114th Congress, 2nd Session – – – – – – – – – – – – House Document 114–151

UPPER TURKEY CREEK, JOHNSON COUNTY AND WYANDOTTE COUNTY, KANSAS, FLOOD RISK MANAGEMENT PROJECT

COMMUNICATION

FROM

THE ASSISTANT SECRETARY OF THE ARMY, CIVIL WORKS, THE DEPARTMENT OF DEFENSE

TRANSMITTING

THE UPPER TURKEY CREEK, JOHNSON COUNTY AND WYANDOTTE COUNTY, KANSAS, FLOOD RISK MANAGEMENT PROJECT FEASIBILITY REPORT WITH INTEGRATED ENVIRONMENTAL ASSESSMENT FOR MARCH 2015

JULY 18, 2016.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

---

U.S. GOVERNMENT PUBLISHING OFFICE

20–778 WASHINGTON : 2016

AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

HOUSE DOCUMENT NUMBER 114-151

T+I
TOW592
print

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

30 JUN 2016

Honorable Paul Ryan
Speaker of the House of Representatives
U.S. Capitol Building, Room H-232
Washington, DC 20515

Dear Mr. Speaker:

In response to a study conducted under the authority of the resolution of the U.S. House of Representatives Committee on Transportation and Infrastructure, adopted on February 16, 2000, the Secretary of the Army supports the authorization and construction of the Upper Turkey Creek Basin Flood Risk Management project, Merriam, Kansas. The proposal is described in the report of the Chief of Engineers, dated December 22, 2015, which includes other pertinent documents. The Secretary of the Army plans to implement the project at the appropriate time, considering National priorities and the availability of funds.

The project study was conducted to analyze and formulate plans for reducing flood risk along the Upper Turkey Creek. The recommended plan includes a levee and floodwall system to reduce risks to life and property located between Antioch Avenue and Shawnee Mission Parkway in Merriam, Kansas. The primary plan features are 3,380 feet of levee up to approximately six feet in height and 6,820 feet of floodwall up to approximately 6.5 feet in height. The floodwall system includes a supporting foundation in the form of an array of auger grout piles. Bridge modification includes headwalls for the purpose of tying in proposed levees and floodwalls at the Merriam Drive Bridge. A 2.1 acre-foot gravity drained stormwater detention pond is included for interior drainage adjacent to the Merriam Marketplace. The project also includes stormwater, water and sanitary utility relocations, and environmental compensatory mitigation of seven acres of mast producing trees.

Based on the October 2015 (FY 2016) price levels, the estimated first cost of the plan is $37,822,000 which includes pre-construction engineering and design costs of $3,066,000. In accordance with the cost sharing provisions of section 103 of the Water Resources Development Act (WRDA) of 1986, as amended, the Federal share of the first costs of the flood risk management features is estimated to be 65 percent or $24,584,000, and the non-Federal share is estimated to be 35 percent or $13,238,000, including the provision of lands, easements, rights-of-way, relocations, and dredged or excavated material disposal areas (LERRDs). The LERRDs for the recommended plan are estimated to cost $9,690,000, which is less than the 35 percent minimum required non-Federal contribution to the project. The remaining non-Federal share will be a cash contribution of $3,548,000. Because this exceeds the 5 percent minimum cash contribution, no additional non-Federal cash contribution is required.

The City of Merriam, Kansas is the non-Federal sponsor and is responsible for the operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) of the project

Printed on Recycled Paper

after construction, at an estimated annual cost of $42,000.

Based on FY 2016 price levels, a discount rate of 3.125 percent and a 50-year period of economic analysis, the total equivalent average annual costs of the proposed project are estimated to be $1,658,000, including monitoring and operations, maintenance, repair, rehabilitation, and replacement. The recommended plan has total annual benefits of $3,476,000 with net annual benefits of $1,818,000. The benefit-to-cost ratio is 2.1 to 1.

An Environmental Assessment (EA) was prepared in accordance with the National Environmental Policy Act. The recommended plan has been identified as the environmentally preferred plan. Adverse environmental impacts have been avoided and minimized where practicable. The EA resulted in a Finding of No Significant Impact to the environment, therefore, preparation of an Environmental Impact Statement is not required. Compensatory mitigation for unavoidable impacts to 3.6 acres of riparian floodplain trees is required. To mitigate for these unavoidable impacts, the U.S. Army Corps of Engineers will plant 185 hard mast producing trees over a 7-acre area within the Upper Turkey Creek watershed.

The Independent External Peer Review was completed by Battelle Memorial Institute. The review comments resulted in updated engineering and economic analyses and expanded narratives throughout the report to support the decision-making process and further justify the recommended plan. All comments from the above referenced reviews have been addressed and incorporated into the final documents.

The Office of Management and Budget (OMB) advises that there is no objection to the submission of the report to Congress and concludes that the report recommendation is consistent with the policy and programs of the President. However, OMB also noted that the project would need to compete with other proposed investments for funding in future budgets. A copy of OMB's letter, dated June 27, 2016, is enclosed. I am providing a copy of this transmittal and the OMB letter to the Subcommittee on Water Resources and Environment of the House Committee on Transportation and Infrastructure, and the Subcommittee on Energy and Water Development of the House Committee on Appropriations. I am also providing an identical letter to the President of the Senate.

Very truly yours,

Jo-Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

Enclosures

3 Enclosures

1. OMB Clearance Letter
2. Report of the Chief of Engineers, December 22, 2015
3. Final Feasibility Report and Environmental Assessment, March 2015

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

June 27, 2016

The Honorable Jo-Ellen Darcy
Assistant Secretary of the Army (Civil Works)
108 Army Pentagon
Washington, DC 20310-0108

Dear Ms. Darcy:

As required by Executive Order 12322, the Office of Management and Budget has reviewed a March 2015 Army Corps of Engineers feasibility study report (report) for the Upper Turkey Creek, Flood Damage Reduction Project, Merriam, Kansas. The report estimates that the project will cost a total of $37,822,000 (October 2015 prices). We have concluded that an authorization to construct this project would be consistent with the policy and programs of the President.

The Office of Management and Budget does not object to you submitting this report to the Congress. When you do so, please advise the Congress that the project would need to compete with other proposed investments in future Budgets.

Sincerely,

John Pasquantino
Deputy Associate Director
Energy, Science, and Water

ENCL 1

DEPARTMENT OF THE ARMY
CHIEF OF ENGINEERS
2600 ARMY PENTAGON
WASHINGTON, DC 20310-2600

REPLY TO
ATTENTION OF

DAEN

DEC 2 2 2015

SUBJECT: Upper Turkey Creek Basin Flood Risk Management Study, Merriam, Kansas

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on flood risk management improvements on Turkey Creek in the city of Merriam, Kansas. It is accompanied by the report of the district and division engineer. These reports were prepared pursuant to the Resolution of the Committee on Transportation and Infrastructure, U.S. House of Representatives, Docket 2616, adopted 16 February 2000, requesting that the Secretary of the Army review the report of the Chief of Engineers on the Turkey Creek Basin, Kansas and Missouri, dated 21 June 1999, and any other pertinent reports, to determine whether any modifications of the recommendations contained therein are advisable at the present time in the interest of flood damage reduction for areas of Turkey Creek Basin in Johnson and Wyandotte Counties, Kansas, upstream of the project for flood damage reduction authorized in Section 101(a)(24) of Public Law 106-53, of the Water Resources Development Act (WRDA) of 1999. Pre-construction engineering and design activities, if funded, would be continued under the authority of the committee resolution cited above.

2. The reporting officers recommend authorizing a plan to reduce flood damages by the construction of new features to significantly reduce risks from flash flooding in the city of Merriam, Kansas. The recommended plan, Alternative 2d, includes recommendations for a levee and floodwall system to protect lives and property located between Antioch Avenue and Shawnee Mission Parkway in Merriam, Kansas. The primary plan features are 3,380 feet of levee up to approximately six feet in height and 6,820 feet of floodwall up to approximately 6.5 feet in height. The floodwall system includes a supporting foundation in the form of an array of auger grout piles. Bridge modification includes headwalls for the purpose of tying in proposed levees and floodwalls at the Merriam Drive Bridge. A 2.1 acre-foot gravity drained stormwater detention pond is included for interior drainage adjacent to the Merriam Marketplace. The project also includes stormwater, water and sanitary utility relocations, and environmental compensatory mitigation of seven acres of mast producing trees.

3. The recommended plan is the National Economic Development (NED) Plan. Project costs are allocated to the flood risk management purpose. Based on the October 2015 price levels, the estimated first cost to the plan is $37,822,000. In accordance with the cost sharing provisions of Section 103 of WRDA 1986, as amended by Section 202 of WRDA 1996, the federal share of the first costs of the flood risk management features is estimated to be 65 percent or $24,584,000, and the non-federal share is estimated to be 35 percent or $13,238,000, including the provision of lands, easements, rights-of-way, relocations, and dredged or

Printed on Recycled Paper

excavated material disposal areas (LERRDs). The LERRDs for the recommended plan are estimated to cost $9,690,000, less than the 35 percent minimum required non-federal contribution to the project. The remaining non-federal share will be a cash contribution of $3,548,000; because this exceeds the minimum cash contribution, no additional non-federal cash contribution is required. The non-federal sponsor, the city of Merriam, Kansas, is responsible for the operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) of the project after construction, a cost currently estimated to be about $42,000 annually. Based on a 3.125 percent discount rate and a 50 year period of analysis, the total equivalent average annual costs of the project, including OMRR&R, are estimated to be $1,658,000. The recommended plan is estimated to reduce expected annual flood damages by 72 percent. Total expected average annual benefits are estimated to be $3,476,000 with net annual benefits of $1,818,000. The benefit-cost ratio is 2.1 to 1.

4. The goals and objectives included in the Campaign Plan of the U.S. Army Corps of Engineers (USACE) have been fully integrated into the feasibility study process. The recommended plan has been designed to avoid or minimize environmental impacts, to reduce risk of loss of life, and to reasonably maximize economic benefits to the community in coordination with the existing flood risk management system. There are no significant direct or cumulative environmental impacts associated with the recommended plan. The long-term environmental and cultural consequences of plan implementation are positive as the reduced flash flood risk will improve protection of the social and environmental fabric that has developed within the study area. The feasibility study team organized and participated in stakeholder and public meetings throughout the process and worked to achieve a balance of project goals with public concerns. The study report describes existing flood risks to the community, risks that will be reduced by the recommended plan, and residual risks that will remain. These residual risks have been communicated to the non-federal sponsor and community stakeholders, and they understand and agree with the analysis. The feasibility study team has reviewed current available information on the estimated future impact of climate change to the region. While a trend towards slightly wetter conditions in the future has been identified in eastern Kansas by the National Weather Service (NWS), the analysis identified no discernible trends that would indicate a significant increase in annual maximum precipitation.

5. In accordance with the USACE guidance on review of decision documents, all technical, engineering and scientific work underwent an open, dynamic and rigorous review process to ensure technical quality. This included an Agency Technical Review (ATR), Type I Independent External Peer Review (IEPR), and a USACE Headquarters policy and legal review. All concerns of the ATR have been addressed and incorporated into the final report. The IEPR was completed by Battelle Memorial Institute in October 2013. A total of 16 comments were made. In summary, the IEPR comments related to report completeness in the areas of hydrology and hydraulic analyses, plan formulation, design, communication of residual risk, mitigation requirements, cost and schedule risk, risk and uncertainty, and economic analysis. The most significant comment was that the study hydrology and hydraulics needed to be updated to take into account the 2013 publication of the NWS's National Oceanic and Atmospheric Administration Atlas 14 report. After an evaluation of the impacts of the updated hydrology and hydraulics and effects on plan formulation, a rigorous sensitivity analysis

determined that these revised results did not alter the plan formulation or economic analyses used to identify the recommended plan as the NED Plan. The process resulted in updated engineering and economic analyses and expanded narratives throughout the report to support the decision-making process and further justify the recommended plan. All comments from the above referenced reviews have been addressed and incorporated into the final document. Overall the reviews resulted in improvements to the technical quality of the report. A Type II IEPR Safety Assurance Review will be conducted prior to initiation of physical construction and periodically thereafter until construction activities are completed.

6. Washington level review indicated that the plan recommended by the reporting officers is technically sound, environmentally and socially acceptable, and economically justified. The plan complies with all essential elements of the U.S. Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Land Related Resources Implementation Studies and complies with other Administration and legislative policies and guidelines. The views of interested parties, including federal, state, and local agencies were considered.

7. I concur with the findings, conclusions, and recommendations of the reporting officers. Accordingly, I recommend that the plan to improve flood risk management for the city of Merriam, Kansas, be authorized in accordance with the reporting officers' recommended plan at a total investment cost of $37,822,000. My recommendation is subject to cost sharing, financing, and other applicable requirements of federal and state laws and policies, including Section 103 of WRDA 1986 (33 U.S.C. 2213), as amended. The non-federal sponsor will provide the non-federal share of project costs including all LERRDs. Further, the non-federal sponsor would be responsible for all OMRR&R. This recommendation is subject to the non-federal sponsor agreeing to comply with all applicable federal laws and policies, including but not limited to:

a. Provide the non-federal share of total project costs, including a minimum of 35 percent but not to exceed 50 percent of total project costs as further specified below:

(1) Provide 35 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

(2) Provide, during construction, a contribution of funds equal to five percent of total project 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 project; and

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

b. Not less than once each year, inform affected interests of the extent of protection afforded by the project; participate in and comply with applicable federal floodplain management and flood insurance programs; comply with Section 402 of WRDA 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 partnership agreement, and to implement such plan not later than one year after completion of construction of the project; and publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the project;

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

d. For so long as the project remains authorized, OMRR&R 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;

e. 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, or OMRR&R of the project;

f. Hold and save the United States free from all damages arising from the construction, OMRR&R of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

g. 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), as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the federal government determines to be required for construction, operation, and maintenance of the project. However, for lands that the federal government determines to be subject to the navigation servitude, only the federal government shall perform such investigations unless the federal government provides the non-federal sponsor with prior specific written direction, in which case the non-federal sponsor shall perform such investigations in accordance with such written direction;

DAEN
SUBJECT: Upper Turkey Creek Basin Flood Risk Management Study, Merriam, Kansas

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

i. Agree, as between the federal government and the non-federal sponsor, that the non-federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, OMRR&R the project in a manner that will not cause liability to arise under CERCLA; and

j. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public law 91-646, as amended by title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 1 00-17), and the Uniform Regulations contained in 49 CFR part 24, in acquiring lands, easements, and rights-of-way, and performing relocations for construction, operation, and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

8. The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It neither reflects 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 they are transmitted to Congress as a proposal for authorization and implementation funding. However, prior to transmittal to Congress, the sponsors, the state, interested federal agencies, and other parties will be advised of any modifications and will be afforded the opportunity to comment further.

THOMAS P. BOSTICK
Lieutenant General, USA
Chief of Engineers

UPPER TURKEY CREEK
JOHNSON COUNTY AND WYANDOTTE COUNTY, KANSAS
FLOOD RISK MANAGEMENT PROJECT

FEASIBILITY REPORT
WITH
INTEGRATED ENVIRONMENTAL ASSESSMENT

March 12, 2015

US Army Corps of Engineers
Kansas City District
Civil Works, Planning Branch
635 Federal Building
601 East 12th Street
Kansas City, MO 64106-2824

TABLE OF CONTENTS

CHAPTER 1 – STUDY INFORMATION 1-1
1.1 Purpose and Need for the Project and Report 1-1
1.2 Study Authority 1-2
1.3 Study Location 1-2
1.4 Study Sponsor and Participants 1-2
1.5 History of Turkey Creek Investigations 1-5
1.6 Existing Programs, Prior Studies, and Projects 1-5
1.6.1 Programs 1-6
1.6.2 Projects 1-10
1.6.3 Studies 1-12
1.7 Planning Process and Report Organization 1-13

CHAPTER 2 – NEED FOR AND OBJECTIVES OF ACTION 2-1
2.1 Study Area Description 2-1
2.2 Federal and Non-Federal Objectives 2-1
2.3 Problems and Opportunities 2-2
2.3.1 Public Concerns 2-2
2.3.2 Flood Hazards 2-3
2.3.3 Ecosystem Restoration 2-6
2.3.4 Water Quality 2-7
2.4 Planning Goals and Objectives 2-9
2.4.1 Reduce Flood Risks 2-9
2.4.2 Use a Systems Approach for the Watershed 2-9
2.5 Planning Constraints 2-10
2.6 Other Planning Considerations 2-11
2.6.1 Recreation 2-11
2.6.2 Green Solutions 2-11

2.6.3 Special Area Management Plan 2-12
2.6.4 Floodplain Management Plan 2-13

CHAPTER 3 – SYSTEM BASELINE CONDITION AND INVENTORY 3-1
3.1 Existing Conditions 3-2
3.1.1 Watershed Assessment 3-2
3.1.2 Environmental Description 3-3
3.2 Resources of Concern 3-3
3.2.1 Geology, Soils, and Geomorphology 3-3
3.2.2 Climate 3-4
3.2.3 Hydraulics and Hydrology 3-4
3.2.4 Water Quality 3-6
3.2.5 Aquatic Habitat 3-7
3.2.6 Wetlands and Waters of the United States 3-8
3.2.7 Terrestrial Habitat 3-8
3.2.8 Fish and Wildlife 3-8
3.2.9 Threatened Or Endangered Species 3-8
3.2.10 Hazardous, Toxic, and Radioactive Waste (HTRW) 3-9
3.2.11 Floodplain 3-9
3.2.12 Land Use 3-10
3.2.13 Critical Facilities 3-11
3.2.14 Socioeconomics 3-11
3.2.15 Environmental Justice 3-15
3.2.16 Transporation 3-16
3.2.17 Recreation 3-18
3.2.18 Cultural Resources 3-18
3.3 Future Without Project Conditions 3-18
3.3.1 Geology, Soils, And Geomorphology 3-18
3.3.2 Climate 3-18
3.3.3 Hydraulics And Hydrology 3-19

3.3.4 Water Quality 3-19
3.3.5 Aquatic Habitat 3-19
3.3.6 Wetlands And Waters Of The United States. 3-19
3.3.7 Terrestrial Habitat 3-19
3.3.8 Fish And Wildlife 3-19
3.3.9 Threatened And Endangered Species 3-20
3.3.10 Hazardous, Toxic, And Radioactive Wastes (HTRW) 3-20
3.3.11 Floodplain 3-20
3.3.12 Land Use 3-20
3.3.13 Socioeconomics 3-20
3.3.14 Environmental Justice 3-20
3.3.15 Transportation 3-20
3.3.16 Recreation 3-21
3.3.17 Cultural Resources 3-21

CHAPTER 4 –PLAN FORMULATION 4-1
4.1 Plan Formulation Methodology 4-1
4.1.1 Systems Approach 4-1
4.1.2 Local Perspective 4-2
4.2 Planning Criteria 4-2
4.3 Project Siting 4-4
4.3.1 Flood Risk Management Project Sites 4-5
4.4 Measures 4-5
4.4.1 Flood Risk Management Measures 4-5
4.4.2 Ecosystem Restoration and Recreation Measures 4-8
4.5 Evaluation of Project Sites and Measures 4-8
4.5.1 Project Sites 4-9
4.5.2 Structural Flood Risk Management Measures 4-9
4.5.3 Nonstructural Flood Risk Management Measures 4-11
4.5.4 Ecosystem Restoration And Recreation Measures 4-13

4.5.5 Measures Screening Review 4-13
4.6 Preliminary Array of Alternative Plans 4-18
4.6.1 Structural Flood Risk Plan Formulation 4-18
4.6.2 Nonstructural Flood Risk Plan Formulation 4-18
4.6.3 Development of Flood Risk Management Alternatives 4-19
4.7 Evaluation Tools 4-20
4.7.1 Period of Analysis 4-22
4.7.2 Modeling 4-22
4.7.3 Performance Measures 4-23

CHAPTER 5 – ALTERNATIVE EVALUATION AND COMPARISON 5-1
5.1 Formulation of Final Array Of Alternatives 5-1
5.2 Evaluation of Final Array of Alternatives 5-15
5.2.1 Economic Evaluation 5-16
5.3 Comparison of Final Alternatives 5-22
5.3.1 Trade-Off Analysis 5-29
5.3.2 Tentative Selection of Plans 5-29
5.3.3 Environmental Evaluation of Alternatives 5-30
5.4 Atlas 14 Update 5-31

CHAPTER 6 – ENVIRONMENTAL EFFECTS 6-1
6.1 Habitat Modeling 6-1
6.2 Effects on Resources of Concern 6-1
6.2.1 Geology, Soils, and Geomorphology 6-1
6.2.2 Climate 6-2
6.2.3 Hydraulics and Hydrology 6-2
6.2.4 Water Quality 6-4
6.2.5 Aquatic Habitat 6-4
6.2.6 Wetlands and Waters of the United States 6-5
6.2.7 Terrestrial Habitat 6-6

6.2.8 Fish and Wildlife 6-7
6.2.9 Threatened and Endangered Species 6-9
6.2.10 Hazardous, Toxic, and Radioactive Wastes 6-9
6.2.11 Floodplain 6-9
6.2.12 Land Use 6-10
6.2.13 Socioeconomics 6-11
6.2.14 Environmental Justice 6-12
6.2.15 Transportation 6-12
6.2.16 Recreation 6-13
6.2.17 Cultural Resources 6-13
6.2.18 Summary of Environmental Affects 6-13
6.3 Alternative Formulation For Compensatory Mitigation 6-15
6.4 Cumulative Impacts 6-21

CHAPTER 7 – THE RECOMMENDED PLAN 7-1
7.1 Plan Accomplishments 7-1
7.2 Construction Features 7-2
7.2.1 Levees and Floodwalls 7-14
7.2.2 Bridge Modifications 7-16
7.2.3 Detention Basin 7-17
7.2.4 Utility Impacts 7-17
7.2.5 Environmental Mitigation 7-18
7.3 Detailed Cost Estimate (MCACES II) 7-19
7.3.1 Initial Costs 7-20
7.3.2 Investment Costs 7-20
7.3.3 Operation, Maintenance, Repair, Replacement, and Rehabilitation Costs 7-20
7.3.4 Annual Costs 7-21
7.3.5 Cost Estimate Uncertainties 7-21
7.4 Design and Construction Considerations 7-22
7.5 Risk and Uncertainty 7-22

7.5.1 Cost and Schedule Risk Analysis 7-22
7.5.2 Residual Risk 7-23
7.5.3 Preliminary Design Uncertainty 7-25
7.6 Real Estate Requirements 7-28
7.6.1 Land Acquisition – Categories 7-28
7.6.1.1 Fee 7-28
7.6.1.2 Permanent Flood Protection Easement 7-29
7.6.1.3 Temporary Easement 7-29
7.6.1.4 Mitigation Lands 7-29
7.6.2 Land Acquisition – Identification of Landowners 7-29
7.6.3 Land Acquisition – Identification of Acquisition Issues 7-29
7.6.4 Relocation Assistance (Public Law 91-646) 7-29
7.6.5 Induced Damages 7-30
7.7 Operation and Maintenance Considerations 7-30
7.8 Summary of Accounts 7-31
7.9 Project Implementation Requirements 7-32
7.9.1 Institutional Requirements 7-32
7.9.2 Project Review Plan 7-35
7.9.3 Public-Private Partnerships 7-36
7.9.4 Fully Funded Cost Estimate 7-36
7.9.5 Division of Responsibilities 7-37
7.9.6 Permits 7-38
7.9.7 Views of Non-Federal Sponsor 7-38

CHAPTER 8 – PUBLIC INVOLVEMENT, REVIEW AND CONSULTATION 8-1
8.1 Public Involvement Program 8-1
8.2 Institutional Involvement 8-1
8.2.1 Study Team 8-1
8.2.2 Agency Participation 8-1
8.2.3 Local and Regional Interests 8-1

8.3 Informational Materials 8-2
8.4 Media Releases 8-2
8.5 Public Open House and Meetings 8-2
8.6 Public Views and Responses 8-4
8.7 Agency Correspondence 8-4

CHAPTER 9 – LIST OF PREPARERS 9-1

CHAPTER 10 -AGENCY COMPLIANCE WITH OTHER ENVIRONMENTAL LAWS 10-1
10.1 Compliance with Other Environmental Laws 10-1
10.2 Compliance with Executive Order 11988 10-2

CHAPTER 11 – RECOMMENDATIONS 11-1

CHAPTER 12 – LIST OF RECIPIENTS 12-1
CHAPTER 13 – REFERENCES 13-1
13.1 Prior Studies and Reports 13-1
13.2 Literature Citations 13-6

FIGURES

Figure 1-1: Watersheds of Kansas City and Turkey Creek 1-3
Figure 1-2: Turkey Creek Basin 1-4
Figure 2-1: Johnson Drive at Turkey Creek Water Surface Elevations 2-4
Figure 2-2: Antioch Road at Turkey Creek Water Surface Elevations 2-5
Figure 2-3: Merriam Existing Inundation 2-6
Figure 3-1: Turkey Creek Upper and Lower Reaches 3-1
Figure 3-2: Land Use within the Turkey Creek Watershed 3-11
Figure 3-3: Transportation Infrastructure around Turkey Creek 3-17
Figure 4-1: Project Sites 4-4
Figure 4-2: Net Benefits Curve 4-24

Figure 5-1: Alternative 1: Channel Widening 5-11
Figure 5-2: Alternative 2: Levees/Floodwalls 5-12
Figure 5-3: Alternative 3: Combination 5-13
Figure 5-4: Alternative 4: Property Buy-Outs 5-14
Figure 6-1: Planning Set "Ce/Ica Analysis 2" Cost and Output 6-19
Figure 6-2: Planning Set "Ce/Ica Analysis 2" Incremental Cost and Output 6-20
Figure 7-1: Recommended Plan (Alternative 2d) - Plate 1 7-3
Figure 7-2: Recommended Plan (Alternative 2d) - Plate 2 7-4
Figure 7-3: Recommended Plan (Alternative 2d) - Plate 3 7-5
Figure 7-4: Recommended Plan (Alternative 2d) - Plate 4 7-6
Figure 7-5: Recommended Plan (Alternative 2d) - Plate 5 7-7
Figure 7-6: Recommended Plan (Alternative 2d) - Plate 6 7-8
Figure 7-7: Inundation Map Without Project (TP-40) - Plate 7 7-9
Figure 7-8: Inundation Map With Project (TP-40) - Plate 8 7-10
Figure 7-9: Inundation Map Without (Atlas 14) - Plate 9 7-11
Figure 7-10: Inundation Map With (Atlas 14) - Plate 10 7-12
Figure 7-11: Typical Levee Cross Section 7-15
Figure 7-12: Typical Flood Wall 7-16
Figure 8-1: Public Hearing PowerPoint Slide "Understanding Flood Risks" 8-3

TABLES

Table 2-1: 3010/3013 – Johnson Drive at Turkey Creek Water Level 2-4
Table 2-2: 3090/3093 – Antioch Road on-Ramp at Turkey Creek Water Level 2-5
Table 3-1: Statistical Rate of Return Correlated to a 24-Hour Rainfall 3-5
Table 3-2: Turkey Creek Watershed Gages in the Storm Watch Gage Network 3-5
Table 3-3: Overall Stream Health Assessment Scores for Upper Turkey Creek 3-7
Table 3-4: Turkey Creek Flood History 3-10
Table 3-5: Population, Employment and Housing Characteristics, 2010 3-12
Table 3-6: Study Area Investment 3-13
Table 3-7: Existing Condition Primary Damages 3-14

Table 3-8: Minority, Low Income, and Vulnerable Populations, 2010 3-15

Table 3-9: Residents Commuting To Work, 2010 3-17

Table 4-1: Supporting Definitions of Screening Criteria 4-14

Table 4-2: Screening Against Planning Criteria for Flood Risk Management Measures 4-16

Table 4-3: Upper Turkey Creek Planning Models 4-20

Table 4-4: Upper Turkey Creek Engineering Models 4-21

Table 5-1: Final Array of Alternatives 5-5

Table 5-2: Equivalent Annual Benefits and Residual Damages with and without Project 5-16

Table 5-3: Detailed Breakdown of Project First Costs by Alternative 5-18

Table 5-4: Detailed Cost Breakdown for Screening Alternatives for Merriam 5-19

Table 5-5: Screening Summary with-Project Annual Benefits, Costs, and Net Benefits 5-20

Table 5-6: Economic Performance with Uncertainty 5-21

Table 5-7: Total Project Costs and Economic Performance for Final Array of Alternatives 5-22

Table 5-8: Comparison of Features for the Final Action Alternatives 5-25

Table 5-9: Screening Alternatives Against Planning Criteria 5-31

Table 5-10: Comparison of Flows from Original (TP-40 based) to Atlas 14 Based Hydrology 5-32

Table 5-11: Comparison of Features - Alternatives 2d and 2g 5-34

Table 5-12: Equivalent Annual Benefits and Residual Damages With and Without Project 5-35

Table 5-13: Detailed Breakdown of Project First Costs by Alternative 5-35

Table 5-14: Detailed Cost Breakdown for Screening Alternatives for Merriam 5-36

Table 5-15: Screening Summary With-Project Annual Benefits, Costs, and Net Benefits 5-36

Table 5-16: Economic Performance With Uncertainty for Merriam Alternatives 5-36

Table 5-17: Annual Performance and Equivalent Long-term Risk for Merriam Reach 3b 5-37

Table 5-18: Conditional Probability of Design Non-Exceedance 5-37

Table 6-1: Summary of the Environmental Impacts for the Alternatives 6-14

Table 6-2: Summary of Results from Green Sunfish HSI Model for Each Alternative 6-15

Table 6-3: Summary of Results from Fox Squirrel HSI Model for Each Alternative 6-15

Table 6-4: Mitigation Options Formulated to Compensate for Impacts to the Riparian Habitat as a Result of Implementing a Structural Alternative 6-16

Table 6-5: Results of IWR Planning Suite Cost Effectiveness Analysis 6-17

Table 6-6: Results of IWR Planning Suite Incremental Cost Analysis....6-18

Table 6-7: Evaluation of Best Buy Options against Minimum Mitigation Requirement.... 6-20

Table 6-8: Mitigation Options and Mitigation Costs Used in Economic Screening.... 6-21

Table 7-1: Recommended Plan Features....7-13

Table 7-2: Cost Estimate Summary (Including Contingencies)....7-19

Table 7-3: Annual Cost Calculation....7-20

Table 7-4: OMRR&R Cost Summary....7-21

Table 7-5: Project Implementation Schedule....7-35

Table 7-6: Total Project Cost Summary....7-36

Table 7-7: Apportionment of Cost....7-37

APPENDICES

APPENDIX A – PLAN FORMULATION AND EVALUATION

APPENDIX B – ENGINEERING DESIGN AND MODELING

APPENDIX C – PUBLIC OUTREACH AND INVOLVEMENT

APPENDIX D – CLEAN WATER ACT SECTION 404 (B) (1) EVALUATION

APPENDIX E – USACE JURISDICTIONAL DETERMINATIONS

APPENDIX F – SOCIO-ECONOMICS

APPENDIX G – REAL ESTATE

APPENDIX H – COMMENTS AND CORRESPONDENCE

APPENDIX I – SELF-CERTIFICATION OF FINANCIAL CAPABILITY

APPENDIX J – ENVIRONMENTAL

APPENDIX K – CULTURAL RESOURCES

APPENDIX L – TOTAL PROJECT COST SUMMARY, COST AND SHEDULE RISK ANALYSIS, COST REPORT, CONTRACT SCHEDULE

APPENDIX M – CE/ICA FOR MITIGATION

APPENDIX N – FINDING OF NO SIGNIFICANT IMPACT (FONSI)

APPENDIX O – MITIGATION

Upper Turkey Creek
Johnson County and Wyandotte County, Kansas
Flood Risk Management Project
Feasibility Report with Integrated Environmental Assessment

** NOTE TO THE READER: The environmental assessment for this study has been integrated into the following feasibility report in accordance with Engineer Regulation 1105-2-100. Sections of the report that are required for compliance with the National Environmental Policy Act (NEPA) are noted by an asterisk (*) in the Table of Contents.*

EXECUTIVE SUMMARY

Kansas City District, Northwestern Division, U.S. Army Corps of Engineers (USACE) conducted this feasibility study under the authority of the Resolution of the Committee on Transportation and Infrastructure, U.S. House of Representatives, Docket 2616, adopted February 16, 2000. The purpose of the study is to determine the federal interest in constructing a flood risk management project in the City of Merriam in Johnson County, Kansas along Turkey Creek. This effort is documented in the feasibility report with an integrated environmental assessment.

The focus of this study is established as the Upper Turkey Creek watershed, located in a heavily urbanized area of approximately 20 square miles where Turkey Creek and tributaries are prone to damaging floods. The primary project sites considered for flood risk management plan formulation were: a) in the City of Merriam, Kansas; b) in the Unified Government of Wyandotte County and Kansas City, Kansas at the Roe Lane Industrial Park, and c) on a flood prone segment of highway, Interstate 35 in Johnson County running between Merriam downstream into the Unified Government area. Only the City of Merriam site has an alternative plan carried forward for recommendation. Alternatives considered include channel widening, levees and floodwalls, and a combination of these. A nonstructural buyout plan was also carried forward in plan formulation in addition to the No Action plan. Nonstructural measures including a flood warning system were reviewed in initial measures evaluation. The local community will continue utilizing the existing warning system with the strong gage network and alert mechanisms under a continued robust flood risk management system. Findings indicate that the most cost effective plan that addresses the flash flood threat and loss of life risk, and maximizes net annual benefits with least environmental effects is a plan for the construction of low height levees and floodwalls.

Under the USACE concept of collaborative planning, after assessing the existing conditions in the watershed, environmental restoration measures were evaluated in a watershed system perspective along with flood risk management. This effort was to consider the possibility of multipurpose formulation including ecosystem restoration. Valuable system baseline information and data were developed, and some preliminary candidate sites for restoration were indentified. Due to there being no cost-sharing sponsor interested in ecosystem restoration measures in this heavily urbanized watershed, those measures were not carried forward into plan formulation.

The Recommended Plan is a levee and floodwall plan along Turkey Creek in the City of Merriam. The features extend from Shawnee Mission Parkway to Merriam Drive, a stretch that includes Merriam's main downtown reach, as well as a commercial and industrial area just south of Johnson Drive. Most of the protected area is on the right bank of Turkey Creek. The features were formulated and evaluated using updated NOAA Atlas 14 rainfall data. The National Economic Development (NED) Plan is Alternative 2d which provides an estimated $1,712,500 in net annual benefits in flood damages reduced, with a benefit-cost ratio of 2.0. The plan includes 6,822 feet of floodwall up to 6.5 feet in height, 3,383 feet of levees up to 6 feet in height, a foundation system with approximately 12,427 auger grout piles, storm sewer modifications, and adjustments to utilities. For interior drainage the plan includes a 2.14 acre-foot detention area. The total estimated first cost is $37,579,000, with a fully funded cost of $43,697,000. The Federal cost is $28,403,000; non-Federal cost of $15,294,000, with the LERRD requirement of $10,934,000 and estimated average annual OMRR&R costs of $40,800.

The Recommended Plan is shown in Figure ES-1. The figure provides an overview of the Recommended Plan in an aerial view of the Turkey Creek in the City of Merriam.

This document is based on the limited information available at this intermediate stage. As the USACE planning process is dynamic and responsive to public and stakeholder input, the content herein may change markedly as more information becomes available. Federal and agency policies governing development of Civil Works planning studies are also subject to change. This document does not necessarily represent the perceptive of higher review levels within the agencies involved or the Executive Branch of the federal government.

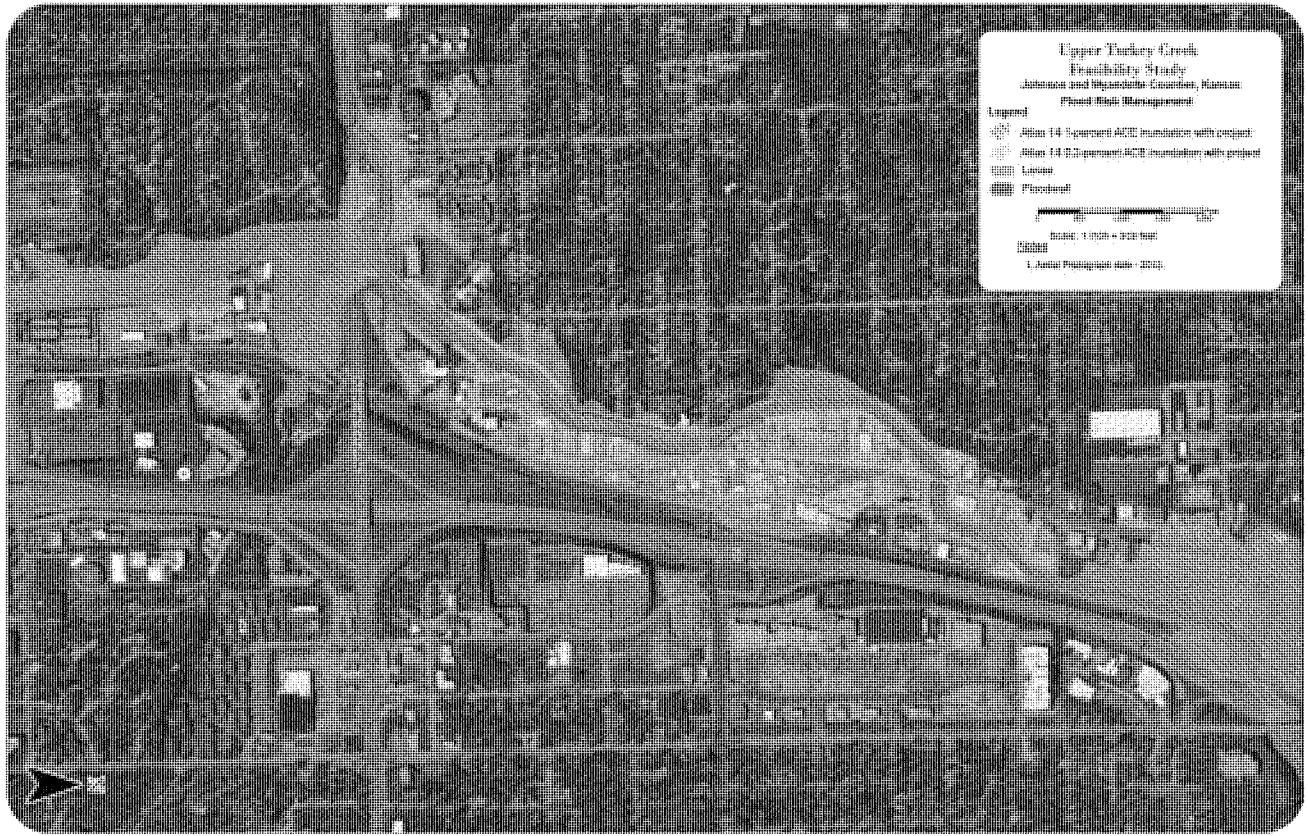


Figure ES-1: Recommended Plan (Alternative 2d)

This document is based on the limited information available at this intermediate stage. As the USACE planning process is dynamic and responsive to public and stakeholder input, the content herein may change markedly as more information becomes available. Federal and agency policies governing development of Civil Works planning studies are also subject to change. This document does not necessarily represent the perceptive of higher review levels within the agencies involved or the Executive Branch of the federal government.

1 CHAPTER 1 – STUDY INFORMATION

1.1 PURPOSE AND NEED FOR THE PROJECT AND REPORT

The purpose of the feasibility study is to identify, evaluate, and recommend to decision makers an appropriate, coordinated, implementable solution to the identified water resources problems and opportunities in the Upper Turkey Creek Basin. Congressional authorization for the Upper Turkey Creek Basin study specifically states this project's primary mission is flood risk management. The feasibility study considers other U.S. Army Corps of Engineers (USACE) mission areas or authorities in accordance with Engineer Regulation (ER) 1105-2-100, *Planning Guidance Notebook*. These mission areas or authorities included the use of a systems approach (specifically a watershed perspective) and collaborative planning, as well as consideration for the ecosystem restoration and recreation mission areas in the plan formulation process. The study product is a decision document in the form of this feasibility report and integrated National Environmental Policy Act (NEPA) environmental assessment (EA) document in accordance with ER 1105-2-100 and the Council on Environmental Quality's (CEQ) Regulations for Implementing NEPA (40 Code of Federal Regulations [CFR] Parts 1500–1508).

The need for the project lies in the potential for flooding that could result in loss of life and/or property damage in the Upper Turkey Creek Basin. Flooding in and around Johnson County, Kansas, led to presidential disaster declarations in 1993 and 1998. The estimated cost of these disasters exceeded $50 million dollars. Heavy rains on October 4, 1998, produced flooding that caused several million dollars in damage to businesses and public property along Turkey Creek in Johnson and Wyandotte Counties, Kansas. Reports indicate that parts of the Kansas City metropolitan area received almost eight inches of rain that day with some locations receiving three to five inches of rain within a three-hour period. More than five inches fell in Lenexa, Kansas, in a little over an hour. Nearly 100 calls for water rescue were received, and numerous roads throughout the area, including individual sections of Interstate 35 (I-35) and Interstate 435 (I-435), were impassible. Two lives were lost, including a death in Lenexa near the intersection of West 93rd Street and Acuff Road, and one in Overland Park, Kansas, on Connell Avenue near 103rd Street. There was also extensive property damage. If the flood peak over I-35 had occurred during rush hour, the loss of life count could have been significant.

The 1998 flood was significant. The 24-hour rainfall amount associated with a 1 percent annual exceedance probability (AEP) (100-year event) for the Johnson County, Kansas, area is 7.8 inches. Also, the 60-minute rainfall amount associated with the 1 percent AEP is 3.75 inches. The storm of October 1998 exceeded the 1 percent AEP for both the 24-hour and 60-minute rainfall amounts.

Following these losses, the U.S. House of Representatives Committee on Transportation and Infrastructure passed the 1999 resolution and adopted the study authority in 2000 (see Section 1.2). The 1999 resolution favored a watershed perspective to future water resource development proposals. A successful plan must fit a broad range of community goals for the whole Turkey Creek watershed to ensure the resulting project would be sustainable in the sense that the community would want to use, maintain, and possibly even enhance the project as a community asset after construction.

The purpose of this report is to present decision makers with the findings of a feasibility phase of this general investigation. This investigation of the Upper Turkey Creek Basin was conducted to determine if it

meets the USACE criteria for Federal involvement in addressing flood hazards, environmental degradation, and related water and land resource needs and opportunities.

This report has detailed analyses of the problems and opportunities and presents the USACE and project sponsor desired outcomes related to planning objectives. Alternatives to address the objectives were developed by the planning team in collaboration with the project sponsor and are presented herein. These alternatives include a range of potential actions including a plan of no action and various combinations of structural and nonstructural measures. The evaluation of economic and environmental impacts is then explained and a feasible plan is selected, where potential Federal cost share is identified. The report also presents details about the USACE and sponsor participation needed to implement the plan. The report concludes with a recommendation for Congressional authorization.

1.2 STUDY AUTHORITY

The Upper Turkey Creek Basin, Kansas, Integrated Feasibility Study and Environmental Assessment is authorized by Resolution of the Committee on Transportation and Infrastructure, U.S. House of Representatives, Docket 2616, adopted February 16, 2000.

> Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That the Secretary of the Army is requested to review the report of the Chief of Engineers on the Turkey Creek Basin, Kansas and Missouri, dated June 21, 1999, and other pertinent reports, to determine whether any modifications of the recommendations contained therein are advisable at the present time in the interest of flood damage reduction for areas of Turkey Creek Basin in Johnson and Wyandotte Counties, Kansas, upstream of the project for flood damage reduction authorized in section 101(a)(24) of Public Law 106-53, the Water Resources Development Act of 1999.

1.3 STUDY LOCATION

The study location includes a portion of the Turkey Creek watershed, which is a right bank tributary of the lower Kansas River (Figure 1-1). The headwaters of the Turkey Creek Basin are in Lenexa, Kansas, just south of 89th Street, and the portion of the watershed upstream of the 4.4 Burlington Northern Santa Fe (BNSF) railroad bridge referred to in this study as Upper Turkey Creek and Lower Turkey Creek is the downstream portion. The entire basin drains 23 square miles before passing through a quarter-mile-long tunnel to the Kansas River. Turkey Creek is approximately 15 miles long and flows parallel to I-35 for almost its entire length. The Turkey Creek drainage basin overlaps the common boundary of Johnson and Wyandotte Counties, Kansas. Countyline Road passes east-west through the basin separating Johnson County to the south from Wyandotte County to the north. For this feasibility report, the Upper Turkey Creek Basin, or sometimes referred to as UTC, is defined as the basin upstream of an authorized flood risk management construction project in the downstream 8,700 feet of the Turkey Creek channel (Figure 1-2), also referred to as Lower Turkey Creek in this report.

1.4 STUDY SPONSOR AND PARTICIPANTS

The City of Merriam, Kansas, is the non-Federal local sponsor for this feasibility study. A Feasibility Cost Sharing Agreement (FCSA) between the City of Merriam, Kansas, and the government was signed in June 2002 and calls for a feasibility study of flood damage reduction and ecosystem restoration in the Turkey Creek Basin at a cost of approximately $2.4 million. Half of the feasibility study cost came from Federal funds. The non-Federal share includes work performed by the non-Federal sponsor as well as cash contributions. The non-Federal sponsor has provided a hydrologic and hydraulic model valued at more than $200,000 in addition to cash payments. The model was obtained through an agreement between Merriam

and Johnson Counties, Kansas. Johnson County and the Unified Government of Wyandotte County and Kansas City, Kansas (UG) both support the study financially through agreements with Merriam County and provided members to the team that monitored the progress of the study.

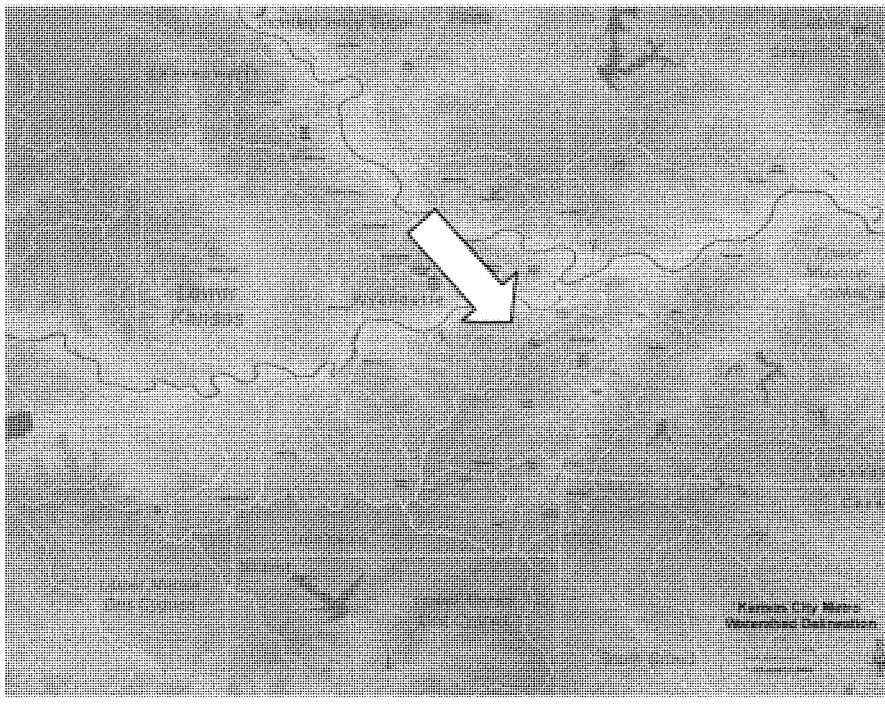


Figure 1-1: Watersheds of Kansas City and Turkey Creek.

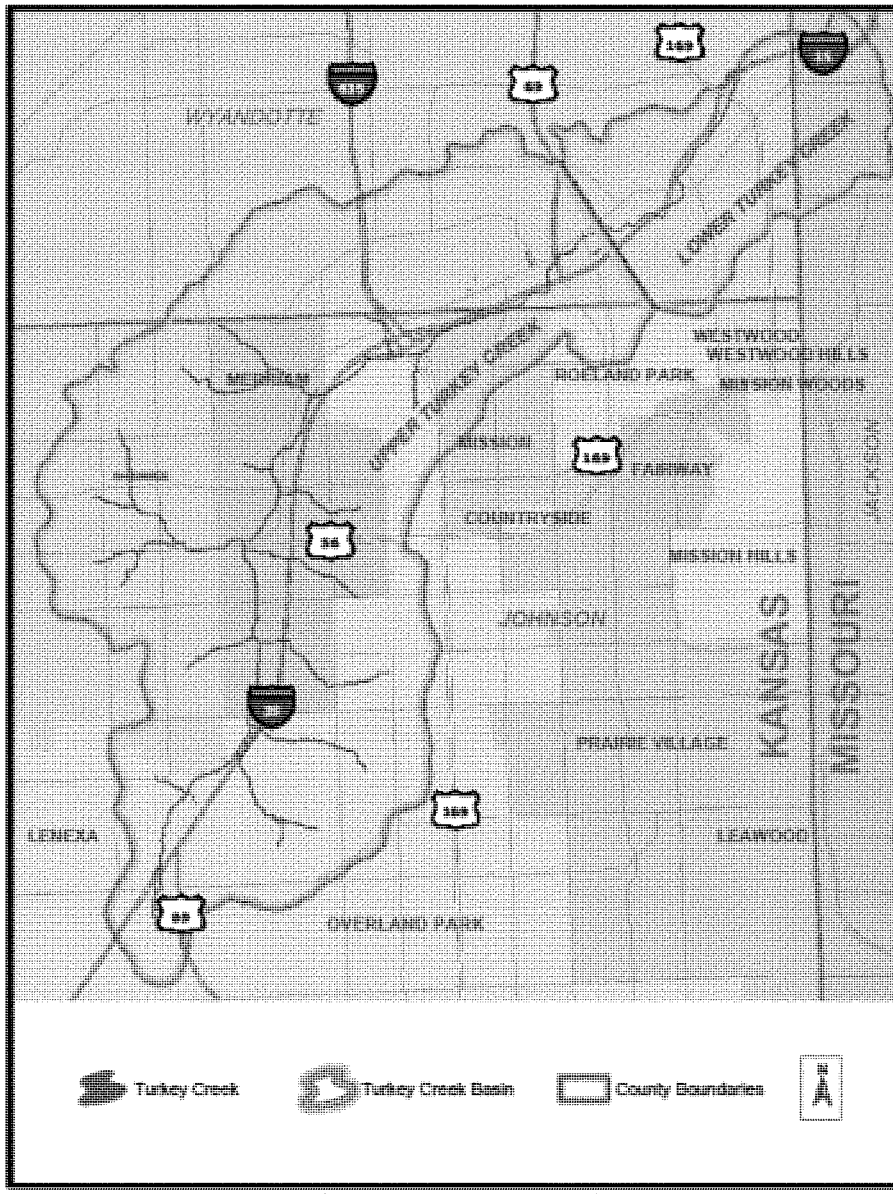


Figure 1-2: Turkey Creek Basin

In addition to the local sponsor, the following agencies and organizations have been major stakeholders and have been active participants in the feasibility study process:

- Johnson County Stormwater Management Program
- Merriam Drainage District
- Mid-America Regional Council and the Turkey Creek Coalition
- Johnson County Public Works and the Stormwater Management Advisory Council
- Kansas Department of Transportation (KDOT)
- U.S. Environmental Protection Agency (EPA)
- Downtown Merriam Partnership

1.5 HISTORY OF TURKEY CREEK INVESTIGATIONS

The Turkey Creek watershed has a history of the USACE involvement. In the past 50 years, major flood events have occurred in 1951, 1958, 1961, 1968, 1977, 1983, 1986, 1993, 1995, 1996, and 1998. Although the floods of 1993 and 1998 were both extreme events, the 1998 flood appears to be the flood of record, based on high water marks, for Turkey Creek.

