Army Corps of Engineers (USACE) Sacramento District American River Watershed Project Folsom Dam Modification Draft Economic Reevaluation Report Appendix D, Attachment II Technical Report: Content Valuation and Depth-Damage Curves for Nonresidential Structures (ARW). It was assumed that non-residential structures in the Jordan Creek floodplain were similar to the prototypical structures used in the development of the non-residential depth-damage curves created in ARW. As noted in the invitation packet to expert-elicitation participants, "Depth refers to the depth of flooding above or below the first floor of the structure." Given these instructions to the panel, with photographs and sample properties depicting the 14 prototypes of commercial structures in the ARW study, a team of economists on the Jordan Creek study used professional judgment to determine that the depth damage curves are applicable to Jordan Creek structures. Refer to the ARW report for further information on how the depth-damage curves were created.

ARW was also used because the study developed a way to calculate non-residential content values based on the type of structure. Content value was determined by applying a value per square foot based on the type of business occupying the structure. Content values were updated from 2009 to Oct 2012 using the

Producer Price Index for finished goods. It was assumed that content distribution and content type was similar in structures in the Jordan Creek floodplain to those structures used in ARW. ARW's content value derivation methodology was approved by the US Army Corps of Engineers. A windshield survey was taken to determine commercial vacancies and vacant buildings were assumed to have no content inside the structure.

After initial runs of Flood Damage Analysis software, damages to several structures within the Jordan Creek 500-year footprint appeared to not represent historic damages. Several actions of reality check (data confirmation) ensued.

1. Building Materials Company outside inventory – Company provided detailed historic depth information and damage information on an OMB-approved survey in 2006 and follow-up interviews; the depth-damage curve to the inventory in the pipe-yard was created with engineering and economic judgment. Given the FDA output, an adjustment was made to the depth-damage curve of the outside inventory for this unique inventory.
2. Lofts – Building was originally windshield surveyed as an empty warehouse. The warehouse was renovated to loft apartments on second and third floors. The first floor remained vacant, but FDA output reported significant damages at high-frequency events. Further investigation revealed several businesses occupied the first floor of the renovated building, as well as a three-foot rise in first floor elevation since original survey.
3. Warehouse – Building first floor elevation (base of garage doors) was originally surveyed with survey crew in 2004. FDA output reported significant damages at the high-frequency events. Further investigation using aerial and street-view photography revealed two open garage doors with truck bays. First floor elevation was adjusted up three feet to account for true first floor elevation.
4. Public property maintenance garage – The building was originally surveyed and assigned commercial auto structure and content curves based on assumption of vehicles and maintenance use. FDA output reported significant damages at the high-frequency events. Further investigation using street view photography indicated that the building consisted of two adjacent structures with two separate functions: a lower-elevation rectangular office-use space and a higher-elevation warehouse-use space.
5. Building Materials Company – Structure first floor elevation was originally surveyed with survey crew in 2004. FDA output reported significant damages at the high-frequency events. Structure was surveyed again and the first floor elevation was corrected.
6. Park pavilion – Pavilion was originally assigned recreation damage curve (P-REC). FDA output reported significant damages given a simple frame structure and basic recreational facility contents. Structure value was corrected to $5000; content value was corrected to $2000.
7. Medical facility – Structure first floor elevation was originally surveyed with survey crew in 2004. FDA output reported significant damages at frequent events, although structure had never reported damage. First floor elevation was corrected using aerial street view photography.
8. Wholesale building materials company – Structure was originally windshield surveyed as vacant. Re-evaluation of the building in 2010 determined that structure was being used as an inventory warehouse with concrete cement blocks raising the first floor elevation by one foot. Interview with company manager provided structure and content values bundled together. Economic judgment and Greene

County assessor data were used to separate structure and content values. First floor elevation was corrected by one foot.

3.3.2.1.3 Public Structures

Most public structures were not included in the county's assessment of structure values. The value of public structures not included in the tax assessments were derived using RSMeans and the methodology explained above in Section 3.3.2.1. Square feet estimates for public structures were taken by the county tax assessor although no value was assigned during assessment. Values were updated to current price levels using the RS Means historical index. Public structures are identified in Table 14.

Table 14: Public Structures

Structure type	Structure Count	Structure values ($)
Recreational - 1 Story	2	10,800
School - 2 Story	2	950,000
Total	**4**	**960,800**

Content values for public structures were found using the ARW methodology described above. A windshield survey was taken to determine public vacancies.

3.3.3 Vehicles

As shown below, it was estimated that .72 vehicles per residence were vulnerable to flooding. Census data for the number of households and vehicles available was used to calculate an average of 1.26 vehicles per household in the city. Vehicles were assumed to be at the one foot below the structure to which they were paired, and damages begin at one foot above the ground level. It was estimated that .80 cars will be at each house at any given time that a flood could occur, as shown in Equation 1. It was assumed that .945 vehicles (75 percent of 1.26) were present during non-work hours and .315 vehicles (25 percent of 1.26) were present during normal working hours. It was assumed that working hours are 40 hours per week, leaving 128 non-working hours per week for a total of 168 hours a week.

Equation 1: (.945*(128/168))+(.315*(40/168))= .80

The city of Springfield does not have a flood warning system and residents are given no formal warning of flash flooding. Springfield officials estimate that residents have less than one hour to evacuate their vehicles from the floodplain. This estimate is based on historical flooding in the Jordan Creek area where it has taken less than an hour for flows to reach peak heights once precipitation began. Precipitation can be very localized resulting in flooding in areas that may not have received much rainfall. Therefore, we assumed that 90 percent of vehicles remained in the floodplain during a high water event.

Equation 2: .80*.90= .72

It was also assumed that a plausible value for a vehicle results by assuming the following relationship for each residence: V = (0.15*S) + 1000 where V is the vehicle value and S is the value of the residential structure (USACE Fort Worth District Lower Colorado Basin Phase I Interim Feasibility Report and Integrated

Environmental Assessment). The Colorado Basin methodology was used because the population demographics are not substantially different from those in this study.

Average vehicle value in the maximum projected floodplain (500-year) using this method was approximately $8,300 (using Consumer Price Index Midwest Private Transportation index to update 2009$ to Oct 2012$). This was consistent with field observations of vehicles within the project area. Vehicle Value (V) was then multiplied by .72 to represent the value of vehicles left at each residence during a flood event. In summary, the value of damageable vehicles at residential properties = number of vehicles per household x vehicle value x the percent of vehicles remaining during a flood event.

The data available (retrieved from US Census, Missouri Department of Motor Vehicles, and Greene County Tax Assessor) to the District did not allow the implementation of the methods outlined in EGM #09-04 to their full extent. If vehicle data for each structure becomes available, the District will use the process listed in the EGM.

Non-residential (including public) vehicle values, were assumed to be $8,300 per vehicle ($8,300 is the average value of a vehicle in the 500-year floodplain, as explained in the preceding paragraph). Vehicle values for non-residential properties were assumed to be at their locations 8 hours per day, 5 days per week. Therefore, vehicle values at non-residential locations are multiplied by .238 (5/7 * 8/24 = .238) to accurately account for this assumption. Detailed aerial photographs of the floodplain were examined to determine the approximate number of vehicles located at each non-residential structure.

After initial runs of FDA, damages to vehicles within the Jordan Creek 500-year footprint appeared to depict greater damages for flood events than reported historic damages. Several actions of correction ensued.

1. Building Materials Company: Vehicle damages were occurring to specialized trucks instead of sedans, trucks, or SUVs. Vehicle damage curve (C-TRK) created for damages to specialized trucks using photos of the specialized trucks, photos of trucks, and the depth damage curves for vehicles provided by HQUSACE.
2. Cars at the Lofts – Parking lot of the lofts and the first floor elevation of the lofts were originally considered equal. FDA output reported significant damages to vehicles at high-frequency events. The lofts and the parking lot were split into two structure entries; the parking lot elevation remained as originally surveyed. Multiple aerial photos were used to count vehicles in the parking lot during business hours. The average number of vehicles in the aerial photos (50) was multiplied by the vehicle value in the methodology to determine the aggregate parking lot vehicle value. Given that there are 33 loft apartments and assuming 1.5 vehicles per apartment, there are 50 cars parked in the lot at night outside of business hours.
3. Local business – Parking lot of the business and the first floor of the business were originally considered equal. FDA output reported significant damages to vehicles at high-frequency events. After examining aerial and street view photography, the business and the parking lot were split into two structure entries in the structure inventory; the business remains at the surveyed first floor elevation and the

parking lot elevation was raised by one foot to correct for the -1 (negative) foot start of damage in the vehicle depth-damage curve.

4. Auto yard – Building was originally windshield surveyed as an auto body repair shop. Originally, the vehicles located within the fenced-in area in the back were counted and valued in the same way as all other vehicle valuations in the study. The FDA output reported significant vehicle damages at high-frequency events. Further investigation of aerial and street view photography revealed that the business operates as a used-car parts supplier. As a result, further analysis was done which led to the following assumptions:
    a. Due to the nature of the business, we assumed the most each vehicle could be worth was $700. $700 was based on the minimum price of classified ad asking prices of barely running cars.
    b. Due to the nature of the business, the minimum each vehicle could be worth was $200. An average of three scrap metal recycling companies equaled $8 per 100 pounds. Assuming an average weight of 3000 pounds and a removal cost of $40 per vehicle from the auto yard to a metal recycler, $200 was the value of a car that can only be sold for scrap.
    c. Based on aerial photos over time, half of the vehicles were be sold and replaced by others, but the other half stayed indefinitely.
    d. Of the vehicles at the business, 5 of the cars were either employee or customer owned and follow the standard vehicle methodology.
    e. 168 vehicles were easily identifiable from aerial photos. A depth-damage curve was created for the vehicles with a maximum percent damage of 55 percent due to the assumptions made.

Three major parking lots exist within the study area. Using the methodology as describe in this section, the vehicle values for the three parking lots are presented in Table 15.

Table 15: Parking Lots

Structure type	Structure Count	Vehicle values ($)
Parking Lots	3	1,384,300

3.4 DEPTH DAMAGE FUNCTIONS

3.4.1 Residential

The city of Springfield, Missouri is a typical Midwestern city. The residences are typical to the type of construction represented by the Corps of Engineers' generic depth-damage curves. EGM #04-01 provided depth-damage curves for residential structures based on house type and applied content damages as a percentage of the structure value in which the contents reside.

3.4.2 Commercial, Industrial, and Public Structures

Depth-damage curves for non-residential properties were estimated using ARW. It was assumed that non-residential structures in the Jordan Creek floodplain were similar to the prototypical structures used in the development of the non-residential depth-damage curves created in ARW. As noted in the invitation packet to expert-elicitation participants, “Depth refers to the depth of flooding above or below the first floor of the structure.” Given these instructions to the panel, depth damage curves can be applicable to Jordan Creek structures. Refer to the ARW report for further information on how the depth-damage curves were created.

ARW was also used because the study developed a way to calculate non-residential content values based on the type of structure. Content value is determined by applying a value per square foot based on the type of business occupying the structure. Content values were updated from 2009 to Oct 2012 using the Producer Price Index for finished goods. It was assumed that content distribution and content type was similar in structures in the Jordan Creek floodplain to those structures used in ARW. ARW’s content value derivation methodology was approved by the US Army Corps of Engineers. A windshield survey was taken to determine commercial vacancies and vacant buildings were assumed to have no content inside the structure.

3.4.3 Vehicles

Automobile depth-damage curves with uncertainty were obtained from ARW. Automobile depth-damage curves from ARW were adjusted down by one foot, given that, on average, vehicles in the study area were parking one foot below the first floor elevation of residences and businesses. A random sample of residences and businesses was taken of vehicle elevations in relation to the FFE of each structure resulting in an average height difference of negative one foot.

3.4.4 Mailed Surveys

In October 2005, a request was submitted to the Office of Management and Budget to survey the residences and businesses within the initial projected 0.002 floodplain. The request was approved in November 2005. In January 2006, surveys were mailed to 234 residences and 211 businesses. By February 2006, 33 residential (14 percent response) and 69 commercial (33 percent response) surveys were returned with information. However, most of the returned surveys were judged to be poor and unusable for the study. The few surveys with quality data were used to check the results from FDA.

3.5 REACH CHARACTERISTICS

The study area encompasses all or parts of four streams (North, South, and Lower Branches of Jordan Creek, and Wilsons Creek) and their reaches. The North Branch is divided into two reaches, the Lower Branch is divided into three reaches, and the South Branch is one reach. Wilsons Creek is included in the most downstream reach of the Lower Branch. These six Reaches are delineated based on their economic distinctions from the other reaches. These six economic reaches are further divided into hydrologic sub-reaches in which raise the confidence level of the analysis. Refer to H&H Appendix for sub-reach delineations. The numbers of structures that fall within the maximum projected floodplain are shown in Table 16. The water flows from the east to the west through the middle of the City of Springfield. When flooding occurs along the creek, it is always of short duration.

Table 16: Structure Inventory

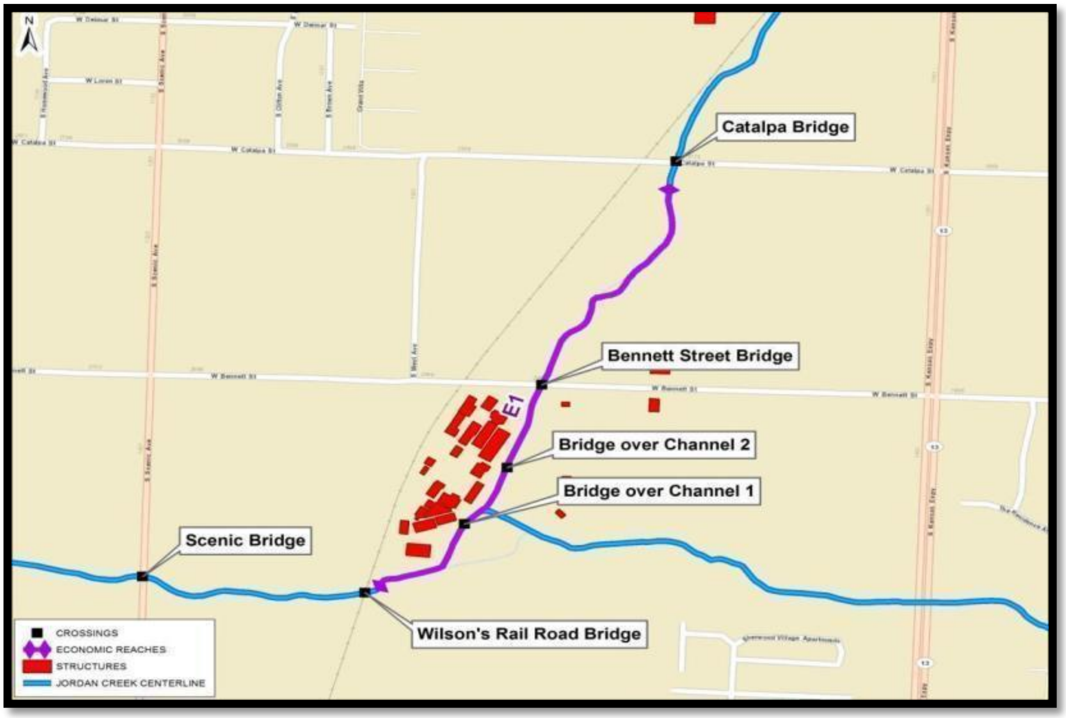
Reach	Number of structures in reach	Structures by type				Structure values ($)	Content values ($)
		Residential	Commercial	Industrial	Public		
E1	32	0	5	27	0	5,438,000	*
E2	54	15	22	17	0	5,068,800	12,131,800
E3	66	2	33	31	0	33,215,800	56,018,400
E4	12	0	4	6	2	1,930,800	5,971,800
E5	50	43	5	0	2	2,447,600	3,665,100
E6	56	0	23	33	0	27,759,800	36,635,200
Total	**270**	**60**	**92**	**114**	**4**	**75,860,700**	*

* Number withheld due to predominance of Archimica's proprietary information that would be revealed.

3.5.1 Reach E1

Reach E1 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. The Archimica plant has almost 98 percent of the total value of structures, contents, and vehicles within Reach E1. While structural values are approximately $5.4 million, machinery and inventories are significantly more than the structural value of the buildings. Given the unique composition of structure to inventory values and the special type of manufacturing by the company, the damages within Reach E1 are different than other reaches and significant inventory losses are sustained with just a few feet of water. Archimica has constructed a floodwall to elevation 1221.5 that was deemed structurally sound by project delivery team engineers. When water elevations exceed 1221.5, water overtops the floodwall and several feet of water inundate the pharmaceutical plant before pumps can remove the water. In the future without project conditions, the wall is overtopped between the 1/10 ACE and the 1/25 ACE.

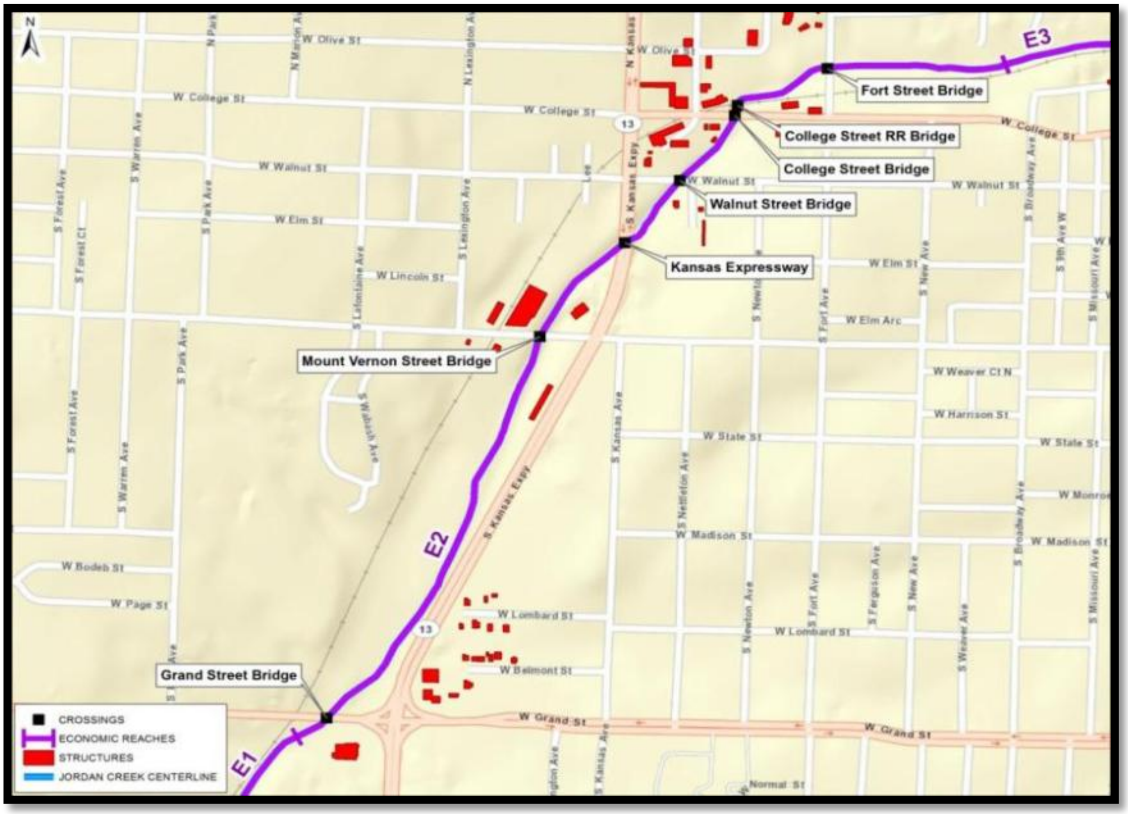
Figure 2: Reach E1



3.5.2 Reach E2

Reach E2 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. Structural values of the 54 structures within Reach E2 are approximately $5 million and content values are approximately $12 million.

Figure 3: Reach E2

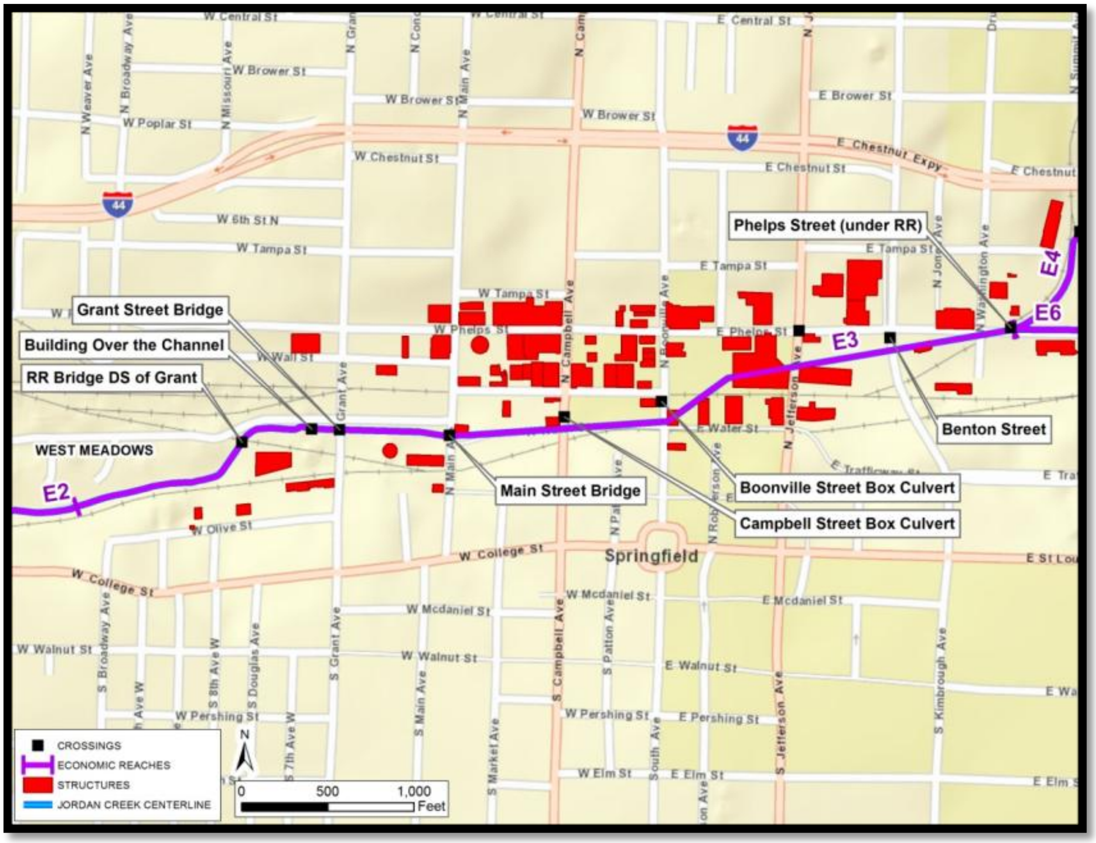


3.5.3 Reach E3

Reach E3 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 Branch where Jordan Creek flows into a set of box culverts capable of conveying the 1/5 to 1/10 ACE. The 30 feet wide, 10 feet 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, creating downtown flooding until it reaches the areas south of downtown where it can return to the channel. The structural values of the 66 structures within Reach E3 total approximately $33.2 million with contents values of approximately $56 million.

Figure 4: Reach E3

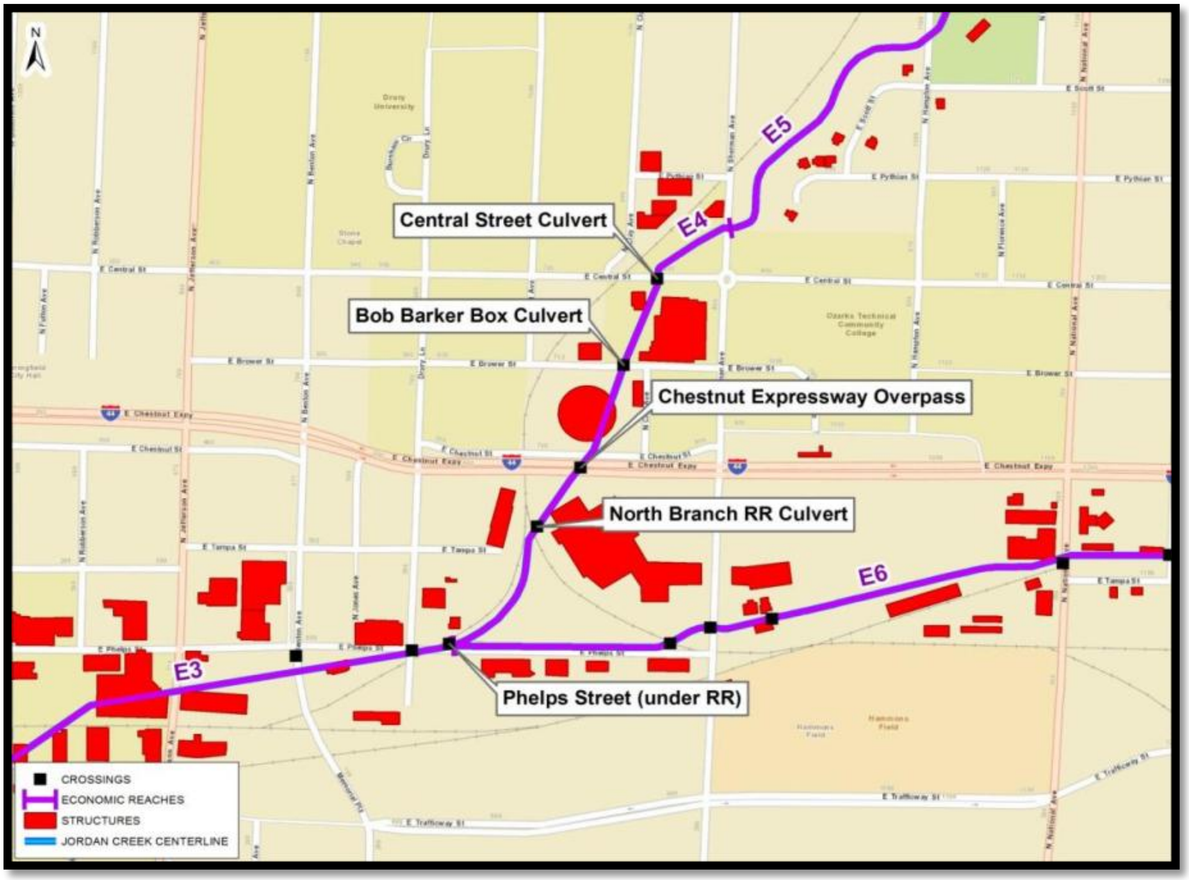


The City's industrial and commercial heart is situated in the Jordan Creek Valley. Along Jordan Creek, it is relatively flat. However, about a city block out on either side of the stream, the terrain gets substantially steeper. This topography concentrates the floodwaters through a narrow corridor. At 1/5 ACE, damages are $570,000. There are substantial damages at the frequent events.

3.5.4 Reach E4

Most of the damages in Reach E4 are 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 structural values of the 12 properties within Reach E4 are approximately $1.9 million with contents values at approximately $6 million.

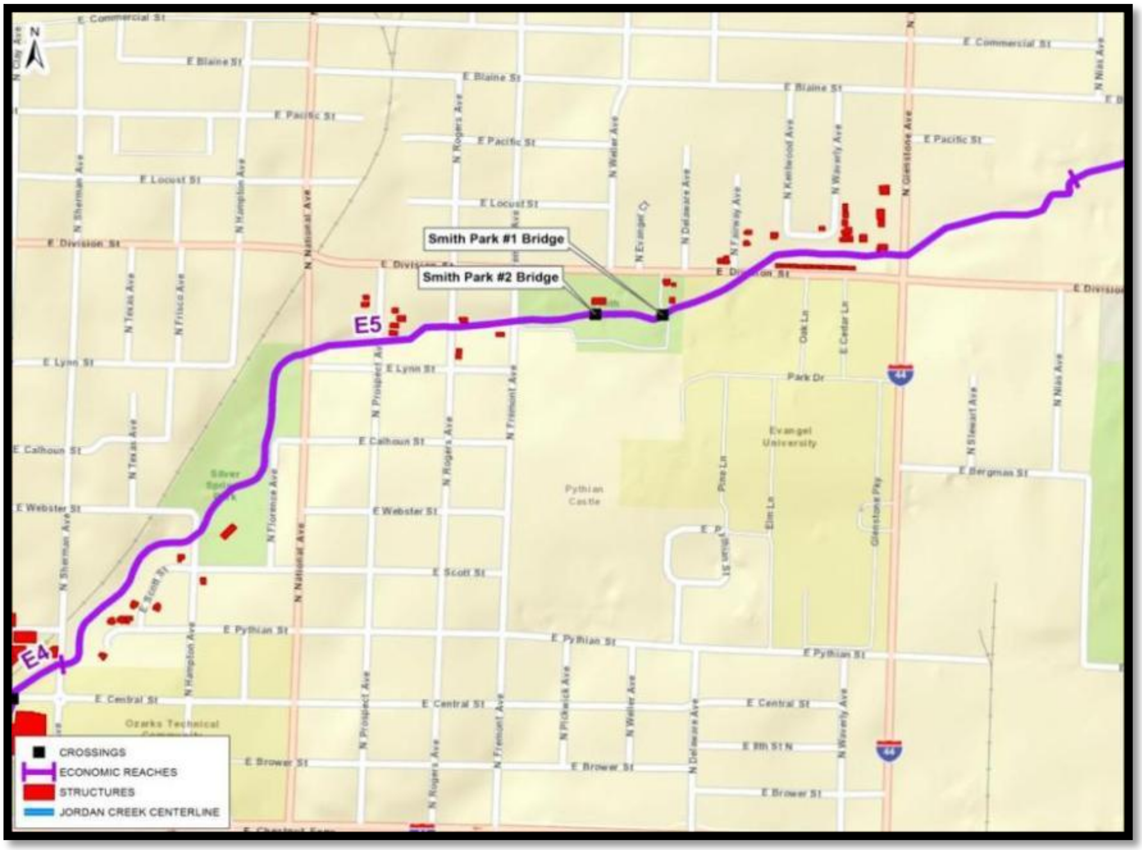
Figure 5: Reach E4



3.5.5 Reach E5

In Reach E5, 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. The structural values of the structures within E5 total approximately $2.5 million with contents valued at approximately $3.7 million.

Figure 6: Reach E5

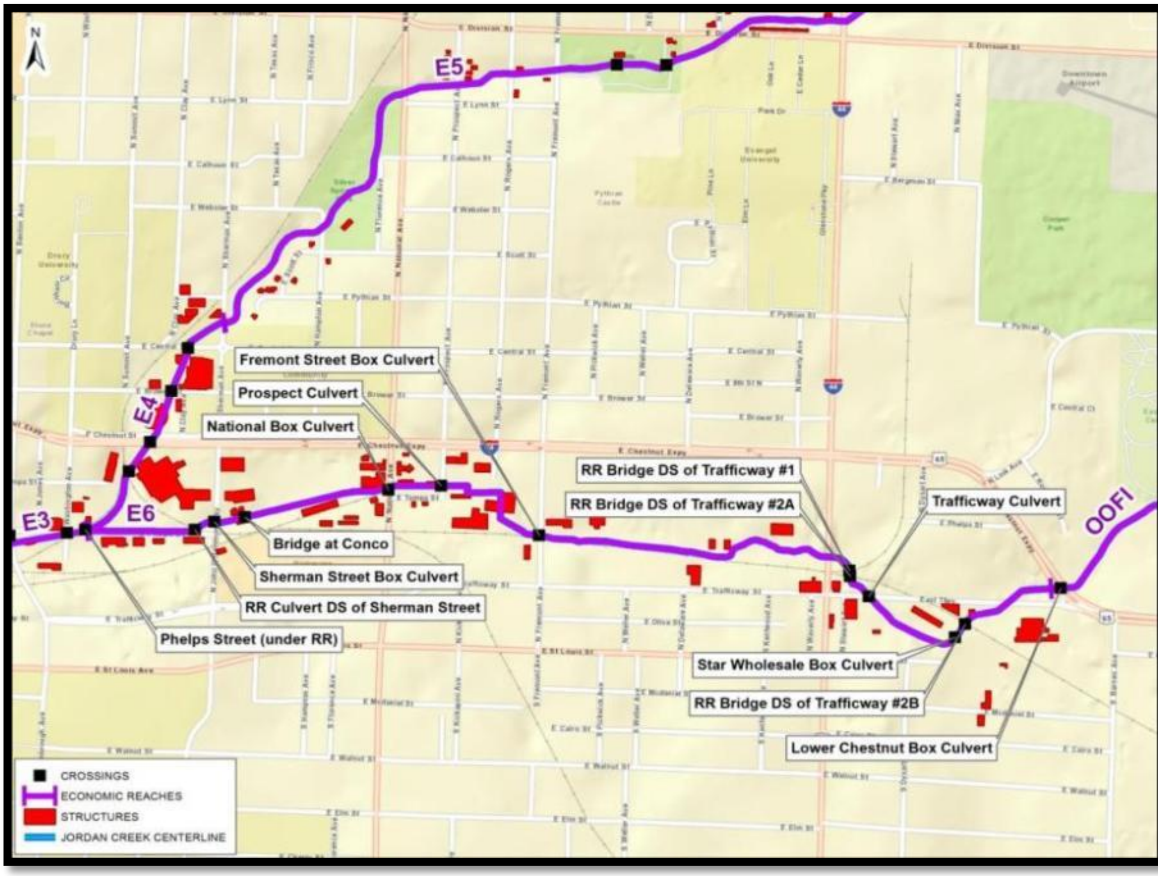


3.5.6 Reach E6

The upstream part of Reach E6 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. The structural values of the structures within E6 total approximately $27.8 million with their contents valued at approximately $36.6 million.

Figure 7: Reach E6



3.6 DAMAGE CALCULATIONS

Hydrologic Engineering Center – Flood Damage Analysis software (FDA) version 1.2.4 was used to calculate flood damages to structures and their content as well as damages to vehicles. FDA used an index point within each stream reach, a structure's FFE, and a structure's stationing along a stream to determine whether structures were in the floodplain and, if so, used a depth-damage relationship to find how much damage occurred to each structure and its contents given a certain water elevation.

3.7 WITHOUT PROJECT CONDITION

3.7.1 Structures, Contents, and Autos: EAD and Single Event Damages

Equivalent Annual Damages were calculated for damages to structures, contents, and vehicles by FDA. Table 17 displays the without project estimates of Equivalent Annual Damages (EAD) as calculated by FDA.

Table 17: Equivalent Annual Damages, Without Project

Reach	EAD: Without Project
E1	2,242,650
E2	278,992
E3	1,037,289
E4	72,076
E5	9,532
E6	882,811
Total	**4,523,350**

Without project estimates of single-event damages in each of the reaches in the study area for specified frequency events are provided in Table 18; the damages shown are at October 2012 price levels. There is a significant increase in damages between the 1/5 ACE and the 1/10 ACE given the overtopping of a floodwall in Reach 1 and overtopping of the box culvert in Reach 3. Damages significantly increase again from the 1/10 ACE to the 1/25 ACE in Reaches 1, 3, and 6.

Table 18: Single Event Damages, Without Project Condition

	Annual Chance Exceedence (Recurrence Interval) Damages							
	0.99 (1- yr)	**0.5 (2-yr)**	**0.2 (5-yr)**	**0.1 (10-yr)**	**0.04 (25-yr)**	**0.02 (50-yr)**	**0.01 (100-yr)**	**0.002 (500-yr)**
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

3.7.2 Other Damages

Some damage categories were calculated outside of the FDA program. Emergency protection, public infrastructure (such as roads and bridges), and utility damages are examples of these categories. For these damages, the methodology and results are described.

3.7.2.1 Emergency Protection Measures

Emergency costs were incurred by government agencies in the aftermath of the flood events and were determined using procedures developed in a study by the U.S. Army Engineer District, Louisville, Kentucky. This study, titled Flood Damage Report for Frankfort, Kentucky, July 1981, provided a basis for estimating these types of costs. Emergency costs were computed using a unit cost for each structure based on the number of structures flooded by frequency in the FDA program and relative duration of flooding. Unit costs were assumed to remain constant. Changes in duration compensated for differences for the long single event in Frankfort and the short, flashy events that occur on Jordan Creek. Flood events create adverse socioeconomic effects that vary in duration from a few days to several months or even years following the particular event. Data from the Frankfort report was used to estimate costs associated with flood events in the Jordan Creek study area. Emergency cost items included protection of life, health, and property, evacuation and reoccupation; emergency care, emergency preparedness; and administrative costs. The Frankfort data was adjusted for price changes as well as being modified to reflect local area conditions with regard to flood durations. Table 19 provides an example of calculating emergency costs for the 1/10 ACE. Given that the total expected annual damage for emergency costs equaled less than $1000 and the differences among plans was insignificant, calculation of emergency costs for alternative plans was removed from analysis. The order of magnitude of benefit is within rounding difference of Alternative Plans’ benefit calculations.

Table 19: Emergency Costs, 1/10 ACE

Reach	Cost Item	Unit Cost Per day (dollars) (1)	Units Affected (2)	Total Costs Without Project
	Protection of life, health & property (3)	$104	30	$3,116
	Evacuation, transition & reoccupation (4)	$104	0	$0
	Emergency & mass care	$234	0	$0
	Emergency Preparedness	$130	30	$3,895
R-1	Administrative Costs	$208	30	$6,231
	Protection of life, health & property (3)	$104	28	$2,908
	Evacuation, transition & reoccupation (4)	$104	8	$831
	Emergency & mass care	$234	8	$1,869
	Emergency Preparedness	$130	28	$3,635
R-2	Administrative Costs	$208	28	$5,816
	Protection of life, health & property (3)	$104	45	$4,674
	Evacuation, transition & reoccupation (4)	$104	1	$104
	Emergency & mass care	$234	1	$234
	Emergency Preparedness	$130	45	$5,842
R-3	Administrative Costs	$208	45	$9,347
	Protection of life, health & property (3)	$104	8	$831
	Evacuation, transition & reoccupation (4)	$104	0	$0
	Emergency & mass care	$234	0	$0
	Emergency Preparedness	$130	8	$1,039
R-4	Administrative Costs	$208	8	$1,662
	Protection of life, health & property (3)	$104	14	$1,454
	Evacuation, transition & reoccupation (4)	$104	13	$1,350
	Emergency & mass care	$234	13	$3,038
	Emergency Preparedness	$130	14	$1,818
R-5	Administrative Costs	$208	14	$2,908
	Protection of life, health & property (3)	$104	35	$3,635
	Evacuation, transition & reoccupation (4)	$104	0	$0
	Emergency & mass care	$234	0	$0
	Emergency Preparedness	$130	35	$4,544
R-6	Administrative Costs	$208	35	$7,270
	Total Emergency Costs by Project Condition			**$78,049**
	Average Annual Emergency Costs			**$780**
	(1) Data from 1981 Report, Flood Damage Report for Frankfort, Kentucky, July 1981. Dollar values adjusted for price level changes and locality conditions to October 2012$. (2) Numbers of units with damages from FDA Model runs. (3) Includes commercial and residential unit. (4) Residential units only.			

3.7.2.2 Infrastructure Damages: Roads, Bridges, and Utilities

Given the type of flooding in the Jordan Creek watershed (flash-flooding), infrastructure covered with water during high water events does not stay submerged for long periods of time. The City of Springfield did not provide data for infrastructure damages that have occurred during past flood events. Consistent with past Little Rock District flood risk management studies (May Branch Fort Smith Arkansas, Fourche Creek Little Rock Arkansas), infrastructure damages were estimated by creating an FDA model which was stripped of content and other damages. The "infrastructure" model was run to calculate EAD for structural damages. Expected annual infrastructure damage in the Without Project condition is $126,573 as shown in Table 20.

Table 20: Equivalent Annual Damages, Infrastructure Damages, Without Project

Reach	Structural EAD: Without Project $	Percentage of Damage	Infrastructure EAD: Without Project $
E1	175,888	15.6%	27,438
E2	64,222	15.6%	10,019
E3	211,667	15.6%	33,020
E4	22,552	15.6%	3,518
E5	4,588	15.6%	716
E6	342,024	15.6%	53,356
Total	**820,940**		**128,067**

There are two railroads in the floodplain that would be affected by flood events. Information obtained from the railroad companies indicated damages will occur if the flood duration approached 48 hours. Duration analysis was performed for locations that are subjected to flooding. The longest duration of flooding for the 500-year event was approximately 6 hours; therefore damages to railroads and rail commerce were not included in this analysis. In historic flood events, the rail lines were overtopped but the duration was not long enough to result in damages incurred by the inability to move goods.

3.8 TRANSPORTATION DELAY ANALYSIS

Flooding can temporarily impede traffic by covering roads and bridges. Even the threat of flooding and concern for public safety may make it necessary to close roads and detour traffic. The costs of traffic disruption include 1) the additional operating cost for each vehicle, including depreciation, maintenance, and gasoline per mile of detour; and 2) the traffic delay cost per passenger.

Examining historic floods along Jordan Creek shows that flooding is extremely flashy with the water reaching its peak stage from normal flow in less than an hour. Once flooding has peaked, water levels usually subside in only a few hours. Historic floods have also shown that flooding was very localized. There have been reports of areas receiving no rainfall that get flooded by rainfall less than a mile upstream. There are also numerous bridges and crossings along Jordan Creek. In some areas there are stream crossings at every street block.

Given the short duration of flooding, the locality of flooding and the, numerous stream crossings, transportation delays were not analyzed. In the past, vehicles have been successful at finding non-inundated crossings only a short distance from their original route. By not analyzing transportation delays, we assumed the risk that there are costs and benefits not taken into account in the overall analysis of alternatives. This risk was perceived to be very minimal.

4 BENEFIT ANALYSIS

4.1 NON-STRUCTURAL MEASURES ANALYSIS

Nonstructural flood risk reduction measures are an important consideration in flood risk management. To analyze the benefits of nonstructural buyout plans, several economists and GIS specialist used FDA output and GIS to identify and analyze "footprint" buyout plans. The buyout plans were analyzed in three rounds, using a 0.8 BCR as a screening tool for plans to move through the first and second rounds (with greater benefits uncertainty) and a 1.0 BCR as a screening tool for plans to move through the third round to a full cost analysis.

4.1.1 First Round

The FDA_Struct.out file from the FDA model of Without Project condition was used as the foundation of EAD analysis. A simple EAD calculating spreadsheet was created, with each tab depicting a "footprint" buyout plan. "Footprint" plans were created for structures which were affected by the 1/2 ACE, the 1/5 ACE, the 1/10 ACE, and the 1/25 ACE. The EAD calculating spreadsheet performed lookup functions (tied with links to the FDA output spreadsheet) to create a list of structures impacted by the flood event (for more than $500) and then to complete a damage table for each structure as seen in Figure 8.

Figure 8: Spreadsheet Calculations of EAD

Existing Conditions			Structure :				
Flood Event	Frequency	Change in Frequency	Damage 1000	Interval EAD	Cumulative EAD	Buyout Cost	Average Annual Cost
1	1.0000		$0				
		0.50000		$499	$499		
2	0.5000		$1,995				
		0.30000		$3,194	$3,693		
5	0.2000		$19,297				
		0.10000		$2,486	$6,178		
10	0.1000		$30,414				
		0.06000		$2,381	$8,559		
25	0.0400		$48,937				
		0.02000		$1,088	$9,646		
50	0.0200		$59,827				
		0.01000		$624	$10,270		
100	0.0100		$64,989				
		0.00800		$557	$10,828		
500	0.0020		$74,373				
		0.00200		$149	$10,977		
~	0		$74,373				
	EAD			$10,977		$110,477.50	$4,924.45

Each "footprint" tab calculated a benefit-cost ratio for a buyout plan: with assuming 100 percent removal of damages, an acquisition and demolition cost of 2.5 multiplied by the structure value, and amortization of the cost over 50 years at 3.75 percent interest. The 2.5 multiplier was a rough estimate received from the Real Estate appraiser that included the cost to buy the structure, the cost to buy property, the cost of relocation and administrative and legal fees. Five structures could not be cost-valued based on structure value due to their business being based on parked vehicles; those were assigned acquisition and demolition costs of 2.5 multiplied by their associated buildings structure values. The buyout analysis results are presented in Table 21.

Table 21: Non-Structural Analysis for "Footprint" Plans

"Footprint" Plan	Structure Count	EAD	AAC	BCR
2-year	26	$938,835	$2,055,391	0.46
5-year	55	$1,560,445	$2,667,778	0.58
10-year	98	$4,285,810	$4,140,341	1.04
25-year	129	$4,427,333	$5,914,661	0.75

4.1.2 Second Round

A next step of screening was performed for the only plan with a BCR greater than 0.8. The second screening round was for the 10-year "footprint" plan to include other structures which were associated with the 98 structures in the first round of analysis. For example: a buyout plan that only considered a warehouse but not the main business was incomplete. To find associated structures, the GIS specialist used a shapefile of structures within the maximum projected floodplain to create a geodatabase. Next, the "FDA_Struct.out" spreadsheet for the Without Project condition was loaded as a geodatabase table.

The "corps_id" field was a common element in the feature class. Using the "corps_id" the geodatabase table was joined to the feature class. Then, using a definition query within ArcMap, properties were displayed by their damages in certain return-period categories (2-year, 5-year, 10-year, etc). For the 10-year "footprint" plan, 12 structures which shared a common parcel owner were included. The buyout analysis result for the additional screening is presented in Table 22.

Table 22: Further Analysis for Non-Structural "Footprint" Plan

"Footprint" Plan	Structure Count	EAD	AAC	BCR
10-year	110	$4,277,900	$5,082,200	0.84

4.1.3 Third Round

Occasionally, spreadsheet calculations of EAD underestimate the EAD that FDA computes. To verify that spreadsheet analysis of buyout plans was not under-representing the damages, a separate FDA model was built and executed, with the 110 structures removed from inventory. FDA calculated the EAD of the 110 structures at $4,202,339 – insignificantly different than the spreadsheet analysis. Given the professional judgment of Real Estate specialists that acquisition costs were conservatively estimated at a multiple of 2.5 the structural values, a BCR of less than 1.0 stopped further analysis of a non-structural buyout plan.

4.2 STRUCTURAL MEASURES ANALYSIS

In the plan formulation process, many structural plans were created and analyzed with FDA. Several structural plans were eliminated through four rounds of the formulation process as documented in the main report. Plans A, B, C, D, E, F, and G were eliminated from further evaluation due to inefficiency as compared to Plan G and then to Plan G2. Net benefits and benefit-cost ratios which were calculated in early formulation are presented in Table 23.[1]

Table 23: Benefits and BCR for Plans A through G, Early Formulation

Plan	Net Benefits	BCR
A	1,752,500	1.3
B	2,798,200	1.6
C	3,017,000	1.7
D	2,335,300	1.4
E	3,243,200	2.0
F	3,208,300	1.8
G	3,858,300	2.2

[1] Estimated benefits and benefit-cost ratios from early formulation cannot be compared to benefits and benefit-cost ratios for Plans G2 and J. Benefits during early formulation were ordinal correct, meaning that Plan G had greater benefits than Plans A through F; however, the benefits were not accurate. In refined formulation, only Plan G retained a benefit-cost ratio greater than 1.

Plans H and I were eliminated from further consideration due to inefficiency as compared to Plan J. Net benefits and benefit-cost ratios which were calculated in refined formulation are presented in Table 24.

Table 24: Benefits and BCR for Plans H and I, Refined Formulation

Plan	Net Benefits	BCR
G	336,700	1.09
G2	719,500	1.2
H	1,339,900	1.6
I	871,300	1.3
J	1,876,300	2.6

The following sections describe the final array of alternatives.

4.2.1 Detention Basins

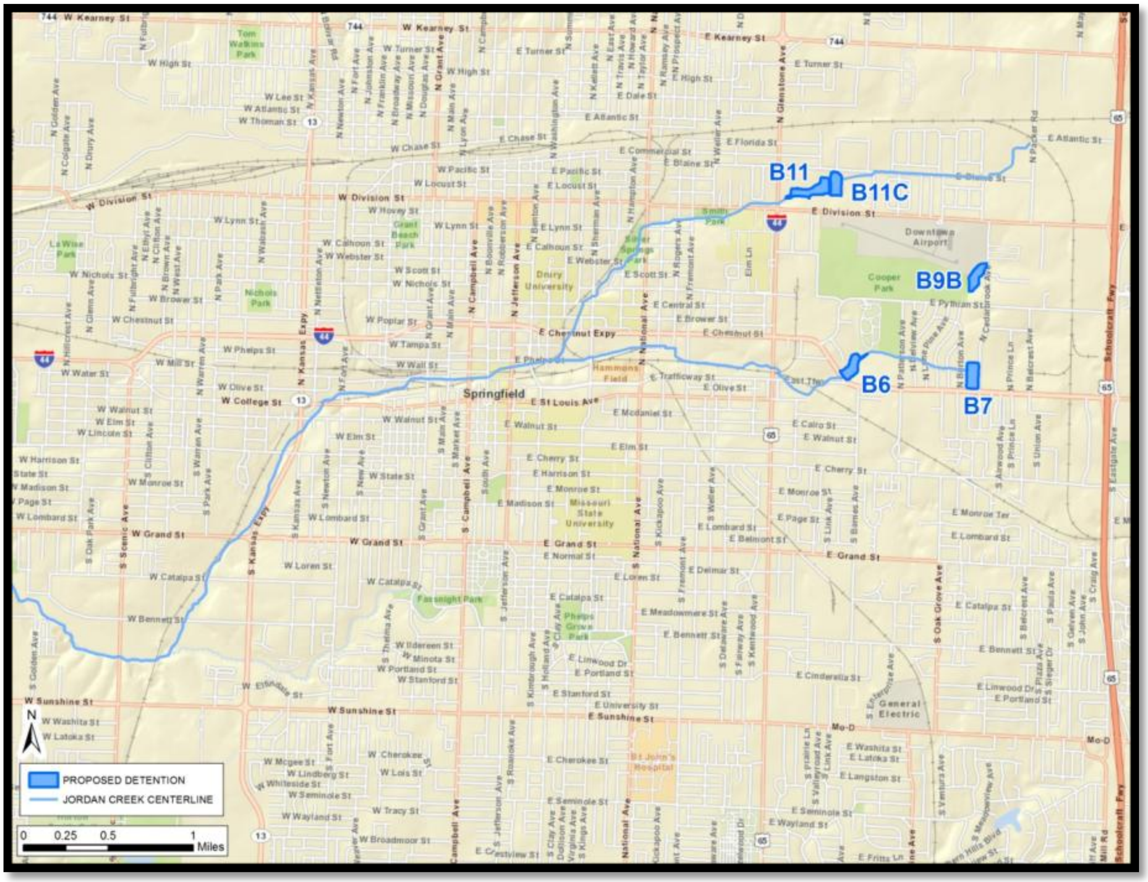
Detention basin analysis (as described in the H&H Appendix) showed the results of the reservoir routing through the basins to determine the basins that provide the most benefit to the project. The resulting basins are shown in Figure 9. The results of the H&H analysis showed five basins provided a significant reduction in flow, two on the North Branch and three on the South Branch. This configuration consists of five detention basins that were deemed efficient in a preliminary H&H analysis. In a preliminary analysis, three detention pond FDA models were created: North Branch only, South Branch only, and All Basins. The benefits from reducing EAD for the three plans in early formulation were compared to initial cost estimates.

Table 25: Detention Pond Screening

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 detention plan with all five detention basins provided greater annual net benefits than the North Branch only plan and the South Branch only plan.

Figure 9: Detention Basins



Estimates of single-event damages for Detention Basin Plan, in each of the reaches in the study area for specified frequency events, are provided in Table 26; the damages shown are at October 2012 price levels. There is a significant change in start of damages between the Without Project and the Detention Basins between the 1/10 ACE and the 1/25 ACE given the overtopping of a floodwall in Reach 1 and overtopping of the box culvert in Reach 3. Adding detention basins to the Jordan Creek system adds storage capacity to the system and has the effect of decreasing the flood damages for frequent events (1/2 ACE, 1/5 ACE, 1/10 ACE). As flood events get larger (and less frequent), the detention basins fill to capacity and are not as effective in reducing flood damages.

Table 26: Single Event Damages, Detention Basins

	Annual Chance Exceedence (Recurrence Interval) Damages							
	0.99 (1- yr)	**0.5 (2-yr)**	**0.2 (5-yr)**	**0.1 (10-yr)**	**0.04 (25-yr)**	**0.02 (50-yr)**	**0.01 (100-yr)**	**0.002 (500-yr)**
Reach E1								
Damage ($)	-	-	600	38,200	20,867,900	24,533,700	27,003,800	29,678,400
Structures (#)	0	0	1	4	29	30	30	30
Reach E2								
Damage ($)	3,000	68,500	361,500	580,200	882,700	1,241,000	1,701,300	2,537,600
Structures (#)	2	4	13	15	17	22	26	34
Reach E3								
Damage ($)	-	77,200	437,200	1,607,500	3,699,100	4,757,200	6,590,900	14,997,500
Structures (#)	0	5	17	25	35	41	43	49
Reach E4								
Damage ($)	-	1,500	25,400	69,800	238,600	360,300	604,900	1,314,700
Structures (#)	0	2	3	4	5	6	6	9
Reach E5								
Damage ($)	-	1,500	5,300	13,300	25,100	33,200	39,900	65,400
Structures (#)	0	2	2	5	6	8	11	16
Reach E6								
Damage ($)	-	12,500	393,400	844,600	2,386,900	4,702,500	6,739,300	11,765,900
Structures (#)	0	2	15	22	28	33	36	39
Total Damage ($)	3,000	161,200	1,223,400	3,153,600	28,100,300	35,627,800	42,680,100	60,359,600
Total Structures (#)	2	15	51	75	120	140	152	177
Damages per Structure ($)	1,514	10,745	23,987	42,048	234,169	254,484	280,790	341,015
Damage Reduced %	46.71%	59.53%	37.83%	79.82%	9.45%	8.24%	10.45%	11.73%

The estimates of EAD for Detention Plan as provided by FDA are shown in Table 27.

Table 27: EAD, Detention Plan

Reach	EAD $	Infrastructure EAD $	Total EAD $
E1	2,218,390	26,856	2,245,246
E2	240,857	8,727	249,585
E3	717,055	23,068	740,123
E4	49,363	2,571	51,934
E5	6,106	484	6,590
E6	520,865	31,252	552,117
Total	**3,752,636**	**92,959**	**3,845,595**

4.2.2 Plan G2

Plan G2 provides a varying level of protection through each of the reaches. Plan G2 includes:

- Regional Detention Basins
- Channel modifications included narrowing the channel and linear feet of modified channel to accommodate a lower level of protection than Plan A or B. Channel improvements occur along about 2.2 miles of channel. Channel widths vary from 5 feet on South Branch to about 37 feet on the lower end of Jordan Creek and on Wilsons Creek. Side slopes vary from 3v to 1h to 5v to 1h depending on real estate restrictions.

The estimates of Equivalent Annual Damages for Plan G2 as provided by FDA are shown in Table 28.

Table 28: EAD, Plan G2

Reach	EAD $	Infrastructure EAD $	Total EAD $
E1	21,154	351	21,505
E2	242,470	8,675	251,146
E3	58,765	1,708	60,473
E4	43,280	2,530	45,809
E5	6,038	459	6,497
E6	110,173	3,132	113,306
Total	**481,880**	**16,856**	**498,736**

Plan G2 estimates of single-event damages in each of the reaches in the study area for specified frequency events are provided in Table 29; the damages shown are at October 2012 price levels.

Table 29: Single Event Damages, Plan G2

	Annual Chance Exceedence (Recurrence Interval) Damages							
	0.99 (1- yr)	**0.5 (2-yr)**	**0.2 (5-yr)**	**0.1 (10-yr)**	**0.04 (25-yr)**	**0.02 (50-yr)**	**0.01 (100-yr)**	**0.002 (500-yr)**
Reach E1								
Damage ($)							300	99,300
Structures (#)	0	0	0	0	0	0	1	6
Reach E2								
Damage ($)	3,000	67,800	359,300	577,200	874,100	1,239,100	1,699,700	2,633,200
Structures (#)	2	4	13	15	17	22	27	34
Reach E3								
Damage ($)	-	-	-	33,800	112,600	252,100	514,900	3,731,200
Structures (#)	0	0	0	1	5	11	18	37
Reach E4								
Damage ($)	-	-	28,300	63,200	226,500	344,100	475,600	956,600
Structures (#)	0	0	2	2	4	5	5	9
Reach E5								
Damage ($)	-	1,600	5,300	13,300	25,100	33,200	39,900	65,400
Structures (#)	0	2	2	5	6	8	11	16
Reach E6								
Damage ($)	-	-	5,400	15,900	591,300	1,368,700	1,915,600	4,111,900
Structures (#)	0	0	2	3	5	11	18	29
Total Damage ($)	3,000	69,400	398,300	703,400	1,829,600	3,237,100	4,645,900	11,597,700
Total Structures (#)	2	6	19	26	37	57	80	131
Damages per Structure ($)	1,516	11,565	20,961	27,056	49,448	56,791	58,073	88,532
Damage Reduced %	46.63%	82.58%	79.76%	95.50%	94.10%	91.66%	90.25%	83.04%

4.2.3 Plan J

Plan J is the optimized Plan. It includes only the channel increments that produce the most net benefits. Plan J includes:

- Regional Detention
- Channel modifications only in the Reach E1 to protect against the 1/500 ACE.
- Stream Crossings –One stream crossing was built for the railroad and one for vehicles. Another stream crossing was modified to accommodate a wider channel.

The estimates of Equivalent Annual Damages for the Plan J as provided by FDA are displayed in Table 30.

Table 30: EAD, Plan J

Reach	EAD $	Infrastructure EAD $	Total EAD $
E1	21,154	351	21,505
E2	240,857	8,727	249,585
E3	717,055	23,068	740,123
E4	49,363	2,571	51,934
E5	6,106	484	6,590
E6	520,865	31,252	552,117
Total	**1,555,400**	**66,454**	**1,621,854**

Plan J estimates of single-event damages in each of the reaches in the study area for specified frequency events are provided in Table 31; the damages shown are at October 2012 price levels.

Table 31: Single Event Damages, Plan J

	Annual Chance Exceedence (Recurrence Interval) Damages							
	0.99 (1- yr)	0.5 (2-yr)	0.2 (5-yr)	0.1 (10-yr)	0.04 (25-yr)	0.02 (50-yr)	0.01 (100-yr)	0.002 (500-yr)
Reach E1								
Damage ($)	-	-	-	-	-	-	300	99,300
Structures (#)	0	0	0	0	0	0	1	6
Reach E2								
Damage ($)	3,000	68,500	361,500	580,200	882,700	1,241,000	1,701,300	2,537,600
Structures (#)	2	4	13	15	17	22	26	34
Reach E3								
Damage ($)	-	77,200	437,200	1,607,500	3,699,100	4,757,200	6,590,900	14,997,500
Structures (#)	0	5	17	25	35	41	43	49
Reach E4								
Damage ($)	-	1,500	25,400	69,800	238,600	360,300	604,900	1,314,700
Structures (#)	0	2	3	4	5	6	6	9
Reach E5								
Damage ($)	-	1,500	5,300	13,300	25,100	33,200	39,900	65,400
Structures (#)	0	2	2	5	6	8	11	16
Reach E6								
Damage ($)	-	12,500	393,400	844,600	2,386,900	4,702,500	6,739,300	11,765,900
Structures (#)	0	1	13	20	26	31	34	37
Total Damage ($)	3,000	161,200	1,222,800	3,115,400	7,232,400	11,094,100	15,676,500	30,780,500
Total Structures (#)	2	14	48	69	89	108	121	151
Damages per Structure ($)	1,514	11,513	25,474	45,151	81,263	102,723	129,558	203,844
Damage Reduced %	46.71%	59.53%	37.86%	80.06%	76.69%	71.43%	67.11%	54.98%

4.3 FLOOD DAMAGE REDUCTION TO RESIDENTIAL AND NONRESIDENTIAL PROPERTIES

4.3.1 Detention Basins

The estimated benefits of the Detention Basins were calculated as the difference between Total EAD for the without project condition less the Total EAD for the Detention Basins. The benefits for Detention Basins are shown in Table 32.

Table 32: Benefits of Detention Basins

Reach	Without: Total EAD $	Detention Basins: Total EAD $	Benefit of Detention Basins $
E1	2,270,088	2,245,246	24,842
E2	289,010	249,585	39,426
E3	1,070,309	740,123	330,186
E4	75,594	51,934	23,660
E5	10,247	6,590	3,658
E6	936,167	552,117	384,050
Total	**4,651,417**	**3,845,595**	**805,822**

4.3.2 Plan G2

The estimated benefits of Plan G2 were calculated as the difference between Total EAD for the without project condition less the Total EAD for Plan G2. The benefits of Plan G2 are displayed in Table 33.

Table 33: Benefits of Plan G2

Reach	Without: Total EAD $	Plan G2: Total EAD $	Benefit of Plan G2 $
E1	2,270,088	21,505	2,248,583
E2	289,010	251,146	37,865
E3	1,070,309	60,473	1,009,836
E4	75,594	45,809	29,785
E5	10,248	6,497	3,751
E6	936,167	113,306	822,861
Total	**4,651,417**	**498,736**	**4,152,681**

4.3.3 Plan J

The estimated benefits of Plan J were calculated as the difference between Total EAD for the without project condition less the Total EAD for Plan J. The benefits of Plan J are displayed in Table 34.

Table 34: Benefits of Plan J

Reach	Without: Total EAD $	Plan J: Total EAD $	Benefit of Plan J $
E1	2,270,088	21,505	2,248,583
E2	289,010	249,585	39,426
E3	1,069,093	740,123	330,186
E4	75,594	51,934	23,660
E5	10,248	6,590	3,698
E6	936,167	552,117	384,050
Total	**4,651,417**	**1,621,854**	**3,029,603**

4.4 INDUCED DAMAGES

Through FDA output, there was no expected inducement of damages in the Jordan Creek Watershed for Detention Basins, Plan G2, or Plan J.

4.5 SUMMARY OF BENEFITS

Benefits for the Jordan Creek watershed were measured by Equivalent Annual Damages reduced as measured by FDA. Benefits for Detention Basins, Plan G2, and Plan J are shown in Table 35.

Table 35: Benefits Compared

Reach	Benefit of Detention Basins $	Benefit of Plan G2 $	Benefit of Plan J $
E1	24,842	2,248,583	2,248,583
E2	39,426	37,865	39,426
E3	330,186	1,009,836	330,186
E4	23,660	29,785	23,660
E5	3,658	3,751	3,698
E6	384,050	822,861	384,050
Total	**805,821**	**4,152,681**	**3,029,603**

4.6 RISK AND UNCERTAINTY ANALYSIS

The analysis followed guidance described in ER 1105-2-101: Risk Analysis for Flood Damage Reduction Studies. As stated in the ER, "A variety of planning and design variables may be incorporated into risk analysis in a flood damage reduction study. Economic Variables in an urban situation may include, but are not limited to, depth-damage curves, structure values, content values, structure first-floor elevations, structure types, flood warning times, and flood evacuation effectiveness. The uncertainty of these variables may be due to sampling, measurement, estimation, and forecasting."

4.6.1 First Floor Elevations

The first floor elevations (FFE) for each structure indentified from the maps, as well as structures requested to be examined by the City of Springfield, were obtained by a professional survey team. FFE, as defined by the surveyors, is the lowest point of the lowest, non-basement floor. Error associated with the professional survey was entered as a normal distribution with 0.02 feet standard deviation.

4.6.2 Structure Value

Most commercial, industrial, and residential property values were obtained from the Greene County Tax Assessor whose estimates are updated every 2 years and can be accessed online. The assessor's estimates, confirmed by the assessor's office, were derived by taking the structure's replacement cost less its depreciation. Error associated with the structure values were entered as a normal distribution with 2.5 percent standard deviation.

4.6.3 Content Value

Content values for non-residential properties were estimated using ARW (as referenced in section 3.3.2.1.2). Error associated with the non-residential content values was entered as a normal distribution with 5 percent standard deviation. Content values for residential properties were based on a Content-to-Structure ratio as given in EGM 04-01.

4.6.4 Vehicle Value

Vehicle values were derived with the methodology from the Fort Worth District's Lower Colorado River Basin study, with no uncertainty on values (given the uncertainty in structure values on which the vehicle values are based).

4.6.5 H&H Exceedance Probability Functions

Functions were derived by using the "Analytical from WSP" function using Log Pearson III statistics with a 20 year equivalent record length within FDA program for each reach along each stream. From EM 1110-2-1619 Table 4-5, "Estimated with rainfall-runoff-routing model calibrated to several events recorded at short-interval event gauge in watershed: 20 to 30 years" was chosen given the information from the H&H Appendix in section 2.3. The H&H model used USGS gages at Scenic Avenue and Bennett Street for the 2000 flood to calibrate the model.

4.6.6 H&H Stage-Discharge Function

Functions were derived by using the "Retrieve from WSP" function using Normal Distribution. Defined uncertainty was calculated within FDA using a normal distribution with "stage where stage becomes constant" and the "standard deviation of error for entered stage" defined by the H&H engineer for each reach along each stream.

4.6.7 Depth-Percent Damage Functions

Depth-percent damage functions were entered for all structures, contents, and vehicles based on the source of the original values. Residential functions were obtained from EGM 04-01. Commercial (as well as industrial and public) functions were entered for all businesses and public structures. Those functions, as well as vehicle functions obtained from ARW.

4.7 CONSEQUENCE OF PROJECT EXCEEDANCE AND RESIDUAL RISK

As stated in ER 1105-2-101, "The flood protection performance will be presented. The risk analysis will quantify the performance of all scales of all alternatives considered for final recommendation. The analysis will evaluate and report residual risk, which includes consequence of project capacity exceedance." In accordance with the policy, several figures (FDA output tables) are presented which depict long-term residual risk by original H&H delineated reaches.

Figure 10: Project Performance, Without Project

Project Performance

File Help

Jordan Creek Study; Springfield Project Performance
by Damage Reaches for the Without
(Without project condition) plan for Analysis Year 2020
(Stages in ft.)
Plan was calculated with Uncertainty

Without Project Base Year Performance Target Criteria:
Event Exceedance Probablility = 0.01
Residual Damage = 5.00 %

Stream Name	Stream Description	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
					Median	Expected	10	30	50	10%	4%	2%	1%	.4%	.2%
Lower	Lower Branch c	L1 L		1222.39	0.0714	0.0858	0.5924	0.9323	0.9887	0.6623	0.1806	0.0474	0.0106	0.0012	0.0002
		L1 R		levee	0.0996	0.1151	0.7057	0.9745	0.9978	0.4462	0.0736	0.0138	0.0023	0.0001	0.0000
		L1 B		1223.09	0.0941	0.1060	0.6737	0.9653	0.9963	0.5139	0.1110	0.0268	0.0058	0.0007	0.0001
		L2		1218.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		L3		1232.87	0.2044	0.2196	0.9162	0.9994	1.0000	0.1367	0.0209	0.0048	0.0011	0.0001	0.0000
		L4		1238.84	0.4302	0.4328	0.9966	1.0000	1.0000	0.0068	0.0006	0.0001	0.0000	0.0000	0.0000
		L5		1241.50	0.3743	0.3821	0.9919	1.0000	1.0000	0.0141	0.0013	0.0002	0.0000	0.0000	0.0000
		L6		1246.70	0.4180	0.4012	0.9941	1.0000	1.0000	0.0377	0.0047	0.0010	0.0002	0.0000	0.0000
		L7		1248.32	0.7257	0.7136	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		L8		1262.51	0.0115	0.0226	0.2040	0.4957	0.6805	0.9793	0.8224	0.6130	0.3993	0.1954	0.1049
		L9		1265.17	0.0619	0.0862	0.5941	0.9331	0.9890	0.6667	0.2755	0.1130	0.0421	0.0106	0.0038
		L10		1271.22	0.3141	0.3230	0.9798	1.0000	1.0000	0.0064	0.0001	0.0000	0.0000	0.0000	0.0000
North	North Branch o	N1		1274.61	0.3027	0.3162	0.9777	1.0000	1.0000	0.0145	0.0007	0.0000	0.0000	0.0000	0.0000
		N2		1277.23	0.1186	0.1383	0.7743	0.9885	0.9994	0.3738	0.0924	0.0275	0.0077	0.0013	0.0003
		N3		1269.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N4		1282.90	0.2554	0.2755	0.9602	0.9999	1.0000	0.0446	0.0029	0.0004	0.0000	0.0000	0.0000
		N5		1283.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N6		1289.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N7		1301.21	0.3684	0.3817	0.9918	1.0000	1.0000	0.0130	0.0007	0.0001	0.0000	0.0000	0.0000
		N8		1317.48	0.6096	0.6015	0.9999	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N9		1321.65	0.1877	0.1971	0.8887	0.9986	1.0000	0.1283	0.0132	0.0022	0.0004	0.0000	0.0000
		N10		1324.50	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N11		1338.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N12		1342.40	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N13		1345.50	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N14		1361.20	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N15		1365.60	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
South	South Branch c	S1		1275.84	0.1895	0.2054	0.8996	0.9990	1.0000	0.2133	0.0430	0.0105	0.0023	0.0002	0.0000
		S2		1279.23	0.4364	0.4277	0.9962	1.0000	1.0000	0.0052	0.0003	0.0000	0.0000	0.0000	0.0000
		S3		1280.22	0.5963	0.5917	0.9999	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		S4		1281.79	0.4016	0.4069	0.9946	1.0000	1.0000	0.0016	0.0000	0.0000	0.0000	0.0000	0.0000
		S5		1290.30	0.1618	0.1811	0.8644	0.9975	1.0000	0.2403	0.0525	0.0154	0.0045	0.0008	0.0002
		S6		1293.50	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		S7		1303.57	0.0303	0.0437	0.3605	0.7385	0.8930	0.9214	0.5643	0.2914	0.1253	0.0353	0.0124
		S8		1309.23	0.3214	0.3431	0.9850	1.0000	1.0000	0.0515	0.0078	0.0018	0.0004	0.0000	0.0000
		S9		1314.07	0.0695	0.0829	0.5792	0.9255	0.9868	0.6850	0.1837	0.0458	0.0094	0.0009	0.0001
		S10		1311.50	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		S11		1323.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		S12		1331.60	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Figure 11: Project Performance, Detention Basins

Project Performance

File Help

Jordan Creek Study; Springfield Project Performance
by Damage Reaches for the Det All
(All 5 Detention Ponds Alternative) plan for Analysis Year 2020
(Stages in ft.)
Plan was calculated with Uncertainty

Without Project Base Year Performance Target Criteria:
Event Exceedance Probablility = 0.01
Residual Damage = 5.00 %

					Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
Stream Name	Stream Description	Damage Reach Name	Damage Reach Description	Target Stage	Median	Expected	10	30	50	10%	4%	2%	1%	.4%	.2%
Lower	Lower Branch c	L1 L		1222.39	0.0715	0.0855	0.5910	0.8930	0.9886	0.6646	0.1768	0.0449	0.0096	0.0011	0.0001
		L1 R		levee	0.0958	0.1118	0.6945	0.9484	0.9973	0.4673	0.0786	0.0147	0.0024	0.0002	0.0000
		L1 B		1223.09	0.0858	0.0998	0.6504	0.9277	0.9948	0.5575	0.1269	0.0311	0.0066	0.0008	0.0001
		L2		1218.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		L3		1232.87	0.1797	0.1958	0.8868	0.9957	1.0000	0.1889	0.0344	0.0088	0.0022	0.0003	0.0001
		L4		1238.84	0.3702	0.3807	0.9917	1.0000	1.0000	0.0148	0.0016	0.0003	0.0000	0.0000	0.0000
		L5		1241.50	0.3209	0.3340	0.9828	1.0000	1.0000	0.0274	0.0029	0.0005	0.0001	0.0000	0.0000
		L6		1246.70	0.3528	0.3618	0.9888	1.0000	1.0000	0.0492	0.0082	0.0021	0.0005	0.0001	0.0000
		L7		1248.32	0.6826	0.6723	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		L8		1262.51	0.0083	0.0169	0.1569	0.3474	0.5741	0.9913	0.8863	0.7065	0.4959	0.2672	0.1565
		L9		1265.17	0.0418	0.0647	0.4875	0.8120	0.9647	0.7952	0.4037	0.1871	0.0764	0.0212	0.0079
		L10		1271.22	0.2175	0.2317	0.9283	0.9986	1.0000	0.0617	0.0037	0.0004	0.0000	0.0000	0.0000
North	North Branch o	N1		1274.61	0.2320	0.2396	0.9354	0.9989	1.0000	0.0551	0.0040	0.0006	0.0001	0.0000	0.0000
		N2		1277.23	0.0798	0.0979	0.6430	0.9239	0.9942	0.5833	0.2061	0.0790	0.0274	0.0062	0.0018
		N3		1269.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N4		1282.90	0.1808	0.2060	0.9004	0.9969	1.0000	0.1458	0.0164	0.0027	0.0004	0.0000	0.0000
		N5		1283.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N6		1289.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N7		1301.21	0.5925	0.5886	0.9999	1.0000	1.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000
		N8		1317.48	0.4841	0.4818	0.9986	1.0000	1.0000	0.0024	0.0001	0.0000	0.0000	0.0000	0.0000
		N9		1321.65	0.1070	0.1214	0.7259	0.9606	0.9985	0.4323	0.0981	0.0269	0.0071	0.0011	0.0003
		N10		1324.50	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N11		1338.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N12		1342.40	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N13		1345.50	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N14		1361.20	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N15		1365.60	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
South	South Branch c	S1		1275.84	0.1161	0.1295	0.7502	0.9688	0.9990	0.4301	0.1587	0.0656	0.0241	0.0056	0.0017
		S2		1279.23	0.2797	0.2993	0.9715	0.9999	1.0000	0.0464	0.0050	0.0009	0.0001	0.0000	0.0000
		S3		1280.22	0.4650	0.4572	0.9978	1.0000	1.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000
		S4		1281.79	0.2143	0.2213	0.9180	0.9981	1.0000	0.0627	0.0035	0.0003	0.0000	0.0000	0.0000
		S5		1290.30	0.0615	0.0831	0.5800	0.8857	0.9869	0.6784	0.2846	0.1215	0.0475	0.0127	0.0045
		S6		1293.50	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		S7		1303.57	0.0127	0.0215	0.1952	0.4190	0.6624	0.9897	0.8418	0.6074	0.3705	0.1580	0.0744
		S8		1309.23	0.2071	0.2303	0.9270	0.9986	1.0000	0.1657	0.0357	0.0107	0.0032	0.0006	0.0002
		S9		1314.07	0.0570	0.0701	0.5163	0.8373	0.9735	0.7815	0.2721	0.0815	0.0205	0.0027	0.0005
		S10		1311.50	0.9990	0.9965	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		S11		1323.00	0.9098	0.8907	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		S12		1331.60	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Figure 12: Project Performance, Plan G2

Project Performance

File Help

Jordan Creek Study; Springfield Project Performance
by Damage Reaches for the Alt G
(Alternative G NED plan) plan for Analysis Year 2020
(Stages in ft.)
Plan was calculated with Uncertainty

Without Project Base Year Performance Target Criteria:
Event Exceedance Probablility = 0.01
Residual Damage = 5.00 %

Stream Name	Stream Description	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
					Median	Expected	10	30	50	10%	4%	2%	1%	.4%	.2%
Lower	Lower Branch c	L1 L		1222.39	0.0001	0.0007	0.0071	0.0177	0.0350	1.0000	0.9992	0.9961	0.9893	0.9779	0.9697
		L1 R		levee	0.0001	0.0016	0.0156	0.0386	0.0757	1.0000	0.9956	0.9787	0.9457	0.8887	0.8499
		L1 B		1223.09	0.0059	0.0111	0.1055	0.2433	0.4274	0.9994	0.9532	0.8217	0.6149	0.3409	0.1931
		L2		1218.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		L3		1232.87	0.1674	0.1847	0.8703	0.9939	1.0000	0.2041	0.0359	0.0092	0.0022	0.0003	0.0001
		L4		1238.84	0.3702	0.3807	0.9917	1.0000	1.0000	0.0148	0.0016	0.0003	0.0000	0.0000	0.0000
		L5		1241.50	0.3209	0.3340	0.9828	1.0000	1.0000	0.0274	0.0029	0.0005	0.0001	0.0000	0.0000
		L6		1246.70	0.3783	0.3814	0.9918	1.0000	1.0000	0.0362	0.0072	0.0019	0.0005	0.0001	0.0000
		L7		1248.32	0.6818	0.6714	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		L8		1262.51	0.0033	0.0073	0.0708	0.1678	0.3074	0.9982	0.9619	0.8788	0.7579	0.5940	0.4986
		L9		1265.17	0.0001	0.0042	0.0411	0.0996	0.1894	0.9994	0.9825	0.9387	0.8689	0.7686	0.7079
		L10		1271.22	0.0077	0.0138	0.1294	0.2927	0.4998	0.9986	0.9303	0.7639	0.5342	0.2695	0.1415
North	North Branch o	N1		1274.61	0.0067	0.0126	0.1186	0.2707	0.4682	0.9985	0.9399	0.7894	0.5705	0.3025	0.1646
		N2		1277.23	0.0762	0.0959	0.6351	0.9196	0.9935	0.5969	0.2184	0.0851	0.0301	0.0071	0.0023
		N3		1269.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N4		1282.90	0.2197	0.2274	0.9243	0.9984	1.0000	0.1068	0.0131	0.0022	0.0004	0.0000	0.0000
		N5		1283.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N6		1289.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N7		1301.21	0.2293	0.2615	0.9517	0.9995	1.0000	0.1131	0.0160	0.0032	0.0007	0.0000	0.0000
		N8		1317.48	0.4841	0.4818	0.9986	1.0000	1.0000	0.0024	0.0001	0.0000	0.0000	0.0000	0.0000
		N9		1321.65	0.1070	0.1214	0.7259	0.9606	0.9985	0.4323	0.0981	0.0269	0.0071	0.0011	0.0003
		N10		1324.50	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N11		1338.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N12		1342.40	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N13		1345.50	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N14		1361.20	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N15		1365.60	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
South	South Branch c	S1		1275.84	0.0092	0.0166	0.1545	0.3427	0.5679	0.9961	0.8977	0.7021	0.4661	0.2222	0.1123
		S2		1279.23	0.0152	0.0250	0.2234	0.4686	0.7176	0.9847	0.7980	0.5409	0.3073	0.1195	0.0526
		S3		1280.22	0.0199	0.0267	0.2373	0.4919	0.7418	0.9803	0.7739	0.5141	0.2954	0.1205	0.0567
		S4		1281.79	0.0057	0.0112	0.1069	0.2463	0.4319	0.9989	0.9474	0.8152	0.6211	0.3692	0.2312
		S5		1290.30	0.0001	0.0004	0.0043	0.0107	0.0212	1.0000	0.9999	0.9999	0.9998	0.9996	0.9995
		S6		1293.50	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		S7		1303.57	0.0142	0.0238	0.2143	0.4528	0.7005	0.9854	0.8115	0.5659	0.3347	0.1373	0.0638
		S8		1309.23	0.2340	0.2457	0.9404	0.9991	1.0000	0.1491	0.0345	0.0107	0.0031	0.0006	0.0002
		S9		1314.07	0.0570	0.0701	0.5163	0.8373	0.9735	0.7815	0.2721	0.0815	0.0205	0.0027	0.0005
		S10		1311.50	0.9990	0.9965	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		S11		1323.00	0.8972	0.8571	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		S12		1331.60	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Figure 13: Project Performance, Plan J

Without Project Base Year Performance Target Criteria:
Event Exceedance Probability = 0.01
Residual Damage = 5.00 %

Stream Name	Stream Description	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
					Median	Expected	10	30	50	10%	4%	2%	1%	.4%	.2%
Lower	Lower Branch c	L1 L		1222.39	0.0001	0.0007	0.0071	0.0177	0.0350	1.0000	0.9992	0.9961	0.9893	0.9779	0.9697
		L1 R		levee	0.0001	0.0016	0.0156	0.0386	0.0757	1.0000	0.9956	0.9787	0.9457	0.8887	0.8499
		L1 B		1223.09	0.0059	0.0111	0.1055	0.2433	0.4274	0.9994	0.9532	0.8217	0.6149	0.3409	0.1931
		L2		1218.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		L3		1232.87	0.1797	0.1958	0.8868	0.9957	1.0000	0.1889	0.0344	0.0088	0.0022	0.0003	0.0001
		L4		1238.84	0.3702	0.3807	0.9917	1.0000	1.0000	0.0148	0.0016	0.0003	0.0000	0.0000	0.0000
		L5		1241.50	0.3209	0.3340	0.9828	1.0000	1.0000	0.0274	0.0029	0.0005	0.0001	0.0000	0.0000
		L6		1246.70	0.3528	0.3618	0.9888	1.0000	1.0000	0.0492	0.0082	0.0021	0.0005	0.0001	0.0000
		L7		1248.32	0.6826	0.6723	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		L8		1262.51	0.0083	0.0169	0.1569	0.3474	0.5741	0.9913	0.8863	0.7065	0.4959	0.2672	0.1565
		L9		1265.17	0.0418	0.0647	0.4875	0.8120	0.9647	0.7952	0.4037	0.1871	0.0764	0.0212	0.0079
		L10		1271.22	0.2175	0.2317	0.9283	0.9986	1.0000	0.0617	0.0037	0.0004	0.0000	0.0000	0.0000
North	North Branch o	N1		1274.61	0.2320	0.2396	0.9354	0.9989	1.0000	0.0551	0.0040	0.0006	0.0001	0.0000	0.0000
		N2		1277.23	0.0798	0.0979	0.6430	0.9239	0.9942	0.5833	0.2061	0.0790	0.0274	0.0062	0.0018
		N3		1269.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N4		1282.90	0.1808	0.2060	0.9004	0.9969	1.0000	0.1458	0.0164	0.0027	0.0004	0.0000	0.0000
		N5		1283.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N6		1289.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N7		1301.21	0.5925	0.5886	0.9999	1.0000	1.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000
		N8		1317.48	0.4841	0.4818	0.9986	1.0000	1.0000	0.0024	0.0001	0.0000	0.0000	0.0000	0.0000
		N9		1321.65	0.1070	0.1214	0.7259	0.9606	0.9985	0.4323	0.0981	0.0269	0.0071	0.0011	0.0003
		N10		1324.50	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N11		1338.00	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N12		1342.40	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N13		1345.50	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N14		1361.20	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		N15		1365.60	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
South	South Branch c	S1		1275.84	0.1161	0.1295	0.7502	0.9688	0.9990	0.4301	0.1587	0.0656	0.0241	0.0056	0.0017
		S2		1279.23	0.2797	0.2993	0.9715	0.9999	1.0000	0.0464	0.0050	0.0009	0.0001	0.0000	0.0000
		S3		1280.22	0.4650	0.4572	0.9978	1.0000	1.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000
		S4		1281.79	0.2143	0.2213	0.9180	0.9981	1.0000	0.0627	0.0035	0.0003	0.0000	0.0000	0.0000
		S5		1290.30	0.0615	0.0831	0.5800	0.8857	0.9869	0.6784	0.2846	0.1215	0.0475	0.0127	0.0045
		S6		1293.50	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		S7		1303.57	0.0127	0.0215	0.1952	0.4190	0.6624	0.9897	0.8418	0.6074	0.3705	0.1580	0.0744
		S8		1309.23	0.2071	0.2303	0.9270	0.9986	1.0000	0.1657	0.0357	0.0107	0.0032	0.0006	0.0002
		S9		1314.07	0.0570	0.0701	0.5163	0.8373	0.9735	0.7815	0.2721	0.0815	0.0205	0.0027	0.0005
		S10		1311.50	0.9990	0.9965	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		S11		1323.00	0.9098	0.8907	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		S12		1331.60	0.9990	0.9967	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

It is also important to relay the residual risk human health and safety risk in such a way that people can easily understand the risk of residual flooding. Given the Tentatively Selected Plan is Plan J, the single event damages for that Plan, as reported as FDA output in Table 36, shows remaining damages by reach and frequency.

Table 36: Residual Flooding, Plan J

	Annual Chance Exceedence (Recurrence Interval) Damages							
	0.99 (1- yr)	**0.5 (2-yr)**	**0.2 (5-yr)**	**0.1 (10-yr)**	**0.04 (25-yr)**	**0.02 (50-yr)**	**0.01 (100-yr)**	**0.002 (500-yr)**
Reach E1								
Damage ($)	-	-	-	-	-	-	300	99,300
Structures (#)	0	0	0	0	0	0	1	6
Reach E2								
Damage ($)	3,000	68,500	361,500	580,200	882,700	1,241,000	1,701,300	2,537,600
Structures (#)	2	4	13	15	17	22	26	34
Reach E3								
Damage ($)	-	77,200	437,200	1,607,500	3,699,100	4,757,200	6,590,900	14,997,500
Structures (#)	0	5	17	25	35	41	43	49
Reach E4								
Damage ($)	-	1,500	25,400	69,800	238,600	360,300	604,900	1,314,700
Structures (#)	0	2	3	4	5	6	6	9
Reach E5								
Damage ($)	-	1,500	5,300	13,300	25,100	33,200	39,900	65,400
Structures (#)	0	2	2	5	6	8	11	16
Reach E6								
Damage ($)	-	12,500	393,400	844,600	2,386,900	4,702,500	6,739,300	11,765,900
Structures (#)	0	1	13	20	26	31	34	37
Total Damage ($)	3,000	161,200	1,222,800	3,115,400	7,232,400	11,094,100	15,676,500	30,780,500
Total Structures (#)	2	14	48	69	89	108	121	151
Damages per Structure ($)	1,514	11,513	25,474	45,151	81,263	102,723	129,558	203,844

5 COST ANALYSIS

5.1 CONSTRUCTION COST

Cost estimates for Detention Basins, G2, and J are presented in the following two figures. In plans G2 and J, the detention pond costs were allocated across reaches by the percentage of benefits provided to each reach. Tables as presented in the following figures do not match exactly to costs in Table 39 and Table 41 due to the allocation of detention pond costs across the reaches.

Flood Risk Management Feasibility Study, Springfield, Missouri (354082)

Preliminary (Class 3) Project Cost Estimate

Plan G2 (without Main and Boonville Street Bridges and channel side trails)

Reach	01 - Lands & Damages (includes 20% contingency)	02 - Relocations	09 - Channels & Canals	15 - Floodway Control and Diversion Structures	Construction Cost (02+09+15)	06 Wildlife Facilities and Sanctuaries[2]	Escalation	Total Contract Cost	Contingency on Construction, percent	Contingency	Planning Engineering & Design	Corps Contra Supervision ar Administratio
								percentages -			8.1	7.7
E1	$1,058,184	$225,233	$4,360,737		$4,585,970	$0		$4,585,970	25	$1,146,493	$371,464	$441,4
E2	$0	$0	$0		$0	$0		$0	30	$0	$0	
E3	$3,182,112	$3,558,062	$7,568,228		$11,126,291	$0		$11,126,291	30	$3,337,887	$901,230	$1,113,7
E4	$0	$0	$0		$0	$0		$0	30	$0	$0	
E5	$0	$0	$0		$0	$0		$0	30	$0	$0	
E6	$5,796,874	$2,373,494	$5,319,193		$7,692,687	$0		$7,692,687	30	$2,307,806	$623,108	$770,0
Total	$10,037,170	$6,156,789	$17,248,158	$0	$23,404,947	$0	$0	$23,404,947		$6,792,186	$1,895,801	$2,325,1

Prepared: 12/18/2012, revised March 2013

[2] - Includes 25% contingency, 8.5 percent PED and 8 percent SIOH.

Detention Basins

Reach & Basin	01 - Lands & Damages (includes 20% contingency)	02 - Relocations	09 - Channels & Canals	15 - Floodway Control and Diversion Structures	Construction Cost (02+09+15)	06 Wildlife Facilities and Sanctuaries[2]	Escalation	Total Contract Cost		Contingency	Planning Engineering & Design includes 23 percent contingency (Feature 30)	Corps Contra Supervision ar Administratio includes 23 percent contingency (Feature 30)
								percentages -		22		
E0N - 11	$1,055,400	$0		$600,003	$600,003	$0		$600,003		$132,001	$59,549	$58,9
E0N - 11c	$608,160	$0		$398,929	$398,929	$0		$398,929		$87,764	$39,593	$39,2
			Reach Subtotal									
E0S - 6	$705,600	$0		$568,624	$568,624	$0		$568,624		$125,097	$56,435	$55,8
E0S - 7	$828,000	$1,232,630		$2,032,995	$3,265,625	$0		$3,265,625		$718,438	$324,106	$320,9
E0S - 9B	$666,000	$0		$386,086	$386,086	$0		$386,086		$84,939	$38,318	$37,9
			Reach Subtotal									
Total	$3,863,160	$1,232,630	$0	$3,986,636	$5,219,267	$0	$0	$5,219,267		$1,148,239	$518,000	$513,0

Figure 14: Cost Estimate for Plan G2 and Detention Basins

Flood Risk Management Feasibility Study, Springfield, Missouri (354082)

(Class 4) Feasibility Study Project Cost Estimate

Plan J

Reach	01 - Lands & Damages (includes 20% contingency)	02 - Relocations	09 - Channels & Canals	15 - Floodway Control and Diversion Structures	Construction Cost (02+09+15)	06 Wildlife Facilities and Sanctuaries	Escalation	Total Contract Cost	Contingency on Construction, percent	Contingency	Planning Engineering & Design includes 23 percent contingency (Feature 30)	Corps Supervi Admin inclu per conti (Feat
								percentages -				
E1	$537,600	$292,301	$5,846,434		$6,138,735	$0		$6,138,735	22	$1,350,522	$610,000	
E2	$0	$0	$0		$0	$0		$0	22	$0	$0	
E3	$0	$0	$0		$0	$0		$0	22	$0	$0	
E4	$0	$0	$0		$0	$0		$0	22	$0	$0	
E5	$0	$0	$0		$0	$0		$0	22	$0	$0	
E6	$0	$0	$0		$0	$0		$0	22	$0	$0	
Total	$537,600	$292,301	$5,846,434	$0	$6,138,735	$0	$0	$6,138,735		$1,350,522	$610,000	
Prepared:	18 Dec 2012, Revised Apr 4, 2013											

Detention Basins

Reach & Basin	01 - Lands & Damages (includes 20% contingency)	02 - Relocations	09 - Channels & Canals	15 - Floodway Control and Diversion Structures	Construction Cost (02+09+15)	06 Wildlife Facilities and Sanctuaries[2]	Escalation	Total Contract Cost		Contingency	Planning Engineering & Design includes 23 percent contingency (Feature 30)	Corps Supervi Admini inclu per contir (Feat
								percentages -		22		
E0N - 11	$1,055,400	$0		$600,003	$600,003	$0		$600,003		$132,001	$59,549	
E0N - 11c	$608,160	$0		$398,929	$398,929	$0		$398,929		$87,764	$39,593	
			Reach Subtotal									
E0S - 6	$705,600	$0		$568,624	$568,624	$0		$568,624		$125,097	$56,435	
E0S - 7	$828,000	$1,232,630		$2,032,995	$3,265,625	$0		$3,265,625		$718,438	$324,106	
E0S - 9B	$666,000	$0		$386,086	$386,086	$0		$386,086		$84,939	$38,318	
			Reach Subtotal									
Total	$3,863,160	$1,232,630	$0	$3,986,636	$5,219,267	$0	$0	$5,219,267		$1,148,239	$518,000	

Figure 15: Cost Estimate for Plan J and Detention Basins

5.2 OPERATIONS AND MAINTENANCE

Operations, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R) cost estimates for Detention Basins, G2, and J are presented in the following estimates (Figure 16 and Figure 17). As the construction costs were allocated, the costs for detention ponds were allocated across the six reaches by the same percentages.

OPERATION, MAINTENANCE, REPAIR, REPLACEMENT AND REHABILITATION

Date Prepared: January 18, 2013

Jordan Creek Flood Risk Management Feasibility Study, Springfield, Missouri

Life Cycle: 50 years

Rate of Return: 3.75 percent

Plan G without Main Street Bridge and Boonville Culvert

Jordan Creek Flood Risk Management Feasibility Study, Springfield, Missouri			O&M and Major Replacement Costs						Equivalent Average Annual O&M/Major Replacement Value			
									Present Value			
Code	Item Description	Estimate O&M Cycle, years	Quantity Factor	Project Quantity	O&M Quantity	Unit	Project Unit Price	O&M Amount	O&M	Major Replacement	Annual Cost	Comments
									$1,228,266	$9,905,099	$642,542	
Reach E1 - Wilson's Creek and South Branch 0+00 to 37+92												
00	Periodic Inspections	1	1	1	1	Job	$281.00	$281	$6,304	0	$281	
	Automobile Bridge Inspections	2	1	1	1	Job	$271.00	$271	$4,348	0	$271	Every 2 years
02	No added OMM&R											
09	Mowings	1	3	4.726	14.2	Acres	$85.58	$1,213	$27,221	0	$1,213	3 times per year
	Woody Vegetation Control	4	0.25	4.726	1.2	Acres	$760.97	$899	$8,843	0	$394	Every four years
	Sediment Removal	1	1		5	CY	$63.68	$318	$7,143	0	$318	Annually
	Trash/Debris Removal	1	1		1	Job	$591.46	$591	$13,269	0	$591	Annually
	Scour Repair	5	0.20		5	CY	$774.72	$592	$4,805	0	$214	Once every 5 years
	Riprap Repair	10	0.10		9	CY	$229.24	$593	$2,642	0	$118	Once every 10 years
	Railway Bridges - Wilson Crk Station 322+92	10	0.01	1	0.1	LS	$648,544.00	$6,485	$29,076	$559,714	$26,245	
	Roadway Bridges - Scenic	10	0.01	1	0.1	LS	$458,473.00	$4,585	$20,555	$395,677	$18,553	Monitor Foundation Shoring
	Subtotal										$48,199	
Reach E2 - Jordan Creek 37+93 to 109+99												
	No Work											
	Subtotal											
Reach E3 - Jordan Creek 110+00 to 166+70												
00	Periodic Inspections	1	1	1	1	Job	$281.00	$281	$6,304	$0	$281	
	Automobile Bridge Inspections	2	1	1	1	Job	$271.00	$271	$4,348	$0	$194	Every 2 years
02		10	0.01	1	0.10	LS	$0.00	$0	$0	$0	$0	
	Roadway Bridges - Campbell Street	10	0.01	1	0.10	LS	$1,172,767.00	$11,728	$52,578	$1,012,135	$47,459	
	Railway Tracks Relocation	10	0.01	1	0.10	LS	$0.00	$0	$0	$0	$0	As was originally. No extra OMM&R
09	Mowings	1	3	4.726	14.2	Acres	$85.58	$1,213	$27,221	$0	$1,213	3 times per year
	Woody Vegetation Control	4	0.25	4.726	1.2	Acres	$760.97	$899	$8,843	$0	$394	Every four years
	Sediment Removal	1	1		5	CY	$63.68	$318	$7,143	$0	$318	Annually
	Trash/Debris Removal	1	1		1	Job	$591.46	$591	$13,269	$0	$591	Annually
	Scour Repair	5	0.20		5	CY	$774.72	$592	$2,656	$0	$118	Once every 5 years
	Riprap Repair	10	0.10		9	CY	$229.24	$593	$2,661	$0	$119	Once every 10 years
	Roadway Bridges - Main Street	10	0.01	1	0.1	LS	$0.00	$0	$0	$0	$0	
	Roadway Bridges - Boonville Street	10	0.01	1	0.1	LS	$0.00	$0	$0	$0	$0	
	Roadway Culvert - Phelps Street 1st Segment	10	0.01	1	0.10	LS	$4,388,718.00	$43,887	$196,758	$3,787,601	$177,600	Once every 10 years
	Roadway Culvert - Phelps Street 2nd Segment	10	0.01	1	0.10	LS	$3,567,448.00	$35,674	$159,938	$3,078,819	$144,365	Once every 10 years
	Subtotal										$372,653	

Page 1 of 2

Figure 16: OMRR&R for G2 and Detention

OPERATION, MAINTENANCE, REPAIR, REPLACEMENT AND REHABILITATION

Date Prepared: January 18, 2013

Jordan Creek Flood Risk Management Feasibility Study, Springfield, Missouri

Life Cycle: 50 years

Rate of Return: 3.75 percent

Plan G without Main Street Bridge and Boonville Culvert

Jordan Creek Flood Risk Management Feasibility Study, Springfield, Missouri			O&M and Major Replacement Costs						Equivalent Average Annual O&M/Major Replacement Value			
									Present Value			
Code	Item Description	Estimate O&M Cycle, years	Quantity Factor	Project Quantity	O&M Quantity	Unit	Project Unit Price	O&M Amount	O&M	Major Replacement	Annual Cost	Comments
Reach E4 - Jordan Creek North Branch 0+00 to 24+75												
	No Work											
	Subtotal											
Reach E5 - Jordan Creek North Branch 24+76 to 81+21												
	No Work											
	Subtotal											
Reach E6 - Jordan Creek South Branch 0+00 to 91+78												
00	Periodic Inspections	1	1	1	1	Job	$281.00	$281	$6,304	$0	$281	
	Automobile Bridge Inspections	2	1	1	1	Job	$271.00	$271	$4,348	$0	$194	Every 2 years
02	No added OMM&R											
09	Mowings	1	3	4.726	14.2	Acres	$85.58	$1,213	$27,221	$0	$1,213	3 times per year
	Woody Vegetation Control	4	0.25	4.726	1.2	Acres	$760.97	$899	$8,843	$0	$394	Every four years
	Sediment Removal	1	1		5	CY	$63.68	$318	$7,143	$0	$318	Annually
	Trash/Debris Removal	1	1		1	Job	$591.46	$591	$13,269	$0	$591	Annually
	Scour Repair	5	0.2		5	CY	$774.72	$592	$2,656	$0	$118	Once every 5 years
	Riprap Repair	10	0.1		9	CY	$229.24	$593	$2,661	$0	$119	Once every 10 years
	National Culvert	10	0.01	1	0.1	LS	$1,207,388.00	$12,074	$54,130	$0	$2,413	
	Railroad Near Sherman	10	0.01	1	0.1	LS	$441,096.00	$4,411	$19,775	$380,680	$17,850	
	Sherman Street Culvert	10	0.01	1	0.1	LS	$298,056.00	$2,981	$13,363	$257,232	$12,062	
	Subtotal										$35,553	
Reach EON - Detention Ponds on North Branch of Jordan Creek												
00	Periodic Inspections	1	1	1	1	Job	$914.00	$914	$20,505	$0	$914	
15	Mowings	1	3	10.7	32.1	Acres	$85.58	$2,747	$61,630	$0	$2,747	3 times per year
	Woody Vegetation Control	4	0.25	10.7	2.7	Acres	$760.97	$2,036	$20,021	$0	$892	Every four years
	Washout Repair	10	0.1		31	CY	$56.50	$1,752	$7,852	$0	$350	Once every 10 years
	Outlet Structure Detention Basin 11	10	0.01	1	0.1	LS	$70,729.29	$7,073	$31,710	$61,042	$24,734	
	Outlet Structure Detention Basin 11c	10	0.01	1	0.1	LS	$95,461.84	$9,546	$42,798	$82,387	$33,383	
	Subtotal										$63,020	
Reach EOS - Detention Ponds on South Branch of Jordan Creek												
00	Periodic Inspections	1	1	1	1	Job	$914.00	$914	$20,505	$0	$914	
15	Mowings	1	3	13	39.0	Acres	$85.58	$3,338	$74,878	$0	$3,338	3 times per year

Page 2 of 2

OPERATION, MAINTENANCE, REPAIR, REPLACEMENT AND REHABILITATION

Date Prepared: January 18, 2013

Jordan Creek Flood Risk Management Feasibility Study, Springfield, Missouri

Life Cycle: 50 years

Rate of Return: 3.75 percent

Plan G without Main Street Bridge and Boonville Culvert

Jordan Creek Flood Risk Management Feasibility Study, Springfield, Missouri			O&M and Major Replacement Costs						Equivalent Average Annual O&M/Major Replacement Value			
									Present Value			
Code	Item Description	Estimate O&M Cycle, years	Quantity Factor	Project Quantity	O&M Quantity	Unit	Project Unit Price	O&M Amount	O&M	Major Replacement	Annual Cost	Comments
	Woody Vegetation Control	4	0.25	13	3.3	Acres	$760.97	$2,473	$24,324	$0	$1,084	Every four years
	Washout Repair	10	0.1		31	CY	$56.50	$1,752	$7,852	$0	$350	Once every 10 years
	Outlet Structure Detention Basin 6	10	0.01	1	0.1	LS	$133,988.00	$13,399	$60,070	$115,636	$46,855	
	Outlet Structure Detention Basin 7	10	0.01	1	0.1	LS	$133,988.00	$13,399	$60,070	$115,636	$46,855	
	Outlet Structure Detention Basin 9B	10	0.01	1	0.1	LS	$67,834.00	$6,783	$30,412	$58,543	$23,721	
	Subtotal										$123,117	

Page 3 of 2

OPERATION, MAINTENANCE, REPAIR, REHABILITATION AND REPLACEMENT

Date Prepared: January 18, 2013

Jordan Creek Flood Risk Management Feasibility Study, Springfield, Missouri

Life Cycle: 50 years

Rate of Return: 3.75 percent

Plan J

Jordan Creek Flood Risk Management Feasibility Study, Springfield, Missouri			O&M and Major Replacement Costs						Equivalent Average Annual O&M/Major Replacement Value			
									Present Value			
Code	Item Description	Estimate O&M Cycle, years	Quantity Factor	Project Quantity	O&M Quantity	Unit	Project Unit Price	O&M Amount	O&M	Major Replacement	Annual Cost	Comments
									$590,029	$1,388,633	$234,479	
Reach E1 - Wilson's Creek and South Branch 0+00 to 37+92												
00	Periodic Inspections	1	1	1	1	Job	$281.00	$281	$6,304	0	$281	
	Automobile Bridge Inspections	2	1	1	1	Job	$271.00	$271	$4,348	0	$271	Every 2 years
02	No added OMM&R											
09	Mowings	1	3	4.726	14.2	Acres	$85.58	$1,213	$27,221	0	$1,213	3 times per year
	Woody Vegetation Control	4	0.25	4.726	1.2	Acres	$760.97	$899	$8,843	0	$394	Every four years
	Sediment Removal	1	1		5	CY	$63.68	$318	$7,143	0	$318	Annually
	Trash/Debris Removal	1	1		1	Job	$591.46	$591	$13,269	0	$591	Annually
	Scour Repair	5	0.20		5	CY	$774.72	$592	$4,805	0	$214	Once every 5 years
	Riprap Repair	10	0.10		9	CY	$229.24	$593	$5,837	0	$260	Once every 10 years
	Railway Bridges - Wilson Crk Station 322+92	10	0.01	1	0.01	LS	$648,544.00	$6,485	$29,076	$559,714	$26,245	
	Roadway Bridges - Scenic	10	0.01	1	0.01	LS	$458,473.00	$4,585	$20,555	$395,677	$18,553	Monitor Foundation Shoring
	Subtotal										$48,342	
Reach E2 - Jordan Creek 37+93 to 109+99												
	No Work											
	Subtotal											
Reach E3 - Jordan Creek 110+00 to 166+70												
	Subtotal										$0	
Reach E4 - Jordan Creek North Branch 0+00 to 24+75												
	No Work											
	Subtotal											
Reach E5 - Jordan Creek North Branch 24+76 to 81+21												
	No Work											
	Subtotal											
Reach E6 - Jordan Creek South Branch 0+00 to 91+78												
00	Periodic Inspections	1	1	1	1	Job			$0	$0	$0	
	Automobile Bridge Inspections	2	1	1	1	Job			$0	$0	$0	Every 2 years
02	No added OMM&R											
09	Mowings	1	3	4.726	14.2	Acres			$0	$0	$0	3 times per year

Page 1 of 2

Figure 17: OMRR&R for J and Detention

OPERATION, MAINTENANCE, REPAIR, REHABILITATION AND REPLACEMENT

Date Prepared: January 18, 2013

Jordan Creek Flood Risk Management Feasibility Study, Springfield, Missouri

Life Cycle: 50 years

Rate of Return: 3.75 percent

Plan J

Jordan Creek Flood Risk Management Feasibility Study, Springfield, Missouri			O&M and Major Replacement Costs						Equivalent Average Annual O&M/Major Replacement Value			
									Present Value			
Code	Item Description	Estimate O&M Cycle, years	Quantity Factor	Project Quantity	O&M Quantity	Unit	Project Unit Price	O&M Amount	O&M	Major Replacement	Annual Cost	Comments
	Woody Vegetation Control	4	0.25	4.726	1.2	Acres			$0	$0	$0	Every four years
	Sediment Removal	1	1		5	CY			$0	$0	$0	Annually
	Trash/Debris Removal	1	1		1	Job			$0	$0	$0	Annually
	Scour Repair	5	0.2		5	CY			$0	$0	$0	Once every 5 years
	Riprap Repair	10	0.1		9	CY			$0	$0	$0	Once every 10 years
	National Culvert	10	0.01	1	0.1	LS			$0	$0	$0	
	Railroad Near Sherman	10	0.01	1	0.1	LS			$0	$0	$0	
	Sherman Street Culvert	10	0.01	1	0.1	LS			$0	$0	$0	
	Subtotal										$0	
Reach EON - Detention Ponds on North Branch of Jordan Creek												
00	Periodic Inspections	1	1	1	1	Job	$914.00	$914	$20,505	$0	$914	
15	Mowings	1	3	10.7	32.1	Acres	$85.58	$2,747	$61,630	$0	$2,747	3 times per year
	Woody Vegetation Control	4	0.25	10.7	2.7	Acres	$760.97	$2,036	$20,021	$0	$892	Every four years
	Washout Repair	10	0.1		31	CY	$56.50	$1,752	$7,852	$0	$350	Once every 10 years
	Outlet Structure Detention Basin 11	10	0.01	1	0.1	LS	$70,729.29	$7,073	$31,710	$61,042	$24,734	
	Outlet Structure Detention Basin 11c	10	0.01	1	0.1	LS	$95,461.84	$9,546	$42,798	$82,387	$33,383	
	Subtotal										$63,020	
Reach EOS - Detention Ponds on South Branch of Jordan Creek												
00	Periodic Inspections	1	1	1	1	Job	$914.00	$914	$20,505	$0	$914	
15	Mowings	1	3	13	39.0	Acres	$85.58	$3,338	$74,878	$0	$3,338	3 times per year
	Woody Vegetation Control	4	0.25	13	3.3	Acres	$760.97	$2,473	$24,324	$0	$1,084	Every four years
	Washout Repair	10	0.1		31	CY	$56.50	$1,752	$7,852	$0	$350	Once every 10 years
	Outlet Structure Detention Basin 6	10	0.01	1	0.1	LS	$133,988.00	$13,399	$60,070	$115,636	$46,855	
	Outlet Structure Detention Basin 7	10	0.01	1	0.1	LS	$133,988.00	$13,399	$60,070	$115,636	$46,855	
	Outlet Structure Detention Basin 9B	10	0.01	1	0.1	LS	$67,834.00	$6,783	$30,412	$58,543	$23,721	
	Subtotal										$123,117	

5.3 INTEREST DURING CONSTRUCTION

Interest during construction was calculated with the following formula:

IDC = (((1+r)^(n*12)-1)/(r))*(p/(n*12))-p; where r=monthly interest rate, n=construction period in years, and p=total project cost. Construction duration was provided by the cost estimator.

6 BENEFIT/COST EVALUATION OF PLANS

6.1.1 Detention Basins

Given cost estimates, interest rates, construction period, and the period of analysis, the annual benefits were compared to the average annual cost of the Detention Basins. Average annual benefits and costs, as well as the benefit-to-cost ratio and the net benefits for Detention Basins are displayed in Table 37.

Table 37: Detention Basin Benefits and Costs

Item	Amount
Interest Rate,%	3.750%
Interest Rate, Monthly	0.307%
Construction Period, Years	1.25
Period of Analysis, Years	50
Total Project Cost	$11,261,700
Interest During Construction ($)	245,500
Investment Cost ($)	11,507,200
Annual Cost	
Amortized Cost ($)	512,900
OMRR&R ($)	186,100
Total Annual Cost ($)	699,000
Annual Benefits	
Structures, Contents, Other ($)	770,800
Infrastructure ($)	35,100
Total Annual Benefits ($)	805,900
Benefit-to-Cost Ratio	**1.15**
Net Benefits ($)	**106,900**

6.1.2 Plan G2

Given cost estimates, interest rates, construction period, and the period of analysis, the annual benefits were compared to the average annual cost of the Plan G2. Average annual benefits and costs, as well as the benefit-to-cost ratio and the net benefits for Plan G2 at 3.75 percent and 7 percent are displayed Table 38.

Table 38: Plan G2 Benefits and Costs

Item	Amount	Amount
Interest Rate,%	3.750%	7%
Interest Rate, Monthly	0.307%	0.565%
Construction Period, Years	3.0	3.0
Period of Analysis, Years	50	50
Total Project Cost	$59,358,500	$59,358,500
Interest During Construction ($)	2,540,800	4,787,600
Investment Cost ($)	61,899,300	64,146,100
Annual Cost		
Amortized Cost ($)	2,759,100	4,648,000
OMRR&R ($)	642,600	642,600
Total Annual Cost ($)	3,401,700	5,290,600
Annual Benefits		
Structures, Contents, Other ($)	4,041,400	4,041,400
Infrastructure ($)	111,200	111,200
Total Annual Benefits ($)	4,152,600	4,152,600
Benefit-to-Cost Ratio	**1.22**	**0.78**
Net Benefits($)	**750,900**	**(1,138,000)**

Looking at G2 by reach, as in Table 38, it was evident that the channel plan in Reach E1 enabled the economic justification of the channels in Reaches E3 and E6.

Table 39: Plan G2, Benefits and Costs for All Reaches

	Reach E1	Reach E2	Reach E3	Reach E4	Reach E5	Reach E6
Interest Rate,%	3.750%	3.750%	3.750%	3.750%	3.750%	3.750%
Construction Period, Years	2.00	1.25	2.75	1.25	1.25	2.00
Period of Analysis, Years	50	50	50	50	50	50
Total Project Cost	$7,958,000	$557,200	$27,982,000	$331,900	$50,100	$22,479,300
Interest During Construction ($)	287,600	12,100	1,420,300	7,200	1,100	812,500
Investment Cost ($)	8,245,600	569,300	29,402,300	339,100	51,200	23,291,800
Annual Cost						
Amortized Cost ($)	367,500	25,400	1,310,600	15,100	2,300	1,038,200
OMRR&R ($)	54,100	9,200	450,000	5,500	800	123,000
Total Annual Cost ($)	421,600	34,600	1,760,600	20,600	3,100	1,161,200
Annual Benefits						
Structures, Contents, Other ($)	2,221,500	36,500	978,500	28,800	3,500	772,600
Infrastructure ($)	27,100	1,300	31,300	1,000	300	50,200
Total Annual Benefits ($)	2,248,600	37,800	1,009,800	29,800	3,800	822,800
BC Ratio	5.3	1.09	0.57	1.4	1.2	0.71
Net Benefits	$1,827,000	$3,200	($750,800)	$9,200	$700	($338,400)

6.1.3 Plan J

Given cost estimates, interest rates, construction period, and the period of analysis, the annual benefits were compared to the average annual cost of the Plan J. Average annual benefits and costs, as well as the benefit-to-cost ratios and the net benefits for Plan J at 3.75 percent and at 7 percent are displayed in Table 40. With $1,831,300 in net benefits, Plan J is the National Economic Development (NED) Plan. Plan J is the alternative plan that reasonably maximizes the net economic benefits consistent with protecting the Nation's environment.

Table 40: Plan J Benefits and Costs

Item	Amount	Amount
Interest Rate,%	3.750%	7.0%
Interest Rate, Monthly	0.307%	0.565%
Construction Period, Years	3.0	3.0
Period of Analysis, Years	50	50
Total Project Cost	$20,479,600	$20,479,600
Interest During Construction ($)	1,140,500	2,162,500
Investment Cost ($)	21,620,100	22,642,100
Annual Cost		
Amortized Cost ($)	963,700	1,640,600
OMRR&R ($)	234,400	234,400
Total Annual Cost ($)	1,198,100	1,875,000
Annual Benefits		
Structures, Contents, Other ($)	2,967,800	2,967,800
Infrastructure ($)	61,600	61,600
Total Annual Benefits ($)	3,029,400	3,029,400
Benefit-to-Cost Ratio	2.5	1.6
Net Benefits ($)	1,831,300	1,154,400

The benefits and cost by reach are presented in Table 41. All reaches have positive net benefits.

Table 41: Plan J, Benefits and Costs for All Reaches

	Reach E1	Reach E2	Reach E3	Reach E4	Reach E5	Reach E6
Interest Rate,%	3.750%	3.750%	3.750%	3.750%	3.750%	3.750%
Construction Period, Years	1.25	1.25	1.25	1.25	1.25	1.25
Period of Analysis, Years	50	50	50	50	50	50
Total Project Cost	$9,572,300	$557,200	$4,679,300	$331,900	$50,100	$5,288,800
Interest During Construction ($)	346,000	12,100	102,000	7,200	1,100	115,300
Investment Cost ($)	9,918,300	569,300	4,781,300	339,100	51,200	5,404,100
Annual Cost						
Amortized Cost ($)	442,100	25,400	213,100	15,100	2,300	240,900
OMRR&R ($)	48,300	0	0	0	0	0
Total Annual Cost ($)	490,400	25,400	213,100	15,100	2,300	240,900
Annual Benefits						
Structures, Contents, Other ($)	2,221,500	38,100	320,200	22,700	3,400	361,900
Infrastructure ($)	27,100	1,300	10,000	900	200	22,100
Total Annual Benefits ($)	2,248,600	39,400	330,200	23,600	3,600	384,000
BC Ratio	4.6	1.6	1.6	1.6	1.6	1.6
Net Benefits	$1,758,200	$14,000	$117,100	$8,500	$1,300	$143,100

7 BENEFITS OUTSIDE OF FEDERAL INTEREST

In evaluating benefits for FRM projects in urban areas, the Corps participates in projects that address discharges that represent a serious threat to life and property. The threshold for determining flows that fall within this category is outlined in 33 CFR Part 238 (ER 1165-2-21, Water Resources Policies and Authorities: Flood Damage Reduction Measures in Urban Areas). This law states that urban water damage associated with a natural stream or modified natural waterway may be addressed by the Corps only downstream from the point where the discharge for the 10 percent chance, or 10 year, flood is greater than 800 cfs, unless an exemption is granted. The analysis to this point has only included structures which were stationed below the points on North Branch and South Branch where the discharge for the 10 percent chance event was greater than 800 cfs.

There are other structures in the Jordan Creek watershed that are affected by flood risk. These structures are located above the point that meets the 800 cfs – 1.5 square mile criteria as discussed in ER 1165-2-21, Paragraph 7.a.(1) and were initially considered to be out of the scope of this project. However, the detention measures are located upstream of the criteria point and upstream of a number of these structures. ER 1165-2-21, Paragraph 7.a.(4) states "Flood reduction measures, such as dams or diversions, may be located upstream of the particular point where the hydrologic criteria (and area criterion, if appropriate) are met, if economically justified by benefits derived within the stream reach which does qualify for flood control improvement." The detention measures are economically justified by benefits derived below the criteria point with a BCR of 1.27 as presented in Table 37. The location of the detention measure essentially re-sets the upper limit of the project scope and the limit of Federal interest. The structures that were initially considered outside of Federal interest will subsequently be included in the total benefits as derived below the detention measures and above initial criteria point.

For Jordan Creek, two additional reaches were delineated for areas outside of the 800 cfs urban limit. E0-North and E0-South are displayed in Figure 18.

Figure 18: Economic Reaches

There were 253 additional structures in the area outside Federal interest. E0-N contained 130 structures. E0-South contained 123 structures. The number and type of structures that fell within the maximum projected floodplain are shown in Table 42.

Table 42: Structure Inventory, Including E0-N AND E0-S

Reach	Number of structures in reach	Structures by type				Structure values ($)
		Residential	Commercial	Industrial	Public	
E1	32	0	5	27	0	5,438,000
E2	54	15	22	17	0	5,068,800
E3	66	2	33	31	0	33,215,800
E4	12	0	4	6	2	1,930,800
E5	50	43	5	0	2	2,447,600
E6	56	0	23	33	0	27,759,800
E0-N	130	97	19	14	0	15,098,400
E0-S	123	117	3	3	0	12,458,000
Total	523	274	114	131	4	103,417,200

Equivalent Annual Damages were calculated for damages to structures, contents, and vehicles by the FDA program. Table 43 provides the without project estimates of EAD as provided by FDA.

Table 43: EAD, Without Project, Including E0-N AND E0-S

Reach	EAD: Without Project $
E1	2,242,650
E2	278,992
E3	1,037,289
E4	72,076
E5	9,533
E6	882,811
E0-N	58,302
E0-S	143,284
Total	**4,724,937**

The “infrastructure” model was run to calculate EAD for structural damages. Expected annual infrastructure damage in the Without Project condition was $142,041 as shown in Table 44.

Table 44: EAD, Infrastructure Damages, Without Project, Including E0-N AND E0-S

Reach	Structural EAD: Without Project $	Percentage of Damage	Infrastructure EAD: Without Project $
E1	175,888	15.6%	27,438
E2	64,222	15.6%	10,019
E3	211,667	15.6%	33,020
E4	22,552	15.6%	3,518
E5	4,588	15.6%	716
E6	342,024	15.6%	53,356
E0-N	14,349	15.6%	2,238
E0-S	74,972	15.6%	11,696
Total	**910,261**		**142,001**

The estimates of Equivalent Annual Damages for the Plan J as provided by FDA are displayed in Table 44.

Table 45: EAD, Plan J, Including E0-N and E0-S

Reach	EAD $	Infrastructure EAD $	Total EAD $
E1	21,154	351	21,505
E2	240,857	8,727	249,585
E3	717,055	23,068	740,123
E4	49,363	2,571	51,934
E5	6,106	484	6,590
E6	520,865	31,252	552,117
E0-N	56,808	2,176	58,984
E0-S	47,793	3,780	51,572
Total	**1,660,000**	**72,410**	**1,732,410**

The estimated benefits of Plan J, calculated as the difference between Total EAD for the without project condition less the Total EAD for Plan J, are displayed in Table 46.

Table 46: Benefits of Plan J, Including E0-N and E0-S

Reach	Without: Total EAD $	Plan G: Total EAD $	Benefit of Plan G $	Plan J: Total EAD $	Benefit of Plan J $
E1	2,270,088	21,505	2,248,583	21,505	2,248,583
E2	289,010	251,146	37,865	249,585	39,426
E3	1,070,309	60,473	1,009,836	740,123	330,186
E4	75,594	45,809	29,785	51,934	23,660
E5	10,247	6,497	3,750	6,590	3,658
E6	936,167	113,306	822,861	552,117	384,050
E0-N	60,541	58,984	1,556	58,984	1,556
E0-S	154,980	51,572	103,408	51,572	103,408
Total	**4,866,937**	**609,292**	**4,257,645**	**1,732,410**	**3,134,527**

Given cost estimates, interest rates, construction period, and the period of analysis, the annual benefits were compared to the average annual cost of the Plan J. Average annual benefits and costs, benefit-to-cost ratios and the net benefits for Plan G and Plan J at 3.75% and at 7% are displayed in Table 47. With $1,936,300 in net benefits, Plan J remains the NED plan.

Table 47: Plan G2 and Plan J Benefits and Costs, Including E0-N and E0-S

Item	G2	G2	J	J
Interest Rate,%	3.750%	7.0%	3.750%	7.0%
Interest Rate, Monthly	0.307%	0.565%	0.307%	0.565%
Construction Period, Years	3.0	3.0	3.0	3.0
Period of Analysis, Years	50	50	50	50
Total Project Cost	$59,358,500	$59,358,500	$20,479,600	$20,479,600
Interest During Construction ($)	2,540,800	4,787,600	1,140,500	2,162,500
Investment Cost ($)	61,899,300	64,146,100	21,620,100	22,642,100
Annual Cost				
Amortized Cost ($)	2,759,100	4,648,000	963,700	1,640,600
OMRR&R ($)	642,600	642,600	234,400	234,400
Total Annual Cost ($)	3,401,700	5,290,600	1,198,100	1,875,000
Annual Benefits				
Structures, Contents, Other ($)	4,138,400	4,138,400	3,064,800	3,064,800
Infrastructure ($)	119,200	119,200	69,600	69,600
Total Annual Benefits ($)	4,257,600	4,257,600	3,134,400	3,134,400
Benefit-to-Cost Ratio	1.3	0.8	2.6	1.7
Net Benefits ($)	855,900	(1,033,000)	1,936,300	1,259,400

8 ANALYSIS OF ECONOMIC VIABILITY

8.1 Sensitivity of Hydrology

As discussed in Section 3.1, the plan formulation and economic analysis were based on the Ultimate Conditions hydrology model. As a sensitivity test, Plan G2 and Plan J were also analyzed with the 2003 hydrology model. As seen in Table 48, Plan G2 is not an economically viable plan under 2003 hydrology. Plan J remains economically viable with 2003 hydrology.

Table 48: Sensitivity Test: Plan G2 and Plan J Benefits and Costs, 2003 Hydrology

Item	G2	G2	J	J
Interest Rate,%	3.750%	7.0%	3.750%	7.0%
Interest Rate, Monthly	0.307%	0.565%	0.307%	0.565%
Construction Period, Years	3.0	3.0	3.0	3.0
Period of Analysis, Years	50	50	50	50
Total Project Cost	$59,358,500	$59,358,500	$20,479,600	$20,479,600
Interest During Construction ($)	2,540,800	4,787,600	1,140,500	2,162,500
Investment Cost ($)	61,899,300	64,146,100	21,620,100	22,642,100
Annual Cost				
Amortized Cost ($)	2,759,100	4,648,000	963,700	1,640,600
OMRR&R ($)	642,600	642,600	234,400	234,400
Total Annual Cost ($)	3,401,700	5,290,600	1,198,100	1,875,000
Annual Benefits				
Structures, Contents, Other ($)	2,628,800	2,628,800	1,872,600	1,872,600
Infrastructure ($)	110,100	110,100	61,300	61,300
Total Annual Benefits ($)	2,738,900	2,738,900	1,933,900	1,933,900
Benefit-to-Cost Ratio	0.81	0.52	1.6	1.03
Net Benefits ($)	(662,800)	(2,551,700)	735,800	58,900

8.2 Monte Carlo Analysis of Viability

The analysis followed guidance described in ER 1105-2-101: Risk Analysis for Flood Damage Reduction Studies. As stated in the ER: "The estimate of net NED benefits and benefit/cost ratio will be reported both as a single expected value and on a probabilistic basis for each planning alternative. The probability that net benefits are positive and that the benefit-to-cost ratio is at or above 1.0 will be presented for each planning alternative."

To estimate the probability that economic annual net benefits for Plan J (with Ultimate Hydrology and Outside of Federal Interest benefits) are positive, an uncertainty model was created using @Risk. For the benefits, FDA provided amounts that damage reduced exceed for three probabilities: 0.25, 0.5, and 0.75. The probabilities and benefits were entered into a cumulative distribution function with the benefits rounded to the hundred-thousand with a minimum and maximum estimated by a polynomial function. Cost estimating provided three values from the MII cost estimating program: 0 percent contingency, 23 percent contingency, and 30 percent contingency. Without performing a more robust uncertainty cost analysis, a triangular distribution with the most likely value and the 10 and 90 percentiles was used.

Benefits: RiskCumul(1100000,5400000,{1900000,2900000,4100000},{0.25,0.5,0.75})

Costs: =RiskTrigen(15930000,20480000,25000000,10,90)

A simulation was created with the following characteristics: 10,000 iterations, Latin Hypercube Sampling, Mersenne Twister Generator, Fixed Initial Seed of 3259. Expected and probabilistic values of the net benefits and costs are shown in Table 49. Expected and probabilistic values of the benefit/cost ratio are shown in Table 50.

Table 49: Expected and Probabilistic Values of Net Benefits

	Expected Annual Benefit and Cost		**Net Benefits**		**Prob. Net Benefit is > 0**	**Net Benefit that is Exceeded with Specified Probability**		
Plan	Benefit	Cost	Mean	Std. Dev.		0.75	0.5	0.25
Plan J	4,474,900	1,234,500	3,240,300	2,135,100	0.91	1,550,000	3,500,000	5,000,000

Table 50: Expected and Probabilistic Benefit/Cost Ratios

	Expected Benefit/Cost Ratio		**Prob. Net Benefit is > 0**	**B/C Ratio that is Exceeded with Specified Probability**		
Plan	Mean	Std. Dev		0.75	0.5	0.25
Plan J	3.69	1.84	0.91	2.25	3.8	5.1

Given the inputs of the simulation, there is a 91 percent chance that the BC ratio is greater than 1 at the current discount rate as shown in Figure 19 and that net benefits are greater than zero as shown in Figure 20. There is an 83.4 percent chance that the BC ratio is greater than 1 at a discount rate of 7 percent as shown in Figure 21, and that net benefits are greater than zero as shown in Figure 22.

Figure 19: Probability of Economic Viability at 3.75%

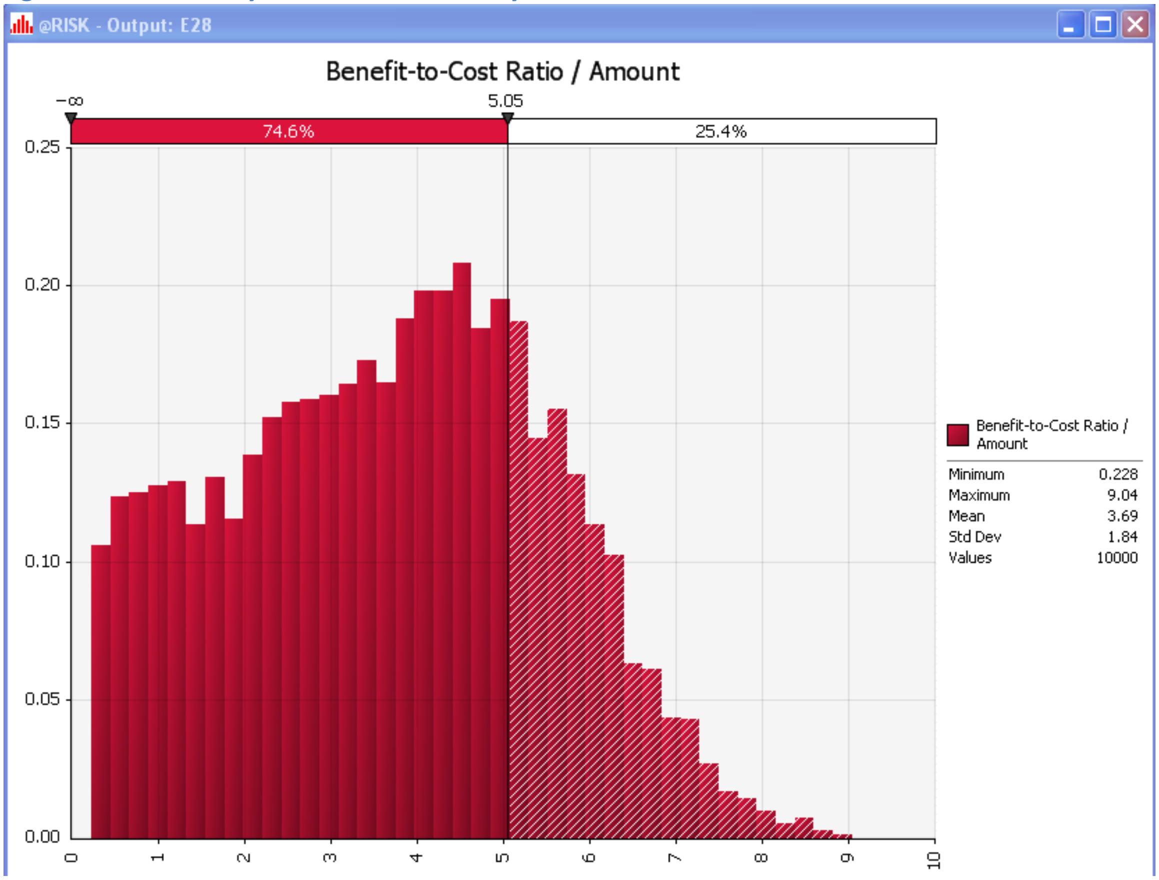


Figure 20: Probability of Positive Net Benefits at 3.75%

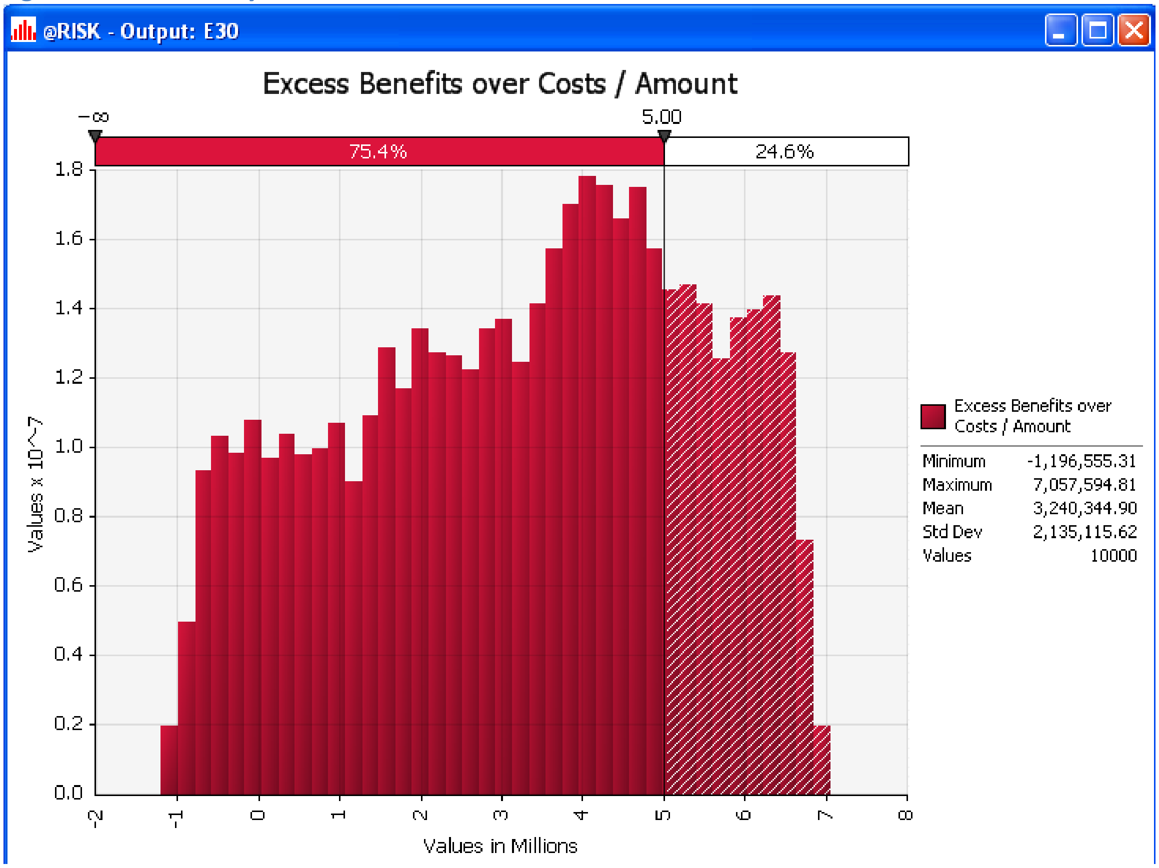


Figure 21: Probability of Economic Viability at 7%

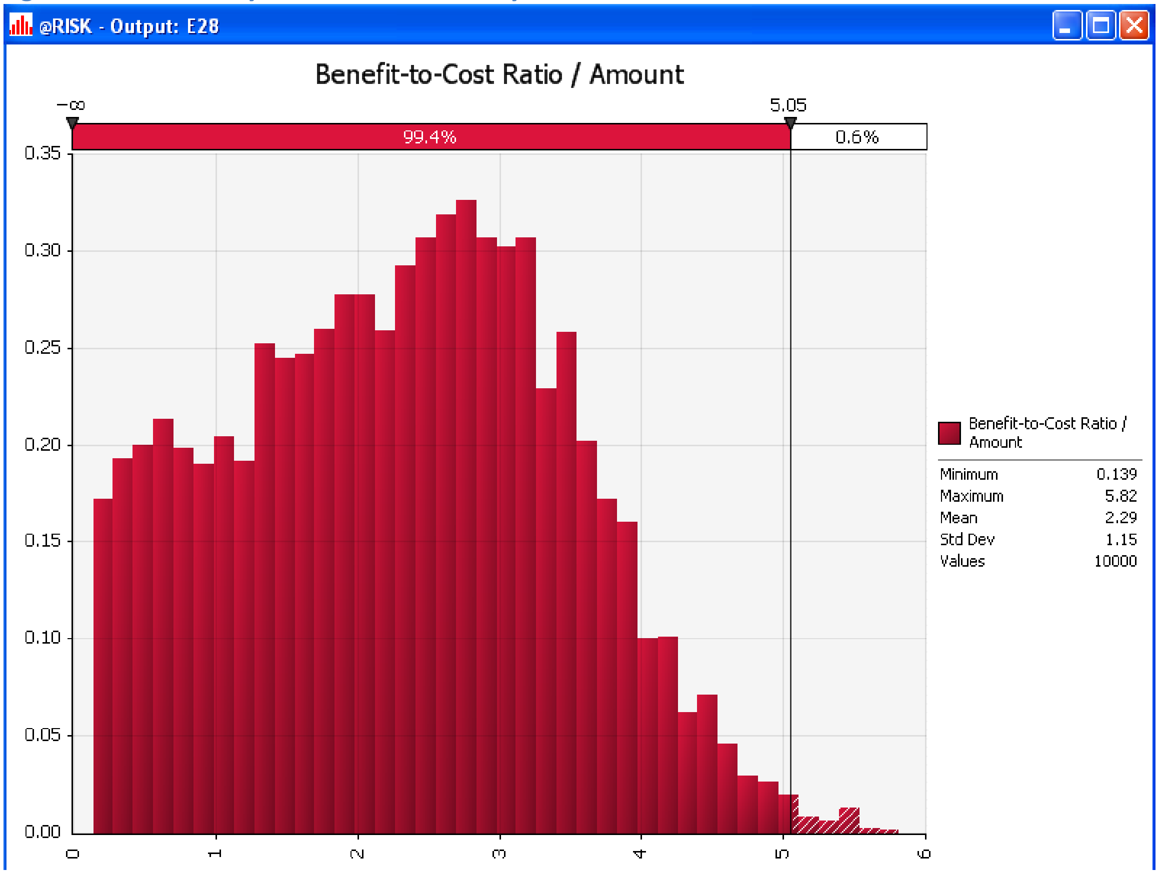
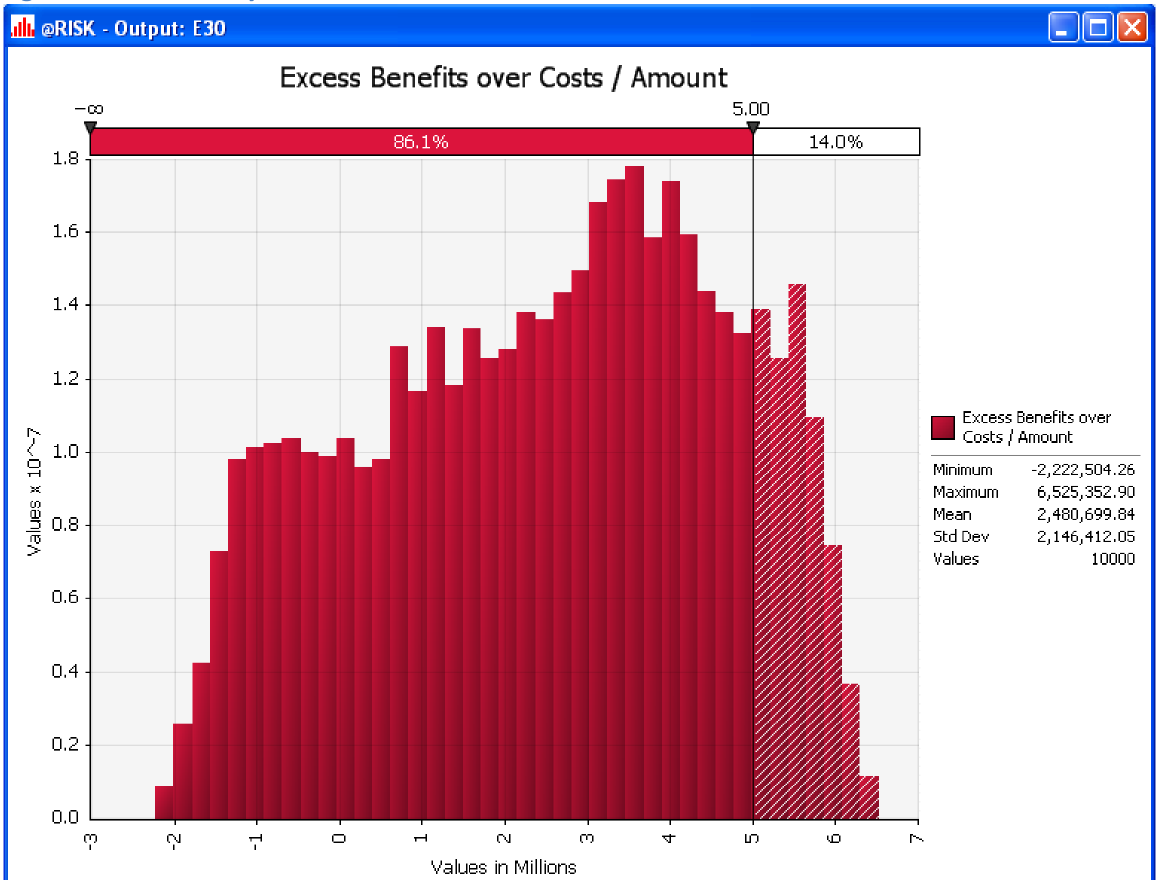


Figure 22: Probability of Positive Net Benefits at 7%



9 FINANCIAL ANALYSIS

9.1 COST APPORTIONMENT

For information on cost apportionment, refer to the main report.

9.2 ABILITY TO PAY

The ability-to-pay test is applied to all flood risk management projects. As a result of the application of the test, some projects may be cost shared at a lower level than the standard non-Federal share, which is the share that would apply to the project before any ability-to-pay consideration. Economic Guidance Memorandum 12-04 is the most current guidance on Ability-to-Pay and provides the procedures and parameters listed within this section. The Ability-to-Pay procedure calculates an Eligibility Factor.

The Eligibility Factor (EF) is: EF= a –b1 x (state income index) –b2 (county income index)

Where: state income index is the average over three years of the state per capita income index (state per capita income divided by the national per capita income) for the state (or states) in which the project is located, and the county income index is the average over three years of the county per capita income index (county per capita income divided by national per capita income) for the county (or counties) in which the project is located.

The parameters a, b1, and b2 were determined using the state and county per capita index data and the condition that a certain fraction of the counties are to have eligibility factors greater than zero. The values of the parameters are: a=19.69; b1=0.083; b2=0.166.

If the EF is one or more, the project is eligible for the full reduction in cost-share to the benefits-based floor. If EF is zero or less, the project is not eligible for a reduction. If EF is between zero and one, the non-Federal cost-share will be reduced proportionately to an amount that is greater than the benefits based floor but less than the standard non-Federal cost share.

EF = 19.69 – (0.083 x 92.66) – (0.166 x 89.05) = -2.78308

For this study, the EF is less than zero; therefore the project is not eligible for a reduction in the standard non-Federal cost share.

9.3 FINANCIAL CAPABILITY

City of Springfield has stated that it is capable and willing to cost share in the project.

10 PLAN FOR ECONOMIC UPDATES

As required by EC 11-2-202 and the Civil Works Policy Memorandum 12-001, the economics of this study will be updated for the development of the Civil Works Budget. As stated in the Memorandum, "It will be limited to reviewing and updating previous assumptions and limited surveying, sampling, and application of other techniques to affirm or develop a reasonable revised estimate of project benefits." Depending on the time which has passed and the verification (or lack of verification) of key benefit assumptions, the scope of work may be limited to reaffirmation, extended to sampling the key data and re-running the FDA model, to fully updating the economic benefits.

Appendix B
Real Estate Plan

REAL ESTATE PLAN

Prepared for

U.S. Army Corps of Engineers

Southwestern Division

Little Rock District

As of

May 1, 2013

Prepared by

Ronald Bridges

Real Estate Division

"ANY CONCLUSION OR CATEGORIZATION CONTAINED IN THIS REAL ESTATE PLAN, OR ELSEWHERE IN THIS PROJECT REPORT, THAT AN ITEM IS A UTILITY OR FACILITY RELOCATION TO BE PERFORMED BY THE NON-FEDERAL SPONSOR AS PART OF ITS LERRD RESPONSIBILITIES IS PRELIMINARY ONLY. THE GOVERNMENT WILL MAKE A FINAL DETERMINATION OF THE RELOCATIONS NECESSARY FOR THE CONSTRUCTION, OPERATION, OR MAINTENANCE OF THE PROJECT AFTER FURTHER ANALYSIS AND COMPLETION AND APPROVAL OF FINAL ATTORNEY'S OPINIONS OF COMPENSABILITY FOR EACH OF THE IMPACTED UTILITIES AND FACILITIES."

REAL ESTATE PLAN

JORDAN CREEK FRM STUDY

SPRINGFIELD, MISSOURI

Table of Contents

Tables

Attachment

Prepared By: Ronald Bridges

Real Estate Division

Date: May 1, 2013

1 Purpose of the Real Estate Plan

The purpose of this Real Estate Plan is to provide real estate acquisition cost estimates for lands required for the completion of the Jordan Creek Feasibility Study, Springfield, Missouri. The study is to provide recommendations for reducing significant flood damages and ecosystem restoration around Jordan Creek. Project area maps, attached as Exhibits A-1 to A-7 show the location of the study area. The City of Springfield, Missouri will be the non-federal or local sponsor (NFS) for this proposed project. Real estate costs will be estimates for Economic Reach E1 at the lower branch of Jordan Creek and Wilson Creek and five (5) detention basins.

The Energy and Water Development Appropriations Act, 2002, (Public Law 107-66) and the Federal Water Project Recreation Act of 1965 (Public Law 89-72, as amended), provides the basis for the activities involved in this study along Jordan Creek in Springfield, Missouri.

2 Description of Lands, Easements, Rights-of-Way, Relocations and Disposal / Borrow Areas (LERRD)

The proposed project will cover an aggregate area of approximately 52.48 acres. The project properties consist of commercial, industrial, and residential properties. There are approximately four (4) ownerships and five (5) parcels affected by the channel alignment of Economic Reach E1 for the recommended plan. Economic Reach E1 covers approximately 10.27 acres of land. The City of Springfield owns approximately 4.10 acres within this reach.

There will be two temporary work area easements required in Economic Reach E1 totaling 1.16 acres in size. A five (5)- year term was considered in estimating the value for the temporary work area easements. The City of Springfield owns the underlying fee land to be encumbered by the two temporary work areas.

Three (3) permanent access road easements will be acquired for access to detention basins B6, B11 and B11C. (See Area Maps - Exhibits “A-3” and “A-6”). The road easement for detention basin B6 will encumber approximately 0.10 acre and one (1) ownership. The two (2) road easements for detention basins B11 and B11C will encumber approximately 0.32 acre and two (2) ownerships.

A permanent utility/pipeline easement area will be required within the right-of-way of East Rockhurst Street and will be approximately 2.05 acres in size. Because drainage and utility construction will occur underneath the existing Rockhurst Street, reconstruction of the street will be required. As of this writing, Bennett Street, situated in Economic Reach E-1, may be modified with a flood diversion structure. The City of Springfield has road easements for both East Rockhurst Street and Bennett Street, and both streets are their operational and financial responsibilities. Both road adjustments are Relocation requirements and the associated real estate Relocation costs have been included in the real estate baseline cost estimate. The City will be required to acquire the permanent utility easement from the underlying fee owner and fund the Relocation portion of the road costs upfront and then submit a request for LERRD credit.

The lands for the channel improvement and temporary work area easements, road and pipeline easements and detention basins are within the corporate limits of the City of Springfield, Missouri.

The five (5) detention basins are situated in residential and multi-family, commercial, and industrial areas of Springfield, Missouri. The detention basins are designated B6 (approximately 7.05 acres in size, encompasses five (5) ownerships and five (5) parcels), B7 (approximately 7.55 acres in size, encompasses one ownership and one (1) parcel, B9B (approximately 6.99 acres in size, encompass five (5) ownerships, and eight (8) parcels), B11 (approximately 10.53 acres, encompasses seven (7)ownerships and eight (8) parcels) and B11C (approximately 6.46 acres, encompasses two (2)ownerships and two (2) parcels). The basins consist in the aggregate approximately 38.58 acres and involve twenty-eight (28) ownerships and thirty-five (35) parcels.

Table 1 – Project Area – NFS Ownership

PROJECT AREA	NON-FEDERAL SPONSOR OWNERSHIP	ACREAGE TO BE ACQUIRED
Reach E1	2.94 acres	7.33 acres
Basin B6		7.05 acres
Basin B7	7.55 acres	
Basin B9B	0.55 acres	6.44 acres
Basin B11		10.53 acres
Basin B11C		6.46 acres
Utility/Pipeline Easement		2.05 acres
Temporary Work Area Easements	1.16 acres	
Access Road Easements		0.42 acre
TOTAL	**12.20 acres**	**40.28 acres**

Table 2 – Project Area Ownerships and Parcels

PROJECT AREA	# OWNERSHIPS	# PARCELS
Reach E1	4	5
Basin B6	5	5
Basin B7	1	1
Basin B9B	5	8
Basin B11	7	8
Basin B11C	2	2
Utility/Pipeline Easement	1	1
Temporary Work Area Easements	1	2
Access Road Easements	2	3
TOTAL	**28**	**35**

There are approximately 13 facilities that require adjustment/relocation for the recommended project. There are two roads (Bennett and Rockhurst), four (4) utilities for water, sanitary sewer, natural gas, and electrical power that encumber approximately 0.66-acre of Reach E1, and Seven

(7) utilities easements for water sanitary sewer, and natural gas that encumber approximately 0.29-acre of detention basin B7. These facilities are within the corporate city limits of Springfield, Missouri. As part of this project, the non-federal sponsor will acquire the appropriate real estate instruments from the facility owner.

Another required relocation is for the Scenic Drive Bridge Relocation in Reach E1. This is a public road. Modification to Scenic Bridge will likely be required because of channel excavation beneath the bridge. The modification may include installing reinforced piers and a mat foundation. We have included this as a NFS responsibility to negotiate and complete as part of LERRD in this REP. However, depending upon final design and a Final Attorney Opinion of Compensability, this item could later become part of construction costs and be subject to cost-sharing.

Prior to the federal project implementation, the sponsor will remove two pedestrian walkways on Jordan Creek to increase the channel width from approximately 45 to 100 feet. Therefore, we have not included any Real Estate costs associated with the removal of these walkways. The land required for the channel widening is accounted in the channel easement calculations. The walkways are on land owned in fee by the City.

There is also a railroad bridge relocation required by this project. Per Section 3 of the 1946 Flood Control Act, existing railroad bridges and approaches thereto are federal responsibilities. This relocation agreement will be accomplished by SWL real estate and the costs included in total project costs. The baseline real estate cost estimate includes federal labor costs to accomplish this acquisition.

Fee Simple

The fee simple title to (land described in Schedule A) 1/ (Tract Nos. ________, __________, and ___________), subject, however, to existing easements for public roads and highways, public utilities, railroad and pipelines.

Channel Improvement Easement

A perpetual and assignable right and easement to construct, operate, and maintain channel improvement works on, over and across (the land described in Schedule A) (Tracts Nos. ______, ______, and ______), for the purposes as authorized by the Act of Congress approved _______________________, including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, buildings, improvements and/or obstructions therefrom; to excavate, dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroad and pipelines.

Temporary Work Area Easement

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____, and _____), for a period not to exceed ____________________, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a (borrow area) (work area), including the right to (borrow and/or deposit fill, spoil and waste material thereon) (move, store and remove equipment and supplies, erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _______________________ Project, together with the right to trim, cut fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads, highways, public utilities, railroads and pipelines.

Road Easement

A perpetual and assignable easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____, and _____) for the location, construction, operation, maintenance, alteration and replacement of (a) road(s) and appurtenances thereto; together with the right to trim,cut, fell and remove therefrom all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way; (reserving, however, to the owners, their heirs and assigns, the right to cross over or under the right-of-way as access to their adjoining land at the locations indicated in Schedule B); subject, however, .to existing easements for public roads and highways, public utilities, railroads and pipelines.

Utility and/or Pipeline Easement

A perpetual and assignable easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____, and _____), for the location, construction, operation, maintenance, alteration; repair and patrol of (overhead) (underground) (specifically name type of utility or pipeline); together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3 LERRD owned by Non-Federal Sponsor

The non-federal sponsor (NFS) has fee ownership in parts of Economic Reach E1 and detention basins B7 and B9B. The non-federal sponsor has a fee ownership of approximately 4.10 acres in Economic Reach E1. Of this acreage, approximately 1.16 acres of the Springfield property will be used for temporary work areas. The remaining 2.94 acres of the City of Springfield's property will be part of the channel improvement easement (see Table 3 – Project Area NFS Ownership, Area Map, Exhibit" A-1"). The NFS has approximately 7.55 acres fee ownership in B7 (see Area Map Exhibit "A-4"), and has approximately 0.55 acre of fee ownership in proposed detention basin B9B (see Area Map, Exhibit "A-5"). However, the NFS has drainage easement interests of approximately 20.16 acres in B6 (approximately 6.0 acres), B11 (approximately 8.68 acres) and B11C (approximately 5.51 acres). If the project is approved and funded, the NFS will make available all necessary real estate interests for the project.

Table 3 – Project Area NFS Ownership

PROJECT AREA	NON-FEDERAL SPONSOR OWNERSHIP
Reach E1	2.94 acres
Basin B6	
Basin B7	7.55 acres
Basin B9B	0.55 acre
Basin B11	
Basin B11C	
Temporary Work Area Easements	1.16 acres
TOTAL	**12.20 acres**

4 Non-Standard Estates

Non-standard estates were not used for this proposed project. Standard estates for fee simple, channel improvement easement, temporary work area, road, pipeline/utility easement are the estates considered for the project. However, because of the degree of damages that would occur on the properties involving the channel improvement easement, the value estimate of the channel improvement easement would be equivalent to the 100% of fee simple.

The NFS has drainage easements encumbering lands used for detention basins B6, B11, and B11C. There is no drainage easement encumbering detention basin B9B. In order to allow for the greatest degree of control of the subject detention basins by the non-federal sponsor, it is recommended that fee simple be the estate used for the acquisition of the remaining real estate interests in the lands for detention basins B6, B11 and B11C and fee simple interest be acquired in detention basin B9B.