Although the 1977 flood is locally known as the Plaza Flood on Brush Creek, significant damage resulted in Rosedale and elsewhere in the Turkey Creek Basin. Flood damage estimates from the September 1977 flood exceeded $8.1 million dollars and prompted the Mid-America Regional Council (MARC), the metropolitan planning organization, to ask the USACE to study the Turkey Creek flood problems as a part of an ongoing Urban Study. The Urban Study determined it was not feasible to develop and implement a program for managing flood risks along Turkey Creek that would contain the 1 percent annual exceedance probability (AEP, or 100-year event) and greater flood events. However, following the 1983 flood, the Cities of Kansas City, Missouri, and Kansas City, Kansas, requested additional studies on Turkey Creek flooding. In 1987, the USACE produced the Reconnaissance Study of Turkey Creek. This commenced a series of studies culminating in an authorized construction project for Lower Turkey Creek in the Water Resources Development Act (WRDA) of 1999. As of 2012, Lower Turkey Creek has an active USACE construction project. One component is the repair of an aging tunnel that diverts all flow from the Turkey Creek watershed through a bluff to the Kansas River. Channel widening has also been done.

Following the 1993 and 1998 flood losses and as Lower Turkey Creek investigations were ongoing, the U.S. House of Representatives Committee on Transportation and Infrastructure passed the 1999 resolution and adopted the Upper Turkey Creek Basin Study authority in 2000. The 1999 resolution favored a watershed perspective to future water resource development proposals. In response to the study authority, the reconnaissance phase of the study was initiated on 16 February 2000 (USACE 2001). This phase of the study resulted in the finding that there was a Federal interest in continuing the study into the feasibility phase. The USACE, Kansas City District, along with the local sponsor, the City of Merriam, Kansas, initiated the feasibility phase of the Upper Turkey Creek watershed in June 2002 to examine measures for flood risk management. This report presents the results of the planning phase.

1.6 EXISTING PROGRAMS, PRIOR STUDIES, AND PROJECTS

This section describes existing programs, prior studies, and projects that are applicable to this feasibility study and were considered in the planning process including identification of problems and opportunities and alternative plan formulation.

1.6.1 PROGRAMS

The following programs are applicable to the Upper Turkey Creek Basin and were considered in the planning process for this feasibility study:

Johnson County Stormwater Management Program

The Johnson County, Kansas Stormwater Management Program (SMP) is a part of the county's public works department. The SMP assists all of the cities in the county in planning, designing, and constructing large stormwater projects. This is an important funding mechanism for smaller cities in the county, such as Merriam. While the annual budget ranges between 10 and 20 million dollars, projects are carefully selected on specific criteria. One merit has to do with projects that involve larger, systems approach. Merriam's position downstream of several major cities has the burden of addressing resulting floodwaters, and this is one reason Merriam has received funding aid. This program is a significant part of the local cost share of this project.

In 1988, the Kansas Legislature authorized counties to adopt a 1/10th-cent sales tax for the purpose of funding stormwater projects. These funds, dedicated to stormwater management, allow Johnson County through its SMP to create a yearly stormwater management plan and provide 75 percent of funding for eligible projects in Johnson County and the cities. The SMP provides financial, technical, and other stormwater assistance services to encourage regional solutions for protecting human lives and property, conserving natural resources, and promoting appropriate public use of Johnson County stream corridors. The Johnson County Stormwater Management Advisory Council (SMAC) operates as an advisory board to the Board of County Commissioners. It is responsible for reviewing recommendations made in the SMP and providing recommendations to the Board of County Commissioners and considering new and innovative ways to properly manage stormwater.

The SMP will recommend that SMP funding be provided to a city's local cost share of the USACE developed construction projects where the project meets the Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP) standards and reduces flood hazards. As a condition the SMP needs levees and or floodwalls to be certifiable in that program per criteria in the NFIP as of 2012.

Clean Water Act Section 319

Section 319 was added to the Clean Water Act (CWA) in 1987 to establish a national program to address nonpoint sources of water pollution. Section 319(h) specifically authorizes the EPA to award grants to states with approved non-point source Assessment Reports and non-point source Management Programs. The funds are to be used to implement programs and projects designed to reduce non-point source pollution. The EPA provides funding for implementation of Kansas' Non-Point Source Management Program through an annual CWA Section 319 grant to the Kansas Department of Health and Environment (KDHE). EPA personnel also provide program guidance and implementation assistance through review of 319 project implementation plans for subgrants to local project sponsors. Other funding is also made available through EPA for water quality related activities, such as the State Wetland Development Grant Program and Targeted Watershed Grant Program, which have been used by local and state partners in Kansas. The annual 319 program grant to Kansas in Federal fiscal year (FFY) 2010 was about $3.5 million. The KDHE provided an EPA 319 grant for funding of the Lower Kansas Watershed Restoration and Protection Strategy (WRAPS) Watershed Plan, which covers the area of the Turkey Creek Basin.

Lower Kansas River Watershed Restoration and Protection Strategy Group

WRAPS is a planning and management framework that engages stakeholders within a particular watershed in a process to:

- Identify watershed restoration and protection needs and opportunities

- Establish management goals for the watershed community
- Create a cost-effective action plan to achieve goals
- Implement the action plan

WRAPS represents a shift from "top-down" government intervention in watershed issues to a more citizen-stakeholder approach, in which funds, guidance, and technical assistance are provided for stakeholders to reach consensus on issues of relevance in their watershed and then design and execute a plan to address those issues.

The Lower Kansas watershed includes parts of six counties including Atchison, Douglas, Jefferson, Johnson, Leavenworth, and Wyandotte Counties. The Lower Kansas WRAPS project area covers the Lower Kansas hydrologic unit code (HUC) level 8, or HUC-8, watershed with the exception of the Wakarusa River drainage, which feeds Clinton Lake. The area has an approved watershed plan completed in 2011. This plan identifies Turkey Creek's ammonia (NH3) total maximum daily load (TMDL) as part of a future priority area and water quality impairment to be addressed.

The WRAPS group could potentially request environmental restoration on Turkey Creek, if so, the planning team has formulated ecosystem restoration sites, which the local communities may choose to implement with just local funds in the future. This work, which the sponsor asked for very early in the feasibility phase, under ecosystem restoration formulation, is primarily discussed in the environmental appendix. This work was considered part of the USACE collaborative planning guidance and was outlined at the project's feasibility scoping meeting.

Federal Emergency Management Agency

The FEMA has many relevant programs. One is the National Flood Insurance Program (NFIP). A second program is Risk Mapping, Assessment, and Planning (MAP), or Risk MAP, which integrates and aligns the individual risk analysis programs of FEMA into a more effective unified strategy. The vision for Risk MAP is to deliver—through collaboration with state, local, and tribal entities—quality data that increase public awareness and lead to mitigation actions that reduce risk to life and property. To achieve this vision, FEMA is transforming its traditional flood identification and mapping efforts into a more integrated process of accurately identifying, assessing, communicating, planning, and mitigating flood-related risks. Risk MAP addresses gaps in flood hazard data to form a solid foundation for risk assessment and floodplain management and to provide state, local, and tribal entities with information needed to mitigate flood-related risks.

For this study, FEMA initiated a Risk MAP discovery phase in 2012 for the Lower Kansas River watershed, which is the name for the HUC-8. The State of Kansas administers all Risk MAP funding through the Kansas Department of Agriculture (KDA), Division of Water Resources.

Kansas Department of Agriculture, Division of Water Resources

The KDA Water Structures Program regulates dams, stream modifications, levees, and floodplain fills for the protection of life, property, and public safety. The program also provides technical assistance and coordination for local communities participating in FEMA's NFIP, Community Rating System (CRS), and Risk MAP, as well as the state levee programs. The State NFIP Coordinator is part of the KDA. Examples of activities regulated by the Water Structures Program include construction, modification, or repair of dams, bridges, culverts, weirs, low-water crossings, low-head dams, intake/outfall structures, boat ramps, pipeline/cable crossings, grassed waterways, other channel modifications, levees along streams, placement of fill within the floodplain, and gravel/sand dredging.

The KDA, specifically the State NFIP Coordinator, has attended this project's team meetings, and KDA is interested in seeing the communities work collaboratively to address system-wide flooding issues. This is a

requirement of participation in FEMA's NFIP. For this reason, KDA will be monitoring the development of the floodplain management plan (see below) for the State of Kansas, and how that plan will improve communities' relationships to neighboring communities that are affected by floodwaters.

Finally, KDA is a co-lead for the Kansas Hazard Mitigation Team (see below), which focuses on the state hazard mitigation plans. Local hazard mitigation plans and floodplain management plans are a part of this effort.

National Flood Risk Management Program

The USACE established the National Flood Risk Management Program (NFRMP) for the purpose of integrating and synchronizing the USACE flood risk management programs and activities, both internally and with counterpart activities of the Department of Homeland Security, FEMA, other Federal agencies, state organizations, and regional and local agencies.

Some of the specific goals of the NFRMP include:

- Providing current and accurate floodplain information to the public and decision makers
- Identifying and assessing flood hazards posed by aging flood damage reduction infrastructure
- Improving public awareness and comprehension of flood hazards and risk
- Integrating flood damage and flood hazard reduction programs across local, state, and Federal agencies
- Improving capabilities to collaboratively deliver and sustain flood damage reduction and flood hazard mitigation services to the nation

As a major Army command, the USACE is assigned mission responsibilities in major construction and other engineering support to the Army and Air Force, in nationwide water resource management, engineering research and development, and real estate services for the Army and the Department of Defense. In addition to these long-standing programs, the USACE has been called upon with increasing frequency to take a leadership role in the nation's flood risk management arena. As a result, the USACE established the NFRMP in May 2006 for the purpose of integrating and synchronizing the USACE flood risk management programs and activities, both internally and externally with counterpart activities of the Department of Homeland Security, FEMA, other Federal agencies, state organizations, regional and local agencies, and non-governmental organizations (NGOs). The official guidance was issued in October 2009, formally establishing the NFRMP in the USACE headquarters, divisions, and districts.

Each district has an appointed flood risk management (FRM) Program Manager, responsible for integrating a district's USACE missions related to flood hazards. These include Emergency Management, the Dam Safety Program, the Levee Safety Program, the Silver Jackets Program, Flood Plain Management Services, Planning Assistance to States Program, and all general investigations that include the USACE FRM mission area. For this project, this program manager is fully in support of the outcome of this report for Turkey Creek.

Silver Jackets Program

The Silver Jackets Program is an innovative USACE program that provides an opportunity to consistently bring together multiple state, Federal, and sometimes tribal and local agencies to learn from one another and apply their knowledge to reduce risk from all natural hazards. State agencies, including those of the State Hazard Mitigation Officer and State NFIP Coordinator, come together with the Federal family of agencies, including the USACE and the FEMA, in a common forum to address the state's flood risk

management priorities. Silver Jacket Programs are developed at the state level, although some states have already established hazard mitigation teams with their own identity and the USACE participates through that existing team. The ultimate goal is to offer an interagency team in every state. As of 2012, 29 active state teams exist.

The program's primary goals are to:

- Create or supplement a mechanism to collaboratively identify, prioritize, and address risk management issues and implement solutions
- Increase and improve risk communication through a unified interagency effort
- Leverage information and resources and provide access to such national programs as the FEMA's Risk MAP program and the USACE's Levee Inventory and Assessment Initiative
- Provide focused, coordinated hazard mitigation assistance in implementing high-priority actions, such as those identified by state mitigation plans
- Identify gaps among agency programs and/or barriers to implementation, such as conflicting agency policies or authorities, and provide recommendations for addressing these issues

Many states have hazard mitigation programs. Some have begun under the Silver Jackets title, while others have already been established in response to the Stafford Act changes in 2000, which required states to have hazard mitigation plans.

Kansas Hazard Mitigation Team

The Kansas Hazard Mitigation Team (KHMT) is a state organized team focused on all hazards mitigation. The team is co-led by the KDA and the Kansas Department of Emergency Management. The stated purpose in establishing this team is to:

- Assess hazard mitigation needs
- Develop and implement statewide hazard mitigation policies
- Promote coordination of mitigation programs at all levels of government
- Pursue alternate mitigation funding strategies

The USACE, Kansas City District, Silver Jackets Coordinator officially conducts the state-level hazard mitigation work with this state led team.

The KHMT focuses on regularly updating the FEMA-required state hazard mitigation plan. For this study, the KHMT is interested in improving floodplain management on Turkey Creek. All local mitigation plans and floodplain management plans are considered part of this initiative. The state remains eligible for FEMA hazard mitigation program and disaster grants as long as the local and state hazard mitigation plans are up-to-date.

Merriam Drainage District

The Merriam Drainage District (MDD) is a state authorized entity per the Kansas Watershed District Act. A three-person board of directors is elected periodically, and their mission is to apply funds collected from a mill levy to maintain a very small portion of Turkey Creek that is located entirely within the City of Merriam, Kansas. The city has no authorized control of this entity, but together MDD and the city's floodplain manager manage the floodplain. The city is enrolled in the FEMA NFIP and must fulfill the role of floodplain management, including actively reaching out to MDD to satisfy conditions of enrollment in the NFIP. Each of these watershed or drainage districts in Kansas is required to have a General Plan describing its mission.

Upper Turkey Creek Floodplain Management Plan

As a conditional requirement for receiving the USACE construction funds, in accordance with Public Law 104-303 of WRDA of 1996, which amends Section 402 of the WRDA of 1986 (also see 33 U.S.C. 701b-12; 100 Stat. 4133), this floodplain management plan (FMP) is in many regards the beginning of a local program. The FMP will echo findings from this report, establish an inter-local Floodplain Committee, and develop a set of action items for improving flood risk management in Upper Turkey Creek. The bounds of this FMP will be limited to the same watershed area authorized by this feasibility study. The action items will be a local responsibility and will have specific timeframes identified for implementation for years to come. These action items will ensure not only the longevity of the project identified in this report but also will improve public understanding of flood risks and reduce future damages and possibility for loss of life. One of the components of this FMP will tie in the operation of the MDD with all floodplain management activities, specifically the MDD's General Plan, as required by Kansas law.

1.6.2 PROJECTS

The following projects have been implemented or are ongoing in the Turkey Creek Basin:

Green Project, Interstate-35, South of 75th Street, Kansas Department of Transportation Project

The KDOT prepared a planning study that has resulted in active construction during the preparation of this feasibility study. The planning study, the *U.S. 69 and Interstate 435 Major Investment Study*, proposed one location known as the Green Project. Construction upstream of 75th Street, in the extreme southern end of Upper Turkey Creek, has been ongoing in 2011 and 2012. Some of the KDOT construction elements include improvements to storm culverts or bridges at locations identified as overtopping the highway in the 1998 flood (see the map in the Reconnaissance Report [USACE 2001]).

Merriam Drainage District, Channel Project

The MDD has modified the Turkey Creek channel from 63rd Street downstream to 51st Street. Modifications began in stages about 1967, and the work was considered complete in 1972, but the MDD has since accomplished an extensive streambank protection effort relying primarily on large blocks of cut stone placed to armor the channel slope. The last segments of armoring were placed in the early 1980s, but large floods can displace some of the stone blocks, and maintenance of the project continues. The MDD's efforts have produced a channel of nearly uniform width, deepened to bedrock through the identified reach, on which this feasibility study is focused. In addition, the MDD has had difficulty in the past with compliance for CWA 404 permitting because the proposed designs for bank stabilization are not sustainable with the large floods displacing the stone blocks. The City of Merriam, in conforming to NFIP requirements, has worked with the MDD in changing its vision, "the free flow of Turkey Creek," from a vision based entirely on channel widening to one considerate of more comprehensive solutions for adjacent communities and property owners. The MDD is now open to more alternatives, which this study has considered. The MDD will be an important financial partner in supporting future phases of design, construction, and especially the operation and maintenance of a Federal cost-shared project on Upper Turkey Creek.

The USACE Turkey Creek Basin, Construction Project

The authorized USACE Turkey Creek Basin, Kansas City, Kansas and Missouri, flood damage reduction project is a $92 million project, which congress authorized in 2003. The project is sponsored by the USACE, Kansas City, Missouri, District, and the UG. The project, located in Lower Turkey Creek, includes a combination of 1,300 feet of improvements to the 28-foot-diameter horseshoe shaped tunnel (built in 1919), bridge modification, channel widening, and a series of enlargements to the hillside

interceptors. The USACE completed the tunnel and channel construction before 2012. The USACE realized substantial savings by collaborating with the KDOT as construction occurred simultaneously on I-35.

Antioch Bridge Project and the Burlington Northern Santa Fe 7.44 Railroad Bridge

Designed by HNTB Corporation, the Antioch Road Replacement Project over I-35 and the BNSF railroad bridge both span Turkey Creek in Merriam. Construction of the Antioch Bridge was finished in 2000. KDOT completed construction of this bridge, as well as channel improvements, at this Turkey Creek crossing. The new bridge alleviates some of the constriction at this crossing, and the new channel design includes gabion revetment rather than stone riprap. Upstream and immediately adjacent, the railroad bridge work also relieved some of the constriction.

Waterfall Park, City of Merriam

The City of Merriam has made wise use of the floodplain just upstream of the railroad bridge. Many structures have been removed from the floodplain area that is inundated just upstream of the Antioch Bridge and the railroad bridge. The city has dedicated the area as a park, which is a compatible use for this frequently flood area. Periodic maintenance has been needed to address erosive conditions at the upstream face of the railroad bridge, where a significant drop in the channel invert provides park visitors with a waterfall. The proximity of the waterfall, and change in channel flow direction both make maintaining bank erosion a challenge.

Johnson County Hazard Mitigation Projects

Johnson County and cities within the county have actively sought to reduce flood risk by planning, designing, and constructing/implementing structural and nonstructural measures. Structural measures implemented recently include channel improvement projects (including straightening, lining, widening, and removing obstructions) and detention projects on both a regional scale and onsite. Nonstructural activities include:

- Home buyouts to remove/relocate homes to areas of lesser risk. For example, following the floods of 1998, 33 homes in Merriam were purchased for a total cost of 5.3 million and were subsequently demolished
- Adoption of floodplain land use ordinances
- Implementation of components of a flood warning system (StormWatch), including county-wide hydrometeorological observation, some computer-aided threat recognition, road barricading, and limited site-specific forecasting

i-Tree Eco Project, Mid-America Regional Council

i-Tree Eco is state-of-the-art, peer-reviewed software from the U.S. Department of Agriculture (USDA), Forest Service, that provides urban forestry analysis and benefits assessment tools. The program provides affordable, easy-to-use tools communities can use to collect and analyze information on their urban forests. i-Tree Eco helps strengthen management and advocacy efforts by quantifying the structure of community trees and the environmental services that trees provide. While it is understood that trees provide numerous community benefits, quantifying them often proves challenging. The Kansas City regional i-Tree program will help identify these benefits by analyzing data such as:

- Effects of trees on energy usage
- Air quality improvements from trees
- Carbon sequestration

- Rainfall interception
- Potential impact of destructive pests

In fall 2010, a sample inventory was conducted for 340 plot locations across the Kansas City region. The randomly selected plots are 1/10 of an acre in size and consist of private and public-owned trees within the nine-county region. Project staff recorded information on species, condition, tree height, trunk diameter, canopy density, and other criteria. Inventory data were analyzed in 2011. The information collected from the i-Tree Eco study will help guide local forestry planning efforts.

1.6.3 STUDIES

The following previously conducted or ongoing studies are related to the Upper Turkey Creek Basin:

- Design Memorandum No. 2, General Design Memorandum, Turkey Creek Diversion, USACE, Kansas City District, January 1956
- Flood Protection Project, Turkey Creek, Merriam, Kansas, USACE, September 1962
- Letter Report for Proposed Inclusion of Turkey Creek Improvements, Modification of Local Protective Works, Kansas River, Kansas City, Kansas (Flood Control Act of 1962), USACE, Kansas City District, May 1968
- Flood Plain Information Report for Turkey Creek in Metropolitan Kansas City, USACE, January 1974
- Turkey Creek Improvement, 75th Street and I-35 Interchange, January 1983
- Planning Aid Report for the Turkey Creek Basin, Kansas and Missouri Reconnaissance Study, U.S. Fish and Wildlife Service (USFWS), Kansas State Office, Manhattan, September 1987
- Reconnaissance Report: Turkey Creek Basin, Kansas and Missouri, USACE, December 1987
- Flood Insurance Study, City of Kansas City, Kansas, FEMA revision of January 1995
- Design Concept Report Supplement: Burlington Northern Railroad at Turkey Creek, HNTB Corporation, August 1996
- Draft Fish and Wildlife Coordination Act Report for the Turkey Creek, Kansas City, Kansas, and Kansas City, Missouri, Local Flood Protection Project, USFWS, Kansas State Office, Manhattan, April 1997
- Use Attainability Analysis of Turkey Creek, Johnson and Wyandotte Counties, Kansas, Gary E. Welker and Dr. Donald G. Huggins, EPA, Environmental Services Division, Kansas City, Kansas and the Kansas Biological Division, University of Kansas, Lawrence, Kansas, July 1997
- Final Fish and Wildlife Coordination Act Report for the Turkey Creek Flood Damage Reduction Project, Kansas City, Kansas, and Kansas City, Missouri, USFWS, Kansas State Office, Manhattan, October 1998
- Feasibility Report and Environmental Assessment, Turkey Creek Basin, Kansas City, Kansas and Missouri, Kansas City District, USACE, December 1998
- TMDLs for the Kansas - Lower Republican Basin, Kansas Department of Health & Environment, June 30, 1999
- Upper Turkey Creek Basin, Johnson and Wyandotte Counties, Kansas: Section 905(b) Analysis, USACE, July 2001

- Draft Supplemental Final Fish and Wildlife Coordination Act Report for the proposed General Reevaluation Report and revised Environmental Assessment, Lower Turkey Creek flood damage reduction project – Kansas City, Kansas and Missouri, USFWS, March 29, 2002, Kansas State Office, Manhattan
- Final Supplemental Final Fish and Wildlife Coordination Act Report for the proposed General Reevaluation Report and revised Environmental Assessment, Lower Turkey Creek flood damage reduction project – Kansas City, Kansas and Missouri, USFWS, September 9, 2002, Kansas State Office, Manhattan
- Stormwater Management Ordinance, Chapter 7, Article 1 of City code of ordinances, City of Merriam, June 24, 2002
- Johnson County Flood Warning/Flood Forecasting: Feasibility Study, Johnson County SMP, August 2002
- General Reevaluation Report and Environmental Assessment, Turkey Creek Basin, Kansas City, Kansas and Kansas City, Missouri, USACE, January 2003
- Upper Turkey Creek Basin Environmental Restoration Report: Feasibility Phase – Draft, USACE, August 2004
- Northeast Johnson County Watershed Study, Johnson County, Kansas. 2005
- Effects of Contaminant Sources on Streamwater Quality in Johnson County, Northeastern Kansas, October 2002 through June 2004, C.J. Lee, D.P. Mau, and T.J. Rasmussen. U.S. Geological Survey (USGS), Fact Sheet 2005–3080, August 2005
- Effects of Nonpoint and Selected Point Contaminant Sources on Stream-Water Quality and Relation to Land Use in Johnson County, Northeastern Kansas, October 2002 through June 2004, C.J Lee, D.P. Mau, and T.J. Rasmussen, 2005, USGS, Scientific Investigations Report 2005–5144
- Special Area Management Plan (SAMP), Upper Turkey Creek Watershed, Watershed Institute, Inc., 2007
- Rock Creek Watershed Planning Final Feasibility Report, USACE, August 2007. Rock Creek Alternative Futures Study, USACE, August 2009
- Manual of Best Management Practices for Stormwater Quality, Mid-America Regional Council and American Public Works Association (APWA), Second Edition, August 2009

Complete descriptions of these studies and reports are included in Chapter 13.

1.7 PLANNING PROCESS AND REPORT ORGANIZATION

The Upper Turkey Creek Basin feasibility study follows the USACE six-step planning process specified in the U.S. Water Resources Council *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G) and ER 1105-2-100. The process identifies and responds to problems and opportunities associated with the Federal objective and specified state and local concerns. 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 areas
3. Formulation of alternative plans

4. Evaluation of the effects of the alternative plans
5. Comparison of the alternative plans
6. Selection of the recommended plan based upon the comparison of alternative plans

In accordance with ER 1105-2-100, the *Planning Guidance Notebook*, the planning process also followed a systems approach, in this case a watershed perspective (per the ER), in completing the six-step process. This approach was consistent with the interests of the local sponsor, in particular the desire to consider environmental enhancement through best management practices (BMPs).

The organization of this report reflects the integration of the feasibility report with the environmental assessment. As required by NEPA, all required components are included and identified with an asterisk (*) throughout. Chapters of the report also relate to the six steps of the planning process as follows:

- Chapter 2, *Need for and Objectives of Action*, covers the first step in the planning process.
- Chapter 3, *System Baseline Condition and Inventory*, covers the second step of the planning process.
- Chapter 4, *Plan Formulation*, covers the third step in the planning process and presents the initial plan formulation considerations.
- Chapter 5, *Alternative Evaluation and Comparison*, covers the fifth step in the planning process and includes evaluation and screening of the array of alternatives.
- Chapter 6, *Environmental Effects*, ensures that the effects analysis is part of the evaluation/comparison process and covers the fourth step of the planning process.
- Chapter 7, *The Recommended Plan*, describes the sixth step of the planning process.
- Chapter 8, *Public Involvement, Review, and Coordination*, describes the public outreach efforts conducted as part of the feasibility study process.

2 CHAPTER 2 – NEED FOR AND OBJECTIVES OF ACTION

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

2.1 STUDY AREA DESCRIPTION

The Kansas City metropolitan area (see Figure 1-1) is divided into many basins. Within these basins, dozens of small, fast-rising streams drain urban and rural watersheds. The flooding risk has increased substantially over time, particularly in the northeastern portion of Johnson County as development has progressed to the southwest over the past several decades.

The Turkey Creek watershed, encompassing parts of Johnson and Wyandotte Counties in Kansas, consists almost exclusively of highly developed urban areas. Turkey Creek and its floodplain have been a part of the Kansas City metropolitan infrastructure since the 1800s. The relatively flat topography associated with the creek and its floodplain has been favorable to the location and development of railroads, highways, and utilities. Commercial and residential development associated with the railroad and highways also has paralleled the creek.

Urbanization and ongoing development in the Upper Turkey Creek watershed has resulted in degradation of environmental resources associated with the creek. The creek has been deepening and widening its channel as a result of high runoff volumes and flow rates associated with urbanization in the watershed. In response, much of the creek channel has been enclosed in culverts, lined with concrete, or otherwise hardened to address channel instability. Stream reaches where the channel has been enclosed or hardened with concrete provide little or no habitat value and represent impassable biological dead zones for most of the fish and other aquatic wildlife in Turkey Creek. Failure of Turkey Creek to attain its designated recreational and aquatic life uses is, in part, a result of these channel modifications.

The modification of natural hydrologic characteristics in the stream and surrounding watershed also has contributed to more flooding. The Turkey Creek Basin experienced major floods in 1951, 1958, 1961, 1968, 1977, 1983, 1986, 1993, 1995, 1996, and 1998. The flood events resulted in significant property damage in the downstream reaches of Turkey Creek. There was one fatality in the 1993 flood in Turkey Creek Basin. In the 1998 flood, multiple fatalities occurred in the Brush Creek Basin, and in Turkey Creek, multiple fatalities were narrowly avoided in several instances.

Johnson County is a county government comprising municipal jurisdictions established within its boundaries and minimal unincorporated area. Kansas City, Kansas, is the dominant municipality in Wyandotte County. In 1997, the Wyandotte County and Kansas City, Kansas, electorate approved a measure to combine the city and county governments under a single executive. The resulting municipal body is referred to as the UG.

The boundaries of the City of Merriam lie in the bottom of the Upper Turkey Creek watershed (see Figure 1-2). Headwaters concentrate all runoff to areas largely in the heart of Merriam. The result of development upstream of this small city has brought more frequent flooding overtime.

2.2 FEDERAL AND NON-FEDERAL OBJECTIVES

The criteria for national or Federal objectives are specified in the *Principles and Guidance* and covered by ER 1105-2-100, *The Planning Guidance Notebook*. The objectives must meet goals that derive from four accounts for all Federal agencies. Under these accounts, the Federal objective is to maximize the net

annual benefits. These accounts include National Economic Development (NED), Regional Economic Development (RED), Other Social Effects (OSE), and Environmental Quality (EQ). Project planning should contribute to the NED consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Contributions to 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 the rest of the nation. The NED plan is that alternative that maximizes net benefits over the period of analysis. The RED is similar in most respects, except looks at the more local or regional benefits. The EQ account displays non-monetary effects on significant natural and cultural resources. These objectives (NER, RED, OSE) are compatible with local initiatives for addressing urban streambank erosion, BMPs, and recreational opportunities (biking trails).

Collaborative planning is encouraged for traditional project-scale planning and is essential to the success of watershed-scale planning. In addition, such collaboration can improve the regulatory climate by addressing all the regulatory issues together and reaching agreements for siting various activities in advance of an action. The USACE uses its planning capability to facilitate, convene, and advise, as well as to work collaboratively with other Federal and state programs in developing solutions to integrate programs, policies, and projects across public agencies that reflect the full range of the national Federal interest.

The local, or non-Federal, objectives also address the economic and environment considerations. Local policies have evolved over the past several decades. Many professional organizations and NGOs have shared the concern that standards of design, for example, for stormwater facilities, should be more consistent with neighboring communities. Previously developed areas were subject to much less stringent policies. In addition, green solutions are now considered important for local objectives. The local chapter of the APWA has established one set of design criteria for the Kansas City metropolitan area. The MARC has had several initiatives that shape the local objectives, including the *Manual of Best Management Practices for Stormwater Quality,* MetroGreen®, and *i-Tree*. Also, MARC has developed a natural hazard mitigation plan for the metropolitan area. As for the City of Merriam, the city's goal is to gain as much assistance as possible in managing flood risks, such as within a floodplain management plan (FMP). The objective is to focus first on the downtown area, adjacent commercial and industrial business sites, and residents. A second objective is to seek to protect these land owners where they are by minimizing the number of property buyouts.

2.3 PROBLEMS AND OPPORTUNITIES

The evaluation of public concerns reflects a range of needs perceived by the public. This section describes these needs in the context of problems and opportunities that can be addressed through water and related land resource management. The principal opportunity is the identification of a plan for significant improvement in flood risk management and reduction of economic damages.

2.3.1 PUBLIC CONCERNS

Input was received through coordination with the sponsor, coordination with other agencies, public review of draft and interim products, and workshops and public meetings. A number of public concerns have been identified during the course of the study. A discussion of public involvement is included in Chapter 8, *Public Involvement, Review, and Consultation*.

The most serious water resources problems in the Upper Turkey Creek Basin include the existing flood hazard and the associated flood damages. The increased runoff caused by the rapid development of the area accounts for most of the flooding problems. Local interests have sought measures to reduce flood damages for many years. Initial concerns were expressed in the study authorization. Turkey Creek floods

have caused substantial damage throughout the basin in 1961, 1977, 1993, and 1998. The primary interest in Merriam is to reduce flood damages in the commercial downtown area that experiences recurring flooding from overbank flows on the main stem of Turkey Creek. The flood of July 1993 caused one fatality and resulted in damages estimated at $3.4 million in Merriam, and $20 million in the lower basin areas. The flood of October 1998 caused an estimated $12 million of damages in Merriam, and damages in the lower basin equivalent to those of 1993. The flood peak occurred in the late evening, and if the peak had occurred during rush hour, loss of life would have been very likely for travelers on I-35, which was overtopped by flood waters at multiple locations.

Frequent flooding of Turkey Creek has caused severe damage to structures, inventory, infrastructure, and transportation access, along with the associated loss of business and wages. The flood damage also has caused intangible costs, such as human suffering and inconvenience. The long-term consequences of flooding include threat of life, increased frequency of structure and inventory damage, slowed economic growth, possible escalation of vacancies in the area, higher costs associated with repairing flood damage, and interrupted transportation access. The recurring nature of the flooding problem represents a threat to the health and safety of those who live and work in the flood-prone areas.

The Merriam Farmers' Market is a community event pavilion located in the City of Merriam. It houses many special events and programs and also is an access point for Werner Park and Turkey Creek Streamway Trail. The local sponsor has expressed concerns and a desire to avoid impacts to the Farmers' Market area and the existing walking/biking trail from proposed alternatives. The public also has voiced concerns during public engagements throughout the feasibility study of potential impacts to the Turkey Creek Streamway Trail.

Part of the Turkey Creek channel in the study area is operated and maintained by the MDD under a state charter that provides the MDD authorities independent of the City of Merriam or Johnson County. The MDD is led by three publically elected board members. This board has represented some of the public concerns at planning meetings for this project. The MDD has institutional responsibilities and real estate holdings in and near the Turkey Creek channel, where channel erosion repairs were needed, and, therefore, involvement of the MDD is a key element in assessing of future planning for Turkey Creek.

2.3.2 FLOOD HAZARDS

The Upper Turkey Creek watershed is centrally located in a metropolitan region that is committed to coordination and watershed-based planning. The watershed planning effort provides an opportunity to promote interagency cooperation, multipurpose project planning, and the protection of existing investment in the flood risk management infrastructure.

The existing flood hazard and associated flood damages constitute the most serious water resources problem in the Turkey Creek Basin. Flooding within the basin is caused principally by the rapid development of the area, which has resulted in a large increase of storm water runoff. This increased runoff, coupled with inadequate channel capacities and undersized bridge openings, accounts for most of the flooding problems. Flooding causes physical damage to property and loss of commercial, industrial, and public activity, along with the associated loss of business and wages. Rail and vehicular traffic also are adversely affected and cause losses to those who are dependent upon those modes of transportation. The recurring nature of the flooding problem represents a threat to the health and safety of those who live and work in the flood-prone areas.

As recorded on Johnson County's Stormwatch website (City of Overland Park 2012), a significant part of the flood hazard is flash flooding. Rate of rise, according to a USGS gage at Ward Parkway on the adjacent Brush Creek, documents a rise of seven feet in one hour. The tributary area is similar in size and degree of urbanization as Turkey Creek. Although no USGS gages are on Turkey Creek, the Stormwatch

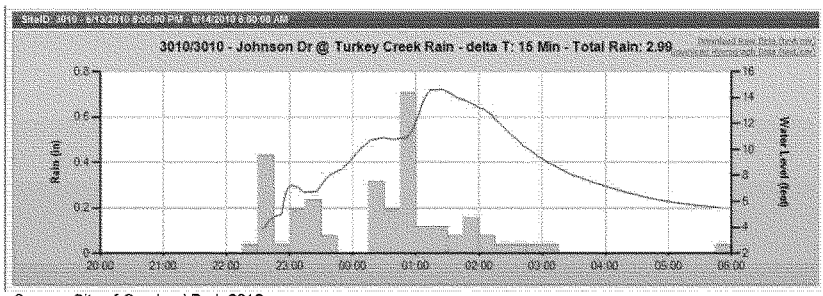
website, which began collecting data following the 1998 flood event, has historical flooding information (Table 2-1).

Table 2-1: Site/Sensor ID 3010/3013 - Johnson Drive at Turkey Creek Water Level
Maximum Water Level Events (on Record)
Sensor was first online on September 14, 1999, at 4:13:48 PM.

Stage (ft)	Date
14.65	6/14/2010
14.6	8/27/2004
14.17	8/9/2007
13.38	8/20/2005
13.18	6/24/2009
12.67	9/13/2008
12.54	6/4/2008
12.3	6/9/2009
12	8/13/2005
11.7	4/5/2010

Source: City of Overland Park 2012

As seen at the Johnson Drive stream gage (Figure 2-1), even a small amount of rain can cause sharp rises in water surface elevations. The Johnson Drive gage is in the heart of the area for which alternatives will be developed as discussed in Chapter 5. Flash flooding, with characteristics shown below, means that little time is available to respond with significant actions. Channel capacity is generally able to convey the 10 percent AEP (10-year event) flow at the top of bank, which means any event added to a 1998 base flood would be hazardous in terms of rate of rise, not to mention extent of inundation. Loss of life is such a high risk, and velocities are high enough for the subject creek, that evacuating and avoiding the area is important.



Source: City of Overland Park 2012

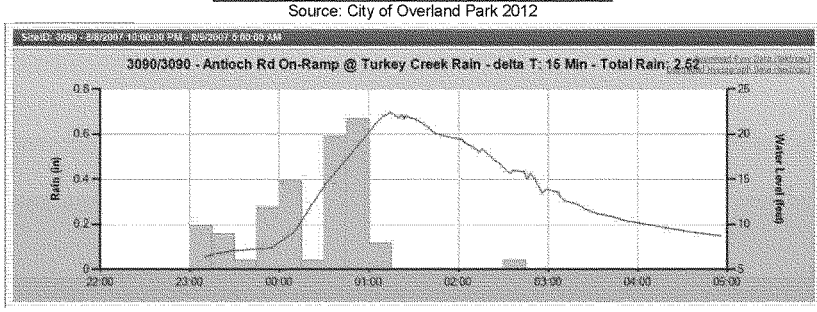
Figure 2-1: Johnson Drive at Turkey Creek Water Surface Elevations

Similar findings are shown just downstream of Johnson Drive at Antioch Road (Table 2-2; Figure 2-2).

Table 2-2: Site/Sensor ID 3090/3093 – Antioch Road On-Ramp at Turkey Creek Water Level
Maximum Water Level Events (on Record)
Sensor was first online on October 6, 2006, at 2:04:31 PM.

Stage (ft)	Date
22.40	08/09/2007
18.13	05/06/2007
18.02	06/04/2008
17.72	06/14/2010
17.67	06/24/2009
17.61	06/03/2008
16.58	06/12/2008
15.66	10/13/2007
15.48	05/06/2012
15.19	07/30/2008

Source: City of Overland Park 2012



Source: City of Overland Park 2012

Figure 2-2: Antioch Road at Turkey Creek Water Surface Elevations

As development occurs in the watershed, the floodwater volumes and flood peaks increase because less water soaks into the ground and more water runoff occurs from the increasing amount of land covered by impervious surfaces, including buildings, roads and parking lots. Increases in impervious land cover have reduced the portion of every rainstorm that historically soaked into the ground and provided recharge water for the shallow groundwater aquifers. Although a majority of the watershed is highly developed, stormwater management ordinances and stormwater management measures implemented in the communities within the Upper Turkey Creek watershed are helping to prevent increases in peak discharges from changes in development that may occur, thereby reducing impacts to flooding on Turkey Creek and its tributaries.

The hydrologic study developed to evaluate flooding on Upper Turkey Creek was analyzed to determine the stage of development in each watershed and to determine whether analysis of future land use was necessary for the hydraulic analysis. This determination was made using Johnson County's Automated Information Mapping System (AIMS) aerial photographs and field observations. Future redevelopment on existing developed areas and in-fill development of small parcels within an otherwise fully developed area was not considered a condition to create a significant change in hydrology.

Within the Upper Turkey Creek watershed, communities must work to preserve routing characteristics so that the USACE flow assumption for runoff (not to increase) remains true. Converting streams to concrete and or straightening their alignments can increase flash flooding to areas downstream. Communities need to be aware of and do coordination as part of expectations of the FEMA NFIP coordination requirements. This means that per the FEMA NFIP, communities (and agencies, such as the state DOT), should already be coordinating any drainage system improvements so as not to induce flood damages on downstream stakeholders.

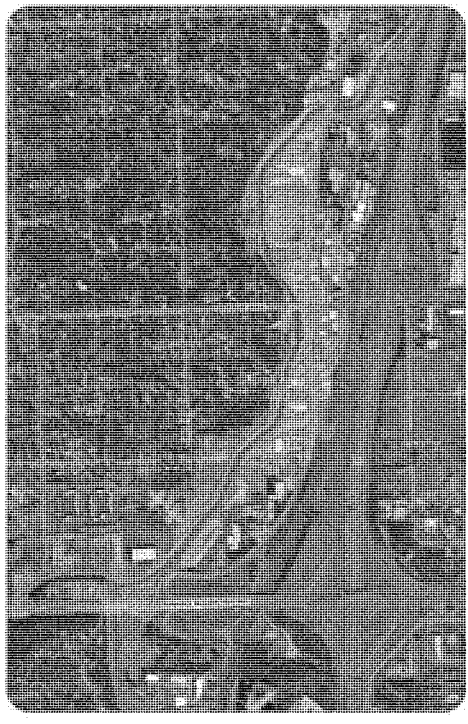


Figure 2-3: Merriam Existing Inundation

In addition, communities must address how to coordinate drainage changes in the future, and this needs to be a process that is addressed in the FMP. Communities are responsible for preparing the FMP per USACE guidance (Policy Guidance Letter No. 52 and Public Law 104-303 WRDA 1996 amending WRDA 1986).

The majority of the Turkey Creek channel that passes through the City of Merriam can contain a 20 percent AEP (5-year event), although two areas flood at the 50 percent AEP (2-year event). Figure 2-3 shows the existing level of inundation through the City of Merriam. The areas along the main stem of Upper Turkey Creek and its tributaries contain limited open space to provide the potential flood storage required to reduce flooding in Merriam. However, some open spaces in the upper reaches and along the banks of the tributary streams may be available for conversion into detention basins, which could reduce peak discharges.

2.3.3 ECOSYSTEM RESTORATION

Although the Upper Turkey Creek project's authority relates to flood risk management, the environmental degradation due to urbanization can be addressed under a systems approach, using a watershed

perspective to provide cost-effective, multipurpose, and environmental benefits to address environmental degradation within an urban environmental setting.

The Upper Turkey Creek Basin is a historically connected tributary to the Kansas and Missouri Rivers, which are important ecological resources for the region. Development in the watershed has degraded these natural systems. Direct development impacts have included floodplain filling, channel straightening, channel re-alignment, concrete lining of channels, channel enclosures, filling on-stream lakes, streambank armoring and fills, loss of streamside vegetation, and disruptions due to numerous road and utility crossings. Indirect impacts have resulted from development in the watershed, increasing the rate at which water reaches the creek and tributaries.

The Upper Turkey Creek Valley is a degraded environmental resource that is still undergoing development. The combination of the direct and indirect impacts has increased the flood peak flows, flood flow volumes, channel flow velocities, and the rapid rate at which stream flows rise and fall after a storm. The result has been instability in the stream as noted by channel incision and streambank erosion. Preventative measures have included enclosing the channels in culverts or lining the channels with concrete in many places. These concrete and enclosed channel sections become generally impassable biological dead zones for most aquatic species in Turkey Creek.

Because of the urban setting and the extensive amount of highly developed ground in the study area, environmental design opportunities for the flood risk management aspects of the project are somewhat limited. Although limited, a few opportunities do exist. For example, environmental design agreements developed for the Lower Turkey Creek project would also fit nicely into any designs for this project. These design agreements include using bioengineering in lieu of riprap where feasible; minimizing the clearing of riparian timber; replanting trees along the new channel; constructing in-stream habitat, such as riffle/pool complexes and a meandering pilot channel, channel overflow benches, riparian tree planting or wetland creation; and avoiding environmentally sensitive areas to preserve the natural stream channel and riparian area. Additionally, opportunities to coordinate with existing local programs include locally funded flood buy-out areas.

Early in the study process preliminary ecosystem restoration needs were considered as a goal throughout the watershed in anticipation of a potential multipurpose project (see Appendix J). However, the ecosystem restoration concerns were not carried forward as an objective or used to formulate because there was no local sponsor with an interest in cost-sharing ecosystem restoration measures.

2.3.4 WATER QUALITY

Increased urbanization has caused changes in land use, resulting in more residential, commercial, and industrial developments and increased impervious surface area that may have a substantial effect on stream water quality. Contamination may come from point sources and nonpoint sources. These contaminants may remain dissolved in stream water, adsorb to streambed or suspended sediment, or accumulate in aquatic life (USGS 2005).

The EPA and the Kansas Biological Survey (KBS) undertook a Use Attainability Analysis (UAA) of Turkey Creek in Johnson and Wyandotte Counties, Kansas (EPA and KBS 1997). The UAA indicates that Turkey Creek is classified by the State of Kansas water quality standards for "non-contact recreation" or recreation where ingestion of surface water is not probable, and this use includes, but is not limited to, wading, boating, fishing, trapping, mussel harvesting, and hunting. The same report notes that Turkey Creek is classified by the state as "expected aquatic life use waters" or surface waters containing habitat types and indigenous biota commonly found or expected in the state. The study performed biological and water quality sampling on three sites on Turkey Creek and compared those sites to three sites sampled on

Mill Creek and three sites sampled on Cedar Creek—two adjacent Johnson County watersheds of similar size that are tributaries to the Kansas River.

The UAA (EPA and KBS 1997) found that contact recreation was an attainable use for Turkey Creek; however, it was not in attainment for its current designated non-contact recreation use in part to fecal coliforms, hazards, and aesthetics. The report also noted that Turkey Creek is not in attainment for expected aquatic life uses. Although the greatest number of fish in the three watersheds was found at the mid-watershed sampling point on Turkey Creek, phytoplankton concentrations, macro invertebrate and fish richness and diversity were significantly lower in Turkey Creek. The report indicated the lack of attainability appeared due to non-point source pollution associated with urbanization and point source pollution associated with a wastewater treatment plant.

Water quality conditions were evaluated visually in 2005 during the stream health assessment of the Upper Turkey Creek watershed. Water quality factors assessed included sediment deposition, water appearance, nutrient enrichment, and the presence of trash. Approximately 69 percent of the reaches included in the assessment exhibited moderate to slight sediment deposition, 81 percent were considered to have moderate nutrient enrichment, and a majority of the reaches contained trash in their floodplains and riparian areas.

Water quality is an important component of ecosystem structure, and good water quality is generally integral to healthy functioning ecosystems. An important USACE contribution in rehabilitating ecosystems, where water characteristics are a critical structural component of those ecosystems, may involve improvement of water quality characteristics using engineering solutions. USACE restoration and protection projects may involve cost-effective solutions to improve aeration, temperature, turbidity, acidity, sedimentation, and other water quality parameters. Consideration should be given to whether the water quality improvements will accomplish restoration of the system because in many instances, other functional or structural ecosystem components may require attention as well.

For ecosystem restoration and protection opportunities, which include water quality issues clearly defined in the missions of other agencies (e.g., non-point source pollutant regulation or removal), it is appropriate to use existing agreements or create new arrangements for collaborative use of respective agency authorities and resources in order to implement a more complete and sustainable approach to the restoration. There may also be instances in which it is appropriate for the USACE to play a supporting role or provide assistance through reimbursable arrangements, rather than to lead the initiative.

The EPA expressed interest in developing a Special Area Management Plan (SAMP) for the Upper Turkey Creek Basin. The EPA contracted the Watershed Institute, Inc. to conduct the initial background research for phase one of the SAMP process and to prepare a summary report. Implementation for the remaining three phases currently has not taken place for the Upper Turkey Creek watershed.

The goal of the SAMP is to attain a balance between aquatic resource conservation, infrastructure maintenance, and sound economic development to minimize the individual and cumulative impacts of future projects. The most important benefit of a SAMP is the streamlining of the process to permit redevelopment in this already developed watershed, mainly by identifying the critical water resources and where mitigation is needed in advance, prior to the occurrence of redevelopment, thereby improving water quality to support native aquatic communities and enhance and maintain high quality aquatic and terrestrial habitat in the Upper Turkey Creek watershed. Stakeholder participation (i.e., local government, businesses, citizens, state and Federal agencies, nonprofit organizations) is essential to successful development and implementation of a SAMP. At the end of the SAMP process, areas should be identified for protection, preservation, and enhancement, as well as areas where future activities would be allowed to occur, if they meet the criteria developed for protection of the watershed.

The watershed assessments performed were used to describe the existing, and potential future, habitat conditions in select locations of the watershed and to analyze environmental effects. However, the water quality concerns were not carried forward as an objective or used to formulate. A plan which includes a primary objective of flood risk management would also benefit water quality by limiting the amount of trash and debris that enters the stream from surrounding industrial/commercial properties during storm events.

2.4 PLANNING GOALS AND 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 alternatives. These planning objectives reflect the problems and opportunities and represent desired positive changes in the process without project conditions.

The principal goal of the feasibility study is to identify a flood risk management alternative that significantly reduces flood risk and flood damages. A systems approach has been used wherein flood risk management and other opportunities for ecosystem restoration consideration and compatible recreation have been considered. Specific ecosystem restoration measures were formulated in the watershed but not carried forward into screening or inclusion in plan formulation because no cost sharing partners were identified. There is the opportunity to accommodate compatible recreation (trail system) in the immediate study area.

2.4.1 REDUCE FLOOD RISKS

The primary goal is to develop alternative plans that will examine the full range of structural and nonstructural measures that address the flood risk management authorization and significantly reduce flood risk. The USACE seeks to identify the plan that provides maximum reduction of net economic flood damages, which is in the national interest, known as the NED plan. The vision consists of the following objectives:

1. Significantly reduce flood risk and damages for events with an AEP in the range of 1 percent in the highly urbanized Upper Turkey Creek watershed caused by recurring and severe flash flooding.
2. In partnership with other floodplain management agencies, provide the sponsor and stakeholders in the study area with a clear understanding of flood and residual flood risk. This will be accomplished through public meetings, inclusion of risk information in the report, public presentation and implementation of the FMP, and ongoing assistance to the sponsor in flood preparedness via the O&M Manual, PL 84-99 Program, and other programs as funding provides. This objective will be accomplished throughout project life including during design, construction and post construction project support.

2.4.2 USE A SYSTEMS APPROACH FOR THE WATERSHED

The use of a systems approach was referenced in both of the previous goals. By using a systems approach, community planners find better solutions that:

- Consider the long-term
- Are more sustainable for the community
- Are the most effective way to spend money

Although three damage reaches, as identified in the USACE reconnaissance report, are separated by some distance, they interact as part of a system, and tracking how various alternatives react to each other is of critical importance to mitigate flood hazards. To address this, the USACE planners have included the

work by Johnson County Public Works regarding FEMA Flood Insurance Rate Map (FIRM) updates, which has included new HEC-RAS models. As the timeline for the project stretched out, their work included more recent updates to the HEC-RAS models. The planners have integrated these updates into analysis tools to aid in the systems approach.

2.5 PLANNING CONSTRAINTS

Unlike planning objectives that represent desired positive changes, planning constraints represent restrictions that should not be violated. Further, plan formulation must provide safe conditions in the interest of public safety and be socially acceptable to the community. The planning constraints identified in this study area are in compliance with local land use plans and the resolution from the Committee on Transportation and Infrastructure, U.S. House of Representatives, Docket 2616, adopted February 16, 2000.

The Upper Turkey Creek Basin of Johnson and Wyandotte Counties, Kansas, is heavily urbanized, comprising residential, commercial, and industrial land uses. The Turkey Creek channel and floodplain have become a common location for public infrastructure including utilities, transportation, drainage diversions, homes, businesses, and public areas. For most of its length in Johnson and Wyandotte Counties, Turkey Creek is constrained between I-35 on one side and naturally high, non-floodplain banks on the opposite side. What may have been a 1,000-foot-wide floodplain a hundred years ago, is from 50 to 400 feet wide today. Further development along the higher bank areas has caused the floodplain, channel banks, and, in some areas, the waterways to be filled in or relocated for development, leaving limited space for conveyance of floodwaters. Therefore, one planning constraint is a lack of space in which to formulate alternatives along the creek.

Another constraint is that deepening a channel is not cost effective due to the geology along the main channel. Geotechnical borings in the area document this constraint (Appendix B). The channel bottom of the creek and tributaries is primarily limestone underlain by black/gray shale. Based on the differences in channel bottom elevations compared to older stormwater and utilities and the development of several waterfalls, it appears the channel bottom in many areas has been lowered or is incising, such as the tributaries. Long stretches of Turkey Creek through the City of Merriam have been lined with limestone blocks to stabilize the stream banks, and many of the tributaries have sections that have been channelized. There have been no natural, undisturbed stretches of Turkey Creek identified to date.

Despite ongoing efforts to reduce flooding the increasing development has resulted in increased flood frequency, peak flood flows, flood flow volumes, and channel velocities. Additionally, these modifications have shortened the lag time from peak precipitation to peak flow.

A systems approach is mindful of potential impacts to the USACE flood risk management project being constructed downstream. Any develop built in Merriam should not adversely affect reaches in Lower Turkey Creek by changes to flow or timing. Already implemented improvements are those to the very large bypass tunnel and the new, widened channel adjacent to the cooperative work with KDOT for I-35. Construction of the levee, railroad bridge improvements, and walled channel is currently happening adjacent to the channel.

In addition to the planning constraints discussed above the following were also considered:

- **Hazardous, Toxic, and Radioactive Waste**—Alternatives cannot cause disturbance of hazardous, toxic, and radioactive waste (HTRW) to minimize and prevent Federal liability under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).
- **Flood Heights**—Alternatives cannot negatively impact the 100-year flood profile (within the floodway, per NFIP).

- **Environmental and Cultural Resources**—Alternatives should be designed to minimize adverse impacts to environmental and cultural resources.
- **FEMA Voluntary Acquisition Program**—Alternatives will not be developed that interfere with restrictive use guidelines established for properties purchased with Hazard Mitigation Grant Program funding.
- **Avoidance of Induced Flooding**—Inducing adverse flood impacts associated with the implementation of any flood risk management project should be avoided.

Part of the Turkey Creek channel in the study area is operated and maintained by the MDD under a state charter that provides the MDD authorities independent of the City of Merriam or Johnson County. The MDD has institutional responsibilities and real estate holdings in and near the Turkey Creek channel; therefore, the future of the MDD is a key element in assessing of any plan for Turkey Creek.

2.6 OTHER PLANNING CONSIDERATIONS

Other purposes will not be the focus of the planning activity, but they may be recognized in the interest of accommodating the flood risk management and ecosystem restoration plan to the plans of others.

2.6.1 RECREATION

The recommended plan may include recreational features directly associated with either flood risk management or ecosystem restoration measures within the cost ceilings established for those purposes. Independent or single-purpose recreational development will not be recommended; however, recreation can be included as part of a multipurpose approach. The total project cost for the recommended alternative attributed to the cost of recreation features, such as trails, is allowed to increase the federal cost up to 10 percent under the USACE policy. In addition, for nonstructural flood risk management (FRM) features, such as buying out a part of the floodplain, the recreation features may cost up to one-half of the total project cost of the nonstructural FRM feature plus recreation.

Recreational opportunities considered in the floodplain of Upper Turkey Creek could include the following:

- **Trail Development**—Multi-use trails (biking, walking, and running) with lanes or other use controls, access to parking and distance information (trails could be interconnected to create a larger system)
- **Access Points for Fishing and Wildlife**—Parking areas and access to pools and other areas where fish may be prevalent, garbage disposal areas, and kiosks of local fish species
- **Nature Viewing Areas**—Viewing platforms and native plantings
- **Park/Greenway Amenities**—Composting restroom facilities, parking areas, lighting, and garbage disposal areas (to reduce trash)
- **Educational Outreach**—Kiosks along trails and at trail heads describing the local biota and the stream processes

2.6.2 GREEN SOLUTIONS

The Kansas City, Missouri, Johnson County, Kansas, the MARC, and the Kansas City Chapter of the APWA have been pushing initiatives forward that are very relevant with this watershed and the project.

Kansas City recently pushed an initiative aimed at treating rain where it falls in the *10,000 Rain Gardens* initiative. The rain gardens are a feature that when aggregated and combined through a large area, can significantly help rain water infiltration into the very clayey soils in this region.

MARC is planning for a greener transit system, and under MetroGreen®, is establishing trails along stream corridors with significant support from local entities, and MARC's work along the Turkey Creek corridor is the TCC. MetroGreen® has been a gradual effort to implement an interconnected system of public and private natural areas, greenways and trails linking together communities throughout the Kansas City metropolitan area. Benefits of MetroGreen® include cost effective improvements of air and water quality; stabilization of streams; reduction of flood risks; protection of wildlife habitat; opportunities for biking, hiking and walking; and ultimately, the formation of a framework around which more sustainable urban development patterns can occur, possibly included as parts of flood risk management project sites. A recent TCC product is a joint resolution, drafted July 21, 2009, that has since been adopted by several cities, including Overland Park, Roeland Park, and the Unified Government of Wyandotte County and Kansas City. The sponsor, Merriam, is also in support. In addition, MARC has expanded from transportation planning into watershed planning. This meaningful work has lead to MARC starting up the TCC, which could be the core of a watershed-level partnership interested in a watershed management plan that includes floodplain management work.

As previously noted, MARC also has an initiative known as i-Tree. Because suburban forests are a significant part of the watershed, the amount of rainfall caught by trees can be another planning consideration. Studies have referenced as much as 50 gallons of water can be held on a mature oak tree. Any policies that continue to support the suburban tree population may be important for the health of the watershed.

Finally, and most relevant, MARC has developed a *Manual of Best Management Practices for Stormwater Quality* (MARC and APWA 2009). Those participating in the manual's development recognize the need to fine tune how BMPs should be standardized in the metropolitan area. The manual has condensed nation-wide BMPs for consideration under local conditions and addresses a variety of features, such as filter strips or native planting. The APWA is also collaborating with the effort.

2.6.3 SPECIAL AREA MANAGEMENT PLAN

The EPA, Region VII, started a process for an SAMP, and the Upper Turkey Creek planning team has considered this information as appropriate in the planning efforts. A SAMP was not implemented at that time. EPA hired a consultant to complete a Phase I of this SAMP from July 31, 2005, through April 30, 2006. With the assistance of the Turkey Creek SAMP Coordinator, The Watershed Institute, Inc. (TWI) and TWI staff:

1. Identified potential stakeholders, including local, state, and Federal government agencies within the Upper Turkey Creek watershed
2. Gathered information and copies of studies, reports, plans, and other available information concerning natural resources, hydrology, water quality monitoring, Geographic Information Systems (GIS) layers, soils, capital improvement and infrastructure programs, economic development programs and projects, parks and trails, and neighborhood plans related to the Upper Turkey Creek watershed.
3. Reviewed all information that has been collected for the watershed
4. Identified data gaps and potential information sources that are needed to complete a SAMP or an Advance Identification (ADID) for the watershed (see http://www.epa.gov/owow/wetlands/facts/fact28.html)
5. Prepared a preliminary summary report for the watershed, identifying the following:
   a. Past and present projects and planning efforts, including who, what, when and where
   b. Existing information sources

c. Relevant studies

d. Current conditions, problems, technical challenges, and restoration opportunities

2.6.4 FLOODPLAIN MANAGEMENT PLAN

With the significant planning work from the feasibility study, the USACE and the sponsor have agreed to prepare an FMP during design phase. Preparation of an FMP is required by Public Law 104-303 of the WRDA of 1996, which amends Section 402 of the WRDA of 1986 (also see 33 U.S.C. 701b-12; 100 Stat. 4133).

The planning team recognizes that few FMPs have been done per Policy Guidance Letter (PGL) 52, in alignment with Public Law 104-303. The planning team has noted that communities frequently do not have the resources to do a comprehensive systems approach to floodplain planning when the subject area crosses multiple urban jurisdictions. Because this effort has been a major focus of this study, the USACE planners have encouraged the sponsor, major stakeholders, and adjacent communities to use relevant portions of the feasibility study as the core of a strong FMP. A significant number of major stakeholders share the flood risks in Upper Turkey Creek: the UG; the MDD; KDOT; the BNSF railroad; and the USACE because of its construction and completed infrastructure downstream.

The development of this plan will help communities in Upper Turkey Creek address several things. First, flood hazards and the beneficial functions of floodplains can be integrated under a living document shared by these communities. Many of the planning considerations in Section 2.6 can be included in the final product. Second, the FMP will establish a communication plan for these communities to work together with a systems approach in the watershed. Finally, and most importantly, the FMP will set up a series of action items for managing flood risks. In addition to implementing features formulated in this report, activities and policies will need to be established, and timeframes for completion of all the action items will also be included. One of the first will be to establish how USACE-constructed features will be maintained in the long term.

3 CHAPTER 3 – SYSTEM BASELINE CONDITION AND INVENTORY

Turkey Creek is a right bank tributary of the lower Kansas River located in Johnson and Wyandotte Counties, Kansas (Figure 3-1). The Turkey Creek watershed is approximately 23 square miles in size. Turkey Creek is approximately 15 miles in long and runs parallel to I-35 nearly its entire length. The watershed contains the some of the most intensely developed urban locations in Johnson and Wyandotte Counties, Kansas. Approximately 75 percent of Turkey Creek consists of residential, commercial, and industrial land use (Lee et al. 2005). Additionally, nearly 30 percent of the watershed consists of constructed impervious surfaces. Construction of the I-35 embankment reduced the width of the Turkey Creek floodplain from approximately 1,000 feet to approximately 50 to 400 feet. Further development has highly altered much of the floodplain and creek channel.

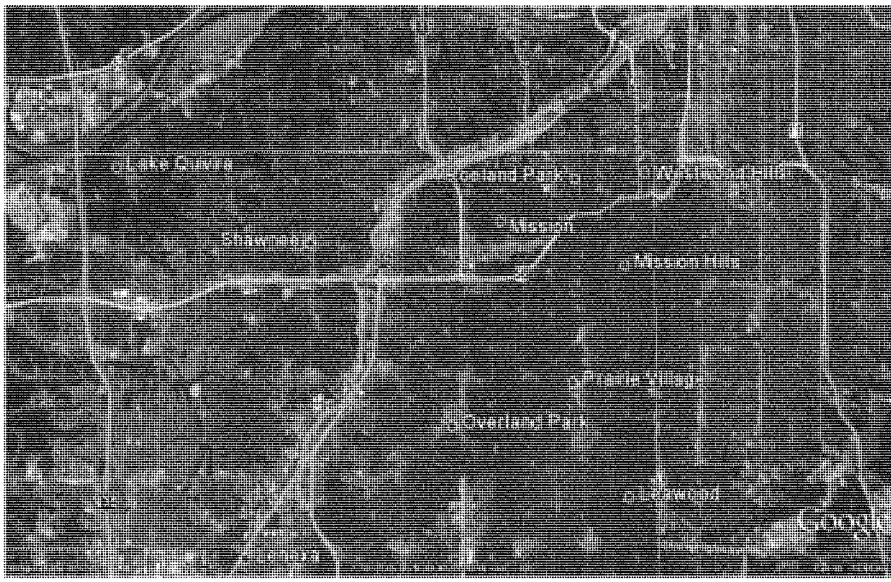


Figure 3-1: Turkey Creek Upper and Lower Reaches
(Source Google ™ Earth ®, © 2012 Google)

Most of Turkey Creek and its tributaries have been channelized, having numerous reaches where the banks have been lined with rock or both the channel and banks have been lined with concrete. At least four lakes exist on the tributaries, and the upper reach of Turkey Creek in Lenexa has several small (one- to two-foot-high) dams. Several waterfalls, approximately five feet or less in height, exist on the creek and tributaries. In at least one of those locations, upstream of 47th Street, the waterfall is at an area where the channel has been relocated. Some of the smaller (three-foot or less) waterfalls found between Lamar and Metcalf Avenues and 63rd and 67th Streets, for example, are due to concrete-covered utility crossings that are exposed. In evaluating the difference in channel bottom elevations of the current creek and tributaries and comparing to that of older adjacent stormwater and utilities, it appears the channel bottom in many areas has been lowered or is incising. In the stretch of stream between Lamar and Metcalf, the limestone along the stream banks appears to be failing, exposing the softer underlying shale material.

Within the City of Merriam in Johnson County, the MDD has modified the Turkey Creek channel from 63rd Street downstream to 51st Street in stages beginning in about 1967. The work was considered complete in 1972, but the MDD has since accomplished an extensive streambank protection effort relying primarily on large cut limestone blocks to armor the channel slope. The last segments of armoring were placed in the early 1980s, but large floods occasionally displace the stone blocks, requiring continual maintenance of the project. The MDD's efforts have produced a channel of nearly uniform width deepened to bedrock through the project area.

3.1 EXISTING CONDITIONS

3.1.1 WATERSHED ASSESSMENT

Physical, habitat, and biological data collection and evaluation was conducted in representative reaches throughout Upper Turkey Creek in May and June 2005 with follow-up in September 2005. Fish surveys and the macroinvertebrate composition of Upper Turkey Creek also were determined through biological surveys conducted along the length of Upper Turkey Creek and its tributaries during the same period. These data were then used to develop an overall stream quality assessment ranking for approximately 100 locations on the Upper Turkey Creek and its tributaries, using a ranking methodology that weights the physical, habitat, and biological assessment scores of a given stream reach and generate a single number to represent the overall conditions at that reach. A report documenting the methods and results of the assessment is provided in Appendix J.

Limited modeling was conducted using HEC-RAS (hydraulic) and HEC-1 (hydrologic) Corps models and using the modeling from the Johnson County watershed study. The Johnson County watershed study included HEC-1 files for that portion of the watershed in Johnson County. The Johnson County HEC-1 model was used as the existing conditions hydrologic model for the Upper Turkey Creek Feasibility Study. Johnson County also provided HEC-RAS files, and after review, they were matched to the USACE-supplied HEC-RAS files. The matched HEC-RAS files were used only to evaluate the two locations along the main stem that appeared most promising for storage to achieve flood reduction, providing results by end of 2005. The HEC-RAS model supplied by the USACE was used for the storage evaluation discussed above and to determine bank shear stress and resultant allowable bio-stabilization techniques at locations where bank stabilization was identified as a problem. The USACE version of the HEC–RAS model contained data for the main stem of the creek and two of the tributaries. The HEC-RAS model from Johnson County, which had most of the other tributaries, was used to calculate shear stress in tributaries not contained in the USACE's HEC-RAS model.

Of the approximately 100 reaches evaluated for stream quality, 33 were located adjacent to locations that were in need of bank stabilization as determined from the HEC-RAS modeling. In 2009, data from the 33 stream quality assessments were later converted into scores that could be input into the Kansas Department of Wildlife and Parks (KDWP) Subjective Evaluation of Aquatic Habitat and Subjective Evaluation of Terrestrial Habitat assessment methods (KDWP 2004). The KDWP's habitat assessment methods are subjective evaluation procedures that can rapidly evaluate aquatic and terrestrial resources through a series of variables designed to provide a holistic evaluation of the physical, chemical, and biological resources. The conversion of data from the initial stream quality assessment to the KDWP subjective assessments was done so that the results could be presented as an output from a single assessment method, rather than a combination of assessment methods. Results from the KDWP subjective evaluations are located in Appendix J, *Stream Assessment*. After further consideration and additional field evaluation, the 33 reaches in need of bank stabilization were reduced to 11 reaches that would be the most feasible locations for ecosystem restoration projects. Results from the KDWP subjective evaluations were used as one method to describe the existing, and potential future, habitat conditions in select locations of the watershed. However, they were not used to formulate alternatives for Federal involvement because there was no local interest in cost sharing.

3.1.2 ENVIRONMENTAL DESCRIPTION

Engineering Circular (EC) No. 1105-2-412 requires that all planning models that the USACE uses must be certified or approved prior to use to ensure that they are technically and theoretically sound and can be used as a functional tool during the planning process. EC 1105-2-412 defines a planning model as "any models and analytical tools that planners use to define water resources management problems and opportunities, to formulate potential alternative to address the problems and take advantage of the opportunities, to evaluate potential effects of alternative and to support decision-making." The use of certified models for all planning activities is mandatory. The USACE National Ecosystem Planning Center of Expertise (ECO-PCX) is responsible for implementation of the certification process for ecological models.

The USFWS Habitat Evaluation Procedure (HEP) was used to evaluate the need for compensatory mitigation for Section 404 authorization and to better compare project alternatives. The HEP method was developed by the USFWS in the 1970s (USFWS 1980). It is a method that can be used to document the quality and quantity of available habitat for selected wildlife species. The HEP provides information for two general types of wildlife habitat comparisons: one, the relative value of different areas at the same point in time, and two, the relative value of the same area at future points in time. By combining these two types of comparisons, the impact of proposed land and water use changes on wildlife habitat can be quantified. The HEP describes habitat for selected wildlife species as a Habitat Suitability Index (HSI) with a value ranging from 0.0 to 1.0. This value is multiplied by the area of available habitat to obtain Habitat Units (HUs). To calculate habitat value over a period of time, such as 50-year period of analysis, HUs are averaged on a yearly basis to provide Average Annual Habitat Units (AAHU). Specific HSI models used for this method were the green sunfish (*Lepomis cyanellus*) and the fox squirrel (*Sciurus niger*). These models were selected because these species are expected to be found in urban environments in the Midwestern United States.[1] The fox squirrel model best represented existing forested habitat that had scattered hard mast canopy trees with little underbrush. Other existing HSI models were not sensitive enough for the existing habitat type to adequately reflect changes in this type habitat, therefore the fox squirrel model was chosen. The HEP method and USFWS HSI models have been approved for use for USACE planning projects in accordance with EC 1105-2-412.

3.2 RESOURCES OF CONCERN

Primary resources of concern identified for evaluation in this study include geology, soils, and geomorphology; climate; hydrology; water quality; aquatic habitat; wetlands and waters of the United States; terrestrial habitat; fish and wildlife; threatened and endangered species; HTRW; floodplain; land use; socioeconomics; environmental justice; transportation; recreation; and cultural resources.

3.2.1 GEOLOGY, SOILS, AND GEOMORPHOLOGY

The study area is part of the Osage Plains physiographic section of western Missouri and eastern Kansas. The topography was developed on Pennsylvanian shale interspersed with beds of limestone and sandstone. The surface geology of the project area consists of Holocene alluvium, and Virgilian Lane Shale and Wyandotte Limestone of the Kansas City Group. Because of human-made features, the floodplain is 50 to 400 feet wide in most locations. Bank heights along Turkey Creek vary from 10 to 20 feet and the stream width averages 25 feet within the project area. The project is located in an area of air quality attainment in accordance with the National Ambient Air Quality Standards (40 CFR part 50).

[1] These models are available online at http://el.erdc.usace.army.mil/emrrp/emris/ EMRIS_PDF/GreenSunfish.pdf and http://el.erdc. usace.army.mil/emrrp/emris/EMRIS_PDF/FoxSquirrel.pdf.

3.2.2 CLIMATE

The climate for the area consists of hot humid summers and cold winters. The mean annual temperature of Kansas City, Missouri, is 53.6 degrees Fahrenheit (°F). July is the warmest month with an average temperature of 78.5°F, and January is the coldest with an average temperature of 25.7°F. Kansas City averages 37.6 inches of precipitation a year, with May through September being the wettest months. Over the past 100 years, precipitation has increased by 10 to 20 percent in the eastern parts of Kansas (EPA 1998). Average temperatures in Manhattan, Kansas, located about 100 miles to the west of the project area, have increased by 1.3°F over the past century (EPA 1998).

3.2.3 HYDRAULICS AND HYDROLOGY

The hydrology of Turkey Creek upstream of the Johnson and Wyandotte County line is dominated by groundwater sources during baseflow conditions and surface water runoff during precipitation events. The amount of impervious cover associated with urban development, approximately 30 percent, has increased the rate of stormwater runoff reaching the creek, thereby causing an increase in the peak discharge volumes of Turkey Creek following storm events. The amount of impervious cover within the Turkey Creek watershed has likely reduced groundwater recharge, thus reducing the baseflow in portions of Turkey Creek. Baseflow conditions of Turkey Creek at 67th Street, just upstream of the downtown Merriam project area, were recorded at approximately 1 cubic foot per second (cfs) as part of a field study conducted by the USGS in November 2000, and July 2003 (Lee et al. 2005). Baseflow conditions downstream of the Johnson and Wyandotte County line are dominated by discharges from the Myron Nelson Wastewater Treatment Plant Complex and typically average around 25 cfs. No USGS gage stations exist on Turkey Creek.

An inventory of the various factors in the existing conditions can be established through a number of ways, including maps, GIS, and using hydrologic and hydraulic modeling software (see Section 4.7 for details).

This study's existing conditions associated with land use, imperviousness, rainfall runoff, and storm drainage systems are captured in a hydrologic model (HEC-1) and a hydraulic model (HEC-RAS). Existing conditions hydrologic modeling began in May 31, 2005, when the Larkin Group Inc. (Larkin) began a study titled *The Northeast Johnson County Watershed Study for Johnson County, Kansas* to assist the county in FEMA FIRM revisions for three or four of the smaller and well-developed watersheds of the county (Larkin 2005).[2] The study was produced by Larkin for the Storm Management Program of Johnson County, Kansas, Public Works. As part of the study, Larkin developed a hydrologic model using the HEC-1 software. Many of the existing enclosed storm drainage systems needed specific assumptions and analytical processes, specifically for setting up an open channel flow tool, to best characterize the watersheds in northeastern Johnson County, which is the portion closest to the center of the Kansas City metropolitan area.

The HEC-1 model produced by Larkin included the complete watershed contributing to Upper Turkey Creek. During the early stage of the feasibility study, planners and hydraulic engineers in the Kansas City District decided to use Larkin's HEC-1 model as the official existing conditions hydrologic model for the Johnson County study.

Statistical rainfall distribution and quantity of precipitation correlates estimated rainfall amounts to statistical rates of return (Table 3-1). Typical return rates are the 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2 percent AEP. The following table correlates the statistical rate of return to the 24-hour rainfall amount and the probability of occurrence. The rainfall amounts were acquired from the U.S. Department of Agriculture Technical Release 55 (TR-55, U.S. Department of Agriculture 1986).

[2] Especially relevant portions of Larkin (2005) are Sections 6 and 7.

Table 3-1: Statistical Rate of Return Correlated to a 24-Hour Rainfall

Annual Exceedance Probability (percentage)	24-hour Rainfall Amount (inches)	Statistical Rate of Return
50	3.6	2-year event
20	4.5	5-year event
10	5.4	10-year event
4	6.2	25-year event
2	7.0	50-year event
1	7.9	100-year event
0.5	8.4	200-year event
0.2	9.3	500-year event

Gages help to establish existing conditions by tying possible flows to statistical records. One USGS stream gage lies within the northeastern watershed. However, this gage, identified as Gage 06893557, is on Brush Creek located near Ward Parkway in Kansas City, Missouri. The gage monitors Brush Creek downstream of the northeastern watershed study area. The USGS has reported data for this gage since 1999, and the average annual mean stream flow for this gage is 10.31 cfs. Based on conversations with Don Wilkinson, of the USGS, in 2002, the 100-year flow at this location has been estimated at approximately 16,000 cfs based on variety of source data, but not enough data has been collected from the gage to verify this estimate. Although this gage is not directly related to Turkey Creek, it was an important calibration tool for Larkin during the preparation of the Johnson County HEC-1 model. The Johnson County Public Works maintains a stream gage network, which is part of the StormWatch system (City of Overland Park 2012) and available on the internet, consisting of five gage stations within the area included in the northeast Johnson County watershed study area. Two of these stream gage stations are within the Turkey Creek watershed (Table 3-2). These gage stations are not set up for stream flow measurement; they collect precipitation and water level data.

Table 3-2: Turkey Creek Watershed Gages in the Storm Watch Gage Network

Gage	Location	Oldest Available Record
3010	Johnson Drive	September 14, 1999
3020	65th Street	March 23, 2000

The large majority of the northeast Johnson County watershed study area is fully developed and urbanized, including the Turkey Creek watershed. A quantitative analysis of existing land use was not required for the study because the required hydrologic data were acquired from a detailed study of impervious surfaces. However, the study area can be roughly characterized as follows:

- About 36.0 square miles of the northeast Johnson County study area is urbanized and fully developed. About 0.5 square mile of undeveloped land, planned for future development is present in the Lake Quivira watershed in western Shawnee, Kansas. This undeveloped land is either pasture or woodlands. Open areas also are present in the community of Lake Quivira, but the planned use is for those areas to remain as wooded open space.
- About 60 to 70 percent of the urban area is residential usage (subdivisions of single-family homes, multi-family dwellings, and apartment complexes).

- About 20 to 25 percent of the land is used for commercial, business, or institutional uses, including retail shopping, restaurants, entertainment, offices, hospitals, schools, churches, and synagogues.
- Less than 5percent of the urban land is used for light industries.
- The remainder of the urban land is open space (such as floodplain areas), parks, golf courses, or transportation corridors.
- The average percent imperviousness for the entire study area is approximately 38 percent.

The basin experienced significant development in the 1980s and 1990s, and basically used up any remaining developable land. This contributed to increased Turkey Creek stormwater flows; however, no flows are expected to increase in the future due to additional impermeable surfaces. The existing stream-hydraulic conditions of Turkey Creek were modeled using the HEC-RAS. The base of the Upper Turkey Creek feasibility study existing condition model was the northeast Johnson County watershed study hydraulic HEC-RAS model. This model was modified in 2003 by USACE engineers to incorporate the proposed new BNSF railroad bridge just downstream of Merriam.

As part of this study, USACE monitored progress on Johnson County Public Work's efforts to update FEMA FIRMs and used HEC-RAS models prepared by the Corps and Johnson County. The Johnson County model was originally based on earlier USACE modeling efforts, and the latest, updated model was combined with the USACE Wyandotte County HEC-RAS segments to model the Merriam portion of Turkey Creek because it had recently undergone review by FEMA. Once approved, the model set the limits for 100-year FEMA FIRMs. The model for the northeast Johnson County watershed study was used for flood reduction improvements within the downtown Merriam area. This area sustained the most damage during the 1998 flood and was the focal point of the study. The channel modifications within this area were predominantly bounded by the Shawnee Mission Parkway and Merriam Drive bridges. The USACE model was used to study flood reduction measures within the Roe Lane Industrial Park. The USACE, Kansas City District's senior hydraulic engineer set up very specific split-flow modeling assumptions and parameters in the Wyandotte County portion of the HEC-RAS model. This segment was not needed to complete the evaluation of the final array of alternatives. This area, which is located at the downstream end of the Upper Turkey Creek reach in Wyandotte County between Route 69 and Roe Lane, not only floods from channel overtopping but also has back flooding problems through a rail opening in the Route 69 bridge. Both models were combined into a single existing conditions model to establish a baseline to evaluate the proposed alternatives during the feasibility phase.

ESTIMATED FLOOD DEPTHS AND VELOCITY: To provide an indication of the nature of the flooding problem, flood depths and velocities for the 1 percent ACE event were estimated for the Merriam Reach of Turkey Creek as follows:

Shawnee Mission Parkway Bridge: 0.22 feet at 6.3 feet/second

Merriam Marketplace: 3.67 feet at 8.1 feet/second

West 61st Street: 3.0 feet at 11.8 feet/second

Merriam Drive Bridge: 1.73 feet at 9.1 feet/second

3.2.4 WATER QUALITY

As with many urban creeks in the Kansas City metropolitan area, water quality within Turkey Creek is impacted by nonpoint sources of pollution. Non-point sources of pollution include urban runoff, such as lawn and garden chemicals, petroleum products, and industrial pollutants. Turkey Creek is listed as an impaired water body under Section 303 (d) of the CWA for total ammonia from unknown sources. Water from a wastewater treatment plant downstream of the project location near the Johnson and Wyandotte County line provides a base flow to the downstream portions of Turkey Creek throughout the year. The wastewater

treatment plant maintains a National Pollutant Discharge Elimination System (NPDES) permit, and currently, there are no violations of this permit.

As noted in Section 1.1.4, the EPA and KBS conducted a UAA of Turkey Creek in Johnson and Wyandotte Counties (Welker and Huggins 1997). EPA and KBS (1997) indicates that Turkey Creek is classified by the State of Kansas water quality standards for "non-contact recreation" or recreation where ingestion of surface water is not probable and this use includes but is not limited to wading, boating, fishing, trapping, mussel harvesting, and hunting. The report notes that Turkey Creek is classified by the state as "expected aquatic life use waters" or surface waters containing habitat types and indigenous biota commonly found or expected in the state. The UAA report also found that Turkey Creek was not in attainment for its current designated non-contact recreation use due in part to fecal coliform, hazards, and aesthetics and that Turkey Creek was not in attainment with regard to expected aquatic life uses. The report indicated the lack of attainability appeared to be due to nonpoint source pollution associated with urbanization and point source pollution associated with wastewater treatment plant discharge. This study also found that concentrations of dieldrin, heptachlor expoxide, diethyl phthalate, Arochlor® (a polychlorinated biphenyl), and mercury exceeded the State of Kansas and/or EPA water quality criteria.

3.2.5 AQUATIC HABITAT

Past channel modifications and urban development have greatly impacted the aquatic habitat within Turkey Creek. In 2005, a stream quality assessment was conducted for the Upper Turkey Creek watershed at approximately 100 reaches of Turkey Creek and its tributaries. The assessment was based on a combination of the Rapid Bioassesment Protocols for Use in Streams and Wadeable Rivers (Barbour et al. 1999), and the USDA, Natural Resources Conservation Service (NRCS), Stream Visual Assessment Protocol (USDA 1998). Seventeen different variables were used to characterize physical stream conditions, habitat characteristics, and the biologic community. Each variable was scored on a scale of 1 to 10. Poor conditions for a given variable would result in a low score, while good conditions would result in a higher score. Those reaches with an overall score of 0 to 6.0 indicated poor conditions, scores of 6.1 to 7.4 indicated fair conditions, scores of 7.5 to 8.9 indicated good conditions, and scores of 9.0 to 10 indicated excellent conditions. As shown in Table 3-3, stream quality conditions were generally evenly distributed between good, fair, and poor categories. Only five assessed stream reaches were characterized as excellent for an urban stream; four of these reaches were located in the northern portions of the Turkey Creek watershed. Reaches with poor conditions were located throughout the watershed, with poor bank stability, riparian impairment, and obstructions to fish passage as variables that often related in low overall scores.

Table 3-3: Overall Stream Health Assessment Scores for Upper Turkey Creek.

Assessment Score	Percent of Reaches
Excellent	5
Good	32
Fair	34
Poor	29
Total	100

Three reaches were evaluated within the project area between Shawnee Mission Parkway and Merriam Drive. These reaches, which were all categorized as poor because of stream assessment scores ranging between 3.91

and 4.75, were among the lowest scores within the entire Upper Turkey Creek watershed. At times, the Turkey Creek channel within the project area becomes dominated with filamentous algae. Emergent aquatic vegetation is virtually non-existent. Additionally, as an indicator of the condition of the aquatic habitat for compliance with Section 404 of the CWA and to better compare alternatives, the HEP method was utilized to calculate a HSI score and determine the existing number of HUs for green sunfish (*Lepomis cyanellus*) within the downtown Merriam reach of the project area. Within this reach, there are approximately 7 acres of aquatic habitat. The HSI for green sunfish was 0.54, resulting in 3.8 HUs for this reach of the river.

3.2.6 WETLANDS AND WATERS OF THE UNITED STATES

The USACE performed a preliminary jurisdictional determination for the project area on March 2, 2012, to determine the presence of wetlands and other classified waters of the United States. No jurisdictional wetlands were identified within the proposed project area. In 2003, the USACE conducted a field inventory of the entire Turkey Creek watershed and identified very few wetlands. At that time, only 5.4 acres were identified as possibly meeting wetland criteria within the entire watershed. Turkey Creek is classified as waters of the United States within the entire project area. To evaluate the existing condition of the riparian corridor for compliance with Section 404 of the CWA and to better compare alternatives, the HEP method was used to calculate an HSI score and determine the existing number of habitat units for the fox squirrel (*Sciurus niger*). Within this reach, the HSI score for the fox squirrel was 0.12, resulting in 3.18 HUs over a 26.5-acre area.

3.2.7 TERRESTRIAL HABITAT

The Turkey Creek drainage basin contains only remnants of the pre-settlement vegetation. The area was initially cleared for farms and homes and later developed for commerce and industry. Currently, tree species typically found within the floodplain and riparian area are dominated by eastern cottonwood, American sycamore, box elder, silver maple, and American elm. Black walnut is also common in some locations, including the project area between Shawnee Mission Parkway and Merriam Drive. The project area is approximately 30 acres in size, and approximately 25 percent of the project area contains tree canopy cover. Most of the locations with tree canopy cover also contain manicured lawns. The remaining areas include buildings, roads, parking lots, and other intensive land use practices.

3.2.8 FISH AND WILDLIFE

Fish species observed in Turkey Creek as part of a UAA study included red shiner, green sunfish, fathead minnow, and creek chub (Welker and Huggins 1997). These same species were identified again in biological samples collected by the EPA at three different locations along Turkey Creek in 2006 to 2009 (www.kcwaters.org). These species of fish are known to be tolerant of polluted waters. The steep angle of the Turkey Creek tunnel as it enters the Kansas River prevents most fish from moving from the Kansas River into Turkey Creek (USFWS 1998). The UAA report (Welker and Huggins 1997) concluded that the fish and macroinvertebrate communities in Turkey Creek are severely degraded by both point and nonpoint sources of pollution. The wastewater treatment plant provides a constant flow of warm water that creates open water in the winter months that is used by waterfowl. However, the warm water may be harmful to aquatic species that depend on cool water for all or part of their life cycle. Wildlife found in the riparian corridor along Turkey Creek includes small mammals, such as eastern cottontail rabbit, gray and fox squirrel, ground hog, opossum, and raccoon. Whitetail deer and a variety of birds such as house sparrow, starling, and American robin, reptiles, and amphibians also use the area.

3.2.9 THREATENED OR ENDANGERED SPECIES

No Federally listed threatened or endangered species are known to occur within or adjacent to the proposed project area. The only Federally listed threatened and endangered species for Wyandotte County, Kansas, is the

pallid sturgeon, and this fish species is restricted to the Kansas and Missouri Rivers. A copy of the letters from USFWS and KDWPT has been placed in the appendix H of this report.

3.2.10 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE (HTRW)

In 2011, the USACE conducted a general records search of HTRW sites located along the Upper Turkey Creek corridor. This search included the EPA Enviromapper; EPA Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) database; KDHE Identified Sites list; KDHE aboveground storage tanks and underground storage tanks assessment database; and KDHE database of registered underground storage tanks.

Findings from the records search indicate that no known hazardous waste sites are located within or adjacent to the project area. In addition, no solid waste facilities, such as former landfills, were identified. There are many records of leaking underground storage tanks throughout the Upper Turkey Creek watershed. Some of these tanks were located near the downstream portion of the proposed project area at 5639 Merriam Drive, Merriam, Kansas. This facility is used as a school bus station. The leaking tanks were used to store waste oil and diesel fuel. The storage tanks were removed and approximately 170 cubic yards of contaminated soil was removed. Additional underground storage tanks are currently registered at this location, although they are not known to be leaking. A complete description of the HTRW records search, including maps, is found in Appendix J, *Existing Conditions*.

3.2.11 FLOODPLAIN

Urban development has greatly impacted the Turkey Creek floodplain over the years. The lower reach of Turkey creek was originally channelized before 1920 during the construction of the tunnel bypass. In addition, the construction of I-35 adjacent to Turkey Creek also has impacted the creek channel and floodplain. Urban development of the floodplain has included fill activity; channelization of drainages, including concrete lining and enclosures; and development of numerous buildings, parking lots, roads, and utilities. Indirect impacts have resulted from development in the watershed and have increased the rate at which water reaches the creek and tributaries. The combination of the direct and indirect impacts has increased the flood peak flows, flood flow volumes, channel flow velocities and the rapid rate at which stream flows rise and fall after a storm (flashiness). The stream system has responded to these hydrologic modifications / alterations within the watershed by attempting to deepen and widen the channel, causing additional stream bank erosion and channel instability.

Frequent flooding in the Turkey Creek basin has been an ongoing issue for decades, causing substantial physical damages to property, significant risk to human life, lost revenues during business operational shutdowns, transportation network impacts, and threats to the viability of downtown Merriam. Records assessing these floods, especially before the 1960s, are limited, and none of the available economic damage estimates for any of the historical events are comprehensive, but Turkey Creek floods are known to have resulted in substantial damage in the upper basin in 1961, 1977, 1993 and 1998 among other years. The flood of July 1993 caused one fatality and resulted in estimated damages of $3.4 million in Merriam (equivalent to approximately $6.5 million in FY 2015 dollars) and $20 million in the lower basin. The flood of October 1998 caused an estimated $12 million in damages in Merriam (nearly $20 million in FY 2015 dollars) as well as damages in the lower basin equivalent to those of 1993. I-35 was overtopped at five different locations during the 1998 event. The flood peak occurred in the late evening, but had the peak occurred during rush hour, the risk of loss of life would have been high for drivers on I-35. Table 3-4 summarizes the existing information available concerning the occurrence of historical floods and estimated economic damages. None of the damage totals shown should be regarded as comprehensive accountings.

Table 3-4: Turkey Creek Flood History

Event	Description of Flooding	Estimated Damages (price level based on year of occurrence)
May 5–6, 1904	Not available.	Unknown
October 21–22, 1908	Not available.	Unknown
September 6–7, 1914	Not available.	Unknown
June 1, 1935	Flood depths up to 7 feet occurred with estimated discharge of 13,650 cfs. Commercial, industrial, and railroad damages were experienced in Merriam, Rosedale, and along Southwest Boulevard.	Unknown
April 21–22, 1944	Not available.	
July 30–31, 1958	Flood damage at Merriam and along Southwest Boulevard, at least 69 buildings damaged. Railroad tracks washed out west of Roe. Estimated discharge of 4,400 cfs at Merriam.	$155,000
September 12–13, 1961	Flooding damaged at least 82 buildings; No. 10 Fire Station was flooded to 1 foot depth, and I-35 was under water.	$240,000
July 21, 1968	Not available.	Unknown
September 12–13, 1977	Significant damage occurred along Southwest Blvd in the Rosedale District (estimated discharge of 11,700 cfs) and in Merriam; numerous buildings were damaged.	$8,100,000
April 1, 1983	Rosedale District and the state line area experienced severe flooding. Flood depths reached an estimated 4–6 feet in the state line area (estimated 12,500 cfs discharge).	Unknown
September 17, 1986	Rosedale District experienced severe damage with many buildings flooded. I-35 northbound lanes under water and other transportation damages occurred. Damages to city infrastructure (e.g., bridges, sewers, and streets).	Unknown
July 10, 1993	Largest flood on record. Damages in Rosedale, state line, and the Kansas City Central Industrial District. One fatality, but loss of life could have been greater had flood occurred during business hours rather than in the early morning hours.	$23,000,000 (partial estimate)
October 4–5, 1998	Severe flash flooding in Merriam and along Southwest Boulevard, numerous flooded buildings, mud and debris deposits. Flood depths and extents of flooding were very similar to the 1993 event. I-35 was closed for a few hours.	$25,000,000 (rough partial estimate)
June 27–28, 1999	Some businesses along Southwest Boulevard flooded (approximately 1-foot depth); people rescued from cars stalled in high water; street intersections closed; I-35 closed at 18th Street, and at Lamar, for a couple of hours.	Unknown
August 28, 2004	Limited flooding; buildings downstream along Southwest Boulevard were evacuated.	Unknown

3.2.12 LAND USE

Land use within the Turkey Creek Basin is primarily urban (Figure 3-2). I-35 and the railroad line both run parallel to Turkey Creek and are the major human-made features in the project area that influence land development patterns. These features have resulted in the area becoming an industrial and commercial corridor with some limited residential development. The project area in downtown Merriam is dominated by industrial and commercial development and several city parks.

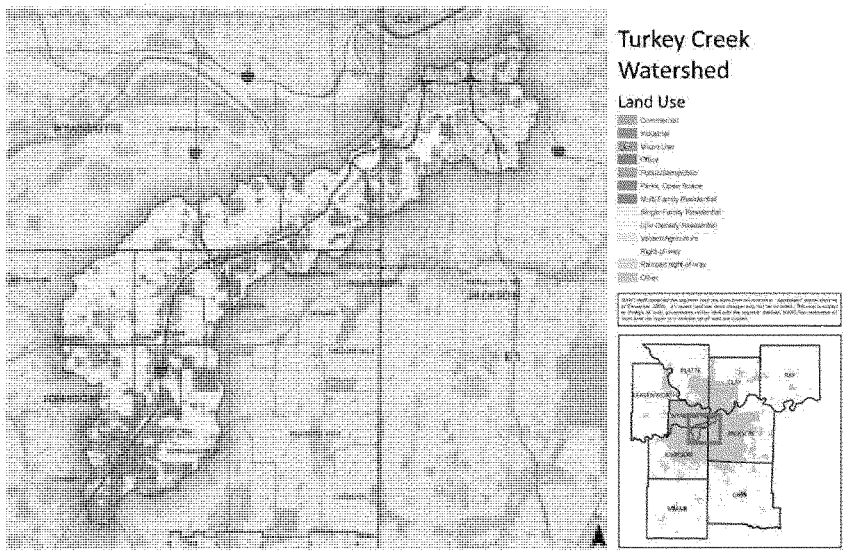


Figure 3-2: Land Use Within the Turkey Creek Watershed
(Source: Mid-America Regional Council [www.marc.org])

3.2.13 CRITICAL FACILITIES

The study area contains only one critical facility: Trinity Nursing and Rehabilitation Center (9700 W. 62nd Street), a Seventh-Day Adventist non-profit facility offering a large range of physical rehabilitation services for long-term care. Trinity has 120 beds, making it one of the largest such facilities in Kansas. Also noteworthy is Interstate Highway 35, a major highway running parallel to Upper Turkey Creek just outside the study area. I-35, which is a vital transportation link for both Merriam and the entire Kansas City metro area, has been inundated by Turkey Creek at several locations near the study area in previous floods.

3.2.14 SOCIOECONOMICS

The Upper Turkey Creek Basin can be described by the study area's demographics, economic indicators, housing conditions, and generalized land use patterns. The study area comprises all, or portions of, various U.S. Bureau of the Census sub-areas designated as census tracts. The study area includes parts of 14 census tracts, Kansas census tracts (KCT) numbers 434, 450, 502, 503.01, 504, 511, 519.03, 519.06, 519.07, 520.01, 520.04, 521.01, 522.01, and 9800.02. The available 2010 Census numbers/estimates were used for this section.

The Merriam project area includes parts of 5 census tracts, all located within Johnson County. These include KCT numbers 519.06, 520.01, 520.04, 521.01, and 522.01.

For comparison purposes, the demographics categories of the study area and its census tracts are also shown for the United States as a whole; the State of Kansas; the Kansas City metropolitan statistical area (MSA); Johnson County, Kansas; Wyandotte County, Kansas; and Merriam, Kansas (see Table 3-5).

Table 3-5: Population, Employment and Housing Characteristics, 2010

	Overall Study Area Census Tracts (RM -1.119 to 7.508)	Merriam Project Area Census Tracts (RM 2.035 to 5.394)	Merriam, Kansas	Johnson County, Kansas	Wyandotte County, Kansas	Kansas City MSA	Kansas	United States
Population 2010	42,503	14,857	11,107	531,228	155,462	1,999,718	2,809,329	303,965,272
Households 2010	19,801	6,804	5,125	210,278	57,207	789,432	1,101,672	114,235,996
Average number of persons per household	2.1	2.1	2.2	2.5	2.7	2.5	2.5	2.6
% Under age 18	20.5%	19.0%	18.6%	26.7%	28.2%	25.8%	25.5%	24.4%
% Over age 65	12.1%	12.6%	13.4%	10.6%	10.7%	11.7%	13.1%	12.7%
Unemployment	6.1%	3.9%	5.2%	4.6%	12.2%	6.8%	6.0%	7.9%
Median household income	$37,744 to $59,486	$41,910 to $59,486	$49,957	$73,733	$38,503	$55,749	$49,424	$51,914
Housing vacancy rate	8.6%	7.5%	6.2%	6.0%	12.5%	9.5%	9.8%	11.4%
Median [a] house value	$73,600 to $159,000	$148,300 to $158,000	$155,000	$209,900	$97,600	$158,000	$122,600	$188,400

Source: U.S. Bureau of Census 2010

Note: MSA – metropolitan statistical area, RM – river mile

[a] Median values given as the range of median values among the census tracts, excluding Census Tract 9800.02, which did not have enough houses or households to provide a meaningful median.

The 2010 population of the overall study area's 14 census tracts was 42,503, and the population of the Merriam reaches was 14,857, which equates to about 2.1 percent and 0.7 percent of population of the Kansas City MSA, respectively. Only nine residential structures are located within the Upper Turkey Creek floodplain in the Merriam reaches. Given that average number of persons per household for the area is 2.1, an estimated 19 persons reside within the floodplain, all in Reach 3b. Approximately 20.5 percent of the overall study area population and 19.0 percent of the Merriam reaches was 17 years of age or younger. About 12.1 percent of the overall study area's population, and 12.6 percent of the population of the Merriam reaches was age 65 or older. There were 19,801 households in the census tracts in the overall study area with an average household size of 2.1. The 6,804 households in the Merriam reaches have an average household size of 2.1, compared with an average household size of 2.2 for Merriam. There were 21,907 housing units in the overall study area, 46.7 percent of which were owner occupied, 43.6 percent were renter occupied, and the remaining 9.6 percent were vacant. In the Merriam reaches, there were 7,440 housing units, 42.9 percent of which were owner occupied, 48.6 percent were renter occupied, and 8.5 percent were vacant.

The two primary economic indicators in the study area are employment and income. The indicators show the number and the quality of the jobs available to the study area population. At the time the data were collected for the 2010 Census, the census tracts in the overall study area experienced unemployment of 6.1 percent. This was significantly below the national average of 7.9 percent. The 3.9 percent unemployment rate for the census tracts

in the Merriam project area was even lower. The range of median household income is $37,744 to $59,486 for the census tracts in the overall study area and $41,910 to $59,486 for the census tracts in the Merriam project area. For comparison, the median population for the United States is in the middle of these ranges at $51,914. The initial Upper Turkey Creek study area (river mile [RM] -1.119 to 7.508) contains approximately 105 commercial and industrial structures, including about 90 commercial and industrial buildings in the Merriam reaches that are the focus of the analysis (RM 2.035 to 5.394). Most of the structures are in zip code 66203, which in the most recent (2007) economic census had an average of 19.4 employees per establishment. Given that some businesses have more than one building in the Merriam reaches, those businesses would employ somewhat less than 1,746 people (the result of multiplying the average number of employees times the number of commercial and industrial structures). Types of businesses cover a wide range including light manufacturing, construction and earthwork, auto repair, automobile sales, tool and die manufacturing, retail, and service businesses.