5 Any existing federal project that lies fully or partially within the LERRD required for the project.

The US Department of Transportation owns an approximate 0.23-acre land area. This land area is part of the right-of-way for the Chestnut Expressway (see Attachment 1-D, Exhibit A-3). This area is located at the southwest boundary of detention basin B6, is at the northern boundary of the

Chestnut Expressway right-of-way and is southeast of Pythian Street. If the fee parcel for detention basin B6 is not modified during design to exclude the Chestnut Expressway lands, fee will be acquired subject to the existing public roads. Therefore, the Chestnut Expressway will not be affected.

6 Any federally owned land

Nothing other than as described in paragraph 5.

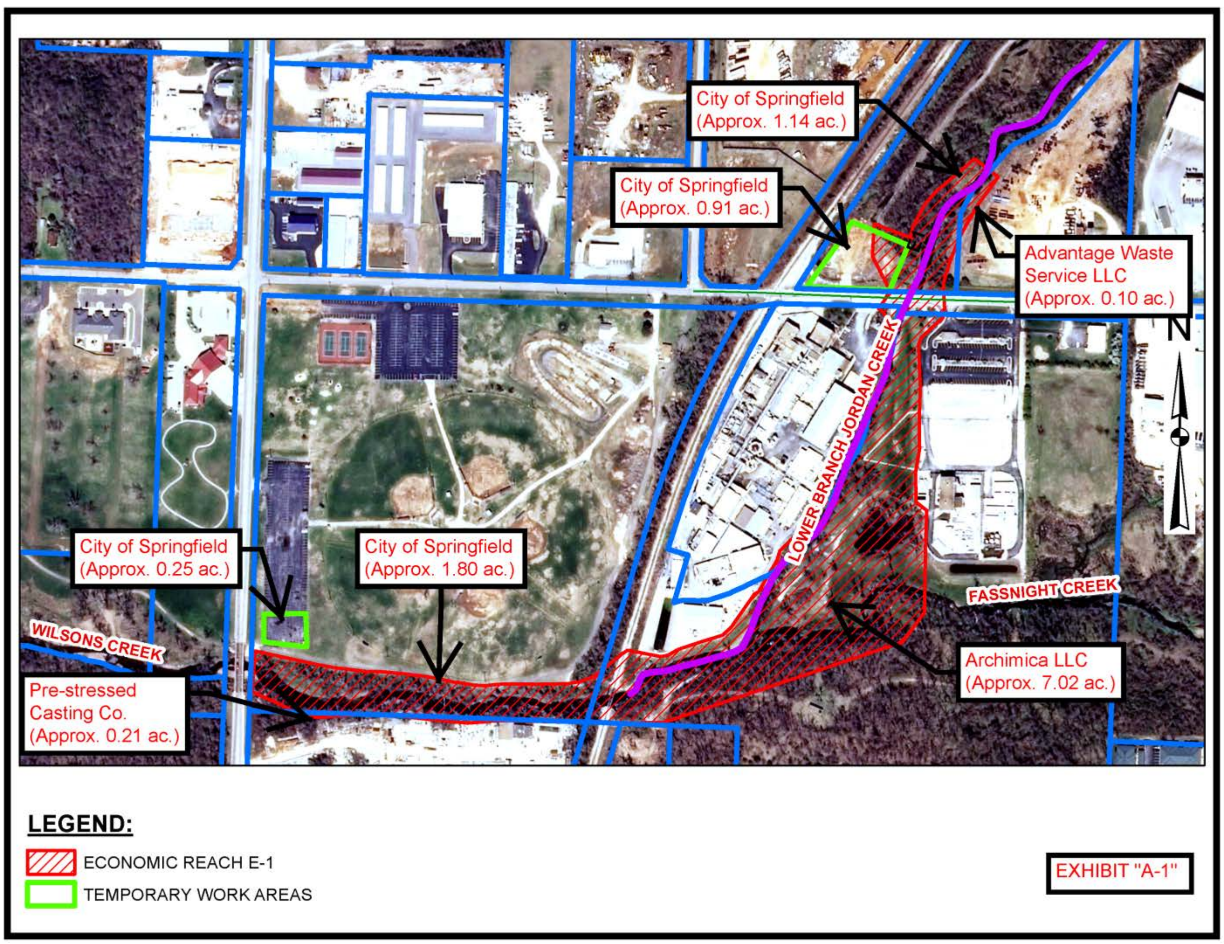
7 LERRD that lies below the ordinary high water mark

Neither Jordan Creek nor Wilson Creek is a navigable stream and is not subject to navigational servitude.

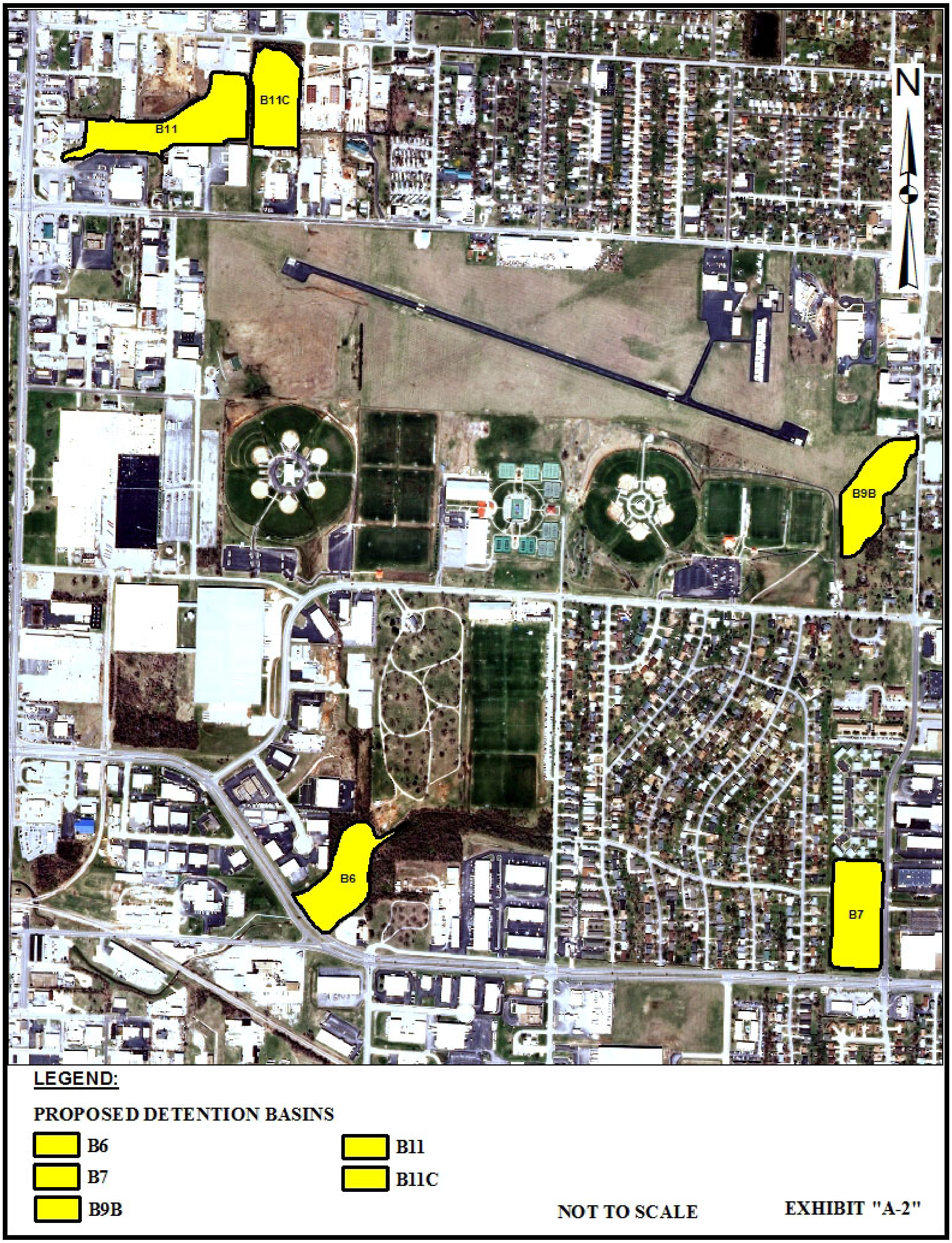
8 Maps depicting project area

The maps depicting the location of Economic Reach E1 and detention basins B6, B7, B9B, B11, and B11C are shown in Area Maps - Exhibits “A-1” to “A-7”.

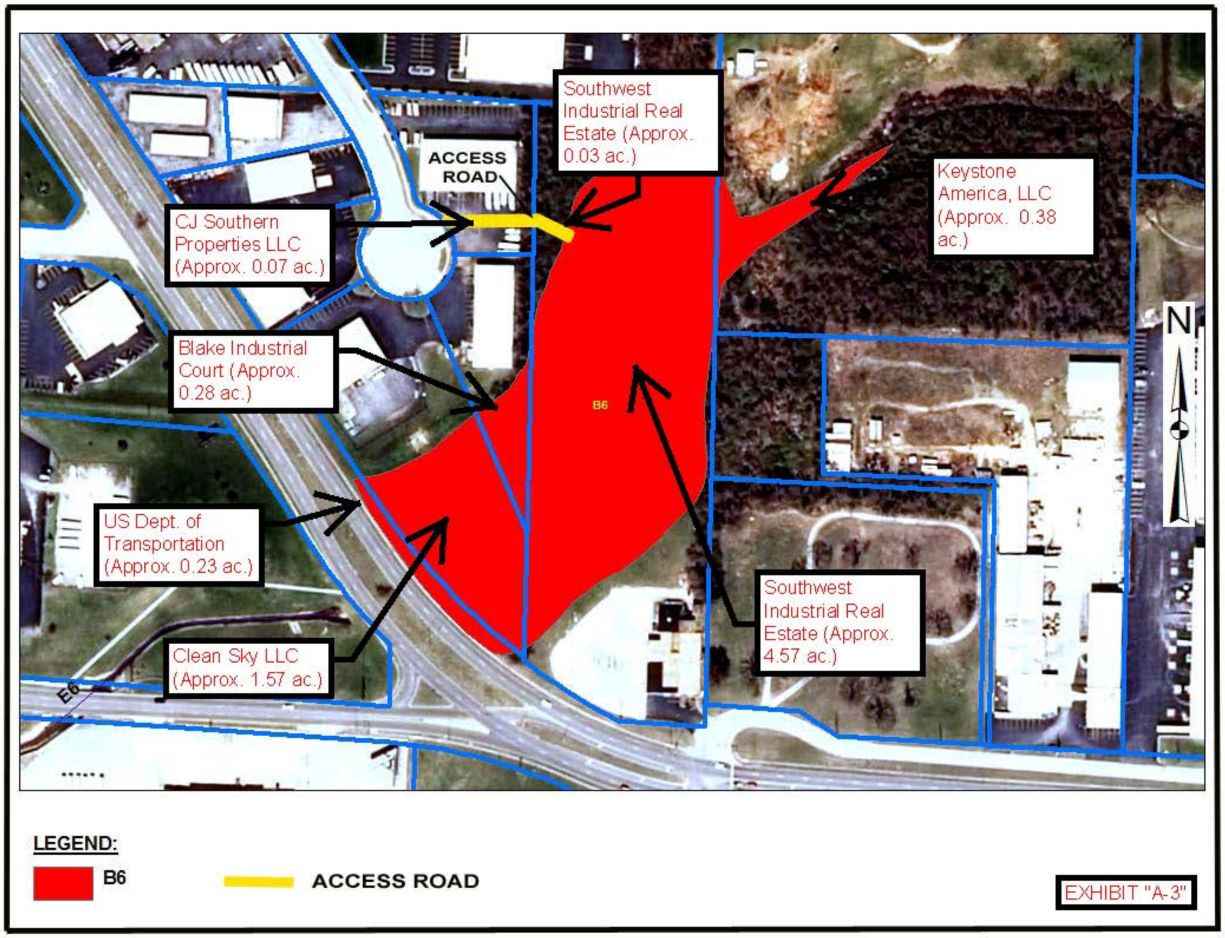
Area Map – Exhibit “A-1”



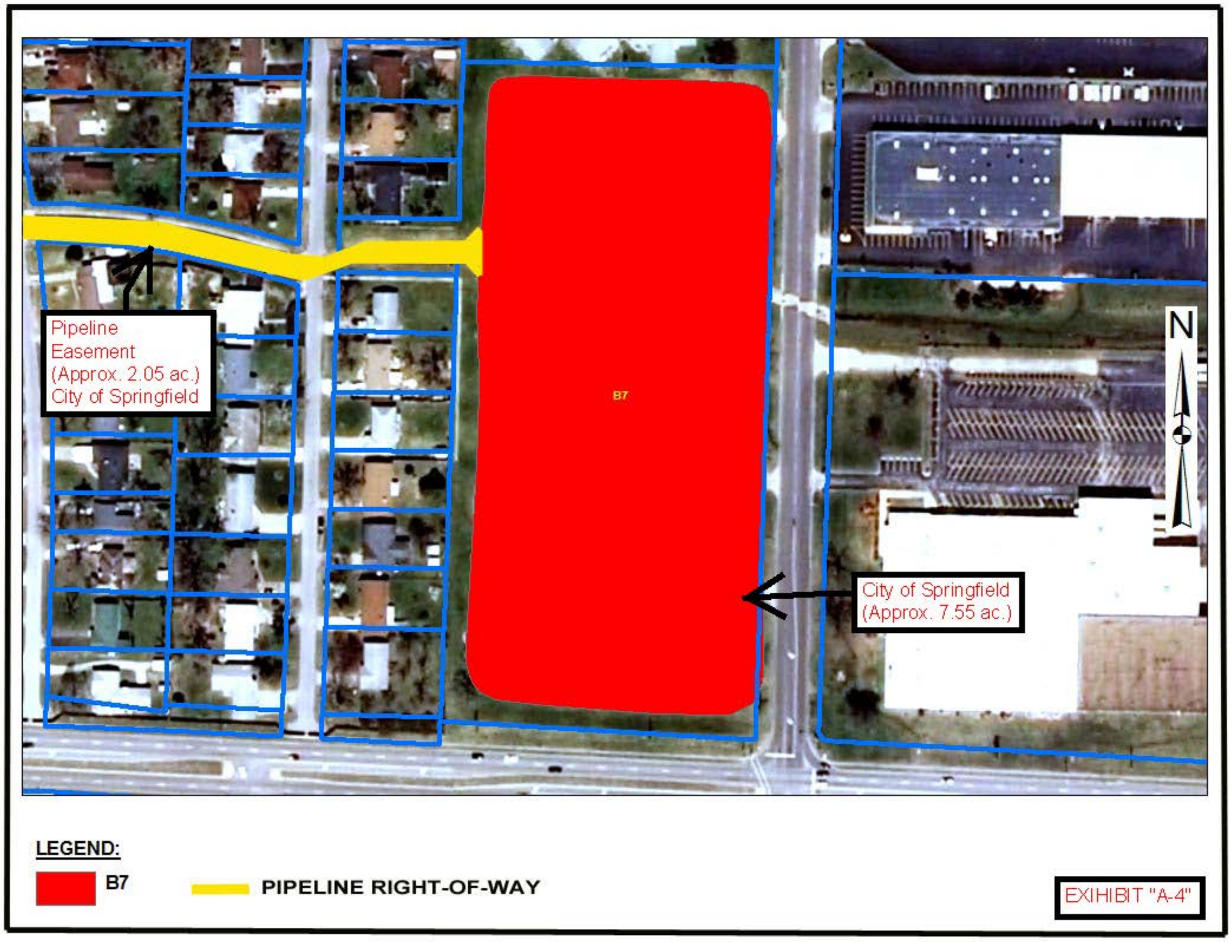
Area Map – Exhibit "A-2"



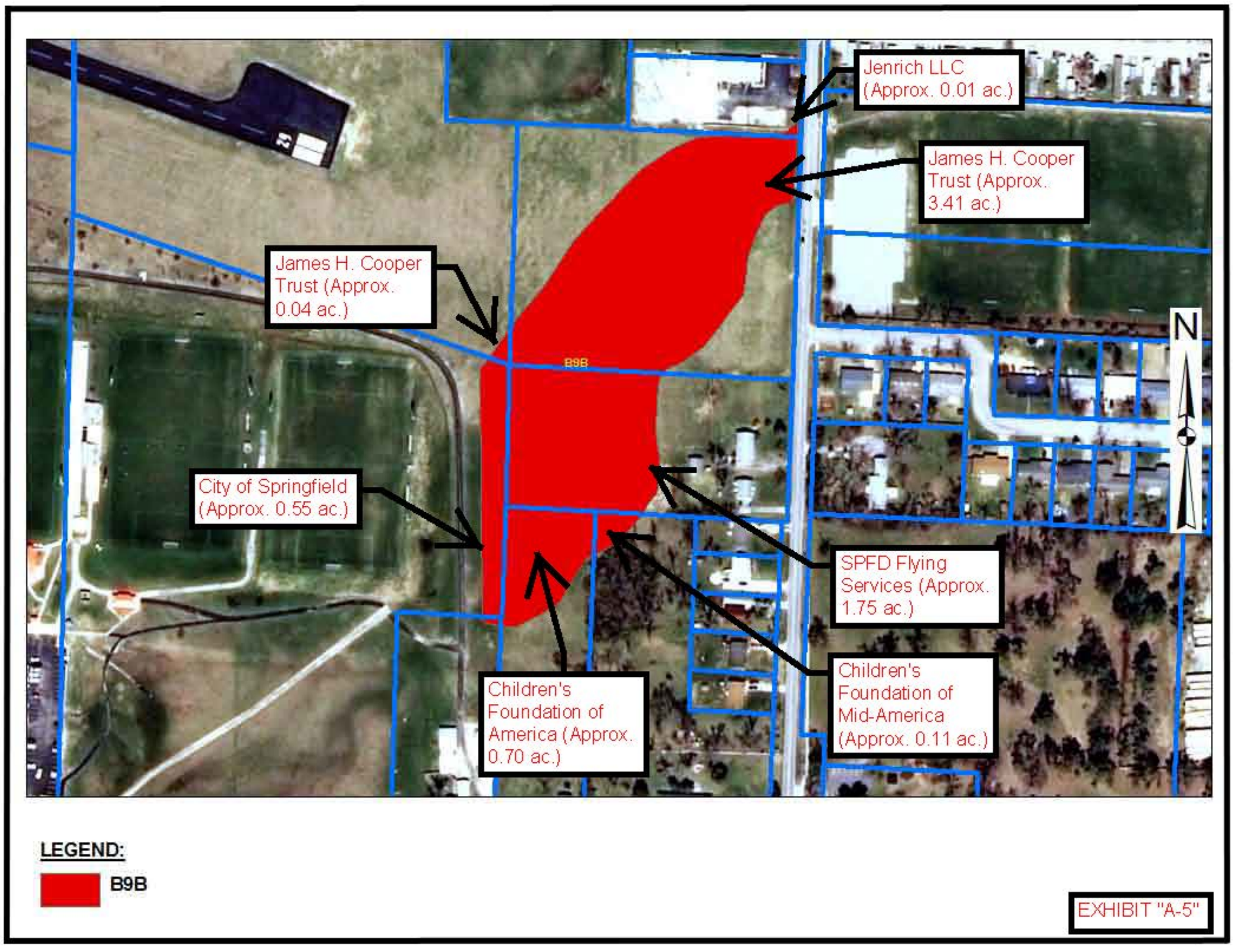
Area Map – Exhibit "A-3"



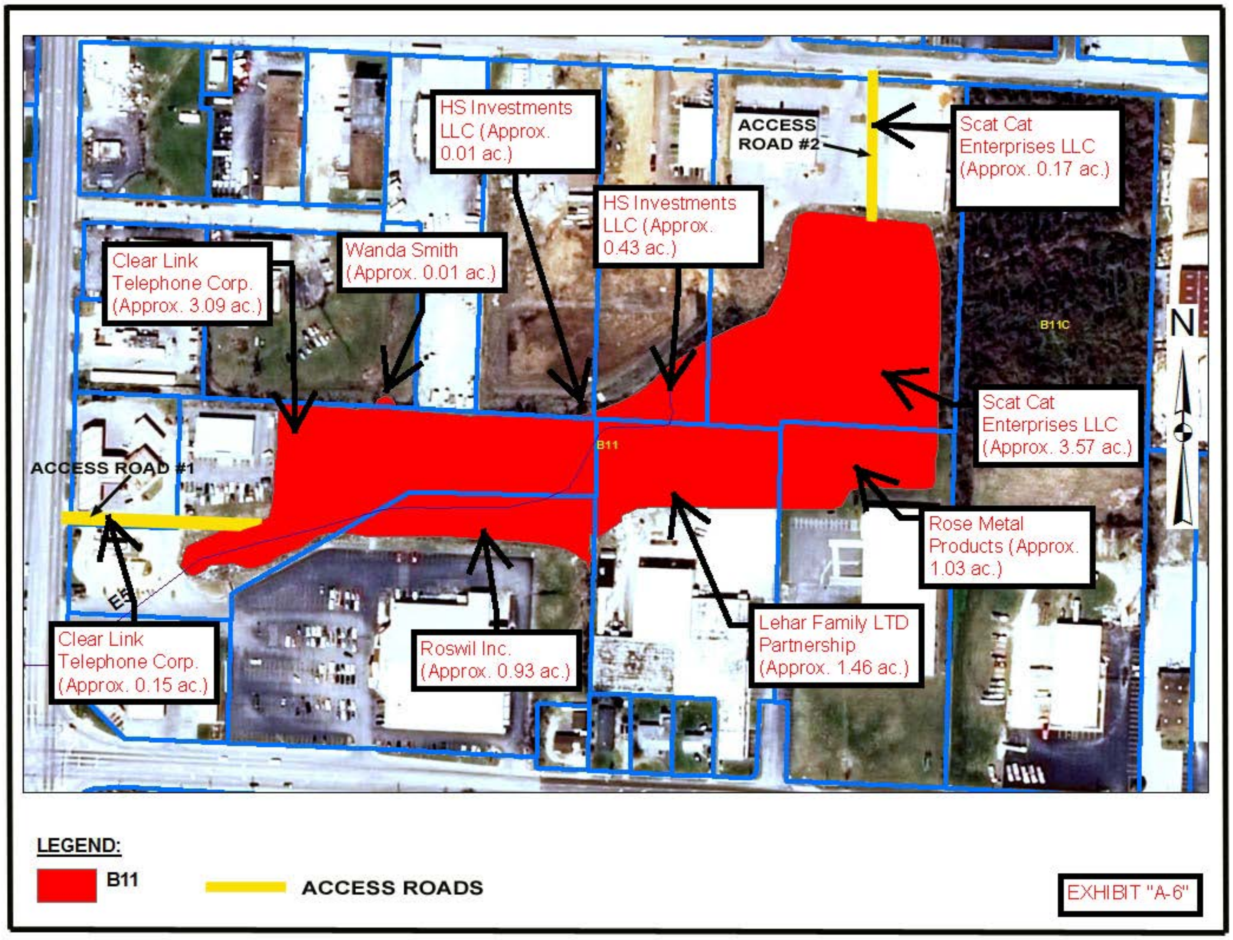
Area Map – Exhibit "A-4"



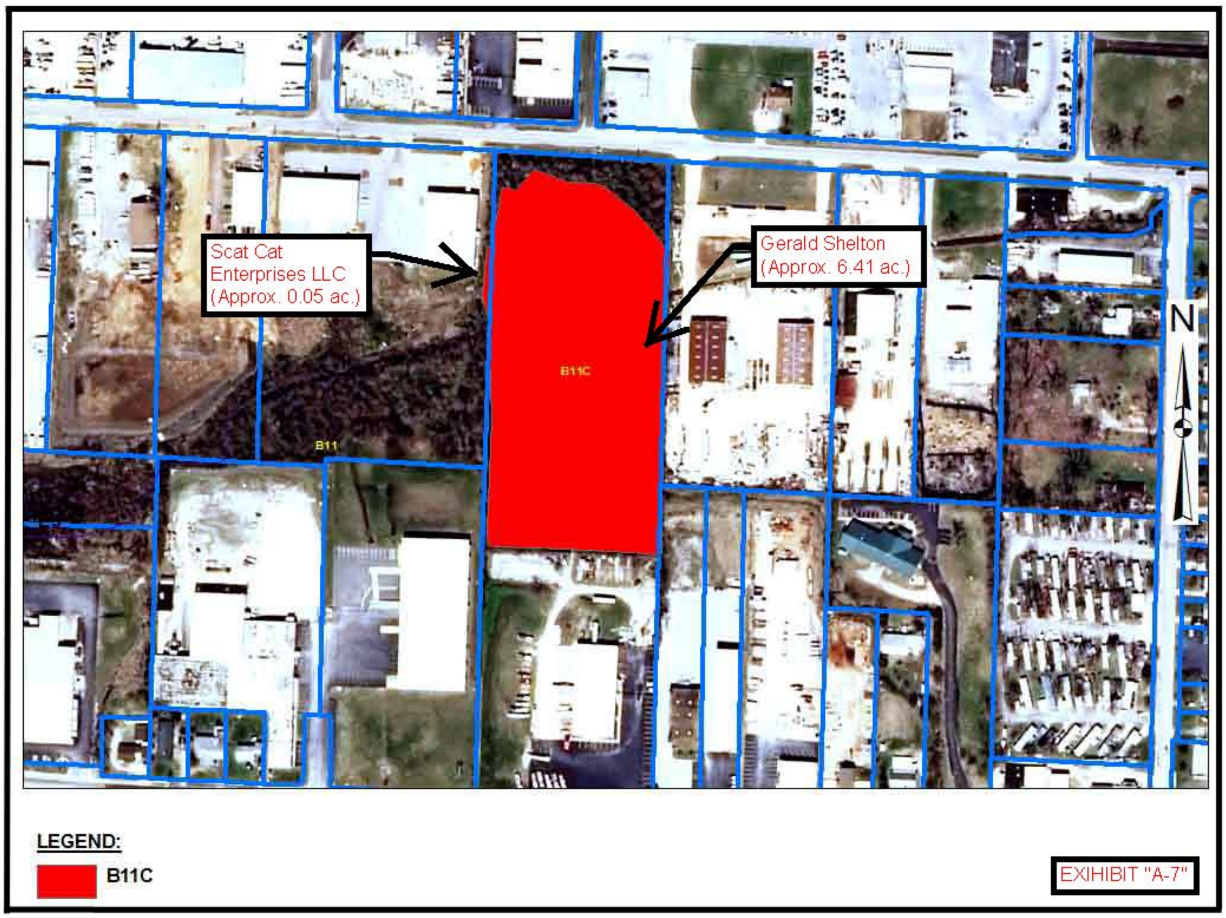
Area Map – Exhibit "A-5"



Area Map – Exhibit "A-6"



Area Map – Exhibit "A-7"



9 Any possible flooding

No induced flooding will occur as a result of the construction of the proposed project.

10 Real Estate Cost Estimate

The cost estimate is based upon real estate cost data and an August 24, 2012 gross appraisal provided by Ronald Bridges, Real Estate Division, US Corps of Engineers, Little Rock District. The estimated land and administrative cost is $4,400,760.00 for this proposed project. This estimate consists of $3,788,760.00 for real estate interests needed for the project, $569,160.00 in estimated non-federal sponsor administrative costs for the acquisition of the real property and real estate interests for the project, and $42,840.00 in estimated federal administrative costs for real estate document review. A twenty percent (20%) contingency is included the estimated land and administrative costs. See

Table 4: Real Estate Baseline Cost Estimate for a fuller cost estimate allocation.

Table 4: Real Estate Baseline Cost Estimate

REAL ESTATE BASELINE COST ESTIMATE JORDAN CREEK FEASIBILITY STUDY SPRINGFIELD, GREENE COUNTY, MISSOURI			
01	**Lands & Damages**	**Administrative & Land Costs**	**Contingency**
01.23	Construction Contract Documents		
01.23.03	Real Estate Analysis Documents		
01.23.03.01	Real Estate Planning Documents		
	Planning by Non-Federal Sponsor	$2,400	20% = $480
	Corps of Engineers Real Estate Plan	$1,400	20% = $280
	Review of Non-Federal Sponsor	$400	20% = $80
01.23.03.02	Real Estate Acquisition Documents		
	Acquisitions by Non-Federal Sponsor (includes estimated survey costs	$380,000	20% = $76,000
	Review of Non-Federal Sponsor	$4,000	20% = $800
01.23.03.03	Real Estate Condemnation Documents		
	Condemnations by Non-Federal Sponsor	$4,000	20% = $800
	Review of Non-Federal Sponsor by Little Rock District Real Estate	$800	20% = $160
01.23.03.05	Real Estate Appraisal Documents		
	Appraisals by Non-Federal Sponsor	$85,000	20% = $17,000
	Review of Non-Federal Sponsor	$22,800	20% = $4,560
01.23.03.15	Real Estate Payment Documents		
	Payments by Non-Federal Sponsor (Land)	$3,788,760	
	Review of Non-Federal Sponsor	$4,000	20% = $800
01.23.03.17	Real Estate LERRD Crediting Documents		
	Preparation by Non-Federal Sponsor	$4,000	20% = $800
	Review of Non-Federal Sponsor by Little Rock District Real Estate	$1,200	20% = $240

09	Wilson Creek RR Bridge (Federal Labor Real Estate)	$35,000	
09	Wilson Creek RR Bridge (Federal Land Payment)	$2,435,126	
02 [1]	NFS Scenic Bridge, Roads And Utility Relocations (Facility replacement payment)	$2,314,416	
02	NFC Road and Utility Relocations (Labor)	$121,000	
01	**TOTAL ADMIN & PAYMENTS**	$4,298,760	
01	**TOTAL CONTINGENCY**		$102,000
01	**ESTIMATED TOTAL**		$4,400,760

[1] The construction costs for the Scenic Bridge Relocation ($454,000) are in the MCACES 09 account. However, the real estate relocation agreement and associated just compensation payment is thought to be a NFS LERR requirement at this writing, so we are including the costs in the 02 account in the REP. This does not in any way alter the total project costs in the MCACES. This item will be finalized after final design and final attorney's opinion in PED.

	FEDERAL COST	NON-FEDERAL COST	TOTAL
Land and Damages		$3,788,760.00	$3,788,760.00
Estimated Administrative Cost	$42,840.00	$ 569,160.00	$ 612,000.00
ESTIMATED TOTAL COSTS	**$42, 840.00**	**$4,357,920.00**	**$4,400,760.00**

11 Relocation Assistance Benefits

As no residences and/or businesses will be displaced by this project, no relocations benefits will be incurred under P.L. 91-646.

12 Mineral Activity

There is no obvious mineral activity occurring within the project areas. All the properties are within City limits and City ordinances severely restrict mineral extraction and drilling. Therefore, there is a very low risk of any third party mineral extraction impacts to the project features.

13 Assessment of Non-Federal Sponsor

See Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability (Exhibit B). The non-federal sponsor (NFS) has been advised of the requirement for documenting expenses for crediting purposes. The NFS will need some guidance in the real estate acquisition process for the proposed federal project. This guidance can take the form of District real estate acquisition checklists, communications with a member of the District acquisition staff for any pertinent information.

14 Application of Zoning Ordinances

The subject properties for the proposed project are zoned as commercial, industrial, single-family residential, and multifamily residential. No zoning changes for the subject properties will occur with this proposed project.

15 Land Acquisition Milestones

The necessary real estate Acquisition is expected to take twenty-eight months after notice to proceed once the Project Partnership Agreement (PPA) is executed.

16 Facility or Utility Relocations

An existing operating railroad bridge, crossing Wilson Creek in Economic Reach E1, is proposed to be demolished and replaced with another bridge. The estimated demolition and construction cost for the bridge is $2,470,126.00 ($54,584.00 for bridge demolition and $2,415,553 for bridge construction). The SWL Real Estate office will negotiate a relocation agreement with the railroad for the required real estate rights to adjust the bridge in exchange for provision of a functionally equivalent facility. Relocation Agreements are real estate contracts to be signed by the appropriate RECO. Since the costs of this bridge are a federal responsibility by law, they will be part of total project construction costs and cost shared accordingly. They are not part of the LERRD costs or the NFS responsibility.

Water, sanitary sewer, storm water drainage, natural gas, and electrical utilities will be impacted by this proposed project in Economic Reach E1 and the detention basin B7. The trenches would be deepened for the underground utilities such as water, sanitary sewer, and natural gas in their individual rights-of-way. The overhead electrical lines would be elevated and poles repositioned within their rights-of-way. An alteration or modification is proposed for Bennett Street by raising the street surface elevation approximately two feet starting from the lowest area of the street and for approximately 300 linear feet of the street. The estimated construction cost is $84,000.00 for this alteration to Bennett Street. At Economic Reach E1, one (1) water pipeline, one (1) sanitary sewer pipeline, one (1) natural gas pipeline, one (1) electrical power pole and an approximate 400-foot section of electrical line under the Wilson Creek railroad bridge would be relocated as part of the project. At detention B7, two (2) water pipelines, one (1) storm water drainage pipeline, two (2) sanitary sewer pipelines, and two (2) natural gas pipelines would be relocated as part of the proposed project. The estimated construction cost is $1,860,416.21 for the storm water drainage, electrical, sanitary sewer, water, and natural gas relocations for this project. See Attachment B – Cost Engineering, Cost Estimate Report, page 1. A non-federal sponsor real estate labor cost is estimated at $121,000.00 plus a 20% contingency to execute relocation agreements to acquire the necessary property rights in exchange for the functionally equivalent facilities.

In accordance with Real Estate Policy Guidance Letter 31, the total facility relocation costs for this project do not exceed 30% of total project costs. The District has completed a real estate assessment and concluded that the facility owners are generally the type eligible for substitute facilities and has completed some research leading them to believe the owners have compensable property interests. Final Attorney Opinions of Compensability will be completed during the PED Phase and completed prior to any notice to proceed to the NFS or initiation of the federal real estate work on the railroad bridge relocation agreement.

In accordance with Real Estate Policy Guidance Letter 31, the total facility relocation costs for this project do not exceed 30% of total project costs. The District has completed a real estate assessment and concluded that the facility owners are generally the type eligible for substitute facilities and has completed some research leading them to believe the owners have compensable property interests. Final Attorney Opinions of Compensability will be completed during the PED Phase and completed prior to any notice to proceed to the NFS or initiation of the federal real estate work on the railroad bridge relocation agreement.

"ANY CONCLUSION OR CATEGORIZATION CONTAINED IN THIS REAL ESTATE PLAN, OR ELSEWHERE IN THIS PROJECT REPORT, THAT AN ITEM IS A UTILITY OR FACILITY RELOCATION TO BE PERFORMED BY THE NON-FEDERAL SPONSOR AS PART OF ITS LERRD

RESPONSIBILITIES IS PRELIMINARY ONLY. THE GOVERNMENT WILL MAKE A FINAL DETERMINATION OF THE RELOCATIONS NECESSARY FOR THE CONSTRUCTION, OPERATION, OR MAINTENANCE OF THE PROJECT AFTER FURTHER ANALYSIS AND COMPLETION AND APPROVAL OF FINAL ATTORNEY'S OPINIONS OF COMPENSABILITY FOR EACH OF THE IMPACTED UTILITIES AND FACILITIES."

Table 6 - Easements

EASEMENTS	Reach E1	Basin B7
Road	Bennett Street	
Water	1	2
Sanitary Sewer	1	2
Storm Water Drainage		1
Natural Gas	1	2
Electrical	2	
TOTAL #	**5**	**7**

17 Known Contaminants

There are three (3) Hazardous, Toxic, or Radioactive Waste (HTRW) areas within the boundary of Economic Reach E1. Two areas, being former landfills, are owned by the City of Springfield. One of the former landfill sites is now Ewing Park. The other HTRW site consists of two parcels owned by Archimica Pharmaceutical Company. According to Section 3.6 Description of the Tentatively Selection Plan, quote "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…"The sponsor is responsible for cleaning the site to a level suitable for channel widening." Section 4.7 Hazardous, Toxic and Radioactive Wastes in the draft feasibility report and environmental assessment for Jordan Creek, screening of the detention basins indicate a low potential for contaminants and no further environmental assessments were recommended for the five detention basin sites. A further environmental assessment was recommended for the landfill site in Reach E1. Though the three (3) HTRW sites within Reach E1, the actual construction in this reach is to occur within the channels of Jordan and Wilson Creeks where there has been no evidence of HTRW contamination and are away from the HTRW sites within Reach E1.

18 Support or opposition to the project

Response has been generally favorable from the State and Local Agencies. No public comments were received during the public comment period.

19 Statement that non-federal sponsor has been notified in writing about the risks associated with acquiring land for this proposed project.

The non-federal sponsor was notified in writing regarding the risks of acquiring land for this project in advance of the Project Partnership Agreement execution.

20 Other Real Estate Issues

As of this writing, there are discussions about elevating the Bennett Street to act as a flood diversion structure. The discussion centers around if there is a more cost efficient way. Currently, the Bennett Street road raising appears in the cost estimate. Should this division structure be built, a non-standard estate would be drafted, submitted to, and approved by USACE. The cost sharing would be adjusted appropriately between the diversion structure (construction cost) and raising the road (LERRD) during design.

Attachment 1

JORDAN CREEK PILOT STUDY
(CITY OF SPRINGFIELD, MISSOURI – NON-FEDERAL SPONSOR)

ASSESSMENT OF NON-FEDERAL SPONSOR'S
REAL ESTATE ACQUISITION CAPABILITY

1. LEGAL AUTHORITY:

(a) Does the non-federal sponsor have legal authority to acquire and hold title to real property for project purposes? Yes

(b) Does the non-federal sponsor have the power of eminent domain for this project? Yes

(c) Does the non-federal sponsor have "quick-take" authority for this project? No.

If not, what is the minimum time? 60-days.

(d) Are any of the lands/interests in land required for the project located outside of the non-federal sponsor's political boundary? No

(e) Any of the lands/interests in land required for the project owned by an entity whose property the non-federal sponsor cannot condemn? No, except for a narrow strip (.23 acres) of a U.S. Dept. of Transportation easement on the SSW edge of Project Basin B-6.

2. HUMAN RESOURCE REQUIREMENTS:

(a) Will the non-federal sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? No, will require orientation on process required

(b) If the answer to 2.a is "yes", has a reasonable plan been developed to provide such training? ________

(c) Does the non-federal sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? No, 2 personnel on staff which may extend the schedule unless others are brought in to assist

(d) Is the non-federal sponsor's projected in-house staffing level sufficient considering its other workload, if any, and the project schedule? NO

(e) Can the non-federal sponsor obtain contractor support, if required, in a timely fashion? YES

(f) Will the non-federal sponsor likely request USACE assistance in acquiring real estate? NO (If "yes", provide description).

[1 of 2]

3. OTHER PROJECT VARIABLES:

(a) Will the non-federal sponsor's staff be located within reasonable proximity to the project site? YES

(b) Has the non-federal sponsor approved the project/real estate schedule milestones? YES, believe land acquisition will require 12-18 months, scheduled for 24 months.

4. OVERALL ASSESSMENT:

(a) Has the non-federal sponsor performed satisfactorily on other USACE projects? N/A

(b) With regard to this project, the non-federal sponsor is anticipated to be: ____Highly capable; ____Fully capable; X Moderately capable; ____Marginally capable; ____Insufficiently capable. (If non-federal sponsor is believed to be? Insufficiently capable?, provide explanation).

5. COORDINATION:

(a) Has this assessment been coordinated with the non-federal sponsor? YES

(b) Does the non-federal sponsor concur with this assessment? YES (If "No", provide explanation).

Prepared by:

Ralph H. Allen (Signature)
RALPH H. ALLEN
Attorney
Date: 10 april 2013

Reviewed and Approved by:

[signature] (Signature)
DONALD L. BALCH
Chief, Real Estate Division
Date: 15 April 13

Appendix C
Engineering Appendix

Table of Contents

List of Tables

Plates and Attachments

APPENDIX C- ENGINEERING APPENDIX

1 General

This appendix documents the engineering analysis and follows the format of Engineering Regulation 1110-2-1150. Included with this appendix are the following reports; the Hydrology and Hydraulics Report (Jordan Creek Feasibility Study H&H Report, Attachment A), the MCACES cost estimate and construction schedule (included in Attachment B). Also attached is the Cost and Schedule Risk Analysis (Attachment C) followed by the engineering plates.

2 Hydrology and Hydraulics (H&H)

A hydraulic and hydrologic study of Jordan Creek and a portion of Wilsons Creek was performed for this study; information obtained from the model was used in developing channel dimensions. The evaluation included water surface profiles for the 1/500, 1/100, 1/50, 1/25, 1/10, 1/5, and 1/1 Annual Chance Exceedence (ACE) storm events for without-project (existing) conditions, without-project (future) conditions, and for several respective with-project alternatives. ACE is defined as the chance of that particular flood happening during any given year, for example; a 1/100 ACE storm event has a 1-percent chance of occurring during any given year. Refer to the Hydrology and Hydraulics report (Attachment A) for in-depth analysis of existing conditions and details of each of the alternative plans.

3 Surveying, Mapping, and Other Geospatial Data Requirements

The City of Springfield hired a surveying and consulting firm to perform a detailed survey at each identified channel cross section along the study reaches. This data was imported directly into GIS as a series of points with elevation attributes. This information was combined with 2-foot elevation data based on a photogrammetric flight from 1999 to create a TIN file. This information combined with aerial photography was utilized in ArcMap to layout, analyze, and compute quantities for the channel and associated work. LiDAR data from 2011 is available and is a useful resource during the design phase.

A more recent and comprehensive topographic survey will be required in order to develop plans and specifications. Due to the abundance of commercial properties affected, it is recommended that an American Land Title Association (ALTA) Land Survey be performed prior to proceeding into PED. This survey will provide topographic features, boundary lines, easements, structures, utilities, streets and railways, etc.

4 Geotechnical

4.1 General - This section presents general criteria based on limited subsurface investigations, analysis methods and assumptions for the geotechnical design of project features. Geotechnical design considerations for permanent structures are provided herein. The considerations consist of design of the structural foundations (bridges and culverts), excavation, backfill and scour protection.

4.2 Design Criteria - The following documents will be used in the geotechnical design of the project.

Engineer Manuals

- EM 1110-1-1905, "Bearing Capacity Analysis", 30 Oct 92
- EM 1110-2-1906, "Laboratory Soils Testing", 20 Aug 86

Other Publications

- *Foundation Analysis and Design*, Bowles, 1968
- *Foundation Engineering Handbook*, Fang, 2nd ed., 1991
- *Fundamentals of Geotechnical Analysis*, Dunn, Anderson, Kiefer, 1980
- *Soil Engineering*, 4th, ed., Spangler, Handy, 1982
- *Soil Mechanics in Engineering*, Terzaghi, Peck, 1967

4.3 Regional Geology - The proposed site is located in the Springfield Plateau geologic region. The Springfield Plateau, mainly an undulating to rolling plain, is on Mississippian and Ordovician age bedrock in this area and is part of the Ozark Uplift. The topography of this region is characterized by plateaus, steep valleys and hills. The immediate area is underlain by limestone of the Mississippian Age. This limestone generally consists of coarse grained gray limestone which is nearly pure calcium carbonate and highly susceptible to solutioning. Isolated chert nodules and discontinuous chert layers are present throughout the formations in this area. The upper surface of this bedrock is generally irregular due to the effects of differential weathering and solutioning activity as can be seen in road cuts along interstate 44, therefore, the depth to bedrock in any given area can vary dramatically. The overburden is residual soil having formed by the weathering of the rock through chemical action of infiltration through the rock formation. Less resistant rock formed the present soil matrix; more resistant rock is still present as weathered and intact gravel, cobbles and boulders. Due to the karst topography of this region, sinkholes and caves are in all stages of development and new sinkholes can appear at the ground surface at any time. The formation of sinkholes is a never ending process as groundwater finds new paths and soil is carried away from an area leaving a cavity. The cavity propagates upward through a continuing process of erosion of the overlying soil by piping and resulting deposition of the eroded material in the voids below. At some point the overlying undermined soil mass collapses because it can no longer support its own weight over the underground cavity. In this respect, it is virtually impossible to determine if sinkhole activity is present at a given location from a boring unless a void or channel is intercepted in an exploratory boring or unless there is some evidence of sinkhole activity at the particular site.

4.4 Seismological Evaluation - The site is located approximately 250 miles west/northwest of the New Madrid Fault Zone in southeast Missouri. In past years (1811-1812) this fault produced large magnitude earthquakes (Richter Magnitude 5+). Numerous small earthquakes (Richter Magnitude 2 to 4) occur along the new Madrid Fault each year. Springfield, Missouri is located in the Uniform Building

Code seismic risk Zone 1. Zone 1 is typified by Mercalli Intensity Scale intensities of V and VI out of a possible intensity rating I to X. The 2009 International Building Code Site Class for the area of the investigation would be Site Class "D". The liquefaction potential for soils on this site would be minimal due to the amount of clays found in the soils.

4.5 Subsurface Investigations and In Situ Tests

Subsurface data was collected in two Phases. A total of 64 borings were drilled in the two phases. Only those borings which lie within the vicinity of the selected plan were presented in the Plates (See Plates G-1 through G-10).

Phase I consisted of 45 borings. These borings were drilled to obtain top of rock depths which would be used to aid in the design and construction of detention ponds. The borings were advanced using 4 inch solid-stem continuous flight augers. An all terrain mounted CME 550X was used to drill the borings. Representative samples were taken of the different soils encountered for visual classification purposes. The termination depth of the borings in Phase I was at the top of rock or to a maximum depth of 10 feet. Generally, the soils were classified based on auger cuttings with minimal split-spoon samples taken.

Phase II consisted of 19 borings that were drilled along the proposed alignment of the new channel and at areas of potential bridges. The borings were drilled with 4-inch diameter solid-stem augers with a truck-mounted CME-75. These borings were terminated at the top of rock or to a maximum depth of 20 feet. Samples were obtained using a split spoon sampler and the number and types of test are indicated in Table 1: Soil Tests.

Table 1: Soil Tests

Test	Number of Samples
Gradation	38
Classification (Lab)	32
Atterberg Limits	37
Moisture Content	100
Unconfined Compressive Strength (Penetrometer)	54
Splitspoons	98

The subsurface conditions encountered at the boring locations are shown on the boring logs. The near surface soil in several of the borings was classified as fill consisting of various mixtures of lean (CL) and fat (CH) clays with chert rock and some debris, base rock and crushed stone. The thickness of the fill varied from 1 foot to approximately 10.5 feet. Below the fill material were in situ soft to stiff clays (CL and CH) varying in thickness from 2 to 13 feet. In situ clays were underlain by cemented limestone bedrock. The top of rock varies through the site from 5.5 ft below the ground surface to greater than 20 feet. The top of rock in most of the drilled holes were located between 10 to 15 feet below the ground surface. The maximum depth of the drilled holes was 20 feet.

4.6 Excavation, Fill, and Slope Stability

As noted in the drilling logs, limestone can be expected as shallow as 5.5 feet below the ground surface., Due to the possibility of rock pinnacles, in some areas the rock may be shallower. Because the work is within the city limits with businesses and homes encompassing the project area, blasting will not be allowed. The rock will likely be removed by using continuous systematic chiseling, edging or other appropriate rock excavation methods. Based on the given soil types in the area, the excavated slopes for the detention ponds and channel should be 1V:4H. The channel side slopes will be covered with turf reinforcement mats, except where vertical walls or concrete paved slopes are to be constructed. Some riprap stone protection for erosion protection may be needed in bends or at transitions. In areas of the detention ponds where rock has been exposed, the rock will need to be over excavated to a minimum depth of 12 inches below planned grade and replaced with compacted impervious material. The following table (Table 2: Boring Depths to Bedrock) presents depths to bedrock based on the exploration information on the boring logs.

Table 2: Boring Depths to Bedrock

Boring	Depth to Bedrock (ft)
GSP-2, JC-14, JC-18, JC-23	Bedrock not encountered. Drilling terminated at 20
WBP-3	Bedrock not encountered. Drilling terminated at 18
JC-9	18
JC-8	17
JC-20	16.3
BESP-1	15.5
CNP-4	Bedrock not encountered. Drilling terminated at 15
JC-2	15
JC-3, JC-19	14.3
CNP-1	14
JC-7	13.5
CNP-3, JC-11	13
JC-1	12.8
JC-12, JC-15	12.5
JC-6	11.5
JC-4	10.5
JC-24	10.3
BESP-3, BUSP-1, BUSP-2, CBSP-1, CBSP-2, CNP-2, CSP-3, FREP-2, FSP-1, FSP-2, FSP-3, FSP-4, FSP-5, GSB-1, GSB-2, GSB-3, GSP-3, GSP-4, HCP-1, HCP-2, NAP-1, NAP-2, PEP-1, PEP-2, PWP-1, PWP-2, SEP-1, WBP-1, WBP-2, NEW-1	Bedrock not encountered. Drilling terminated at 10
GSP-1, BSP-1,JC-13	10
CSP-1, NEW-2	Bedrock not encountered. Drilling terminated at 8.5
JC-16	7.5
SEP-3	7
WSP-3	6
FREP-1, SEP-2	5.5

4.7 Design Parameters –

The table below (Table 3: Soil Parameters) presents preliminary design values used in the design of the box culvert foundations and retaining walls. The values presented are generalized and additional studies are necessary to confirm the subsurface conditions. The allowable bearing capacity presented includes a factor of safety of 3 and skin friction capacity values include a factor of safety of 2. The following table assumes a groundwater depth of 5 feet.

Table 3: Soil Parameters

DESCRIPTION	SOIL PARAMETERS
	IMPERVIOUS SOILS
Angle of Internal Friction (φ)	$\varphi=0^o$
Moist Unit Weight (γ_m)	105 pcf
Saturated Unit Weight (γ_s)	115 pcf
Cohesion (c)	400 psf
At-Rest Coefficient (K_o)	0.8
Bearing Capacity (Q_a)	1,200 psf

If bridges are replaced or modified, the design of those bridges should be based on current Missouri Department of Transportation or Union Pacific Railway design practices. Deep foundations could be considered to support the bridges. Deep foundation alternatives types could include, but are not limited to drilled piers, driven piles and auger-cast-in-place piles.

Based on a preliminary review of the subsurface conditions, it appears that the most cost effective deep foundation alternative would be drilled piers. The soft native overburden soils and the existing fill that was generally encountered in the borings would not significantly contribute to supporting the structures through skin friction.

The table below (Table 4: Design Values for Drilled Piers) provides preliminary design values for drilled piers. The below values are generalized and additional studies are necessary to confirm the subsurface conditions. The below allowable bearing capacity includes a factor of safety of 3, skin friction capacity values include a factor of safety of 2 and assumes groundwater at a depth of 5 feet below ground surface.

Table 4: Design Values for Drilled Piers

Depth (ft)	Soil/Rock Type and Effective Unit Weight (pcf)	Allowable End Bearing Capacity (psf)	Allowable Skin Friction (psf)	Cohesion (psf)	Allowable Passive Pressure (psf)	Internal Angle of Friction (Degrees)
0 - 5	Fill – 110	N/A	N/A	250	250	0
5 – 18	Lean and Fat Clay - 60	N/A	200	500	500	0
18	Limestone – 85	10,000	1,000	0	6,000	42

4.8 Potential disposal sites.

No potential disposal areas have been identified at this time. The sponsor indicated that they are always able to find close disposal sites when doing similar projects. During the design phase disposal sites will be located and included in the plans and specifications, or made the responsibility of the contractor subject to government approval of the disposal site.

5 Environmental Engineering

5.1 Use of environmentally renewable materials.

There is little opportunity to incorporate renewable materials in this project. The majority of the work will consist of excavation for the channel and detention ponds. One of the major construction materials will be concrete which will be used for bridges, bridge shoring, channel walls, culverts, and outlet structures for detention ponds. Concrete while not considered to be renewable, could be composed of recycled concrete.

5.2 Design of positive environmental attributes into the project.

The channel side slopes will be mostly vegetated utilizing a grass and wildflower seed mix. The addition of detention basins will add more opportunity for infiltration, sedimentation, and filtration. A low flow channel will be considered during the final design, in an attempt to aid habitat improvement and channel maintenance/sediment removal.

5.3 Inclusion of environmentally beneficial operations and management for the project.

The intent is to promote a more natural channel using a wildflower and grass seed mix. This will reduce the amount of mowing as is typical on a conventional grass swale. This approach should reduce emissions from mowing equipment and the use of oil and gas.

5.4 Beneficial uses of spoil or other project refuse during construction and operation.

It is anticipated that a majority of the spoil material will be reused as fill material on other projects within and around the city. If necessary the material will be deposited in disposal areas not yet identified. The plan for disposal of spoil material will avoid and minimize adverse impact to the maximum extent practicable.

5.5 Energy savings features of the design.

Due to the scope and nature of this flood risk management project, there are no feasibly obtainable energy saving features available.

5.6 Maintenance of the ecological continuity in the project with the surrounding area and within the region.

The landscape of the project site will be altered by the excavation for the channel and detention ponds. However, the long term change in ecology of the area will be minimized as the areas will be returned to a vegetated condition to promote the habitat and minimize erosion.

5.7 Consideration of indirect environmental costs and benefits.

There are no significant indirect impacts anticipated.

5.8 Integration of environmental sensitivity into all aspects of the project.

Environmental sensitivity will be incorporated into the design and construction of the project to the maximum extent practicable.

5.9 Consideration of environmental problems on similar projects with respect to the Environmental Review Guide for Operations (ERGO).

The perusal of the Environmental Review Guide for Operations (ERGO) with respect to environmental problems that have become evident at similar existing projects and, through foresight during this design stage, have been mitigated/addressed in the project design. There are minimal environmental impacts, requiring no mitigation, from the proposed project. The construction of the project will not proceed until the Sponsor has provided a clean corridor free of any HTRW contamination.

5.10 Incorporation of environmental compliance measures into the project design.

A Storm-Water Pollution Prevention Plan (SWPPP) will be prepared by the construction contractor and implemented for the project. The Sponsor will be required by the partnering agreement to provide land free and clear of HTRW contamination. Acquisition of required state and Federal permits will be completed prior to any construction activity.

6 Civil Design

6.1 Site selection and project development

In order to find a solution for flood risk management, various channel alignments and detention basins were evaluated to determine the available alternatives. The Project Delivery Team (PDT) conducted site visits, considered existing improvements via aerial photography, and prepared preliminary cost comparisons in order to help facilitate selection of the most feasible channel alignment.

The Federal interest limit of the proposed channel includes approximately 1.8 miles on Wilsons Creek, 3.2 miles on Lower Jordan Creek, 2.2 miles on North Branch of Jordan, and 2.1 miles on South Branch of Jordan Creek (see Figure 1.1 of the main report for a map of the study area). Jordan Creek flows through the City of Springfield, Missouri into Wilsons Creek and eventually drains into the James River. The channel has varying depths and a portion of it is located along an old railroad easement. The proposed channel was designed to have a trapezoidal cross-section with a benched maintenance trail approximately 2’ higher than the flow line elevation, and gentle side slopes (typically 4H:1V) covered with turf reinforcement mats and hydro seeding. Reach E1 did not include the benched maintenance trail. Toe stones were included in areas where work occurs to stabilize the low flow portion of the channel. The channel was laid out in a manner that was hydraulically functional while minimizing the need to remove or relocate existing homes, businesses and other structures. Where it was not feasible to construct a trapezoidal channel due to real estate limitations, vertical concrete walls were incorporated.

6.2 Project Alternatives

As stated in the main report, the study area was divided into six economic reaches (E1-E6). During the formulation process, the team looked at different types of plans for the study area. The first structural measure to be considered was regional detention basins.

6.2.1 Detention Basins

The City of Springfield, serving as the H&H team member, initially looked at 24 different sites for potential regional detention ponds. These were narrowed down to 5 sites through analysis performed within the HEC-1 model. For a thorough explanation of the detention basin selection; see the H&H Report (Attachment A to this appendix). The five selected basins were: Basin B6, Basin B7, Basin B9B, Basin B11, and Basin B11C.

Basin B6

This proposed basin is located just upstream of Chestnut Expressway along the South Branch of Jordan Creek (see Plate C-3). The stream valley would be excavated to a depth of approximately 9 feet and expanded to the northeast. There are at least three property owners who would be impacted by this project and the City would need to acquire the land or obtain an easement from each. A detailed outlet structure was not designed for this basin. Instead, the rating curve was adjusted to optimize the storage capacity. For estimation purposes, a cast in place concrete outlet structure consisting of a 20’ wide sharp crested weir at elevation 1309’ was assumed with the downstream box controlling flows during large events. The weir would have end contractions with a small slot in the bottom for very low flows.

Basin B7

Located in Glenwood Park (see Plate C-4), this existing regional basin would be expanded to control peak flows and reduce flooding along Rockhurst Street. The existing basin would be excavated an additional 5-feet and the park area would be excavated an additional 2-feet. The lower portion of the basin would overtop into the park area at about the 5 to 10-yr event. The cast in place concrete outlet structure would consist of two 42-inch diameter openings that would tie into twin 42” diameter RCPs with a flow line at elevation 1331’ that would travel along Rockhurst Street and discharge downstream of Patterson Avenue. The outlet structure would also include a 5-foot wide, 6’ tall high flow weir above the 42” diameter outlets that would discharge into the existing ditch system along Rockhurst.

Basin B9B

This proposed basin is located north of Pythian Street and just west of Cedarbrook Avenue (see Plate C-5) and will be part of a two basin system when combined with an existing basin (B9C). The existing valley would be excavated to a depth of 8-feet and a berm constructed on the downstream end. The cast in place concrete control structure would consist of two 36-inch diameter openings connecting to 36” diameter RCPs and a 20’ overflow weir at elevation 1351’ that would discharge into basin B9C. This basin encroaches on parts of 4 different privately owned properties and land acquisitions or storm-water easements would be necessary. This basin will be located next to a small privately owned, public-use airport. This pond is designed to drain quickly, therefore not exceeding the maximum 48-hour detention period specified in FAA Advisory Circular 150/5200-33B. The necessary measures will be incorporated during design to prevent access of hazardous wildlife to open water and minimize aircraft-wildlife interactions.

Basin B11
An existing regional detention basin is currently located upstream of Glenstone Avenue (see Plate C-6). The proposed basin would expand the existing basin to the east. Additional land acquisition and/or storm-water easements wound need to be pursued from adjacent property owners. The cast in place concrete outlet structure for this basin would consist of a 15-foot sharp crested weir at elevation 1325’ just above the flow line. This weir would have two contractions and would look like a large “H” structure with the weir submerged by about 7’ during the 100-yr event. There is an existing weir in place that would likely be modified to meet the proposed storage requirements.

Basin B11C
This proposed basin is located south of Blaine Street at Link Avenue (see Plate C-6) and is currently a vacant wooded area. This area would be excavated and a control structure added. This basin attempts to minimize the impact to vegetation by only including excavation on the south side of the stream. This area would be excavated to the depth of the existing channel and a control structure would be added downstream. This would leave the north portion of the lot available for development and should make land acquisition more palatable to the owner. Side slope of basin would be 6:1. Area could be planted with wetland vegetation to provide additional water quality benefits. The cast in place concrete outlet structure was assumed to be an 18-ft wide, sharp crested weir at elevation 1333’ with two end contractions.

6.2.2 Channelization
Channelization was the next structural measure that the team analyzed. Consideration was given to existing bridges, buildings, utilities, roads and railroads that would be impacted by the selected plan. Due to these constraints, there was only one feasible route available for the proposed channel alignment. The other routes considered but not included as alternates presented obstacles such as excavating through a landfill, removing high value buildings, and/or relocating long sections of railroad. The alternates that the PDT chose consisted of channels with varying levels of protection along the same channel alignment.

Plan A
Plan A consisted of the five regional detention basins on the North and South Branches. Also, the channels, Reaches (E1-E6) were designed to provide property protection against the 1/100 ACE storm. Optimization of Plan A through HEC-FDA analysis and preliminary cost estimates resulted in a more economically efficient Plan B.

Plan B

Plan B was also designed to provide building protection to about the 1/100 ACE through channelization and the same 5 detention basins. Plan B had components that were eliminated as they were not cost effective. The major variances from Plan A include:

- In Reach E2, Sta: 36+56 to 43+14, planned improvements to Grand Street Bridge and channelization work were omitted.
- In Reach E3, Sta: 149+41 to 170+00, a planned box culvert under Phelps Street from Jefferson Street to Washington St is exchanged for an open channel to the south of Phelps Street. This would require RR line relocation or commercial buyouts.
- In Reach E5, Sta: 75+00 to 81+45, all planned bridge replacements and associated channel work in the Smith Park area of the North Branch were omitted.
- In Reach E6, all planned work to the east of Fremont Street on the South Branch was omitted. This included two RR bridges at Sta: 76+80 and Sta: 77+18, and a RR culvert at Sta: 91+41.

Plan C

Plan C utilized essentially the same structural measures as Plan B, however it was designed to offer protection against the 1/50 ACE storm. Other than channel geometry revisions to reduce the channel size, the variances between Plan C and Plan B include:

- In Reach E2, all proposed channel work between Sta: 73+13 to 81+28 and from 91+76 to 98+36 was omitted. Also the planned RR bridge just upstream of College St. was omitted.
- In Reach E4, the planned bridge reconstruction for the Central Street crossing was omitted.

Plan D

Plan D utilized essentially the same structural measures as Plan B; however it was designed to offer protection against the 1/500 ACE storm. Other than channel geometry revisions to increase the channel size, the only variance between Plan D and Plan B was an extension of the channel work at the downstream end of Reach E1. This work added channelization underneath Scenic Bridge requiring foundation modification.

Plan E

Plan E also utilized the essentially the same structural measures as Plan B, however it was designed to offer protection against the 1/25 ACE storm. Other than channel geometry revisions to reduce the channel size, the variances between Plan E and Plan B included:

- In Reach E1, all planned channel work upstream of Sta: 2+14 on Jordan creek is omitted.
- In Reach E2, all planned channel work from Sta: 72+55 to 81+28 and from 91+76 to 98+36 is omitted. This plan also omits the planned RR bridge just upstream of College St.
- In Reach E3, all planned channel work downstream of Sta: 128+00 is omitted.
- In Reach E4, all planned channel work upstream of Sta: 18+36 is omitted including the bridge for Central Street.
- In Reach E6, all planned channel work upstream of Sta: 45+09 is omitted including the culvert for Freemont Street.

The PDT, attempting to optimize the performance of the plans, performed a reach by reach analysis with the varying levels of protection to form additional plans. Plan F and Plan G were created by combining the reaches from Plans B-E to optimize for both performance and for efficiency.

Plan F

Plan F offers protection against property damage for a 1/500 ACE in Reach E1 (from Plan D) and a 1/100 ACE (from Plan B) in Reaches E3 and E6. This plan also contains the five regional detention basins on the North and South Branches. There were no structural improvements considered for Reaches E2 and E4 for this plan.

Plan G

Plan G provided protection against property damage for a 1/500 ACE in Reach E1 (from Plan D) and a 1/25 ACE (from Plan E) in Reaches E3 and E6. This plan also contains the five detention basins on the North and South Branches. There were no structural improvements considered for Reaches E2 and E4 for this plan.

The PDT then attempted to optimize Plan G. Plans G2- J are variations of Plan G. This analysis was also used to gain a better understanding of how the different components in Plan G performed.

Plan G2

Plan G2 provided protection against property damage for a 1/500 ACE in Reach E1 (from Plan D) and a 1/25 ACE (from Plan E) in Reaches E3 and E6. This plan also contained the five detention basins on the North and South Branches. There were no structural improvements considered for Reaches E2 and E4 for this plan. Unlike Plan G, this plan did not contain the proposed Main Street or Booneville Street Bridges.

Plan H

Plan H is essentially Plan G, but the culvert along Phelps Street was omitted.

Plan I

Plan I is a copy of Plan G, however the detention basins were omitted.

Plan J

Plan J contains only an excavated channel on Reach E1 providing the 1/500 ACE protection (from Plan D) and the 5 regional detention basins on the North and South Branches. This plan was determined to be the National Economic Development (NED) plan and was chosen as the selected plan. Plan J is presented on plates C1-C-7.

On Wilsons Creek, approximately 2,100 feet of channel widening will occur. The widening will start at Sta: 310+00, approximately 100 feet west of the Scenic bridge and end at the confluence of Wilsons Creek and Jordan Creek. Bridge modification to Scenic Bridge is likely required as a result of channel excavation beneath the bridge. The modification was assumed to be shoring up of the piers of the bridge by installing new piers and a mat foundation. The railroad bridge over Wilsons Creek at the southeast corner of the ball fields is a construction and is therefore replaced, see Table 5: Railroad Bridge Data, for more information.

Table 5: Railroad Bridge Data

RR X-ing	Bridge/Culvert	RR Company	Channel Reach	Station
Wilsons Creek Bridge	Bridge	Missouri and Northern Arkansas Railroad (MNA RR)	E1	322+90

Based on discussions with MNA RR, the construction of the crossing can be executed such that the work can occur within an acceptable outage window. This will prevent the need to build a shoofly to maintain RR traffic during construction. A shoofly is a temporary stretch of track that takes trains around construction.

One of MNA RR's proposed solutions for the Wilsons Creek Bridge is to utilize a "Saddlecap" method. This would involve the end bents being designed to where all shaft (pier or abutment columns) installations were constructed on each side of the existing bridge deck. Then a concrete cap would be formed and constructed under the existing bridge between the bents to complete the substructure (all while rail traffic is active on the existing track and structure). After this phase is finished, the superstructure spans would be assembled onsite (in an off-line area) and prepared for being erected during a track outage window. Once a span is set and rails reconnected, traffic is resumed until time to erect the next span (if additional spans are required). Thus any disruption to the rail traffic is minimized due to most work being performed off-line and with short outages during the switchover. MNA RR has stated that a 3 day outage window could be accommodated, which would allow this type of construction method to be a feasible option.

A formal agreement with all involved RR entities will be established upon project approval.

On Jordan Creek, widening will occur from its confluence with Wilsons Creek upstream to Sta. 11+17 on Jordan Creek which is about 350 feet North of the Bennett Street bridge. Two pedestrian walkways crossing over the channel will be removed by the Sponsor and the channel is widened from approximately 45' to 100'. No modifications will be made to the bridge on Bennett Street crossing over the channel. The street leading to the bridge from the West side acts as a flood diversion structure which provides some protection for the Archimica plant on the North side. However, the street has a sag in it which allows water to flow over it starting at the 1/10 ACE flood event. The flood water after overtopping the street is then on the protected side of the Archimica plant facility's floodwall. A flood diversion structure is planned and has been estimated at Bennett Street to prevent water from overtopping the street. The planned barrier consists of raising the road surface in the feasibility study; however, there are various options that are possible solutions to provide a flood diversion structure at this location. This approach is considered an effective higher cost option. Other options such as building a levee or flood wall shall be analyzed further during PED. The actual design will depend upon factors such as cost, constructability, and minimization of disruptions to vehicular traffic and the operations of the Archimica plant.

The Archimica plant sits on the confluence of Fassnight and Jordan Creeks protected by a floodwall on the East and South sides. A structural analysis was completed on the floodwall, and it was determined to be structurally sound. No work is planned for the floodwall. Should the floodwall need to be raised at some point in the future substantial excavation and rebuilding would be required.

The proposed construction will affect several existing streets thereby creating the need for culverts, bridges, and bridge modifications. Traffic at each bridge or culvert location will be rerouted until it is deemed safe and appropriate to use the newly constructed crossing. For a list of road and railroad structure types, dimensions and locations see Plate S-1.

6.3 Quantity Computations

The channel quantities were computed by the Average End Area Method. Cross sections depicting existing geometry channel compared with the proposed geometry were exported out of HEC-RAS into CAD software. Cut and fill areas were measured in CAD and transferred into a spreadsheet which totaled the quantities for each alternative by economic reach. Based upon the soil borings, we estimated that 5percent of the cut quantities will be rock, which will affect the amount of effort, type of machinery, and cost to remove the material.

The site quantities (vegetation, stabilization, tree clearing, demolition, roads, railroads, walls, etc.) were determined by extracting and estimating quantities from HEC-RAS cross sections and from aerial photography. The aerial photography data utilized was accessed through Google Earth and from imagery received from the sponsor which was incorporated into ArcMap with the proposed improvements.

Utility quantities were calculated by inserting GIS data received from Springfield City Utilities into ArcMap to identify potential utility conflicts. Aerial imagery was also utilized to identify utility conflicts. Quantities for utility relocation were estimated for areas where conflicts were suspected.

6.4 Assumptions For All Plans Considered

There are two pedestrian walkways bridging across the creek located in Reach E1- located on the east side of the Archimica Plant. These walkways will need to be removed for construction in the channel. The sponsor stated that they will coordinate and be responsible for removal of the bridges and replacement, if needed.

The RR contacts have indicated that bridges can be replaced without having to build shooflys. Therefore no quantities have been included for constructing an alternate/temporary bypass for the RR.

We assumed utilities crossing the channel where channelization was occurring would require lowering or relocation, unless the channel was not being lowered at that location.

In general, a proposed right of way width of 20' beyond the top bank of the proposed channel was assumed. Staging/lay down areas were selected to be in close proximity to the reaches.

6.5 Real Estate

This project will require the acquisition of real estate in order to construct the detention basins and the right of way to construct the flood reduction channel. In general, the required right of way for the channel was determined by utilizing the proposed channel top-of-bank to top-of-bank dimension plus 20' feet on each side for construction, access, and maintenance. The right of way was increased in areas where street and railroad reconstruction is required. Also, real estate acquisition will be required for staging/lay down areas.

6.6 Relocations.

Utilities located in the vicinity of the project were identified by using GIS files provided by Springfield City Utilities. For the selected plan sanitary sewer, potable water, gas, electric and telephone lines will have to be removed and relocated in order to construct the channel and detention basins. In general, quantities reflect a like for like replacement, meaning that the same size and type of material would be utilized in the relocation of a utility to accommodate the proposed channel work. The Corps of Engineers was required to sign a confidentiality agreement to obtain the fore mentioned utility information. For this reason, utilities will not be depicted in the plates of this appendix.

There are no planned railroad relocations in the selected plan. Regarding road relocations, Rockhurst Street will be excavated to install the twin 42" RCP culverts coming out of detention basin B7 and the sanitary sewer will be relocated under the street to accommodate the culverts. After that work is completed, the road will be replaced. Also, a portion of Bennett Street will be relocated, vertically, if that is the chosen solution to providing a flood diversion to prevent water from overtopping Bennett Street.

6.7 Risk for Cost Overruns in Civil Design

6.7.1 Utilities

Utilities are always a challenge when constructing a project of this type. It is difficult to determine where underground utilities are located. Record files have been utilized in the design of this project, but it is quite common for utility lines to be present when not indicated on the drawings. This is especially true regarding abandoned utility lines. The depth of the utilities is also hard to predict, hence knowing whether or not a utility crossing the channel needs to be relocated is challenging. It is reasonable to believe that there are more utilities in the ground than what we have record of.

6.7.2 Unknown Site Conditions

Unknown site conditions are always a potential risk on a project. This project area contains many locations where HTRW is being cleaned up. There is a possibility that more HTRW could be discovered during construction. Also, there are a couple of identified cultural resource sites that were within the project area of some of the alternatives. Any new sites found could affect cost and schedule. Other possible unknown site conditions include utilities, rock formations, and artificial subsurface obstructions.

6.8 Design Criteria and Standards.
The following documents and standards, as a minimum, will be incorporated in the design of this flood risk management project.

- "Design Standards for Public Improvements" City of Springfield, Missouri
- "Manual on Uniform Traffic Control Devices (MUTCD)", Federal Highway Administration
- "Americans with Disabilities Act and the Architectural Barriers Act Guidelines" (ADAAG)
- "International Building Code"
- Architectural and Engineering Instruction Manual (AEIM), Southwestern Division
- Unified Facilities Criteria (UFC)
- ASTM International Standards
- SpecsIntact will be utilized to develop the project specifications

7 Structural Requirements

7.1 General -
This section provides the criteria, design planning and analysis for which the design decisions were made and the structural requirements that are presented and assumed in the cost estimate.

7.2 Design Criteria –
The current edition of the following documents will be used in the structural design of this flood control project.

- AASHTO LRFD Bridge Design Specifications; Design Load shall be based on the HL-93 Design Loading
- Missouri Standard Specifications for Highway Construction
- Manual For Railway Engineering (AREMA)
- American Concrete Institute Standards (ACI 318)
- American Institute of Steel Construction (AISC – Manual of Steel Construction

7.3 Structural Systems

Railroad Bridge

There is an existing railroad bridge crossing over Wilsons Creek in Reach E1. This bridge is planned as a 90' long bridge to replace the existing 54' long bridge. The cost estimate included additional length beyond 90' to account for necessary excavation required to construct the 90' long structure. For this railroad bridge, a precast concrete box beam system was assumed based on Union Pacific Railroad 3 span Precast Channel Bridge (PCB) 90' length. Plate S-1 provides an example of the type of bridge system that would be designed for this project. During the initial stages of the design, Union Pacific (UP) Railroad was contacted for guidance and coordination. During the discussions UP recommended that we use their replacement bridge design for several reasons. First of all, it is readily available. Next, the design system is already approved. And, bridges can be replaced with a minimum amount of design time. Based on the geotechnical information, rock formations are sporadic and it is not possible to predict whether or not rock will be encountered during construction. The geotechnical engineer recommended assuming drilled pier foundations for most, if not all, of the structures. Therefore, the railroad design will have to be modified to have the steel HP piles embedded in concrete to achieve the required design capacity of the railroad and hydraulic loading.

Foundation System

The geotechnical information indicated that the in situ clays were underlain by cemented limestone bedrock. The top of rock varies through the site from 5.5 feet below the ground surface to greater than 20 feet. The top of rock found in most of the soil borings was around 10 to 15 feet below the ground surface. Based on conversations with the local engineers, the possibility for rock pinnacles is very high. A drilled pier foundation system was recommended for these structures. The quantities are based on 20 feet deep drilled piers. This is conservative based on the current information. However, the current cost estimates are based on square foot estimates for these structures.

Foundation Modifications

There were about five structures in the study that would require foundation modifications based on the hydraulic requirements and the existing structural conditions. Little or no information was known about many of the existing structural foundation systems. Therefore some piers/and mat foundation quantities were provided for estimating purposes. Sheet piling wall foundation modifications may be required when the existing structural foundation information is known or discovered. In the selected plan foundation modification will only be required on the Scenic Bridge in Reach E1. The plan and estimate included drilling 3 cast in place concrete piers 2 ft diameter around each of the columns on the 2 column open bridge bents. A pier cap was also included around the concrete piers. The purpose was to protect the existing foundation from scour. This was a reasonable design assumption to make at the feasibility level. Additional analysis will be conducted during PED to determine the appropriate design for this structure.

Retaining Wall at Archimica Plant

The floodwall along Archimica is a reinforced CMU block retaining wall that was constructed to protect against flood waters and to protect the stream bank or slope failure that would take away from the plant parking areas. The CMU block wall has been designed and constructed to elevation 1222.0. See Plate S-3 for the floodwall section. The wall appears to be structurally sound, based on preliminary calculations and a visual inspection. The largest risk seems to be from scour or undermining of the footing during an extreme event.

Vertical Concrete Walls in the Channel

In Reach E1, it was necessary to include vertical concrete walls to provide sufficient flow area within the available channel area which was restricted due to real estate limitations. These walls were designed and estimated as cast in place concrete walls. During design, differing wall options will be considered during further analysis to determine the most cost effective and suitable wall system once we have the soil conditions and final geometry of the channel.

7.4 Structural System Chart -

As the feasibility study continued, a chart was developed in order to track what changes were being made to each channel crossing structure in each of the subsequent plans. This chart was modified after an Agency Technical Review (ATR) comment recommended that this chart be used to communicate more fully the type of structure, bridge type, foundation type and number of spans if the structure was a bridge. This chart is located on Plate S-2.

7.5 Risk for Cost Overruns in the Structural Design

7.5.1 Railroad Bridge crossing

Coordination with the railroad bridges has some inherit unknowns based on who owns the line, who operates on the line, and the individual entities that are involved with the design approval and coordination. Every effort was made to coordinate with the railroads involved, in order to use a typical design system that would alleviate as many problems as possible.

7.5.2 Structural modifications to existing bridges

Very little information was known about the existing structures and what could be done to modify the existing structure to pass the water flow or channel volume required. When a channel and a plan has been chosen, additional work will be required to find the existing construction information and detailed site inspections will be required to provide a more detailed design for these modifications.

7.5.3 Foundation Design

Rock pinnacles and soft areas are always potential risks that are associated with any feasibility design.

8 Electrical and Mechanical Requirements

The feasibility study includes functional design requirements, technical design criteria and quantity takeoff for relocation of all electric and telecom utilities above ground and underground within the project boundary that will interfere with the new channel system. Also for future reference we have included the “Springfield City Utility POC Information.pdf” which lists names and phone numbers for electric and telecom utility points of contact. Quantities were obtained using the GIS data in ARCMAP provided by City Utilities of Springfield, MO, and Google Earth Pro along with photos it generates.

Technical design criteria for relocating the electric and telecom utilities and for providing under bridge lighting at bridge structures shall, at a minimum comply, with the requirements of the following criteria, latest edition.

- **NFPA 70: National Electrical Code** – this will apply to electrical work associated with the under bridge lighting. Examples would be conduit, conductors, controls and enclosures.
- **City of Springfield Electric Utilities Standards Book and ANSI C2: National Electrical Safety Codes –** these will apply to electrical work associated with electric and telecom utility poles, conductors, clearances, separation, trenches, and manholes.

9 Hazardous and Toxic Materials

Currently, the upper branches of Jordan Creek are located in mostly residential and light commercial areas. The lower branch, within the downtown area of Springfield, is more industrialized with heavy commercial activity. Industrial development of the downtown area began in the late 1800s with a number of businesses including print shops, materials yards, foundries, and the city owned manufactured gas plant. By the 1930s, the downtown area experienced an increase in oil and gasoline facilities along with auto repair and salvage businesses. By the 1970s, the downtown area was characterized as more light industrial with increasing residential and light commercial development along the upper branches. Two historic city landfills are located along the lower portion of the lower branch.

In 1999, the City of Springfield received a USEPA Brownfields Assessment Demonstration Pilot grant for a 0.8 square mile area surrounding Jordan Valley in the historic downtown area of Springfield. Since then, the City of Springfield has expanded its assessment area and conducted environmental assessments throughout the Jordan Creek corridor. Through the USEPA Brownfields Program, along with other state related programs, the City of Springfield has received over $3,000,000 from Federal and State partners towards assessment and cleanup of properties within the city. A large portion of these funds have been used in the assessment and cleanup of properties along the Jordan Creek corridor. Plate H-1 represents environmental assessments and screenings completed as of April 2012.

In April 2012, an environmental review was prepared by Seagull Environmental Technologies under contract with the City of Springfield. The environmental review evaluated all available information on 70 properties along the Jordan Creek corridor with potential HTRW impacts to channel and associated structure modifications. The review summarizes previous environmental investigations and recommends additional assessment activities where needed. The review also provides a range of cost estimates for remedial activities. For properties without completed assessments, environmental conditions for surrounding properties along with available historic documents were used to determine potential site conditions and remedial costs. See Plate H-2 for detailed estimates for each individual site. The environmental review identified 3 sites with documented or suspected HTRW contamination within the areas impacting Plan J. The low range cost estimate for the 3 sites combined was estimated at $67,500 and the high range estimated cost for these sites was estimated at $1,340,000. Plate H-3 provides the remediation cost estimate for Plan J. While Plate H-4 depicts the indentified contaminated areas at the Archimica Plant, this site is designed to be protected by the floodwall, therefore actual remedial cost is estimated to be from $32,500 up to $340,000.

The Missouri Department of Natural Resources is currently reviewing completed environmental assessments and other documentation for these same properties to determine if or where additional action is needed.

10 Construction Procedures and Water Control Plan

The construction of the culverts and bridges will be sequenced in order to minimize the impact on the local traffic patterns. Some streets will be required to be temporarily closed during construction, specifically Rockhurst Street. Where possible, the work will be installed in sections allowing traffic to be detoured around construction. Otherwise, sequencing the installation of the structures will be necessary to allow vehicular traffic to be rerouted around the local collector streets during construction.

Barriers will be installed near the edge of the excavated channel at locations where the channel intersects an existing road.

It is anticipated that the bridges, railroad crossings and the culverts will be constructed by using the adjacent in-place soil as a natural cofferdam. Groundwater and rainwater will have to be considered during construction of these features. A combination of ditches, well points, sumps or pumps will need to be used for removal of water from the excavations for satisfactory completion of the work.

Erosion control measures will also be put in place to minimize the erosion on the excavated slopes and all adjacent land that may have been stripped of vegetation.

11 Initial Reservoir Filling and Surveillance Plan - Not applicable

12 Flood Emergency Plans for Areas Downstream of Corps Dams – Not Applicable

13 Environmental Objective and Requirements

This information is provided in the main body of the report.

14 Reservoir Clearing - Not applicable

15 Operation and Maintenance

The sponsor will be responsible for annually traversing the entire length of the channel and looking at the condition of the channel bottom and side slopes and concrete structures. The sponsor will ensure that the earthen side slopes are mowed appropriately; and that undesirable weeds and woody growth will be removed by herbicides or cutting. The concrete structures will also need to be inspected annually for damage and deterioration and repaired immediately to prevent further damage to the structure. The sponsor will be responsible for repair to any damaged sections of the riprap as well as removal of plant growth within the riprap.

16 Access Roads

This project is located within the city of Springfield and in most cases it will be feasible to use the existing public city streets for transportation miscellaneous construction equipment and hauling of excavated material, debris and construction materials. A maintenance path was included in many sections of the trail for the initial alternatives, but the path was not a part of Reach E1. Since the selected plan only includes Reach E1, there will be no sections of the channel with a maintenance path. The project site will have construction easements along the top banks of the excavated channel. The easements will provide sufficient right of way for the sponsor to go back in the future and perform maintenance as required.

17 Corrosion Mitigation

Coatings and/or cathodic protection will be included in the design as required for materials which are installed in the soil.

18 Project Security

This project, consisting only of channelization and detention ponds, is not anticipated to require a security plan.

19 Cost Estimates

The baseline cost estimate for the selected plan (Plan J) representing the scope of work was developed using MCACES in the Civil Works Work Breakdown Structure format. The estimate reflected the recent material and petroleum products price increases to the month of December 2012. Quantities were calculated and provided by the Designers in the District. The cost estimate for each feature was escalated to the midpoint of construction using the most current indices for Civil Works Construction Cost Index System (CWCCIS) EM 1110-2-1304. Contingencies were developed using input from the PDT and the abbreviated cost risk spreadsheet provided by the Civil Works Center of Expertise for Cost Estimates they ranged about 23 percent (22.85 percent to 23.15 percent). For specific cost information refer to the MCACES cost estimate located in Attachment B. The Cost and Schedule Risk Analysis is located in Attachment C.

20 Schedule for Design and Construction

The schedule for the tentatively selected plan, Plan J, is located within Attachment B.

21 Special Studies – Not Applicable

22 Plates, Figures, and Drawings

Plates included in the engineering appendix include: the plan view of the selected channel, typical cross section of the channel, plan of borings and boring logs, HTRW assessments and cleanup costs, and structural system chart.

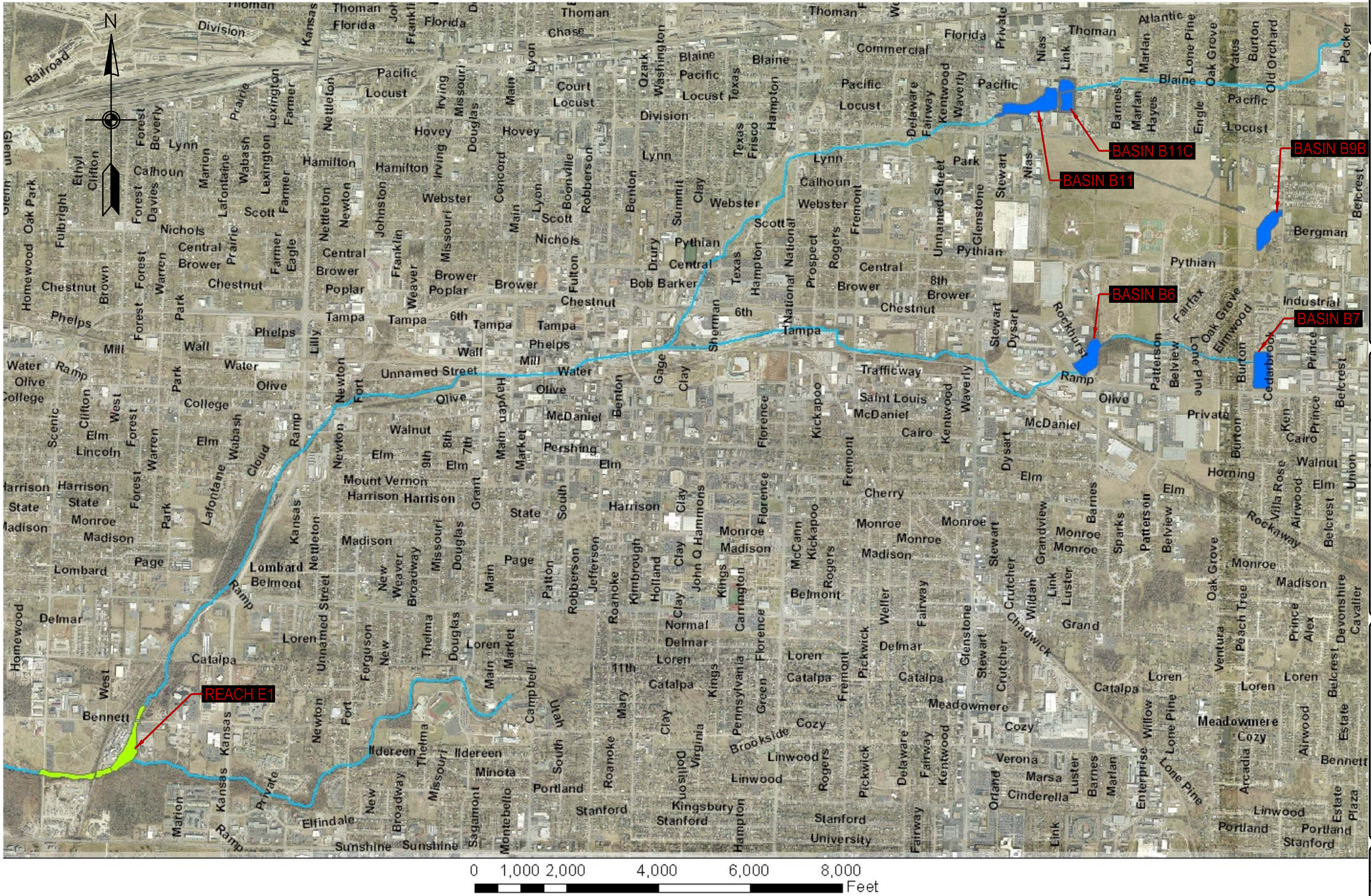
23 Data Management

During the feasibility study, electronic data was compiled and maintained in project folders for each discipline involved on the server. This data is backed up regularly by USACE's data manager (ACE-IT). The project information will be available for the next phase of the project.

24 Use of Metric System Measurements

The Sponsor specifically requested that the project be designed in English units. They have stated that the English system is consistent with their current standards, specifications and bidding practices. The City of Springfield uses data from their projects to compare trending of quantity costs; therefore, conflicting unit systems would complicate this process. With English units being the locally familiar system in this area, the material testing companies would likely be forced to work with unfamiliar units. The surveys used to produce the H&H models were all done in English units. Converting these survey drawings from English to Metric would have created additional work effort for the design team resulting in slips in the schedule and additional costs.

Engineering Plates



US Army Corps of Engineers
Little Rock District

Symbol	Description	Date	Appr.

Date: JANUARY 2013
Solicitation No.: N/A
Contract No.:

Designed by: NHB
Drawn by: NHB
Reviewed by: NPG

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

Submitted by:

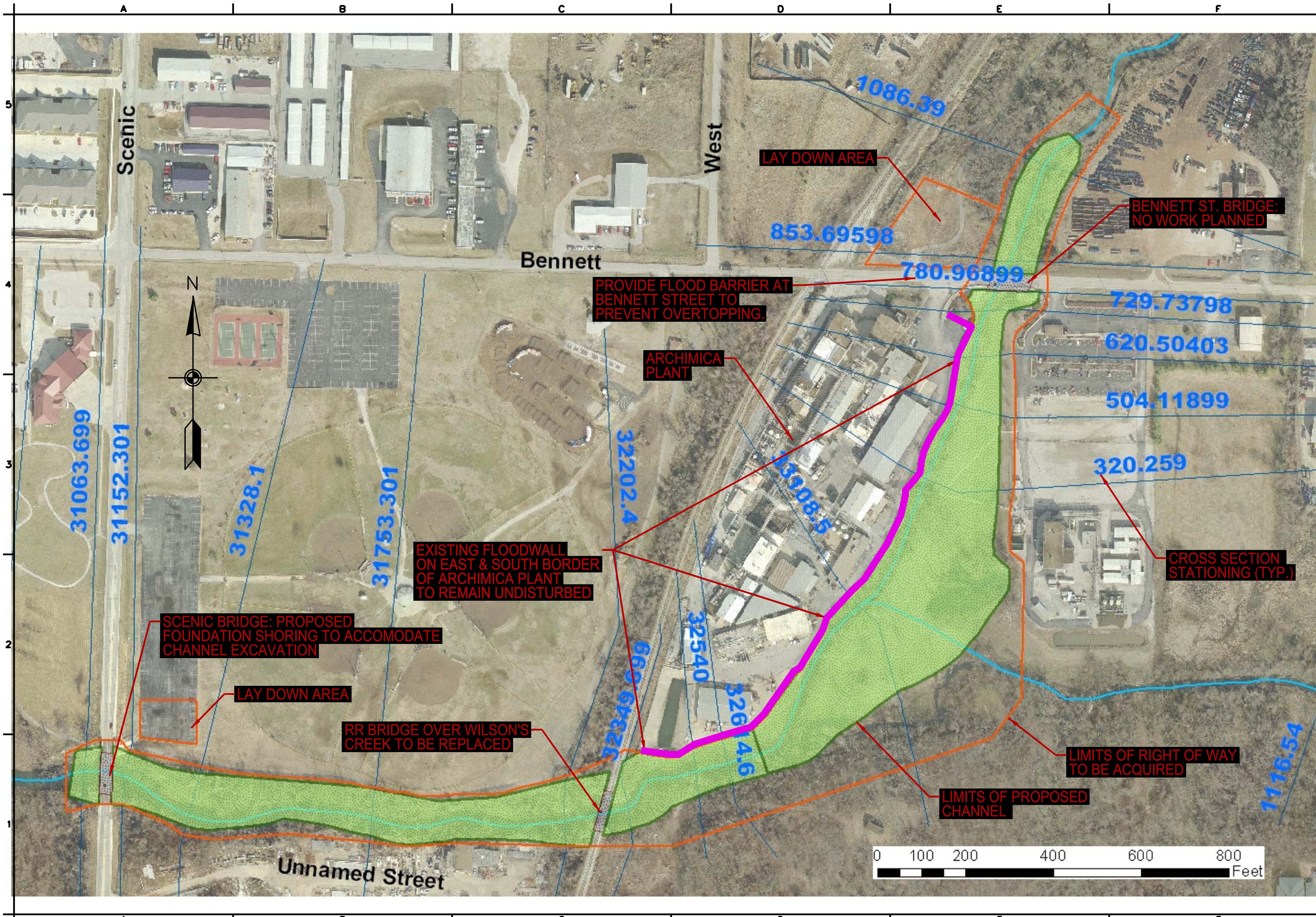
Chief, General Engineering Section

CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI
JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

PROJECT SITE MAP

Drawing Code/
Serial No.

Drawing Ref. No.
PLATE C-1



US Army Corps of Engineers
Little Rock District

Date: MARCH 2013
Solicitation No.: N/A
Contract No.:
Designed by: NHB
Drawn by: NHB
Reviewed by: NPG

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

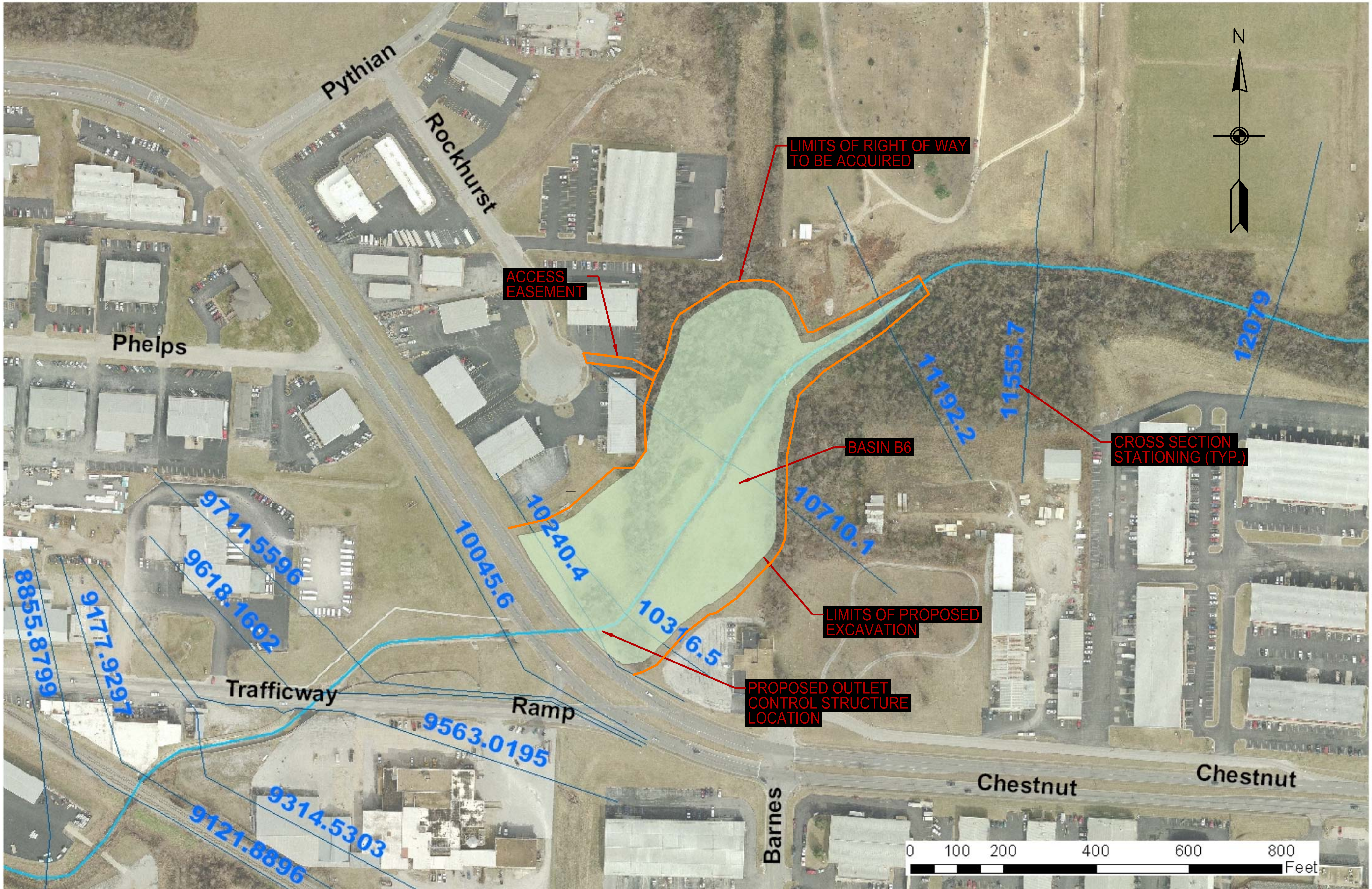
Submitted by:
Chief, General Engineering Section

CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI
JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

REACH E-1 PLAN

Drawing Code/ Serial No.

Drawing Ref. No.
PLATE C-2



US Army Corps of Engineers
Little Rock District

Symbol	Description	Date	Appr.

Designed by: NHB
Drawn by: NHB
Reviewed by: NPG
Date: MARCH 2013
Solicitation No.: N/A
Contract No.:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

Submitted by:
Chief, General Engineering Section

CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI
JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

BASIN 6 PLAN

Drawing Code/
Serial No.

Drawing Ref. No.
PLATE C-3

US Army Corps of Engineers
Little Rock District

Symbol | Description | Date | Appr.

Designed by: NHB
Drawn by: NHB
Reviewed by: NPG
Date: MARCH 2013
Solicitation No.: N/A
Contract No.:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

Submitted by:

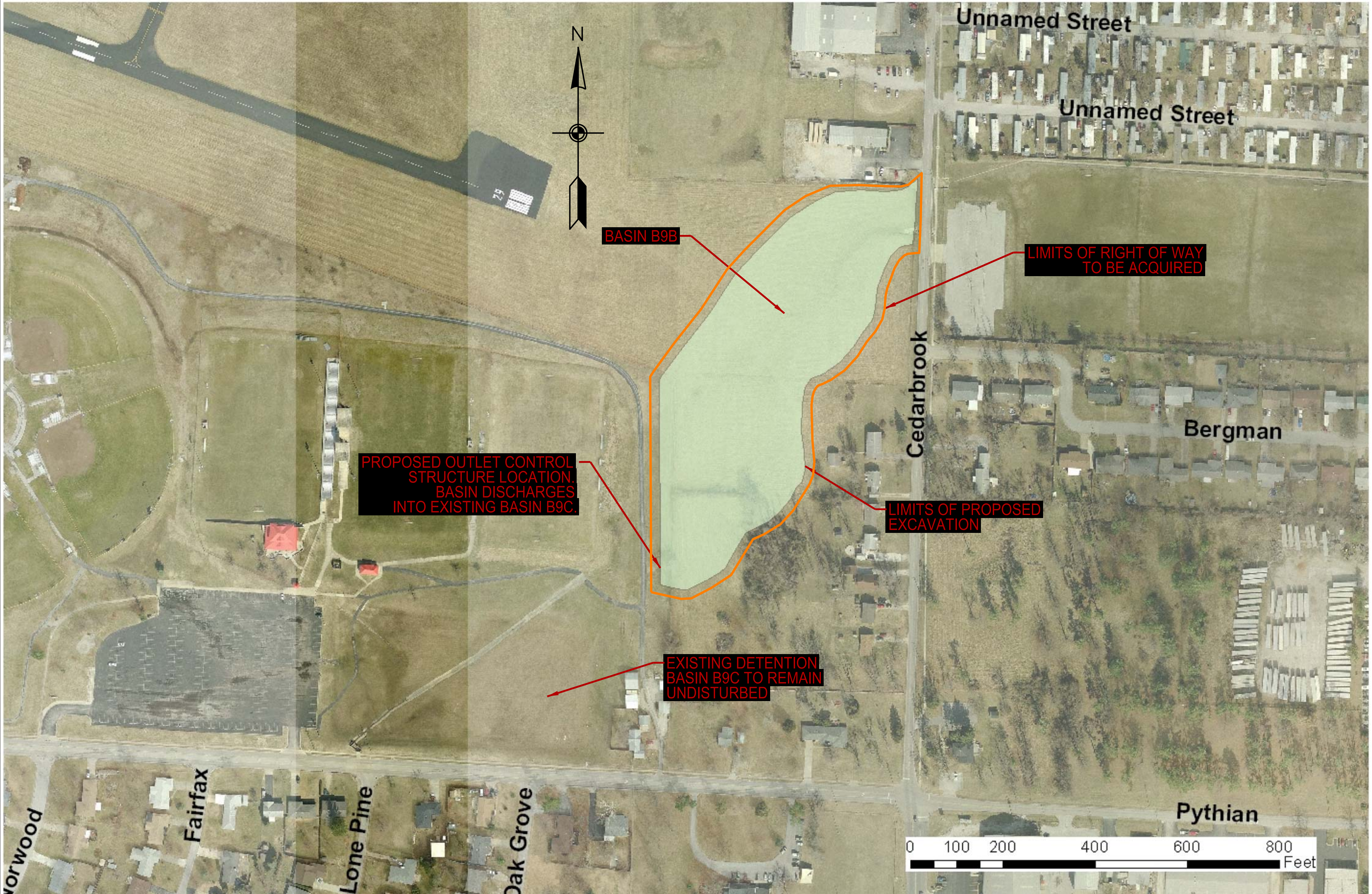
Chief, General Engineering Section

CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI
JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

BASIN 7 PLAN

Drawing Code/
Serial No.

Drawing Ref. No.
PLATE C-4



US Army Corps of Engineers
Little Rock District

Symbol	Description	Date	Appr.

Date: MARCH 2013	Solicitation No.: N/A	Contract No.:
Designed by: NHB	Drawn by: NHB	Reviewed by: NPG

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

Submitted by:

Chief, General Engineering Section

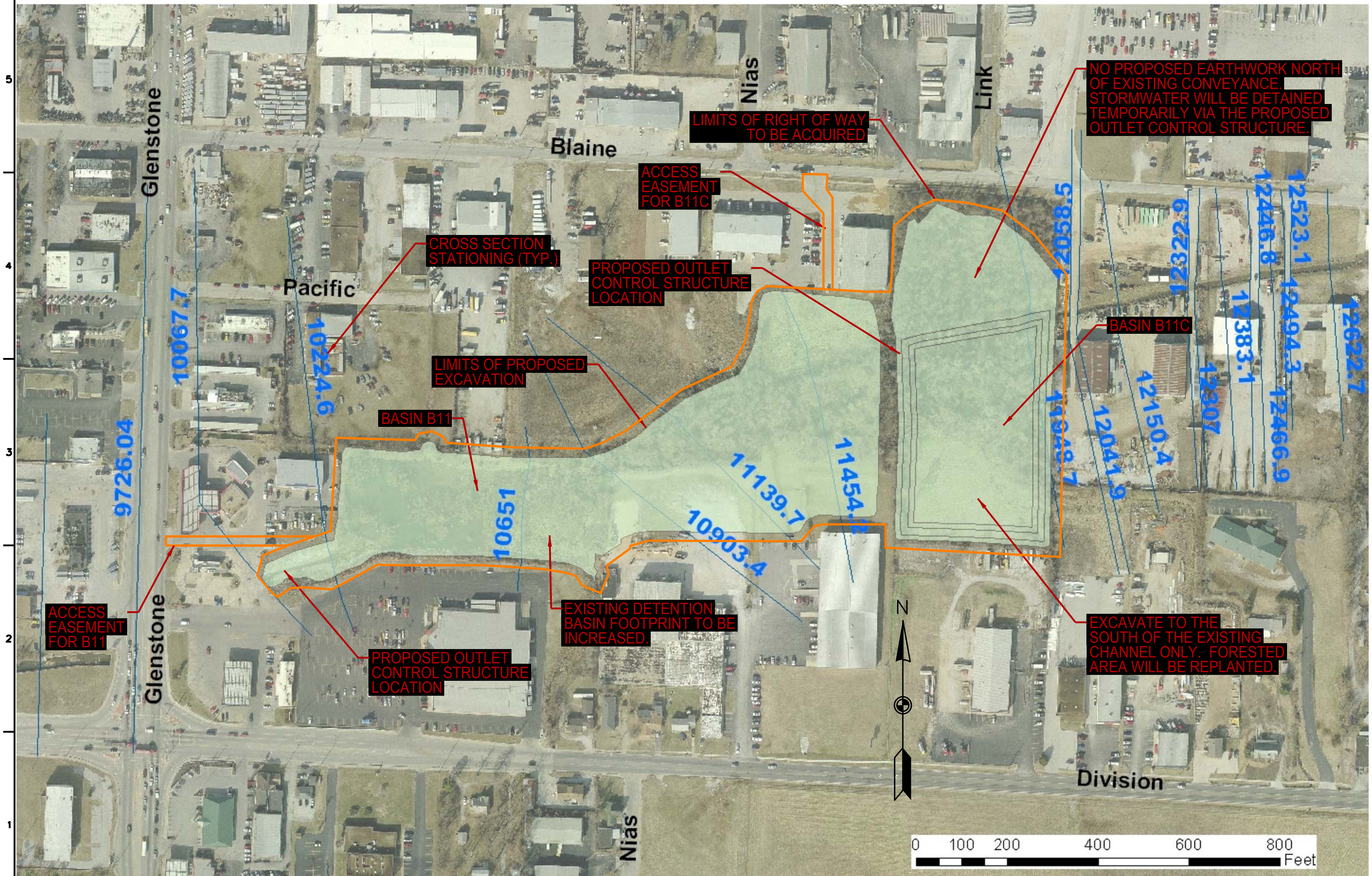
CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI
JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

BASIN 9B PLAN

Drawing Code/ Serial No.

Drawing Ref. No.

PLATE C-5



US Army Corps of Engineers
Little Rock District

Symbol	Description	Date	Appr.

Designed by: NHB
Drawn by: NHB
Reviewed by: NPG
Date: MARCH 2013
Solicitation No.: N/A
Contract No.:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

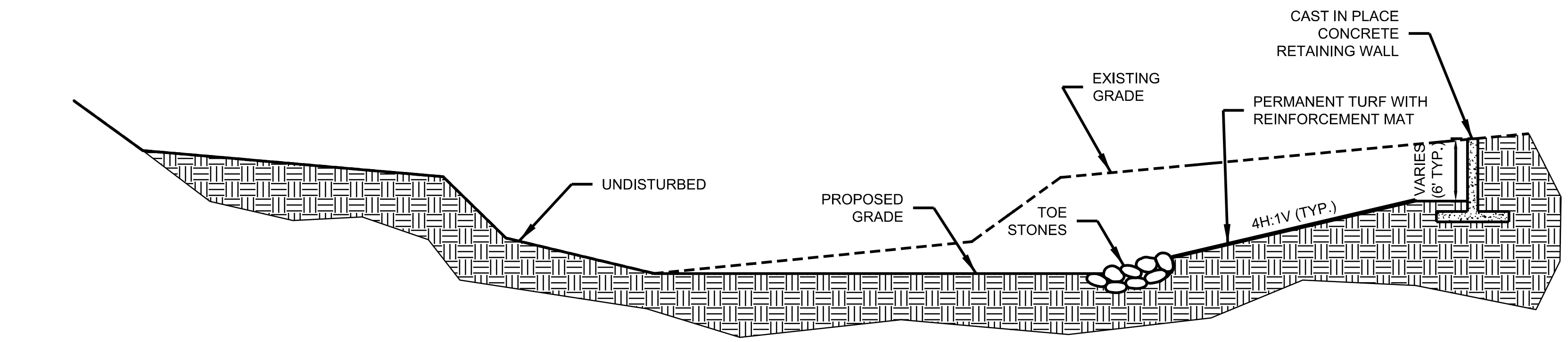
Submitted by:
Chief, General Engineering Section

CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI
JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

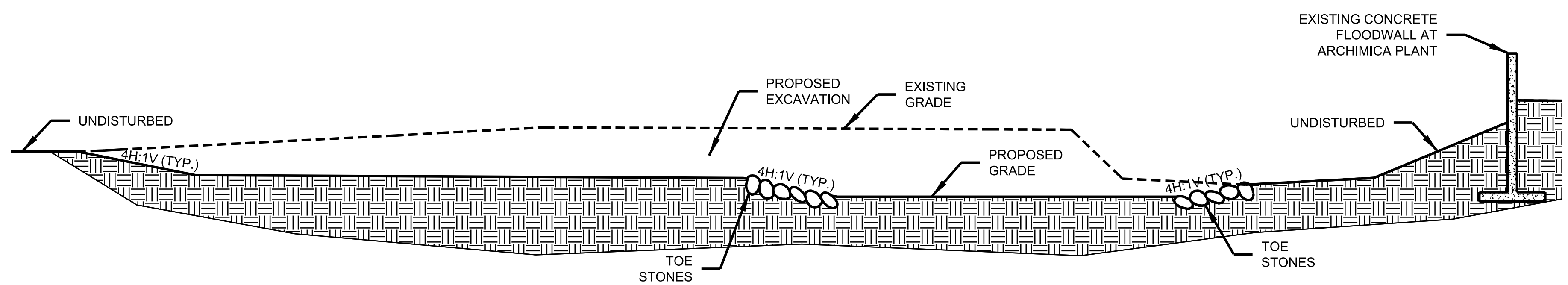
BASINS 11 & 11C PLAN

Drawing Code/ Serial No.

Drawing Ref. No.
PLATE C-6



TYPICAL SECTION
SCENIC TO WILSON RR
STA: 317+53



TYPICAL SECTION
WILSON RR TO BENNETT ST.
STA: 3+20

NOTE:
ACTUAL STRUCTURE CONFIGURATION WILL VARY FOR EACH OF THE DETENTION BASINS.

TYPICAL DETENTION BASIN
OUTLET CONTROL STRUCTURE

US Army Corps
of Engineers
Little Rock District

Symbol | Description | Date | Appr.

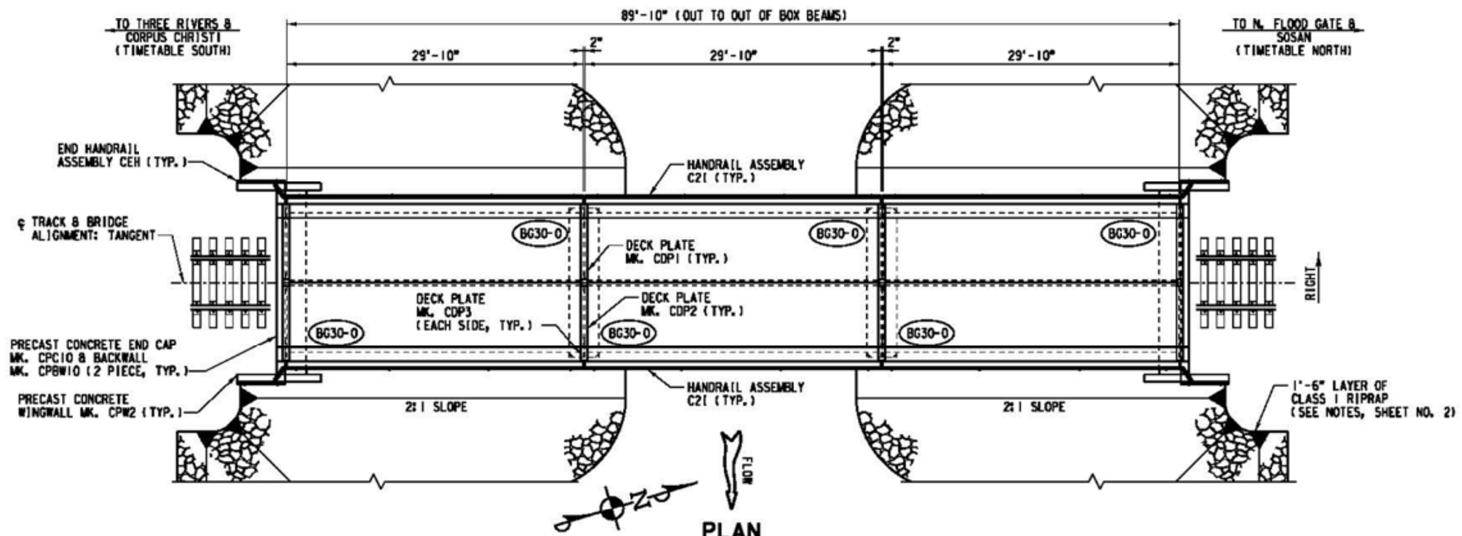
Date: MARCH 2013
Solicitation No.: N/A
Contract No.:
Designed by: NHB
Drawn by: NHB
Reviewed by: NPG

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS
Submitted by:
Chief, General Engineering Section

CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI
JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY
TYPICAL DETAILS

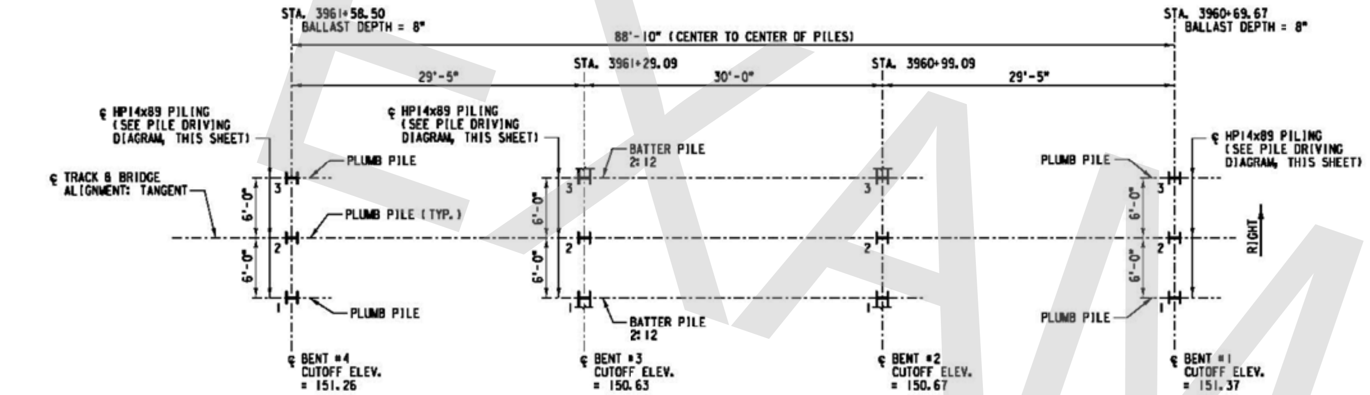
Drawing Code/
Serial No.

Drawing Ref. No.
PLATE C-7



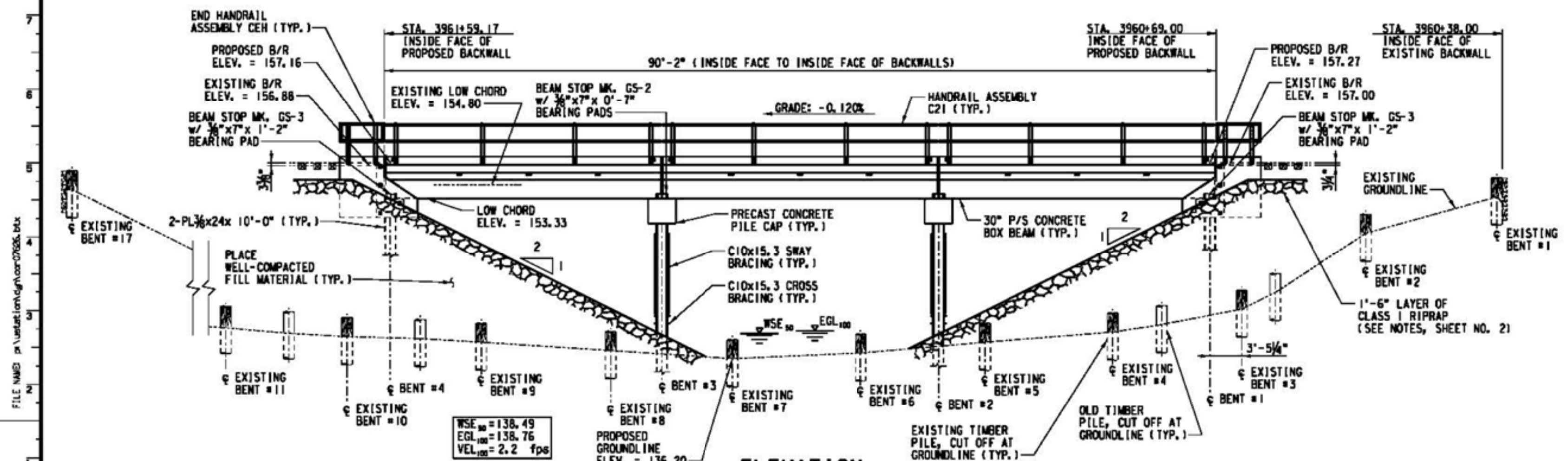
PLAN

SCALE: 1/8"=1'-0"



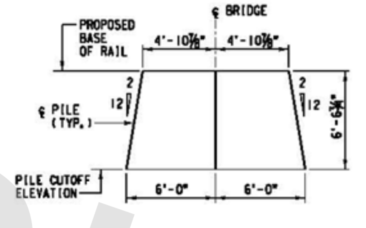
PILE LAYOUT

SCALE: 1/8"=1'-0" AT PILE CUTOFF



ELEVATION

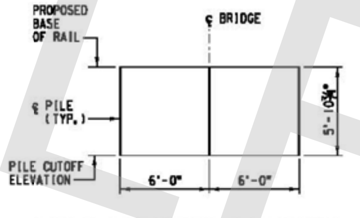
SCALE: 1/8"=1'-0"



PILE DRIVING DIAGRAM

SCALE: NO SCALE

℄ BENTS #2 AND #3



PILE DRIVING DIAGRAM

SCALE: NO SCALE

℄ BENTS #1 AND #4

BILL OF MATERIAL

REQ'D.	UNIT	DESCRIPTION	STORE ITEM NO.	ORDERED BY
6	EA.	30" x 29'-10" PRESTRESSED CONCRETE BOX BEAM MK. BG30-0, TYPE I w/ SLOPED CURB (REF. 3)	511-7828	MANAGER TRACK PROJECT
2	EA.	PRECAST CONCRETE END CAP MK. CPC10 FOR 30" CONCRETE BOX BEAM (REF. 6 AND 8)	511-0480	
2	EA.	PRECAST CONCRETE BACKWALL MK. CPBW10 FOR 30" CONCRETE BOX BEAM (REF. 6 AND 8)	511-7854	
4	EA.	PRECAST CONCRETE WINGWALL MK. CPW2 FOR 30" CONCRETE BOX BEAM (REF. 4)	511-0036	
2	EA.	15'-0" PRECAST CONCRETE PILE CAP w/ BEARING PADS FOR BOX BEAMS (REF. 5 AND 6)	511-0350	
12	EA.	HP14x89x 40'-0" STEEL PILE (ASTM A572 GRADE 50, PLAIN)	510-7557	
12	EA.	HP14x89x 60'-0" STEEL PILE (ASTM A572 GRADE 50, PLAIN)	510-7593	
12	EA.	PILE SPLICER FOR HP14x89 STEEL PILE	510-8065	
12	EA.	HP14x89 STEEL POINTS	510-8063	
8	EA.	C10x15.3x 20'-0" BRACE (ASTM A572 GRADE 50, PLAIN) (FIELD CUT TO LENGTH)	247-6649	
4	EA.	BEAM STOP MK. GS-2 (REF. 7)	510-0595	
4	EA.	BEAM STOP MK. GS-3 (REF. 7)	510-0596	
6	EA.	HANDRAIL ASSEMBLY C2[FOR 29'-10" CONCRETE INTERIOR SPAN (REF. 7)	510-0472	
4	EA.	END HANDRAIL ASSEMBLY CEH FOR CONCRETE SPAN (REF. 7)	513-3020	
4	EA.	DECK PLATE MK. CDP1, GALVANIZED (REF. 7)	510-0590	
4	EA.	DECK PLATE MK. CDP2, GALVANIZED (REF. 7)	510-0591	
8	EA.	DECK PLATE MK. CDP3, GALVANIZED (REF. 7)	510-0592	
8	EA.	3/8"x7"x 0'-7" ELASTOMERIC BEARING PAD	510-3635	
4	EA.	3/8"x7"x 1'-2" ELASTOMERIC BEARING PAD	510-3637	
4	EA.	PL3/8x24x 10'-0" (A36, PLAIN)	510-7650	
34	EA.	1/2"x28"x 6'-4" PREMOLDED EXPANSION JOINT FILLER PER ASTM D1751	511-8213	
380	TON	RIPRAP, CLASS 1	562-2764	
2	EA.	BRIDGE MARKER SIGN PER ENGINEERING STANDARDS DRAWING NO. 0507	P00-2616	MANAGER BRIDGE CONST.
2	EA.	PRIVATE PROPERTY/NO TRESPASSING SIGN	393-3651	
2	EA.	9 FT. STEEL MOUNTING POST	393-7510	
2	EA.	SIGN MOUNTING HARDWARE KIT	393-7314	
27	TON	WELL-GRADED 1 1/2" MINUS CRUSHED ROCK		
4750	CU. YD.	FILL MATERIAL		
1	LOT	PL-400 HEAVY DUTY CONSTRUCTION ADHESIVE		

EST. WT. OF STEEL PILING = 85,440 LB.
EST. WT. OF STEEL CROSS AND SWAY BRACING = 2,450 LB.
EST. WT. OF MISC. STEEL (NOT INCL. BOLTS) = 4,620 LB.

DRAWING SCHEDULE

THIS SET	SHEET NO.	DESCRIPTION
	1	GENERAL ARRANGEMENT AND BILL OF MATERIAL
	2	NOTES AND TOP OF RAIL PROFILE

REF.	NO.	DWG. NO.	SHEET NO.	REV. NO.	DESCRIPTION
	1	530000	A1-A7	A	BOX AND SLAB BEAM, CONSTRUCTION PLANS
	2	530000	B1-B5	A	30" BOX BEAM, CONSTRUCTION DETAILS
	3	500000	BG1, BG2	F	30" DOUBLE BOX BEAM, FABRICATION PLANS
	4	501000	A1	-	PRECAST END CAP FOR 30" BOX BEAM
	5	501000	C1, C2	-	PRECAST CONCRETE PILE CAP
	6	531010	1	-	PRECAST CONCRETE PILE CAP BEARING PADS
	7	502000	1-4	A	STEEL HARDWARE AND HANDRAIL ASSEMBLIES
	8	531200	1-7	-	SINGLE TRACK TWO PIECE END CAP

EST. WT. OF PRECAST CONCRETE

BOX BEAM MK. BG30-0 = 49,500 LB. EA. (24.8 TON)
15'-0' PILE CAP = 19,700 LB. EA. (9.9 TON)
END CAP MK. CPC10 = 17,650 LB. EA. (9.8 TON)
BACKWALL MK. CPBW10 = 7,280 LB. EA. (3.7 TON)
WINGWALL MK. CPW2 = 4,900 LB. EA. (2.5 TON)

NO.	DATE	REVISIONS
	/ /	
	/ /	
	/ /	
	/ /	

FORMER MOPAC BRIDGE NO. 76.2

UNION PACIFIC RAILROAD
Office of AVP Engineering Design/Construction

US Army Corps of Engineers
Little Rock District

Symbol	Description	Date	Appr.

Date: JANUARY 2012
Solicitation No.: N/A
Contract No.:
Designed by: UP RR
Drawn by: UP RR
Reviewed by: N/A

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

Submitted by:
Chief, General Engineering Section

CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI

JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

EXAMPLE RR BRIDGE DESIGN

Drawing Code/
Serial No.

Drawing Ref. No.
PLATE S-1

New - New structure where one does not currently exist or new structure in different location than original structure
Replaced = Replaced structure being built
Modified = the structure/foundation is modified
removed - the structure is removed
Unchanged = No changes to existing structure
Indicates RR Structure

structure	station	location	reach	action	plan_a	plan_d	plan_b	plan_c	plan_e	plan_f	plan_g	plan_h	Plan_i	Plan_j
Scenic Bridge	311+18	Wilson's	E1	Bridge	Unchanged	Modified	Unchanged	Unchanged	Unchanged	Modified	Modified	Modified	Modified	Modified
Bridge Type						Found. Mod.				Found. Mod.	Found. Mod.	Found. Mod.	Found. Mod.	Found. Mod.
Foundation Type						Drilled Piers				Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers
Wilson's Rail Road Bridge	322+94	Wilson's	E1	Bridge	Replaced	Replaced	Replaced	Modified	Modified	Replaced	Replaced	Replaced	Replaced	Replaced
Bridge Type					Pre. Conc. Girder	Pre. Conc. Girder	Pre. Conc. Girder	Found. Mod.	Found. Mod.	Pre. Conc. Girder	Pre. Conc. Girder	Pre. Conc. Girder	Pre. Conc. Girder	Pre. Conc. Girder
Foundation Type					Drilled Piers	Drilled Piers	Drilled Piers			Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers
No. of Spans					3 Span	3 Span	3 Span			3 Span	3 Span	3 Span	3 Span	3 Span
Bennett Street Bridge	8+03	Jordan - Lower Branch 3	E1	Bridge	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Catalpa Bridge	23+93	Jordan - Lower Branch 3	E1	Bridge	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Grand Street Bridge	40+94	Jordan - Lower Branch 3	E2	Bridge	Replaced	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Bridge Type					Conc. Box Bm									
Foundation Type					Drilled Piers									
No. of Spans					3 Span									
Mount Vernon Street Bridge	71+13	Jordan - Lower Branch 3	E2	Bridge	Replaced	Replaced	Replaced	Replaced	Replaced	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Bridge Type					Conc. Box Bm	Conc. Box Bm	Conc. Box Bm	Conc. Box Bm	Conc. Box Bm					
Foundation Type					Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers					
No. of Spans					3 Span	3 Span	3 Span	2 Span	2 Span					
Kansas Expressway	79+84	Jordan - Lower Branch 3	E2	Bridge	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Walnut Street Bridge	85+26	Jordan - Lower Branch 3	E2	Bridge	Replaced	Replaced	Replaced	Replaced	Replaced	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Bridge Type					Conc. Box Bm	Conc. Box Bm	Conc. Box Bm	Conc. Box Bm	Conc. Box Bm					
Foundation Type					Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers					
No. of Spans					3 Span	3 Span	3 Span	2 Span	2 Span					
College Street Bridge	91+10	Jordan - Lower Branch 3	E2	Bridge	Replaced	Replaced	Replaced	Replaced	Replaced	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Bridge Type					Conc. Box Bm	Conc. Box Bm	Conc. Box Bm	Conc. Box Bm	Conc. Box Bm					
Foundation Type					Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers					
No. of Spans					3 Span	3 Span	3 Span	2 Span	2 Span					
College Street RR Bridge	91+85	Jordan - Lower Branch 3	E2	Bridge	Replaced	Replaced	Replaced	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Bridge Type					Pre. Conc. Girder	Pre. Conc. Girder	Pre. Conc. Girder							
Foundation Type					Drilled Piers	Drilled Piers	Drilled Piers							
No. of Spans					4 Span	4 Span	4 Span							
Fort Street Bridge	98+51	Jordan - Lower Branch 3	E2	Bridge	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
RR Bridge DS of Grant	120+82	Jordan - Lower Branch 3	E3	Bridge	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Building Over the Channel	125+24	Jordan - Lower Branch 3	E3	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Unchanged
Grant Street Bridge	126+83	Jordan - Lower Branch 3	E3	Existing Bridge to Remain	Modified	Modified	Modified	Modified	Unchanged	Modified	Unchanged	Unchanged	Unchanged	Unchanged
Bridge Type					Found. Mod.	Found. Mod.	Found. Mod.	Found. Mod.		Found. Mod.				
Foundation Type					Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers		Drilled Piers				
Main Street Bridge	133+28	Jordan - Lower Branch 3	E3	Bridge	Replaced	Replaced	Replaced	Replaced	Replaced	Replaced	Replaced	Replaced	Replaced	Unchanged
Bridge Type					Conc. Box Bm	Conc. Box Bm	Conc. Box Bm	Conc. Box Bm	Conc. Box Bm	Conc. Box Bm	Conc. Box Bm	Conc. Box Bm	Conc. Box Bm	
Foundation Type					Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers	
No. of Spans					3 Span	3 Span	3 Span	2 Span	2 Span	3 Span	2 Span	3 Span	3 Span	
Campbell Street	139+85	Jordan - Lower Branch 2	E3	Bridge	New	New	New	New	New	New	New	New	New	Unchanged
Bridge Type					Conc. Box Bm	Conc. Box Bm	Conc. Box Bm	Conc. Box Bm	Conc. Box Bm	Conc. Box Bm	Conc. Box Bm	Conc. Box Bm	Conc. Box Bm	
Foundation Type					Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers	
No. of Spans					2 Span	3 Span	2 Span	2 Span	2 Span	2 Span	2 Span	2 Span	2 Span	
Boonville Street Box Culvert	145+57	Jordan - Lower Branch 2	E3	Box Culverts	New	New	New	New	New	New	New	New	New	Unchanged
Phelps Street	151+48	Jordan - Lower Branch 2	E3	Box Culverts	New	New	New	New	New	New	New	Unchanged	New	Unchanged
Benton Street	159+67	Jordan - Lower Branch 2	E3	Exisiting Bridge to Remain	Modified	Modified	Modified	Modified	Modified	Modified	Modified	Unchanged	Modified	Unchanged
Phelps Street (under RR)	165+63	Jordan - Lower Branch 2	E3	Box Culverts	New	New	New	New	New	New	New	Unchanged	New	Unchanged
North Branch RR Culvert	7+43	Jordan - North Branch	E4	Box Culverts	Replaced	Replaced	Replaced	Replaced	Replaced	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Chestnut Expressway Overpass	10+64	Jordan - North Branch	E4	Existing Bridge to Remain	Modified	Modified	Modified	Modified	Modified	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Bridge Type					Found. Mod.	Found. Mod.	Found. Mod.	Found. Mod.	Found. Mod.					
Foundation Type					Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers	Drilled Piers					
Lower Chestnut	11+35	Jordan - North Branch	E4	Bridge	New	New	New	New	New	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Bob Barker Box Culvert	15+99	Jordan - North Branch	E4	Removed	Removed	Removed	Removed	Removed	Removed	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Central Street Culvert	20+34	Jordan - North Branch	E4	Bridge	Replaced	Replaced	Replaced	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Bridge Type					Conc. Box Bm	Conc. Box Bm	Conc. Box Bm							
Foundation Type					Drilled Piers	Drilled Piers	Drilled Piers							
No. of Spans					1 Span	1 Span	1 Span							
Smith Park#1 Bridge	75+30	Jordan - North Branch	E5	Bridge	Replaced	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Bridge Type					Prefab. Steel Brdge									
Foundation Type					Conc. Abutments									
No. of Spans					1 Span									
Smith Park#2 Bridge	79+98	Jordan - North Branch	E5	Bridge	Replaced	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Bridge Type					Prefab. Steel Brdge									
Foundation Type					Conc. Abutments									
No. of Spans					1 Span									
Bridge over Channel 1	1+14	Jordan - South Branch	E6	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Unchanged	Removed	Unchanged
Bridge over Channel 2	7+48	Jordan - South Branch	E6	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Unchanged	Removed	Unchanged
RR Culvert DS of Sherman Street	9+77	Jordan - South Branch	E6	Box Culverts	Replaced	Replaced	Replaced	Replaced	Replaced	Replaced	Replaced	Unchanged	Replaced	Unchanged
Sherman Street Box Culvert	12+02	Jordan - South Branch	E6	Box Culverts	Replaced	Replaced	Replaced	Replaced	Replaced	Replaced	Replaced	Replaced	Replaced	Unchanged
Bridge at Conco	14+84	Jordan - South Branch	E6	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Unchanged	Removed	Unchanged
National Box Culvert	28+60	Jordan - South Branch	E6	Box Culverts	Replaced	Replaced	Replaced	Replaced	Replaced	Replaced	Replaced	Replaced	Replaced	Unchanged
Prospect Culvert (added Oct. 2012)	33+37	Jordan - South Branch	E6	Box Culverts	Replaced	Replaced	Replaced	Replaced	Replaced	Replaced	Replaced	Replaced	Replaced	Unchanged
Star Wholesale Box Culvert	44+31	Jordan - South Branch	E6	Box Culverts	New	New	New	New	New	New	New	New	New	Unchanged
Fremont Street Box Culvert	46+18	Jordan - South Branch	E6	Box Culverts	Replaced	Replaced	Replaced	Replaced	Unchanged	Replaced	Unchanged	Unchanged	Unchanged	Unchanged
RR Bridge DS of Trafficway #1	76+81	Jordan - South Branch	E6	Bridge	Replaced	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Bridge Type					Pre. Conc. Girder									
Foundation Type					Drilled Piers									
No. of Spans					2 Span									
RR Bridge DS of Trafficway #2A	77+30	Jordan - South Branch	E6	Bridge	Replaced	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Bridge Type					Pre. Conc. Girder									
Foundation Type					Drilled Piers									
No. of Spans					2 Span									
Trafficway Culvert	83+58	Jordan - South Branch	E6	Box Culverts	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
RR Bridge DS of Trafficway #2B	91+39	Jordan - South Branch	E6	Bridge	Replaced	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Bridge Type					Pre. Conc. Girder									
Foundation Type					Drilled Piers									
No. of Spans					2 Span									

US Army Corps of Engineers
Little Rock District

Symbol | Description | Date | Appr.

Date: JANUARY 2012
Solicitation No.: N/A
Contract No.:
Designed by: DCE
Drawn by: NHB
Reviewed by: NPG

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

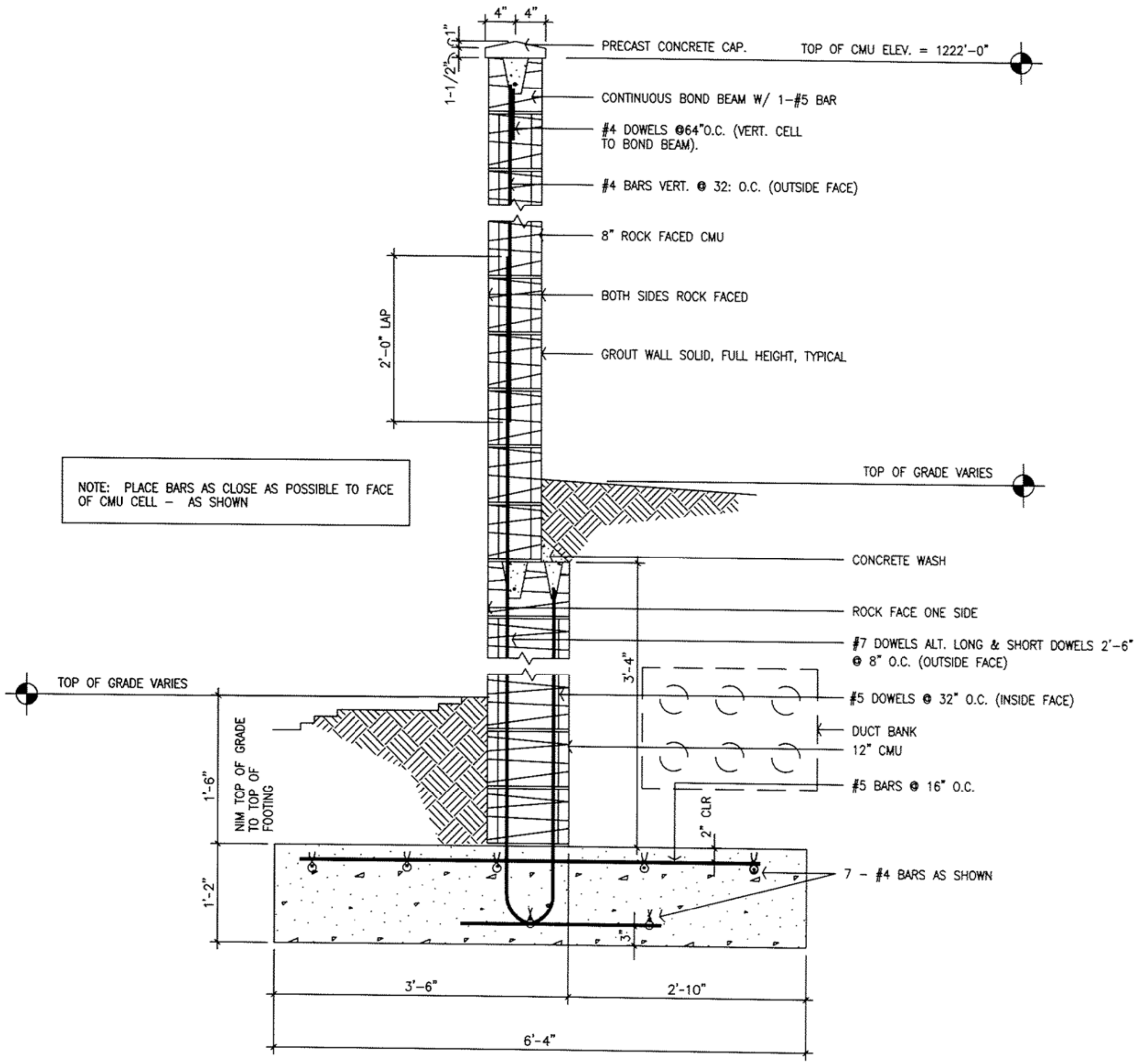
Submitted by:
Chief, General Engineering Section

CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI
JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

STRUCTURAL SYSTEM CHART

Drawing Code/ Serial No.

Drawing Ref. No.
PLATE S-2



(2) FLOODWALL SECTION

US Army Corps of Engineers
Little Rock District

Symbol	Description	Date	Appr.

Designed by: DCE
Drawn by: NHB
Reviewed by: NPG
Date: JANUARY 2012
Solicitation No.: N/A
Contract No.:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

Submitted by:
Chief, General Engineering Section

CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI
JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

EXISTING FLOODWALL
AT ARCHIMICA PLANT

Drawing Code/
Serial No.

Drawing Ref. No.
PLATE S-3

US Army Corps of Engineers
Little Rock District

Symbol	Description	Date	Appr.

Date: JANUARY 2013
Solicitation No.: N/A
Contract No.:
Designed by: NHB
Drawn by: NHB
Reviewed by: NPG

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

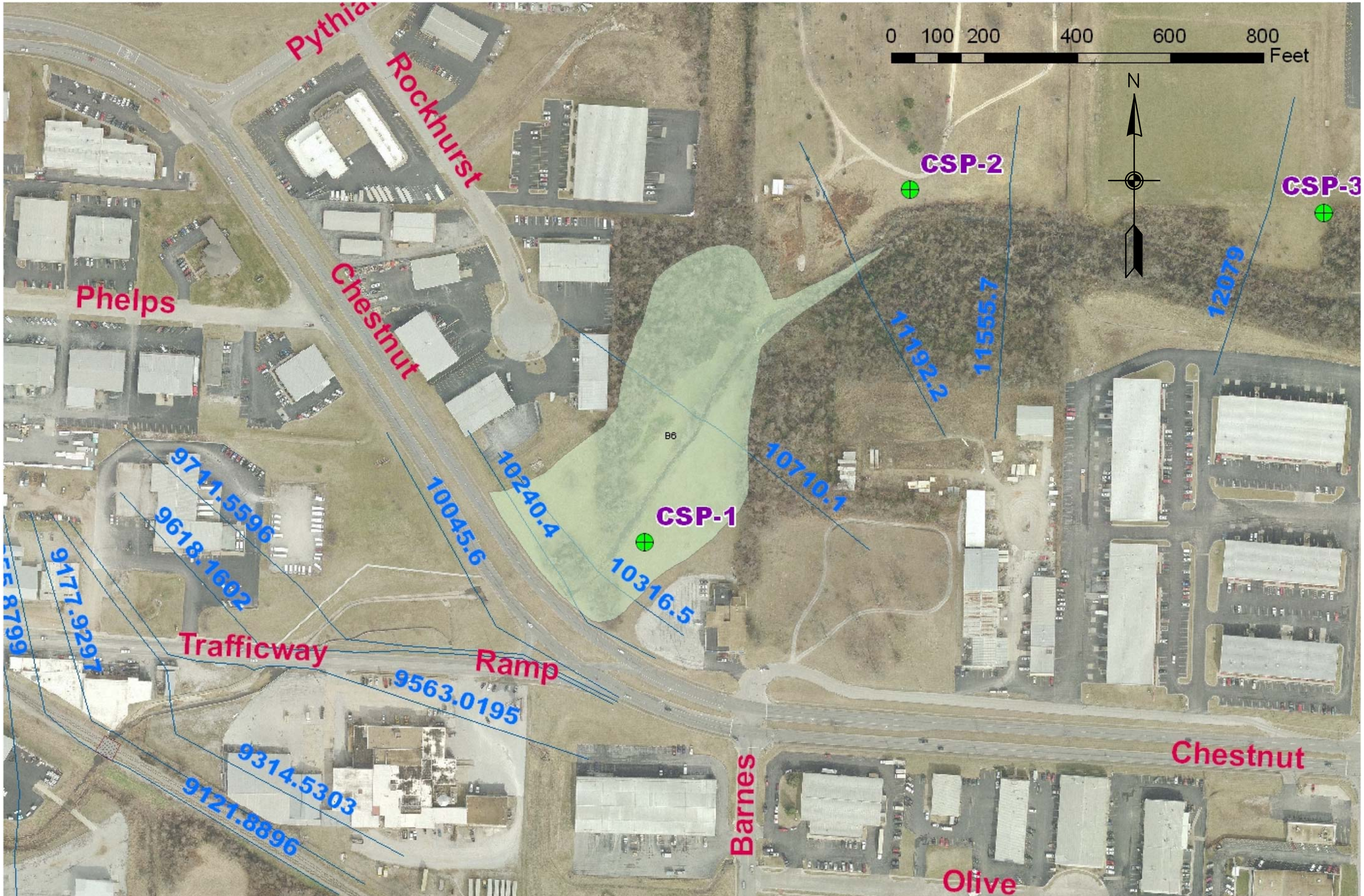
Submitted by:
Chief, General Engineering Section

CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI
JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

BORING LOGS PLAN 1

Drawing Code/ Serial No.

Drawing Ref. No.
PLATE G-1



US Army Corps of Engineers
Little Rock District

Symbol	Description	Date	Appr.

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

Submitted by:

Chief, General Engineering Section

Designed by: NHB	Date: JANUARY 2013
Drawn by: NHB	Solicitation No.: N/A
Reviewed by: NPG	Contract No.:

CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI

JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

BORING LOGS PLAN 2

Drawing Code/ Serial No.

Drawing Ref. No.
PLATE G-2

US Army Corps of Engineers
Little Rock District

Symbol	Description	Date	Appr.

Designed by: NHB
Date: JANUARY 2013
Drawn by: NHB
Solicitation No.: N/A
Reviewed by: NPG
Contract No.:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

Submitted by:

Chief, General Engineering Section

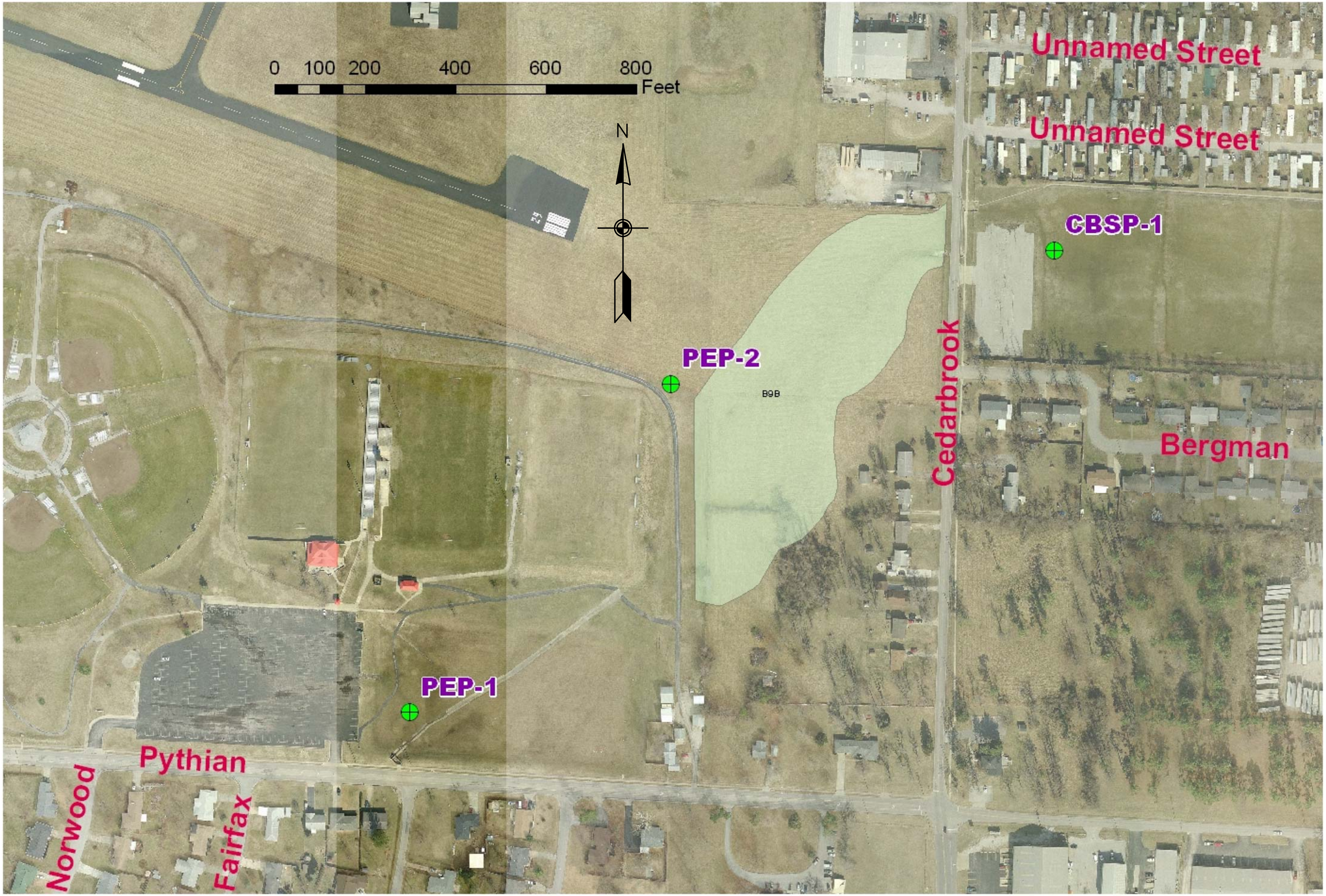
CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI

JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

BORING LOGS PLAN 3

Drawing Code/ Serial No.

Drawing Ref. No.
PLATE G-3



US Army Corps of Engineers
Little Rock District

Symbol	Description	Date	Appr.

Designed by: NHB	Date: JANUARY 2013	
Drawn by: NHB	Solicitation No.: N/A	
Reviewed by: NPG	Contract No.:	

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

Submitted by:

Chief, General Engineering Section

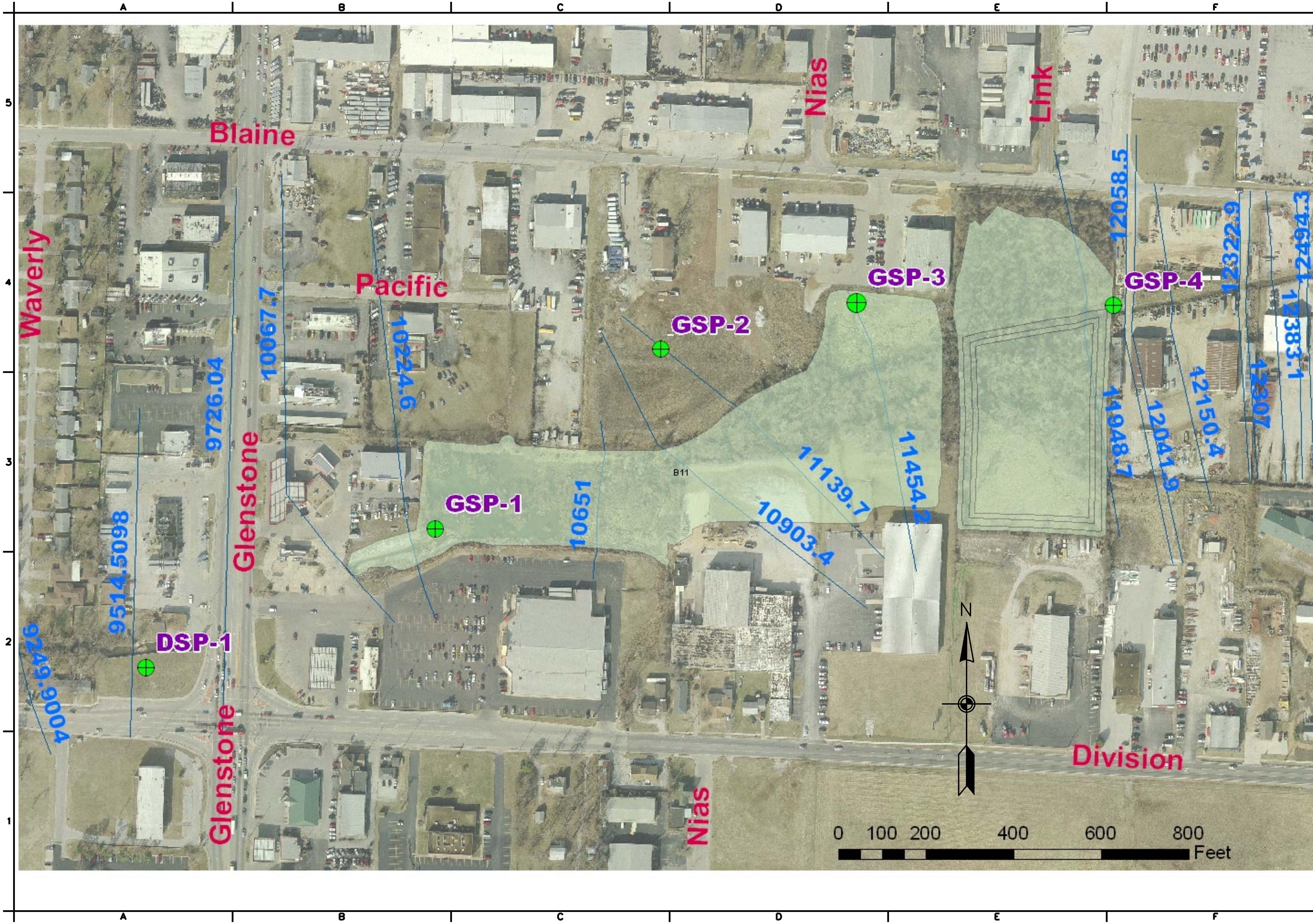
CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI

JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

BORING LOGS PLAN 4

Drawing Code/
Serial No.

Drawing Ref. No.
PLATE G-4



US Army Corps of Engineers
Little Rock District

Symbol	Description	Date	Appr.

Designed by: NHB
Drawn by: NHB
Reviewed by: NPG
Date: JANUARY 2013
Solicitation No.: N/A
Contract No.:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

Submitted by:

Chief, General Engineering Section

CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI

JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

BORING LOGS PLAN 5

Drawing Code/
Serial No.

Drawing Ref. No.
PLATE G-5

A/E ANDERSON ENGINEERING, INC.

ENGINEERS • SURVEYORS • LABORATORIES • GEOTECHNICAL

SPRINGFIELD OFFICE: 2045 W. Woodland Street, Springfield, Mo. 65807 (417) 866-2741
JOPLIN OFFICE: 501 E. 15th Street Joplin, Mo. 64804, (417) 782-7399
FT. LEONARD WOOD OFFICE: P.O. Box 147 Ft. Leonard Wood, MO. 65473, (573) 336-8906

BORING LOG

CLIENT: U.S. Army Corps of Engineers
PROJECT: Jordan Creek – New Channel Alignment
Springfield, Missouri

BORING NO. JC–1
CLIENT NO. 69515
DATE DRILLED: 06/15/07
DRILL RIG: 03 DRILLER: G.W.

TOTAL DEPTH DRILLED: 15.0'
WATER LEVEL OBSERVATIONS: DURING DRILLING 3.0 FT.
AT COMPLETION 3.0 FT.