INVESTMENT

Initially the entire study area was divided into nine reaches for assessment, and more detailed investment and damage information for the future without project condition was developed in the City of Merriam, Kansas as the study progressed. Comprehensive, structure-by-structure field surveys of the 0.2 percent floodplain from mile -1.199 to mile 7.5087 were carried out by Corps economics staff, and field survey updates were completed periodically throughout the study, most recently in 2014. The field surveys identified a total of 105 commercial structures and 10 residential structures. Of these, 91 commercial structures and 9 residential structures are in the Merriam reaches. Merriam was divided into three reaches along the Turkey Creek main stem for the economic analysis:

- Reach 3A – from river mile 2.035 near Antioch Road to river mile 2.593 near 55th Street
- Reach 3B – from river mile 2.593 near 55th Street to river mile 3.855 near Shawnee Mission Parkway
- Reach 3C – from river mile 3.855 near Shawnee Mission Parkway to river mile 5.394 at 75th Street

Table 3-6 below provides a summary of study area investment subject to flooding. Total investment in the study area was estimated in FY 2012 prices for the screening process. This total has been updated to FY 2015 prices. However, the screening was done at the FY 2012 price level and the discussion of the future without-project condition and the alternatives screening in this report is referenced to the FY 2012 price level. Total investment was estimated at $113.7 million in 2012 and is updated to $120.6 million in 2015. (The increase is based purely on price level adjustment and does not otherwise involve revised structure inventory data.) Investment in the three study area reaches is estimated at $24.9 million (FY 2015 dollars) for Reach 3a (20 structures), $75 million for Reach 3b (78 structures), and $20.7 million for Reach 3c (2 structures).

Table 3-6: Study Area Investment

Reach	# Structures/ groups of structures	1 Oct 11 prices ($1,000s)			1 Oct 14 prices ($1,000s)		
		Structure / infrastructure investment	Contents investment*	Reach Totals	Structure / infrastructure investment	Contents investment*	Reach Totals
Reach 3a	20	$8,600.0	$14,800.0	$23,300.0	$9,300.0	$15,600.0	$24,900.0
Reach 3b	78	$28,600.0	$42,600.0	$71,200.0	$29,500.0	$46,500.0	$76,000.0
Reach 3c	2	$11,400.0	$7,800.0	$19,200.0	$12,400.0	$8,300.0	$20,700.0

Study Area Totals	**100**	**$48,400.0**	**$65,200.0**	**$113,700.0**	**$51,200.0**	**$69,400.0**	**$120,600.0**

ECONOMIC DAMAGES

Single-event economic damages, as computed in HEC-FDA, are summarized here for three events:

0.10 ACE Event—A flood event of this magnitude and frequency could impact approximately 58 structures. Reach 3a would incur an estimated $211,000 in damages with a maximum depth of 1.4 feet to structures, approximately $2,000 in damages to roads, and approximately $10,000 in clean-up costs. Reach 3b would incur approximately $8.2 million in damages with a maximum depth of 5.1 feet to structures, approximately $53,000 in damages to roads, and $456,000 in clean-up costs. Reach 3c would incur approximately $2,000 in road damages. (These damage totals are in FY 2012 dollars.)

0.01 ACE Event—A flood event of this magnitude and frequency could impact an estimated 86 structures. Reach 3a would incur approximately $6.1 million in damages with a maximum depth of 5.3 feet to structures, approximately $57,000 in damages to roads, and approximately $234,000 in clean-up costs. Reach 3b would incur approximately $17.6 million in damages with a maximum depth of 6.3 feet to structures, approximately $109,000 in damages to roads, and nearly $1 million in clean-up costs. Reach 3c would incur approximately $2.6 million in damages with a maximum depth of 1.8 feet to structures, approximately $22,000 in road damages, and approximately $258,000 in clean-up costs.

0.002 ACE Event—A flood event of this frequency and magnitude could impact an estimated 98 structures. Reach 3a would incur approximately $13.1 million in damages with a maximum depth of 8.9 feet to structures, approximately $70,000 in damages to roads, and approximately $509,000 in clean-up costs. Reach 3b would incur approximately $27.2 million in damages with a maximum depth of 7.5 feet to structures, approximately $183,000 in damages to roads, and approximately $1.5 million in clean-up costs. Reach 3c would incur approximately $4.1 million in damages with a maximum depth of 2.3 feet to structures, approximately $28,000 in road damages, and approximately $416,000 in clean-up costs.

Table 3-7 shows the existing condition primary damages by flood frequency event and reach for the structural, contents, and other categories. The table is in 2012 price levels, consistent with the phase and timeframe for screening of plans

Table 3-7: Existing Condition Primary Damages (with Risk and Uncertainty) for Structures, Contents, and Other for Selected Events

Damage Category	Existing Condition (2012) Primary Damages (October 2011 prices, $1,000s)		
	0.1 exceedance probability	0.01 exceedance probability	0.002 exceedance probability
Reach 3a			
Structural	$31.3	$1,819.0	$3,605.6
Contents	$176.0	$4,139.0	$9,243.0
Other	$15.9	$410.3	$876.2
Total	$223.2	$6,368.3	$13,724.8
Reach 3b			
Structural	$1,930.4	$4,474.6	$7,144.8
Contents	$4,583.3	$10,744.3	$17,704.6
Other	$2,207.6	$3,451.2	$4,053.2

Damage Category	Existing Condition (2012) Primary Damages (October 2011 prices, $1,000s)		
	0.1 exceedance probability	0.01 exceedance probability	0.002 exceedance probability
Total	$8,721.3	$18,670.1	$28,902.7
Reach 3c			
Structural	$2.1	$1,646.4	$2,394.7
Contents	$0.0	$1,199.9	$2,162.0
Other	$0.0	$0.0	$0.0
Total	$2.1	$2,846.3	$4,556.7
Study Area Total			
Structural	$1,963.8	$7,940.0	$13,145.1
Contents	$4,759.3	$16,083.2	$29,109.6
Other	$2,223.5	$3,861.5	$4,929.4
Total	$8,946.6	$27,884.7	$47,184.2

3.2.15 ENVIRONMENTAL JUSTICE

Executive Order 12898 on environmental justice requires consideration of social equity issues, particularly any potential disproportionate impacts to minority or low-income groups. The study evaluated demographic and census data for the project area and analyzed the potential effects of the proposed project on minority and low-income groups. As can be seen in Table 3-5, the minority populations for the overall study area and the Merriam project area are lower than the national averages. This is also the case for under-18 and over-65 populations relative to the national average. The percentage of the population below poverty level, on the other hand, is somewhat higher for both the overall study area (14.9 percent) and the Merriam project area (17.5 percent) than the national average of 13.8 percent. Only nine residential structures are located and approximately 19 people reside in the floodplain of the Merriam reaches (RM 2.035 to 5.394). Block-level census data for these structures are distorted by the presence of a nursing home just outside the floodplain, so the data for the Merriam project area census tracts, as shown in Table 3-5, are likely to provide a better estimate (in terms of percentages) for the demographics within the floodplain.

Table 3-8: Minority, Low Income, and Vulnerable Populations, 2010

	Overall Study Area Census Tracts	Merriam Project Area Census Tracts	Merriam, Kansas	Johnson County, Kansas	Wyandotte County, Kansas	Kansas City MSA	Kansas	United States
Population 2010	42,503	14,857	11,107	531,228	155,462	1,999,718	2,809,329	303,965,272
% Black or African American	7.4%	10.1%	8.7%	4.0%	26.2%	12.3%	5.8%	12.5%
% Hispanic	14.0%	14.7%	16.1%	6.6%	24.8%	7.7%	9.8%	15.7%
% Asian	2.8%	2.7%	2.9%	4.1%	2.5%	2.2%	2.4%	4.7%
% Below	14.9%	17.5%	14.8%	5.5%	21.3%	11.1%	12.4%	13.8%

	Overall Study Area Census Tracts	Merriam Project Area Census Tracts	Merriam, Kansas	Johnson County, Kansas	Wyandotte County, Kansas	Kansas City MSA	Kansas	United States
poverty level								
Unemployment	6.1%	3.9%	5.2%	4.6%	12.2%	6.8%	6.0%	7.9%
% Under age 18	20.5%	19.0%	18.6%	26.7%	28.2%	25.8%	25.5%	24.4%
% Over age 65	12.1%	12.6%	13.4%	10.6%	10.7%	11.7%	13.1%	12.7%
% Foreign born	9.4%	9.5%	11.4%	7.9%	14.2%	6.0%	6.3%	12.7%
% Foreign born and entered US 2000 or later	3.3%	3.8%	3.6%	3.2%	5.9%	2.4%	2.4%	3.8%

Source: U.S. Bureau of Census 2010

Note: MSA – metropolitan statistical area

3.2.16 TRANSPORTATION

One of the most used roads in the Kansas City metropolitan area and the state of Kansas is the stretch of I-35 that runs through Johnson County, more-or-less parallel to Upper Turkey Creek throughout most of the study area (Figure 3-3). According to the KDOT, the daily traffic counts for this stretch of I-35 range from 108,000 just east of Roe Lane to 155,000 just south of 67th Street. In Reach 1b, where I-35 runs through the Upper Turkey Creek floodplain, the daily traffic count is 117,000. At the point nearest the Merriam Project area (although out of the floodplain), the traffic count for I-35 is 125,000. The road that runs most prominently through the floodplain of the Merriam project area is Merriam Drive, which has an average daily traffic count of 4,610. Shawnee Mission Parkway at the south end of the Merriam Project area has an average daily traffic count of 43,440.

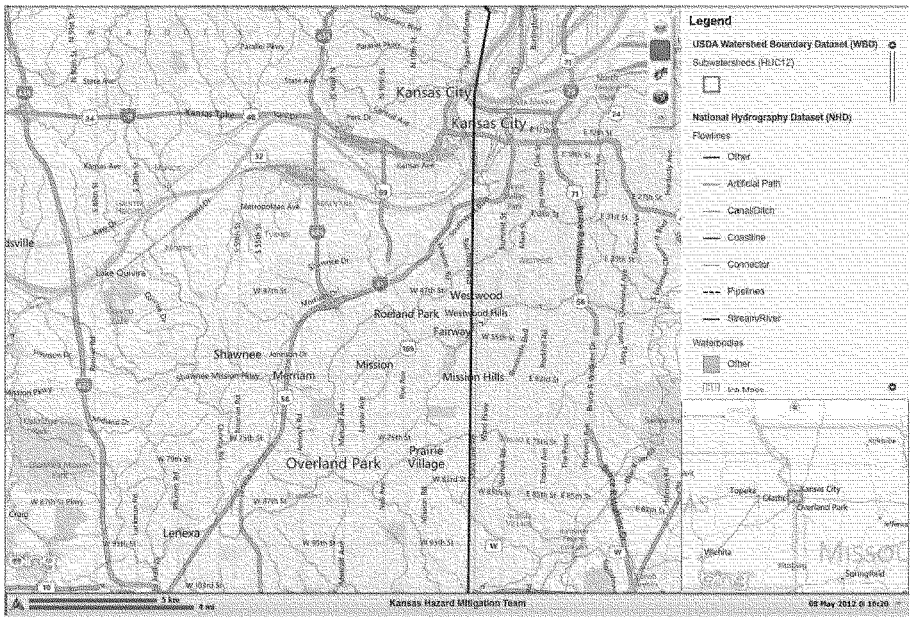


Figure 3-3: Transportation Infrastructure around Turkey Creek

In comparison to the national average, more residents of the study area drive to work alone (85.3 percent to 76 percent), and fewer residents use public transportation (0.4 percent to 4.9 percent). The residents of the study area also have average commute times (18.4 minutes) that are significantly less than the national average (25.2 minutes).

Table 3-9: Residents Commuting to Work, 2010

	Overall Study Area Census Tracts	Merriam Project Area Census Tracts	Merriam, Kansas	Johnson County, Kansas	Wyandotte County, Kansas	Kansas City MSA	Kansas	United States
Drove alone	85.3%	86.1%	85.3%	85.1%	80.5%	83.0%	81.4%	76.0%
Carpooled	8.4%	8.3%	9.2%	7.0%	11.4%	9.1%	9.7%	10.4%
Public transit	0.4%	0.4%	0.4%	0.4%	1.4%	1.3%	0.5%	4.9%
Walked	1.5%	1.2%	1.3%	1.0%	1.8%	1.4%	2.6%	2.8%
Other means	1.4%	0.9%	0.8%	1.1%	3.3%	1.3%	1.4%	1.7%
Worked at home	3.1%	3.1%	3.1%	5.4%	1.6%	3.9%	4.3%	4.1%
Mean travel time to work (minutes)	18.4	18.6	18.4	20.2	21.1	22.6	18.8	25.2

Source: U.S. Bureau of Census 2010
Note: MSA – metropolitan statistical area

3.2.17 RECREATION

Several city parks are located adjacent to Turkey Creek within the project area, including the Merriam Marketplace in downtown Merriam, which includes facility used for the Farmers' Market; Campbell Park located at 61st and Knox Streets; and Werner Park located near 57th and Knox Streets. Another park within the project area is the Turkey Creek Streamway Park. This park has a paved walking trail that follows the west bank of Turkey Creek from 75th Street to Werner Park. None of these parks have received funding through the Land and Water Conservation Fund; therefore, requirements of Section 6(f), of the Land and Water Conservation Act, governing the conversion of these lands to other uses is not applicable. Since 2007, a group known as the Turkey Creek Coalition has worked to develop a plan that would extend the Turkey Creek Streamway Trail from the suburbs of Johnson County to downtown Kansas City. The Turkey Creek Coalition is an informal association comprising public and private participants dedicated to developing this trail. It is supported by representatives from various city, state, and Federal government entities; local, state and Federal elected officials; local businesses and organizations; and private citizens. Detailed information about this initiative can be found at http://www.marc.org/metrogreen/Current_Projects/turkeycreek.aspx.

3.2.18 CULTURAL RESOURCES

Section 106 of the National Historic Preservation Act (NHPA) of 1966 (amended June 17, 1999) requires Federal agencies to take into account the effects of their undertakings on historic properties. By definition, historic properties are properties eligible for or listed on the National Register of Historic Places (NRHP). Federal undertakings refer to any Federal involvement including funding, permitting, licensing, or approval. Federal agencies are required to define and document the Area of Potential Effect (APE) for undertakings. The APE is defined as the geographic area or areas within which an undertaking may directly or indirectly cause changes in the character or use of historic properties, if such properties exist.

No sites listed on or eligible for listing on the NRHP are recorded within the Upper Turkey Creek APE. However, one historic military trail, the Fort Leavenworth-to-Fort Scott Road, is mapped as bisecting the project area. A historical marker is present at the location of the crossing. No trace of the old road remains in the area, primarily the result of the surrounding urban development. An archeological survey of the project area identified no archeological sites. The results of the archeological survey were documented in a report and coordinated with the Kansas State Historic Preservation Officer (SHPO) in a letter dated May 9, 2012. Because no cultural resource sites were identified during the survey and no trace remains of the former military road, the USACE determined the project would have "no effect" on historic properties. The SHPO concurred with this determination in a letter dated May 15, 2012. The survey report and SHPO coordination letters are included in Appendix K.

3.3 FUTURE WITHOUT PROJECT CONDITIONS

Primary resources of concern identified for evaluation include geology, soils, and geomorphology; climate; hydrology; water quality; aquatic habitat; wetlands; terrestrial habitat; fish and wildlife; threatened and endangered species; HTRW; floodplain; land use; socioeconomics; environmental justice; transportation; recreation; and cultural resources.

3.3.1 GEOLOGY, SOILS, AND GEOMORPHOLOGY

The existing conditions for geology, soils, and geomorphology within the Turkey Creek study area would not be expected to change under the future without project condition.

3.3.2 CLIMATE

If the climate trend over the past 100 years continues, eastern Kansas would continue to see increases in precipitation and temperature (USEPA 1998). More intense rainfall events would likely lead to an increase

flooding (USEPA 1998). Any increase in flooding would be particularly detrimental in urban areas, such as the Turkey Creek watershed.

3.3.3 HYDRAULICS AND HYDROLOGY

Without a flood risk management project along Turkey Creek, there would not be any expected major changes from existing conditions in the hydraulics of Turkey Creek within the project area. Flood risk would be sustained at levels that currently exist. However, if higher and more intense rainfall occurs due to changes in climate, there would be an increase in flooding along Turkey Creek, resulting in an increase risk to human health and safety, as well as an increase in property damage.

3.3.4 WATER QUALITY

As more stringent water quality standards are developed, the water quality of Turkey Creek is expected to continue to improve compared to existing conditions. It is believed that out-of-bank flooding along Turkey Creek flushes pollutants, which occur on adjacent lands as a result of the industrial, commercial, and residential development, into the creek. Any structural flood risk management alternative that would help contain floodwaters in the Turkey Creek channel would likely result in minor improvements to the water quality of Turkey Creek. Any non-structural alternatives for flood risk management may or may not result in minor improvements to the water quality, depending on whether any land use changes would occur as a result a particular alternative.

3.3.5 AQUATIC HABITAT

Currently, the aquatic habitat in Turkey Creek is in a degraded condition. No major improvements to the aquatic habitat along Turkey Creek are expected in the future with or without a flood risk management project. Any major improvements to aquatic habitat along Turkey Creek within the project area would require changes to the creek hydraulics.

3.3.6 WETLANDS AND WATERS OF THE UNITED STATES

The future without a flood risk management project would not result in any change in the number of wetlands within the project area. Most wetlands that may have historically existed along Turkey Creek have been filled. Depending on the design of a flood risk management project, new stormwater detention basins could be developed to provide some wetland functions.

3.3.7 TERRESTRIAL HABITAT

No change is expected in the terrestrial habitat of the project area in the future. The area would continue to consist predominately of manicured lawns, buildings, roads, parking lots, and other intensive land use practices. If a watershed-wide ecosystem restoration project were implemented to retain stormwater and reduce the rate at which runoff enters Turkey Creek, there would likely be improvements to the terrestrial habitat if these projects incorporated terrestrial vegetation. The extent of these improvements would be related to the extent of any ecosystem restoration projects.

3.3.8 FISH AND WILDLIFE

In the future, fish and wildlife would continue to consist of species that are tolerant of urban conditions with or without a flood risk management project. These species would likely consist of small animals, such as eastern cottontail rabbit, gray and fox squirrel, opossum, raccoon, groundhogs, and a variety of birds. Whitetail deer would also likely be abundant. Any ecosystem restoration efforts may increase the number of individuals of certain species, but because of the degree of urbanization in the watershed, an ecosystem restoration project would unlikely result in any additional species becoming present within the watershed.

3.3.9 THREATENED AND ENDANGERED SPECIES

Currently, no federally listed species, candidate species, or designated critical habitat occur within the Turkey Creek watershed. It is not expected that this condition will change in the future with or without a flood risk reduction project.

3.3.10 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTES

It is not expected that there will be any changes in the future concerning HTRW with or without a flood risk management project when compared to existing condition. It is unlikely that any hazardous waste sites would develop within the project area unless a major spill or leakage occurred. A flood risk management project would not change the likelihood of this occurring. One possible exception to the above, any underground storage tanks may be a problem in the watershed, and cleanup activities might occur in future. A flood risk management project would not have any effect on leaking storage tanks.

3.3.11 FLOODPLAIN

The future without a flood risk management project would not be significantly different than that described under existing conditions. However, some business and industry may make the decision to move to other locations if flooding problems become too burdensome. Additionally, there may be a greater risk to human health and safety and flood damage if climate conditions result in an increase in the intensity of storm events.

3.3.12 LAND USE

Without a flood risk management project, land use along Turkey Creek is not expected to change much. It is expected that the Turkey Creek watershed would continue to be used for industrial, commercial, and residential purposes. For the most part, the watershed has been completely developed. Several city parks within the project area would be expected to continue providing recreational opportunities for people who live and work in the area.

3.3.13 SOCIOECONOMICS

The future without a flood risk management project would be characterized by continuation of the current flood risk in the Upper Turkey Creek floodplain. Commercial and residential structures would be subject to physical damages from flood events, and the area also would experience a decrease in business income and tax revenue due to business closures during these events. After flood events occur, some businesses and residents may be forced to relocate outside the floodplain.

3.3.14 ENVIRONMENTAL JUSTICE

The future without a flood risk management project would not be expected to have any disproportionate impacts on minority or low-income groups in the Turkey Creek project area or surrounding areas. Only nine residential structures are located in the floodplain, and the census data do not show an exceptionally high presence of minority or low-income families in the area.

3.3.15 TRANSPORTATION

The future without a flood risk management project would not be expected to have any foreseeable permanent impacts on transportation activity or infrastructure in the Turkey Creek project area or surrounding areas. A future with a flood risk management project would reduce expected damage to roads in the floodplain.

3.3.16 RECREATION

In the future, the outdoor recreational opportunities along Turkey Creek would increase if the Turkey Creek Coalition's plan to extend the Turkey Creek Streamway Trail from the suburbs of Johnson County to downtown Kansas City is constructed.

3.3.17 CULTURAL RESOURCES

Because no NRHP-listed or eligible sites are present in the project area and unrecorded sites are unlikely because of urban development, there would be no impacts to cultural resources in the future with or without a flood risk management project.

4 CHAPTER 4 –PLAN FORMULATION

This chapter presents the results of the third step of the planning process, which is the formulation of alternative plans, and describes the development of alternative plans that address the planning objectives. An array of flood risk management measures and alternatives were developed to address one or more of the planning objectives. Watershed-based considerations have been included to the extent practicable. The alternatives described in this section are the basis for determining the costs and duration for elements of this feasibility study and, ultimately, the overall project schedule and cost.

In formulating, comparing, evaluating, and selecting alternatives for the Upper Turkey Creek project, the purpose, or performance goal, that we have pursued has simply been to maximize flood risk reduction (or minimize residual risk) within the broader goals and constraints of economic efficiency, environmental considerations, and sponsor finances.

4.1 PLAN FORMULATION METHODOLOGY

The results of the existing conditions analysis, observations and effects from historic and recent flood events were used to formulate potential solutions targeted at lowering the risk of flooding using a watershed perspective. Three primary sites of flood vulnerability were identified during the reconnaissance phase of the study: City of Merriam, Johnson County, Kansas; Roe Lane Industrial Area in Wyandotte County, Kansas; and the low-lying areas of I-35 in Johnson and Wyandotte Counties. These areas were the subject of subsequent flood risk management plan formulation and screening.

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

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

4.1.1 SYSTEMS APPROACH

One key challenge is to ensure that as the public and government leaders make flood risk management decisions, they integrate environmental, social, and economic factors and consider all available tools to improve public safety. This challenge is especially difficult when evaluating how the various systems in the environment and supporting our economy are closely interwoven. In the case of an urbanized watershed, many tradeoffs occur between areas upstream and downstream of the various stakeholders. Few understand the tradeoffs that previous decision makers have made that brought the communities to the situation they are in today. Therefore, one plan formulation methodology is to use a systems approach when formulating alternatives and evaluating those measurable outputs.

Because time and money also are important factors that limit the extent to which a systems approach can be applied, the planning team has taken advantage of as many existing tools as possible. One primary tool available from interagency efforts for this study is the watershed hydrologic and hydraulic models from Johnson County's update to the FEMA FIRMs (August 2009). These tools, developed by the local communities, enable a system approach. They consider the complex, enclosed urban storm drainage systems and the contributing drainage areas. A second system approach is to evaluate the state of the ecosystems in the study area with environmental field assessments using a watershed perspective.

4.1.2 LOCAL PERSPECTIVE

The local study sponsor, the City of Merriam, Kansas, recognizes the significant flooding threat from Turkey Creek. The MDD maintains the existing local channel project constructed in Merriam. The MDD has stable financing to maintain the channel, but it recognizes that the flood threat exceeds its technical and financial resources. Johnson County's SMP provides for local cost-shared assistance in addressing flooding problems. However, the cost of more comprehensive flood protection would place serious imposition on that program.

In 1988, the Kansas Legislature authorized counties to adopt a 1/10th-cent sales tax for the purpose of funding stormwater projects. These funds, dedicated to stormwater management, allow Johnson County through its SMP to create a yearly stormwater management plan and provide 75 percent of funding for eligible projects in Johnson County and the cities. The SMP provides financial, technical, and other stormwater assistance services to encourage regional solutions for protecting human lives and property, conserving natural resources, and promoting appropriate public use of Johnson County stream corridors. The Johnson County SMAC operates as an advisory board to the Board of County Commissioners. It is responsible for reviewing recommendations made in the SMP and providing recommendations to the Board of County Commissioners and considering new and innovative ways to properly manage stormwater.

The information in this report has been presented to the community through the use of clear and strategic communications with an emphasis on transparency. Direct input provided during the reconnaissance and feasibility phases from sponsors and stakeholders, at public meetings, and through written public comments provided a wide array of potential measures. The various alternatives were compared for their ability to meet the goals of the both the City of Merriam and the UG. Subsequent discussions with the non-federal sponsor were considered throughout the screening process.

Johnson County has continually expressed an interest in working with the City of Merriam and MDD in collaboration with the USACE for a flood risk management project. Initially in the study, the UG expressed interest in flood protection measures at the Roe Lane Industrial Park area (downstream from Merriam) but later on declined participation in a future cost shared project.

4.2 PLANNING CRITERIA

The USACE planning criteria requires that plans be evaluated against four criteria listed in the United States Water Resources Council's P&G: completeness, effectiveness, efficiency, and acceptability.

The following criteria were used to assess the overall characteristics of each alternative measure to identify those most likely to meet the project purpose and objectives.

- Engineering adequacy of the proposed solutions (effectiveness)
- Contribution to planning objectives (related to completeness of solution)
- Consistency with planning constraints and authorities

- Environmental, cultural, and public acceptability
- Early cost indicators (early efficiency indicators for screening purposes)
- Floodway conveyance considerations
- Hazardous and regulated waste site constraints (where applicable)
- Constructability (are construction techniques and quality difficult to attain at reasonable price)
- Construction site constraints (given existing features and development)

Effectiveness—Whether the measure or alternative would be effective in maintaining an acceptable level of flood risk management. The engineering adequacy of alternatives was analyzed and reviewed during the initial screening process. Conceptual measures were assessed for their potential to contribute substantially to the overall effectiveness of any alternative.

Environmental Effects—Direct and indirect effects of natural resources and cultural resources. Direct effects are those effects associated with the construction. Indirect effects are those effects that would occur as a result of a change in environmental conditions resulting from the construction or operation of the project. This criterion is related to the desire to minimize environmental effects and produce an environmentally sustainable project. It is also a component of overall effectiveness. Environmental effects of alternatives were reviewed in concert with appropriate resource agency guidance. Any alternative that had major disruptive effects on the environment was normally eliminated during the screening process. A typical formulation exercise would involve adjusting some of the alternative measures so as to minimize any environmental effects when such impacts could not reasonably be avoided.

Social Effects—Direct and indirect effects on socioeconomic resources, such as transportation, regional growth, public safety, employment, recreation, public facilities, and public services. This criterion is a component of overall effectiveness.

Acceptability—The environmental, cultural, and public acceptability of alternatives. Acceptability was analyzed and reviewed during the screening process. Controversy and potential effects on community cohesion and compliance with policy are indicators of acceptability.

Implementability—The existence of significant outstanding technical, social, legal or institutional issues that could affect the ability to implement the alternative. Implementability is related to the P&G criterion for acceptability.

Cost—The first cost of the project, costs of local operations and maintenance and long-term residual costs. These costs were used to determine if an alternative was prudent for further examination. As the evaluation process continued, cost estimates and economics were refined. Cost is related to two P&G criteria: efficiency and acceptability. Cost alone is not used to eliminate any alternatives, but cost is considered in relationship to the other criteria and for cost affordability considerations.

Risk—The uncertainties, vulnerabilities and potential consequences of the alternative. Risk is related to the P&G criteria of effectiveness and acceptability.

Separable Mitigation—The potential need for mitigation resulting from the project's implementation to address environmental, hydraulic, or other impacts. This criterion is related to all four of the P&G criteria.

Cost Effectiveness—Detailed cost estimating and economic analysis. The detailed cost estimate and economic analysis normally focused only on those alternatives that remained viable solutions after early screening criteria were passed. This criterion is a comparison of expected economic benefits and estimated costs for each alternative and between alternatives. Cost effectiveness is a primary

consideration in determining whether there is a federal interest in the project and to what extent federal participation can be justified. This is a component of the P&G criteria of efficiency.

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

Sustainability Considerations—The consideration of sustainable measures and activities important for the long-term viability of the community. The development and screening of alternatives also involved the consideration of a number of criteria suggested during the reconnaissance phase.

- The expected benefits will extend over long periods, i.e., 50 years or more.
- The proposed work will be compatible with applicable Federal, state, and local laws and ordinances, as well as ongoing efforts.
- Public health, safety, and well-being will be protected.
- The proposed work to be implemented will be compatible with local sponsor priorities.
- The most practical property interest/estates will be used and will vary between project features.
- The non-Federal sponsor is willing to cost share the planning, design, and construction of features and is willing to operate and maintain projects.

4.3 PROJECT SITING

The reconnaissance phase found two distinct and independent project sites that merited additional evaluation and development of flood risk management measures for the Upper Turkey Creek watershed. They are reaches of Turkey Creek associated with the downtown area in the City of Merriam, Kansas, and the Roe Lane Industrial Park in Wyandotte County. Flood risk management measures were considered for both the downtown Merriam area and Roe Lane Industrial Park. The I-35 corridor areas most prone to flooding were evaluated and dismissed from further consideration due to lack of a cost-sharing partner in that reach and low likelihood of measures that would significantly reduce flood damages. Ongoing coordination with KDOT revealed that it will continue to work with local jurisdictions to improve flood response in that corridor and the planning team will continue to highlight the flood risk there and cooperate with these activities to the maximum extent possible. Figure 4-1 shows the three flood risk management projects sites that were evaluated during

Figure 4-1: Project Sites

the initial plan formulation.

4.3.1 FLOOD RISK MANAGEMENT PROJECT SITES

The Merriam Reach project site is an area extending from Shawnee Mission Parkway downstream to Merriam Drive. This is river station (RS) 3.7260 to RS 2.6230. The channel was evaluated with respect to current and anticipated future hydrology, hydraulics, and watershed urbanization. Flood risk management features evaluated for this area involved replacement of bridges, retrofit of one bridge, channel modification, levees and floodwalls, and potential evacuation (removal) of structures. The planning goal is to contain flooding within the channel or modify the conveyance to the extent that flood damage to structures would be significantly reduced.

The Roe Lane Industrial Park in Wyandotte County is farther downstream; it begins just upstream of the Congressional project limit extending upstream to the railroad crossing of Turkey Creek just north of I-35 (RS 1.2720 to RS -0.5410). The Turkey Creek channel was evaluated for adequacy with respect to the anticipated future urbanization of the watershed. Flood risk management alternatives for this area involved replacing existing bridge structures with longer structures and reshaping the channel. The planning goal was to contain the flooding in the channel or modify conveyance to the extent that flood damage to structures would be significantly reduced.

4.4 MEASURES

A measure is a feature or activity at a site that addresses one or more of the planning objectives. Throughout the watershed, specific management measures, either a feature or an activity, can be implemented at specific geographic sites or across broad areas of the watershed to achieve desired effects. A feature is a physical element that generally requires site construction. An activity is an institutional (drainage district, city, or county) action that causes a change without immediate physical change, which may be a one-time occurrence or ongoing. Several alternative measures were identified for consideration in evaluating future possible actions in the Upper Turkey Creek watershed. Each measure was assessed using screening criteria and a determination was made regarding whether it should be retained in the formulation of alternative plans. Analyses for identification of the NED plan involved identifying an array of measures to achieve the stated objectives and then determining the most cost-effective combination of those measures that fully address the identified problems. Measures become part of alternatives, making each alternative unique in how measures are formulated together.

4.4.1 FLOOD RISK MANAGEMENT MEASURES

Flood risk management measures are either structural or nonstructural. Structural alternatives modify the flood and "take floods away from people" by features such as channels, levees, and dams. Nonstructural alternatives basically "take people away from floods," leaving the flood to pass unmodified. Nonstructural measures include both features and activities. Example nonstructural activities include land use regulations, redevelopment and relocation policies, disaster preparedness, flood warning and forecasting systems, flood plain information, flood plain acquisition and easements. Nonstructural measures also include features such as flood proofing, and onsite detention of flood waters by protection of natural storage areas or in human-made areas. Documenting the full menu of measures will contribute to better flood risk management in the watershed, and this information will be carried forward in the FMP.

Importantly, the public must be educated about flood risk management risks and actions that can be taken to reduce these risks. Because of this complex arrangement of responsibilities, only a life-cycle, comprehensive, and collaborative watershed perspective enables communities to sustain an effective

reduction of risks from flooding.

The methods used to evaluate the formulated alternatives include those for the primary authorized mission, flood risk management. The methods used for characterizing water surface elevations included standard hydraulic modeling program, HEC-RAS, and the standard hydrologic program, HEC-1. The HEC-Hydrologic Modeling System (HMS) was required for portions of the work. Because of the high degree of urbanization and the number of enclosed conveyance systems, standard practices (i.e., formulae for time of concentration adjustments) were used in the modeling and the characterization of hydrology patterns. The hydraulic and hydrologic modeling also used the hydrologic and hydraulic analysis prepared by Johnson County to develop the revised Flood Insurance Study.

STRUCTURAL FLOOD RISK MANAGEMENT MEASURES

The following structural measures were considered for flood risk management during plan formulation.

- **Off-line Impoundment Detention**—Floodwaters can be managed by providing off-line or channel storage, which is designed to contain only the peak of the flood hydrograph. The excess flow is diverted out of the stream over a long weir on the side of the channel into a separate storage facility.
- **In-line Impoundment/Detention**—Impoundment and managed release of floodwaters by a dam, reservoir, and detention basin can be an effective flood management measure. The dam site should be upstream but fairly close to the area to be protected and should be capable of storing sufficient amounts of water.
- **Levees**—A levee is defined as an earthen embankment whose primary purpose is to furnish flood protection from seasonal high water and that is therefore subject to water loading for periods of only a few days or weeks a year. Traditionally, in areas of high property values, high land use, and good foundation conditions, levees are built of compacted earth with relatively steep slopes and the levee alignment is dictated primarily by flood protection requirements. Levees built with smaller sections and steeper slopes generally require more comprehensive investigation and analysis during design than do levees with broad sections and flatter slopes whose design is more empirical.
- **Floodwalls**—The application of floodwalls was considered where space limitations made levees infeasible. A floodwall is defined as any wall having as its principal function the prevention of flooding of adjacent land. They are frequently built at the edge of the water to withstand periods of high water. Most floodwalls are of the inverted T type. The cross bar of the T serves as a base and the stem serves as the water barrier. When founded on earth, a vertical base key is sometimes used to increase resistance to horizontal movement. If the wall is founded on rock, a key is usually not provided. Where required, the wall can be supported on piles.
- **Bridge Retrofit or Replacement**—Flooding is increased where an existing bridge causes a substantial constriction in the channel flow area. It is sometimes necessary to replace the bridge with a wider or higher structure, thus modifying a bridge to increase the amount of flow area under the bridge. Although this can be costly, if the bridge is the managing factor in the flooding, the modifications are necessary to realize substantial benefits from other flood reduction measures, such as channel modifications.
- **Channel Modifications**—Reduced flood stages can be achieved by the widening, deepening, clearing, and straightening of the stream channel. Channelization results in a uniform channel cross section that improves hydraulic efficiency and thus allows the channel to contain larger storm events. The advantage of channel modifications is that they afford flood reduction/protection without advance actions prior to a flood event and do not fail when flows

exceed the design capacity.

- **Flow Diversion**—Diverting water during high flows rather than replacing the bridge or culvert is sometimes more cost effective at locations where flooding is caused by an inadequate structure. This option is only feasible in very specific circumstances.

NONSTRUCTURAL FLOOD RISK MANAGEMENT MEASURES

The following nonstructural measures were considered for flood risk management during plan formulation.

- **Flood Proofing**—Flood proofing is a combination of structural changes and adjustments incorporated in the design, construction, and alteration of individual buildings, structures, properties, and contents primarily for the purpose of eliminating or reducing water entry, thus, reducing flood damages. Nonstructural alternatives include a plan for flood proofing existing development in the protected areas comparable to the protection that would be provided by structural alternatives. Flood proofing measures could include the following:
  - **Dry Flood Proofing**—Features applied to a structure, or adjacent to a structure, to prevent entrance of flood waters
  - **Wet Flood Proofing**—Features applied to a structure and/or its contents that prevent flooding, or damage from flooding, by allowing flood water to enter the structure
- **Elevation**—Lifting of existing structures to an elevation greater than flood elevations using fill material, extended foundation walls, piers, posts or piles.
- **Relocation**—Physical movement of at-risk structures out of the flooding area and buying land upon which the structure is located.
- **Floodplain Evacuation**—The permanent relocation or evacuation of existing developments subject to flood damages involves the acquisition of land and structures in the floodplain either by purchase or through the exercise of powers of eminent domain, if necessary. Following this action, commercial and industrial developments and residential property on the floodplain are either dismantled or moved to a site away from the flood-prone area. Roads, railroads, telephone, and sewerage utilities also would have to be removed from the floodplain. Floodplain acquisition can be used to retire land that frequently floods to preclude Federal disaster payments, allow levee setbacks, or limit use of the land. However, all measures must be economically, environmentally, and socially defensible and technically sound. All long-term benefits must be weighed against the cost of continued damage on an average annual basis.
- **Flood Warning Systems**—A flood emergency preparedness system consists of a warning mechanism and a response plan. The implementation of flood warning systems is a long-term goal for many of the governmental agencies within the Upper Turkey Creek Basin.
- **Floodplain Ordinance**—The City of Merriam has a floodplain ordinance to ensure compliance with the FEMA NFIP. The City of Merriam must modify the existing ordinance or otherwise adopt a resolution that establishes the FMP, which will be drafted in conjunction with this study, as a formal planning document for managing floodwaters and the floodplains in the city.
- **Stream Setback or Buffer Ordinance**—Offsetting streams for the dedicated use by floodwater conveyance and environmental enhancement is a wise activity to consider and can be combined with structural measures. Within these areas or zones, the use of environmental features, including native plants and bioengineered stabilized stream banks, allow natural water quality improvement processes. These techniques also encourage infiltration of water to the groundwater table. Compatible uses, including parks and sports fields, are part of this type of policy. The policy can be reinforced with a stream setback/buffer, designated through an established offset

distance from the stream bank. This type of activity supports the beneficial use of floodplains and is considered wise use of the floodplain.

- **Freeboard Ordinance**—New development of finish floor elevations, by Kansas State law, must be a minimum of one foot above the base flood water surface, as defined by the NFIP. However, in some locations, communities adopt higher distances, which results in wider floodplains. These areas can then be left to support beneficial functions of floodplains.
- **Floodplain Management Plan**—An FMP is a living document (updated regularly) that explains flood risks, historical decisions about managing the flood risks, and, most importantly, a list of action items with specific details about what, who, and when the actions items will be conducted. The FMP will provide the public with better understanding of the residual risks of the alternative that is selected for any USACE construction cost sharing. The FMPs are policies used by FEMA and USACE. The USACE requires sponsors to have one as a condition for receiving construction funding. FEMA hazard mitigation grant programs and the NFIP Community Rating System (CRS) also require them. Besides the USACE criteria, the CRS criteria will be satisfied, and if the City engages in more eligible CRS activities, then not only will flood insurance premiums be reduced but also the public will better understand flood risks. The sponsor will prepare the Floodplain Management Plan coincident with design phase.
- **Emergency Action Plan**—The response to a flood event can be planned in advance within an Emergency Action Plan (EAP). Considerations such as evacuation routes, rally points for flood fight personnel, and other details can be established in an EAP. Plans such as this should be referenced in FMPs, and usually each should be a stand-alone document.
- **Local Hazard Mitigation Plan**—This type of plan may address all natural hazards, not just flooding. The preparation of such a plan allows a community to target repetitive loss properties, possibly for engaging FEMA hazard mitigation grants and for buyouts when a window of opportunity opens after a flood event. These plans must be completed in advance of events to be eligible for hazard mitigation grants. An FMP could be a sub-chapter or large section of such a plan. Note that county-wide plans are typically too broad to capture all the actionable items within an FMP, and a county-level mitigation plan may make a community less safe and unable to score higher points in the FEMA CRS.

4.4.2 ECOSYSTEM RESTORATION AND RECREATION MEASURES

Early in the study, ecosystem restoration measures were considered for potential multipurpose plan formulation throughout the watershed, but no cost-sharing sponsors were identified as willing to participate. However the data gathered in this early phase are very useful in facilitating a thorough understanding of the environmental conditions in the watershed. Recreation measures were not formulated, but consideration was given for accommodation of sponsor recreation features that will not impact project purposes. This primarily applies to accommodation of sponsor desires to maintain or, in some locations, expand a trail along Turkey Creek.

4.5 EVALUATION OF PROJECT SITES AND MEASURES

The initial plan formulation concepts that guided early portions of the feasibility study were based on producing a plan and report that addressed all areas within the study area. This approach began in the abbreviated studies conducted during the reconnaissance phase, which indicated the possibility of system-wide alternatives.

The initial broad feasibility evaluations of existing conditions undertaken during the first several years of this study allowed subsequent formulation efforts more focus. The development of measures was

narrowed to alternatives that indicated significant risk, offered the best opportunity for significant flood risk management improvements, and had the greatest potential for economic return on investment. These alternatives also were reviewed for compatibility with the basic planning objectives and constraints that emphasized the desirability of a relatively uniform level of flood risk management across the system.

The results of the preliminary evaluation of the project sites and measures considered and discussed in Section 4.3 and Section 4.4 include:

4.5.1 PROJECT SITES

Interstate 35 Project Site—Preliminary flood risk management measures were developed along the portion of I-35 most prone to flooding but were eliminated from further consideration because there was no likelihood of significant damage reduction. A state and locally managed flood response plan currently in place appears to be the most feasible alternative for the I-35 site. As a result, the I-35 project site was not carried forward in the development of flood risk management alternatives.

Roe Land Industrial Park Project Site—The Roe Lane Industrial Park project site flood risk management measures were developed but the UG found resources to be too strained to pursue a flood risk management project. As a result, the Roe Lane Industrial Park project site was not carried forward in the development of flood risk management alternatives.

Merriam Reach Project Site—The Merriam Reach project site was carried forward in the development of Alternative 1, Channel Widening; Alternative 2, Levees/Floodwalls; and Alternative 3, Combination. The City of Merriam is an active partner with a strong interest in flood risk management.

4.5.2 STRUCTURAL FLOOD RISK MANAGEMENT MEASURES

Off-Line Impoundment Detention—A preliminary investigation was performed of several tributaries to Upper Turkey Creek by review of aerial photography and selected site visits to locate potential areas for off-line impoundment/detention.

To achieve a reduction in discharge on the order of 45 to 50 percent of the 1 percent AEP flow, it is estimated that flood storage in excess of 1,000 acre-feet would be required. The areas along the tributaries in this watershed contain no significant open space to provide the potential flood storage required to reduce flooding in Merriam or downstream.

Significant property acquisition would be necessary to create the required volume of flow storage of approximately 1,000 acre-feet. Depending upon depth, this would require an area of at least 100 acres in zones that could affect the hydrograph, and realistically more than that. The Upper Turkey Creek watershed is highly developed and the volume of open space required to achieve a significant reduction in peak discharges to reduce flood elevations would require the acquisition of developed real estate. The cost of land acquisition, relocations, construction, and application of USACE Dam Safety criteria would make any such measures cost prohibitive in this watershed. This acquisition would likely exceed the cost of the Buy-Out non-structural plan. As a result, this measure was eliminated from further consideration in the development of alternatives. A similar evaluation was performed during the initial planning phases for the Lower Turkey Creek Basin project (currently under construction) with the same result.

In-line Impoundment/Detention—It was initially attempted to store potential flood flows within upstream watershed areas of Turkey Creek by creating flood storage within existing or proposed over bank areas of Upper Turkey. Analysis was conducted using HEC-1 on two potential in-line storage areas, identified as Area 1 and Area 2. Area 1 was from approximately 70th Street to 75th Street and Area 2 was from approximately 76th Street to 80th Street. It is estimated that the 1 percent AEP discharges would have to be reduced as much as 45 to 50 percent in order to remain within the channel. In order to achieve

a reduction in discharge on the order of 45 to 50 percent of the 1 percent AEP event, it is estimated that flood storage in access of 1,000 acre-feet would be required. Several alternatives were analyzed using different volumes and depths for Area 1 and Area 2.

After extensive work with both the HEC-1 and HEC-RAS models, it was determined that the available volume of flood storage in these two proposed storage areas are not sufficient to significantly reduce peak flood flows in the flood damage areas. The ability to significantly increase the volume of storage necessary to effectively reduce the peak discharges and reduce water surface elevations was not feasible. The areas along the main stem of Upper Turkey Creek and its tributaries contain limited open space to provide the potential flood storage required to reduce flooding in Merriam. Because of the high urbanization of the Upper Turkey Creek Basin and its narrow and steep nature, the availability of useful detention basin sites is limited. The area of open space, from review of aerial photography, does not appear adequate for the total estimated volume required. Therefore, land acquisition would be necessary to create the required volume of flow storage of approximately 1,000 acre-feet. The Upper Turkey Creek watershed is highly developed and the volume of open space required to achieve a significant reduction in reducing peak discharges to reduce flood elevations would require the acquisition of developed real estate. This acquisition would likely exceed the cost of the Buy-Out plan and was therefore eliminated from further consideration. As a result, this measure was eliminated from consideration in the development of alternatives. A similar evaluation was performed during the initial planning phases for the Lower Turkey Creek Basin project (currently under construction) with the same result.

Levees—Based on the review of the channel cross sections and hydraulic analyses, it was determined that levees between two and six feet in height could provide protection for up to a 1 percent chance of discharge with the possibility of larger levees for greater discharges. As a result, this measure was retained in the development of Alternative 2, Levees/Floodwalls; and Alternative 3, Combination. Levees by themselves require a wider footprint than floodwalls and real estate and existing buildings are a constraint. Therefore, levees and floodwalls were only considered in combination in the development of Alternative 2, Levees/Floodwalls; and Alternative 3, Combination.

Flood Walls—The preliminary review of channel cross sections and hydraulic analyses indicated that flood walls would be a viable measure for flood risk management in areas where there was insufficient space for construction of levees. As a result, this measure was retained in the development of Alternative 2, Levees/Floodwalls; and Alternative 3, Combination. However, an alternative utilizing floodwalls only was not considered due to a higher overall cost to construct floodwalls in comparison to the cost to construct levees. Therefore, floodwalls and levees were only considered in combination in the development of Alternative 2, Levees/Floodwalls; and Alternative 3, Combination.

Bridge Retrofit or Replacement—The preliminary evaluation indicated that the Merriam Drive and Shawnee Mission Parkway crossings would require modifications since both the 10 and 1 percent AEP events overtop the bridge, and the constriction causes a two-foot rise in water surface elevation in the upstream storm profile. As a result, the modification of these crossings was retained in the development of Alternative 1, Channel Widening; and Alternative 3, Combination.

Channel Modifications—Hydraulic analyses indicated that channel modifications, either alone or in conjunction with levees and floodwalls, would have potential for significant flood risk reduction. As a result, this measure was retained in the development of Alternative 1, Channel Widening; and Alternative 3, Combination.

Flood Diversion Around Structure—A flood diversion tunnel was considered and evaluated in the development of alternatives, but was eliminated from further consideration in the development of alternatives. The cost for a diversion tunnel was estimated at approximately $200 million and a drop shaft and detention facilities would also be required at additional costs. The diversion would need to operate by

gravity flow while only removing 40 percent of the peak flows in downtown Merriam. The intensive investment, topography and geology in the study area precluded this from being a practical measure. As a result, this measure was eliminated from consideration in the development of alternatives. A similar evaluation was performed during the initial planning phases for the Lower Turkey Creek Basin project (currently under construction) with the same result.

4.5.3 NONSTRUCTURAL FLOOD RISK MANAGEMENT MEASURES

Flood Warning Systems—Integration of a flood warning system across jurisdictional boundaries was investigated because the effectiveness or acceptability of some of the nonstructural flood risk management solutions may be affected by the accuracy and reliability of flood warning. A flood warning system is an integrated package of equipment, plans, procedures, and human resources that permits its users to:

- Detect and recognize a flood hazard early in its existence, prior to the point at which lives and property are at imminent risk
- Notify those whose lives and/or property are at risk
- Make wise decisions and respond in a timely, efficient manner to the near-future flooding
- Make wise decisions about how to recover from flooding, once the threat has passed

In August 2002, the Johnson County SMP retained a project team led by the Peridian Group to complete a study to determine the feasibility of a flood warning/flood forecasting system in Johnson County, Kansas. If the system were determined to be feasible, the next step would be to develop an implementation plan and identify the potential costs.

The result of this work is StormWatch, a website maintained cooperatively by Johnson County with the local communities. The flood warning system feature was not used to formulate alternatives in which there would be a Federal cost share interest. The August 2002 Johnson County SMP study determined that the implementation of a website, StormWatch, maintained cooperatively by Johnson County with the local communities was a feasible plan for a flood warning/flood forecasting system in Johnson County, Kansas.

A dedicated flood warning system for the Turkey Creek watershed was not developed by local governments nor considered for detailed plan formulation, primarily because StormWatch already has precipitation and stream gages in Merriam. There was not a likely Federal interest in further expansion of the system to a Federally cost shared flood warning system. Because of this and the flash flooding occurring in as little as 30 minutes, a dedicated flood warning system solely for the Turkey Creek watershed was not considered practical by the community or the Corps of Engineers.

In addition to StormWatch, the KDOT has developed a smarter traffic control system in the I-35 reach of Johnson County, one that better communicates with the public. KDOT constructed a series of electronic signs to communicate transportation-related messages to travelers on the highways in the entire Kansas City metropolitan area, including I-35 in Johnson County and the City of Merriam. This tool, KC Scout, could be linked with StormWatch to enhance communication techniques, possibly even leveraging KC Scout's website and electronic cameras. Planners have approached KDOT about combining these tools to address flood hazards where Turkey Creek and I-35 overlap. Because KDOT and Johnson County already have significantly advanced these tools, this was not carried further into plan formulation.

Flooding along the I-35 corridor, just upstream of the Wyandotte/Johnson County line, occurs for storms as frequent as the 10 percent AEP event at select portions of the roadway. Flood risk management measures were developed along the portion of I-35 most prone to flooding but were eliminated from

further consideration. Structural measures would not have the ability to significantly reduce flood damages. KDOT's KC Scout and Johnson County's StormWatch are considered by the local agencies as adequate nonstructural measures at this time. The USACE will continue to coordinate with these agencies as this project moves forward and as other opportunities for addressing flood risk may arise.

Limited Floodplain Buyout—Some additional consideration was given to more limited buyout alternatives, focused on areas with the highest concentrations of expected flood damages. It was determined that these alternatives would not offer as much net economic benefit as the structural alternatives and would not be locally acceptable, due to the economic void that would be left in downtown Merriam.