DESCRIPTION — APPROX. SURFACE ELEVATION: ______

Description
Grass covered dark gray, gray, brown and yellowish brown lean clay with 10–20% chert and some glass and wood debris, moist and medium stiff (possible fill)
Dark gray lean clay with 0–10% chert, moist and medium stiff
Gray lean clay with yellowish brown mottles and 0–10% chert, moist and medium to soft
Gray lean clay with yellowish brown mottles and 0–10% chert, moist and stiff
Limestone, weathered
Limestone, moderately hard
Discontinued drilling

DRILLING METHOD: Solid Stem Augers

TYPE SAMPLE	UNCONFINED COMPRESSIVE STRENGTH– LBS/FT 2	WATER CONTENT	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	UNIFIED SOIL CLASSIFICATION
3 3 5		23.8	37	21	16	CL
3 3 4		28.3				
1 1 1	500*	32.9	43	22	21	CL
3 7 6	4000*	28.6				
5 8 50/2"		32.6				

NOTE: * Penetrometer
0' to 1.5': Hue 10YR: 3/1, 5/1

A/E ANDERSON ENGINEERING, INC.
ENGINEERS • SURVEYORS • LABORATORIES • GEOTECHNICAL
SPRINGFIELD OFFICE: 2045 W. Woodland Street, Springfield, Mo. 65807 (417) 866-2741
JOPLIN OFFICE: 501 E. 15th Street Joplin, Mo. 64804, (417) 782-7399
FT. LEONARD WOOD OFFICE: P.O. Box 147 Ft. Leonard Wood, MO. 65473, (573) 336-8906

BORING LOG

CLIENT: U.S. Army Corps of Engineers
PROJECT: Jordan Creek – New Channel Alignment
Springfield, Missouri

BORING NO. JC–2
CLIENT NO. 69515
DATE DRILLED: 06/15/07
DRILL RIG: 03 DRILLER: G.W.

TOTAL DEPTH DRILLED: 16.0'
WATER LEVEL OBSERVATIONS: DURING DRILLING 12.0 FT.
AT COMPLETION 10.0 FT.

DESCRIPTION — APPROX. SURFACE ELEVATION: ______

Description
Grass covered dark brown, dark gray, and yellowish brown lean clay and red fat clay with 10–30% chert, moist and medium to stiff (possible fill)
Gray lean clay with yellowish brown mottles and 0–10% chert, moist and stiff
Yellowish brown and gray mottled lean clay with 20–40% chert, moist and very stiff
Limestone, weathered
Limestone, moderately hard
Discontinued drilling

DRILLING METHOD: Solid Stem Augers

TYPE SAMPLE	UNCONFINED COMPRESSIVE STRENGTH– LBS/FT 2	WATER CONTENT	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	UNIFIED SOIL CLASSIFICATION
4 3 3		17.6				
5 3 7	3000*	24.7	41	33	8	CL
3 3 6	3000*	23.8				
4 5 7	7000*	23.9				
15 15 14		29.8	48	21	27	CL
50/5"		23.4				

NOTE: * Penetrometer
0' to 1.5': Hue 7.5YR: 3/2, Hue 2.5YR: 4/6, 3/0

A/E ANDERSON ENGINEERING, INC.
ENGINEERS • SURVEYORS • LABORATORIES • GEOTECHNICAL
SPRINGFIELD OFFICE: 2045 W. Woodland Street, Springfield, Mo. 65807 (417) 866-2741
JOPLIN OFFICE: 501 E. 15th Street Joplin, Mo. 64804, (417) 782-7399
FT. LEONARD WOOD OFFICE: P.O. Box 147 Ft. Leonard Wood, MO. 65473, (573) 336-8906

BORING LOG

CLIENT: U.S. Army Corps of Engineers
PROJECT: Jordan Creek – New Channel Alignment
Springfield, Missouri

BORING NO. JC–3
CLIENT NO. 69515
DATE DRILLED: 06/15/07
DRILL RIG: 03 DRILLER: G.W.

TOTAL DEPTH DRILLED: 15.0'
WATER LEVEL OBSERVATIONS: DURING DRILLING 12.0 FT.
AT COMPLETION 14.0 FT.

DESCRIPTION — APPROX. SURFACE ELEVATION: ______

Description
Crushed stone
Brown, reddish brown and gray lean clay with 20–40% chert, moist and stiff to medium (possible fill)
Gray lean clay with yellowish brown mottles and 0–10% chert, moist and medium to soft
Gray lean clay with 20–40% chert, moist and stiff
Limestone, moderately hard
Discontinued drilling

DRILLING METHOD: Solid Stem Augers

TYPE SAMPLE	UNCONFINED COMPRESSIVE STRENGTH– LBS/FT 2	WATER CONTENT	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	UNIFIED SOIL CLASSIFICATION
12 5 4		7.4				
3 2 2	1000*	24.4 39.4				
5 3 3	2000* 500*	19.3 24.6	35	17	18	CL
0 0 0	500*	37.2	43	22	21	CL
4 6 9		29.3				

NOTE: * Penetrometer
0' to 1.5': Crushed stone recovered

US Army Corps of Engineers
Little Rock District

Symbol	Description	Date	Appr.

Designed by: NHB
Drawn by: NHB
Reviewed by: NPG
Date: JANUARY 2013
Solicitation No.: N/A
Contract No.:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

Submitted by:
Chief, General Engineering Section

CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI
JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

BORING LOGS PROFILES 1

Drawing Code/ Serial No.

Drawing Ref. No.
PLATE G-6

A	B	C	D	E	F

ANDERSON ENGINEERING, INC.
A/E — ENGINEERS • SURVEYORS • LABORATORIES • GEOTECHNICAL

SPRINGFIELD OFFICE: 2045 W. Woodland Street, Springfield, Mo. 65807 (417) 866-2741
JOPLIN OFFICE: 501 E. 15th Street Joplin, Mo. 64804, (417) 782-7399
FT. LEONARD WOOD OFFICE: P.O. Box 147 Ft. Leonard Wood, MO. 65473, (573) 336-8906

BORING LOG

CLIENT: U.S. Army Corps of Engineers
PROJECT: Jordan Creek – New Channel Alignment, Springfield, Missouri
BORING NO. JC-4
CLIENT NO. 69515
DATE DRILLED: 06/15/07
DRILL RIG: 03 DRILLER: G.W.

TOTAL DEPTH DRILLED: 10.5'
WATER LEVEL OBSERVATIONS: DURING DRILLING 9.0 FT. AT COMPLETION 8.0 FT.

DEPTH	ELEV.	DESCRIPTION (APPROX. SURFACE ELEVATION: ______)	DRILLING METHOD	TYPE SAMPLE	UNCONFINED COMPRESSIVE STRENGTH–LBS/FT 2	WATER CONTENT	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	UNIFIED SOIL CLASSIFICATION
0–1.5		Brown and gray lean clay with red fat clay and 10–20% chert, moist and very stiff (possible fill)	Solid Stem Augers	3 3 4	6500*	26.3	37	19	18	CL
1.5–3		Gray brown lean clay with yellowish brown mottles and 0–10% chert, moist and stiff to very stiff								
3–5.5		Yellowish brown lean clay with gray mottles and 20–40% chert, moist and very stiff		5 4 14	4000*	18.6				
5.5–9		Reddish brown fat clay with yellowish brown and gray mottles and 10–20% chert, moist and very stiff		13 7 9		14.3	52	26	26	CH
9–10.5		Red fat clay with 10–20% chert and weathered limestone, moist and medium		8 3 3		40.4				
10.5		Limestone, possible pinnacle Discontinued drilling								

NOTE: * Penetrometer
0' to 1.5': Hue 10YR:3/1, Hue 7.5YR:3/2, Hue 2.5YR:3/6

ANDERSON ENGINEERING, INC.
A/E — ENGINEERS • SURVEYORS • LABORATORIES • GEOTECHNICAL

SPRINGFIELD OFFICE: 2045 W. Woodland Street, Springfield, Mo. 65807 (417) 866-2741
JOPLIN OFFICE: 501 E. 15th Street Joplin, Mo. 64804, (417) 782-7399
FT. LEONARD WOOD OFFICE: P.O. Box 147 Ft. Leonard Wood, MO. 65473, (573) 336-8906

BORING LOG

CLIENT: U.S. Army Corps of Engineers
PROJECT: Jordan Creek Flood Control Project, Springfield, Missouri
BORING NO. BESP-1
CLIENT NO. 68907
DATE DRILLED: 12/2/05
DRILL RIG: ATV DRILLER: G.W.

TOTAL DEPTH DRILLED: 17.0'
WATER LEVEL OBSERVATIONS: DURING DRILLING 15.5' FT. AT COMPLETION 0 FT.

DEPTH	ELEV.	DESCRIPTION (APPROX. SURFACE ELEVATION: ______)	DRILLING METHOD	TYPE SAMPLE	UNCONFINED COMPRESSIVE STRENGTH–LBS/FT 2	WATER CONTENT	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	UNIFIED SOIL CLASSIFICATION
0–9.5		Dark reddish brown lean clay, dark red fat clay and dark brown lean clay with 20–40% chert and some asphalt and concrete debris, moist and medium to stiff (possible fill)	Solid Stem Augers	3 3 4						
9.5–10.7		Dark brown and grayish brown lean clay with 10–20% chert, moist and stiff (possible fill)		9 17 17						
10.7–12		Yellowish brown and gray lean to fat clay with 20–40% chert, moist and stiff (possible fill)								
12–15.5		Brown silty lean clay with 0–20% chert, moist and medium to stiff								
15.5–17		Limestone, hard								
17		Discontinued drilling								

NOTE: * Penetrometer
10YR Hue: 3/3, 2.5YR Hue: 3/4,3/6

ANDERSON ENGINEERING, INC.
A/E — ENGINEERS • SURVEYORS • LABORATORIES • GEOTECHNICAL

SPRINGFIELD OFFICE: 2045 W. Woodland Street, Springfield, Mo. 65807 (417) 866-2741
JOPLIN OFFICE: 501 E. 15th Street Joplin, Mo. 64804, (417) 782-7399
FT. LEONARD WOOD OFFICE: P.O. Box 147 Ft. Leonard Wood, MO. 65473, (573) 336-8906

BORING LOG

CLIENT: U.S. Army Corps of Engineers
PROJECT: Jordan Creek Flood Control Project, Springfield, Missouri
BORING NO. CSP-1
CLIENT NO. 68907
DATE DRILLED: 12/02/05
DRILL RIG: ATV DRILLER: G.W.

TOTAL DEPTH DRILLED: 8.5'
WATER LEVEL OBSERVATIONS: DURING DRILLING none FT. AT COMPLETION none FT.

DEPTH	ELEV.	DESCRIPTION (APPROX. SURFACE ELEVATION: ______)	DRILLING METHOD	TYPE SAMPLE	UNCONFINED COMPRESSIVE STRENGTH–LBS/FT 2	WATER CONTENT	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	UNIFIED SOIL CLASSIFICATION
0–2		Grass covered very dark brown silty lean clay with 10–20% chert, moist and medium	Solid Stem Augers	3 3 13						
2–3		Gray brown lean clay with 0–10% chert, moist and stiff								
3–5.5		Brown lean clay with 10–20% chert, moist and stiff								
5.5–8.5		Reddish brown lean clay with 10–20% chert, moist and very stiff								
8.5		Limestone Discontinued drilling								

NOTE: * Penetrometer
10YR Hue: 2/2

US Army Corps of Engineers
Little Rock District

Symbol	Description	Date	Appr.

Designed by: NHB | Date: JANUARY 2013
Drawn by: NHB | Solicitation No.: N/A
Reviewed by: NPG | Contract No.:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

Submitted by:
Chief, General Engineering Section

CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI
JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

BORING LOGS PROFILES 2

Drawing Code/ Serial No.

Drawing Ref. No.
PLATE G-7

ANDERSON ENGINEERING, INC.

ENGINEERS • SURVEYORS • LABORATORIES • GEOTECHNICAL

SPRINGFIELD OFFICE: 2045 W. Woodland Street, Springfield, Mo. 65807 (417) 866-2741
JOPLIN OFFICE: 501 E. 15th Street Joplin, Mo. 64804, (417) 782-7399
FT. LEONARD WOOD OFFICE: P.O. Box 147 Ft. Leonard Wood, MO. 65473, (573) 336-8906

BORING LOG

CLIENT: U.S. Army Corps of Engineers
PROJECT: Jordan Creek Flood Control Project, Springfield, Missouri
BORING NO. BUSP-1
CLIENT NO. 68907
DATE DRILLED: 12/02/05
DRILL RIG: ATV DRILLER: G.W.

TOTAL DEPTH DRILLED: 10.0'
WATER LEVEL OBSERVATIONS: DURING DRILLING none FT. AT COMPLETION none FT.

DESCRIPTION (APPROX. SURFACE ELEVATION: ____)	DRILLING METHOD	TYPE SAMPLE	UNCONFINED COMPRESSIVE STRENGTH–LBS/FT 2	WATER CONTENT	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	UNIFIED SOIL CLASSIFICATION
Grass covered gray lean clay, moist and stiff	Solid Stem Augers	4 13 22						
Gray to light gray lean clay with 20–40% chert, moist and very stiff								
Reddish brown lean clay with 20–40% chert, moist and stiff								
Dark red fat clay with 0–20% chert and occasional chert cobble, moist and very stiff								
Discontinued drilling (10')								

NOTE: * Penetrometer
10YR Hue: 5/1, Hue: 6/1

ANDERSON ENGINEERING, INC.

ENGINEERS • SURVEYORS • LABORATORIES • GEOTECHNICAL

SPRINGFIELD OFFICE: 2045 W. Woodland Street, Springfield, Mo. 65807 (417) 866-2741
JOPLIN OFFICE: 501 E. 15th Street Joplin, Mo. 64804, (417) 782-7399
FT. LEONARD WOOD OFFICE: P.O. Box 147 Ft. Leonard Wood, MO. 65473, (573) 336-8906

BORING LOG

CLIENT: U.S. Army Corps of Engineers
PROJECT: Jordan Creek Flood Control Project, Springfield, Missouri
BORING NO. BUSP-2
CLIENT NO. 68907
DATE DRILLED: 12/02/05
DRILL RIG: ATV DRILLER: G.W.

TOTAL DEPTH DRILLED: 10.0'
WATER LEVEL OBSERVATIONS: DURING DRILLING none FT. AT COMPLETION none FT.

DESCRIPTION (APPROX. SURFACE ELEVATION: ____)	DRILLING METHOD	TYPE SAMPLE	UNCONFINED COMPRESSIVE STRENGTH–LBS/FT 2	WATER CONTENT	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	UNIFIED SOIL CLASSIFICATION
Grass covered very dark gray silty lean clay with 0–10% chert, moist and stiff	Solid Stem Augers	3 9 13						
Dark red fat clay with 0–20% chert and occasional chert cobble, moist and very stiff								
Discontinued drilling (10')								

NOTE: * Penetrometer
10YR Hue: 3/1

ANDERSON ENGINEERING, INC.

ENGINEERS • SURVEYORS • LABORATORIES • GEOTECHNICAL

SPRINGFIELD OFFICE: 2045 W. Woodland Street, Springfield, Mo. 65807 (417) 866-2741
JOPLIN OFFICE: 501 E. 15th Street Joplin, Mo. 64804, (417) 782-7399
FT. LEONARD WOOD OFFICE: P.O. Box 147 Ft. Leonard Wood, MO. 65473, (573) 336-8906

BORING LOG

CLIENT: U.S. Army Corps of Engineers
PROJECT: Jordan Creek Flood Control Project, Springfield, Missouri
BORING NO. PEP-2
CLIENT NO. 68907
DATE DRILLED: 12/01/05
DRILL RIG: ATV DRILLER: G.W.

TOTAL DEPTH DRILLED: 10.0'
WATER LEVEL OBSERVATIONS: DURING DRILLING none FT. AT COMPLETION none FT.

DESCRIPTION (APPROX. SURFACE ELEVATION: ____)	DRILLING METHOD	TYPE SAMPLE	UNCONFINED COMPRESSIVE STRENGTH–LBS/FT 2	WATER CONTENT	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	UNIFIED SOIL CLASSIFICATION
Grass covered dark brown silty lean clay, moist and medium	Solid Stem Augers	3 9 9						
Brown lean clay with 40–60% chert, moist and very stiff								
Reddish brown lean clay with 20–40% chert, moist and very stiff								
Dark red fat clay with 0–10% chert and occasional chert cobble, moist and very stiff								
Discontinued drilling (10')								

NOTE: * Penetrometer
10YR Hue: 3/3

US Army Corps of Engineers
Little Rock District

Symbol | Description | Date | Appr.

Designed by: NHB | Date: JANUARY 2013
Drawn by: NHB | Solicitation No.: N/A
Reviewed by: NPG | Contract No.:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

Submitted by:
Chief, General Engineering Section

CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI
JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

BORING LOGS PROFILES 3

Drawing Code/Serial No.

Drawing Ref. No.
PLATE G-8

A/E ANDERSON ENGINEERING, INC.
ENGINEERS • SURVEYORS • LABORATORIES • GEOTECHNICAL

SPRINGFIELD OFFICE: 2045 W. Woodland Street, Springfield, Mo. 65807 (417) 866-2741
JOPLIN OFFICE: 501 E. 15th Street Joplin, Mo. 64804, (417) 782-7399
FT. LEONARD WOOD OFFICE: P.O. Box 147 Ft. Leonard Wood, MO. 65473, (573) 336-8906

BORING LOG

CLIENT: U.S. Army Corps of Engineers
PROJECT: Jordan Creek Flood Control Project, Springfield, Missouri
BORING NO. GSP-1
CLIENT NO. 68907
DATE DRILLED: 12/19/05
DRILL RIG: ATV DRILLER: G.W.

TOTAL DEPTH DRILLED: 12.0'
WATER LEVEL OBSERVATIONS: DURING DRILLING 10.0 FT. AT COMPLETION none FT.

DEPTH (ft)	DESCRIPTION (APPROX. SURFACE ELEVATION: ______)	DRILLING METHOD	TYPE SAMPLE
0–9	Grass and gravel covered very dark grayish brown lean clay, very dark gray lean clay, brownish yellow lean clay, reddish brown lean clay and dark red fat clay with 10–20% chert and occasional chert cobble with some concrete and asphalt debris, moist and medium to stiff (possible fill)	Solid Stem Augers	3 3 6
9–10	Yellowish brown lean clay with 0–10% chert, moist and stiff		
10–12	Limestone, hard		
12	Discontinued drilling		

Columns: DEPTH, ELEV., DESCRIPTION, SOIL GRAPH, DEPTH, DRILLING METHOD, TYPE SAMPLE, UNCONFINED COMPRESSIVE STRENGTH-LBS/FT 2, WATER CONTENT, LIQUID LIMIT, PLASTIC LIMIT, PLASTICITY INDEX, UNIFIED SOIL CLASSIFICATION

NOTE: * Penetrometer
10YR Hue: 3/2, Hue: 3/1, Hue: 6/6, 2.5YR Hue: 4/4, Hue: 3/6

A/E ANDERSON ENGINEERING, INC.
ENGINEERS • SURVEYORS • LABORATORIES • GEOTECHNICAL

SPRINGFIELD OFFICE: 2045 W. Woodland Street, Springfield, Mo. 65807 (417) 866-2741
JOPLIN OFFICE: 501 E. 15th Street Joplin, Mo. 64804, (417) 782-7399
FT. LEONARD WOOD OFFICE: P.O. Box 147 Ft. Leonard Wood, MO. 65473, (573) 336-8906

BORING LOG

CLIENT: U.S. Army Corps of Engineers
PROJECT: Jordan Creek Flood Control Project, Springfield, Missouri
BORING NO. GSP-2
CLIENT NO. 68907
DATE DRILLED: 12/02/05
DRILL RIG: ATV DRILLER: G.W.

TOTAL DEPTH DRILLED: 20.0'
WATER LEVEL OBSERVATIONS: DURING DRILLING 18.0 FT. AT COMPLETION 16.0 FT.

DEPTH (ft)	DESCRIPTION (APPROX. SURFACE ELEVATION: ______)	DRILLING METHOD	TYPE SAMPLE
0–8.5	Grass covered dark brown and brown lean clay with dark red fat clay and 10–20% chert with some asphalt debris, moist and stiff (possible fill)	Solid Stem Augers	4 7 9
8.5–14	Dark gray lean to fat clay with 0–5% chert, moist and stiff		
14–20	Brown lean clay with 0–5% chert, moist and stiff		
20	Discontinued drilling		

NOTE: * Penetrometer
10YR Hue: 3/3, Hue: 5/3, 2.5YR Hue: 3/6

A/E ANDERSON ENGINEERING, INC.
ENGINEERS • SURVEYORS • LABORATORIES • GEOTECHNICAL

SPRINGFIELD OFFICE: 2045 W. Woodland Street, Springfield, Mo. 65807 (417) 866-2741
JOPLIN OFFICE: 501 E. 15th Street Joplin, Mo. 64804, (417) 782-7399
FT. LEONARD WOOD OFFICE: P.O. Box 147 Ft. Leonard Wood, MO. 65473, (573) 336-8906

BORING LOG

CLIENT: U.S. Army Corps of Engineers
PROJECT: Jordan Creek Flood Control Project, Springfield, Missouri
BORING NO. GSP-3
CLIENT NO. 68907
DATE DRILLED: 12/7/05
DRILL RIG: ATV DRILLER: G.W.

TOTAL DEPTH DRILLED: 10.0'
WATER LEVEL OBSERVATIONS: DURING DRILLING 0 FT. AT COMPLETION 0 FT.

DEPTH (ft)	DESCRIPTION (APPROX. SURFACE ELEVATION: ______)	DRILLING METHOD	TYPE SAMPLE
0–3.5	Grass covered very dark gray lean clay, brownish yellow fat clay, light gray fat clay and dark yellowish brown lean clay with 0–20% chert and a trace dark red fat clay, moist and medium to stiff (possible fill)	Solid Stem Augers	1 4 4
3.5–7.5	Brown lean clay with 10–20% chert and occasional chert cobbles, moist and medium to stiff		
7.5–10	Yellowish brown lean to fat clay with gray and red mottles and 0–10% moist and medium to stiff		
10	Discontinued drilling		

NOTE: * Penetrometer
10YR Hue: 3/1,6/6,7/1,4/4, 2.5YR Hue: 3/6

US Army Corps of Engineers
Little Rock District

Symbol	Description	Date	Appr.

Designed by: NHB
Drawn by: NHB
Reviewed by: NPG
Date: JANUARY 2013
Solicitation No.: N/A
Contract No.:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

Submitted by:
Chief, General Engineering Section

CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI
JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

BORING LOGS PROFILES 4

Drawing Code/ Serial No.

Drawing Ref. No.
PLATE G-9

A/E ANDERSON ENGINEERING, INC.
ENGINEERS • SURVEYORS • LABORATORIES • GEOTECHNICAL

SPRINGFIELD OFFICE: 2045 W. Woodland Street, Springfield, Mo. 65807 (417) 866-2741
JOPLIN OFFICE: 501 E. 15th Street Joplin, Mo. 64804, (417) 782-7399
FT. LEONARD WOOD OFFICE: P.O. Box 147 Ft. Leonard Wood, MO. 65473, (573) 336-8906

BORING LOG

CLIENT: U.S. Army Corps of Engineers
PROJECT: Jordan Creek Flood Control Project
Springfield, Missouri

BORING NO. GSP-4
CLIENT NO. 68907
DATE DRILLED: 12/7/05
DRILL RIG: ATV DRILLER: G.W.

TOTAL DEPTH DRILLED: 10.0'
WATER LEVEL OBSERVATIONS: DURING DRILLING 0 FT.
AT COMPLETION 0 FT.

DEPTH	ELEV.	DESCRIPTION APPROX. SURFACE ELEVATION: ______	SOIL GRAPH	DEPTH	DRILLING METHOD	TYPE SAMPLE	UNCONFINED COMPRESSIVE STRENGTH-LBS/FT 2	WATER CONTENT	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	UNIFIED SOIL CLASSIFICATION
0–3.5		Grass covered dark brown silty lean clay and dark red fat clay with 0-20% chert and some concrete debris, moist and medium to stiff (possible fill)			Solid Stem Augers	8 5 4						
3.5–5		Dark gray lean clay, yellowish brown lean clay and red lean clay with 10-20% chert and occasional chert cobbles, moist and medium to stiff (possible fill)										
5–9		Brown silty lean clay with 10-20% chert, moist and medium to stiff										
9–10		Yellowish brown lean to fat clay with 10-20% chert, moist and stiff										
10		Discontinued drilling										

Depth scale: 1–20

NOTE: * Penetrometer
10YR Hue: 3/3, 2.5YR Hue: 3/6

US Army Corps of Engineers
Little Rock District

Symbol	Description	Date	Appr.

Date: JANUARY 2013
Solicitation No.: N/A
Contract No.:
Designed by: NHB
Drawn by: NHB
Reviewed by: NPG

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

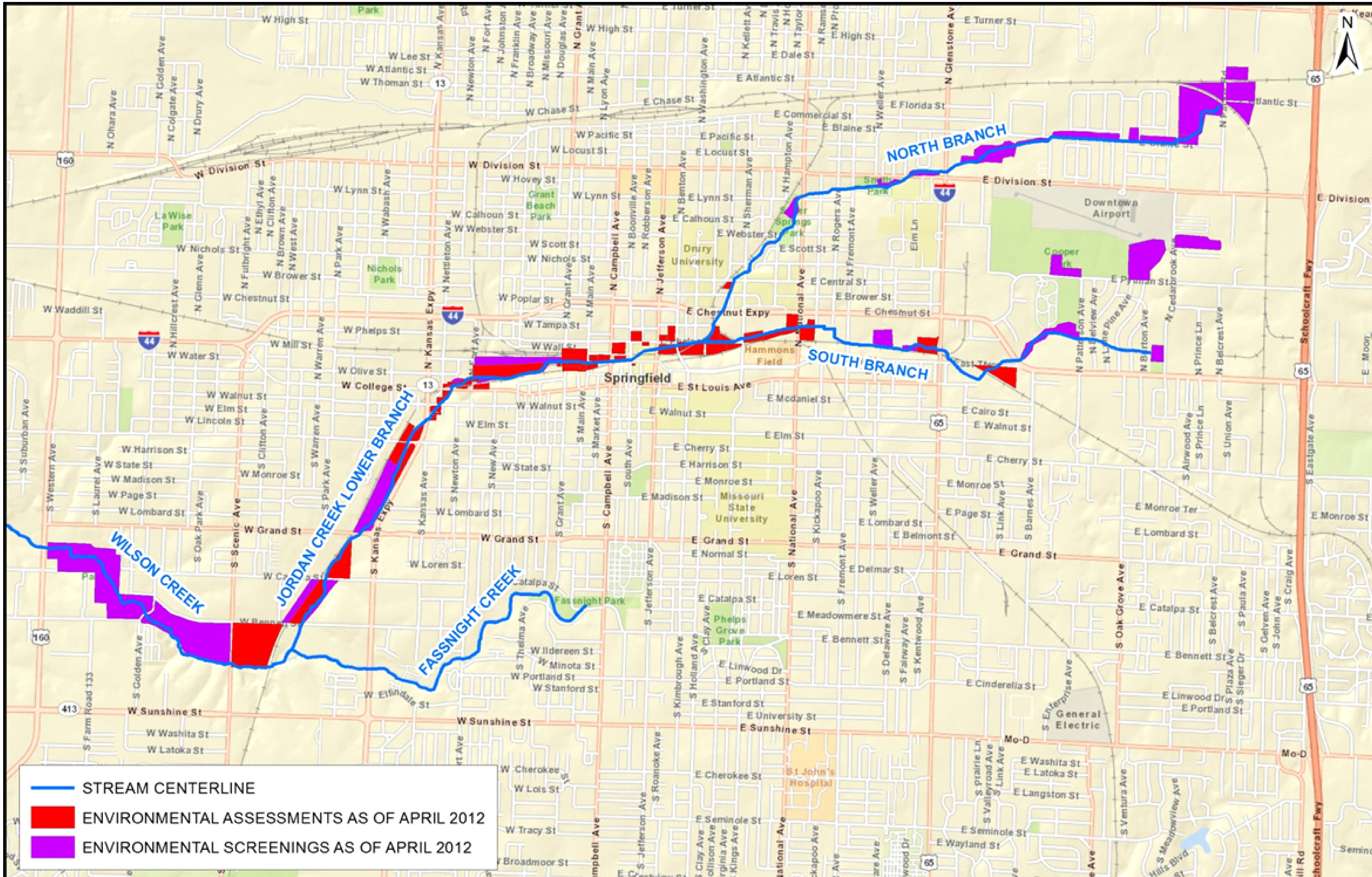
Submitted by:
Chief, General Engineering Section

CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI
JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

BORING LOGS PROFILES 5

Drawing Code/
Serial No.

Drawing Ref. No.
PLATE G-10



US Army Corps of Engineers
Little Rock District

Symbol	Description	Date	Appr.

Designed by: WJP
Drawn by: WJP
Reviewed by: RS
Date: JANUARY 2013
Solicitation No.: N/A
Contract No.:

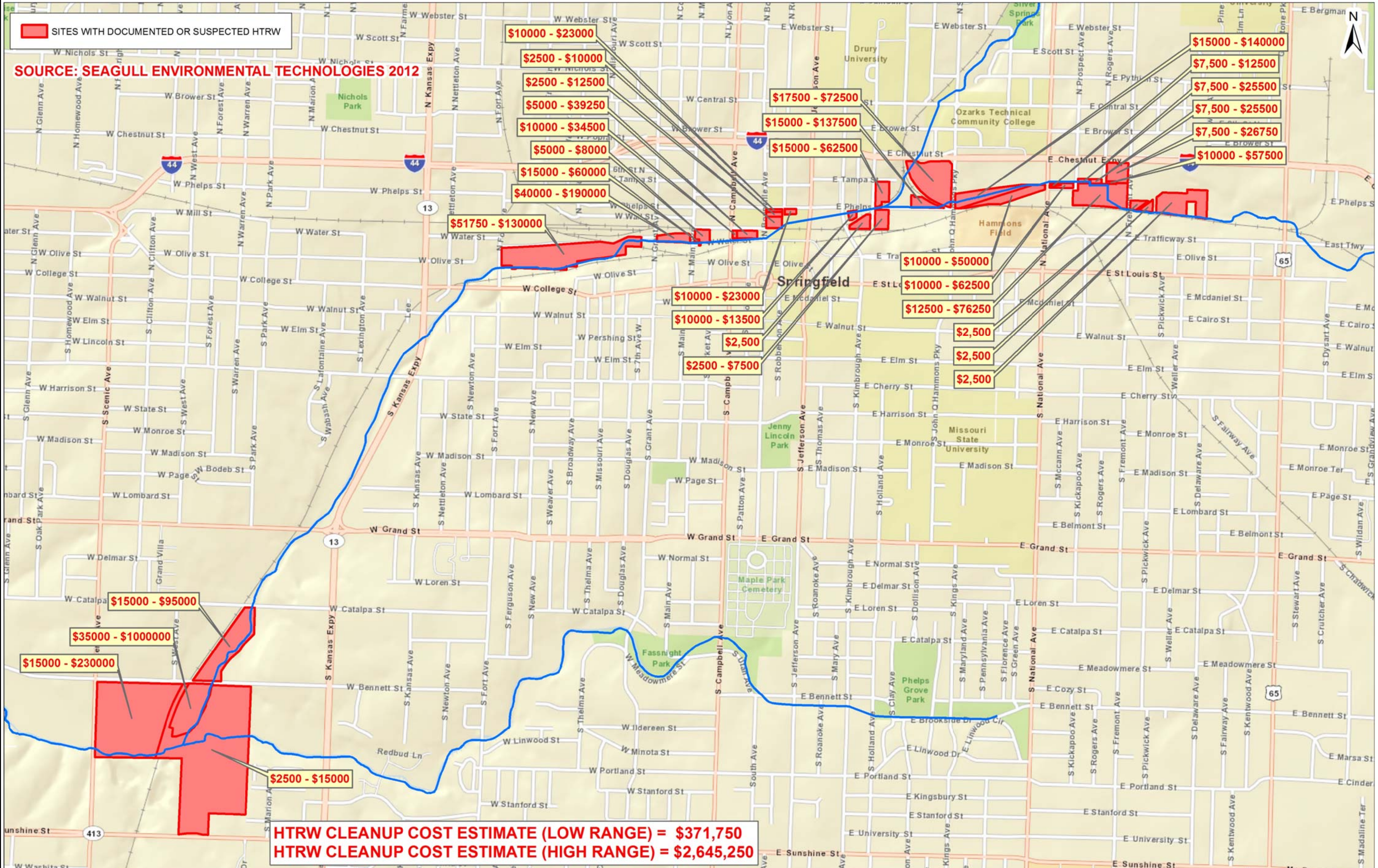
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

Submitted by:
Chief, General Engineering Section

CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI
JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY
ENVIRONMENTAL ASSESSMENTS &
SCREENINGS AS OF APRIL 2012

Drawing Code/
Serial No.

Drawing Ref. No.
PLATE H-1



US Army Corps of Engineers
Little Rock District

Designed by: WJP | Drawn by: WJP | Reviewed by: RS
Date: JANUARY 2013 | Solicitation No.: N/A | Contract No.:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

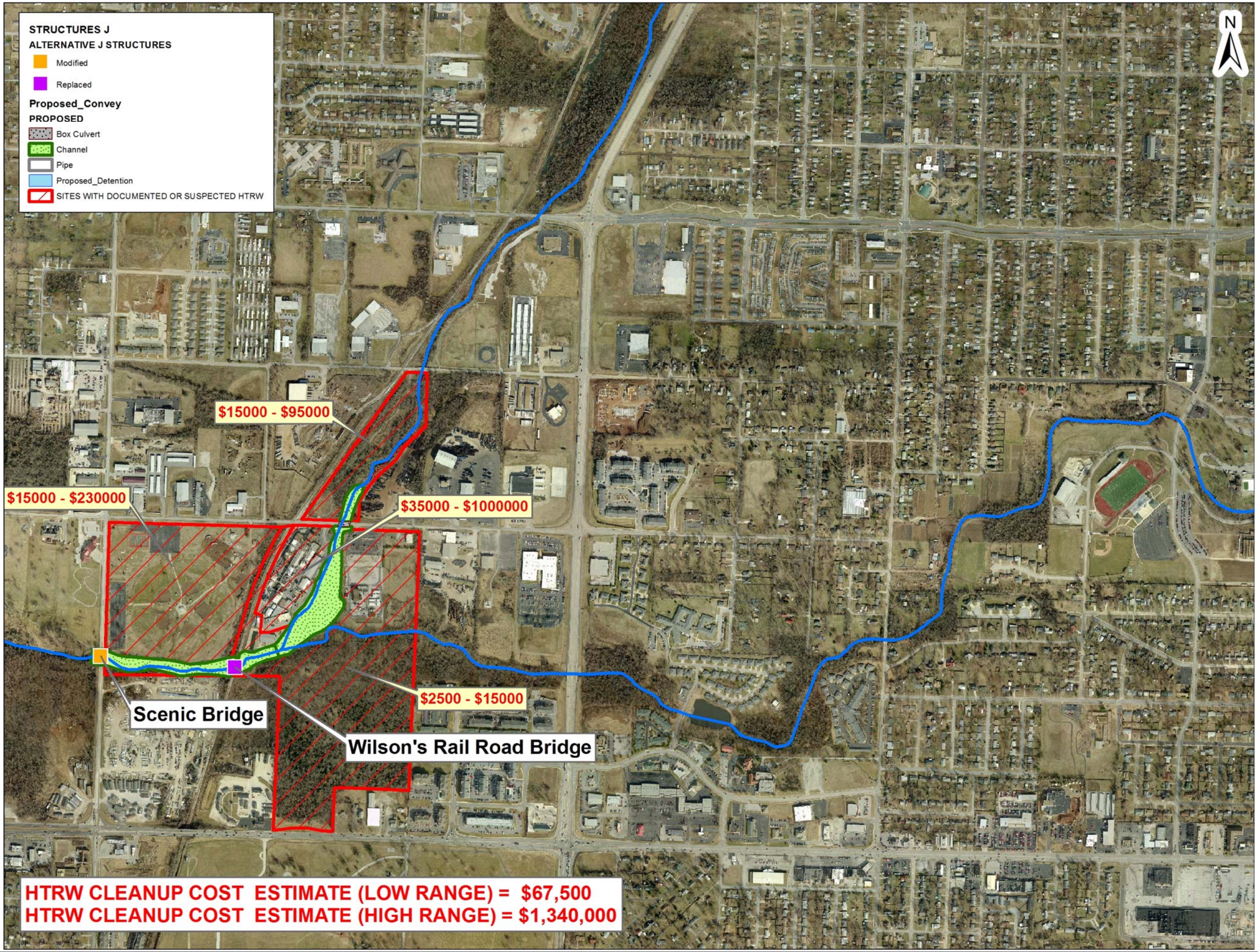
Submitted by:
Chief, General Engineering Section

CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI
JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

HTRW CLEANUP COST ESTIMATES

Drawing Code/ Serial No.

Drawing Ref. No.
PLATE H-2



US Army Corps of Engineers
Little Rock District

Symbol	Description	Date	Appr.

Designed by: WJP | Drawn by: WJP | Reviewed by: RS

Date: JANUARY 2013 | Solicitation No.: N/A | Contract No.:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

Submitted by:

Chief, General Engineering Section

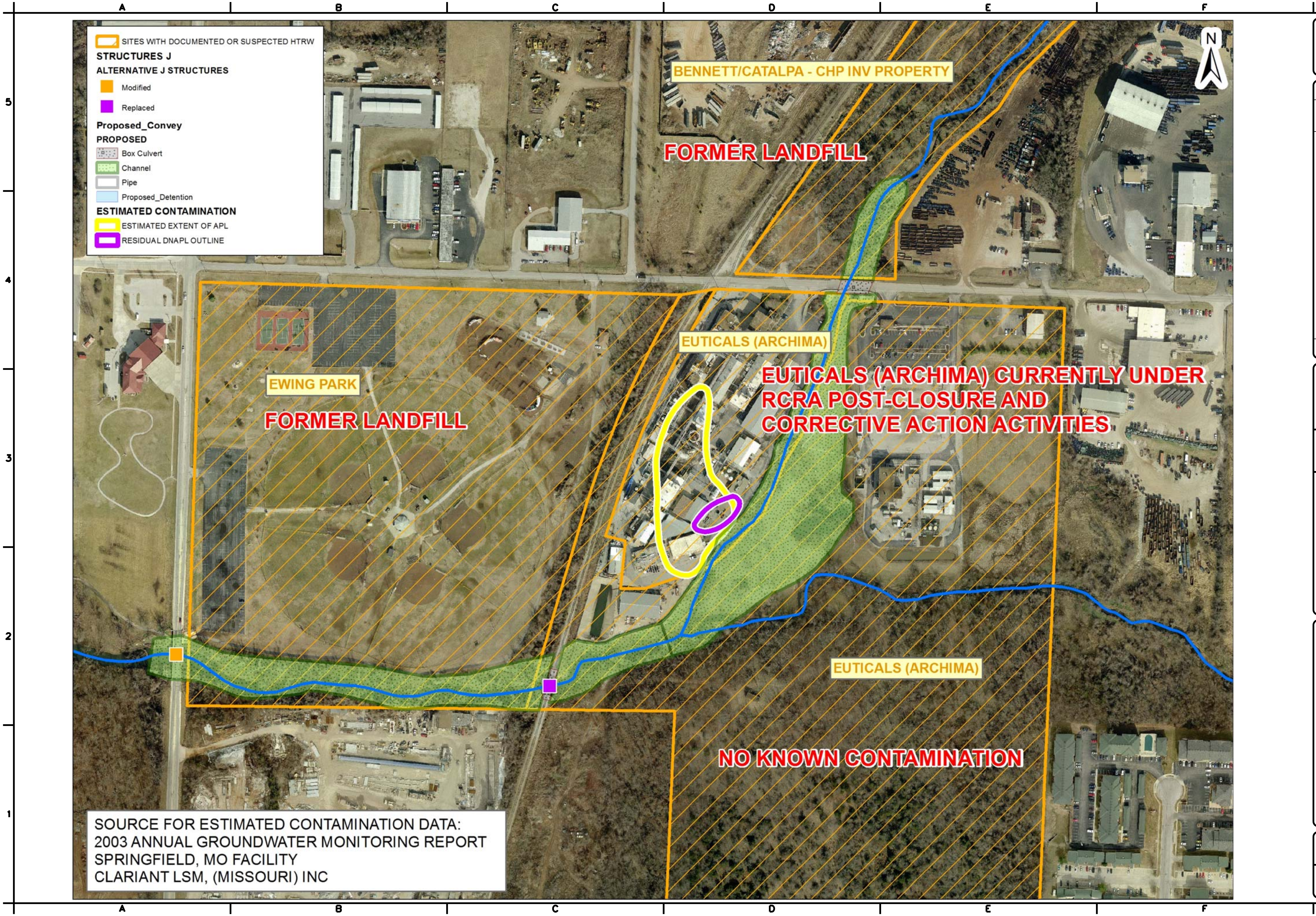
CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI

JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY

HTRW REMEDIATION COST
ESTIMATE FOR PLAN J

Drawing Code/
Serial No.

Drawing Ref. No.
PLATE H-3



US Army Corps of Engineers
Little Rock District

Symbol	Description	Date	Appr.

Date: JANUARY 2013
Solicitation No.: N/A
Contract No.:
Designed by: WJP
Drawn by: WJP
Reviewed by: RS

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

Submitted by:
Chief, General Engineering Section

CITY OF SPRINGFIELD
GREENE COUNTY, MISSOURI
JORDAN CREEK
FLOOD RISK MANAGEMENT
FEASIBILITY STUDY
IDENTIFIED CONTAMINATION AREAS
AT ARCHIMICA PLANT

Drawing Code/
Serial No.

Drawing Ref. No.
PLATE H-4

Attachment A

Jordan Creek Feasibility Study

H&H Report

This report can be downloaded from the following website:

http://www.swl.usace.army.mil/Missions/Planning/SpringfieldMissouriFeasibilityStudy.aspx

Attachment B

Cost Analysis,

Construction Schedule,

& MCACES Cost Estimate

This attachment can be downloaded from the following website:

http://www.swl.usace.army.mil/Missions/Planning/SpringfieldMissouriFeasibilityStudy.aspx

Attachment C

Cost and Schedule

Risk Analysis

This attachment can be downloaded from the following website:

http://www.swl.usace.army.mil/Missions/Planning/SpringfieldMissouriFeasibilityStudy.aspx

Jordan Creek Feasibility Study Springfield, Missouri

Jordan Creek Feasibility Study H&H Report

Model Created By:

Errin Kemper

City of Springfield, MO.

May 2013

Table of Contents: Page

List of Plates

List of Appendices

1. Introduction

Through a cooperative effort undertaken by the City of Springfield and US Army Corp of Engineers as part of the Jordan Creek Feasibility Study, a hydraulic and hydrologic study of Jordan Creek and a portion of Wilsons Creek, tributaries of the James River, located within the city limits of Springfield, Missouri was initiated in 2004. Historically, this basin has suffered numerous floods due to increased urbanization and insufficient drainage capacity. The purpose of this study is to determine the feasibility of flood damage reduction alternatives for the Jordan Creek watershed. This report presents a description of the analytical approach, analyses performed, and the results obtained for a detailed hydrologic and hydraulic study of the approximately 10.2 miles of Jordan Creek and Wilsons Creek that passes through the City. Results of this study include water surface profiles for the 100%, 50%, 20%, 10%, 4%, 2%, 1%, and 0.2% Annual Chance Exceedance (ACE) storm events for without-project (existing) conditions, without-project (future) conditions, and for several respective with-project alternatives.

2. General

2.1. Scope of Work

An analysis of the watershed and stream hydrology and hydraulics was performed using the US Army Corp of Engineers' HEC-1 flood hydrograph modeling package in conjunction with the HEC-RAS river analysis system. The results of this modeling effort were used to develop depth-duration-frequency rating curves for each portion of the study stream. The system was first analyzed under current and future development watershed conditions assuming no implementation of flood damage reduction alternatives. These scenarios were then modified to include a number of project alternatives aimed at reducing flood damages at different portions of the stream.

The downstream limit of federal interest is at the US Hwy 160 crossing of Wilsons Creek at RS 23800. The downstream modeling limit is at Scenic Drive near RS 31152 on Wilsons Creek. The effects of proposed project alternatives in the 1.4 mile reach between Scenic Drive and US Hwy 160 will be considered. Cumulative drainage area at the downstream model limit is about 19.3 sq-mi. The analyses extend upstream along Jordan Creek, North Branch of Jordan Creek, and South Branch of Jordan Creek. The upstream limit of federal interest on North Branch is at about RS 11300, where the drainage area is 1.85 sq-mi. Drainage area 300 feet upstream at RS 11600 is 1.35 sq-mi. The upstream limit of federal interest on South Branch is about 800 feet upstream of Chestnut Expressway at about RS 10950, where the drainage area is 1.58 sq-mi.

2.2. **Watershed Descriptions**

2.2.1. North Branch Jordan

The North Branch of Jordan Creek drains 3.59 sq-mi 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 watershed is evenly divided between industrial/commercial in the upper portions of the watershed and residential in the lower portions of the watershed. The stream travels in a pair of roadside ditches for the first 4000-ft and passes through a regional detention basin on its way through the watershed. Just before the joining the South Branch, the stream passes through a 1000-ft tunnel located under an industrial area. One unique characteristic of this 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 sq-mi (14%) of the watershed, thereby reducing peak flow. The North Branch sub-watershed includes approximately 14 additional stormwater detention basins that were specifically constructed for that purpose.

2.2.2. South Branch Jordan

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

2.2.3. Lower Branch Jordan

The North and South Branches converge to form the Lower Branch of Jordan Creek, which carries runoff form 4.21 sq-mi 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 watershed is highly urbanized with a high number of industrial/commercial developments on the upstream side of the 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 stormwater nearly 3400-ft through the Springfield downtown area. Different portions of this tunnel, which measures approximately 30-ft wide and 10-ft tall, were constructed around the 1930s. The Lower Branch sub-watershed includes 3 constructed detention basins.

2.2.4. Wilsons Creek

Jordan Creek and Fassnight Creek converge to form Wilsons Creek approximately 2000-ft upstream of Scenic Avenue, with Fassnight Creek adding runoff from 5.52 sq-mi of drainage area. Due to limited floodplain development, only a short reach of Wilsons Creek has been included in the study. Wilsons Creek is a natural channel with a moderate slope.

2.3. **Available Historical Data**

Since 1999, the City of Springfield has maintained a number of rainfall gages throughout the Jordan Creek watershed. In the last several years, this number has increased significantly with the addition of a new gage network. Previous to 1999, the local airport was the best source for rainfall information. However, due to the spatial variability of intense storms in Springfield and the location of this gage, the local airport gage may inaccurately reflect the rainfall totals over the Jordan Creek watershed. For example: in June 2008, the airport reported a total precipitation depth of 3.88 inches while gages in the Jordan Creek watershed reported depths of 4.5 to 5.4 inches.

In recent years, including the July 2000 flood, Doppler radar images have provided a source of rainfall information. The results of published regional rainfall frequency analyses were used in lieu of analyses based on local data due to the short period of record for which local data is available. Reliable local precipitation data sufficient to accurately describe the spatial and temporal variation in significant observed rainfall events does not exist in conjunction with reliable observed peak stream flow data, and thus was not used for hydrologic model calibration.

The USGS has continually operated a flow gage at Scenic Avenue near the downstream limits of this study since 1931, but annual peak flow data is available only since 1999. During the flood of July 2000, this gage appeared to give inaccurate readings for the large flood flows. The rating curve for this gage has since been modified, but information on the July 2000 storm is still questionable. During the 2000 storm event, a local gage was in place on the North Branch of Jordan Creek and was destroyed by flood flows before any useful information was taken.

In addition to the USGS gage at Scenic Avenue, the pharmaceutical manufacturing plant just downstream of Bennett Street on Jordan Creek maintains a series of stream gages. Data for this gage was available during the flood of July 12, 2000.

Appendix HH-F summarizes the information available from the USGS gage at Scenic and the gage downstream of Bennett Street and compares this data to the hydrologic and hydraulic models created as part of this study. Appendix F also summarizes the estimated flood heights taken from high water marks found throughout the watershed.

2.4. **Previous Studies**

Hydrology and Hydraulics Report South Branch Jordan Creek – Box Culvert from National Avenue to Sherman Avenue; December 2004; Harrington and Cortelyou. Size an enclosed structure between National Avenue and Sherman Avenue.

Jordan Creek – South Branch Sinkhole Assessment Project; Spring 2005; SMSU. An evaluation of Sinkhole Flooding, Stability & Non-point Sources.

Jordan Creek – Story of an Urban Stream; Loring Bullard. An historic account of Jordan Creek.

Flood Insurance Study, City of Springfield, Missouri, 2002 – The City revised the Federal Emergency Management Agency (FEMA) preliminary flood insurance studies. The City developed more detailed hydrologic and hydraulic models and used recent aerial photos, two-foot contours, and GIS technology to produce improved mapping. The revised maps are currently issued by FEMA as "Preliminary". The potential effective date is unknown at this time.

Flood Insurance Study, City of Springfield, Missouri, FEMA, Preliminary by Michael Baker, Jr. Inc., June 2000 – This study revises and updates the previous Flood Insurance Study/Flood Insurance Rate Map for Springfield, Greene, and Christian counties, Missouri. The information will be used to update existing floodplain regulations and further promote sound land use and floodplain.

James River-Wilson 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 Wilson Creek. The project included measurements of physical and chemical parameters, biological studies, and a groundwater study.

Flood Plain Information – Wilson Creek and Tributaries; November 1968; U.S. Army Corps of Engineers, Little Rock District. Provides information and photographs regarding flooding.

Comprehensive Stormwater Report for Springfield Missouri; 1964; Crawford, Murphy, Tillie. Established peak flow rates and identified capital improvement needs.

Water Resources Data – Missouri; Annual Publication; USGS. Gage data at two to three locations below the Jordan Creek watershed.

Jordan Creek Baseline Water Quality Project – August 2004 to July 2005. Ozarks Environmental and Water Resources Institute and Missouri State University. This report describes the baseline water quality trends for the upper Wilson-Jordan Creek watershed.

Major Rainfall Events of 2000 – Springfield Missouri; 2000; Todd Wagner, PE., Engineering Division, Department of Public Works, City of Springfield, Missouri. Summarizes the rainfall events and flooding from the July 2000 rains.

Preliminary Report on Flood Damage Resulting From 7/12/2000 Rain Event; 2000; Todd Wagner, PE. Summary of the rainfall and flood damage that occurred during the July 12, 2000 rainfall event.

City of Springfield Inter-Office Memorandum: 634 E Phelps – Commercial Metal Property; 2008; Errin Kemper, PE. Department of Public Works, City of Springfield, Missouri., Memorandum on the reported flood depths at 634 E Phelps and 509 N Washington.

Lessons Learned – Flooding September 23-25, 1993 – November 1993. City of Springfield Missouri. Documents the lessons learned during the September 1993 floods.

2.5. **Historic Floods**

Records available to the City of Springfield indicate that the following flood events have occurred in the Jordan Creek watershed. Prior to the 1900's, major floods occurred in 1844, 1859, 1866, 1868, 1871, and 1876. The current large box culvert which carries the Jordan Creek through most of the downtown area was constructed in 1928, primarily as a response to the 1909 flood. Many of the other large box culverts and channels along Jordan Creek were constructed during the 1930s.

2.5.1. July 1909

The U.S. Weather Bureau recorded 6.55 inches of rainfall in 24 hours on July 7, 1909. The resulting flood was considered to be a landmark flood in later years. Newspaper articles stated that "the water was all over the Wilson and Jordan Creek bottoms" and that it was the "worst rain ever known in Springfield". Many people were rescued from the flood, but there were no human causalities. It was estimated that over 100 horses had drowned and damages to downtown businesses topped one-half million dollars.

2.5.2. June 1932

The precipitation on June 26-27 amounted to 6.8 inches in 24 hours with 3.4 inches occurring in a 2 hour period. Two persons drowned in streams in and near Springfield. The flood was the largest known flood up to that time on Jordan Creek. The peak discharge at the USGS gage on Wilson Creek was estimated to be about 3,600 cfs. It is assumed that the gage referenced in reports was located at Scenic Ave. The following are newspaper excerpts concerning the June 1932 flood at Springfield. *From the Springfield News Leader and Press – June 27, 1932*: "CITY SUFFERS HEAVILY IN FLOOD: CHIEF HAVOC ALONG THE JORDAN. Widespread damage from last night's sudden deluge and resulting floods were reported all day today. Chief damage was in the Jordan Valley, where everything was flooded, including homes and warehouses. Extensive, severe, and expensive damage to City streets was reported by the City Engineer…. In the offices of the Kelly Coal Company the water was 26 ½ inches above the floor, seven and a quarter inches higher than during the cloudburst of 1909."

2.5.3. July 1951

Total precipitation from this storm amounted to only 3.9 inches. However, 2.13 inches fell in one hour and 3.1 inches were recorded in a 3 hour period. The flood resulted in heavy damage along Jordan Creek. Water was over the platform of the Frisco freight station and was waist deep at the Hoffman-Taft plant on West Bennett Street. The following are newspaper excerpts concerning the July 1951 flood at Springfield. *From the Springfield News Leader and Press – July 4, 1951*: "HOLIDAY STORM BRINGS CITY FLASH FLOODS, HEAVY DAMAGE. Fickle weather last night and early today, sending rivers out of their banks; dashing Springfield with record rainfall and causing thousands of dollars of property damage….Jordan Creek ran out of its banks early in the night flooding numerous streets…leaving about a foot of water standing in the freight yards…Most extensive damage was caused at Hoffman-Taft, Inc., a pharmaceutical manufacturing plant…Hundreds of drums of valuable chemicals were carried away by the flash flood."

2.5.4. September 1993

Severe flooding occurred several times throughout September 1993, the most severe resulting from 8.3 inches of rainfall in 30 hours on September 24-25. With soil conditions already saturated from previous rains, the storms of September 24th and 25th produced massive flooding throughout the Jordan Creek watershed. The storm was categorized as a 100-yr flood and Greene County was declared a disaster area.

2.5.5. July 2000

On July 12, 2000, the Jordan Creek watershed received 6-8 inches of rain in approximately 6 hours (the majority of the rainfall occurring in a 2-hr timeframe), resulting in what appeared to be on the order of a 2% to 1% ACE event. The temporal distribution of this rainfall event appeared to match very closely to the Huff's 1st quartile distribution used for this hydrologic analysis. Floodwaters were 4 to 6 feet deep in some places and swept through at least 124 homes and displaced more than 100 people. The following day, city officials estimated at least $2 million in damages to public property including damages to roads and parks. Coal deliveries to the city's power plant were also delayed because of flood damages to railroad tracks (*Springfield News-Leader*, July 14, 2000). Immediately after the storm event, City crews collected photographs of a few of the high water marks left behind. These photos have allowed the City to compare flood heights from the 2000 storm with those produced by the hydraulic model. See Appendix HH-E and F for more information.

2.5.6. May 2002

On May 8, 2002 the Jordan Creek watershed received 3.47 inches of rain in approximately 6 hours (the total for the entire day was 4.72 inches). This storm was estimated at a 20% ACE event. The USGS gage estimated a peak flow of 4360 cfs while the HEC-1 model produced for this study indicates a 5-yr 6 hour peak flow of 4457 cfs.

2.5.7. September 2005

On September 15, 2005 the Jordan Creek watershed received 2.23 inches of rain in one hour. 3 hours later, the watershed received another 1.86 inches over a period of 1.5 hours. The USGS gage does not have a record of exactly when the river levels peaked compared to the rainfall event so it is difficult estimate the frequency of storm that caused the peak. However, given the response time of the watershed it is likely that the peak occurred during or after the second rainfall event. Since the HEC-1 model used for this study is a single-event simulation, it is difficult to make a reasonable flow comparison but it appears that the storm was on the order of a 50% to 20% ACE event with a short (1-2hr) duration.

2.5.8. June 2008

On June 13, 2008 the Jordan Creek watershed received 4.5 to 5.4 inches of rain over a period of about 8 hours. By 2008, the City of Springfield was operating a complex rain gage network across the city. The 4 gages located within the watershed indicated a storm with a 10% to 4% annual chance frequency. The USGS gage at Scenic Avenue along Wilsons Creek, at the downstream limits of the project, indicated a peak discharge of 5760 cfs. According to the hydrologic model produced as a part of this study, the corresponding peak flow rate should be between 5530 (10% ACE) and 6995 (4% ACE). In addition, field observations and flooding reports made during the June 13 have allowed the City to compare observed water surface elevations with those shown in the hydraulic study. See Appendix HH-F for more details.

3. **Without Project Hydrologic Modeling**

3.1. **Overview**

This report presents the results of a hydrologic modeling effort created by the City of Springfield in cooperation with the US Army Corp of Engineers. Each model was created using the Army Corp of Engineers HEC-1 flood hydrograph package and simulates the rainfall-runoff process for large storm events in the Jordan-Fassnight Creek watershed. Two separate models were created in order to simulate runoff for current land use conditions and expected ultimate development land use conditions. The *current* land use model reflects development in the watershed as of about 2003. This includes current impervious areas and all significant storm water improvements and detention basins. The *ultimate development* model is a variation of the current model with land uses projected to 2053 based on current zoning. More information on the development of these models is found below.

3.2. **Physical Watershed Parameters**

Each sub basin found in the HEC-1 model is defined as "an area contributing flow to the watershed". Characteristics of each sub basin were input into the model in order to represent how the watershed responds to a rainfall event. In HEC-1, each watershed parameter is described on a "card" or line of code.

A GIS layer is available that shows the boundaries of each sub basin as well as information on the various characteristics of each. Each version of the model uses the same sub basin delineation. These sub basins are shown on Plate E.

3.2.1. Basin Statistics

The Table 1 includes the general statistics for each major watershed used in the model.

Table 1: Basin Statistics

	North Branch	South Branch	Lower Branch	Fassnight Creek
Number of Sub Basins	70	75	53	32
Total Area (acres)	2298	3239	2692	3531
Sub Basin Size Range (acres)	5.1 – 136.5	7.4 – 132.6	0.7 – 256.0	13.2 – 383.7
Sub Basin Mean Area (acres)	32.8	42.6	50.8	110.3

3.2.2. Area (BA Card)

The area for each individual sub basin in the model was calculated using ESRI's ArcMap software. Area for each basin is listed in both acres and square miles in the model input.

3.2.3. Overland Flow Elements (UK Card)

Most of the sub basins used in this model contain two overland flow elements. One element represents overland flow across the directly connected impervious areas found within each sub basin. The second element represents overland flow across the pervious surfaces within the sub basin. For each of these overland flow elements, an SCS Curve Number (CN) is defined in order to describe infiltration across the basin and to establish rainfall runoff volumes.

The length and slope of each overland flow element was estimated using the City's two-foot digital contours and digital aerial photos and represents an average value for each element in the sub basin.

A "Manning's roughness factor" for overland flow was used for each overland flow element. Typically, a roughness factor of 0.10 was used to describe the impervious flow element while a roughness factor of 0.20-0.25 was used to describe the pervious flow element.

3.2.4. SCS Curve Number and % Impervious (LS Card)

3.2.4.1 Current Development Model

For each type of overland flow element, an SCS Curve Number was defined in order to establish infiltration parameters. For the flow element representing impervious areas, a CN of 98 was chosen according to the SCS Curve Number guidelines. For the pervious overland flow element, a CN was used that best represented the pervious areas found in the watershed. CN values were determined using the City of Springfield's "Design Standards for Public Improvements" AMC II. This "pervious" CN was estimated through the use of an automated GIS procedure developed by the City of Springfield.

This procedure divides each watershed into a series of one-meter grid cells. Using infrared satellite imagery, the different color bands are manipulated so that each cell falls into one of three categories; tree cover (low reflectivity), w/o tree cover (med reflectivity), and impervious (high reflectivity). Each of these cells are then classified according to soil type, and land cover. A curve number is assigned to each grid cell according to this classification. Once a CN has been established for each cell, the average grid cell value is calculated over all of the pervious areas within a sub basin and a % impervious is calculated for all cells found to be impervious. The Table 2 shows the CN values used to calculate the composite CN for each basin. Appendix HH-A contains a table of all sub basins and their respective pervious Curve Numbers and % Imperviousness. The watershed is small urban and well defined which led the modeling to give a high degree of certainty (i.e. low uncertainty) with regards to the definition of the infiltration rates.

Table 2: Table of Curve Numbers

Grid Cell Classification	Curve Number
Impervious Areas	98
HSG B w/o Tree Cover	73
HSG B w Tree Cover	61
HSG C w/o Tree Cover	82
HSG C w Tree Cover	74
HSG D w/o Tree Cover	86
HSG D w Tree Cover	80
Compacted Fill w/o Tree Cover	86
Compacted Fill w Tree Cover	80

Future Conditions Model

For the future conditions model, GIS was used to find a percentage of imperviousness for each sub basin based on current zoning. A GIS layer was created that assigned a % impervious to each zoned area as well as each street and right-of-way. This layer was then used to assign a % impervious to each sub basin. Appendix HH-C contains values of % impervious used for each type of zoning. It should be noted that these values do not include streets and right-of-way. In other words: a zoning of R-SF (residential single family) may indicate an impervious value of 25% but with the streets included in the analysis, the overall impervious area for a totally R-SF sub basin will likely be around 40%.

In addition, for all pervious flow elements found in the model, the curve numbers used were 15% higher than those found in the current development model. This is an effort to simulate the effects of development (i.e. grading, compacting, sodding) on pervious areas. 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 equates to about 15 percent. It is a reasonable assumption to assume that there will be areas that redevelop more than other areas, but the soils in general will become more compacted during the period of evaluation.

3.2.5. Channel Flow Routing Elements

As part of the process of determining model parameters, the wave celerity output from HEC-1 was used as an estimate of runoff velocity in the modeled channels. Every channel section was checked during the modeling process to make sure the velocity estimate fell within a reasonable range (Usually 2-12 fps based on the slopes in this watershed). If a velocity was found to be too high or low either the channel’s geometry or roughness coefficient were modified accordingly. The modeler ensured that geometries and roughness coefficients fell within a range consistent from one sub basin to the next

Current Development Model

The channelized flow elements for each sub basin were determined by examining the information contained on the City’s GIS system. Aerial photographs and digital contours were used to estimate flow lengths, slopes, and geometry for each channel.

Manning’s roughness coefficients, as well as channel geometry, were established so that channel flow velocities would remain reasonable. While these parameters may not accurately reflect the physical geometry of the watershed, they force the kinematic wave and dynamic equations to more effectively model channelized flow during the overbank flooding condition.

Future Conditions Model

In an effort to simulate the effects of future stormwater conveyance on the watershed’s time of concentration, roughness factors for each of the channelized flow elements were reduced. The rational being that as a parcel of land develops, pipes and channels will 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%. In effect, this assumes that any “improved” channels will remain improved and any “rough channels” ($n > 0.035$) will be improved in the future.

3.2.6. Kinematic Wave Routing (RK Card)

For the overland flow elements and relatively short routing reaches in the headwaters, the Kinematic Wave equation was used to model channelized flow. While this method does not provide for attenuation of the flood wave, it is applicable in areas where flood storage is minor.

Overall, the use of Manning's roughness coefficients for channel flow was higher than those published for use with a "normal depth" type equation, simply because the kinematic wave equation produces higher velocities. However, the mannings n values were adjusted to produce a reasonable response time throughout each sub watershed.

3.2.7. Muskingum-Cunge Routing (RD Card)

For main channel routing in areas with a significant contributing watershed, the Muskingum-Cunge method is used with an 8-point cross section. In order to determine which reaches were to be modeled in this manner, the watershed was examined for areas with significant channel geometry as well as significant upstream drainage area. The Muskingum-Cunge procedure allows the use of multiple Manning's "n" values at different depths to better simulate peak attenuation during flood events. Each of these reaches were modeled using one of four representative 8-point cross sections; small, medium, large, and "downtown" (representing the large underground box culvert). Each channel was examined to determine which category it fit into and the corresponding 8-point cross section was used. The channel length and slope used was determined from the information available on the GIS. Cross sections of each of the three standard channel sections are included in Appendix HH-D.

3.2.8. Modified-Puls Routing (SV-SQ Cards)

For sub basins LJ34, LJ6, LJ2, LJ25, LJ8, LJ2, SJ27, SJ44A, SJ44B, SJ45, and NB58 the Modified-Puls method was used to better simulate peak attenuation due to large amounts of flood storage. These areas in the watershed were chosen because of the backwater effects caused by a nearby culvert or constriction. Using storage-flow values found in the HEC-RAS model, a relationship was built to route flow through each of these sub basins. Appendix HH-B contains a table of information used for each routing element. Some of these routing features provided very little attenuation of the flood hydrograph while others caused a significant decrease in peak flow.

3.2.9. Reservoir Routing Elements

Areas of detention within a watershed are one of the primary factors affecting the rainfall-runoff response. These detention areas include local detention basins, regional (in-line) detention basins, and areas of ponded water behind highway and railroad culverts.

The occurrence of debris in the waterway has very little impact on peak flows. The watershed is primarily urban with comparatively little woody vegetation adjacent to the waterway. Property owners are required to maintain detention basins and keep them functioning. Occasionally, clean out of debris from a culvert or pipe occurs, but the storage behind these structures is insignificant and does not impact overall peak flows (if the culvert backs up, the water just runs overland).

Elevation vs. Storage (SA and SE Cards)

The elevation-storage relationship for each reservoir routing element was determined from the City's digital two-foot contour maps. The area of each closed contour within a basin was calculated and entered into the HEC-1 model.

Elevation vs. Outflow (SQ and SE Cards)

The elevation-outflow relationship for each reservoir routing element was typically determined from field measurements of the controlling outlet structure. However, when as-built construction plans were available, they were used to develop the outflow-rating curve.

Future Conditions Model

The City of Springfield's Stormwater Detention Ordinance requires that all new development provide detention such that peak flows leaving the site do not increase. In an effort to simulate this in the *ultimate development* model, a number of "mock" detention basins were added at various locations. Each of these basins represent probable locations for on-site or regional detention as the watershed develops. A total of 38 "mock" detention basins were placed downstream of areas that showed significant amounts of potential development. Each of these basins were designed so that peak flows for the 1-, 10-, and 100-yr events matched the "current development" model at the same location. Many of these "fake basins" were placed downstream of small sub basins, but most were representative of regional detention and covered larger areas.

Nearly all potential development was accounted for using a "fake basin". However, in areas with small development potential or areas along the stream where the local ordinances would not require detention, basins were not included. As expected, the peak flows immediately downstream of each mock basin matched that produced in the current conditions model. However, the increase in runoff volume produced by additional impervious area (development) causes an increase in peak flows throughout each stream.

3.2.10. Sinkholes

Much of the South Branch of Jordan Creek contains sinkholes. Approximately 20% of this watershed contains sinkholes that do not overflow during a 1% ACE event and therefore do not contribute flow to the rest of the watershed. However, there are many sinks that do fill up during a rainfall event and eventually spill into a nearby sink or drainage way. These sinkholes were modeled in HEC-1 as a series of reservoirs. The depth-volume relationship was calculated using the City's 2' digital contour data and the depth-outflow characteristics were estimated using broad-crested weir equations to simulate sinkhole overtopping. The model contains all of the sinkholes that contribute flow to Jordan Creek as well as a few that do not overtop.

3.3. Rainfall Data

The HEC-1 models were set up using a single-event simulation of a synthetic rainfall event. The rainfall data used for each HEC-1 model is from the "Rainfall Frequency Atlas of the Midwest" by Floyd A. Huff and James R. Angel. This report was prepared in conjunction with the Midwestern Climate Center and the Illinois State Water Survey. The City of Springfield feels that the information contained in this report provides an accurate representation of the types of storms seen in this area.

3.3.1. Depth

The depth of rainfall for each simulated storm was taken from Table 7 of the Rainfall Atlas of the Midwest - “Sectional Mean Frequency Distributions for Storm Periods of 5 Minutes to 10 Days and Recurrence Intervals of 2 Months to 100 Years in Missouri.” The entire table can be found in Appendix HH-H of this report. Tables 3-5 are a summary of this data.

Table 3: Duration vs. Depth of Rainfall

Storm Duration	1% ACE Rainfall Depth
24-hr	8.18
18-hr	7.69
12-hr	7.12
6-hr	6.14
3-hr	5.24
2-hr	4.74

For rainfall frequencies other than the 1% ACE, a fraction of the total 1% ACE rainfall depth was determined using Table 4.

Table 4: Frequency vs. % of Total 100-yr Depth

Frequency (yr)	% of Total 100-yr Depth
1	0.37
2	0.46
5	0.59
10	0.68
25	0.80
50	0.90
100	1

Table 5: Hypothetical Design Storm Precipitation

Hypothetical Design Storm Precipitation [in]								
Duration [hrs]	Recurrence Interval [yrs]							
	1	2	5	10	25	50	100	500
3	1.94	2.41	3.09	3.56	4.19	4.72	5.24	6.39
6	2.27	2.82	3.62	4.18	4.91	5.52	6.14	7.49
12	2.61	3.28	4.17	4.84	5.71	6.40	7.12	8.69

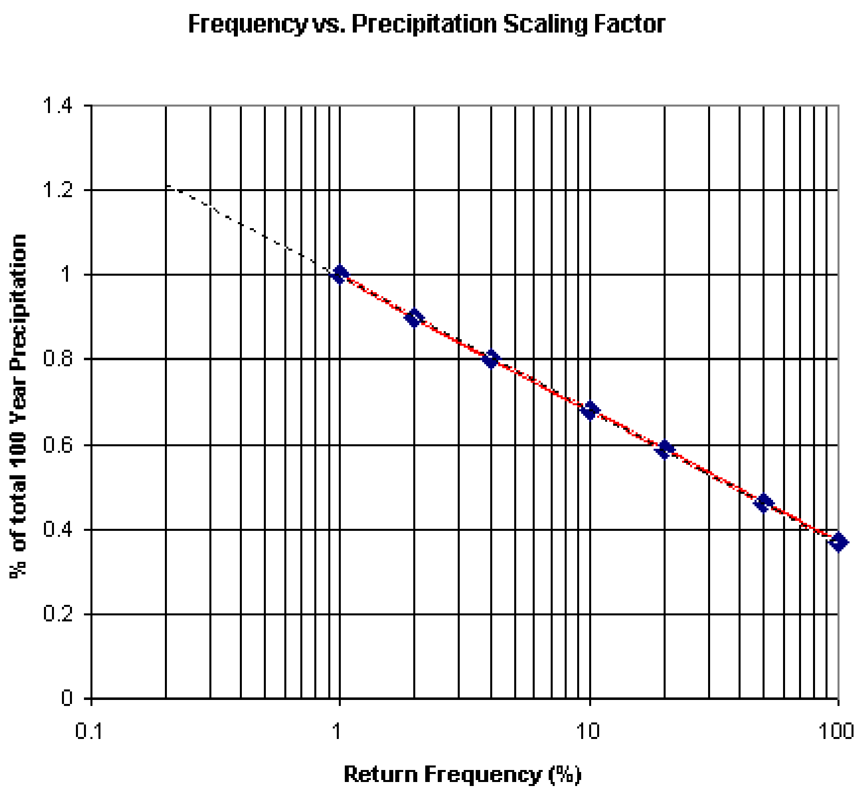
In addition, fractions of the 1% ACE rainfall depths found in table 4 were computed and used as the basis for extrapolating the 0.2% ACE rainfall depth which was found to be 122% of the 1% ACE event. Tables 6 displays this information.

Table 6: 500-yr Storm Extrapolation

The following information is from the "Rainfall Atlas of the Midwest" and was used to estimate the 0.2% ACE storm event

Recurrence interval	% Probability	% of 1% ACE event
1	100	0.3672
2	50	0.4609
5	20	0.5859
10	10	0.6797
25	4	0.8021
50	2	0.8984
100	1	1
500	0.2	

0.2% ACE event estimated at 122% of 100 year total rainfall



3.3.2. Duration

Simulations of the 2-hr, 3-hr, 6-hr, 12-hr, 18-hr, and 24-hr storms were performed using HEC-1. For each flow rate used in the HEC-RAS model, the largest peak flow rate simulated from each of these storms was used. However, due to the inability of a small duration storm to produce rainfall over a large area as it is simulated in the HEC-1, the 2-hour storm became inapplicable for a drainage area greater than 1.5 square miles. For the same reason, the 3-hour storm became inapplicable for a drainage area greater than 10 square miles.

3.3.3. Distribution

The distribution of each storm was taken from the "Rainfall Atlas of the Midwest - Table 10. *Median Time Distributions of Heavy Storm Rainfall at a Point."* Figure 1 is an illustration of these distributions. The City of Springfield recommends the use of these rainfall distributions in its design criteria manual. It has also been observed that many of the major rainfall events in this area tend to follow these distributions closely. The 1st Quartile distribution was used for all storms with duration of 1 to 6 hours. The 2nd Quartile distribution was used for all storms with a 12-hour duration and the 3rd Quartile distribution was used for all storms with 18 to 24 hour duration.

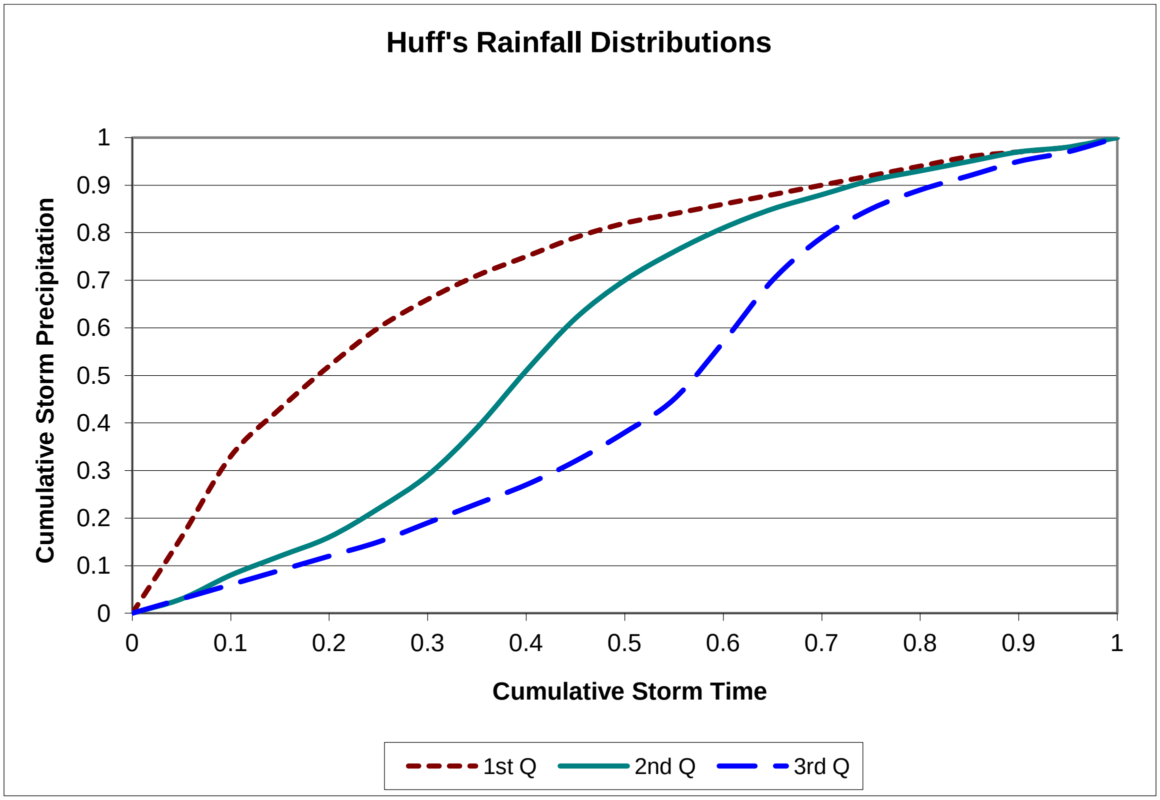


Figure 1: Huff's Rainfall Distributions

3.4. **Flow Analysis Results**

For each location in the watershed corresponding to a point in the hydraulic model, flows were determined for each frequency-duration combination. These results are summarized in Plate A. In addition, Appendix HH-F shows how flows from the HEC-1 model compare to the USGS Gage at Scenic Avenue located just downstream of the project area on Wilsons Creek.

4. **Without Project Hydraulic Modeling**

4.1. **Overview**

This HEC-RAS model was created as part of the USACE Jordan Creek Feasibility Study and includes all of Jordan Creek as well as portions of Fassnight Creek and Wilsons Creek. Included in Appendix HH-G of this report is photographic documentation of each reach as of October 2005.

4.1.1. Jordan Creek

Jordan Creek is a classic urban stream throughout most of its length. The upstream reaches consist of grass ditches with small culverts capable of carrying the 100% to 50% ACE events. The mid section of each reach includes concrete and natural channels, some regional detention, larger culverts capable of conveying the 20%-10% ACE event, and a number of very long tunnel reaches with varying capacity. The downstream portion of this stream is mostly natural channel with an assortment of conveyance improvements, bridge and culvert structures, and grade controls such as culverts and utility crossings.

4.1.2. Fassnight Creek

Fassnight Creek is primarily a natural urban stream with an assortment of culverts, utility crossings (i.e. grade controls), and channel improvements. Near the downstream end of the reach is a small lake that serves as an in-line regional detention basin. While Fassnight Creek is included in the hydraulic model, the reach is not a formal part of this study.

4.1.3. Wilsons Creek

The portion of Wilsons Creek included in this study is a natural urban stream with a gravel bed and very few man-made obstructions in the overbank areas. This reach includes two bridge structures and no channel conveyance improvements.

4.2. **Spatial Geometry**

The HEC-RAS model extends throughout the Jordan Creek and Fassnight Creek watersheds as well as a portion of the Wilsons Creek watershed. The extents of the detailed hydraulic modeling are included in Table 7 below.

Table 7: Stream Hydraulic Study Limits

Stream	Upstream Limit	Downstream Limit	Total Length
Jordan Creek – North Branch	40-ft downstream of Packer Rd.	Confluence with Jordan Creek – South Branch	18,653 ft (3.5 mi)
Jordan Creek – South Branch	200-ft upstream of Burton Ave.	Confluence with Jordan Creek – North Branch	14,475 ft (2.7 mi)
Jordan Creek – Lower Branch	Confluence with Jordan Creek North and South Branches	Confluence with Fassnight Creek	16,695 ft (3.2 mi)
Fassnight Creek	Fassnight Park 530-ft downstream of Campbell Ave.	Confluence with Lower Jordan	11,358 ft (2.2 mi)
Wilsons Creek	Confluence of Jordan Creek – Lower Branch and Fassnight Creek	1970-ft downstream of Scenic Ave.	3,963 ft (0.75 mi)

The HEC-RAS model is made up of a total of eleven different reaches representing the five streams and two major tunnels. There are a total of 553 cross sections, 63 bridges and culverts, and 2 lateral structures. Figure 2 shows the reach connectivity.

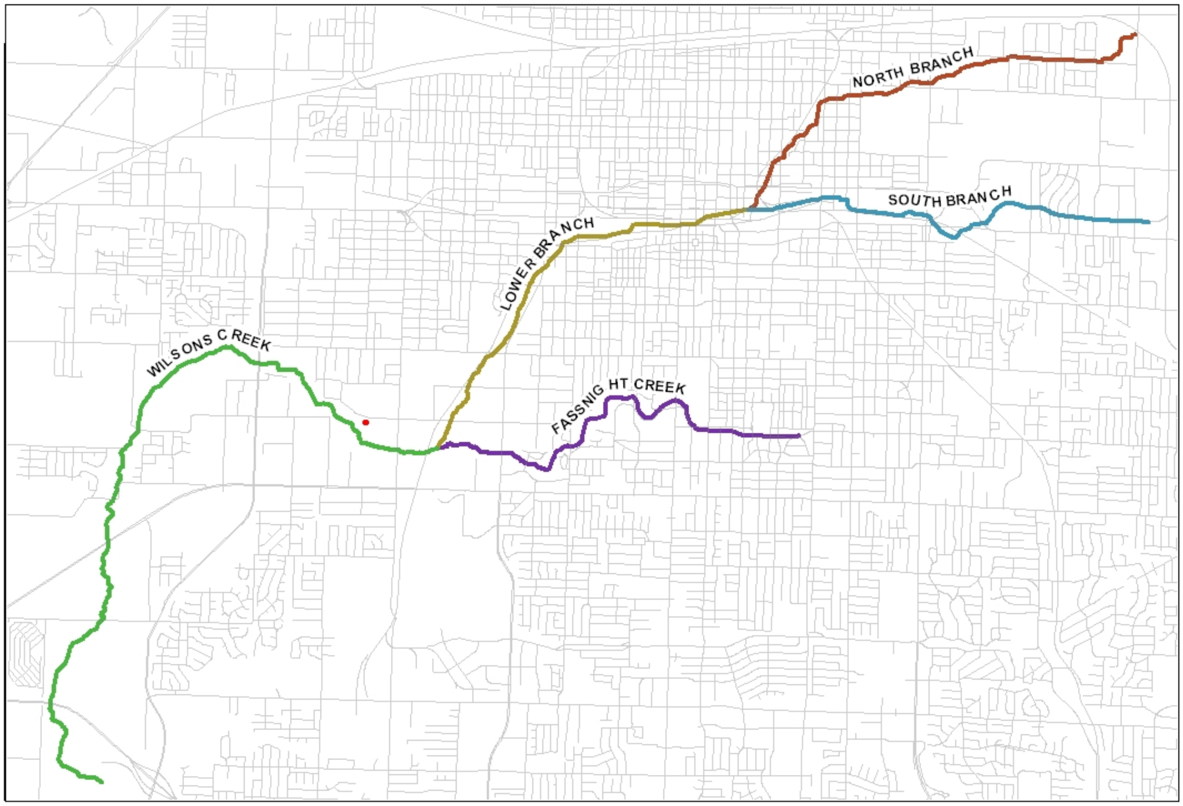


Figure 2: Reach Connectivity

4.3. Hydraulic Model Parameters

This model was created using HEC-RAS 3.1.3 as well as ESRI's ArcGIS. Many of the parameters used to build this model were processed in GIS before being imported into HEC-RAS through the use of HEC-GeoRAS.

4.3.1. Cross Section Geometry

The first step in building this model was to create a shapefile in GIS showing the proposed location of each cross section. This preliminary layout was sent to the USACE for review and discussion. Once the layout was finalized, the City of Springfield hired Landmark Surveying and Consulting, LLC to perform a very detailed survey of the study reaches. The City supplied Landmark Surveying with a map showing the location of all proposed cross sections (see Plate B). For each cross section, the surveyor was instructed to acquire elevation data at the top of bank, toe of bank, flow line, and any significant change in channel geometry. In addition, the survey was to include detailed drawing of all bridge and culvert structures. Once the survey was complete, Landmark Surveying provided the City with the following data: an electronic file containing the location of each survey point found within the stream channel; detailed drawings and measurements of all stream crossings, and a detailed drawing of the three major tunnel sections.

This digital data was imported directly into GIS as a series of points with elevation attributes. Since these points were surveyed at a specific location along the channel, they were placed in GIS at, or very near, the location of the cross section shapefile. Therefore, the next step was to slightly modify each cross-section so that it intersected each survey point at the proper location. This step was taken to ensure that once the elevation data was extrapolated from the TIN, the exact survey points would be used.

TIN Creation

In general, the detailed survey only included areas within the channel banks. GIS was used to create a 3D polyline shapefile (parallel to flow) that connected all points designated as a bank station. This resulted in a shapefile that encompassed all of the survey data. The next step was to create a TIN of the survey data using the imported points and the 3D boundary line as the source data. A TIN encompassing the entire cross section length was also created using the digital 2-foot elevation data available to the City based on a photogrammetric flight from 1999. The 3D polyline created from the survey was also included as data for this TIN. The 2-foot TIN was clipped by the 3D polyline and merged with the survey TIN. Since both TINs were created using the 3D polyline, there was a seamless transition between the two TINs when the data was merged. The result was a TIN file that included 2-foot contour data in the overbank areas and survey data in the channel.

Elevation data was extrapolated from the TIN at each cross section using HEC-GeoRAS. In addition, all downstream flow lengths were also calculated using GeoRAS.

Bank Elevations

When the station-elevation data was first extrapolated from HEC-GeoRAS, the bank stations were set according to the attributes assigned by the survey data. However, in order to create a more consistent channel section from one cross section to the next, many of these bank stations were adjusted in RAS.

4.3.2. Culvert Geometry

The stream survey included detailed elevations of the road deck at each stream crossing. A shapefile of bridge locations was created depicting each overflow cross section. Using this information, road deck elevations were extrapolated from a TIN in much the same way as the cross section data. Then, using the detailed drawings supplied by the surveyor, the bridge or culvert details were entered into HEC-RAS individually.

4.3.3. Tunnel Geometry

There are four major tunnels in the watershed: “Jordan Underground” on Lower Jordan, “Fremont to National” on South Branch, the “Tindle Mills tunnel” and a tunnel beneath the railroad tracks just downstream of Tindle Mills on North Branch. Each of these tunnels were surveyed in detail and included in the model as described below.

Tindle Mill Tunnel and Downstream Railroad Tunnel

The Tindle Mill tunnel is about 500 feet long; the railroad tunnel just downstream is about 300 feet long. Both were modeled as cross-sections with lids to better account for overland flow. The Tindle Mills tunnel is a 9'x9.3' culvert at the upstream end, opening to as large as 15'x14' as you move downstream, then contracting to 9'x9.7' at the downstream end. The tunnel opening portion of the lidded cross-sections was modeled at 9'x9.3' for its entire length under the assumption that this is likely the controlling section. The downstream tunnel under the railroad tracks consists of two 8.4'x8.4' barrels at the upstream end which transition to a single 10'x9.5 foot barrel about midway of the tunnel. The tunnel opening portion of the lidded cross-sections was modeled at 10'x9.5' assuming that this sections controls. The overtopping conditions were dictated by the overland portions of the cross sections and included significant blocked obstructions representing buildings in the flowpath.

Jordan Underground

The Jordan Underground tunnel starts at the confluence of the North and South Branches and travels through downtown 3354-ft to a point just upstream of Main Ave. The dimensions of this tunnel vary greatly throughout its length and as a consequence, the tunnel was modeled as a stream section with a lid. The lid was placed such that the water surface would not exceed the elevation of the lid; therefore the cross section area and wetted perimeter represent the actual geometry. While the flow through the tunnel was modeled in one reach called "Jordan Underground" the overland flow was modeled in another reach called "Lower Branch 2". This reach represents the flows as the box is overtopped.

Fremont to National Tunnel

This tunnel is located on South Branch of Jordan Creek and starts just downstream of Fremont Ave and extends 1643-ft downstream to National Ave. This box varies significantly throughout its length and contains a number of utility crossings that impede flow. As a result, the tunnel was modeled as a separate reach much like Jordan Underground. In this case, flow through the tunnel was modeled in a reach called "Fremont Box" and the overland flow was modeled in a separate reach called "South Branch 2".

4.3.4. Flow splits and junctions

This model includes six different flow splits and junctions occurring at each stream confluence and at each end of a tunnel reach. For a flow split, in order to properly quantify the flows through the structure, an initial estimate was made regarding the capacity of the tunnel at various flood frequencies. Then, the "optimize flows" option was checked in the model. Flow optimizations at junctions are performed by computing the water surface profiles for all of the reaches, then comparing the computed energy grade lines for the cross sections just downstream of the junction. If the energy in all the reaches below a junction is not within a specified tolerance (0.1 feet), then the flow going to each reach is redistributed and the profiles are recalculated. This methodology continues until a balance is reached. For each stream junction, the backwater analysis for each upstream cross section begins from the downstream section in the junction. Due to the connectivity of the study stream, the only downstream boundary condition needed for this model was for the Wilsons Creek reach. Flow optimization, as described above, was performed for the Current Conditions without Project HEC-RAS model. From this analysis, a rating curve of box capacity through the Jordan Creek Underground section and the Fremont Box was established and used to set peak flows for all subsequent models. The resulting rating curves can be found in Appendix HH-M.

4.3.5. Roughness coefficients

Roughness coefficients for each cross section were determined from aerial photos and digital field photos. Initially, all roughness coefficients were extracted from GIS using GeoRAS. This resulted in a number of horizontally varying coefficients across each section. Per advice from the USACE, the number of coefficients used for each section was greatly reduced. For most cross sections, three roughness coefficients were found to represent the channel and each overbank for the reach downstream of the cross section. In some areas where the overbank roughness varied significantly with water surface elevation or the channel was not clearly defined, multiple roughness coefficients were input that vary horizontally.

4.3.6. Ineffective Flow Areas

There were three instances where IFAs were used in this model: areas downstream of buildings (shadows), areas within a channel or overbank where it was determined to not actively convey flow, and areas around bridges and culverts that did not actively convey flow.

Building Shadows

Using GIS, a shapefile was created representing the ineffective flow area behind each building. This generally resulted in a triangular shaped polygon. The location of these IFAs was extrapolated out of GIS using HEC-GeoRAS.

Channel and Overbank IFAs

IFAs were entered at various locations throughout the model where it was determined that a section of the channel or overbank did not actively convey flow. This was usually due to a geometric constraint either upstream or downstream of the cross section. An example of this can be seen on North Branch at RS 4286 where an IFA was used so that a tributary channel was not used to convey flow. IFAs were also used in some circumstances where a utility crossing was not addressed with an in-line structure.

Bridge and Culvert IFAs

When applicable, IFAs were used around bridge and culvert structures to indicate portions of the cross section that did not actively convey flow. It was generally assumed that flow contracted at a 1:1 ratio upstream of a structure and expanded at a 4:1 ratio downstream of a structure.

4.3.7. Blocked Obstructions

When the finished floor elevations along the stream were surveyed, a shapefile was created depicting the boundary of each structure. This shapefile was used by Geo-RAS to mark the location of each blocked obstruction. This generally included buildings only, whereas any obstruction caused by fences, trees, cars, etc was accounted for with roughness coefficients.

4.3.8. Interpolated cross sections

Interpolated cross sections were created at various locations in the model. Generally, this was done to better represent a transition between two cross sections. Specific examples of interpolated cross sections are described under "Special Conditions".

4.3.9. Calculation Tolerances

The default calculation tolerances in HEC-RAS were modified for the "Current" and "Ultimate Development" plans. The following changes were made: 1) the maximum number of iterations was increased from 20 to 30, 2) the maximum number of iterations used for split flow was decreased from 60 to 20, 3) the maximum difference in junction split flow was increased from 0.02' to 0.05'.

4.3.10. Special Conditions

In order to model the flow conditions effectively, a number of unique methods were used. These are independently described below.

Confluence at North and South Branch

A "natural ground" lateral weir was used just upstream of the confluence of North and South Branches to model high flow interchange of flow between the branches near the confluence.

Upstream Section of North Branch

The detention basin upstream of RS 16820 was included in the RAS model. An inline structure was used to model the uncontrolled outflow and the profile elevations through the pond verified against the HEC-1 routing results.

Jordan Creek Improvements Phase 1&2

In 2006-2007, a large section of North Branch between National Avenue and Fremont Avenue (immediately downstream of RS 6990) was modified to reduce flooding and improve the neighborhood. The old concrete box culvert has been removed and an open channel was constructed. Once the project was complete, an as-built survey was used to update the HEC-RAS model in this area to reflect the new improvements.

Lower Jordan at Kansas Exp

Each cross section of Lower Jordan Creek between RS 5689 and RS 3859 includes the main channel and floodplain to the west of Kansas Expressway and the ditch to the east of Kansas Expressway. A left levee was used to accurately reflect flow conditions in this reach since Kansas Expressway in this reach does not overtop.

Lower Jordan South of Bennett

An industrial facility is located in the right overbank of this area and is protected by a concrete floodwall. This wall is included in the surveyed cross sections. Ineffective flow designations and increased n-values were used to simulate the flow restriction due to congestion in the industrial facility behind the flood wall. A lateral weir was used in the right overbank to model movement of high flows across the railroad track embankment and Bennett Street west of the railroad embankment. Flow leaving across the lateral weir re-entered Wilsons Creek just downstream of the railroad embankment.

Changes in Water Surface Elevation

In some locations throughout the model, certain profiles would default to critical depth when an elevation could not be found within the specified tolerance. At these locations, the water surface elevation was manually set to a reasonable elevation, often defined by the bounding profiles. This approach allowed the model to produce a set of smooth and reasonable profiles. When comparing two sets of profiles for FDA (for example Current vs. Future Flow conditions) each cross section was checked to make sure that a lower peak flow did not result in a higher water surface elevation. When these instances occurred, the profile with the lower peak flow was manually adjusted to produce a lower water surface. These instances were very few and minor in nature, usually on the order of a 0.01', and did not significantly affect the results.

4.3.11. Water Surface Profiles

Water surface profiles for each simulation are included in Plates C & D.

4.4. Steady Flow Data

The HEC-1 and HEC-RAS models were examined in order to determine the best places to perform a flow change in the RAS model. These points are shown in a shapefile called "HEC-1 Points of Interest" and each flow rate is listed in an Excel spreadsheet table included in Plate Series A – Flow Data Tables. The Ultimate Conditions Model and the Current Conditions Model share the same stream geometry and differ only in the flows simulated.

4.4.1. Current Flow Conditions

This represents flows from the HEC-1 model titled "JRDFSNT.HC1". These flowrates represent the watershed under 2003 (approximately) development conditions.

4.4.2. Future Flow Conditions

This represents flows from the HEC-1 model titled "JRDFSNTU.HC1". These flowrates represent the watershed under estimated ultimate development (2053) conditions.

4.5. Risk and Uncertainty Analysis

EM 1110-2-1619, *Risk Based Analysis for Flood Damage Reduction Studies*, August 1, 1996 requires that an uncertainty analysis be performed for Flood Damage Reduction Studies. For this study, the current conditions model was modified by raising the roughness coefficients by a set percentage. All channel roughness was increased by 40% (i.e. a coefficient of 0.05 was increased to 0.07), all overbank coefficients were increased by 33% (i.e. a coefficient of 0.12 was increased to 0.16) and all tunnel sections were increased by 10%. These increases were based on a reasonable range of "n" factors for each section type and appear to give reasonable results. After looking at the options, the City settled on this approach because they didn't want the results to be influenced by judgment at a particular portion of the stream. The resulting water surface profiles are smooth and appear to be reasonable.

The current conditions model was also modified by reducing all roughness coefficients by 40%. Based on earlier comments by the Corps, the City did not expect a set of reasonable profiles. However, in most places, they were better than expected. There were still quite a few crossing profiles and errors. As a result, all positive changes in WSE (where lower n factors provided a higher WSE) were excluded from the sample.

Appendix HH-J indicates the "SD of Error" for each stream reach. At every cross section at each reach, the WSE from the current model was compared to the WSE for the two modifications mentioned above. The standard deviation of "error" was found for 1) each profile in each reach, 2) all profiles in each reach. The SD was calculated using the following formula:

$$\sqrt{\frac{\sum (x-\bar{x})^2}{n}}$$

It was assumed that the data studied made up the entire sample.

Also included in this analysis is the "Stage where error becomes constant" for each reach. Appendix HH-J contains graphs showing how the standard deviation of error for each reach corresponds to each profile. Based on this analysis and discussions between the City and USACE, it was determined that the 10% ACE (10-yr) profile is the stage where error becomes constant.

4.6. **Summary of Conclusions**

The results of this hydraulic analysis were compared against historic stream gage data in an effort to check for reasonableness. Results of this comparison are found in Appendix HH-F. Overall, the water surface profiles calculated by HEC-RAS compare reasonably well with historic flood levels.

The HEC-1 created as a part of this study included simulations of both the Current and Future development conditions. As expected, anticipated development produces an increase in peak flow throughout the watershed. This increase ranged from 3.0% to 32.7% in the North and South Branches of Jordan Creek. Overall, the greatest potential impact of development occurs on South Branch. Downstream of the North and South Branch confluence, peak flow increases are on the order of 10%. See Plate A for a comparison of peak flows throughout the modeled area.

The HEC-RAS model was used to simulate the change in water surface elevations as a result of anticipated development. Table 8 summarizes the change in the 1% ACE water surface due to potential development in the watershed. See Plates C & D for the hydraulic profiles.

Table 8: Change is Water Surface Elevation (WSE) due to Developement

Average Change in WSE	0.25
Median Change in WSE	0.21
Standard Deviation in WSE	0.21
Max Change in WSE	1.26

Since settlement first occurred along the Jordan Valley, this stream has been the source of severe flood losses. This analysis clearly shows that the flooding along Jordan Creek will continue to become worse if left unchecked. In addition, with the flood hazards reduced and the aesthetic attributes improved, this stream has the potential to become a great asset to the community.

5. With Project Hydrologic Modeling

5.1. Regional Detention Analysis

In order to determine the effectiveness of regional detention basins throughout the watershed, the HEC-1 model was modified to include a number of proposed detention basins.

5.1.1. Preliminary Analysis

Initially, 24 different sites were selected throughout the watershed as possible locations for regional detention. Figure 3 shows the location of these sites.

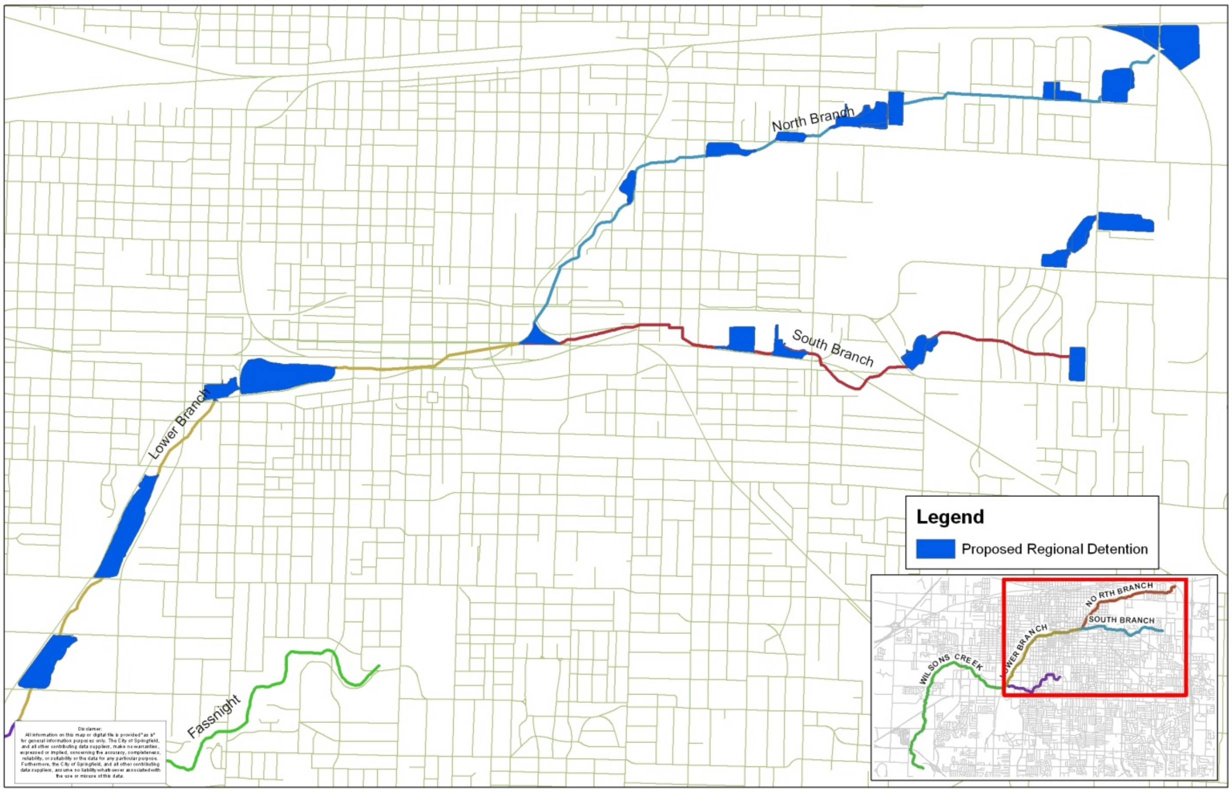


Figure 3: Preliminary Regional Detention Basins

The Current Conditions HEC-1 model was modified appropriately and each detention basin was designed to maximize effectiveness while remaining within reasonable vertical and horizontal limitations. Once this initial analysis was complete, each basin was examined to determine the potential flow reduction. Basins were analyzed both individually and in series with other basins. Appendix HH-K gives a summary of each preliminary basin and outlines the peak flow reduction immediately downstream as well as the specific design constraints. Many of these basins could not be made large enough to have a significant impact on peak flows. This was especially true as the contributing watershed increased. From this analysis, it was determined that nine basins had the potential to significantly reduce peak flows under both current and ultimate development conditions.

5.1.2. Refined Analysis

Based on the preliminary analysis, it was determined that nine regional detention basins have the potential to significantly reduce flows along Jordan Creek. Figure 4 shows the location of each of these basins. In addition, some of these basins (B11 & B11A) were modified to preserve riparian vegetation and in one case (B6B) a similar basin was analyzed in a new location.

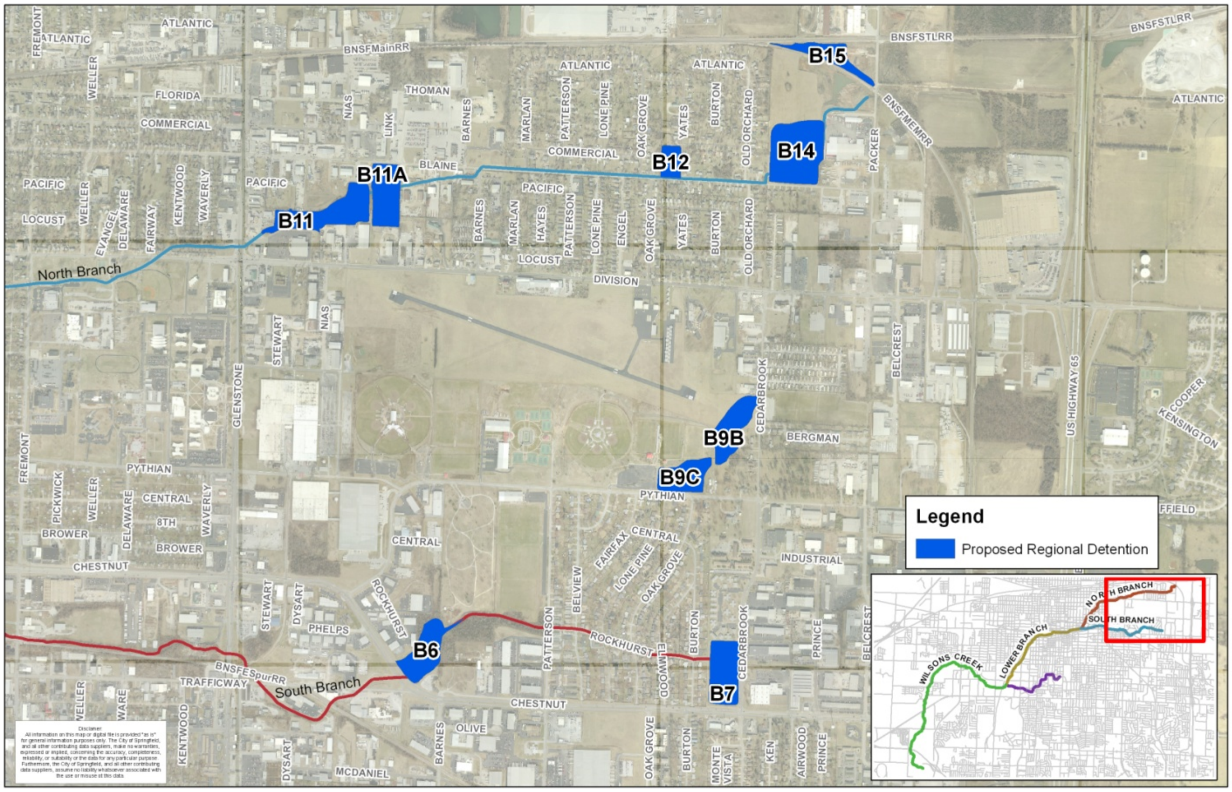


Figure 4: Regional Detention Basins (Refined Analysis)

5.1.3. Current Conditions

For the Current Conditions with Regional Detention Analysis, peak flows from the HEC-1 model JRDFSNTX.HC1 were entered into the HEC-RAS model. The geometry remained unchanged from the existing conditions geometry.

Special Conditions

South Branch – Glenwood Basin to Patterson Ave.

The proposed regional detention basin B7 includes two 42" RCPs that extend from the basin outlet, along Rockhurst Street, to Patterson Ave. According to the detention basin rating curve found in the HEC-1 model, these pipes carry 130-161cfs during a storm event. Since these flows will be contained in a pipe, the corresponding flows were subtracted from the peak flows found in the HEC-RAS model which only simulates the remaining channel. To facilitate this removal, a flow change location was added at RS 12079 (proposed pipe discharge location) and estimated pipe flows were removed from the modeled flows at RS 14475 & 12585. This change will adequately simulate the overflows from the proposed detention basin.

North Branch – Blaine Street

The proposed detention basins B14 and B12 would likely require construction of a 42-48" RCP along Blaine Street to carry discharge from the basins. These pipes would have a larger capacity than the existing channel. The HEC-RAS model assumes that the existing channel will be carrying the resulting flows from these basins and the water surface elevations reflect this. In reality, if pipes were constructed, the 1% ACE flow could be contained in the pipe and damages along Blaine Street (Damage Reach N11 and N12) would be greatly reduced. These damage reaches are outside of the federal limits pertaining to this study.

Jordan Underground

In order to properly simulate the existing capacity of the large system, the HEC-RAS model was ran using the flow optimization on the upstream junction of "Jordan Underground". The calculated capacity of the box for each storm event was then entered as the peak flows to "Jordan Underground". These peak flows were subtracted from the flows found for Lower Branch 2 and the result was an estimate of overland flows through this reach.

In-line Structures

In some locations there are in-line structures included in the HEC-RAS geometry to simulate flow over an existing detention basin control structure. If regional detention is constructed in these locations (i.e. the existing basin is expanded) the resulting in-line structure will likely be somewhat different. However, comparing the WSE at these locations with the WSE in the proposed regional detention model shows the two to be comparable. Therefore, the in-line structures were not modified and the "current conditions" geometry remains unchanged from that used in the current conditions model.

5.1.4. Future (Ultimate Development) Conditions

For the Future Conditions with Regional Detention Analysis, peak flows from the HEC-1 model JRDFSNTZ.HC1 were entered into the HEC-RAS model. The geometry remained unchanged from the existing conditions geometry.

Special Conditions

South Branch – Glenwood Basin to Patterson Avenue

In the Current Conditions model, peak flows were decreased in this area to simulate the two pipes needed for basin B7. The Future Conditions did not account for the potential underground piping system. It is anticipated that this will cause an increase in damages through this area, above what would be expected. However, this damage reach (S10) is outside of the federal limits pertaining to this study.

North Branch – Blaine Street

The proposed detention basins B14 and B12 would likely require construction of a 42-48" RCP along Blaine Street to carry discharge from the basins. These pipes would have a larger capacity than the existing channel. The HEC-RAS model assumes that the existing channel will be carrying the resulting flows from these basins and the water surface elevations reflect this. In reality, if pipes were constructed, the 1% ACE flow could be contained in the pipe and damages along Blaine Street (Damage Reach N11 and N12) would be greatly reduced. These damage reaches are outside of the federal limits pertaining to this study.

Jordan Underground

In order to properly simulate the existing capacity of the large system, the HEC-RAS model was ran using the flow optimization on the upstream junction of "Jordan Underground". The calculated capacity of the box for each storm event was then entered as the peak flows to "Jordan Underground". These peak flows were subtracted from the flows found for Lower Branch 2 and the result was an estimate of overland flows through this reach.

In-line Structures

In some locations there are in-line structures included in the HEC-RAS geometry to simulate flow over an existing detention basin control structure. If regional detention is constructed in these locations (i.e. the existing basin is expanded) the resulting in-line structure will likely be somewhat different. However, comparing the WSE at these locations with the WSE in the proposed regional detention model shows the two to be comparable. Therefore, the in-line structures were not modified and the "current conditions" geometry remains unchanged from that used in the current conditions model.

A simplified analysis of each basin was performed to determine each basin's impact on peak flows throughout the watershed. This analysis included an examination of the 2 hr 1% ACE peak flow immediately downstream of each basin (at the next downstream hydrograph combination) as well as an assessment of the impact throughout the project reach. Flow points were assessed at Glenstone Ave and Central Street on the North Branch, Chestnut Expressway and Fremont Ave on the South Branch, the confluence of North Branch and South Branch (upstream end of the downtown reach), and Catalpa Street on the Lower Branch. Results of this study are found in Appendix HH-L and summarized in the "Conclusions" of this section. Plate F shows each proposed regional basin in detail.

Basin B15

This regional detention basin is located along North Branch of Jordan Creek just north of the RR tracks near Packer Road. This area currently ponds water during a storm event and discharges through a 30-inch pipe. The proposed basin would require the excavation of additional material and a new 12-inch RCP outflow pipe. Design assumptions include:

- Current 1% ACE water surface elevation will not increase such that it does not encroach additionally on RR right-of-way.
- The remaining adjacent lot will be developable.
- The storage area currently fills to Elev 1380+ and spills over to the west.
- In order to add a 12" RCP at a lower elevation, a new pipe would likely need to be bored under the RR Tracks.

Basin B14

There is an existing regional detention basin located on this parcel of City-owned property. The flow line of the basin would be lowered to a point that matches the existing downstream channel. The discharge will be a 42” RCP at this elevation. In addition, this basin will be expanded to the north. This basin lowers peak flows to a point that the 1% ACE flow can be contained in a pipe or series of pipes along Blaine Street. The City anticipates that, with the development of this basin, pipes would be installed along Blaine Street to Barnes Avenue. This system would carry flows from the basin as well as additional flows from this area. Blaine street would eventually be widened to a curb and gutter street. Design assumptions include:

- Additional land acquisitions would be necessary since proposed basin encroaches on adjacent property.
- All slopes are a maintainable 4:1 or greater.
- Stormwater flows from the Packer Road-Blaine Street intersection will be diverted into this basin. These flows are currently carried in a ditch along the south side of Blaine Street.

Basin B12

There is an existing wet pond located in the North West corner of Blaine Street and Yates Avenue. The proposed basin would require additional excavation of this area to a depth of approximately 5 feet. This basin would act as an in-line storage area for the system along Blaine Street. Stormwater would be diverted into the basin from either the existing channel or the anticipated pipe system. The control structure for this system would consist of the downstream piping or channel system. The neighborhood to the north of this area has some serious flooding issues. By building basin B12, the City would have the vertical depth required to construct a stormwater improvement into this neighborhood. Design assumptions include:

- 1% ACE water surface elevation will remain below the top of the street.
- The system along Blaine Street would surcharge into this basin and be metered out based on the capacity of the downstream system.
- This area could be further excavated to provide a permanent pool water feature for the neighborhood.

Basin B11A

This proposed basin is located south of Blaine Street at Link Avenue and is currently a vacant wooded area. This area would be excavated and a control structure added. Design assumptions include:

- Side slope of basin would be 15:1. This would accommodate the planting of new trees to replace some of those removed during construction.
- The precise dimensions of an outlet structure were not determined but rather the basin was designed around a rating curve that optimized storage. It appears that this rating curve could be reasonably achieved through the use of a pipe and weir system.

- Basin B11A is located just upstream of Basin B11 but is elevated enough that tail water conditions created by B11 do not submerge the control structure.

Basin B11C

A modification of B11A, this basin attempts to minimize the impact to vegetation by only including excavation on the south side of the stream. This area would be excavated to the depth of the existing channel and a control structure would be added downstream. This would leave the north portion of the lot available for development and should make land acquisition more palatable to the owner. Design assumptions include:

- Side slope of basin would be 6:1. Area could be planted with wetland vegetation to provide additional water quality benefits.
- The outlet structure was assumed to be an 18-ft sharp crested weir at elevation 1333.
- Basin B11C is elevated high enough that the backwater from B11 does not submerge the control structure.

Basin B11

An existing regional detention basin is currently located upstream of Glenstone Avenue. The proposed basin would expand the existing basin to the east. Additional land acquisition and/or stormwater easements wound need to be pursued from adjacent property owners. The outlet for this basin would likely consist of a 15-foot weir located near the current control structure. Design assumptions include:

- Peak flows would not exceed the capacity of the box under Glenstone Avenue.
- Since the initial sizing of this basin, many of the surrounding businesses have added fill and expanded into the proposed basin area. This has somewhat reduced the available area, and effectiveness, of basin B11. However, final design may include expansion into these areas. For example: the new detention basin to the north could be removed and graded as part of the regional facility. This business could then discharge runoff directly into the regional basin. By using this area, the basin will likely not impact any of the space currently used by surrounding businesses.

Basin B11B

Since basin B11 includes extensive removal of riparian vegetation, B11B attempts to minimize this impact by leaving the stream area intact. Excavation will take place in adjacent detention basins, lowering their flow line to match the stream channel. Design assumptions include:

- The outlet structure would be very similar to what was designed for B11.
- Each adjacent detention basin was excavated to the channel flow line with 4:1 side slopes.

Basin B9B

This proposed basin is located north of Pythian Street and just west of Cedarbrook Avenue and is part of two proposed basins. The existing valley would be excavated to a depth of 8-feet and a berm constructed on the downstream end. The control structure would consist of two 36-inch RCPs and an overflow weir that would discharge into basin B9C. This basin encroaches on parts of 4 different privately owned properties and land acquisitions or stormwater easements would be necessary. Design assumptions include:

- The calculations for the outlet structure do not include tail water conditions from basin B9C. However, this basin is elevated enough that the effect should be minimal.
- If we are able to increase flows from Basin B9C with an additional pipe, the size of this basin could be reduced.

Basin B9C

Located just downstream of Basin B9B, this basin includes expansion of the existing regional detention facility at Cooper Park. The outflow for this basin would consist of the existing 4-inch CMP that runs down Pythian Street and Patterson Avenue. The neighborhood to the south of this basin experiences significant flooding and the basin has overtopped a number of times in recent years. Design assumptions include:

- The existing 48-inch CMP system along Pythian Street has been damaged in several locations. These areas would need to be repaired to accommodate the design flows.
- The design includes blocking the existing weir and box structure that discharges at Lone Pine Avenue. If needed, this system could be used to carry some flow during a large storm event. However, these ditches are often the source of flooding in the neighborhood and existing capacity should not be exceeded.

Basin B7

Located in Glenwood Park, this existing regional basin would be expanded to control peak flows and reduce flooding along Rockhurst Street. The existing basin would be excavated an additional 5-feet and the park area would be excavated an additional 2-feet. The lower portion of the basin would overtop into the park area at about the 5 to 10-yr event. The outlet structure would consist of two 42-inch RCPs that would travel along Rockhurst Street and discharge downstream of Patterson Avenue. The structure would also include a 5-foot high flow weir that would discharge into the existing ditch system along Rockhurst. Design assumptions include:

- The estimated capacity of the existing system along Rockhurst is 250 cfs. The basin was designed so that the 1% ACE overflow would not exceed this capacity.
- There is a sanitary sewer line along Rockhurst that may cause a conflict. It was assumed that this could be worked around during final design.

Basin B6

This proposed basin is located just upstream of Chestnut Expressway along the South Branch of Jordan Creek. The stream valley would be excavated to a depth of approximately 9 feet and expanded to the northeast. There are at least three property owners who would be impacted by this project and the City would need to acquire the land or obtain an easement from each. In conjunction with other basins in this watershed, this basin will reduce peak flows and keep the 1% ACE water surface elevation from overtopping Chestnut Expressway. Design assumptions include:

- A detailed outlet structure was not designed for this basin. Instead, the rating curve was adjusted to optimize the storage capacity. An outlet that produces this assumed rating curve would likely consist of a weir-pipe configuration just upstream of the existing box culvert.

Basin B6B

This basin is located in the soccer field just downstream of Patterson Avenue on South Branch and was designed as an alternative to B6. This basin could potentially include a dam across the stream and excavation of the area north of the channel with minimal impact to vegetation on the south side of the channel. Design assumptions include:

- 10:1 side slopes.
- The outlet structure was assumed to be a 15-ft sharp crested weir at elevation 1318. This produced a 1% ACE water surface elevation lower than the edge of Patterson Ave.
- It was assumed that the backwater from this basin would not affect the culvert under Patterson Ave. This would need further analysis and is dependent on construction of basins B9 and B7.

Alternative Locations

B9A – Proposed Basin B9A, located in the soccer fields east of Cedarbrook Avenue and north of Bergman Street, could be a reasonable alternative to Basin B9C. Although not included in the analysis, this basin would include excavating the soccer fields to a depth of 5-feet and allowing them to flood during heavy rain. The proposed grading would require that the new fields be orientated east-west and would probably result in the loss of at least one field. However, the new grading would result in an elevated viewing area along each side of the field which could be viewed as an amenity.

B12A – Proposed basin B12A includes excavation of the residential lots north of Blaine Street, just upstream of basin B12. Initial analysis indicates that this would produce results very similar to basin B12.

5.1.5. Conclusions

Based on the simplified analysis of each basin individually and in series, the following conclusions were made:

North Branch

Basin B15 does an excellent job of reducing peak flows immediately downstream. However, the total 1% ACE flow reduction is on the order of 50 cfs which has little to no impact once you move downstream any distance. In addition, this basin would require significant excavation and land acquisition from the railroad. **Basin B15 is not considered a viable alternative for regional detention.**

Basins B14 and B12 reduce peak flows immediately downstream, greatly reducing flooding along Blain Street. However, these reductions are very small within the limits of federal interest (2.6% reduction downstream of Glenstone). **These basins are a very attractive alternative for the City to reduce local flooding, but do not appear to provide a significant benefit for this project.**

Basins B11, B11A, B11B, and B11C are all variations of a regional detention facility located just upstream of Glenstone Ave on North Branch. Of these, Basins B11 and B11C appear to be the most attractive alternatives. B11 includes enlarging the existing basin to the east and B11C will require excavation along the south side of the stream. Together these basins reduce flows along North Branch by 13 to 30% and reduce flows through the downtown area by almost 6%. It should be noted that **these two basins are responsible for nearly all of the peak flow reduction downstream of the North/South Branch confluence.**

South Branch

Basins B9B and B9C, located upstream of Pythian Street, reduce peak flows to the capacity of the existing local system. Of these two basins, B9B is responsible for nearly all of the peak flow reduction. **By constructing basin B9B, we can reduce flows throughout South Branch by 2 to 9%.** This basin contributes very little to flow reduction downstream of the confluence.

Basin B7 involves expanding the existing Glenwood Park regional basin. By itself, **this basin reduces peak flows along South Branch by 4 to 24%,** but contributes very little to flow reduction downstream of the confluence.

Basins B6 and B6B are somewhat similar regional basins located upstream of Chestnut Expressway. Both basins reduce peak flows when used in series with B6B and B7, but have very little flow reduction when used independently. B6B would require a dam structure across the stream and excavation of the soccer fields on the north side of the stream. This will likely result in tail water effects along the Rockhurst Street stormwater system. Basin B6 would require less excavation since Chestnut Expressway would be used as the downstream control structure and would **result in peak flow reductions of 6 to 12% along South Branch**. This basin contributes very little to flow reduction downstream of the confluence.

Recommendation

Based on this analysis, the City of Springfield recommends further study of the following basins:

- B11 – Expansion of the existing basin upstream of Glenstone Ave. The west end of the existing basin would remain undisturbed and the basin would be expanded to the east.
- B11C – Construction of a new basin south of Blaine at Link. A control structure would be built across the channel and excavation would take place south of the stream channel. The vegetation north of the channel would remain undisturbed and the area would be available for future development.
- B9B – New basin in Cooper Park. A control structure would be built and the new basin would discharge directly into the existing regional basin along Pythian Street.
- B7 – Expansion of the existing basin at Glenwood Park. A new system would be constructed along Rockhurst Street allowing the flow line of the basin to be lowered.
- B6 – Expansion of the existing storage area behind Chestnut Expressway.

It appears that these basins represent the greatest potential reduction in peak flow within the limits of federal interest. Each group of basins, North Branch & South Branch, is responsible for reducing flows in different areas. The City proposes that the entire group of basins be analyzed to determine their cost effectiveness. Based on this analysis, it should be apparent whether or not each group is independently viable.

5.1.6. Final Basin Analysis

Since proposed regional detention basins within a specific (North or South) reach perform in series with other basins in the same reach, the recommended basins were modeled as either North Branch basins only, South Branch basins only, or All basins. The results are described below.

North Branch Basins

The North Branch series of basins included **B11 and B11C**. The resulting model, titled "JRDFSB111.HC1", was simulated for all frequency/duration combinations under Current Conditions watershed development. Each basin was sized according to reasonable geometric restraints and the outlet structure was optimized to reduce flows during flood conditions and maintain approximately 1-ft of freeboard during the 1% ACE event.

South Branch Basins

The South Branch series of basins included **B9B, B6 and B7**. The resulting model, titled "JRDFSSOUTH.HC1", was simulated for all frequency/duration combinations under Current Conditions watershed development. Each basin was sized according to reasonable geometric restraints and the outlet structure was optimized to reduce flows during flood conditions and maintain approximately 1-ft of freeboard during the 1% ACE event.

All Recommended Basins

The All Basins analysis included **B11 and B11C as well as B9B, B6 and B7**. The resulting model, titled "JRDFSALL.HC1", was simulated for all frequency/duration combinations under Current Conditions watershed development. Each basin was sized according to reasonable geometric restraints and the outlet structure was optimized to reduce flows during flood conditions and maintain approximately 1-ft of freeboard during the 1% ACE event.

Results

From the FDA analysis, it was determined that the "All Recommended Basins" scenario provided the greatest benefits in damage reduction. Based on this analysis, the resulting flow rates were used for design in each of the hydraulic alternatives.

6. With Project Hydraulic Modeling

6.1. Detention Analysis

For each of the detention scenarios modeled (See With Project Hydrologic Modeling) the HEC-RAS model was modified with the revised flows from the HEC-1 analysis. At both the confluence of the North and South Branches and at Fremont Avenue, the flow splits into two separate reaches, one representing the large underground box and another representing overland flow. All model geometry remained the same for these reaches but the rating curve indicating the capacity of each culvert section had to be modified since the incoming flows had changed. Appendix HH-M contains the rating curve used for each structure. These curves were originally derived through an iterative process using the Without Project HEC-RAS model.

6.2. Channel Improvements

For the With-Project HEC-RAS models, multiple scenarios were modeled covering different frequency events at different locations. Several design assumptions were held consistent throughout each scenario:

- Proposed improvements were sized using flows from the Ultimate Development w/ All Recommended Basins HEC-1 model. Once the structure geometry was determined, the Current Conditions w/ All Recommended Basins model flows were added so that the HEC-RAS model reflects both Current and Ultimate Conditions Water Surface Elevations.
- Assumed very little residual buyouts or floodproofing. (i.e. Protect all structures within reason, unless they must be removed to construct the improvement).
- Construct linear trail system along channel
- Address in-stream habitat quality and quantity (channel modifications to include mild, natural side slopes, w/ natural bottoms and specific low-flow channels where appropriate)
- At the confluence of the North and South Branches, it is anticipated that a new structure would need to be built that would direct a portion of the flow into the proposed channel improvements and a portion of the flow into the existing box culvert. Because the existing model simulated the downtown area as two separate reaches, including the existing box culvert, it was necessary to insert a new rating curve at this location to model flows into the new structure. This rating curve can be found in Appendix HH-N.

6.2.1. Plan A – 1% ACE

Plan A includes channel and bridge modifications throughout the study area at all locations where significant economic damages were found. In areas where no significant damages were present, improvements were not considered. Details regarding plan A can be found in Appendix HH-O.

Design Methodology:

Modify the Current Conditions Geometry with channel and bridge modifications such that the 1% ACE profile is lower than each of the adjacent finished floor elevations. While this does not eliminate all damages to streets and parking lots, it should eliminate nearly all structure and content damage for each building. The proposed improvements may or may not contain the 1% ACE and some overland flooding will result in areas where the finished floor elevations are elevated above the ground surface.

Special Conditions:

Pharmaceutical Plant Downstream of Bennett:

The pharmaceutical plant downstream of Bennett Street is protected by a flood wall with an approximate height of 1222.5. Based on a field inspection of this flood wall, it was determined that the wall would stay in place. The proposed improvements for Plan A were designed to keep the 1% ACE profile below the top of this wall. During scoping for this plan, the team considered the option of constructing a taller flood wall around the plant and installing a flood gate at the entrance. Initial cost estimates for this proposal indicated that it was not economically feasible. In addition, the team examined the possibility of constructing a box culvert upstream of Bennett Street and diverting flows to the west side of the plant. Several factors (including cost, environmental concerns, and topography) led to the determination that this option was not economically feasible.

Confluence of North and South Branch:

The confluence of the North and South Branches of Jordan Creek is located in the downtown area near Washington Street. The Without Project HEC-RAS model separates this portion of the stream into two different reaches (see W/O Project Hydraulic Model) where one reach represents the large box culvert that runs underground, while the other reach represents the overland flow through downtown. For the With Project scenario, the overland reach was modified with all channel improvements and the underground reach remained to carry the box culvert flows. It is anticipated that the upstream section of the existing box culvert would need to be reconstructed to gather flows from the confluence and divert the resulting flows into the existing box and the new channel improvements. Modeling of this was accomplished with a rating curve derived from HY-8 (see Appendix HH-N).

South Branch at Fremont

There is an existing box culvert that extends from Fremont Avenue to National Avenue along the South Branch of Jordan. All channel improvement scenarios assume that this box will be removed where reasonable and abandoned in place in a few locations. As a result, the box culvert portion of the model received 1cfs of flow for all scenarios. All other flows were assumed to be carried by the new improvements.

Results

The Plan A alternative includes improvements that greatly reduce damages up to the 1% ACE for every section of the study area. A spreadsheet outlining these improvements can be found in Appendix HH-O and Plate(s) G show the general limits of these improvements.

6.2.2. Plan B – 1% ACE (Cost Effective Plan)

Plan B is a copy of Plan A with the several areas removed because it was determined through a preliminary analysis that these areas were not economically justified. Details regarding plan B can be found in Appendix HH-P.

Design Methodology

Once Plan A was complete, the economic benefits were established for each reach. These benefits were compared to a preliminary cost estimate and those reaches that were obviously not feasible were not included in Plan B.

Grand Street Improvements

The FDA analyses from Plan A indicated that damage reduction due to the proposed Grand Street Improvements were approximately $4500 annually. An initial estimate done by the local sponsor showed construction costs for replacing the Grand Street bridge and the corresponding channel improvements to be around $1.4 million resulting in an annual cost of approximately $32,000. Even if initial estimates are grossly inaccurate, it was apparent that this portion of the project was not economically feasible simply because there are very few structures in this area.

Smith Park Improvements

The FDA analysis from Plan A indicated annual damages of approximately $1800 to several small structures in Smith Park. The preliminary cost estimate to replace two pedestrian bridges and widen the channel was approximately $400,000 with an annual cost of $8500. Considering that these structures were not generally inhabited and were only used for park functions, it was apparent that improvements to Smith Park were not feasible.

Rail Road Crossing at Chestnut Street

The FDA analysis indicated that annual damages were very low at an estimated $2000. The preliminary cost estimated for this improvement was $2.5 million. Under Without Project Conditions, these railroad crossings cause backwater, resulting in significant flooding. However, they are located high in the reach and the proposed detention basins reduce peak flows to the point where additional improvements are not feasible.

Phelps Street (Washington to Jefferson)

Based on the preliminary cost estimate for this segment of improvements, it was determined that there were significant cost savings by constructing an open channel rather than a box culvert from Washington Avenue to Jefferson Avenue just downstream of the confluence. This change was implemented in Plan B.

Results

By using preliminary cost estimates to remove areas that were clearly not feasible, Plan B significantly reduces damages at the 1% ACE in all areas where a proposed project is reasonable. A spreadsheet summary of these improvements can be found in Appendix HH-P and Plate(s) H show the general limits of these improvements.

6.2.3. Plan C – 2% ACE (50 year)

Plan C represents the channel improvements necessary to provide a 2% ACE level of protection throughout the project area. Details regarding plan C can be found in Appendix HH-Q.

Design Methodology

Plan C began as a copy of Plan B, with the same geographic extents. However, the channel modifications from Plan B were further modified until the 2% ACE water surface profile is lower than each of the adjacent finished floor elevations. While this does not eliminate all damages to streets and parking lots in the 2% ACE event, it should eliminate nearly all structure and content damage for each building. The proposed improvements may or may not contain the 2% ACE and some overland flooding will result in areas where the finished floor elevations are elevated above the ground surface.

Results

The 2% ACE plan does not quite provide the same level of protection as the 1% ACE and the bridge and channel structures are generally smaller. To decrease the capacity of the channel, in many cases we were able to shorten or remove retaining walls needed in the 1% ACE plan.

6.2.4. Plan D – 0.2% ACE (500 year)

Plan D represents the channel improvements necessary to provide a 0.2% ACE level of protection throughout the project area. Details regarding plan D can be found in Appendix HH-R.

Design Methodology

Plan D also began as a copy of Plan B, with the same geographic extents. The channel modifications from Plan B were further modified to meet the following guidance: 1)The 0.2% ACE water surface profile is lower than each of the adjacent finished floor elevations. 2) The proposed channel must contain the 1% ACE profile, and 3) Consistent with the City's design standards, each bridge and culvert must convey the 1% ACE profile. While this does not eliminate all damages to streets and parking lots in the 0.2% ACE event, it should eliminate nearly all structure and content damage for each building. The proposed improvements may or may not contain the 0.2% ACE and some overland flooding will result in areas where the finished floor elevations are elevated above the ground surface. However, this plan should nearly eliminate overland and parking lot flooding during the 1% ACE event.

Results

In general, the 0.2% ACE resulted in channel and structure sizes that were larger than the 1% ACE. This plan reduces damages above the 1% ACE plan and has the added benefit of generally containing the 1% ACE profile and should keep any future FEMA SFHA within the channel boundary.

6.2.5. Plan E – 4% ACE (25 year)

Plan E represents the channel improvements necessary to provide at 4% ACE level of protection throughout the project area. Details regarding plan E can be found in Appendix HH-S.

Design Methodology

Plan E began as a copy of Plan B, with nearly the same geographic extents (see the exception below). However, the channel modifications from Plan B were further modified until the 4% ACE water surface profile is lower than each of the adjacent finished floor elevations. While this does not eliminate all damages to streets and parking lots in the 4% ACE event, it should eliminate nearly all structure and content damage for each building. The proposed improvements may or may not contain the 4% ACE and some overland flooding will result in areas where the finished floor elevations are elevated above the ground surface.

Fremont Avenue (South Branch)

In each of the previous plans, the Fremont Avenue bridge on South Branch was replaced. In this plan, the existing structure is left in place and the downstream channel improvements provide the necessary level of protection.

6.2.6. Plan F – 1% ACE Reach 3 & 6 with 0.2% ACE Reach 1

Plan F includes a 1% ACE channel through reaches 3 & 6 with a 0.2% ACE channel through reach 1. Includes sections of projects from the previously developed models.

Design Methodology

After examining the economic results from plans A through E, sections of these plans were selected based on their benefit-cost ratio, net benefits, and other factors considered important by the Team but not necessarily reflected in the economic results. Plan F began as a copy of Plan B and sections of the geometry were imported from other HEC-RAS files as outlined below.

Reach E1 – Downstream of Bennett Street

Since the economic results indicate that a 0.2% ACE level of protection will provide the greatest net benefits in this area, the geometry from Plan D was selected. This reach is hydraulically independent of the other project areas, so the selection of a level of protection throughout this reach did not impact the water surface profiles for any other reach.

Reach E2 – Mt Vernon Street to Fort Avenue

The economic results from the previous plans indicate that channel and bridge improvements in this reach are not economically feasible. As a result, all improvements were removed from the model (the Without Project Geometry was imported into this reach). This reach is hydraulically independent and modifying these improvements have no impact on other study areas.

Reach E3 & E6 – Downtown to Fremont Avenue

The economic results indicated that the 4% ACE level of protection plan resulted in the greatest net benefits. However, due to other considerations (outlined elsewhere in this report) this plan reflects the 1% ACE level of protection found in Plan B for these two reaches. These reaches are NOT hydraulically independent and improvements in reaches E3 & E6 have an impact on the water surface profiles for reach E4.

Reach E4 – Confluence to Central Street

The economic results indicate that channel and bridge improvements in this reach are not economically feasible. However, by making improvements in reaches E3 & E6, the reduced backwater effects result in lower water surface profiles through reach E4. No improvements were assumed through this reach.

6.2.7. Plan G – 4% ACE Reach 3 & 6 with 0.2% ACE Reach 1

Plan G includes a 4% ACE channel through reaches 3 & 6 with a 0.2% ACE channel through reach 1. Includes sections of projects from the previously developed models.

Design Methodology

After examining the economic results from plans A through E, sections of these plans were selected based exclusively on the total net benefits. Plan F began as a copy of Plan E and sections of the geometry were imported from other HEC-RAS files as outlined below.

Reach E1 – Downstream of Bennett Street

Since the economic results indicate that a 0.2% ACE level of protection will provide the greatest net benefits in this area, the geometry from Plan D was selected. This reach is hydraulically independent of the other project areas, so the selection of a level of protection throughout this reach did not impact the water surface profiles for any other reach.

Reach E2 – Mt Vernon Street to Fort Avenue

The economic results from the previous plans indicate that channel and bridge improvements in this reach are not economically feasible. As a result, all improvements were removed from the model (the Without Project Geometry was imported into this reach). This reach is hydraulically independent and modifying these improvements have no impact on other study areas.

Reach E3 & E6 – Downtown to Fremont Avenue

The economic results indicated that the 4% ACE level of protection plan resulted in the greatest net benefits through these two reaches. As a result, the geometry represents what is found in Plan E. These reaches are NOT hydraulically independent and improvements in reaches E3 & E6 have an impact on the water surface profiles for reach E4.

Reach E4 – Confluence to Central Street

The economic results indicate that channel and bridge improvements in this reach are not economically feasible. However, by making improvements in reaches E3 & E6, the reduced backwater effects result in lower water surface profiles through reach E4. No improvements were assumed through this reach.

6.2.8. Plan H – 4% ACE (Select Locations)

Plan H includes the 4% ACE channel found in previous plans, but reduced to select locations where the apparent benefits could be maximized.

Design Methodology

After examining the economic results from plan G, this plan attempts to remove some of the more costly portions of the project in an effort to optimize the net benefits. Plan H began as a copy of Plan G and sections of the geometry were imported from other HEC-RAS files as outlined below.

Reach E1 – Downstream of Bennett Street

Since the economic results indicate that a 0.2% ACE level of protection will provide the greatest net benefits in this area, the geometry from Plan D was selected. This reach is hydraulically independent of the other project areas, so the selection of a level of protection throughout this reach did not impact the water surface profiles for any other reach.

Reach E2 – Mt Vernon Street to Fort Avenue

The economic results from the previous plans indicate that channel and bridge improvements in this reach are not economically feasible. As a result, all improvements were removed from the model (the Without Project Geometry was imported into this reach). This reach is hydraulically independent and modifying these improvements have no impact on other study areas.

Reach E3 & E6 – Downtown to Fremont Avenue

This plan includes channel improvements from Main Avenue to Boonville Avenue and from just downstream of National Avenue to Fremont Avenue. This removes a large portion of improvements in between Boonville and National. These reaches are NOT hydraulically independent and improvements in reaches E3 & E6 have an impact on the water surface profiles for reach E4, although not as significant as in earlier plans.

Reach E4 – Confluence to Central Street

The economic results indicate that channel and bridge improvements in this reach are not economically feasible. However, by making improvements in reaches E3 & E6, the reduced backwater effects result in lower water surface profiles through reach E4. No improvements were assumed through this reach.

6.2.9. Plan I – Plan G w/o Detention

Plan I is a copy of plan G, but the flows were modified such that the detention basins were not included.

Design Methodology

Plan I began as a copy of Plan G and the flow inputs were copied from the Without Project model(s).

6.2.10. Plan J – Regional Detention & Reach E1

Plan J includes the five regional detention basins with the 0.2% ACE improvements in reach E1.

Design Methodology

Plan J is a copy of the Without Project plan with the geometry from Plan D (0.2% ACE).

List of Plates

List of Appendixes

Plate A: Flow data tables

Point of Interest		Current Development 100 Yr Peak Flow	Critical 100yr Duration (hr) 1	2	3	6	12	18	24	Future Development 100 Yr Peak Flow	Critical 100yr Duration (hr) 1	2	3	6	12	18	24	% Increase
North Branch	X-SEC																	
HCNB9	18653	166	----	----	----	----	X	----	----	175	----	----	----	----	X	----	----	5.4%
RRNB31	16668	193	----	----	----	----	X	X	----	204	----	----	----	----	X	----	----	5.7%
NB17	15747	213	----	----	----	----	----	X	----	225	----	----	----	----	----	X	----	5.6%
HCNB12	14505	626	----	X	----	----	----	----	----	676	----	X	----	----	----	----	----	8.0%
HCNB13	13249	745	----	X	----	----	----	----	----	819	----	X	----	----	----	----	----	9.9%
NB12	11949	756	----	----	X	----	----	----	----	844	----	----	X	----	----	----	----	11.6%
HCNB17	11140	1055	----	----	X	----	----	----	----	1169	----	----	X	----	----	----	----	10.8%
HCNB19	10225	1179	----	----	X	----	----	----	----	1285	----	----	X	----	----	----	----	9.0%
RNB39B	10068	1175	----	----	X	----	----	----	----	1280	----	----	X	----	----	----	----	8.9%
HCNB21	9515	1511	----	----	X	----	----	----	----	1564	----	----	X	----	----	----	----	3.5%
NB42	8776	1575	----	----	X	----	----	----	----	1623	----	----	X	----	----	----	----	3.0%
HCNB25	8293	1625	----	----	X	----	----	----	----	1681	----	----	X	----	----	----	----	3.4%
NB44	7084	1714	----	----	X	----	----	----	----	1767	----	----	X	----	----	----	----	3.1%
NB54	5346	2216	----	----	X	----	----	----	----	2318	----	----	X	----	----	----	----	4.6%
HCNB29	5026	2280	----	----	X	----	----	----	----	2377	----	----	X	----	----	----	----	4.3%
HCNB30	3659	2429	----	----	X	----	----	----	----	2516	----	----	X	----	----	----	----	3.6%
HCNB31	1837	2627	----	----	X	----	----	----	----	2746	----	----	X	----	----	----	----	4.5%
HCNB32	610	2734	----	----	X	----	----	----	----	2848	----	----	X	----	----	----	----	4.2%
South Branch																		
RRSJ6	14475	773	----	X	----	----	----	----	----	835	----	X	----	----	----	----	----	8.0%
HCSJ6	12585	1378	----	X	----	----	----	----	----	1676	----	X	----	----	----	----	----	21.6%
HCSJ7	10710	1585	----	X	----	----	----	----	----	1955	----	X	----	----	----	----	----	23.3%
HCSJ8	8856	1917	----	----	X	----	----	----	----	2523	----	----	X	----	----	----	----	31.6%
SJ34	7825	1927	----	----	X	----	----	----	----	2478	----	----	X	----	----	----	----	28.6%
HCSJ11	7131	2069	----	----	X	----	----	----	----	2673	----	----	X	----	----	----	----	29.2%
HCSJ12	6309	2160	----	----	X	----	----	----	----	2683	----	----	X	----	----	----	----	24.2%
SJ37	5006	2247	----	----	X	----	----	----	----	2749	----	----	X	----	----	----	----	22.3%
Est Box Capacity	1643	725	----	----	X	----	----	----	----	728	----	----	X	----	----	----	----	0.4%
SJ37 - Box Capacity	4432	1523	----	----	X	----	----	----	----	2021	----	----	X	----	----	----	----	32.7%
SJ44A	2584	2674	----	----	X	----	----	----	----	3064	----	----	X	----	----	----	----	14.6%
SJ44B	1390	2868	----	----	X	----	----	----	----	3202	----	----	X	----	----	----	----	11.6%
SJ45	761	2897	----	----	X	----	----	----	----	3218	----	----	X	----	----	----	----	11.1%
Lower Branch																		
HC75	16700	5608	----	----	X	----	----	----	----	6022	----	----	X	----	----	----	----	7.4%
Est Box Capacity	3354	2346	----	----	X	----	----	----	----	2374	----	----	X	----	----	----	----	1.2%
HC75 – Box Capacity	16690	3262	----	----	X	----	----	----	----	3648	----	----	X	----	----	----	----	11.8%
HC75	13427	5608	----	----	X	----	----	----	----	6022	----	----	X	----	----	----	----	7.4%
HCLJ7	13132	5683	----	----	X	----	----	----	----	6163	----	----	X	----	----	----	----	8.4%
HCLJ15	9733	6060	----	----	----	X	----	----	----	6650	----	----	----	X	----	----	----	9.7%
HCLJ16	8274	6157	----	----	----	X	----	----	----	6771	----	----	----	X	----	----	----	10.0%
HCL25X	5689	6341	----	----	----	X	----	----	----	6969	----	----	----	X	----	----	----	9.9%
HCLJ19	3859	6737	----	----	----	X	----	----	----	7411	----	----	----	X	----	----	----	10.0%
HCLJ20	2266	6806	----	----	----	X	----	----	----	7491	----	----	----	X	----	----	----	10.1%
HCL34X	621	6777	----	----	----	X	----	----	----	7482	----	----	----	X	----	----	----	10.4%
Fassnight Creek																		
F11B	11358	3270	----	----	X	----	----	----	----	3963	----	----	X	----	----	----	----	21.2%
COMB14	9487	3988	----	----	X	----	----	----	----	4854	----	----	X	----	----	----	----	21.7%
F14	7121	3988	----	----	X	----	----	----	----	4854	----	----	X	----	----	----	----	21.7%
COMB9	6405	4650	----	----	X	----	----	----	----	5641	----	----	X	----	----	----	----	21.3%
COMB10	4641	4726	----	----	X	----	----	----	----	5739	----	----	X	----	----	----	----	21.4%
COMB11	3883	4726	----	----	X	----	----	----	----	5739	----	----	X	----	----	----	----	21.4%
COMB12	2816	4354	----	----	X	----	----	----	----	5753	----	----	X	----	----	----	----	32.1%
COMB13	2020	4456	----	----	X	----	----	----	----	5692	----	----	X	----	----	----	----	27.7%
Wilsons Creek																		
COMBJF	33108	9859	----	----	----	X	----	----	----	11009	----	----	----	X	----	----	----	11.7%

Point of Interest	Current Development Maximum 100 yr Flowrate (cfs)	Hr	1	2	3	6	12	18	24		Point
North Branch											North Branch
HCNB9	166	12	----	----	----	----	X	----	----	5	HCNB9
RRNB31	193	12	----	----	----	----	X	X	----	5	RRNB31
NB17	213	18	----	----	----	----	----	X	----	6	NB17
HCNB12	626	2	----	X	----	----	----	----	----	2	HCNB12
HCNB13	745	2	----	X	----	----	----	----	----	2	HCNB13
NB12	756	3	----	----	X	----	----	----	----	3	NB12
HCNB17	1055	3	----	----	X	----	----	----	----	3	HCNB17
HCNB19	1179	3	----	----	X	----	----	----	----	3	HCNB19
RNB39B	1175	3	----	----	X	----	----	----	----	3	RNB39B
HCNB21	1511	3	----	----	X	----	----	----	----	3	HCNB21
NB42	1575	3	----	----	X	----	----	----	----	3	NB42
HCNB25	1625	3	----	----	X	----	----	----	----	3	HCNB25
NB44	1714	3	----	----	X	----	----	----	----	3	NB44
NB54	2216	3	----	----	X	----	----	----	----	3	NB54
HCNB29	2280	3	----	----	X	----	----	----	----	3	HCNB29
HCNB30	2429	3	----	----	X	----	----	----	----	3	HCNB30
HCNB31	2627	3	----	----	X	----	----	----	----	3	HCNB31
HCNB32	2734	3	----	----	X	----	----	----	----	3	HCNB32
South Branch											South Branch
RRSJ6	773	2	----	X	----	----	----	----	----	2	RRSJ6
HCSJ6	1378	2	----	X	----	----	----	----	----	2	HCSJ6
HCSJ7	1585	2	----	X	----	----	----	----	----	2	HCSJ7
HCSJ8	1917	3	----	----	X	----	----	----	----	3	HCSJ8
SJ34	1927	3	----	----	X	----	----	----	----	3	SJ34
HCSJ11	2069	3	----	----	X	----	----	----	----	3	HCSJ11
HCSJ12	2160	3	----	----	X	----	----	----	----	3	HCSJ12
SJ37	2247	3	----	----	X	----	----	----	----	3	SJ37
Est Box Capacity	725	3	----	----	X	----	----	----	----	3	Est Box Capacity
SJ37 - Box Capacity	1523	3	----	----	X	----	----	----	----	3	SJ37 - Box Capacity
SJ44A	2674	3	----	----	X	----	----	----	----	3	SJ44A
SJ44B	2868	3	----	----	X	----	----	----	----	3	SJ44B
SJ45	2897	3	----	----	X	----	----	----	----	3	SJ45
Lower Branch											Lower Branch
HC75	5608	3	----	----	X	----	----	----	----	3	HC75
Est Box Capacity	2346	3	----	----	X	----	----	----	----	3	Est Box Capacity
HC75 - Box Capacity	3262	3	----	----	X	----	----	----	----	3	HC75 - Box Capacity
HC75	5608	3	----	----	X	----	----	----	----	3	HC75
HCLJ7	5683	3	----	----	X	----	----	----	----	3	HCLJ7
HCLJ15	6060	6	----	----	----	X	----	----	----	4	HCLJ15
HCLJ16	6157	6	----	----	----	X	----	----	----	4	HCLJ16
HCL25X	6341	6	----	----	----	X	----	----	----	4	HCL25X
HCLJ19	6737	6	----	----	----	X	----	----	----	4	HCLJ19
HCLJ20	6806	6	----	----	----	X	----	----	----	4	HCLJ20
HCL34X	6777	6	----	----	----	X	----	----	----	4	HCL34X
Fassnight Creek											
F11B	3270	3	----	----	X	----	----	----	----	3	F11B
F14	3988	3	----	----	X	----	----	----	----	3	F14
F14	3988	3	----	----	X	----	----	----	----	3	F14
COMB10	4650	3	----	----	X	----	----	----	----	3	COMB10
COMB11	4726	3	----	----	X	----	----	----	----	3	COMB11
COMB11	4726	3	----	----	X	----	----	----	----	3	COMB11
COMB12	4354	3	----	----	X	----	----	----	----	3	COMB12
COMB13	4456	3	----	----	X	----	----	----	----	3	COMB13
Wilsons Creek											
COMBJF	9859	6	----	----	----	X	----	----	----	4	COMBJF

Point	1 Hour Peak Flows 1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	2 Hour Peak Flows 1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr
HCNB9									56	71	92	107	123	133	154	173
RRNB31									51	63	81	106	140	156	172	215
NB17									56	69	89	113	153	172	192	241
HCNB12									113	173	261	335	443	530	626	844
HCNB13									136	208	306	392	525	630	745	1009
RRSJ6									176	250	363	451	570	667	773	1038
HCSJ6									226	337	518	678	890	1074	1378	1981
HCSJ7									279	434	671	861	1114	1322	1585	2279

Point	3 Hour Peak Flows 1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	6 Hour Peak Flows 1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr
North Branch																
HCNB9	54	73	101	118	137	156	165	177	47	66	98	116	142	157	165	178
RRNB31	52	73	109	131	152	173	188	214	51	69	108	129	155	173	189	218
NB17	57	78	115	140	162	185	203	246	55	74	114	138	163	182	205	245
HCNB12	113	166	243	309	400	478	560	744	106	147	204	250	312	363	427	571
HCNB13	135	201	294	372	484	581	682	915	125	178	247	305	388	457	529	702
NB12	157	234	337	425	547	647	756	1009	143	205	287	356	454	534	620	815
HCNB17	225	341	496	617	777	908	1055	1391	197	290	417	516	657	771	886	1148
HCNB19	263	389	564	699	872	1014	1179	1552	224	329	476	589	747	873	1002	1301
RNB39B	257	383	556	693	868	1010	1175	1544	223	325	471	583	742	867	994	1295
HCNB21	343	490	714	889	1120	1301	1511	1970	287	415	603	745	943	1094	1253	1632
NB42	358	508	742	925	1165	1355	1575	2058	299	431	627	776	981	1138	1303	1698
HCNB25	369	522	763	951	1200	1397	1625	2124	308	443	645	798	1009	1170	1339	1748
NB44	387	547	802	999	1263	1473	1714	2248	324	465	678	840	1064	1233	1412	1845
NB54	507	723	1054	1310	1653	1923	2216	2916	420	603	882	1097	1389	1609	1837	2364
HCNB29	521	743	1082	1345	1699	1978	2280	2998	432	619	905	1128	1428	1657	1892	2433
HCNB30	551	790	1148	1429	1808	2107	2429	3185	457	657	961	1199	1519	1764	2017	2591
HCNB31	593	854	1237	1542	1952	2279	2627	3425	493	709	1036	1295	1643	1911	2190	2813
HCNB32	625	895	1294	1612	2034	2373	2734	3558	519	746	1084	1355	1716	1995	2287	2939
South Branch																
RRSJ6	163	231	332	411	516	602	693	914	126	179	257	315	393	456	524	680
HCSJ6	216	320	497	638	829	1048	1325	1856	184	276	421	528	692	872	1077	1475
HCSJ7	273	417	643	820	1056	1253	1551	2178	236	352	541	681	871	1053	1289	1784
HCSJ8	348	540	819	1060	1390	1616	1917	3182	305	461	702	906	1242	1503	1758	2648
SJ34	351	544	824	1063	1396	1626	1927	3118	309	467	709	914	1253	1515	1772	2628
HCSJ11	415	641	952	1213	1523	1781	2069	3379	368	555	822	1053	1396	1671	1952	2881
HCSJ12	453	687	1015	1285	1585	1871	2160	3379	400	600	883	1125	1473	1757	2053	2951
SJ37	480	719	1060	1337	1636	1940	2247	3456	424	634	931	1182	1533	1829	2137	3047
Est Box Capacity	479	718	751	744	733	729	725	717								
SJ37 - Box Capacity	1	1	309	593	903	1212	1523	2739								
SJ44A	557	821	1204	1536	1940	2273	2674	3813	507	740	1086	1368	1795	2133	2501	3446
SJ44B	595	868	1269	1616	2096	2444	2868	3953	550	793	1160	1457	1935	2266	2660	3613
SJ45	601	876	1279	1628	2119	2477	2897	3974	556	802	1172	1471	1957	2287	2685	3639
Lower Branch																
HC75	1202	1700	2477	3093	4145	4842	5608	7440	1069	1513	2199	2733	3656	4260	4881	6409
Est Box Capacity	1201	1699	2039	2120	2249	2307	2346	2436								
HC75 - Box Capacity	1	1	438	973	1896	2535	3262	5004								
HC75	1202	1700	2477	3093	4145	4842	5608	7440	1069	1513	2199	2733	3656	4260	4881	6409
HCLJ7	1401	1955	2813	3438	4370	4998	5683	7279	1252	1747	2522	3120	3995	4591	5213	6665
HCLJ15									1505	2076	2955	3652	4629	5361	6060	7657
HCLJ16									1530	2112	3003	3710	4692	5438	6157	7772
HCL25X									1573	2169	3079	3806	4801	5595	6341	7994
HCLJ19									1665	2289	3243	4010	5057	5933	6737	8466
HCLJ20									1681	2309	3268	4042	5094	5979	6806	8548
HCL34X									1688	2314	3273	4046	5092	5941	6777	8561
F11B	783	1024	1392	1722	2267	2740	3270	4467	634	810	1080	1351	1787	2143	2533	3430
F14	914	1230	1716	2154	2813	3366	3988	5411	743	980	1352	1674	2221	2669	3158	4273
F14	914	1230	1716	2154	2813	3366	3988	5411	743	980	1352	1674	2221	2669	3158	4273
COMB10	1091	1459	2017	2530	3296	3934	4650	6291	897	1177	1609	1989	2621	3155	3734	5053
COMB11	1107	1480	2049	2573	3352	3999	4726	6393	913	1198	1639	2029	2672	3216	3807	5152
COMB11	1107	1480	2049	2573	3352	3999	4726	6393	913	1198	1639	2029	2672	3216	3807	5152
COMB12	1097	1484	2043	2538	3160	3742	4354	6260	922	1206	1657	2048	2665	3139	3686	5119
COMB13	1111	1511	2099	2616	3247	3831	4456	6392	933	1236	1712	2130	2768	3256	3819	5213
COMBJF									2293	3158	4457	5530	6995	8355	9859	12777

Point	12 Hour Peak Flows 1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	18 Hour Peak Flows 1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	24 Hour Peak Flows 1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr
North Branch																								
HCNB9	47	66	98	117	143	157	166	182	49	67	98	117	142	154	163	181	45	62	89	107	133	148	157	175
RRNB31	52	72	112	132	161	179	193	225	54	74	112	132	160	177	193	224	51	69	101	124	152	169	183	211
NB17	57	77	120	142	171	192	211	256	58	79	120	143	171	193	213	256	55	74	109	134	163	183	200	238
HCNB12	107	145	199	246	318	374	428	542	109	147	199	253	320	364	415	522	100	133	180	231	287	326	372	459
HCNB13	125	174	237	288	371	436	505	645	128	173	232	289	368	423	480	608	117	156	210	261	329	374	425	533
NB12	143	200	272	330	414	489	568	730	145	197	263	321	408	474	537	678	132	176	237	287	367	418	473	593
HCNB17	196	277	381	462	573	666	777	995	196	269	362	438	554	645	731	917	175	237	321	385	491	560	640	801
HCNB19	224	314	431	521	646	745	865	1111	222	302	407	489	614	715	811	1015	197	264	357	428	542	619	704	882
RNB39B	221	309	428	517	641	742	861	1107	219	298	403	485	609	711	807	1011	194	262	354	425	538	616	702	879
HCNB21	281	390	538	648	801	923	1061	1363	274	370	500	599	743	867	984	1230	240	322	433	519	650	744	845	1059
NB42	292	405	559	673	831	958	1100	1413	284	384	518	621	769	897	1018	1273	248	333	447	536	671	769	873	1094
HCNB25	300	416	574	691	853	984	1128	1451	291	393	531	637	787	919	1044	1305	254	341	458	550	686	788	894	1124
NB44	314	436	603	726	897	1038	1186	1527	304	411	557	668	824	962	1097	1373	266	356	480	577	717	828	940	1183
NB54	401	557	779	946	1167	1349	1536	1954	386	524	715	858	1055	1224	1400	1749	335	454	614	738	907	1051	1192	1498
HCNB29	412	571	802	974	1202	1389	1582	2010	395	538	735	882	1086	1258	1440	1799	343	466	631	758	931	1080	1225	1539
HCNB30	435	605	852	1036	1280	1479	1684	2138	417	570	780	938	1154	1335	1529	1912	362	494	669	805	987	1145	1299	1633
HCNB31	467	652	920	1122	1387	1603	1826	2313	447	613	841	1013	1247	1440	1650	2066	389	532	722	869	1064	1234	1402	1762
HCNB32	489	684	962	1173	1448	1672	1902	2407	468	641	878	1057	1298	1497	1715	2144	407	556	753	905	1107	1283	1458	1831
South Branch																								
RRSJ6	111	159	222	266	326	374	424	522	107	147	201	237	288	328	371	456	90	123	167	200	240	273	309	384
HCSJ6	184	271	391	486	637	778	917	1159	182	261	368	452	581	673	795	993	160	226	315	385	491	567	645	825
HCSJ7	235	344	498	613	792	948	1126	1440	232	330	465	566	723	835	977	1227	203	285	397	484	611	704	799	1020
HCSJ8	307	446	665	908	1217	1410	1645	2273	306	436	707	902	1161	1356	1595	2061	268	379	622	778	993	1186	1429	1784
SJ34	311	452	672	915	1228	1421	1658	2286	310	441	713	909	1171	1366	1608	2075	271	383	627	785	1000	1194	1438	1795
HCSJ11	369	527	776	1034	1374	1580	1840	2494	368	511	802	1021	1309	1534	1759	2309	321	446	705	884	1121	1312	1592	1991
HCSJ12	398	568	830	1094	1450	1678	1936	2595	398	549	848	1080	1384	1621	1841	2421	347	479	749	938	1186	1380	1671	2092
SJ37	420	601	875	1142	1513	1759	2018	2682	420	578	886	1128	1444	1690	1912	2517	366	505	782	981	1238	1441	1735	2176
Est Box Capacity																								
SJ37 - Box Capacity																								
SJ44A	499	708	1018	1302	1768	2090	2390	3076	494	678	1019	1308	1705	1995	2262	2938	430	591	904	1143	1439	1702	2013	2543
SJ44B	540	761	1090	1377	1882	2232	2560	3293	533	728	1079	1388	1816	2125	2419	3118	464	634	959	1209	1519	1815	2130	2703
SJ45	546	770	1101	1389	1900	2254	2586	3325	539	737	1089	1400	1833	2144	2441	3145	469	641	968	1220	1532	1832	2147	2726
Lower Branch																								
HC75	1035	1441	2027	2485	3304	3916	4479	5727	1006	1360	1904	2392	3128	3640	4150	5278	874	1189	1680	2094	2613	3114	3600	4552
Est Box Capacity																								
HC75 - Box Capacity																								
HC75	1035	1441	2027	2485	3304	3916	4479	5727	1006	1360	1904	2392	3128	3640	4150	5278	874	1189	1680	2094	2613	3114	3600	4552
HCLJ7	1207	1666	2338	2854	3663	4271	4851	6119	1167	1568	2171	2706	3438	3974	4498	5633	1012	1380	1902	2366	2939	3457	3952	4948
HCLJ15	1441	1965	2748	3350	4230	4950	5619	7048	1390	1856	2531	3114	3963	4604	5200	6447	1213	1661	2223	2755	3426	4009	4577	5735
HCLJ16	1465	1999	2792	3407	4289	5025	5711	7162	1416	1891	2579	3163	4025	4680	5288	6559	1234	1691	2262	2800	3480	4067	4646	5820
HCL25X	1506	2053	2867	3500	4393	5170	5883	7374	1459	1946	2650	3242	4119	4803	5459	6761	1257	1746	2332	2884	3584	4183	4781	5996
HCLJ19	1596	2170	3028	3701	4625	5484	6259	7848	1553	2065	2806	3420	4331	5082	5821	7208	1333	1861	2480	3062	3805	4434	5074	6370
HCLJ20	1612	2191	3055	3733	4663	5512	6315	7932	1570	2086	2832	3450	4366	5123	5871	7285	1344	1883	2505	3091	3841	4474	5124	6432
HCL34X	1621	2202	3067	3748	4683	5488	6321	7950	1573	2096	2844	3467	4381	5126	5853	7289	1337	1897	2516	3102	3855	4485	5141	6457
F11B	427	643	966	1212	1536	1793	2069	2665	438	629	897	1102	1374	1590	1818	2313	380	537	751	921	1143	1319	1507	1909
F14	533	797	1203	1515	1929	2257	2606	3365	542	783	1121	1382	1727	2003	2293	2920	472	670	943	1160	1444	1668	1907	2420
F14	533	797	1203	1515	1929	2257	2606	3365	542	783	1121	1382	1727	2003	2293	2920	472	670	943	1160	1444	1668	1907	2420
COMB10	628	937	1421	1796	2292	2683	3102	4014	637	925	1329	1645	2057	2389	2737	3491	556	794	1124	1384	1726	1995	2283	2901
COMB11	640	954	1449	1832	2339	2739	3167	4100	648	943	1356	1679	2101	2441	2796	3568	566	810	1147	1414	1764	2039	2335	2968
COMB11	640	954	1449	1832	2339	2739	3167	4100	648	943	1356	1679	2101	2441	2796	3568	566	810	1147	1414	1764	2039	2335	2968
COMB12	650	970	1472	1852	2363	2720	3112	4017	659	959	1378	1701	2126	2460	2781	3519	576	825	1167	1439	1789	2068	2369	2968
COMB13	670	1003	1530	1930	2467	2839	3248	4194	682	998	1437	1777	2224	2575	2908	3683	596	860	1219	1505	1874	2169	2486	3112
COMBJF	2232	3069	4238	5202	6538	7693	9042	11725	2205	3021	3983	4823	6036	7080	8206	10616	1854	2727	3540	4289	5343	6188	7135	9277

Point of Interest	Ultimate Development Maximum 100 yr Flowrate (cfs)	Hr	1	2	3	6	12	18	24		Point
North Branch											North Branch
HCNB9	175	12	----	----	----	----	X	----	----	5	HCNB9
RRNB31	204	12	----	----	----	----	X	----	----	5	RRNB31
NB17	225	18	----	----	----	----	----	X	----	6	NB17
HCNB12	676	2	----	X	----	----	----	----	----	2	HCNB12
HCNB13	819	2	----	X	----	----	----	----	----	2	HCNB13
NB12	844	3	----	----	X	----	----	----	----	3	NB12
HCNB17	1169	3	----	----	X	----	----	----	----	3	HCNB17
HCNB19	1285	3	----	----	X	----	----	----	----	3	HCNB19
RNB39B	1280	3	----	----	X	----	----	----	----	3	RNB39B
HCNB21	1564	3	----	----	X	----	----	----	----	3	HCNB21
NB42	1623	3	----	----	X	----	----	----	----	3	NB42
HCNB25	1681	3	----	----	X	----	----	----	----	3	HCNB25
NB44	1767	3	----	----	X	----	----	----	----	3	NB44
NB54	2318	3	----	----	X	----	----	----	----	3	NB54
HCNB29	2377	3	----	----	X	----	----	----	----	3	HCNB29
HCNB30	2516	3	----	----	X	----	----	----	----	3	HCNB30
HCNB31	2746	3	----	----	X	----	----	----	----	3	HCNB31
HCNB32	2848	3	----	----	X	----	----	----	----	3	HCNB32
South Branch											South Branch
RRSJ6	835	2	----	X	----	----	----	----	----	2	RRSJ6
HCSJ6	1676	2	----	X	----	----	----	----	----	2	HCSJ6
HCSJ7	1955	2	----	X	----	----	----	----	----	2	HCSJ7
HCSJ8	2523	3	----	----	X	----	----	----	----	3	HCSJ8
SJ34	2478	3	----	----	X	----	----	----	----	3	SJ34
HCSJ11	2673	3	----	----	X	----	----	----	----	3	HCSJ11
HCSJ12	2683	3	----	----	X	----	----	----	----	3	HCSJ12
SJ37	2749	3	----	----	X	----	----	----	----	3	SJ37
Est Box Capacity	728	3	----	----	X	----	----	----	----	3	Est Box Capacity
SJ37 - Box Capacity	2021	3	----	----	X	----	----	----	----	3	SJ37 - Box Capacity
SJ44A	3064	3	----	----	X	----	----	----	----	3	SJ44A
SJ44B	3202	3	----	----	X	----	----	----	----	3	SJ44B
SJ45	3218	3	----	----	X	----	----	----	----	3	SJ45
Lower Branch											Lower Branch
HC75	6022	3	----	----	X	----	----	----	----	3	HC75
Est Box Capacity	2374	3	----	----	X	----	----	----	----	3	Est Box Capacity
HC75 - Box Capacit	3648	3	----	----	X	----	----	----	----	3	HC75 - Box Capacity
HC75	6022	3	----	----	X	----	----	----	----	3	HC75
HCLJ7	6163	3	----	----	X	----	----	----	----	3	HCLJ7
HCLJ15	6650	6	----	----	----	X	----	----	----	4	HCLJ15
HCLJ16	6771	6	----	----	----	X	----	----	----	4	HCLJ16
HCL25X	6969	6	----	----	----	X	----	----	----	4	HCL25X
HCLJ19	7411	6	----	----	----	X	----	----	----	4	HCLJ19
HCLJ20	7491	6	----	----	----	X	----	----	----	4	HCLJ20
HCL34X	7482	6	----	----	----	X	----	----	----	4	HCL34X
Fassnight Creek											
F11B	3963	3	----	----	X	----	----	----	----	3	F11B
F14	4854	3	----	----	X	----	----	----	----	3	F14
F14	4854	3	----	----	X	----	----	----	----	3	F14
COMB10	5641	3	----	----	X	----	----	----	----	3	COMB10
COMB11	5739	3	----	----	X	----	----	----	----	3	COMB11
COMB11	5739	3	----	----	X	----	----	----	----	3	COMB11
COMB12	5753	3	----	----	X	----	----	----	----	3	COMB12
COMB13	5692	3	----	----	X	----	----	----	----	3	COMB13
Wilsons Creek											
COMBJF	11009	6	----	----	----	X	----	----	----	4	COMBJF

Point	1 Hour Peak Flows								2 Hour Peak Flows							
	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr
North Branch																
HCNB9									68	84	104	119	130	137	160	177
RRNB31									64	77	110	133	152	163	178	223
NB17									68	84	118	144	167	184	216	283
HCNB12									158	220	311	383	488	574	676	933
HCNB13									189	261	375	468	600	704	819	1106
NB12																
HCNB17																
HCNB19																
RNB39B																
HCNB21																
NB42																
HCNB25																
NB44																
NB54																
HCNB29																
HCNB30																
HCNB31																
HCNB32																
South Branch																
RRSJ6									222	301	417	505	622	714	835	1095
HCSJ6									323	444	619	753	1114	1402	1676	2291
HCSJ7									363	503	721	936	1325	1630	1955	2666
HCSJ8																
SJ34																
HCSJ11																
HCSJ12																
SJ37																
Est Box Capacity																
SJ37 - Box Capacity																
SJ44A																
SJ44B																
SJ45																
Lower Branch																
HC75																
Est Box Capacity																
HC75 - Box Capacity																
HC75																
HCLJ7																
HCLJ15																
HCLJ16																
HCL25X																
HCLJ19																
HCLJ20																
HCL34X																
F11B																
F14																
F14																
COMB10																
COMB11																
COMB11																
COMB12																
COMB13																
COMBJF																

Point	3 Hour Peak Flows								6 Hour Peak Flows							
	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr
North Branch																
HCNB9	68	92	117	133	157	167	172	184	63	89	117	140	160	167	173	185
RRNB31	70	90	129	145	170	184	197	219	67	93	127	152	175	185	198	223
NB17	74	95	137	154	179	196	216	275	72	98	134	159	183	197	215	251
HCNB12	160	216	298	363	455	533	627	846	146	190	256	307	379	446	515	686
HCNB13	190	259	364	448	566	660	769	1014	173	227	312	377	465	541	629	816
NB12	210	284	402	495	620	725	844	1111	192	255	350	425	526	609	702	918
HCNB17	291	391	585	712	875	1015	1169	1490	261	346	500	615	758	870	993	1278
HCNB19	323	435	645	781	960	1117	1285	1644	292	389	557	688	845	969	1106	1425
RNB39B	315	431	637	776	954	1111	1280	1639	287	386	551	682	839	961	1101	1419
HCNB21	387	537	771	942	1157	1351	1564	2057	353	480	677	842	1034	1184	1361	1749
NB42	397	556	795	978	1203	1402	1623	2141	365	497	701	872	1072	1228	1412	1814
HCNB25	412	578	823	1014	1249	1450	1681	2218	378	515	723	901	1108	1268	1457	1871
NB44	433	605	860	1065	1316	1523	1767	2335	394	539	757	943	1161	1330	1529	1965
NB54	588	822	1157	1420	1752	2014	2318	3095	518	711	997	1235	1520	1733	1973	2543
HCNB29	604	842	1185	1455	1797	2068	2377	3173	530	728	1021	1264	1558	1778	2021	2609
HCNB30	639	888	1252	1536	1903	2195	2516	3346	558	767	1078	1332	1650	1889	2141	2763
HCNB31	698	968	1365	1672	2079	2403	2746	3621	603	829	1170	1442	1795	2061	2337	2997
HCNB32	728	1007	1417	1734	2153	2491	2848	3743	629	862	1219	1499	1864	2142	2431	3110
South Branch																
RRSJ6	210	280	381	458	559	640	727	950	177	228	298	353	432	496	565	717
HCSJ6	311	420	579	721	1070	1324	1570	2104	274	362	481	623	882	1062	1246	1631
HCSJ7	358	497	696	921	1283	1560	1858	2496	324	439	613	795	1078	1296	1513	2001
HCSJ8	433	640	934	1190	1596	1930	2523	3713	397	573	820	1074	1445	1744	2054	3050
SJ34	438	644	938	1197	1604	1937	2478	3642	403	580	828	1083	1453	1755	2066	3034
HCSJ11	532	750	1088	1338	1729	2082	2673	3980	484	675	963	1210	1593	1914	2248	3338
HCSJ12	576	798	1153	1420	1787	2143	2683	3941	526	722	1028	1272	1660	1990	2333	3398
SJ37	610	835	1201	1484	1841	2204	2749	4024	562	760	1083	1331	1717	2056	2413	3512
Est Box Capacity	609	747	746	736	731	733	728	711								
SJ37 - Box Capacity	1	88	455	748	1110	1471	2021	3313								
SJ44A	719	982	1398	1800	2174	2462	3064	4480	666	896	1274	1619	2027	2347	2747	4002
SJ44B	787	1060	1488	1947	2397	2753	3202	4710	730	972	1366	1747	2211	2515	2893	4237
SJ45	793	1068	1498	1961	2421	2786	3218	4730	736	980	1378	1762	2233	2543	2913	4263
Lower Branch																
HC75	1497	2035	2843	3674	4567	5270	6022	7923	1358	1823	2543	3219	4095	4672	5273	7109
Est Box Capacity	1496	1928	2090	2199	2285	2341	2374	2456								
HC75 - Box Capacity	1	107	753	1475	2282	2929	3648	5467								
HC75	1497	2035	2843	3674	4567	5270	6022	7923	1358	1823	2543	3219	4095	4672	5273	7109
HCLJ7	1766	2380	3283	4008	4867	5501	6163	8048	1595	2126	2931	3596	4476	5041	5661	7392
HCLJ15									1924	2557	3514	4205	5249	5945	6650	8338
HCLJ16									1960	2606	3582	4282	5338	6050	6771	8465
HCL25X									2009	2672	3671	4395	5492	6227	6969	8665
HCLJ19									2125	2827	3879	4649	5834	6624	7411	9176
HCLJ20									2143	2850	3910	4688	5878	6683	7491	9265
HCL34X									2148	2852	3911	4693	5828	6658	7482	9261
F11B	1045	1373	1853	2256	2869	3390	3963	5271	831	1087	1446	1738	2183	2582	3013	3995
F14	1341	1780	2394	2882	3581	4185	4854	6384	1078	1424	1905	2286	2826	3300	3828	5028
F14	1341	1780	2394	2882	3581	4185	4854	6384	1078	1424	1905	2286	2826	3300	3828	5028
COMB10	1572	2079	2794	3371	4182	4873	5641	7400	1284	1688	2255	2707	3357	3913	4533	5946
COMB11	1601	2116	2844	3433	4258	4960	5739	7525	1314	1727	2306	2771	3436	4001	4631	6073
COMB11	1601	2116	2844	3433	4258	4960	5739	7525	1314	1727	2306	2771	3436	4001	4631	6073
COMB12	1614	2098	2734	3219	3979	4587	5753	6340	1331	1736	2308	2713	3308	3861	4423	6165
COMB13	1646	2148	2801	3291	4054	4662	5692	6493	1367	1790	2382	2803	3412	3973	4542	6232
COMBJF									2919	3840	5256	6420	8075	9547	11009	13579

Point	12 Hour Peak Flows								18 Hour Peak Flows								24 Hour Peak Flows							
	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr
North Branch																								
HCNB9	58	83	114	137	157	166	175	188	58	80	110	133	152	161	170	187	53	72	98	121	143	154	162	180
RRNB31	66	90	129	153	177	191	204	232	65	88	125	148	172	188	201	230	60	80	114	136	163	178	190	216
NB17	71	96	137	162	188	206	223	265	70	93	135	157	186	205	225	265	65	86	124	146	176	193	211	245
HCNB12	140	180	243	297	365	418	470	588	133	172	236	287	345	391	444	543	120	155	210	257	307	348	393	475
HCNB13	165	213	281	347	433	497	560	695	156	202	270	332	404	459	520	638	140	181	239	296	354	403	456	554
NB12	184	238	314	384	480	551	623	774	173	223	297	365	446	505	571	704	155	200	261	324	390	442	501	612
HCNB17	245	318	432	526	656	756	855	1059	229	296	396	489	606	688	772	987	204	264	348	429	524	594	689	865
HCNB19	274	356	483	587	725	836	947	1178	256	329	439	535	668	758	850	1078	227	293	384	469	577	653	751	945
RNB39B	271	353	480	583	722	832	942	1175	254	327	436	532	665	755	846	1076	225	290	382	467	574	651	748	941
HCNB21	335	438	593	718	883	1015	1150	1441	312	402	535	642	805	916	1026	1295	273	353	463	560	689	782	890	1120
NB42	347	454	616	745	915	1051	1191	1492	323	416	554	664	832	946	1061	1337	282	365	478	578	711	807	917	1155
HCNB25	358	469	635	768	942	1082	1226	1538	332	428	570	683	855	973	1091	1373	290	375	492	593	731	829	941	1185
NB44	375	492	666	805	988	1134	1285	1620	347	448	596	714	893	1018	1144	1434	303	392	514	619	764	869	982	1240
NB54	480	633	859	1038	1276	1456	1647	2068	440	571	757	909	1130	1294	1457	1805	382	496	649	777	966	1101	1241	1560
HCNB29	491	649	880	1065	1311	1496	1693	2127	450	584	774	931	1157	1329	1497	1853	391	509	667	798	991	1131	1275	1601
HCNB30	517	684	930	1130	1392	1590	1798	2259	473	617	817	987	1225	1409	1589	1965	412	538	706	845	1049	1198	1351	1695
HCNB31	557	742	1009	1228	1511	1727	1952	2451	510	669	887	1071	1327	1526	1721	2128	445	582	765	915	1134	1295	1460	1830
HCNB32	580	774	1051	1277	1571	1796	2026	2542	531	696	922	1113	1376	1583	1785	2204	463	606	796	950	1176	1343	1515	1895
South Branch																								
RRSJ6	144	184	237	274	324	365	419	534	125	159	204	237	279	312	347	442	106	136	174	203	238	266	296	366
HCSJ6	244	318	430	546	715	841	956	1210	220	285	376	468	593	698	800	998	192	249	327	392	502	574	650	823
HCSJ7	291	389	545	687	892	1048	1196	1511	263	339	471	589	738	871	998	1245	232	298	403	493	624	714	816	1027
HCSJ8	361	518	772	1006	1309	1572	1809	2437	328	482	749	935	1192	1446	1689	2104	291	432	648	801	1017	1253	1457	1814
SJ34	366	524	779	1014	1319	1582	1822	2451	333	486	757	945	1203	1456	1702	2119	296	438	654	808	1025	1262	1467	1826
HCSJ11	434	608	871	1134	1452	1748	1995	2683	395	550	851	1053	1336	1599	1864	2362	351	494	735	899	1131	1386	1618	2027
HCSJ12	473	651	918	1195	1518	1826	2090	2793	433	584	899	1110	1403	1672	1948	2478	382	525	778	951	1186	1448	1697	2128
SJ37	506	685	963	1245	1575	1893	2170	2888	463	614	943	1160	1464	1736	2024	2578	407	551	815	997	1235	1503	1762	2214
Est Box Capacity																								
SJ37 - Box Capacity																								
SJ44A	601	803	1156	1460	1864	2203	2538	3323	546	742	1104	1354	1716	2023	2325	3037	482	655	964	1176	1455	1753	2065	2596
SJ44B	659	869	1242	1552	1998	2340	2701	3520	596	800	1176	1443	1833	2166	2471	3243	524	697	1031	1257	1547	1868	2200	2767
SJ45	666	877	1252	1564	2016	2357	2723	3546	602	807	1185	1455	1849	2184	2492	3269	529	703	1039	1267	1560	1883	2217	2789
Lower Branch																								
HC75	1245	1633	2262	2769	3568	4105	4699	6066	1133	1480	2064	2527	3223	3763	4266	5466	992	1284	1808	2191	2701	3218	3728	4677
Est Box Capacity																								
HC75 - Box Capacity																								
HC75	1245	1633	2262	2769	3568	4105	4699	6066	1133	1480	2064	2527	3223	3763	4266	5466	992	1284	1808	2191	2701	3218	3728	4677
HCLJ7	1460	1908	2602	3163	3972	4532	5138	6497	1327	1709	2356	2877	3578	4133	4657	5840	1155	1485	2058	2491	3060	3571	4099	5095
HCLJ15	1753	2292	3096	3748	4652	5309	5963	7485	1592	2040	2773	3374	4191	4790	5394	6706	1376	1776	2428	2927	3588	4170	4737	5877
HCLJ16	1786	2336	3152	3814	4736	5411	6076	7605	1625	2082	2822	3435	4265	4880	5494	6827	1403	1811	2474	2981	3651	4239	4819	5977
HCL25X	1841	2400	3236	3914	4857	5571	6254	7816	1681	2136	2892	3516	4361	4997	5668	7013	1453	1875	2543	3071	3761	4362	4965	6163
HCLJ19	1963	2546	3428	4140	5141	5933	6665	8282	1801	2267	3057	3711	4593	5289	6056	7475	1556	2008	2705	3269	4001	4629	5279	6560
HCLJ20	1984	2571	3461	4178	5185	5990	6739	8364	1822	2290	3084	3743	4631	5332	6106	7552	1576	2031	2730	3300	4038	4669	5324	6627
HCL34X	1998	2582	3475	4194	5196	5985	6747	8391	1835	2302	3097	3756	4646	5340	6097	7550	1589	2043	2741	3311	4049	4679	5328	6646
F11B	572	804	1144	1398	1729	1990	2265	2864	542	738	1014	1222	1497	1713	1941	2432	458	621	840	1012	1235	1411	1596	1997
F14	742	1030	1464	1789	2212	2544	2896	3656	691	941	1294	1559	1909	2183	2473	3096	585	794	1074	1294	1579	1804	2040	2550
F14	742	1030	1464	1789	2212	2544	2896	3656	691	941	1294	1559	1909	2183	2473	3096	585	794	1074	1294	1579	1804	2040	2550
COMB10	881	1218	1742	2130	2637	3036	3459	4372	818	1120	1543	1861	2282	2612	2958	3710	696	947	1285	1549	1891	2162	2448	3062
COMB11	902	1244	1782	2178	2698	3105	3539	4473	836	1145	1579	1903	2334	2671	3026	3796	712	969	1315	1586	1936	2213	2506	3136
COMB11	902	1244	1782	2178	2698	3105	3539	4473	836	1145	1579	1903	2334	2671	3026	3796	712	969	1315	1586	1936	2213	2506	3136
COMB12	923	1269	1803	2204	2685	3066	3476	4387	854	1166	1607	1930	2365	2669	3009	3757	729	990	1340	1617	1967	2248	2536	3130
COMB13	962	1323	1874	2288	2789	3183	3604	4545	889	1213	1670	2007	2459	2777	3129	3905	759	1030	1396	1684	2049	2343	2642	3263
COMBJF	2847	3568	4769	5789	7178	8442	9804	12377	2646	3307	4259	5136	6378	7410	8611	10912	2285	2970	3795	4561	5592	6413	7369	9530

Point of Interest	X-SEC	Current Development: Peak Flow 100yr	Critical 100yr Duration (hr): 1	2	3	6	12	18	24	Current w/ Regional Detention: Peak Flow 100yr	Critical 100yr Duration (hr): 1	2	3	6	12	18	24	% Increase
North Branch																		
HCNB9	18653	166	----	----	----	----	X	----	----	122	----	----	----	----	X	X	----	-26.5%
RRNB31	16668	193	----	----	----	----	X	X	----	141	----	----	----	----	----	X	----	-26.9%
NB17	15747	213	----	----	----	----	----	X	----	147	----	----	----	----	----	X	----	-31.0%
HCNB12	14505	626	----	X	----	----	----	----	----	299	----	X	----	----	----	----	----	-52.2%
HCNB13	13249	745	----	X	----	----	----	----	----	434	----	X	----	----	----	----	----	-41.7%
NB12	11949	756	----	----	X	----	----	----	----	530	----	----	X	----	----	----	----	-29.9%
HCNB17	11140	1055	----	----	X	----	----	----	----	802	----	----	X	----	----	----	----	-24.0%
HCNB19	10225	1179	----	----	X	----	----	----	----	962	----	----	X	----	----	----	----	-18.4%
RNB39B	10068	1175	----	----	X	----	----	----	----	793	----	----	X	----	----	----	----	-32.5%
HCNB21	9515	1511	----	----	X	----	----	----	----	1022	----	----	X	----	----	----	----	-32.4%
NB42	8776	1575	----	----	X	----	----	----	----	1074	----	----	X	----	----	----	----	-31.8%
HCNB25	8293	1625	----	----	X	----	----	----	----	1113	----	----	X	----	----	----	----	-31.5%
NB44	7084	1714	----	----	X	----	----	----	----	1194	----	----	X	----	----	----	----	-30.3%
NB54	5346	2216	----	----	X	----	----	----	----	1715	----	----	X	----	----	----	----	-22.6%
HCNB29	5026	2280	----	----	X	----	----	----	----	1800	----	----	X	----	----	----	----	-21.1%
HCNB30	3659	2429	----	----	X	----	----	----	----	1993	----	----	X	----	----	----	----	-17.9%
HCNB31	1837	2627	----	----	X	----	----	----	----	2243	----	----	X	----	----	----	----	-14.6%
HCNB32	610	2734	----	----	X	----	----	----	----	2359	----	----	X	----	----	----	----	-13.7%
South Branch																		
RRSJ6	14475	773	----	X	----	----	----	----	----	373	----	X	X	----	----	----	----	-51.7%
HCSJ6	12585	1378	----	X	----	----	----	----	----	679	----	X	----	----	----	----	----	-50.7%
HCSJ7	10710	1585	----	X	----	----	----	----	----	992	----	X	----	----	----	----	----	-37.4%
HCSJ8	8856	1917	----	----	X	----	----	----	----	1471	----	----	X	----	----	----	----	-23.3%
SJ34	7825	1927	----	----	X	----	----	----	----	1486	----	----	X	----	----	----	----	-22.9%
HCSJ11	7131	2069	----	----	X	----	----	----	----	1753	----	----	X	----	----	----	----	-15.3%
HCSJ12	6309	2160	----	----	X	----	----	----	----	1889	----	----	X	----	----	----	----	-12.5%
SJ37	5006	2247	----	----	X	----	----	----	----	1999	----	----	X	----	----	----	----	-11.0%
Est Box Capacity	1643	725	----	----	X	----	----	----	----	725	----	----	X	----	----	----	----	0.0%
SJ37 - Box Capacity	4432	1523	----	----	X	----	----	----	----	1274	----	----	X	----	----	----	----	-16.3%
SJ44A	2584	2674	----	----	X	----	----	----	----	2505	----	----	X	----	----	----	----	-6.3%
SJ44B	1390	2868	----	----	X	----	----	----	----	2791	----	----	X	----	----	----	----	-2.7%
SJ45	761	2897	----	----	X	----	----	----	----	2833	----	----	X	----	----	----	----	-2.2%
Lower Branch																		
HC75	16700	5608	----	----	X	----	----	----	----	5150	----	----	X	----	----	----	----	-8.2%
Est Box Capacity	3354	2346	----	----	X	----	----	----	----	2332	----	----	X	----	----	----	----	-0.6%
HC75 - Box Capacity	16690	3262	----	----	X	----	----	----	----	2818	----	----	X	----	----	----	----	-13.6%
HC75	13427	5608	----	----	X	----	----	----	----	5150	----	----	X	----	----	----	----	-8.2%
HCLJ7	13132	5683	----	----	X	----	----	----	----	5332	----	----	X	----	----	----	----	-6.2%
HCLJ15	9733	6060	----	----	----	X	----	----	----	5724	----	----	----	X	----	----	----	-5.5%
HCLJ16	8274	6157	----	----	----	X	----	----	----	5821	----	----	----	X	----	----	----	-5.5%
HCL25X	5689	6341	----	----	----	X	----	----	----	6016	----	----	----	X	----	----	----	-5.1%
HCLJ19	3859	6737	----	----	----	X	----	----	----	6438	----	----	----	X	----	----	----	-4.4%
HCLJ20	2266	6806	----	----	----	X	----	----	----	6491	----	----	----	X	----	----	----	-4.6%
HCL34X	621	6777	----	----	----	X	----	----	----	6457	----	----	----	X	----	----	----	-4.7%
Fassnight Creek																		
F11B	11358	3270	----	----	X	----	----	----	----	3270	----	----	X	----	----	----	----	0.0%
COMB14	9487	3988	----	----	X	----	----	----	----	3988	----	----	X	----	----	----	----	0.0%
F14	7121	3988	----	----	X	----	----	----	----	3988	----	----	X	----	----	----	----	0.0%
COMB9	6405	4650	----	----	X	----	----	----	----	4650	----	----	X	----	----	----	----	0.0%
COMB10	4641	4726	----	----	X	----	----	----	----	4726	----	----	X	----	----	----	----	0.0%
COMB11	3883	4726	----	----	X	----	----	----	----	4726	----	----	X	----	----	----	----	0.0%
COMB12	2816	4354	----	----	X	----	----	----	----	4354	----	----	X	----	----	----	----	0.0%
COMB13	2020	4456	----	----	X	----	----	----	----	4456	----	----	X	----	----	----	----	0.0%
Wilsons Creek																		
COMBJF	33108	9859	----	----	----	X	----	----	----	9627	----	----	----	X	----	----	----	-2.4%

Point of Interest	Current Flows w/ Regional Detention Maximum 100 yr Flowrate (cfs)	Hr	Critical 100 yr Duration (hr) 1	2	3	6	12	18	24		Point
North Branch											North Branch
HCNB9	122	12	----	----	----	----	X	X	----	5	HCNB9
RRNB31	141	18	----	----	----	----	----	X	----	6	RRNB31
NB17	147	18	----	----	----	----	----	X	----	6	NB17
HCNB12	299	2	----	X	----	----	----	----	----	2	HCNB12
HCNB13	434	2	----	X	----	----	----	----	----	2	HCNB13
NB12	530	3	----	----	X	----	----	----	----	3	NB12
HCNB17	802	3	----	----	X	----	----	----	----	3	HCNB17
HCNB19	962	3	----	----	X	----	----	----	----	3	HCNB19
RNB39B	793	3	----	----	X	----	----	----	----	3	RNB39B
HCNB21	1022	3	----	----	X	----	----	----	----	3	HCNB21
NB42	1074	3	----	----	X	----	----	----	----	3	NB42
HCNB25	1113	3	----	----	X	----	----	----	----	3	HCNB25
NB44	1194	3	----	----	X	----	----	----	----	3	NB44
NB54	1715	3	----	----	X	----	----	----	----	3	NB54
HCNB29	1800	3	----	----	X	----	----	----	----	3	HCNB29
HCNB30	1993	3	----	----	X	----	----	----	----	3	HCNB30
HCNB31	2243	3	----	----	X	----	----	----	----	3	HCNB31
HCNB32	2359	3	----	----	X	----	----	----	----	3	HCNB32
South Branch											South Branch
RRSJ6	373	2	----	X	X	----	----	----	----	2	RRSJ6
HCSJ6	679	2	----	X	----	----	----	----	----	2	HCSJ6
HCSJ7	992	2	----	X	----	----	----	----	----	2	HCSJ7
HCSJ8	1471	3	----	----	X	----	----	----	----	3	HCSJ8
SJ34	1486	3	----	----	X	----	----	----	----	3	SJ34
HCSJ11	1753	3	----	----	X	----	----	----	----	3	HCSJ11
HCSJ12	1889	3	----	----	X	----	----	----	----	3	HCSJ12
SJ37	1999	3	----	----	X	----	----	----	----	3	SJ37
Est Box Capacity	725	3	----	----	X	----	----	----	----	3	Est Box Capacity
SJ37 - Box Capacity	1274	3	----	----	X	----	----	----	----	3	SJ37 - Box Capacity
SJ44A	2505	3	----	----	X	----	----	----	----	3	SJ44A
SJ44B	2791	3	----	----	X	----	----	----	----	3	SJ44B
SJ45	2833	3	----	----	X	----	----	----	----	3	SJ45
Lower Branch											Lower Branch
HC75	5150	3	----	----	X	----	----	----	----	3	HC75
Est Box Capacity	2332	3	----	----	X	----	----	----	----	3	Est Box Capacity
HC75 - Box Capacity	2818	3	----	----	X	----	----	----	----	3	HC75 - Box Capacity
HC75	5150	3	----	----	X	----	----	----	----	3	HC75
HCLJ7	5332	3	----	----	X	----	----	----	----	3	HCLJ7
HCLJ15	5724	6	----	----	----	X	----	----	----	4	HCLJ15
HCLJ16	5821	6	----	----	----	X	----	----	----	4	HCLJ16
HCL25X	6016	6	----	----	----	X	----	----	----	4	HCL25X
HCLJ19	6438	6	----	----	----	X	----	----	----	4	HCLJ19
HCLJ20	6491	6	----	----	----	X	----	----	----	4	HCLJ20
HCL34X	6457	6	----	----	----	X	----	----	----	4	HCL34X
Fassnight Creek											
F11B	3270	3	----	----	X	----	----	----	----	3	F11B
F14	3988	3	----	----	X	----	----	----	----	3	F14
F14	3988	3	----	----	X	----	----	----	----	3	F14
COMB10	4650	3	----	----	X	----	----	----	----	3	COMB10
COMB11	4726	3	----	----	X	----	----	----	----	3	COMB11
COMB11	4726	3	----	----	X	----	----	----	----	3	COMB11
COMB12	4354	3	----	----	X	----	----	----	----	3	COMB12
COMB13	4456	3	----	----	X	----	----	----	----	3	COMB13
Wilsons Creek											
COMBJF	9627	6	----	----	----	X	----	----	----	4	COMBJF

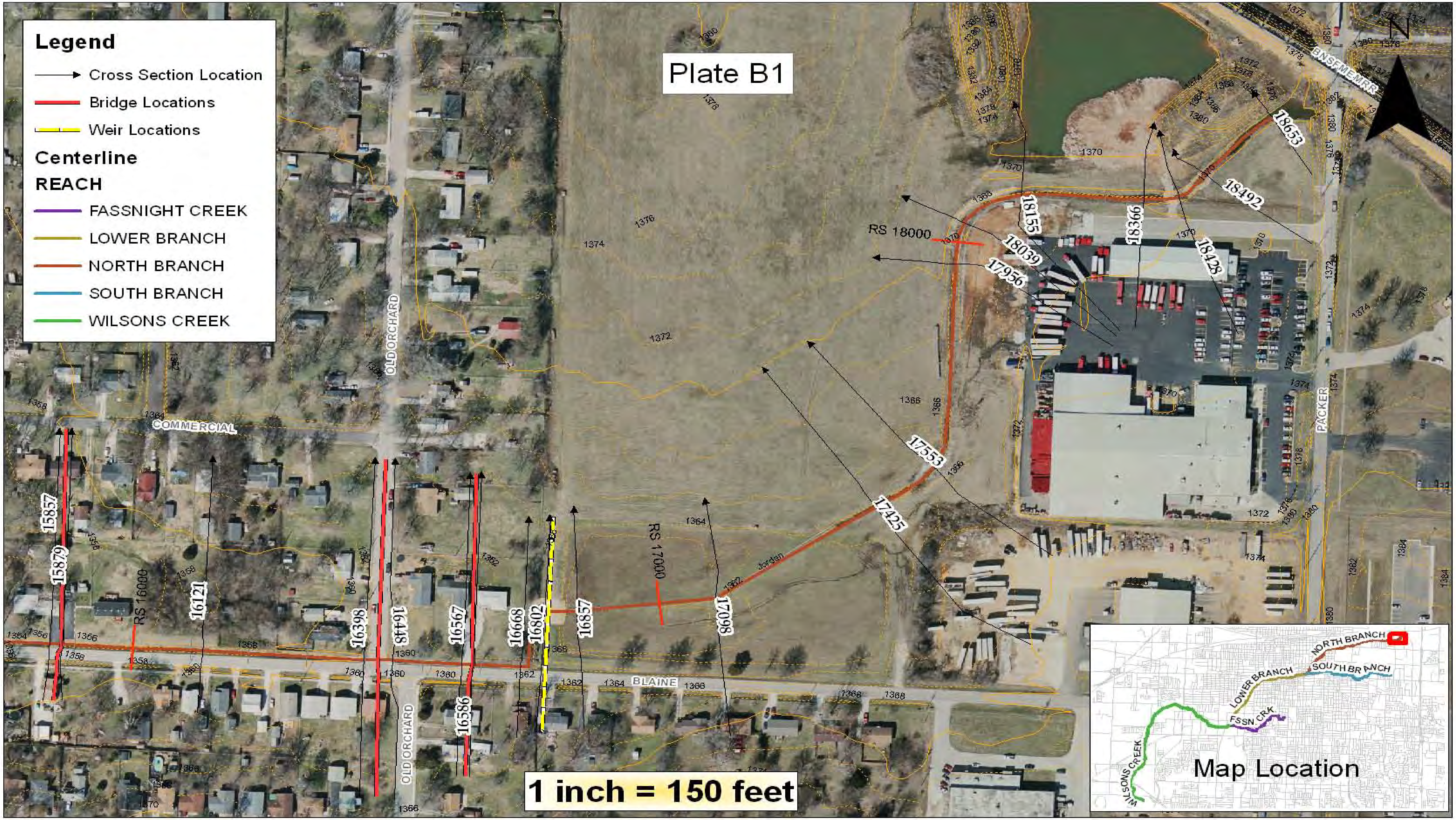
Point	2 Hour Peak Flows 1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr
HCNB9	27	35	49	61	73	82	103	122
RRNB31	34	45	61	67	77	83	91	103
NB17	39	52	71	80	99	113	129	166
HCNB12	66	101	140	175	223	256	299	393
HCNB13	89	142	212	260	320	374	434	562
RRSJ6	109	131	176	222	278	323	373	477
HCSJ6	166	227	317	392	497	586	679	887
HCSJ7	217	304	448	565	722	853	992	1325

Point	3 Hour Peak Flows 1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	6 Hour Peak Flows 1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr
North Branch																
HCNB9	31	45	64	75	89	105	115	128	37	51	70	86	102	113	119	133
RRNB31	39	52	65	73	83	92	99	110	45	61	75	85	97	104	110	157
NB17	42	57	73	83	97	109	122	152	47	64	78	90	103	110	118	166
HCNB12	68	99	137	171	215	251	289	373	64	90	125	155	194	222	253	323
HCNB13	93	136	200	247	300	351	406	522	83	121	169	206	258	302	345	447
NB12	115	172	258	322	399	462	530	680	103	151	217	263	324	378	435	556
HCNB17	179	274	418	522	624	709	802	1004	156	234	342	422	523	594	673	845
HCNB19	224	323	488	613	742	848	962	1214	184	274	401	497	622	701	792	994
RNB39B	201	291	415	511	617	702	793	992	177	257	362	445	550	631	712	894
HCNB21	277	385	541	662	799	906	1022	1275	237	341	474	582	722	820	924	1156
NB42	292	402	564	691	838	952	1074	1341	248	356	496	608	757	860	970	1214
HCNB25	302	416	582	713	868	986	1113	1390	257	368	512	629	783	890	1004	1257
NB44	321	442	616	755	926	1054	1194	1504	272	389	543	667	833	948	1071	1343
NB54	440	624	871	1058	1305	1502	1715	2199	368	527	743	914	1144	1316	1488	1859
HCNB29	455	646	907	1105	1367	1576	1800	2306	379	544	767	944	1182	1363	1543	1929
HCNB30	485	695	986	1209	1505	1741	1993	2557	405	583	824	1016	1272	1469	1668	2089
HCNB31	529	761	1090	1345	1684	1955	2243	2879	441	636	903	1113	1395	1615	1840	2315
HCNB32	562	804	1149	1418	1777	2054	2359	3030	469	674	956	1175	1470	1701	1937	2443
South Branch																
RRSJ6	109	130	175	220	277	321	373	481	99	126	167	207	262	305	350	455
HCSJ6	167	225	320	396	504	585	674	875	162	224	306	376	470	544	623	799
HCSJ7	216	303	455	565	712	833	961	1268	207	292	411	505	640	742	850	1096
HCSJ8	272	405	597	744	1034	1241	1471	2004	265	382	558	729	972	1150	1354	1810
SJ34	276	410	602	750	1038	1253	1486	2032	269	388	565	737	983	1160	1369	1830
HCSJ11	332	509	742	919	1197	1479	1753	2411	320	470	674	839	1124	1355	1586	2136
HCSJ12	360	557	818	1019	1296	1586	1889	2591	346	513	737	912	1199	1451	1704	2291
SJ37	379	591	877	1097	1401	1669	1999	2750	366	545	789	979	1258	1531	1801	2423
Est Box Capacity	479	718	751	744	733	729	725	717								
SJ37 - Box Capacity	1	1	126	353	668	940	1274	2033								
SJ44A	468	711	1066	1341	1792	2139	2505	3413	437	651	951	1184	1487	1840	2195	2979
SJ44B	520	764	1147	1447	1976	2375	2791	3739	475	703	1029	1283	1619	1979	2368	3223
SJ45	528	772	1159	1462	2002	2409	2833	3794	481	712	1041	1298	1639	2008	2395	3260
Lower Branch																
HC75	1089	1547	2225	2766	3722	4427	5150	6815	937	1341	1951	2425	3064	3706	4270	5664
Est Box Capacity	1089	1547	1988	2079	2202	2274	2332	2409								
HC75 - Box Capacity	1	1	237	687	1520	2153	2818	4406								
HC75	1089	1547	2225	2766	3722	4427	5150	6815	937	1341	1951	2425	3064	3706	4270	5664
HCLJ7	1313	1841	2624	3223	4073	4724	5332	6756	1130	1614	2291	2843	3543	4173	4736	6053
HCLJ15									1412	1991	2779	3432	4278	4992	5724	7187
HCLJ16									1440	2028	2829	3493	4355	5075	5821	7327
HCL25X									1483	2083	2910	3592	4480	5239	6016	7575
HCLJ19									1577	2209	3085	3808	4755	5595	6438	8119
HCLJ20									1591	2229	3111	3841	4796	5617	6491	8211
HCL34X									1573	2233	3115	3844	4800	5565	6457	8197
Fassnight Creek																
F11B	783	1024	1392	1722	2267	2740	3270	4467	634	810	1080	1351	1787	2143	2533	3430
F14	914	1230	1716	2154	2813	3366	3988	5411	743	980	1352	1674	2221	2669	3158	4273
F14	914	1230	1716	2154	2813	3366	3988	5411	743	980	1352	1674	2221	2669	3158	4273
COMB10	1091	1459	2017	2530	3296	3934	4650	6291	897	1177	1609	1989	2621	3155	3734	5053
COMB11	1107	1480	2049	2573	3352	3999	4726	6393	913	1198	1639	2029	2672	3216	3807	5152
COMB11	1107	1480	2049	2573	3352	3999	4726	6393	913	1198	1639	2029	2672	3216	3807	5152
COMB12	1097	1484	2043	2538	3160	3742	4354	6260	922	1206	1657	2048	2665	3139	3686	5119
COMB13	1111	1511	2099	2616	3247	3831	4456	6392	933	1236	1712	2130	2768	3256	3819	5213
Wilsons Creek																
COMBJF									2174	3113	4364	5424	6869	8149	9627	12610

Point	12 Hour Peak Flows 1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	18 Hour Peak Flows 1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr
North Branch																
HCNB9	40	55	75	90	108	115	122	136	41	56	76	92	108	115	122	136
RRNB31	49	64	81	94	105	112	134	174	50	65	83	96	107	114	141	178
NB17	51	67	84	98	109	117	139	182	52	68	86	100	111	120	147	188
HCNB12	70	95	132	158	191	214	241	301	76	102	137	161	191	213	239	296
HCNB13	87	122	167	205	251	286	322	404	93	127	173	206	246	276	310	386
NB12	106	150	206	250	306	352	395	495	112	153	207	249	296	334	374	465
HCNB17	158	224	311	378	464	523	591	734	161	223	303	366	442	494	551	681
HCNB19	186	260	361	436	535	605	684	848	186	255	346	418	504	565	631	779
RNB39B	176	248	337	408	502	567	639	793	177	244	326	391	474	533	593	730
HCNB21	232	323	436	525	644	731	821	1018	229	313	414	495	600	678	755	926
NB42	243	338	456	550	674	765	860	1066	239	326	431	516	625	708	788	967
HCNB25	251	349	470	567	695	789	888	1101	246	335	444	531	643	729	812	997
NB44	265	369	499	601	737	839	945	1177	259	353	468	560	680	773	866	1065
NB54	350	488	669	811	998	1148	1295	1609	338	465	625	749	914	1042	1172	1443
HCNB29	360	503	692	838	1032	1188	1341	1667	348	479	645	773	944	1077	1212	1493
HCNB30	383	538	742	900	1109	1277	1444	1798	370	511	691	828	1013	1156	1302	1607
HCNB31	415	585	811	985	1215	1400	1586	1978	401	555	753	904	1106	1264	1426	1763
HCNB32	437	618	854	1036	1276	1469	1666	2074	423	583	790	947	1158	1323	1493	1844
South Branch																
RRSJ6	95	125	159	193	244	283	325	416	92	123	149	176	222	256	292	369
HCSJ6	166	230	306	369	463	531	605	763	168	231	297	350	431	493	558	703
HCSJ7	210	301	401	485	608	704	803	1019	211	297	383	464	566	653	743	933
HCSJ8	272	396	587	758	991	1168	1343	1797	275	396	621	776	976	1134	1338	1773
SJ34	276	401	593	765	1001	1181	1359	1811	279	402	629	784	986	1144	1350	1787
HCSJ11	331	475	674	879	1145	1356	1574	2031	331	470	720	902	1136	1315	1511	2029
HCSJ12	359	514	729	938	1221	1448	1688	2172	360	510	768	966	1215	1406	1600	2150
SJ37	379	545	776	985	1285	1524	1779	2294	382	540	807	1016	1277	1479	1682	2251
Est Box Capacity																
SJ37 - Box Capacity																
SJ44A	452	653	928	1151	1542	1851	2169	2817	456	639	942	1200	1532	1792	2045	2692
SJ44B	489	705	1005	1233	1647	1992	2337	3045	494	690	1006	1280	1627	1927	2202	2879
SJ45	495	713	1017	1248	1663	2014	2362	3078	501	698	1016	1293	1643	1947	2225	2906
Lower Branch																
HC75	930	1313	1845	2250	2862	3475	4013	5143	920	1262	1757	2192	2763	3269	3716	4739
Est Box Capacity																
HC75 - Box Capacity																
HC75	930	1313	1845	2250	2862	3475	4013	5143	920	1262	1757	2192	2763	3269	3716	4739
HCLJ7	1102	1540	2162	2635	3259	3889	4448	5606	1081	1471	2026	2510	3142	3652	4133	5153
HCLJ15	1339	1852	2578	3147	3885	4586	5260	6611	1307	1772	2408	2936	3665	4304	4877	6037
HCLJ16	1364	1888	2625	3206	3961	4662	5355	6739	1333	1808	2456	2992	3736	4377	4963	6145
HCL25X	1405	1945	2701	3301	4081	4791	5534	6966	1377	1873	2531	3078	3845	4501	5135	6365
HCLJ19	1495	2068	2867	3507	4341	5082	5919	7461	1468	2011	2692	3270	4082	4773	5498	6823
HCLJ20	1512	2090	2894	3540	4383	5128	5972	7548	1482	2034	2719	3301	4120	4815	5516	6904
HCL34X	1514	2103	2907	3555	4402	5145	5959	7556	1478	2045	2730	3316	4136	4826	5494	6911
Fassnight Creek																
F11B	427	643	966	1212	1536	1793	2069	2665	438	629	897	1102	1374	1590	1818	2313
F14	533	797	1203	1515	1929	2257	2606	3365	542	783	1121	1382	1727	2003	2293	2920
F14	533	797	1203	1515	1929	2257	2606	3365	542	783	1121	1382	1727	2003	2293	2920
COMB10	628	937	1421	1796	2292	2683	3102	4014	637	925	1329	1645	2057	2389	2737	3491
COMB11	640	954	1449	1832	2339	2739	3167	4100	648	943	1356	1679	2101	2441	2796	3568
COMB11	640	954	1449	1832	2339	2739	3167	4100	648	943	1356	1679	2101	2441	2796	3568
COMB12	650	970	1472	1852	2363	2720	3112	4017	659	959	1378	1701	2126	2460	2781	3519
COMB13	670	1003	1530	1930	2467	2839	3248	4194	682	998	1437	1777	2224	2575	2908	3683
Wilsons Creek																
COMBJF	2118	3039	4118	5057	6356	7463	8671	11400	2095	2975	3898	4713	5885	6828	7924	10280

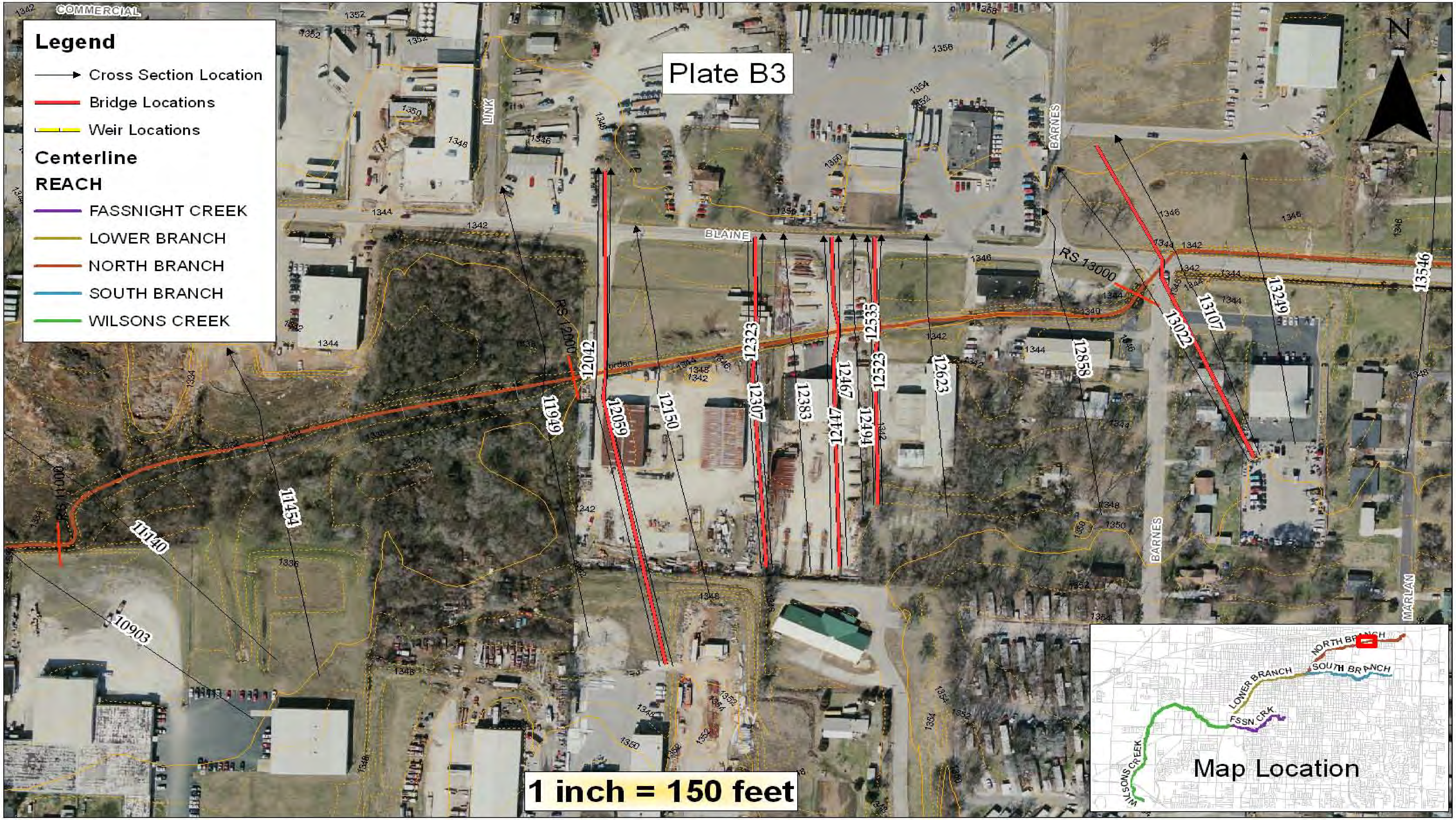
Point	24 Hour Peak Flows 1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr
North Branch								
HCNB9	40	54	73	88	104	114	120	134
RRNB31	49	64	81	94	106	115	137	177
NB17	51	67	84	98	110	119	143	188
HCNB12	72	97	128	149	177	197	221	271
HCNB13	87	118	160	188	222	250	280	346
NB12	103	140	188	223	264	298	333	411
HCNB17	145	198	270	323	387	437	490	606
HCNB19	166	226	305	366	438	495	555	687
RNB39B	160	219	293	350	421	476	533	658
HCNB21	204	278	367	439	528	598	669	824
NB42	212	288	382	456	550	623	697	858
HCNB25	218	296	392	469	566	641	719	886
NB44	229	312	414	495	601	681	766	945
NB54	298	408	548	655	796	905	1019	1260
HCNB29	307	420	565	676	821	934	1052	1301
HCNB30	326	448	603	722	878	999	1127	1394
HCNB31	353	485	656	785	957	1090	1230	1523
HCNB32	371	509	687	822	1001	1139	1286	1592
South Branch								
RRSJ6	81	109	129	156	190	222	253	322
HCSJ6	150	206	264	315	379	437	498	626
HCSJ7	189	262	346	412	500	574	653	817
HCSJ8	245	370	570	702	862	1024	1239	1548
SJ34	248	374	575	709	870	1033	1248	1561
HCSJ11	297	424	659	809	995	1148	1401	1763
HCSJ12	323	454	704	864	1062	1218	1481	1870
SJ37	341	480	739	908	1116	1280	1545	1960
Est Box Capacity								
SJ37 - Box Capacity								
SJ44A	405	564	860	1074	1324	1542	1822	2336
SJ44B	438	607	914	1141	1406	1644	1940	2499
SJ45	443	614	923	1152	1419	1660	1957	2523
Lower Branch								
HC75	812	1118	1572	1952	2403	2784	3238	4111
Est Box Capacity								
HC75 - Box Capacity								
HC75	812	1118	1572	1952	2403	2784	3238	4111
HCLJ7	949	1306	1798	2227	2745	3149	3622	4559
HCLJ15	1148	1587	2128	2624	3251	3713	4269	5359
HCLJ16	1169	1616	2166	2669	3305	3774	4337	5445
HCL25X	1160	1670	2236	2754	3407	3893	4471	5623
HCLJ19	1229	1787	2386	2933	3629	4148	4758	6000
HCLJ20	1237	1809	2411	2962	3667	4192	4808	6062
HCL34X	1228	1823	2423	2973	3682	4211	4827	6091
Fassnight Creek								
F11B	380	537	751	921	1143	1319	1507	1909
F14	472	670	943	1160	1444	1668	1907	2420
F14	472	670	943	1160	1444	1668	1907	2420
COMB10	556	794	1124	1384	1726	1995	2283	2901
COMB11	566	810	1147	1414	1764	2039	2335	2968
COMB11	566	810	1147	1414	1764	2039	2335	2968
COMB12	576	825	1167	1439	1789	2068	2369	2968
COMB13	596	860	1219	1505	1874	2169	2486	3112
Wilsons Creek								
COMBJF	1714	2650	3459	4180	5214	6026	6857	8922

Plate Series B – HEC-RAS Model Cross Section Locations




Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B2
N
1 inch = 150 feet
Map Location
COMMERCIAL
BLAINE
PACIFIC
PATTERSON
LONE PINE
OAK GROVE
YATES
HAYES
MARLAN
ENGEL
13546
13626
13677
13739
13910
13949
14018
RS 14000
14035
14071
14295
14373
14392
14505
14970
RS 15000
15078
15128
15215
15476
15611
15636
15747
15857
15879

Plate Series B – HEC-RAS Model Cross Section Locations



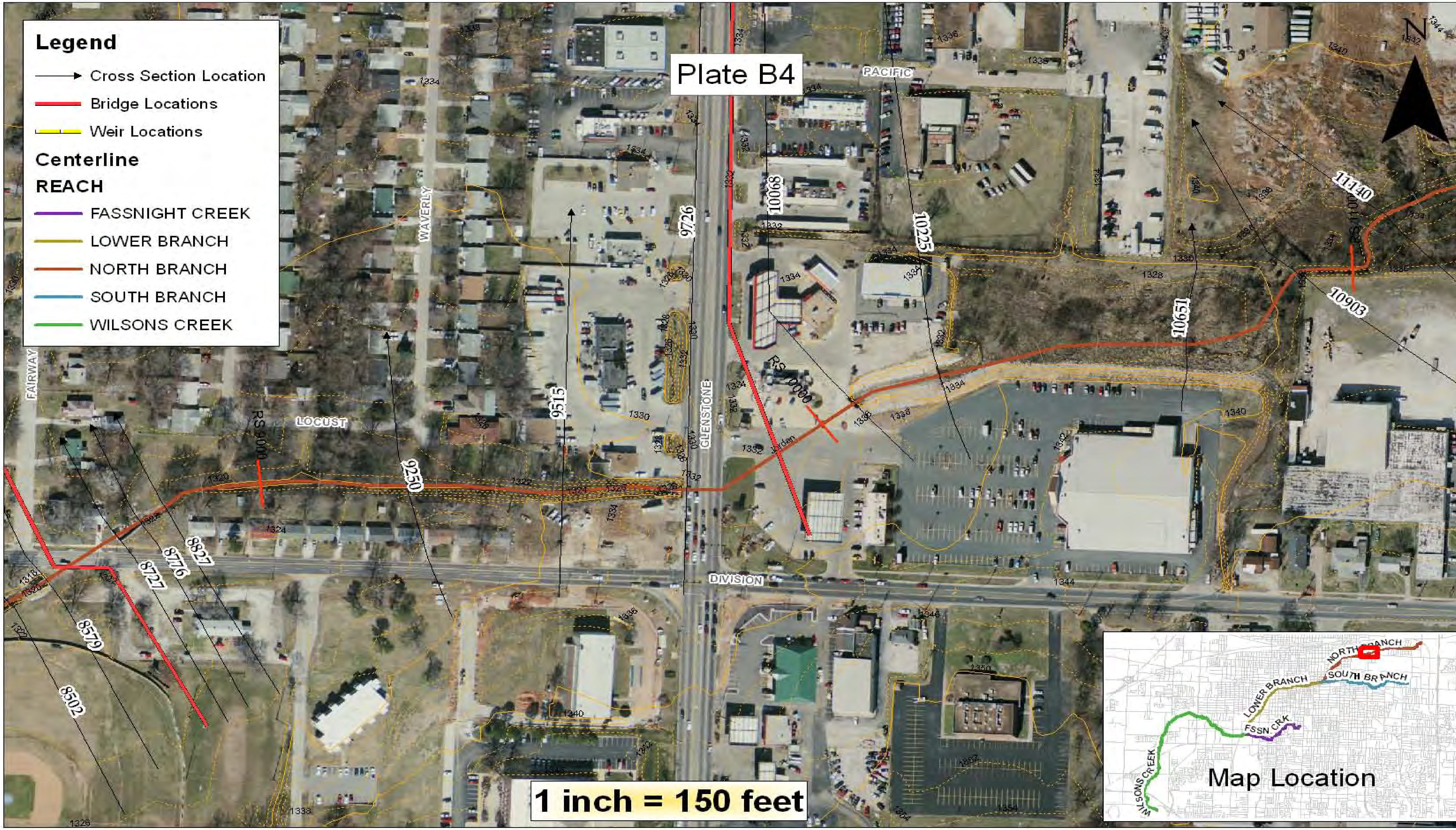
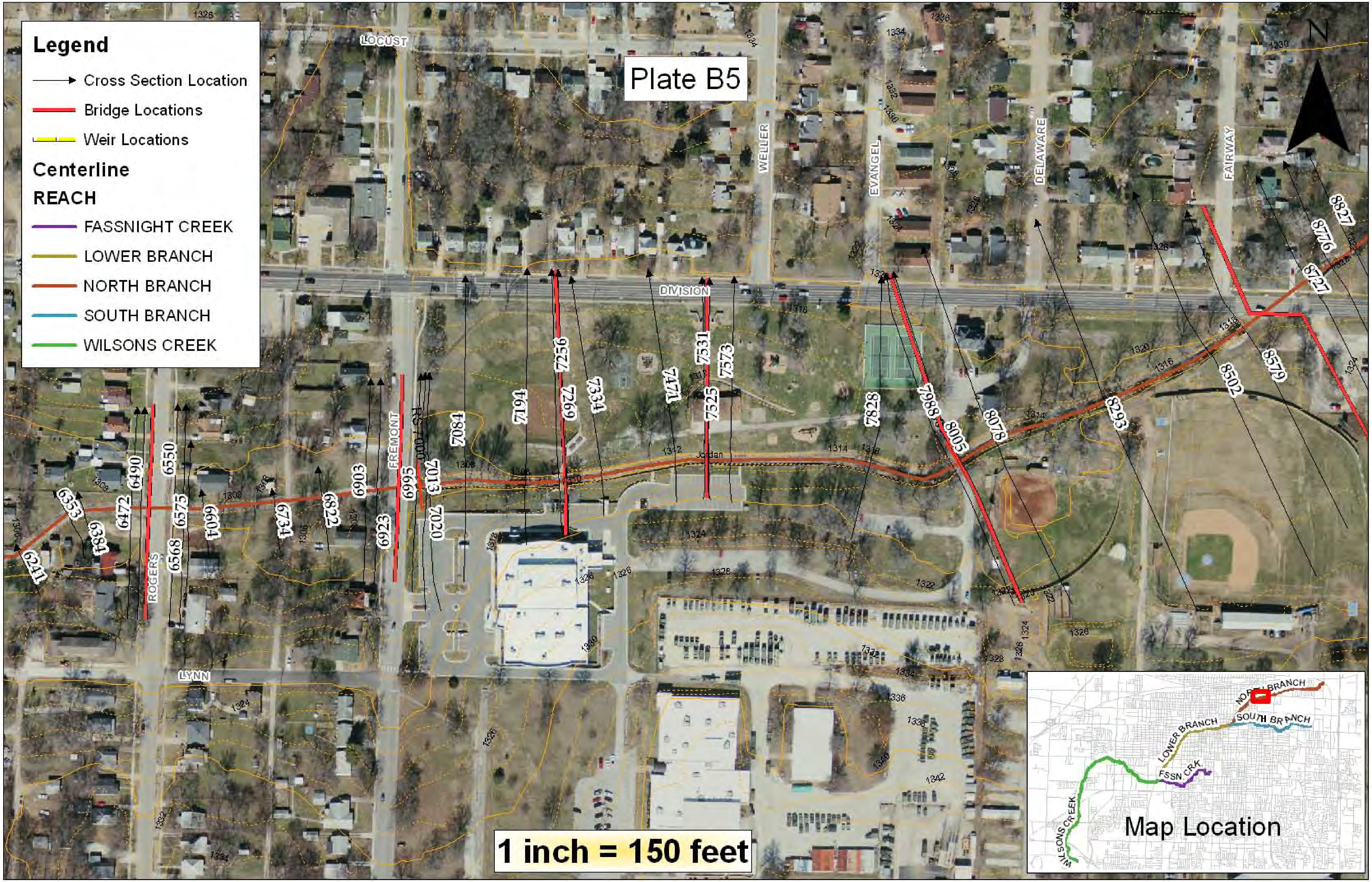
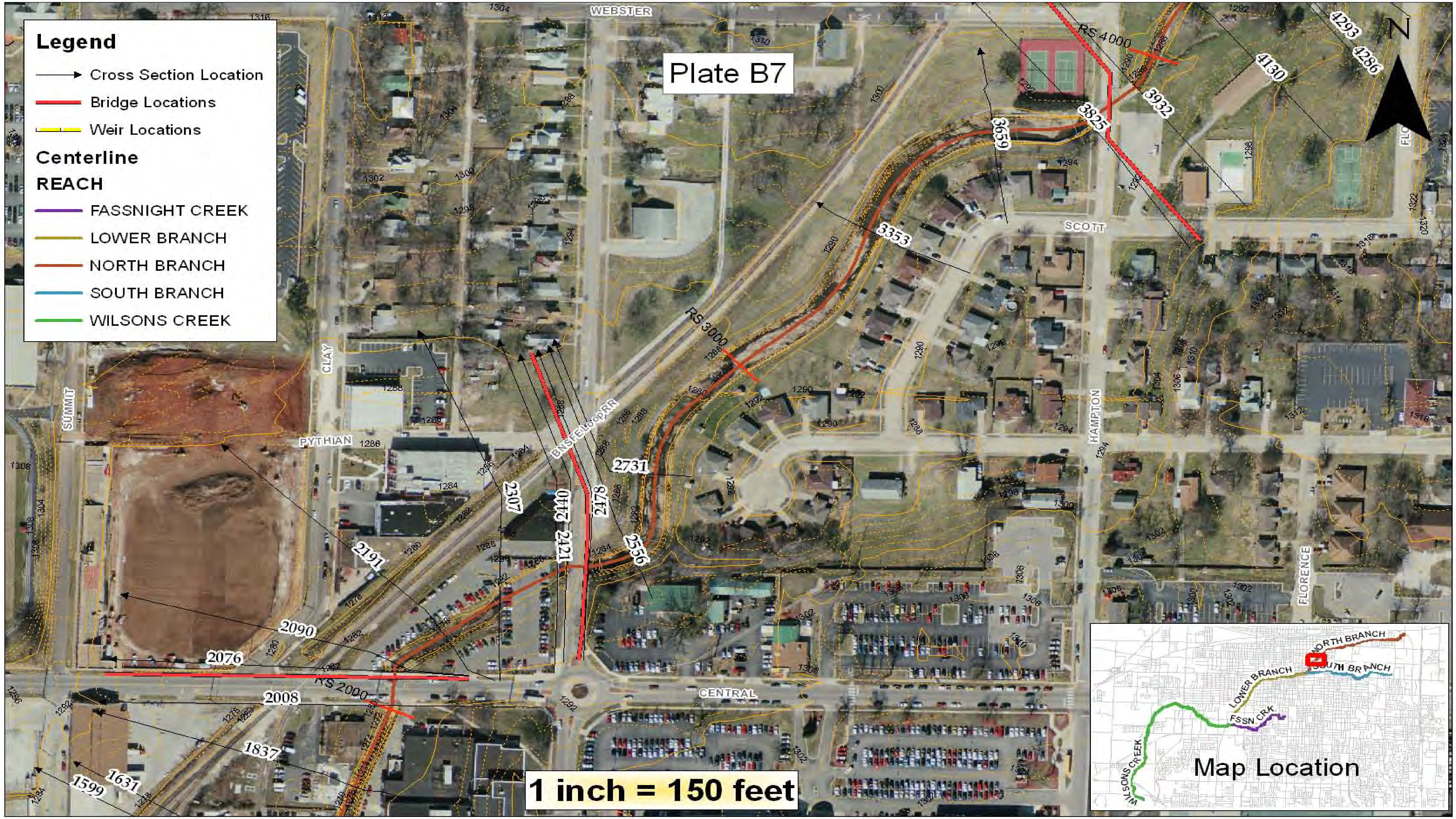


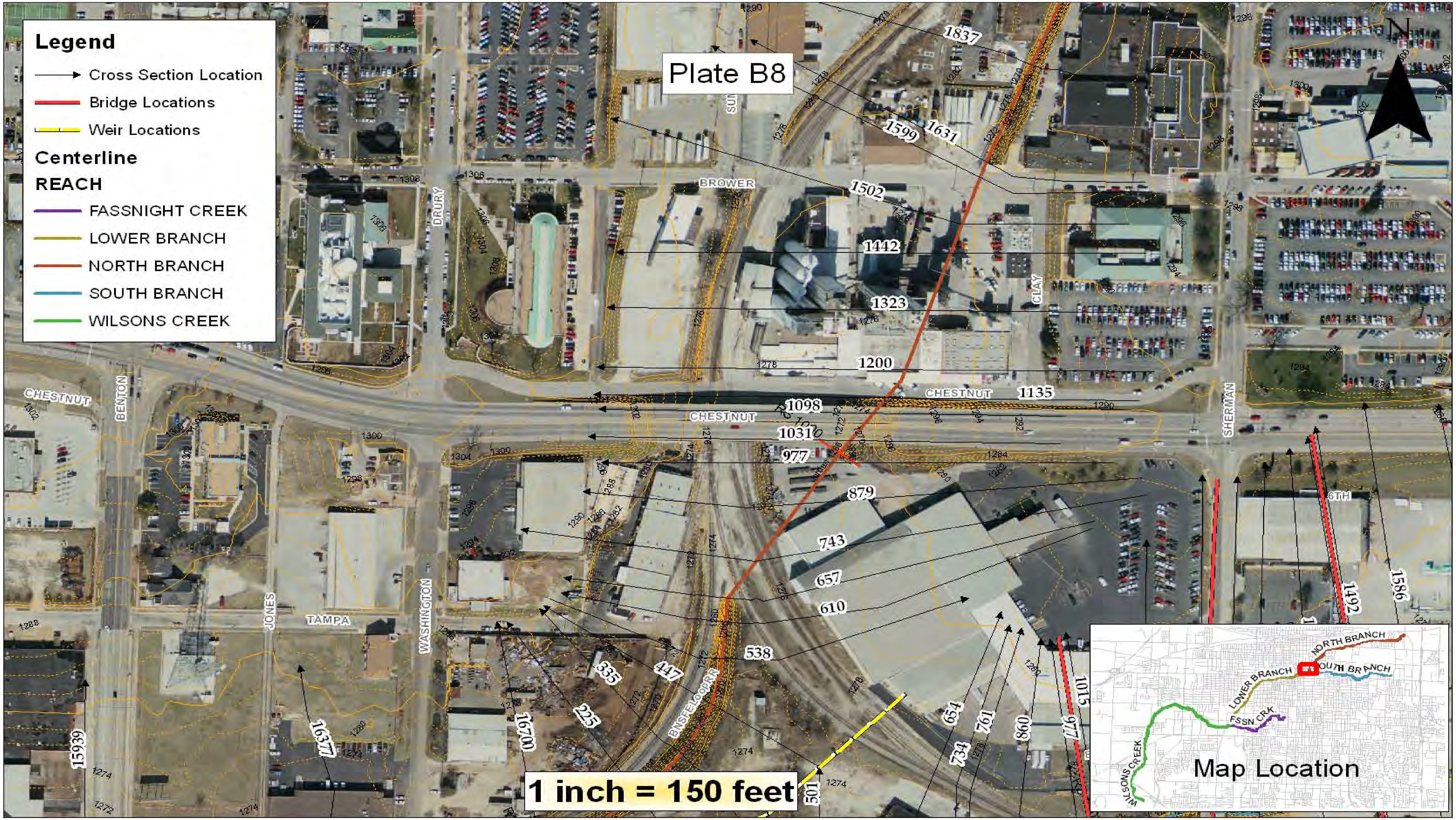
Plate B4
Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
PACIFIC
WAVERLY
GLENSTONE
DIVISION
LOCUST
FAIRWAY
RS 9000
RS 10000
8502
8579
8727
8776
8827
9250
9515
9726
10068
10225
10651
10903
11140
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK



Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B5
LOCUST
WELLER
EVANGEL
DELAWARE
FAIRWAY
DIVISION
FREMONT
ROGERS
LYNN
Jordan
RS 7000
6241
6353
6381
6472
6490
6550
6568
6575
6604
6734
6822
6903
6923
6995
7013
7020
7084
7194
7256
7269
7334
7471
7525
7531
7573
7828
7988
8005
8078
8293
8502
8579
8727
8776
8827
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B6
1 inch = 150 feet
Map Location
NATIONAL
PROSPECT
ROGERS
FLORENCE
HAMPTON
FRISCO
TEXAS
CALHOUN
LYNN
WEBSTER
BNSF-Loop RR
RS 5000
RS 6000
5026
4823
4517
4400
4293
4286
4130
3932
3825
3659
5346
5459
5544
5576
5607
5691
5799
5882
5953
5981
6043
6061
6094
6157
6241
6353
6384
6472
6490
6550
6568
6604


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B7
WEBSTER
SCOTT
PYTHIAN
CENTRAL
CLAY
SUMMIT
HAMPTON
FLORENCE
BNSF Fe Loop RR
RS 4000
RS 3000
RS 2000
4293
4286
4130
3932
3825
3659
3353
2731
2556
2478
2440
2421
2307
2191
2090
2076
2008
1837
1631
1599
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B8
N
1 inch = 150 feet
Map Location
CHESTNUT
BROWER
DRURY
BENTON
JONES
TAMPA
WASHINGTON
CLAY
SHERMAN
6TH
BNSF LOOP RR
1837
1631
1599
1502
1442
1323
1200
1135
1098
1031
977
879
743
657
610
538
447
335
225
16700
16377
15939
501
654
734
761
860
977
1015
1492
1586
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B9
1 inch = 150 feet
N
ROCKHURST
ELMWOOD
CEDARBROOK
CHESTNUT
13038
13205
13320
13344
13400
13458
13545
13648
13738
13838
13905
RS 14000
14073
14231
14287
14475
RS 15000
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK

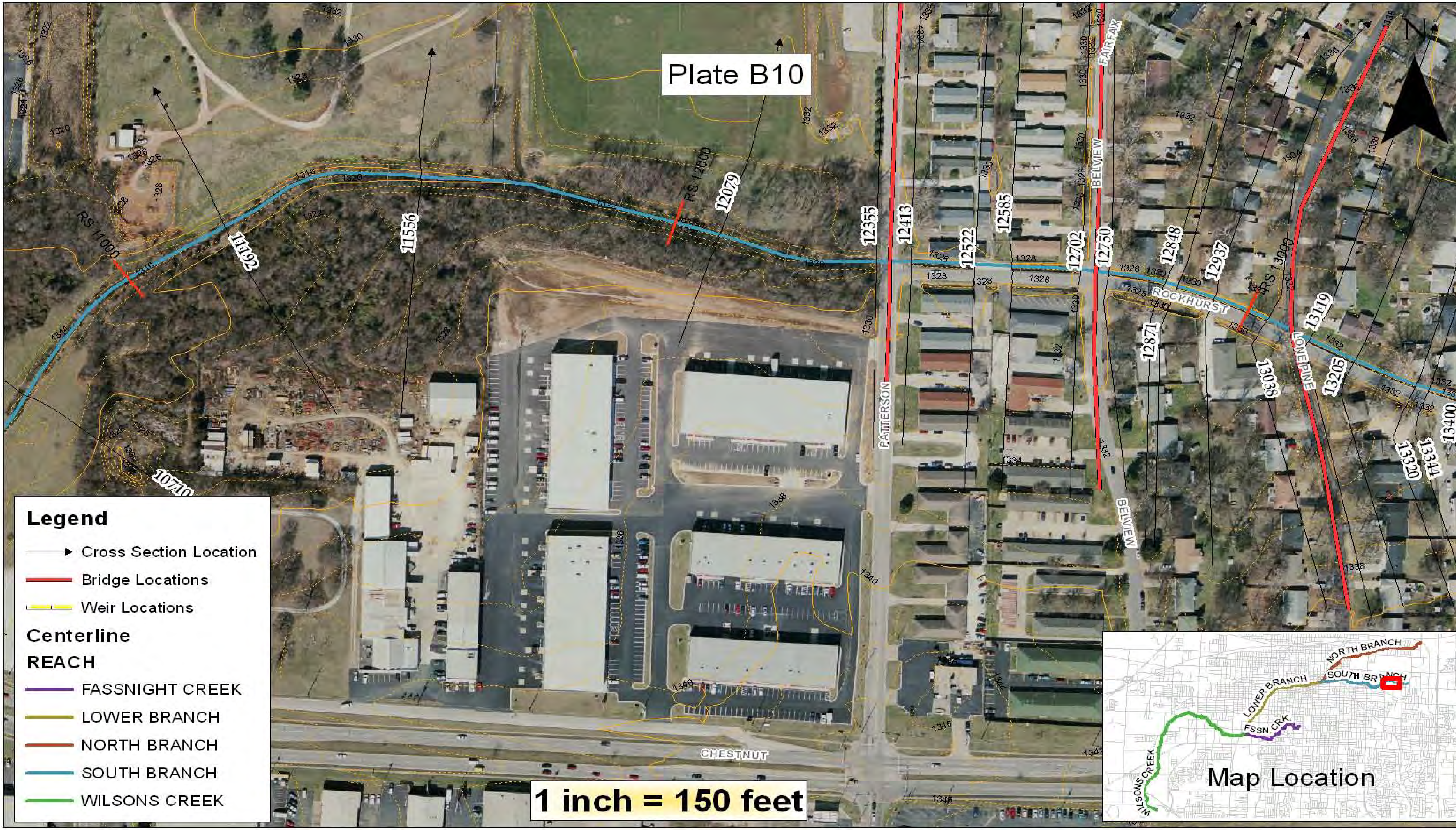
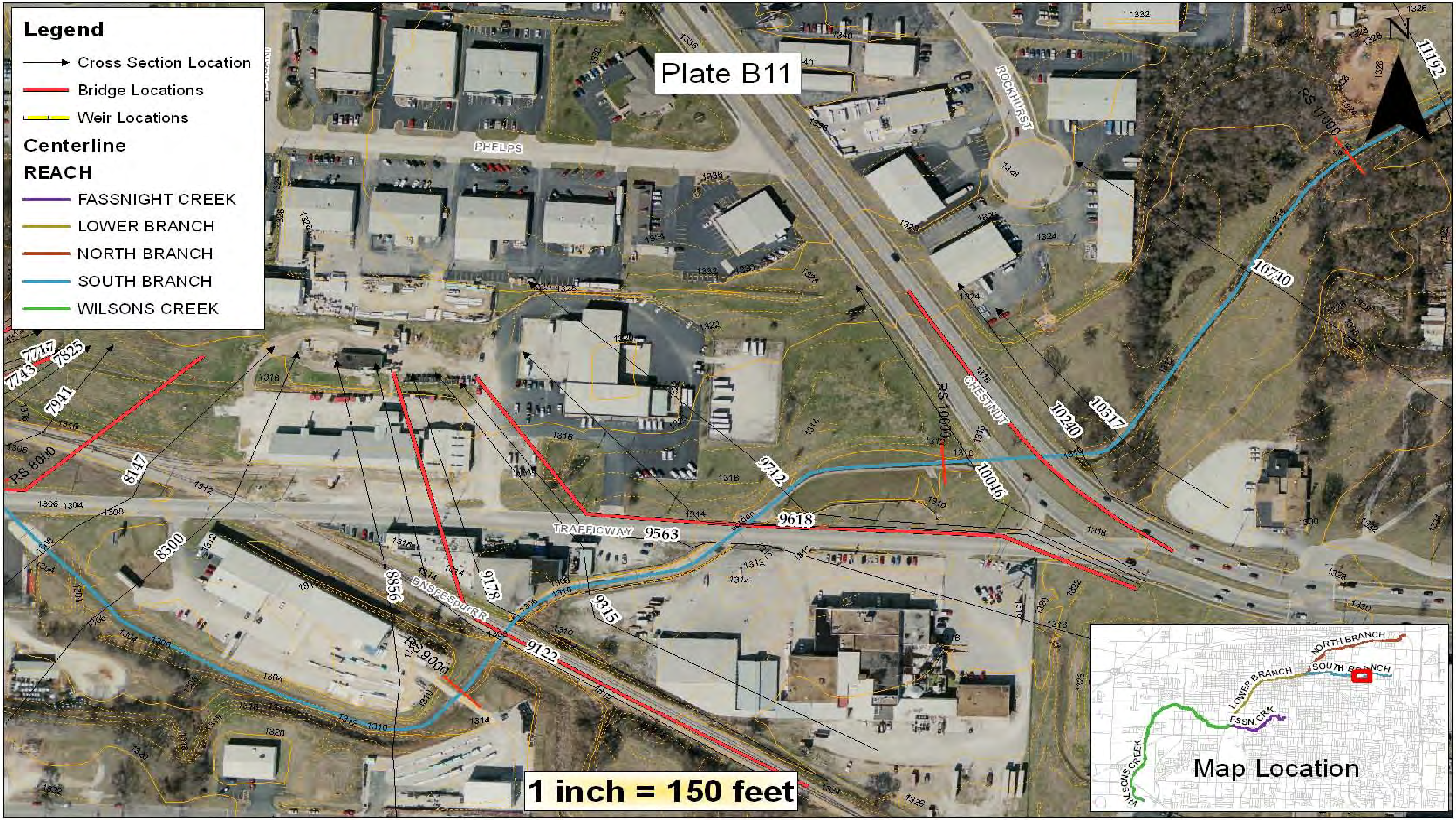


Plate B10
RS 11000
11162
11556
RS 12000
12079
12355
12413
12522
12585
12702
12750
12848
12871
12937
RS 13000
13038
13119
13205
13320
13344
13400
10710
PATTERSON
BELVIEW
FAIRFAX
ROCKHURST
LONE PINE
CHESTNUT
Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B11
1 inch = 150 feet
Map Location
PHELPS
ROCKHURST
CHESTNUT
TRAFFICWAY
BNSF Spur RR
RS 8000
RS 9000
RS 10000
RS 11000
7717
7743
7825
7941
8147
8300
8856
9122
9178
9315
9563
9618
9712
10046
10240
10317
10710
11192
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK

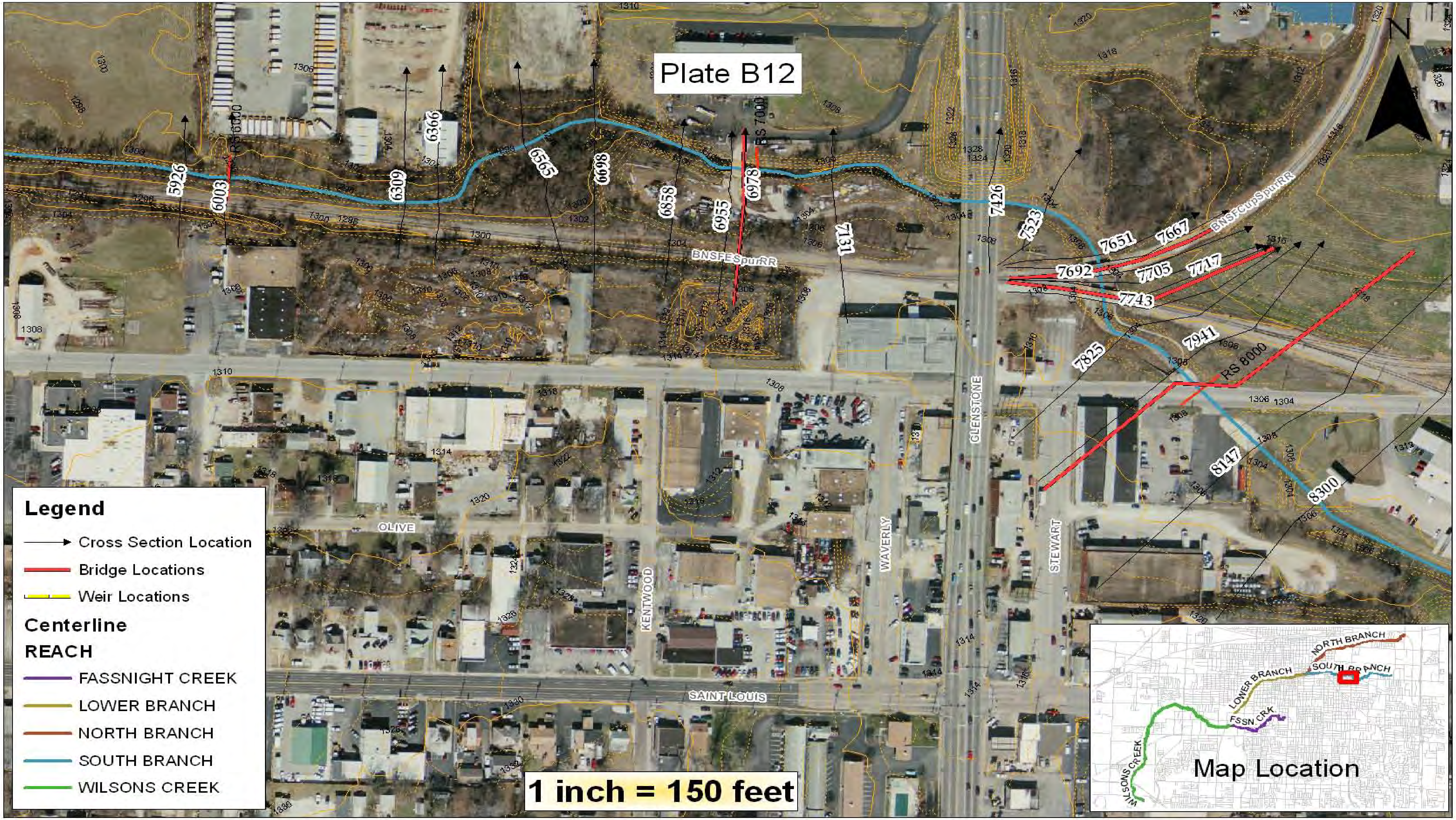


Plate B12
Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
1 inch = 150 feet
Map Location
5926
6003
RS 6000
6309
6366
6565
6698
6858
6955
6978
RS 7000
7131
7426
7523
7651
7667
7692
7705
7717
7743
7825
7941
RS 8000
8147
8300
BNSFESpurRR
BNSFCupSpurRR
OLIVE
KENTWOOD
WAVERLY
GLENSTONE
STEWART
SAINT LOUIS
NORTH BRANCH
LOWER BRANCH
SOUTH BRANCH
FSSN CRK
WILSONS CREEK


Plate B13
Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
1 inch = 150 feet
Map Location
3255
3380
3977
RS 4000
4432
4510
4576
4647
RS 5000
5006
5499
5926
PROSPECT
TAMPA
FREMONT
TRAFFICWAY
OLIVE
BNSFE Spur RR
Jordan
N

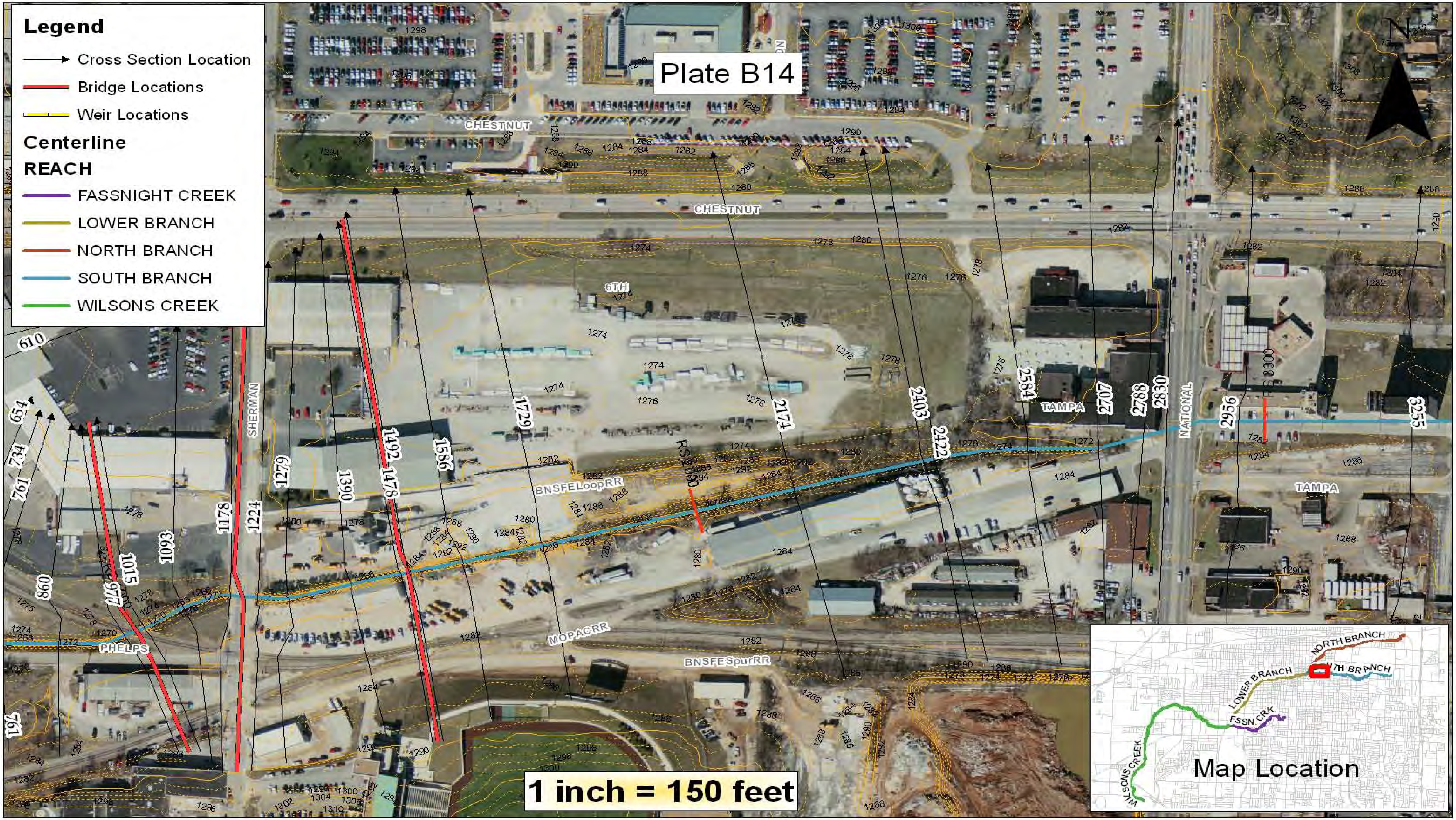
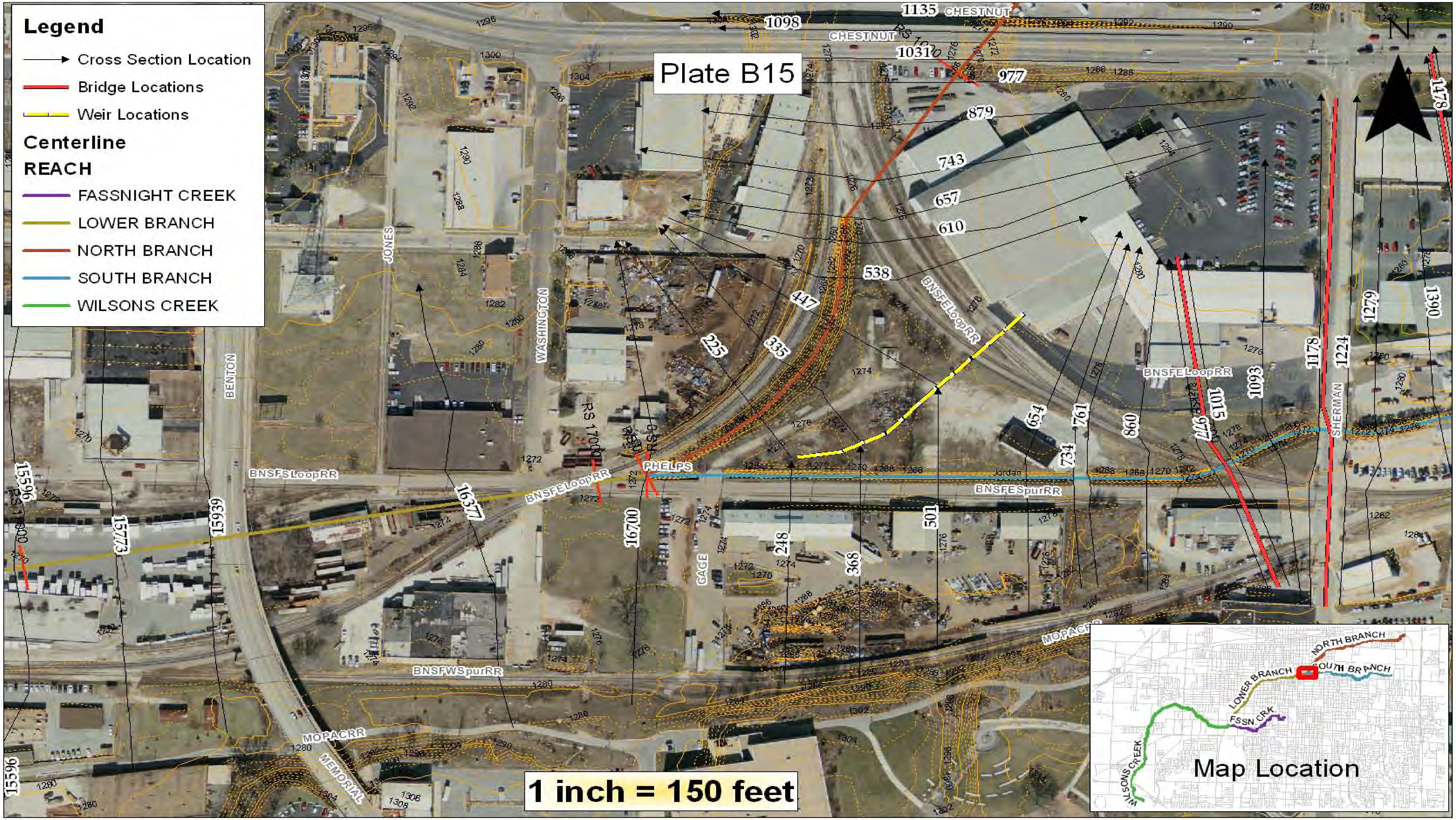
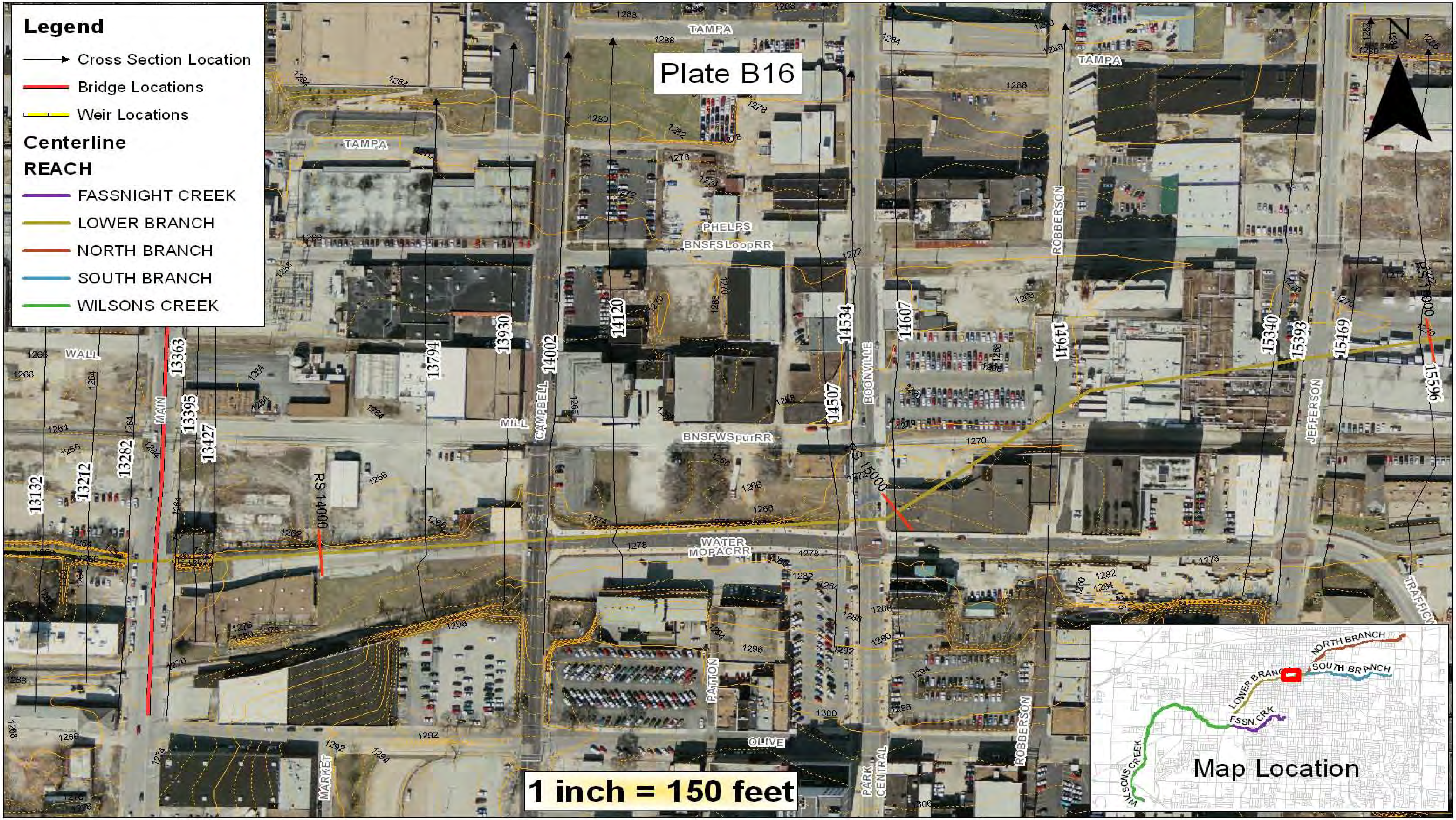
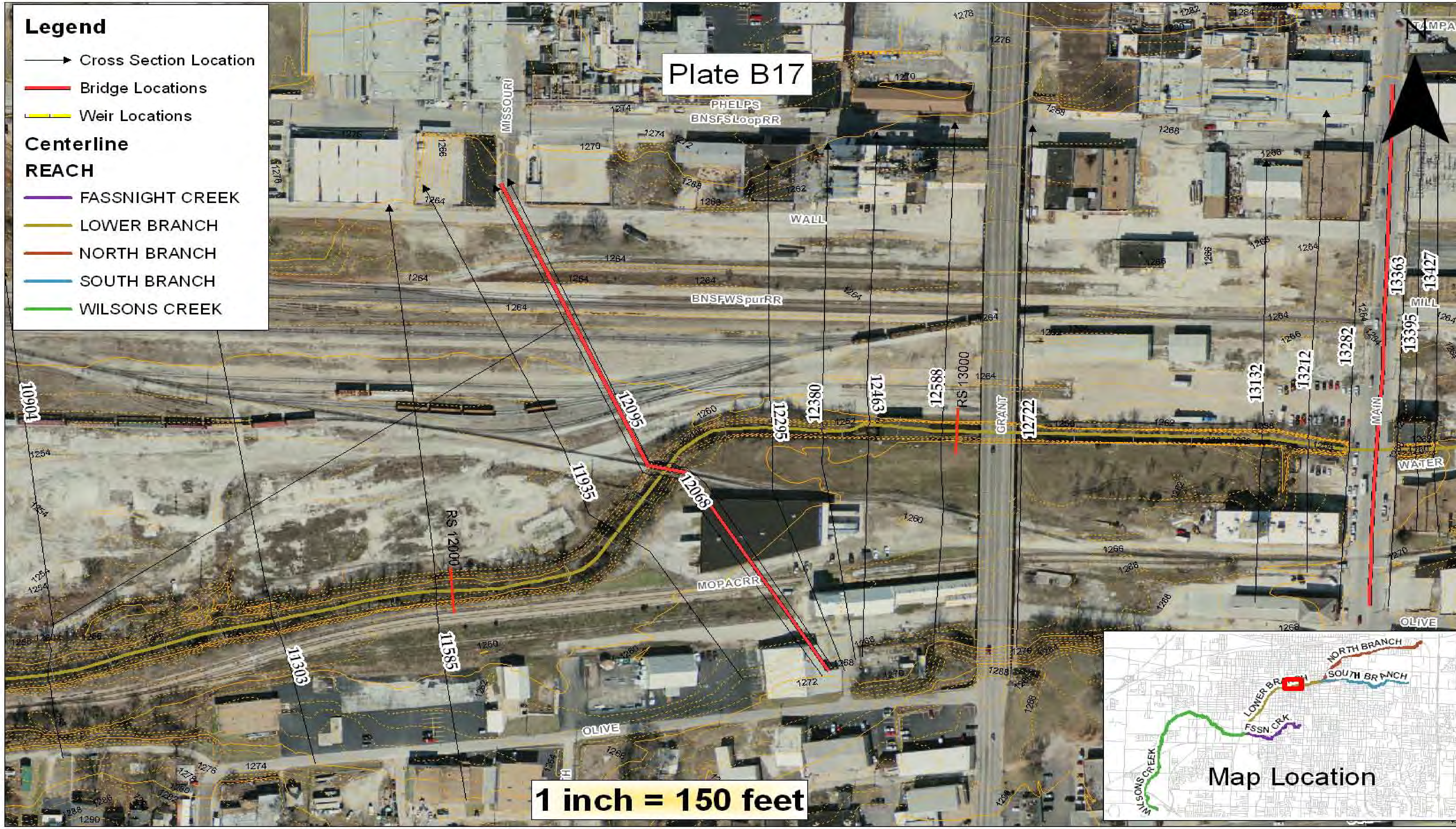
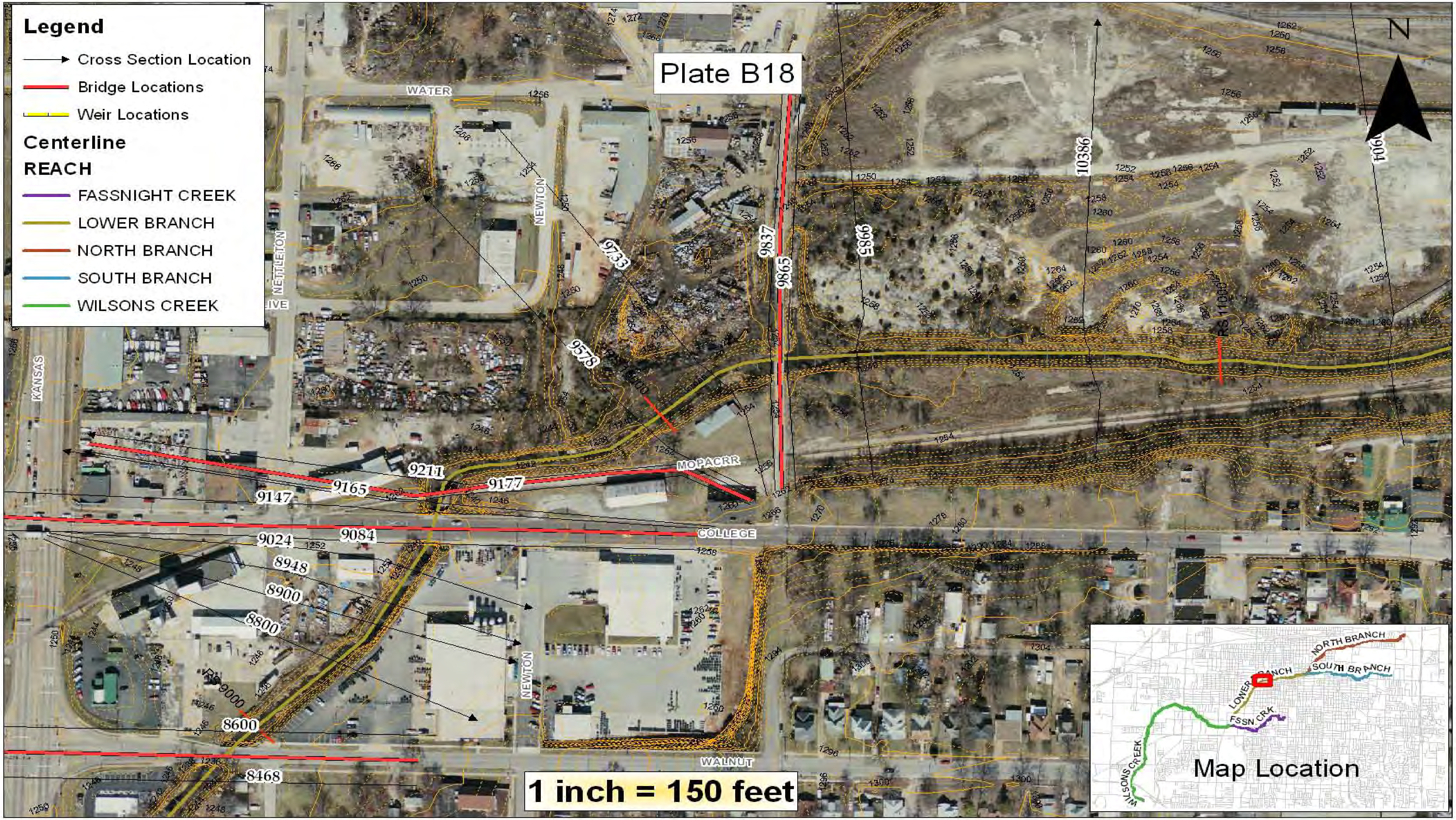


Plate B14
Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
CHESTNUT
SHERMAN
NATIONAL
TAMPA
PHELPS
6TH
BNSFE Loop RR
MOPAC RR
BNSFE Spur RR
Map Location
1 inch = 150 feet


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B15
N
1 inch = 150 feet
Map Location
NORTH BRANCH
LOWER BRANCH
SOUTH BRANCH
FSSN CRK
WILSONS CREEK
CHESTNUT
JONES
WASHINGTON
BENTON
GAGE
SHERMAN
PHELPS
MEMORIAL
BNSFELoopRR
BNSFESpurRR
BNSFWSpurRR
MOPACRR
1135
1098
1031
977
879
743
657
610
538
447
335
225
654
761
860
734
501
368
248
16700
16377
15939
15773
15596
1015
1093
1178
1224
1279
1390


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B16
1 inch = 150 feet
Map Location
TAMPA
PHELPS
BNSFSLoopRR
BNSFWSpurRR
WATER
MOPACRR
OLIVE
MAIN
CAMPBELL
BOONVILLE
ROBBERSON
JEFFERSON
WALL
MILL
MARKET
PATTON
PARK CENTRAL
13132
13212
13282
13363
13395
13427
RS 14000
13794
13930
14002
14120
14507
14534
14607
RS 15000
14911
15340
15393
15469
15596
RS 15900
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B17
PHELPS
BNSFSLoopRR
MISSOURI
WALL
BNSFWSpurRR
MOPACRR
OLIVE
GRANT
MAIN
WATER
MILL
TAMPA
10904
11303
11585
RS 12000
11935
12095
12068
12295
12380
12463
12588
RS 13000
12722
13132
13212
13282
13363
13395
13427
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK

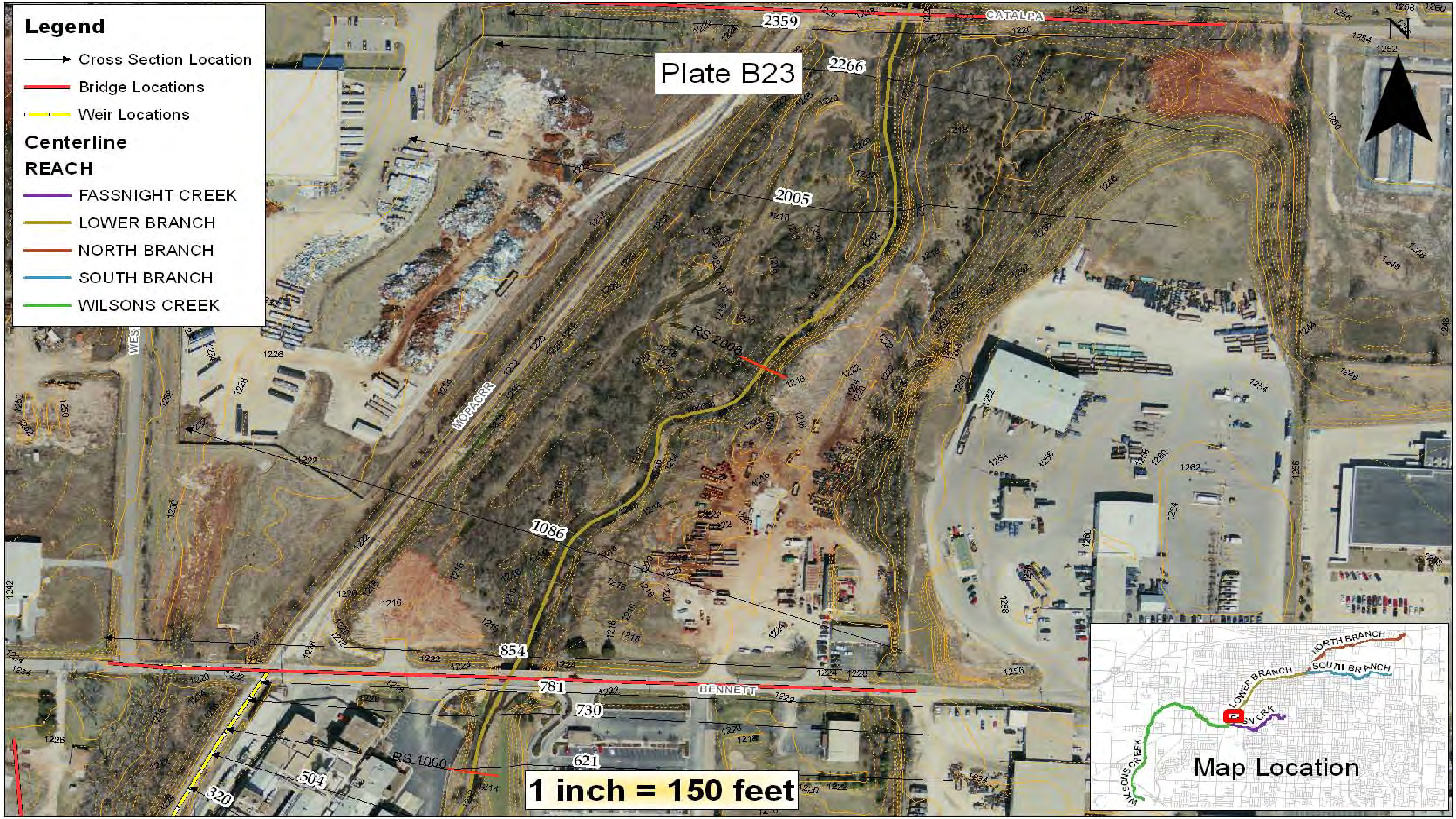

Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B18
N
WATER
NEWTON
NETTLETON
KANSAS
MOPACRR
COLLEGE
WALNUT
9733
9578
9837
9865
9965
10386
10904
11060
9211
9165
9177
9147
9084
9024
8948
8900
8800
8600
8468
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK

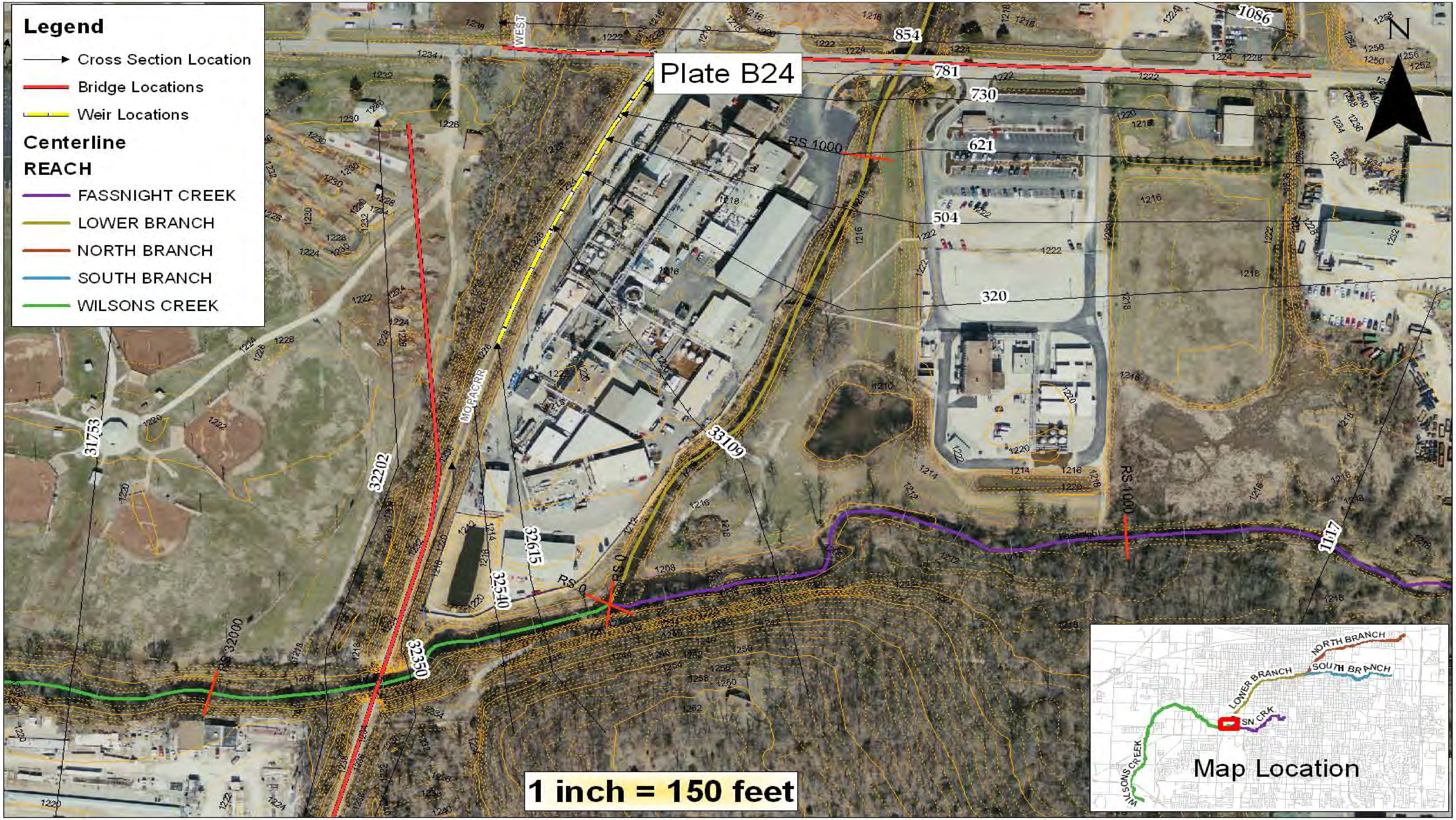

Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B19
1 inch = 150 feet
Map Location
N
8600
8468
8277
8128
7984
7848
7671
7314
7152
7073
6929
6594
RS 8000
RS 7000
WALNUT
KANSAS
NETTLETON
NEWTON
LEXINGTON
CLOUD
LINCOLN
MOPAC RR
MOUNT VERNON
WABASH
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B20
N
6929
6594
5689
RS 6000
5003
HARRISON
LA FONTAINE
WABASH
MOPACRR
KANSAS
STATE
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
FSSN CRK
WILSONS CREEK


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B21
RS 6000
5689
5003
4790
4638
4419
4137
4052
3859
LOMBARD
BELMONT
KANSAS
GRAND
MOPACRR
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
FSSN CRK
WILSONS CREEK
N


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B22
GRAND
CATALPA
KANSAS
MOPACRR
RS 4000
RS 3000
4137
4052
3859
3300
2722
2677
2515
2432
2359
2266
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B23
2359
2266
2005
RS 2000
1086
854
781
730
621
504
320
RS 1000
CATALPA
BENNETT
MOPAC RR
1 inch = 150 feet
N
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
WILSONS CREEK


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B24
1 inch = 150 feet
Map Location
N
854
781
730
621
504
320
1086
RS 1000
33109
31753
32202
32615
32540
32350
RS 32000
RS 0
1117
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
WILSONS CREEK


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B25
N
30367
30828
31064
SCENIC
31152
31328
31753
RS 30000
RS 31000
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK


Plate B26
Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
29145
29796
30367
30828
RS 29000
RS 30000
BENNETT
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK

Plate Series C – Without Project Hydraulic Profiles

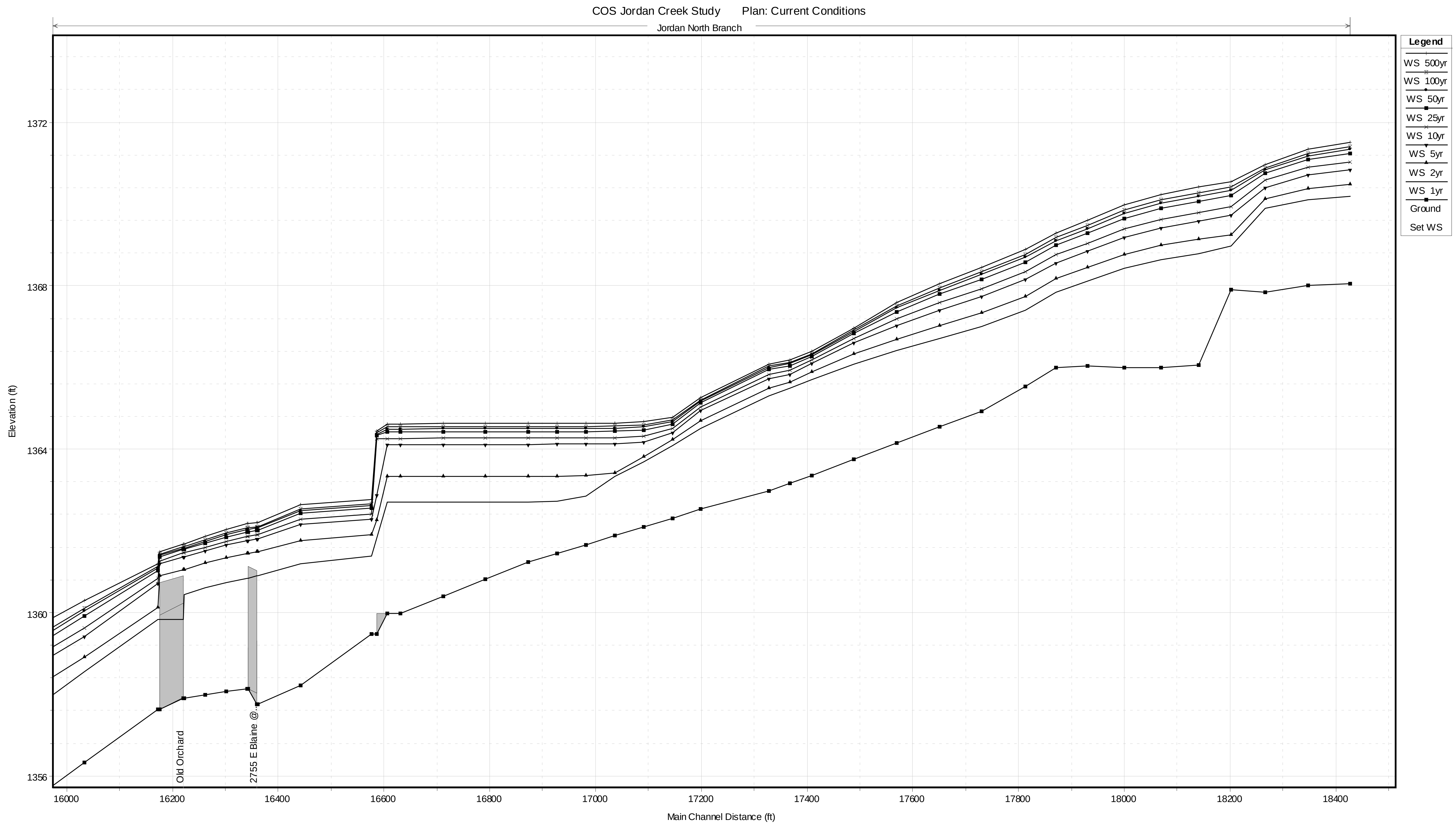


Plate Series C – Without Project Hydraulic Profiles

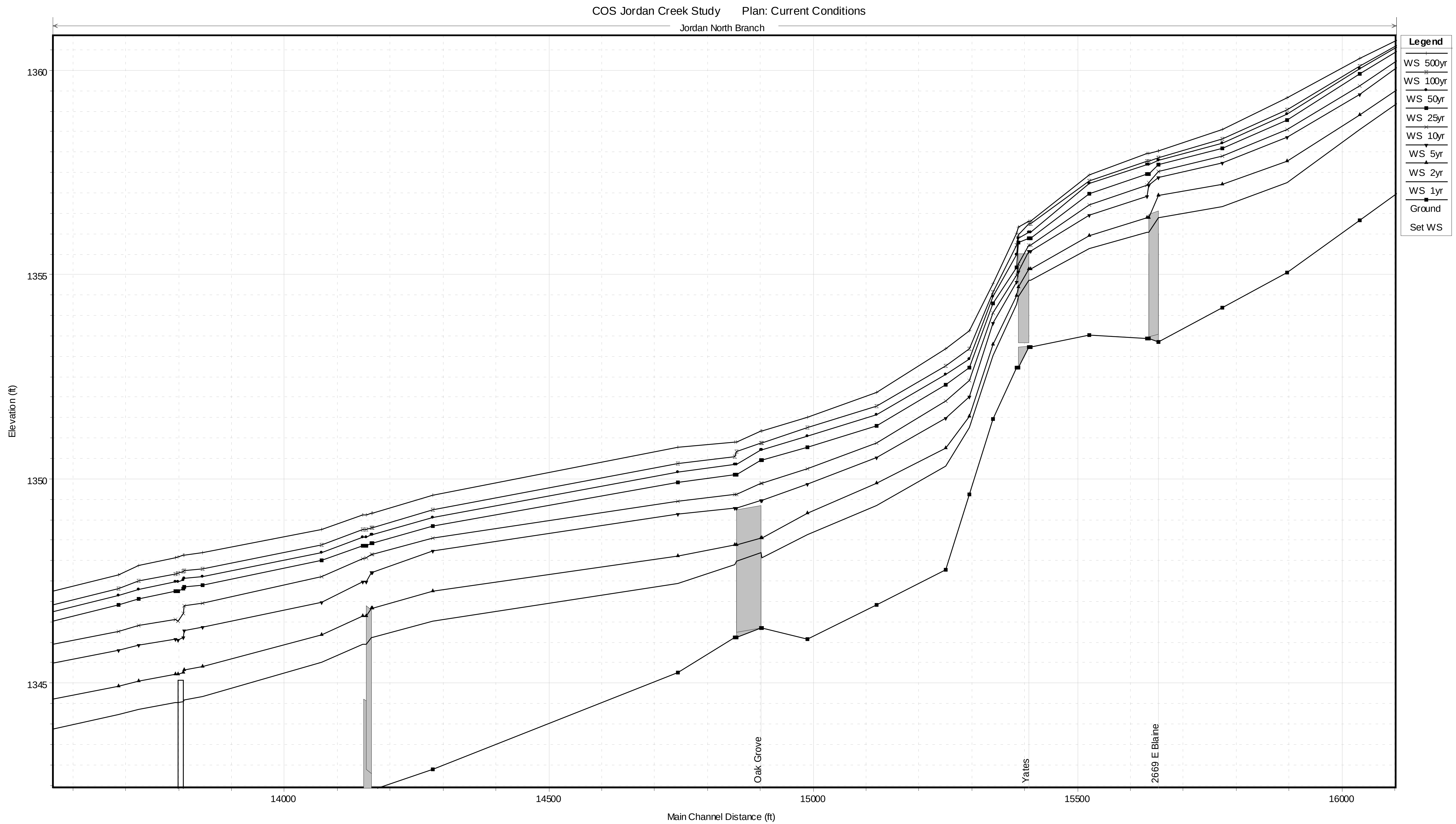
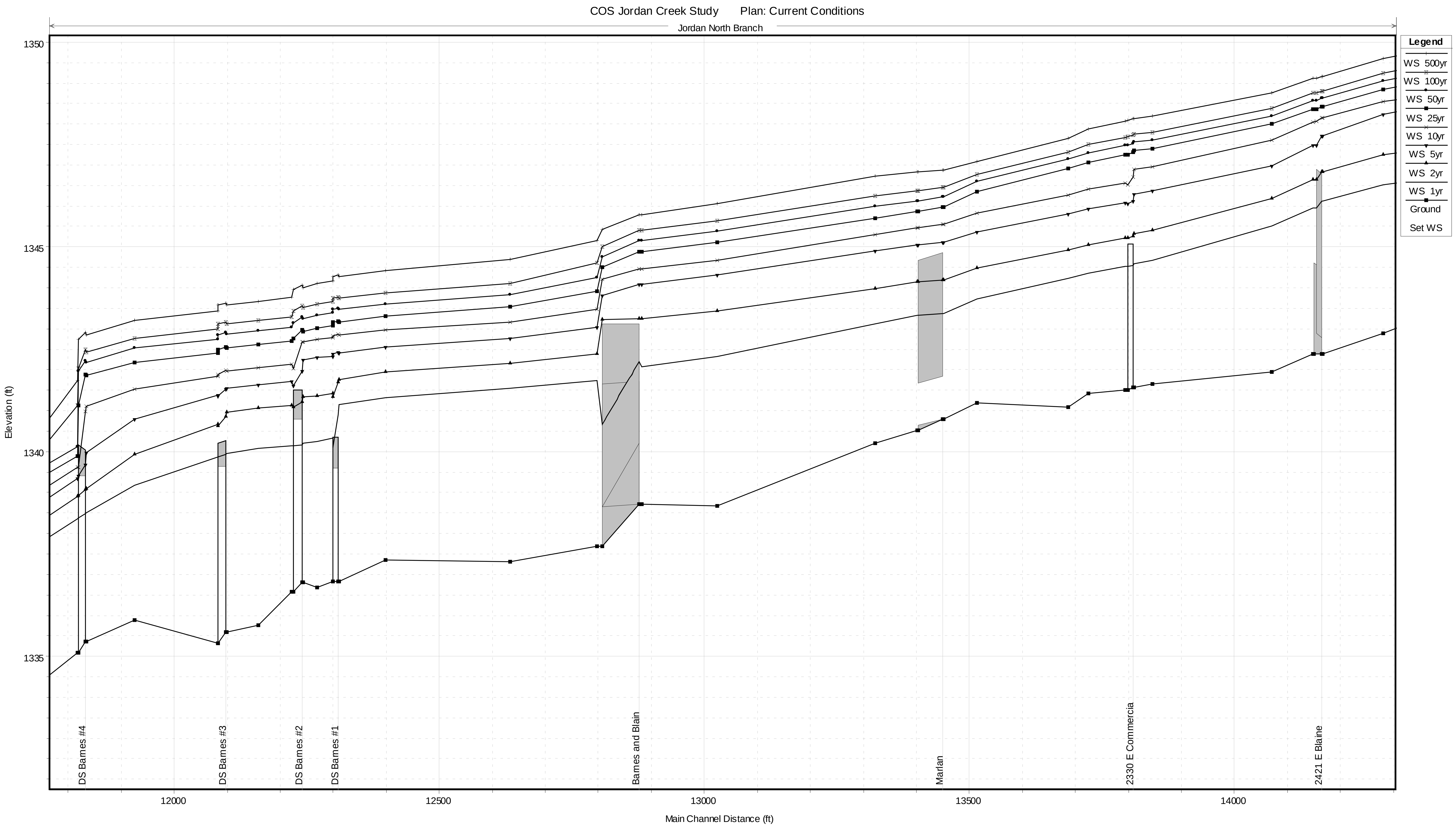
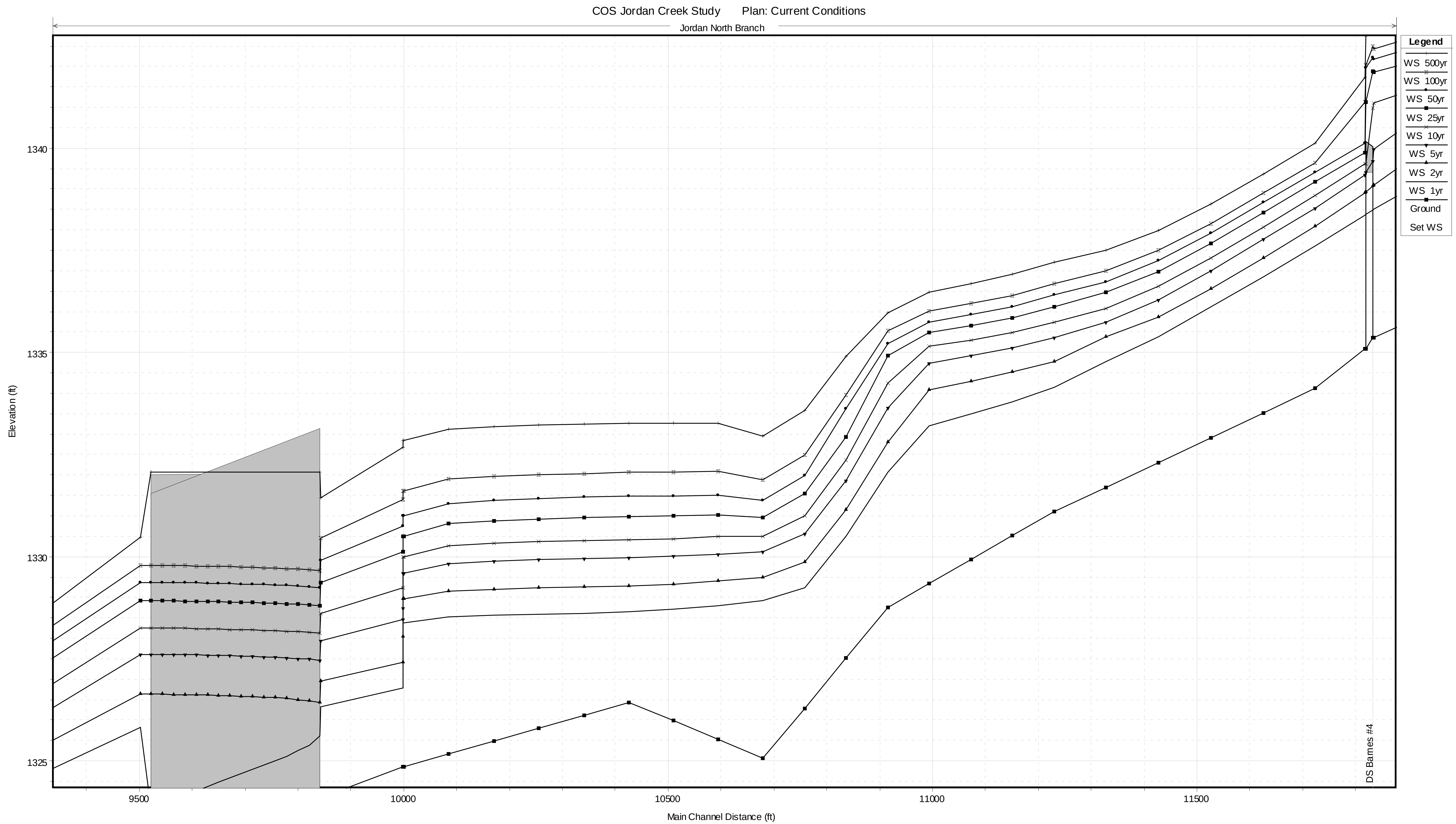
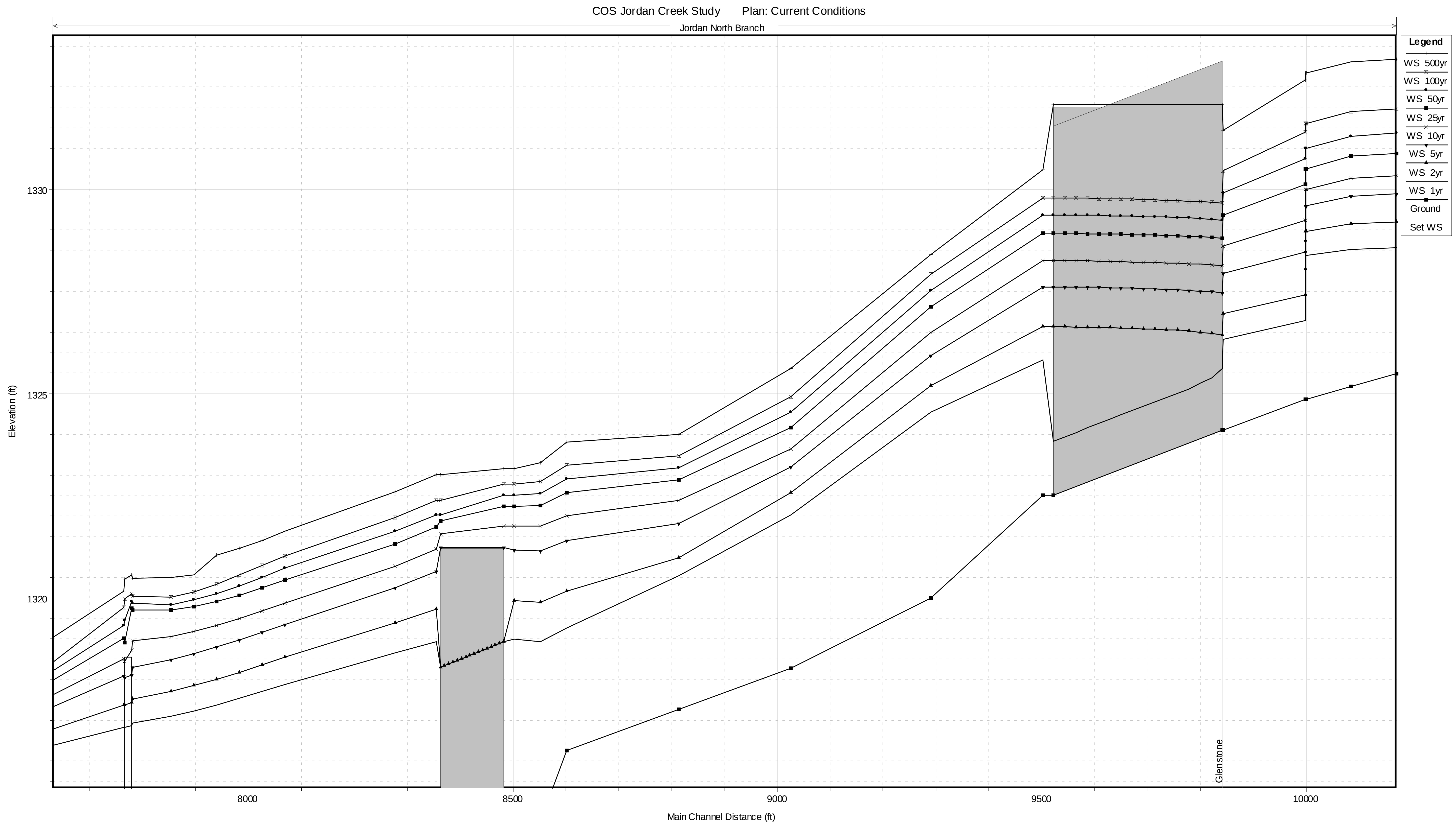


Plate Series C – Without Project Hydraulic Profiles



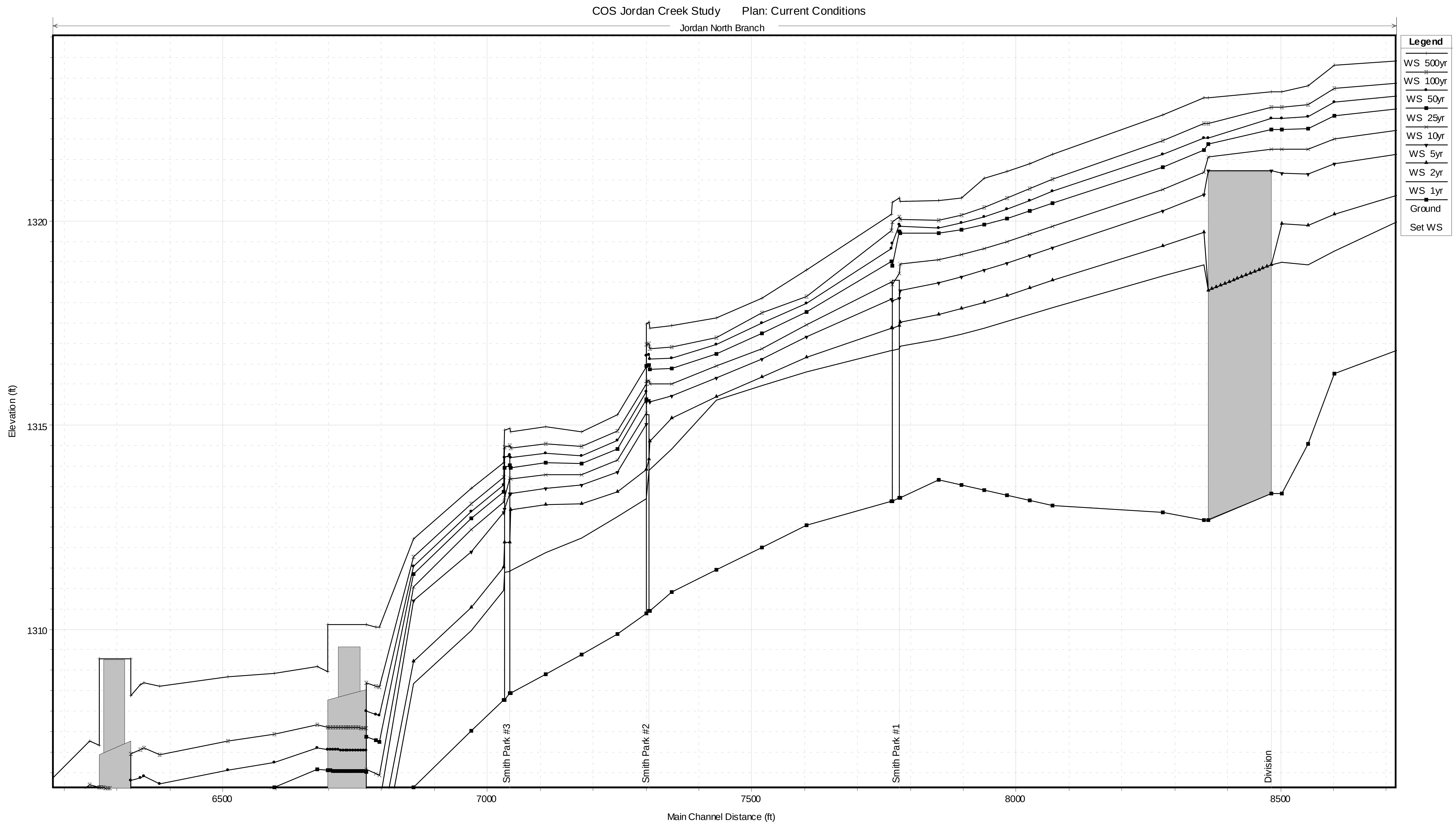


COS Jordan Creek Study Plan: Current Conditions
Jordan North Branch
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
Elevation (ft)
1340
1335
1330
1325
9500
10000
10500
11000
11500
Main Channel Distance (ft)
DS Barnes #4



COS Jordan Creek Study Plan: Current Conditions
Jordan North Branch
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
1330
1325
1320
Elevation (ft)
Glenstone
8000
8500
9000
9500
10000
Main Channel Distance (ft)

Plate Series C – Without Project Hydraulic Profiles



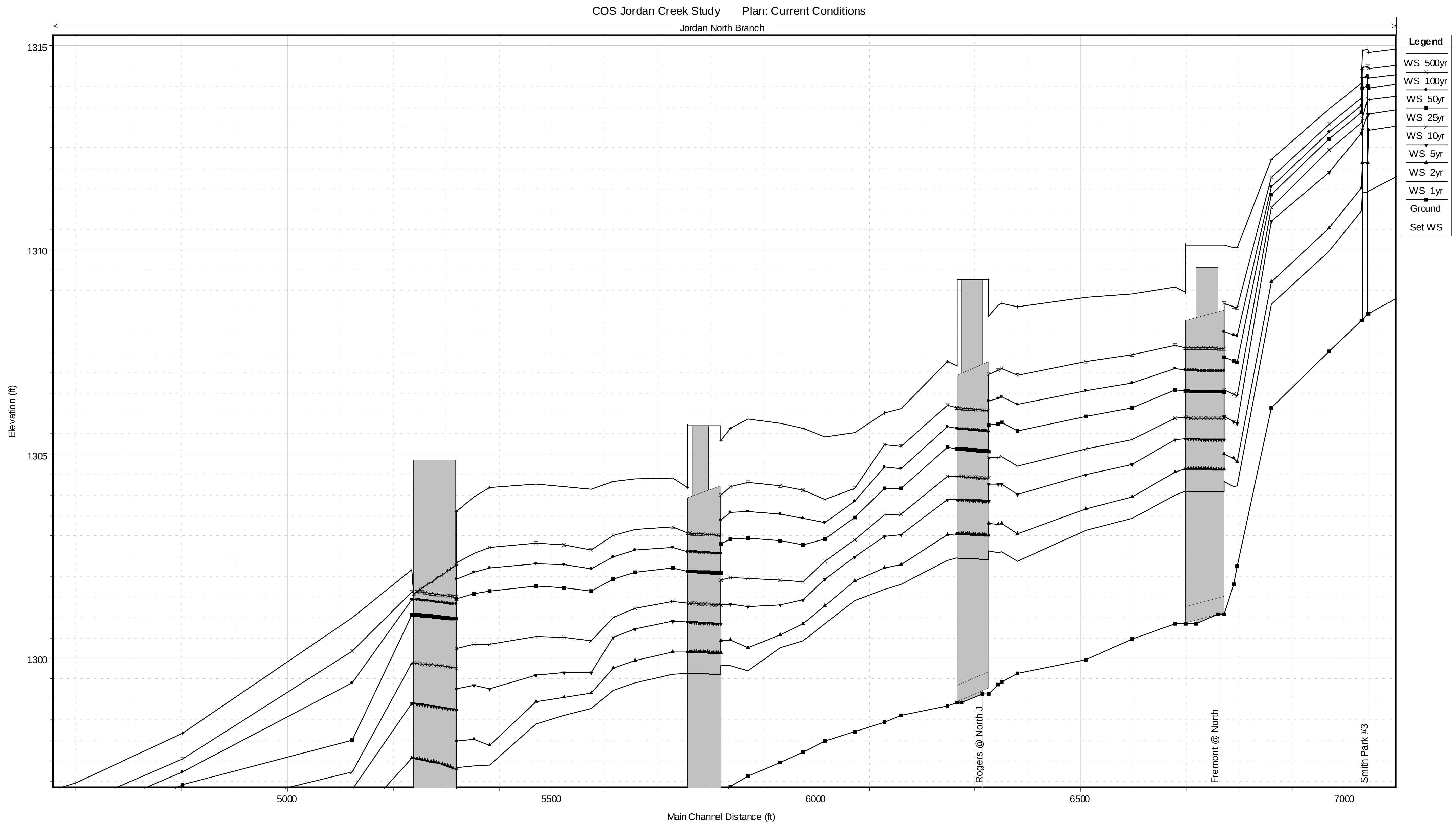

COS Jordan Creek Study Plan: Current Conditions
Jordan North Branch
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
1315
1310
1305
1300
Elevation (ft)
Rogers @ North J
Fremont @ North
Smith Park #3
5000
5500
6000
6500
7000
Main Channel Distance (ft)