Floodplain Evacuation or "Buyout"—The property buyout alternative is considered a nonstructural flood risk management alternative. The floodplain buyout alternative was carried forward for further consideration in plan formulation. Generally, home buyouts involve those homes located within the flood zone being bought and demolished or transported to a safer location. The associated costs with this alternative are the acquisition of the structure at fair market value and the costs to demolish or relocate these units. There are various benefits that can result from structure buyouts in an affected area: the reduction of damage to public property, the reduction of emergency costs during a flood, the reduction of administrative costs during a flood, reoccupation costs, and the reduction in flood insurance subsidies to communities. Usually, several public meetings are conducted by a watershed-wide coalition to outline the plans and answer residents' specific questions.

Other Nonstructural Measures—The other nonstructural flood risk management measures were considered early in the study and are described above in Section 4.3.1.2, including flood proofing, flood insurance, zoning codes, stream setback ordinances, and public education, but they were not carried further into plan formulation. These measures were not effective at protecting existing development comparable to the protection that would be provided by structural alternatives. As a result, these measures were eliminated from consideration in the development of alternatives. However, through the efforts of this study and other efforts in cooperation with FEMA and Silver Jackets, the education of the community regarding flood risks is ongoing. Johnson County has proactively pursued and implemented stream setback ordinances that encourage wiser use of the floodplain.

The results of the preliminary evaluation of the other nonstructural measures considered and discussed in Section 4.3 include:

- **Dry Flood Proofing**—Features applied to a structure, or adjacent to a structure, to prevent entrance of flood waters. The depth of flooding for the 1 percent AEP event was compared to the first floor elevations of the structures within the Upper Turkey Creek floodplain. A majority of the structures would be subject to a depth of flooding in the 5 foot to 7 foot range. The number of structures within the floodplain and the feasibility of constructing individual ring levees, or erecting permanent flood barriers for each property were determined to be impractical based upon the wide diversity of construction types among structures, the short time of concentration, less than six hours, and flashy nature of the stream and watershed.
- **Wet Flood Proofing**—Features applied to a structure and/or its contents that prevent flooding, or damage from flooding, by allowing flood water to enter the structure. This was also eliminated as a feasible alternative as most of the structures first floors are below flood stage, and again the short time of concentration to peak would not provide sufficient time to remove or raise equipment, above the flood elevation.
- **Elevation**—Lifting of existing structures to an elevation greater than flood elevations using fill material, extended foundation walls, piers, posts or piles. A majority of the structures within the

projects area(s) are light industrial/commercial and have loading docks and floors at ground level for the operations, which would make raising of the structures impractical.

- **Relocation**—Physical movement of at-risk structures out of the flooding area and buying land upon which the structure is located. The water shed is extremely developed and the number of structures which would be required to be re-located exceeds the amount of available vacant land within the immediate project area.

4.5.4 ECOSYSTEM RESTORATION AND RECREATION MEASURES

Ecosystem Restoration Measures—Early in the study process preliminary ecosystem restoration measures were considered throughout the watershed in anticipation of a potential multipurpose project. The ecosystem restoration measures were not carried forward or used to formulate because there was no local sponsor with an interest in cost-sharing ecosystem restoration measures.

Recreation Measures—Recreation measures were not formulated, but consideration was given for accommodation of sponsor recreation features that will not impact project purposes. This primarily applies to accommodation of sponsor desires to maintain or, in some locations, expand a trail along Turkey Creek.

4.5.5 MEASURES SCREENING REVIEW

The preliminary screening of measures allows the planning team to narrow the list of measures most suitable to mitigating the flood hazards. How the study team applied the criteria to various measures allows the reader to better understand the plan formulation conclusions. The process is described below and is provided to show how the study team applied the criteria to various measures prior to development of the preliminary array of alternatives.

Measures that meet the criteria the most received this symbol: ◉

The symbol constitutes (and depicts) a bull's eye and means the measure is "Highly Effective" or "Recommended" in meeting planning objectives and should be formulated into an alternative for this study.

Measures that meet the criteria fairly well received this symbol: ◓

The symbol means the measure is "Effective" in meeting planning objectives.

Measures that may meet the criteria received this symbol: ○

The symbol means the measure is "Neutral" or possibly "Further Evaluation Needed" as to how the measure may meet planning objectives. Study funding often limits the ability to fully evaluate this. Other realities are that a hypothetical model may not exist to allow a determination on the measure's possible performance.

Measures that do not really meet the criteria received this symbol: ◒

The symbol means the measure is "Not Recommended" in meeting planning objectives.

Measures that cannot meet the criteria use this symbol: ●

The symbol means the measure is "Not Recommended" and more definitively defeats or detracts from meeting planning objectives. Specific meaning of each metric is described in the following table.

Table 4-1: Supporting Definitions of Screening Criteria

Screening Criteria	Metric[1]	Notes
Completeness	Highly effective Effective Neutral Not effective Not effective and detracts from objectives	• Extent to which a given measure provides and accounts for all necessary investments or other actions • A complete measure includes all elements necessary to function independently to achieve the planning objectives
Effectiveness	Highly effective Effective Neutral Not effective Not effective and detracts from objectives	• Overall effectiveness of a measure in maintaining an acceptable level of flood risk management in the Upper Turkey Creek project area based on technical analysis, such as with a model, to the USACE mission area, whether flood risk management or ecosystem restoration • Conceptual measures were assessed to determine their potential to contribute substantially to the overall effectiveness of any alternative
Environmental Effects	Highly effective Effective Neutral Not effective Not effective and detracts from objectives	• Produce an environmentally sustainable project • Component of overall effectiveness
Social Effects	Highly effective Effective Neutral Not effective Not effective and detracts from objectives	• Criteria for how this satisfies the project's planning objectives • Component of overall effectiveness
Acceptability	Highly effective (publically acceptable) Effective Neutral Not effective with some social controversy Not effective and detracts from objectives (unacceptable to many stakeholders)	• Indicators of acceptability include controversy and potential effects on community cohesion and compliance with policy
Implementability	Highly effective Effective Neutral Not effective Not effective and detracts from objectives	• This is about compatibility with policies at the local, state or federal level and consideration of issues that could affect the ability to implement the measure or alternative • Constructability with common methods • Ability of local sponsor to support within or without the municipalities boundaries or ability to fund the measure • Degree of inter-local collaboration needed to achieve the measure either on multiple properties or throughout a watershed
Cost	Highly effective (costs are achievable) Effective Further study needed Not effective (costs high and likely not budgetable) Not effective and detracts from objectives	• First cost of project, costs of local operations and maintenance and long-term residual costs • Basis is available funding ability from local, county, state or federal, or a combination • Sponsor capital improvement plan sets the

Screening Criteria	Metric[1]	Notes
	(Costs are too excessive)	neutral threshold around $5.8 million • Federal is variable • Considered in relation to efficiency and acceptability
Risk	Highly effective (reduces risk) Effective Further study needed Not effective Not effective and detracts from objectives	• Uncertainties, vulnerabilities, and potential consequences of the measure • How measure address flood risks • Risk is the probability multiplied by the consequence • Effective measures reduce flood risk, though some risk remains • Workability and viability of a measure as part of a formed alternative are part of the criteria
Separable Mitigation	High effective (mitigatable) Effective Neutral Not effective Not effective and detracts from objectives	• Need for compensatory mitigation under Clean Water Act • Is mitigation possible • Effects to project cost
Cost Effectiveness	Highly effective (costs very low) Effective Further study needed Not effective Not effective and detracts from objectives (costs very high)	• Compares expected economic benefits and estimated costs of alternatives • Primary in consideration of federal interest
Floodway Conveyance Considerations	Highly effective Effective Neutral Not effective Not effective and detracts from objectives	• Avoidance of impacts to established conveyance
Sustainability Considerations	Highly effective Effective Neutral Not effective Not effective and detracts from objectives	• Consideration of sustainable measures and activities for the viability of the community (i.e., health and safety, minimal maintenance, willing project sponsor)

[1]The symbol legend (Highly effective to Not effective and detracts from objectives):

In addition to the evaluation and discussion of the project sites and measures eliminated and project sites and measures carried forward in Sections 4.5.1 through 4.5.4 the table below represents preliminary screening. The table juxtaposes the criteria against the full spectrum of structural and nonstructural measures. Only the flood risk management screening is presented. As the planning process develops, new information is often found. The screening represented conditions found at the time the planning work was done.

Table 4-2: Screening Against Planning Criteria for Flood Risk Mauagement Measures[1]

Measure	Completeness	Effectiveness	Environmental Effects	Social Effects	Acceptability	Implementability	Cost	Risk	Separable Mitigation	Cost Effectiveness	Floodway Conveyance Considerations	Sustainability Considerations	Notes
STRUCTURAL													
Off-line Impoundment / Detention	●	◒[1]	○	●	◒	●	○	◒	◓	○	◍	◓	1) Not enough land area and volume available
In-line Impoundment / Detention	◒	◒[1]	◒	◒	◓	○	○	◒	○	○	◍	◓	1) No volume available
Levees[3]	◓	◍	◓	◓	◓	○	◓	◓	◍	◍	◓[2]	◓	2) No negative change in flood conveyance
Floodwalls[3]	◓	◍	◓	◓	◓	◓	○	○	◍	◓	◓[2]	◓	2) No negative change in flood conveyance
Bridge Retrofit or Replacement (widening)[3]	◍	◍	◓	◍	◓	◓	◓	◓	◍	◒	◍	◓	(No note)
Channel Modifications (widening)[3]	◓	◓	◒	◒	◓	○	◒	◓	◒	◒	◍	◓	(No note)
Flow Diversion	○	◒	●	○	◓	●	●	○	◒	●	○	○	Affects base flow

[1]The symbol legend (Highly effective to Not effective and detracts from objectives): ◍ ◓ ○ ◒ ●

[3] Carried forward in the development of flood risk management alternatives.

Table 4-2: Screening Against Planning Criteria for Flood Risk Management Measures (Continued[1]

Measure	Completeness	Effectiveness	Environmental Effects	Social Effects	Acceptability	Implementability	Cost	Risk	Separable Mitigation	Cost Effectiveness	Floodway Conveyance Considerations	Sustainability Considerations
NONSTRUCTURAL												
Flood Proofing												
Dry flood proofing	○	◒	○	○	◒	●	○	○	NA	○	◍	◍
Wet flood proofing	○	◒	○	○	◒	◒	○	◒	NA	○	◍	◍
Elevation	○	◒	◓	○	○	○	○	○	NA	○	◍	◍
Relocation	●	◓	◓	●	◒	◒	○	◓	◓	○	◓	○
Flood Warning Systems	○	◒	◍	○	◒	○	○	◒	NA	◍	NA	◍
Floodplain Evacuation or "Buyout"[3]	●	◓	◓	●	○	○	●	◓	◓	●	◍	○

[1]The symbol legend (Highly effective to Not effective and detracts from objectives): ◍ ◓ ○ ◒ ●

[3] Carried forward in the development of flood risk management alternatives.

No cost share partner stepped forward for the ecosystem restoration. The study had a significant effort developing ecosystem restoration strategies in the watershed for the purpose of

- Channel bottom armoring (prevent down-cutting)
- Removal of obstructions to fish passage
- Detention basin retrofits for water quality
- Opened up enclosed channels
- Bioengineered stream banks
- Re-establish floodplain to channel connectivity
- Rainfall infiltration

The results appear in two interim reports done for the non-Federal sponsor and the adjacent communities. These reports are located in Appendix J.

4.6 PRELIMINARY ARRAY OF ALTERNATIVE PLANS

Based on the identified problems and opportunities, project goals, objectives, and conditions in this study area, measures with the greatest potential for meeting planning objectives were formulated into alternative plans. The planning steps of formulating, evaluating, and comparing alternative plans were accomplished iteratively as information about the alternatives developed. The product of this process was to establish the alternatives for the evaluation step in the P&G six step planning process.

4.6.1 STRUCTURAL FLOOD RISK PLAN FORMULATION

The capacity of the Turkey Creek channel was evaluated with respect to the hydraulic analyses, watershed urbanization, and structures subject to flood hazards. Structural measures reduce flood risk by modifying the characteristics of the flood. They are often employed to reduce peak flows (flood storage), direct floodwaters away from flood prone property (flood barriers), or facilitate flow of water through or around an area (channel modification or diversions). All of these features have the potential to reduce flood damages; however, not all are likely to be appropriate in every situation.

A flood risk management alternative plan for the study area could involve replacing bridges, retrofitting one bridge, channel widening, channel benching, constructing vertical channel walls where space is too constrained for widening or benching, and making plans for minor evacuation.

Based upon judgment and existing conditions analyses, the structural flood risk management measures retained were used to develop basic series of alternative concepts or "themes" that would be necessary for the alternatives to address the planning objectives.

- Alternative 1 Concepts: Channel Widening
- Alternative 2 Concepts: Levees / Floodwalls
- Alternative 3 Concepts: Combination of Channel Widening and Levees / Floodwalls

4.6.2 NONSTRUCTURAL FLOOD RISK PLAN FORMULATION

The Federal government has endeavored to support nonstructural approaches (such as flood warning systems, flood-proofing of structures, floodplain management, and property buyout). Nonstructural approaches have merit when the site characteristics and the flooding threat are compatible with the nonstructural capabilities and found acceptable to stakeholders. Additionally, it may be possible to

combine nonstructural and structural measures to improve the overall level of flood risk management. The ability for this to be feasible depends on the specific conditions of the area being considered.

Based upon judgment and existing conditions analyses, the nonstructural flood risk management measures retained were used to develop a nonstructural alternative concept or "theme" that would be necessary for the alternatives to address the planning objectives.

- Alternative 4 Concept: Buyout

The planning team conducted a real estate cost analysis for the inundation area of the 1 percent AEP event, or the NFIP base flood extents. This floodplain buyout alternative used the following assumptions.

- Properties within the 1 percent AEP floodplain that were affeeted by improvements or use were considered a complete take. The minimum land take was estimated at $5,000.
- A cursory examination of the project improvements and lands was completed to determine the Land, Easement, Right-of-Ways, Relocations, and Disposal areas (LERRDs). Some structures were eliminated if not located within the 1 percent AEP floodplain.
- Appraised values were obtained from the County Appraiser's Office. The appraised values are considered consistent with current values. Values missing from appraiser's data were calculated at a value of $50,000/acre if over the $5,000 minimum.
- Relocation was estimated in 2008 and will be recalculated in the Real Estate Plan during the Gross Appraisal.
- A 25 percent contingency was included in the total real estate value.
- Non-Federal sponsor incidental costs associated with acquisition were estimated based on required components, such as appraisals, tract surveys, legal support, and additional Public Law 91-646 cast. Due to level of detail for this alternative, a set amount of 10 percent of total costs including contingency was used.
- No cost for utility, railroad, or road relocations was included based on level of detail of this alternative. Mapping indicated that all three are impacted by the 1-percent AEP flood and could cause significant costs to relocate.

4.6.3 DEVELOPMENT OF FLOOD RISK MANAGEMENT ALTERNATIVES

The study team performed preliminary technical analysis of proposed measures and evaluated these using the screening criteria to focus on the most implementable alternatives. Those measures that appeared to be most viable with respect to planning criteria were refined and further developed. Using the information developed, the study team compared the alternatives to each other to screen out inferior plans and identify the most feasible and beneficial plans. Initial screening results were presented to the non-Federal sponsor in November 2009. This discussion was used to narrow the alternatives further.

Three basic series or concepts of structural alternatives were developed: Channel Widening Alternatives, Levees and Floodwalls Alternatives, and Combination Channel Widening and Levees/Floodwalls Alternatives and one nonstructural alternative was developed, Buyout.

Alternative 1: Channel Widening—Channel widening was considered as a flood abatement measure in areas where overbank expansion was available. Because the majority of the channel currently has a hard slate bottom, channel bottom deepening was minimized. The proposed channel bottom width was kept constant, wherever possible, with a maximum side slope in most areas of 2H:1V (or horizontal: vertical), which allows the channels to be lined with either biostabilization, rip rap or concrete block measures. Areas that require steeper slopes in excess of 1H:1V would be treated with hardened revetments, such as

pre-cast retaining wall block or the local limestone blocking currently used by MDD in the Merriam downtown stream reaches. For the Merriam and Roe Lane Industrial Park reaches, channel widening was considered with rip rap slope protection as well as biostabilization. Bridge modifications were also considered in channel widening alternatives.

Alternative 2: Levees and Floodwalls—A levee is a compacted and engineered earthen embankment. For this study, practical levee dimensions ranged from heights of 2 to 7 feet high and practical proportional footprints ranging from 2 to 3H to 1V. Floodwalls were used when overbank area or proximity to structures precluded a levee footprint. The proposed floodwalls would consist of a reinforced concrete retaining wall generally with a minimum thickness of two feet. Bridge modifications were not considered a part of this alternative.

Alternative 3: Combination of Channel Widening and Levees/Floodwalls—The combination alternative minimizes the required channel width by introducing either a levee or a floodwall where needed. A combination of channel widening and levee walls was considered and could be more cost effective than levees or floodwalls alone, while providing better flood protection than channel widening alone. The channel widening component of the combination alternative included rip rap slope stabilization, biostabilization slope protection, and necessary bridge modifications.

The biostabilization slope protection measures considered in the early development of Alternative 1, Channel Widening; and Alternative 3, Combination were not carried forward for further evaluation due to the excessive cost of operation and maintenance for these features and their lack of reliability at withstanding flows compared to less costly structural alternatives considered. Although not evaluated in detail, it is not expected that the biostabilization would substantially improve the overall environmental quality of the Turkey Creek watershed.

Alternative 4: Non-structural: Buyout—Once structures in the floodplain are removed, they are no longer subject to flood damages. There are many considerations associated with a property buyout including demolition, relocation, and other costs. The floodplain can be considered for restoration after a property buyout would be implemented.

4.7 EVALUATION TOOLS

Evaluation tools are described, as follows, from the feasibility study's quality assurance or review plan. The project delivery team (PDT) used the following planning models in the development of this study:

Table 4-3: Upper Turkey Creek Planning Models

Model Name and Version	Brief Description of the Model and Application
HEC-FDA 1.2.4	The Hydrologic Engineering Center's Flood Damage Reduction Analysis (HEC-FDA) software provides the capability to perform an integrated hydrologic engineering and economic analysis during the formulation and evaluation of flood risk management plans. The HEC-FDA is designed to assist USACE PDT members in using risk analysis procedures for formulating and evaluating flood risk management measures (EM 1110-2-1619, ER 1105-2-101).
IWR-PLAN 1.0.11.0	The Institute for Water Resources' (IWR) Planning Suite is a model that assists with formulating plans, cost-effectiveness, and incremental cost analysis, which are required in ecosystem restoration projects and any compensatory mitigation.
Habitat Suitability Index Models: Green Sunfish	For use in doing cost effectiveness and incremental cost analysis of the Clean Water Act compensatory mitigation for the affected stream.
Habitat Suitability Index	For use in doing cost effectiveness and incremental cost analysis of

Model Name and Version	Brief Description of the Model and Application
Models: Fox Squirrel	the Clean Water Act compensatory mitigation for the affected forested area.

The PDT used the following engineering models in the development of the study:

Table 4-4: Upper Turkey Creek Engineering Models

Model Name and Version	Brief Description of the Model and Application
HEC-1, version 4.1	The PDT used the USACE Hydrologic Engineering Center's model to reevaluate peak flows of Turkey Creek at specified locations, screen out detention basins as possible features in alternatives as a means as reducing peak discharges and resultant water surface elevations; use for load points to HEC-RAS existing conditions analysis and proposed improvements.
HEC-RAS 4.0	The PDT used the USACE Hydrologic Engineering Center's River Analysis System to establish peak water surface elevations for a range of probabilities (8 profiles) for existing and proposed alternatives input for HEC-FDA (see below).

A HEC-RAS model was developed for the projeet area consistent with the recently adopted Johnson County flood insurance study, and included the addition of the Roe Lane Industrial Park project site in Wyandotte County. Once the storm frequency flood profiles were developed, the extent of flooding was generated and analyzed using a GIS. Software tools for the determination of the discharges were developed and applied. GIS was used to identify the extent of the proposed alternatives, impact on properties and structures, land ownership, easement areas required, existing utility information, and existing and proposed floodplains. GIS also was used as a tool in the development of cost estimates for the various alternatives and ecological restoration measures.

The evaluation and comparison of structural flood risk management alternatives involved the identification of the most critical areas of flooding and occurrence of flood damages and determination of the best alternative for flood risk management. This study focused on the areas where damages and losses are greatest and most amenable to practical damage reduction measures.

Flood frequency analysis is required to identify the flood magnitude for each return period. Therefore, a comprehensive flood frequency analysis has been carried out for the entire project area. The HEC-RAS model was used to determine flood inundation depth in the floodplain areas. The model was developed to predict discharges and water levels of each reach for different return periods of floods in existing situation and mitigation plan alternatives.

Flood damage estimation in inundated areas is one of the key parts of the flood studies. In order to provide an accurate damage amount, a flood damage survey was performed in the most critical areas of the floodplains in addition to gathering historical data of damage from recent floods. Therefore, estimating potential damage must be based on the vulnerability of the region as a method of damage analysis. A GIS database was built using maps and the results from the model.

The planning team conducted physical, habitat, and biological data collection and evaluation in representative reaches throughout Upper Turkey Creek in May and June 2005. These data were then used to develop an overall stream health assessment ranking for approximately 100 reaches on the Upper Turkey Creek and its tributaries. Several additional environmental tools were also used for evaluation of

potential restoration measures. The KDWP's Aquatic Habitat Model and Terrestrial Habitat Model along with the Kansas Stream Mitigation Guidance (KSMG) were used to evaluate aquatic and terrestrial resources. These data were not used for further plan formulation but were used to assess the watershed system and potential effects of flood risk measures.

4.7.1 PERIOD OF ANALYSIS

In addition to the existing conditions of 2012, a base condition and a future condition were analyzed. The base year for the economic analysis, i.e., the year when the project would be completed and operational, is 2018. The future condition year is 2042.

In this analysis, the economic database for the existing condition also was used to characterize the base and future conditions. These conditions initially were defined separately to allow the addition of planned development late in the study completion period based on the most current information about future development. Because economic development plans potentially affecting the future without-project condition tend to be fluid and speculative, assumptions in this area were established as late in the study as possible. Ultimately, however, no imminent projects that met the criteria for inclusion were identified: (a) high likelihood of implementation, (b) firm identification of a location, and (c) availability of information on industrial classification and estimated investment. Therefore, the economic database used in the existing conditions analysis was carried through to the base and future conditions without change.

Annualized estimates of damages, benefits and costs in this analysis assumed the FFY 2012 Federal interest rate of 4.000 percent and a period of analysis of 50 years based on official guidance for evaluation of Federal levees. All estimates are expressed in October 2011 prices unless otherwise noted.

4.7.2 MODELING

A hydrologic model (HEC-1) and a hydraulic model (HEC-RAS) are each combinations of models first begun by Johnson County Public Works models between 2005 and 2009 to update FEMA FIRMs and the USACE around 2005 and 2006 for Turkey Creek reaches within Wyandotte County. The consulting engineer firm, Larkin, contracted with Johnson County creating those models for results presented in the northeast Johnson County watershed study, and Larkin also did similar work for the USACE (as part of work in-kind credit to the sponsor, Merriam) in Wyandotte County. The products received external review with Dr. Parr of the University of Kansas. They are described as combinations because the latest updates were taken by the USACE planning team around 2009 to enhance the modeling tools to evaluate planned alternatives.

The versions of both the hydrologic and hydraulic model are approved and certified according to USACE guidance. The planning team used HEC-1 version 4.1 to reevaluate peak rainfall runoff flows of Turkey Creek at specified locations, screen out detention basins as possible features in alternatives as a means as reducing peak discharges and resultant water surface elevations, and use for the load points to HEC-RAS existing conditions analysis and proposed improvements. The flood risk management alternatives were analyzed using HEC River Analysis System, or HEC-RAS 3.1.3. The HEC-RAS is software developed by the USACE to conduct one-dimensional steady flow river hydraulic calculations. As mentioned in Section 3.2.3, the base of the existing Upper Turkey Creek feasibility study existing condition model was the hydraulic HEC-RAS model. The alternatives were initially formulated for the 10-, 2-, and 1 percent AEP events. For levee and flood wall alternatives and combination alternatives, 0.5- and 0.2 percent AEP events were also considered. Bridge modifications are required for some alternatives and are discussed below.

The flood risk management alternatives were then analyzed using two planning models. The first is FDA (HEC-FDA) software developed by the USACE for doing risk analysis. The second is the Institute for Water Resources' (IWR) Planning Suite, a model that assists with analyzing cost effectiveness.

The HEC-FDA software, version 1.2.4, provides the capability to perform an integrated hydrologic engineering and economic analysis during the formulation and evaluation of flood risk management plans, following Federal and USACE policy regulations (ER 1105-2-100 and ER 1105-2-101). HEC-FDA uses discharge-exceedance probability, stage-discharge, and damage-stage functions and applies Monte Carlo simulation to compute expected damage and account for uncertainty. According to policy, newly constructed Corps levees are essentially assumed to be structurally reliable up to the point of overtopping. For any event in which the levee is overtopped, the overtopping would be enough to exceed the design of the levee and render any associated structural problems moot. After any flood event that damages the levee, there would be a potential need for repair, rehabilitation, and/or replacement; the OMRR&R component of the annual costs is intended to account for costs such as these. Therefore, the HEC-FDA model assumes the newly constructed levees and floodwalls to be structurally reliable throughout the 50-year period of analysis.

Mitigation options to meet requirements for compensatory restoration were evaluated using the USACE Institute for Water Resources IWR Planning Suite software. The IWR Planning Suite software was version 1.0.11.0, and is a Certified Decision Support Software to assist with the formulation and comparison of alternative plans. Specifically the model does cost effectiveness and incremental costs analysis (CE/ICA), identifying the plans which are the best financial investments. IWR Planning Suite can assist with plan formulation by combining solutions to planning problems and calculating the additive effects of each combination, or "plan;" however, the compensatory restoration options that were evaluated for Upper Turkey Creek were viewed as mutually exclusive from one another. So the compensatory restoration options were evaluated only in comparison to each other, without evaluating combinations of restoration options.

4.7.3 PERFORMANCE MEASURES

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

The process includes damage cost assessment for different flood levels in various plans separately. It was therefore necessary to conduct a cost/benefit analysis for the alternative flood mitigation schemes and select the best alternative by means of flood risk management based analysis and cost assessment.

The HEC-FDA software was used in the benefit analysis for the various mitigation alternatives. A risk-based damage analysis was conducted to identify annual benefits of a certain mitigation alternative, and economic assessment was performed based on cost/benefit analysis to select the best alternatives. HEC-FDA software was used in this study for the following purposes:

- Determination of expected benefits of the proposed flood mitigation plans with regards to expected damage reduction by implementing the plan in comparison with not implementing the plan condition
- Description of the uncertainty of computing probability versus discharge, discharge versus stage, and damage versus stage and determining the effects in reducing the damages

A flood mitigation plan can decrease damages by reducing discharge, stage, or damage susceptibility. The net benefit of these plans can be calculated by a costs/benefits analysis of a project in optimum design flood. The optimum return period of design flood can be determined by a trade-off between construction costs and operational benefits in certain plans considering risk of failure of the structure.

The average annual **without-project damage** is calculated in the HEC-FDA program, using water-surface profile data and floodplain property inventory data. The average annual **with-project damage** (residual damage) is also calculated in HEC-FDA, using water-surface profile data and floodplain property inventory data.

Benefit = Without-Project Damage – With-Project Damage

The average annual **cost** is determined by annualizing the project's initial cost and adding the expected average annual cost of operations and maintenance.

Benefit-Cost (BC) Ratio = Benefit ÷ Cost

Net Benefit = Benefit - Cost

In Figure 4-2 the hypothetical **NED plan** is the plan with the highest **net benefits**.

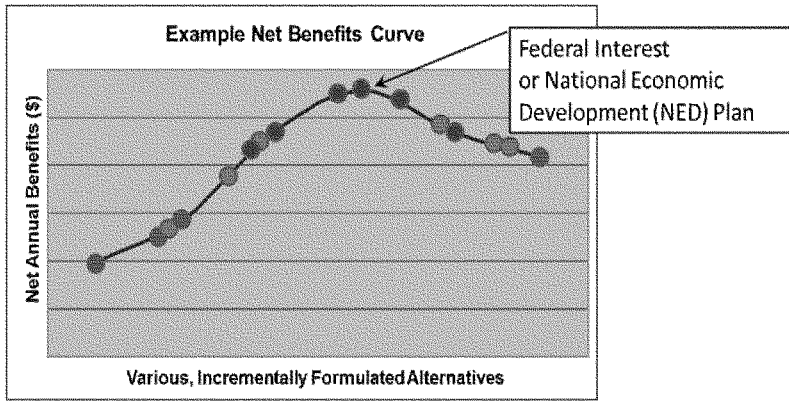


Figure 4-2: Net Benefits Curve

The current document focuses on economic impacts; however, it is important to consider environmental, social, and economic impacts as part of the planning process.

5 CHAPTER 5 – ALTERNATIVE EVALUATION AND COMPARISON

The fourth and fifth steps of the six-step planning process are evaluation and comparison. The process further develops the plan formulation work from the third step. Within this chapter, the planning team determines cost estimates for each alternative based on the measures used to develop that alternative. Benefits, or flood damages prevented, also are taken into account. The process allows the planning team to identify the alternative that maximizes the net annual benefits. The planning team conducted iterative analyses of alternatives and generally what is reflected in the final array were evaluated in the interim step as well, with two slightly modified alternatives added in the final array.

5.1 FORMULATION OF FINAL ARRAY OF ALTERNATIVES

NOTE: At this point in the report we have adopted the term annual chance of exceedance, abbreviated as "ACE", when referring to the magnitude of specific flood events. The term annual exceedance probability, abbreviated as "AEP", is applied to the performance of a project in terms of the risk of the design being exceeded by a flood event. The capacity in the Merriam Reach of the Turkey Creek channel was evaluated and served as a basis for formulation of alternatives for reducing flood risk and damages. The HEC-RAS model indicates that the majority of the Turkey Creek channel that passes through the City of Merriam can contain the 20 percent ACE flood event, although two areas flood at the 50 percent ACE event. It is estimated that the 1 percent ACE-event flows would have to be reduced as much as 45 to 50 percent in order to remain within the channel.

In order to evaluate projects of differing performance levels to serve as an adequate basis for comparison and cost-benefit analysis, several scales of three structural alternative concepts were evaluated that would pass different discharges. Using all of the information developed, conceptual designs and cost estimates were prepared for an array of structural alternatives for the Merriam Reach project site.

The Alternative 1 concept is Channel Widening (Figure 5-1); Alternative 2 concept is Levees and Floodwalls (Figure 5-2); Alternative 3 concept is a Combination of Channel Widening and Levees/Floodwalls (Figure 5-3); and Alternative 4 is the Property Buy-Outs (Figure 5-4). Several flow capacity levels were used to formulate plans within each of the alternative concepts 1 through 3. Alternative 1, Channel Widening, and Alternative 3, Combination of Channel Widening and Levees/Floodwall, were evaluated with and without modifications to major bridge structures within the downtown Merriam area. Table 5-1 includes a description and comparison of the final array of alternatives that were carried forward through the full screening.

Based on a review of the Merriam channel cross section and hydraulic analyses, the planning team observed that levees between approximately two and six feet in height could provide protection for up to the 1 percent ACE event. However, the addition of levees alone would not contain the floodwaters within the channel. The Merriam Drive and Shawnee Mission Parkway culverts create a rise in the water surface elevation of the various storm profiles and result in floodwaters overtopping the roads.

The Merriam Drive and Shawnee Mission Parkway bridges would require modifications because both the 10 percent ACE and 1 percent ACE events overtop the bridge, and the constriction causes a two-foot rise in water surface elevation in the upstream storm profile.

Analysis during formulation revealed that for Alternative 2c (with levees and floodwalls) had 86 percent reliability in passing the 1 percent discharge. It was desirable for this alternative array to consider an additional plan that would have at least a 90 percent or greater reliability in passing the 1 percent ACE discharge, and so an additional alternative plan was developed for that level of performance and evaluated. A description of the alternative arrays evaluated is summarized below and in Table 5-1.

Merriam Alternative 1 Array: Channel Widening

The channel widening alternative array (Figure 5-1) was considered varying levels of design using channel bottom widths ranging from 40 to 100 feet and varying side slopes throughout downtown Merriam. Structural modifications were also considered to the Shawnee Mission and Merriam Drive bridges, including increasing the bridge span across the creek, removing the existing culverts that were replaced with piers, and raising the bridge deck to allow flows to pass without overtopping the bridge decks. The pedestrian bridge at RS 3.568 was modified under Alternatives 1d and 1e to span 160 feet with a vertical clearance height of four feet to help reduce flood levels at the upstream bridge section. The intent of Alternative 1, Channel Widening, was to modify only those sections that could not accommodate specific levels of discharge. Project concept design cross sections for individual projects are included in Appendix B.

The following Channel Widening alternatives were considered for Merriam under the Alternative 1 concept, Channel Widening:

- **Alternative 1**: Channel Widening
  - 1a: Bottom width 40-46 ft, 3:1 side slope, existing bridges, 10,500 cfs flow capacity
  - 1b: Bottom width 60 ft, 2:1 side slope, with existing bridges, 14,700 cfs flow capacity
  - 1c: Bottom width 60 ft, 2:1 side slope, with bridge modifications, 14,700 cfs flow capacity
  - 1d: Bottom width 100 ft, 2:1 side slope, with existing bridges, 15,300 cfs flow capacity
  - 1e: Bottom width 100 ft, 2:1 side slope, with bridge modifications, 15,300 cfs flow capacity

Merriam Alternative 2: Levees/Floodwalls

Alternative 2, Levees/Floodwalls (Figure 5-2), involves the installation of concrete floodwalls and/or earthen levees in the downtown Merriam project area and considered five levels of design using the existing overbank area for floodway flow, thus increasing the distance between the levee walls. The pedestrian bridge at RS 3.568 was modified under the Alternatives 2b, 2c, 2d, 2e, and 2f to span across the new levee walls.

As a result of levees and floodwalls, local drainage systems often back-up and result in localized flooding of stormwater behind the systems. To address this issue, the inclusion of a flap gate on drainage outfalls is necessary. In addition, the development of a ponding area behind the levee system is required. Concept design cross sections for individual projects are included in Appendix B.

The following Levees/Floodwalls alternatives were considered for Merriam under the Alternative 2 concept, Levees/Floodwalls:

- **Alternative 2**: Levees/Floodwalls
  - 2a: 8,500 ft of levee and floodwall up to 4 ft high, top-of-levee (TOL) elevation of 917.11 at RM 3.298
  - 2b: 8,500 ft of levee and floodwall up to 5 ft high, TOL elevation of 920.05 at RM 3.298
  - 2c: 8,500 ft of levee and floodwall up to 6 ft high, TOL elevation of 920.49 at RM 3.298
  - 2d: 8,500 ft of levee and floodwall up to 6 ft high, TOL elevation of 920.98 at RM 3.298
  - 2e: 8,500 ft of levee and floodwall up to 6 ft high, TOL elevation of 921.21 at RM 3.298
  - 2f: 8,500 ft of levee and floodwall up to 8 ft high, TOL elevation of 922.78 at RM 3.298

Merriam Alternative 3: Combination Channel Widening and Levees/Floodwalls

Under Alternative 3, Combination Channel Widening and Levees/Floodwalls rip rap would be used for stabilization. Projects concept design cross sections are included in Appendix B.

Under this alternative, varying levels of design were considered using channel bottom widths ranging from 40 to 120 feet and varying side slopes throughout downtown Merriam. Levee and floodwall systems were used in sections to either contain flood flows or provide a one-foot level of freeboard protection. Protection heights generally remained at or below three feet, including one foot of freeboard. Levee and wall heights are considerably lower than those proposed under Alternative 2 because of the reductions in water surface elevations that occur due to the channel widening described under Alternative 1. Structural modifications were also considered to the Shawnee Mission and Merriam Drive bridges, including increasing the bridge span across the creek, removing the existing culverts that were replaced with piers, and raising the bridge deck to allow flows to pass without overtopping the bridge decks. The pedestrian bridge at RS 3.568 was modified under Alternatives 3b, 3c, 3d, and 3e to help reduce flood levels at the upstream bridge section.

The following Combination Channel Widening and Levees/Floodwalls alternatives were considered for Merriam under the Alternative 3 concept, Combination Channel Widening and Levees/Floodwalls:

- **Alternative 3**: Combination Channel Widening and Levees/Floodwalls
  - 3a: 50 ft channel bottom, 3,600 ft of levee and floodwall up to 3 ft high and TOL elevation of 916.36 at RM 3.298, with existing bridges
  - 3b: 60 ft channel bottom, 9,100 ft of levee and floodwall up to 3 ft high and TOL elevation of 917.80 at RM 3.298, with existing bridges
  - 3c: 60 ft channel bottom, 8,100 ft of levee and floodwall up to 3 ft high and TOL elevation of 916.86 at RM 3.298, with bridge modifications
  - 3d: 100 ft channel bottom, 4,400 ft of levee and floodwall up to 3 ft high and TOL elevation of 916.64 at RM 3.298, with existing bridges
  - 3e: 100 ft channel bottom, 1,700 ft of levee and floodwall up to 3 ft high and TOL elevation of 915.93 at RM 3.298, with bridge modifications

Alternatives of the Alternative 3 concept larger than Alternatives 3d and 3e were not carried through the full screening of alternatives due to diminishing economic benefits. The residual damages in the reach protected by the levee (Reach 3b) with Alternative 2e are only 2.1 percent of the without-project damages.

Merriam Alternative 4: Property Buy-Outs

Consideration was given to nonstructural alternatives that could provide benefits of flood risk management, reduction of future potential flood damages, and lower long-term costs to the federal government.

Floodplain acquisition can be used to retire land that frequently floods to preclude Federal disaster payments, allow levee setbacks, or limit use of the land. However, all measures must be economically, environmentally, and socially defensible and technically sound. All long-term benefits must be weighed against the cost of continued damage on an average annual basis.

Using GIS, the 1 percent ACE event inundation polygon was intersected with property owners for the Merriam Reach project site to determine the affected parcels. If the 1 percent ACE event affected the current use of a property, the entire parcel was considered to be taken, both land and improvements. If an insignificant portion of a parcel was in the 1 percent ACE event, but its current use remained intact, a

minimum estimate of $5,000 was considered to be representative. Values missing from appraisers' data were calculated at a value of $50,000 per acre if over the $5,000 minimum.

Table 5-1: Final Array of Alternatives

Alternative	Channel Widening	Levees/Floodwalls	Bridge Modifications
Alternative 1: Channel Widening			
1a	• Average bottom width = 40-60 feet • Average side slope = 3H:1V	NA	NA
1b	• Average bottom width = 60 feet • Average side slope = 2H:1V	NA	NA
1c	• Average bottom width = 60 feet • Average side slope = 2H:1V • Channel modifications upstream of Shawnee Mission Road to improve the transition of the channel to the wider bridge opening.	NA	Merriam Drive Bridge: • The 53-foot-bridge span was increased to 88 feet with four equally spaced piers. The bottom of the deck was raised 1 foot to accommodate the 2 percent ACE-event flows. Shawnee Mission Road Bridge: • The four existing 14-foot wide culverts were removed and replaced with a 210-foot span supported by six piers spaced at 30-foot intervals.
1d	• Average bottom width = 100 feet • Average side slope = 2H:1V	NA	NA

Alternative	Channel Widening	Levees/Floodwalls	Bridge Modifications
1e	• Average bottom width = 100 feet • Average side slope = 2H:1V • Channel modifications upstream of Shawnee Mission Road to improve the transition of the channel to the wider bridge opening.	NA	Merriam Drive Bridge: • The 53-foot bridge span was increased to 88 feet with four equally spaced piers. The bottom of the deck was raised 1 foot to accommodate the 2 percent ACE-event flows. Shawnee Mission Road Bridge: • The four existing 14-foot wide culverts were removed and replaced with a 210-foot span supported by six piers spaced at 30-foot intervals.
Alternative 2: Levees/Floodwalls			
2a	NA	Left Bank: • 1,500 feet of floodwall (2 to 4 feet high; average 10 feet bottom width) • 1,600 feet of levee (2 to 4 feet high; 20- to 30-foot bottom width) Right Bank: • 4,000 feet of floodwall (2 to 3 feet high; average 10-foot bottom width) • 1,400 feet of levee (2 to 3 feet high; 20- to 25-foot bottom width)	NA

Alternative	Channel Widening	Levees/Floodwalls	Bridge Modifications
2b	NA	Left Bank: • 1,000 feet of levee/floodwall (5 feet high; 35-foot levee bottom width; average 10-foot floodwall bottom width) • 450 feet of levee (4 feet high; 30-foot bottom width) • 1,800 feet of floodwall (4 feet high; average 10-foot bottom width) Right Bank: • 1,500 feet of levee/floodwall (3 to 5 feet high; 25- to 35-foot levee bottom width; average 10-foot floodwall bottom width) • 1,750 feet of levee (5 to 6 feet high; 35- to 40-foot bottom width) • 1,000 floodwall (4 feet high; average 10-foot bottom width) • 1,100 feet of floodwall (3 feet high; average 10-foot bottom width)	NA
2c	NA	Left Bank: • 1,000 feet of levee/floodwall (5 feet high; 35-foot levee bottom width; average 10-foot floodwall bottom width) • 450 feet of levee (4 feet high; 30-footbottom width) • 1,800 feet of floodwall (3 feet high; 10-foot average bottom width) Right Bank: • 1,500 feet of levee/floodwall (3 to 5 feet high; 25- to 35-foot levee bottom width; 10-foot floodwall average bottom width) • 1,750 feet of levee (5 and 6 feet high; 35- to 40-foot bottom width) • 1,000 floodwall (4 feet high; average -foot bottom width) • 1,100 feet of floodwall (3 feet high; average 10-foot bottom width)	NA

Alternative	Channel Widening	Levees/Floodwalls	Bridge Modifications
2d	NA	Left Bank: • 700 feet of levee/floodwall (5 feet high; 35-foot levee bottom width; average 10-foot floodwall bottom width) • 450 feet of levee (4 feet high; 30-foot bottom width) • 280 feet of floodwall (5 feet high; average 10-foot bottom width) • 800 feet of floodwall (6 feet high; average 10-foot bottom width) • 1,800 feet of floodwall (3 feet high; average 10-foot bottom width) Right Bank: • 2,050 feet of levee/floodwall (5 to 6 feet high; 35- to 40-foot levee bottom width; average 10-foot floodwall bottom width) • 1,500 feet of levee/floodwall (4 feet high; 30-foot wide levee bottom width; average 10-foot floodwall bottom width) • 400 feet of levee (5 feet high; 35-foot bottom width) • 1,000 floodwall (4 feet high; average -foot bottom width) • 1,100 feet of floodwall (3 to 5 feet high; average 10-foot bottom width)	Pedestrian Bridge Located at River Mile/Station 3.568: Modification to span 175 feet across the new levee walls
2e	NA	Left Bank: • 1,400 feet of levee (4 to 6 feet high; 30- to 40-foot bottom width) • 3,300 feet of floodwall (4 to 6 feet high; average 10-foot bottom width) Right Bank: • 500 feet of levee (4 to 6 feet high; 30- to 40-foot bottom width) • 6,500 feet of floodwall (4 to 6 feet high; average 10-foot bottom width)	NA

Alternative	Channel Widening	Levees/Floodwalls	Bridge Modifications
2f	NA	Left Bank: • 500 feet of levee (5 to 8 feet high; 35- to 50-foot bottom width) • 4,600 feet of floodwall (5 to 8 feet high; average 10-foot bottom width) Right Bank: • 500 feet of levee (5 to 8 feet high; 35- to 50-foot bottom width) • 6,500 feet of floodwall (5 to 8 feet high; average 10-foot bottom width)	NA
Alternative 3: Combination Channel Widening and Levees/Floodwalls			
3a	• Average bottom width = 50 feet • Average side slope = 3H:1V • Increased channel bottom width of 70 feet to several channel sections downstream of Shawnee Mission Parkway to accommodate mainstem and tributary flows	Left Bank: • 300 feet of levee (2 feet high; 20-foot bottom width) Right Bank: • 3,300 feet of levee/floodwall (1 to 3 feet high; average 10-foot bottom width)	NA
3b	• Average bottom width = 60 feet • Average side slope = 2H:1V • Increased channel bottom width of 90 to 120 feet to several channel sections downstream of Shawnee Mission Parkway to accommodate mainstem and tributary flows	Left Bank: • 3,600 feet of levee/floodwall (1 to 3 feet high; 15- to 25-foot levee bottom width; average 10-foot floodwall bottom width) Right Bank: • 5,500 feet of levee/floodwall (3 to 5 feet high; 25- to 35-foot levee bottom width; average 10-foot floodwall bottom width)	NA
3c	• Average bottom width = 60 feet • Average side slope = 2H:1V • Increased channel bottom width to several channel sections upstream and downstream of Shawnee Mission Parkway to transition to and from the modified 210-foot bridge opening • Increased channel bottom width to 95 feet immediately upstream and downstream of Merriam Drive Bridge 1H:1V side slopes	Left Bank: • 2,900 feet of levee/floodwall (1 to 3 feet high; 15- to 25-foot levee bottom width; average 10-foot floodwall bottom width) Right Bank: • 5,200 feet of levee/floodwall (3 to 5 feet high; 25- to 30-foot levee bottom width; average 10-foot floodwall bottom width)	Shawnee Mission Parkway Bridge: • Enlarged to span 210 feet across 6 piers Merriam Drive Bridge: • Enlarged to span 88 feet across 4 piers Pedestrian Bridge Located at River Mile/Station 3.568: • Modification to span 114 feet across the new levee walls

Alternative	Channel Widening	Levees/Floodwalls	Bridge Modifications
3d	• Average bottom width = 100 feet • Average side slope = 2H:1V • Increased channel bottom width of 90 to 120 feet to several channel sections downstream of Shawnee Mission Parkway to accommodate mainstem and tributary flows	Left Bank: • 900 feet of levee/floodwall (2 to 4 feet high; 20- to 30-foot levee bottom width; average 10-foot floodwall bottom width) Right Bank: • 3,500 feet of levee/floodwall (3 to 5 feet high; 25- to 35-foot levee bottom width; average 10-foot floodwall bottom width)	Pedestrian Bridge Located at River Mile/Station 3.568: • Modification to span 167 feet across the new levee walls
3e	• Average bottom width = 100 feet • Average side slope = 2H:1V • Increased channel bottom width to 200 feet between to accommodate the new bridge openings • Increased channel bottom width to 95 feet immediately upstream and downstream of Merriam Drive Bridge 1H:1V side slopes	Left Bank: • 400 feet of levee/floodwall (2 feet high; 20-foot levee bottom width; average 10-foot wide floodwall bottom width) Right Bank: • 1,700 feet of levee/floodwall (1 to 3 feet high; 15- to 25-foot levee bottom width; average 10-foot floodwall bottom width)	Shawnee Mission Parkway Bridge: • Enlarged to span 210 feet across 6 piers Merriam Drive Bridge: • Enlarged to span 179 feet across 7 piers Pedestrian Bridge Located at River Mile/Station 3.568: • Modification to span 160 feet across the new levee walls