Plate Series C – Without Project Hydraulic Profiles

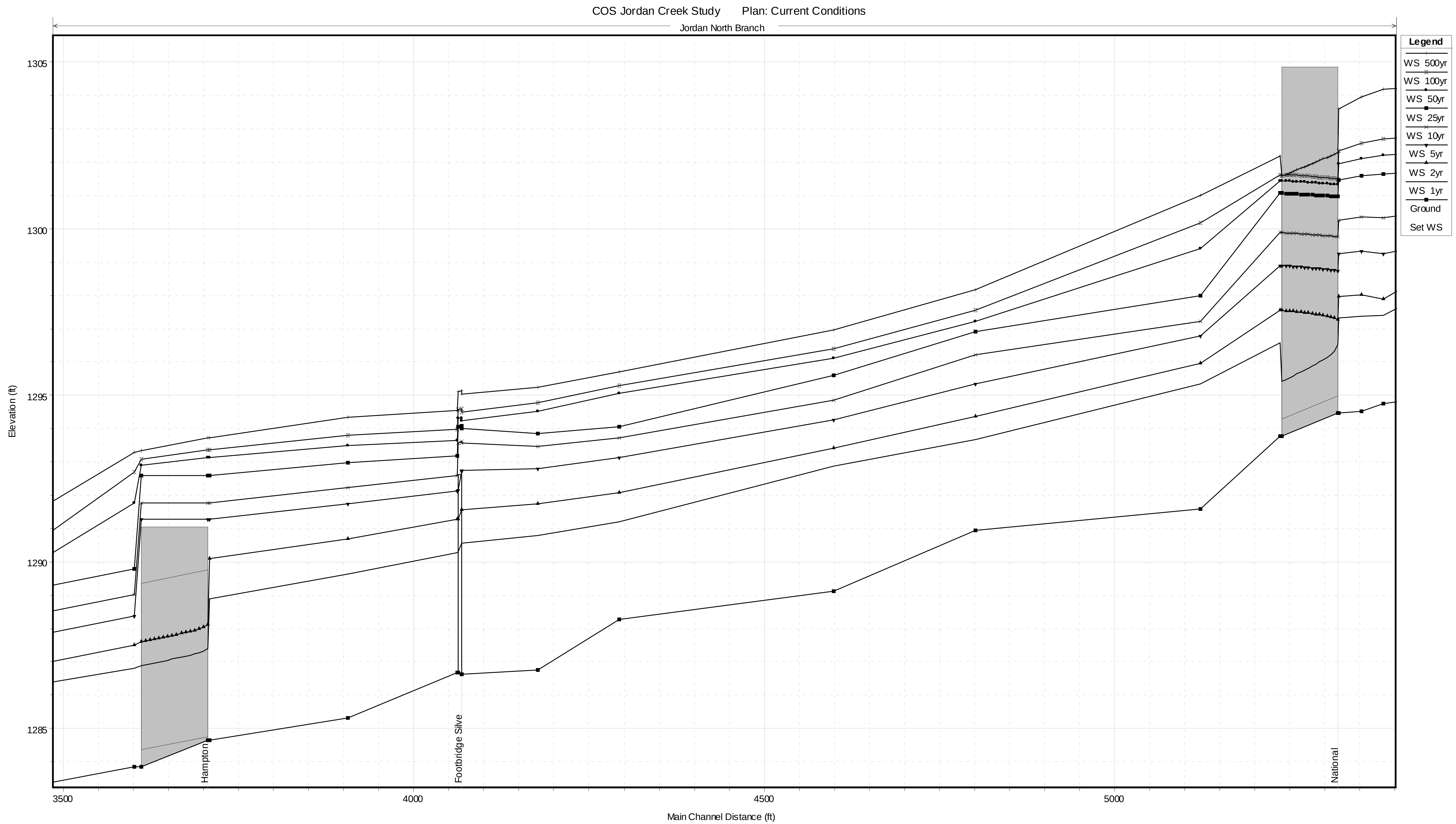


Plate Series C – Without Project Hydraulic Profiles

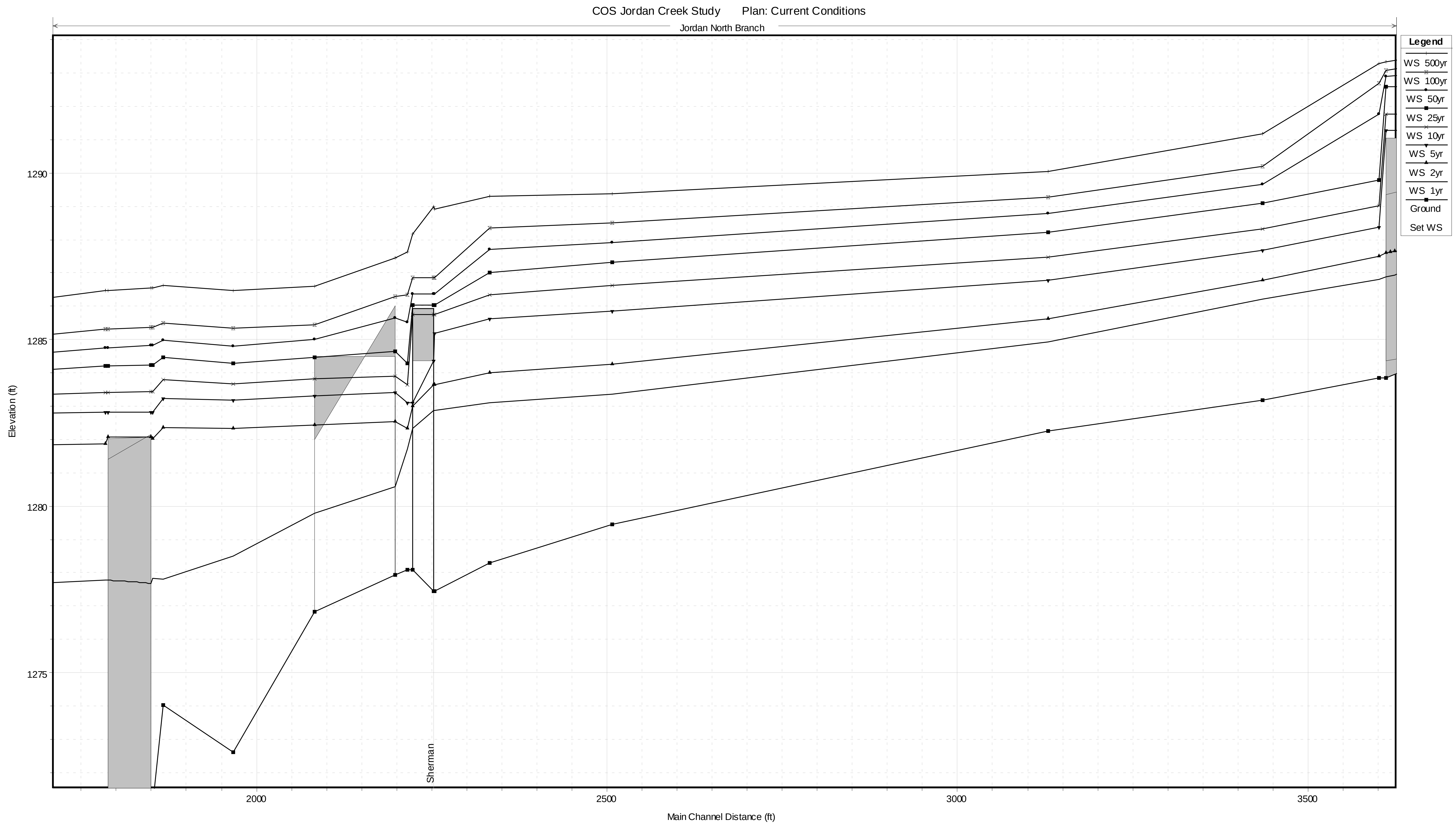


Plate Series C – Without Project Hydraulic Profiles

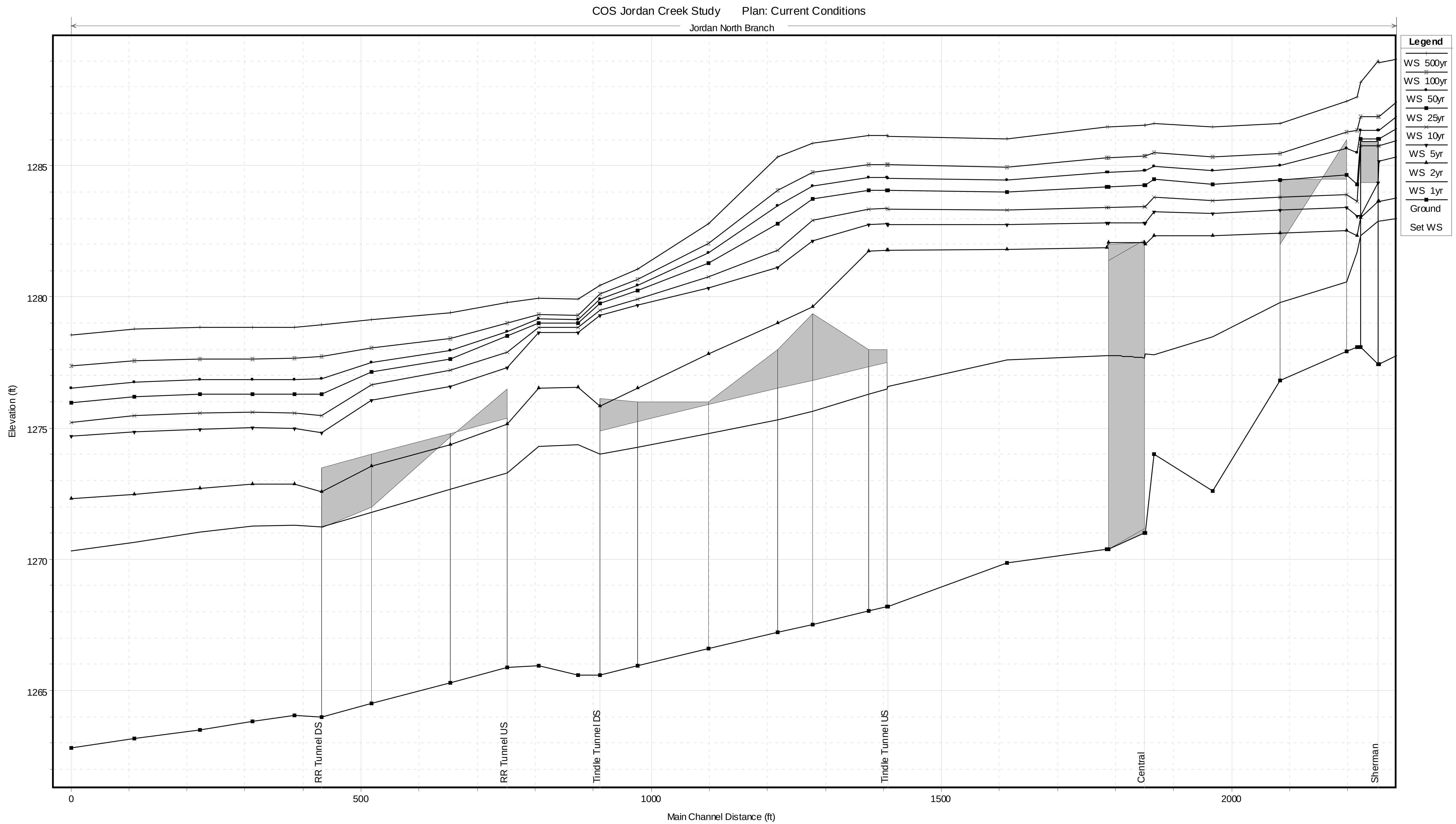


Plate Series C – Without Project Hydraulic Profiles

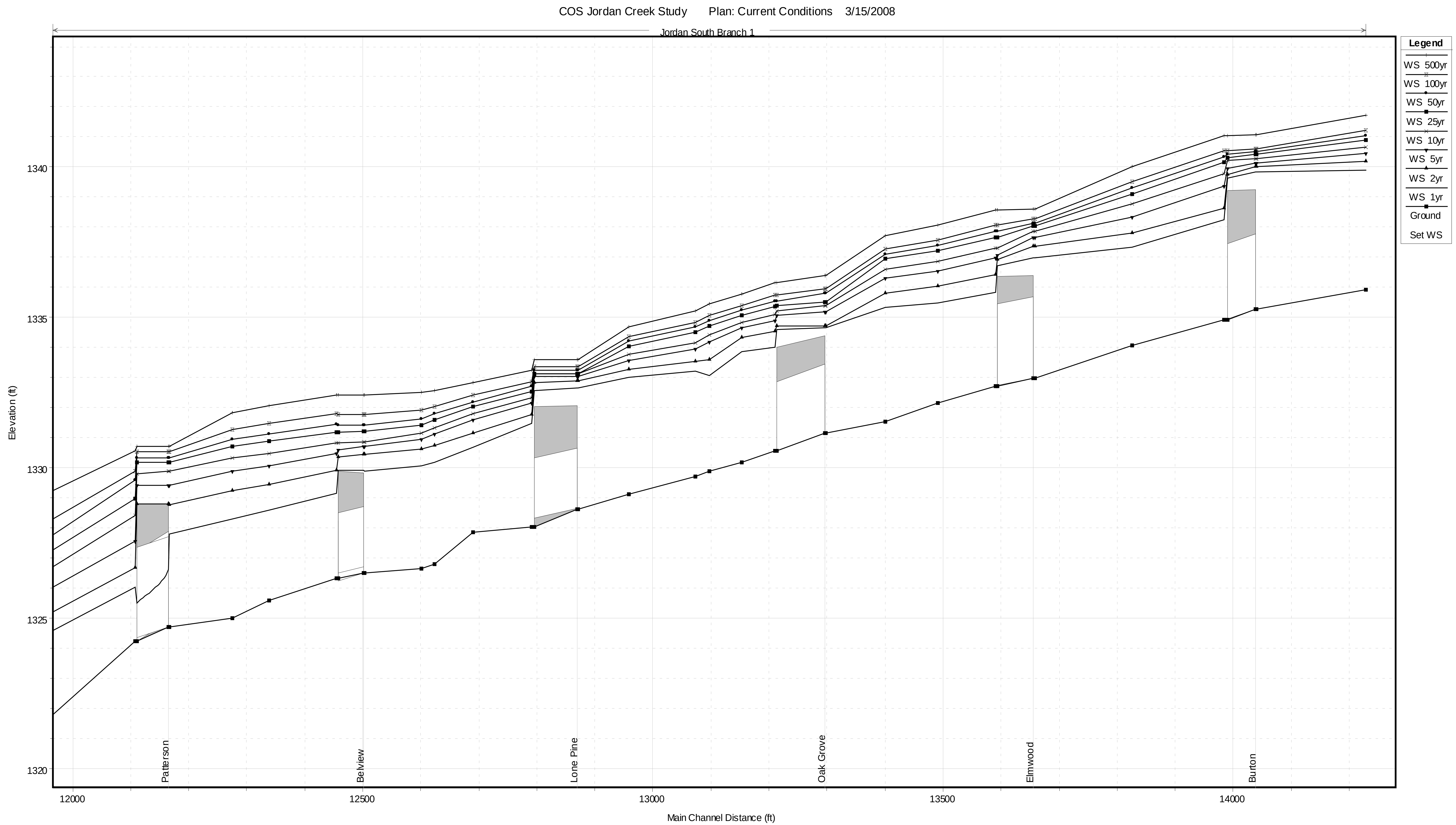


Plate Series C – Without Project Hydraulic Profiles

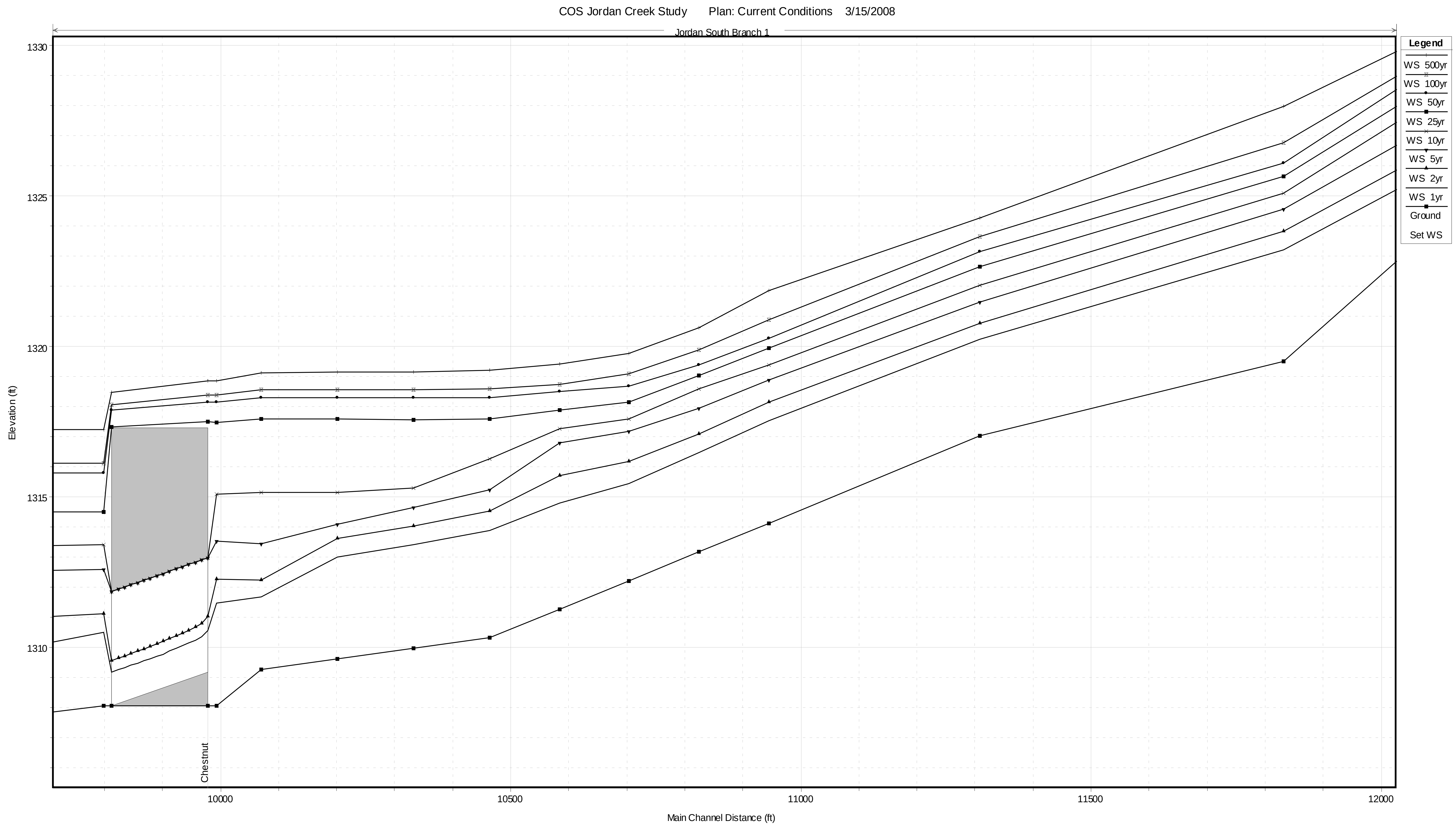


Plate Series C – Without Project Hydraulic Profiles

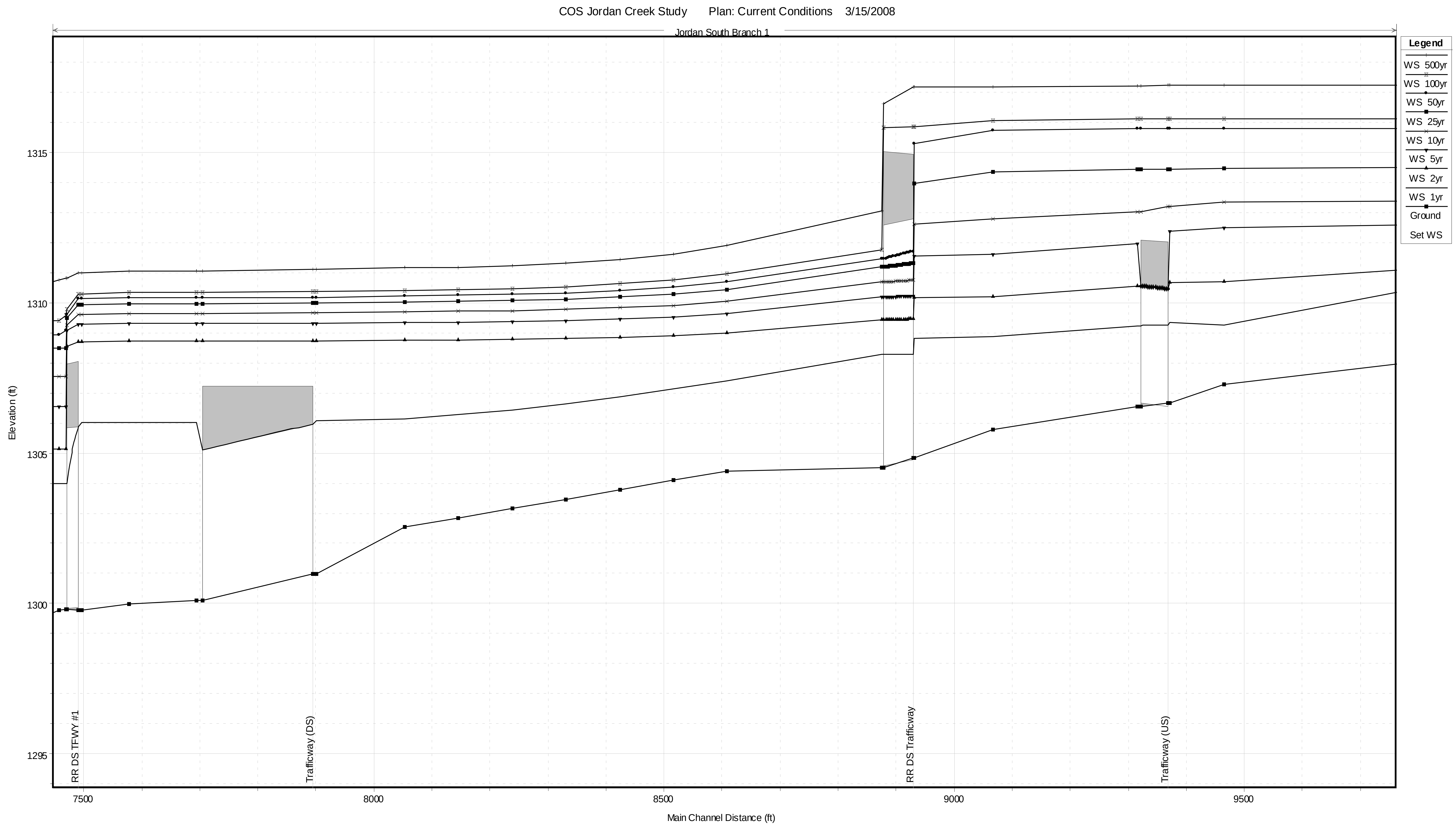


Plate Series C – Without Project Hydraulic Profiles

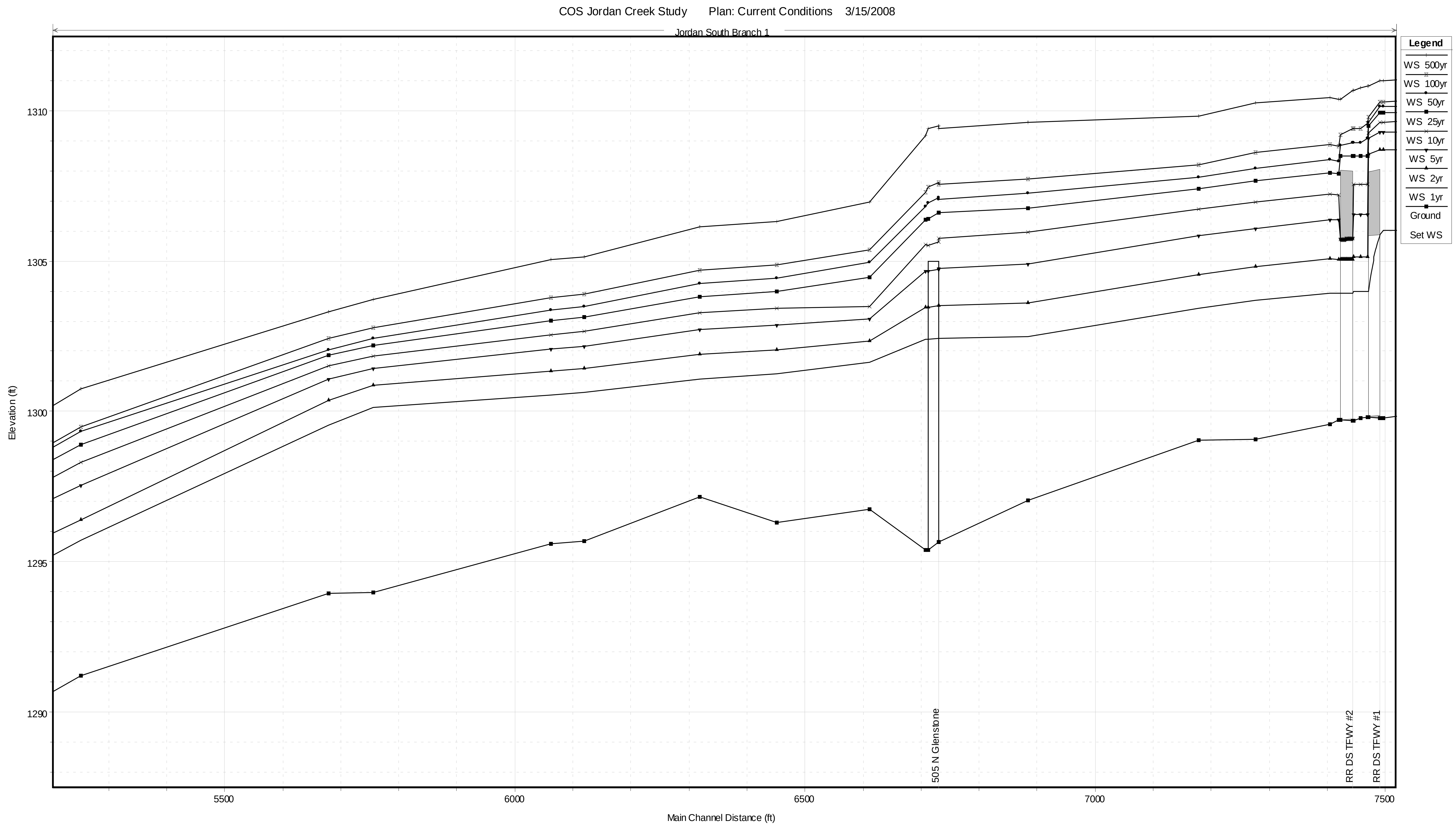
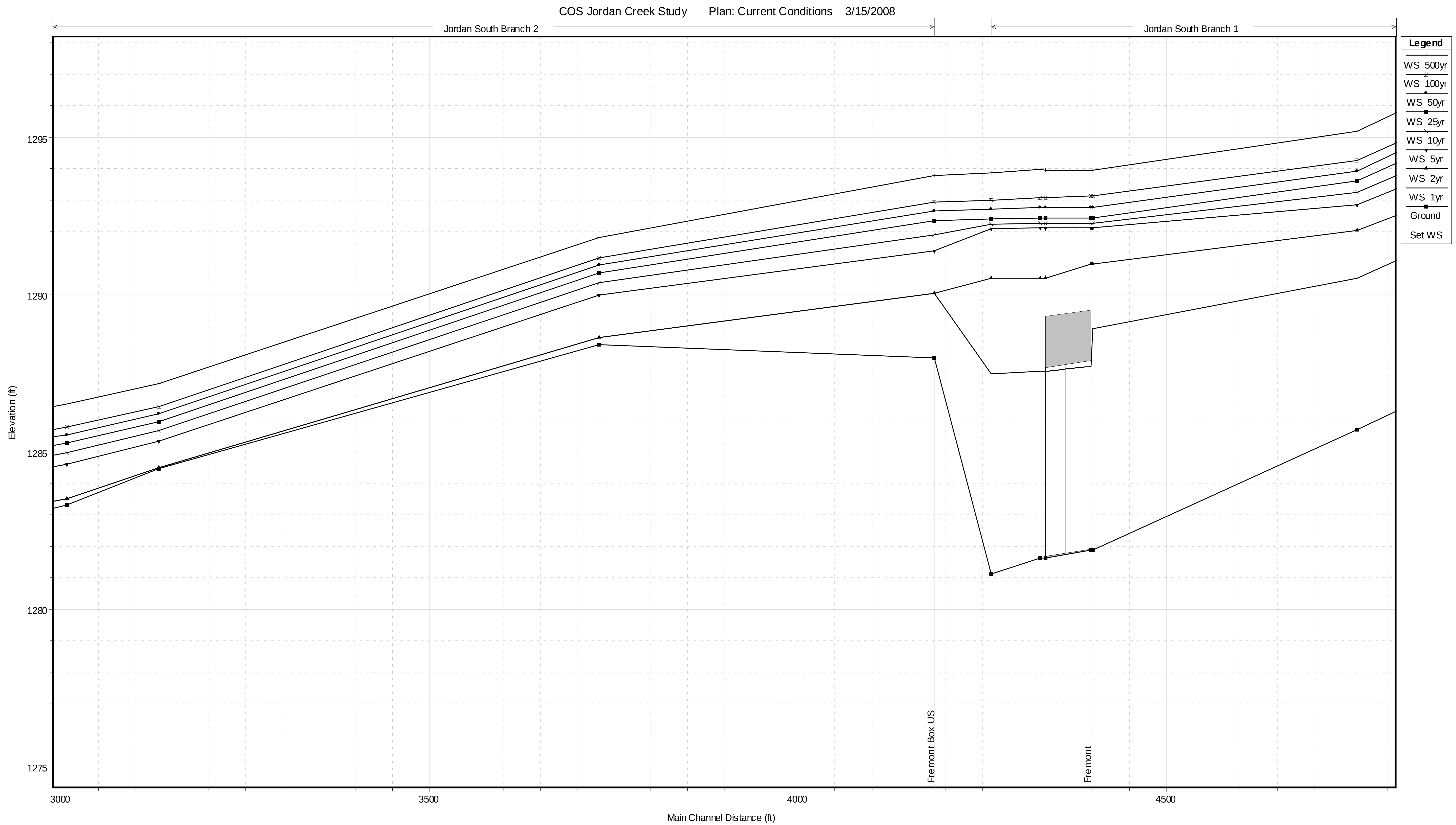
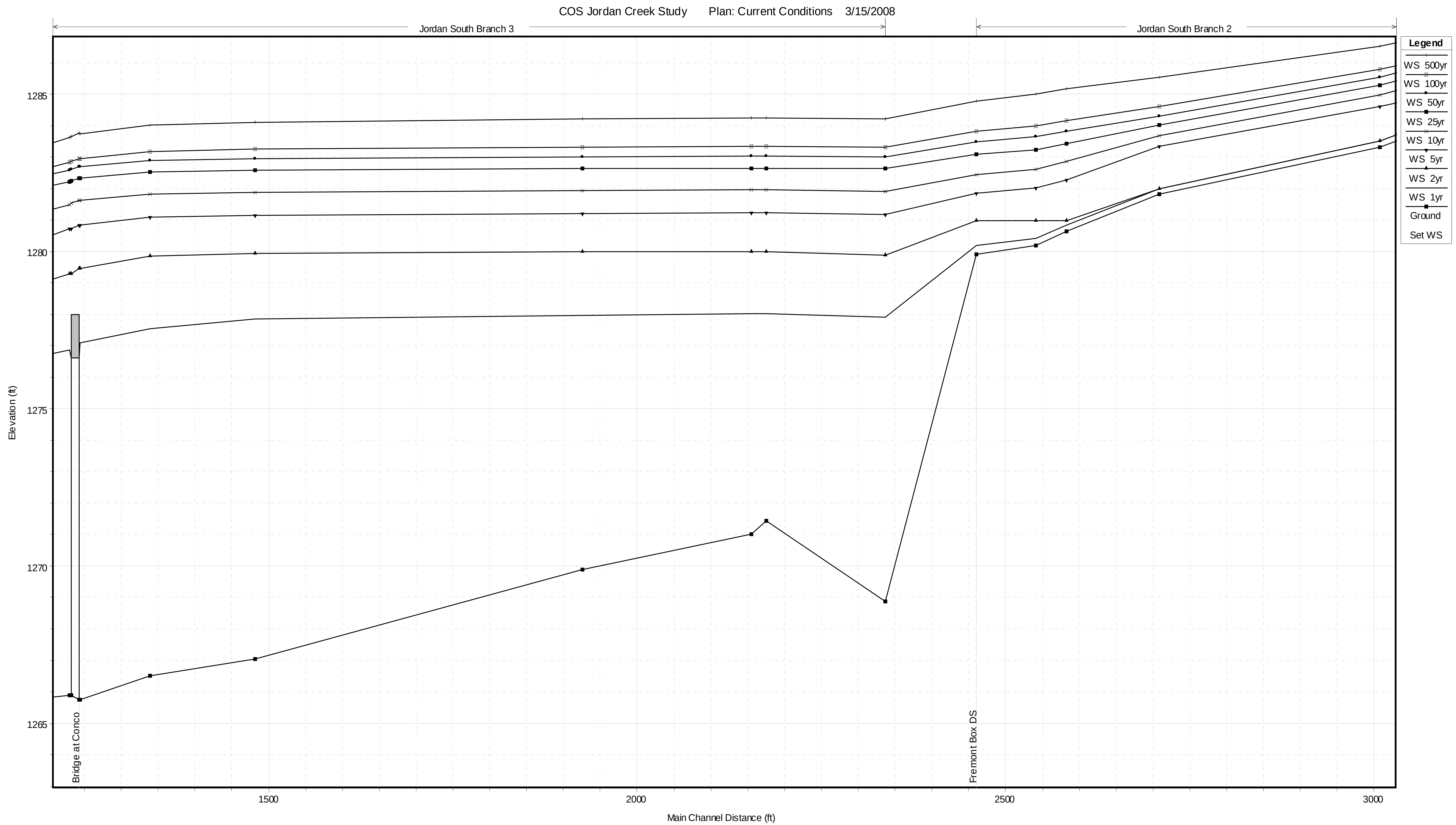


Plate Series C – Without Project Hydraulic Profiles




COS Jordan Creek Study Plan: Current Conditions 3/15/2008
Jordan South Branch 3
Jordan South Branch 2
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
Elevation (ft)
1285
1280
1275
1270
1265
Bridge at Conco
Fremont Box DS
1500
2000
2500
3000
Main Channel Distance (ft)

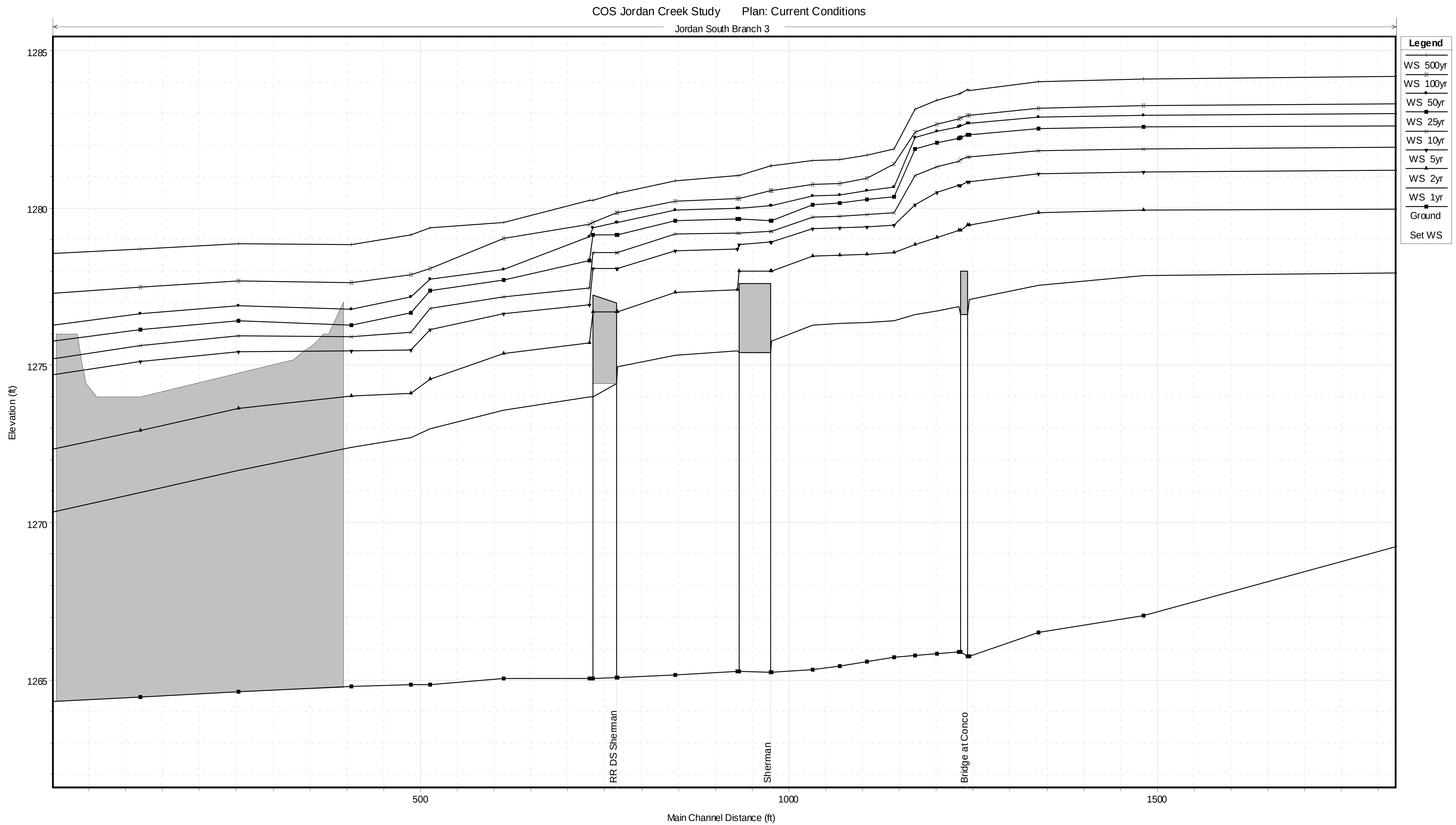
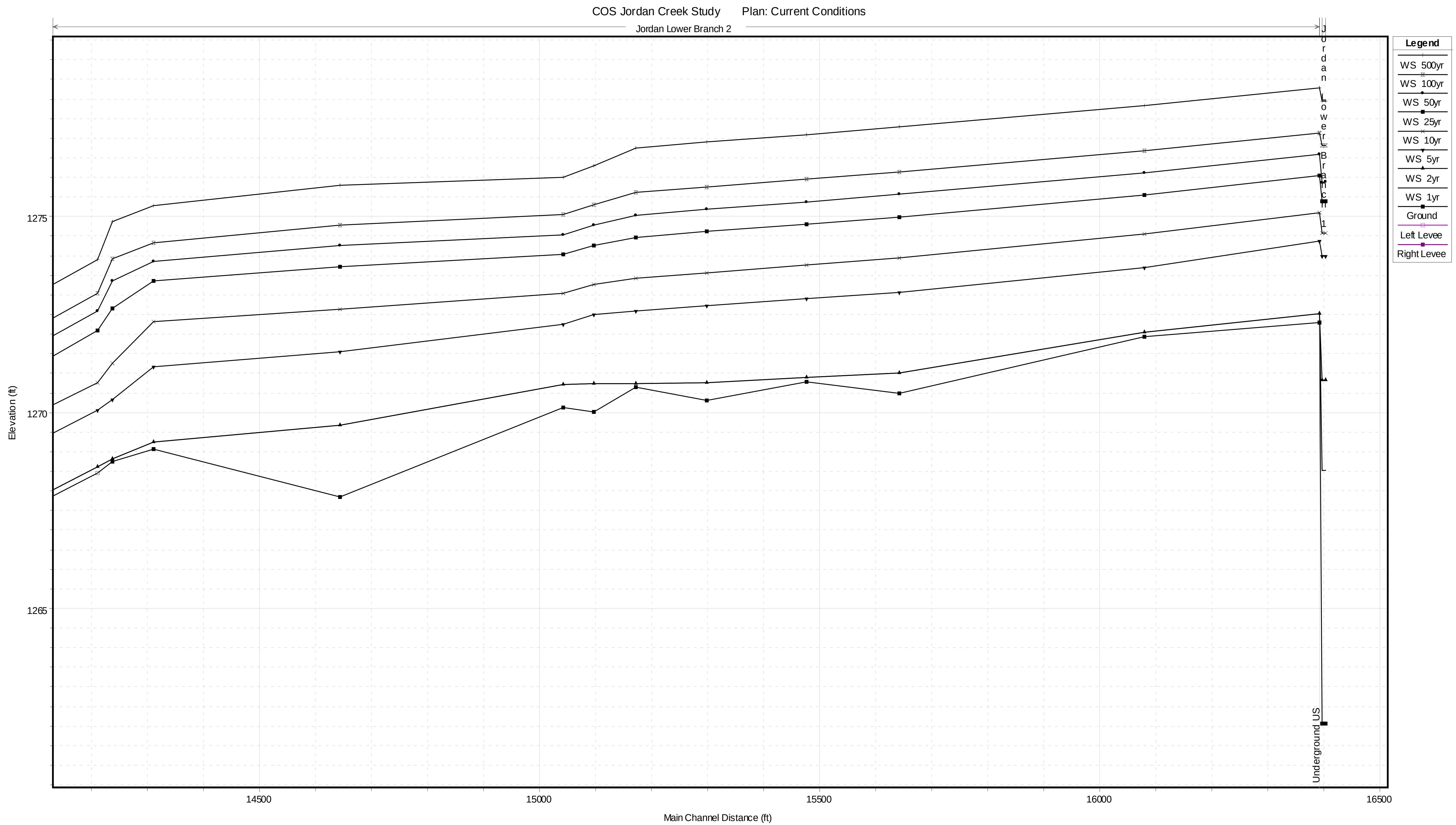

COS Jordan Creek Study Plan: Current Conditions
Jordan South Branch 3
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
Elevation (ft)
1285
1280
1275
1270
1265
RR DS Sherman
Sherman
Bridge at Conco
500
1000
1500
Main Channel Distance (ft)

Plate Series C – Without Project Hydraulic Profiles



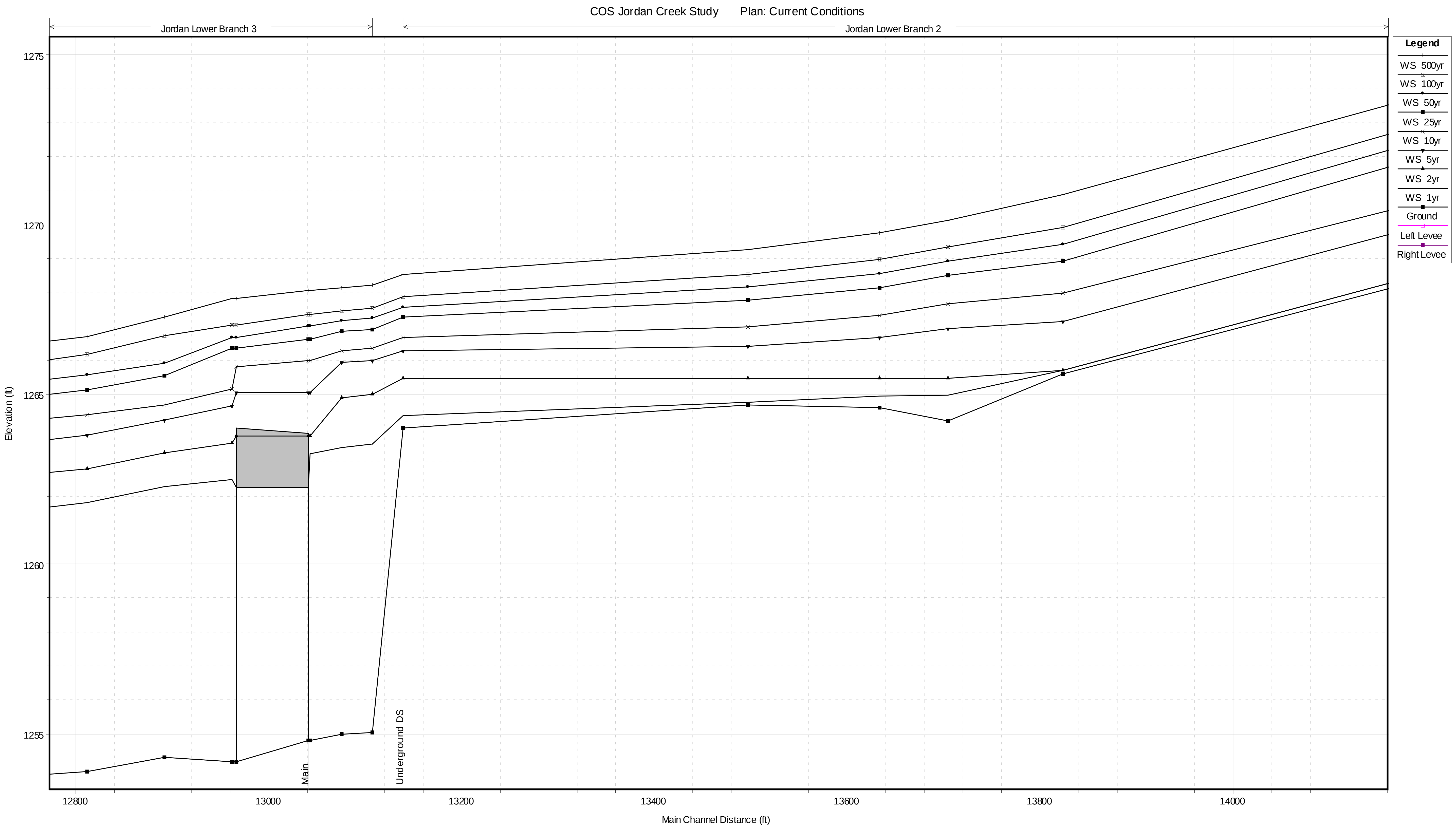
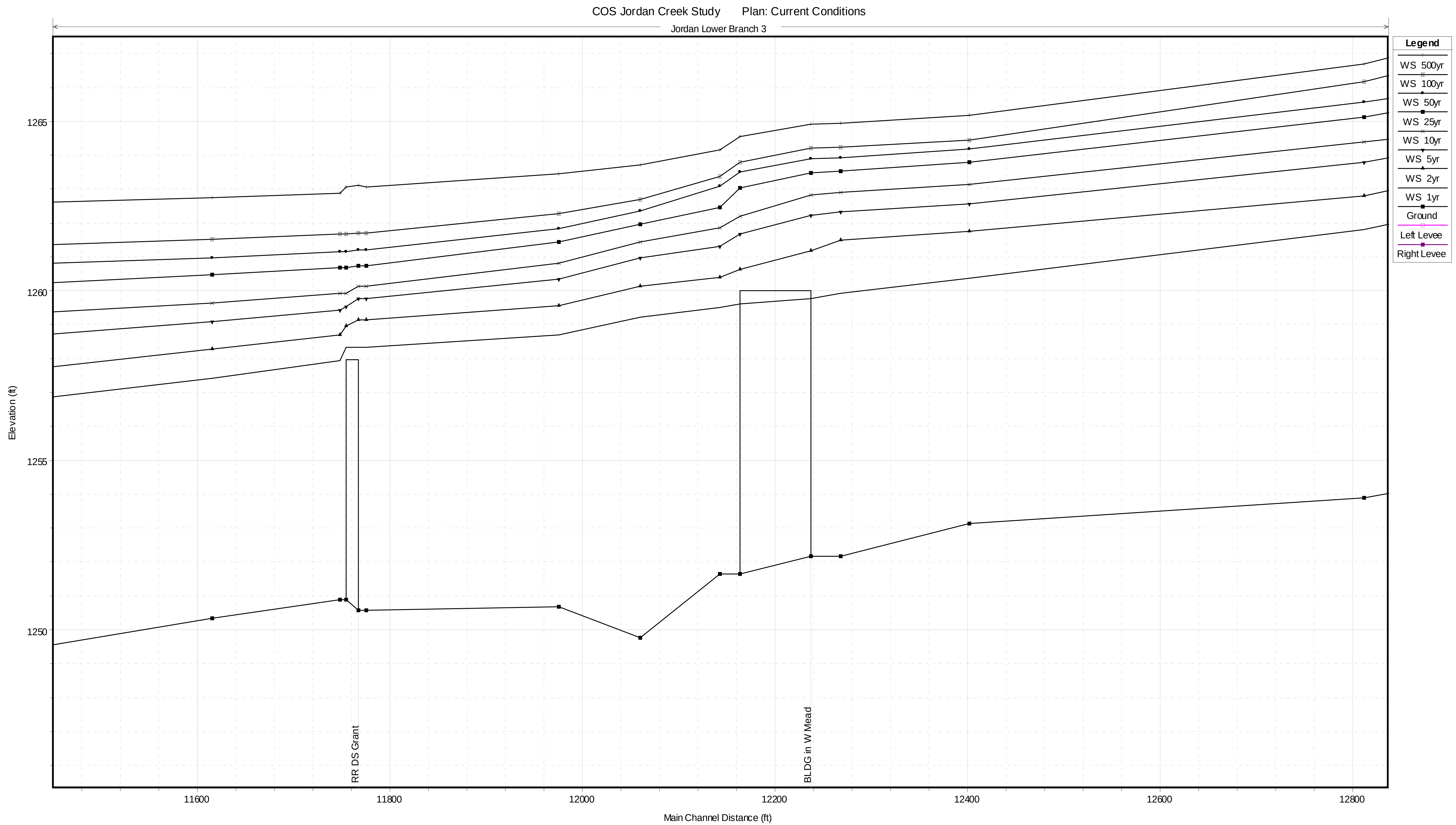

COS Jordan Creek Study Plan: Current Conditions
Jordan Lower Branch 3
Jordan Lower Branch 2
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Left Levee
Right Levee
Elevation (ft)
1275
1270
1265
1260
1255
Main
Underground DS
12800
13000
13200
13400
13600
13800
14000
Main Channel Distance (ft)

Plate Series C – Without Project Hydraulic Profiles



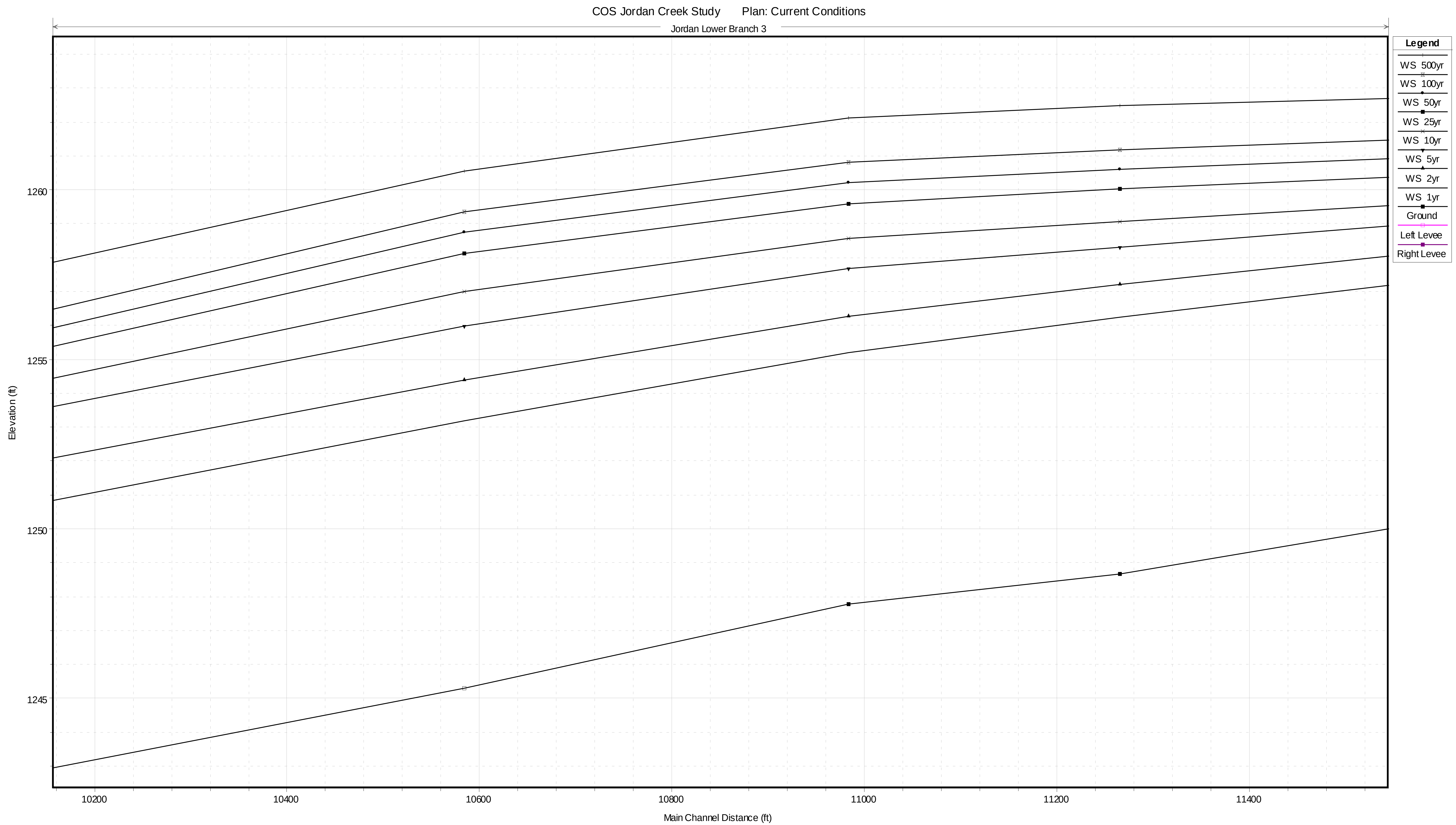
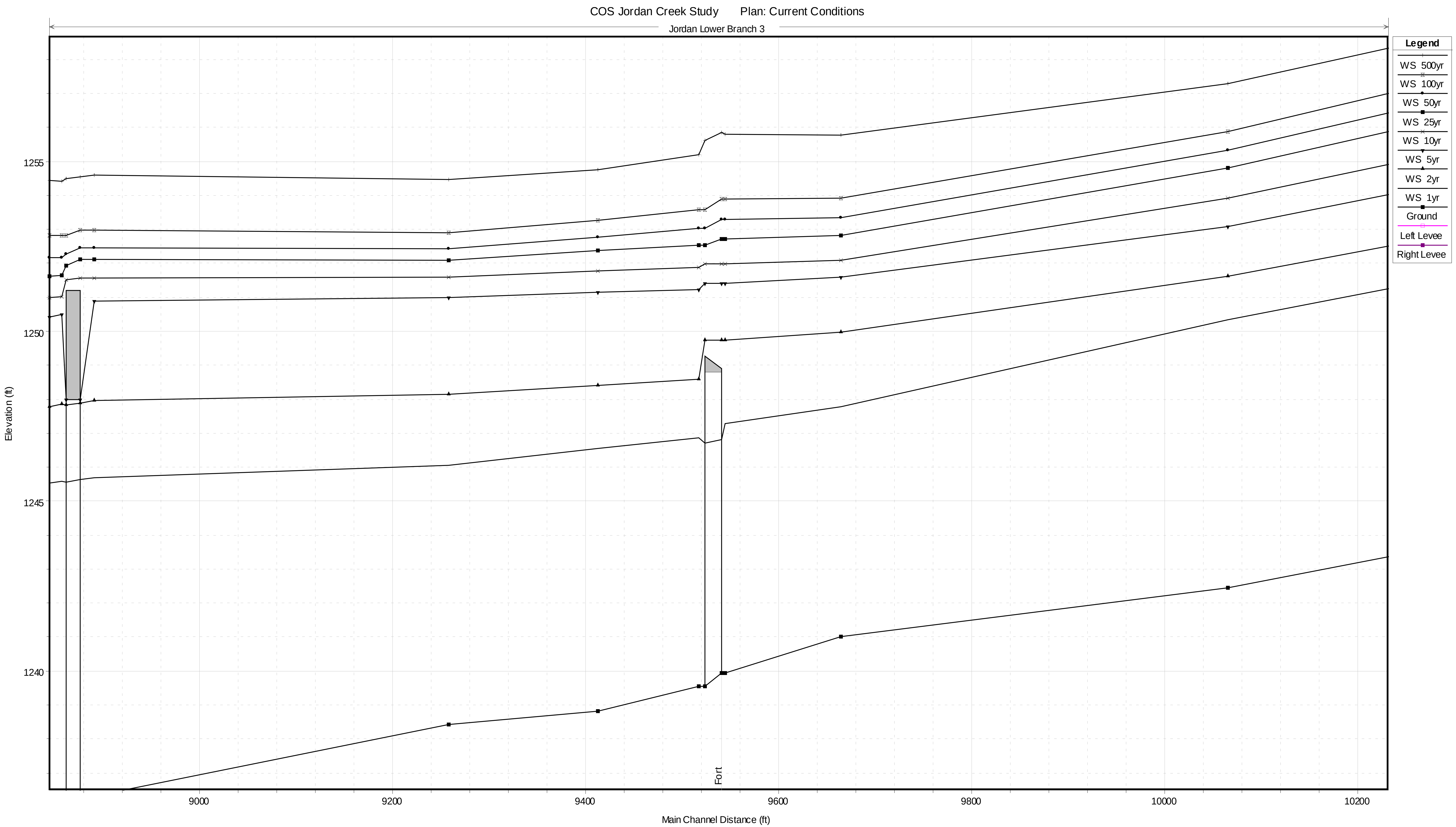

COS Jordan Creek Study Plan: Current Conditions
Jordan Lower Branch 3
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Left Levee
Right Levee
Elevation (ft)
1260
1255
1250
1245
10200
10400
10600
10800
11000
11200
11400
Main Channel Distance (ft)

Plate Series C – Without Project Hydraulic Profiles



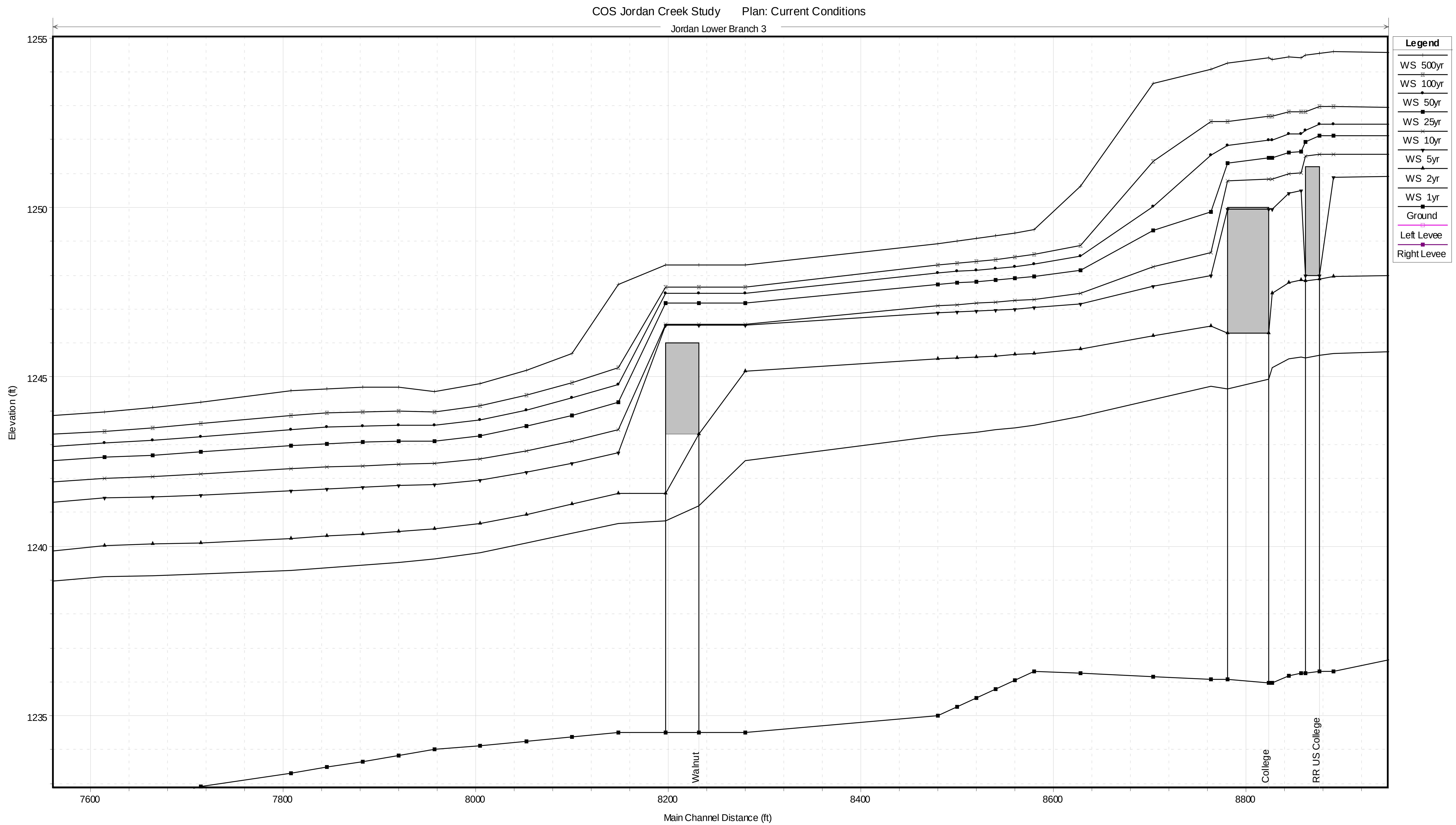

COS Jordan Creek Study Plan: Current Conditions
Jordan Lower Branch 3
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Left Levee
Right Levee
Elevation (ft)
1255
1250
1245
1240
1235
Main Channel Distance (ft)
7600
7800
8000
8200
8400
8600
8800
Walnut
College
RR US College

Plate Series C – Without Project Hydraulic Profiles

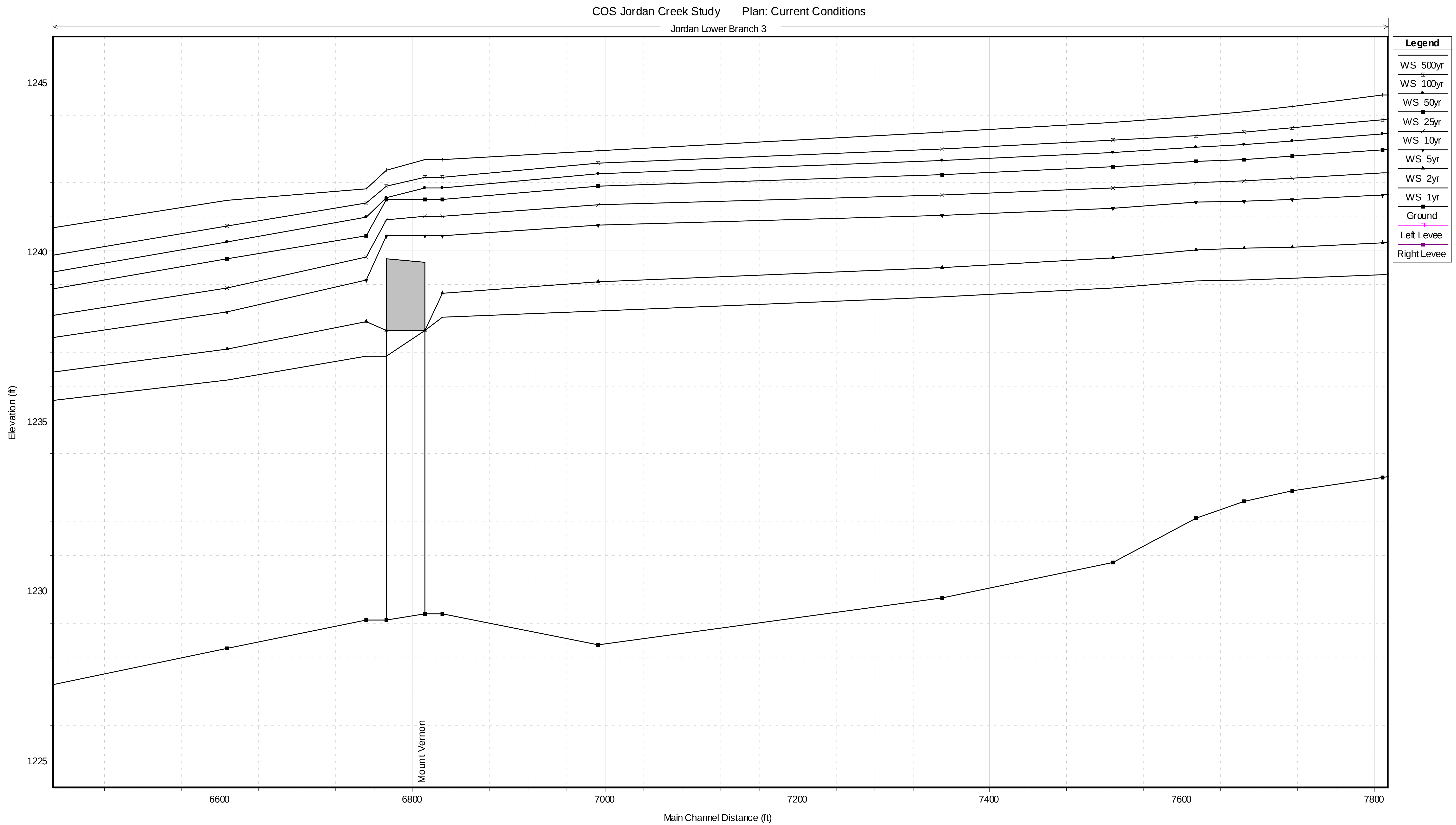


Plate Series C – Without Project Hydraulic Profiles

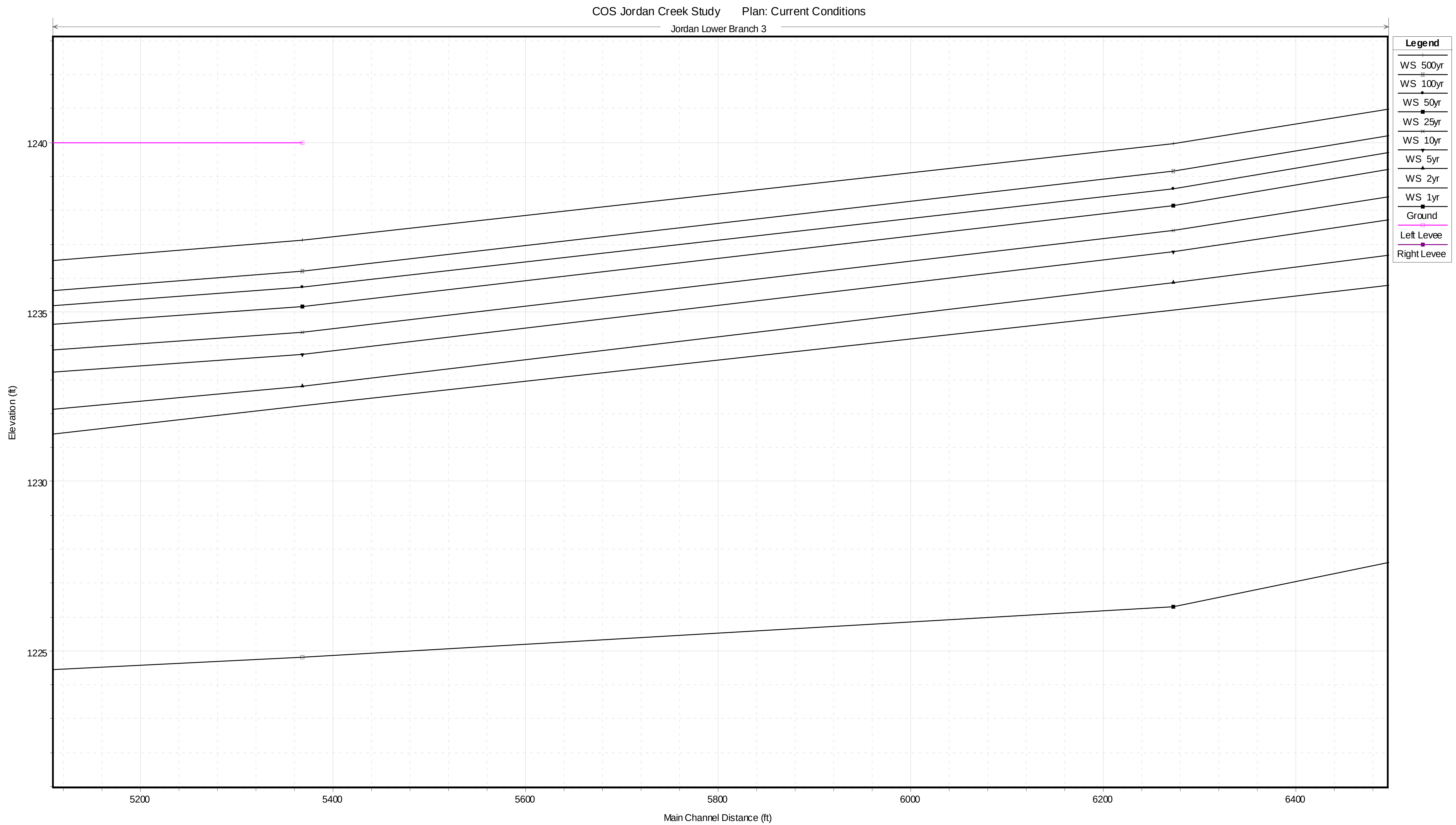
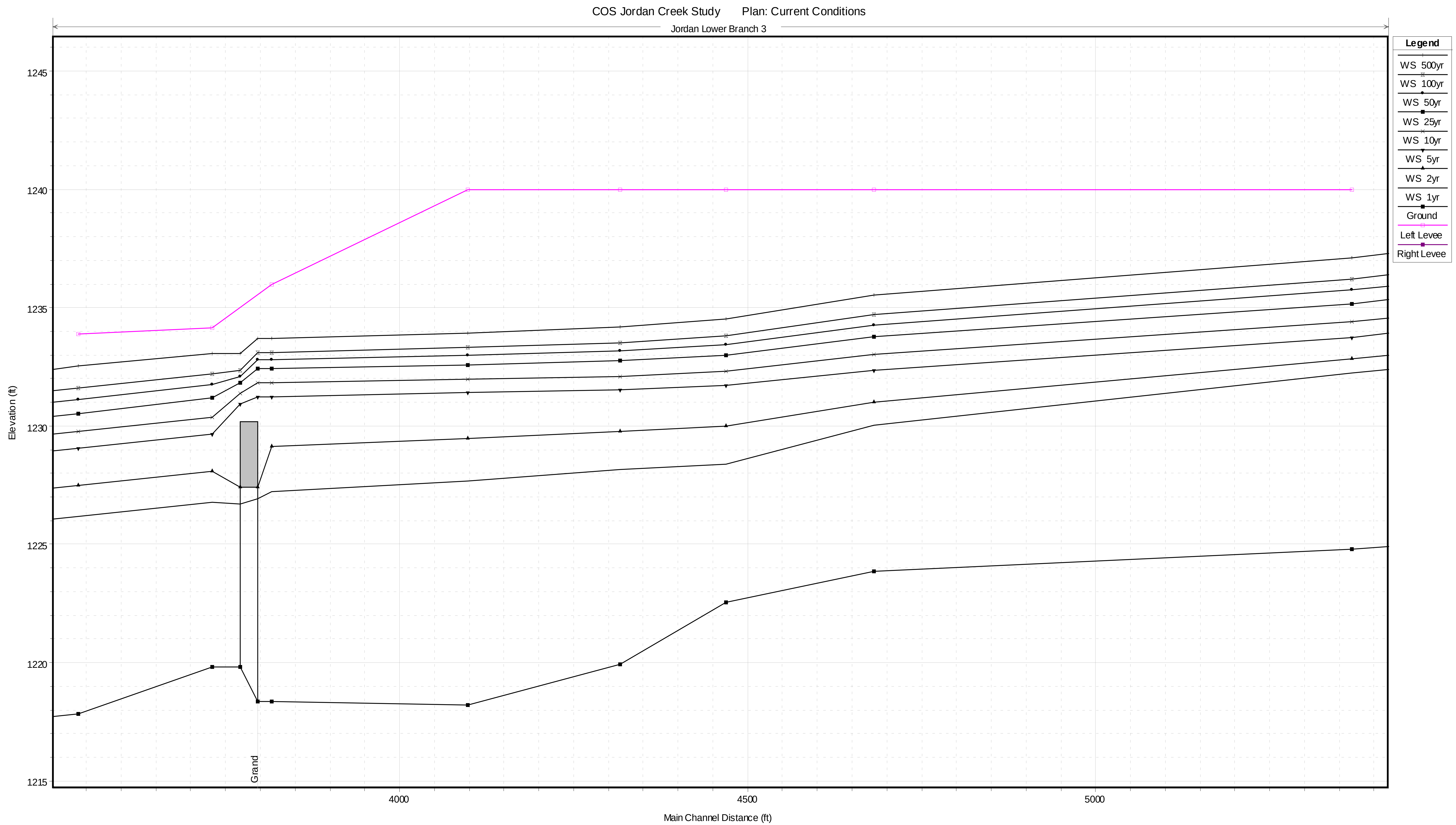


Plate Series C – Without Project Hydraulic Profiles



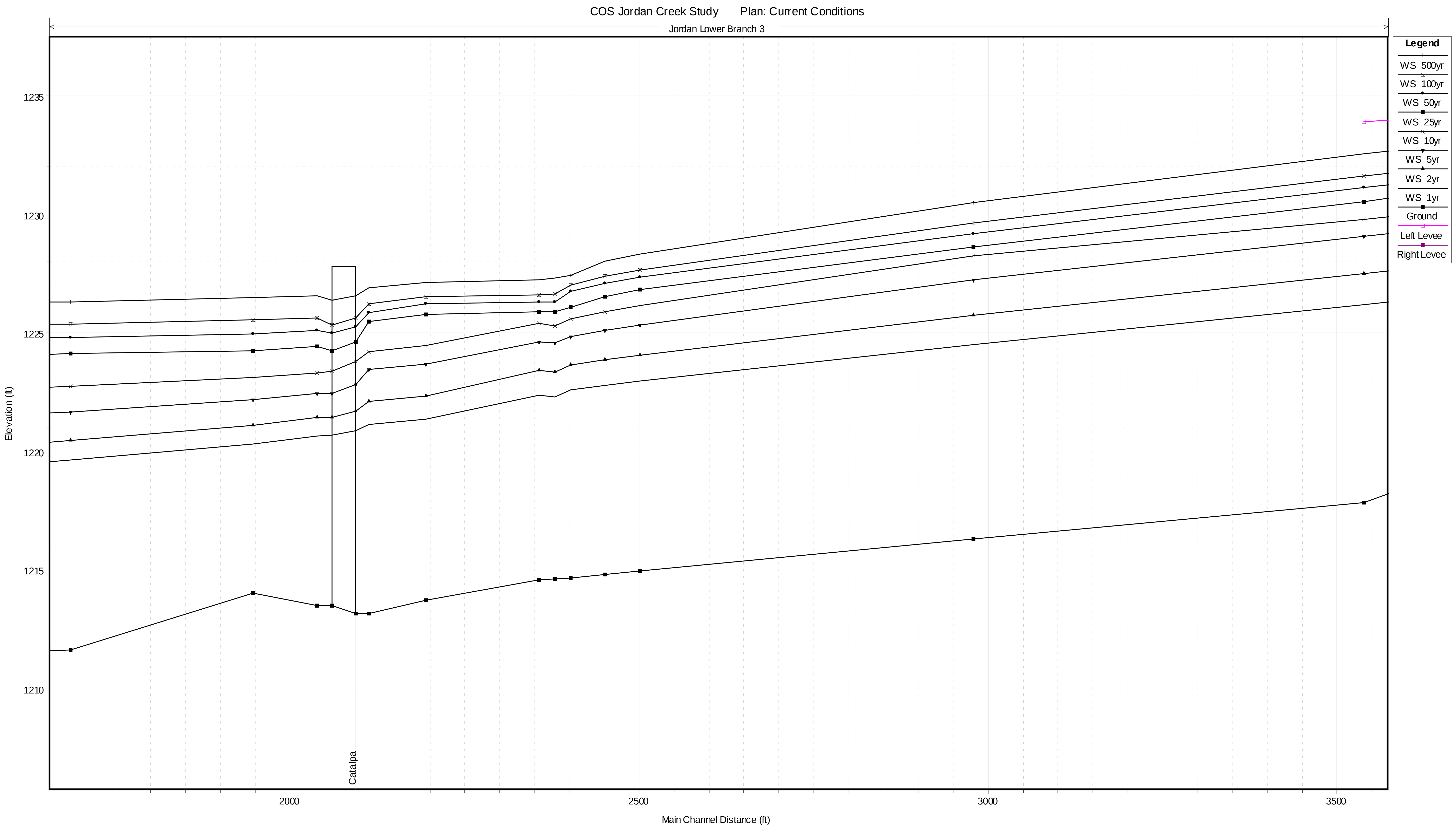

COS Jordan Creek Study Plan: Current Conditions
Jordan Lower Branch 3
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Left Levee
Right Levee
Elevation (ft)
1235
1230
1225
1220
1215
1210
Catalpa
2000
2500
3000
3500
Main Channel Distance (ft)

Plate Series C – Without Project Hydraulic Profiles

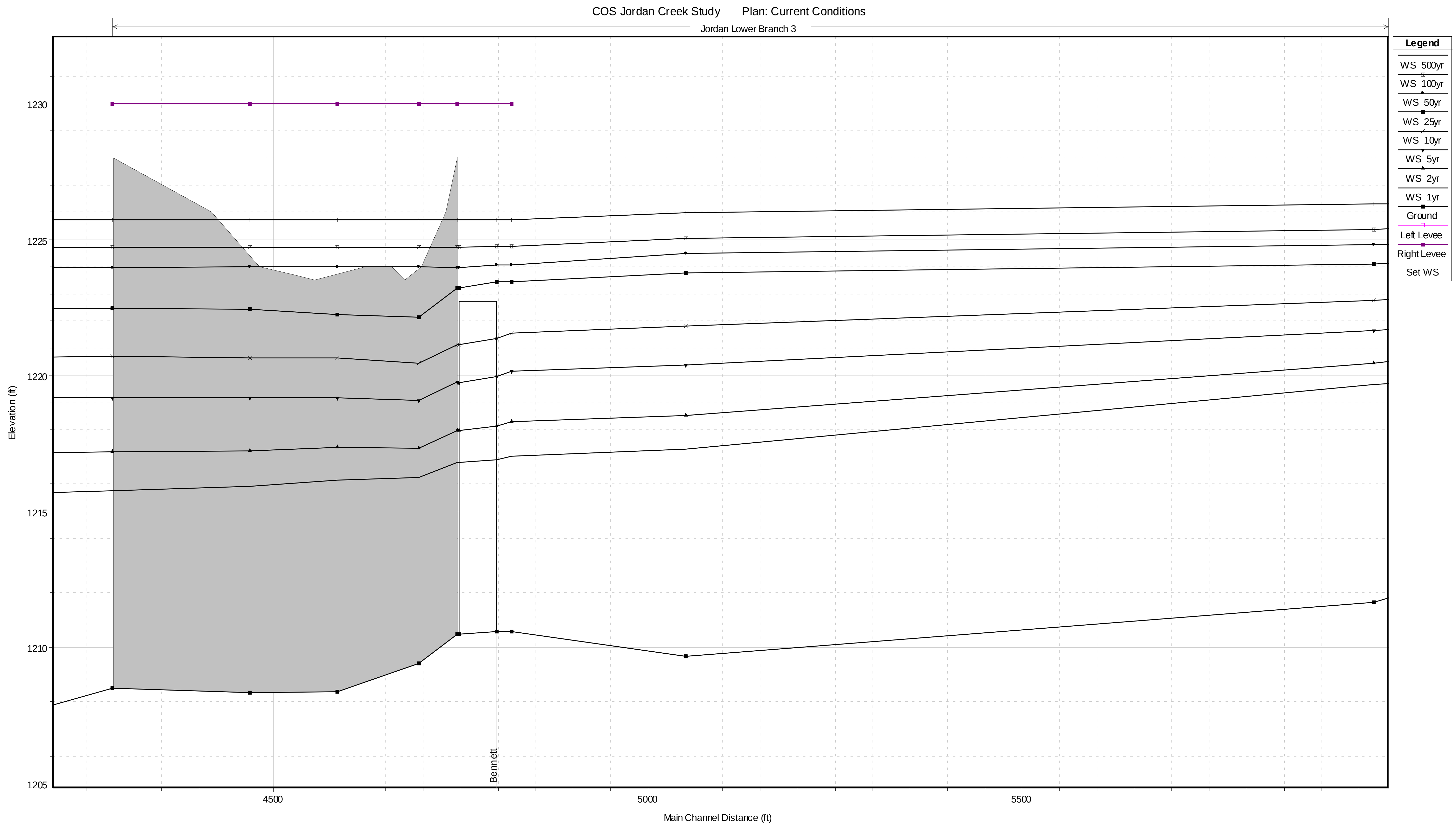


Plate Series C – Without Project Hydraulic Profiles

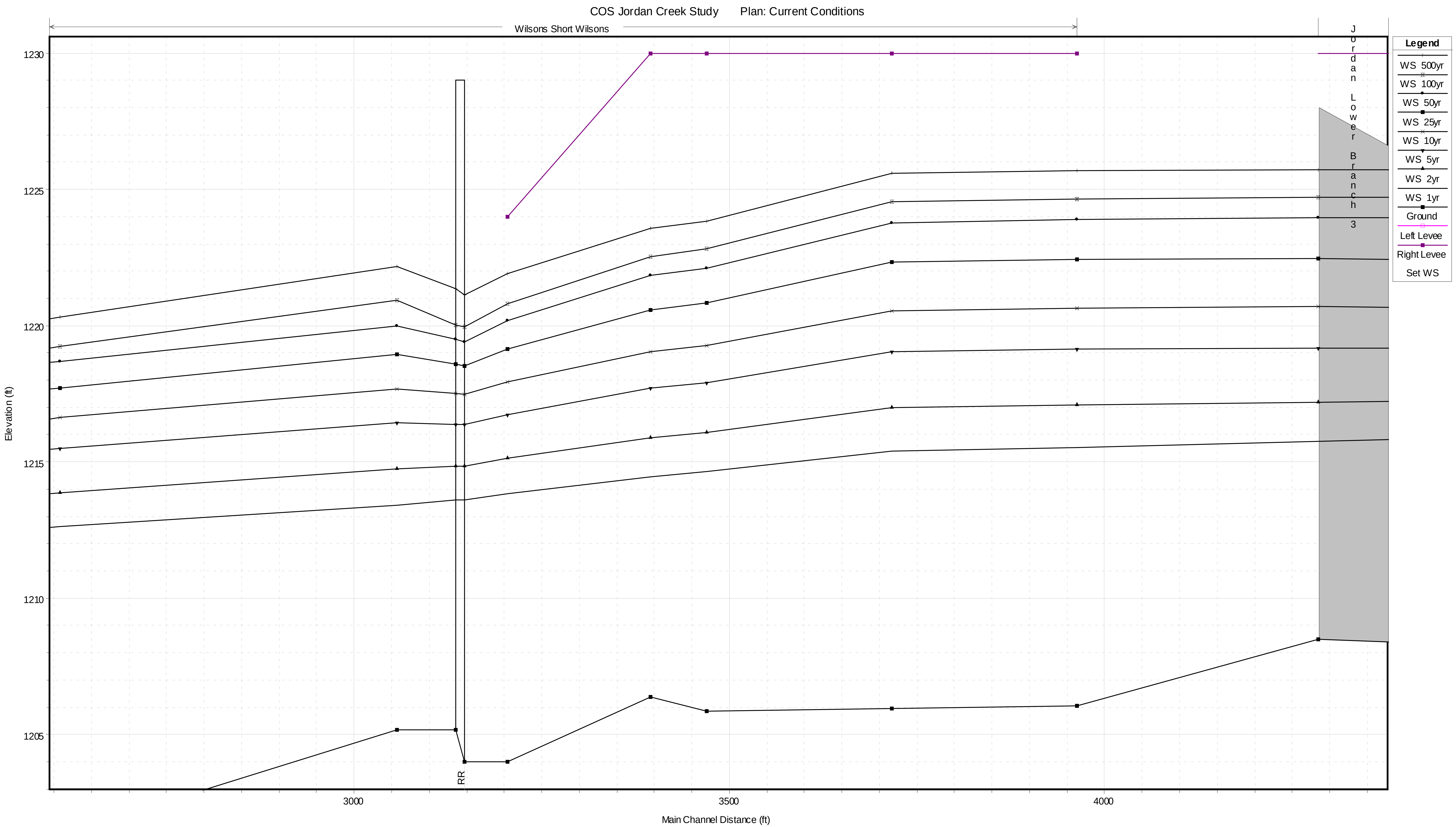
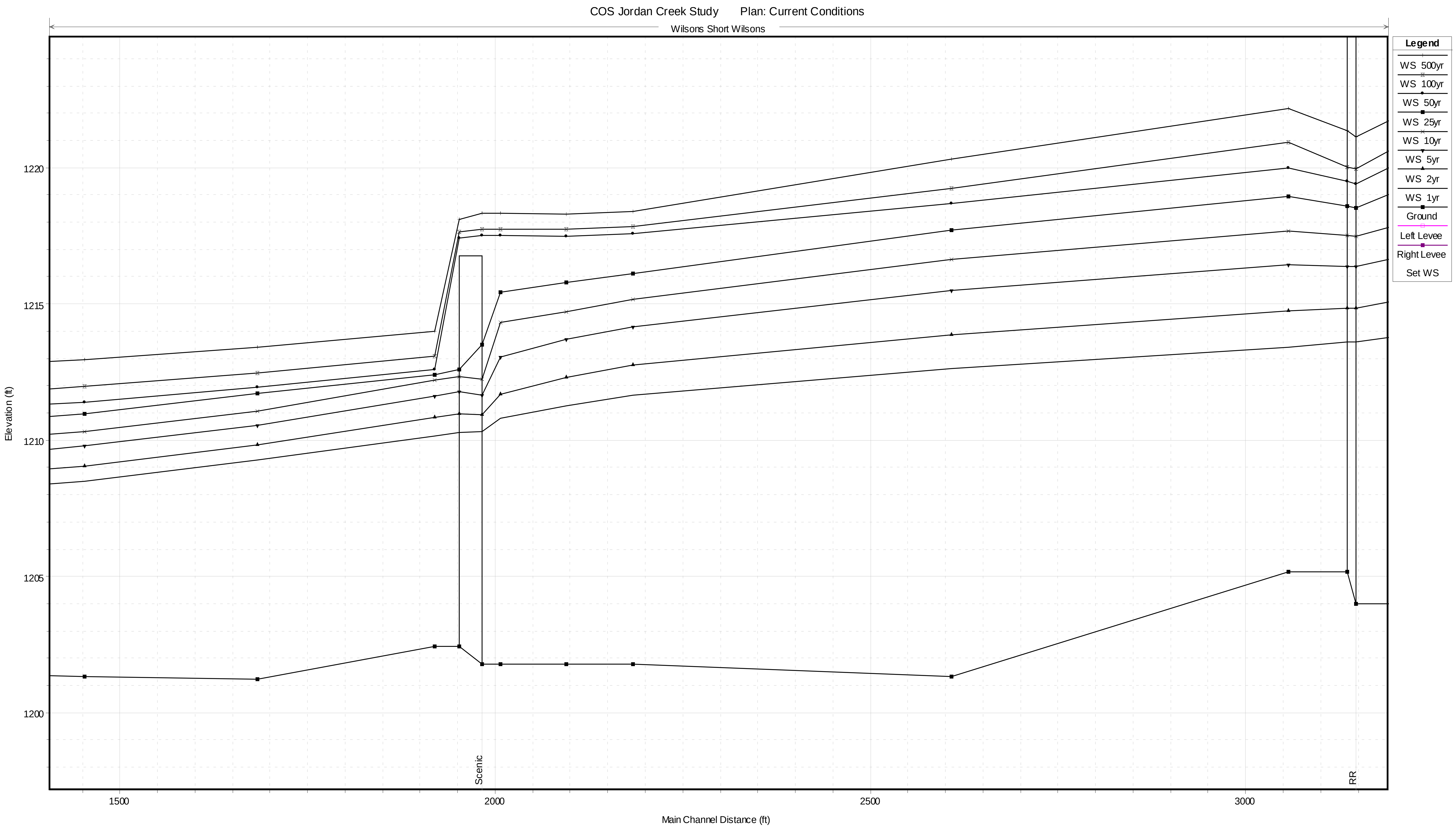


Plate Series C – Without Project Hydraulic Profiles



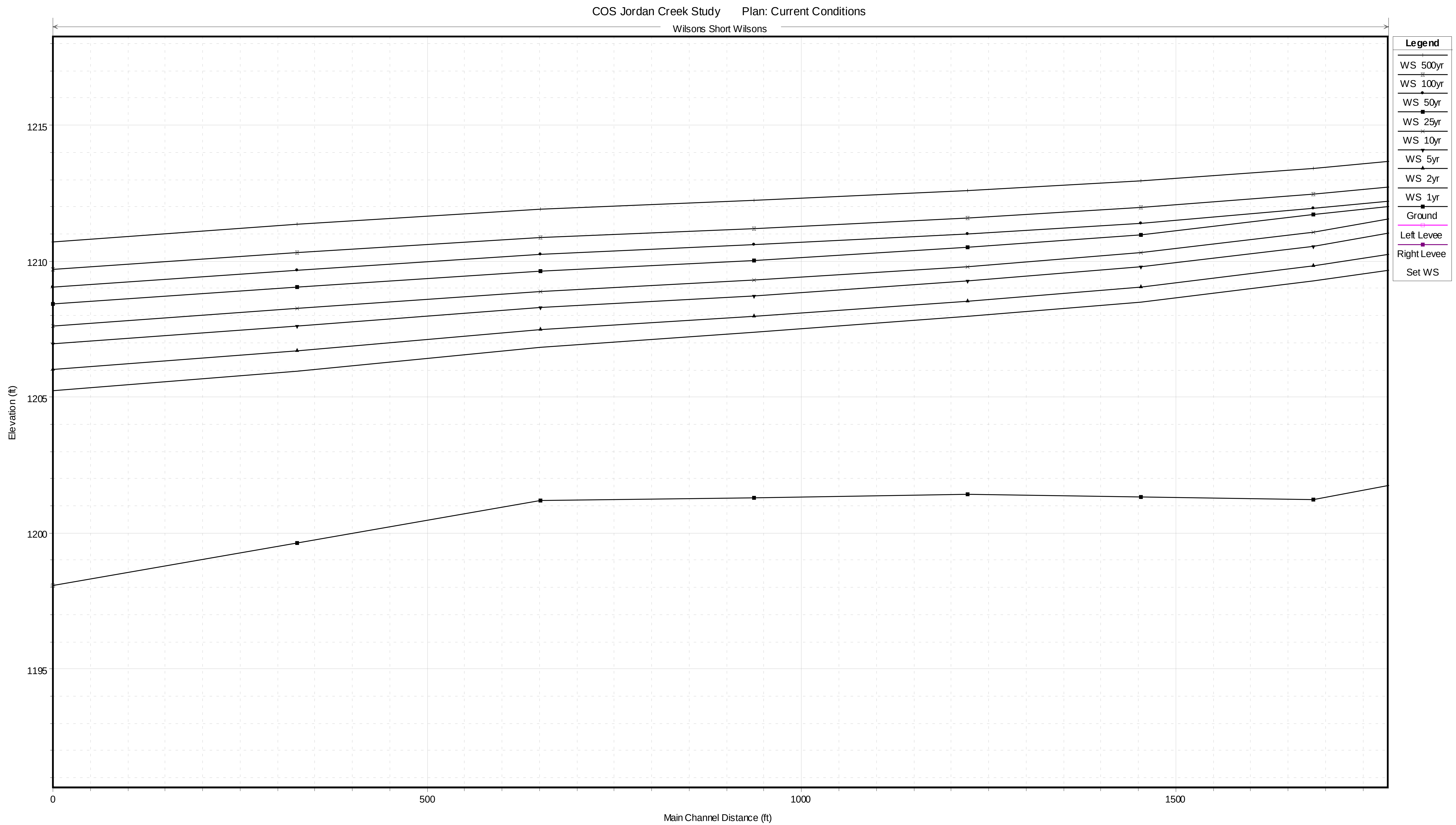

COS Jordan Creek Study Plan: Current Conditions
Wilsons Short Wilsons
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Left Levee
Right Levee
Set WS
Elevation (ft)
1215
1210
1205
1200
1195
0
500
1000
1500
Main Channel Distance (ft)

Plate Series D – Future Conditions Without Project Hydraulic Profiles

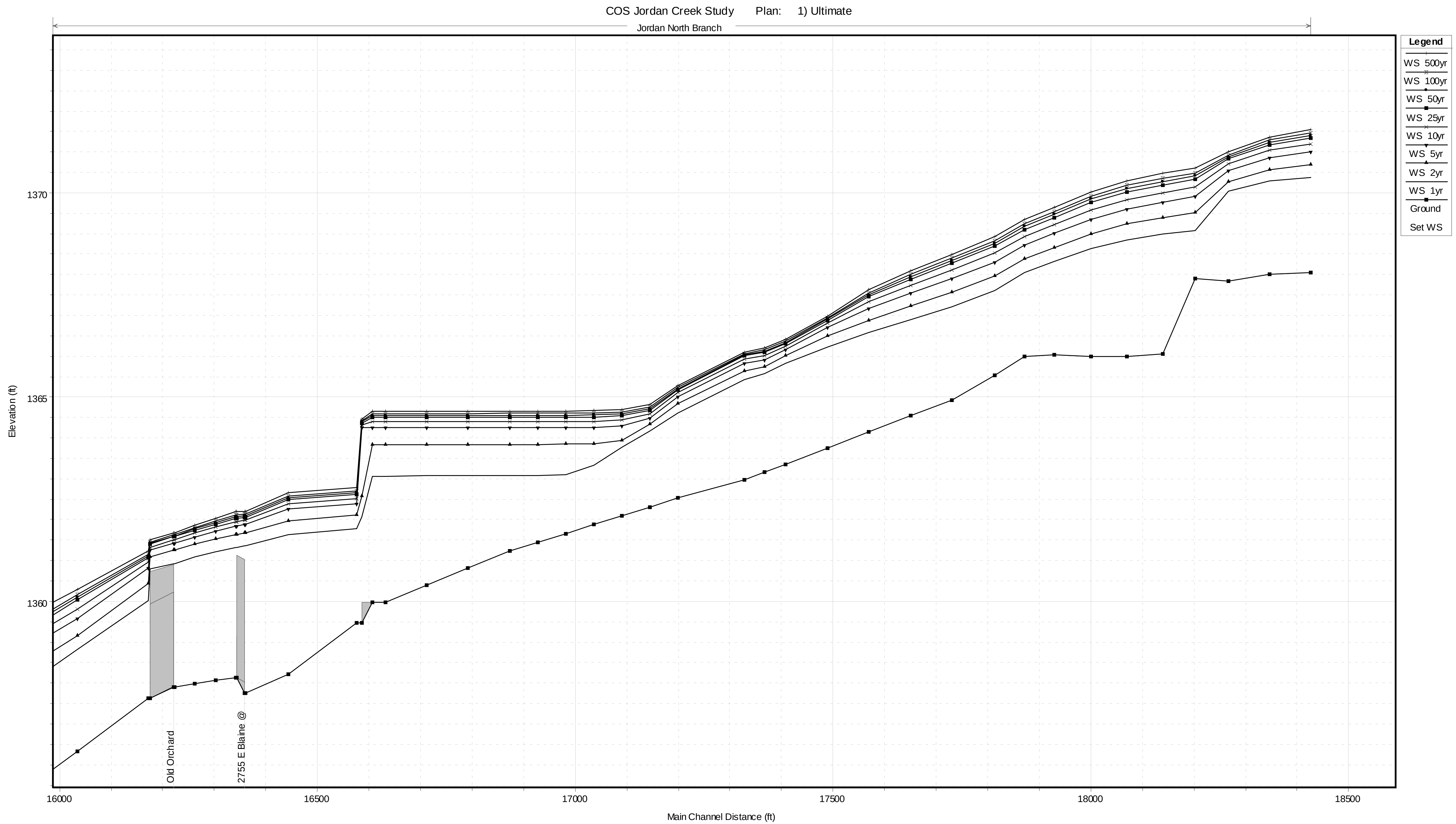


Plate Series D – Future Conditions Without Project Hydraulic Profiles

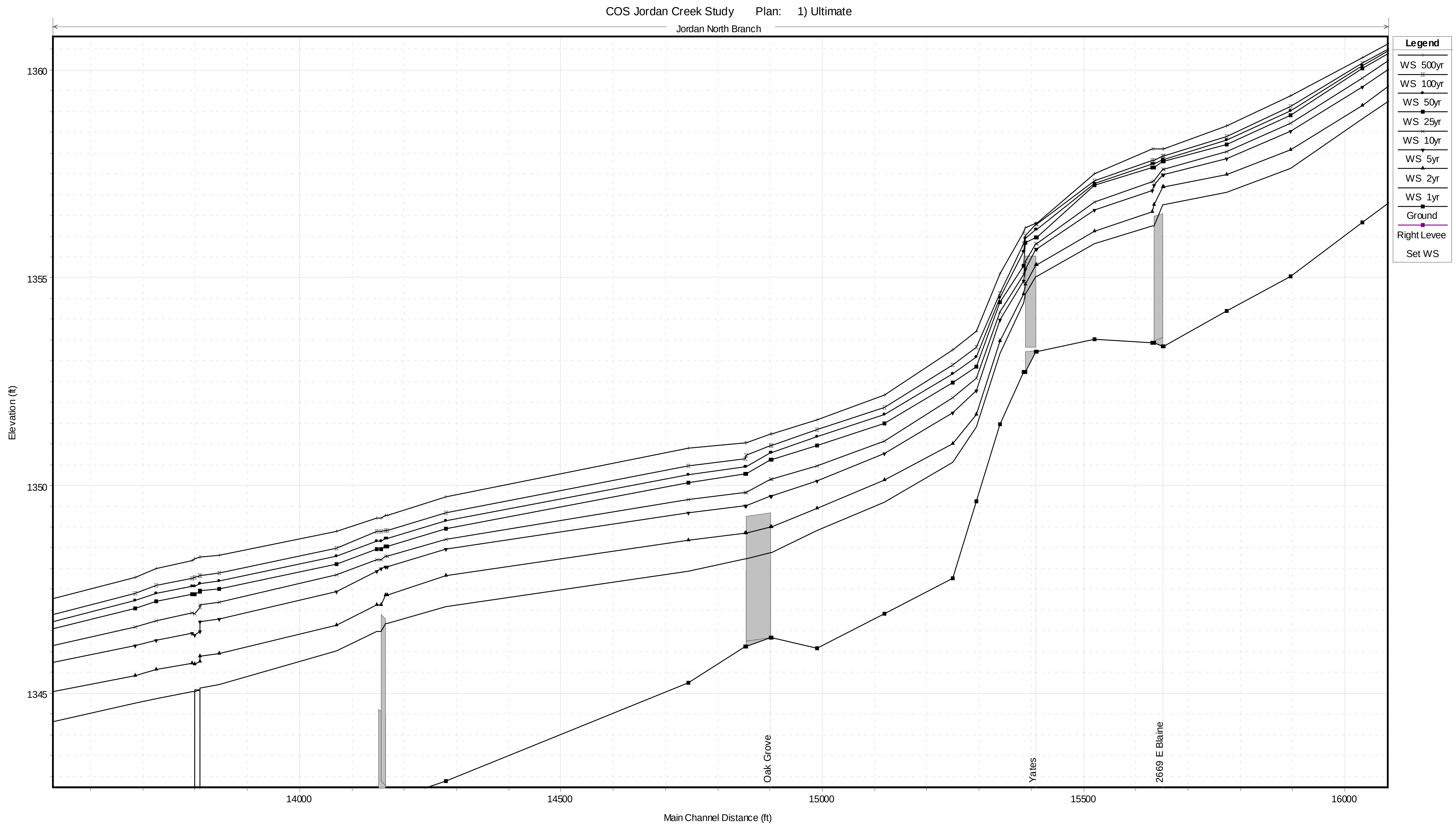


Plate Series D – Future Conditions Without Project Hydraulic Profiles

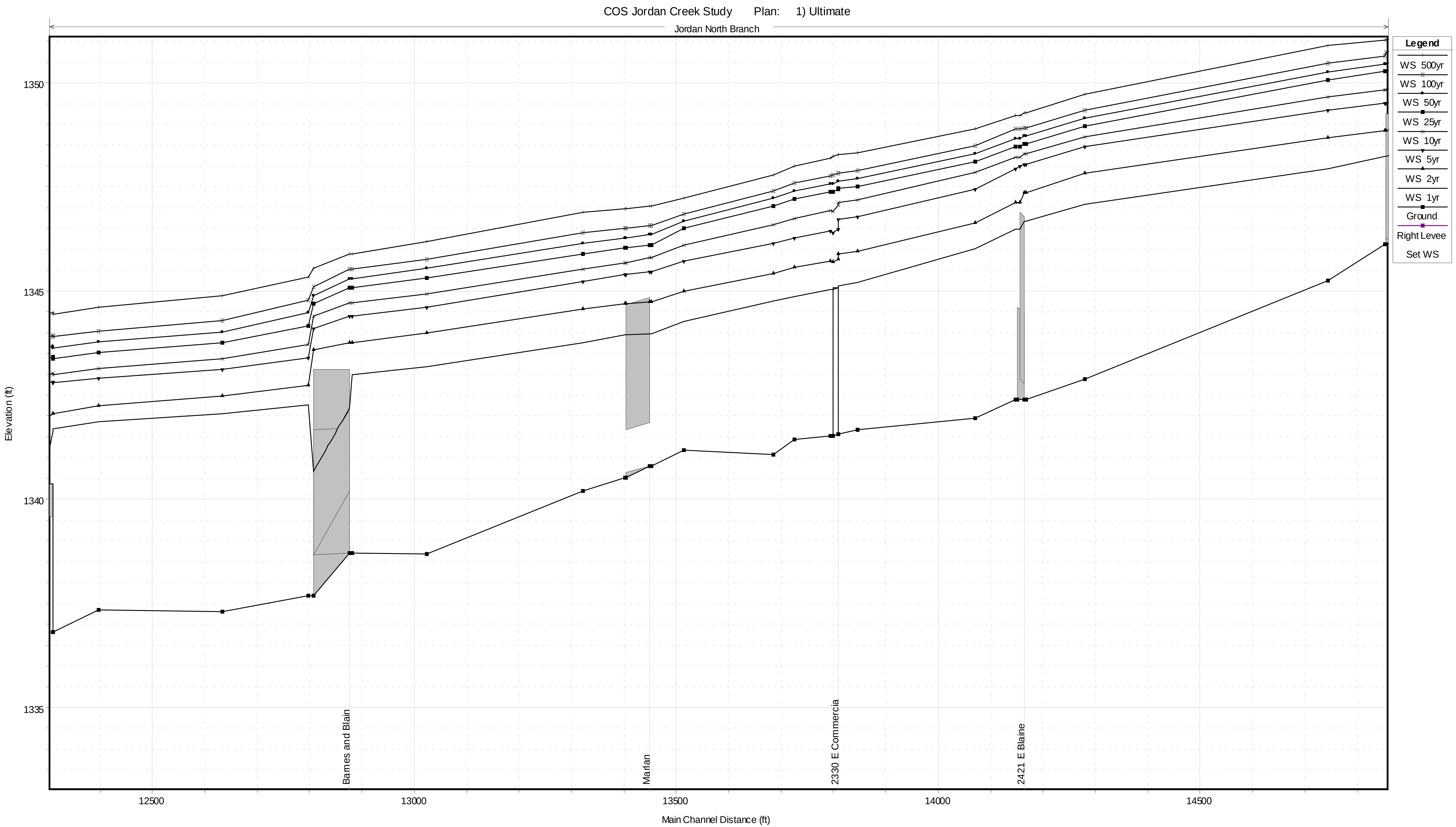


Plate Series D – Future Conditions Without Project Hydraulic Profiles

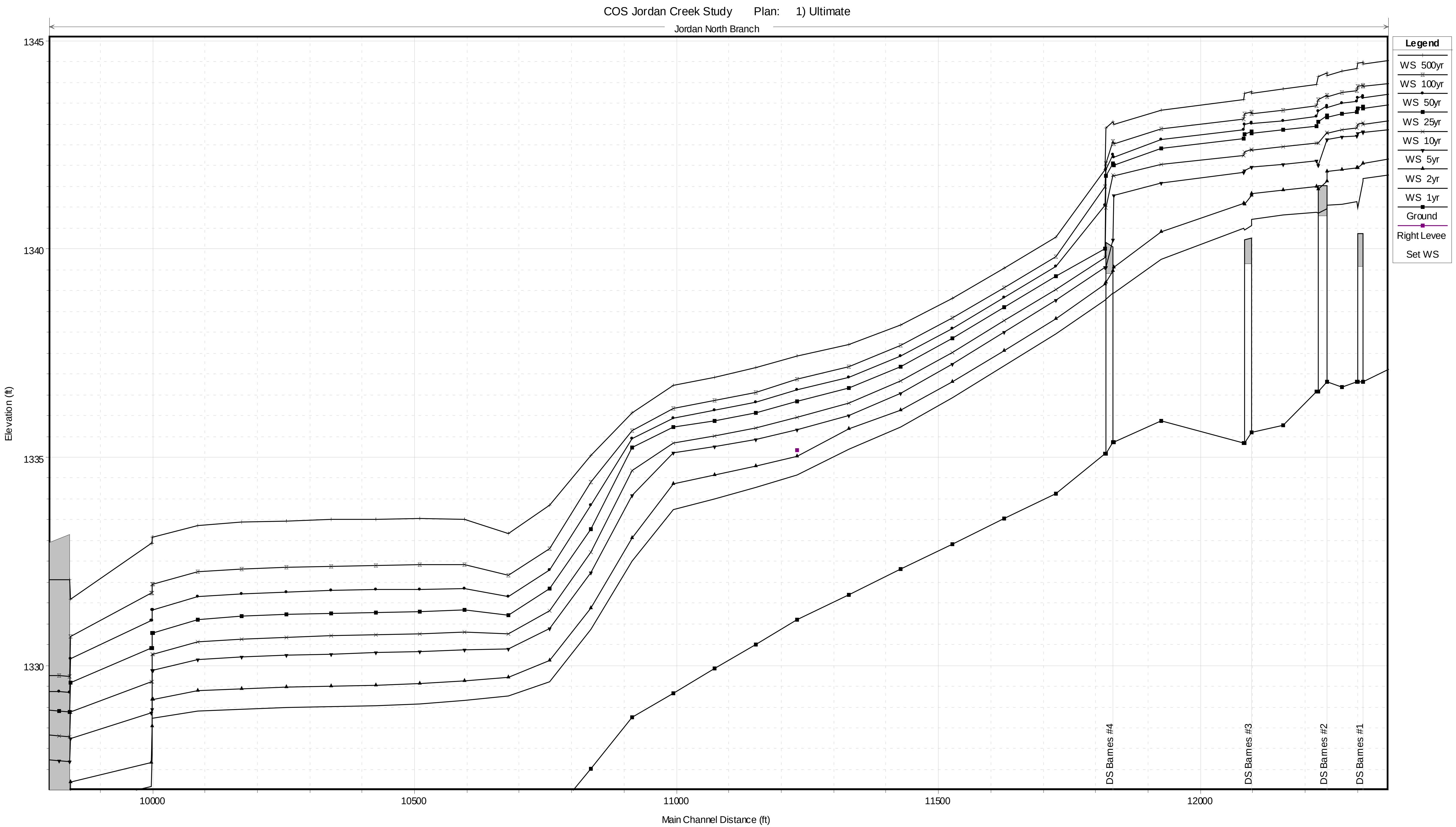


Plate Series D – Future Conditions Without Project Hydraulic Profiles

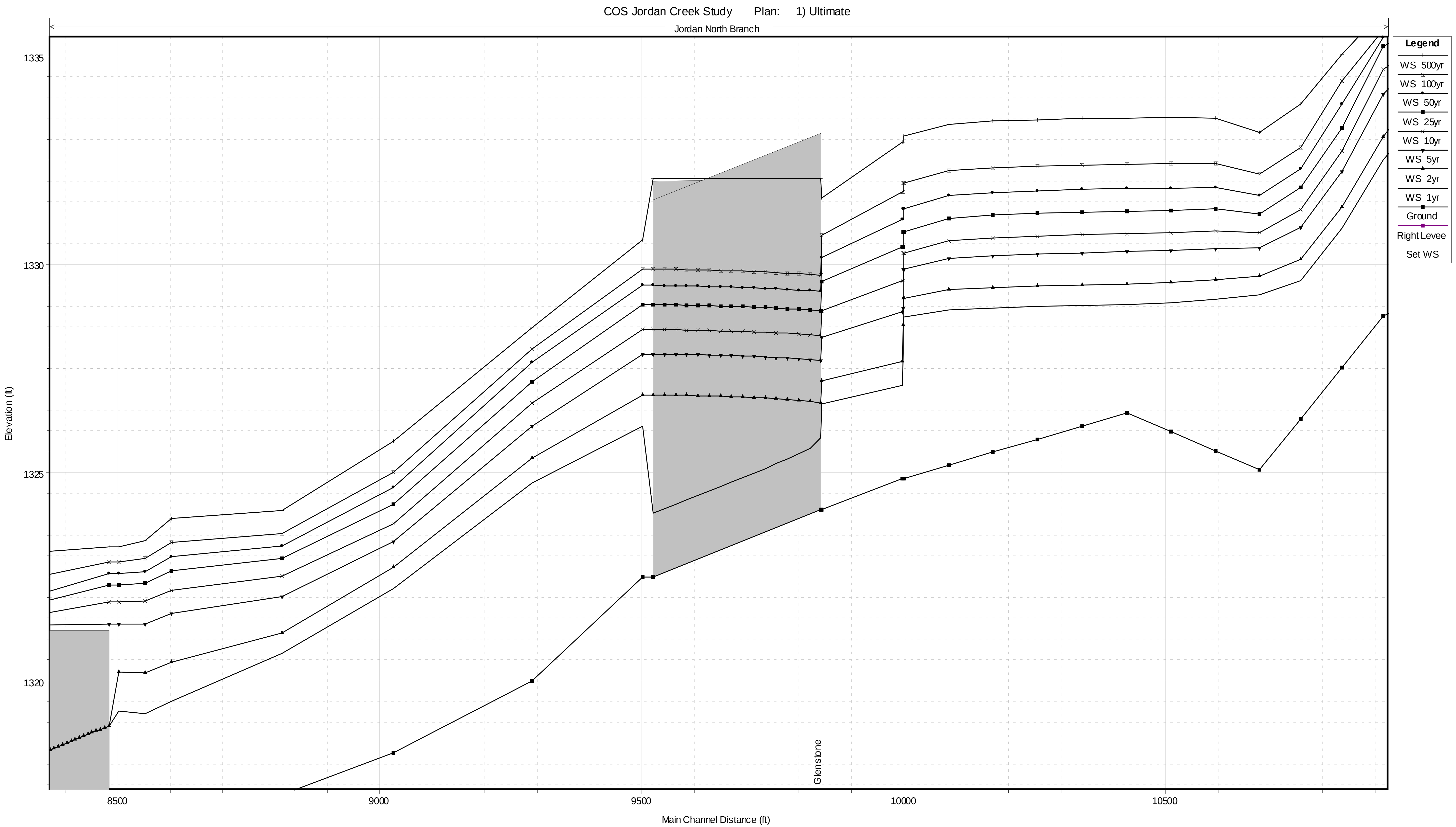
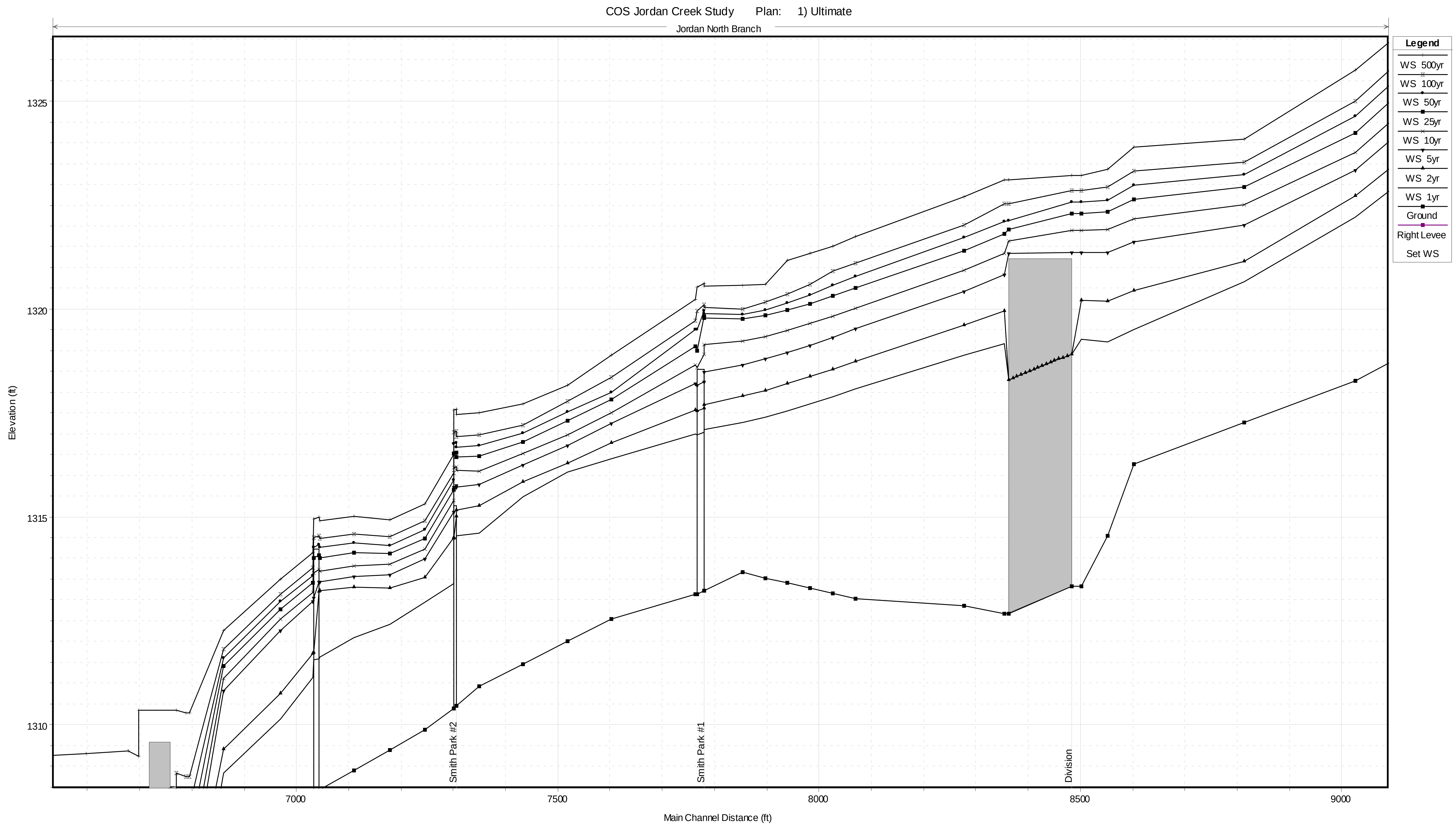


Plate Series D – Future Conditions Without Project Hydraulic Profiles



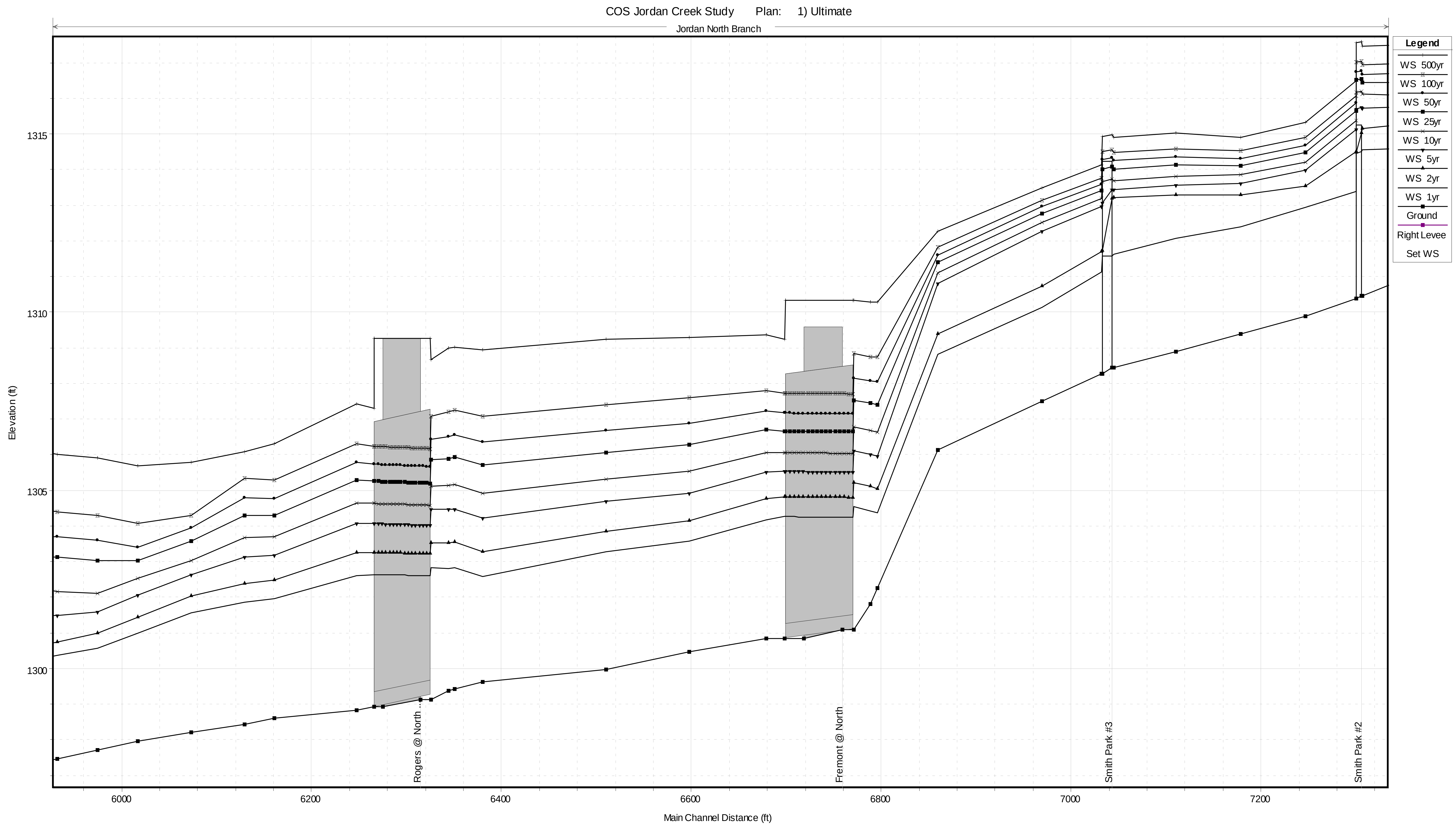

COS Jordan Creek Study Plan: 1) Ultimate
Jordan North Branch
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Right Levee
Set WS
Elevation (ft)
1315
1310
1305
1300
Rogers @ North ...
Fremont @ North
Smith Park #3
Smith Park #2
6000
6200
6400
6600
6800
7000
7200
Main Channel Distance (ft)

Plate Series D – Future Conditions Without Project Hydraulic Profiles

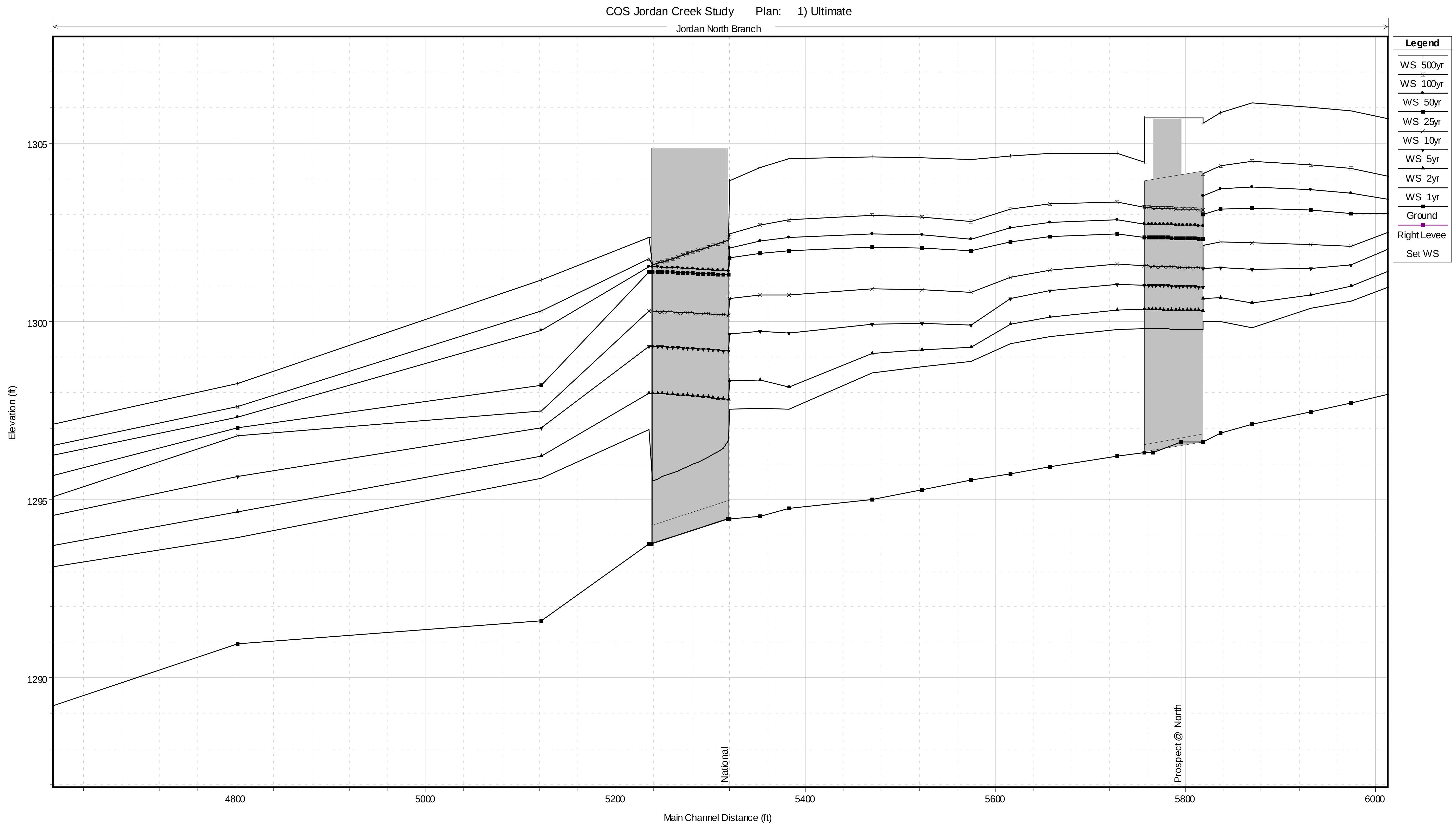


Plate Series D – Future Conditions Without Project Hydraulic Profiles

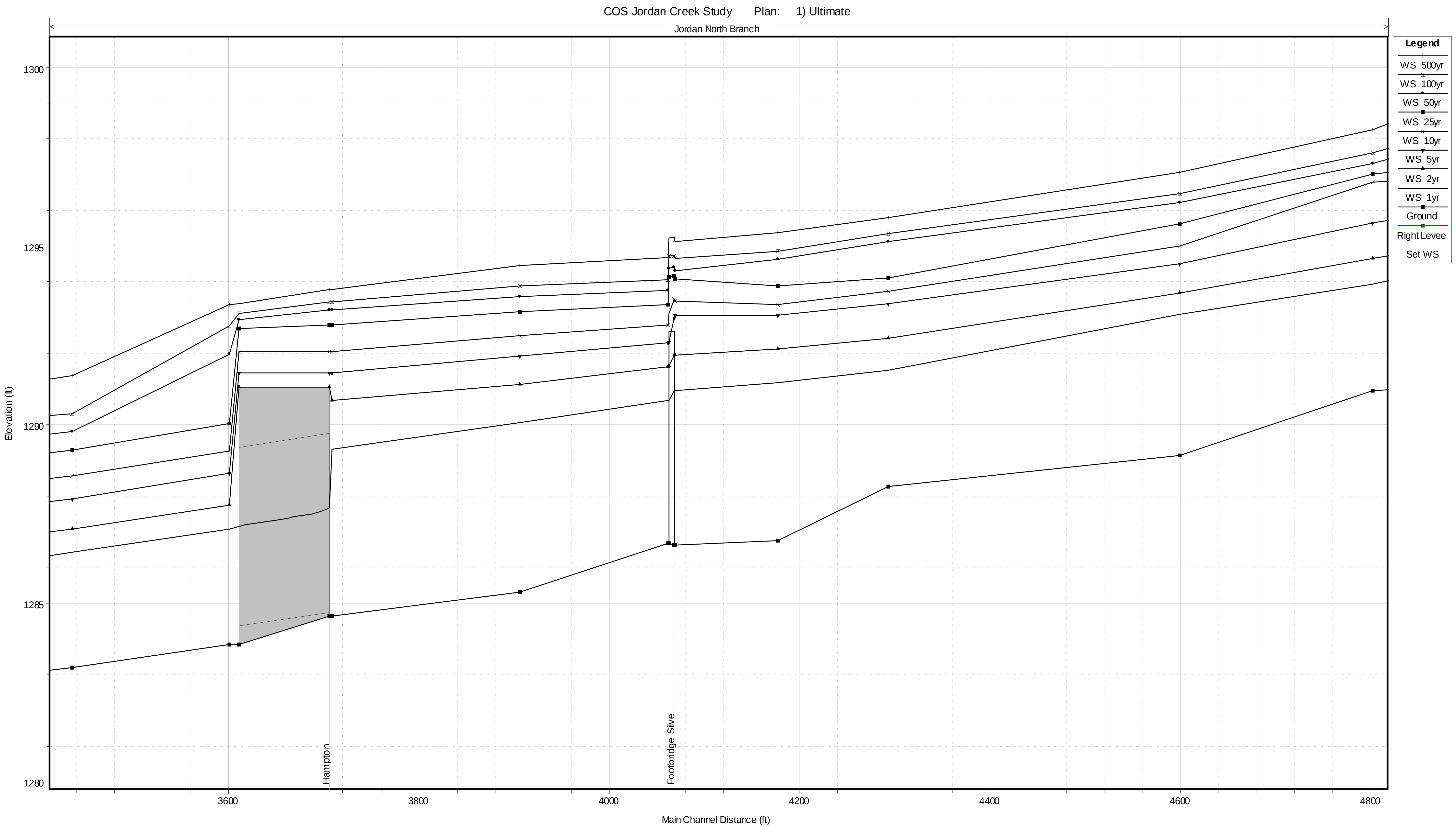


Plate Series D – Future Conditions Without Project Hydraulic Profiles

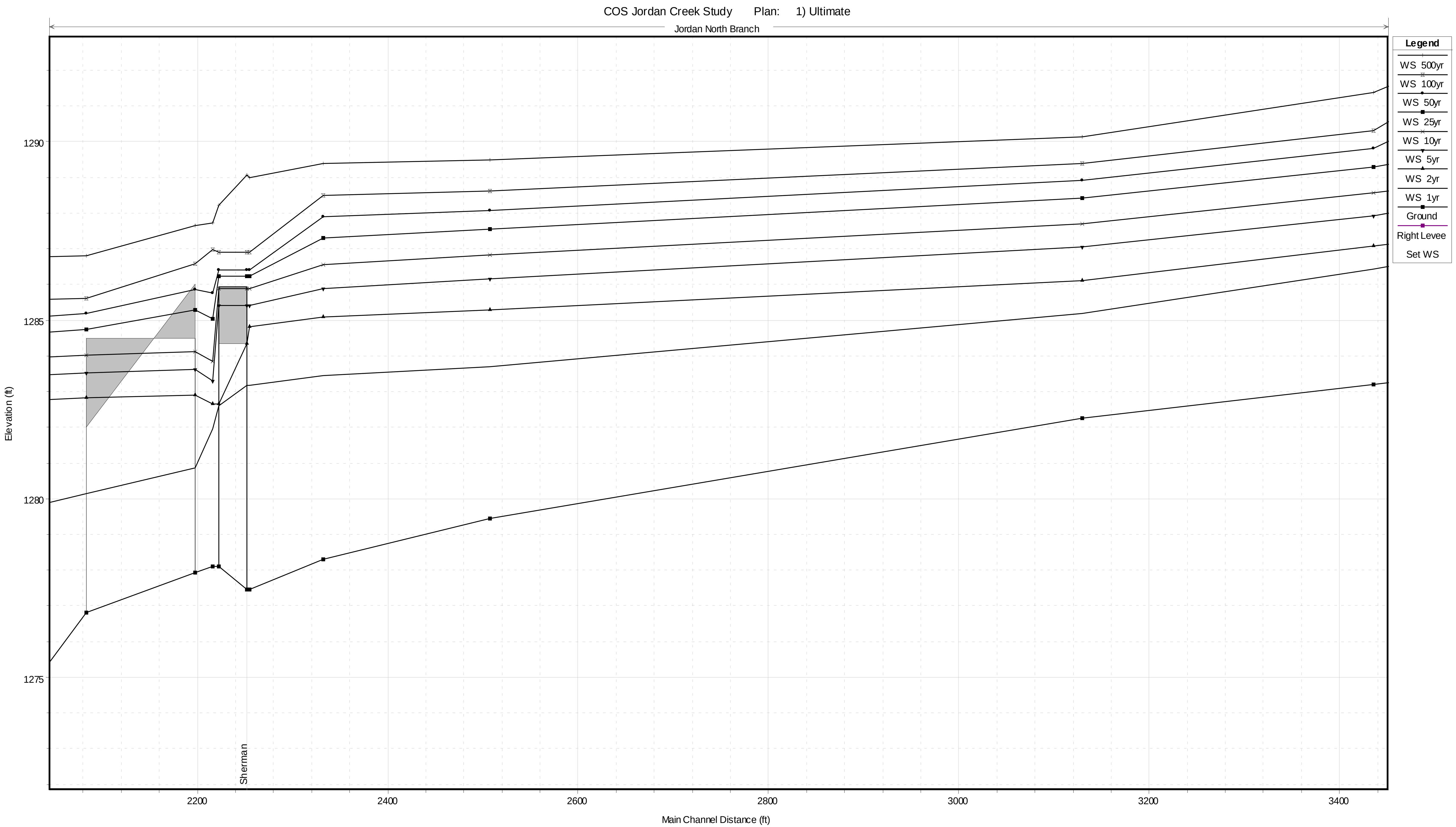


Plate Series D – Future Conditions Without Project Hydraulic Profiles

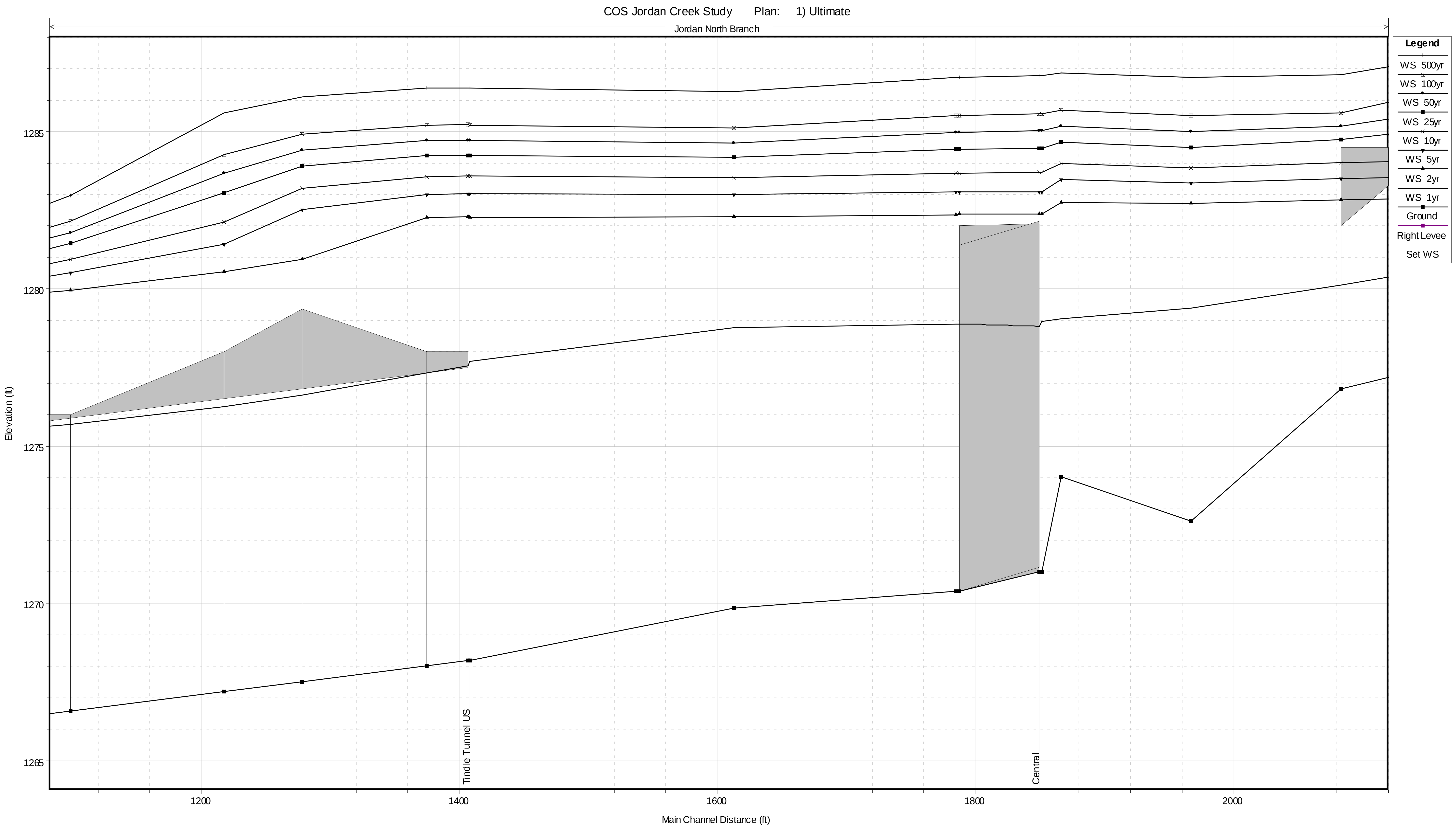


Plate Series D – Future Conditions Without Project Hydraulic Profiles

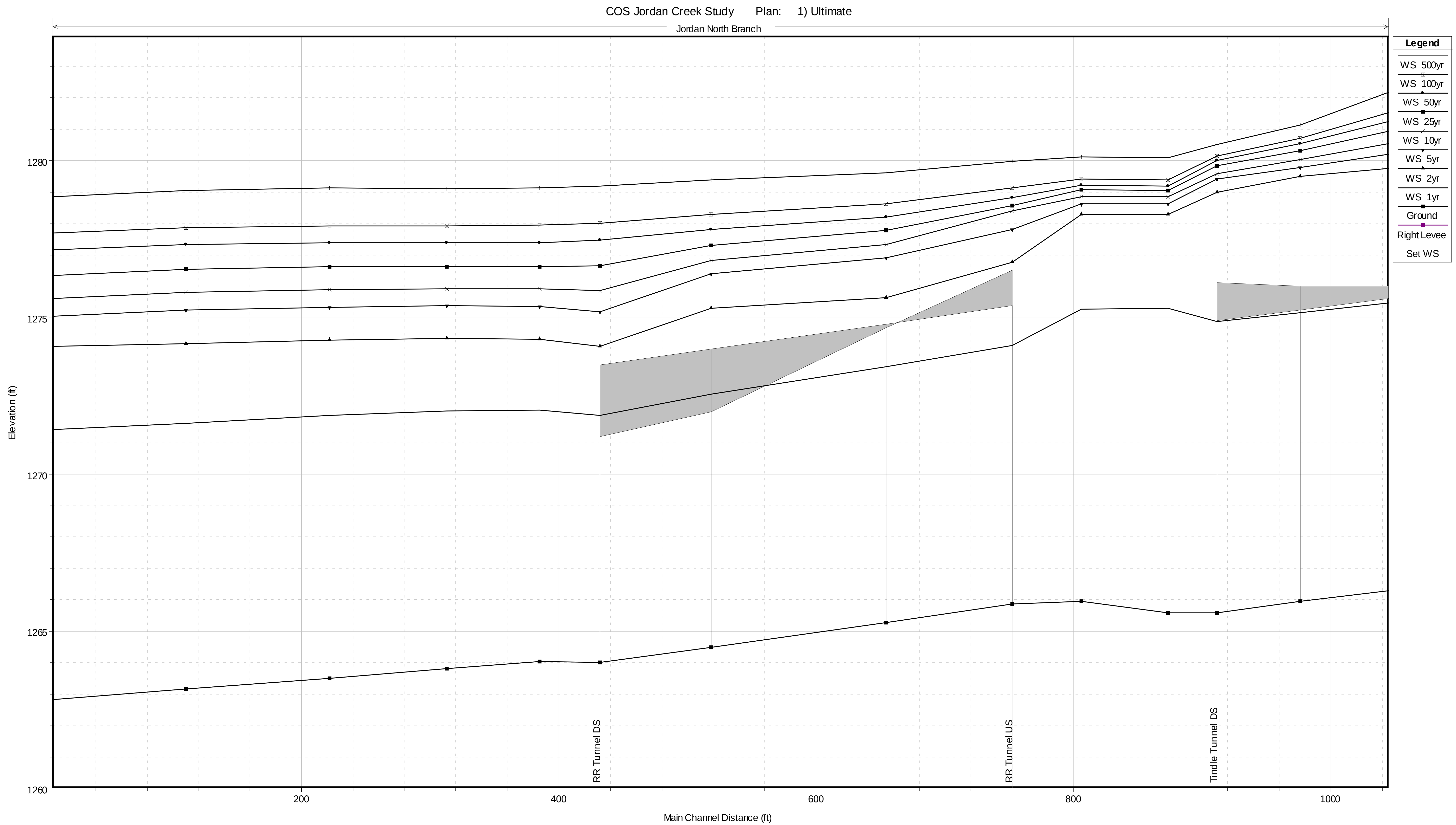


Plate Series D – Future Conditions Without Project Hydraulic Profiles

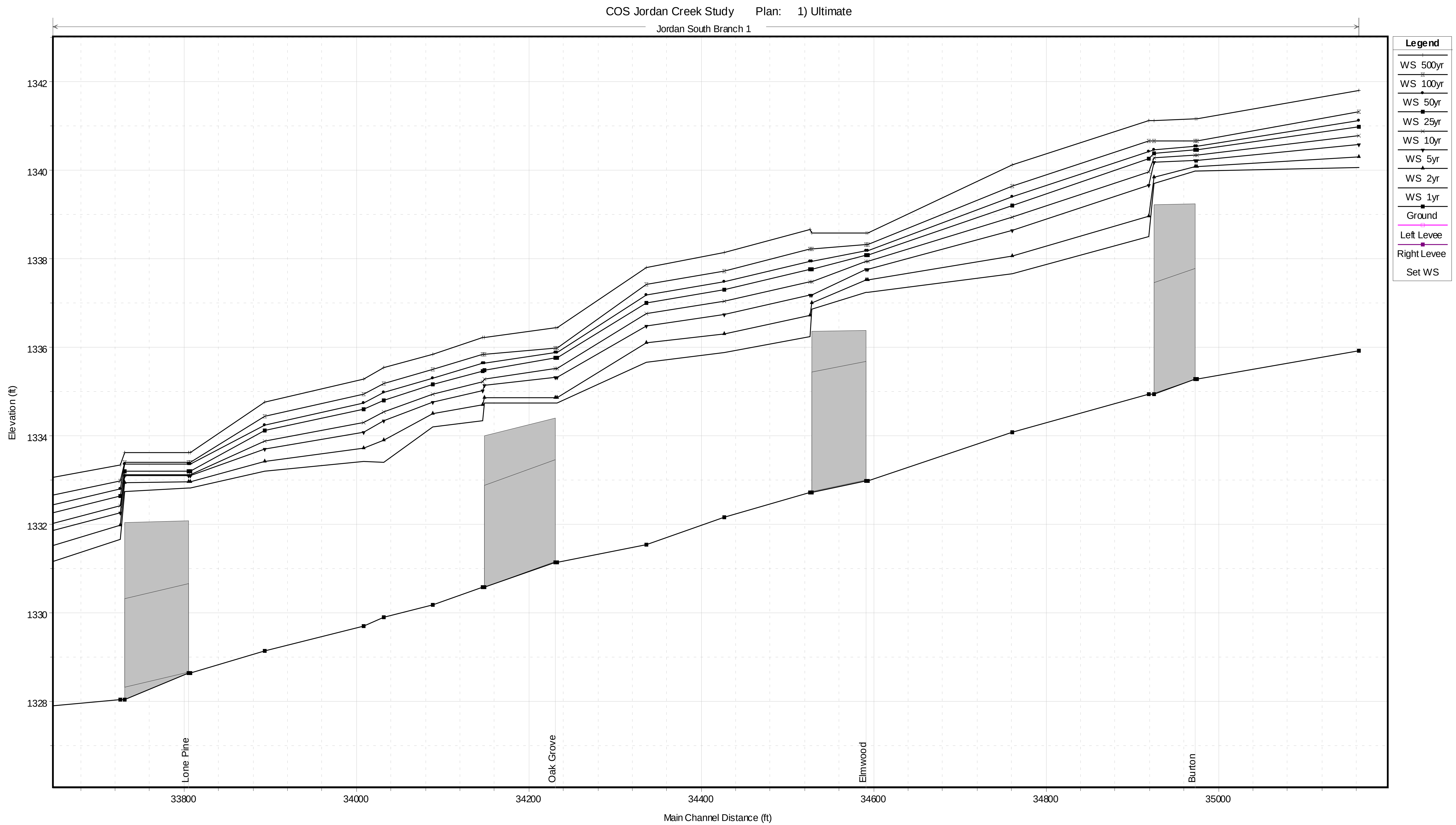


Plate Series D – Future Conditions Without Project Hydraulic Profiles

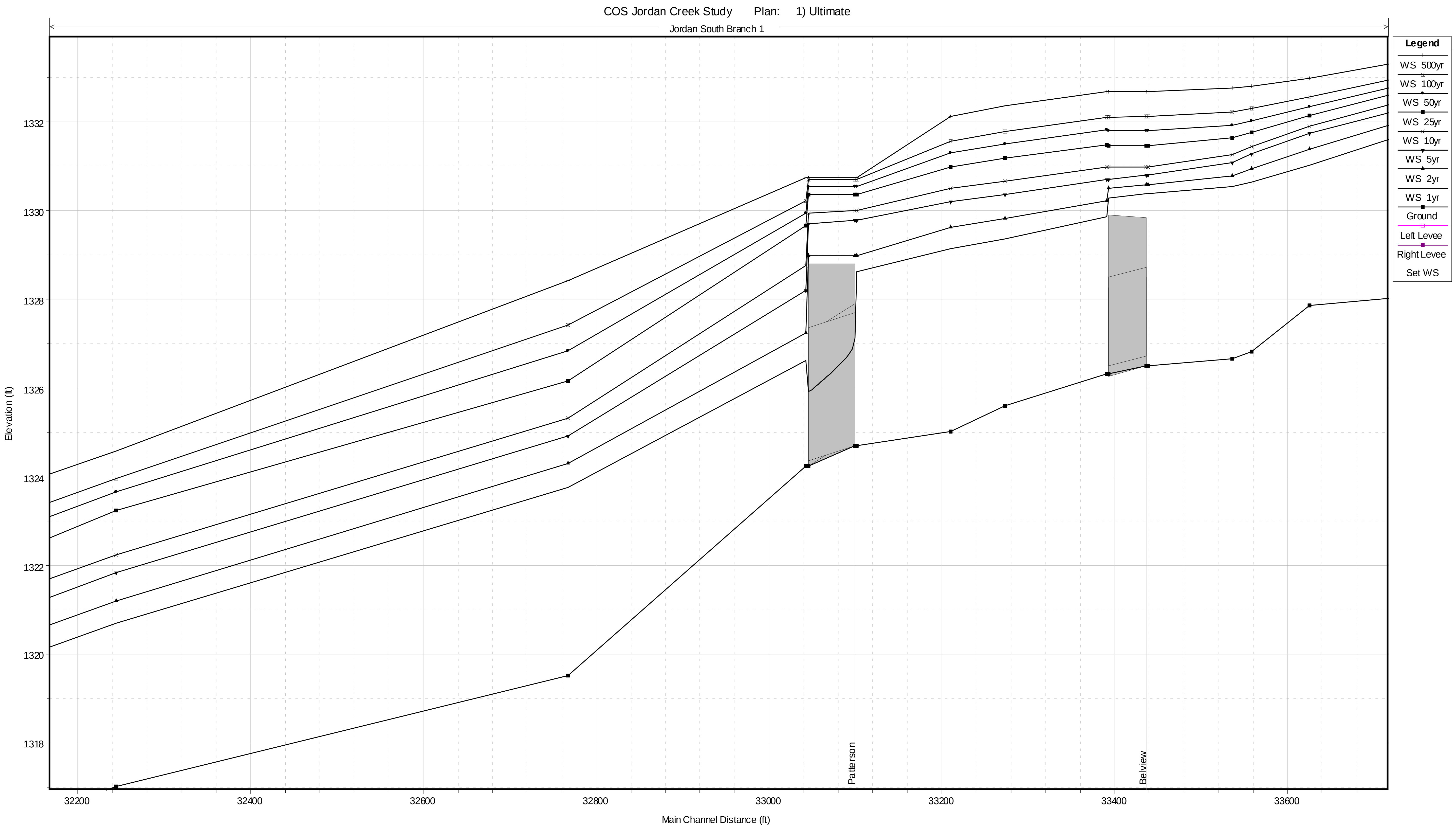


Plate Series D – Future Conditions Without Project Hydraulic Profiles

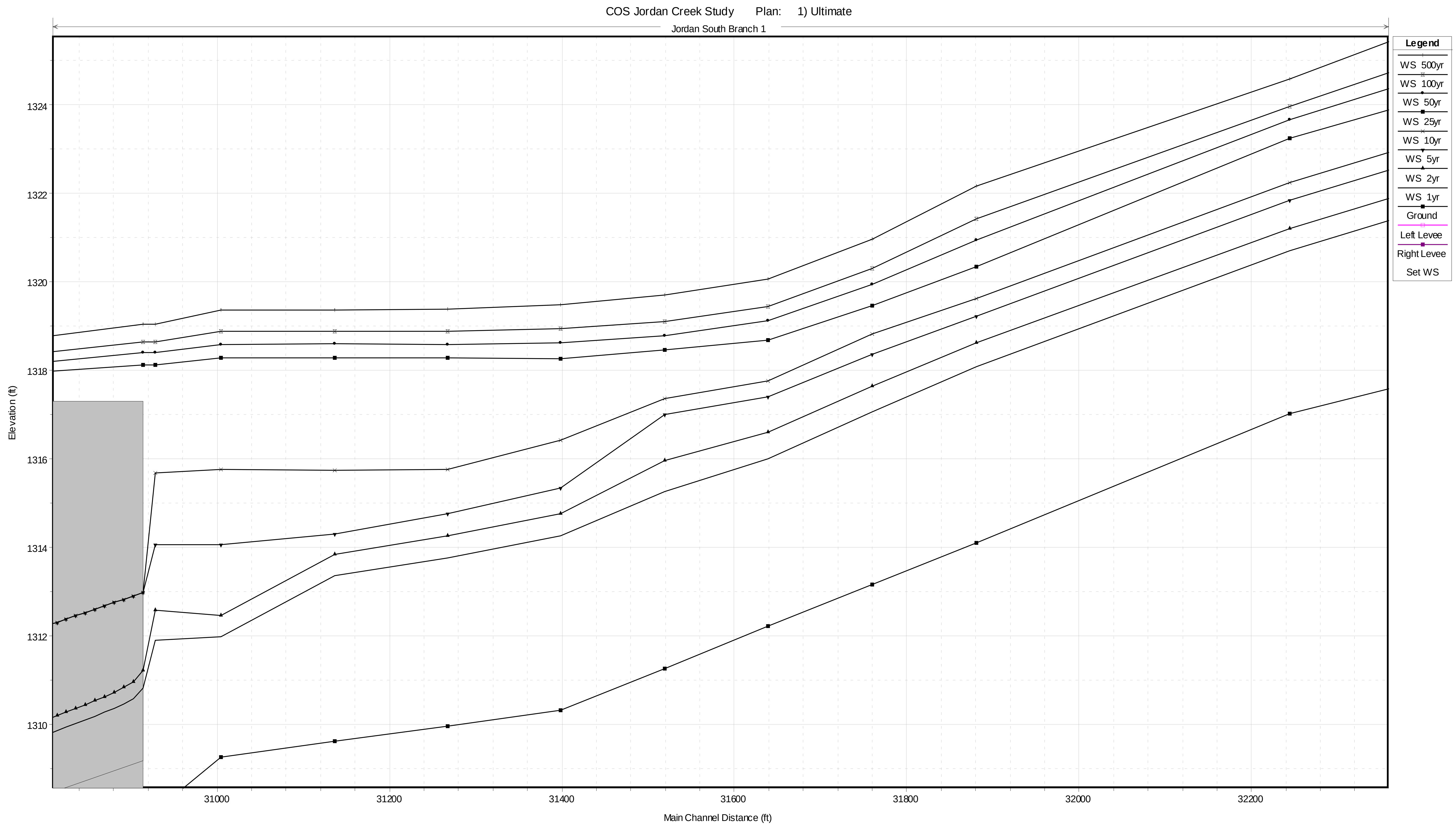


Plate Series D – Future Conditions Without Project Hydraulic Profiles

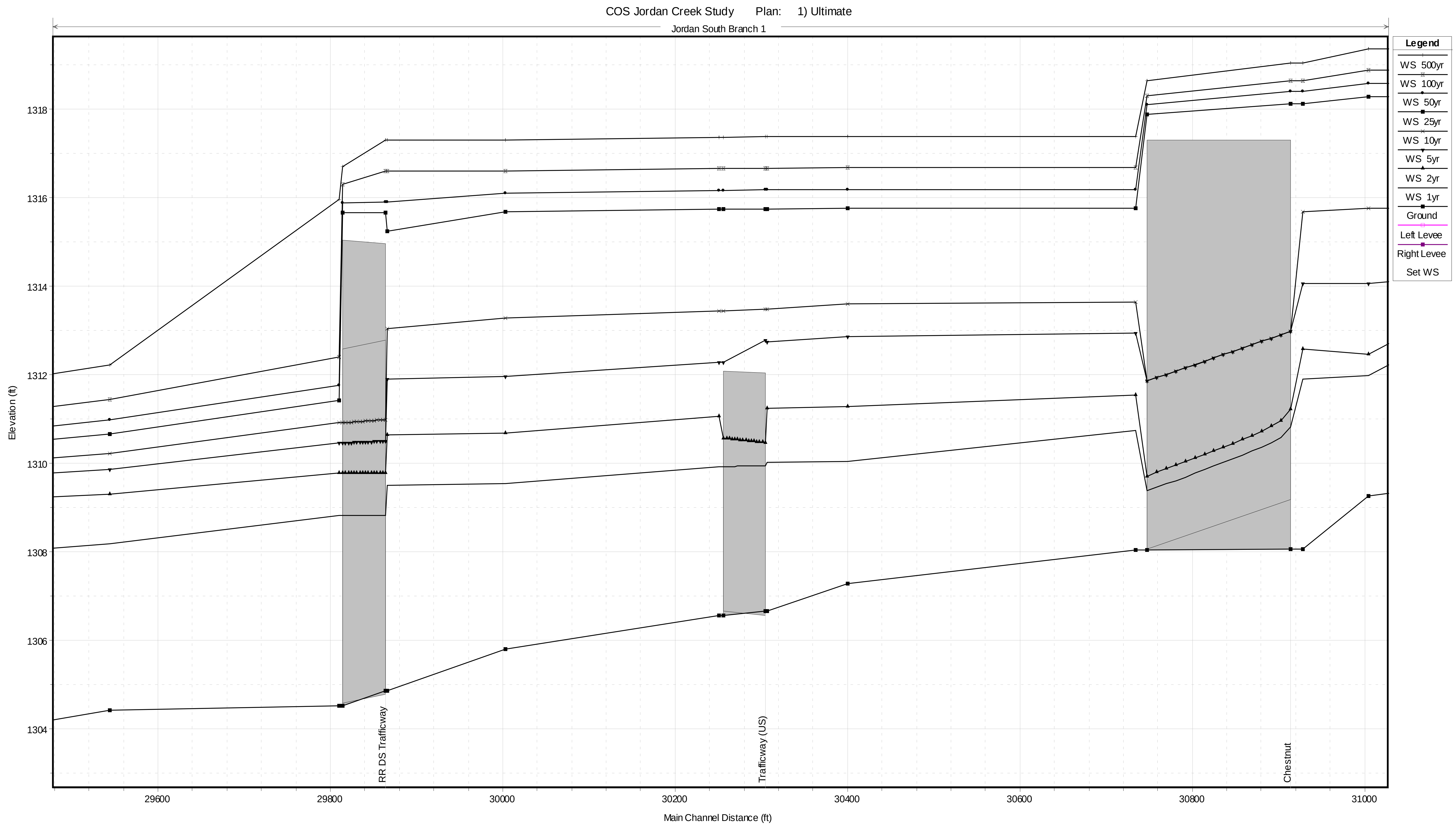
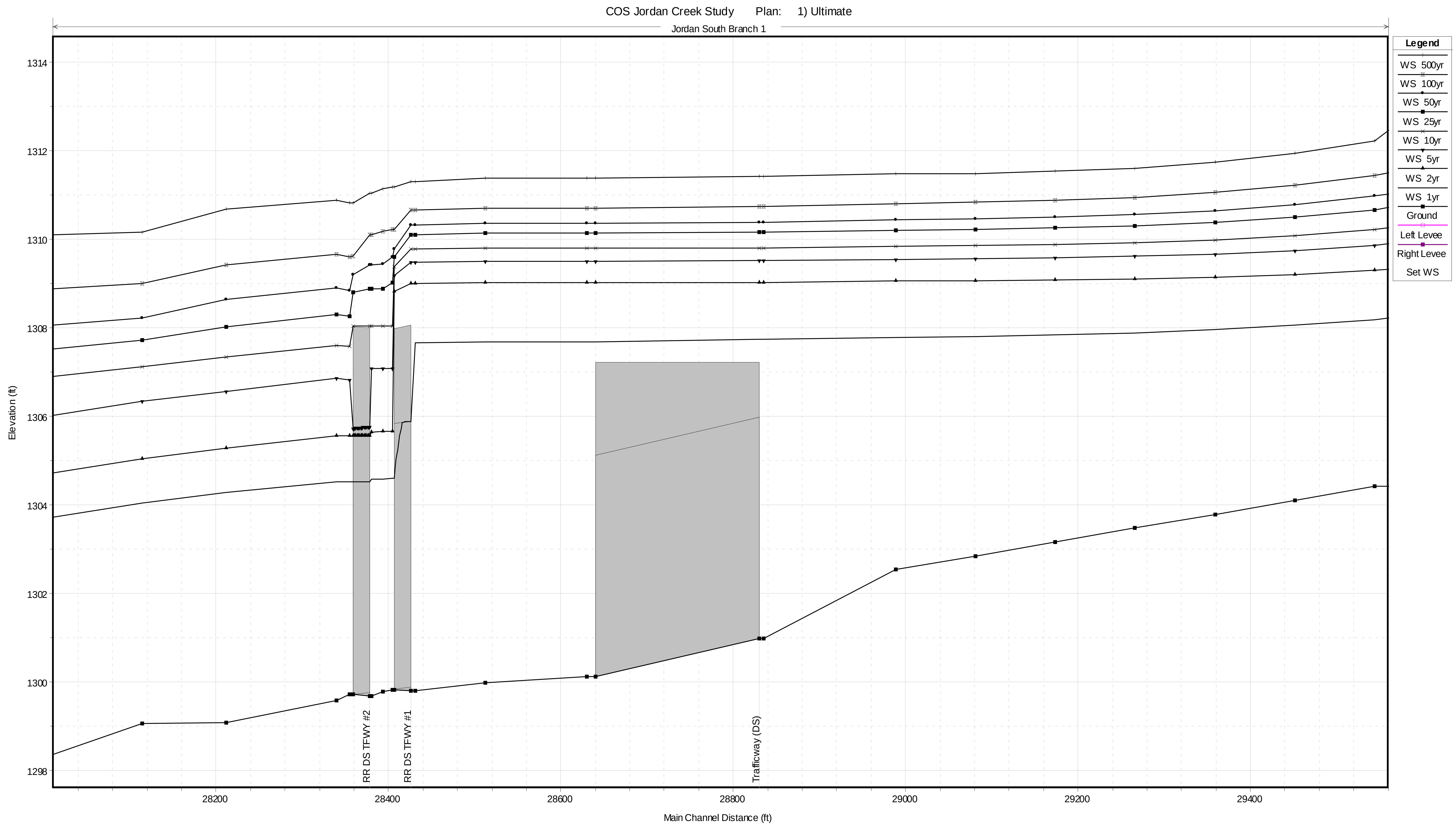
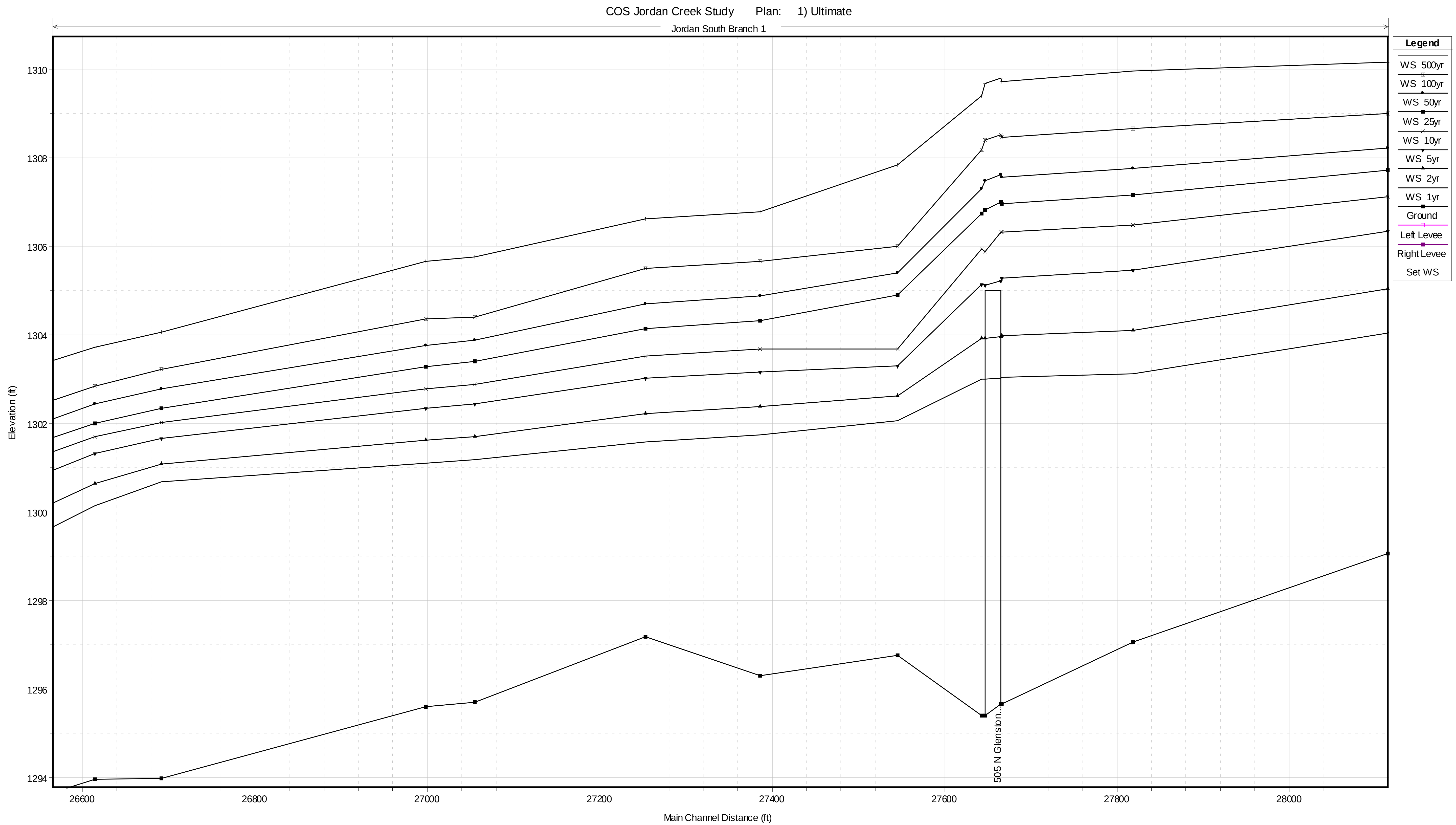
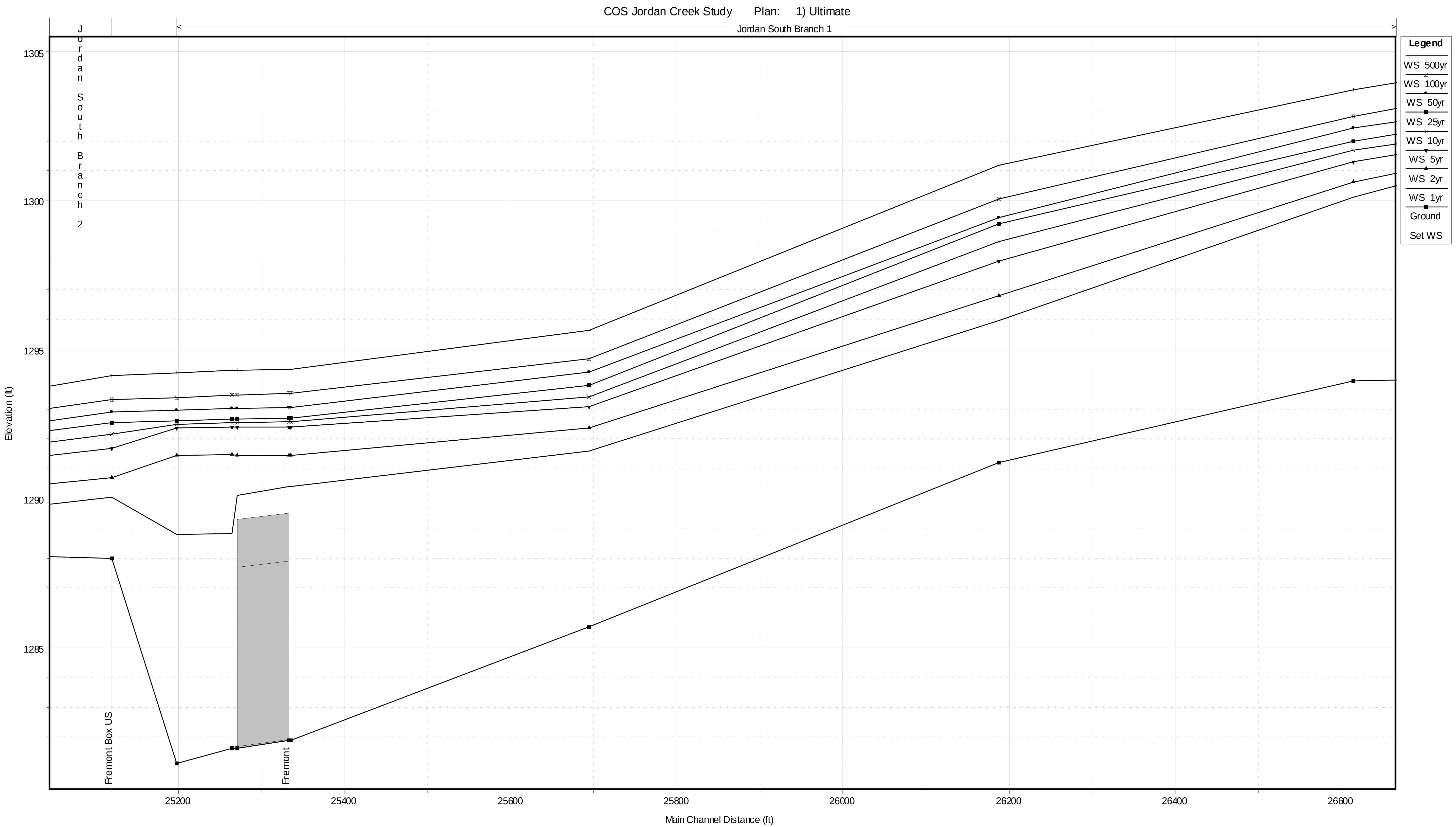


Plate Series D – Future Conditions Without Project Hydraulic Profiles





COS Jordan Creek Study Plan: 1) Ultimate
Jordan South Branch 1
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Left Levee
Right Levee
Set WS
Elevation (ft)
1310
1308
1306
1304
1302
1300
1298
1296
1294
505 N Glenston...
26600
26800
27000
27200
27400
27600
27800
28000
Main Channel Distance (ft)


COS Jordan Creek Study Plan: 1) Ultimate
Jordan South Branch 1
Jordan South Branch 2
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
Elevation (ft)
1305
1300
1295
1290
1285
Fremont Box US
Fremont
25200
25400
25600
25800
26000
26200
26400
26600
Main Channel Distance (ft)

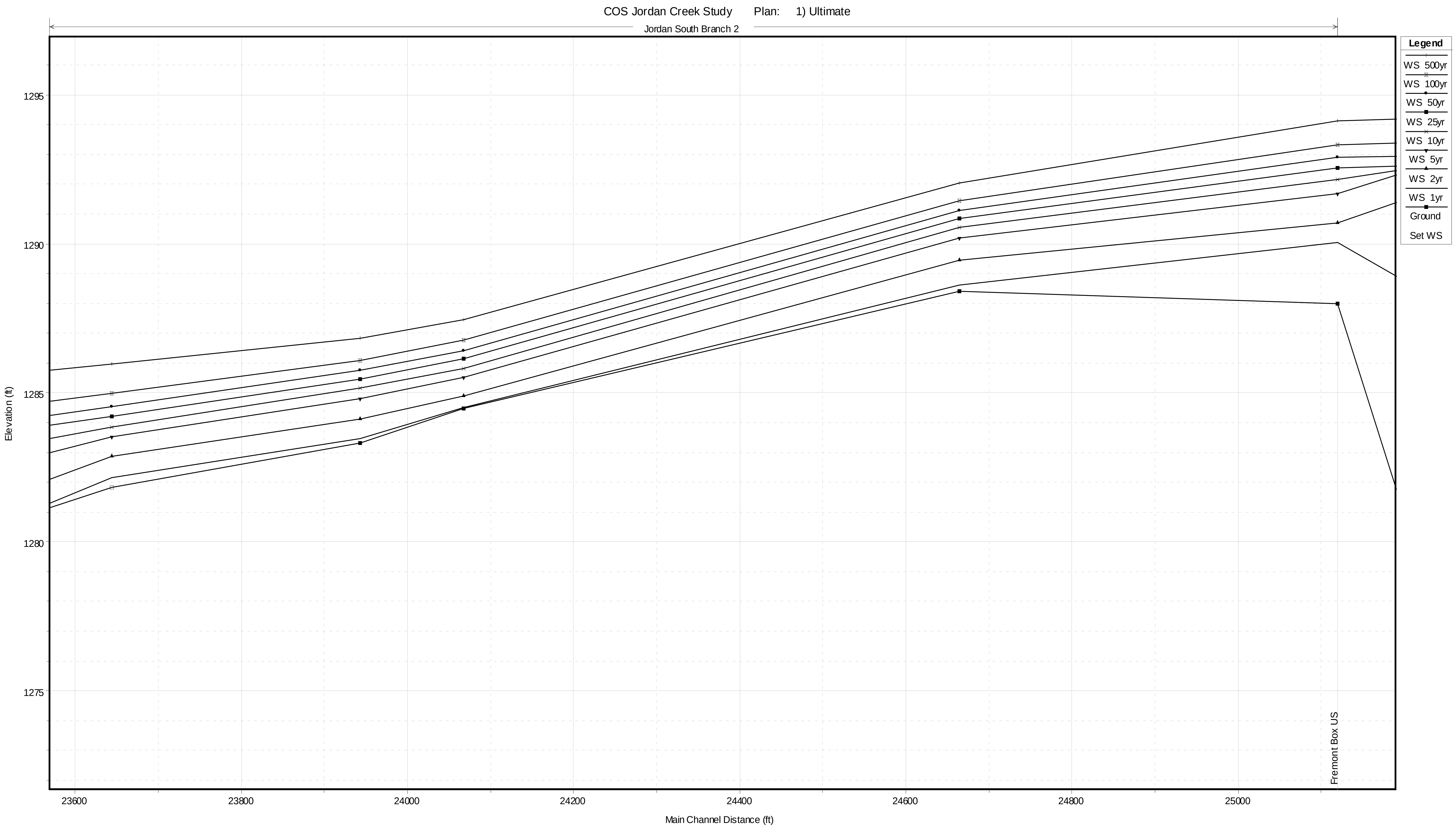
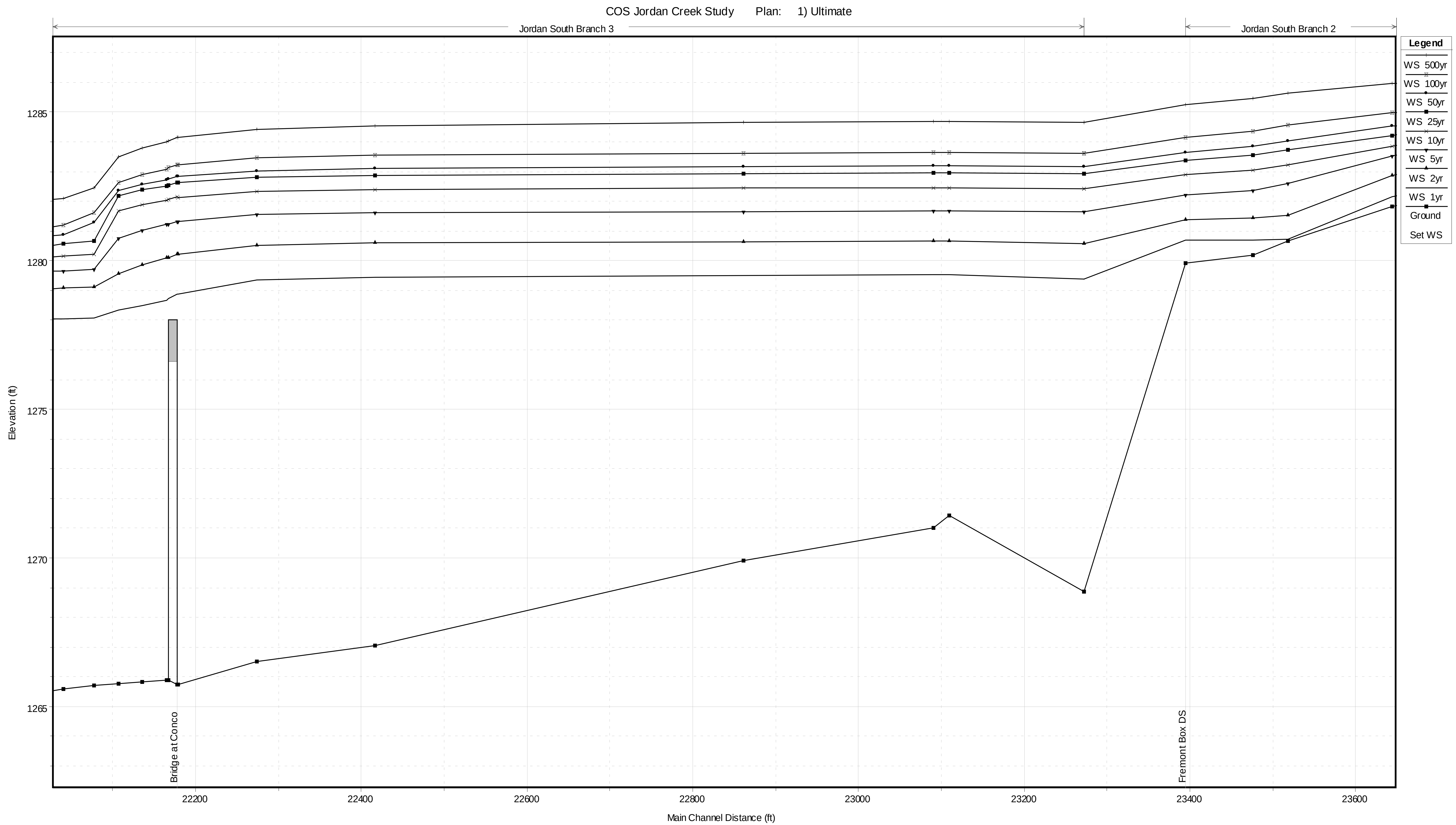

COS Jordan Creek Study Plan: 1) Ultimate
Jordan South Branch 2
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
Elevation (ft)
1295
1290
1285
1280
1275
Fremont Box US
23600
23800
24000
24200
24400
24600
24800
25000
Main Channel Distance (ft)

Plate Series D – Future Conditions Without Project Hydraulic Profiles



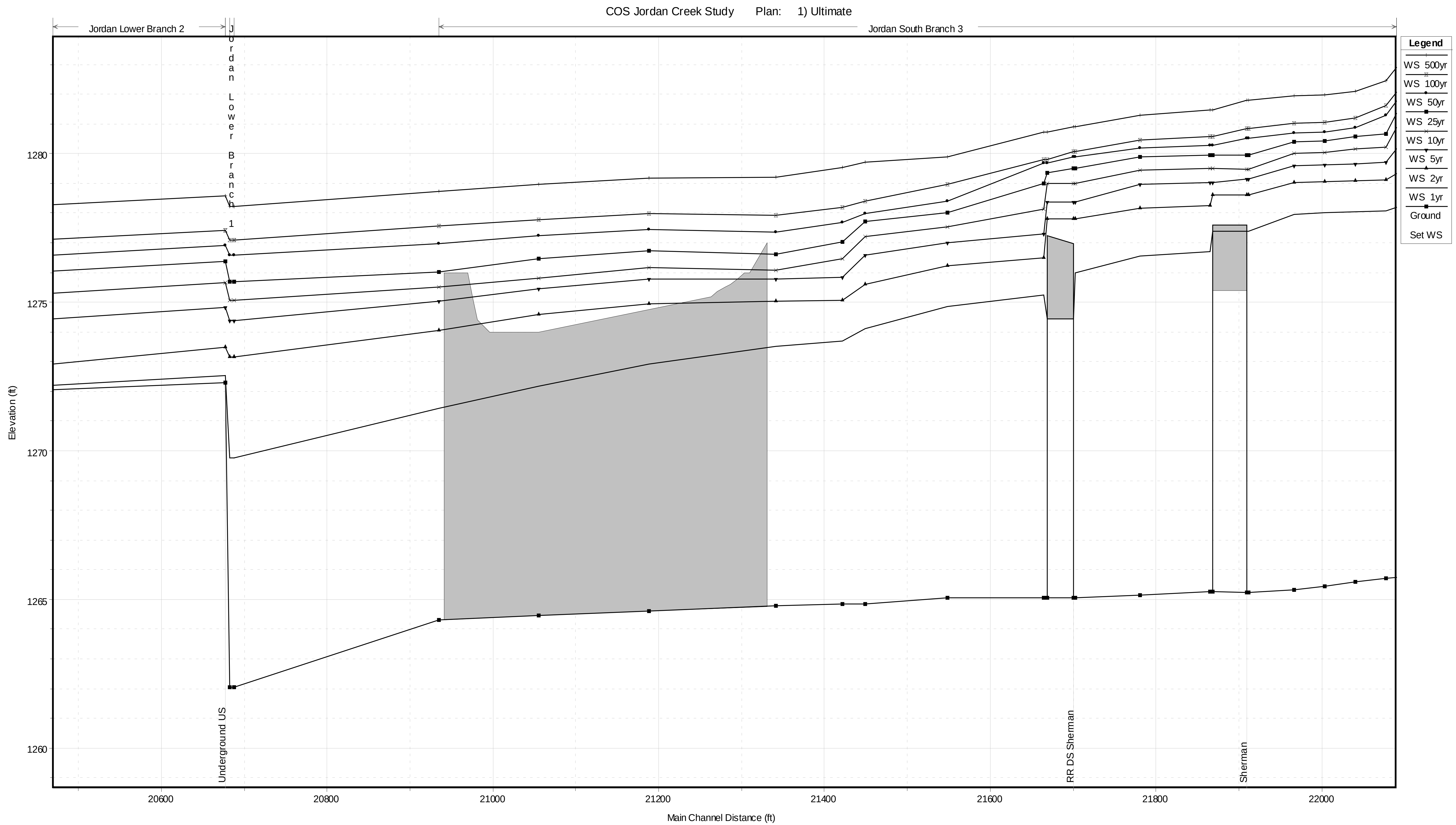
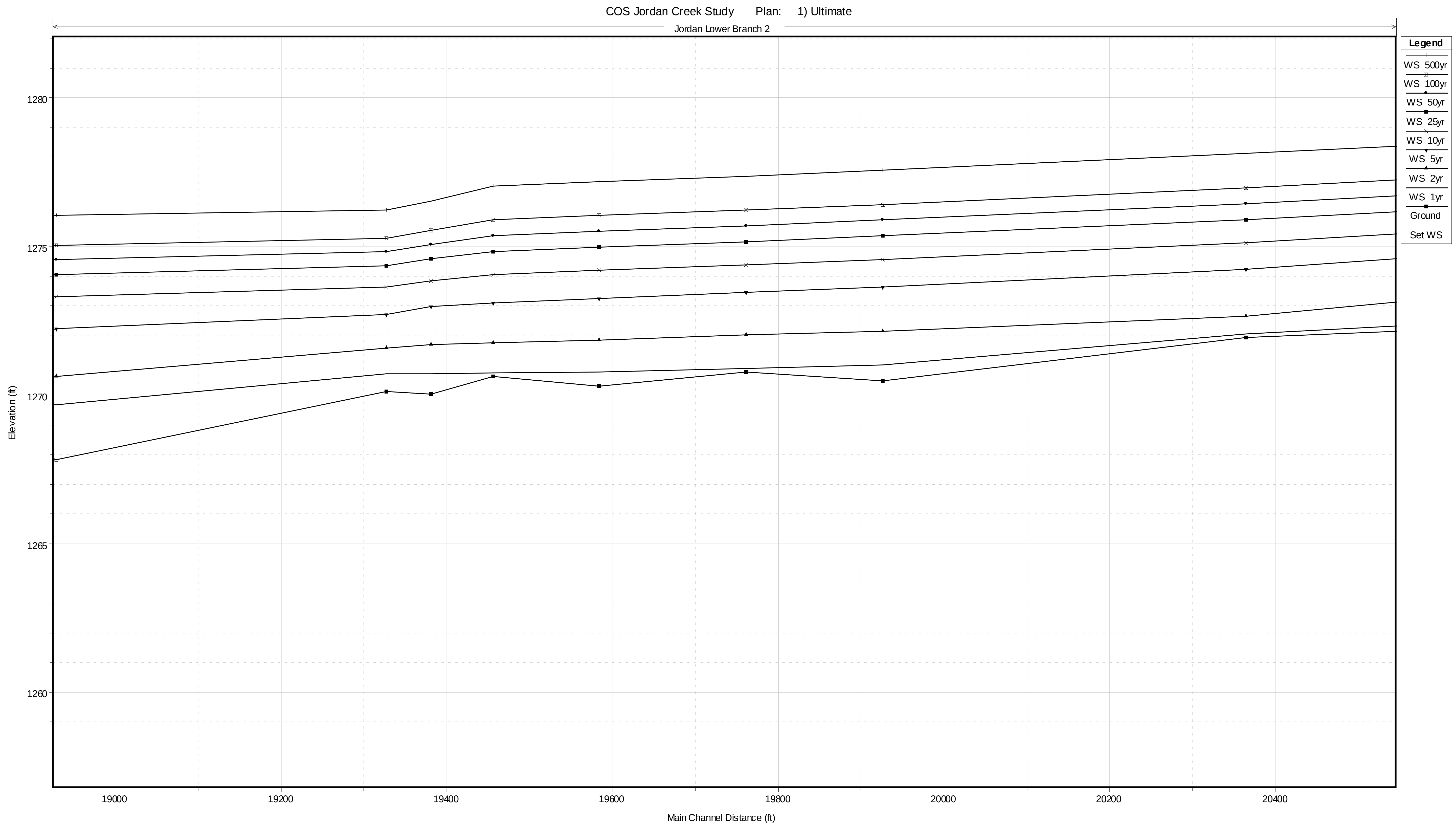

COS Jordan Creek Study Plan: 1) Ultimate
Jordan Lower Branch 2
Jordan Lower Branch 1
Jordan South Branch 3
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
Elevation (ft)
1280
1275
1270
1265
1260
Underground US
RR DS Sherman
Sherman
20600
20800
21000
21200
21400
21600
21800
22000
Main Channel Distance (ft)

Plate Series D – Future Conditions Without Project Hydraulic Profiles



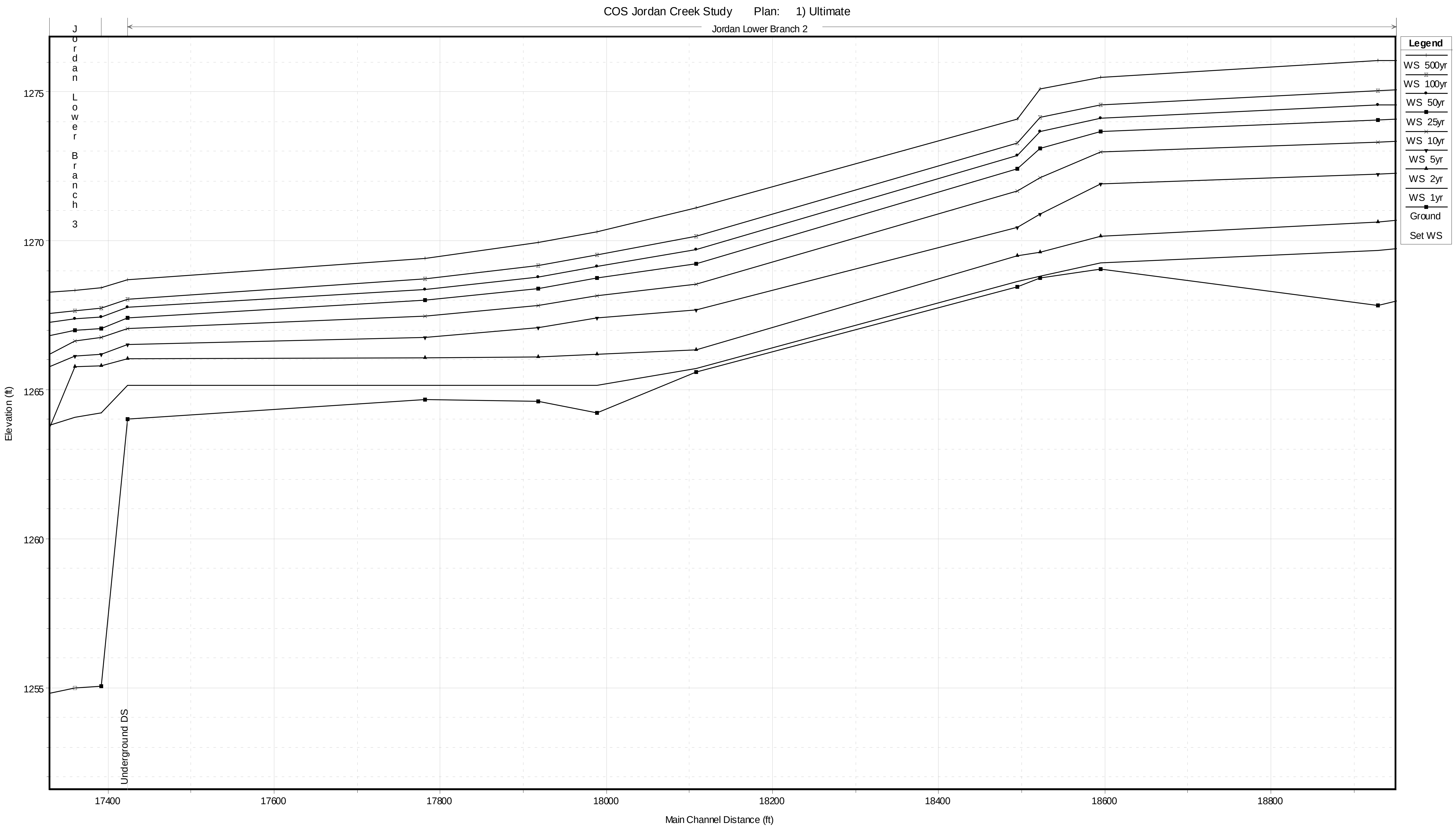

COS Jordan Creek Study Plan: 1) Ultimate
Jordan Lower Branch 2
Jordan Lower Branch 3
Underground DS
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
Elevation (ft)
1275
1270
1265
1260
1255
Main Channel Distance (ft)
17400
17600
17800
18000
18200
18400
18600
18800

Plate Series D – Future Conditions Without Project Hydraulic Profiles

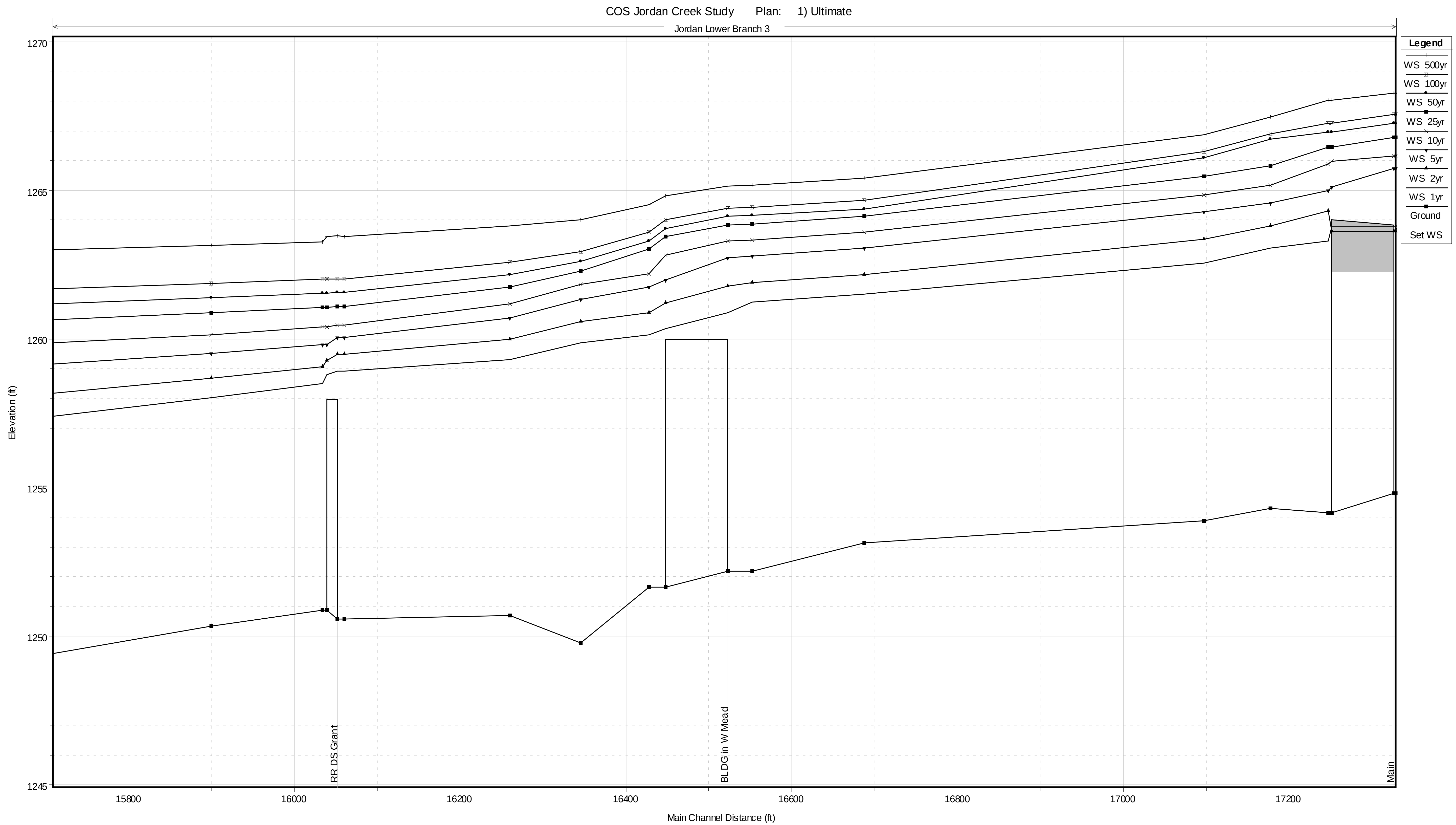


Plate Series D – Future Conditions Without Project Hydraulic Profiles

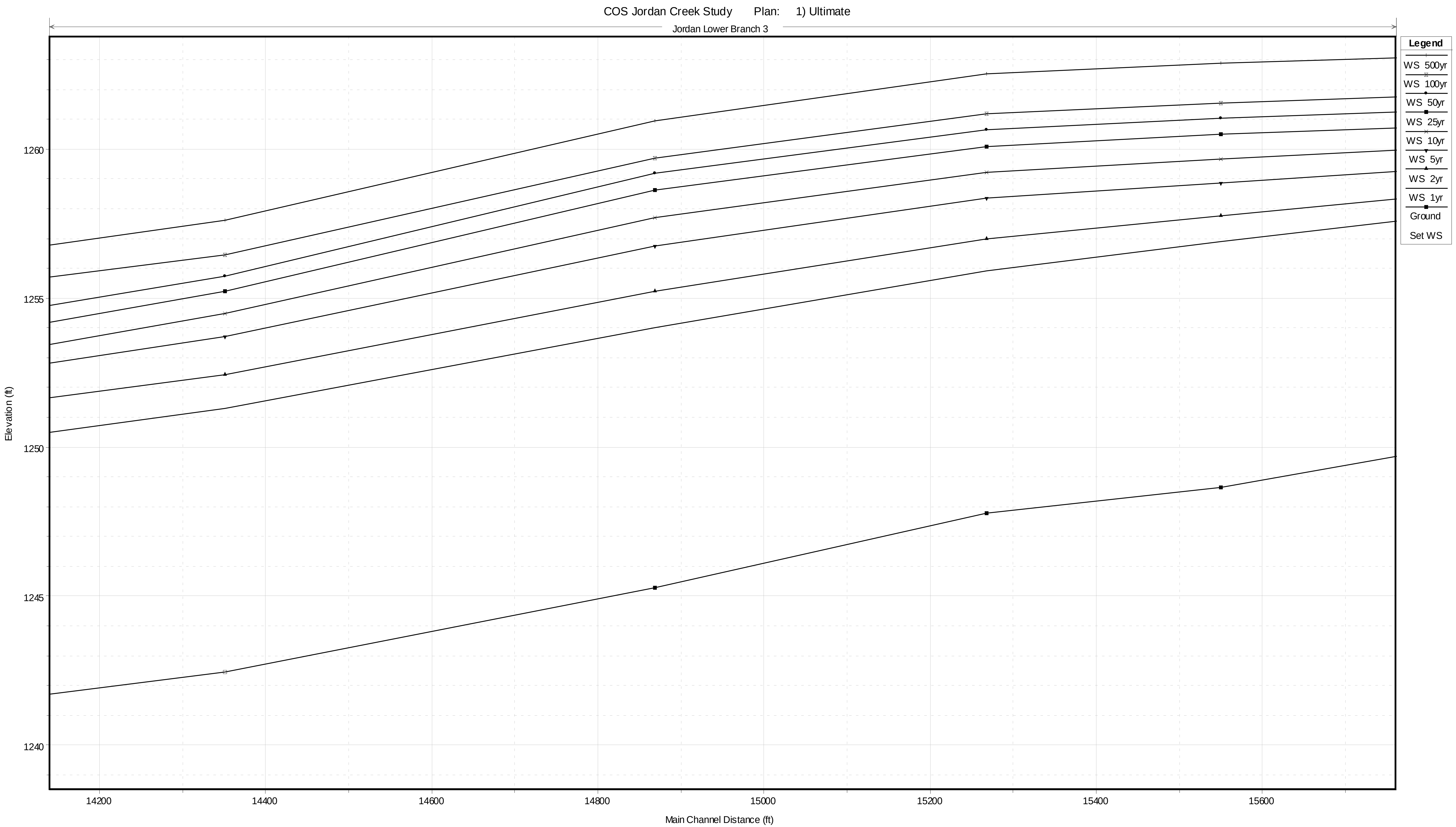
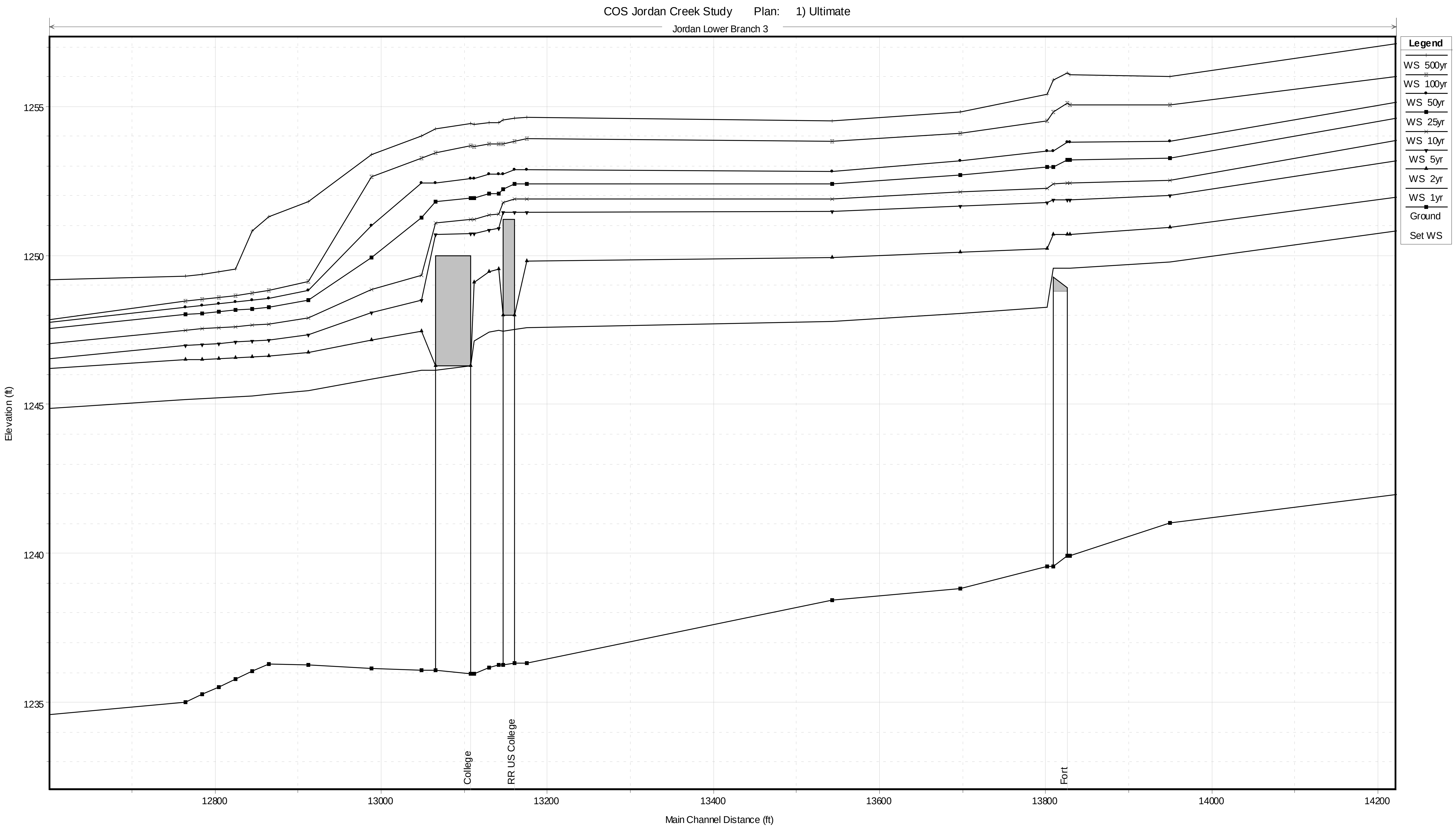
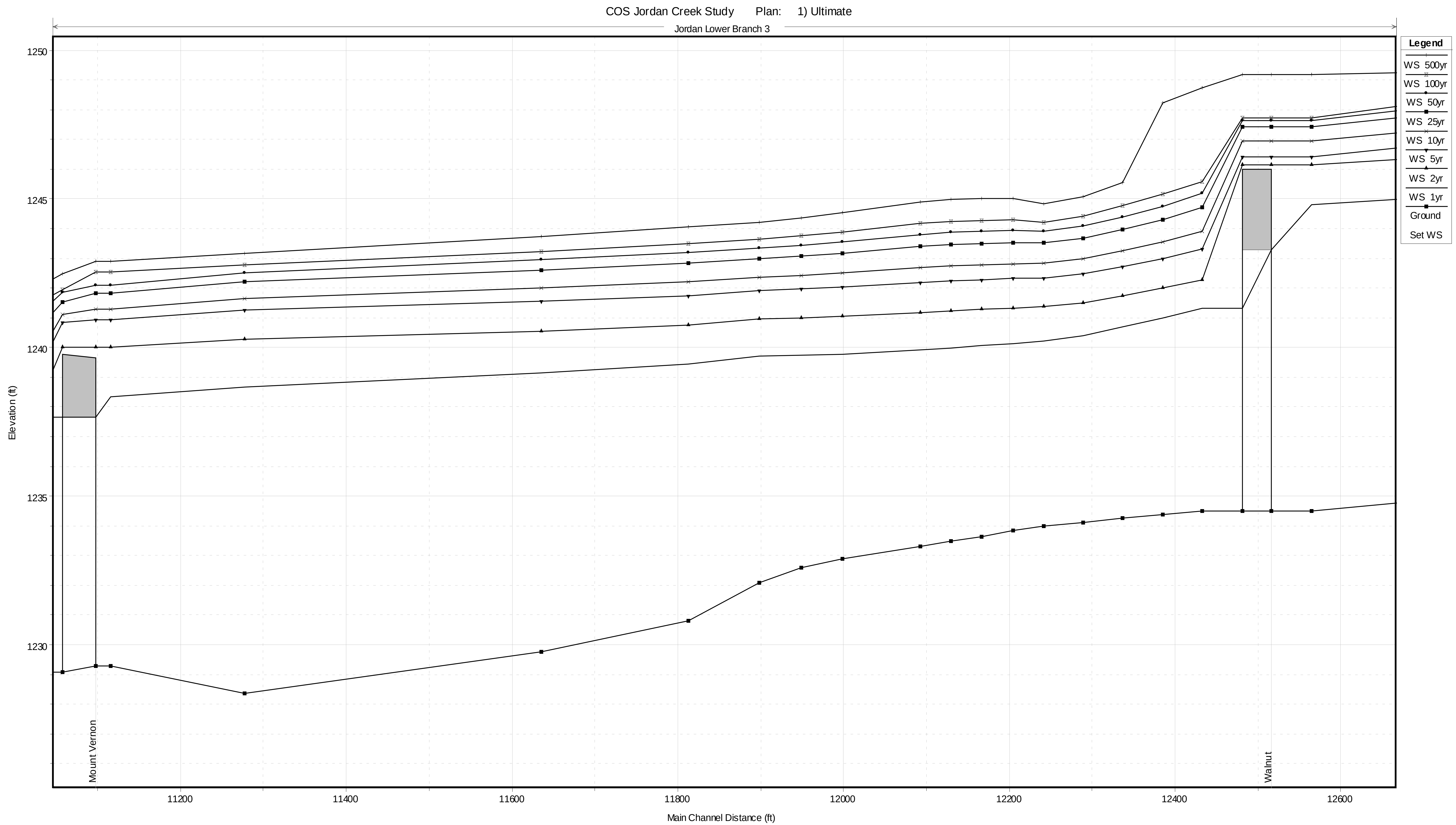


Plate Series D – Future Conditions Without Project Hydraulic Profiles




COS Jordan Creek Study Plan: 1) Ultimate
Jordan Lower Branch 3
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
Elevation (ft)
1250
1245
1240
1235
1230
Mount Vernon
Walnut
11200
11400
11600
11800
12000
12200
12400
12600
Main Channel Distance (ft)

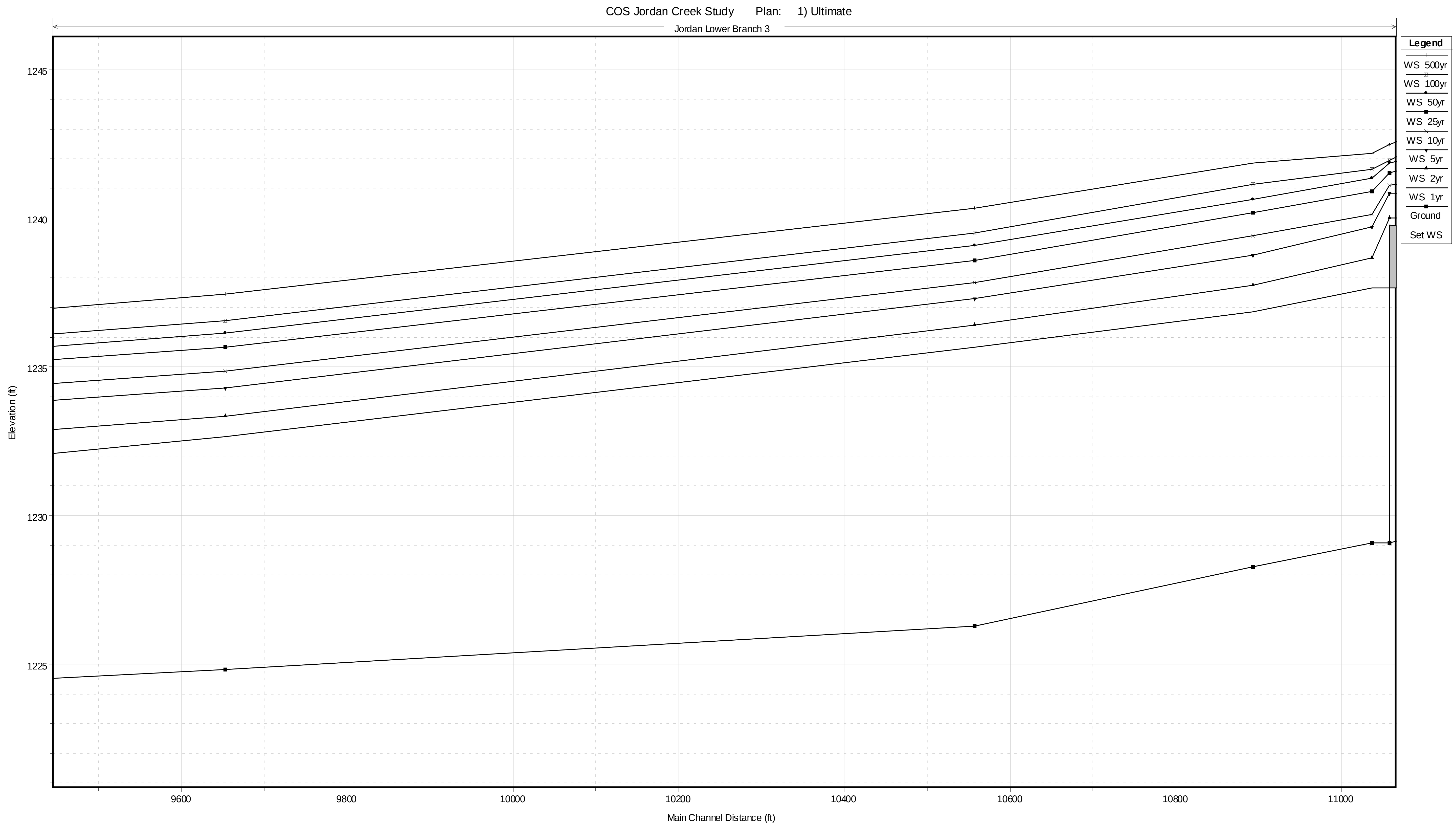

COS Jordan Creek Study Plan: 1) Ultimate
Jordan Lower Branch 3
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
1245
1240
1235
1230
1225
Elevation (ft)
9600
9800
10000
10200
10400
10600
10800
11000
Main Channel Distance (ft)

Plate Series D – Future Conditions Without Project Hydraulic Profiles

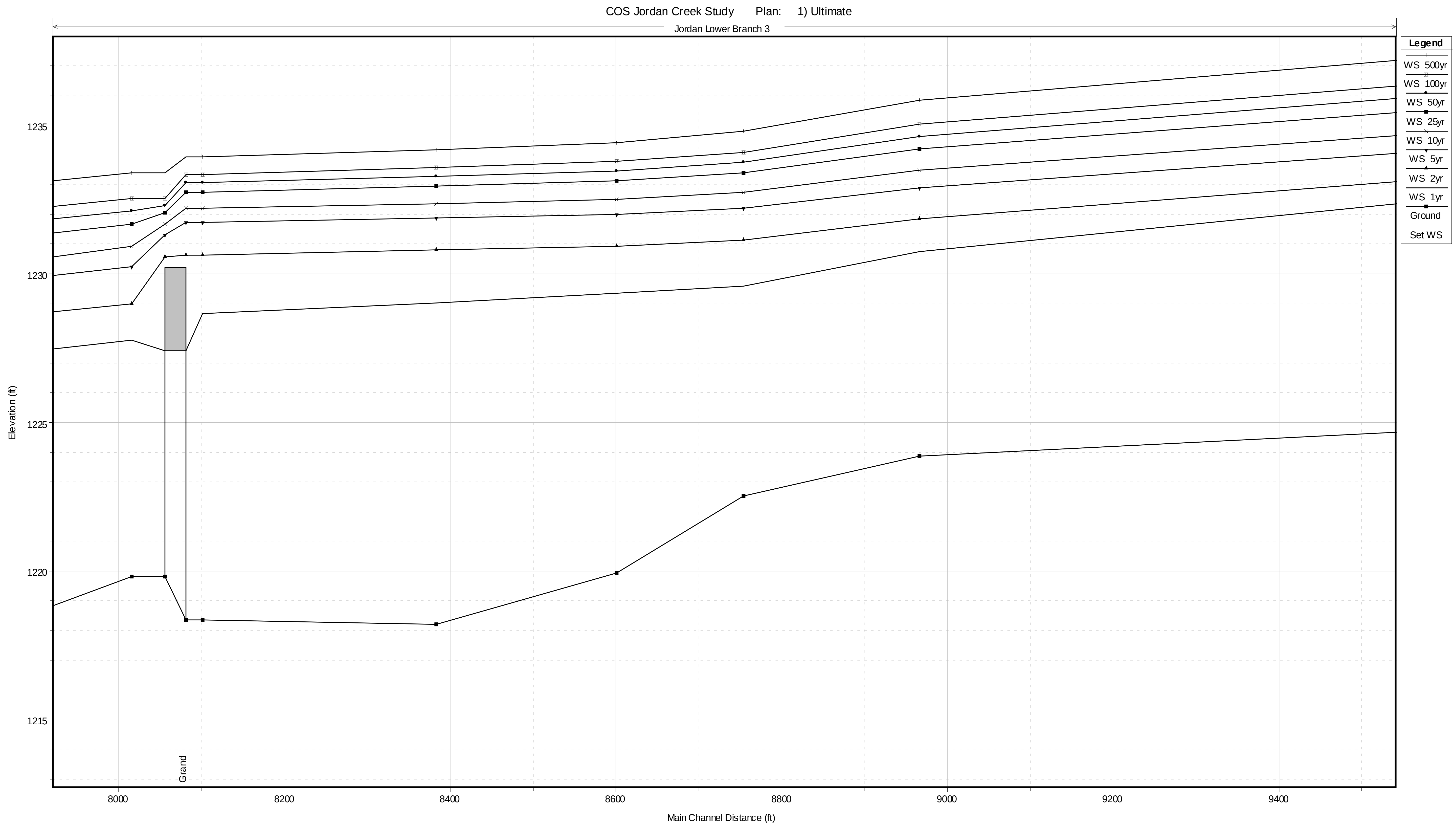


Plate Series D – Future Conditions Without Project Hydraulic Profiles

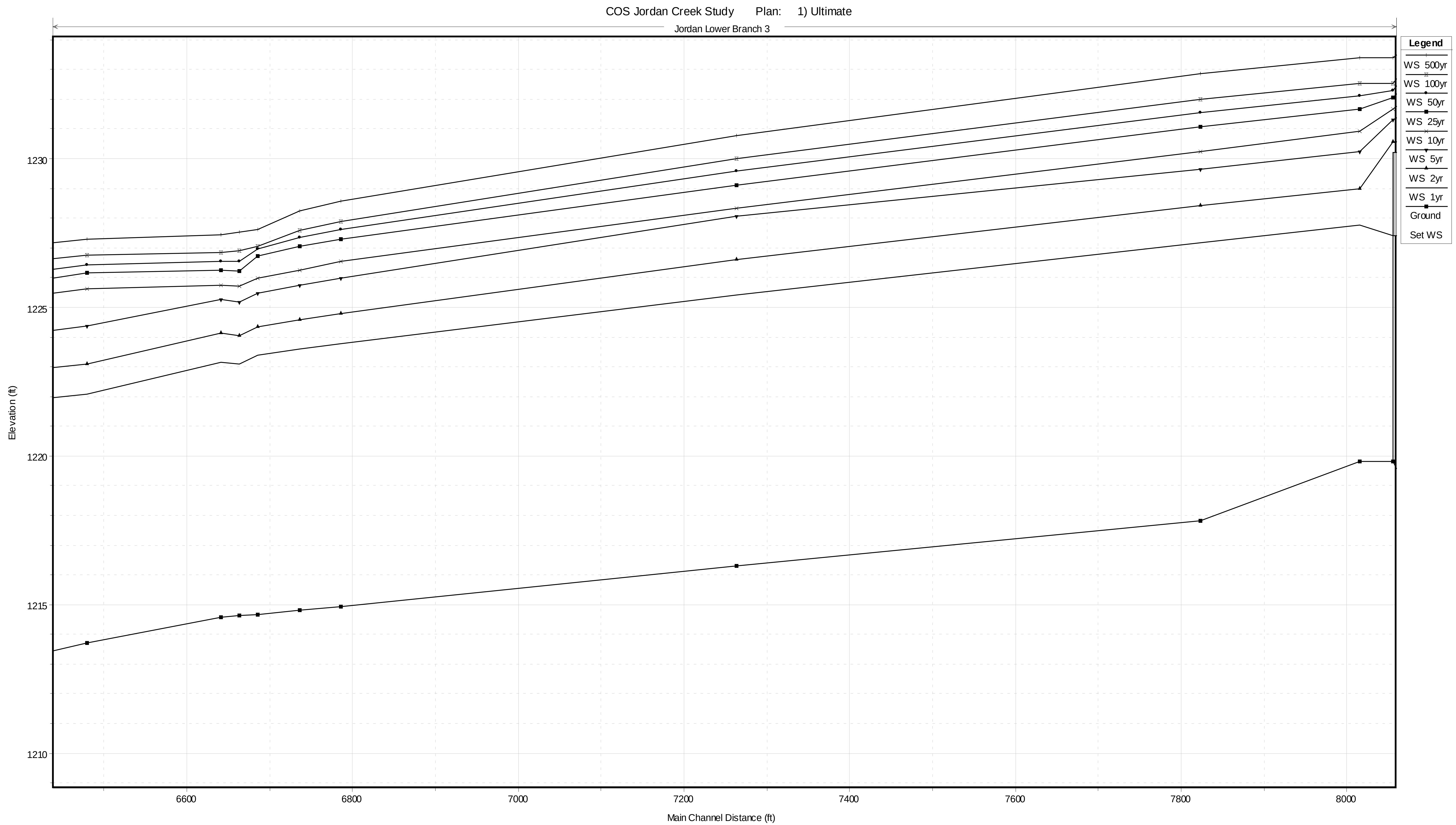
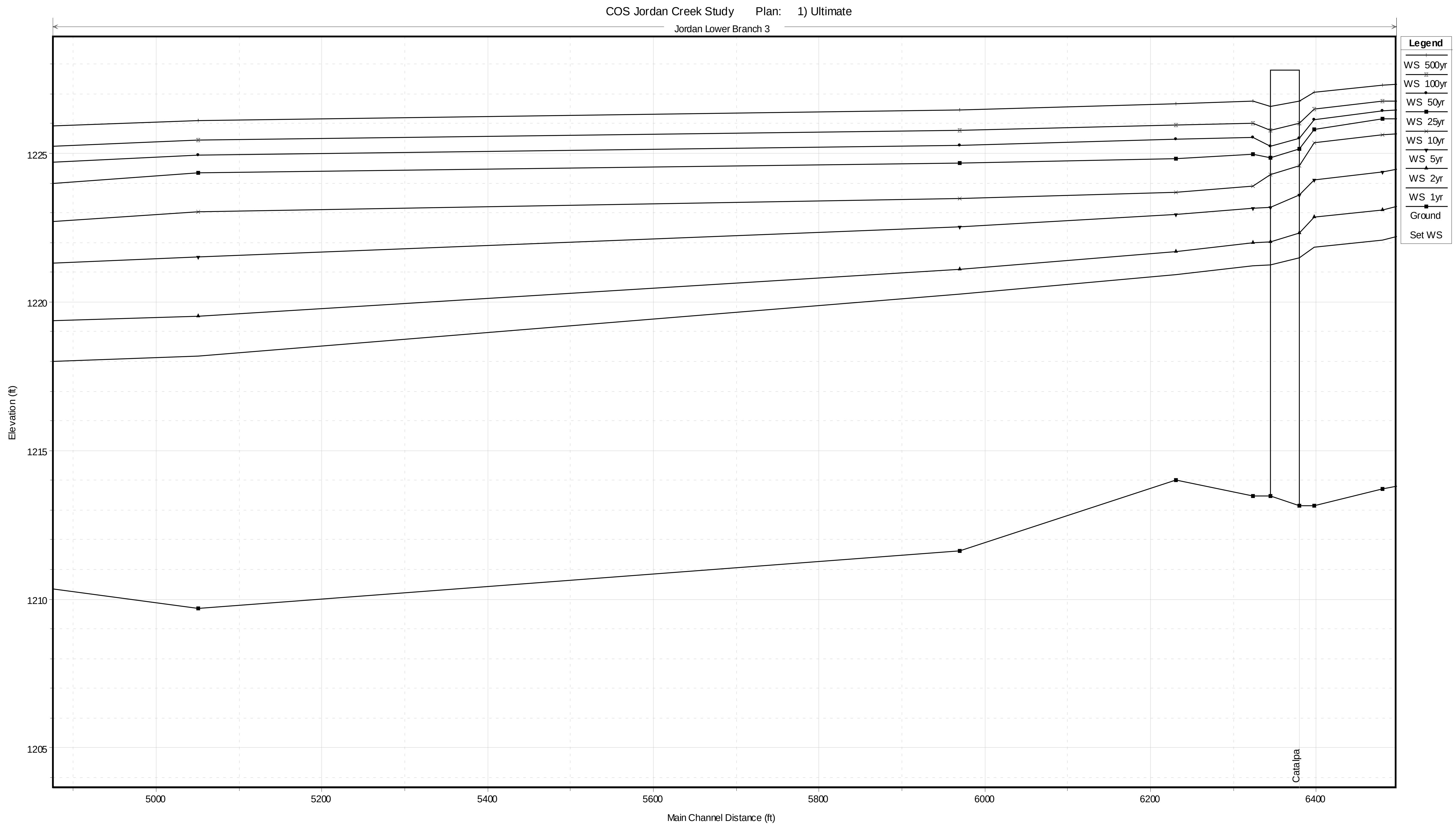


Plate Series D – Future Conditions Without Project Hydraulic Profiles



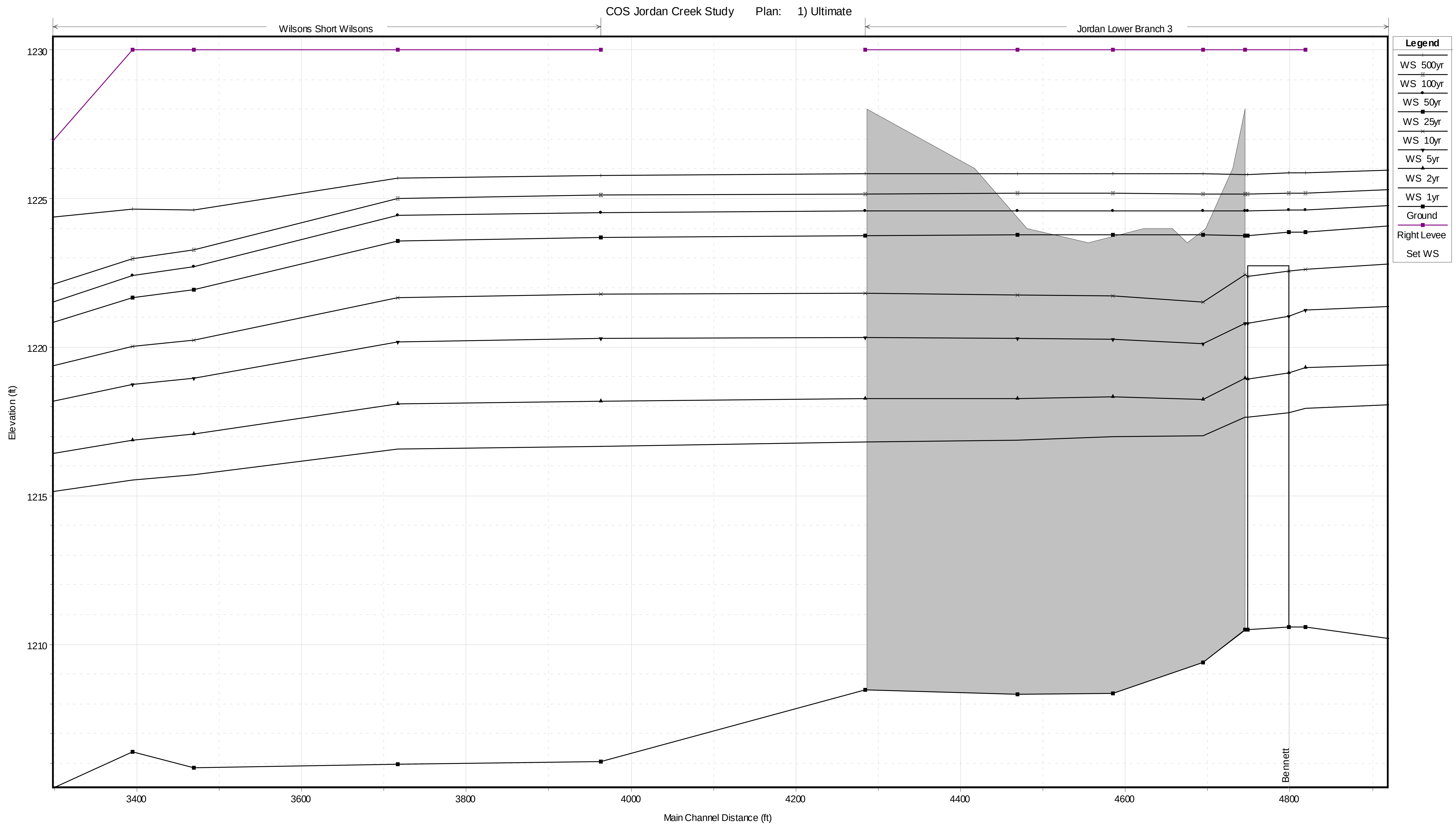

COS Jordan Creek Study Plan: 1) Ultimate
Wilsons Short Wilsons
Jordan Lower Branch 3
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Right Levee
Set WS
Elevation (ft)
1230
1225
1220
1215
1210
Main Channel Distance (ft)
3400
3600
3800
4000
4200
4400
4600
4800
Bennett

Plate Series D – Future Conditions Without Project Hydraulic Profiles

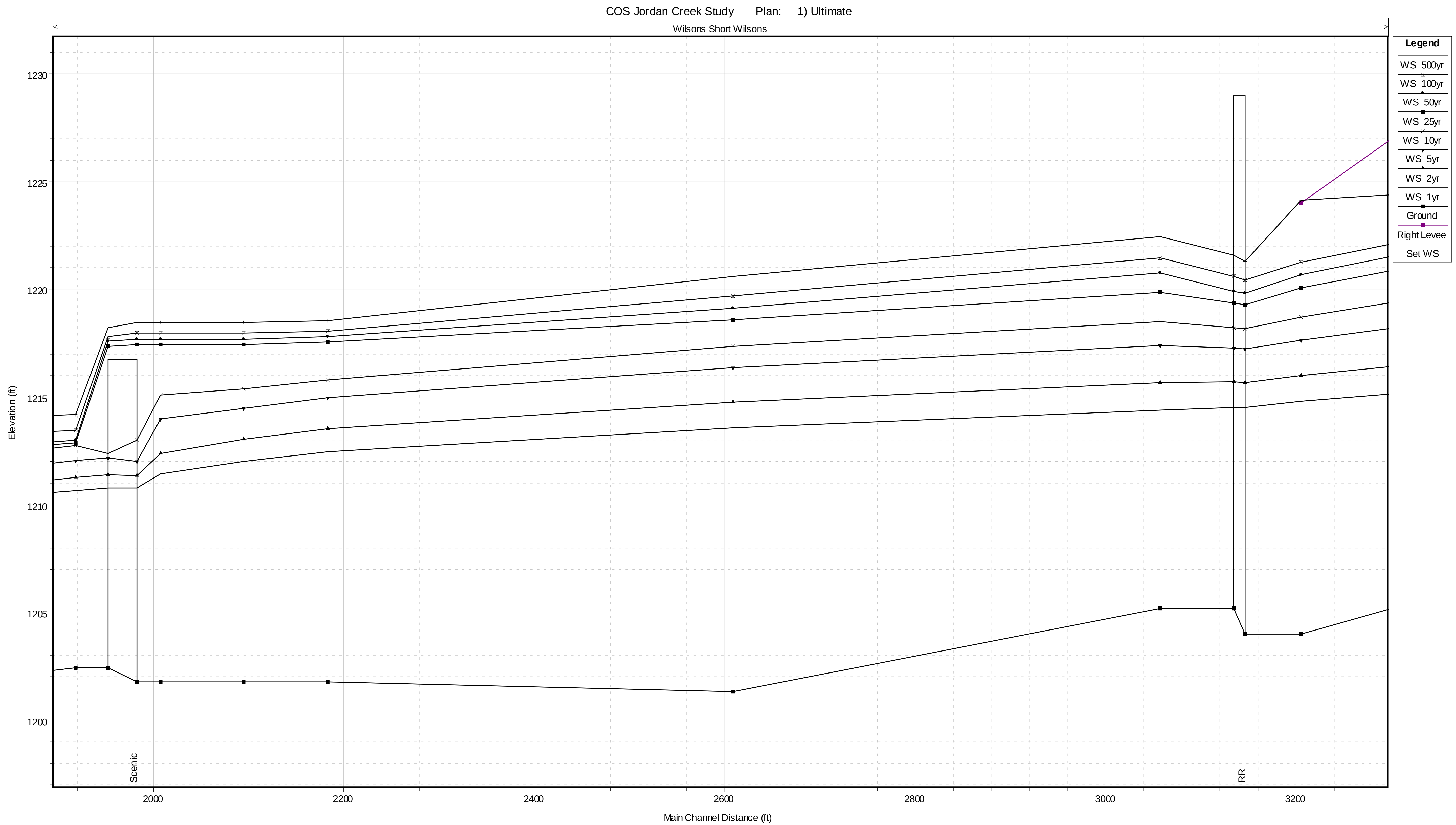
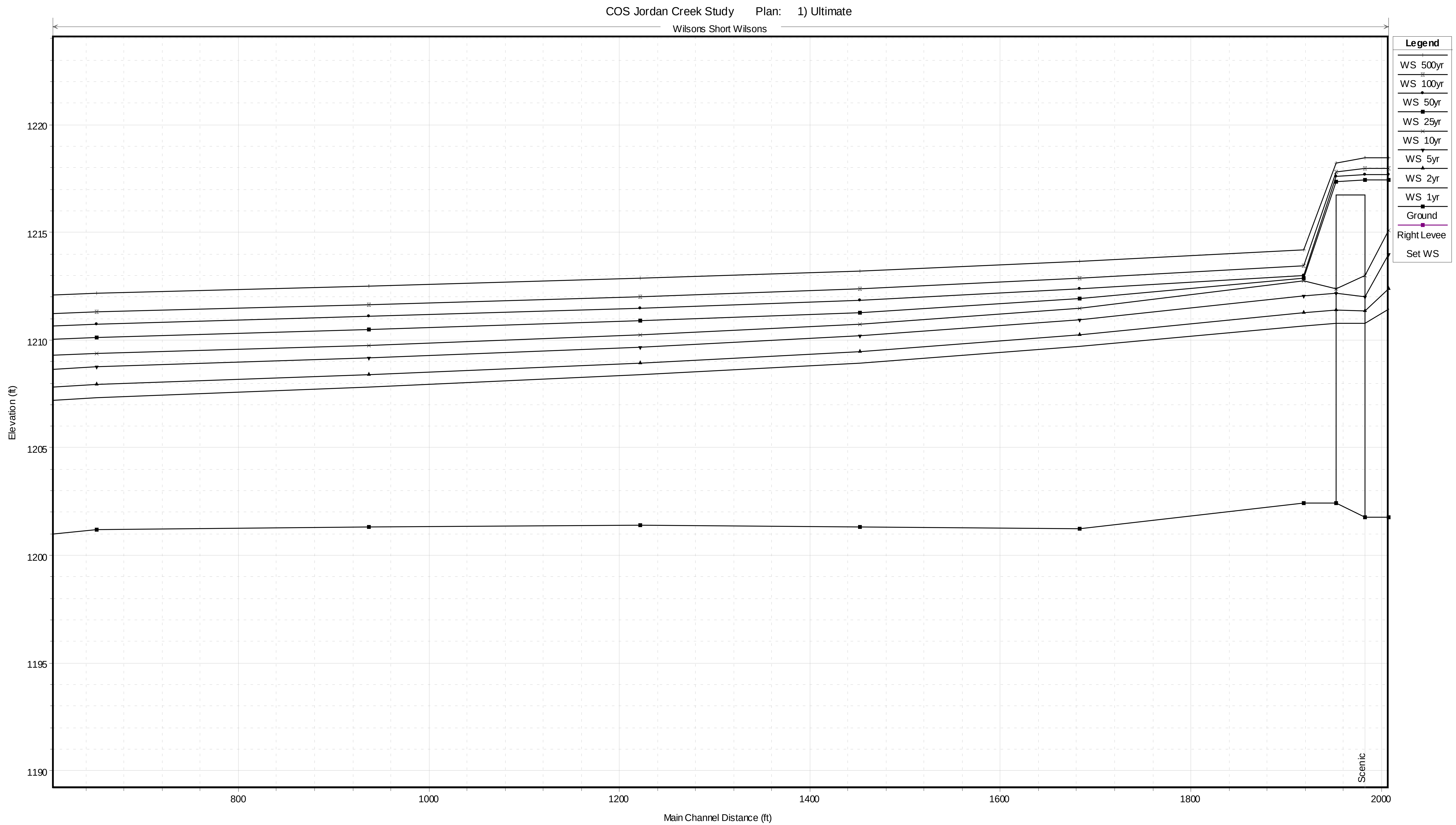
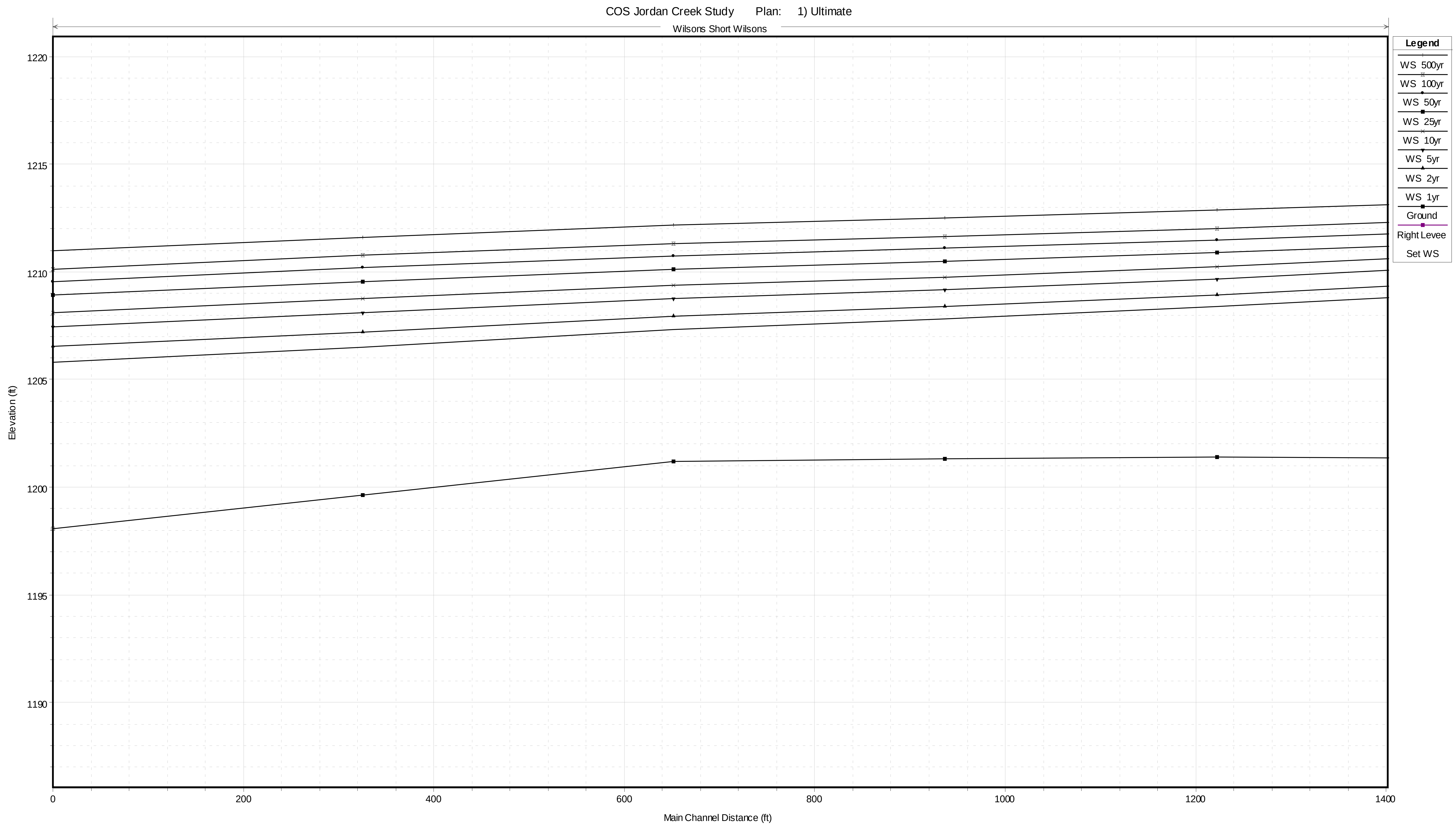
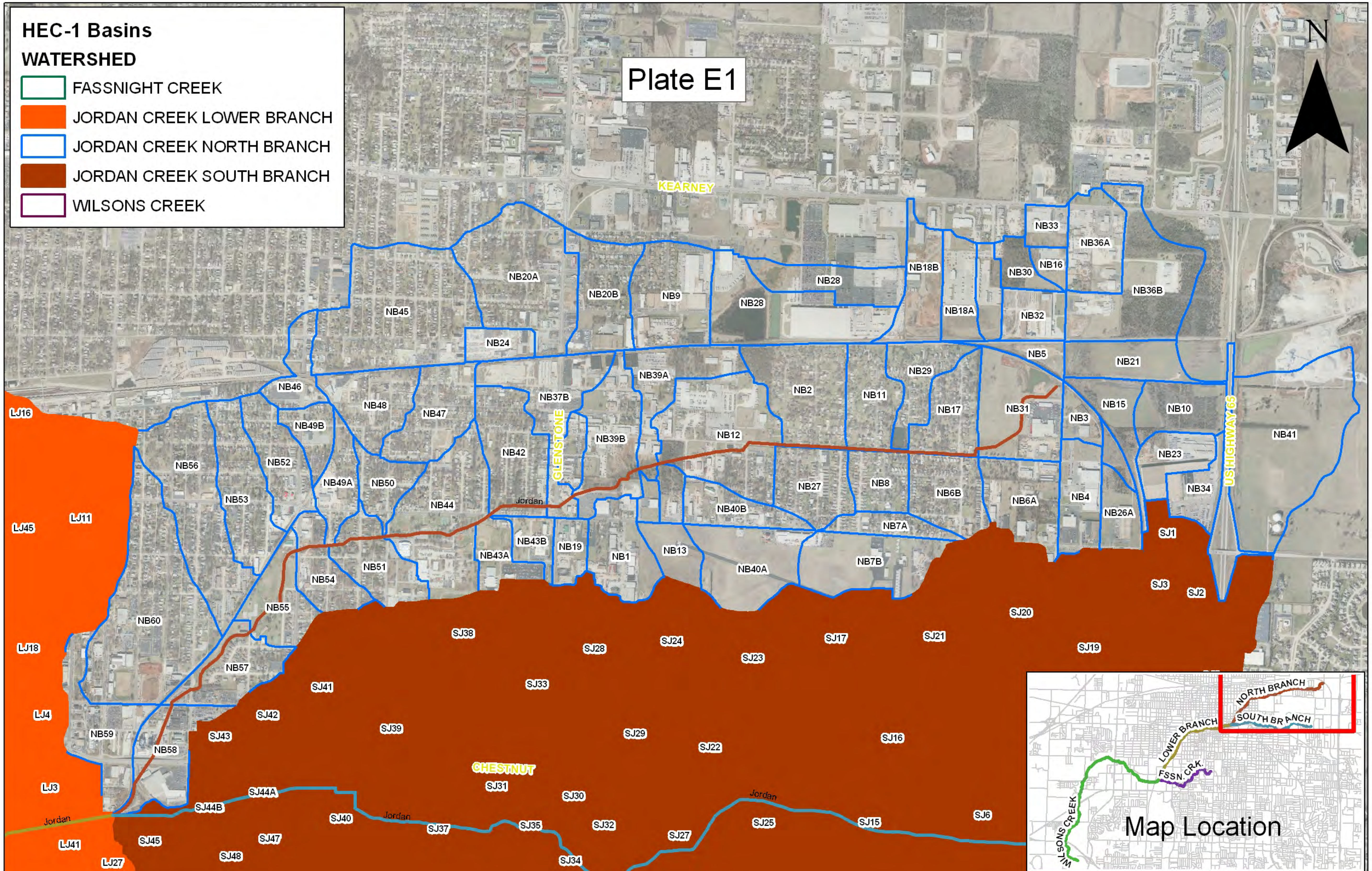


Plate Series D – Future Conditions Without Project Hydraulic Profiles





COS Jordan Creek Study Plan: 1) Ultimate
Wilsons Short Wilsons
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Right Levee
Set WS
Elevation (ft)
1220
1215
1210
1205
1200
1195
1190
0
200
400
600
800
1000
1200
1400
Main Channel Distance (ft)



HEC-1 Basins
WATERSHED
FASSNIGHT CREEK
JORDAN CREEK LOWER BRANCH
JORDAN CREEK NORTH BRANCH
JORDAN CREEK SOUTH BRANCH
WILSONS CREEK
Plate E1
N
KEARNEY
GLENSTONE
US HIGHWAY 65
CHESTNUT
Jordan
NB33
NB36A
NB16
NB30
NB18B
NB28
NB20A
NB20B
NB9
NB36B
NB18A
NB32
NB45
NB24
NB5
NB21
NB39A
NB29
NB46
NB48
NB37B
NB2
NB11
NB47
NB49B
NB17
NB31
NB15
NB10
NB3
NB41
NB12
NB39B
NB42
NB56
NB52
NB23
NB49A
NB50
NB27
NB8
NB6B
NB34
NB53
NB44
NB40B
NB6A
NB4
NB26A
NB7A
NB43B
NB19
NB1
NB13
NB43A
NB51
NB7B
NB40A
NB54
NB55
NB60
NB57
NB59
NB58
LJ16
LJ11
LJ45
LJ18
LJ4
LJ3
LJ41
LJ27
SJ1
SJ3
SJ2
SJ20
SJ19
SJ38
SJ28
SJ24
SJ17
SJ21
SJ23
SJ41
SJ33
SJ42
SJ39
SJ29
SJ22
SJ16
SJ43
SJ31
SJ30
SJ44A
SJ44B
SJ40
SJ37
SJ35
SJ32
SJ27
SJ25
SJ15
SJ6
SJ45
SJ47
SJ48
SJ34
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN. CRK.
WILSONS CREEK
Map Location

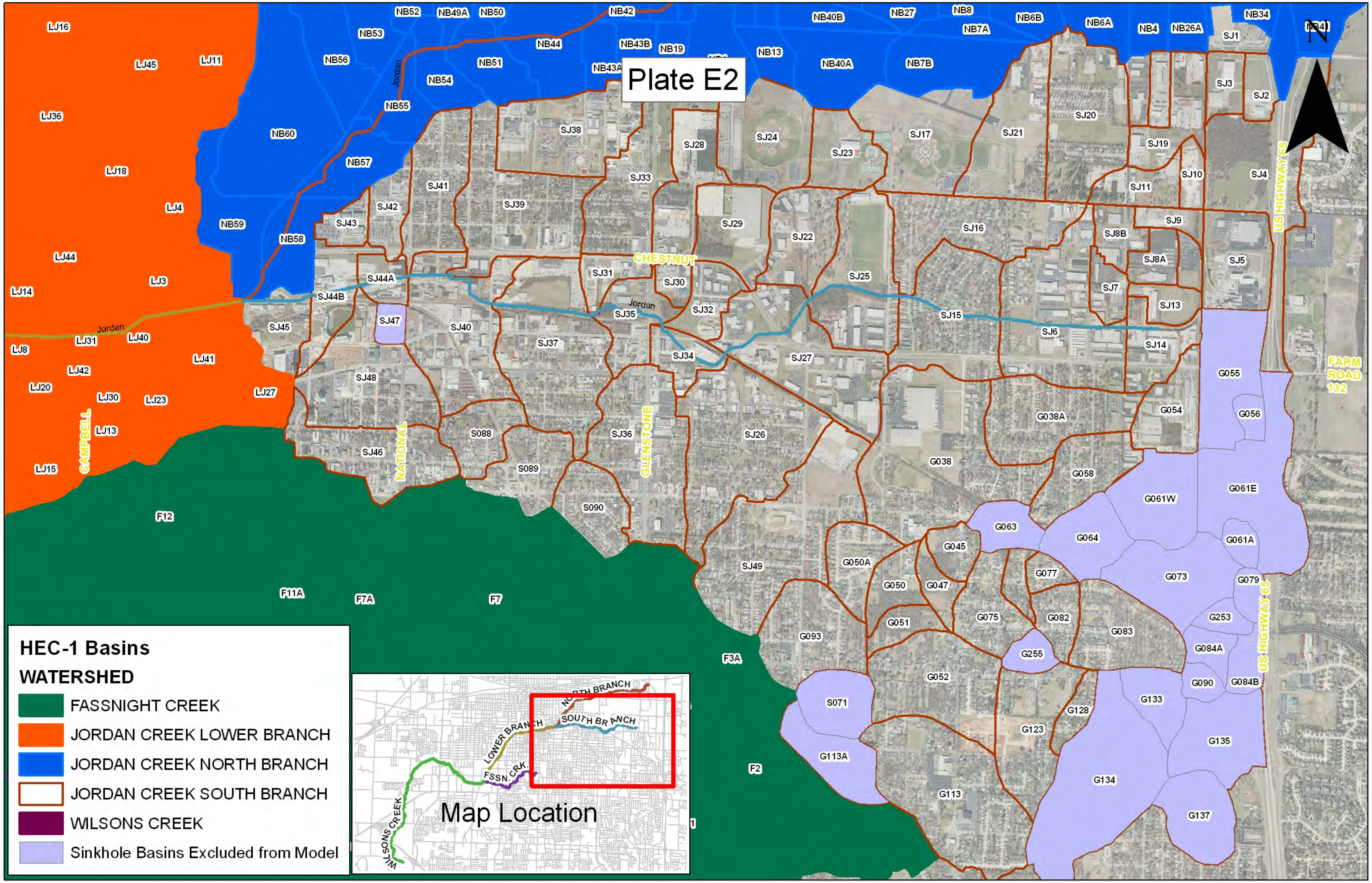
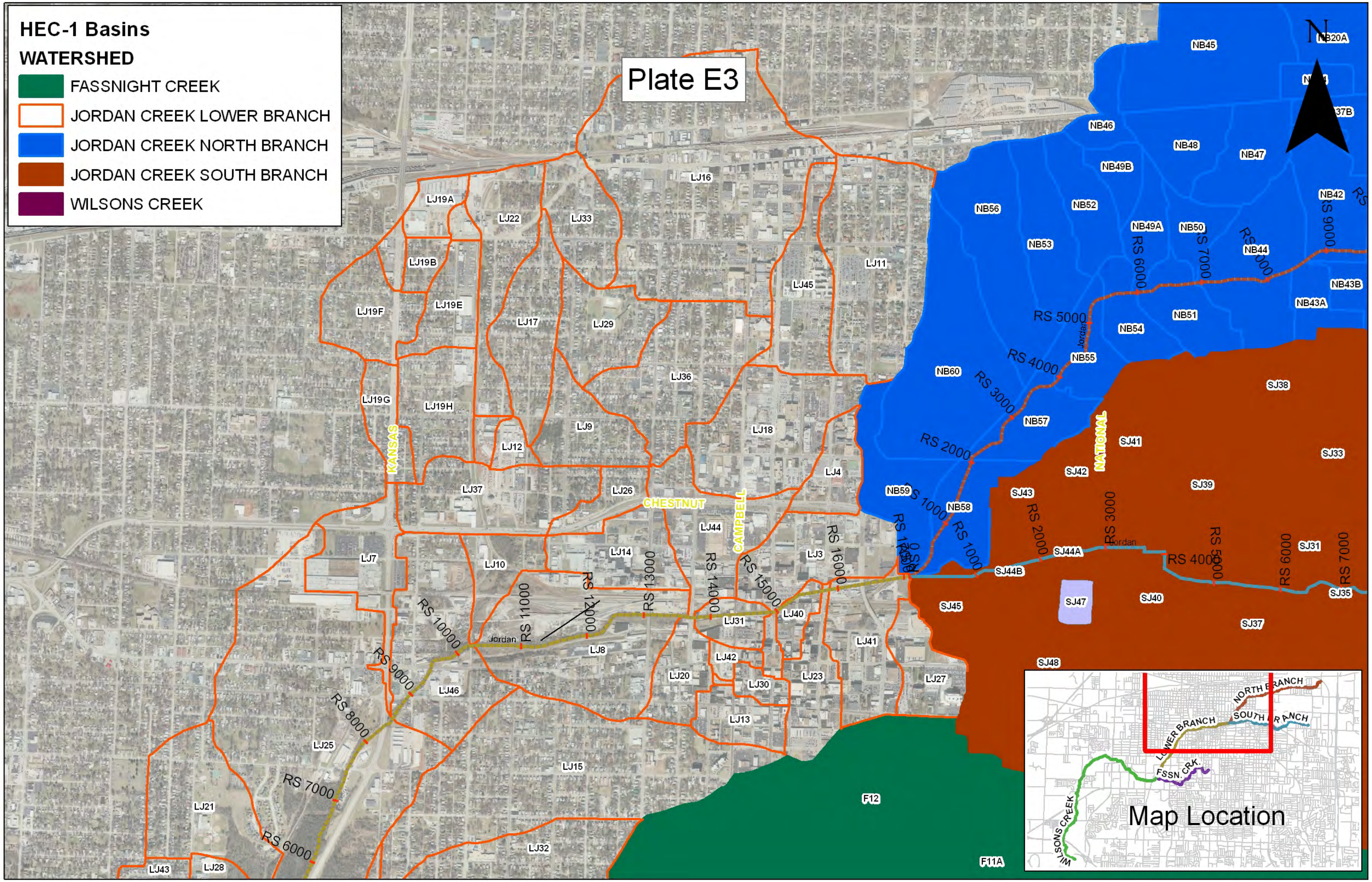
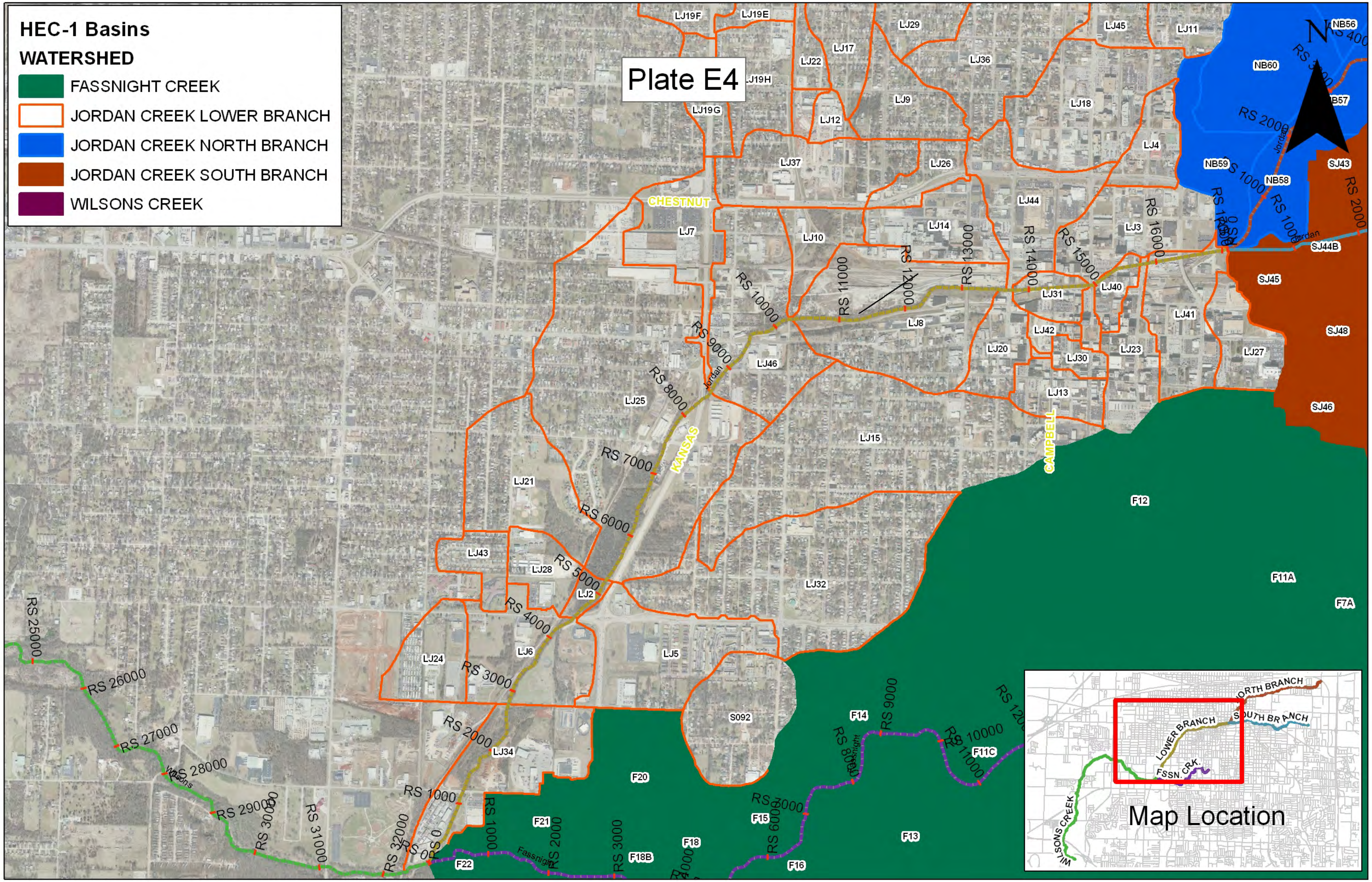
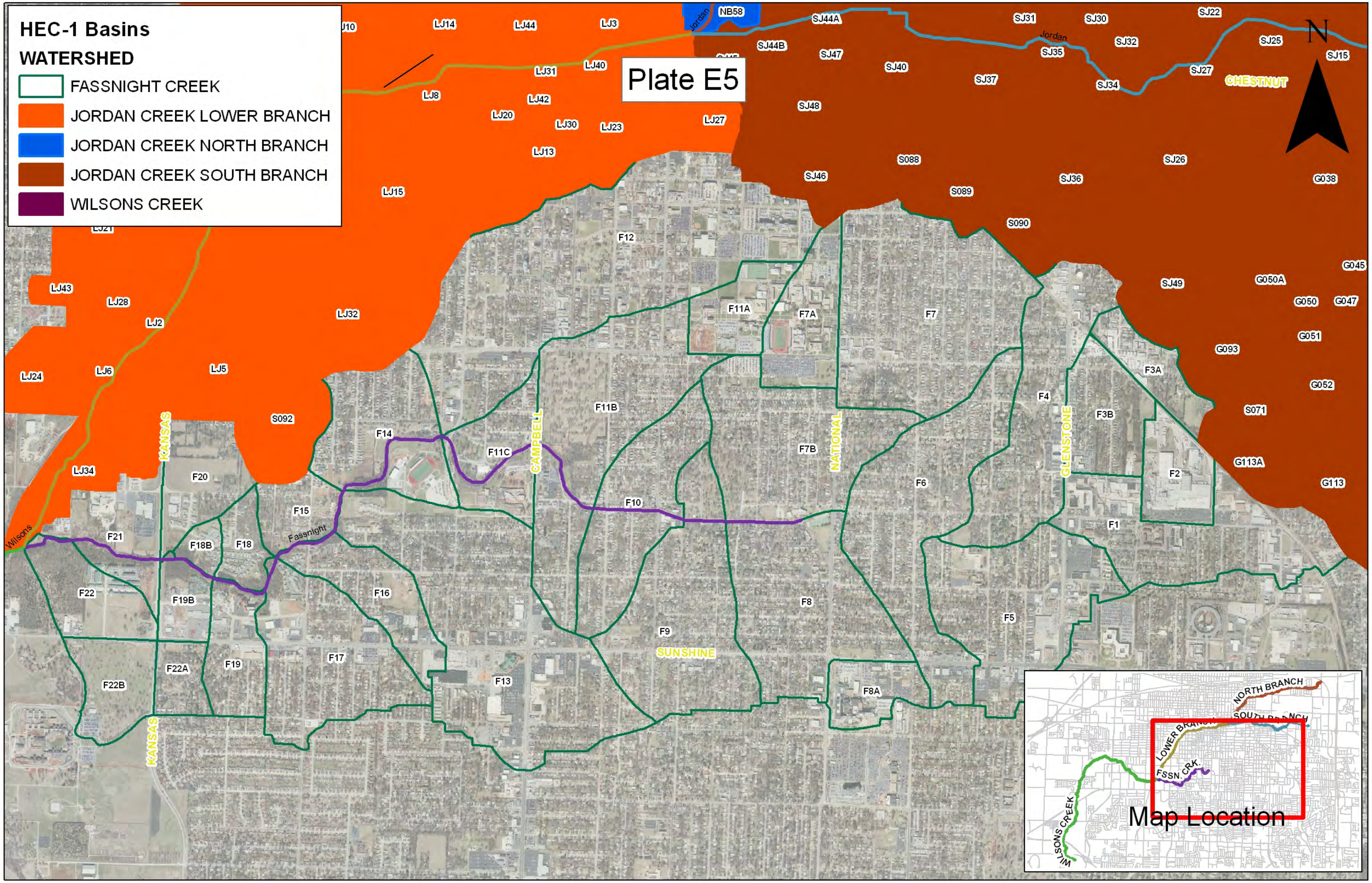
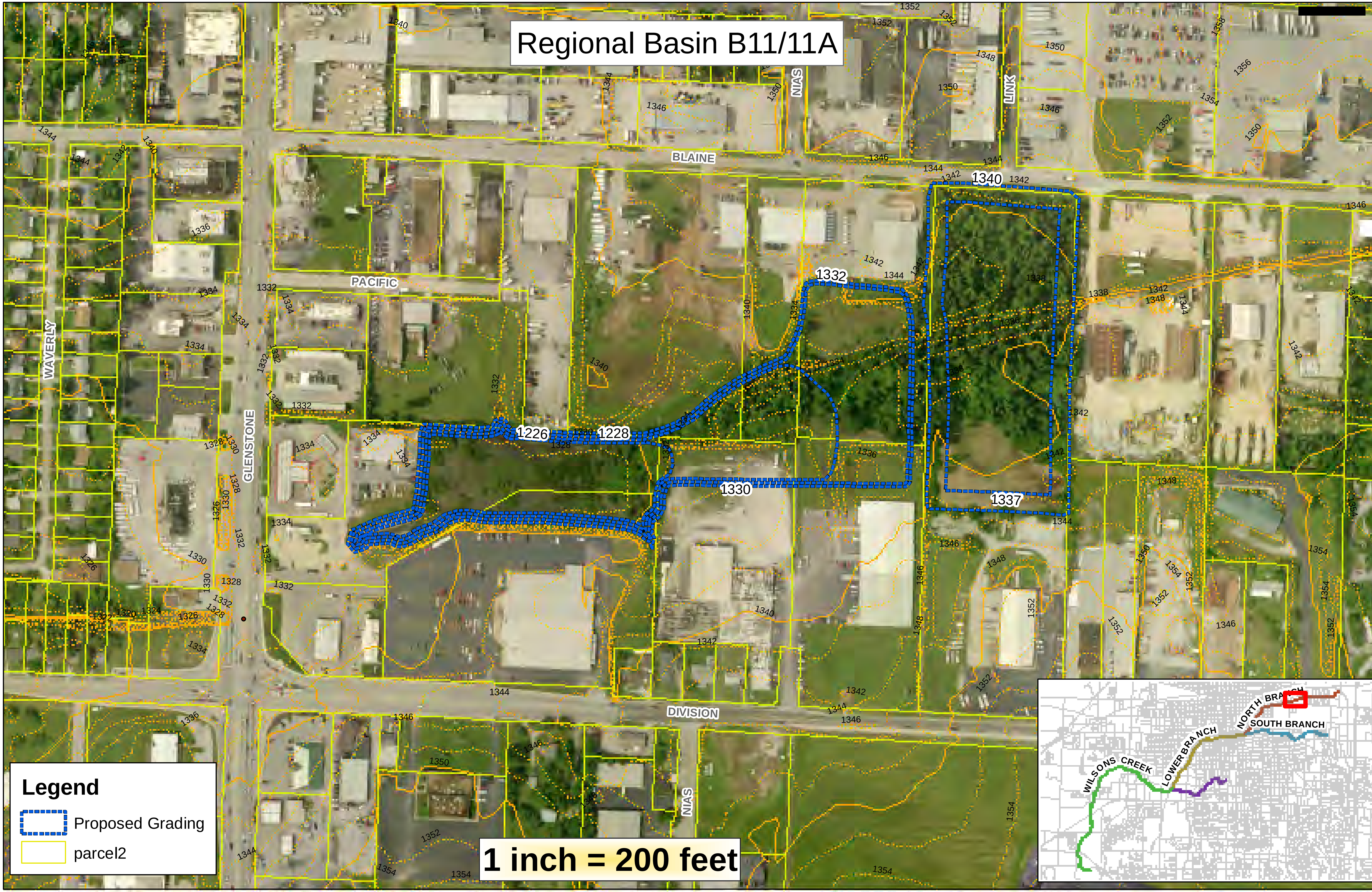


Plate E2
HEC-1 Basins
WATERSHED
FASSNIGHT CREEK
JORDAN CREEK LOWER BRANCH
JORDAN CREEK NORTH BRANCH
JORDAN CREEK SOUTH BRANCH
WILSONS CREEK
Sinkhole Basins Excluded from Model
Map Location
CHESTNUT
NATIONAL
GLENSTONE
CAMPBELL
US HIGHWAY 65
FARM ROAD 132
N

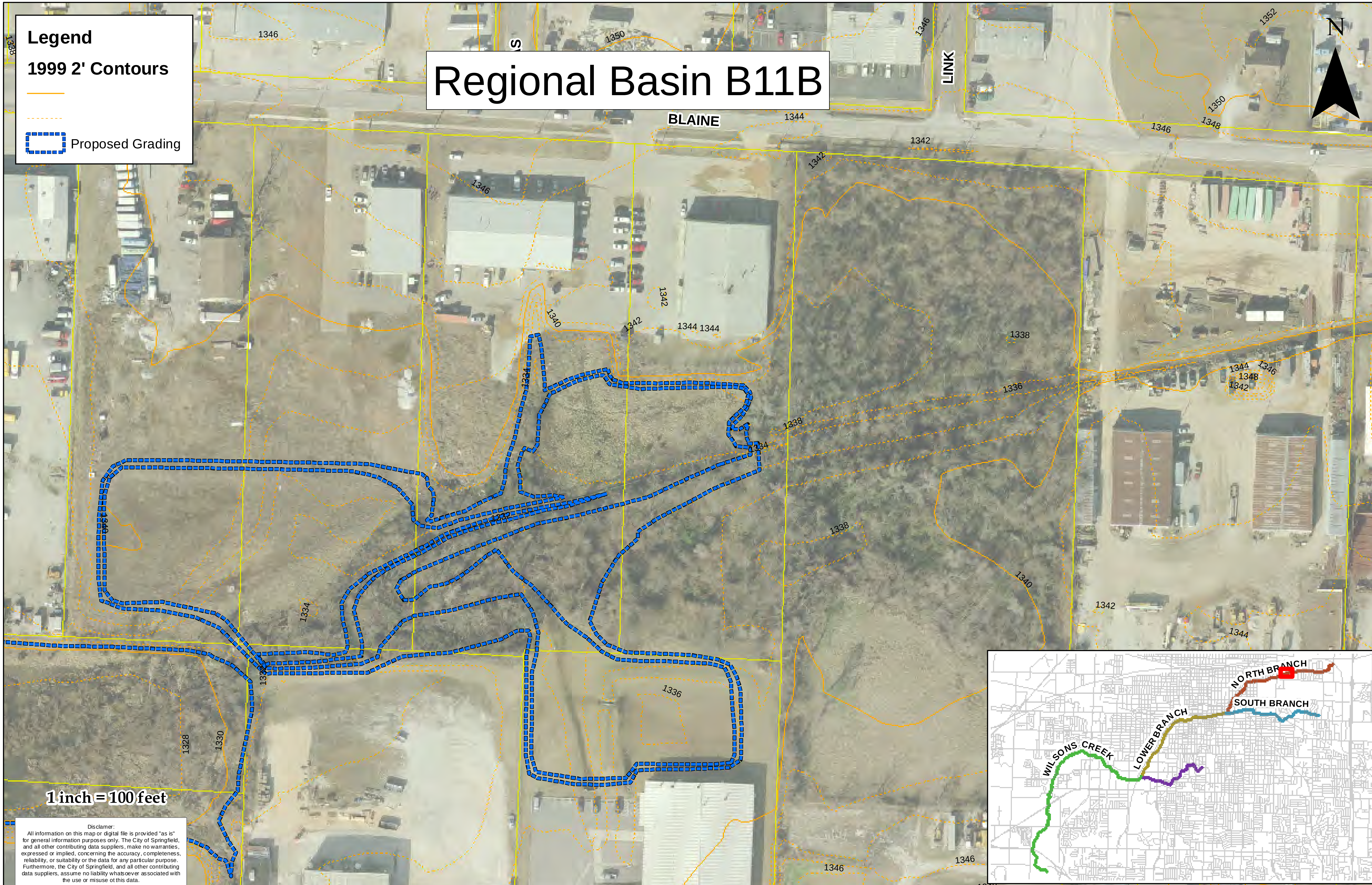

HEC-1 Basins
WATERSHED
FASSNIGHT CREEK
JORDAN CREEK LOWER BRANCH
JORDAN CREEK NORTH BRANCH
JORDAN CREEK SOUTH BRANCH
WILSONS CREEK
Plate E3
N
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN. CRK.
WILSONS CREEK
KANSAS
CHESTNUT
CAMPBELL
NATIONAL
RS 5000
RS 4000
RS 3000
RS 2000
RS 1000
RS 6000
RS 7000
RS 9000
RS 10000
RS 11000
RS 12000
RS 13000
RS 14000
RS 15000
RS 16000
RS 8000


HEC-1 Basins
WATERSHED
FASSNIGHT CREEK
JORDAN CREEK LOWER BRANCH
JORDAN CREEK NORTH BRANCH
JORDAN CREEK SOUTH BRANCH
WILSONS CREEK
Plate E4
N
CHESTNUT
KANSAS
CAMPBELL
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN. CRK.
WILSONS CREEK


HEC-1 Basins
WATERSHED
FASSNIGHT CREEK
JORDAN CREEK LOWER BRANCH
JORDAN CREEK NORTH BRANCH
JORDAN CREEK SOUTH BRANCH
WILSONS CREEK
Plate E5
N
KANSAS
CAMPBELL
NATIONAL
GLENSTONE
SUNSHINE
CHESTNUT
Map Location



Regional Basin B11/11A
BLAINE
PACIFIC
DIVISION
GLENSTONE
WAVERLY
NIAS
LINK
1340
1332
1226
1228
1330
1337
Legend
Proposed Grading
parcel2
1 inch = 200 feet
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
WILSONS CREEK

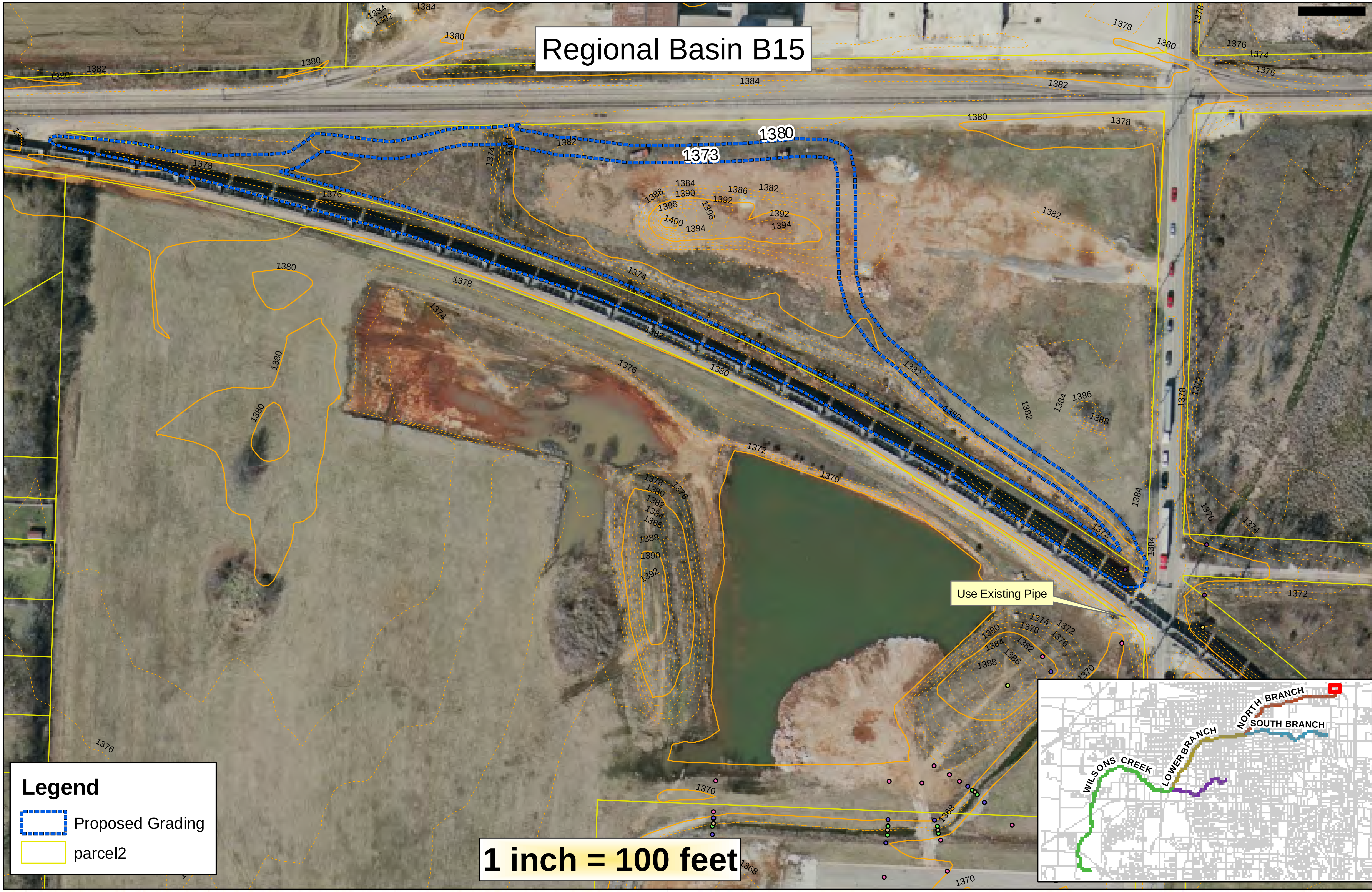


Regional Basin B11B
Legend
1999 2' Contours
Proposed Grading
N
BLAINE
LINK
1346
1350
1344
1342
1338
1336
1334
1332
1340
1348
1352
1328
1330
1 inch = 100 feet
Disclamer:
All information on this map or digital file is provided "as is" for general information purposes only. The City of Springfield, and all other contributing data suppliers, make no warranties, expressed or implied, concerning the accuracy, completeness, reliability, or suitability or the data for any particular purpose. Furthermore, the City of Springfield, and all other contributing data suppliers, assume no liability whatsoever associated with the use or misuse ot this data.
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
WILSONS CREEK


Regional Basin B11C
Legend
1999 2' Contours
Proposed Grading
N
BLAINE
1338
1340
1342
1344
1346
1348
1350
1352
1336
1334
1332
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
WILSONS CREEK
1 inch = 100 feet
Disclamer:
All information on this map or digital file is provided "as is"
for general information purposes only. The City of Springfield,
and all other contributing data suppliers, make no warranties,
expressed or implied, concerning the accuracy, completeness,
reliability, or suitability or the data for any particular purpose.
Furthermore, the City of Springfield, and all other contributing
data suppliers, assume no liability whatsoever associated with
the use or misuse ot this data.


Regional Basin B12
1349
1353
Proposed Pipes
Legend
Proposed Grading
parcel2
1 inch = 100 feet
WILSONS CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH

Regional Basin B14


Regional Basin B15
1380
1373
Use Existing Pipe
Legend
Proposed Grading
parcel2
1 inch = 100 feet
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
WILSONS CREEK

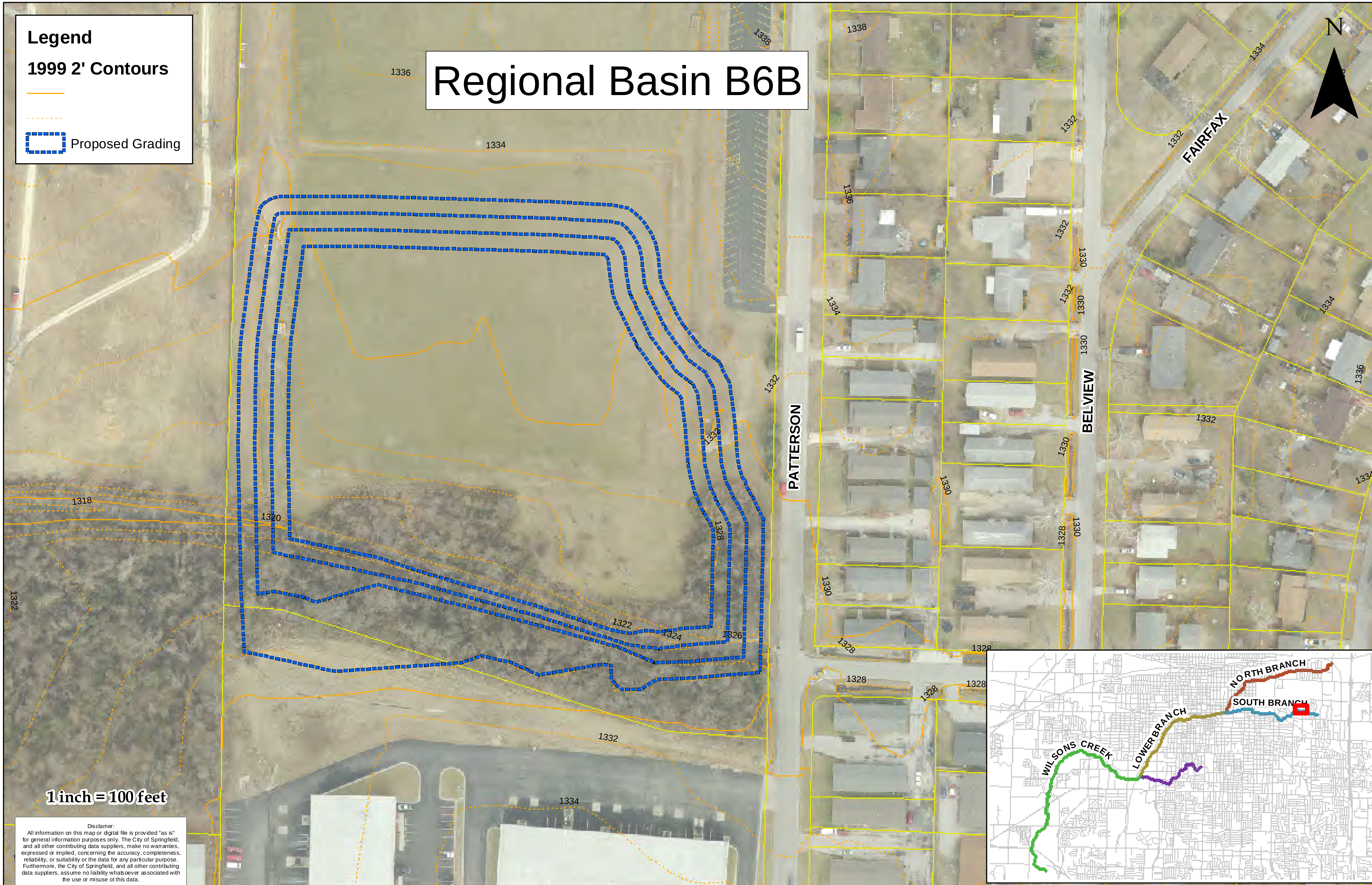
Regional Basin B6

Legend

- Proposed Grading
- parcel2

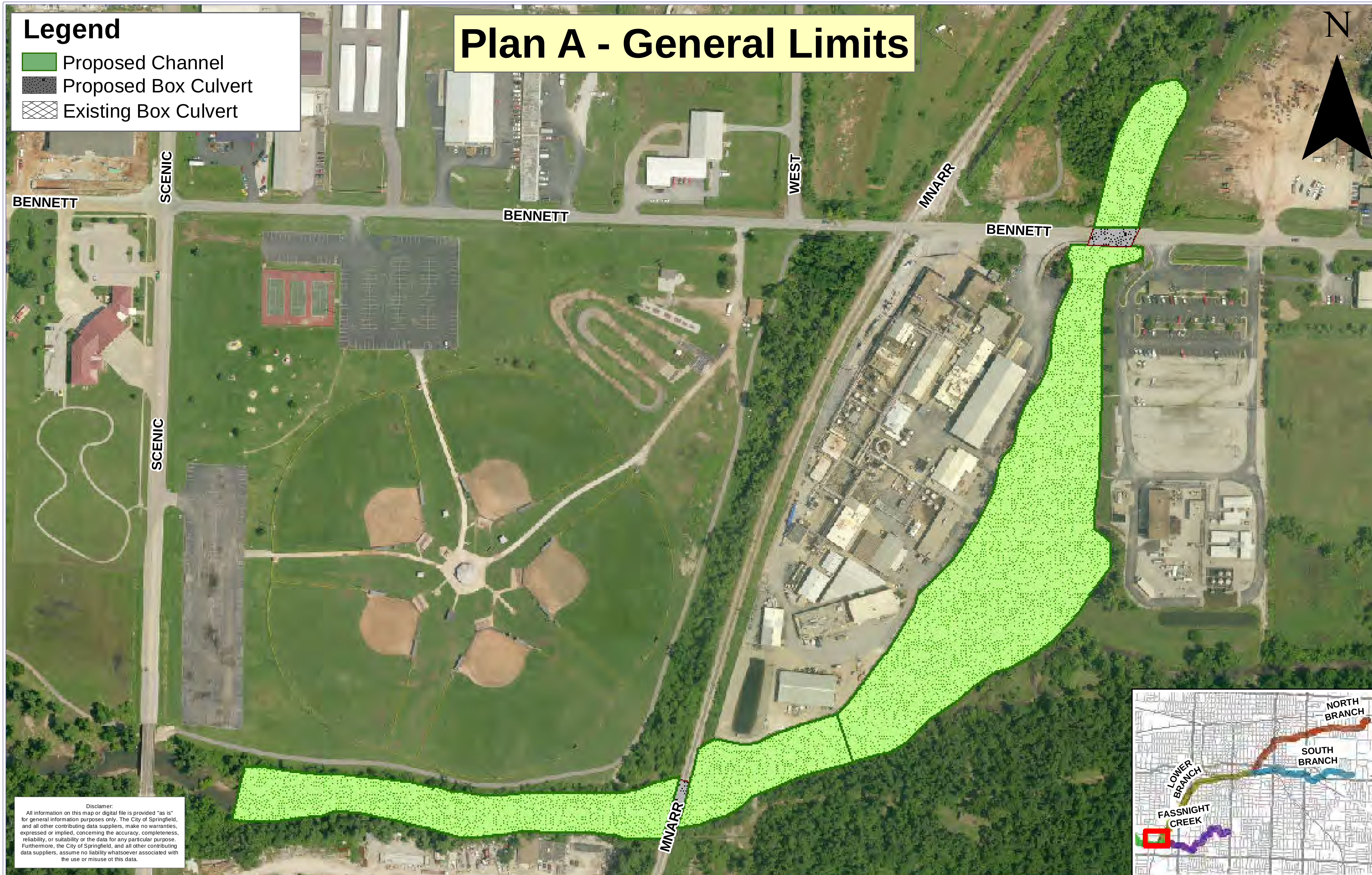
1 inch = 100 feet

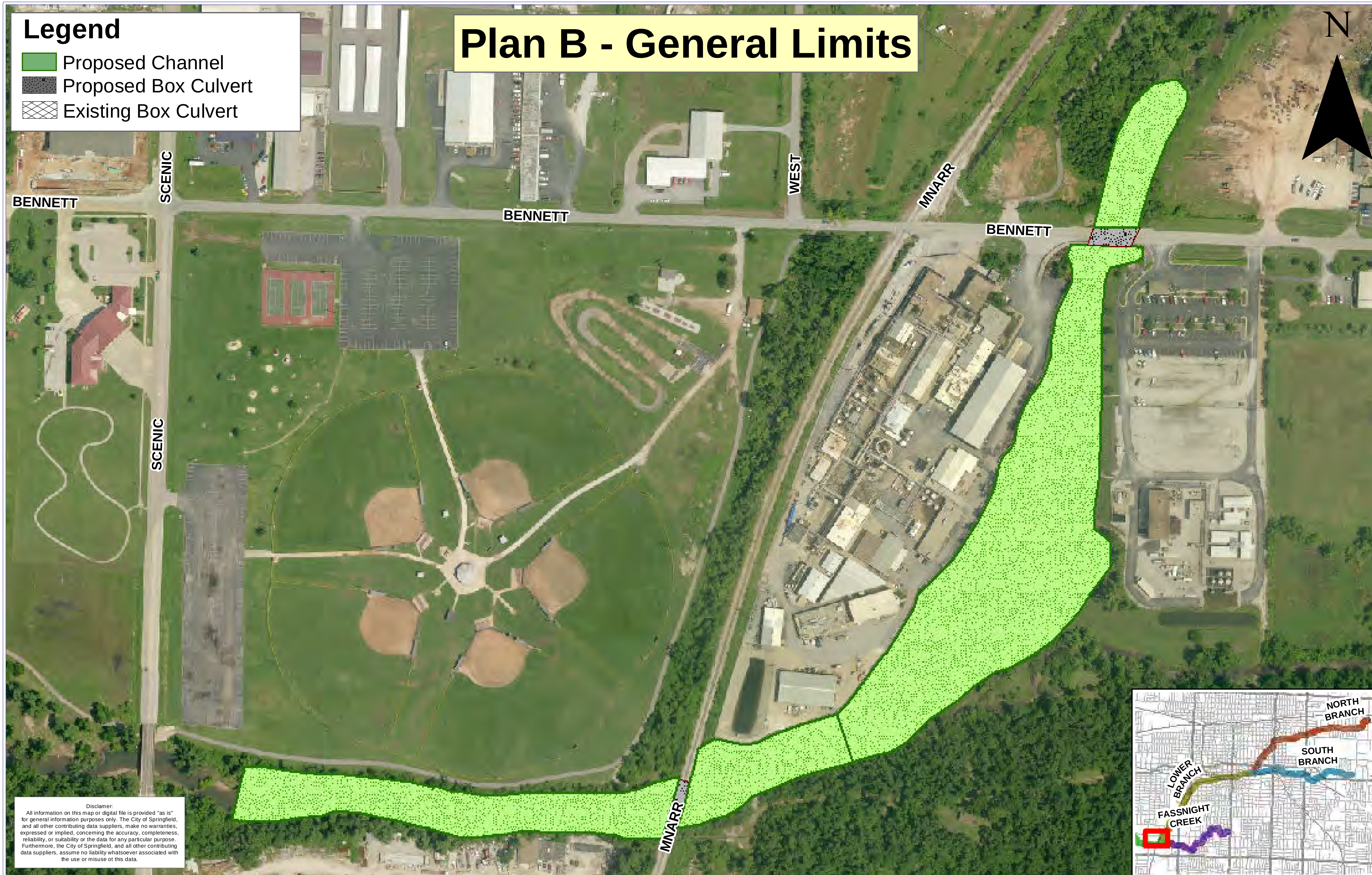
Regional Basin B6B




Regional Basin B7
Pipe System
1 inch = 100 feet
Legend
Proposed Grading
parcel2
ELMWOOD
ROCKHURST
BURTON
CEDARBROOK
CHESTNUT
WILSONS CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
1342
1336
1332
1334
1338
1340


Regional Basin B9B/B9C
Legend
Proposed Grading
parcel2
1 inch = 200 feet
PYTHIAN
CEDARBROOK
BERGMAN
FAIRFAX
LONE PINE
OAK GROVE
CENTRAL
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
WILSONS CREEK


Plan A - General Limits
Legend
Proposed Channel
Proposed Box Culvert
Existing Box Culvert
N
BENNETT
SCENIC
BENNETT
WEST
MNARR
BENNETT
SCENIC
MNARR
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FASSNIGHT CREEK
Disclamer:
All information on this map or digital file is provided "as is"
for general information purposes only. The City of Springfield,
and all other contributing data suppliers, make no warranties,
expressed or implied, concerning the accuracy, completeness,
reliability, or suitability or the data for any particular purpose.
Furthermore, the City of Springfield, and all other contributing
data suppliers, assume no liability whatsoever associated with
the use or misuse ot this data.


Plan B - General Limits
Legend
Proposed Channel
Proposed Box Culvert
Existing Box Culvert
N
BENNETT
SCENIC
BENNETT
WEST
MNARR
BENNETT
SCENIC
MNARR
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FASSNIGHT CREEK
Disclamer:
All information on this map or digital file is provided "as is"
for general information purposes only. The City of Springfield,
and all other contributing data suppliers, make no warranties,
expressed or implied, concerning the accuracy, completeness,
reliability, or suitability or the data for any particular purpose.
Furthermore, the City of Springfield, and all other contributing
data suppliers, assume no liability whatsoever associated with
the use or misuse ot this data.

Appendix HH-A – Sub Basin Information

Sub Basin	*Square Miles*	*Acres*	*Pervious CN*	*Current % Imp*	*Ultimate % Imp*	*Watershed*
F7B	0.2528	161.8	67.0	30.0	40.0	FASSNIGHT CREEK
F15	0.0580	37.1	65.0	15.0	42.0	FASSNIGHT CREEK
F18	0.0423	27.1	65.0	15.0	64.0	FASSNIGHT CREEK
F6	0.2961	189.5	73.0	40.0	45.0	FASSNIGHT CREEK
F11A	0.0772	49.4	74.0	70.0	80.0	FASSNIGHT CREEK
F20	0.0983	62.9	65.0	20.0	58.0	FASSNIGHT CREEK
F9	0.2741	175.4	63.0	35.0	40.0	FASSNIGHT CREEK
F4	0.2283	146.1	76.0	45.0	50.0	FASSNIGHT CREEK
F10	0.1800	115.2	66.0	35.0	40.0	FASSNIGHT CREEK
F21	0.1087	69.6	76.0	8.0	76.0	FASSNIGHT CREEK
F18B	0.0206	13.2	72.0	8.0	79.0	FASSNIGHT CREEK
F12	0.5995	383.7	68.0	38.0	66.0	FASSNIGHT CREEK
F16	0.1072	68.6	62.0	35.0	53.0	FASSNIGHT CREEK
F14	0.1739	111.3	75.0	30.0	40.0	FASSNIGHT CREEK
F11B	0.3152	201.7	64.5	30.0	35.0	FASSNIGHT CREEK
F13	0.4619	295.6	67.0	43.0	56.0	FASSNIGHT CREEK
F22B	0.0834	53.4	60.0	10.0	80.0	FASSNIGHT CREEK
F7A	0.1091	69.8	74.0	40.0	45.0	FASSNIGHT CREEK
F19B	0.0470	30.1	62.0	40.0	82.0	FASSNIGHT CREEK
F7	0.3708	237.3	75.0	35.0	40.0	FASSNIGHT CREEK
F1	0.2336	149.5	74.0	40.0	45.0	FASSNIGHT CREEK
F3B	0.1072	68.6	77.0	25.0	35.0	FASSNIGHT CREEK

F17	0.2188	140.0	62.0	42.0	57.0	FASSNIGHT CREEK
F19	0.0834	53.4	61.0	43.0	61.0	FASSNIGHT CREEK
F22A	0.0430	27.5	64.0	38.0	48.0	FASSNIGHT CREEK
F5	0.2625	168.0	72.0	45.0	50.0	FASSNIGHT CREEK
F22	0.0942	60.3	61.0	5.0	76.0	FASSNIGHT CREEK
F11C	0.1064	68.1	68.0	30.0	43.0	FASSNIGHT CREEK
F2	0.0788	50.4	79.0	80.0	85.0	FASSNIGHT CREEK
F3A	0.0630	40.3	74.0	35.0	45.0	FASSNIGHT CREEK
F8	0.2581	165.2	64.0	40.0	45.0	FASSNIGHT CREEK
F8A	0.0634	40.6	64.0	85.0	85.0	FASSNIGHT CREEK
LJ33	0.0592	37.9	81.9	18.5	66.5	JORDAN CREEK LOWER BRANCH
LJ38	0.0087	5.6	73.0	35.8	82.8	JORDAN CREEK LOWER BRANCH
LJ3	0.0855	54.7	76.4	65.3	81.4	JORDAN CREEK LOWER BRANCH
LJ19F	0.0613	39.2	83.0	25.0	45.0	JORDAN CREEK LOWER BRANCH

Sub Basin	*Square Miles*	*Acres*	*Pervious CN*	*Current % Imp*	*Ultimate % Imp*	*Watershed*
LJ15	0.2859	183.0	77.1	16.9	47.4	JORDAN CREEK LOWER BRANCH
LJ42	0.0102	6.5	78.6	76.9	80.7	JORDAN CREEK LOWER BRANCH
LJ26	0.0287	18.4	82.0	26.7	70.9	JORDAN CREEK LOWER BRANCH
LJ43	0.0295	18.9	78.3	16.5	40.8	JORDAN CREEK LOWER BRANCH
S092	**0.0928**	**59.4**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK LOWER BRANCH**
LJ18	0.1258	80.5	82.0	58.4	75.1	JORDAN CREEK LOWER BRANCH
LJ9	0.0586	37.5	79.5	9.8	47.3	JORDAN CREEK LOWER BRANCH
LJ19A	0.0233	14.9	87.0	95.0	95.0	JORDAN CREEK LOWER BRANCH
LJ29	0.0650	41.6	78.2	13.1	38.1	JORDAN CREEK LOWER BRANCH
LJ39	0.0011	0.7	82.0	96.7	96.7	JORDAN CREEK LOWER BRANCH
LJ44	0.0875	56.0	81.1	63.9	81.2	JORDAN CREEK LOWER BRANCH
LJ8	0.1734	111.0	79.6	38.5	65.0	JORDAN CREEK LOWER BRANCH
LJ12	0.0133	8.5	73.9	54.6	81.0	JORDAN CREEK LOWER BRANCH
LJ24	0.0525	33.6	78.0	13.4	55.6	JORDAN CREEK LOWER BRANCH
LJ34	0.1097	70.2	79.1	23.6	80.8	JORDAN CREEK LOWER BRANCH

LJ40	0.0169	10.8	74.8	85.7	85.7	JORDAN CREEK LOWER BRANCH
LJ23	0.0509	32.6	78.3	81.0	81.0	JORDAN CREEK LOWER BRANCH
LJ16	0.3600	230.4	81.9	38.0	62.6	JORDAN CREEK LOWER BRANCH
LJ13	0.0361	23.1	82.0	83.1	83.1	JORDAN CREEK LOWER BRANCH
LJ5	0.1164	74.5	78.0	22.7	64.5	JORDAN CREEK LOWER BRANCH
LJ19D	0.0069	4.4	87.0	98.0	98.0	JORDAN CREEK LOWER BRANCH
LJ7	0.0727	46.5	84.3	46.4	84.3	JORDAN CREEK LOWER BRANCH
LJ19C	0.0111	7.1	85.0	60.0	75.0	JORDAN CREEK LOWER BRANCH
LJ36	0.1261	80.7	81.9	24.0	48.4	JORDAN CREEK LOWER BRANCH
LJ25	0.4000	256.0	76.2	16.7	61.2	JORDAN CREEK LOWER BRANCH

Sub Basin	*Square Miles*	*Acres*	*Pervious CN*	*Current % Imp*	*Ultimate % Imp*	*Watershed*
LJ31	0.0239	15.3	78.2	64.7	80.6	JORDAN CREEK LOWER BRANCH
LJ27	0.0470	30.1	81.1	63.6	76.8	JORDAN CREEK LOWER BRANCH
LJ22	0.0822	52.6	80.3	18.0	66.6	JORDAN CREEK LOWER BRANCH
LJ30	0.0136	8.7	82.0	96.9	96.9	JORDAN CREEK LOWER BRANCH
LJ2	0.0100	6.4	85.6	7.5	85.6	JORDAN CREEK LOWER BRANCH
LJ6	0.0980	62.7	77.2	9.4	69.5	JORDAN CREEK

						LOWER BRANCH
LJ19H	0.0655	41.9	82.0	30.0	65.0	JORDAN CREEK LOWER BRANCH
LJ45	0.0767	49.1	82.0	53.0	72.1	JORDAN CREEK LOWER BRANCH
LJ21	0.1061	67.9	74.8	15.4	40.0	JORDAN CREEK LOWER BRANCH
LJ46	0.1361	87.1	74.3	25.3	74.3	JORDAN CREEK LOWER BRANCH
LJ17	0.0772	49.4	80.9	15.0	45.4	JORDAN CREEK LOWER BRANCH
LJ41	0.0755	48.3	79.6	70.1	78.4	JORDAN CREEK LOWER BRANCH
LJ4	0.0375	24.0	80.4	54.4	80.9	JORDAN CREEK LOWER BRANCH
LJ11	0.1664	106.5	82.0	27.6	58.8	JORDAN CREEK LOWER BRANCH
LJ35	0.0080	5.1	81.6	79.9	80.0	JORDAN CREEK LOWER BRANCH
LJ19G	0.0331	21.2	87.0	44.0	50.0	JORDAN CREEK LOWER BRANCH
LJ20	0.0394	25.2	80.5	62.9	76.0	JORDAN CREEK LOWER BRANCH
LJ28	0.0353	22.6	72.4	21.2	76.6	JORDAN CREEK LOWER BRANCH
LJ19E	0.0450	28.8	87.0	57.0	65.0	JORDAN CREEK LOWER BRANCH
LJ37	0.0997	63.8	76.5	30.1	68.6	JORDAN CREEK LOWER BRANCH
LJ10	0.0380	24.3	75.4	14.9	83.2	JORDAN CREEK LOWER BRANCH
LJ14	0.0648	41.5	81.0	76.7	81.7	JORDAN CREEK

						LOWER BRANCH
LJ32	0.2433	155.7	76.1	13.1	41.4	JORDAN CREEK LOWER BRANCH
NB8	0.0317	20.3	78.9	30.3	34.4	JORDAN CREEK NORTH BRANCH
NB13	0.0239	15.3	81.1	6.1	80.4	JORDAN CREEK NORTH BRANCH
NB15	0.0322	20.6	81.5	30.2	65.0	JORDAN CREEK NORTH BRANCH
Sub Basin	*Square Miles*	*Acres*	*Pervious CN*	*Current % Imp*	*Ultimate % Imp*	*Watershed*
NB7B	0.0681	43.6	79.1	16.3	80.5	JORDAN CREEK NORTH BRANCH
NB42	0.0673	43.1	78.8	36.9	53.1	JORDAN CREEK NORTH BRANCH
NB56	0.1078	69.0	77.7	40.2	49.6	JORDAN CREEK NORTH BRANCH
NB31	0.0738	47.2	80.9	23.8	77.5	JORDAN CREEK NORTH BRANCH
NB44	0.0995	63.7	76.2	35.0	45.0	JORDAN CREEK NORTH BRANCH
NB23	0.0317	20.3	81.5	82.1	93.0	JORDAN CREEK NORTH BRANCH
NB38	0.0200	12.8	81.3	53.6	80.4	JORDAN CREEK NORTH BRANCH
NB52	0.0477	30.5	78.9	42.6	59.5	JORDAN CREEK NORTH BRANCH
NB6B	0.0489	31.3	79.0	31.2	35.1	JORDAN CREEK NORTH BRANCH
NB37A	0.0148	9.5	77.8	78.1	79.2	JORDAN CREEK NORTH BRANCH
NB34	0.0264	16.9	79.1	86.0	86.0	JORDAN CREEK NORTH BRANCH

NB47	0.0552	35.3	78.8	41.4	62.9	JORDAN CREEK NORTH BRANCH
NB11	0.0458	29.3	83.1	28.4	36.4	JORDAN CREEK NORTH BRANCH
NB55	0.0447	28.6	72.6	37.3	46.2	JORDAN CREEK NORTH BRANCH
NB43B	0.0191	12.2	78.7	51.2	80.7	JORDAN CREEK NORTH BRANCH
NB4	0.0408	26.1	80.6	53.9	81.2	JORDAN CREEK NORTH BRANCH
NB9	0.0716	45.8	77.4	50.9	69.0	JORDAN CREEK NORTH BRANCH
NB7A	0.0214	13.7	78.8	33.6	43.8	JORDAN CREEK NORTH BRANCH
NB12	0.1072	68.6	78.4	48.3	77.9	JORDAN CREEK NORTH BRANCH
NB36B	0.1002	64.1	80.6	27.0	78.6	JORDAN CREEK NORTH BRANCH
NB49A	0.0306	19.6	78.1	51.6	78.2	JORDAN CREEK NORTH BRANCH
NB19	0.0192	12.3	79.1	78.1	79.4	JORDAN CREEK NORTH BRANCH
NB3	0.0155	9.9	81.2	45.8	84.5	JORDAN CREEK NORTH BRANCH
NB32	0.0291	18.6	79.8	80.0	80.5	JORDAN CREEK NORTH BRANCH
NB37B	0.0684	43.8	78.9	77.3	78.8	JORDAN CREEK NORTH BRANCH

NB40A	0.0680	43.5	79.0	7.9	80.4	JORDAN CREEK NORTH BRANCH
Sub Basin	*Square Miles*	*Acres*	*Pervious CN*	*Current % Imp*	*Ultimate % Imp*	*Watershed*
NB17	0.0452	28.9	79.9	24.4	33.7	JORDAN CREEK NORTH BRANCH
NB59	0.0650	41.6	75.7	78.8	84.7	JORDAN CREEK NORTH BRANCH
NB20B	0.0592	37.9	79.1	49.6	58.4	JORDAN CREEK NORTH BRANCH
NB2	0.0758	48.5	80.2	26.2	41.3	JORDAN CREEK NORTH BRANCH
NB18B	0.0445	28.5	81.0	22.4	82.1	JORDAN CREEK NORTH BRANCH
NB39A	0.0525	33.6	74.4	59.0	81.5	JORDAN CREEK NORTH BRANCH
NB49B	0.0231	14.8	78.8	39.2	69.4	JORDAN CREEK NORTH BRANCH
NB6A	0.0550	35.2	80.1	37.4	71.5	JORDAN CREEK NORTH BRANCH
NB45	0.1483	94.9	79.0	43.7	64.7	JORDAN CREEK NORTH BRANCH
NB20A	0.1147	73.4	79.0	49.7	62.6	JORDAN CREEK NORTH BRANCH
NB26A	0.0258	16.5	80.1	36.6	83.9	JORDAN CREEK NORTH BRANCH
NB54	0.0378	24.2	74.5	50.7	66.7	JORDAN CREEK NORTH BRANCH
NB26B	0.0083	5.3	80.4	8.7	60.0	JORDAN CREEK NORTH BRANCH
NB29	0.0394	25.2	82.2	28.0	36.3	JORDAN CREEK NORTH BRANCH

NB36A	0.0481	30.8	79.3	80.9	80.9	JORDAN CREEK NORTH BRANCH
NB48	0.0494	31.6	79.1	40.6	77.7	JORDAN CREEK NORTH BRANCH
NB51	0.0475	30.4	76.5	33.2	63.1	JORDAN CREEK NORTH BRANCH
NB43A	0.0270	17.3	78.2	39.6	79.9	JORDAN CREEK NORTH BRANCH
NB16	0.0106	6.8	78.7	46.8	79.7	JORDAN CREEK NORTH BRANCH
NB5	0.0150	9.6	81.3	28.4	60.0	JORDAN CREEK NORTH BRANCH
NB21	0.0412	26.4	82.3	10.0	65.0	JORDAN CREEK NORTH BRANCH
NB27	0.0480	30.7	79.0	32.4	46.6	JORDAN CREEK NORTH BRANCH
NB33	0.0158	10.1	79.1	58.0	81.0	JORDAN CREEK NORTH BRANCH
NB60	0.1608	102.9	78.1	40.3	59.5	JORDAN CREEK NORTH BRANCH
NB58	0.0536	34.3	70.3	84.8	84.8	JORDAN CREEK NORTH BRANCH
NB41	0.1564	100.1	77.7	9.5	85.4	JORDAN CREEK NORTH BRANCH
Sub Basin	*Square Miles*	*Acres*	*Pervious CN*	*Current % Imp*	*Ultimate % Imp*	*Watershed*
NB57	0.0497	31.8	70.6	40.3	54.5	JORDAN CREEK NORTH BRANCH
NB50	0.0278	17.8	77.4	36.5	56.5	JORDAN CREEK NORTH BRANCH
NB35	0.0080	5.1	79.4	30.6	81.4	JORDAN CREEK NORTH BRANCH
NB1	0.0502	32.1	79.0	61.8	80.6	JORDAN CREEK

						NORTH BRANCH
NB25	0.0278	17.8	79.5	89.9	89.9	JORDAN CREEK NORTH BRANCH
NB24	0.0195	12.5	78.8	85.4	85.4	JORDAN CREEK NORTH BRANCH
NB40B	0.0339	21.7	79.0	48.0	75.6	JORDAN CREEK NORTH BRANCH
NB39B	0.0659	42.2	76.2	58.2	79.7	JORDAN CREEK NORTH BRANCH
NB53	0.0641	41.0	77.6	38.1	48.2	JORDAN CREEK NORTH BRANCH
NB10	0.0409	26.2	82.3	8.1	80.7	JORDAN CREEK NORTH BRANCH
NB18A	0.0328	21.0	80.2	51.5	80.1	JORDAN CREEK NORTH BRANCH
NB46	0.0281	18.0	79.1	42.8	65.0	JORDAN CREEK NORTH BRANCH
NB14	0.0125	8.0	79.4	32.5	80.7	JORDAN CREEK NORTH BRANCH
NB30	0.0177	11.3	79.0	8.4	80.0	JORDAN CREEK NORTH BRANCH
NB28	0.0437	28.0	77.5	76.1	76.1	JORDAN CREEK NORTH BRANCH
NB28	0.0916	58.6	77.5	76.1	76.1	JORDAN CREEK NORTH BRANCH
SJ1	0.0216	13.8	82.0	85.5	85.5	JORDAN CREEK SOUTH BRANCH
G054	0.0517	33.1	87.0	50.0	81.6	JORDAN CREEK SOUTH BRANCH
G064	**0.0497**	**31.8**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
SJ8B	0.0266	17.0	78.9	50.0	81.4	JORDAN CREEK

						SOUTH BRANCH
S090	0.0512	32.8	77.7	12.7	39.8	JORDAN CREEK SOUTH BRANCH
SJ17	0.1091	69.8	81.9	5.9	70.0	JORDAN CREEK SOUTH BRANCH
G133	**0.0344**	**22.0**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
SJ35	0.0486	31.1	74.3	37.4	81.4	JORDAN CREEK SOUTH BRANCH
SJ2	0.0209	13.4	82.0	25.1	81.1	JORDAN CREEK SOUTH BRANCH
SJ8A	0.0234	15.0	78.9	90.0	90.0	JORDAN CREEK SOUTH BRANCH

Sub Basin	*Square Miles*	*Acres*	*Pervious CN*	*Current % Imp*	*Ultimate % Imp*	*Watershed*
SJ18	0.0155	9.9	81.7	64.9	80.6	JORDAN CREEK SOUTH BRANCH
G075	0.0516	33.0	71.0	15.0	34.3	JORDAN CREEK SOUTH BRANCH
G082	0.0278	17.8	70.0	10.0	32.8	JORDAN CREEK SOUTH BRANCH
G255	**0.0166**	**10.6**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
SJ39	0.1319	84.4	79.3	24.7	45.0	JORDAN CREEK SOUTH BRANCH
SJ10	0.0164	10.5	80.3	64.2	80.3	JORDAN CREEK SOUTH BRANCH
G123	0.0856	54.8	76.2	5.0	31.7	JORDAN CREEK SOUTH BRANCH
G137	**0.0559**	**35.8**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
SJ42	0.0314	20.1	74.1	50.7	63.0	JORDAN CREEK SOUTH BRANCH

SJ40	0.1322	84.6	77.6	60.2	70.0	JORDAN CREEK SOUTH BRANCH
S089	0.0570	36.5	78.3	14.2	51.7	JORDAN CREEK SOUTH BRANCH
SJ33	0.1056	67.6	80.2	52.6	69.3	JORDAN CREEK SOUTH BRANCH
G135	**0.0697**	**44.6**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
G038A	0.0958	61.3	76.8	30.0	40.5	JORDAN CREEK SOUTH BRANCH
SJ48	0.1167	74.7	77.9	48.4	70.8	JORDAN CREEK SOUTH BRANCH
SJ4	0.1484	95.0	76.9	15.2	84.8	JORDAN CREEK SOUTH BRANCH
SJ24	0.0894	57.2	82.0	22.1	70.0	JORDAN CREEK SOUTH BRANCH
G045	0.0234	15.0	62.9	5.0	27.5	JORDAN CREEK SOUTH BRANCH
G056	**0.0120**	**7.7**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
G063	**0.0286**	**18.3**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
G058	0.0589	37.7	82.4	10.0	33.0	JORDAN CREEK SOUTH BRANCH
G061W	**0.0692**	**44.3**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
SJ44A	0.0225	14.4	74.1	49.1	82.9	JORDAN CREEK SOUTH BRANCH
G084A	**0.0186**	**11.9**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
G076	0.0155	9.9	70.9	5.0	31.4	JORDAN CREEK SOUTH BRANCH

SJ27	0.1405	89.9	78.3	48.0	82.5	JORDAN CREEK SOUTH BRANCH
Sub Basin	*Square Miles*	*Acres*	*Pervious CN*	*Current % Imp*	*Ultimate % Imp*	*Watershed*
SJ19A	0.0159	10.2	82.0	85.7	85.7	JORDAN CREEK SOUTH BRANCH
SJ44B	0.0483	30.9	74.6	61.5	80.9	JORDAN CREEK SOUTH BRANCH
SJ36	0.1336	85.5	79.2	39.3	61.6	JORDAN CREEK SOUTH BRANCH
SJ13	0.0222	14.2	79.0	19.5	80.4	JORDAN CREEK SOUTH BRANCH
SJ23	0.0498	31.9	81.4	7.1	70.0	JORDAN CREEK SOUTH BRANCH
SJ7	0.0222	14.2	72.6	63.8	81.0	JORDAN CREEK SOUTH BRANCH
SJ49	0.1819	116.4	77.1	17.5	50.0	JORDAN CREEK SOUTH BRANCH
G128	0.0189	12.1	77.3	29.3	29.3	JORDAN CREEK SOUTH BRANCH
SJ45	0.0434	27.8	78.6	47.6	60.0	JORDAN CREEK SOUTH BRANCH
SJ5	0.0677	43.3	77.6	54.9	72.0	JORDAN CREEK SOUTH BRANCH
SJ3	0.0241	15.4	81.2	39.2	82.4	JORDAN CREEK SOUTH BRANCH
SJ11	0.0338	21.6	78.4	37.8	80.1	JORDAN CREEK SOUTH BRANCH
G052	0.1106	70.8	69.9	15.0	30.0	JORDAN CREEK SOUTH BRANCH
SJ15	0.1200	76.8	79.4	10.3	44.1	JORDAN CREEK SOUTH BRANCH
SJ29	0.0642	41.1	80.6	44.8	80.8	JORDAN CREEK

						SOUTH BRANCH
G084B	**0.0209**	**13.4**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
G038	0.2072	132.6	64.0	50.0	56.2	JORDAN CREEK SOUTH BRANCH
SJ26	0.1703	109.0	76.6	18.9	59.6	JORDAN CREEK SOUTH BRANCH
G083	0.0781	50.0	76.8	15.0	34.8	JORDAN CREEK SOUTH BRANCH
SJ22	0.0658	42.1	80.2	27.3	80.9	JORDAN CREEK SOUTH BRANCH
S071	**0.0434**	**27.8**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
SJ41	0.0775	49.6	77.9	16.4	50.0	JORDAN CREEK SOUTH BRANCH
G061A	**0.0139**	**8.9**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
G073	**0.0806**	**51.6**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
G058	0.0003	0.2	82.4	10.0	33.0	JORDAN CREEK SOUTH BRANCH
SJ38	0.1095	70.1	81.8	32.7	80.4	JORDAN CREEK SOUTH BRANCH
Sub Basin	*Square Miles*	*Acres*	*Pervious CN*	*Current % Imp*	*Ultimate % Imp*	*Watershed*
G047	0.0203	13.0	64.8	2.0	24.3	JORDAN CREEK SOUTH BRANCH
G134	**0.1614**	**103.3**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
SJ14	0.0455	29.1	78.8	64.0	82.8	JORDAN CREEK SOUTH BRANCH
G061E	**0.1195**	**76.5**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**

G090	**0.0133**	**8.5**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
G079	**0.0144**	**9.2**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
SJ34	0.0313	20.0	75.7	44.2	81.7	JORDAN CREEK SOUTH BRANCH
S088	0.0448	28.7	78.5	14.5	50.3	JORDAN CREEK SOUTH BRANCH
SJ37	0.1600	102.4	76.4	34.0	72.0	JORDAN CREEK SOUTH BRANCH
SJ19	0.0516	33.0	81.4	46.5	79.2	JORDAN CREEK SOUTH BRANCH
G253	**0.0138**	**8.8**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
SJ25	0.1091	69.8	78.8	19.7	78.1	JORDAN CREEK SOUTH BRANCH
G050A	0.0442	28.3	80.0	20.0	34.7	JORDAN CREEK SOUTH BRANCH
SJ21	0.0978	62.6	81.9	5.9	70.0	JORDAN CREEK SOUTH BRANCH
SJ6	0.1542	98.7	79.7	47.9	67.0	JORDAN CREEK SOUTH BRANCH
G050	0.0308	19.7	72.4	6.0	26.0	JORDAN CREEK SOUTH BRANCH
G055	**0.0744**	**47.6**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
G093	0.0866	55.4	77.0	10.0	34.4	JORDAN CREEK SOUTH BRANCH
SJ20	0.1191	76.2	80.4	19.2	54.5	JORDAN CREEK SOUTH BRANCH
SJ31	0.0245	15.7	76.2	61.5	81.1	JORDAN CREEK SOUTH BRANCH

SJ12	0.0127	8.1	79.5	58.1	80.7	JORDAN CREEK SOUTH BRANCH
SJ30	0.0138	8.8	81.8	48.5	71.5	JORDAN CREEK SOUTH BRANCH
G077	0.0139	8.9	72.9	8.0	30.7	JORDAN CREEK SOUTH BRANCH
SJ28	0.0697	44.6	81.5	74.0	77.1	JORDAN CREEK SOUTH BRANCH
SJ16	0.1086	69.5	79.7	14.4	46.7	JORDAN CREEK SOUTH BRANCH
SJ47	**0.0116**	**7.4**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**

Sub Basin	*Square Miles*	*Acres*	*Pervious CN*	*Current % Imp*	*Ultimate % Imp*	*Watershed*
G051	0.0217	13.9	66.7	23.0	23.0	JORDAN CREEK SOUTH BRANCH
SJ9	0.0167	10.7	79.8	54.1	80.9	JORDAN CREEK SOUTH BRANCH
SJ43	0.0200	12.8	73.0	63.7	79.2	JORDAN CREEK SOUTH BRANCH
SJ32	0.0356	22.8	80.9	48.2	84.7	JORDAN CREEK SOUTH BRANCH
G113	0.1683	107.7	77.5	12.0	34.1	JORDAN CREEK SOUTH BRANCH
SJ46	0.0900	57.6	76.5	40.7	67.8	JORDAN CREEK SOUTH BRANCH
G113A	**0.0483**	**30.9**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**

**Highlighted Basins have been excluded from the model because they do not contribute flow due to the presence of a sinkhole or quarry.