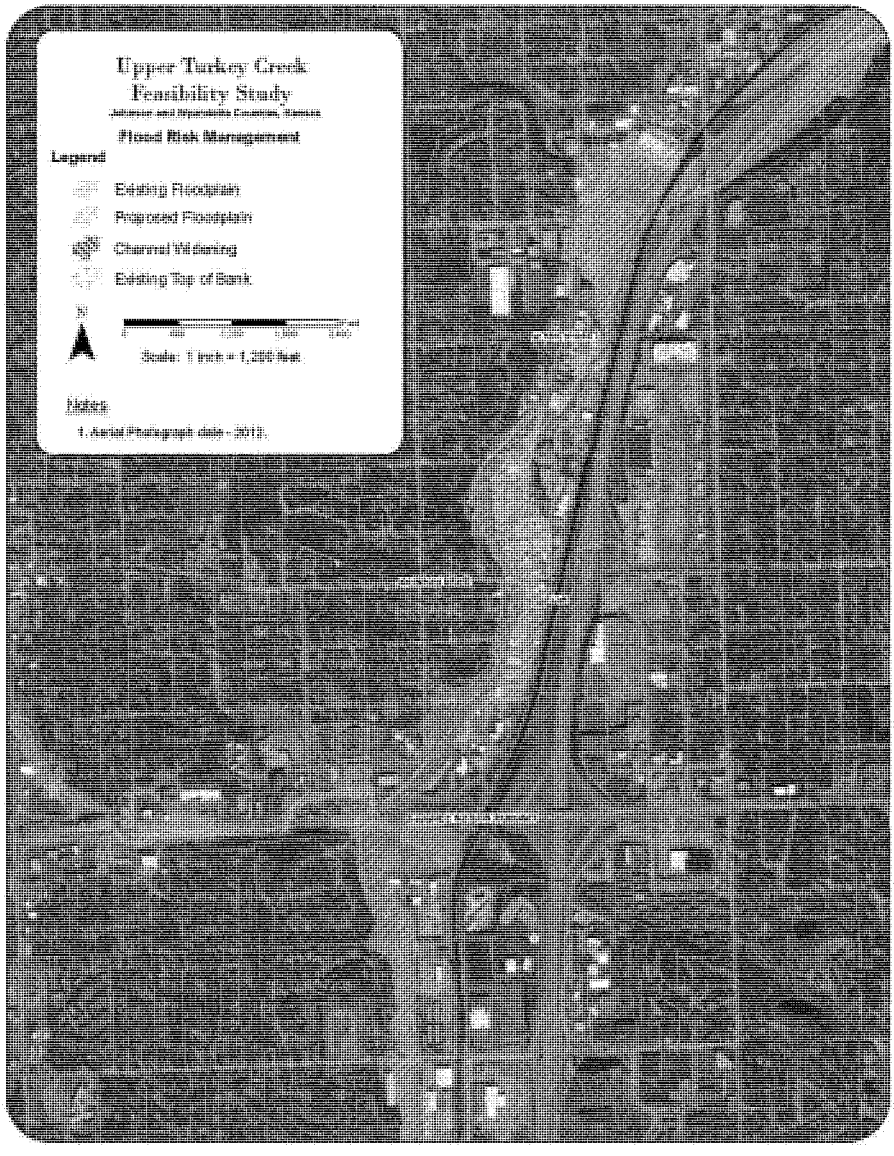


Figure 5-1: Alternative 1: Channel Widening

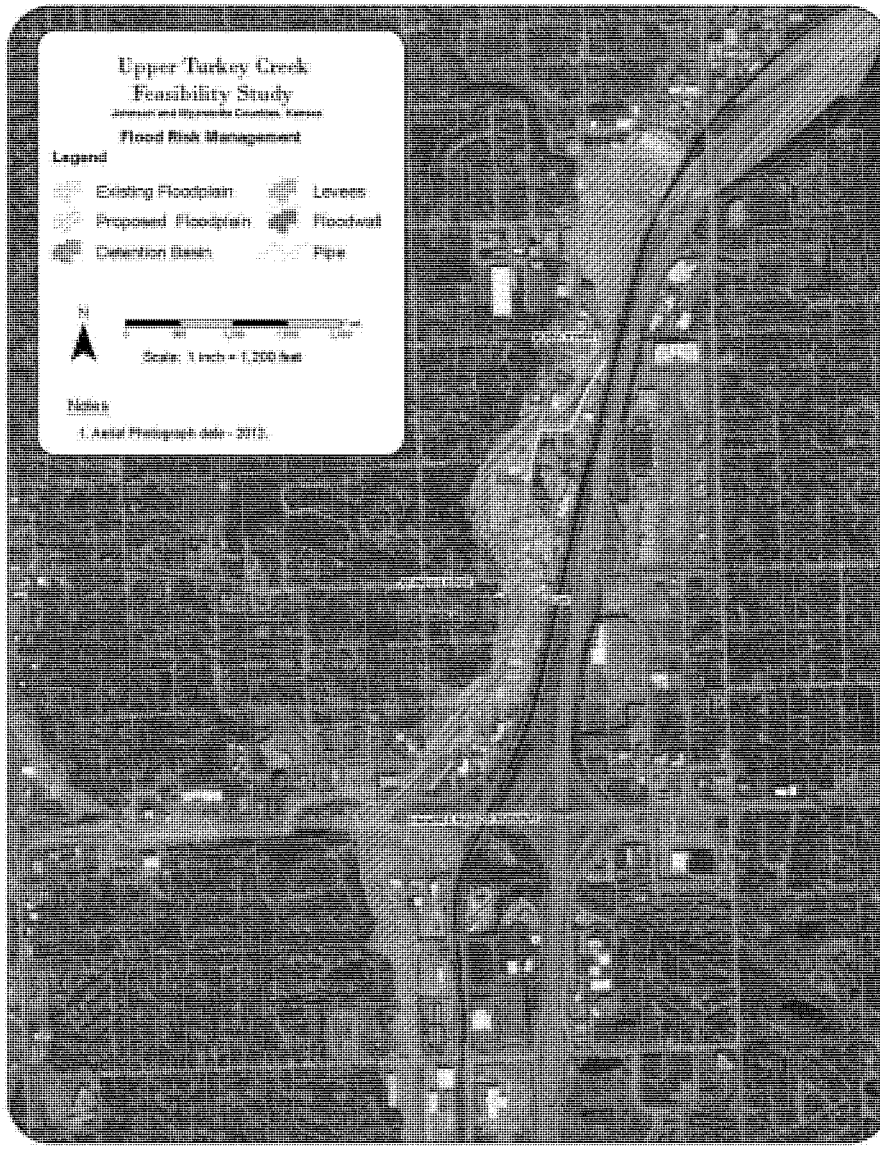


Figure 5-2: Alternative 2: Levees/Floodwalls

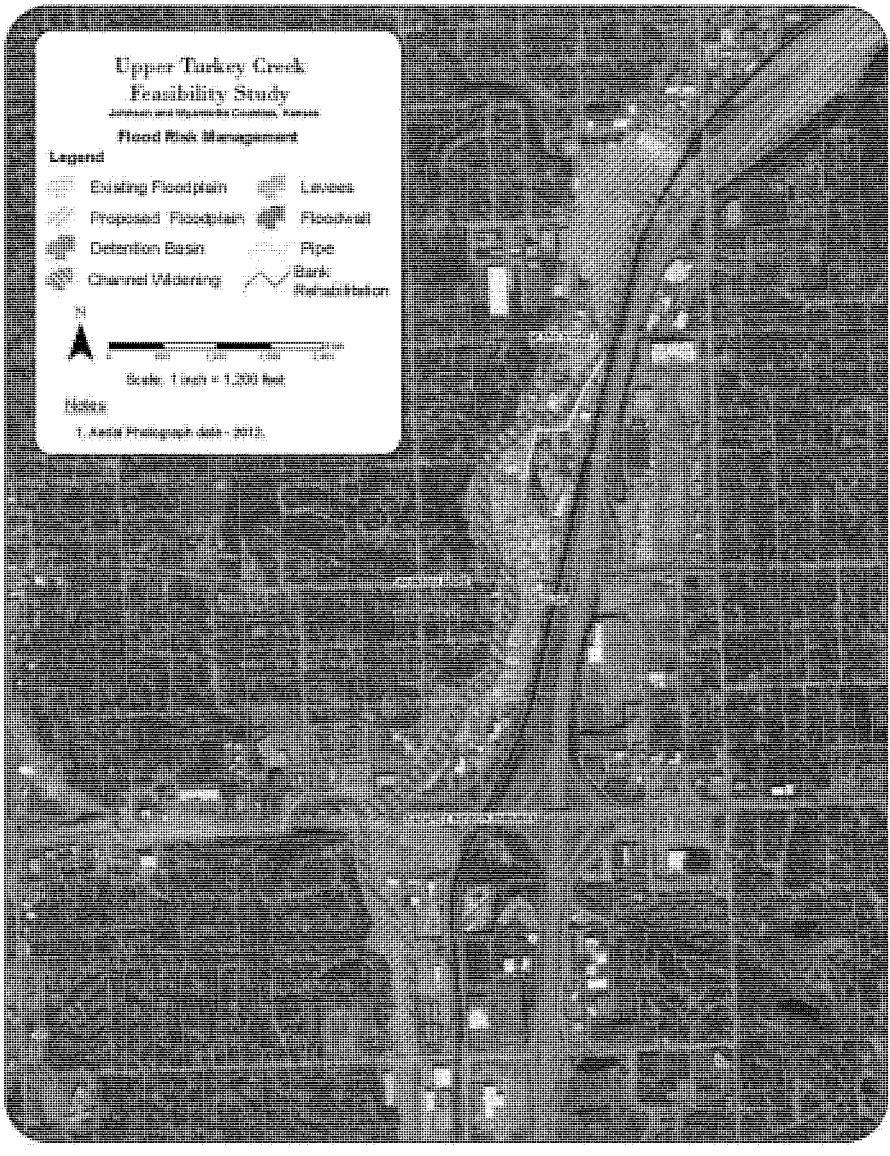


Figure 5-3: Alternative 3: Combination

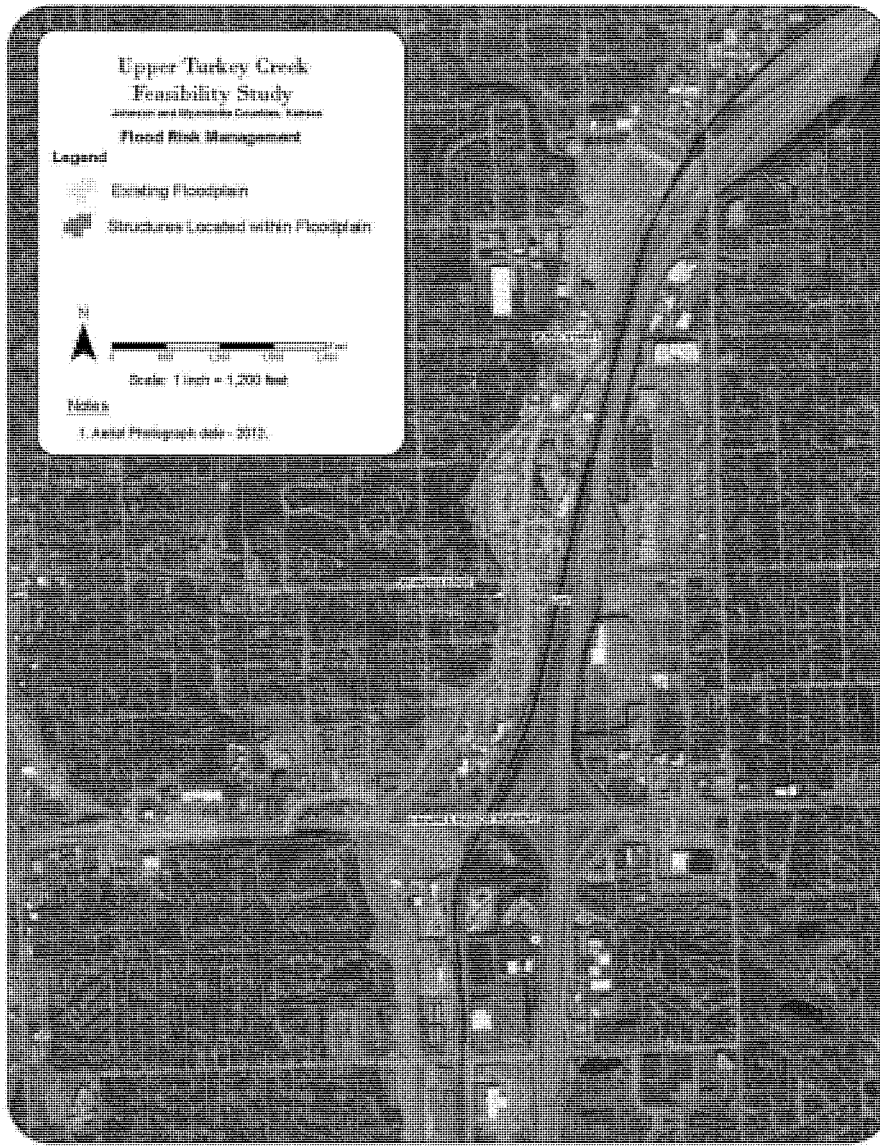


Figure 5-4: Alternative 4: Property Buy-Outs

5.2 EVALUATION OF FINAL ARRAY OF ALTERNATIVES

Alternatives were examined and compared considering the Federal criteria for completeness, efficiency, effectiveness, and acceptability. As alternatives passed through this evaluation and screening process, the economic analysis of each alternative's incremental cost was used as a ranking factor in the final selection. Having passed review for engineering adequacy, environmental and public acceptability, and other evaluation criteria as described below, the remaining alternative with the highest net benefits to the national economy was identified as a component of the overall recommended National Economic Development (NED) Plan.

The development and screening of alternatives involved the consideration of a number of evaluation factors or criteria previously discussed in Section 4.2, *Planning Criteria*.

The following Channel Widening alternatives were considered in the final array for Merriam:

- **Alternative 1**: Channel Widening
  - **Alternative 1a:** Bottom width 40-46 ft, 3:1 side slope, existing bridges, 10,500 cfs flow capacity
  - **Alternative 1b:** Bottom width 60 ft, 2:1 side slope, with existing bridges, 14,700 cfs flow capacity
  - **Alternative 1c:** Bottom width 60 ft, 2:1 side slope, with bridge modifications, 14,700 cfs flow capacity
  - **Alternative 1d:** Bottom width 100 ft, 2:1 side slope, with existing bridges, 15,300 cfs flow capacity
  - **Alternative 1e:** Bottom width 100 ft, 2:1 side slope, with bridge modifications, 15,300 cfs flow capacity

The following Levees/Floodwalls alternatives were considered in the final array for Merriam:

- **Alternative 2**: Levees/Floodwalls
  - **Alternative 2a:** 8,500 ft of levee and floodwall up to 4 ft high, TOL elevation of 917.11 at RM 3.298
  - **Alternative 2b:** 8,500 ft of levee and floodwall up to 5 ft high, TOL elevation of 920.05 at RM 3.298
  - **Alternative 2c:** 8,500 ft of levee and floodwall up to 6 ft high, TOL elevation of 920.49 at RM 3.298
  - **Alternative 2d:** 8,500 ft of levee and floodwall up to 6 ft high, TOL elevation of 920.98 at RM 3.298
  - **Alternative 2e:** 8,500 ft of levee and floodwall up to 6 ft high, TOL elevation of 921.21 at RM 3.298
  - **Alternative 2f:** 8,500 ft of levee and floodwall up to 8 ft high, TOL elevation of 922.78 at RM 3.298

The following Combination Channel Widening and Levees/Floodwalls alternatives were considered for Merriam:

- **Alternative 3**: Combination/Channel Widening and Levees/Floodwalls
  - **Alternative 3a:** 50 ft channel bottom, 3,600 ft of levee and floodwall up to 3 ft high and TOL elevation of 916.36 at RM 3.298, with existing bridges

- **Alternative 3b:** 60 ft channel bottom, 9,100 ft of levee and floodwall up to 3 ft high and TOL elevation of 917.80 at RM 3.298, with existing bridges
- **Alternative 3c:** 60 ft channel bottom, 8,100 ft of levee and floodwall up to 3 ft high and TOL elevation of 916.86 at RM 3.298, with bridge modifications
- **Alternative 3d:** 100 ft channel bottom, 4,400 ft of levee and floodwall up to 3 ft high and TOL elevation of 916.64 at RM 3.298, with existing bridges
- **Alternative 3e:** 100 ft channel bottom, 1,700 ft of levee and floodwall up to 3 ft high and TOL elevation of 915.93 at RM 3.298, with bridge modifications

Alternative 4, Property Buy-Outs, was also considered in the final array of alternatives.

5.2.1 ECONOMIC EVALUATION

NED Analysis of Benefits and Costs

Economic costs and benefits resulting from a project are evaluated in terms of their impacts on national wealth, without regard to where in the United States the impacts may occur. NED benefits must result directly from a project and must represent net increases in the economic value of goods and services to the national economy. NED costs represent the costs of diverting resources from other uses in implementing a flood-risk management project, as well as the costs of economic losses resulting from detrimental effects of a project. Such other detrimental effects of a project could include, for example, induced flooding in areas other than the project study area.

Residual Damages and Benefits of Screening Alternatives

For the screening of alternatives, the future condition with- and without-project equivalent annual damages (EAD) were calculated with risk and uncertainty in the HEC-FDA program reflecting October 2011 prices and the FY 2012 Federal interest rate of 4.000 percent. This section, and the table below, shows the benefits of each alternative and the with-project equivalent residual annual damages that would be expected to occur if each alternative considered were in place. Equivalent annual damages (EAD) under the future without-project condition are also shown for comparison purposes.

Table 5-2: Equivalent Annual Benefits (EAD) and Residual Damages With and Without Project

(October 2011 Prices, 4.000% Interest Rate, 50-Year Period of Analysis, $1,000s)

Alternative	EAD Reach 3a[a]	EAD Reach 3b[b]	EAD Reach 3c[c]	Total EAD Reaches 3a 3b, and 3c	EAD reduced by FRM Alternatives in Merriam
Future Without Project	$ 426.4	$ 2,881.6	$ 148.6	$ 3,456.7	NA
Alternative 1, Channel Widening					
Alternative 1a	$ 426.0	$ 1,965.9	$ 148.6	$ 2,540.5	$ 916.2
Alternative 1b	$ 426.4	$ 1,928.4	$ 148.6	$ 2,503.4	$ 953.3
Alternative 1c	$ 426.4	$ 1,203.5	$ 148.4	$ 1,778.2	$ 1,678.5
Alternative 1d	$ 426.4	$ 850.6	$ 148.4	$ 1,425.4	$ 2,031.3
Alternative 1e	$ 426.4	$ 381.2	$ 148.4	$ 955.9	$ 2,500.8

Alternative	EAD Reach 3a[a]	EAD Reach 3b[b]	EAD Reach 3c[c]	Total EAD Reaches 3a 3b, and 3c	EAD reduced by FRM Alternatives in Merriam
Alternative 2, Levees and Floodwalls					
Alternative 2a	$ 426.4	$ 1,130.7	$ 148.6	$ 1,705.7	$ 1,751.0
Alternative 2b	$ 426.4	$ 230.2	$ 148.6	$ 805.2	$ 2,651.5
Alternative 2c	$ 426.4	$ 225.2	$ 148.6	$ 800.2	$ 2,656.5
Alternative 2d	**$ 426.4**	**$ 69.6**	**$ 148.6**	**$ 644.6**	**$ 2,812.1**
Alternative 2e	$ 426.4	$ 47.8	$ 148.6	$ 622.8	$ 2,833.9
Alternative 2f	$ 426.4	$ 7.0	$ 148.6	$ 582.1	$ 2,874.6
Alternative 3, Combination of Channel Widening and Levees/Floodwalls					
Alternative 3a	$ 426.0	$ 559.1	$ 148.6	$ 1,133.7	$ 2,323.0
Alternative 3b	$ 426.4	$ 390.0	$ 148.6	$ 965.0	$ 2,491.7
Alternative 3c	$ 426.4	$ 327.7	$ 148.4	$ 902.5	$ 2,554.2
Alternative 3d	$ 426.4	$ 87.0	$ 148.4	$ 661.7	$ 2,795.0
Alternative 3e	$ 426.4	$ 61.9	$ 148.4	$ 636.6	$ 2,820.1
Alternative 4, Property Buy-Outs	$ 14.6	$ 32.9	$ 12.1	$ 59.7	$ 3,397.0

Notes: Any discrepancies are due to rounding.
[a] Reach 3a = River Mile (RM) 2.035 to RM 2.593; downstream of potential levee.
[b] Reach 3b = RM 2.594 to RM 3.825; potential levee area.
[c] Reach 3c = RM 3.826 to RM 5.394; upstream of potential levee.

Annual Project Costs

Screening cost estimates (October 2011 price level) and estimated construction periods for each of the alternatives were developed using level of detail appropriate to this phase. Interest during construction (IDC) for each alternative was calculated based on the total first cost for each alternative, the starting and completion dates for each phase, assumed equal monthly expenditures during each phase, and the FY12 federal interest rate of 4.000 percent. Ongoing federal funding issues were not considered in the starting and completion dates of the phases; appropriate funding was assumed available for each phase. Total first cost for each alternative includes the estimated construction cost, cost for lands, easements and rights-of-way, PED cost, environmental mitigation cost, supervision and administration cost, and contingencies. The construction costs shown in Table 5-3 include engineering during construction, as well as supervision and administration, but not PED, which is shown in a separate column. Interest during construction calculated for each alternative was then added to the total first cost to derive the economic cost of each alternative. The economic cost was then annualized based on a 50-year life and a 4.000 percent interest rate. More detailed information on project costs are included Appendix A and Appendix B, Chapter 1.

Table 5-3: Detailed Breakdown of Project First Costs by Alternative

(October 2011 Prices, 4.000% Interest Rate, 50-Year Period of Analysis, $1,000s)

Alternative	Construction Cost (includes EDC and S&A)	PED Cost	LERRD Cost	Mitigation Cost (Compensatory Restoration)	Total First Cost
Future Without Project	NA	NA	NA	NA	NA
Alternative 1, Channel Widening					
Alternative 1a	$ 6,616.4	$ 615.5	$ 3,241.1	$ 29.3	$ 10,502.3
Alternative 1b	$ 8,235.6	$ 766.1	$ 4,744.7	$ 29.3	$ 13,775.7
Alternative 1c	$ 15,249.9	$ 1,418.6	$ 4,744.7	$ 29.3	$ 21,442.5
Alternative 1d	$ 10,984.2	$ 1,021.8	$ 5,652.2	$ 29.3	$ 17,687.5
Alternative 1e	$ 19,178.1	$ 1,784.0	$ 5,652.2	$ 29.3	$ 26,643.6
Alternative 2, Levees and Floodwalls					
Alternative 2a	$ 8,360.6	$ 777.7	$ 2,369.3	$ 24.0	$ 11,531.6
Alternative 2b	$ 9,618.5	$ 894.7	$ 3,943.3	$ 24.0	$ 14,480.5
Alternative 2c	$ 11,631.2	$ 1,082.0	$ 3,963.5	$ 24.0	$ 16,700.7
Alternative 2d	**$ 12,232.1**	**$ 1,137.9**	**$ 3,963.5**	**$ 24.0**	**$ 17,357.5**
Alternative 2e	$ 12,641.6	$ 1,176.0	$ 3,963.5	$ 24.0	$ 17,805.1
Alternative 2f	$ 15,239.9	$ 1,417.7	$ 3,963.5	$ 24.0	$ 20,645.1
Alternative 3, Combination of Channel Widening and Levees/Floodwalls					
Alternative 3a	$ 9,071.6	$ 843.9	$ 3,901.6	$ 29.3	$ 13,846.4
Alternative 3b	$ 16,355.3	$ 1,521.4	$ 4,191.7	$ 29.3	$ 22,097.7
Alternative 3c	$ 21,176.7	$ 1,969.9	$ 4,168.6	$ 29.3	$ 27,344.5
Alternative 3d	$ 14,173.0	$ 1,318.4	$ 4,872.8	$ 29.3	$ 20,393.5
Alternative 3e	$ 21,136.5	$ 1,966.2	$ 5,189.2	$ 29.3	$ 28,321.2
Alternative 4, Property Buy-Outs	$ -	$ -	$ 58,232.5	$ -	$ 58,232.5

Notes: Any discrepancies are due to rounding.

Annual OMRR&R Costs

The costs for operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) were estimated in October 2011 prices for each alternative and were based on a life cycle cost analysis. The analysis includes only new OMRR&R costs (net of present without-project costs) that the sponsors would be expected to incur based on the new proposed alternative. The analysis considered and accounted for the OMRR&R in each year of occurrence and then computed a present worth value of the future OMRR&R costs. The present worth value was then annualized using a Federal interest rate of 4.000 percent and a 50-year period of analysis.

Induced Damages

Induced damages created by a proposed flood risk alternative must be included as costs in the economic screening; however, based on results from HEC-FDA, the alternatives evaluated for Upper Turkey Creek do not have significant induced damages on adjacent stream reaches.

Total Annual Costs

The total annual cost of each alternative that are compared with the benefits of the project is the sum of the direct project costs: annual economic cost and annual OMRR&R cost. Table 5-4 provides a detailed breakdown of costs for the alternatives considered. (Reminder: These are screening phase costs that will not match the later more detailed total project cost estimate developed for the recommended plan as is often the case in this type of study.)

Table 5-4: Detailed Cost Breakdown for Screening Alternatives for Merriam

(October 2011 Prices, 4.000% Interest, 50-Year Period of Analysis, $1,000s)

Alternative	Project First Cost	Interest During Constr.	Total Investment Cost	Annual Economic Cost	Annual OMRR&R Cost	Annual Induced Damages	Total Average Annual Cost
Future Without Project	NA	NA	NA	NA	NA	NA	NA
Alternative 1, Channel Widening							
Alternative 1a	$ 10,502.3	$ 497.4	$ 10,999.7	$ 512.0	$ 100.9	$ 0.0	$ 612.9
Alternative 1b	$ 13,775.7	$ 853.3	$ 14,629.0	$ 681.0	$ 126.5	$ 0.0	$ 807.5
Alternative 1c	$ 21,442.5	$ 1,516.8	$ 22,959.3	$ 1,068.8	$ 133.7	$ 0.0	$ 1,202.5
Alternative 1d	$ 17,687.5	$ 1,135.1	$ 18,822.6	$ 876.2	$ 152.5	$ 0.0	$ 1,028.7
Alternative 1e	$ 26,643.6	$ 2,344.0	$ 28,987.6	$ 1,349.4	$ 162.5	$ 0.0	$ 1,511.9
Alternative 2, Levees and Floodwalls							
Alternative 2a	$ 11,531.6	$ 520.8	$ 12,052.4	$ 561.0	$ 179.9	$ 0.0	$ 740.9
Alternative 2b	$ 14,480.5	$ 897.3	$ 15,377.8	$ 715.8	$ 198.9	$ 0.0	$ 914.7
Alternative 2c	$ 16,700.7	$ 1,007.7	$ 17,708.4	$ 824.3	$ 210.8	$ 0.0	$ 1,035.1
Alternative 2d	**$ 17,357.5**	**$ 1,040.1**	**$ 18,397.6**	**$ 856.4**	**$ 212.1**	**$ 0.0**	**$ 1,068.5**
Alternative 2e	$ 17,805.1	$ 1,306.4	$ 19,111.5	$ 889.6	$ 215.3	$ 0.0	$ 1,104.9
Alternative 2f	$ 20,645.1	$ 1,760.4	$ 22,405.5	$ 1,043.0	$ 229.4	$ 0.0	$ 1,272.4
Alternative 3, Combination of Channel Widening and Levees/Floodwalls							
Alternative 3a	$ 13,846.4	$ 642.5	$ 14,488.9	$ 674.5	$ 187.6	$ 0.0	$ 862.1
Alternative 3b	$ 22,097.7	$ 1,284.3	$ 23,382.0	$ 1,088.4	$ 247.0	$ 0.0	$ 1,335.4
Alternative 3c	$ 27,344.5	$ 1,897.5	$ 29,242.0	$ 1,361.2	$ 245.0	$ 0.0	$ 1,606.2
Alternative 3d	$ 20,393.5	$ 1,232.1	$ 21,625.6	$ 1,006.7	$ 252.2	$ 0.0	$ 1,258.9
Alternative 3e	$ 28,321.2	$ 2,435.7	$ 30,756.9	$ 1,431.7	$ 252.0	$ 0.0	$ 1,683.7

Alternative	Project First Cost	Interest During Constr.	Total Investment Cost	Annual Economic Cost	Annual OMRR&R Cost	Annual Induced Damages	Total Average Annual Cost
Alternative 4, Property Buy-Outs	$ 58,232.5	$ 0.0	$ 58,232.5	$ 2,710.7	$ 0.0	$ 0.0	$ 2,710.7

Note: Any discrepancies are due to rounding.

Summary of Economic Screening of Alternatives Considered

Table 5-5 displays a summary of total annual costs (including OMRR&R costs), annual benefits, residual damages, and net benefits for each alternative evaluated. The benefit/cost ratio and the net benefits for the alternatives considered are also shown.

Table 5-5: Screening Summary With-Project Annual Benefits, Costs, and Net Benefits

(October 2011 Prices, 4.000% Interest Rate, 50-Year Period of Analysis, $1,000s)

Reach Alternative	Total Annual Costs of Project [a]	Annual Benefits	Residual Damages	Benefit/ Cost Ratio	Net Benefits
Future Without Project	NA	NA	$ 3,456.7	NA	NA
Alternative 1, Channel Widening					
Alternative 1a	$ 612.9	$ 916.2	$ 2,540.5	1.5	$ 303.3
Alternative 1b	$ 807.5	$ 953.3	$ 2,503.4	1.2	$ 145.8
Alternative 1c	$ 1,202.5	$ 1,678.5	$ 1,778.2	1.4	$ 476.0
Alternative 1d	$ 1,028.7	$ 2,031.3	$ 1,425.4	2.0	$ 1,002.6
Alternative 1e	$ 1,511.9	$ 2,500.8	$ 955.9	1.7	$ 988.9
Alternative 2, Levees and Floodwalls					
Alternative 2a	$ 740.9	$ 1,751.0	$ 1,705.7	2.4	$ 1,010.1
Alternative 2b	$ 914.7	$ 2,651.5	$ 805.2	2.9	$ 1,736.8
Alternative 2c	$ 1,035.1	$ 2,656.5	$ 800.2	2.6	$ 1,621.4
Alternative 2d	$ 1,068.5	$ 2,812.1	$ 644.6	2.6	$ 1,743.6
Alternative 2e	$ 1,104.9	$ 2,833.9	$ 622.8	2.6	$ 1,729.0
Alternative 2f	$ 1,272.4	$ 2,874.6	$ 582.1	2.3	$ 1,602.2
Alternative 3, Combination of Channel Widening and Levees/Floodwalls					
Alternative 3a	$ 862.1	$ 2,323.0	$ 1,133.7	2.7	$ 1,460.9
Alternative 3b	$ 1,335.4	$ 2,491.7	$ 965.0	1.9	$ 1,156.3
Alternative 3c	$ 1,606.2	$ 2,554.2	$ 902.5	1.6	$ 948.0
Alternative 3d	$ 1,258.9	$ 2,795.0	$ 661.7	2.2	$ 1,536.1
Alternative 3e	$ 1,683.7	$ 2,820.1	$ 636.6	1.7	$ 1,136.4

Reach Alternative	Total Annual Costs of Project [a]	Annual Benefits	Residual Damages	Benefit Cost Ratio	Net Benefits
Alternative 4, Property Buy-Outs	$ 2,710.7	$ 3,397.0	$ 59.7	1.3	$ 686.3

Notes: Any discrepancies are due to rounding.
[a] Includes PED, LERRD, construction, environmental mitigation measures, interest during construction, and OMRR&R.
**

Economic Performance with Uncertainty for Screening Alternatives Considered

The economic performance and effectiveness of the alternatives are compared in Table 5-6 below. The table displays the expected value and probabilistic values of EAD and EAD reduced, thus showing the impact of uncertainty in evaluation of project benefits. The damages reduced represent the project benefits and are shown in terms of annualized equivalent values as computed in the HEC-FDA program.

Table 5-6: Economic Performance with Uncertainty

(October 2011 Prices, 4.000% Interest Rate, 50-Year Period of Analysis, $1,000s)

Plan	Top of Levee/ Floodwall Elevation (feet)	Expected Value and Probabilistic Values of EAD and EAD Reduced					
		Equivalent Annual Damage			Probability EAD Reduced Exceeds Indicated Amount		
		Without Plan	With Plan	Damage Reduced	.75	.50	.25
Future Without Project	NA	$ 3,456.7	$ 3,456.7	NA	NA	NA	NA
Alternative 1, Channel Widening							
Alternative 1a	NA	$ 3,456.7	$ 2,540.5	$ 916.2	$621.0	$964.1	$1,224.7
Alternative 1b	NA	$ 3,456.7	$ 2,503.4	$ 953.3	$604.2	$953.2	$1,275.4
Alternative 1c	NA	$ 3,456.7	$ 1,778.2	$ 1,678.5	$921.4	$1,544.2	$2,267.7
Alternative 1d	NA	$ 3,456.7	$ 1,425.4	$ 2,031.3	$1,085.4	$1,863.6	$2,765.3
Alternative 1e	NA	$ 3,456.7	$ 955.9	$ 2,500.8	$1,176.3	$2,194.4	$3,395.8
Alternative 2, Levees and Floodwalls							
Alternative 2a	917.11	$ 3,456.7	$ 1,705.7	$ 1,751.0	$1,001.5	$1,564.2	$2,391.6
Alternative 2b	920.05	$ 3,456.7	$ 805.2	$ 2,651.5	$1,222.3	$2,250.6	$3,653.5
Alternative 2c	920.49	$ 3,456.7	$ 800.2	$ 2,656.5	$1,231.1	$2,261.4	$3,665.0
Alternative 2d	920.98	$ 3,456.7	$ 644.6	$ 2,812.1	$1,256.0	$2,291.8	$3,791.9
Alternative 2e	921.21	$ 3,456.7	$ 622.8	$ 2,833.9	$1,262.1	$2,299.2	$3,800.6
Alternative 2f	922.78	$ 3,456.7	$ 582.1	$ 2,874.6	$1,289.3	$2,332.4	$3,839.9
Alternative 3, Combination of Channel Widening and Levees/Floodwalls							
Alternative 3a	916.36	$ 3,456.7	$ 1,133.7	$ 2,323.0	$1,162.1	$ 2,132.1	$3,071.3
Alternative 3b	917.80	$ 3,456.7	$ 965.0	$ 2,491.7	$1,209.1	$2,206.1	$3,317.3
Alternative 3c	916.86	$ 3,456.7	$ 902.5	$ 2,554.2	$1,215.6	$2,231.1	$3,412.3

Plan	Top of Levee/ Floodwall Elevation (feet)	Expected Value and Probabilistic Values of EAD and EAD Reduced					
		Equivalent Annual Damage			Probability EAD Reduced Exceeds Indicated Amount		
		Without Plan	With Plan	Damage Reduced	.75	.50	.25
Alternative 3d	916.64	$ 3,456.7	$ 661.7	$ 2,795.0	$1,252.1	$2,287.0	$3,786.5
Alternative 3e	915.93	$ 3,456.7	$ 636.6	$ 2,820.1	$1,267.2	$2,305.5	$3,808.4
Alternative 4, Property Buy-Outs	NA	$ 3,456.7	$ 59.7	$ 3,397.0	$1,503.5	$3,715.7	$4,590.1

5.3 COMPARISON OF FINAL ALTERNATIVES

Note: Any discrepancies are due to rounding.

From the array of final alternatives, the planning team chose the alternative from each concept (Alternative 1, Channel Widening; Alternative 2, Levees and Floodwalls; Alternative 3, Combination of Channel Widening and Levees/ Floodwalls) with the highest net annual benefits for further consideration as a refinement to the screening. The alternatives range from downstream of the Merriam Drive Bridge over Turkey Creek to the upstream face of the Shawnee Mission Parkway culvert. The neighborhoods protected in all alternatives included in the final array are proceeding north to south; Merriam downtown or Farmers' Market area, Industrial and Railway Drive, and the Parkway vicinity.

Planners conducted an economic analysis, which is an iterative process that reveals the alternative with the highest net annual benefits with corresponding higher orders of magnitude of protection (see Section 5.2). Table 5-7 outlines the costs and economic performance of each alternative.

Table 5-7: Total Project Costs and Economic Performance for Final Array of Alternatives

Alternative	1d	2d	3d	4 Property Buy-Outs
Construction (including S&A)	$10,984,200	$12,232,100	$14,173,000	$ 000
PE&D	$ 1,021,800	$ 1,137,900	$ 1,318,400	$ 000
LERRD	$ 5,652,200	$ 3,963,500	$ 4,872,800	$58,232,500
Environmental mitigation	$ 29,300	$ 24,000	$ 29,300	$ 000
Total First Cost	$17,687,500	$17,357,500	$20,393,500	$58,232,500
Interest during construction	$ 1,135,100	$ 1,040,100	$ 1,232,100	$ 000
Total investment cost	$18,822,600	$18,397,600	$21,625,600	$58,232,500
Annual economic cost	$ 876,200	$ 856,400	$ 1,006,700	$ 2,710,700
OMRR&R	$ 152,500	$ 212,100	$ 252,200	$ 000
Residual damages with project	$ 1,425,400	$ 655,600	$ 661,700	$ 59,700
Average annual costs	$ 1,028,700	$ 1,068,500	$ 1,258,900	$ 2,710,700
Average annual benefits	$ 2,031,300	$ 2,812,100	$ 2,795,000	$ 3,397,000
Net annual benefits	$ 1,002,600	$ 1,743,600	$ 1,536,100	$ 686,300
B/C ratio	2.0	2.6	2.2	1.3

The following alternatives from each plan formulation concept with the highest net annual benefits from the final array of alternatives were carried forward and were evaluated under plan formulation and under NEPA:

- No Action
- Alternative 1d: Channel Widening
- Alternative 2d: Levees/Floodwalls
- Alternative 3d: Combination/Channel Widening and Levees/Floodwalls
- Alternative 4: Property Buy-Outs

A summary of project features for the alternatives considered with the highest net annual benefits from the final array of alternatives is included as Table 5-8. Project design cross sections for individual projects are included in Appendix B.

No Action Alternative

The District is required to consider the No Action Alternative in order to comply with the requirements of the NEPA. Under the No Action Alternative, it is assumed that no project would be implemented by the District to achieve the planning objectives. The No Action Alternative forms the basis against which all other alternatives are measured.

No additional flood risk management would be provided under the No Action Alternative. Without modification to the existing flood risk management system, the study area would continue to be at significant risk from frequent dangerous and damaging floods and the affected community would be faced with continued life safety and economic development concerns. The problem would likely worsen with time if no action is taken because flood insurance rates could rise and force existing development out of the study area.

Alternative 1d: Channel Widening

Alternative 1d (see Figure 5-1) in downtown Merriam downtown or the Farmers' Market area would widen Upper Turkey Creek to a 90-foot average channel bottom width with a 170-foot average channel top width and 2H:1V side slopes between Merriam Drive and Johnson Drive. Within the Industrial and Railway Drive area, Upper Turkey Creek would be widened to a 100-foot average channel bottom width with a 160-foot average channel top width and 2H:1V side slopes between Johnson Drive and West 61st Street. Within the Parkway vicinity, Upper Turkey Creek would be widened to a 110-foot average channel bottom width, a 175-foot average channel top width, and 3H:1V side slopes between West 61st Street to just south of Shawnee Mission Parkway, and from south of Shawnee Mission Parkway to approximately 0.2 mile upstream the channel would be widened to a 200-foot average channel bottom width to accommodate new bridge openings. Rip rap would be used for stabilization under this alternative.

For the purpose of achieving lower water surface elevations in through the Merriam Reach, modifications would be made to both the Shawnee Mission Parkway and Merriam Drive Bridges. The Merriam Drive Bridge would be enlarged to conform to the new channel shape. The proposed bridge spans 179 feet across seven piers. The lower bridge deck elevation also would be raised by 1 foot. The Shawnee Mission Parkway Bridge would be enlarged to span 210 feet across six piers. The lower bridge deck would be raised 2.85 feet to ensure that the deck would not obstruct storm flows. Between RS 3.855 and RS 3.665, the channel bottom width would transition to 200 feet to accommodate the new bridge openings. This

proposed bridge and channel configuration would reduce the upstream water surface by approximately 6 feet and reduce overtopping the road. The pedestrian bridge at RS 3.568 would be modified to span 160 feet with a vertical clearance height of 4 feet to reduce flood levels by 6.87 feet at the upstream bridge section.

Table 5-8: Comparison of Features for the Final Action Alternatives

Features	Alternative 1d: Channel Widening	Alternative 2d: Levees/Floodwalls	Alternative 3d: Combination
Levees/floodwalls: left bank	NA	Merriam Downtown: • 280 feet of floodwall (5 feet high) upstream of Merriam Drive Industrial and Railway Drive: • 800 feet of floodwall (4 to 6 feet high) begins at 300 feet upstream of Johnson Drive to 500 feet upstream of West 60th Street • 440 feet of levee (5 feet high) along the bike path to 100 feet north of West 61st Street Parkway Vicinity: • 725 feet of floodwall (5 feet high) from 100 feet south of West 61st Street along the bike path to Knox Avenue where it joins West 62nd. Street • 700 feet of levee (3 to 5 feet high) from West 62nd Street to West 62nd Terrace • 930 feet of floodwall (3 feet high) from West 62nd Terrace to Shawnee Mission Parkway	Merriam Downtown: • 80 feet of floodwall (3 feet high) upstream of Merriam Drive Parkway Vicinity: • 400 feet of levee (2 feet high) from 100 feet south of W. 61st Street to 300 feet north of W. 61st Street • 930 feet of floodwall (2 to 3 feet high) along W. 62nd Terrace to Shawnee Mission Parkway
Levees/Floodwalls: Right Bank	NA	Merriam Downtown: • 550 feet of floodwall (5 to 6 feet high) from Merriam Drive upstream to West 57th Street, then • 900 feet of levee (6 feet high) then • 550 feet of floodwall (6 feet high) downstream of Johnson Drive Industrial and Railway Drive: • 1,100 feet of floodwall (4 to 6 feet high) south of Johnson Drive to 400 feet north of West 61st Street • 400 feet of levee (5 feet high) to West 61st Street Parkway Vicinity: • 1,000 feet of floodwall (5 feet high) from West 61st Street to 400 feet north of Shawnee Mission Parkway, then • 300 feet of levee (5 feet high) • 100 feet floodwall (4 feet high) to Shawnee Mission Parkway	Merriam Downtown: • 500 feet of floodwall (3 feet high) from Merriam Drive to point approximately 300 feet north of Farmers' Market • 950 feet of levee (3 to 5 feet high) along bank at Farmers' Market, then • 600 feet of floodwall (5 feet high) downstream of Johnson Drive Industrial and Railway Drive: • 850 feet of floodwall (ranging from 1 to 4 feet high) from Johnson Drive to 300 feet south of West 60th Street Parkway Vicinity: • 850 feet of floodwall (2 feet high) along Shawnee Mission Parkway

Features	Alternative 1d: Channel Widening	Alternative 2d: Levees/Floodwalls	Alternative 3d: Combination
Channel Widening	Merriam Downtown: • Average bottom width = 90 feet • Average top width = 170 feet • Average side slope = 2H:1V Industrial and Railway Drive: • Average bottom width = 100 feet • Average top width = 160 feet • Average side slope = 2H:1V Parkway Vicinity: From West 61st Street to just downstream of Shawnee Mission Parkway • Average bottom width = 110 feet • Average top width = 175 feet • Average side slope = 3H:1V From just downstream of Shawnee Mission Parkway to 0.2 mile upstream of Shawnee Mission Parkway. • Average bottom width = 200 feet • Average top width = 175 feet • Average side slope = 3H:1V	NA	Merriam Downtown: • Average bottom width = 90 feet • Average top width = 170 feet • Average side slope = 2H:1V Industrial and Railway Drive: • Average bottom width = 100 feet • Average top width = 160 feet • Average side slope = 2H:1V Parkway Vicinity: • Average bottom width = 110 feet • Average top width = 175 feet • Average side slope = 3H:1V
Flap Gates	NA	Merriam Downtown: • Flap gates on all drainage structures discharging to creek (total of 2 gates) Industrial and Railway Drive: • 3 flap gates on triple culvert south of Johnson Drive • Flap gates on all drainage structures (total of 2 gates) Parkway Vicinity: • Flap gates on all drainage structures discharging to creek (total of 6 gates)	Merriam Downtown: • Flap gates on all drainage structures discharging to creek (total of 2 gates) Industrial and Railway Drive: • 3 flap gates on triple culvert south of Johnson Drive • Flap gates on all drainage structures (total of 2 gates) Parkway Vicinity: • Flap gates on all drainage structures discharging to creek (total of 6 gates)
Bridge Modifications/ Headwalls	Merriam Downtown: • Merriam Drive Bridge – modification to span 179 feet across 7 piers Parkway Vicinity: • Shawnee Mission Bridge – modification to span 210 feet across 6 piers and lower bridge deck raised 2.85 feet • Modification to pedestrian bridge at RM 3.568 to span 160 feet across the new channel	Merriam Downtown: • Merriam Drive Bridge – approximately 4 foot high headwall Parkway Vicinity: • Pedestrian Bridge located at River Mile/Station 3.568 - modification to span 175 feet across the new levee walls	Merriam Downtown: • Merriam Drive Bridge – approximately 4 foot high headwall Parkway Vicinity: • Pedestrian Bridge located at River Mile/Station 3.568 – modification to span 175 feet across the new levee walls

Features	Alternative 1d: Channel Widening	Alternative 2d: Levees/Floodwalls	Alternative 3d: Combination
Modified Storm sewer	NA	Merriam Downtown: • 500 feet of storm drainage replacement • Interior drainage system, including 2.14 acre-foot (80 feet wide by 360 feet long) grass detention basin • 830 feet of pipe rework • 2,100 feet of storm sewer trunk line	Merriam Downtown: • 500 feet of storm drainage replacement • Interior drainage system, including 2.14 acre-foot (80 feet wide by 360 feet long) grass detention basin • 830 feet of pipe rework • 2,100 feet of storm sewer trunk line
Utility Impacts/ Relocations	Merriam Downtown: • Sanitary sewer line reconstruction at crossing south of Farmers' Market. Industrial and Railway Drive: • Water line reconstruction south of Johnson Drive Parkway Vicinity: • Sanitary sewer line reconstruction at Shawnee Mission Parkway • Water line reconstruction near Shawnee Mission Parkway	Merriam Downtown: • Sanitary sewer line reconstruction at crossing south of Farmers' Market. Industrial and Railway Drive: • Water line reconstruction south of Johnson Drive Parkway Vicinity: • Sanitary sewer line reconstruction at Shawnee Mission Parkway • Water line reconstruction near Shawnee Mission Parkway	Merriam Downtown: • Sanitary sewer line reconstruction at crossing south of Farmers' Market. Industrial and Railway Drive: • Water line reconstruction south of Johnson Drive Parkway Vicinity: • Sanitary sewer line reconstruction at Shawnee Mission Parkway • Water line reconstruction near Shawnee Mission Parkway
Real Estate	Temporary Easement: 6.23 acres Permanent Easement: 24.94 acres	Temporary Easement: 10.15 acres Permanent Easement: 5.21 acres	Temporary Easement: 8.03 acres Permanent Easement: 25.58 acres

Alternative 2d: Levees/Floodwalls

Alternative 2d (see Figure 5-2) involves the installation of concrete floodwalls and earthen levees in the project area. The Merriam downtown or Farmers' Market area would require construction of 280 feet of floodwall 5 feet high upstream of Merriam Drive on the left bank of Upper Turkey Creek. On the right bank of the creek, the alternative includes 550 feet of floodwall 5 to 6 feet high from Merriam Drive upstream to West 57th Street, then 990 feet of levee 6 feet high, and 550 feet of floodwall 6 feet high downstream of Johnson Drive. Two flap gates would be required on drainage structures discharging to the creek, and the Merriam Drive Bridge would require the incorporation of an approximately 4-foot high headwall. Storm sewer modifications would include 500 feet of storm drainage replacement, and an additional 830 feet of pipe rework, a 2,100-foot storm sewer trunk line, and a 2.14-acre/feet grass detention basin approximately 80 feet wide by 360 feet long located east of the Farmers' Market for internal drainage. Impacts to utilities would include reconstruction of a sanitary sewer line at the crossing south of the Farmers' Market.

The Industrial and Railway Drive area would require construction of 800 feet of floodwall 4 to 6 feet high beginning 300 feet upstream of Johnson Drive to 500 feet upstream of West 60th Street, then 440 feet of levee 5 feet high along the bike path to 100 feet north of West 61st Street on the left bank of the creek. On the right bank of the creek, the alternative includes 1,100 feet of floodwall 4 to 6 feet high south of Johnson Drive to 400 feet north of West 61st Street, then 400 feet of levee 5 feet high to West 61st Street. Three flap gates would be required on the triple culvert south of Johnson Drive.

The Parkway vicinity would require construction of 725 feet of floodwall 5 feet high from 100 feet south of West 61st Street along the bike path to Knox Avenue where it joins West 62nd Street, then 700 feet of

levee 3 to 5 feet high from West 62nd Street to West 62nd Terrace, and 930 feet of floodwall 3 feet high along West 62nd Terrace to Shawnee Mission Parkway on the left bank of the creek. On the right bank of the creek, the alternative includes 1,000 feet of floodwall 5 feet high from West 61st Street to 400 feet north of Shawnee Mission Parkway, then 300 feet of levee 5 feet high, and 100 feet of floodwall 4 feet high to Shawnee Mission Parkway. Six flap gates would be required on drainage structures discharging to the creek, and the pedestrian bridge near West 62nd Terrace would require modification to span 175 feet. Impacts to utilities would include reconstruction of a sanitary sewer and water line at and near Shawnee Mission Parkway.

Alternative 3d: Combination Channel Widening and Levees/Floodwalls

Alternative 3d (see Figure 5-3) involves the installation of concrete floodwalls and/or earthen levees in the project area along with channel widening with the same flap gates, headwall, and detention basin as discussed under Alternative 2d. Levee and floodwall heights would be considerably lower than those proposed under Alternative 2d as a result of reductions in water surface elevations that would occur due to the channel widening described under Alternative 1d. Rip rap would be used for stabilization under this alternative.

Under Alternative 3d (see Figure 5-3), in the Merriam downtown or Farmers' Market area, Upper Turkey Creek would be widened to a 90-foot average channel bottom width with a 170-foot average channel top width and 2H:1V side slopes between Merriam Drive and Johnson Drive. The left bank of the creek in the Merriam downtown or Farmers' Market area would require construction of 80 feet of floodwall, 3 feet high upstream of Merriam Drive. On the right bank of the creek, the alternative includes 500 feet of floodwall 3 feet high from Merriam Drive upstream to approximately 300 feet north of the Farmers' Market, then 950 feet of levee 3 to 5 feet high along the bank at the Farmers' Market, and 600 feet of floodwall 5 feet high downstream of Johnson Drive. Two flap gates would be required on drainage structures discharging to the creek, and the Merriam Drive Bridge would require the incorporation of an approximately 4-foot-high headwall. Storm sewer modifications would include 500 feet of storm drainage replacement, and an additional 830 feet of pipe rework, a 2,100-foot storm sewer trunk line, and a 2.14-acre-foot grass detention basin, approximately 80 feet wide by 360 feet long located east of the Farmers' Market, for internal drainage. Impacts to utilities would include reconstruction of a sanitary sewer line at the crossing south of the Farmers' Market.

Within the Industrial and Railway Drive area, Upper Turkey Creek would be widened to a 100-foot average channel bottom width with a 160-foot average channel top width and 2H:1V side slopes between Johnson Drive and West 61st Street. The left bank of the creek in the Industrial and Railway Drive area does not include levees or floodwalls. On the right bank of the creek, the alternative includes construction of 850 feet of floodwall ranging from 1 to 4 feet high from Johnson Drive to 300 feet south of West 60th Street. Three flap gates are required on the triple culvert south of Johnson Drive.

Within the Parkway vicinity, Upper Turkey Creek would be widened to a 110-foot average channel bottom width with a 175-foot average channel top width and 3H:1V side slopes between West 61st Street to Shawnee Mission Parkway. The left bank of the creek in the Parkway vicinity would require construction of 400 feet of levee 2 feet high from 100 feet south of West 61st Street to 300 feet north of 61st Street, then 930 feet of floodwall 2 to 3 feet high along West 62nd Terrace to Shawnee Mission Parkway. On the right bank of the creek, the alternative includes 850 feet of floodwall 2 feet high along Shawnee Mission Parkway. Six flap gates would be required on drainage structures discharging to the creek and the pedestrian bridge near West 62nd Terrace would require modification to span 175 feet. Impacts to utilities would include reconstruction of a sanitary sewer and water line at and near Shawnee Mission Parkway.

Alternative 4: Property Buy-Outs

Under Alternative 4, Property Buy-Outs (see Figure 5-4), 222 parcels affecting approximately 135 acres would be purchased and relocated for which the current use of the property would be impacted by the 100-year floodplain in the Merriam Reach project area. The buy-out would include the entire parcel, both land and improvements. If an insignificant portion of the parcel is located within the floodplain, but its current use would remain intact, a minimum amount of compensation would be provided, estimated at $5,000 for the economic analysis. Existing utility, railroad or roads would not be relocated; therefore, future flood damages to this infrastructure would continue into the future.