Appendix HH-B – Modified-Puls Routing Elements

South Branch

	From STA	1729		**To STA**		2584				**MP44**		
		Volume				Volume			**Flow**	**Volume**		
50% 1yr		2.68		**3**		3.98		**4**	**262**	**1**	Length	855
1yr	0	4.26	0.45	**5**	0	6.89	5.8	**13**	**524**	**8**	Velocity	2.6
10yr	3.89	7.77	13.6	**25**	4.39	12.91	52.12	**69**	**1480**	**44**	**NSTPS**	**5**
25yr	6.25	8.27	18.38	**33**	7.01	13.7	61.63	**82**	**1941**	**49**		
100yr	10.98	9.02	27.3	**47**	12.35	14.84	77.09	**104**	**2715**	**57**		
500yr	16.06	9.68	36.09	**62**	18.53	15.9	92.62	**127**	**3651**	**65**		
150% 500yr	26.35	10.76	51.49	**89**	31.74	17.6	118.9	**168**	**5476.5**	**80**		

South Branch

	From STA	1224		**To STA**		1729				**MP44B**		
		Volume				Volume			**Flow**	**Volume**		
50% 1yr		1.82		**2**		2.68		**3**	**308**	**1**	Length	505
1yr	0	2.89	0.03	**3**	0	4.26	0.45	**5**	**616**	**2**	Velocity	1.9
10yr	3.19	5.52	6.03	**15**	3.89	7.77	13.6	**25**	**1716**	**11**	**NSTPS**	**4**
25yr	5.09	5.92	8.8	**20**	6.25	8.27	18.38	**33**	**2256**	**13**		
100yr	8.97	6.55	14.93	**30**	10.98	9.02	27.3	**47**	**3159**	**17**		
500yr	12.93	7.08	20.7	**41**	16.06	9.68	36.09	**62**	**4178**	**21**		
150% 500yr	21.16	7.95	31.01	**60**	26.35	10.76	51.49	**89**	**6267**	**28**		

South Branch

	From STA	297		**To STA**		1178				**MP45**		
		Volume				Volume			**Flow**	**Volume**		
50% 1yr		0.51		**1**		1.74		**2**	**312**	**1**	Length	881
1yr		0.83	0.03	**1**	0	2.77	0.03	**3**	**624**	**2**	Velocity	3.23
10yr	0.93	1.76	1.08	**4**	3.13	5.36	5.82	**14**	**1751**	**11**	**NSTPS**	**5**
25yr	2.16	1.93	2.28	**6**	4.98	5.75	8.42	**19**	**2297**	**13**		

100yr	3.37	2.08	3.39	**9**	8.77	6.36	14.24	**29**	**3204**	**21**
500yr	4.66	2.23	4.45	**11**	12.63	6.88	19.74	**39**	**4231**	**28**
150% 500yr	7.68	2.51	6.6	**17**	20.62	7.74	29.51	**58**	**6346.5**	**41**

South Branch

	From STA	9178			**To STA**	11192				**MP27**		
		Volume				Volume			**Flow**	**Volume**		
50% 1yr	0.88	7.97	1.02	**10**	0.89	9.72	1.05	**12**	**124**	**2**	Length	2014
1yr	1.27	11.89	2.29	**15**	1.37	14.78	2.43	**19**	**248**	**3**	Velocity	5.14
10yr	9.54	23.57	12.57	**46**	12.8	32.28	15.01	**60**	**809**	**14**	**NSTPS**	**7**
25yr	13.78	25.68	16.23	**56**	21.91	36.66	23.57	**82**	**1043**	**26**		
100yr	21.09	28.51	24.74	**74**	41.55	43.8	45.08	**130**	**1487**	**56**		
500yr	33.19	32.78	41.32	**107**	58.56	49.37	66.6	**175**	**2024**	**67**		
150% 500yr	48.45	37.75	66.77	**153**	80.53	55.87	98.32	**235**	**3036**	**82**		

Lower Branch

	From STA	9865			**To STA**	12068				**MP8**		
		Volume				Volume			**Flow**	**Volume**		
50% 1yr	1.65	46.58	7.22	**55**	1.65	53.49	7.28	**62**	**708**	**7**	Length	2203
1yr	8.92	75.84	29.77	**115**	8.92	87.36	30.46	**127**	**1415**	**12**	Velocity	2.25
10yr	102.4	147.1	230	**479**	110.6	168.8	271.6	**551**	**3949**	**71**	**NSTPS**	**16**
25yr	148	160.6	321.3	**630**	161.6	184.3	379.2	**725**	**4858**	**95**		
100yr	227.9	180.4	456.5	**865**	250.4	206.9	540	**997**	**6340**	**132**		
500yr	331.5	201.1	607.2	**1140**	363.7	230.3	718.4	**1312**	**8048**	**172**		
150% 500yr	681.3	254	1053	**1988**	733.5	288.1	1225	**2246**	**12072**	**258**		

Lower Branch

<u>From STA</u>		320		**<u>To STA</u>**		2359				**MP34**		
		Volume				Volume			**<u>Flow</u>**	**<u>Volume</u>**		
50% 1yr	0.2	2.22		**2**	1.58	11.28	3.19	**16**	**960**	**14**	Length	2039
1yr	1.33	4.9	0	**6**	8.28	17.9	13.38	**40**	**1920**	**33**	Velocity	1.3
10yr	8.18	13.06	0.13	**21**	60	36.35	68.76	**165**	**5181**	**144**	**NSTPS**	**26**
25yr	13.3	15.62	7.04	**36**	88.68	41.83	117.3	**248**	**6617**	**212**		
100yr	21.9	19.59	27.53	**69**	145.2	50.79	194	**390**	**8869**	**321**		
500yr	32.09	23.88	39.97	**96**	216.6	61.42	283.8	**562**	**11242**	**466**		
150% 500yr	61.57	34.03	78.28	**174**	412.8	87.89	543.8	**1044**	**16863**	**871**		

Lower Branch

<u>From STA</u>		2432		**<u>To STA</u>**		4081				**MP6**		
		Volume				Volume			**<u>Flow</u>**	**<u>Volume</u>**		
50% 1yr	1.58	11.63	3.2	**16**	1.65	20.43	3.2	**25**	**960**	**9**	Length	1649
1yr	8.3	18.36	13.45	**40**	8.84	31.74	14.01	**55**	**1920**	**14**	Velocity	4.3
10yr	60.44	37.07	69.46	**167**	73.32	58.75	91.85	**224**	**5181**	**57**	**NSTPS**	**6**
25yr	89.67	42.67	119	**251**	111.5	66.84	156.3	**335**	**6617**	**83**		
100yr	146.7	51.73	196.6	**395**	177.3	77.58	241.9	**497**	**8869**	**102**		
500yr	219.1	62.44	288.1	**570**	259.5	90.27	344.9	**695**	**11242**	**125**		
150% 500yr	420.3	89.32	555.9	**1065**	558.5	128.2	699.8	**1386**	**16863**	**321**		

Lower Branch

<u>From STA</u>		4137		**<u>To STA</u>**		4419				**MP2**		
		Volume				Volume			**<u>Flow</u>**	**<u>Volume</u>**		
50% 1yr	1.65	20.71	3.2	**26**	1.65	22.23	3.21	**27**	**912**	**2**	Length	282
1yr	8.84	32.17	14.02	**55**	8.86	34.72	14.66	**58**	**1824**	**3**	Velocity	2.2
10yr	73.51	59.33	92.24	**225**	78.8	64.66	105.1	**249**	**4926**	**24**	**NSTPS**	**2**
25yr	112	67.49	157.6	**337**	117.7	72.98	171.3	**362**	**6240**	**25**		
100yr	178.2	78.33	243.8	**500**	185.5	84.23	259.9	**530**	**8305**	**29**		
500yr	262.6	91.11	347.3	**701**	275.6	97.46	366.3	**739**	**10459**	**38**		

150% 500yr	563	129.1	702.9	**1395**	579.2	135.9	724.4	**1440**	**15689**	**44**		
Lower Branch												
<u>From STA</u>		4419		**<u>To STA</u>**		7848				**MP25**		
		Volume				Volume			**<u>Flow</u>**	**<u>Volume</u>**		
50% 1yr	1.65	22.23	3.21	**27**	1.65	36.77	7.22	**46**	**912**	**19**	Length	3429
1yr	8.86	34.72	14.66	**58**	8.91	58.39	29.74	**97**	**1824**	**39**	Velocity	2.2
10yr	78.8	64.66	105.1	**249**	94.78	110.8	205.6	**411**	**4926**	**163**	**NSTPS**	**26**
25yr	117.7	72.98	171.3	**362**	137.2	122.4	289.5	**549**	**6240**	**187**		
100yr	185.5	84.23	259.9	**530**	211.9	139	411.7	**763**	**8305**	**233**		
500yr	275.6	97.46	366.3	**739**	310.4	157.3	551	**1019**	**10459**	**279**		
150% 500yr	579.2	135.9	724.4	**1440**	647.5	204.6	968.6	**1821**	**15688.5**	**381**		
North Branch												
<u>From STA</u>		335		**<u>To STA</u>**		2800				**MP58**		
		Volume				Volume			**<u>Flow</u>**	**<u>Volume</u>**		
50% 1yr		0.58		**1**		2.99		**3**	**329**	**2**	Length	2465
1yr		1.02	0.03	**1**		5.3	0.04	**5**	**657**	**4**	Velocity	2
10yr	1.1	2.69	2.35	**6**	1.48	9.98	11.8	**23**	**1789**	**17**	**NSTPS**	**21**
25yr	1.85	2.93	3.61	**8**	3.98	11.4	17.24	**33**	**2261**	**24**		
100yr	2.77	3.21	5.15	**11**	6.61	13.23	26.15	**46**	**3030**	**35**		
500yr	3.82	3.47	6.73	**14**	9.71	14.37	34.86	**59**	**3909**	**45**		
150% 500yr	6.51	3.95	10.27	**21**	16.76	16.23	50.08	**83**	**5863.5**	**62**		

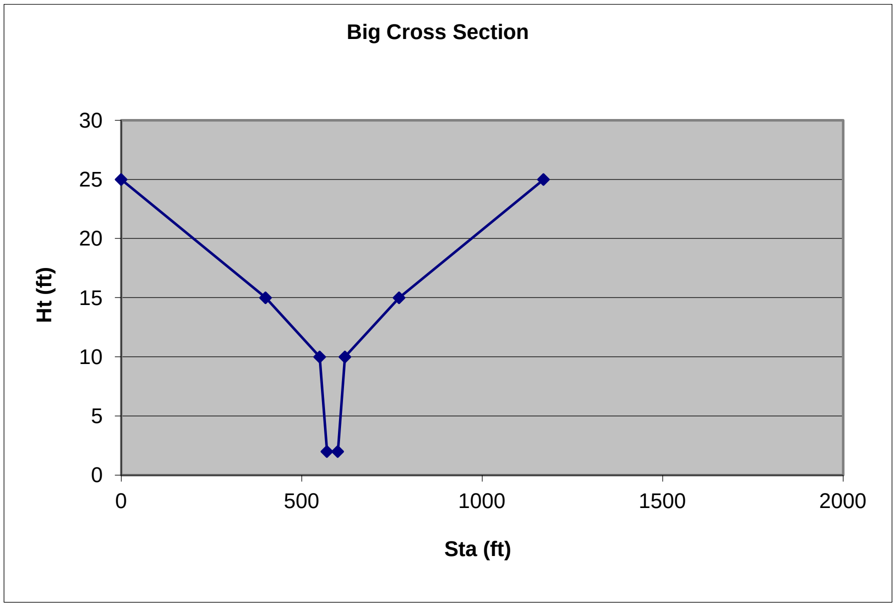
Velocity is avg of 100yr US and DS.

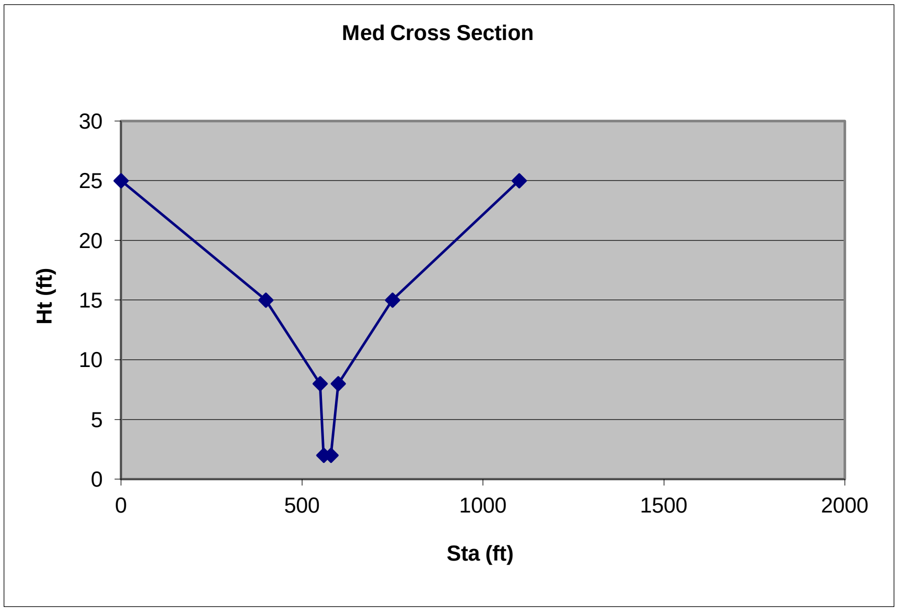
Appendix HH-C – Ultimate Impervious Values Based on Zoning

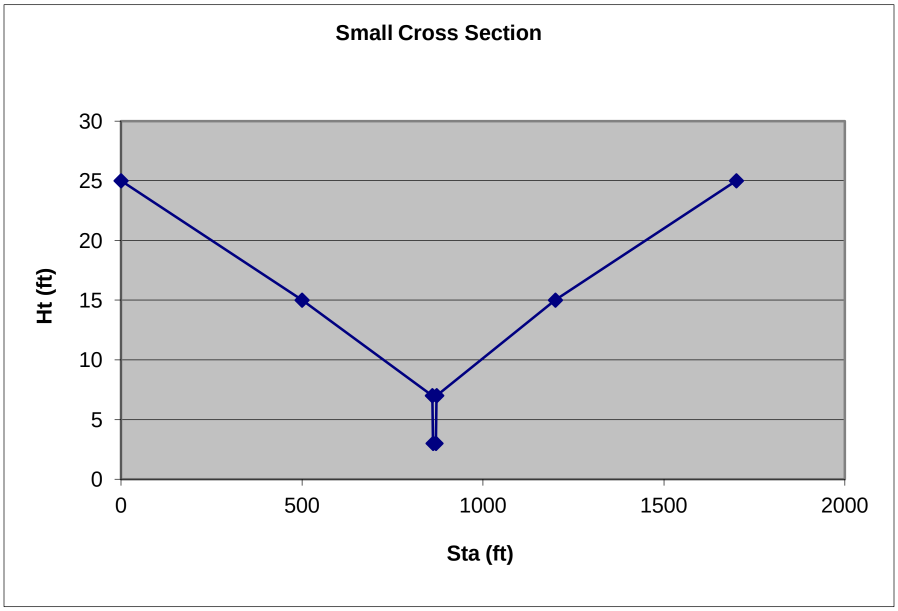
These impervious percentages have been estimated by the City of Springfield's Storm Water Services Division for the purpose of estimating runoff for the USACE Jordan Creek Study.

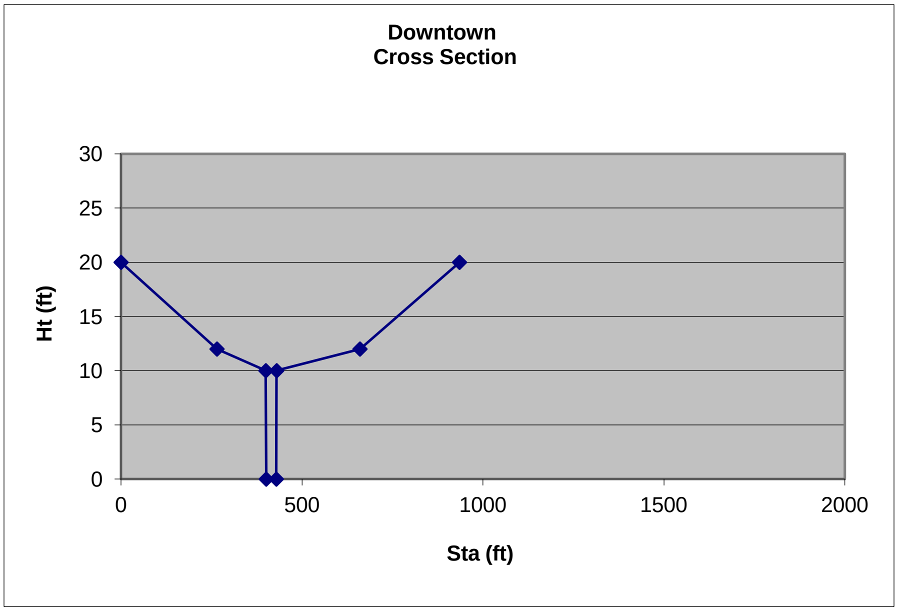
Zoning District	Description	% Impervious
R-SF	Single Family Residential	25
R-TH	Townhouse Residential	40
R-LD	Low-Density Multi-Family Residential	45
PD	Planned Development	85
AO	Airport Overlay	75
LB	Limited Business	60
GR	General Retail	75
HC	Highway Commercial	85
CS	Commercial Service	72
CC	Center City	72
RI	Restricted Industrial	72
LI	Light Industrial	70
R-MD	Medium-Density Multi-Family Residential	55
R-HD	High-Density Multi-Family Residential	60
R-MHC	Manufactured Homes	20
O-1	Office	70
O-1	Office	70
GI	Governmental and Institutional	80
UN	University	40
UC	Urban Conservation	10
L	Landmarks	45
GM	General Manufacturing	80
HM	Heavy Manufacturing	80
IC	Industrial Commercial	85

Appendix HH-D – Dynamic Routing Cross Sections






Small Cross Section
30
25
20
15
10
5
0
Ht (ft)
0
500
1000
1500
2000
Sta (ft)


Downtown
Cross Section
30
25
20
15
10
5
0
Ht (ft)
0
500
1000
1500
2000
Sta (ft)

Appendix HH-E – Historic Flood Photos

South Branch of Jordan Creek at Fremont Avenue (looking South along Fremont Ave) July 12, 2000 South Branch RS 4647

South Branch of Jordan Creek at National Avenue and Chestnut Expressway (looking South along National Ave) July 12, 2000. Note that the depth of water at this time is approximately 2-feet over National. This photo was taken after the peak of the storm has occurred.

South Branch RS 2830.

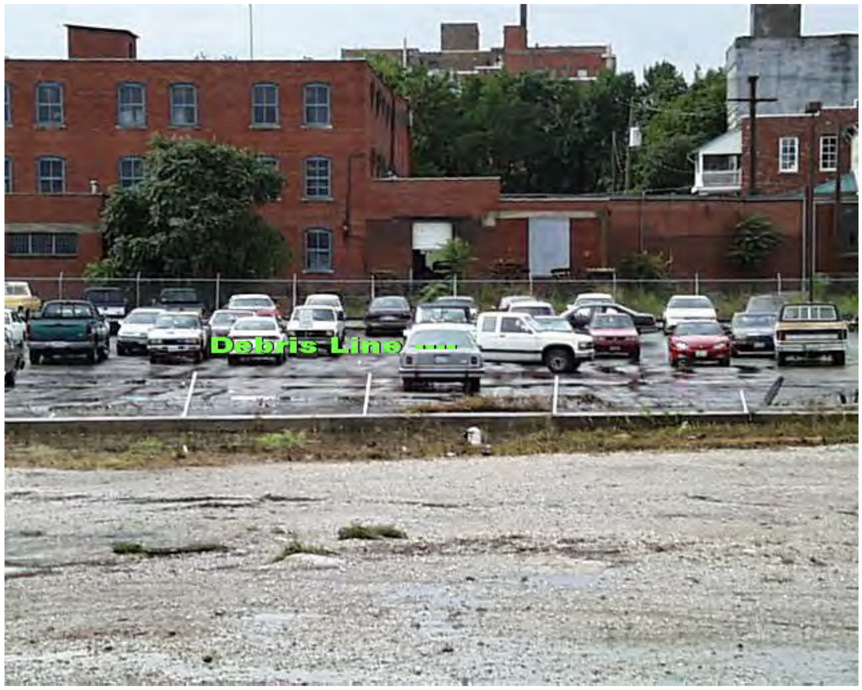
South Branch of Jordan Creek (looking south at Pharmaceutical Manufacturing Plant South of Bennett Street) July 12, 2000. This photo was taken at approximately 6:30 AM, after the peak flow had occurred. Many structures in this facility were flooded during this event.

(Lower Branch RS 621)

South Branch of Jordan Creek (looking south across Chestnut Expressway and the river valley, just downstream of National Avenue (Lower Branch RS 2174). July 12, 2000.

Lower Branch of Jordan Creek. 210 N Nettleton Avenue (Lower Branch RS 9211). The debris line on the garage door measures 34-inches from the floor. The FFE of the building is 1248.14, giving a WSE of 1250.97. This photo was taken after flood waters receded on July 12, 2000. See Appendix F for WSE comparison.

North Branch of Jordan Creek, on N Hampton Avenue crossing. (North Branch RS 3825). The debris line on the ground is estimated at elevation 1292+. This photo was taken after flood waters receded on July 12, 2000. See Appendix F for WSE comparison.



Lower Branch of Jordan Creek, at 410 N Boonville Avenue (between Lower Branch RS 14607 & 14941). The ground elevation is estimated at 1269.5 with an estimated distance of 3.5-ft to the top of the trunk. This photo was taken after flood waters receded on July 12, 2000. See Appendix F for WSE comparison.

Appendix HH-F – Model Comparisons with Observed High Water Marks and Stream Gage Data

The following appendix shows a comparison of the Without Project Current Conditions hydraulic and hydrologic models with stream gage data and observed high water marks from various recorded storm events. These comparisons do not attempt to comment on the accuracy of the models nor do they constitute a model calibration. The accuracy of many of these observations is subject to the time the observation was made, the accuracy with which the high water mark was estimated, the accuracy of available rainfall data, and the precision of the gage data.

Storm Event	Location of Observation	Notes	Estimated Flood Height	Corresponding WSE from "Jordan Creek Feasibility Study"	Difference
12-Jul-00	410 N Boonville Ave between RS 14607 and 14941 on Lower Branch	Flood height estimated from photo of a car in parking lot showing a debris line on trunk. Used limited survey data to establish ground elevation.	1273	1274.5	-1.5
12-Jul-00	634 E Phelps, 120-ft downstream of RS 248 on South Branch	Flood height reported by Commercial Metals	1275	1277	-2
12-Jul-00	509 N Washington Ave. at RS 16377 on Lower Branch	Flood height reported by property owner	1275.9	1276.68	-0.78
12-Jul-00	N Hampton Ave. upstream of RS 3825 on North Branch	Flood height estimated from photo of debris line and limited survey data.	1292	1292.68	-0.68

12-Jul-00	210 N Nettleton Ave. at RS 9211	Flood height estimated from photo of debris line and FFE survey of building.	1250.97	1252.97	-2
12-Jul-00	Pharmaceutical Manufacturing Plant - Downstream of Bennett Street on Lower Branch	WSE reported from stream gage.	1219.8	1219.95	-0.15
13-Jun-08	634 E Phelps, 120-ft downstream of RS 248 on South Branch	Flood height reported by Commercial Metals	1273.5	*1275.2 (10-yr) 1275.78 (25-yr)	**-1.99
13-Jun-08	509 N Washington Ave. at RS 16377 on Lower Branch	Flood height reported by property owner	1273.5	*1274.54 (10-yr) 1275.55 (25-yr)	**-1.55
13-Jun-08	600 N Prospect Ave. at RS 3977	Measured debris line from floor of building. FFE is known.	1290.9	*1290.37 (10-yr) 1290.69 (25-yr)	**.37

*Estimated frequency of storm is 10 to 25-yr.

**Average of 10-yr and 25-yr WSE was used for comparison.

Storm Event	USGS Gage at Scenic Ave. (Gage #07052000)	Estimated Frequency of Storm from City's Rain Gage Network	Peak Flow from "Jordan Creek Feasibility Study"
12-Jul-00	*6750	50-100yr	8355-9859 cfs
8-May-02	4360 cfs	5yr	4457 cfs
15-Sep-05	2890 cfs	2-5 yr	**3303-3914 cfs
13-Jun-08	5760 cfs	10-25yr (2 gages reporting 10-yr, 1 gage reporting 25-yr)	5530-6995 cfs

*Gage data was shown to be incorrect. USGS revised the reading, but there still may be issues with its accuracy.

**Peak flows are a result of simulating the 1 and 2hr storm events.

Appendix HH-G – October 2004 Stream Photos

The following appendix includes photos and documentation from the site visit taken by Travis Stanford, CEWL-EC-HH on October 25-29, 2004:

DATE: 5-Nov-04
REF: Springfield, MO - Section 905b Study
SUBJ: Notes from Site Visit of 25-29 October 2004
BY: Travis Stanford, CESWL-EC-HH

<u>The site visit included field inspection of the following stream reaches:</u>

North Branch Jordan Creek: Packer Road crossing D/S to confluence with South Branch Jordan Creek
South Branch Jordan Creek: Cedarbrook Avenue crossing D/S to confluence with North Branch Jordan Creek
Jordan Creek: Head of Jordan Creek at confluence of North and South Branches D/S to head of Wilson Creek at confluence of Jordan Creek with Fassnight Creek
Wilson Creek: Head of Wilson Creek at confluence of Jordan Creek with Fassnight Creek D/S to U.S. Hwy 160 (West Bypass) crossing

<u>The site visit included field inspection of the following tunnels:</u>

Jordan Underground Tunnel
North Branch Fremont to National Tunnel
South Branch Fremont to National Tunnel
Tindle Mills Tunnel
Cooper Supply and RR Tunnel

Insp. Date: **26-Oct-04**

North Branch Jordan Creek

Walked D/S from Packer Road crossing to confluence of North Branch with South Branch just east of Washington St. at U/S end of Jordan Underground.

RR embankments in vicinity of Packer Road crossing form three significant detention areas U/S of Packer Road and one lesser detention area D/S of Packer Road, all of which feed North Branch Jordan Creek.

Photo Sequence #	Filename	Description / Notes
14	DCP_3683	D/S from Packer Road crossing.
		Riprap channel bed lining extends D/S about 700 FT then intermittent stretches of riprap and natural cobble to U/S end of detention pond. Grasslined side slopes typical this reach. Packer Road to detention pond reach reconstructed about 10 years ago as per Errin Kemper.
15	DCP_3684	D/S from about 700 FT below Packer Road. Directly behind first business on left bank downstream of and fronting on Packer Road.
16	DCP_3685	D/S from U/S end of detention pond constructed by the city. Blaine St. runs along south side of basin (to left of photo). Pond outlet is just U/S of intersection of Blaine St. with Old Orchard St.
17	DCP_3686	D/S from right bank levee at detention pond outlet.
18	DCP_3687	D/S at Blaine St. north side ditch at confluence with detention pond outlet.
		+/- 1.5 hours after brief morning storm observed leading edge of runoff migrating down Blaine St. south side ditch at this location.
19	DCP_3688	D/S from intersection of Blaine and Yates.
20	DCP_3689	U/S at ditch on west side of Yates from intersection of Blaine and Yates.
		Eastmost route for Industrial Park runoff into North Branch Jordan Creek. Observed leading edge of runoff migrating down this ditch at about 0930 hours.
21	DCP_3690	D/S at +/- 2.5 FT tall low flow diversion structure. Intersection of Blaine and Hayes is to left of photo.
		Structure diverts flow from the north side to the south side of Blaine through a culvert which connects to the culvert at the Hayes St. crossing of the ditch on the south side of Blaine. Flow overtopping the diversion structure continues D/S in the north side ditch to the intersection of Blaine and Barnes where high flows overtop Blaine and flow across the Blaine/Barnes intersection into the channel D/S of Barnes.
22	DCP_3691	D/S at Hayes St. crossing of the ditch along the south side of Blaine St.
23	DCP_3692	D/S from intersection of Barnes and Blaine.
		Channel migrates southward from Blaine St. Channel changes abruptly from clean grasslined above Barnes St. to thick brushy banks below Barnes St.
24	DCP_3693	D/S at channel from D/S face of Barnes St.
25	DCP_3694	Location is D/S of Barnes St. where business drive to Springfield Bumper and Body Parts crosses channel. Looking U/S at channel.
26	DCP_3695	Location is D/S of Barnes St. where business drive to Springfield Bumper and Body Parts crosses channel. Looking D/S at channel. Crossing seen just D/S is business drive to Design Fabrication.
27	DCP_3696	Location is detention pond behind Cabinet Mart, Inc. on south side of Blaine between Barnes and Glenstone. Looking D/S at detention pond wall along right bank of channel.
28	DCP_3697	Location is detention pond behind Cabinet Mart, Inc. on south side of Blaine between Barnes and Glenstone. Looking D/S at channel from D/S (SW) corner of detention pond where detention pond low flow outlet is located.
29	DCP_3698	Location is detention pond behind Cabinet Mart, Inc. on south side of Blaine

		between Barnes and Glenstone. Looking U/S from left bank just below detention pond outlet located at SW corner of pond. Low flow outlet active but not visible. Clogged but flowing this day.
		Incised channel with wooded and thicketed overbanks typical from Cabinet Mart detention pond outlet D/S to +/- 600 FT U/S of Glenstone, then transitions to broad broad wetland type area (thick grass/weeds and scattered willows) that continues D/S to parking lots U/S of Glenstone crossing.
30	DCP_3699	D/S from left bank at culverts under parking lot and Glenstone.
31	DCP_3700	U/S from U/S end of culverts under parking lot and Glenstone.
32	DCP_3701	D/S from D/S end of culverts under parking lot and Glenstone.
33	DCP_3702	D/S from right bank at D/S end of culverts under parking lot and Glenstone.
		Box culvert storm drain contributes flow from right bank (bottom right of photo); Pipe contributes left bank. Culvert crosses under Glenstone just north of the intersection of Glenstone and Division.
34	DCP_3703	U/S from U/S end of entrance channel to double box under Division St.
		Steep treelined banks typical Glenstone to head of this entrance channel. Note significant drop in channel bed.
35	DCP_3704	D/S from U/S end of entrance channel to double box under Division St.
		Culverts cross Division St. just east of intersection of Division and Fairway St.
36	DCP_3705	D/S from D/S end of Division St. crossing.
37	DCP_3706	U/S at Division St. crossing from left bank just below.
		Note pooled water.
38	DCP_3707	D/S at the most U/S Smith Park footbridge.
		Natural rock channel bed from Glenstone to this first footbridge below Division Street, then masonry stone bed and banks through Smith Park to Fremont St.
39	DCP_3708	D/S from right bank in Smith Park at typical channel section between most U/S footbridge and Fremont St.
		Several drops in channel bed along this reach.
40	DCP_3709	D/S at Fremont to National double box tunnel entrance.
41	DCP_3710	U/S from entrance to right barrel of Fremont to National double box tunnel.
		Channel drops +/- 3 FT over about 275 feet distance from most D/S footbridge in Smith Park to U/S end of tunnel at Fremont.
		As per Errin Kemper City has developed a three phase plan for converting the North Branch Jordan Creek Fremont to National tunnel to open channel. Phase 1 is currently out for bids.

42	DCP_3711	U/S from just D/S of Rogers St. crossing of Fremont to National double box culvert.
43	DCP_3712	D/S from just D/S of Rogers St. crossing of Fremont to National double box culvert.
		Top of tunnel on grade for entire reach.
44	DCP_3713	U/S at Fremont to National tunnel exit from right bank in Silver Springs Park.
		Note vertical drop from tunnel floor to channel bed.
45	DCP_3714	D/S in Silver Springs Park from right bank just D/S of D/S end of Fremont to National tunnel. Cars traveling National St. to left of photo.
46	DCP_3715	D/S from right bank about 50 FT U/S of footbridge in Silver Springs Park. U/S end of Hampton St. double box crossing in distance.
47	DCP_3716	D/S from D/S end of Hampton St. double box crossing.
48	DCP_3717	D/S from right bank +/- 150 FT D/S of Hampton St. crossing where channel bends sharply to the left.
		Willows across channel not as thick as appears in this photo.
49	DCP_3718	U/S at typical channel with gabion side walls between Hampton and Sherman.
50	DCP_3719	D/S from right bank just above Sherman St. double box crossing.
51	DCP_3720	D/S at entrance to double box under parking lot immediately D/S of Sherman St.
		About 15 FT distance between D/S face of Sherman St. crossing and U/S face of this double box under the parking lot.
66	DCP_3734	U/S at exit of double box beneath parking lot located immediately D/S of Sherman St.
65	DCP_3733	D/S at entrance of Central St. single barrel box from right edge of channel +/- 100 FT U/S.
		Channel bends sharp left and drops +/- 2 FT over about 10 feet distance into mouth of culvert.
64	DCP_3732	D/S at entrance to Central St. single barrel box from right bank just U/S.
53	DCP_3721	D/S from D/S face of Central St. crossing. Entrance to tunnel under Brower St. and Tindle Mills in distance.
54	DCP_3722	U/S from Brower St. D/S end of Central St. crossing in distance.
55	DCP_3723	D/S from U/S face of Chestnut Expressway overpass immediately south of Tindle Mills. Outlet of tunnel under Brower St. and Tindle Mills is in foreground of photo just beyond guardrail. Entrance to tunnel under Cooper Supply Co. lot and RR tracks in distance.
56	DCP_3724	U/S at outlet of tunnel under Brower St. and Tindle Mills from U/S end of tunnel under Cooper Supply Co. lot and RR tracks.
		Open channel beneath Chestnut Expressway between the two tunnels.
57	DCP_3725	U/S into tunnel under Tindle Mills looking through eastmost opening connecting tunnel to loading dock parking lot on south side of Tindle Mills. See photo DCP_3726.
58	DCP_3726	U/S at rectangular openings connecting tunnel under Tindle Mills to loading dock parking lot on south side of Tindle Mills. Photo DCP_3725 taken through rectangular opening to right of this photo. Photo DCP_3727 taken through rectangular opening to left of this photo.
		CMP arch to right of photo not connected to tunnel - carries flow under Tindle Mills from north side of building to south side.

59	DCP_3727	U/S through westmost rectangular opening connecting tunnel under Tindle Mills to loading dock parking lot on south side of Tindle Mills. **Tunnel under Tindle Mills is actually part tunnel and part restricted open channel. Top of wall along right of channel under building is seen to right of photo. Rectangular openings connecting the north side parking lot to the channel beneath the building can be seen (daylight) in distance. +/- 1 FT space between ground and bottom of building support beams.**
60	DCP_3728	D/S from exit of tunnel under Cooper Supply Co. lot and RR tracks.
61	DCP_3729	U/S at exit of tunnel under Cooper Supply Co. lot and RR tracks from 100 FT D/S.
62	DCP_3730	U/S at Chestnut Expressway overpass (and Tindle Mills beyond) from right bank +/- 100 FT below D/S end of tunnel under Cooper Supply Co. lot and RR tracks. Cooper Supply Co. building to right of photo.
63	DCP_3731	D/S at entrance to Jordan Underground from left bank of South Branch Jordan Creek at confluence with North Branch Jordan Creek.

Insp. Date: **27-Oct-04**

South Branch Jordan Creek

Walked D/S from Cedarbrook Avenue crossing to confluence of South Branch with North Branch just east of Washington St. at U/S end of Jordan Underground.

RR embankments in vicinity of Packer Road crossing form three significant detention areas U/S of Packer Road and one lesser detention area D/S of Packer Road, all of which feed North Branch Jordan Creek.

Photo Sequence #	Filename	Description / Notes
P29	DCP_3763	U/S from U/S end of Cedarwood Avenue double box crossing. U/S face vertical; no wingwalls.
P30	DCP_3764	D/S from D/S end of Cedarwood Avenue double box crossing. Tapered wingwalls parallel to channel this end of culvert. Looking west across Glenwood Park detention basin at outlet in distance.
P31	DCP_3765	U/S (east) from Glenwood Park detention basin outlet. Cedarwood Avenue double box crossing in distance.
P32	DCP_3766	D/S (west) from Glenwood Park detention basin outlet. Burton St. single barrel culvert crossing in distance.
P33	DCP_3767	D/S from Burton St. crossing at typical concrete lined channel extending from Burton to Belview St. along north side of Rockhurst St. Channel crossed by numerous private drives and a few streets.
P34	DCP_3768	U/S from Belview St. crossing.
P35	DCP_3769	U/S from intersection of Belview and Rockhurst at typical ditch along south side of Rockhurst between Burton and Patterson St.
P36	DCP_3770	D/S from Belview St. crossing.
P37	DCP_3771	D/S from Patterson St. crossing. Concrete apron extends 50 FT D/S of Patterson then transitions to natural channel. Medium to large chunks of rock and concrete in channel bed for +/- 100 FT beyond end of concrete apron, then cobbles anf gravel. Thicket cover medium to dense both banks.
P38	DCP_3772	U/S at Patterson crossing from 50 FT D/S. Main channel double box to left of photo. Single box to right of photo carries flow from the ditch along the south side of Rockhurst.
P39	DCP_3773	D/S from +/- 500 FT below Patterson. Soccer fields in ROB.
P40	DCP_3774	Looking north from top RB at detention pond outlet along west side of soccer fields in ROB between Patterson Avenue and Lincoln Cemetary.
P41	DCP_3775	D/S from a point opposite Lincoln Cemetary on ROB.
P42	DCP_3776	U/S at low weir (+/- 2.5 FT above channel bed) located about 200 FT D/S of SW corner of Lincoln Cemetary.
P43	DCP_3777	D/S from just below low weir shown in photo DCP_3776.
P44	DCP_3778	D/S at Chestnut Expressway triple box crossing.
P45	DCP_3779	U/S from +/- 100 FT U/S of U/S end of Chestnut Expressway crossing.
P46	DCP_3780	D/S from Chestnut Expressway triple box crossing. Trafficway St. upstream crossing in distance to left of photo.
P47	DCP_3781	U/S at exit of Chestnut Expressway crossing.

P48	DCP_3782	D/S at upstream Trafficway St. triple box crossing.
P49	DCP_3783	D/S at RR crossing below upstream Trafficway St. crossing from +/- 100 FT U/S.
P50	DCP_3784	U/S from +/- 100 FT above RR crossing just below upstream Trafficway St. crossing.
P51	DCP_3785	D/S from atop RR crossing just below upstream Trafficway St. crossing. Tributary enters on LB immediately below RR crossing.
P52	DCP_3786	U/S at RR crossing below upstream Trafficway St. crossing from LB in center of channel bend to right +/- 300 FT below RR crossing.
P53	DCP_3787	D/S from from LB in center of channel bend to right +/- 300 FT below RR crossing below upstream Trafficway St. crossing.
P54	DCP_3788	D/S at downstream Trafficway St. crossing from RB +/- 150 FT U/S of crossing. Culverts appeat to have recently been extended U/S to facilitate left bank parking lot expansion. Current total length +/- 200 FT.
P55	DCP_3789	D/S from LB in center of sharp right bend +/- 150 FT below downstream Trafficway St. crossing. Looking at the upstream of two closely spaced RR crossings where RR splits just U/S of Glenstone St. overpass.
P56	DCP_3790	U/S at downstream Trafficway St. crossing from LB +/-150 FT D/S.
P57	DCP_3791	U/S at the downstream of two closely spaced RR crossings where RR splits just U/S of Glenstone St. overpass.
P58	DCP_3792	D/S at Glenstone St. bridge. D/S of Glenstone the uniform trapezoidal channel transitions to incised channel with thick brush on steep banks. NOTE: Bridge shown in aerial photos +/- 100 FT D/S of Glenstone no longer exists. Apparently moved to location +/- 350 FT D/S of Glenstone (see photo DCP_3794)
P59	DCP_3793	D/S from +/- 150 FT D/S of Glenstone.
P60	DCP_3794	U/S at double box crossing behind Pinnacle Sign Co. +/- 350 FT D/S of Glenstone.
P61	DCP_3795	D/S from double box crossing behind Pinnacle Sign Co. +/- 350 FT D/S of Glenstone.
		+/- 200 FT D/S of Pinnacle Sign Co. crossing the stream braids through a mini-bottomland area with significant log/debris jams. A significant tributary enters on the RB about 500 FT below this double box crossing.
P62	DCP_3796	U/S at main channel from confluence with right bank tributary.
P63	DCP_3797	U/S at right bank tributary from confluence with main channel.
P64	DCP_3798	D/S from confluence.
P65	DCP_3799	D/S from +/- 150 FT below confluence of right bank tributary. From this point the stream parallels the RR tracks on the north side of the tracks down to Fremont St.
P66	DCP_3800	D/S from about half-way between confluence of right bank tributary and Fremont St. Log/debris jam functioning as +/- 3 FT tall weir.
P67	DCP_3801	U/S from about half-way between confluence of right bank tributary and Fremont St. Log/debris jam functioning as +/- 3 FT tall weir.
P17	DCP_3751	D/S at Fremont St. double barrel crossing from LB +/- 100 FT U/S.
P16	DCP_3750	U/S from Fremont St. crossing.
P15	DCP_3749	D/S from Fremont St. crossing. Entrance to Fremont to National tunnel is +/-180 FT D/S of Fremont St.

P14	DCP_3748	U/S at Fremont St. crossing from LB +/- 100 FT D/S
P68	DCP_3802	D/S from D/S end of Fremont to National tunnel located +/- 150 FT D/S of National St.
P69	DCP_3803	U/S from end of concrete channel +/- 300 FT below D/S end of Fremont to National tunnel. 30-inch diameter storm drain enters from right bank this location.
P70	DCP_3804	D/S from end of concrete channel +/- 300 FT below D/S end of Fremont to National tunnel. Rock riffle at this location backs water an estimated 700 FT.
P71	DCP_3805	U/S from willow tree debris jam functioning as +/- 3 FT weir. Location is +/- 130 FT D/S of west end of DOC warehouse building sitting on left bank. Willow growing horizontally across channel from right bank. Vertical limestone left bank; steep vegetated right bank.
P72	DCP_3806	D/S from willow tree debris jam functioning as +/- 3 FT weir. Vertical limestone LB; steep vegetated RB. Debris on right side of channel D/S is dilapidated masonry retaining wall.
P73	DCP_3807	Looking down from LB on willow tree debris jam functioning as +/- 3 FT weir.
P74	DCP_3808	U/S from driveway bridge across channel at Concrete Co. of Springfield.
P75	DCP_3809	D/S from driveway bridge across channel at Concrete Co. of Springfield.
P76	DCP_3810	U/S at driveway bridge across channel at Concrete Co. of Springfield from +/- 50 FT D/S.
P77	DCP_3811	D/S at Sherman St. crossing.
P78	DCP_3812	D/S from atop Sherman St. crossing.
P79	DCP_3813	U/S at RR crossing just below Sherman St.
P80	DCP_3814	D/S from RR crossing just below Sherman St. Channel parallels Phelps St. on north side of Phelps down to confluence of South Branch with North Branch at U/S end of Jordan Underground. Two driveways cross the channel between this RR crossing and the confluence.

At 1500 hours flow in channel is +/- 4 inches deep in channel thalweg formed by channel bottom that drops about 6 inches from sidewalls to center.

Heavy rain begins about 1508 hours. Heavy rainfall transitions to light rain in about 1 minute at about 1530 hours.

Watched water rise about 1.5 FT from 1524 to 1544 hours.

At 1550 hours estimated 15 fps velocity in South Branch channel just U/S of confluence with North Branch. Velocity high but noticeably slower in North Branch.

Insp. Date: 28-Oct-04

Jordan Creek

Walked D/S from Main St. crossing to confluence of Jordan and Fassnight Creeks at head of Wilson Creek.

Photo Sequence #	Filename	Description / Notes
P10	DCP_3679	D/S at channel and Main St. crossing from D/S end of Jordan Underground left barrel.
P11	DCP_3680	D/S from D/S face of Main St. bridge.
P12	DCP_3681	D/S from location of confluence of left bank tributary +/- 100 FT below Main St. bridge.
P13	DCP_3682	U/S at left bank tributary from confluence with Jordan Creek +/- 100 FT below Main St. bridge.
		P10 thru P13 shot on 25 Oct 04.
P1	2004_10280003	D/S at ROB from U/S side of Main St. Trees and low concrete wall to left are on RB of Jordan Creek.
		Appears a significant amount of ROB overland flow crossing Main St. probably does not enter the Jordan Creek channel immediately D/S fo the Jordan Underground exit due to high ground and low concrete wall along the RB of Jordan Creek that extends D/S from the Main St. bridge and ends +/- 50 FT U/S of the U/S face of the Grant St. overpass. Appears ROB overland flow would enter the Jordan Creek channel significantly at and below the Grant St. overpass.
		D/S of the Grant St. overpass the ROB is old gravel paved area between Jordan Creek and the RR tracks in the ROB.
P2	2004_10280004	D/S at building over creek +/- 100 FT D/S of D/S face of Grant St. overpass.
P3	2004_10280005	U/S at Grant St. overpass from U/S face of building over creek +/- 100 FT D/S of D/S face of overpass.
		Unable to estimate what appeared to be a significant grade change at rock riffle beneath the Grant St. overpass.
P4	2004_10280006	D/S from D/S face of building over creek +/- 100 FT D/S of D/S face of Grant St. overpass.
		Standing atop what appears to be a pair of 5 FT outside diameter storm sewer risers that stick up +/- 6 FT above the channel bed. Risers are in line with flow, thus block a 5 FT width of the right side of the channel. RB tributary enters through double box +/- 20 FT D/S of D/S face of building over creek.
P5	2004_10280007	U/S from +/- 100 FT U/S of RR crossing. Building over creek and Grant St. overpass in background.
P6	2004_10280008	D/S from +/- 100 FT U/S of RR crossing.
P7	2004_10280009	D/S from D/S face of RR bridge.
P8	2004_10280010	D/S from +/- 600 FT below RR bridge.
		Noted a number of rock riffle channel bed elevation changes from RR bridge down to this point.
P9	2004_10280011	D/S from +/-750 FT U/S of Fort St. crossing at point opposite small mountain of concrete waste on ROB near creek.
		Note concrete washed into channel from upslope.
		Observed what appeared to be a transient encampment on the RB +/- 500 FT below the small mountain of concrete waste.
P10	2004_10280012	D/S from left edge of channel at D/S face of Fort St. bridge. Note significant ponding U/S of this rock/debris riffle.
		Note ponding U/S of this rock/debris riffle.
P11	2004_10280013	U/S at Fort St. bridge from channel +/- 60 FT D/S. Left and right overbanks at this crossing noticeably higher elevation than top of roadway.
		Left and right overbanks at this crossing noticeably higher elevation than top of roadway.
P12	2004_10280014	D/S at remnants of old crossing structure +/-350 FT below Fort St. crossing.
P13	2004_10280015	D/S from remnants of old crossing structure +/-350 Ft below Fort St. crossing.
P14	2004_10280016	U/S at remnants of old crossing structure +/-350 Ft below Fort St. crossing from +/- 60 FT D/S.

		+/- 250 FT D/S of this old structure the creek bends sharply left and passes under a RR and College St.
P15	2004_10280017	D/S at College St. crossing from atop RR crossing just U/S of College St.
P16	2004_10280018	U/S at RR crossing from U/S face right end of College St. crossing.
P17	2004_10280019	D/S from D/S face left end of College St. crossing.
		Vertical wall left side of channel for +/- 250 FT D/S of College St. Note what appears to be rock riffle / channel restriction in vicinity of end of wall.
P18	2004_10280020	**Rock/debris forms low water dam at D/S end of left barrel at College st. crossing.**
P19	2004_10280021	D/S at Walnut St. bridge from +/- 100 FT U/S.
		Bridge deck is skewed but barrels are aligned +/- parallel to flow.
P20	2004_10280022	U/S from atop U/S face of Walnut St. bridge.
		Rock riffle in distance appears significant but cannot estimate elevation drop.
P21	2004_10280023	D/S from atop D/S face of Walnut St. bridge.
P22	2004_10280024	Looking west from center of Walnut St. crossing at intersection of Walnut St. with Kansas Expressway.
		Observation of intersection topography - low point in Kansas Expwy is just south of where RR crosses Kansas Expwy on grde between College and Walnut Streets. High flow in ROB will first overtop Kansas Expwy at this point, cross Walnut St. just west of Kansas Expwy, and flow into the ROB D/S of Walnut and west of Kansas Expwy.
P23	2004_10280025	D/S from +/-150 FT U/S of Kansas Expwy.
		Significant rock deposit island around willows on left side of channel. Noted 4 FT diameter storm drain enters from RB just U/S of Kansas Expwy.
P24	2004_10280026	Creek under Kansas Expwy from RB at U/S end of right abutment.
P25	2004_10280027	D/S from right edge of channel beneath center of northbound (U/S) lanes.
		Large rock/debris island in center of channel at D/S face of bridge. Requires flow depth to +/- 10 FT below bridge low chord to submerge solid part of island (excluding vegetation growing from island). Flow passes to right and left of island.
P26	2004_10280028	U/S from left edge of channel at D/S face of Kansas Expwy bridge.
		Note island at U/S face of bridge on left side of channel (right side of this photo) and gravel bar extending U/S in center of channel under bridge.
P27	2004_10280029	D/S from atop D/S face of Kansas Expwy. Standing +/- 40 FT riverward of U/S end of right abutment.
P28	2004_10280030	U/S at Mt Vernon triple box bridge from +/- 100 FT D/S.
P29	2004_10280031	D/S from +/- 100 FT D/S of Mt. Vernon St. crossing.
		Channel contraction in photo is +/- 200 FT D/S of Mt. Vernon St. crossing.
P30	2004_10280032	U/S from atop U/S face of Mt. Vernon St. crossing.
		D/S of Kansas Expwy began to note more significant pooling of water U/S of riffles as evidenced by lower velocity in pools and began to see gravel and coarse sand deposits.
P31	2004_10280033	D/S at ROB +/- 800 FT below Mt. Vernon St. crossing.
		Typical bottomland environment. Medium density undergrowth with light amount of deadfalls; not as dense as appears in photo. Discovered maintained walking path on right bank alongside creek. Did not see upstream terninus on way down RR tracks from Mt. Vernon St.
		Where's Waldo? Near the center of this photo is a nice sized whitetail deer staring at the camera.
P32	2004_10280034	U/S from left edge of channel +/- 900 FT below Mt. Vernon St. crossing.
P33	2004_10280035	D/S from left edge of channel +/- 900 FT below Mt. Vernon St. crossing.
		Note exposed rock slabs on left edge of channel and gravel bed just U/S of them.
P34	2004_10280036	**Typical wooded overbank between Mt. Vernon and Grand Street crossings. Generally thin to medium density undergrowth between well spaced trees with**

		occassional deadfalls. Ground carpeted with vinelike vegetation.
P35	2004_10280037	See description of photo 2004_10280036.
P36	2004_10280038	U/S from minor rock riffle +/- 250 FT above Grand St. crossing.
		Looking at D/S end of major rock riffle that appears to drop several feet over a relatively short distance.
		Located major rock riffle next morning. Left bank tributary passes under Kansas Expwy +/- 570 FT north of the intersection of Kansas Expwy and Grand St. and enters enters Jordan Creek 100 FT D/S at about midway of the riffle. Riffle easily accessed from tributary crossing of Kansas Expwy. Estimate +/- 6 FT drop in elevation of channel bed over about 250 feet distance along the creek.
P37	2004_10280039	D/S at Grand St. crossing from right edge of channel at minor rock riffle +/- 250 FT U/S.
		Tributary enters on right bank +/- 200 FT U/S of Grand St. crossing. Do not know if it carries runoff from the west side of the RR tracks.
P38	2004_10280040	D/S from D/S face of Grant St. bridge at left abutment.
		Note rough finished concrete weir +/- 40 FT D/S of bridge.
P39	2004_10280041	D/S from right edge of channel +/- 500 FT below Grand St. crossing.
		Rock riffle +/- 50 FT D/S.
P40	2004_10280042	U/S from at concrete encased pipe that forms weir +/- 300 FT U/S of Catalpa St. crossing.
		Photo taken from atop concrete foundation/encasement around base of power pole on right edge of channel about 50 FT below weir.
P41	2004_10280043	U/S from atop U/S face of Catalpa St. crossing.
P42	2004_10280044	D/S from atop D/S face of Catalpa St. crossing at right end of bridge.
		Catalpa street bridge noticeably perched. Flood flows will overtop roadway left of bridge first.
P43	2004_10280045	U/S from right edge of channel +/- 250 Ft below Catalpa St. crossing.
P44	2004_10280046	D/S from +/- 500 FT below Catalpa St.
		Creek begins to assume a more winding pattern below Catalpa Street.
P45	2004_10280047	D/S from right edge of channel between Catalpa and Bennett St
		Gravel point bar in bend.
P46	2004_10280048	D/S from right edge of channel +/- 350 FT U/S of Bennett St. crossing.
P47	2004_10280049	Standing at intersection of Bennett St. and RR mainline just west of Bennett St. crossing of Jordan Creek. Looking +/- NE at rock dike.
		Crown of rock dike +/- 4 FT higher than RR tracks but dike will first overtop where right end of dike ties into RR embankment. Overflow of any significant duration may be expected to erode the RR embankment and/or the rock dike.
P48	2004_10280050	Looking west along Bennett St. from U/S side of Bennett St. bridge at right abutment.
		Left end of rock dike shown in photo 2004_10280049 can be seen here ending on the west side of the paved entrance to a substantial area of ROB fill. Ditch to right of photo connected directly to Jordan Creek immediately U/S of Bennett St. bridge on RB.
		Expected to find a significant culvert under Bennett St. immediately west of the RR tracks but could not locate. If one exists at this location it is small and/or clogged and overgrown.
		D/S of Mt. Vernon St. the RR on the right bank transitions from constructed on grade to embankment above grade which continues down to the Wilson Creek crossing just below the head of Wilson Creek at the confluence of Jordan and Fassnight Creeks. Appears from some point just below Mt. Vernon St. runoff from west of the RR tracks passes down the west side of the RR embankment to Wilson Creek, but may have missed connections which allow runoff from west of the tracks to flow into Jordan Creek.
		Post-field trip inspection of contours and aerial photography indicates there may be an opening through the RR embankment about 1600 FT south of Mt. Vernon St as measured along the RR tracks. This correlates with the tributary observed entering the right bank of Jordan Creek +/- 200 FT U/S of the Grand St. crossing.
P49	2004_10280051	D/S from atop Bennett St. crossing.
		1415 hours - received permission from Clariant security (bob McCoy) to walk along creek through Clariant property.

P50	2004_10280052	U/S from +/- 150 FT below Bennett St. bridge. **Note Clariant LOB parking lot fill posing flow restriction as flow exits bridge opening. Bridge opening otherwise quite hydraulically efficient - abutment slopes concrete paved and radiused U/S and D/S of both abutments.** **Bridge significantly perched with 30-inch curb walls U/S and D/S.** **Roadway will overtop bridge to left and right before bridge overtops.**
P51	2004_10280053	D/S from +/- 150 FT below Bennett St. bridge.
P52	2004_10280054	U/S from LOB at first footbridge D/S of Bennett St.
P53	2004_10280055	U/S from LOB at second footbridge D/S of Bennett St.
P54	2004_10280056	D/S at Wilson Creek from head at confluence of Jordan and Fassnight Creeks.
P55	2004_10280057	U/S at Jordan Creek from head of Wilson Creek at confluence of Jordan and Fassnight Creeks.
P56	2004_10280058	U/S at Fassnight Creek from head of Wilson Creek at confluence of Jordan (at left of photo) and Fassnight Creeks. **Clariant RB floodwall extends from Bennett St. bridge down past confluence of Jordan and Fassnight Creeks, along RB of Wilson Creek, and ties in to the RR embankment.**

Insp. Date: **28-Oct-04**

Wilson Creek

Walked D/S from head of Wilson Creek at confluence of Jordan and Fassnight Creeks to U.S. Hwy 160 (West Bypass) crossing.

Photo Sequence #	Filename	Description / Notes
P54	2004_10280056	D/S at Wilson Creek from head at confluence of Jordan and Fassnight Creeks.
P57	2004_10280059	D/S at RR crossing located +/- 450 FT below head of Wilson Creek.
		Departed Clariant property via RR embankment at 1445 hours.
P58	2004_10280060	U/S at RR bridge from +/- 60 FT D/S of right abutment. Looking +/- SE across creek at left abutment.
		Ditch along west side of RR tracks enters Wilson Creek immediately D/S of RR crossing.
P59	2004_10280061	D/S from 20 FT below RR crossing.
P60	2004_10280062	U/S from +/- 120 FT below RR crossing.
P61	2004_10280063	D/S from +/- 150 FT U/S of Scenic Drive crossing.
		USGS gage at Scenic Drive crossing.
P62	2004_10280064	U/S from +/- 200 FT below Scenic Drive crossing.
P63	2004_10280065	D/S from +/- 200 FT below Scenic Drive crossing.
		Note raft of logs and debris right side of channel.
P64	2004_10280066	U/S from +/- 1300 FT below Scenic Drive.
		Log jam has formed debris/sediment bar.
P65	2004_10280067	D/S from +/- 1300 FT below Scenic Drive.
		Channel splits around two islands in succession. U/S island +/- 200 FT long and maximum of about 4 FT tall above channel bed. D/S island starts about 30 FT D/S of U/S island. D/S island +/- 100 FT long and maximum of about 5 FT tall above channel bed. D/S island can be seen to left of photo 2004_10280068.
P66	2004_10280068	D/S from +/- 1500 FT below Scenic Drive.
		ROB undergrowth thin to medium density between Scenic Drive and old Golden St. crossing.
P67	2004_10280069	D/S from +/- 2000 FT below Scenic Drive.
		Channel restriction where +/- 10-inch pipe crosses.
P68	2004_10280070	U/S from +/- 2250 FT below Scenic Drive.
P69	2004_10280071	D/S from +/- 2250 FT below Scenic Drive.
		Channel bends sharply left at this location. Right bank actively eroding in bend.
P70	2004_10280072	D/S at old Golden St. crossing from RB +/- 60 FT U/S.
		Exit geometry typical of entrance geometry.
P71	2004_10280073	D/S from old Golden St. crossing.
		Roadway embankments still in place to left and right of crossing.
P72	2004_10280074	D/S from +/- 600 FT below old Golden St. crossing.
		Tributary enters from right bank at this location. Can be seen to

		right of photo.
P73	2004_10280075	D/S from +/- 1400 FT below old Golden St. crossing.
		Pasture with horses on ROB this location. Medium to dense undergrowth in ROB from pastures to ROB ball fields +/- 1000 FT farther D/S.
P74	2004_10280076	D/S from +/- 1300 FT above U.S. Hwy 160 crossing.
		Tributary enters from RB +/- 800 U/S of U.S. Hwy 160 crossing.
P75	2004_10280077	D/S from +/- 500 FT above U.S. Hwy 160 crossing.
		Medium to heavy density brush/thicket cover in LOB for +/- 700 FT U/S of U.S. Hwy 160.
P76	2004_10280078	D/S at U.S. Hwy 160 crossing. Standing on LB +/- 150 FT U/S of left abutment.
		Three pier bents between abutments all parallel with flow.
P77	2004_10280079	D/S from rock riffle beneath D/S face of U.S. Hwy 160 bridge.
P78	2004_10280080	U/S from rock riffle beneath D/S face of U.S. Hwy 160 bridge.

Insp. Date: **25-Oct-04**

Jordan Creek Underground

Three sections of double box culvert connected by bridge openings, one large single barrel box culvert, and a large opening beneath a building structure.

Walked left barrel from D/S end at Main St. to U/S end at confluence of North and South Branches of Jordan Creek just east of Washington St. Returned D/S through right barrel.

Typical characteristics of the double box culvert sections of the tunnel:

a) Floor of each barrel of the double box culvert slopes from base of walls to center forming triangular low flow section. Center is +/- 1.5 FT lower elevation than wall at base.
b) Exposed aggregate typical for about the middle third of floor.
c) Occasional limited deposits of gravel and rock. May be expected to deposit during flow recession and wash out at high flows.
d) Typically uniform geometry but some changes in cross-sectional area due to differing culvert roof height, occasional roof beams that probably support some overhead structure, and overhead pipes across box culvert barrels.

Photo Sequence #	Filename	Description / Notes
1	DCP_3670	D/S from U/S face of old stonework single arch bridge at Campbell St. crossing.
		Double box culvert transitions to bridge opening at U/S and D/S faces of bridge. Note misalignment on left reduces effective flow area at transition from bridge opening to culvert.
2	DCP_3671	D/S from left barrel just above Campbell Street crossing.
		Note misalignment on left reduces effective flow area where left barrel transitions to bridge opening.
		+/- 1 FT diameter hole in left barrel roof between Campbell and Booneville Streets connects to storm drain catch basin above. Located at about STA 1100 as previously designated by City paint marks on tunnel wall.
3	DCP_3672	U/S from middle of single concrete arch bridge at Booneville St. crossing.
		D/S face of single arch bridge transitions to double box culvert. U/S face of bridge opening transitions to larger single opening underneath building structure supported by concrete columns and steel beams (unseen beyond concrete columns). U/S side of opening under building transitions to large single barrel culvert with some steel beams overhead and floor sloping downward from base of walls to center forming triangular low flow section. Observed small amount of debris and gravel through opening under building and a few large rocks.
4	DCP_3673	D/S from single large culvert at transition from single barrel culvert to opening under building structure located immediately U/S of Booneville St. crossing.
		Overhead steel beams limit effective depth to +/- 8 FT for significant distance under building. Overhead concrete arch also limits effective flow area. Single large culvert extends U/S some distance and transitions to double box culvert which continues to upstream end of tunnel at confluence of North and South Branches of Jordan Creek.
5	DCP_3674	**Typical arch doorway opening observed at random locations provides flow interchange between barrels of double box culvert.**
6	DCP_3675	U/S from U/S end of left barrel at confluence of North Branch Jordan Creek (to left of photo) and South Branch of Jordan Creek (to right of photo).
7	DCP_3676	U/S at gravel bar in right barrel of double box between U/S end (at confluence of North and South branches) and Booneville St.
		In this reach of double box culvert noted more gravel bars in right barrel than left barrel. Most significant deposit observed near D/S end of this reach.
8	DCP_3677	D/S at some larger rocks on floor and overhead steel beams in single barrel upstream of Boonville St.
9	DCP_3678	D/S at opening under building just U/S of Booneville St.
10	DCP_3679	D/S at Main St. bridge from left barrel at D/S end of Jordan Underground

Insp. Date: **27-Oct-04**

North Branch Fremont to National Double Box Tunnel

Walked right barrel from U/S end at Fremont St. to D/S end at National St. Returned U/S through left barrel. Tunnel passes under Fremont, Rogers, Prospect, and National Streets.

General Observations

Controlling flow section appears to be Fremont St. crossing at U/S end of tunnel. However, additional flow enters the tunnel via two lateral storm drains and via street gutters at road crossings.

Variable flow depth and velocity throughout tunnel indicates variations in slope but did not observe any abrupt changes in slope of tunnel floor. Possibly one in vicinity of Rogers St. crossing in left barrel but floor covered with rock deposits.

Fine aggregate typically exposed across width of tunnel floor. Noticeably more in right barrel than left barrel. Flow volume and duration probably greater in right barrel due to connecting lateral storm drains.

Photo Sequence #	Filename	Description / Notes
		Tunnel height increases about 8-inches immediately D/S fo Fremont St. crossing. +/- 6 FT wide X 4 FT high storm drain enters right side of right barrel immediately D/S of Fremont St. Invert of storm drain outlet +/- 1 FT higher than tunnel invert.
P1	DCP_3735	D/S in right barrel.
		Presence of a few large rocks indicative of quite high velocity flow.
P2	DCP_3736	D/S in right barrel.
		Large rocks deposited to left of right barrel just U/S of 30-degree right bend.
		+/- 3 FT wide X 5 FT high storm drain enters right side of right barrel immediately U/S of Prospect St. Invert of storm drain outlet +/- 1 FT higher than tunnel invert.
		Observed +/- 1FT high X 2 FT wide port at base of divider wall between Fremont and Rogers Streets; and a second just D/S of Prospect St.
P3	DCP_3737	U/S in left barrel.
		Large rocks deposited to left of left barrel just U/S of 30-degree right bend.
P4	DCP_3738	U/S in left barrel from just below Rogers St. crossing.
		Rock deposits may be due to widening of left barrel at Rogers St. but notes incomplete. Left barrel widens from +/- 12 FT wide U/S of Rogers St. to +/- 18 FT wide through the Rogers Street crossing, then back down to +/- 12 FT wide D/S of Rogers St. Uncertain if right barrel did the same at the Rogers St. crossing.

Insp. Date: **27-Oct-04**

South Branch Fremont to National Double Box Tunnel

Walked tunnel from U/S end +/- 175 FT below Fremont St. down to within +/- 300 FT of outlet. Could see daylight from outlet but water knee deep at this point. Later this day found cause of backwater - rock riffle +/- 275 FT D/S of tunnel outlet.

General Observations

Tunnel dimensions +/- 8 FT X 8 FT.

Tunnel constructed for hydraulic efficiency. Tunnel bends are smooth large radius curves. Floor of tunnel slopes from sidewalls to center thalweg. +/- 4-inch drop from sidewall to center of tunnel floor.

Photo Sequence #	Filename	Description / Notes
P5	DCP_3739	D/S at U/S end of tunnel.
		Note 1955 stamp on tunnel entrance.
P6	DCP_3740	U/S from just inside U/S end of tunnel.
P7	DCP_3741	D/S at +/- 10-inch pipe crossing tunnel.
P8	DCP_3742	U/S from just D/S of significant grade change.
		Tunnel floor and roof drop +/- 2 FT over about 10 feet distance.
P9	DCP_3743	U/S at +/- 12-inch pipe crossing tunnel.
		Pipe located +/- 30 FT D/S of grade change.
P10	DCP_3744	U/S at lateral tunnel entering from right.
		Lateral tunnel +/- 6 FT X 6FT and 60 FT long. Enters main tunnel about 75 FT D/S of grade change. Lateral tunnel invert +/- 2 FT higher than main tunnel invert. Post-trip inspcetion of topo and aerial photography indicates this lateral tunnel enters the main tunnel about 850 FT U/S of the main tunnel outlet.
P11	DCP_3745	U/S at lateral tunnel inlet.
		Tributary makes sharp left and drops +/- 5 FT into lateral tunnel entrance.
P12	DCP_3746	U/S from U/S end of lateral tunnel.
		Thick rock/gravel deposit across entire floor of main tunnel begins just D/S of lateral tunnel connection, extends D/S +/- 200 FT then transitions back to concrete floor.
P13	DCP_3747	D/S at +/- 12-inch pipe crossing tunnel somewhere D/S of lateral tunnel connection. Barely visible in photo but it is there.

Insp. Date: **27-Oct-04**

Tindle Mills Tunnel

Walked tunnel from D/S end at U/S face of Chestnut Expwy overpass just south of Tindle mills to within +/- FT of U/S end at north side of Brower St. Knee deep water at this point.

General Observations

Tunnel under Tindle Mills is actually part tunnel and part restricted open channel. Top of wall along right of channel under building is below bottom of building support beams. Rectangular openings connect both the north side and south side parking lots to the channel beneath the building. +/- 1 FT space between ground and bottom of building support beams to right of right side retaining wall under building. Uncertain if flow can enter or leave the channel beneath the building at other than the rectangular ports on the U/S and D/S faces of the building and one port observed in left channel wall.

Gravel with medium to large rocks typical in bed of larger section of the tunnel throughout. Smaller dimension sections at the U/S and D/S ends have relatively clean bed with exposed aggregate but also contain gravel deposits along the inside of bends.

Photo Sequence #	Filename	Description / Notes
P56	DCP_3724	U/S at D/S end of tunnel. D/S end of tunnel located approximately coincident with the U/S face of Chestnut Expwy overpass.
		Tunnel +/- 10 FT X 10 FT from D/S end U/S to south (D/S) face of Tindle Mills building.
P18	DCP_3752	D/S from D/S face of loading dock on south side of Tindle Mills building.
P19	DCP_3753	U/S from D/S face of loading dock on south side of Tindle Mills building.
		+/- 10 FT wide tunnel D/S of Tindle Mills building widens to about 18 FT just U/S of the D/S (south) face of the building. Note ledges on right side of channel, overhead beams and rough cut port at top of wall on left side of channel.
P20	DCP_3754	U/S from about midway of Tindle Mills building.
		Note significant rock deposit on floor.
P21	DCP_3755	D/S from about midway of Tindle Mills building.
		Channel under building reduces to '+/- 10 FT X 10 FT tunnel at D/S face of building (to right of photo).
P22	DCP_3756	D/S from U/S face of Tindle Mills building.
P23	DCP_3757	U/S from U/S face of Tindle Mills building.
		Note concrete ledge on left side of channel (right side of photo) beyond protruding wingwall. Ledge is +/- 4 FT wide and 2.5 FT tall above tunnel floor.
P24	DCP_3758	D/S from about center of bend near U/S end of tunnel.
P25	DCP_3759	U/S from about center of bend near U/S end of tunnel.
		Tunnel width reduces from +/- 15 FT wide to +/- 10 FT X 10 FT. Tunnel height increases about 1.5 FT at this point. Section +/- 10 FT X 10 FT from U/S end to about 100 FT below U/S entrance.

Insp. Date: **27-Oct-04**

Cooper Supply and RR Tunnel

Walked tunnel from U/S end at D/S face of Chestnut Expwy overpass to D/S end.

General Observations

From U/S end tunnel is double box for about half its length then each barrel contracts and the tunnel transitions to a single barrel.

Medium to large rock and gravel typical across bed of both barrels in double barrel section.

Floor of single barrel section clean with exposed aggregate throughout.

Photo Sequence #	Filename	Description / Notes
55	DCP_3723	D/S from U/S face of Chestnut Expressway overpass immediately south of Tindle Mills. Entrance to tunnel under Cooper Supply Co. lot and RR tracks in distance.
P26	DCP_3760	D/S from just inside U/S end of right barrel.
P27	DCP_3761	D/S at +/- 24-inch pipe crossing tunnel just U/S of transition from double to single barrel.
		Pipe hard to see but there. Passes through double barrel divider wall and crosses left barrel of tunnel.
P28	DCP_3762	D/S in right barrel from pipe crossing.
		About 20 FT D/S of the pipe crossing both barrels contract to about 5 FT width at transition to +/- 12 FT wide single barrel.
61	DCP_3729	U/S at exit of tunnel under Cooper Supply Co. lot and RR tracks from 100 FT D/S.

2004_10280003.JPG

2004_10280004.JPG

2004_10280005.JPG

2004_10280006.JPG

2004_10280007.JPG

2004_10280008.JPG

2004_10280009.JPG

2004_10280010.JPG


2004_10280011.JPG


2004_10280012.JPG


2004_10280013.JPG

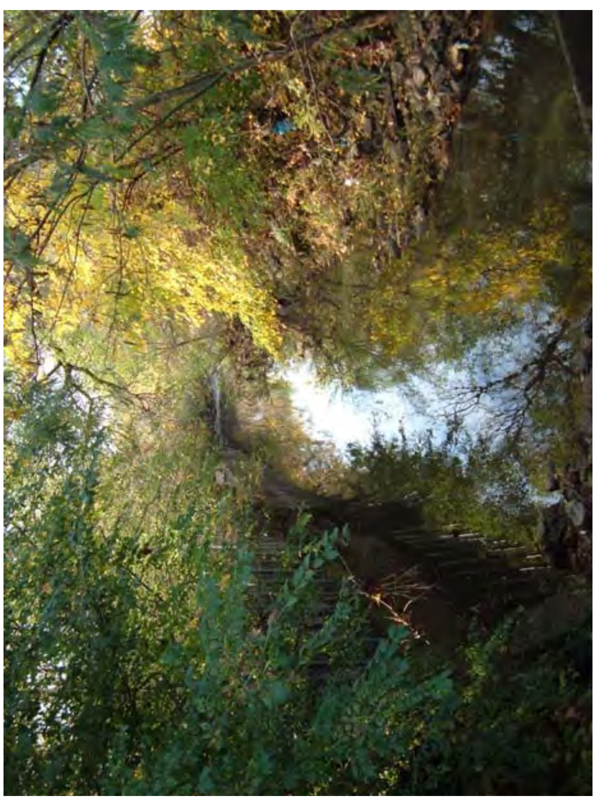

2004_10280014.JPG


2004_10280015.JPG


2004_10280016.JPG


2004_10280017.JPG


2004_10280018.JPG



2004_10280019.JPG

2004_10280020.JPG

2004_10280021.JPG

2004_10280022.JPG

2004_10280023.JPG

2004_10280024.JPG

2004_10280025.JPG

2004_10280026.JPG

2004_10280027.JPG

2004_10280028.JPG

2004_10280029.JPG

2004_10280030.JPG


2004_10280031.JPG


2004_10280032.JPG


2004_10280033.JPG

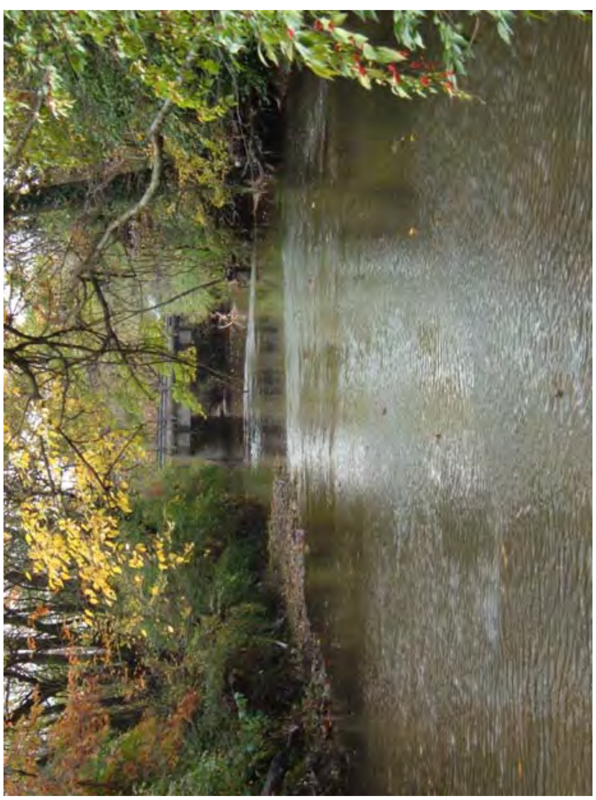

2004_10280034.JPG


2004_10280035.JPG


2004_10280036.JPG


2004_10280037.JPG


2004_10280038.JPG



2004_10280039.JPG

2004_10280040.JPG

2004_10280041.JPG

2004_10280042.JPG

2004_10280043.JPG

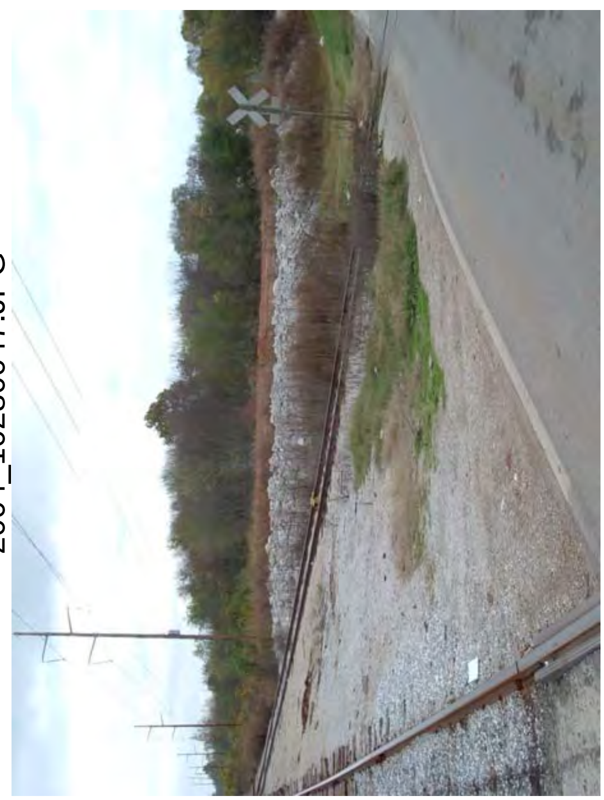
2004_10280044.JPG

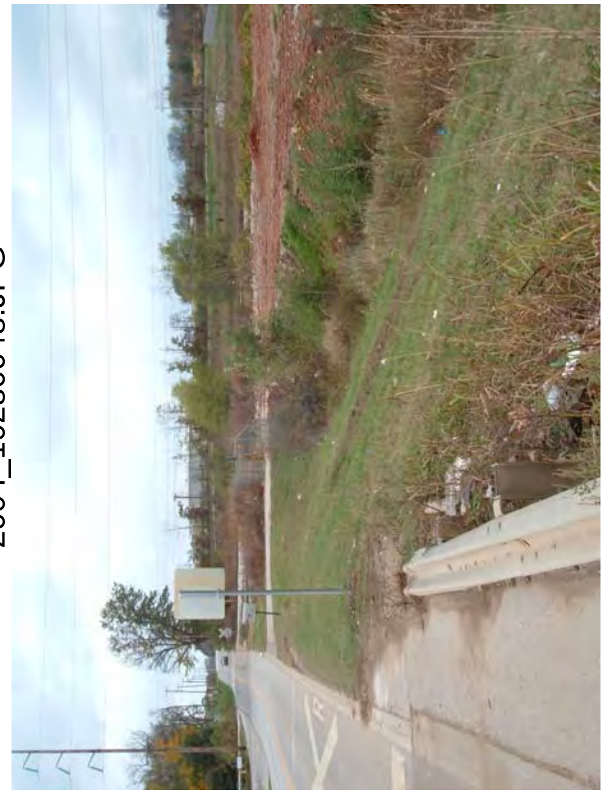
2004_10280045.JPG

2004_10280046.JPG


2004_10280047.JPG


2004_10280048.JPG


2004_10280049.JPG


2004_10280050.JPG


2004_10280051.JPG


2004_10280052.JPG


2004_10280053.JPG


2004_10280054.JPG


2004_10280055.JPG


2004_10280056.JPG


2004_10280057.JPG


2004_10280058.JPG

2004_10280059.JPG

2004_10280060.JPG

2004_10280061.JPG

2004_10280062.JPG

2004_10280063.JPG

2004_10280064.JPG

2004_10280065.JPG

2004_10280066.JPG

2004_10280067.JPG

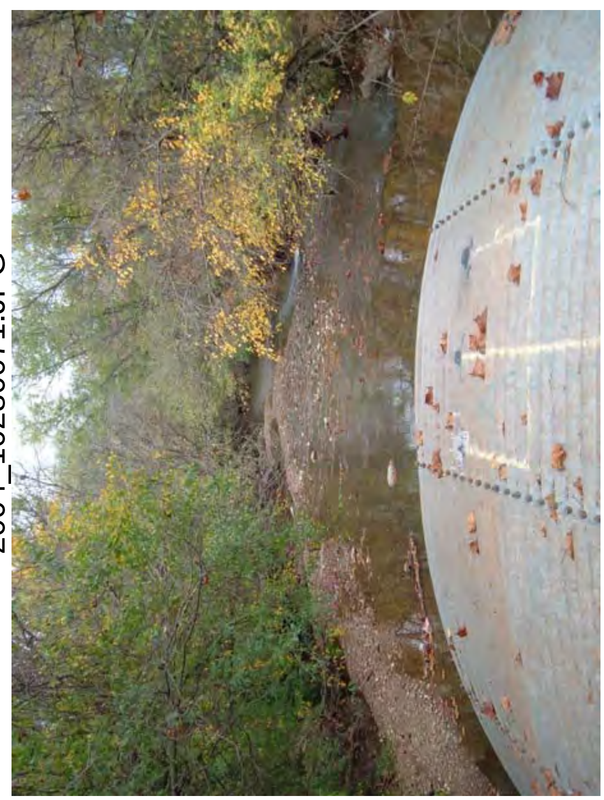
2004_10280068.JPG

2004_10280069.JPG

2004_10280070.JPG


2004_10280071.JPG


2004_10280072.JPG


2004_10280073.JPG


2004_10280074.JPG

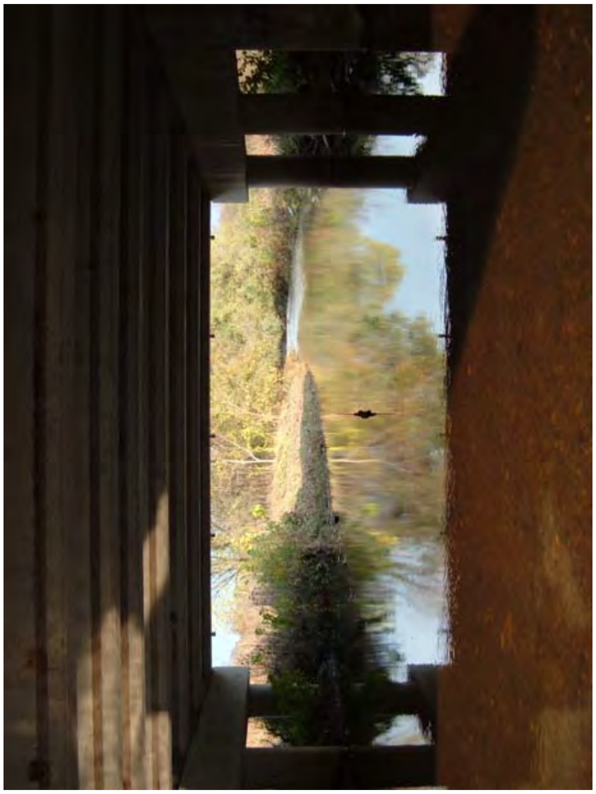

2004_10280075.JPG


2004_10280076.JPG

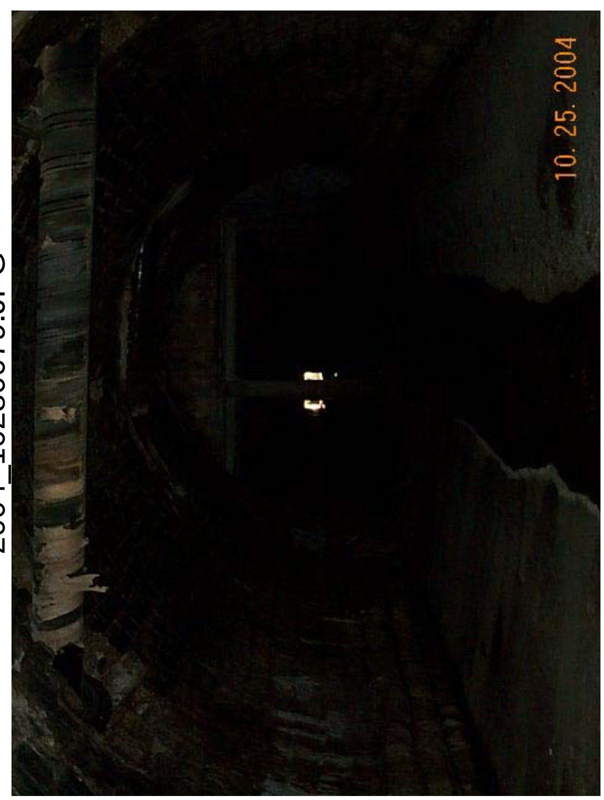

2004_10280077.JPG


2004_10280078.JPG

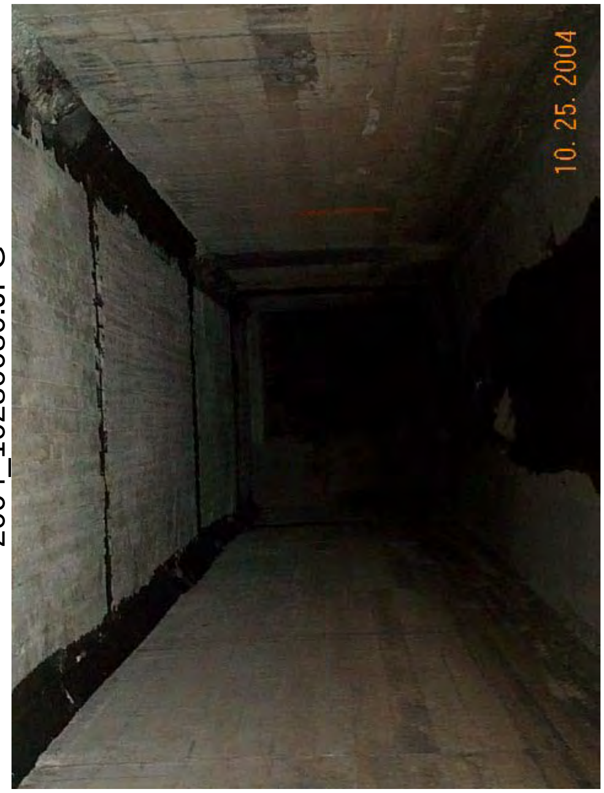
2004_10280079.JPG



2004_10280080.JPG



DCP_3670.JPG



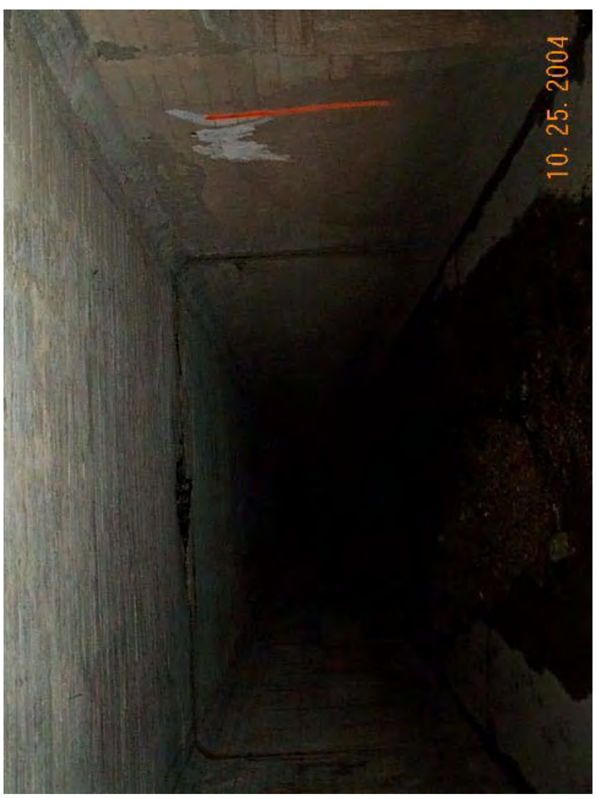
DCP_3671.JPG

DCP_3672.JPG

DCP_3673.JPG

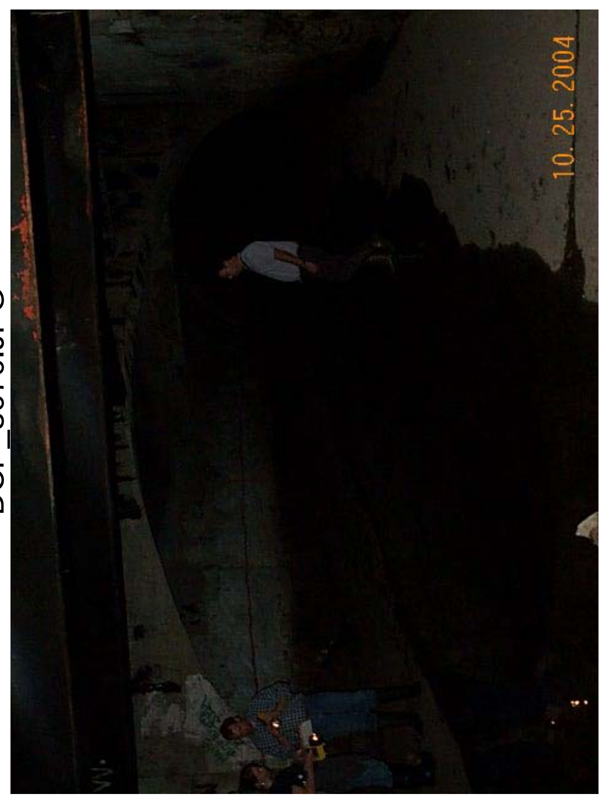
DCP_3674.JPG

DCP_3675.JPG

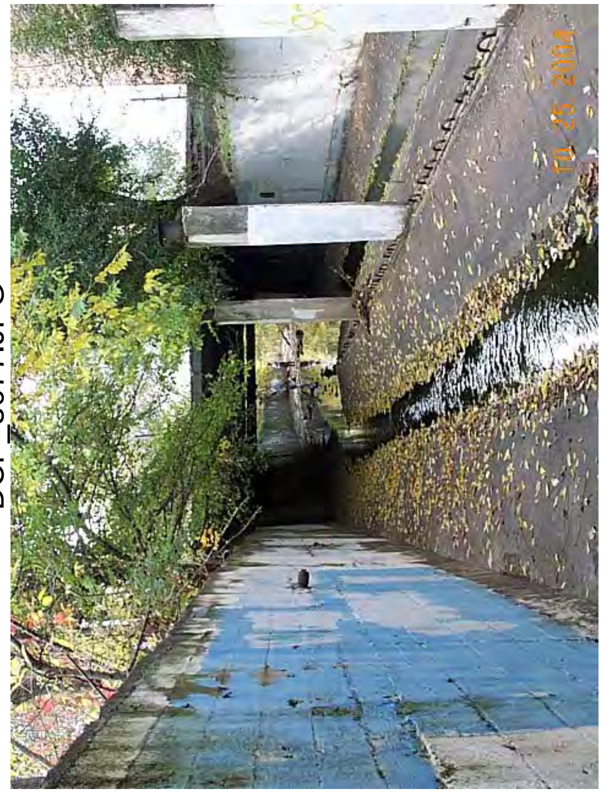


DCP_3676.JPG

DCP_3677.JPG



DCP_3678.JPG



DCP_3679.JPG

DCP_3680.JPG

DCP_3681.JPG

DCP_3682.JPG

DCP_3683.JPG

DCP_3684.JPG

DCP_3685.JPG

DCP_3686.JPG

DCP_3687.JPG

DCP_3688.JPG

DCP_3689.JPG

DCP_3690.JPG

DCP_3691.JPG

DCP_3692.JPG

DCP_3693.JPG

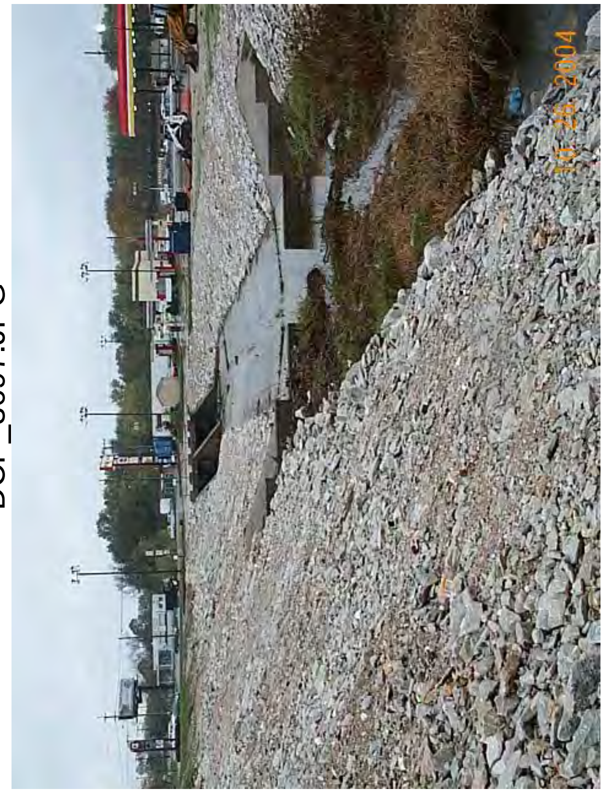

DCP_3694.JPG


DCP_3695.JPG

DCP_3696.JPG

DCP_3697.JPG

DCP_3698.JPG

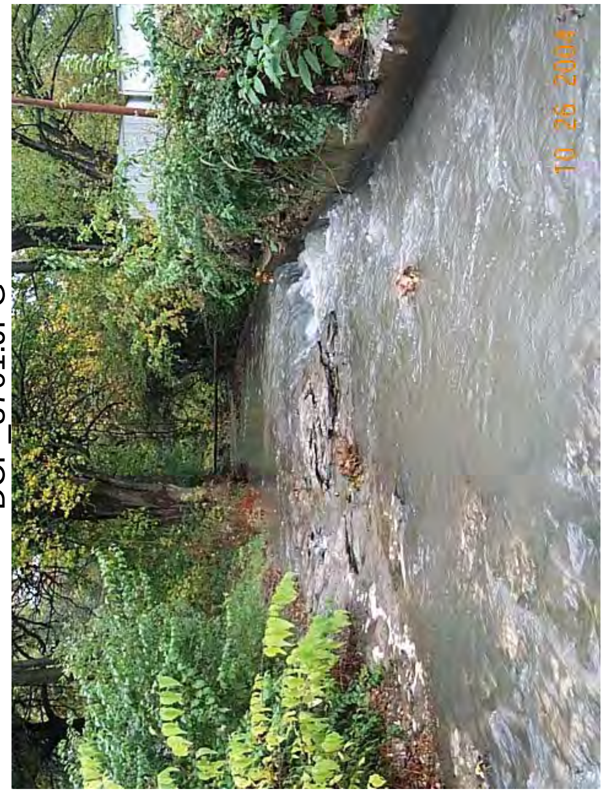


DCP_3699.JPG

DCP_3700.JPG

DCP_3701.JPG

DCP_3702.JPG



DCP_3703.JPG

DCP_3704.JPG

DCP_3705.JPG

DCP_3706.JPG

DCP_3707.JPG

DCP_3708.JPG

DCP_3709.JPG

DCP_3710.JPG

DCP_3711.JPG

DCP_3712.JPG

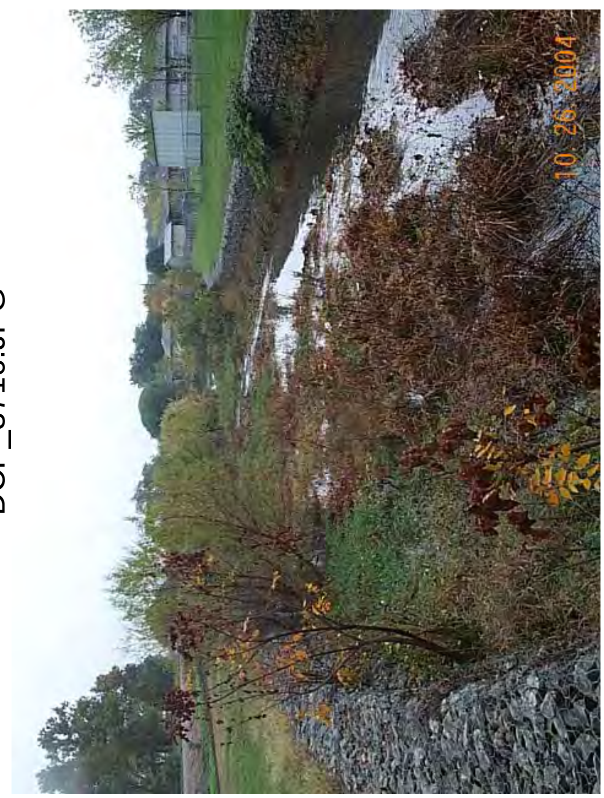
DCP_3713.JPG

DCP_3714.JPG

DCP_3715.JPG


DCP_3716.JPG


DCP_3717.JPG


DCP_3718.JPG


DCP_3719.JPG

DCP_3720.JPG

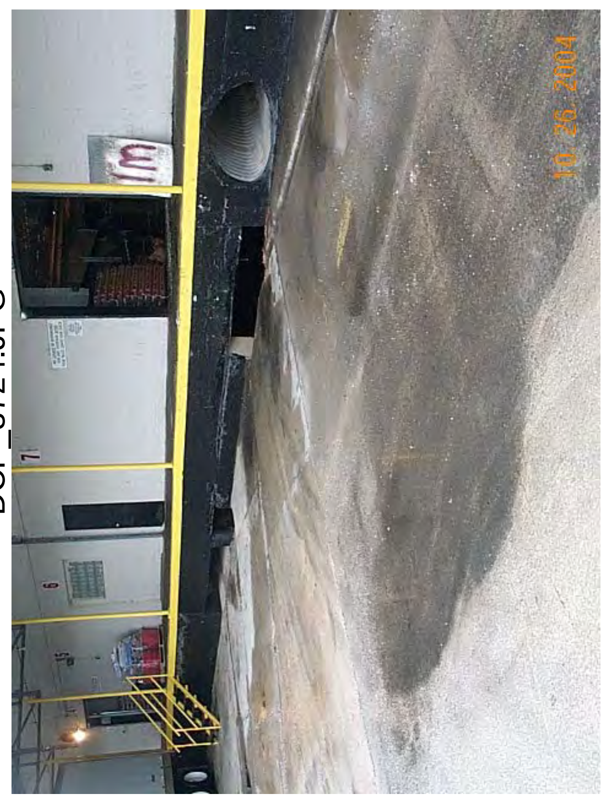
DCP_3721.JPG

DCP_3722.JPG

DCP_3723.JPG

DCP_3724.JPG

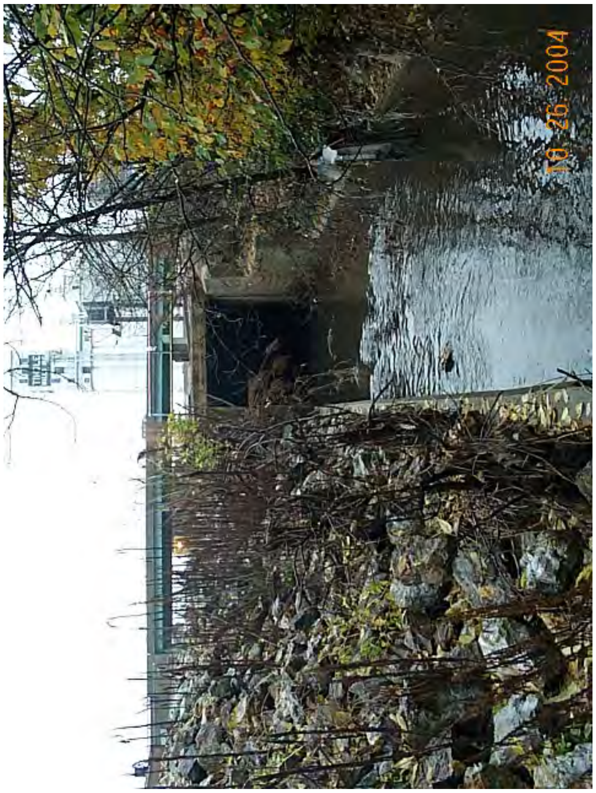
DCP_3725.JPG



DCP_3726.JPG

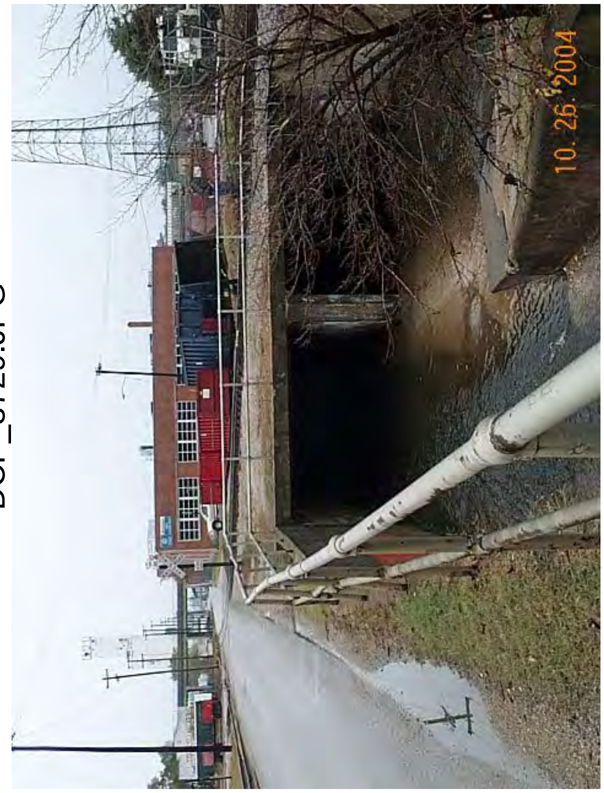
DCP_3727.JPG

DCP_3728.JPG

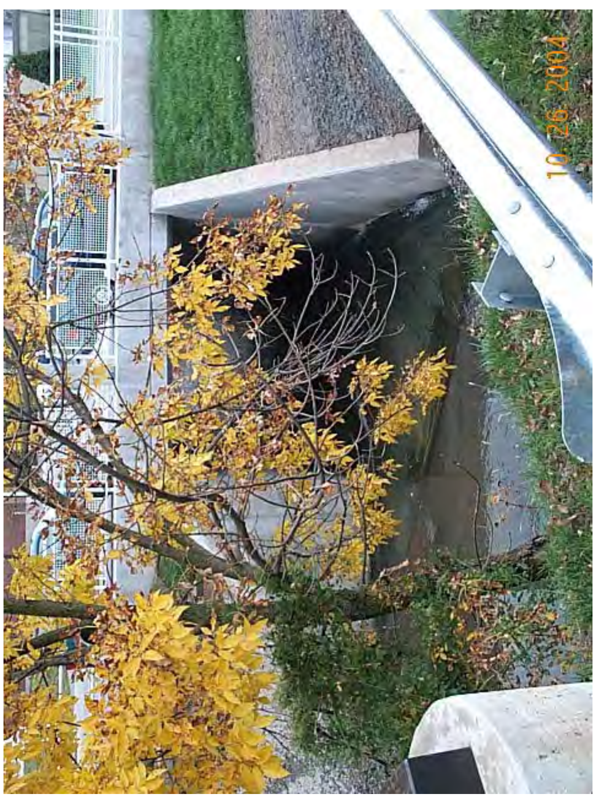


DCP_3729.JPG

DCP_3730.JPG



DCP_3731.JPG

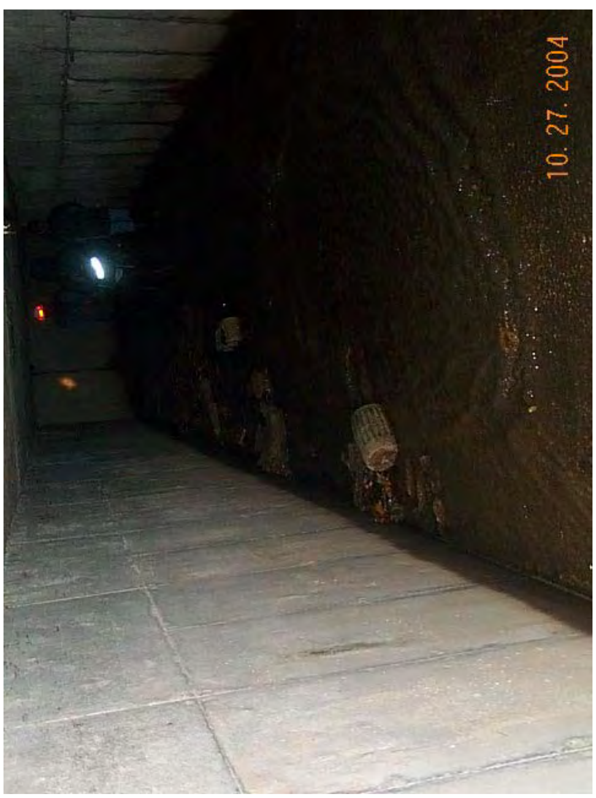


DCP_3732.JPG

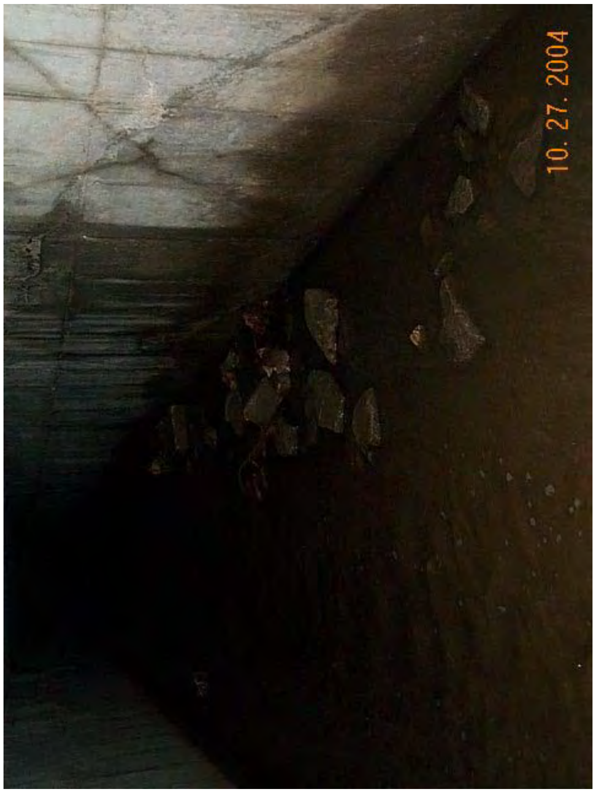
DCP_3733.JPG

DCP_3734.JPG

DCP_3735.JPG



DCP_3736.JPG



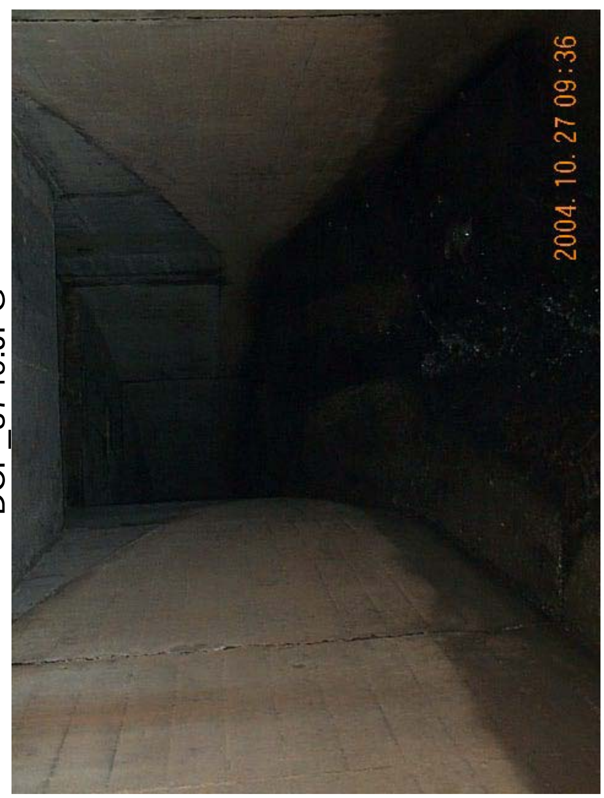
DCP_3737.JPG

DCP_3738.JPG

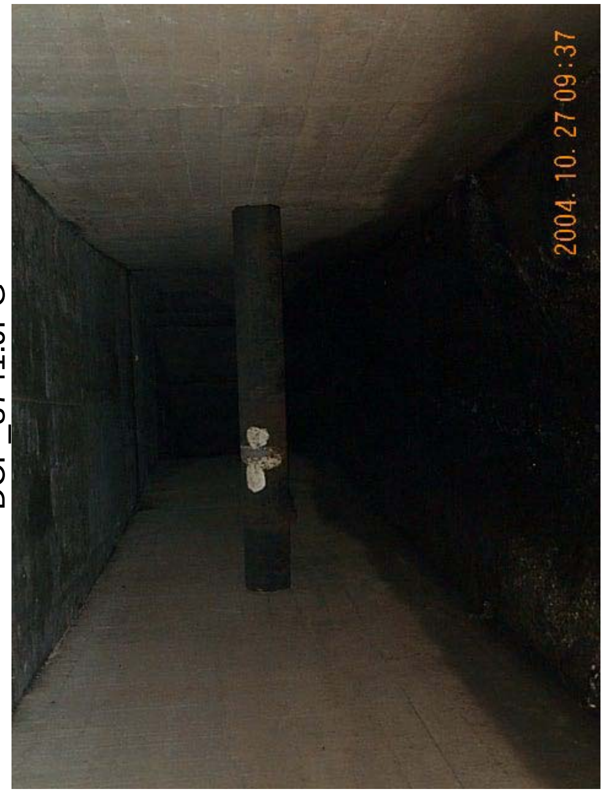

DCP_3739.JPG

DCP_3740.JPG

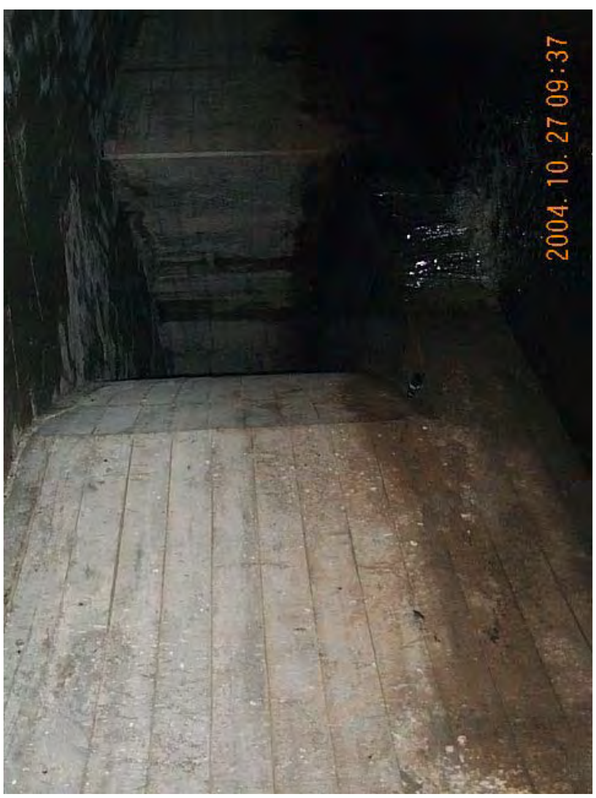
DCP_3741.JPG



DCP_3742.JPG



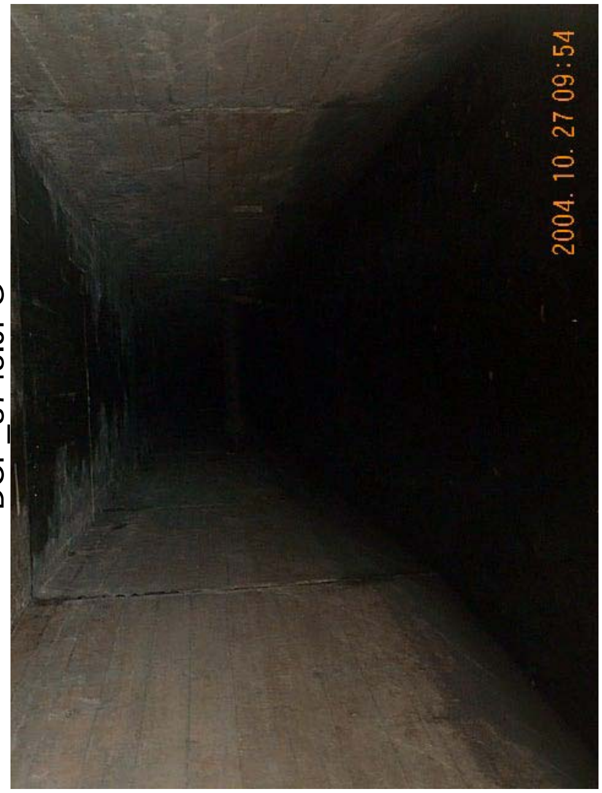
DCP_3743.JPG



DCP_3744.JPG

DCP_3745.JPG

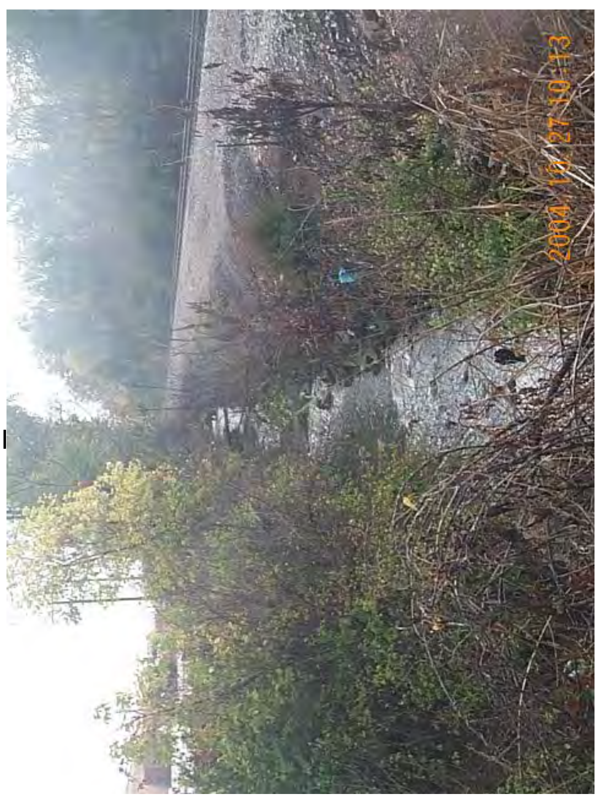
DCP_3746.JPG



DCP_3747.JPG

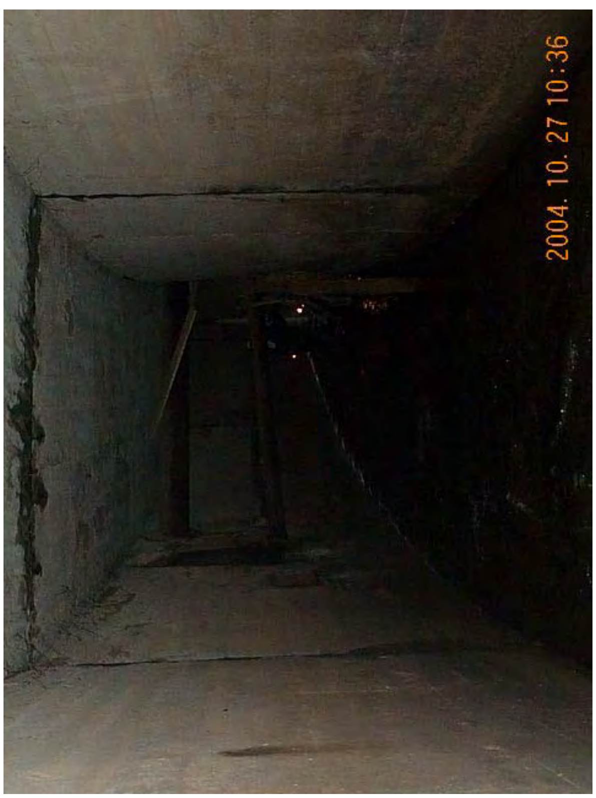
DCP_3748.JPG

DCP_3749.JPG

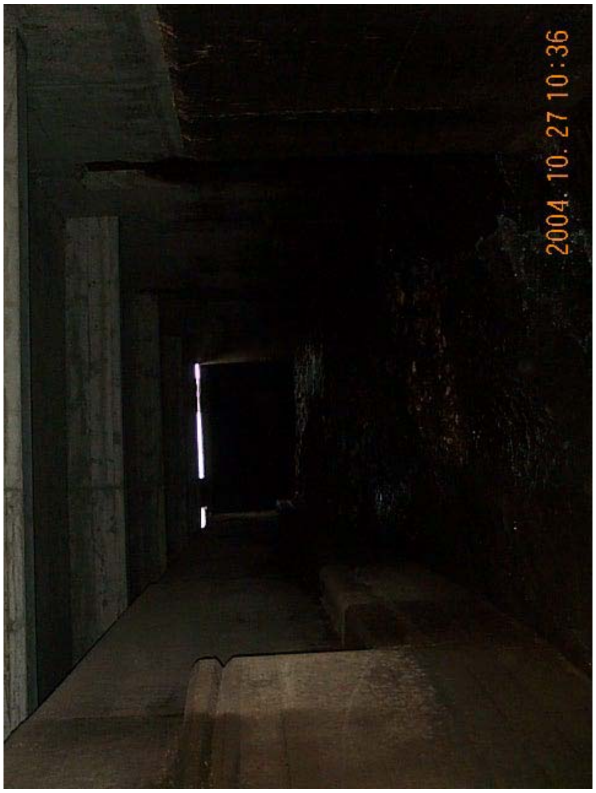


DCP_3750.JPG

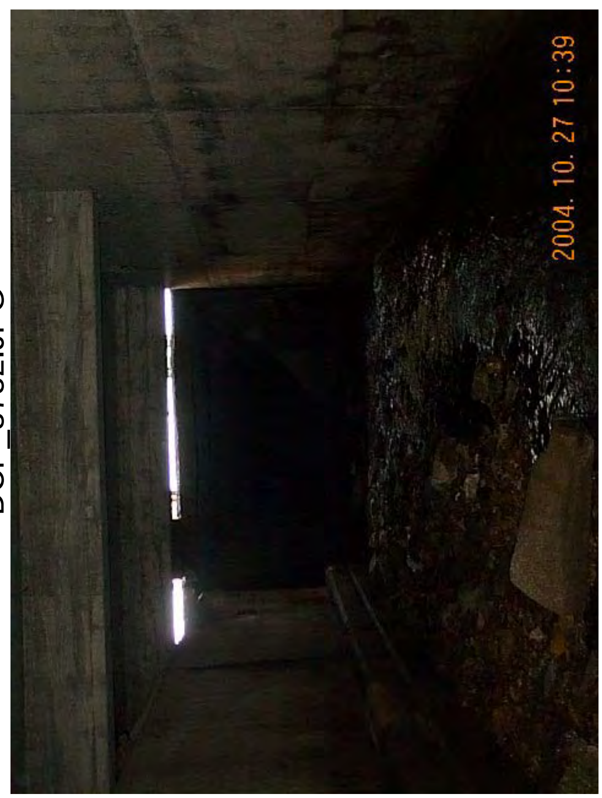
DCP_3751.JPG



DCP_3752.JPG

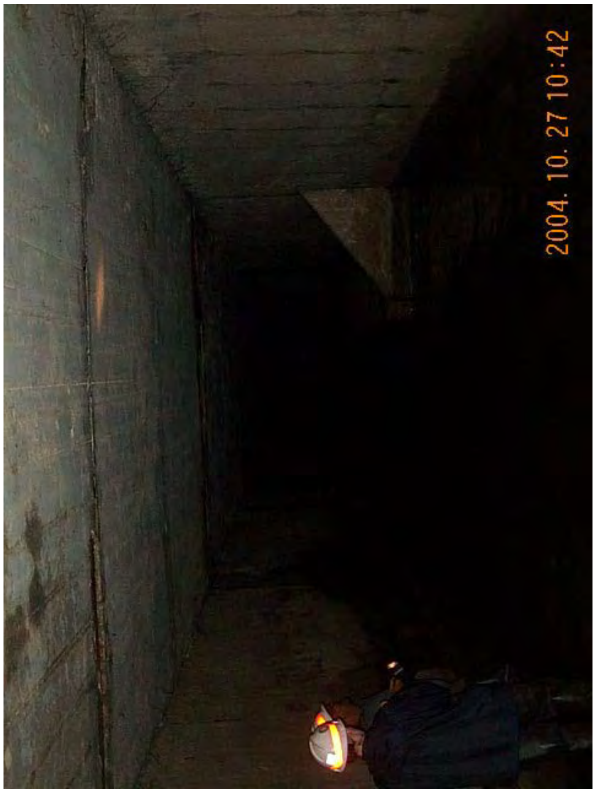


DCP_3753.JPG

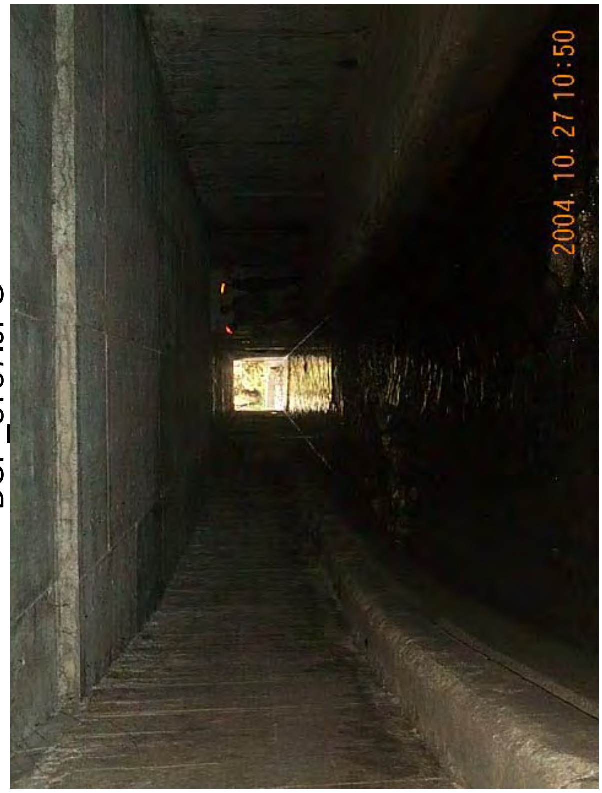


DCP_3754.JPG

DCP_3755.JPG

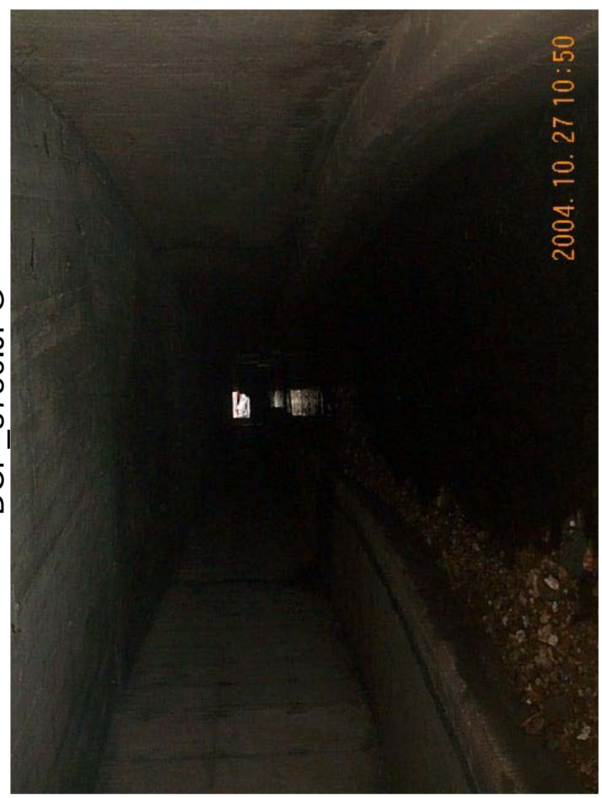


DCP_3757.JPG



DCP_3759.JPG

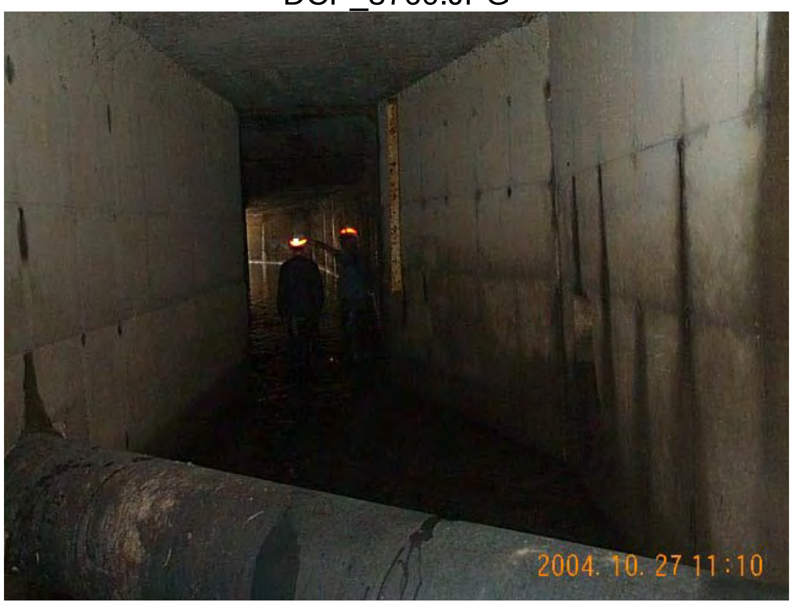
DCP_3756.JPG



DCP_3758.JPG

DCP_3760.JPG

DCP_3761.JPG



DCP_3762.JPG

DCP_3763.JPG

DCP_3764.JPG

DCP_3765.JPG

DCP_3766.JPG

DCP_3767.JPG

DCP_3768.JPG

DCP_3769.JPG

DCP_3770.JPG

DCP_3771.JPG

DCP_3772.JPG

DCP_3773.JPG

DCP_3774.JPG

DCP_3775.JPG

DCP_3776.JPG

DCP_3777.JPG

DCP_3778.JPG

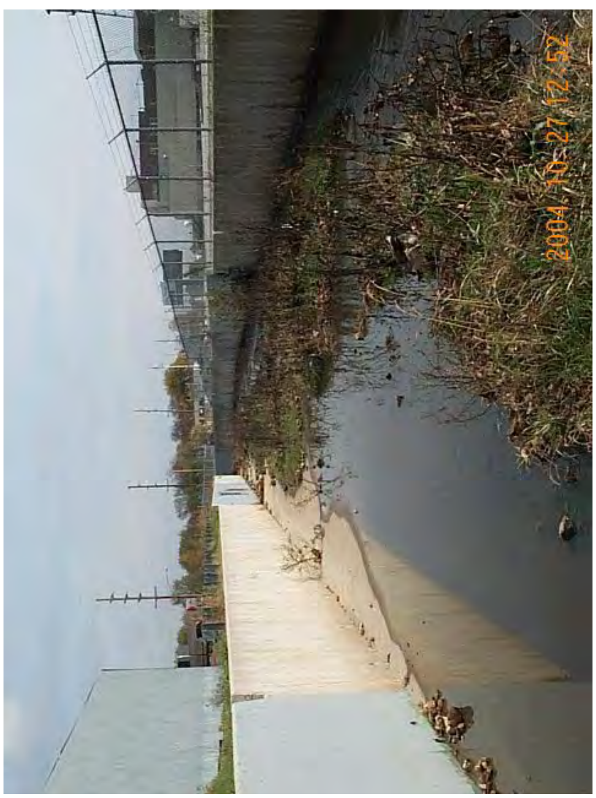
DCP_3779.JPG

DCP_3780.JPG

DCP_3781.JPG

DCP_3782.JPG

DCP_3783.JPG



DCP_3784.JPG

DCP_3785.JPG

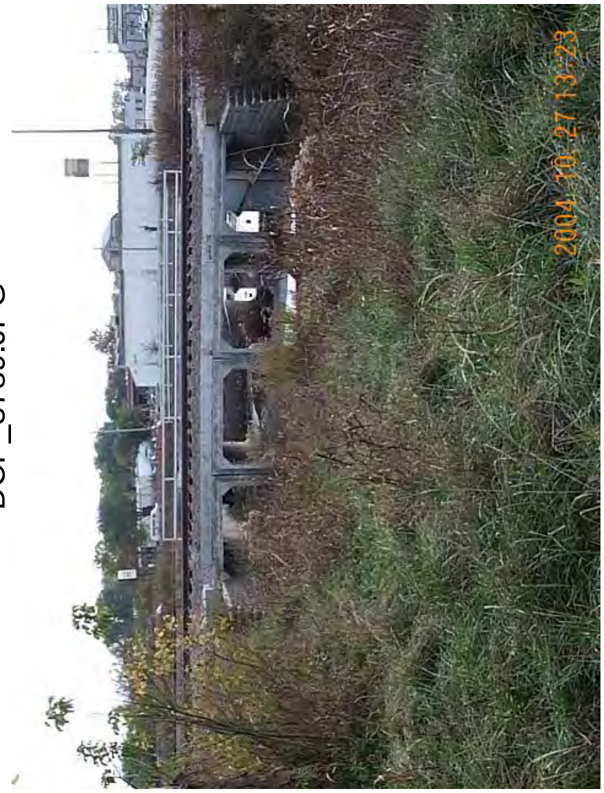
DCP_3786.JPG

DCP_3787.JPG


DCP_3788.JPG


DCP_3789.JPG


DCP_3790.JPG


DCP_3791.JPG

DCP_3792.JPG

DCP_3793.JPG

DCP_3794.JPG

DCP_3795.JPG


DCP_3796.JPG


DCP_3797.JPG


DCP_3798.JPG


DCP_3799.JPG

DCP_3800.JPG

DCP_3801.JPG

DCP_3802.JPG

DCP_3803.JPG


DCP_3804.JPG


DCP_3805.JPG


DCP_3806.JPG


DCP_3807.JPG

DCP_3808.JPG

DCP_3809.JPG

DCP_3810.JPG


DCP_3811.JPG

DCP_3813.JPG

DCP_3812.JPG

DCP_3814.JPG

Appendix HH-H – Rainfall Table from the Rainfall Atlas of the Midwest

The following appendix includes Sectional Mean Frequency Distributions from the "Rainfall Frequency Atlas of the Midwest" by Floyd A. Huff and James R. Angel. Midwestern Climate Center – National Weather Service, Bulletin 71 (MCC Research Report 92-03). 1992.

Table 7. Sectional Mean Frequency Distributions for Storm Periods of 5 Minutes to 10 Days and Recurrence Intervals of 2 Months to 100 Years in Missouri

Sectional code (see figure 1 on page 4)

01 - Northwest Prairie   *04 - West Ozarks*
02 - Northeast Prairie   *05 - East Ozarks*
03 - West Central Plains   *06 - Bootheel*

Rainfall (inches) for given recurrence interval

Section	*Duration*	*2-month*	*3-month*	*4-month*	*6-month*	*9-month*	*1-year*	*2-year*	*5-year*	*10-year*	*25-year*	*50-year*	*100-year*
01	10-day	2.18	2.62	3.02	3.55	4.08	4.44	5.60	7.01	8.01	9.27	10.20	11.25
01	5-day	1.82	2.17	2.46	2.85	3.28	3.56	4.50	5.69	6.60	7.78	8.71	9.71
01	72-hr	1.62	1.90	2.15	2.50	2.87	3.12	3.99	5.11	5.98	7.07	7.92	8.82
01	48-hr	1.48	1.73	1.93	2.23	2.57	2.79	3.59	4.63	5.43	6.43	7.17	7.99
01	24-hr	1.39	1.62	1.77	2.05	2.33	2.53	3.27	4.25	4.98	5.89	6.58	7.30
01	18-hr	1.31	1.52	1.67	1.93	2.19	2.38	3.07	3.99	4.68	5.54	6.19	6.86
01	12-hr	1.21	1.41	1.54	1.78	2.02	2.20	2.84	3.70	4.33	5.12	5.72	6.35
01	6-hr	1.04	1.22	1.33	1.54	1.75	1.90	2.45	3.19	3.74	4.42	4.93	5.48
01	3-hr	0.89	1.04	1.13	1.31	1.49	1.62	2.09	2.72	3.19	3.77	4.21	4.67
01	2-hr	0.81	0.94	1.03	1.19	1.35	1.47	1.90	2.46	2.89	3.42	3.82	4.23
01	1-hr	0.65	0.76	0.83	0.96	1.09	1.19	1.54	2.00	2.34	2.77	3.09	3.43
01	30-min	0.52	0.60	0.66	0.76	0.86	0.94	1.21	1.57	1.84	2.18	2.43	2.70
01	15-min	0.37	0.44	0.48	0.55	0.63	0.68	0.88	1.15	1.34	1.59	1.78	1.97
01	10-min	0.29	0.34	0.37	0.43	0.49	0.53	0.69	0.89	1.05	1.24	1.38	1.53
01	5-min	0.17	0.19	0.21	0.24	0.28	0.30	0.39	0.51	0.60	0.71	0.79	0.88
02	10-day	2.21	2.66	3.07	3.61	4.15	4.51	5.41	6.64	7.62	8.90	9.92	11.02
02	5-day	1.79	2.14	2.42	2.81	3.23	3.51	4.27	5.37	6.27	7.53	8.51	9.57
02	72-hr	1.63	1.91	2.16	2.50	2.88	3.13	3.82	4.81	5.66	6.81	7.74	8.76
02	48-hr	1.48	1.74	1.93	2.24	2.58	2.80	3.44	4.33	5.09	6.14	6.99	7.91
02	24-hr	1.38	1.60	1.75	2.03	2.30	2.50	3.10	3.94	4.64	5.60	6.38	7.21
02	18-hr	1.29	1.50	1.64	1.90	2.16	2.35	2.91	3.70	4.36	5.26	6.00	6.78
02	12-hr	1.19	1.39	1.52	1.76	2.00	2.17	2.70	3.43	4.04	4.87	5.55	6.27
02	6-hr	1.03	1.20	1.32	1.52	1.73	1.88	2.32	2.95	3.48	4.20	4.78	5.41
02	3-hr	0.88	1.02	1.12	1.30	1.47	1.60	1.98	2.52	2.97	3.58	4.08	4.61
02	2-hr	0.80	0.93	1.01	1.17	1.33	1.45	1.80	2.29	2.69	3.25	3.70	4.18
02	1-hr	0.64	0.75	0.82	0.95	1.08	1.17	1.46	1.85	2.18	2.63	3.00	3.39
02	30-min	0.51	0.60	0.65	0.75	0.86	0.93	1.15	1.46	1.72	2.07	2.36	2.67
02	15-min	0.37	0.44	0.48	0.55	0.63	0.68	0.84	1.06	1.25	1.51	1.72	1.95
02	10-min	0.29	0.33	0.36	0.42	0.48	0.52	0.65	0.83	0.97	1.18	1.34	1.51
02	5-min	0.17	0.19	0.21	0.24	0.28	0.30	0.37	0.47	0.56	0.67	0.77	0.87
03	10-day	2.38	2.87	3.30	3.89	4.47	4.86	6.10	7.59	8.62	9.88	10.87	11.72
03	5-day	2.04	2.44	2.76	3.20	3.68	4.00	4.92	6.12	7.06	8.33	9.31	10.36
03	72-hr	1.79	2.10	2.38	2.76	3.17	3.45	4.25	5.33	6.20	7.39	8.32	9.30
03	48-hr	1.66	1.94	2.16	2.50	2.88	3.13	3.90	4.92	5.71	6.78	7.66	8.57
03	24-hr	1.55	1.80	1.97	2.28	2.59	2.81	3.50	4.41	5.16	6.16	6.93	7.74
03	18-hr	1.45	1.69	1.85	2.14	2.43	2.64	3.29	4.15	4.85	5.79	6.51	7.28
03	12-hr	1.34	1.56	1.71	1.98	2.24	2.44	3.05	3.84	4.49	5.36	6.03	6.73
03	6-hr	1.16	1.35	1.48	1.71	1.94	2.11	2.62	3.31	3.87	4.62	5.20	5.80
03	3-hr	0.99	1.15	1.26	1.46	1.66	1.80	2.24	2.82	3.30	3.94	4.44	4.95
03	2-hr	0.90	1.04	1.14	1.32	1.50	1.63	2.03	2.56	2.99	3.57	4.02	4.49
03	1-hr	0.73	0.84	0.92	1.07	1.21	1.32	1.64	2.07	2.43	2.90	3.26	3.64
03	30-min	0.57	0.67	0.73	0.84	0.96	1.04	1.30	1.63	1.91	2.28	2.56	2.86
03	15-min	0.42	0.49	0.53	0.62	0.70	0.76	0.95	1.19	1.39	1.66	1.87	2.09
03	10-min	0.32	0.38	0.41	0.48	0.54	0.59	0.73	0.93	1.08	1.29	1.46	1.63
03	5-min	0.19	0.22	0.24	0.28	0.31	0.34	0.42	0.53	0.62	0.74	0.83	0.93

Table 7. Concluded

Rainfall (inches) for given recurrence interval

Section	*Duration*	*2-month*	*3-month*	*4-month*	*6-month*	*9-month*	*1-year*	*2-year*	*5-year*	*10-year*	*25-year*	*50-year*	*100-year*
04	10-day	2.63	3.17	3.65	4.30	4.94	5.37	6.59	8.05	9.13	10.49	11.52	12.61
04	5-day	2.12	2.54	2.87	3.33	3.83	4.16	5.21	6.50	7.45	8.70	9.68	10.77
04	72-hr	1.91	2.24	2.54	2.94	3.39	3.68	4.62	5.81	6.69	7.90	8.85	9.85
04	48-hr	1.75	2.05	2.28	2.64	3.04	3.30	4.14	5.25	6.07	7.17	8.05	8.97
04	24-hr	1.65	1.92	2.10	2.43	2.76	3.00	3.77	4.79	5.55	6.56	7.34	8.18
04	18-hr	1.55	1.80	1.97	2.28	2.59	2.82	3.54	4.50	5.22	6.17	6.90	7.69
04	12-hr	1.44	1.67	1.83	2.11	2.40	2.61	3.28	4.17	4.83	5.71	6.39	7.12
04	6-hr	1.24	1.44	1.57	1.82	2.07	2.25	2.83	3.59	4.16	4.92	5.51	6.14
04	3-hr	1.06	1.23	1.34	1.56	1.77	1.92	2.41	3.07	3.55	4.20	4.70	5.24
04	2-hr	0.96	1.11	1.22	1.41	1.60	1.74	2.19	2.78	3.22	3.80	4.26	4.74
04	1-hr	0.78	0.90	0.99	1.14	1.30	1.41	1.77	2.25	2.61	3.08	3.45	3.84
04	30-min	0.61	0.71	0.78	0.90	1.02	1.11	1.39	1.77	2.05	2.43	2.72	3.03
04	15-min	0.45	0.52	0.57	0.66	0.75	0.81	1.02	1.29	1.50	1.77	1.98	2.21
04	10-min	0.35	0.40	0.44	0.51	0.58	0.63	0.79	1.01	1.17	1.38	1.54	1.72
04	5-min	0.20	0.23	0.25	0.29	0.33	0.36	0.45	0.57	0.67	0.79	0.88	0.98
05	10-day	2.30	2.77	3.20	3.76	4.32	4.70	5.96	7.36	8.29	9.48	10.34	11.31
05	5-day	1.92	2.30	2.60	3.02	3.47	3.77	4.78	5.99	6.86	8.02	8.97	9.93
05	72-hr	1.75	2.05	2.32	2.69	3.09	3.36	4.24	5.31	6.10	7.15	7.99	8.90
05	48-hr	1.61	1.88	2.09	2.42	2.79	3.03	3.82	4.78	5.50	6.47	7.24	8.06
05	24-hr	1.53	1.79	1.95	2.26	2.57	2.79	3.51	4.39	5.03	5.94	6.64	7.42
05	18-hr	1.44	1.68	1.83	2.12	2.41	2.62	3.30	4.13	4.73	5.58	6.24	6.97
05	12-hr	1.34	1.56	1.70	1.97	2.24	2.43	3.05	3.82	4.38	5.17	5.78	6.46
05	6-hr	1.15	1.34	1.46	1.69	1.92	2.09	2.63	3.29	3.77	4.45	4.98	5.57
05	3-hr	0.98	1.15	1.25	1.45	1.65	1.79	2.25	2.81	3.22	3.80	4.25	4.75
05	2-hr	0.89	1.04	1.13	1.31	1.49	1.62	2.04	2.55	2.92	3.45	3.85	4.30
05	1-hr	0.72	0.84	0.92	1.06	1.21	1.31	1.65	2.06	2.36	2.79	3.12	3.49
05	30-min	0.57	0.66	0.72	0.83	0.95	1.03	1.30	1.62	1.86	2.20	2.46	2.75
05	15-min	0.41	0.48	0.52	0.61	0.69	0.75	0.95	1.19	1.36	1.60	1.79	2.00
05	10-min	0.32	0.38	0.41	0.48	0.54	0.59	0.74	0.92	1.06	1.25	1.39	1.56
05	5-min	0.18	0.21	0.23	0.27	0.30	0.33	0.42	0.53	0.60	0.71	0.80	0.89
06	10-day	2.45	2.94	3.39	3.99	4.59	4.99	6.43	7.99	9.01	10.25	11.15	12.07
06	5-day	2.09	2.50	2.83	3.28	3.77	4.10	5.19	6.46	7.31	8.39	9.20	10.04
06	72-hr	1.91	2.24	2.53	2.94	3.38	3.67	4.67	5.81	6.60	7.58	8.35	9.12
06	48-hr	1.74	2.03	2.26	2.62	3.02	3.28	4.14	5.13	5.84	6.75	7.47	8.21
06	24-hr	1.64	1.91	2.09	2.42	2.75	2.99	3.74	4.65	5.29	6.16	6.83	7.51
06	18-hr	1.55	1.80	1.97	2.28	2.59	2.81	3.52	4.37	4.97	5.79	6.42	7.06
06	12-hr	1.43	1.66	1.82	2.11	2.39	2.60	3.25	4.05	4.60	5.36	5.94	6.53
06	6-hr	1.23	1.43	1.57	1.81	2.06	2.24	2.81	3.49	3.97	4.62	5.12	5.63
06	3-hr	1.05	1.22	1.34	1.55	1.76	1.91	2.39	2.98	3.39	3.94	4.37	4.81
06	2-hr	0.95	1.11	1.21	1.40	1.59	1.73	2.17	2.70	3.07	3.57	3.96	4.36
06	1-hr	0.78	0.90	0.99	1.14	1.30	1.41	1.76	2.19	2.49	2.90	3.21	3.53
06	30-min	0.61	0.71	0.78	0.90	1.02	1.11	1.38	1.72	1.96	2.28	2.53	2.78
06	15-min	0.45	0.52	0.57	0.66	0.75	0.81	1.01	1.26	1.43	1.66	1.84	2.03
06	10-min	0.35	0.40	0.44	0.51	0.58	0.63	0.79	0.98	1.11	1.29	1.43	1.58
06	5-min	0.20	0.23	0.25	0.29	0.33	0.36	0.45	0.56	0.63	0.74	0.82	0.90

Appendix HH-I – Summary Table of Regional Detention Basins

Proposed Regional Detention Basins

Basin Name	Reach Name	Location Description	Station	Top of Berm Elevation	Depth (ft)	Surface Area (acres)	Volume (ac-ft)	Est. Excavation Volume (cubic yd)	Outlet Description	Weir Length (ft)	Weir Elevation	Pipe Size (in)	Pipe Elevation	Notes
B15	North Branch	West side of Packer Rd, N of RR	18653	1380	11	3.99	30.1	38,900	12" RCP	N/A	N/A	12	1369	Keep WSE at existing and do not encroach on RR ROW. Currently overtopps. Lower existing pipe
B14	North Branch	North of Blaine, W of Packer	16668	1366	7.8	11.39	53.9	67,500	42" RCP	N/A	N/A	42	1358.2	As drawn, low flow does not have enough slope. May need to move basin north to avoid recent building dev.
B12	North Branch	Corner of Blaine and Yates	15476	1353	5.2	2.29	9.4	15,000	No Outlet	N/A	N/A	N/A	1347.8	In-line basin that catches flow from the north. Proposed system along Blaine would surcharge into basin and be released based on system capacity.
B11A	North Branch	South of Blaine at Link	11949	1340	7	6.24	19.2	19,000	12' Sharp Crest Weir	12	1333	N/A	N/A	15:1 SS. Basin not affected by TW from B11. Would have to remove & replant a number of trees.
B11	North Branch	South of Blaine US Glenstone	10225	1332	7.7	8.68	36.4	24,800	15' Weir into Box	15	1325	N/A	N/A	Keeps peak flows low enough to eliminate flooding along Glenstone Ave.
B9B	South Branch	NW Corner of Pythian & Cedarbrook	N/A	1352	8	5.68	27.7	34,700	2-36" RCP and Weir	20	1351	36	1344	Construct berm on DS end. Does not account for TW from B9C.
B9C	South Branch	NW Corner of Pythian & Cedarbrook	N/A	1344	8	5.02	30.5	29,800	48" RCP	N/A	N/A	48	1338	Discharge into existing system. Basin will keep flows in system. Current basin overtopps.
B6	South Branch	Upstream of Chestnut Exp.	10240	1317	8.7	5.99	35.6	51,300	Weir into Box	Unknown	Unknown	N/A	N/A	Physical outlet not designed. Design based on reasonable rating curve. Outlet probably consists of something like a 10' weir at ele 1309
B7	South Branch	East end of Rockhurst Street	14475	1342	12	6.73	46.2	58,000	2-42" RCP & 5' Weir	5	1336	42	1331	Lower FL of basin. Discharge through two 42" pipes that run along Rockhurst St to Patterson. Any flows reaching the weir can be conveyed using existing drainage along Rockhurst.

Appendix HH-J – Standard Deviation of Error for Without Project – Current Conditions Model

Reach	Profile	Standard Deviation of Error for all x-sec in reach based on a HIGHER "n" factor (40% in channel, 33% in overbank)	Standard Deviation of Error for all x-sec in reach based on a LOWER "n" factor (40% overall reduction)	Standard Deviation of Error for all x-sec in reach based on both "n" value assumptions	Stage where Error Becomes Constant
South	1yr	0.33	0.82	0.64	
	2yr	0.27	0.42	0.36	
	5yr	0.23	0.43	0.35	
	10yr	0.22	0.39	0.32	
	25yr	0.29	0.60	0.46	
	50yr	0.27	0.35	0.31	
	100yr	0.23	0.29	0.27	
	500yr	0.26	0.35	0.31	
	ALL	**0.27**	**0.50**	**0.40**	
Use	**0.3**	0.25	0.40	0.34	**10 year**
North	1yr	0.97	0.60	0.82	
	2yr	0.53	1.30	1.00	
	5yr	0.22	0.57	0.42	
	10yr	0.28	0.52	0.41	
	25yr	0.37	0.39	0.38	
	50yr	0.29	0.30	0.30	
	100yr	0.27	0.33	0.31	
	500yr	0.25	0.25	0.25	
	ALL	**0.47**	**0.66**	**0.57**	
Use	**0.3**	0.28	0.39	0.34	**10 year**
Lower	1yr	0.43	0.52	0.49	
	2yr	0.40	0.53	0.47	
	5yr	0.40	0.58	0.51	
	10yr	0.39	0.64	0.53	
	25yr	0.39	0.67	0.55	
	50yr	0.35	0.65	0.53	
	100yr	0.37	0.68	0.54	
	500yr	0.50	0.52	0.51	
	ALL	**0.41**	**0.61**	**0.52**	
Use	**0.45**				**10 year**
Wilsons	1yr	0.29	0.36	0.34	
	2yr	0.30	0.38	0.36	
	5yr	0.35	0.38	0.38	
	10yr	0.42	0.37	0.46	
	25yr	0.37	0.30	0.42	
	50yr	0.29	0.49	0.44	
	100yr	0.37	0.54	0.49	
	500yr	0.58	0.63	0.61	
	ALL	**0.39**	**0.47**	**0.46**	
Use	**0.4**				**10 year**

Notes by Travis Stanford:

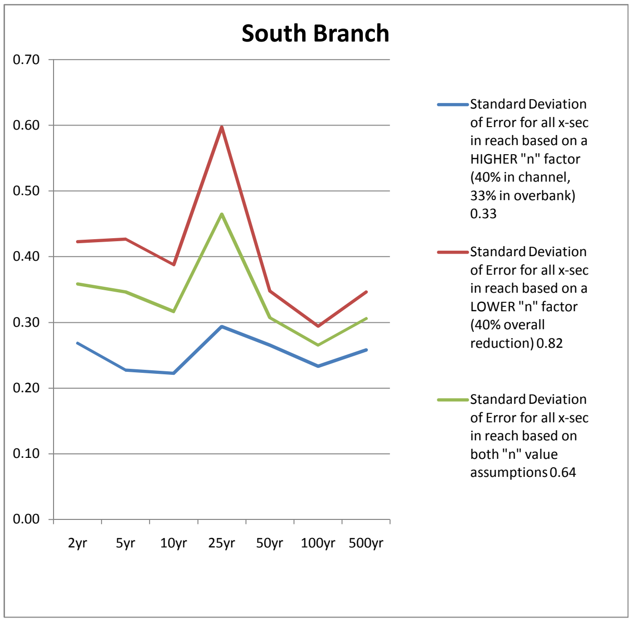
SOUTH: 1-yr error for lower n-values looked like an outlier. Averaged the other values, then estimated use 0.30 to give more weight to error based on higher n-values.