5.3.1 TRADE-OFF ANALYSIS

Three alternatives from the screening array Alternative 2 series, all levee and floodwall plans, are very similar in terms of net annual economic benefits, those being 2b, 2d, and 2e. They also would have very similar effects and requirements for implementation. Throughout several iterations of analyses conducted in the process of adjusting economic and cost data, they have remained very close and Alternative 2d has consistently remained the plan with the maximum net annual benefits. For these reasons, it is highly unlikely that future changes in interest rates and price levels would alter the relative ranking of these three plans. Alternative 2d would pass the 1 percent ACE event through downtown Merriam with an estimated assurance (conditional non-exceedance probability) of 95.7 percent. In comparing the three alternatives, 2b would be approximately $2.88 million less in first cost, but would provide less flood risk reduction and allow greater risk, providing an estimated assurance of passing the 1 percent ACE event of 84.7 percent and allowing more structures to be damaged at a higher level. Alternative 2e would be higher in cost than Alternative 2d by $447,600, but would provide an estimated 97.1 percent assurance in passing the 1 percent ACE event. It would provide very similar flood risk reduction to the structures in the City of Merriam relative to Alternative 2d. Table 5-2 shows that selection of Alternative 2b would reduce annual damages to $230,200, which is about 8 percent of without-project condition damages. Alternative 2d, while entailing higher project costs, would reduce residual damages to $69,600, or 2.4 percent of without-project damages, and Alternative 2e, the most expensive of these three alternatives, would further reduce residual damages to 1.7 percent of without-project damages ($47,800).

Alternative 2d would provide significantly greater net annual benefits in reduction of flood damages than would Alternatives 1d, 3d, and 4 (see Table 5-9). The study analysis shows that channel modifications and levees and floodwall combined with channel modifications would be less efficient than alternatives consisting solely of low height levees and floodwalls. The nonstructural buy-out Alternative 4 would have significantly more costs and less net annual benefits and would be a complete disruption of the economic integrity of the city of Merriam. Other smaller configurations of buyout plans were considered and had significantly less net annual benefits than the NED Plan (Alternative 2d). Additionally, not all costs that would be necessary were included in the buy-out alternatives were they to be actually implemented.

The No Action Alternative would allow for significant and unacceptable flood risk and economic flood damage susceptibility to persist in the city of Merriam. It would not meet the planning objectives of this study. Significant flood damages and risk to life would be significantly greater absent a Federal flood risk management project.

5.3.2 TENTATIVE SELECTION OF PLANS

NED Plan

The NED Plan is Alternative 2d, which would maximize the net annual benefits while significantly reducing flood risk. Economic justification for the NED Plan project is relatively strong with a benefit-

cost ratio of 2.6. This finding of economic justification is strong enough that it is unlikely to be overthrown by changes in purely economic variables, such as year-to-year changes in federal interest rates or subsequent updates of the economic floodplain inventory that might identify abnormally high changes in occupancy. In order for economic justification to be challenged, a significant change in the engineering parameters of the project probably would be required. This could involve a major shift in estimated project costs or a revision of hydrologic/hydraulic data pertaining to flood flows and overbank stages, including uncertainty estimates. But within the context of the existing engineering parameters for the study, the benefit-cost ratio of the selected plan should not be fundamentally affected.

Because the top three alternatives in the NED screening, 2b, 2d, and 2e, were close in economic efficiency (net annual benefits of the three plans differ by only 0.8 percent), it might be expected that changes in any variable could affect rankings of alternatives, possibly overthrowing the NED plan identification. However, in this case all three alternatives are similar structural projects involving levees/floodwalls, distinguished only by differing project scales and the costs associated with these scales. For that reason, changes in cost estimates or other factors would most likely have a similar effect on all of the top alternatives rather than challenging the rankings in terms of NED outputs.

The current NED Plan after the screening evaluation is Alternative 2d, which would provide an estimated $2,812,100 in annual benefits and $1,743,600 in net annual benefits and has a benefit-cost ratio of 2.6 (October 2011 price level and Federal interest rate of 4.0 percent). The plan includes 6,035 feet of floodwall up to 6 feet in height, 2,740 feet of levees up to 5 feet in height, a total 3,340 feet of storm drainage work, and a 2.14 acre-foot detention area. It has a total estimated first cost of $17,863,267, and annual costs are estimated at $1,068,500. The plan has a general cost of $11,611,123, non-Federal cost of $6,252,143, and from that a lands, easements, rights-of-way, relocations and disposal areas (LERRD) requirement of $4,149,489, and estimated annual O&M costs of $212,100. Compensatory mitigation pursuant to environmental compliance is estimated at $24,000.

Federal Interest

A Flood Risk Management Project in the city of Merriam, Kansas, provides significant flood risk reduction and economic damages reductions, meets the planning objectives, and also provides significant benefits in a priority mission area of USACE. The NED Plan, Alternative 2d is in the federal interest for cost sharing in implementation.

5.3.3 ENVIRONMENTAL EVALUATION OF ALTERNATIVES

To evaluate the need for any compensatory mitigation that may be required for CWA Section 404 Authorization, the HEP method was used. Specific HSI models used for this method were the green sunfish (*Lepomis cyanellus*) and the fox squirrel (*Sciurus niger*). Using the green sunfish model, it was determined that no compensatory mitigation would be needed for any of the alternatives evaluated for in-stream impacts. Two of the alternatives, Channel Widening and Channel Widening with Levees and Floodwalls, would actually increase the amount of aquatic habitat resulting in an overall net gain in the number of average annual habitat units (AAHUs) for this species. However, compensatory mitigation would be necessary for impacts to the riparian corridor as indicated by the fox squirrel model. The amount of mitigation necessary would vary depending on the alternative implemented. Mitigation options considered include planting hard mast tree species to provide enough AAHUs to meet or exceed the number of AAHUs that would be lost as a result of implementing a particular alternative. A detailed evaluation of environmental impacts is presented in Chapter 6.

5.4 ATLAS 14 UPDATE

In late 2013 the study's Independent External Peer Review (IEPR) brought to light that the National Oceanographic and Atmospheric Administration (NOAA) had recently published updated rainfall frequency information in the document titled "*Hydrometeorological Design Studies Center Frequency Data Server Atlas 14* (NOAA 2013)", replacing the TP-40 document, which would change the probability of flooding in the Upper Turkey Creek study area. Corps of Engineers guidance requires that the most up-to-date NOAA rainfall information be utilized for hydrology in the formulation and design of flood risk management plans. Given the potential change in discharge accounted for in this new rainfall data, the Corps of Engineers vertical team determined that the opportunity to evaluate the plans under Atlas 14 should be taken during the feasibility phase of the project. The Atlas 14 rainfall estimates were formally adopted at this point in the study. An updated HEC-RAS model was developed incorporating Atlas 14 in the hydrology with a resultant revised hydraulic model. The Atlas 14-based model showed flood probabilities that were generally higher than previous estimates. This meant that any with-project alternative would have both greater benefits and greater residual damages than previously estimated. The alternatives were reevaluated under the Atlas 14 conditions using the Federal criteria for completeness, efficiency, effectiveness, and acceptability. It was reaffirmed that levees and floodwalls (Alternative 2 array) better meets the criteria than channelization either singly or in combination with levees and floodwalls, the sensitivity analysis focused on whether or not a levee and floodwall project was still justified and what the recommended levee/floodwall height should be. A summary of these results can be found in Table 5-11.

Table 5-9: Screening Alternatives Against Planning Criteria[1]

Measure	Completeness	Effectiveness	Efficiency	Acceptability
STRUCTURAL				
Alternative 1, Channel Widening	◓	◓	○	◓
Alternative 2, Levees and Floodwalls	◓	◍	◓	◓
Alternative 3, Combination of Channel Widening and Levees/Floodwalls	◓	◓	○	◓
NON- STRUCTURAL				
Alternative 4, Property Buyouts	●	◓	◒	○

[1]The symbol legend (Highly effective to Not effective and detracts from objectives): ◍ ◓ ○ ◒ ●

Table 5-10 shows a comparison of flows under previous hydrology, and under the new Atlas 14 hydrology for selected locations in the Merriam project reach. More detailed information regarding hydraulic analyses is contained in the Engineering Appendix.

Table 5-10: Comparison of Flows from Original (TP-40 based) to Atlas 14 Based Hydrology

Channel Location	Original 1 percent ACE Discharge cfs	Atlas 14 1 percent ACE Discharge cfs	Original 0.2 percent ACE Discharge cfs	Atlas 14 0.2 percent ACE Discharge cfs
Shawnee Mission Parkway Bridge	9,210	10,380	11,250	13,360
Johnson Drive Bridge	15,670	17,691	19,100	22,290

The following is a comparison of flow depths and velocities for the 1 percent ACE event under original and Atlas 14 based flows at selected locations in Merriam, without project condition:

Shawnee Mission Parkway Bridge: **Original-** 0.22 ft at 6.3 fps; **Atlas 14** - 1.32 ft at 5.3 fps

Merriam Marketplace: **Original-** 3.67 ft at 8.1 fps; **Atlas 14-** 4.67 ft at 7.8 fps

West 61st Street: **Original-** 3.0 ft at 11.8 fps; **Atlas 14-** 3.0 ft at 12.3 fps

Merriam Drive Bridge: **Original-** 1.73 ft at 9.1 fps; **Atlas 14-** 2.9 ft at 8.3 fps

Based upon these findings, a new plan - "**Alternative 2g**" - was formulated to accomplish a sensitivity analysis. Alternative 2g was intended to achieve a level of reliability equivalent to what had been previously estimated for the NED Plan. The NED Plan (Alternative 2d) happens to have been a plan that met Corps of Engineers requirements for National Flood Insurance Program (NFIP) certification under the previous hydrology and hydraulics. Thus, for comparison Alternative 2g was developed such that it would meet Corps of Engineers and FEMA criteria for NFIP certification against the 1 percent ACE event discharge under Atlas 14. This would also serve as a likely upper bound for the updated benefit-cost analysis. The updated benefits and costs of the NED Plan (with top-of-levee elevation of 920.98 at the index point) were compared against the Alternative 2g (with top-of-levee elevation of 922.69 at the index point), and both plans were compared against the future without-project condition, using the updated Atlas-14-based discharge-frequency data.

Alternative 2g was developed with costs estimated at the same level of detail as the NED Plan (Alternative 2d). Table 5-13 depicts a summary comparison of primary features for the NED Plan (Alternative 2d) and Alternative 2g. The required height of levees and floodwalls for Alternative 2g was on average 2-3 feet higher throughout the project area than for Alternative 2d. The increase in the 1 percent ACE discharge caused a significant hydraulic challenge at the Merriam Drive Bridge at the downstream end of the project. It was determined in analysis that in addition to raising the parapet walls at that bridge from 4 feet to 8 feet high, a triple box 5x5 RCB hydraulic diversion structure 320 feet long would be required to successfully pass the design discharge. This configuration was determined to be optimal in performance versus cost after several alternative box and culvert combinations were modeled. The replacement of the Merriam Drive Bridge would be more costly than any of the bypass alternatives evaluated, and would still not address significant hydraulic inefficiency at that location. At the Johnson Drive Bridge, where no modifications to the bridge were deemed necessary with Alternative 2d, the hydraulic analysis showed that under Alternative 2g, parapet walls 7 feet high would be required. The length of floodwall and levee for Alternative 2g was less than the NED Plan (Alternative 2d). This is

because in Reach 3, in order to achieve successful hydraulic tie-in to high ground under the Atlas 14 design flow, the tie-in point would have to be well downstream of the Shawnee Mission Parkway Bridge, just downstream of the pedestrian bridge.

Revised Screening to Verify NED Plan. In order to sufficiently verify the plan having the highest net annual economic benefits under Atlas 14 flow conditions, it was determined that there was a need to reevaluate certain screening level plans in comparison to Alternatives 2d and 2g. In reviewing the results of the initial screening and Atlas 14 sensitivity analyses, it was determined that the narrow difference in net benefits between Alternatives 2b, 2c and 2d in the initial screening necessitated an additional step to confirm the plan with highest net benefits in the Atlas 14 flow regime. The comparison was limited to these three alternatives from the original screening array because Alternative 2d appeared to represent a peak in net benefits – i.e., net benefits for the next largest alternative, 2e, dropped slightly. The comparison of Alternatives 2b and 2c with the NED Plan (Alternative 2d) required that 2b and 2c be updated in a manner reasonably consistent with the updating of Alternative 2d and Alternative 2g. Therefore, in addition to refinement of features and costs for Alternative 2d and development of features and costs for Alternative 2g, alternatives 2b and 2c were also updated to reflect current estimates of features and costs and were also analyzed under the Atlas 14 flow regime for comparison to Alternative 2d and Alternative 2g. The floodwall and levee profiles for Alternatives 2b and 2c were determined in the refined analysis on average only 1 foot and 0.5 feet lower than Alternative 2d. The engineering features required for Alternatives 2b and 2c were virtually the same and in the same lengths as those required in Alternative 2d, except the heights were lower than 2d, as stated. As such, the features for those plans as estimated were virtually identical to Alternative 2d, only lower in overall average height.

Engineering and Cost Updates. As is often encountered during refinement of alternative plan details, certain engineering refinements were deemed necessary in updating the array of plans compared at this phase of study. During the engineering analysis for the Atlas 14 Update, it was determined that the existing stacked rock wall lining the channel in most locations was not adequately reliable to support a cantilever T-type reinforced concrete floodwall without a foundation ground modification. This is because of the relatively close proximity of the floodwall foundation to the existing channel walls. The geotechnical engineers decided to design an array of auger cast grout piles for a suitable ground modification to ensure floodwall foundation stability. This was necessary for the final engineering refinement to the Alternatives 2b, 2c, 2d, and 2g. This required that there be over 12,300 total for Alternative 2d, a similar number of piles for Alternatives 2b and 2c, and a greater number was required for Alternative 2g. Additionally, the team determined that due to the number of storm drainage pipes and utilities, that there would be more relocations required than originally estimated. The engineers also re-routed and consolidated the larger storm sewers into junction boxes with flap gates. All of these improvements were necessary engineering changes that affected the most cost effective plans and Alternative 2g in a similar manner. The team also determined that for Alternative 2d the maximum height from ground in one location was actually 6.5 instead of 6 feet. In the refined analysis and in applying consideration of actual site conditions and features, experience from other similar projects, the OMRR&R and mitigation costs were estimated to be lower than in previous screening analysis and essentially the same for all plans considered in this comparison. The additional box culverts in Alternative 2g could result in somewhat higher annual OMRR&R costs, but those were not included for the purposes of this comparison. After revised cost estimates were developed and the new array of plans was evaluated in HEC-FDA economic analysis, the team's economist verified that Plan 2d is the plan with the highest net annual economic benefits.

Table 5-11: Comparison of Features - Alternatives 2d and 2g

Alternative	Alternative Plan 2d	Alternative 2g
Primary Features Comparison	- 6,822 ft floodwall 3-6.5 ft high - 3,383 ft levee 3-6 ft high - 4 ft high parapet wall on upstream and downstream sides of Merriam Drive Bridge	- 5,565 ft floodwall 6-8' high - 2,300 ft levee 7-8 ft high - 320 ft. long triple 5x5 box culvert hydraulic diversion at downstream of project under Merriam Drive Bridge - 8 ft high parapet wall on upstream and downstream sides of Merriam Drive Bridge - 7 ft high parapet wall on upstream and downstream sides of Johnson Drive Bridge

Tables 5-12 through 5-16 compare the updated NED Plan, Alternative 2g , and Alternatives 2b and 2c with the Future Without-Project Condition, using the same metrics used for the initial screening in Tables 5-2 through 5-6. Table 5-14 shows the benefits of each alternative and the with-project equivalent residual annual damages that would be expected to occur if each alternative considered were in place.

Table 5-12: Equivalent Annual Benefits and Residual Damages With and Without Project

(October 2014 Prices, 3.375% Interest Rate, 50-Year Period of Analysis, $1,000s)

Alternative	Equivalent Annual Flood Damages in Reach 3a	Equivalent Annual Flood Damages in Reach 3b	Equivalent Annual Flood Damages in Reach 3c	Total Equivalent Annual Damages/Residual Damages in Reaches 3a, 3b, and 3c	Total Benefits from FRM Alternatives in Merriam
Future Without Project	$ 702.9	$ 3,709.6	$ 337.2	$ 4,749.6	NA
Alternative 2b	$ 702.9	$ 549.0	$ 337.2	$ 1,589.0	$ 3,160.6
Alternative 2c	$ 702.9	$ 397.4	$ 337.2	$ 1,437.5	$ 3,312.1
Alternative 2d (NED Plan)	$ 702.9	$ 264.9	$ 337.2	$ 1,304.9	$ 3,444.7
Alternative 2g	$ 702.9	$ 6.7	$ 337.2	$ 1,046.7	$ 3,702.9

Note: Any discrepancies are due to rounding.

Table 5-13 shows project first costs for each of the alternatives. The construction costs shown include "engineering during construction" and "supervision & administration," but not PED. The LERRD costs shown include "lands & damages," as well as "relocations."

Table 5-13: Detailed Breakdown of Project First Costs by Alternative

(October 2014 Prices, 3.375% Interest Rate, 50-Year Period of Analysis, $1,000s)

Alternative	Construction Cost (includes EDC and S&A)	PED Cost	LERRD Cost	Mitigation Cost (Compensatory Restoration)	Total First Cost
Future Without Project	NA	NA	NA	NA	NA
Alternative 2b	$ 23,883.0	$ 2,712.0	$ 10,122.0	$ 15.0	$ 36,732.0
Alternative 2c	$ 24,261.0	$ 2,748.0	$ 10,122.0	$ 15.0	$ 37,146.0
Alternative 2d (NED Plan)	$ 24,655.0	$ 2,787.0	$ 10,122.0	$ 15.0	$ 37,579.0
Alternative 2g	$ 29,771.0	$ 3,287.0	$ 9,954.0	$ 15.0	$ 43,026.0

Note: Any discrepancies are due to rounding; EDC – Engineering During Construction, LERRD – Land, Easement, Rights-of-way, Relocations, and Disposal, PED – Preconstruction Engineering and Design, S&A – Supervision and Administration

Table 5-14 provides a detailed breakdown of the average annual cost of each alternative. For this updated, each annual cost (as well as IDC) was calculated using a federal interest rate of 3.375 percent and a 50-year period of analysis.

Table 5-14: Detailed Cost Breakdown for Screening Alternatives for Merriam

(October 2014 Prices, 3.375% Interest, 50-Year Period of Analysis, $1,000s)

Alternative	Project First Cost	Interest During Constr.	Total Investment Cost	Annual Economic Cost	Annual OMRR&R Cost	Annual Induced Damages	Total Average Annual Cost
Future Without Project	NA	NA	NA	NA	NA	NA	NA
Alternative 2b	$ 36,732.0	$ 2,946.4	$ 39,678.4	$ 1,653.7	$ 40.8	$ 0.0	$ 1,694.5
Alternative 2c	$ 37,146.0	$ 2,974.1	$ 40,120.1	$ 1,672.1	$ 40.8	$ 0.0	$ 1,712.9
Alternative 2d (NED Plan)	$ 37,579.0	$ 3,003.9	$ 40,582.9	$ 1,691.4	$ 40.8	$ 0.0	$ 1,732.2
Alternative 2g	$ 43,026.0	$ 4,021.1	$ 47,047.1	$ 1,960.8	$ 40.8	$ 0.0	$ 2,001.6

Note: Any discrepancies are due to rounding.

Table 5-15 displays a summary of total annual costs (including OMRR&R costs), annual benefits, residual damages, and net benefits for each alternative. The benefit/cost ratio and the net benefits for the alternatives considered are also shown.

Table 5-15: Screening Summary With-Project Annual Benefits, Costs, and Net Benefits

(October 2014 Prices, 3.375% Interest Rate, 50-Year Period of Analysis, $1,000s)

Reach Alternative	Total Annual Costs of Project[a]	Annual Benefits	Residual Damages	B/C Ratio	Net Benefits
Future Without Project	NA	NA	$ 4,749.6	NA	NA
Alternative 2b	$ 1,694.5	$ 3,160.6	$ 1,589.0	1.9	$ 1,466.1
Alternative 2c	$ 1,712.9	$ 3,312.1	$ 1,437.5	1.9	$ 1,599.2
Alternative 2d (NED Plan)	$ 1,732.2	$ 3,444.7	$ 1,304.9	2.0	$ 1,712.5
Alternative 2g	$ 2,001.6	$ 3,702.9	$ 1,046.7	1.8	$ 1,701.3

Note: Any discrepancies are due to rounding.
[a] Includes PED (Preconstruction Engineering and Design); LERRD (Lands, Easements, Rights-of-way, Relocations, and Disposal); construction; EDC (Engineering During Construction); S&A (Supervision and Administration); environmental mitigation; interest during construction; and OMRR&R (Operation, Maintenance, Repair, Rehabilitation, and Replacement).

Table 5-16 shows expected values and probabilistic values of equivalent annual damage and reduction in equivalent annual damage for each of the alternatives.

Table 5-16: Economic Performance With Uncertainty for Merriam Alternatives

(October 2014 Prices, 3.375% Interest Rate, 50-Year Period of Analysis, $1,000s)

Plan	Top of Levee/ Floodwall Elev. (feet)	Expected Value and Probabilistic Values of EAD and EAD Reduced					
		Equivalent Annual Damage			Probability EAD Reduced Exceeds Indicated Amount		
		Without Plan	With Plan	Damage Reduced	.75	.50	.25
Future Without Project	NA	$ 4,749.6	$ 4,749.6	NA	NA	NA	NA
Alternative 2b	920.05	$ 4,749.6	$ 1,589.0	$ 3,160.6	$ 1,706.4	$ 2,835.7	$4,262.1
Alternative 2c	920.49	$ 4,749.6	$ 1,437.5	$ 3,312.1	$ 1,727.0	$ 2,938.8	$4,445.8

Plan	Top of Levee/ Floodwall Elev. (feet)	Expected Value and Probabilistic Values of EAD and EAD Reduced					
		Equivalent Annual Damage			Probability EAD Reduced Exceeds Indicated Amount		
		Without Plan	With Plan	Damage Reduced	.75	.50	.25
Alternative 2d (NED Plan)	920.98	$ 4,749.6	$ 1,304.9	$ 3,444.7	$ 1,749.1	$ 2,986.1	$4,620.3
Alternative 2g	922.69	$ 4,749.6	$ 1,046.7	$ 3,702.9	$ 1,811.3	$ 3,062.2	$4,891.1

Notes: Any discrepancies are due to rounding.
EAD – equivalent annual damages

Annual Performance and Equivalent Long-Term Risk

Long-term risk indicates how successfully the project would protect against flooding given the uncertainties and over a long period. Table 5-17 shows (for each alternative) the long-term risk or probability of the target stage/top-of-project being exceeded in a 10-, 30-, and 50-year period, given uncertainties.

Table 5-17: Annual Performance and Equivalent Long-term Risk for Merriam Reach 3b

Plan	Top of Levee/ Floodwall Elevation (feet)	Annual Performance (expected annual probability of design being exceeded)	Equivalent Long-term Risk (probability of exceedance over the indicated time period)		
			10 Years	30 Years	50 Years
Future Without Project	NA	0.283	0.9640	0.9998	1.0000
Alternative 2b	920.05	0.011	0.1086	0.2498	0.4371
Alternative 2c	920.49	0.008	0.0777	0.1831	0.3326
Alternative 2d (NED Plan)	920.98	0.005	0.0507	0.1220	0.2292
Alternative 2g	922.69	0.0001	0.0011	0.0028	0.0055

Conditional Probability of Design Non-Exceedance

Table 5-18 shows the probability that the target stage associated with each plan will not be exceeded, given the occurrence of the 1 percent ACE event.

Table 5-18: Conditional Probability of Design Non-Exceedance

Plan	Top of Levee/ Floodwall Elevation (feet)	Conditional Probability of Design Containing 1% ACE Event
Future Without Project	NA	0.001
Alternative 2b	920.05	0.644
Alternative 2c	920.49	0.740
Alternative 2d (NED Plan)	920.98	0.829
Alternative 2g	922.69	0.995

The original NED Plan (Alternative 2d), analyzed under the Atlas 14 flow regime was shown to have higher annual benefits than Alternative 2g, Alternative 2b, and Alternative 2c. Alternative 2g is very close to Alternative 2d in net annual benefits, but has significantly higher in cost. Alternative 2d has an estimated 83 percent reliability against the Atlas 14 1 percent ACE event, but will physically contain the nominal 1 percent ACE event Atlas 14 profile.

Sensitivity analyses conducted using Atlas 14 flows indicated that levee and floodwall heights between Alternative 2d and Alternative 2g elevations will require an additional parapet wall at the Johnson Drive Bridge, a parapet wall at the Merriam Drive Bridge, and a very large flow bypass conveyance at the Merriam Drive Bridge, all features incurred in Alternative 2g. Thus, increasing plan elevations above Alternative 2d will incur the significant cost impact. Our analysis indicated that there are not reasonable increments of plan elevation between Alternative 2d and 2g that would be more cost effective or affordable than Alternative 2d. Any plan above Alternative 2d in height would cross a hydraulic threshold and require walls very similar to the 7-foot parapet wall at the Johnson Drive Bridge and the 8-foot high parapet wall at the Merriam Drive Bridge. Any plan above Alternative 2d in height would also require a large diversion / conveyance similar in size and cost to the triple box configuration needed for Alternative 2g at the Merriam Drive Bridge. Attempting to formulate plans in between these would be an excessively costly exercise that would not result in a positive outcome.

Sponsor Preference. During the formulation of Alternative 2g, the Sponsor, City of Merriam was engaged in the evaluation process. The City staff and City Council carefully evaluated the comparative cost, features, performance, and residual risk associated with the Alternatives 2d and 2g. The City has requested that Plan 2d be the Recommended Plan, even though they are fully aware that it is has an 83 percent conditional probability of containing the 1 percent ACE event, versus 99.5 percent associated with Alternative 2g. Alternative 2d would significantly decrease flood risk to life and average annual damages to economic investment. Alternative 2d is affordable to the City, and the City does not consider Alternative 2g to be affordable or practical for construction. The City's staff has advised the Corps of Engineers of their opinion that the Corps of Engineers has likely underestimated costs to bridges for Alternative 2g. They believe that parapet walls above 4 feet (i.e. 7 feet at Johnson Drive and 8 feet at Merriam Drive) would be impractical, and that other more costly modifications to the bridges would likely be required. The impact of raising the levees and floodwalls to 7 and 8 feet, as is the case for Alternative 2g, is considered to be an unacceptable impact to the stream corridor, trail, and aesthetics by the City's elected officials, and this was also reflected in the citizen feedback indicated in the last public meeting held in 2014 to update the community of study findings. The City, County, and State agencies have established a response process for flood risk management and preparedness. This includes a system of rain and stage gages in the Turkey Creek basin, known as "Stormwatch," used for real time flood warning and response activities. The Sponsor is committed to managing residual risk and has good confidence in their ability to do so, working in established close relationships with their partner agencies.

1 CHAPTER 6 – ENVIRONMENTAL EFFECTS

An environmental analysis was conducted for the No-Action Alternative, three structural alternatives, and one non-structural alternative. It should be noted that within each of the three structural concepts only the alternative that provided the greatest National Economic Development (NED) benefit was evaluated for environmental effects. Only slight differences in the project footprint occur under the alternatives considered; therefore, similar impacts would occur under the alternatives considered.

United States Fish and Wildlife Service (USFWS) has reviewed the project alternatives and provided comments meeting Fish and Wildlife Coordination Act requirements during the public comment period (Appendix H). USFWS did not elect to provide comments earlier in the study process because the project is in an area in which the ecosystem is already highly degraded (See Appendix H).

6.1 HABITAT MODELING

To evaluate the need for any compensatory mitigation that may be required for Clean Water Act (CWA) Section 404 Authorization and to better compare alternatives, the Habitat Evaluation Procedure (HEP) method was used. HEP describes habitat for selected wildlife species as an Habitat Suitability Index (HSI) with a value ranging from 0.0 to 1.0, with values closer to 0.0 representing poor habitat and values closer to 1.0 representing good habitat. The HSI value is multiplied by the area of available habitat to obtain Habitat Units (HUs). To calculate habitat value over a period of time, such as 50-year period of analysis, HUs are averaged on a yearly basis to provide an Average Annual Habitat Units (AAHU). Specific HSI models used for this method were the green sunfish (*Lepomis cyanellus*) and the fox squirrel (*Sciurus niger*).[1] The HEP method and the USFWS HSI models have been approved for use for USACE planning projects in accordance with EC 1105-2-412, Assuring Quality of Planning Models. Details of the HEP analysis are found in Appendix M, *Compensatory Mitigation Determination*.

6.2 EFFECTS ON RESOURCES OF CONCERN

Primary resources of concern identified for evaluation include geology, soils and geomorphology, climate, hydrology, water quality, aquatic habitat, wetlands and waters of the United States, terrestrial habitat, fish and wildlife, threatened and endangered species, HTRW, floodplain, land use, socioeconomics, environmental justice, transportation, recreation, and cultural resources.

6.2.1 GEOLOGY, SOILS, AND GEOMORPHOLOGY

No-Action: The existing geology, soils, or geomorphology would not change within the project area under this alternative.

Alternative 1d—Channel Widening: Under this alternative, minor, long-term impacts to the geomorphology of Turkey Creek would occur within the project area. The channel bottom would be widened to a width of approximately 100 feet with a side slope of 2H:1V. These changes would allow for a greater conveyance of water during flood events when compared to the No-Action Alternative. Existing soils would be removed from locations where the channel would be widened, resulting in minor, long-term impacts. Additionally, construction activities would cause short-term impacts to the soil. Dust from construction activities may also lead to a short-term minor impact to air quality. The project is located in an

[1] These models are available online at http://el.erdc.usace.army.mil/hsi/GreenSunfish.pdf and http://el.erdc.usace.army.mil/hsi/FoxSquirrel.pdf.

area of air quality attainment in accordance with the National Ambient Air Quality Standards and these short-term construction related impacts are not expected to change this status. This alternative would not affect the geology of the project area.

Alternative 2d—Levees and Floodwalls: Constructing levees and floodwalls would cause minor, long-term impacts to the geomorphology of the Turkey Creek floodplain from the physical presence of the levee and floodwall structures. Because the banks of the creek are armored with limestone blocks, it is not likely that any changes would occur to the geomorphology of the creek channel. A grass detention basin approximately 2.1 acre in size would be constructed north of the Merriam Marketplace and would cause minor, long-term impacts to soils and geomorphology at this particular location. Ground disturbance necessary for construction would cause additional minor, short-term impacts to soils. Dust from construction activities may also lead to a short-term minor impact to air quality. The project is located in an area of air quality attainment in accordance with the National Ambient Air Quality Standards and these short-term construction related impacts are not expected to change this status. The existing geology of the project area would not be affected under this alternative.

Alternative 3d—Channel Widening with Levees and Floodwalls: This alternative would cause minor, long-term impacts to the geomorphology of Turkey Creek within the project area from widening the channel bottom and sloping the sides of the channel. Additionally, the levees and floodwalls would constitute a change in the geomorphology of the Turkey Creek floodplain. A grass detention basin approximately 2.1 acre in size would be constructed on the east side of the Merriam Marketplace and would cause minor, long-term impacts to soils and geomorphology at this particular location. Ground disturbance necessary for construction would cause additional minor, short-term impacts to soils. Dust from construction activities may also lead to a short-term minor impact to air quality. The project is located in an area of air quality attainment in accordance with the National Ambient Air Quality Standards and these short-term construction related impacts are not expected to change this status. The existing geology of the project area would not be affected under this alternative. These changes would allow for a greater conveyance of water during flood events when compared to the other alternatives.

Alternative 4—Property Buy-Outs: This alternative would not change the geology or geomorphology of the project area. There may be minor, long-term beneficial impacts to soils within the project area if buildings and parking lots were to be removed and the project area left in a more natural condition. In total, 222 parcels of property, affecting about 135 acres, would be purchased. These properties are currently used for industrial, retail, and residential purposes.

6.2.2 CLIMATE

No-Action: The No-Action Alternative would not improve flood risk management along Turkey Creek. If the region continues to see increases in rainfall, and in particular any increase in the intensity of storm events, the risk of flooding would increase even more than the current risk level.

Alternative 1d—Channel Widening, Alternative 2d—Levees and Floodwalls, Alternative 3d—Channel Widening with Levees and Floodwalls, and Alternative 4—Property Buy-Outs: All of these alternatives would improve flood risk management along Turkey Creek compared to the No-Action Alternative. Changes in precipitation patterns could impact the level of flood risk management provided by these alternatives. These changes would not affect any features associated with these alternatives.

6.2.3 HYDRAULICS AND HYDROLOGY

No-Action: Under the No-Action Alternative, there would not be any foreseeable changes to the hydraulics or hydrology of Turkey Creek. The City of Merriam would not see any improvements to flood risk management compared to its current level of risk.

Alternative 1d—Channel Widening: This alternative would cause minor, long-term impacts to the hydraulics of Turkey Creek. The width of the channel bottom would be more than doubled under this alternative, allowing for greater water conveyance during flood events. Water velocity during baseflow conditions would be similar under this alternative compared to the No-Action Alternative, but the depth of water would be reduced. Construction equipment operating in the creek channel also may cause minor, short-term impacts to the hydraulics of the Creek. This alternative is not expected to have any substantial impact on the hydrology of the Turkey Creek watershed. The hydraulic modeling results show no increase in flooding upstream or downstream of the project reach. These results give reasonable confidence that the project will not induce additional damages upstream or downstream of its limits. The project reach consists of an urban watershed in which flood waters move rapidly through the overbank floodplain area. See Appendix B, Chapter 3 for detailed hydrologic and hydraulic conditions and analysis and Figure 5-1 for the proposed floodplain upstream and downstream of the project area.

Alternative 2d—Levees and Floodwalls: This alternative would cause minor, long-term impacts to the hydraulics of Turkey Creek. During flood events, it would constrain more water within the channel and reduce the likelihood of flooding adjacent to the channel. A grass detention basin approximately 2.1 acre in size would be constructed on property that is north of the Merriam Marketplace. About 4,000 linear feet of replacement and new stormwater drainage lines would be associated with the detention basin. Construction equipment operating in the creek channel also may cause minor, short-term impacts to the hydraulics of the creek. The recommended detention basin should not result in significant changes to the peak flows downstream of the Merriam Marketplace reach. This alternative is not expected to have any substantial impact on the hydrology of the Turkey Creek watershed. The hydraulic modeling results show no increase in flooding upstream or downstream of the project reach. These results give reasonable confidence that the project will not induce additional damages upstream or downstream of its limits. The project reach consists of an urban watershed in which flood waters move rapidly through the overbank floodplain area. See Appendix B, Chapter 3 for detailed hydrologic and hydraulic conditions and analysis and Figure 5-2 for the proposed floodplain upstream and downstream of the project area.

Alternative 3d—Channel Widening with Levees and Floodwalls: This alternative would have minor, long-term impacts to the hydraulics of Turkey Creek, as described under Alternatives 1d and 2d. A grass detention basin approximately 2.1 acre in size would be constructed on property that is part of the Merriam Marketplace. About 4,000 linear feet of replacement and new stormwater drainage lines would be associated with the detention basin. Construction equipment operating in the creek channel also may cause minor, short-term impacts to the hydraulics of the creek. The recommended detention basin should not result in significant changes to the peak flows downstream of the Merriam Marketplace reach. This alternative is not expected to have any substantial impact on the hydrology of the Turkey Creek watershed. The hydraulic modeling results show no increase in flooding upstream or downstream of the project reach. These results give reasonable confidence that the project will not induce additional damages upstream or downstream of its limits. The project reach consists of an urban watershed in which flood waters move rapidly through the overbank floodplain area. See Appendix B, Chapter 3 for detailed hydrologic and hydraulic conditions and analysis and Figure 5-3 for the proposed floodplain upstream and downstream of the project area.

Alternative 4—Property Buy-Outs: This alternative is not expected to change the hydraulics or hydrology of Turkey Creek. However, if structures were to be removed as part of the buy-out, there would be less resistance to water flow during flood events, which would be expected to reduce flood elevations. In addition to reducing property damage, this alternative would reduce the threat to human health and safety during flood events by removing people and property away from flood prone locations. Appendix B contains a more detail hydraulic and hydrologic analysis.

6.2.4 WATER QUALITY

No-Action: Under the No-Action Alternative, the water quality of Turkey Creek would not change. Turkey Creek water quality would continue to be negatively impacted by point and non-point sources of pollution.

Alternative 1d—Channel Widening: The channelization of Turkey Creek within the project area would cause minor, short-term impacts to water quality due to construction activities occurring within the creek channel and on the creek banks. Additionally, two sewer lines and two waterlines that currently cross under Turkey Creek would be replaced. During construction, downstream waters could see a temporary increase in turbidity. Construction activities under this alternative would require a CWA Section 401 State Water Quality Certification. Additionally, the construction contractor would be required to obtain a Section 402 NPDES permit from Kansas Department of Health and Environment (KDHE) prior to beginning any construction activities. Best management practices (BMPs) would be implemented to minimize the incidental fallback of material into the waterway and to minimize the introduction of fuel, petroleum products, or other deleterious material from entering the waterway. Such measures could include the using erosion control fences; storing equipment, solid waste, and petroleum products above the ordinary high water mark and away from areas prone to runoff; and requiring that all equipment be clean and free of leaks. To prevent fill from reaching water sources by wind or runoff, fill would be covered, stabilized, or mulched, and silt fences would be used as required. Once construction is complete, the water quality of Turkey Creek would return to its pre-construction state. This alternative would not cause significant, adverse, long-term impacts to water quality.

Alternative 2d—Levees and Floodwalls: Alternative 2d, the Recommended Plan, would have minor, short-term construction related impacts to water quality due to activities occurring within the creek channel and on the creek banks in order to construct the levees and floodwalls. Additionally, two sewer lines and two waterlines that currently cross under Turkey Creek would be replaced. During construction, downstream waters would experience an increase in turbidity. However, it is expected that these short-term increases in turbidity would be less than would occur under either Alternative 1 or Alternative 3 because the amount of construction activity occurring in the creek channel would be less. The detention basin may result in minor, long-term beneficial impacts to water quality by removing some suspended sediment from stormwater runoff before it would enter Turkey Creek. CWA Section 401 State Water Quality Certification has been obtained from the KDHE (Appendix D). . Additionally, the construction contractor would be required to obtain a Section 402 NPDES stormwater permit from KDHE prior to beginning any construction activities. BMPs would be implemented as described for Alternative 1d. This alternative would likely result in a minor long-term benefit to water quality by limiting the amount of trash and debris that enters the stream from surrounding industrial/commercial properties during storm events.

Alternative 3d—Channel Widening with Levees and Floodwalls: This alternative would cause similar minor, short-term, construction-related impacts as identified in Alternative 1, Channel Widening. As with the other construction alternatives, this alternative would require CWA Section 401 and 402 permits prior to beginning construction. This alternative would likely result in a minor long-term benefit to water quality by limiting the amount of trash and debris that enters the stream from surrounding industrial/commercial properties during storm events.

Alternative 4—Property Buy-Outs: This alternative is not expected to cause any impacts to water quality. It is unlikely that any CWA Section 404 authorization or Section 401 permits would be required. A Section 402 NPDES stormwater permit would be necessary to remove existing buildings.

6.2.5 AQUATIC HABITAT

No-Action: The No-Action Alternative would not change the aquatic habitat within the project area. The aquatic habitat would remain in a degraded condition, due to large portions of Turkey Creek being

channelized within the project area providing little habitat for benthic or invertebrate populations. The HEP method was used to evaluate the existing number of HUs for green sunfish within the project area, as an indicator of the condition of the aquatic habitat. Over a 50-year period of analysis, there would be 3.8 AAHUs for green sunfish within the project area. More detailed information on the HEP analysis is provided in Appendix M, *Compensatory Mitigation Determination*.

Alternative 1d—Channel Widening: Widening the Turkey Creek channel would cause short-term, construction-related impacts to the aquatic habitat. Long-term widening would cause a slight decrease in habitat quality but would result in an overall increase in the number of AAHUs for green sunfish because the amount of aquatic habitat within the project area would increase from 7 acres to 20 acres, an increase of approximately 13 acres. This alternative would result in 8.5 AAHUs, a net gain of 4.7 AAHUs when compared to the No-Action Alternative for green sunfish.

Alternative 2d—Levees and Floodwalls: Constructing levees and floodwalls would cause short-term, construction-related impacts to the aquatic habitat of Turkey Creek as a result of disturbances from heavy equipment operating in the creek to access the bank. After the project construction is complete, the aquatic habitat would be expected to return to its existing state, providing 3.8 AAHUs for green sunfish over the 50-year period of analysis. Long-term benthic or invertebrate populations would be similar to the no action alternative.

Alternative 3d—Channel Widening with Levees and Floodwalls: This alternative would have similar short-term, construction-related impacts to the aquatic habitat as Alternative 1. This alternative would result in 8.5 AAHUs for green sunfish, a net gain of 4.7 AAHUs compared to the No-Action Alternative.

Alternative 4—Property Buy-Outs: This alternative would not likely affect aquatic habitat. Over a 50-year period of analysis, there would be 3.8 AAHUs for green sunfish within the project area.

6.2.6 WETLANDS AND WATERS OF THE UNITED STATES

No-Action: The No-Action Alternative would not adversely impact any wetlands or jurisdictional waters of the United States. No wetlands are located within or adjacent to the project area.

Alternative 1d—Channel Widening: This alternative would not affect wetlands. This alternative would result in the widening of a jurisdictional water of the United States, Turkey Creek. This alternative would require a CWA Section 404 Authorization and a CWA Section 401 State Water Quality Certification for the project prior to the commencement of any construction activities.

To evaluate the need for any compensatory mitigation that may be required for CWA Section 404 Authorization, the HEP method was used. Specific HSI models used for this method were the green sunfish and the fox squirrel. This alternative would result in a net gain of 4.7 AAHUs for green sunfish. However, it would result in a habitat loss of 3.9 AAHUs for fox squirrel as a result of removing 6 acres of riparian trees along the bank of Turkey Creek. Fox squirrel habitat loss would be compensated for by planting 290 hard mast producing trees within the Turkey Creek watershed over an 11-acre area, as this type of mitigation would closely replicate the open-canopy mast producing trees with little underbrush habitat that would be lost. The City of Merriam would be responsible for providing lands to plant these trees as part of the cost sharing agreement. There have been preliminary discussions with the city to use open parklands owned by the city for mitigation locations. It has been assumed that any lands provided by the city would not have any existing fox squirrel habitat. No trees would be planted within 15 feet of any levee or floodwall, complying with Engineering Technical Letter 1110-2-571 Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures (April 10, 2009). Detailed information concerning this compensatory mitigation is found in Appendix M, *Compensatory Mitigation Determination*.

Alternative 2d—Levees and Floodwalls: Alternative 2d, the Recommended Plan, would not affect wetlands. This alternative would cause minor, short-term impacts to Turkey Creek, a jurisdictional water of the United States, as a result of construction to build portions of the levees and floodwalls. To evaluate the need for any compensatory mitigation that may be required for CWA Section 404 Authorization, green sunfish and the fox squirrel HSI models were utilized. Alternative 2 would not result in any habitat loss for green sunfish. However, it would result in a loss of 2.7 AAHUs for fox squirrel by removing approximately 3.6 acres of trees along the bank of Turkey Creek. This habitat loss would be compensated for by planting 185 hard mast producing trees over a 7-acre area, as this type of mitigation would closely replicate the open-canopy mast producing trees with little underbrush habitat that would be lost. The City of Merriam would be responsible for providing lands to plant these trees as part of the cost sharing agreement. There have been preliminary discussions with the city to use open parklands owned by the city for mitigation. It has been assumed that any lands provided by the city would not have any existing fox squirrel habitat. No trees would be planted within 15 feet of any levee or floodwall, complying with Engineering Technical Letter 1110-2-571 Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures (April 10, 2009). Additional information concerning compensatory mitigation is found in Appendix M, *Compensatory Mitigation Determination*.

CWA Section 404 Authorization has been prepared for the Recommended Plan and is included in Appendix D. CWA Section 401 State Water Quality Certification has also been obtained and is also included in Appendix D.

Alternative 3d—Channel Widening with Levees and Floodwalls: Alternative 3d would not affect wetlands. Under this alternative, Turkey Creek, a jurisdictional water of the United States, would be widened, requiring CWA Section 404 Authorization and CWA Section 401 State Water Quality Certification for the project prior to the commencement of any construction activities. As under Alternative 1, this alternative would result in a net gain of 4.7 HUs for green sunfish. It would result in a loss of 4.2 AAHUs for fox squirrel from removing 7 acres of riparian trees from along the bank of Turkey Creek. This habitat loss would be compensated for by planting 290 hard mast producing trees over an 11-acre area, as this type of mitigation would closely replicate the open-canopy mast producing trees with little underbrush habitat that would be lost. The City of Merriam would be responsible for providing lands to plant these trees as part of the cost sharing agreement. There have been preliminary discussions with the city to use open parklands owned by the city for mitigation. It has been assumed that any lands provided by the city would not have any existing fox squirrel habitat. No trees would be planted within 15 feet of any levee or floodwall, complying with Engineering Technical Letter 1110-2-571 Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures (April 10, 2009). Additional information concerning compensatory mitigation is found in Appendix M, *Compensatory Mitigation Determination*.

Alternative 4—Property Buy-Outs: Alternative 4 would not adversely impact any wetlands or jurisdictional waters of the United States. No wetlands are located within or adjacent to the project area. This alternative would not result in any changes to the AAHUs for green sunfish. Because of limited resources and the size of the project footprint for this alternative, AAHU for fox squirrel were not determined. However, it would be expected that there would be an increase in the number of AAHUs for this species over the long-term assuming that the area where properties would be bought out would be converted to green space.

6.2.7 TERRESTRIAL HABITAT

No-Action: The No-Action Alternative would not affect the existing terrestrial habitat within the project area.

Alternative 1d—Channel Widening: Widening Turkey Creek would convert approximately 13 acres of urban terrestrial habitat into aquatic habitat. In total, this alternative would result in the removal of riparian trees that provide about 6.3 acres of canopy cover. This cover is patchy in distribution and contains little overall connectivity due to urban development along Turkey Creek. Most of the project area contains manicured grass, parking lots, and buildings with little woody understory vegetation. As previously described, approximately 290 hard mast producing trees would be replanted over an 11-acre area for compensatory mitigation for CWA Section 404 compliance for the loss of riparian trees resulting from this alternative. The mitigation would closely replicate the open-canopy mast producing trees with little underbrush habitat that would be lost. Because the trees would take time to mature, this alternative would cause minor, long-term impacts to terrestrial habitat.

Alternative 2d—Levees and Floodwalls: Alternative 2d, the Recommended Plan, would result in the removal of riparian trees that provide approximately 3.6 acres of canopy cover. These trees are patchy in distribution and contain little overall connectivity. There is limited woody understory vegetation. Approximately 185 hard mast producing trees, such as oaks and walnut, would be planted over a 7-acre area for compensatory mitigation for CWA Section 404 compliance for the loss of riparian trees that would occur with the Recommended Plan. The mitigation would closely replicate the open-canopy mast producing trees with little underbrush habitat that would be lost. A map of potential mitigation planting sites is located in Appendix M. Because these trees would take time to mature, this alternative would cause minor, long-term impacts to the terrestrial habitat.

Alternative 3d—Channel Widening with Levees and Floodwalls: This alternative would convert approximately 13 acres of urban terrestrial habitat into aquatic habitat. In total, trees would be removed that provide approximately 6.4 acres of canopy cover. These riparian trees are patchy in distribution and contain little overall connectivity. The remaining project area contains manicured grass, parking lots, and buildings. Approximately 290 hard mast producing trees would be planted over an 11-acre area for compensatory mitigation for CWA Section 404 compliance for the loss of riparian trees. The mitigation would closely replicate the open-canopy mast producing trees with little underbrush habitat that would be lost. Because the trees would take time to mature, this alternative would cause minor, long-term impacts to the terrestrial habitat.

Alternative 4—Property Buy-Outs: Buying out and removing properties within designated locations subject to frequent flooding would likely result in more green space providing an improvement to the existing terrestrial habitat resulting in a minor, long-term benefit to terrestrial habitat.. Because of limited resources and the size of the project footprint for this alternative, AAHU for fox squirrel were not determined. However, it would be expected that there would be an increase in the number of AAHUs for this species over the long-term in the location where properties would be bought out and converted to green space.

6.2.8 FISH AND WILDLIFE

No-Action: The No-Action Alternative would not adversely impact any fish or wildlife. Fish and wildlife tolerant of an urban landscape would continue to persist. Over a 50-year period of analysis, there would be 3.8 AAHUs for green sunfish within the project area, and from 3.2 to 4.2 AAHUs for fox squirrel, varying by the size of the project footprint evaluated.

Alternative 1d—Channel Widening: This alternative would cause minor, short-term construction related impacts to fish and wildlife from construction noise, direct displacement of organisms, and potential decreases in water quality from excavation of the creek banks that may negatively impact species that are not tolerant of temporary increases in turbidity. BMPs, as described in Section 6.2.4, would help minimize impacts to water quality. Any organisms that would leave the project area as a result of noise or direct

displacement would be expected to either return to the area after construction has been completed or use similar habitat types in locations adjacent to the project. In the long term, this alternative would result in minor benefits to aquatic resources. Two barriers to fish movement would be removed under this alternative. These barriers are approximately 3 to 4 feet in height. One is a utility crossing that runs perpendicular to the creek channel that has been encased in concrete. The second is a vertical drop in the bedrock of the channel bottom that is probably the result of channelizing Turkey Creek in the past. Widening the channel would also increase the amount of habitat available to aquatic species by approximately 13 acres. Another minor, long-term benefit under this alternative would be the removal of limestone blocks that have been placed along most of the creek channel within the project area, creating vertical banks. The banks would be sloped from 2H:1V to 3H:1V and stabilized with quarry run rock. While quarry run rock would not be a desirable habitat for most wildlife species, the reduced slope of the channel banks would improve access to Turkey Creek for some wildlife such as squirrels and rabbits. One minor, long-term impact to wildlife would be the removal of riparian trees that provide approximately 6.3 acres of canopy cover. To offset the removal of these trees, approximately 290 hard mast producing trees would be planted within the Upper Turkey Creek watershed. To comply with the Migratory Bird Treaty Act, the taking of migratory birds, their eggs, and nests would be avoided by conducting field surveys if construction were to take place during the migratory bird nesting season, generally considered to be from April 1 to July 15. If active nests were identified during the survey that could not be avoided, either temporally or spatially, USFWS would be consulted.