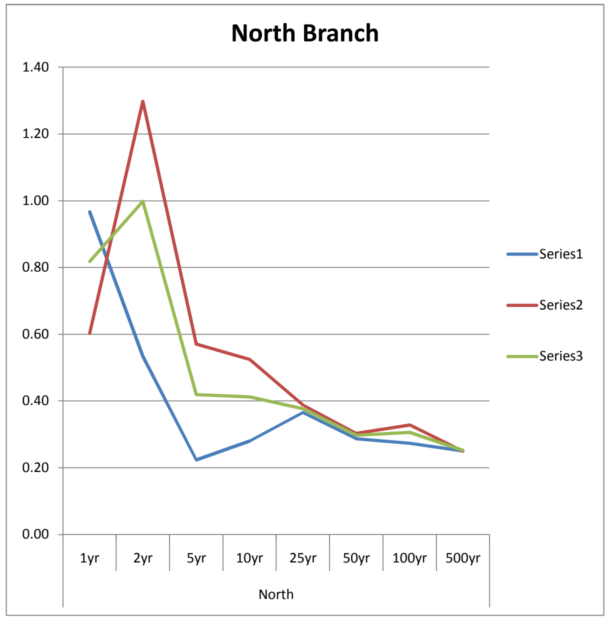
NORTH: 1-yr error for higher n-values and 2-yr error for lower n-values looked like outliers. Averaged the other values, then estimated use 0.30 to give more weight to error based on higher n-values.

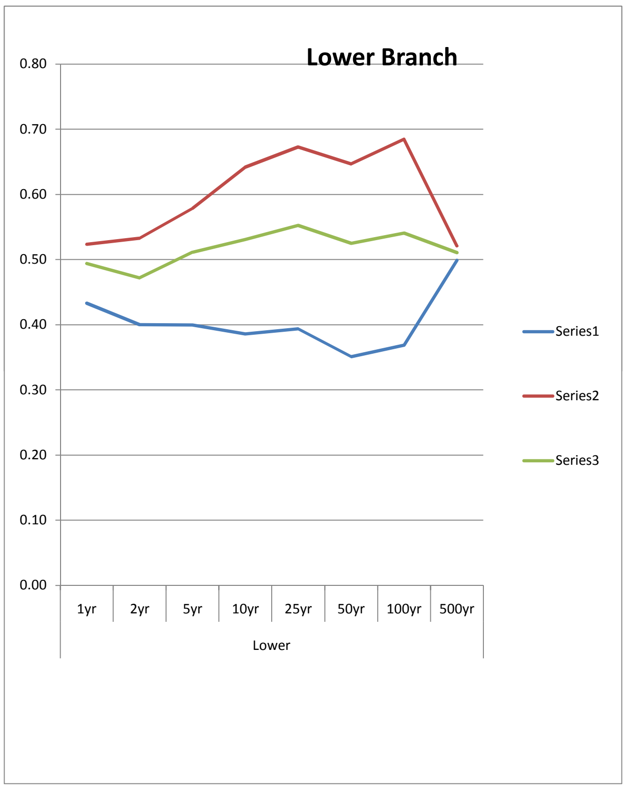
LOWER: No apparent outliers. Estimated use 0.45 to give more weight to error based on higher n-values.

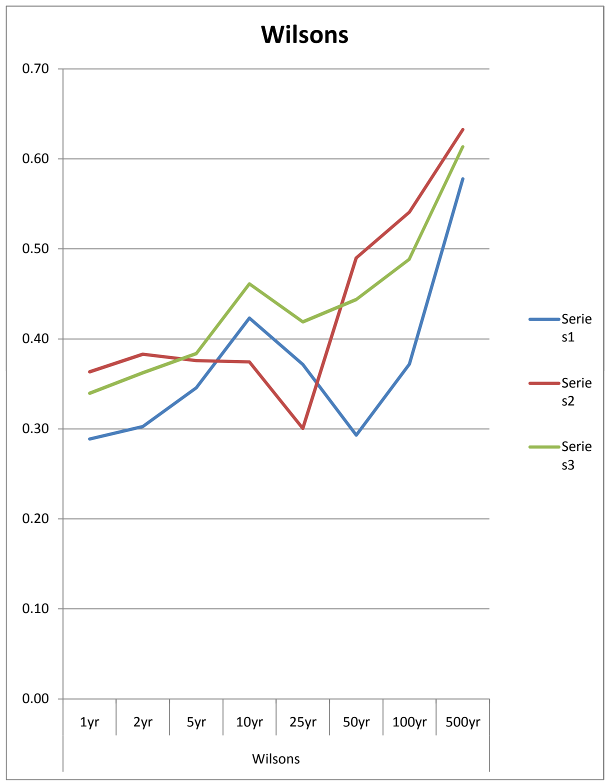
WILSONS: No apparent outliers. Estimated use 0.4 to give more weight to error based on higher n-values.

Estimated 10-year for stage where error becomes constant from visual inspection of 10-yr stage at cross-sections in each reach. 10-year was out of channel at most locations in all the reaches. Selecting the 10-yr stage will result in zero error at the thalweg, with the error increasing linearly to the maximum at the 10-yr stage, then constant maximum erro for all higher stages.


South Branch
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2yr
5yr
10yr
25yr
50yr
100yr
500yr
Standard Deviation of Error for all x-sec in reach based on a HIGHER "n" factor (40% in channel, 33% in overbank) 0.33
Standard Deviation of Error for all x-sec in reach based on a LOWER "n" factor (40% overall reduction) 0.82
Standard Deviation of Error for all x-sec in reach based on both "n" value assumptions 0.64


North Branch
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1yr
2yr
5yr
10yr
25yr
50yr
100yr
500yr
North
Series1
Series2
Series3


Lower Branch
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1yr
2yr
5yr
10yr
25yr
50yr
100yr
500yr
Lower
Series1
Series2
Series3


Wilsons
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1yr
2yr
5yr
10yr
25yr
50yr
100yr
500yr
Wilsons
Series1
Series2
Series3

Appendix HH-K – Proposed Regional Detention – Preliminary Basin Summary

Proposed Regional Detention Basins - Preliminary Analysis

Basin Name	Reach Name	Location Description	Approx Surface Area (acres)	Approx Storage Volume (ac-ft)	Approx Peak Flow Reduction at discharge (initial estimate - based on 100yr event)	Notes
B1	Lower Branch	Upstream of Bennett Street	18	170	<1% for 100yr Event	Preliminary analysis showed that there was not enough storage volume available to cause a significant reduction in peak flow.
B2	Lower Branch	Upstream of Grand Street	25	300	< 1%	Preliminary analysis showed that there was not enough storage volume available to cause a significant reduction in peak flow.
B3	Lower Branch	West Meadows Area (upstream of Fort)	29	140	5%	The West Meadows is a Brownfield site and the cost of excavation would be very high. Even in series with other basins, this facility did not cause a significant reduction in peak flow.
B3A	Lower Branch	Between Fort Ave and College Street	6	75	1%	Construction of this basin would involve relocation of the railroad or the construction of a large railroad bridge spanning the basin. The reduction in peak flow was not significant.
B4	Confluence	East "Wye" - Confluence of North and South Branch	4	35	<1%	Not enough available storage volume to cause a significant decrease in the peak.
B5	South Branch	1000-ft upstream of Fremont Avenue	9	96	6%	While basin resulted in a 6% reduction in peak flow, it will require acquisition of private property, significant excavation, modification to the downstream channel, and loss of riparian corridor. Also, the control structure required to regulate the basin might cause the 500yr WSE to surcharge in an extremely large event.
B5A	South Branch	2000-ft upstream of Fremont Avenue	5	37	6%	While basin resulted in a 6% reduction in peak flow, it will require acquisition of private property, significant excavation, and loss of riparian corridor.

B6	South Branch	Upstream of Chestnut Exp.	5.99	35.6	24%	Basin provides good reduction in peak. While it includes significant excavation and land acquisition, it was further analyzed as a viable alternate.
B7	South Branch	East end of Rockhurst Street	6.73	46.2	70%	Basin could potentially reduce peak flows to the capacity of the existing system. Basin was included as a viable alternate.
B9A	South Branch	East side of Cedarbrook Avenue, Norh of Pythian Street	11	157	97%	Construction of this basin would involve excavating the existing soccer fields. Of the three basins (9A, B, & C) only two of three are needed. It was determined that this was the least likely due to it's impact on the soccer fields.
B9B	South Branch	NW Corner of Pythian & Cedarbrook	5.68	27.7	97%	The upper stage of a two-stage basin with B9C. Together they reduce flows to the capacity of the existing system.
B9C	South Branch	NW Corner of Pythian & Cedarbrook	5.02	30.5	97%	Discharge into existing system. Basin will keep flows in system. Current basin overtops.
B10	North Branch	Downstream of National Ave. (Silver Springs Park)	4	25	1-8%	8% reduction only occurs when in series with B14, B12, B11, B10B. It was determined that this basin gave marginal results.
B10A	North Branch	Downstream of Division Street. (Smith Park)	6	40	<10%	Limited flow reduction and located in a Historic Park. Construction would result in destruction of historic structures.
B10B	North Branch	Downstream of Glenstone Ave.	3	26	7-30%	30% reduction only occurs when in series with B14, B12, and B11. Requires acquisition of 11 homes and damage to riparian corridor.

B11	North Branch	South of Blaine US Glenstone	8.68	36.4	80%	Basin construction would involve acquisition from 8 property owners, significant excavation, and damage to the riparian corridor. However, the peak flow reductions were significant, so this basin was included as a viable alternative.
B11A	North Branch	South of Blaine at Link	6.24	19.2	50%	Basin construction would involve removal of several trees. The peak flow reduction was significant, so it was included as a viable alternate.
B12	North Branch	NW Corner of Blaine and Yates	2.29	9.4	25%	In-line basin that catches flow from the north. Proposed system along Blaine would surcharge into basin and be released based on system capacity. Was considered as a viable alternative.
B12A	North Branch	NE Corner of Blaine and Yates	3	6	2%	Gave marginal results when depth was limited to existing sytem. Would likely be comparable to B12 with similar volume. Requires acquisition of 4 homes.
B14	North Branch	North of Blaine, W of Packer	11.39	53.9	95%	Requires expansion of City owned basin. Considered a viable alternative.
B15	North Branch	West side of Packer Rd, N of RR	3.99	30.1	98%	Would likely require permission from Railroad and land acquisition. Were unable to determine if upstream water actually reached the basin or was diverted.
B16-17-18	North Branch	East of Packer Rd, N of RR	18	400	45-70%	Three separate basins were analyzed in this area, divided by the two RR tracks and the access road. The storage area was also designed as one large basin (with each area joined by a large pipe). Regardless of how the basin was analyzed, it did not provide a substantial decrease in peak flows when compared to the existing constriction under the railroad tracks.

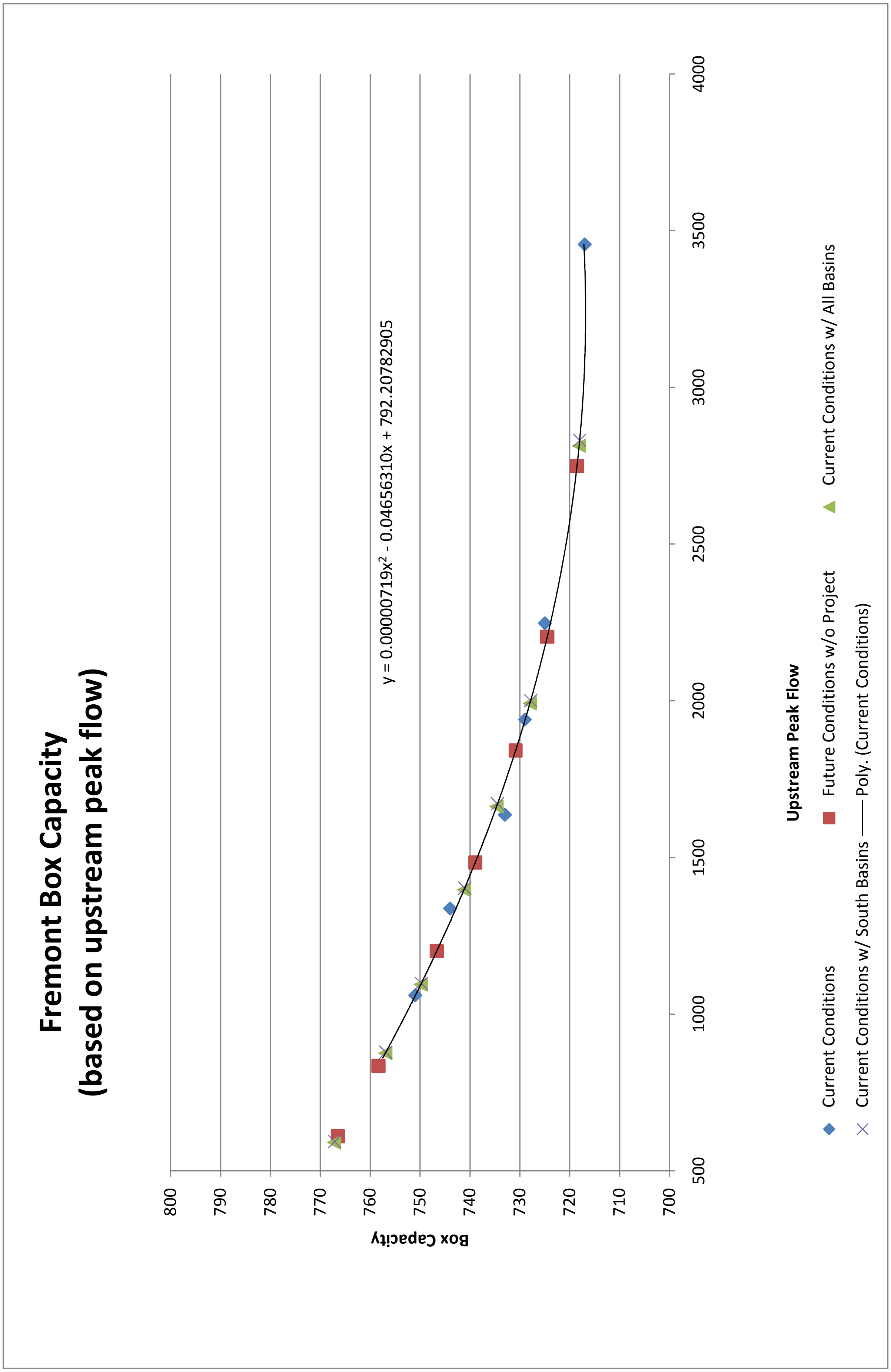
Appendix HH-L – Summary Table of Regional Detention Analysis

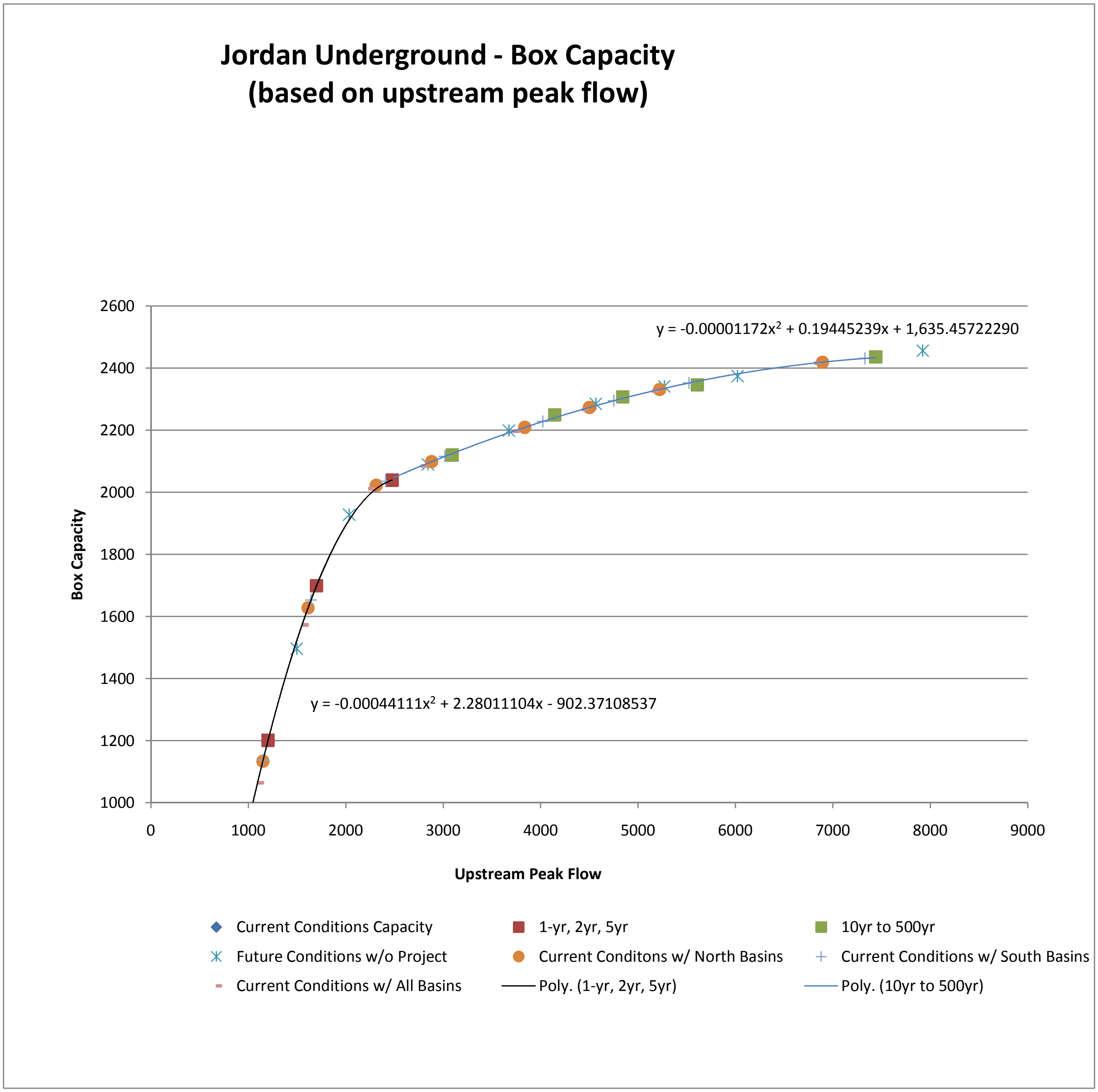
Proposed Regional Detention Basins - Analysis of Impact on Peak Flows

									Confluence of NB & SB			Catalpa Street on LB			NB DS of Glenstone			NB at Central Street			SB at RR DS of Trafficway			SB at Fremont			
Basin Configuration	Reach Name	Location Description	Approx Surface Area of Basin (acres)	Approx Storage Volume (ac-ft)	Analysis Point DS	Reduction In 100yr Peak Immediately Downstream of Basin (located at next hydrograph combination)	With Basin Peak Flow DS	W/O Bains Peak Flow DS	Reduction in 100yr Peak Flow @ Confluence (HC75)	With Basin Peak Flow @ HC75	W/O Basin Peak Flow @ HC75	Reduction in 100yr Peak Flow @ Catalpa St (HCLJ20)	With Basin Peak Flow @ HCLJ202	W/O Basins Peak Flow @ HCLJ20	Reduction in 100yr Peak Flow @ HCNB21	With Basin Peak Flow @ HCNB21	W/O Basin Peak Flow @ HCNB21	Reduction in 100yr Peak Flow @ HCNB31	With Basin Peak Flow @ HCNB31	W/O Basin Peak Flow @ HCNB31	Reduction in 100yr Peak Flow @ Confluence HCSJX	With Basin Peak Flow @ HCSJX	W/O Basin Peak Flow @ HCSJX	Reduction in 100yr Peak Flow @ SJ37	With Basin Peak Flow @ SJ37	W/O Basin Peak Flow @ SJ37	Notes
B6	South Branch	Upstream of Chestnut Exp.	5.99	35.6	HCSJX	0.0%	1522.0	1522.0	0.0%	5876.0	5874.0	0.0%	7103.0	7103.0	0.0%	1627.0	1627.0	0.0%	2781.0	2781.0	0.0%	1522.0	1522.0	0.0%	2260.0	2260.0	This basin only functions when in series with B7 & B9(B&C). When the flows are reduced by these upstream basins, a control structure can be placed upstream of Chestnut. Otherwise, the storage behind the culvert is already accounted for with Modified Puls Routing element MP27.
B6B	South Branch	West side of Patterson	7.5	39.8	SJ25	14.6%	1207	1414	0.0%	5874	5874	0.0%	7103	7103	0.0%	1627	1627	0.0%	2781	2781	6.0%	1431	1522	0.0%	2260	2260	This basin includes excavation of the stream valley and soccer field just downstream of Patterson Ave on South Branch. It appears to function very similar to Basin B6 with less reduction and more excavation.
B6 (IN SERIES WITH B9B & C AND B7)	South Branch					N/A		N/A	N/A			N/A		N/A	0.0%	1627	1627.0	0.0%	2781	2781.0	11.8%	*	1522.0	5.7%	*	2260.0	This line shows the effects of B6 without any other basins. The fields were calculated by finding the difference between the following scenarios (All Basins - Basins B9B&C and B7)
B6B (IN SERIES WITH B9B & C AND B7)	South Branch					N/A		N/A	N/A		N/A	N/A		N/A	0.0%	1627	1627	0.0%	2781	2781	2.7%	*	1522	2.7%	*	2260	This line shows the effect of B6B without any other basins. The field was calculated by finding the difference between the following scenarios (B6B IN SERIES WITH B9B & C, B7 AND B9B & C, B7)
B7	South Branch	East end of Rockhurst Street	6.73	46.2	SJ15	51.7%	431.0	892.0	0.4%	5848.0	5874.0	0.1%	7099.0	7103.0	0.0%	1627.0	1627.0	0.0%	2781.0	2781.0	24.4%	1150.0	1522.0	3.8%	2173.0	2260.0	Glenwood Park Basin. Basin could potentially reduce peak flows to the capacity of the existing system and solve a number of local flooding problems along Rockhurst Street.
B9B	South Branch	NW Corner of Pythian & Cedarbrook	5.68	27.7	RRSJ21	75.8%	104.0	429.0	0.1%	5868.0	5874.0	0.0%	7103.0	7103.0	0.0%	1627.0	1627.0	0.0%	2781.0	2781.0	8.7%	1390.0	1522.0	2.3%	2207.0	2260.0	The upper stage of a two-stage basin with B9C. Together they reduce flows to the capacity of the existing system. Notice that you get nearly the same results without construction basin B9C and leaving the existing basin in place.
B9C	South Branch	NW Corner of Pythian & Cedarbrook	5.02	30.5	RRSJ21	53.6%	199.0	429.0	0.1%	5868.0	5874.0	0.0%	7103.0	7103.0	0.0%	1627.0	1627.0	0.0%	2781.0	2781.0	6.2%	1428.0	1522.0	2.2%	2211.0	2260.0	Plan calls for regrading existing regional basin. Discharge into existing system. Basin will keep flows in system. Current basin overtops.
B9B & C	South Branch	NW Corner of Pythian & Cedarbrook	14.92	58.2	RRSJ21	80.7%	83	429	0.1%	5868.0	5874.0	0.0%	7103.0	7103.0	0.0%	1627.0	1627.0	0.0%	2781.0	2781.0	8.9%	1387.0	1522.0	2.3%	2207.0	2260.0	Two basins work in series with each other. The reductions shown here are not much greater than those shown with B9B.
B11	North Branch	South of Blaine US Glenstone	8.68	36.4	HCNB21	19.2%	1315.0	1627.0	3.7%	5656.0	5874.0	0.7%	7056.0	7103.0	19.2%	1315.0	1627.0	9.3%	2521.0	2781.0	0.0%	1522.0	1522.0	0.0%	2260.0	2260.0	Basin construction would involve acquisition from 8 property owners, significant excavation, and damage to the riparian corridor. The existing regional basin would remain but the area east would require extensive regrading.
B11A	North Branch	South of Blaine at Link	6.24	19.2	HCNB17	15.5%	935.0	1106.0	2.7%	5718.0	5874.0	0.5%	7067.0	7103.0	12.8%	1418.0	1627.0	6.4%	2603.0	2781.0	0.0%	1522.0	1522.0	0.0%	2260.0	2260.0	Basin construction would involve removal of several trees and property acquisition.
B11B	North Branch	Upstream of Glenstone	N/A		HCNB19	4.6%	1170	1227	2.5%	5730	5874	0.4%	7072	7103	10.6%	1455	1627	6.2%	2608	2781	0.0%	1522	1522	0.0%	2260	2260	Since Basins B11 and B11A require extensive grading and damage to vegetation, Basin B11B includes minimal grading within riparian corridor. Basins adjacent to stream are excavated and connected to the main channel. A small dam and weir is located on DS end. Peak flow reduction immediatly downstream from basin is small, but the change

B11C	North Branch	South of Blaine at Link			HCNB17	13.8%	953	1106	3.4%	5673	5874	0.7%	7055	7103	14.0%	1400	1627	8.5%	2546	2781	0.0%	1522	1522	0.0%	2260	2260	This is a modification of B11A. This basin preserves the trees north of the stream. The area south of the stream will be excavated to the flowline of the stream with 6:1 side slopes. An 18-ft weir and dam will be placed dowstream of the basin area.
B11 & B11C						N/A		N/A	5.6%	5546	5874	1.1%	7022	7103	30.8%	1126	1627	13.1%	2418	2781	0.0%	1522	1522	0.0%	2260	2260	Represents the combination of B11 with B11B. While this will significantly impact the riparian vegitation, the impacts to peak flows are significant. The basin will have a minimal slope, allowing aquatic vegitation and potential wetlands.
B11 & B11A						N/A		N/A	5.9%	5525	5874	1.2%	7015	7103	33.6%	1080	1627	13.7%	2399	2781	0.0%	1522	1522	0.0%	2260	2260	Two regional basins which appear to give the greatest benefit throughout Lower Branch.
B12	North Branch	NW Corner of Blaine and Yates	2.29	9.4	HCNB12	22.5%	485.0	626.0	0.2%	5864.0	5874.0	0.0%	7102.0	7103.0	2.4%	1588.0	1627.0	0.4%	2769.0	2781.0	0.0%	1522.0	1522.0	0.0%	2260.0	2260.0	In-line basin that catches flow from the north. Proposed system along Blaine would surcharge into basin and be released based on system capacity. Is considered as a viable alternative for reducting local peaks when used in series with B14. This basin would also provide a lower flowline for a future system to the north.
B14	North Branch	North of Blaine, W of Packer	11.39	53.9	HCNB11	49.3%	273.0	538.0	0.1%	5869.0	5874.0	0.0%	7103.0	7103.0	0.7%	1615.0	1627.0	0.1%	2778.0	2781.0	0.0%	1522.0	1522.0	0.0%	2260.0	2260.0	Requires expansion of City owned basin. Basin B14 does an excelent job of reducing peak flows to the capacity of a new pipe under Blaine street, but does not provide much downstream reduction. Even though the reduction is outside of the project area, this basin could significantly reduce flooding for many homes along Blaine.
B14 & B12 (IN SERIES)						N/A		N/A	0.1%	5866	5874.0	0.0%	7102	7103.0	2.6%	1584	1627.0	0.5%	2767	2781.0	0.0%	1522	1522.0	0.0%	2260	2260.0	Basin B14 in series with B12. The addition of B12 provides slightly more peak flow reduction. This reduction is more significant along Blaine Street.
B15	North Branch	West side of Packer Rd, N of RR	3.99	30.1	HCNB9	33.1%	103	154	0.1%	5869	5874.0	0.0%	7103	7103.0	0.4%	1620.0	1627.0	0.1%	2778.0	2781.0	0.0%	1522.0	1522.0	0.0%	2260.0	2260.0	Would likely require permission from Railroad and land acquisition. Were unable to determine if upstream water actually reached the basin or was diverted. This basin is not a likely alternative.
All 9 Regional Basins in Series (B15, B14, B12, B11, B11A, B9B, B9C, B7, B6)	Norh/South Branch	All Basins Combined In Series	65	387		N/A		N/A	6.4%	5498	5874	1.3%	7008	7103	36.1%	1039	1627	13.7%	2399	2781	43.9%	854	1522	9.6%	2042	2260	The "Basic 9" proposed regional detention basins in series together.
Basins B14, B9B & C, B7 (CITY OWNED BASINS)						N/A		N/A	0.5%	5847	5874.0	0.1%	7099	7103.0	1.4%	1605.0	1627.0	0.3%	2773.0	2781.0	32.1%	1034.0	1522.0	3.9%	2172.0	2260.0	All Detention Basins on City Owned Property . These Basins Give the greatest reduction immediately downstream.
City's Preferred Option						N/A		N/A	6.1%	5518	5874.0	1.2%	7016	7103.0	30.8%	1126.0	1627.0	13.1%	2418.0	2781.0	43.8%	855.0	1522.0	9.6%	2042.0	2260.0	Based on this analysis. Basins B11, B11C, B9B, B7, & B6 appear to be the optimal combination of regional detention to reduce flows within the Federal Study Limits.

Appendix HH-M – Overland Rating Curves for Determining HEC-RAS Flows


Fremont Box Capacity
(based on upstream peak flow)
y = 0.00000719x² - 0.04656310x + 792.20782905
Box Capacity
800
790
780
770
760
750
740
730
720
710
700
500
1000
1500
2000
2500
3000
3500
4000
Upstream Peak Flow
Current Conditions
Future Conditions w/o Project
Current Conditions w/ All Basins
Current Conditions w/ South Basins
Poly. (Current Conditions)



Jordan Underground - Box Capacity
(based on upstream peak flow)
y = -0.00001172x² + 0.19445239x + 1,635.45722290
y = -0.00044111x² + 2.28011104x - 902.37108537
Box Capacity
2600
2400
2200
2000
1800
1600
1400
1200
1000
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Upstream Peak Flow
Current Conditions Capacity
1-yr, 2yr, 5yr
10yr to 500yr
Future Conditions w/o Project
Current Conditons w/ North Basins
Current Conditions w/ South Basins
Current Conditions w/ All Basins
Poly. (1-yr, 2yr, 5yr)
Poly. (10yr to 500yr)

Appendix HH-N – HY-8 Rating Curves for Determining Flow Split at Confluence during With Project Conditions

Existing Box Culvert 2 @ 15' W x 8' H

Conventional Headwall		Existing Box Culvert w/ improved 1.5:1 (90°) beveled headwall		Existing Box Culvert w/ 4:1 Side Tapered Inlet (35' Face Width) Square Edge top (90°) wingwall	
HW (Elev.)	Q (cfs)	HW (Elev.)	Q (cfs)	HW (Elev.)	Q (cfs)
1262.12	0	1262.12	0	1262.12	0
1264.35	250	1264.23	250	1264.22	250
1265.81	500	1265.66	500	1265.66	500
1267.25	750	1267.09	750	1267.09	750
1268.39	1000	1268.22	1000	1268.21	1000
1269.50	1250	1269.30	1250	1269.30	1250
1270.72	1500	1270.51	1500	1270.51	1500
1272.56	1750	1272.31	1750	1272.30	1750
1274.50	2000	1274.18	2000	1274.17	2000
1274.99	2050	1276.63	2250	1276.61	2250
1275.48	2100				
1275.97	2150				
1276.46	2200				
1277.04	2250				
1279.46	2500				

New Box Culvert 1 @ 30' W x 10' H

Conventional Headwall		New Box Culvert w/ improved 1.5:1 (90°) beveled headwall		New Box Culvert w/ 4:1 Side Tapered Inlet (38' Face Width) Square Edge top (90°) wingwall	
HW (Elev.)	Q (cfs)	HW (Elev.)	Q (cfs)	HW (Elev.)	Q (cfs)
1262.14	0	1262.14	0	1262.14	0
1266.14	600	1265.83	600	1265.83	600
1268.51	1200	1268.00	1200	1268.00	1200
1270.49	1800	1269.82	1800	1269.82	1800
1272.26	2400	1271.45	2400	1271.45	2400
1273.87	3000	1272.94	3000	1273.32	3000
1275.36	3500	1274.33	3600	1274.32	3500
1277.82	4200	1275.65	4200	1275.99	4200
		1277.11	4800		
		1278.91	5400		

New Box Culvert 1 @ 32' W x 10' H					
Conventional Headwall		New Box Culvert w/ improved 1.5:1 (90°) beveled headwall		New Box Culvert w/ 4:1 Side Tapered Inlet (38' Face Width) Square Edge top (90°) wingwall	
HW (Elev.)	Q (cfs)	HW (Elev.)	Q (cfs)	HW (Elev.)	Q (cfs)
1262.14	0	1262.14	0	1262.14	0
1265.06	400	1264.85	400	1264.84	400
1266.80	800	1266.43	800	1266.43	800
1268.25	1200	1267.76	1200	1267.76	1200
1269.55	1600	1268.95	1600	1268.95	1600
1270.74	2000	1270.04	2000	1270.04	2000
1271.85	2400	1271.06	2400	1271.06	2400
1272.89	2800	1272.02	2800	1272.02	2800
1273.89	3200	1272.94	3200	1273.13	3200
1274.96	3600	1273.88	3600	1273.82	3600
1276.20	4000	1274.94	4000	1274.67	4000

New Box Culvert 2 @ 20' W x 10' H					
Conventional Headwall		New Box Culvert w/ improved 1.5:1 (90°) beveled headwall		New Box Culvert w/ 4:1 Side Tapered Inlet (38' Face Width) Square Edge top (90°) wingwall	
HW (Elev.)	Q (cfs)	HW (Elev.)	Q (cfs)	HW (Elev.)	Q (cfs)
1262.14	0	1262.14	0	1262.14	0
1264.66	400	1264.47	400	1264.55	400
1266.13	800	1265.83	800	1265.83	800
1267.37	1200	1266.98	1200	1266.98	1200
1268.47	1600	1268.00	1600	1268.00	1600
1269.48	2000	1268.94	2000	1268.94	2000
1270.43	2400	1269.83	2400	1269.83	2400
1271.32	2800	1270.66	2800	1270.66	2800
1272.17	3200	1271.46	3200	1271.46	3200
1272.99	3600	1272.22	3600	1272.22	3600
1273.79	4000	1272.96	4000	1272.96	4000

New Box Culvert at Sta. 977 @ 38' W x 9.5' H

Conventional Headwall		New Box Culvert w/ improved		New Box Culvert w/ 4:1 Side	
HW (Elev.)	Q (cfs)	HW (Elev.)	Q (cfs)	HW (Elev.)	Q (cfs)
1265.87	0	1265.87	0		
1268.11	320	1267.86	320		
1269.40	640	1269.02	640		
1270.50	960	1270.00	960		
1271.44	1280	1270.88	1280		
1272.52	1600	1272.18	1600		
1274.06	1920	1273.81	1920		
1275.78	2240	1275.60	2240		
1276.96	2560	1276.78	2560		
1278.04	2880	1277.81	2880		
1279.16	3200	1278.82	3200		

ATTACHMENT B - COST ENGINEERING

JORDAN CREEK FLOOD-RISK MANAGEMENT FEASIBILITY STUDY, SPRINGFIELD, MISSOURI

19.1.0 INTRODUCTION

This appendix contains a summary of the detailed feasibility cost estimate prepared for the Springfield, Missouri Flood-Risk Management Feasibility Study. The study area lies entirely within the city limits of Springfield, Missouri. The streams studied, upstream from southwest to northeast, are the upper end of Wilsons Creek, Jordan Creek and its North Branch and South Branch tributaries. The streams start in the northeast portion of Springfield and flow southwest-ward to the central west part of Springfield. The total drainage area for the study is about 19.3 square miles. The total study area is 13.75 square miles. The total length of the streams studied is approximately 6.9 miles. The main land uses of the study area vary from sparsely developed industrial to highly congested commercial. The stream conditions range from natural configuration with wooded banks to a man-modified channel forced through concrete culverts with buildings built over the culvert or concrete lined with vertical sidewalls. The land terrain is gently rolling. The geology of the area is rich soil overlying limestone bedrock with the rock occasionally rising to protrude into the channel bottom.

Input for the cost estimates was obtained from the Project Delivery Team (PDT) consisting of the City of Springfield including the Storm Water Services Division of the Public Works Department and Design Branch, Planning, Environmental and Economics personnel of the Little Rock District of the U.S. Army Corps of Engineers. Guidance for preparation of these cost estimates was obtained from ER 1110-2-1150 Engineering and Design (E&D) for Civil Works Projects, ER 1110-1-1300 E&D Cost Engineering Policy and General Requirements, ER 1110-2-1302 Civil Works Cost Engineering, and ETL 1110-2-573 E&D Construction Cost Estimating Guide for Civil Works. The cost estimates were prepared using Micro-Computer Aided Cost Estimating System MII version 4, build.4. Supporting cost libraries or databases were MII 2010 cost library, 2011 Equipment expense library (EP 1110-1-8, dated November 30, 2011) and the 2012 R. S. Means labor rates library for Springfield, Missouri.

Cost estimates were prepared at two levels - Class 4, initially, and Class 3 for inclusion in this feasibility report. Preliminary or Class 4 cost estimates were prepared for nine channel and/or detention basin plans designated as Alternatives A through J with levels of protection (LOP) from rainfall events having a reoccurrence interval ranging from 500 years to 25 years. Alternative J, the National Economic Development Plan (NED), is the tentatively selected plan and consists of a LOP from the 500 year storm in reach E1 with the five detention ponds in the upper watershed. Two of the detention basins are located on the north branch tributary and three detention basins are located on the south branch tributary of Jordan Creek. See the main report for a description of the study reaches for this feasibility study.

The quantities used in these cost estimates were developed primarily by the Civil Designer and Structural Designer from over 500 surveyed field cross sections from the HEC models from which the economic analyses were conducted. Quantity calculations by the designers were aided by the combination of Excel, ArcMap, HEC RAS, AutoCAD, and Google Earth software.

The cost estimate presented in this cost appendix is for the design and construction of the tentatively selected plan, Plan J, which includes channel excavation of soil and rock, railroad bridges, automobile bridges and culverts, and water, sewer, natural gas, communications and electrical utilities relocations.

19.2.0 PRICE LEVEL

Project costs are presented in December 2012 dollars and all project costs have been escalated to October 2014 price levels for inclusion in the 2015 budget. Labor rates for the estimates have been inflated over the construction period of this project. It is assumed that the metropolitan area of Springfield, Missouri, 2010 population of approximately 275,000, will have sufficient equipment operators, skilled craftsmen, and laborers to meet the needs of the contractors. The contractor is envisioned to only bring key personnel such as the project superintendent and one other key person to this job site. Only these persons will be provided living expenses in and above their salaries. Other sources of cost in these cost estimates are the 2010 MII Cost Library. Equipment costs are from the 2011 Region 5, which includes Springfield, Missouri, equipment rates from Engineering Pamphlet (EP) 1110-1-8 Construction Equipment Ownership and Operating Expense Schedule.

The costs of all alternative estimates, especially Alternative J, are considered fair and reasonable to a prudent and capable contractor.

19.3.0 COST ESTIMATE STRUCTURE

The cost estimates for the alternatives presented in this feasibility study were prepared by cost engineers in the Cost Engineering Section of Little Rock District. The cost estimates were organized according to the Civil Works – Work Breakdown Structure (CWWBS) and designated by using a source tag that designated the plan ID, reach ID, two levels (Feature and Sub-feature) of the Civil Works Work Breakdown Structure and subsequent levels of the source tag were from the April 2012 Masterformat® 2012 Numbers and Titles. The cost estimate work breakdown format shown in the MII source tag was structured to reflect the alternative and reach as well as two levels of the CWBS for which the estimate is being prepared for example AA_RR_FFSS - AA being the alternative, RR the reach, FF CWBS feature designator, and SS is the sub-feature designator.

Project features in the total project cost summary (TPCS) are in accordance with the CWWBS:

01 Lands and Damages include the real estate acquisitions of project lands, easements and rights-of ways. Costs are real estate, non-Federal's sponsors cost for land surveys, title preparation, legal opinions and Federal costs of reviewing the non-Federal sponsor's documents for legal sufficiency.

02 Relocations – Automobile Roadway and Bridge relocations, Railroad track moving and utility relocations include the cost for moving automobile roads and bridges, railroad track and/or utilities to make room for the enlarged channel features of the project.

09 Channels and Canals include the estimated costs to excavate the proposed channel improvements and construct related features.

15 Floodway Control and Diversion Structures includes the cost of construction of the detention ponds. Construction measures are excavation of the pond storage area and modification of the outlet weir.

30 Planning, Engineering and Design (PED). Provides the estimated engineering design costs based on a percentage of the construction cost features.

31 Construction Management (CM) provide the estimated CM or Supervision and Administration costs based on a percentage of the construction cost features.

Contingencies are added to the cost estimates in the TPCS base on the results of the cost and schedule risk analysis performed on December 18, 2012. Results of the cost risk study yielded a 23 percent contingency which has been added to the construction costs of the relocations, channels, planning, engineering and design, and construction management.

Escalation factors to the Effective Price Level Date and the Fully Funded Project Estimate Amount through the end of construction have also been included as part of the TPCS. The inflation was based upon a schedule developed based on an assumed monthly construction production rate (dollars) which is typically $500,000 to $1,000,000 per month.

Key assumptions for estimating the construction costs of the proposed improved Jordan Creek channel are as follows:

- Work analyses were performed on the major cost items based on the feasibility level of design.
- All excavated material from enlargement of the channel must be hauled away for offsite disposal within ten miles of the work area as advised by the non-Federal sponsor.
- The working area associated with the channel excavation was sufficient for dump trucks to pull through even after the channel was enlarged.
- The dump truck pull through scenario permitted the hydraulic excavator to work in an efficient manner.
- For the final plans, the job office overhead was based upon a detailed calculated rate based upon typical labor, equipment and supplies, and applied as a running percentage on the direct cost.
- The latest Department of Defense Unit Cost data were used to cost the automobile and railway bridges in the cost estimates due to the time constraints.

19.4.0 DISCUSSIONS OF COSTS BY FEATURE

19.4.1 01-Lands and Damages

The cost estimate for Lands and Damages is based on the estimated acres impacted by the project footprint as determined by the Civil and Structural Designer and estimated by Little Rock District Real Estate Division personnel. There are several types of real estate instruments required to obtain all land rights needed to construct this project. See the Real Estate Appendix for more detailed information regarding the development of the cost for Lands and Damages.

19.4.2 02 Relocations

This section summarizes cost estimate information related to relocating roadway paving and bridges, utilities, and building demolition.

19.4.2.02.1 Road Bridges and Roads

Bridge costs were based upon the Department of Defense (DoD) Pricing Guide for FY 2011 utilizing the square feet of proposed bridge decks. These square foot costs were derived from bridges constructed at various locations across the country within the previous year.

19.4.2.02.2 Utility Relocations

Many utilities will be impacted by the construction of the Jordan Creek channel improvements regardless of which plan is selected. In consultation with the City of Springfield and its utility departments and private utilities, i.e. telephone cables, the various utilities were located, designated by type, and size. The designers consulted this list during the design of the improved channel and it was noted what modifications were required to move the utility out of the way of the flow in the improved channel. Underground utilities which include water, sanitary sewer, communication cables, and natural gas, were designated to be lowered during the improvement of the channel. Overhead utilities, primarily electrical lines, were relocated after study by its respective designer often by the installation of new poles and possibly additional lengths of properly sized wire. Costs were added to the alternative's cost estimate based upon the action recommendation by the designers.

19.4.3 09-Channels and Canals

Results of the Hydrology and Hydraulic studies set the size and bottom elevation for the channel improvements to lessen Flood-Risks along Jordan Creek within Springfield, Missouri. The civil designer along with input from other PDT members added required features to make the channel functional. The other features along with the excavation quantities were provided to the cost estimators. The estimators assembled the necessary labor, equipment and materials to construct the project and yielded the project cost.

19.5.0 CONTRACTOR AND INDIRECT COST CONSIDERATIONS

The cost estimator assumed the work is done by a prime contractor which performs the excavation work as well as project management functions. Specialty work such as bridge construction and utility relocations are to be done by subcontractors hired by the prime contractor. This arrangement makes for two levels of contracting and two levels of markup costs (job office overhead, home office overhead, profit, and bond).

19.5.1 Prime Contractor

The prime contractor's job office overhead (JOOH) was calculated based upon the typical number of supervisory people, temporary office, equipment, and office supplies and the construction time estimated for the project. The calculated JOOH was 39 percent for Plan J channel contractor and 33 percent for the detention basin contractor in Plan J.

The home office overhead (HOOH) expenses are those cost incurred by the contractor for its overall business management of their main office expenses. These main offices expenses include cost such as upper management, accounting, personnel, and legal. This cost estimator set the HOOH at 8 percent of the construction cost. Typically, HOOH ranges from 5 percent to 10 percent of the construction cost.

The profit for the prime contractor was calculated to be 9.38 percent of the running construction cost, which includes direct cost, JOOH and HOOH markups, as determined utilizing the profit weighted guidelines method in ETL 1110-2-573.

Performance and payment bond premium of 0.35 percent of the running construction cost, including the direct cost, JOOH, HOOH, and profit, as determined by the MII embedded bond premium table for Class B work.

19.5.2 Subcontractors

JOOH rates for the subcontractors were assumed to be a constant 13 percent on the job. Mobilization and demobilization were assumed to be included within this percentage. Including in the mobilization is the cost to move equipment, support equipment and supplies to the close proximity of the work area.

HOOH for the subcontractors is assumed to be a constant 8 percent to cover the subcontractors' permanent offices or home office expense.

Profit for the subcontractors was computed by the weighted guidelines methods to be 9.38 percent.

19.6.0 30-PLANNING, ENGINEERING AND DESIGN

The Planning, Engineering and Design (PED) costs are the costs from authorization until the first construction contract is awarded. This work includes detailed surveys, soil investigations and preparation of the plans and specifications to guide the contractor to construct the project. Discussions with the PDT yielded a PED cost of 8.1 percent of the estimated construction cost.

19.7.0 31 CONSTRUCTION MANAGEMENT

The Construction Management costs are determined as a percent of the estimated construction costs. For this feasibility level estimate, a percentage of 7.7 percent of the construction cost was used in consultation with Construction Branch personnel.

19.8.0 CONTINGENCY

Current regulations require formal analyses of schedule and costs risks. See the Attachment C for the abbreviated Cost Risk Analysis Study documentation that was performed on December 18, 2012. The results of the cost risk study were that a 23 percent contingency was appropriate for construction costs, planning, engineering, and design, and construction management.

The purpose of contingencies is an added cost included in the cost estimate to cover unknowns. Unknowns could include:

- Quantity variation.
- Hidden features that will require modification or removal to construct the project as planned.
- Construction components not identified during conduct of the feasibility study. For example, is a temporary bypass required by railroad officials in order to replace the railroad bridge over Wilsons Creek.
- Additional costs to cover inflation while waiting for the project’s authorization and appropriations.
- Additional costs to cover inflation while the non-Federal sponsors raises their cost share funds.
- Delays due to litigation.
- Previously unknown HTRW.

19.9.0 PROJECT SCHEDULE

Project schedules for the NED alternative was developed by the Little Rock District PDT. The construction scenario is that the channel improvement of reach E1 and the detention basins are to be constructed concurrently. The detention basin work is to be performed on one basin at a time. The NED alternative has an estimate construction period of 3 years and has a required average annual funding need of $ 4 million.

19.10.0 OPERATIONS, MAINTENANCE, REPAIR, REHABILITATION AND REPLACEMENT (OMRR&R) COSTS

A detailed OMRR&R cost estimate for this project has been prepared and is attached to this appendix. This estimate is to account for the net increase in project costs to operate and maintain the project features and to recognize costs for the repair, rehabilitation and replacement of primarily bridges and culverts. This cost will be required 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 which showed woody growth all along Jordan Creek outside of the business district between Main Street and Phelps Street indicating no regular maintenance. The difference in maintenance of bridges and culverts is due to the change in physical size of the structure.

19.11.0 FINAL FEASIBILITY ESTIMATE

The final feasibility cost estimate as presented in the following Total Project Cost Summary (TPCS) for the Jordan Creek Flood-Risk Management Feasibility Study is as follows:

Cost of NED Alternative (Plan J)
Jordan Creek, Springfield, Missouri
Flood-Risk Management Feasibility Study

Plan J National Economic Development Plan	
FY 2015 Price Level	$ 21,051,000
Fully Funded Amount	$ 21,873,000

WALLA WALLA COST ENGINEERING MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

For Project No. 354082

Jordan Creek, Springfield, MO - Flood Risk Management Project

The Jordan Creek, Springfield MO, Flood Risk Management Project, as presented by Little Rock District, has undergone a successful Cost Agency Technical Review (Cost ATR), performed by the Walla Walla District Cost Engineering Mandatory Center of Expertise (Cost MCX) team. The Cost ATR included study of the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies. This certification signifies the products meet the quality standards as prescribed in ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of April 15, 2013, the Cost MCX certifies the estimated total project cost of:

FY 2015 Price Level: $21,239,000
Fully Funded Amount: $21,873,000

It remains the responsibility of the District to correctly reflect these cost values within the Final Report and to implement effective project management controls and implementation procedures including risk management throughout the life of the project.

JACOBS.MICHAEL.P.1160569537

Digitally signed by JACOBS.MICHAEL.P.1160569537
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=JACOBS.MICHAEL.P.1160569537
Date: 2013.04.15 10:59:36 -07'00'

Michael P. Jacobs, P.E.
Chief, Cost Engineering MCX
Walla Walla District

US Army Corps of Engineers®

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: Plan J (NED Plan), Jordan Creek FRM Study, Springfield, Missouri 354082
LOCATION: Greene County, Missouri

DISTRICT: SWL Little Rock District PREPARED: 12/20/2012
POC: CHIEF, COST ENGINEERING, Bruce Watson

This Estimate reflects the scope and schedule in report; Appendix C, Jordan Creek FRM Feasibility Study

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
						Program Year (Budget EC): 2015 Effective Price Level Date: 1 OCT 14								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	**TOTAL ($K)**	Spent Thru: 1-Oct-12 ($K)		COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*	*N*	*O*
02	RELOCATIONS	$1,525	$335	22%	$1,860	3.3%	$1,576	$347	$1,922			$1,601	$352	$1,953
09	CHANNELS & CANALS	$5,846	$1,286	22%	$7,133	3.3%	$6,041	$1,329	$7,370			$6,317	$1,390	$7,707
15	FLOODWAY CONTROL & DIVERSION STRUCTURE	$3,987	$877	22%	$4,864	3.3%	$4,119	$906	$5,025			$4,212	$927	$5,139
	CONSTRUCTION ESTIMATE TOTALS:	$11,358	$2,499		$13,857	3.3%	$11,736	$2,582	$14,317			$12,130	$2,669	$14,799
01	LANDS AND DAMAGES	$3,667	$733	20%	$4,401	3.3%	$3,789	$758	$4,547			$3,802	$760	$4,562
30	PLANNING, ENGINEERING & DESIGN	$917	$211	23%	$1,128	6.9%	$980	$225	$1,205			$1,016	$234	$1,249
31	CONSTRUCTION MANAGEMENT	$889	$204	23%	$1,093	6.9%	$950	$219	$1,169			$1,026	$236	$1,262
	PROJECT COST TOTALS:	$16,831	$3,648	22%	$20,479		$17,455	$3,784	**$21,239**			$17,974	$3,899	$21,873

ESTIMATED FEDERAL COST:	65.0%	**$14,217**
ESTIMATED NON-FEDERAL COST:	35.0%	**$7,656**
ESTIMATED TOTAL PROJECT COST:		**$21,873**

_______________ CHIEF, COST ENGINEERING, Bruce Watson

_______________ PROJECT MANAGER, Karyn Adams

_______________ CHIEF, REAL ESTATE, Don Balch

_______________ CHIEF, PLANNING, Patricia Anslow

_______________ CHIEF, ENGINEERING, Tony Batey

No Federal Operations Required CHIEF, OPERATIONS, John Balgavy

_______________ CHIEF, CONSTRUCTION, DeJuan Carter

_______________ CHIEF, CONTRACTING, Sandra Easter

_______________ CHIEF, PM-PB, Brinda Jackson

_______________ CHIEF, DPM, Dr. Randy Hathaway

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Plan J (NED Plan), Jordan Creek FRM Study, Springfield, Missouri 354082
LOCATION: Greene County, Missouri
This Estimate reflects the scope and schedule in report; Appendix C, Jordan Creek FRM Feasibility Study

DISTRICT: SWL Little Rock District PREPARED: 12/20/2012
POC: CHIEF, COST ENGINEERING, Bruce Watson

ESTIMATED COST — Estimate Prepared: 3-Apr-13; Effective Price Level: 1-Oct-12

PROJECT FIRST COST (Constant Dollar Basis) — Program Year (Budget EC): 2015; Effective Price Level Date: 1 OCT 14

TOTAL PROJECT COST (FULLY FUNDED)

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 1 or CONTRACT 1 (Detention Ponds)													
02	RELOCATIONS	$1,233	$271	22%	$1,504	3.3%	$1,274	$280	$1,554	2015Q4	1.4%	$1,291	$284	$1,575
09	CHANNELS & CANALS													
15	FLOODWAY CONTROL & DIVERSION STRUCTURE	$3,987	$877	22%	$4,864	3.3%	$4,119	$906	$5,025	2016Q2	2.3%	$4,212	$927	$5,139
	CONSTRUCTION ESTIMATE TOTALS:	$5,219	$1,148	22%	$6,367		$5,393	$1,186	$6,579			$5,503	$1,211	$6,714
01	LANDS AND DAMAGES	$3,219	$644	20%	$3,863	3.3%	$3,326	$665	$3,992	2015Q1		$3,326	$665	$3,992
30	PLANNING, ENGINEERING & DESIGN													
0.5%	Project Management	$26	$6	23%	$32	6.9%	$28	$6	$34	2015Q1		$28	$6	$34
1.0%	Planning & Environmental Compliance	$52	$12	23%	$64	6.9%	$56	$13	$68	2015Q1		$56	$13	$68
4.8%	Engineering & Design	$252	$58	23%	$310	6.9%	$269	$62	$331	2015Q1		$269	$62	$331
0.5%	Engineering Tech Review ITR & VE	$26	$6	23%	$32	6.9%	$28	$6	$34	2015Q1		$28	$6	$34
0.5%	Contracting & Reprographics	$26	$6	23%	$32	6.9%	$28	$6	$34	2015Q1		$28	$6	$34
0.5%	Engineering During Construction	$26	$6	23%	$32	6.9%	$28	$6	$34	2016Q2	4.9%	$29	$7	$36
0.3%	Planning During Construction	$13	$3	23%	$16	6.9%	$14	$3	$17	2016Q2	4.9%	$15	$3	$18
	Project Operations			23%										
31	CONSTRUCTION MANAGEMENT													
7.8%	Construction Management	$407	$94	23%	$501	6.9%	$435	$100	$535	2016Q2	4.9%	$456	$105	$561
	Project Operation:			23%										
0.2%	Project Management	$10	$2	23%	$12	6.9%	$11	$2	$13	2016Q2	4.9%	$11	$3	$14
	CONTRACT COST TOTALS:	$9,277	$1,985		**$11,261**		$9,615	$2,058	$11,672			$9,749	$2,087	**$11,836**

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: Plan J (NED Plan), Jordan Creek FRM Study, Springfield, Missouri 354082
LOCATION: Greene County, Missouri
This Estimate reflects the scope and schedule in report; Appendix C, Jordan Creek FRM Feasibility Study

DISTRICT: SWL Little Rock District PREPARED: 12/20/2012
POC: CHIEF, COST ENGINEERING, Bruce Watson

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			3-Apr-13	Program Year (Budget EC):			2015					
		Effective Price Level:			1-Oct-12	Effective Price Level Date:			1 OCT 14					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 2 or CONTRACT 2 (Reaches E1)													
02	RELOCATIONS	$292	$64	22%	$357	3.3%	$302	$66	$368	2016Q3	2.7%	$310	$68	$378
09	CHANNELS & CANALS	$5,846	$1,286	22%	$7,133	3.3%	$6,041	$1,329	$7,370	2017Q3	4.6%	$6,317	$1,390	$7,707
	CONSTRUCTION ESTIMATE TOTALS:	$6,139	$1,351	22%	**$7,489**		$6,343	$1,395	$7,738			$6,627	$1,458	$8,085
01	LANDS AND DAMAGES	$448	$90	20%	$538	3.3%	$463	$93	$555	2016Q3	2.7%	$475	$95	$571
30	PLANNING, ENGINEERING & DESIGN													
0.5%	Project Management	$31	$7	23%	$38	6.9%	$33	$8	$41	2016Q3	5.9%	$35	$8	$43
1.0%	Planning & Environmental Compliance	$61	$14	23%	$75	6.9%	$65	$15	$80	2016Q3	5.9%	$69	$16	$85
4.8%	Engineering & Design	$296	$68	23%	$364	6.9%	$316	$73	$389	2016Q3	5.9%	$335	$77	$412
0.5%	Engineering Tech Review ITR & VE	$31	$7	23%	$38	6.9%	$33	$8	$41	2016Q3	5.9%	$35	$8	$43
0.5%	Contracting & Reprographics	$31	$7	23%	$38	6.9%	$33	$8	$41	2016Q3	5.9%	$35	$8	$43
0.5%	Engineering During Construction	$31	$7	23%	$38	6.9%	$33	$8	$41	2017Q4	10.8%	$37	$8	$45
0.3%	Planning During Construction	$15	$3	23%	$18	6.9%	$16	$4	$20	2017Q4	10.8%	$18	$4	$22
	Project Operations			23%										
31	CONSTRUCTION MANAGEMENT													
7.5%	Construction Management	$460	$106	23%	$566	6.9%	$492	$113	$605	2017Q4	10.8%	$545	$125	$670
	Project Operation:			23%										
0.2%	Project Management	$12	$3	23%	$15	6.9%	$13	$3	$16	2017Q4	10.8%	$14	$3	$17
	CONTRACT COST TOTALS:	$7,555	$1,663		**$9,217**		$7,840	$1,726	$9,566			$8,225	$1,811	**$10,037**

OPERATION, MAINTENANCE, REPAIR, REHABILITATION AND REPLACEMENT

Date Prepared: April 9, 2013

Jordan Creek Flood Risk Management Feasibility Study, Springfield, Missouri

Life Cycle: 50 years

Rate of Return: 3.75 percent

Plan J

Jordan Creek Flood Risk Management Feasibility Study, Springfield, Missouri			O&M and Major Replacement Costs						Equivalent Average Annual O&M/Major Replacement Value			
									Present Value			
Code	Item Description	Estimate O&M Cycle, years	Quantity Factor	Project Quantity	O&M Quantity	Unit	Project Unit Price	O&M Amount	O&M	Major Replacement	Annual Cost	Comments
									$590,029	$1,388,633	$234,479	
Reach E1 - Wilson's Creek and South Branch 0+00 to 37+92												
00	Periodic Inspections	1	1	1	1	Job	$281.00	$281	$6,304	0	$281	
	Automobile Bridge Inspections	2	1	1	1	Job	$271.00	$271	$4,348	0	$271	Every 2 years
02	No added OMM&R											
09	Mowings	1	3	4.726	14.2	Acres	$85.58	$1,213	$27,221	0	$1,213	3 times per year
	Woody Vegetation Control	4	0.25	4.726	1.2	Acres	$760.97	$899	$8,843	0	$394	Every four years
	Sediment Removal	1	1		5	CY	$63.68	$318	$7,143	0	$318	Annually
	Trash/Debris Removal	1	1		1	Job	$591.46	$591	$13,269	0	$591	Annually
	Scour Repair	5	0.20		5	CY	$774.72	$592	$4,805	0	$214	Once every 5 years
	Riprap Repair	10	0.10		9	CY	$229.24	$593	$5,837	0	$260	Once every 10 years
	Railway Bridges - Wilson Crk Station 322+92	10	0.01	1	0.01	LS	$648,544.00	$6,485	$29,076	$559,714	$26,245	
	Roadway Bridges - Scenic	10	0.01	1	0.01	LS	$458,473.00	$4,585	$20,555	$395,677	$18,553	Monitor Foundation Shoring
	Subtotal										$48,342	
Reach E2 - Jordan Creek 37+93 to 109+99												
	No Work											
	Subtotal											
Reach E3 - Jordan Creek 110+00 to 166+70												
	Subtotal										$0	
Reach E4 - Jordan Creek North Branch 0+00 to 24+75												
	No Work											
	Subtotal											
Reach E5 - Jordan Creek North Branch 24+76 to 81+21												
	No Work											
	Subtotal											
Reach E6 - Jordan Creek South Branch 0+00 to 91+78												
00	Periodic Inspections	1	1	1	1	Job			$0	$0	$0	
	Automobile Bridge Inspections	2	1	1	1	Job			$0	$0	$0	Every 2 years
02	No added OMM&R											
09	Mowings	1	3	4.726	14.2	Acres			$0	$0	$0	3 times per year

OPERATION, MAINTENANCE, REPAIR, REHABILITATION AND REPLACEMENT

Date Prepared: April 9, 2013

Jordan Creek Flood Risk Management Feasibility Study, Springfield, Missouri

Life Cycle: 50 years

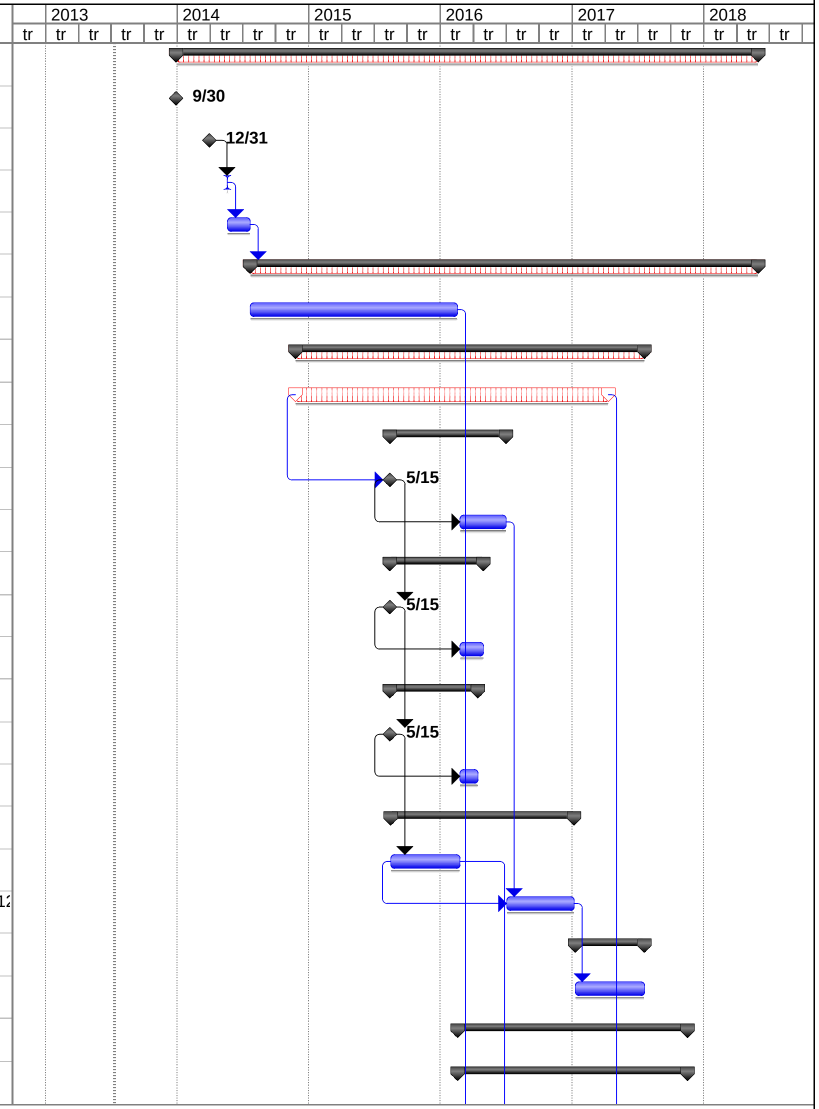
Rate of Return: 3.75 percent

Plan J

Jordan Creek Flood Risk Management Feasibility Study, Springfield, Missouri			O&M and Major Replacement Costs						Equivalent Average Annual O&M/Major Replacement Value			
									Present Value			
Code	Item Description	Estimate O&M Cycle, years	Quantity Factor	Project Quantity	O&M Quantity	Unit	Project Unit Price	O&M Amount	O&M	Major Replacement	Annual Cost	Comments
	Woody Vegetation Control	4	0.25	4.726	1.2	Acres			$0	$0	$0	Every four years
	Sediment Removal	1	1		5	CY			$0	$0	$0	Annually
	Trash/Debris Removal	1	1		1	Job			$0	$0	$0	Annually
	Scour Repair	5	0.2		5	CY			$0	$0	$0	Once every 5 years
	Riprap Repair	10	0.1		9	CY			$0	$0	$0	Once every 10 years
	National Culvert	10	0.01	1	0.1	LS			$0	$0	$0	
	Railroad Near Sherman	10	0.01	1	0.1	LS			$0	$0	$0	
	Sherman Street Culvert	10	0.01	1	0.1	LS			$0	$0	$0	
	Subtotal										$0	
Reach EON - Detention Ponds on North Branch of Jordan Creek												
00	Periodic Inspections	1	1	1	1	Job	$914.00	$914	$20,505	$0	$914	
15	Mowings	1	3	10.7	32.1	Acres	$85.58	$2,747	$61,630	$0	$2,747	3 times per year
	Woody Vegetation Control	4	0.25	10.7	2.7	Acres	$760.97	$2,036	$20,021	$0	$892	Every four years
	Washout Repair	10	0.1		31	CY	$56.50	$1,752	$7,852	$0	$350	Once every 10 years
	Outlet Structure Detention Basin 11	10	0.01	1	0.1	LS	$70,729.29	$7,073	$31,710	$61,042	$24,734	
	Outlet Structure Detention Basin 11c	10	0.01	1	0.1	LS	$95,461.84	$9,546	$42,798	$82,387	$33,383	
	Subtotal										$63,020	
Reach EOS - Detention Ponds on South Branch of Jordan Creek												
00	Periodic Inspections	1	1	1	1	Job	$914.00	$914	$20,505	$0	$914	
15	Mowings	1	3	13	39.0	Acres	$85.58	$3,338	$74,878	$0	$3,338	3 times per year
	Woody Vegetation Control	4	0.25	13	3.3	Acres	$760.97	$2,473	$24,324	$0	$1,084	Every four years
	Washout Repair	10	0.1		31	CY	$56.50	$1,752	$7,852	$0	$350	Once every 10 years
	Outlet Structure Detention Basin 6	10	0.01	1	0.1	LS	$133,988.00	$13,399	$60,070	$115,636	$46,855	
	Outlet Structure Detention Basin 7	10	0.01	1	0.1	LS	$133,988.00	$13,399	$60,070	$115,636	$46,855	
	Outlet Structure Detention Basin 9B	10	0.01	1	0.1	LS	$67,834.00	$6,783	$30,412	$58,543	$23,721	
	Subtotal										$123,117	

20130405 Plan J NED Plan Construction Schedule, Jordan Creek, Springfield, MO FRM Feasibility Study 354082

ID		Task Name	Duration	Start	Finish	Predecessors
1		**Springfield, MO Flood Risk Mgt Project - Plan J**	**1108 days**	**Mon 9/30/13**	**Fri 3/2/18**	
2		Complete Feasibility Study	0 days	Mon 9/30/13	Mon 9/30/13	
3		Receive Congressional Authorization	0 days	Tue 12/31/13	Tue 12/31/13	
4		Sign the Project Partnership Agreement	1 day	Tue 2/18/14	Tue 2/18/14	3FS+33 days
5		Appropriations for PED	44 days	Wed 2/19/14	Tue 4/22/14	4
6		**Implementation Period**	**968 days**	**Wed 4/23/14**	**Fri 3/2/18**	**5**
7		PED	18 mons	Wed 4/23/14	Wed 11/18/15	
8		**Phase 1**	**664 days**	**Wed 8/27/14**	**Thu 4/20/17**	
9		Lands and Damages for Entire Project	594 days	Wed 8/27/14	Tue 1/10/17	
10		**Detention Basin 11 Construction**	**220 days**	**Fri 5/15/15**	**Fri 4/1/16**	
11		Relocations	0 mons	Fri 5/15/15	Fri 5/15/15	9SS+180 days
12		Detention Basin 11 Construction	88 days	Thu 11/26/15	Fri 4/1/16	11SS+132 days
13		**Detention Basin 11c Construction**	**176 days**	**Fri 5/15/15**	**Fri 1/29/16**	
14		Relocations	0 mons	Fri 5/15/15	Fri 5/15/15	11
15		Detention Basin 11c Construction	44 days	Thu 11/26/15	Fri 1/29/16	14SS+132 days
16		**Detention Basin 6 Construction**	**165 days**	**Fri 5/15/15**	**Thu 1/14/16**	
17		Relocations	0 mons	Fri 5/15/15	Fri 5/15/15	14
18		Detention Basin 6 Construction	33 days	Thu 11/26/15	Thu 1/14/16	17SS+132 days
19		**Detention Basin 7 Construction**	**352 days**	**Mon 5/18/15**	**Fri 10/7/16**	
20		Relocations	132 days	Mon 5/18/15	Wed 11/25/15	17
21		Detention Basin 7 Construction	132 days	Mon 4/4/16	Fri 10/7/16	20SS+132 days,1
22		**Detention Basin 9B Construction**	**132 days**	**Tue 10/11/16**	**Thu 4/20/17**	
23		Detention Basin 9B Construction	132 days	Tue 10/11/16	Thu 4/20/17	21
24		**Phase II**	**440 days**	**Fri 11/20/15**	**Fri 8/18/17**	
25		**Reach 1**	**440 days**	**Fri 11/20/15**	**Fri 8/18/17**	

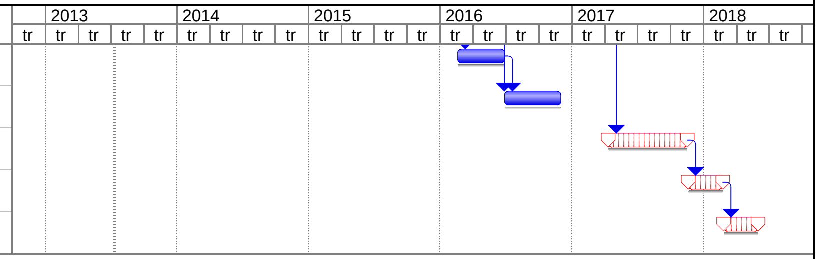


Project: 20130405 Plan J NED Plan Co
Date: Mon 4/8/13

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

20130405 Plan J NED Plan Construction Schedule, Jordan Creek, Springfield, MO FRM Feasibility Study 354082

ID	Task Name	Duration	Start	Finish	Predecessors
26	Final Design Reach 1	88 days	Fri 11/20/15	Mon 3/28/16	7
27	Relocations	5 mons	Tue 3/29/16	Wed 8/31/16	20,26
28	Reach 1 Project Construction	7 mons	Wed 1/11/17	Fri 8/18/17	9
29	Project Closeout	66 days	Mon 8/21/17	Fri 11/24/17	28
30	Final project accounting	66 days	Mon 11/27/17	Fri 3/2/18	29



Project: 20130405 Plan J NED Plan Co
Date: Mon 4/8/13

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

Attachment C -
Project Cost and Schedule Risk Analysis Report

Springfield, Missouri
Flood Risk Management

Draft Feasibility Report and
Environmental Assessment

National Economic Development Plan – Plan J – Channel Improvements in Reach E1 and Construction of Detention Basins on North Branch and South Branch Tributaries

Prepared by:

U.S. Army Corps of Engineers,
Little Rock District

EXECUTIVE SUMMARY

This Attachment presents a recommendation for the project cost contingencies for the Jordan Creek, Springfield, Missouri Flood Risk Management (FRM) Feasibility Study (FS), Plan J, the National Economic Development alternative. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal abbreviated risk analysis study was conducted on December 18, 2012. The purpose of this risk analysis study was to establish project contingencies by identifying and measuring the cost impact of project uncertainties with respect to the estimated project cost. Since the project cost was less than $40 million, the use of the simplified cost and schedule risk analysis is permissible.

The most likely project cost (at price level) for the Springfield, Missouri flood risk management study NED plan is approximately $16.8 million. After conducting the abbreviated cost risk analysis study with the project delivery team, the recommended overall project contingency value is $3.56 million or 22 percent yielding a total project cost of $20.5 million.

1.0 PURPOSE

Under the auspices of the US Army Corps of Engineers, Little Rock District, this report presents a recommendation for the project cost contingencies for the Jordan Creek Flood Risk Management Feasibility Study in Springfield, Missouri.

2.0 BACKGROUND

The purpose of the Jordan Creek FRM FS is to determine appropriate future actions, if any, concerning channel improvements to Jordan Creek to manage flood risks within Springfield, Missouri. This feasibility study report documents the planning process undertaken to assess potential channel improvements to Jordan Creek.

3.0 REPORT SCOPE

The scope of the risk analysis report is to calculate and present the cost contingencies at the 80 percent confidence level using the risk analysis processes, as mandated by the US Army Corps of Engineers Engineer Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works, ER 111-2-1302, Civil Works Cost Engineering and Engineer Technical Letter 1110-2-573, Construction Cost Estimating Guide for Civil Works. The report presents the contingency results for cost risks for all project features. The study and presentation does not include consideration for life cycle costs.

3.1 Project Scope

The formal process included PDT involvement for the identification and development of the likelihood of risks occurring and the qualitative evaluation of magnitude of the cost of the risk. The analysis process evaluated the most likely MII cost estimate and the likelihood of change on various cost components and the cost impact of the possible changes.

4. DISCUSSION OF CONTINGENCIES.

4.a Cost Risk Methodology.

The cost risk methodology used for this feasibility study was the abbreviated cost risk template obtained from the Civil Works Cost Engineering and Agency Technical Review Mandatory Center of Expertise located within the Walla Walla District Cost Engineering Branch. Major portions of costs from the previously prepared cost estimate were listed in the Input and Results Table by feature and sub-feature level including 01 Lands and Damages. Cost risks associated with seven various categories of risk were considered as to the likeliness of their occurrence and the cost impact if these events happened. These categories were project scope growth, acquisition strategy, construction elements, quantities for current scope, specialty fabrication or equipment, cost estimate assumptions, and external project risks.

The contingencies that evolved using the abbreviated cost risk template and the PDT meeting ranged from 19.36 percent for the earthwork - unclassified excavation to 31.5 percent for the earthwork – rock excavation. The reason for the higher contingency for the rock excavation was that the rock surface is irregular and its quantity was not well defined by detailed investigations.

Feature 01 Lands and Damages cost was given a contingency of 20 percent by the Real Estate Division PDT member. This contingency was entered into the MII cost estimate and carried through for the remainder of the cost estimate and conduct of the study. The likelihood and impact of cost variation was not considered further in the cost risk analysis.

4.b Major Risks

The major cost risks associated with the Springfield FRM study are inflation between the completing of the feasibility study, authorization, and receipt of funds to construct the project and the requirement of the railroad to require a temporary bypass during the replacement of the railroad bridge. The inflation risk is likely and is anticipated to have a significant effect on the cost. Also, another major risk is that the railroad officials would change their mind and require a bypass during the replacement of the railroad bridge over Wilson Creek. This risk is considered unlikely, but if it did occur the cost impact would be critical (greater than a $1M). See the full completed cost risk template for further information

4.c Minor Risks

Minor risks include encountering unknowns during the construction process. The most common unknown would most probably be abandoned utilities that the utility has forgotten about. The cost impact of these is expected to be negligible. Another unknown is buried concrete foundations. Again, the likelihood is unlikely and cost impact is projected to be negligible.

5.0 SUMMARY

Based on the results of the cost risk analysis study conducted on December 18, 2012 by the Project Delivery Team, an overall project contingency of 22 percent is recommended.

Abbreviated Risk Analysis

Jordan Creek FRM Study, Springfield, Missouri
Feasibility Study

Meeting Date: 18-Dec-12

PDT Members
Note: PDT involvement is commensurate with project size and involvement.

Project Management:	Karyn Adams
Planner:	
Study Manager:	Laura Cameron
Contracting:	Kina Williams, Chief, O&M and Civil Works Br.
Real Estate:	Ron Bridges (did not attend)
Relocations:	
OTHER:	
Engineering & Design:	Nick Barner
Technical Lead:	Nick Barner
Geotech:	
Hydrology:	Errin Kemper & Kathy Funkhouser (did not attend)
Civil:	Nick Barner
Structural:	Daniel C. Evans (did not attend)
Mechanical:	N/A
Electrical:	Marvin M. Emmerling (did not attend)
Cost Engineering:	George Losak
Construction:	Tim Tripp
Operations:	Not Applicable
Non-federal Sponsor	Errin Kemper (Reviewed draft)
OTHER:	
OTHER:	
OTHER:	
OTHER:	
OTHER:	
OTHER:	
OTHER:	

Input & Results Table

Abbreviated Risk Analysis

Project (less than $40M): **Jordan Creek FRM Study, Springfield, Missouri**
Project Development Stage: Feasibility Study
Risk Category: **Moderate Risk: Typical Project or Possible Life Safety**

Total Construction Contract Cost = **$ 11,358,002**

	CWWBS	Feature of Work	Contract Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ 3,667,300		20.00%	$ 733,460	$ 4,400,760.00
1	02 01 ROADS, Construction Activities	Automobile Roads	$ 35,313		27.06%	$ 9,555	$ 44,867.78
2	02 02 RAILROADS, Construction Activities	Not used.	$ -		0.00%	$ -	$ -
3	02 03 CEMETERIES, UTILITIES, AND STRUCTURES, Construction Activities	Utilities (water, sewer, electric & telephone)	$ 256,988		28.78%	$ 73,955	$ 330,943.10
4	09 01 CHANNELS	Earthwork - Unclassified Excavation	$ 2,299,485		19.36%	$ 445,085	$ 2,744,569.20
5	09 01 CHANNELS	Earthwork - Rock Excavation	$ 292,474		31.50%	$ 92,122	$ 384,595.18
6	09 01 CHANNELS	Exterior Improvements - Retaining Walls	$ 453,584		28.78%	$ 130,531	$ 584,114.64
7	09 01 CHANNELS	Fabricated Railroad Bridges	$ 1,979,871		20.41%	$ 404,044	$ 2,383,914.90
8	09 01 CHANNELS	Fabricated Automobile Bridges	$ 394,631		20.41%	$ 80,535	$ 475,165.31
9	09 01 CHANNELS	Other (Erosion Control, Turfing, Clearing & Grubbing)	$ 426,390		23.15%	$ 98,726	$ 525,115.73
10	15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Detention Basin Construction (5) - Earthwork (excavation, disposal &	$ 3,303,139		23.15%	$ 764,806	$ 4,067,945.07
11	15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Detention Basin Outlet Works (5) (concrete)	$ 683,497		23.15%	$ 158,256	$ 841,753.33
12		**Remaining Construction Items**	**$ 1,232,631**	*12.2%*	19.53%	$ 240,733	$ 1,473,364.07
13	30 PLANNING, ENGINEERING, AND DESIGN	**Planning, Engineering, & Design**	$ 917,000		23.15%	$ 212,321	$ 1,129,321.42
14	31 CONSTRUCTION MANAGEMENT	**Construction Management**	$ 889,000		23.15%	$ 205,838	$ 1,094,838.32

Totals

	Contract Cost	% Contingency	$ Contingency	Total
Real Estate	$ 3,667,300	20.00%	$ 733,460	$ 4,400,760.00
Total Construction Estimate	$ 11,358,002	22.00%	$ 2,498,346	$ 13,856,348
Total Planning, Engineering & Design	$ 917,000	23.15%	$ 212,321	$ 1,129,321
Total Construction Management	$ 889,000	23.15%	$ 205,838	$ 1,094,838
Total	$ 16,831,302		$ 3,649,966	$ 20,481,268

Risk Register

Jordan Creek FRM Study, Springfield, Missouri
Feasibility Study
Abbreviated Risk Analysis

Meeting Date: 18-Dec-12

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Element	Feature of Work	Concerns Pull Down Tab (ENABLE MACROS THRU TRUST CENTER) (Choose ALL that apply)	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Project Scope Growth							
						Max Potential Cost Growth	75%
PS-1	Automobile Roads	• Design confidence?	Scope fixed little growth forecast. Varied from current plans Chemical Plant sits lower	We need to raise the road in Reach 1 near the Bennet Street Bridge. Because of the design of the road, that is close to the entrance to the Chemical Plant. There may be issues with the construction as it pertains to reworking the entrance to the plant and the continuity to the bridge.	Likely	Marginal	2
PS-2	Not used.	• Potential for scope growth, added features and quantities?	Scope fixed little growth forecast.	We coordinated with the railroad how to build the new bridge. We are building the bottom of the bridget first and only taking the bridge out of service for a short time. If the management of the railroad changes, there is a slight possibility that we would have to reroute the track entirely which would result in cost and schedule impacts.	Unlikely	Negligible	0
PS-3	Utilities (water, sewer, electric & telephone)	• Potential for scope growth, added features and quantities?	The possibility exists that there are unknown utilities within the expanded channel section.	Rockherst Street may contain unknown utilities. As with many urban areas, the utilities are not well defined.	Likely	Marginal	2
PS-4	Earthwork - Unclassified Excavation	• Potential for scope growth, added features and quantities?	Channel size increased. Behind retaining wall?	Project size is set and not foreseen to change. The survey was fairly accurate. Over 500 cross sections used to compute quantities. The civil designer used inroads to calculate the earth work quantities.	Unlikely	Marginal	0
PS-5	Earthwork - Rock Excavation	• Potential for scope growth, added features and quantities?	Rock within the improved channel section. Volume not known. Assumed 5% rock excavation.	The area is Karst. Even with soil borings, there may be hidden rock outcroppings. There is the potential for more rock removal than estimated. There is also a potential for less excavation.	Likely	Marginal	2
PS-6	Exterior Improvements - Retaining Walls	• Potential for scope growth, added features and quantities?	Scope fixed little growth forecast.	Little requirment for additional quantity. There are no retaining walls improvements currently in the cost estimate. There is a large retaining wall in the project that has the slight possibility of needing to be rebuilt or repaired.	Possible	Significant	2
PS-7	Fabricated Railroad Bridges	• Potential for scope growth, added features and quantities?	Scope fixed little growth forecast.	Current railroad management has stated no Shoefly required. However, if one is for some reason required (change in managements or regulations), there will be a significant change in cost.	Unlikely	Significant	1
PS-8	Fabricated Automobile Bridges	• Potential for scope growth, added features and quantities?	Minimal design	None. Existing Bridge is very high and its opening has compacity to allow the creek to flow under it.	Unlikely	Significant	1
PS-9	Other (Erosion Control, Turfing, Clearing & Grubbing)	• Potential for scope growth, added features and quantities?		Low cost item. Scope and quantity not likely to change because the quanities were fairly accurate.	Unlikely	Negligible	0
PS-10	Detention Basin Construction (5) - Earthwork (excavation, disposal & compacted fill)	• Investigations sufficient to support design assumptions?	Little concern.	The earthwork was straight forward. The detention basins were designed using 2 foot contours using inroads.	Unlikely	Negligible	0
PS-11	Detention Basin Outlet Works (5) (concrete)	• Potential for scope growth, added features and quantities?	No design, Oversized concrete outlet structure, but actually a small structure. No defined channel at these location.	The outlets were modeled in the H&H models and were designed as modeled. However, the configuration of the outlet structures may change in any of the 5 detention basins. As they are designed, it is extremely unlikely that there will be a cost increase due to the conservative nature of the design.	Unlikely	Negligible	0
PS-12	Remaining Construction Items	• Potential for scope growth, added features and quantities?	Zero cost item.	There are no remaining items.	Unlikely	Negligible	0

Risk Register

Jordan Creek FRM Study, Springfield, Missouri
Feasibility Study
Abbreviated Risk Analysis

Meeting Date: 18-Dec-12

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Element	Feature of Work	Concerns Pull Down Tab (ENABLE MACROS THRU TRUST CENTER) (Choose ALL that apply)	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
PS-13	Planning, Engineering, & Design	• Potential for scope growth, added features and quantities?		The engineering is very straightforward. The largest design issue is the foundation modifications under Scenic Bridge.	Unlikely	Negligible	0
PS-14	Construction Management	• Potential for scope growth, added features and quantities?		The constructions is straightforward. Contigencies were added to account for the potential to uncover utilities, which is the biggest risk during construction.	Unlikely	Negligible	0
Acquisition Strategy							
						Max Potential Cost Growth	**30%**
AS-1	Automobile Roads	• Contracting plan firmly established?	Small Business Contractor reqired by higher authority. New Planning paradigm. Sole Source/Competitive	Lack of Planning and design will add to unknowns. Work is not complicated. PDT and nonfederal sponsor will push for competative acquisition. Small business contractors generally lead to a higher cost.	Likely	Significant	3
AS-2	Not used.	• Contracting plan firmly established?	Small Business Contractor Source Restrictions? Ability to perform? RR Certified Contractor required.	The Railroad bridge replacement will be coordinated tighttly with the railroad. The contractor for the project may be forced to subcontract with the railroad. Small business contractors generally lead to a higher cost.	Unlikely	Negligible	0
AS-3	Utilities (water, sewer, electric & telephone)	• Contracting plan firmly established?	Small Business Contractor required by USACE policy.	City owned or private with restrictions as to who will be allowed to work on their assets. There may need to be tight coordination with the utility to allow a representative to be present during the construction and connection. Small business contractors generally lead to a higher cost.	Likely	Significant	3
AS-4	Earthwork - Unclassified Excavation	• Contracting plan firmly established?	Small Business Contractor required by USACE policy.	Not complicated work. A knowledgeable contractor should accomplish without any trouble. Small business contractors generally lead to a higher cost.	Likely	Marginal	2
AS-5	Earthwork - Rock Excavation	• Contracting plan firmly established?	Small Business Contractor required by USACE policy..	Not complicated work. A knowledgeable contractor should accomplish without any trouble. Small business contractors generally lead to a higher cost.	Likely	Significant	3
AS-6	Exterior Improvements - Retaining Walls	• Contracting plan firmly established?	Small Business Contractor required by USACE policy.	There is not significan retaining walls being constructed. However, it may be work that needs to be subcontracted out if damage occurs to the existing retaining wall. Small business contractors generally lead to a higher cost.	Likely	Significant	3
AS-7	Fabricated Railroad Bridges	• Contracting plan firmly established?	Small Business Contractor required by USACE policy.	The railroad bridge will need to be replaced by a contractor that regularly works with the railroad. It may be more expensive because there is a limited pool of contractors, and the contractors may not be local. Small business contractors generally lead to a higher cost.	Likely	Significant	3
AS-8	Fabricated Automobile Bridges	• Contracting plan firmly established?	Small Business Contractor??	Lack of Planning and design will add to unknowns. Work is not complicated. PDT and nonfederal sponsor will push for competative acquisition. Small business contractors generally lead to a higher cost.	Likely	Significant	3

Risk Register

Jordan Creek FRM Study, Springfield, Missouri
Feasibility Study
Abbreviated Risk Analysis

Meeting Date: 18-Dec-12

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Element	Feature of Work	Concerns Pull Down Tab (ENABLE MACROS THRU TRUST CENTER) (Choose ALL that apply)	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
AS-9	Other (Erosion Control, Turfing, Clearing & Grubbing)	• Contracting plan firmly established?	Small Business Contractor required by USACE policy.	Small business contractors generally lead to a higher cost. The work is straightforward earthwork.	Likely	Significant	3
AS-10	Detention Basin Construction (5) - Earthwork (excavation, disposal & compacted fill)	• Contracting plan firmly established?	Small Business Contractor required by USACE policy.	Small business contractors generally lead to a higher cost. The work is straightforward earthwork.	Likely	Significant	3
AS-11	Detention Basin Outlet Works (5) (concrete)	• Contracting plan firmly established?	Small Business Contractor required by USACE policy.	Small business contractors generally lead to a higher cost. Work can be accomodated by an experienced contractor	Likely	Significant	3
AS-12	Remaining Construction Items	• Contracting plan firmly established?	Small Business Contractor required by USACE policy.	Small business contractors generally lead to a higher cost. Work can be accomodated by an experienced contractor	Likely	Significant	3
AS-13	Planning, Engineering, & Design	• Contracting plan firmly established?	8A - x% more	Small business requires extra clauses and work for solicitation. Work is scheduled to occur in house.	Likely	Significant	3
AS-14	Construction Management	• Contracting plan firmly established?		Work is straight forward and is scheduled to occur in house.	Likely	Significant	3
Construction Elements							
						Max Potential Cost Growth	**25%**
CE-1	Automobile Roads	• Accelerated schedule or harsh weather schedule?	Small Business Contractor.	The road sits on a levee that protects the Archimica plant. The road is being raised to protect the plant. There is a chance for schedule delays due to harsh weather.	Likely	Negligible	1
CE-2	Not used.	• Accelerated schedule or harsh weather schedule?	Impact Schedule=>Cost	Railroad owners will allow pre-certified contractors to work on their facilities. The schedule will be determined by the owners and operators of the railline.	Unlikely	Negligible	0
CE-3	Utilities (water, sewer, electric & telephone)	• Accelerated schedule or harsh weather schedule?	Exact quantity and obstructions in right of way	There is a possibility for relocating sewer lines under any one of the detentions basins. It is anticipated that the basins will not affect the sewer lines.	Likely	Marginal	2
CE-4	Earthwork - Unclassified Excavation	• Accelerated schedule or harsh weather schedule?	Small Business Contractor required by USACE policy.	Assumed contractor is competent. There is a potential for harsh weather if the earthwork is performed in the spring or winter.	Likely	Marginal	2

Risk Register

Jordan Creek FRM Study, Springfield, Missouri
Feasibility Study
Abbreviated Risk Analysis

Meeting Date: 18-Dec-12

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Element	Feature of Work	Concerns Pull Down Tab (ENABLE MACROS THRU TRUST CENTER) (Choose ALL that apply)	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
CE-5	Earthwork - Rock Excavation	• Accelerated schedule or harsh weather schedule?	Small Business Contractor required by USACE policy. Rock at Isolated locations yet to be determined.	Due to irregular surface of rock strata, the exact quantity is not known. Looking at previous data, 5 percent of excavation was judged to be rock.	Likely	Marginal	2
CE-6	Exterior Improvements - Retaining Walls	• Accelerated schedule or harsh weather schedule?		Quantity is small and not anticipated to increase.	Likely	Marginal	2
CE-7	Fabricated Railroad Bridges	• Accelerated schedule or harsh weather schedule?		Work is straight forward. Must be in a minimal amount of time to limit rail interruptions	Unlikely	Negligible	0
CE-8	Fabricated Automobile Bridges	• Accelerated schedule or harsh weather schedule?	None in project.	Foundation will be reinforced, but there is no work on the bridge deck.	Unlikely	Negligible	0
CE-9	Other (Erosion Control, Turfing, Clearing & Grubbing)	• Accelerated schedule or harsh weather schedule?	Small Business Contractor required by USACE policy.	Quantity is small and not anticipated to increase. It may encounter delays due to weather.	Likely	Marginal	2
CE-10	Detention Basin Construction (5) - Earthwork (excavation, disposal & compacted fill)	• Accelerated schedule or harsh weather schedule?	Small Business Contractor required by USACE policy.	There is a possibility for relocating sewer lines under any one of the detentions basins. It is anticipated that the basins will not affect the sewer lines. Inclement weather may cause delays.	Likely	Marginal	2
CE-11	Detention Basin Outlet Works (5) (concrete)	• Accelerated schedule or harsh weather schedule?	Small Business Contractor required by USACE policy.	Outlet works may be delayed by inclement weather; however, those outlet works will likely be precast concrete.	Likely	Marginal	2
CE-12	Remaining Construction Items	• Accelerated schedule or harsh weather schedule?	No cost with work feature. All cost in other features.	There are few remaining constructions items.	Unlikely	Negligible	0
CE-13	Planning, Engineering, & Design	• Accelerated schedule or harsh weather schedule?	Small Business Contractor required by USACE policy.	A tight schedule may result from delays in funding or unexpected design considerations due to rock or utility relocations.	Likely	Marginal	2
CE-14	Construction Management	• Accelerated schedule or harsh weather schedule?	Small Business Contractor required by USACE policy.	Likely subject to changes in weather.	Likely	Marginal	2
Quantities for Current Scope							
						Max Potential Cost Growth	**20%**
Q-1	Automobile Roads	• Level of confidence based on design and assumptions?	Scope fixed little growth forecast.	There is little cost associated with this element, and it was designed based on the worst case scenario.	Likely	Marginal	2

Jordan Creek FRM Study, Springfield, Missouri
Feasibility Study
Abbreviated Risk Analysis

Meeting Date: 18-Dec-12

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Element	Feature of Work	Concerns Pull Down Tab (ENABLE MACROS THRU TRUST CENTER) (Choose ALL that apply)	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Q-2	Not used.	• Level of confidence based on design and assumptions?	Scope fixed little growth forecast.	It is unlikely we will need construct an alternate bridge and realign the tracks, but if we do, the cost will be substantial.	Unlikely	Negligible	0
Q-3	Utilities (water, sewer, electric & telephone)	• Level of confidence based on design and assumptions?	Scope fixed little growth forecast.	Not all locations known. Work would be minimal. Project sponsor is responsible for this work.	Likely	Marginal	2
Q-4	Earthwork - Unclassified Excavation	• Level of confidence based on design and assumptions?	Scope fixed little growth forecast.	We used a fairly accurate survey and inroads to determine the quantities.	Likely	Marginal	2
Q-5	Earthwork - Rock Excavation	• Level of confidence based on design and assumptions?	Total excavation scope fixed little growth forecast.	Little investigations conducted. More investigations would not lead to a better answer due to the karst nature of the rock.	Likely	Significant	3
Q-6	Exterior Improvements - Retaining Walls	• Level of confidence based on design and assumptions?	Scope fixed. Little growth forecast.	There is little retaining wall in the scope.	Likely	Marginal	2
Q-7	Fabricated Railroad Bridges	• Level of confidence based on design and assumptions?	Scope fixed little growth forecast.	It is unlikely we will need construct an alternate bridge and realign the tracks, but if we do, the cost will be substantial.	Unlikely	Significant	1
Q-8	Fabricated Automobile Bridges	• Level of confidence based on design and assumptions?	None in project.	None, but if we for some reason need to replace Scenic Bridge, it will be costly.	Unlikely	Significant	1
Q-9	Other (Erosion Control, Turfing, Clearing & Grubbing)	• Level of confidence based on design and assumptions?		Variation always occurs.	Likely	Marginal	2
Q-10	Detention Basin Construction (5) - Earthwork (excavation, disposal & compacted fill)	• Level of confidence based on design and assumptions?	Little design accomplished	Basin size is limited so change in quanitity will be limited.	Likely	Marginal	2
Q-11	Detention Basin Outlet Works (5) (concrete)	• Level of confidence based on design and assumptions?	Little design accomplished	Basin size is limited so change in quanitity will be limited.	Likely	Marginal	2
Q-12	Remaining Construction Items	• Level of confidence based on design and assumptions?		Few construction items.	Likely	Marginal	2
Q-13	Planning, Engineering, & Design	• Level of confidence based on design and assumptions?		Changes occur but will be marginal	Likely	Marginal	2
Q-14	Construction Management	• Level of confidence based on design and assumptions?		Changes will occur, but they will be minor.	Likely	Marginal	2
Specialty Fabrication or Equipment							
						Max Potential Cost Growth	**75%**
FE-1	Automobile Roads	• Unusual parts, material or equipment manufactured or installed?		Components and/or equipment required will be standard.	Unlikely	Marginal	0

Risk Register

Jordan Creek FRM Study, Springfield, Missouri
Feasibility Study
Abbreviated Risk Analysis

Meeting Date: 18-Dec-12

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Element	Feature of Work	Concerns Pull Down Tab (ENABLE MACROS THRU TRUST CENTER) (Choose ALL that apply)	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
FE-2	Not used.	• Unusual parts, material or equipment manufactured or installed?		No. Railroad tracks are standard.	Unlikely	Negligible	0
FE-3	Utilities (water, sewer, electric & telephone)	• Unusual parts, material or equipment manufactured or installed?		Components and/or equipment required will be standard.	Unlikely	Marginal	0
FE-4	Earthwork - Unclassified Excavation	• Unusual parts, material or equipment manufactured or installed?		Components and/or equipment required will be standard.	Unlikely	Marginal	0
FE-5	Earthwork - Rock Excavation	• Unusual parts, material or equipment manufactured or installed?		Components and/or equipment required will be standard.	Unlikely	Marginal	0
FE-6	Exterior Improvements - Retaining Walls	• Unusual parts, material or equipment manufactured or installed?		Components and/or equipment required will be standard.	Unlikely	Marginal	0
FE-7	Fabricated Railroad Bridges	• Unusual parts, material or equipment manufactured or installed?		Components and/or equipment required will be standard.	Unlikely	Marginal	0
FE-8	Fabricated Automobile Bridges	• Unusual parts, material or equipment manufactured or installed?		Components and/or equipment required will be standard.	Unlikely	Marginal	0
FE-9	Other (Erosion Control, Turfing, Clearing & Grubbing)	• Unusual parts, material or equipment manufactured or installed?		Components and/or equipment required will be standard.	Unlikely	Marginal	0
FE-10	Detention Basin Construction (5) - Earthwork (excavation, disposal & compacted fill)	• Unusual parts, material or equipment manufactured or installed?		Components and/or equipment required will be standard.	Unlikely	Marginal	0
FE-11	Detention Basin Outlet Works (5) (concrete)	• Unusual parts, material or equipment manufactured or installed?		Components and/or equipment required will be standard.	Unlikely	Marginal	0
FE-12	Remaining Construction Items	• Unusual parts, material or equipment manufactured or installed?		None	Unlikely	Marginal	0
FE-13	Planning, Engineering, & Design	• Unusual parts, material or equipment manufactured or installed?		If we need items that are not standard, it may require additional design work.	Unlikely	Marginal	0
FE-14	Construction Management	• Unusual parts, material or equipment manufactured or installed?		If we need items that are not standard, it may require additional construction managment work.	Unlikely	Marginal	0
Cost Estimate Assumptions							
						Max Potential Cost Growth	**35%**
CT-1	Automobile Roads	• Assumptions regarding crew, productivity, overtime?	Cost variation	Features are standard.	Likely	Marginal	2

Risk Register

Jordan Creek FRM Study, Springfield, Missouri
Feasibility Study
Abbreviated Risk Analysis

Meeting Date: 18-Dec-12

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Element	Feature of Work	Concerns Pull Down Tab (ENABLE MACROS THRU TRUST CENTER) (Choose ALL that apply)	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
CT-2	Not used.	• Reliability and number of key quotes?		Features are standard.	Unlikely	Negligible	0
CT-3	Utilities (water, sewer, electric & telephone)	• Reliability and number of key quotes?		Features are standard.	Likely	Marginal	2
CT-4	Earthwork - Unclassified Excavation	• Reliability and number of key quotes?		Features are standard.	Likely	Marginal	2
CT-5	Earthwork - Rock Excavation	• Reliability and number of key quotes?		The reliabilty is not very good on the rock excavation, but a number has been added to the cost estimate which is generally what is seen with jobs in Springfield.	Likely	Marginal	2
CT-6	Exterior Improvements - Retaining Walls	• Reliability and number of key quotes?		Features are standard.	Likely	Marginal	2
CT-7	Fabricated Railroad Bridges	• Reliability and number of key quotes?		Standard desgn. Fixed length. Contractor precertified or approved by railroad owner.	Likely	Marginal	2
CT-8	Fabricated Automobile Bridges	• Reliability and number of key quotes?		No new bridges for automobiles. Only foundation strengthening at one bridge.	Likely	Marginal	2
CT-9	Other (Erosion Control, Turfing, Clearing & Grubbing)	• Reliability and number of key quotes?	Standard work effort. Fixed quantitiy.	Standard effort.	Likely	Marginal	2
CT-10	Detention Basin Construction (5) - Earthwork (excavation, disposal & compacted fill)	• Reliability and number of key quotes?		Design not fixed.	Likely	Marginal	2
CT-11	Detention Basin Outlet Works (5) (concrete)	• Reliability and number of key quotes?		Conservative quantities prepared by designer.	Likely	Marginal	2
CT-12	Remaining Construction Items	• Reliability and number of key quotes?	No cost assigned to this feature.	None	Likely	Marginal	2
CT-13	Planning, Engineering, & Design	• Reliability and number of key quotes?		None	Likely	Marginal	2
CT-14	Construction Management	• Reliability and number of key quotes?		None	Likely	Marginal	2

Risk Register

Jordan Creek FRM Study, Springfield, Missouri
Feasibility Study
Abbreviated Risk Analysis

Meeting Date: 18-Dec-12

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Element	Feature of Work	Concerns Pull Down Tab (ENABLE MACROS THRU TRUST CENTER) (Choose ALL that apply)	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
External Project Risks							
						Max Potential Cost Growth	40%
EX-1	Automobile Roads	• Potential for severe adverse weather?		Inflation, Authorization, funding, etc.	Likely	Marginal	2
EX-2	Not used.	• Potential for severe adverse weather?		Inflation, Authorization, funding, etc.	Unlikely	Negligible	0
EX-3	Utilities (water, sewer, electric & telephone)	• Potential for severe adverse weather?		Inflation, Authorization, funding, etc.	Likely	Marginal	2
EX-4	Earthwork - Unclassified Excavation	• Potential for severe adverse weather?		Inflation, Authorization, funding, etc.	Likely	Marginal	2
EX-5	Earthwork - Rock Excavation	• Potential for severe adverse weather?		Inflation, Authorization, funding, etc.	Likely	Marginal	2
EX-6	Exterior Improvements - Retaining Walls	• Potential for severe adverse weather?		Inflation, Authorization, funding, etc.	Likely	Marginal	2
EX-7	Fabricated Railroad Bridges	• Potential for severe adverse weather?		Inflation, Authorization, funding, etc.	Likely	Marginal	2
EX-8	Fabricated Automobile Bridges	• Potential for severe adverse weather?		Inflation, Authorization, funding, etc.	Likely	Marginal	2
EX-9	Other (Erosion Control, Turfing, Clearing & Grubbing)	• Potential for severe adverse weather?		Inflation, Authorization, funding, etc.	Likely	Marginal	2
EX-10	Detention Basin Construction (5) - Earthwork (excavation, disposal & compacted fill)	• Potential for severe adverse weather?		Inflation, Authorization, funding, etc.	Likely	Marginal	2
EX-11	Detention Basin Outlet Works (5) (concrete)	• Potential for severe adverse weather?		Inflation, Authorization, funding, etc.	Likely	Marginal	2
EX-12	Remaining Construction Items	• Potential for severe adverse weather?	No cost with this feature of work.	None	Likely	Marginal	2
EX-13	Planning, Engineering, & Design	• Potential for severe adverse weather?		Inflation, Authorization, funding, etc.	Likely	Marginal	2
EX-14	Construction Management	• Potential for severe adverse weather?		Inflation, Authorization, funding, etc.	Likely	Marginal	2

WBS Risk Matrix

Jordan Creek FRM Study, Springfield, Missouri
Feasibility Study
Abbreviated Risk Analysis

Typical Risk Elements	Potential Risk Areas													
	Automobile Roads	Not used.	Utilities (water, sewer, electric & telephone	Earthwork - Unclassified Excavatio	Earthwork - Rock Excavation	Exterior Improvements - Retaining	Fabricated Railroad Bridges	Fabricated Automobile Bridg	Other (Erosion Control, Turfing, Clearing &	Detention Basin Construction (5) Earthwork	Detention Basin Outlet Works (5) (concrete)	Remaining Construction Item	Planning, Engineering, & Design	Construction Management
Project Scope Growth	2	-	2	-	2	2	1	1	-	-	-	-	-	-
Acquisition Strategy	3	-	3	2	3	3	3	3	3	3	3	3	3	3
Construction Elements	1	-	2	2	2	2	-	-	2	2	2	-	2	2
Quantities for Current Scope	2	-	2	2	3	2	1	1	2	2	2	2	2	2
Specialty Fabrication or Equipment	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cost Estimate Assumptions	2	-	2	2	2	2	2	2	2	2	2	2	2	2
External Project Risks	2	-	2	2	2	2	2	2	2	2	2	2	2	2

Appendix D
404 (b) (1) Analysis

SHORT-FORM
Evaluation of Section 404(b)(1) Guidelines

Formal review should follow close of public notice comment period.

APPLICANT: Jordan Creek Flood RMS Springfield, Missouri APPLICATION NUMBER: N/A

1. Review of Compliance (Section 230.10(a)-(d)).
A review of the permit application indicates that:

	Preliminary 1/	Final 2/
a. The discharge represents the least environmentally damaging practicable alternative and if in a special aquatic site, the activity associated with the discharge must have direct access or proximity to, or be located in the aquatic ecosystem to fulfill its basic purpose (if no, see section 2 and information gathered for EA alternative);	YES ✓ NO ☐*	YES ✓ NO ☐
b. The activity does not appear to: 1) violate applicable state water quality standards or effluent standards prohibited under Section 307 of the CWA; 2) jeopardize the existence of Federally listed endangered or threatened species or their habitat; and 3) violate requirements of any Federally designated marine sanctuary (if no, see section 2b and check responses from resource and water quality certifying agencies);	YES ✓ NO ☐*	YES ✓ NO ☐
c. The activity will not cause or contribute to significant degradation of waters of the United States including adverse effects on human health, life stages of organisms dependent on the aquatic ecosystem, diversity, productivity and stability, and recreational, aesthetic, and economic values (If no, see section 2);	YES ✓ NO ☐*	YES ✓ NO ☐
d. Appropriate and practicable steps have been taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem (If no, see section 5).	YES ✓ NO ☐*	YES ✓ NO ☐

*1/, 2/ See page 3.

2. Technical Evaluation Factors (Subparts C-F).

	N/A	Not Significant	Significant
a. Physical and chemical characteristics of the Aquatic Ecosystem (Subpart C-F)			
1) Substrate impacts.	☐	✓	☐
2) Suspended particulates/turbidity impacts.	☐	✓	☐
3) Water column impacts.	☐	✓	☐
4) Alteration of current patterns and water circulation.	☐	✓	☐
5) Alteration of normal water fluctuations/hydroperiod.	☐	✓	☐
6) Alteration of salinity gradients.	☐	✓	☐
b. Biological Characteristics of the Aquatic Ecosystem (Subpart D).			
1) Effect on threatened/endangered species and their habitat.	✓	☐	☐
2) Effect on the aquatic food web.	☐	✓	☐
3) Effect on other wildlife(mammals, birds, reptiles, amphibians)	☐	✓	☐
c. Special Aquatic sites (Subpart E).			
1) Sanctuaries and refuges.	✓	☐	☐
2) Wetlands.	☐	✓	☐
3) Mud flats.	✓	☐	☐
4) Vegetated shallows.	✓	☐	☐
5) Coral reefs.	✓	☐	☐
6) Riffle and pool complexes.	☐	✓	☐
d. Human Use Characteristics (Subpart F).			
1) Effects on municipal and private water supplies.	☐	✓	☐
2) Recreational and Commercial fisheries impacts.	☐	✓	☐
3) Effects on water-related recreation.	☐	✓	☐
4) Aesthetic impacts.	☐	✓	☐
5) Effects on parks, national and historical monuments, national seashores, wilderness areas, research sites, similar preserves.	✓	☐	☐

Remarks: Where a check is placed under the significant category, preparer add explanation below.

3. Evaluation of Dredged or Fill Material (Subpart G). 3/

a. The following information has been considered in evaluating the biological availability of possible contaminants in dredged or fill material. (Check only those appropriate.)

1) Physical characteristics.......... ☑
2) Hydrography in relation to known or anticipated sources of contaminants.......... ☑
3) Results from previous testing of the material or similar material in the vicinity of the project.......... ☑
4) Known, significant, sources of persistent pesticides from land runoff or percolation.......... ☑
5) Spill records for petroleum products or designated (Section 311 of CWA) hazardous substances. ☑
6) Other public records of significant introduction of contaminants from industries, cities or other sources.......... ☑
7) Known existence of substantial material deposits of substances which could be released in harmful quantities to the aquatic environment by man-induced discharge activities.......... ☑
8) Other sources (specify).......... ☐

List appropriate references (attach sheet if necessary).

b. An evaluation of the appropriate information in 3a above indicates that there is reason to believe the proposed dredge or fill material is not a carrier of contaminants, or that levels of contaminants are substantively similar at extraction and that the dredged material will be constrained and not allowed to flow beyond the boundaries of the disposal site. The material meets the testing exclusion criteria .... YES ☑ NO ☐

4. Disposal Site Delineation (Section 230.11(f)).

a. The following factors, as appropriate, have been considered in evaluating the disposal site

1) Depth of water at disposal site.......... ☑
2) Current velocity, direction, and variability at disposal site.......... ☑
3) Degree of turbulence.......... ☑
4) Water column stratification.......... ☑
5) Discharge vessel speed and direction.......... ☐
6) Rate of discharge.......... ☑
7) Dredged material characteristics (constituents, amount, and type of material, settling velocities) .... ☑
8) Number of discharges per unit of time.......... ☑
9) Other factors affecting rates and patterns of mixing (specify).......... ☐

List appropriate references (attach sheet if necessary).

b. An evaluation of the appropriate factors in 4a above indicates that the disposal site and/or size of mixing zone are acceptable.......... YES ☑ NO ☐

5. Actions to Minimize Adverse Effects (Subpart H).

All appropriate and practicable steps have been taken, through application of recommendation of Section 230.70-230.77 to ensure minimal adverse effects of the proposed discharge.

List actions taken. (attach sheet if necessary).......... YES ☑ NO ☐

N.B. Return to section 1 for final stage of compliance review. See also note 3/, page 3.

6. Factual Determination (Section 230.11).

A review of appropriate information as identified in items 2-5 above indicates that there is minimal potential for short or long-term environmental effects of the proposed discharge as related to:

a. Physical substrate at the disposal site (review sections 2a, 3, 4, encl 5 above)........YES ☑ NO ☐
b. Water circulation, fluctuation and salinity (review sections 2a, 3, 4, and 5)...........YES ☑ NO ☐
c. Suspended particulates/turbidity (review sections 2a, 3, 5, and 6).....................YES ☑ NO ☐
d. Contaminant availability (review sections 2a, 3, and 4)..................................YES ☑ NO ☐
e. Aquatic ecosystem structure and function (review sections 2b and c, 3, and 5)...........YES ☑ NO ☐
f. Disposal site (review sections 2, 4, and 5)..YES ☑ NO ☐
g. Cumulative impact on the aquatic ecosystem...YES ☑ NO ☐
h. Secondary impacts on the aquatic ecosystem. ....YES ☑ NO ☐

7. Evaluation Responsibility (*See page 3).

a. This evaluation was prepared by:
Jim Ellis
Position: Biologist
Date: 12 March 2013

b. This evaluation was reviewed by:
Dana Coburn
Position: Chief, Environmental Branch
Date: 18 April 2013

8. Findings.

a. The proposed disposal site for discharge of dredged or fill material complies with the Section 404(b)(1) guidelines.. ☑

b. The proposed disposal site for discharge of dredged or fill material complies with the Section 404(b)(1) guidelines with the inclusion of the following conditions: (attach sheet if necessary).. ☐

c. The proposed disposal site for discharge of dredged or fill material does not comply with the Section 404(b)(1) guidelines for the following reason(s):

1) There is a less damaging practicable alternative.. ☐
2) The activity:
   violates applicable state water quality standards................................ ☐
   jeopardizes a Federally listed endangered or threatened species.................. ☐
   violates requirements of a Federally designated marine sanctuary................. ☐
3) The proposed discharge will result in significant degradation of the aquatic ecosystem...... ☐
4) The proposed discharge does not include all practicable and appropriate measures to minimize potential harm to the aquatic ecosystem.. ☐

SIGNATURE Dana O. Coburn
for Patricia Anslow
Chief, Planning and Environmental Division

* A negative, significant, or unknown response indicates that the permit application may not be in compliance with the Section 404(b)(1) Guidelines.

1/ Negative responses to three or more of the compliance criteria at this stage indicate that the proposed projects may not be evaluated using this "short term procedure." Care should be used in assessing pertinent portions of the technical information of items 2 a thru d below before completing the final review of compliance.

2/ Negative response to one of the compliance criteria at this stage indicates that the proposed project does not comply with the guidelines. If the economics of navigation and anchorage of Section 404(b)(2) are to be evaluated in the decision-making process, the "short form evaluation process is inappropriate."

3/ If the dredged or fill material cannot be excluded from individual testing, the "short-form" evaluation process is inappropriate.

Appendix E
Agency Correspondence

List of Letters

1 5 DEC 2004

STATE OF MISSOURI
Bob Holden, Governor • Stephen M. Mahfood, Director
DEPARTMENT OF NATURAL RESOURCES
www.dnr.mo.gov

December 1, 2004

Johnny McLean
Acting Chief, Environmental Section
Corps of Engineers, Little Rock District
P.O. Box 867
Little Rock, Arkansas 72203-0867

Re: Jordan Creek Watershed (COE) Springfield, Greene County, Missouri

Dear Mr. McLean:

Thank you for submitting information on the above referenced project for our review pursuant to Section 106 of the National Historic Preservation Act (P.L. 89-665, as amended) and the Advisory Council on Historic Preservation's regulation 36 CFR part 800, which require identification and evaluation of cultural resources.

We have reviewed the information provided concerning the above referenced project. We have determined that there is a moderate to high potential for the presence of archaeological sites near and within the area of the proposed project, as indicated by the topographic location and the location of sites 23GR428, 23GR429, 23GR430, 23GR432 and 23GR433 with the watershed area, and that an archaeological survey should be conducted. This survey should be completed prior to the initiation of project-related construction activities. We have also enclosed a listing of properties listed in the National Register of Historic Places in Greene County.

A list of independent archaeological contractors who can perform such services is available through the Department of Natural Resources, Division of Administrative Support. The list can be obtained by calling (573) 751-0958 and requesting the "archaeological contractors list." Note that any 36 CFR Part 61 qualified archaeologist may perform an archaeological survey. If you choose a contractor not on the list, please be certain to include his or her curriculum vitae in the report. We would appreciate two (2) copies of the archaeological survey report when it is finished so we may complete the review and comment process.

If you have any questions, please write Judith Deel at State Historic Preservation Office, P.O. Box 176, Jefferson City, Missouri 65102 or call Ms. Deel at 573/751-7862. Please be sure to include the SHPO Log Number **(003-GR-05)** on all future correspondence or inquiries relating to this project.

Sincerely,

STATE HISTORIC PRESERVATION OFFICE

Mark A. Miles

Mark A. Miles
Director and Deputy State
Historic Preservation Officer

Enclosure: As stated

c Joe Cothern, EPA
Chris Davies, COE/LR
Alana Owen, Springfield

Integrity and excellence in all we do

Recycled Paper

Missouri Department of Natural Resources 30 years

Letter 1: December 1, 2004 from MDNR

Divisions and Programs

Home Page | Site Map

Forms and Permits | Publications | Media Center | State Parks | Current Issues | Keyword Search | FAQ

OAC Home | Environmental Assistance | Energy Center | Historic Preservation
Communications and Education | Community Assistance | Urban Offices | Broadcast E-mail Lists

State Historic Preservation Office

- Frequently Asked Questions
- National Register
- History & Heritage
- Tax Credits
- Archaeology
- Certified Local Governments
- Grants
- Section 106 Review
- Survey & Inventory
- Technical Assistance
- Planning
- Commissions & Boards
- Events
- Report an Environmental Problem

Greene County

Abou Ben Adhem Shrine Mosque, 601 St. Louis St., Springfield (9/09/82)

Anderson, Elijah Teague, House, 406 N Pine, Republic (11/14/80)

Bentley House, 603 E Calhoun, Springfield (11/14/80)

Benton Avenue AME Church, 830 North Benton, Springfield, (10/14/01)

Berry Cemetery, 1431 W. Farm Rd. 74, Ash Grove vicinity (11/13/04)

Boegel and Hine Flour Mill-Wommack Mill, E side of North Main St., S of intersection
Fair Grove (11/06/86)

Boone, Nathan, House, Nathan Boone Homestead State Historic Site, 1.75 mi. N of Asl
Hwy. V (10/01/69)

Campbell Avenue Historic District (*Springfield, Missouri MPS*), 200 and 300 blocks of
Ave., and 300 block of Park Central W, Springfield (6/25/99)

Christ Episcopal Church, 601 E Walnut, Springfield (3/26/87)

College Apartments (*Springfield, Missouri MPS*), 408 E. Walnut St., Springfield (5/01/0

Commercial Street Historic District, Commercial St., Springfield (5/24/83)

Day House, 614 South St., Springfield (11/07/76)

Gillioz Theater, 325 Park Central E, Springfield (7/09/91)

Gilmore Barn, US 160, 3.5 mi. E of Ash Grove, Ash Grove vicinity (4/08/94)

Heer's Department Store (*Springfield, Missouri MPS*), 138 Park Central Square, Spring

Holland Building (*Springfield, Missouri MPS*), 205 Park Central East, Springfield (11/15

Hotel Sansone (*Springfield, Missouri MPS*), 312 Park Central E, Springfield (05/05/00)

Jefferson Street Footbridge, Jefferson Ave., bet. Commercial and Chase Sts., Springfi

Keet-McElhany House, 435 E Walnut, Springfield (3/22/84)

Kite, Robert B. and Vitae A., Apartment Building, 769-771 South Ave., Springfield (1/:

Landers Theater, 311 E Walnut, Springfield (8/12/77)

Lincoln School, 815 N Sherman, Springfield (5/31/00)

Marquette Hotel (*Springfield, Missouri MPS*), 400 E Walnut, Springfield (05/05/00)

Marx-Hurlburt Building (*Springfield, Missouri MPS*), 311-315 E. Park Central Sq., Sprir (9/02/03)

Mid-Town Historic District, roughly bounded by Pacific, Clay, Pythian, Summit, Calhou Central, Benton, Division, and Jefferson, Springfield (7/13/89)

Mid-Town Historic District (*Boundary Increase I*), roughly along N. Robberson Ave. an Ave., Springfield (8/09/02)

Netter-Ullman Building, 317 Park Central East, Springfield (4/18/03)

Oberman, D.M., Manufacturing Company Building, 600 North Boonville Avenue, Sprii (4/18/2002)

Old Calaboose, 409 W McDaniel, Springfield (11/14/80)

Palace Hotel (*Springfield, Missouri MPS*), 501 College St., Springfield (11/27/02)

Pearson Creek Archaeological District District includes: 23GR28; 23GR46; 23GR47; : 23GR49; 23GR50; 23GR61; 23GR116; 23GR117; 23GR119; 23GR120; 23GR123; 23G 23GR133; 23GR134; 23GR135; 23GR167; 23GR176; 23GR177; 23GR341; Phelps Digg Mines; Gem Mines; Suffold and Eversal Shafts; Daisy Mine; Lewis & Benz Mines; Meyer Wolverine & O'Day Mines; Nathalie & Kodak Mines; Kershner Cemetery; Schoolcraft's C Marker; and Simpson Cemetery (10/11/78)

Rock Fountain Court Historic District, 2400 W. College St., Springfield (4/02/03)

St. John's Mercy Hospital Building, 620 W. Scott, Springfield (9/02/03)

South Avenue Commercial Historic District (*Springfield, Missouri MPS*), Walnut and I South and Robberson Aves., Springfield (6/25/99)

South-McDaniel-Patton Commercial Historic District (*Springfield, Missouri MPS*), Ro by S. Campbell Ave., W. McDaniel St., South Ave., and W. Walnut St., Springfield (3/07/

Springfield National Cemetery, 1702 E Seminole St., Springfield (8/27/99)

Springfield Warehouse and Commercial Historic District (*Springfield, Missouri MPS*) Mill and W Phelps Sts. and Boonville Ave., Springfield (6/25/99)

Stone Chapel, Drury College Campus, Benton & Central Sts., Springfield (10/21/82)

U.S. Customhouse and Post Office, 830 Boonville Ave., Springfield (6/27/79)

Walnut Street Commercial Historic District (*Springfield, Missouri MPS*), Walnut St., S (6/25/99)

Walnut Street Historic District, roughly bounded by McDaniel, Walnut, Elm Sts. & She Springfield (3/21/85)

Walnut Street Historic District (*Boundary Decrease I*), along East Elm Street, Springfie

Walnut Street Historic District (*Boundary Increase I*), roughly along E. Walnut St., fron 800 Blocks, Springfield (8/05/02)

Washington Avenue Baptist Church (Second Baptist Church), 729 North Washingto (12/22/00; removed 10/06/01)

West Walnut Street Commercial Historic District (*Springfield, Missouri MPS*), roughly blocks of West Walnut Street and 300-400 blocks of South Campbell Avenue, Springfiel

Wilson's Creek National Battlefield, SW of Springfield on MO 174 (also in Christian Co (10/15/66)

Wise Feed Company Building, 438-440 S. Campbell Ave., Springfield (1/06/03)

SHPO Home Page | Missouri National Register County List | Acronym Key | Recent Listi

---

Land | Air | Water | Energy | State Parks | Assistance | Disclaimer & Privacy | State Home Page | Site Ma
Kids & Education | Waste & Recycling | Historic Preservation | Human Resources | Merchandise | Search

Department of Natural Resources
P. O. Box 176, Jefferson City, MO 65102

1-800-361-4827 / (573) 751-7860
E-mail: moshpo@dnr.mo.gov
Revised on Thursday November 18 2004

Heritage Review Report

Missouri Department of Conservation
Attn: Shannon Cave
Public Involvement Coordinator
P. O. Box 180
Jefferson City, MO 65102
Shannon.Cave@mdc.mo.gov
573-522-4115 Ext. 3250

Mr. Johnny McLean
Department of the Army
Little Rock District, Corps of Engineers
P. O. Box 867
Little Rock, AR 72203-0867

Project type: Flood damage and ecosystem restoration study
Location: Springfield, MO, Jordan Creek drainage
County: Greene
Described in query as: Flood damage and ecosystem restoration study
Date query received: November 19, 2004
cc: Gene Gardner, Chris Vitello

Enclosures:
Management Recommendations for Construction Projects Affecting Missouri Streams and Rivers
Management Recommendations for Construction Projects Affecting Missouri Wetlands
Management Recommendations for Ozark Cavefish

This is not a site clearance letter, but a report of Missouri Department of Conservation records concerning public lands and sensitive resources known to be near and possibly affected by the proposed project. There are no records within the study area *per se*, but because of the area's karst geology, an approximately two mile wide buffer around the designated drainage led to the following listings:

Species/habitats with Federal restrictions: (see reverse for explanation)

Scientific Name	Common Name	Federal Status	State Status	State Rank	Ownership	Section	Township/ Range
AMBLYOPSIS ROSAE	OZARK CAVEFISH	T	E	S2	PRIVATE	04	028N022W
AMBLYOPSIS ROSAE	OZARK CAVEFISH	T	E	S2	PRIVATE	05	028N022W
AMBLYOPSIS ROSAE	OZARK CAVEFISH	T	E	S2	PRIVATE	32	029N022W

FEDERAL STATUS - The federal status is derived from the provisions of the federal Endangered Species Act, which is administered by the U.S. Fish and Wildlife Service. The Endangered Species Act provides federal protection for plants and animals listed as Endangered or Threatened. E = Endangered, T = Threatened, C = Candidate, PE = Proposed Endangered for Federal listing.

Species/habitats with State restrictions: (see reverse for explanation)

Scientific Name	Common Name	State Status	State Rank	Ownership	Section	Township/Range
LEPUS CALIFORNICUS	BLACK-TAILED JACKRABBIT	E	S1	PRIVATE	16	029N022W
TYTO ALBA	BARN OWL	E	S2	PRIVATE	31	029N021W
ACCIPITER COOPERII	COOPER'S HAWK		S3	PRIVATE	31	029N021W
AGALINIS PURPUREA	PURPLE FALSE FOXGLOVE		S2	PRIVATE	09	029N021W
AMB. ROSAE RECHARGE AREA	OZARK CAVEFISH RECHARGE AREA		S2	PRIVATE	17	029N022W
BUTEO SWAINSONI	SWAINSON'S HAWK		S2	PRIVATE	34	029N021W

Letter 2: November 23, 2004 from Heritage Review Report

MISSOURI DEPARTMENT OF CONSERVATION

Headquarters

2901 West Truman Boulevard, P.O. Box 180, Jefferson City, Missouri 65102-0180
Telephone: 573/751-4115 ▲ Missouri Relay Center: 1-800-735-2966 (TDD)

JOHN D. HOSKINS, Director

January 3, 2005

Mr. Johnny McLean
Department of the Army
Little Rock District, Corps of Engineers
P. O. Box 867
Little Rock, AR 72203-0867

Dear Mr. McLean:

Re: Jordan Creek drainage flood damage and ecosystem restoration, Springfield, MO

Thank you for your recent letter regarding the Missouri Department of Conservation's (MDC) input of the above referenced study. Enclosed is a "heritage review" which identifies records on the state's database of species and habitats of conservation concern. This is a report we typically provide to projects seeking information to comply with federal and state environmental laws. In addition, I consulted with various staff about recommendations of a more general nature, and convey the following:

1. There is repeated mention of channelization in the project plan. As a rule, channelization should be minimized to the fullest extent possible and a more natural meander pattern should be maintained or restored where feasible. Likewise, natural stream substrates should be maintained or established versus concrete lined channels.

2.. Construction BMPs should be followed throughout the project and erosion control should be a top priority. The Heritage Database review references several of our BMP documents. Reiterating the importance of these practices would be useful.

3. This project impinges on karst areas and potential habitat for species such as the Ozark cavefish. Sinkhole and losing stream reaches are pretty well defined in Greene County and efforts to avoid impacting these sensitive areas are critical. I would suggest that COE contact Loring Bullard at the Watershed Committee of the Ozarks for help in delineating sinkholes and losing stream reaches and U.S. Fish and Wildlife Service (USFWS) to discuss possible Section 7 consultation.

4. Riparian corridor maintenance or re-establishment should be a focus of this project. Wherever possible, a minimum 50-foot wide corridor of trees and shrubs should be an objective of this project.

5. Native plant species should be used in all plantings and follow-up efforts to ensure the long-term success of the project plan. We might note the availability of selected plant species through our nursery.

Letter 3: January 3, 2005 from MDC

Mr. Johnny McLean
Page 2
January 3, 2005

6. Detention/retention basins could be managed as moist-soil units using native plantings to enhance wildlife habitat, birding opportunities and aesthetics. Ideally we could incorporate some fisheries features into some of these basins, although I suspect basin depth and long-term water retention would be limiting. Under these conditions, establishing quality fish populations and possible water quality concerns could be difficult to overcome.

Finally, MDC values the input of cooperators in the Stream Team program. There are three significant Non-Governmental Organizations (NGOs) in this area which include: Watershed Committee of the Ozarks (Loring Bullard), Ozark Greenways (Terry Whatley), and James River Basin Partnership (Holly Neill). A staff member from our office communicated with each cooperator listed above and summarized their input as follows:

- Avoid estimating the total cost for a comprehensive restoration plan. Other major watershed projects proposed in Springfield have been rejected or delayed because the total cost prompted too much opposition. Focus on the most cost effective actions, or break proposed actions into phases, so the most effective measures are enacted as soon as possible. These projects should include conspicuous locations that demonstrate significant aesthetic improvement, as well as flood control and ecosystem benefits. Cooperate with the city and other partners to share resources and achieve mutual goals as much as possible.

- Control runoff as close to the source as possible with porous surfaces, retention basins, landscaping, etc. Apparently the city has limited citywide control over runoff, but has some areas with special restrictions due to sinkholes and sensitive watersheds. Special watershed restrictions for Jordan Creek are likely to negatively impact redevelopment in central city and be counterproductive.

- Where possible, maintain existing floodplains in natural state; maintain existing natural stream beds and stream banks; restore banks and stream beds to natural conditions; restore floodplain areas that have been filled in or cut off from a stream channel, and "daylight" sections of stream that have been confined to culverts or covered by buildings.

Thank you for the opportunity to review and comment, and let me know if I may further assist.

Sincerely,

SHANNON CAVE
PUBLIC INVOLVEMENT COORDINATOR

SC:kb

Enclosure

DEPARTMENT OF THE ARMY
LITTLE ROCK DISTRICT CORPS OF ENGINEERS
POST OFFICE BOX 867
LITTLE ROCK, ARKANSAS 72203-0867
(501) 324-5751 FAX 324-5501 http://www.swl.usace.army.mil

February 21, 2012

Planning and Environmental Division
Environmental Branch

«salutation» «fn» «ln»
«title»
«agency»
«office»
«add1»
«add2»
«city», «state» «zip»

Dear «salutation» «ln»:

The Little Rock District, U.S. Army Corps of Engineers is conducting a flood risk management study in the Jordan Creek watershed within the city limits of Springfield, Missouri. The study area is located within the White River Basin, extending approximately six miles along Jordan Creek, including North Branch and South Branch Jordan Creek. The study area (see enclosure) includes Jordan Creek, North Branch Jordan Creek, South Branch Jordan Creek and the upstream portion of Wilson Creek. In order to evaluate the impacts of any proposed action resulting from the study, the Little Rock District will be preparing an environmental assessment of the proposed action and alternatives evaluated in this study.

Alternatives evaluated in this study, aside from the no action alternative, will include structural and non-structural measures that reduce flood risks associated with a 2%, 1% and 0.2% flood event (50, 100, and 500 year recurrence interval, respectively). Due to the urban nature of the drainage, with development resulting in channel modifications and confinement, the channel footprint will be similar in each alternative, incorporating detention basins, as well as structural and non-structural features which are anticipated to undergo some modifications depending on the selected alternative.

The feasibility study on Jordan Creek began in May 2004. A public scoping meeting was held on October 26, 2004 at the Ozarks Technical Community College. The meeting used an "open house" format and provided interested agencies and the public an opportunity to provide comments regarding the need for the study and possible solutions to flooding along Jordan Creek. In November 2004, an agency coordination letter requesting any pertinent information, comments or concerns regarding this proposed project was sent out.

Since 2004, the City of Springfield and the Corps have signed a feasibility cost sharing agreement (FCSA). The team has been developing baseline hydrologic and hydraulic information, along with alternatives development.

Letter 4: February 21, 2012 Updated Coordination Letter

At this time we are re-engaging resource agencies and stakeholders. We request any updated information your agency may have regarding the study proposal by March 21, 2012. This information will assist the Corps in determining the existing conditions of the Jordan Creek watershed as well as develop possible solutions to reduce flooding along the creek. If comments are not received by this date, we will assume your agency has no preliminary comments on the proposed action.

Comments should be addressed to Mr. Mike Rodgers, U.S. Army Corps of Engineers, Little Rock District, Planning and Environmental Division, P.O. Box 867, Little Rock, Arkansas 72203-0867, telephone number (501) 324-5030, email: michael.r.rodgers@usace.army.mil. If you have any additional questions, please contact the undersigned at (501) 324-5601 or email at Dana O. Coburn@usace.army.mil.

Sincerely,

Encl.

Dana O. Coburn
Chief, Environmental Branch

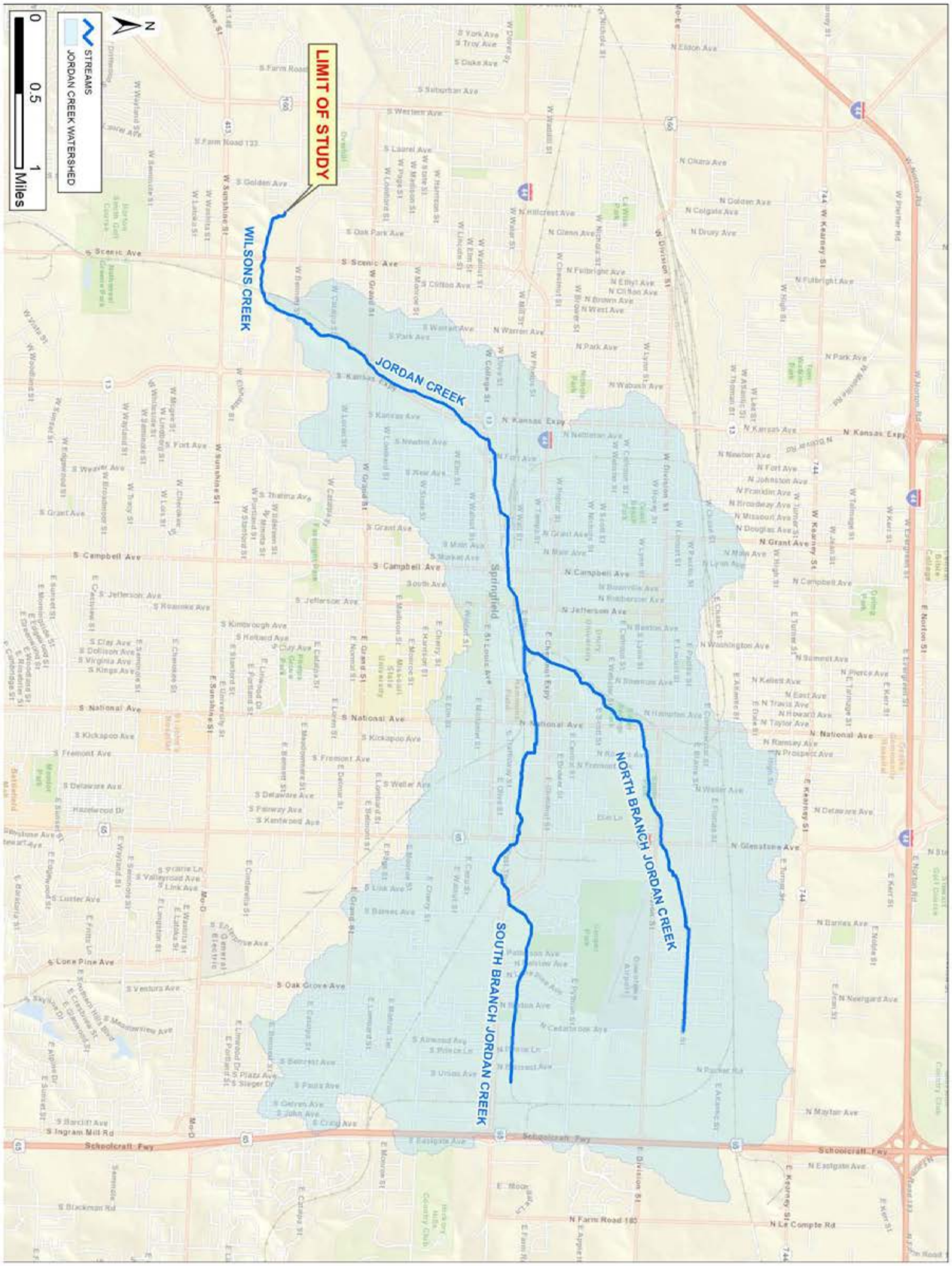


Figure 1. Jordan Creek Feasibility Study Project Area

STATE OF MISSOURI

Jeremiah W. (Jay) Nixon, Governor • Sara Parker Pauley, Director

DEPARTMENT OF NATURAL RESOURCES

www.dnr.mo.gov

APR 3 2012

Mr. Mike Rodgers
U.S. Army Corps of Engineers, Little Rock District
Planning and Environmental Division
P.O. Box 867, Little Rock, Arkansas 72203-0867

Re: Flood Risk Management Study, Jordan Creek Watershed, Springfield, Missouri

Dear Mr. Rodgers:

The Missouri Department of Natural Resources (department) appreciates the opportunity to review the information submitted for the proposed Flood Risk Management Study for the Jordan Creek Watershed in Springfield, Missouri. The department offers the following comments for consideration.

Water Quality

Since the Corps of Engineers conducted the initial Feasibility Study on Jordan Creek in 2004, EPA has established Total Maximum Daily Load or TMDLs for Jordan and Wilson Creeks in the Springfield metro area. These TMDLs use storm water runoff as a surrogate for unknown toxicity from multiple point and urban nonpoint sources. Jordan Creek and the upper portions of Wilson Creek above the Springfield wastewater treatment plant are significantly impaired by urban storm water runoff. Feasibility studies to determine the effectiveness of structural and non-structural best management practices will aid the City of Springfield in determining the most effective way to implement the requirements of these TMDLs to achieve reductions in storm water runoff.

The Wilson Creek and Jordan Creek TMDLs can be found on the department's TMDL web page at the following link: http://www.dnr.mo.gov/env/wpp/tmdl/2375-wilsons-3374-jordan-cks-tmdl.pdf

Hazardous Materials

There are numerous sites in the Jordan Creek area that are listed in the department's databases as potentially containing hazardous materials. We are providing general information below. We are also attaching additional site information including address, GPS data, etc. for Tanks and Voluntary Cleanup Program (VCP) sites. The department is also providing maps of the study area showing the location of Tanks sites, Superfund sites, Dry Cleaner sites, VCP sites, and Resource Conservation and Recovery Act (RCRA) permitted sites.

Underground Storage Tank (UST) sites

The department's databases include information on six UST sites with open remediation cases, and another three UST sites that are actively remediating.

Recycled Paper

Letter 5: April 3, 2012 from MDNR

Jordan Creek Watershed
Page Two

Superfund sites
Robert E. Lee Lumber site. No impact is expected during this project. No further action was required at the site after the owner confirmed that it was never a wood-treating facility.
Solid State Circuits, 616 Boonville Road. Trichloroethene (TCE) and lead in soil and groundwater. The site was proposed for Missouri Registry of Hazardous Waste sites, but the proposal was withdrawn when the onsite wells were closed.

Syntex, 2460 West Bennett Street. This is now an active RCRA site, with known groundwater contamination of As, Ba, benzene, TCE, PCE and several other metals and VOCs. Soil contamination has been remediated.

RCRA permitted sites
There is one RCRA permitted site, one interim status facility, and one resource recovery site that appear to be within the ¼ mile boundary of the Jordan Creek Study Area as described below.

1. Archimica (MOD095038329) is located at 2460 W. Bennett Street, Springfield and is on the very western end of the study area. This facility is a RCRA Permitted site and is currently an active manufacturer of pharmaceutical chemicals.
2. Zenith Electronics (MOD043941798) is located at 2500 E. Kearney, Springfield and is a closed Interim Status facility. This facility is located at the southern edge of the lower branch of Jordan Creek.
3. Computer Recycling Center (MOR000520023) is a closed Resource Recovery facility and was located at 1434 North National, Springfield. This site is located on the northern edge of the upper branch of Jordan Creek.

In addition, there is one other RCRA site that is just outside and on the upper eastern edge of the study area that might also be of interest. This fourth facility is the VOPAK USA INC - SPRINGFIELD VWR (MOD000823229) located at 220 S. Barnes, Springfield.
Based on the information available, it is likely that there are sites in the study area with hazardous materials present that would be impacted by whatever action the Corps of Engineers chooses as a result of this study.

We appreciate the opportunity to provide comments for the proposed Flood Risk Management Study for the Jordan Creek Watershed in Springfield, Missouri. If you have any questions or need clarification, please contact me, phone number (573) 751-3195. The address for correspondence is Department of Natural Resources, P.O. Box 176, Jefferson City, MO 65102. Thank you.

Sincerely,

DEPARTMENT OF NATURAL RESOURCES

Jane Beetem

Jane Beetem
Policy Coordinator

JB/mkc

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Columbia Ecological Services Field Office
101 Park DeVille Drive, Suite A
Columbia, Missouri 65203-0057
Phone: (573) 234-2132 Fax: (573) 234-2181

June 28, 2012

JUL 02 2012

Colonel Glen A. Massett
District Engineer
Little Rock District, Corps of Engineers
Little Rock, Arkansas 72203

Dear Colonel Massett:

This planning assistance letter is submitted by the U.S. Fish and Wildlife Service (Service) to the Little Rock District, U.S. Army Corps of Engineers (Corps), for use in the Jordan Creek Feasibility Study within the City of Springfield, Missouri. Information and planning assistance are provided in accordance with the provisions of, and under the authority of, the Fish and Wildlife Coordination Act (Coordination Act) (48 stat. 401, as amended; 16 U.S.C. 661 et seq.), and the "Agreement Between the U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers for Funding Fish and Wildlife Coordination Activities." The comments of this letter do not, however, fulfill the reporting requirements of the Service under Section 2(b) of the Coordination Act.

The Service has reviewed the proposed project under the Section 7 of the Endangered Species Act and has made a preliminary determination that no federally listed species are known to occur within the project site. We will make a final determination under Section 7 of the Endangered Species Act when the project alternatives are reviewed.

Description of the Study Area and Proposed Project

The project proposal as submitted included the H&H Report dated November 2010, involving modifications to address urban flooding in Jordan Creek within the City of Springfield in Greene County, Missouri.

The Service commends the City of Springfield for attempting to address the cumulative negative effects resulting from altering Jordan Creek and conveying water through channelized concrete lined channels in sections of Springfield. We support the primary objectives of the project and are providing additional recommendations to mitigate project impacts. We would like to emphasize that although severely deteriorated, the Jordan Creek riparian corridor still provides habitat for countless species of aquatic and riparian wildlife. On a recent site visit, we observed numerous fish, shore birds, amphibians and various other bird species throughout the project area. We believe with appropriate planning, the project can improve and enhance environmental services provided by Jordan Creek.

Letter 6: June 28, 2012 from USFWS

The Service is aware that the project consultant recommended a design to address constantly changing development projects in an urban environment. We do not believe additional studies are necessary in formulating hydrological design. The Service would like to discuss, at some point during project planning, the assumptions stated on page 14 of the H&H Report.

The initial report provided general engineering recommendations for the expansion or development of detention basins to reduce impacts associated with flooding along Jordan Creek. We generally don't recommend or support impounding and altering stream systems, but in this case the detention basins may be a suitable alternative to temporarily store flood water throughout the Jordan Creek basin. The detention basins may also provide suitable habitat for amphibians and shore and wading birds. We believe the in-stream structures could be designed to allow free passage of aquatic species. We recommend that the Corps follow the Missouri Department of Conservation's "Best management Recommendations for Construction Projects Affecting Missouri Streams and Rivers."

The Service believes that "rough channels" in combination with detention basins, may actually reduce flooding by slowing the flow of floodwaters in the downtown sections of Springfield. The Service believes it is counterproductive to convert natural stream channels into concrete ditches in an attempt to reduce flood impacts.

The Service would like for the city to consider the following general recommendations where possible:

- Improve all existing stream channels to appropriate width and depth ratios and use native stream bed materials.
- Convert existing concrete box structures (culverts) to more natural openings. New culverts should be bottomless or should be placed at least 10% below grade. When culverts are placed properly, head cuts should not occur in the stream.
- Open the sections of stream that are currently piped and replace them with new stream channels with 3:1 bank slopes on at least one side. In all other sections of streams that are concrete lined, remove at least one of the stream slopes and construct 3:1 bank slopes.
- Increase the use of storm water detention basins with common flow lines to adjacent stream channels and basin floors. The detention basins should be planted with native wetland vegetation. The constructed vegetated sites should be monitored for at least 5 years and replanted if exotic species invade the sites.
- Plant native tree and shrub species along project corridors to improve riparian habitat.
- Timber stand improvements may be appropriate in some locations, but should be done in consultation with a professional forester.
- Replant all disturbed areas with native vegetation.

Based on the project proposal we reviewed, the project footprint will not impact any public recreational areas that receive funding under the Water and Conservation Fund. During the design phase, the Service is available to provide assistance to improving fish and wildlife habitat within the Jordan Creek Basin

The Service appreciates the opportunity to provide these comments and recommendations early in the Corps project planning phase. Please continue to inform us as the project progresses. If you have any questions regarding our comments or recommendations, please contact Bryan Simmons of my staff at 417-836-5302, or by email at bryan_simmons@fws.gov.

Sincerely,

Amy Salveter

Amy Salveter
Field Supervisor

Cc: Mike Rodgers, U.S. Army Corps of Engineers, Little Rock District

STATE OF MISSOURI Jeremiah W. (Jay) Nixon, Governor • Sara Parker Pauley, Director
DEPARTMENT OF NATURAL RESOURCES
www.dnr.mo.gov

February 7, 2013

Patricia M. Anslow, Chief
Planning & Environmental Division
Corps of Engineers, Little Rock District
P.O. Box 867
Little Rock, Arkansas 72203-0867

Re: Jordan Creek Flood Control Project (COE) Greene County, Missouri

Dear Ms. Anslow:

Thank you for submitting information on the above referenced project for our review pursuant to Section 106 of the National Historic Preservation Act (P.L. 89-665, as amended) and the Advisory Council on Historic Preservation's regulation 36 CFR Part 800, which require identification and evaluation of cultural resources.

We have reviewed the information provided concerning the above referenced project. Based on this review, we concur that archaeological sites 23GR2023, 23GR2024 and 23GR2026, properties that may be eligible for inclusion in the National Register of Historic Places, have been successfully avoided by redesign, and that measures are in place in ensure ongoing protection during construction and future maintenance activities. We have no objection to the initiation of project activities.

Please be advised that, should project plans change, information documenting the revisions should be submitted to this office for further review. In the event that cultural materials are encountered during project activities, all construction should be halted, and this office notified as soon as possible in order to determine the appropriate course of action.

If you have any questions, please write Judith Deel at State Historic Preservation Office, P.O. Box 176, Jefferson City, Missouri 65102 or call 573/751-7862. Please be sure to include the SHPO Log Number **(018-GR-13)** on all future correspondence or inquiries relating to this project.

Sincerely,

STATE HISTORIC PRESERVATION OFFICE

Mark A. Miles

Mark A. Miles
Director and Deputy
State Historic Preservation Officer

MAM:jd

c Rodney Parker, COE/LR

Recycled Paper

Letter 7: February 7, 2013 from SHPO

MISSOURI DEPARTMENT OF CONSERVATION

Headquarters
2901 West Truman Boulevard, P.O. Box 1RO, JdJerson Missouri 65102-0!80
Tel•eph<cmec 573/751-4115 • Missouri Relay Center: 1-800-735-2966 (TDD)

ROBERT L ZIEHMER Director

March 4, 2013

Ms. Laura Cameron
U.S, Army Corps of Engineers
Little Rock District
P.O. Box867
Little Rock, Arkansas 72203

RE: REQUEST COMMENTS ON DRAFT INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT FOR THE JORDAN CREEK FLOOD RISK MANAGEMENT STUDY

Dear Ms. Cameron:

Thank you for the opportunity to comment on the **Draft Integrated Feasibility Report and Environmental Assessment for the Jordan Creek Flood Risk Management Study.** The proposed project is located on Jordan Creek, a small urban stream that flows through a heavily commercialized and industrialized area of Springfield, MO. The draft report contains an economic analysis, real estate plan, engineering, and a draft Finding of No Significant Impact (FONSI). The draft document presents the results of the feasibility study to analyze flood risk management issues related to reduction of flood damages in and around Jordan Creek.

The Missouri Department of Conservation (Department) is the agency responsible for forest, fish, and wildlife resources in Missouri. As such, we actively participate in project review when projects might affect those resources. Our comments and recommendations are for your consideration and are offered to reduce impacts to the forest, fish, and wildlife resources in the project area.

After reviewing the document, the Department believes that Plan J and Option G2 both could provide some environmental benefits to the area. Some of those benefits include:

- Detention basins promote infiltration, thereby improving water quality and hydrology.
- The channel modifications mentioned in the draft document involve stream widening, but do not include channelization which was a concern mentioned in the Departments comments back in 2005 (included in Appendix E).
- Modifications that "daylight" the stream would be beneficial.
- The Department supports modifications that return natural substrate to the channel rather than keeping it in concrete. A natural substrate will benefit aquatic life and increase roughness which will reduce stream velocity and minimize erosion and limit flood impacts.
- Restoration of riparian corridors will provide a variety of benefits but the Department stresses that it needs to be accomplished using native species.

Letter 8: March 4, 2013 from MDC

Ms. Cameron
March 4, 2013
Page 2

- Amenities such as trails create a connection between people and the stream. The department supports a design that would accommodate this type of amenity in the future.

Thank you for the opportunity to provide comments. If you have any questions about these comments, please contact me at (573) 522-4115, Extension 3346 or by email at alan.leary@mdc.mo.gov.

Sincerely,

Alan W. Leary

ALAN W. LEARY
POLICY COORDINATOR

AWL/ck

c: Andy Austin, Kara Tvedt

From: Simmons, Bryan
To: Cameron, Laura L SWL
Subject: Re: Springfield Jordan Creek
Date: Monday, April 01, 2013 12:11:42 PM

Ok, Laura, again I apologize about the delay and problems I had last week with my computer and file access. I got that problem fixed and now have full file access.

However, since then, I have inquired with my FO supervisor and she conveyed that the Planning Aide Letter we provided earlier was in fact our FWCA letter for this phase of the project.

So, I am now slightly confused about this request. Is the compliance act report in your last email part of the FWCA process?

Since there are no final design plans yet to review, other than the few comments regarding the pilot channel inclusion in the plans we talked about over the phone, our concerns were largely addressed in the PAL letter. Based upon what you included to the plan set per our phone meeting, not sure if we really need to write another inclusive letter in regards to our phone call.

Just let me know

--Bryan

--Bryan

On Mon, Mar 25, 2013 at 2:12 PM, Cameron, Laura L SWL <Laura.L.Cameron@usace.army.mil> wrote:

It appears that I need a "compliance act report" from you. Does that ring a bell on what we need?

llc

Laura L. Cameron, P.E., LEED A.P.
Project Manager/Study Manager
Planning and Environmental Office
US Army Corps of Engineers-Little Rock
Phone 501-324-5037
Mobile 501-251-5785
Fax 501-324-5605
CESWL-PE
700 W. Capitol
PO Box 867
Little Rock AR 72203

Letter 9: April 1, 2013 email from USFWS

From: Bax, Stacia
To: Coburn, Dana O SWL
Cc: Anslow, Patricia M SWL; Cameron, Laura L SWL; Schulte, Carrie; Beetem, Jane; MDNR MVS External Stakeholder; Singleton, Robert SWL
Subject: Jordon Creek Flood Risk Management Study
Date: Thursday, April 25, 2013 3:52:00 PM

Hi Dana,

I have read the Missouri Department of Conservation comments and briefly looked at study, both provided earlier today. While a more thorough review will be necessary, the project currently appears to be certifiable. We intend to issue a Clean Water Act Section 401 Water Quality Certification, most likely with conditions, for this project. However, a final certification would be pending the finalization of project plans and designs as well an inventory of specific stream and wetland impacts and benefits.

The use of low impact development technics in the watershed would greatly improve the timing and amount of stormwater received by Jordan Creek and other waters. Removing concreted, uniform channels and replacing them with an open channel with more natural characteristics (e.g., a sinuous, low flow channel) is certainly encouraged. While we do not promote in-channel detention basins, the final plans will need to be evaluated to determine their potential impact, both positive and negative.

Construction shall not begin before a final certification has been issued. We will continue to work on the final certification of the project. Please provide the plans and designs once they have been completed.

Should you have any questions, please feel free to contact me.

Thanks,

Stacia Bax

CWA Section 401 Water Quality Certifications

Wetland and Stream Special Projects, Operating Permits Section,

Water Protection Program, Missouri Department of Natural Resources

PO BOX 176, 1101 Riverside Dr., Jefferson City, MO 65102

573-526-4586 (Office) 573-522-9920 (FAX)

stacia.bax@dnr.mo.gov

Letter 10: April 25, 2013 Letter from MDNR