Alternative 2d—Levees and Floodwalls: Alternative 2d, the Recommended Plan, would cause minor, short-term construction-related impacts to fish and wildlife from the construction noise, direct displacement of organisms, and potential decreases in water quality during construction that may negatively impact species that are not tolerant of these changes. BMPs, as described in Section 6.2.4, would help minimize impacts to water quality. Any organisms that would flee the project area as a result of noise or direct displacement would be expected to either return to the area after construction has been completed or use similar habitat types in locations adjacent to the project. One minor, long-term impact to wildlife would be the removal of riparian trees that provide approximately 3.6 acres of canopy cover. To offset the removal of these trees, approximately 185 hard mast producing trees would be planted in the Upper Turkey Creek watershed. A map of potential mitigation planting sites is located in Appendix M. A minor, long-term impact to wildlife would be that the levees and flood walls may physically restrict access to Turkey Creek. However, the 15- to 20-foot vertical drop along the creek banks due to the channelization with limestone blocks already limits wildlife access to Turkey Creek. To comply with the Migratory Bird Treaty Act, the taking of migratory birds, their eggs, and nests would be avoided by conducting field surveys if construction were to take place during the migratory bird nesting season, generally considered to be from April 1 to July 15. If active nests were identified during the survey but could not be avoided, either temporally or spatially, USFWS would be consulted.

Alternative 3d—Channel Widening with Levees and Floodwalls: As with the other alternatives that involve construction, this alternative would cause minor, short-term construction-related impacts from construction noise, direct displacement of organisms, and potential decreases in water quality during construction that may negatively impact species that are not tolerant of these changes. BMPs, as described in Section 6.2.4, would help minimize impacts to water quality. Any organisms that would flee the project area as a result of noise or direct displacement would be expected to return to the area after construction has been completed or use similar habitat types in locations adjacent to the project. In the long term, this alternative would result in minor benefits to aquatic resources within the project area. The two barriers to fish movement, previously described for Alternative 1, would be removed under this alternative. Widening the channel also would increase the amount of habitat available to aquatic species by approximately 13 acres. One minor, long-term impact to wildlife would be the removal of riparian trees that provide

approximately 6.4 acres of canopy cover. To offset the removal of these trees, approximately 290 hard mast producing trees would be planted in the Upper Turkey Creek watershed. A minor, long-term impact to wildlife would be that the levees and flood walls may physically restrict access to Turkey Creek. However, most of the creek banks along Turkey Creek in the project area consist of a vertical limestone wall that is 15 to 20 feet in height. These vertical banks already limit wildlife access to Turkey Creek. Actions to comply with the Migratory Bird Treaty Act would be the same as those described for Alternatives 1d and 2d.

Alternative 4—Property Buy-Outs: Buying properties in locations subject to frequent flooding, and subsequently removing any structures, would likely result in more green space that may provide some minor, indirect benefits to fish and wildlife. This alternative would not cause any long-term, negative impacts to fish and wildlife. This alternative would not result in any changes to the AAHUs for green sunfish. Because of limited resources and the size of the project footprint for this alternative, AAHUs for fox squirrel were not determined. However, it would be expected that there would be an increase in the number of AAHUs for this species over the long-term assuming that the area where properties would be bought out would be converted to green space.

6.2.9 THREATENED AND ENDANGERED SPECIES

No-Action: The No-Action Alternative would have no effect on any Federally-listed threatened or endangered species.

Alternative 1d—Channel Widening, Alternative 2d—Levees and Floodwalls, Alternative 3d—Channel Widening with Levees and Floodwalls, and Alternative 4—Property Buy-Outs: These alternatives would have no effect on any federally-listed threatened or endangered species, candidate species, or designated critical habitat. No federally listed species, candidate species, or designated critical habitats are located in or adjacent to the project area. A copy of the USFWS and Kansas Department of Wildlife, Parks, and Tourism (KDWPT) letters concurring that no affect has been placed in the appendix H of this report.

6.2.10 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTES

No-Action: This alternative would involve any ground disturbance; therefore, there would not be any impacts to HTRW sites.

Alternative 1d—Channel Widening, Alternative 2d—Levees and Floodwalls, Alternative 3d—Channel Widening with Levees and Floodwalls, and Alternative 4—Property Buy-Outs: Based on a records search, these alternatives are not expected to affect HTRW sites. However, because of the urban nature of the project site, any construction specifications developed for the alternative would include provisions to develop a contingency plan if any hazardous wastes or contaminated soils are encountered during construction.

6.2.11 FLOODPLAIN

No-Action: The No-Action Alternative would not change the existing characteristics or uses of the floodplain.

Alternative 1d—Channel Widening: Under this alternative, the greater conveyance of flood waters through the main channel and under the Merriam Drive and Shawnee Mission Bridges would cause minor, long-term impacts to the floodplain due to a reduction in floodplain area and the frequency of overbank flows. Because the floodplain has already been completely developed, it is not expected to induce any additional development.

Alternative 2d—Levees and Floodwalls: Under Alternative 2d, constraining more floodwater within the main channel would cause minor, long-term impacts to the floodplain. Because the floodplain has already been developed, this alternative is not expected to induce any additional development.

Alternative 3d—Channel Widening with Levees and Floodwalls: Under Alternative 3d, increasing the conveyance of flood waters and also constraining more flood water within the main channel would cause minor, long-term impacts to the floodplain. This alternative is not expected to induce any additional development within the floodplain.

Alternative 4—Property Buy-Outs: Property buy-outs would result in minor, long-term beneficial impacts to the floodplain. In total, 222 parcels of property, affecting about 135 acres, would be purchased. These properties are currently used for industrial, retail, and residential purposes.

6.2.12 LAND USE

No-Action: The No-Action Alternative would not change land use within the property area. The negative impacts of flooding would remain at current levels.

Alternative 1d—Channel Widening: This alternative would have a minor, long-term impact on land use adjacent to the Turkey Creek channel within the project area because additional land would be required on both sides of the creek to expand the width of the channel from its current width of approximately 50 feet to a top width of approximately 160 to 175 feet, depending on location. Implementation of this alternative would require obtaining approximately 31.17 acres of land immediately adjacent to the creek channel that is currently used for commercial and industrial developments and city parks. The two pedestrian bridges over Turkey Creek in the project area would be modified to span the width of the new channel.

Alternative 2d—Levees and Floodwalls: This alternative would have minor, long-term impacts on land use adjacent to the Turkey Creek channel within the project area. About 15.4 acres of land adjacent to the Turkey Creek channel would be needed to construct the levees and floodwalls, including about 30 feet of land from the existing Turkey Creek top of bank. Implementation of Alternative 2d also could require minor modifications, such as moving parking areas and existing industrial and commercial properties adjacent to the channel. Additionally, the property located to the north of the Merriam Marketplace would need to be acquired to construct a detention basin to collect stormwater runoff coming from locations landward of the levees and floodwall. It is not anticipated that any businesses would need to be bought out or relocated under this alternative. To minimize impacts to land use, floodwalls would be used in locations where there is not enough room between the channel and existing buildings to construct a levee. The two pedestrian bridges that span Turkey Creek in the project area would be increased in length so that they would extend over the new levee.

Alternative 3d—Channel Widening with Levees and Floodwalls: This alternative would have a long-term impact on land use adjacent to the Turkey Creek channel in the project area. Additional land would be required on both sides of the creek to expand the width of the channel from its current width of approximately 50 feet to a top width of approximately 160 to 175 feet, depending on location. Additional land would also be needed for levees and floodwalls. Implementation of this alternative would require obtaining approximately 33.6 acres of land immediately adjacent to the creek channel that is currently used for commercial and industrial developments and city parks. The two pedestrian bridges that span Turkey Creek in the project area would be increased in length so that they would extend over the new levee.

Alternative 4—Property Buy-Outs: Under Alternative 4, property buy-outs would result in long-term impacts to existing land use in locations along the Turkey Creek channel within the project area. In total, 222 parcels of property, totaling about 135 acres, would be purchased. These properties are currently used for industrial, retail, and residential purposes. Potentially, these locations could be returned to green space.

6.2.13 SOCIOECONOMICS

No Action: The future without a flood risk management project would not be expected to have any foreseeable impacts on the population or employment of the Turkey Creek project area or surrounding areas. Existing flood risk to the homes and business properties in the floodplain (approximately $4.7 million per year, based on Atlas-14, see Chapter 5, Table 5-12) would continue over the period of analysis.

Alternative 1d—Channel Widening: The future with a channel widening project flood risk management project would not be expected to have any foreseeable adverse impacts on the population or employment in the Turkey Creek project area or surrounding areas. This channel widening project would reduce the expected damage to the homes and business properties in the floodplain by an average of approximately $2.0 million per year over the period of analysis (estimate based on TP-40, see Chapter 5, Table 5-5) and decrease the likelihood that families and businesses would be forced to relocate outside the floodplain. This alternative would contribute to the safety of those working or residing within the floodplain by decreasing the probability of floodwater inundating the floodplain. During the period of construction, some noise would occur during normal daytime construction hours. With the construction occurring in an area that is primarily commercial and industrial, the noise impact on the community would probably be minimal.

Alternative 2d—Levees and Floodwalls: The future with the levee and floodwall project would slightly reduce employment in the Turkey Creek project area but not have any foreseeable adverse impacts on the population of the Turkey Creek project area or surrounding areas. This levee and floodwall project would reduce the expected damage to the homes and business properties in the floodplain by an average of approximately $3.4 million per year over the period of analysis (based on Atlas-14, see Chapter 5, Table 5-12) and decrease the likelihood that families and businesses would be forced to relocate outside the floodplain. This alternative would contribute to the safety of those working or residing within the floodplain by decreasing the probability of floodwater inundating the floodplain. This alternative would require relocating three businesses in the floodplain. These businesses have a combined estimated employment between 19 and 29 people. It is uncertain whether or not these businesses would relocate within the city of Merriam. For a couple of weeks during the period of construction, a culvert would be placed along Merriam Drive (the road that runs most prominently through the Merriam floodplain, with an average daily traffic count of 4,610), creating some delay. The likely impact would be Merriam Drive shutting down to one lane at a time. Also during the period of construction, some noise would occur during normal daytime construction hours. With the construction occurring in an area that is primarily commercial and industrial, the noise impact on the community would probably be minimal.

Alternative 3d—Channel Widening with Levees and Floodwalls: The future with a flood risk management project that combines channel widening with levees and floodwalls would slightly reduce employment in the Turkey Creek project area but not have any foreseeable adverse impacts on the population of the Turkey Creek project area or surrounding areas. Similar to Alternative 2, this flood risk management project would reduce the expected damage to the homes and business properties in the floodplain by an average of approximately $2.8 million over the period of analysis (estimate based on TP-40, see Chapter 5, Table 5-5) and decrease the likelihood that families and businesses would be forced to relocate outside the floodplain. This alternative would contribute to the safety of those working or residing within the floodplain by decreasing the probability of floodwater inundating the floodplain. This alternative would require relocating at least two businesses in the floodplain. It is uncertain whether or not these businesses would relocate within the city of Merriam. For a couple of weeks during the period of construction, a culvert would be placed along Merriam Drive (which has an average daily traffic count of 4,610), creating some delay. The likely impact would be Merriam Drive shutting down to one lane at a time. Also during the period of construction, some noise would occur during normal daytime construction hours.

With the construction occurring in an area that is primarily commercial and industrial, the noise impact on the community would probably be minimal.

Alternative 4—Property Buy-outs: The future with a property buyout of the floodplain would reduce the population and employment of the Turkey Creek project area. Under a future condition with this non-structural alternative, the bought-out homes and business properties would no longer incur any of their expected average annual damage of approximately $3.4 million (estimate based on TP-40, see Chapter 5, Table 5-5). A future under this alternative would result in families and businesses currently within the project area floodplain relocating outside the floodplain. Some businesses and residents would likely relocate within the city of Merriam; however, some businesses could move out of the study area if they cannot find suitable locally available facilities. This probability is particularly high under Alternative 4 because of the larger number of structures involved. If businesses move outside Merriam, the city would lose the associated jobs and tax revenue. This alternative would contribute to public safety by decreasing the consequences of floodwater inundating the floodplain.

6.2.14 ENVIRONMENTAL JUSTICE

No Action: The future without a flood risk management project would not be expected to have any disproportionate impacts on minority or low-income groups in the Turkey Creek project area or surrounding areas. **Alternative 1d—Channel Widening, Alternative 2d—Levees and Floodwalls, Alternative 3d—Channel Widening with Levees and Floodwalls, and Alternative 4—Property Buy-Outs:** These alternatives would not be expected to have any disproportionate impacts on minority or low-income groups in the Turkey Creek project area or surrounding areas. The minority populations for the overall study area and the Merriam project area are lower than the national averages. The percentage of the population below poverty level, on the other hand, is slightly higher in the Merriam project area (17.5 percent) than the national average of 13.8 percent. However, all of the alternatives would provide socioeconomic benefits by improving flood risk management within the project area.

6.2.15 TRANSPORTATION

No Action: The future without a flood risk management project would not be expected to have any foreseeable permanent impacts on transportation activity or infrastructure in the Turkey Creek project area or surrounding areas.

Alternative 1d—Channel Widening: A future with a channel widening flood risk management project would reduce the expected average annual damage to roads in the floodplain by approximately $14,000. Under this alternative, minor, short-term impacts to local traffic would occur during project construction.

Alternative 2d—Levees and Floodwalls: A future with a levee and floodwall project would reduce the expected average annual damage to roads in the floodplain by more than $16,000. Under this alternative, minor, short-term impacts to local traffic would occur during project construction.

Alternative 3d—Channel Widening with Levees and Floodwalls: A future with a flood risk management project that combines channel widening with levees and floodwalls would also reduce the expected average annual damage to roads in the floodplain by more than $16,000. Under this alternative, minor, short-term impacts to local traffic would occur during project construction.

Alternative 4—Property Buy-Outs: The future with a floodplain property buyout would not have a significant impact on the expected physical damages to roads in the floodplain. Removing the homes and businesses from the floodplain would likely reduce use of Merriam Drive and other roads in the floodplain.

6.2.16 RECREATION

No-Action: The No-Action Alternative would not impact recreation.

Alternative 1d—Channel Widening: This alternative would cause minor, long-term impacts to recreation resources along Turkey Creek. It would require using approximately 2 to 3 acres of the Merriam Marketplace, Campbell Park, and Werner Park to make room for a larger channel. Additionally, there may be impacts to the Turkey Creek Streamway Park. However, efforts would be made during the more detailed engineering and design phase of the project to retain a trail adjacent to Turkey Creek throughout the project area. Additionally, implementation of this alternative would cause minor, short-term impacts to the parks during project construction because these areas may not be available for public use.

Alternative 2d—Levees and Floodwalls: This alternative would cause minor, long-term impacts to recreation along Turkey Creek. It would require using a total of approximately 1 acre of the Merriam Marketplace and Campbell Park to make room for the levees and floodwalls. Additionally, there may be impacts to the Turkey Creek Streamway Park. However, efforts would be made during the more detailed engineering and design phase of the project to retain a trail adjacent to Turkey Creek throughout the project area. Implementation of this alternative may also cause minor, short-term impacts to the parks during project construction because these areas may not be available for public use.

Alternative 3d—Channel Widening with Levees and Floodwalls: This alternative would have minor, long-term impacts to recreation along Turkey Creek. It would require using approximately 2 to 3 acres of the Merriam Marketplace, Campbell Park, and Werner Park to make room for a larger channel and levees and floodwalls. Turkey Creek Streamway Park also would be impacted. However, efforts would be made during the more detailed engineering and design phase of the project to retain a trail adjacent to Turkey Creek throughout the project area. Additionally, implementation of this alternative would cause minor, short-term impacts to the parks during project construction because these areas may not be available for public use.

Alternative 4—Property Buy-Outs: Property buy-outs would not have any long-term adverse impacts on recreation in the project area. Potentially, the City of Merriam could convert the locations where properties have been bought out into additional city parks.

6.2.17 CULTURAL RESOURCES

No Action: The No-Action Alternative would not impact any cultural resources.

Alternative 1d—Channel Widening, Alternative 2d—Levees and Floodwalls, Alternative 3d—Channel Widening with Levees and Floodwalls, and Alternative 4—Property Buy-Outs: Because no cultural resource sites were recorded in the project area or identified during an archeological survey and because the area has been heavily disturbed by surrounding urban development, these alternatives would not adversely impact cultural resource sites. If in the unlikely event that archeological material is discovered during project construction, work in the area of the discovery would cease until the discovery is investigated by a qualified archeologist and the find is coordinated with the State Historic Preservation Officers (SHPO) and the Tribes.

6.2.18 SUMMARY OF ENVIRONMENTAL AFFECTS

A matrix was developed to summarize the impacts that each of the alternatives would have on each of the resources that were evaluated (Table 6-1). None of the alternatives would result in any significant adverse impacts to the human environment.

Table 6-1: Summary of the Environmental Impacts for the Alternatives

(Because there would not be any impacts to climate, wetlands, threatened and endangered species, HTRW, environmental justice, and cultural resources, these resource areas were omitted from the table.)

	No Action	Alternative 1d	Alternative 2d	Alternative 3d	Property Buy-Outs
Geology, Soils, and Geomorphology	O	□ (Soil disturbance) ▲ (Geomorphic ↑ in channel capacity)	□ (Soil disturbance) ■ (Levees in floodplain) ▲(2.1-acre detention basin)	□ (Soil disturbance) ■ (Levees in floodplain) ▲ (Geomorphic ↑ in channel capacity, 2.1-acre detention)	▲ (Potential to convert impervious cover to more natural soil type)
Hydraulics and Hydrology	O	□ (Construction equipment in channel) ▲(↑ in channel capacity)	□ (Construction equipment in channel) ■ (Constrained channel capacity)	□ (Construction equipment in channel) ■ (Constrained channel capacity) ▲(↑ in channel capacity)	▲(Potential for less resistance for flood waters)
Water Quality	O	□ (↑ in turbidity)	□ (↑ in turbidity)	□ (↑ in turbidity)	O
Aquatic Habitat	O	□ (Physical disturbance) ▲(↑ of 13 acres of habitat)	□ (Physical disturbance)	□ (Physical Disturbance) ▲(↑ of 13 Acres of Habitat)	O
Terrestrial Habitat	O	□ (Physical disturbance) ■ (6 acres of trees removed)	□ (Physical disturbance) ■ (4 acres of trees removed)	□ (Physical disturbance) ■ (6 acres of trees removed)	▲(Potential to restore more natural floodplain habitat)
Fish and Wildlife	O	□ (Physical disturbance) ■ (6 acres of trees removed) ▲(↑ of 13 acres of aquatic habitat)	□ (Physical disturbance) ■ (4 acres of trees removed)	□ (Physical disturbance) ■ (6 acres of trees removed) ▲(↑ of 13 acres of aquatic habitat)	▲(Potential to restore more natural floodplain habitat)
Floodplain	O	▲(↑ in channel capacity)	■ (Constrained channel capacity)	■ (Constrained channel capacity) ▲(↑ in channel capacity)	▲ (135 acres of developed properties removed from floodplain)
Land Use	O	■ (31.17 acres of developed properties needed for widening channel)	■ (15.4 acres of developed properties needed for widening channel)	■ (33.6 acres of developed properties needed for widening channel)	■ (135 acres of developed properties removed from floodplain)
Socioeconomics	O	▲ (Reduction of property damages by $2.7 million/year)	▲ (Reduction of property damages by $3.0 million/year) ■ (Relocation of 3 businesses)	▲ (Reduction of property damages by $3.0 million/year) ■ (Relocation of at least 2 businesses)	▲ (Reduction of property damages by $3.7 million/year) ■ (Relocation of 28 businesses and 9 residences)
Transportation	O	□ (Traffic delays, potential detours) ▲(Reduced road damage estimated at $14,000/year)	□ (Traffic delays, potential detours) ▲(Reduced Road Damage Estimated at $16,000/year)	□ (Traffic delays, potential detours) ▲(Reduced Road Damage Estimated at $16,000/year)	O
Recreation	O	□ (Restricted access to parks and trails) ■ (Removal of 2-3 acres of park lands)	□ (Restricted access to parks and trails) ■ (Removal of approximately 1 acre of park lands)	□ (Restricted access to parks and trails) ■ (Removal of 2-3 acres of park lands)	▲ (Potential to develop additional parkland or flood resilient recreational facilities in vacated floodplain)

Notes: O – No impact; □ – Minor, short-term negative impact resulting from construction; ■ – Minor, long-term negative impact; ▲ – Minor, long-term beneficial impact

6.3 ALTERNATIVE FORMULATION FOR COMPENSATORY MITIGATION

To evaluate the need for any compensatory mitigation that may be required for CWA Section 404 Authorization, the HEP method was used. Specific HSI models used for this method were the green sunfish (*Lepomis cyanellus*) and the fox squirrel (*Sciurus niger*). Screening level costs were utilized to identify appropriate mitigation plans for each study alternative. The cost for the final mitigation plan was updated prior to finalization of the study. Using the green sunfish model, it was determined that no compensatory mitigation would be needed for any of the alternatives evaluated for in-stream impacts (Table 6-2). Two of the alternatives—Alternative 1d, Channel Widening, and Alternative 3d, Channel Widening with Levees and Floodwalls—would increase the amount of aquatic habitat, resulting in an overall net gain in the number of AAHUs for this species. However, compensatory mitigation would be necessary for impacts to the riparian corridor as indicated by the fox squirrel model (Table 6-3). The amount of mitigation necessary would vary depending on the alternative implemented.

Table 6-2: Summary of Results from Green Sunfish HSI Model for Each Alternative

Alternative	Green Sunfish AAHU Future Without Project	Green Sunfish AAHU Future With Project	Mitigation Required
No-Action Alternative	3.77	3.77	No
Alternative 1d: Channel Widening	3.77	8.47	No
Alternative 2d: Levees and Floodwalls	3.77	3.77	No
Alternative 3d: Combination Widening and Levees and Floodwalls	3.77	8.47	No
Alternative 4: Property Buy-Outs	3.77	3.77	No

Notes: AAHU – Average annual habitat unit, HSI – Habitat Suitability Index, NA – Not applicable

Table 6-3: Summary of Results from Fox Squirrel HSI Model for Each Alternative

Alternative	Fox Squirrel AAHU Future Without Project	Fox Squirrel AAHU Future With Project	Mitigation Required
No-Action Alternative[a]	3.2 to 4.2	3.2 to 4.2	No
Alternative 1d: Channel Widening	3.94	0	Yes
Alternative 2d: Levees and Floodwalls	2.74	0	Yes
Alternative 3d: Combination Widening and Levees and Floodwalls	4.23	0	Yes
Alternative 4: Property Buy-Outs[b]	See footnote b	See footnote b	No

Notes: AAHU – Average annual habitat unit, HSI – Habitat Suitability Index, NA – Not applicable

[a] The AAHU varied based by the size of the project footprint evaluated for comparison with Alternatives 1d, 2d, or 3d.

[b] Due to limited resources and the size of the project footprint for this alternative, AAHUs for fox squirrel were not determined. However, it would be expected that there would be an increase in the number of AAHUs for this species over the long-term.

To compensate for riparian habitat lost as a result of implementing a structural alteruative, various mitigation options were developed. Each of these mitigation options would require planting hard mast producing trees, such as oak, walnut, and/or pecan. No trees would be planted within 15 feet of any levee or

floodwall, complying with Engineering Technical Letter 1110-2-571, Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures (April 10, 2009). Variables that were manipulated to develop various mitigation options included the initial size of the tree that would be planted, the density of the trees, and the size of the planting area. As shown in Table 6-4, a total of 24 mitigation options were developed.

Table 6-4: Mitigation Options Formulated to Compensate for Impacts to the Riparian Habitat as a Result of Implementing a Structural Alternative

Mitigation Option	Caliper of Tree When Planted	Density of Trees	Number of Acres Planted
Mitigation Option 1	5/8 inch	35 foot x 35 foot	5
Mitigation Option 2	5/8 inch	40 foot x 40 foot	5
Mitigation Option 3	5/8 inch	45 foot x 45 foot	5
Mitigation Option 4	1 inch	35 foot x 35 foot	5
Mitigation Option 5	1 inch	40 foot x 40 foot	5
Mitigation Option 6	1 inch	45 foot x 45 foot	5
Mitigation Option 7	5/8 inch	35 foot x 35 foot	7
Mitigation Option 8	5/8 inch	40 foot x 40 foot	7
Mitigation Option 9	5/8 inch	45 foot x 45 foot	7
Mitigation Option 10	1 inch	35 foot x 35 foot	7
Mitigation Option 11	1 inch	40 foot x40 foot	7
Mitigation Option 12	1 inch	45 foot x45 foot	7
Mitigation Option 13	5/8 inch	35 foot x 35 foot	9
Mitigation Option 14	5/8 inch	40 foot x 40 foot	9
Mitigation Option 15	5/8 inch	45 foot x 45 foot	9
Mitigation Option 16	1 inch	35 foot x 35 foot	9
Mitigation Option 17	1 inch	40 foot x 40 foot	9
Mitigation Option 18	1 inch	45 foot x 45 foot	9
Mitigation Option 19	5/8 inch	35 foot x 35 foot	11
Mitigation Option 20	5/8 inch	40 foot x 40 foot	11
Mitigation Option 21	5/8 inch	45 foot x 45 foot	11

Mitigation Option	Caliper of Tree When Planted	Density of Trees	Number of Acres Planted
Mitigation Option 22	1 inch	35 foot x 35 foot	11
Mitigation Option 23	1 inch	40 foot x 40 foot	11
Mitigation Option 24	1 inch	45 foot x 45 foot	11

The future condition of variables in the fox squirrel HSI model was predicted for each of the mitigation options, Appendix M. Selection of the most appropriate mitigation option was then determined through the CE/ICA process using IWR-Planning Suite. An additional criterion for selecting a mitigation option is that it must provide enough AAHUs to meet or exceed the number of AAHUs that would be lost as a result of implementing a particular alternative.

Each of the mitigation options was mutually exclusive from the others. Therefore, no additional permutations or combinations of options were evaluated under CE/ICA. IWR Planning Suite was used to determine which of the options were "cost effective" and which options were "best buys." Cost effective options are those options for which there is no other option that achieves greater output at a lesser cost (identified in Table 6-5). Best buy options are the array of cost effective options for which the average cost for the *incremental* output is strictly increasing (identified in Table 6-6). The output used for CE/ICA was the Fox Squirrel AAHU. The cost used for CE/ICA was average annual cost, including the cost of purchasing trees, installation, PED, and real estate. The full calculation of costs can be found in Appendix M. In addition to Tables 6-5 and 6-6, the results of CE/ICA are also displayed graphically in Figures 6-1 and 6-2.

Table 6-5: Results of IWR Planning Suite Cost Effectiveness Analysis

Mitigation Option	Total Cost	Average Annual Cost[a]	Fox Squirrel AAHU Gain	Cost Effective?
No Mitigation	$0	$0	0.00	Yes
Mitigation Option 1	$14,802	$689	2.26	Yes
Mitigation Option 2	$13,851	$645	2.23	Yes
Mitigation Option 3	$13,323	$620	2.18	Yes
Mitigation Option 4	$30,483	$1,419	2.78	No
Mitigation Option 5	$25,612	$1,192	2.71	No
Mitigation Option 6	$22,906	$1,066	2.58	No
Mitigation Option 7	$20,722	$965	3.16	Yes
Mitigation Option 8	$19,392	$903	3.12	Yes
Mitigation Option 9	$18,652	$868	3.06	Yes
Mitigation Option 10	$42,676	$1,987	3.89	No
Mitigation Option 11	$35,857	$1,669	3.80	No
Mitigation Option 12	$32,069	$1,493	3.61	No
Mitigation Option 13	$26,643	$1,240	4.06	Yes

Mitigation Option	Total Cost	Average Annual Cost[a]	Fox Squirrel AAHU Gain	Cost Effective?
Mitigation Option 14	$24,932	$1,161	4.01	Yes
Mitigation Option 15	$23,982	$1,116	3.93	Yes
Mitigation Option 16	$54,870	$2,554	5.00	No
Mitigation Option 17	$46,102	$2,146	4.88	No
Mitigation Option 18	$41,232	$1,919	4.64	No
Mitigation Option 19	$32,564	$1,516	4.97	Yes
Mitigation Option 20	$30,473	$1,419	4.90	Yes
Mitigation Option 21	$29,311	$1,364	4.80	Yes
Mitigation Option 22	$67,063	$3,122	6.12	Yes
Mitigation Option 23	$56,347	$2,623	5.97	Yes
Mitigation Option 24	$50,394	$2,346	5.67	No

Note: IWR – Institute of Water Resources
[a] The average annual cost was determined using an October 2011 price level and the FY 2012 federal interest rate of 4.000% over a 50-year period of analysis.

Table 6-6: Results of IWR Planning Suite Incremental Cost Analysis

Mitigation Option	Average Annual Cost	Fox Squirrel AAHU Gain	Best Buy?
No Mitigation	$0	0.00	Yes
Mitigation Option 1	$689	2.26	No
Mitigation Option 2	$645	2.23	No
Mitigation Option 3	$620	2.18	No
Mitigation Option 7	$965	3.16	No
Mitigation Option 8	$903	3.12	No
Mitigation Option 9	$868	3.06	Yes
Mitigation Option 13	$1,240	4.06	No
Mitigation Option 14	$1,161	4.01	No
Mitigation Option 15	$1,116	3.93	Yes
Mitigation Option 19	$1,516	4.97	No
Mitigation Option 20	$1,419	4.90	Yes
Mitigation Option 21	$1,364	4.80	Yes

Mitigation Option	Average Annual Cost	Fox Squirrel AAHU Gain	Best Buy?
Mitigation Option 22	$3,122	6.12	Yes
Mitigation Option 23	$2,623	5.97	Yes
Mitigation Option 24	$2,346	5.67	No

Note: IWR – Institute of Water Resources

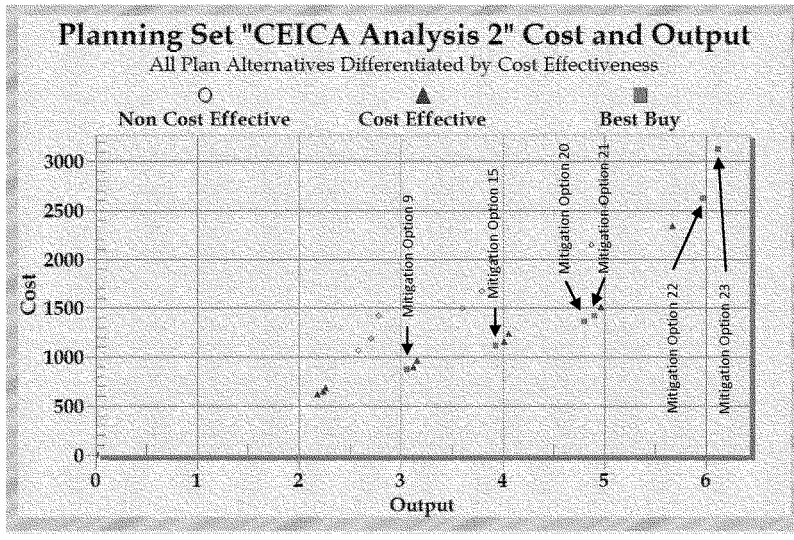


Figure 6-1: Planning Set "CE/ICA Analysis 2" Cost and Output

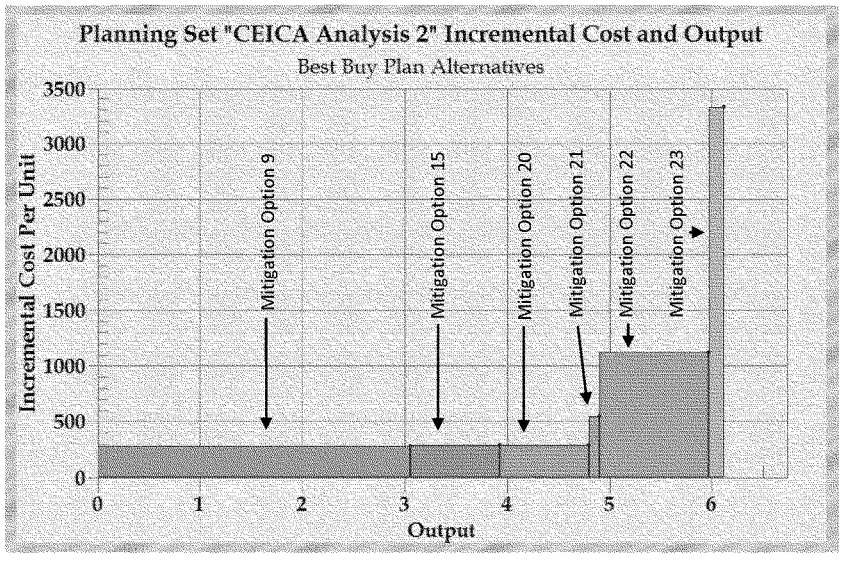


Figure 6-2: Planning Set "CE/ICA Analysis 2" Incremental Cost and Output

***output is in Average Annual Habitat Units (AAHUs),**
****each color bar represents a mitigation option alternative**

The criteria for determining which mitigation option(s) would be used in the economic screening were that the option:

1. Is a best buy option as determined by CE/ICA
2. Meets the minimum mitigation requirement for a given alternative
3. Is the lowest-cost option of the options that meet criteria 1 and 2

The best buy options are evaluated for criteria 2 in Table 6-7. The final results of all criteria are shown in Table 6-8.

Table 6-7: Evaluation of Best Buy Options against Minimum Mitigation Requirement

Mitigation Option (Re-ordered by ascending cost and output)	Fox Squirrel AAHU Gain	Meets Minimum Mitigation Requirement for Alt 1d (3.94)	Meets Minimum Mitigation Requirement for Alt 2d (2.74)	Meets Minimum Mitigation Requirement for Alt 3d (4.23)	Meets Minimum Mitigation Requirement for Alt 4 (0.00)
No Mitigation	0.00	No	No	No	Yes
Mitigation Option 9	3.06	No	Yes	No	Yes
Mitigation Option 15	3.93	No	Yes	No	Yes
Mitigation Option 21	4.80	Yes	Yes	Yes	Yes
Mitigation Option 20	4.90	Yes	Yes	Yes	Yes

Mitigation Option (Re-ordered by ascending cost and output)	Fox Squirrel AAHU Gain	Meets Minimum Mitigation Requirement for Alt 1d (3.94)	Meets Minimum Mitigation Requirement for Alt 2d (2.74)	Meets Minimum Mitigation Requirement for Alt 3d (4.23)	Meets Minimum Mitigation Requirement for Alt 4 (0.00)
Mitigation Option 23	5.97	Yes	Yes	Yes	Yes
Mitigation Option 22	6.12	Yes	Yes	Yes	Yes

Table 6-8: Mitigation Options and Mitigation Costs Used in Economic Screening

Alternative	Mitigation Option Used in Economic Screening	Total Cost[a]
Alternative 1d: Channel Widening	Mitigation Option 21	$29,311
Alternative 2d: Levees and Floodwalls	Mitigation Option 9	$18,652
Alternative 3d: Combination Widening and Levees and Floodwalls	Mitigation Option 21	$29,311
Alternative 4: Property Buy-Outs	No Mitigation	$0

[a] Screening level costs were utilized to identify appropriate mitigation plans for each study alternative. The cost for the final mitigation plan was updated prior to finalization of the study.

6.4 CUMULATIVE IMPACTS

The CEQ Regulations defines cumulative impacts as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time" (CEQ 1997). The cumulative impacts addressed in this document consist of the impacts of multiple actions that result in similar effects on the natural resources. The geographical areas of consideration are actions located within the Turkey Creek watershed.

Much of the original Turkey Creek floodplain has been developed for urban uses, including industrial, commercial, and residential areas. Turkey Creek originally flowed into the Missouri River, but a major flood in the 1800s moved its mouth from the Missouri River to the Kansas River. Since that time, Turkey Creek has been channelized, moved and filled, and placed in a tunnel for some of its length. The lower reach of the creek was originally channelized before 1920, during the construction of the tunnel bypass. In addition, the construction of I-35 and the railroad through the Turkey Creek valley has also impacted the creek channel and floodplain. Urban development of the floodplain has included fill activity, channelization of drainages including concrete lining and enclosures, and development of numerous buildings, parking lots, roads, and utilities. Within the Merriam project area, Merriam Drainage District (MDD) has channelized Turkey Creek from 63rd Street downstream to 51st Street in the late 1960s and early 1970s. MDD has produced a channel of nearly uniform width, deepened to bedrock, through the Merriam project area.

The recommended plan in this study is not expected to result in cumulative impacts with past actions that have occurred in the watershed. The location that the project would provide socioeconomic benefits too is highly urbanized and area is fully developed with residential, commercial, and industrial land uses. The project would provide socioeconomic benefits to the area, but is not expected to contribute to future development that could result in any additional environmental impacts. Space within the project area limits any additional development.

In addition to the alternatives evaluated in this Integrated Feasibility Report and EA, USACE is currently constructing another flood risk management project on Turkey Creek under a separate authorization. Construction of this project, Lower Turkey Creek, began in 2004 and is expected to be completed in 2016. The Lower Turkey Creek project is being constructed along the downstream 8,700 feet of Turkey Creek before it enters the Kansas River. The project is being constructed in several phases. Work completed to date includes a realignment and widening of the channel immediately adjacent to I-35 for approximately 4,000 feet, rehabilitation of a 1,200-foot-long tunnel, construction of an engineered channel for 1,500 feet, replacement of a railroad bridge, construction of a levee 2,500 feet long, and development of an 18-acre environmental enhancement area. Future work will include replacement of a bridge, widening and benching of 1,800 feet of channel, replacement of a second railroad bridge, and construction of a series of hillside interceptors to direct water from upland areas directly to Turkey Creek.

Another major construction activity occurring in the Turkey Creek watershed and relatively close to the creek in some locations is numerous construction projects along I-35. These projects are part of a phased plan to widen I-35 and redo numerous interchanges along the interstate in Johnson County to meet future traffic demands. The I-35 construction projects are scheduled to be completed by 2015.

A project that replaced a traffic bridge on Antioch Road and a railroad bridge over Turkey Creek was completed in the year 2000. These bridges are both located within Merriam, Kansas. These bridges were designed to reduce channel constrictions along Turkey Creek. Additionally, gabion revetments were used to stabilize the banks of the creek in the vicinity of the bridges. Other construction activities within the Turkey Creek watershed are expected to continue indefinitely into the future as development and redevelopment continues in the highly urbanized watershed.

Turkey Creek has relatively poor water quality as the result of urban runoff and effluent from a waste water treatment plant. In addition, the aquatic community in the creek lacks diversity and is dominated by species that are tolerant of polluted waters. Much of Turkey Creek has only limited riparian habitat due to the presence of industrial properties, fencing, roads, and other intensive land use practices. Intensive development within the Turkey Creek watershed has resulted in a narrow to non-existent riparian corridor along the channel. As part of this study, potential measures to benefit the ecosystem were developed early in the study process as part of a systems approach and are included in Appendix J. However, there was not support from the local sponsor to further develop these measures into implementable plans because they would not have any measurable benefits for flood risk management on a scale that would be able to be reasonably implanted. It is hoped that these plans could be refined at some point in the future by either the sponsor or some other interested entity and implemented. The current project is not expected preclude or inhibit any efforts that may be undertaken in the future to improve water quality or benefit fish and wildlife habitat.

In the past, watershed planning efforts have been initiated to improve the environment within the Upper Turkey Creek watershed. In 2005 and 2006, EPA contracted the Watershed Institute, Inc. to prepare background research as the first phase of a Special Area Management Plan (SAMP) for the Upper Turkey Creek watershed. The goal of SAMP is to achieve a balance between aquatic resource conservation, infrastructure maintenance, and sound economic development to minimize the individual and cumulative impacts of future projects. Implementation for the remaining three phases of the SAMP has not occurred. At this time, it seems unlikely that SAMP will be further developed or implemented for Turkey Creek. However, if one is ever implemented in the future, the SAMP would not be impacted by the current project.

The sponsor will prepare the Floodplain Management Plan (FMP) during design phase. Any action items developed as part of FMP will be a local responsibility and will have specific timeframes identified for

implementation to ensure not only the longevity of the project identified in this report but also to improve public understanding of flood risks and reduce future damages and threats to public safety.

The recommended plan is not expected to result in cumulative impacts with other past, ongoing projects or projects that may occur in the future. The primary environmental impact associated with the recommended plan is to riparian trees. This impact would be mitigated at part of the project. Other minor impacts, primarily related to short-term construction related impact and long-term geomorphic changes would occur in locations that have already been modified in the past. These impacts are similar in intensity to past disturbances and are typical in context with other activities in the area and are not expected to have long-term cumulative adverse effects to the human environment. The recommend plan would not prevent future efforts to improve environmental conditions with the watershed.

7 CHAPTER 7 – THE RECOMMENDED PLAN

The USACE Planning Guidance Notebook, ER 1105-2-100, states, "A plan that reasonably maximizes net national economic development benefits, consistent with the Federal objective, is to be formulated. This plan is to be identified as the National Economic Development (NED) plan." The Environmental Assessment for this study has been integrated into the following Feasibility Report in accordance with ER 1105-2-100. Sections of the report that are required for compliance with the National Environmental Policy Act (NEPA) are noted by an asterisk (*) in the Table of Contents.

The feasibility study's project delivery team identified Alternative 2d as the NED Plan and selected Alternative 2d as the Recommended Plan. Alternative 2d is the plan that reasonably maximizes the net NED benefits (as shown in the initial screening of alternatives in Section 5.3 and post-Atlas-14 sensitivity-analysis described in Section 5.4), while also being environmentally acceptable (as shown in Chapter 6). Alternative 2d would pass the 1 percent Annual Chance of Exceedance (ACE) event through downtown Merriam with an estimated assurance (conditional non-exceedance probability) of 82.9 percent, provide greater net annual benefits in reduction of flood damages than the other alternatives, and meet the needs of the local community.

The cost of the NED Plan Alternative 2d increased significantly during development of the detailed plan analysis. This is not uncommon when considering the proposed selected/NED Plan in more detail that the costs will increase as more engineering and cost estimating effort is applied. The sensitivity analysis completed in Section 5.4 utilizing updated features and costs for the most economically effective plans 2c, 2b and the Atlas 14 Plan confirmed Plan 2d as the plan with the highest net annual benefits.

A Cost and Schedule Risk Analysis (CSRA) was performed on the Recommended Plan (Alternative 2d). The project cost including the contingency estimate that resulted from CSRA for Alternative 2d is $37,579,000 (price level date 1 Oct 2014). There is also an additional economic cost of interest during construction (IDC) of $3,003,900, for a total investment cost of $40,582,900. Total annual NED cost is $1,732,200. Total annual benefits are $3,444,700. The benefit-cost ratio is 2.0 to 1, with net benefits of $1,712,500.

7.1 PLAN ACCOMPLISHMENTS

The Recommended Plan meets the objectives identified in Chapter 2, Section 2.4. The Principles and Guidelines for Water and Related Land Resources Studies (P&G) define effectiveness as a measure of the extent to which a plan achieves its objectives. The Recommended Plan meets the criteria of effectiveness, because it reduces risk to the City business district and public facilities, and allows these facilities to remain functional during all but the largest flood events. Additionally, through the systems approach used by USACE throughout the study numerous collaborative planning achievements were met. These include working jointly with the cities and counties on watershed based tools to reduce flood hazards, developing environmental restoration strategies, integrating recreational trails, and working with numerous stakeholder groups within the watershed.

Given the cost, the Recommended Plan is estimated to provide the greatest level of damage reduction of approximately 73 percent of total equivalent annual damages within the Upper Turkey Creek watershed to the city of Merriam with residual damages of 27 percent of the future without-project damages.

Because of the area of the City that is susceptible to flooding and the velocity of the flood waters, there is a risk for loss of life during flood fighting and other emergency measures. The flood of July 1993 caused one fatality and resulted in damages estimated at $3.4 million in Merriam, and $20 million in the lower basin areas. The flood of October 1998 caused an estimated $12 million of damages in Merriam, and

damages in the lower basin equivalent to those of 1993. The flood peak occurred in the late evening, and if the peak had occurred during rush hour, loss of life would have been very likely for travelers on I-35, which was overtopped by flood waters at multiple locations. The Recommended Plan would substantially reduce flood risk in the City of Merriam to 69 commercial/industrial structures and nine residential structures and would also likely reduce the risk of loss of life from flooding, due to the decreased probability of a flood event inundating the floodplain with short warning time.

There is one critical facility in the floodplain, the nursing home located at 62nd Street. The property is subjected to potential flooding in the without-project condition and it will be protected by the recommended plan.

The planners and hydraulic engineers developed inundation maps for the without and with-project conditions to depict estimates of flooding and the effects of the Recommended Plan. Those are located in plates at the beginning of Section 7.2.

7.2 CONSTRUCTION FEATURES

The Recommended Plan is a levee and floodwall plan in the city of Merriam. These features would extend approximately from Shawnee Mission Parkway to Merriam Drive, which is a 1.5-mile stretch that includes Merriam's main downtown reach. Most of the protected area is on the right bank of Turkey Creek while much of the left bank remains as an unoccupied floodplain. The features are designed for a small urban watershed and include levees no more than 6.5 feet high. The Recommended Plan includes 6,822 feet of floodwall up to 6.5 feet high, 3,383 feet of levees up to 6 feet high, utility modifications, approximately 12,427 Auger Grout Piles, and a 2.14 acre-foot detention area (Figures 7-1 through 7-6). These figures are plates depicting the primary features of the project in plan view by reach of the creek. In addition, Figures 7-7 and 7-8 are plates showing the inundation from flooding for the nominal 1 percent-ACE and the 0.2 percent-ACE events in the without project and with-project conditions. The blue hatching overlay shows the 1 percent-ACE event flooding extent, and the 0.2 percent-ACE event is shown by the lighter blue shading.

An overview of major construction features is included in sections below, and a summary of the Recommended Plan features is included in Table 7-1 by reach.

- Levees and floodwalls
- Ground Modification
- Bridge modifications/headwalls
- Utility modifications
- Environmental mitigation

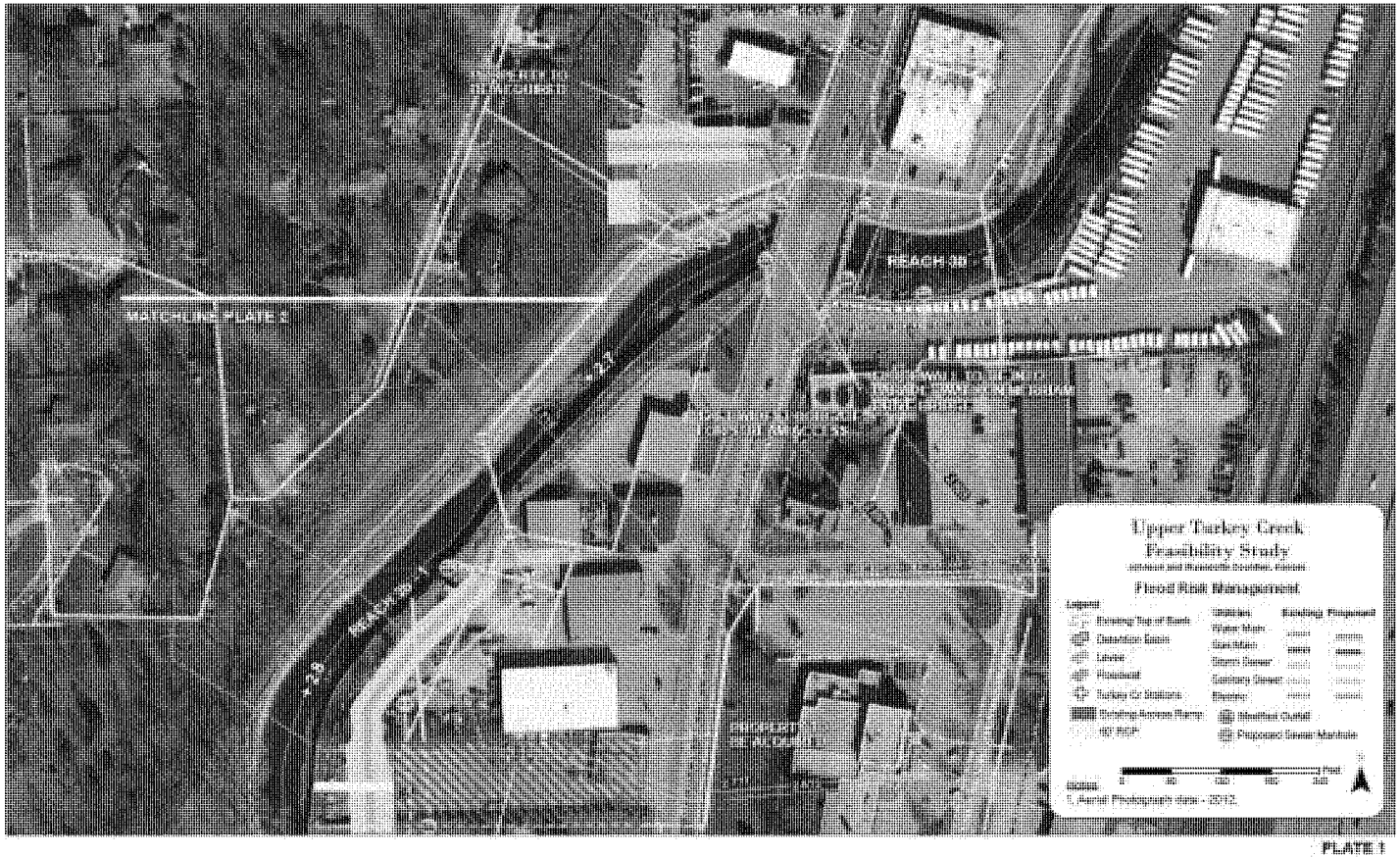


Figure 7-1: Recommended Plan (Alternative 2d) - Plate 1

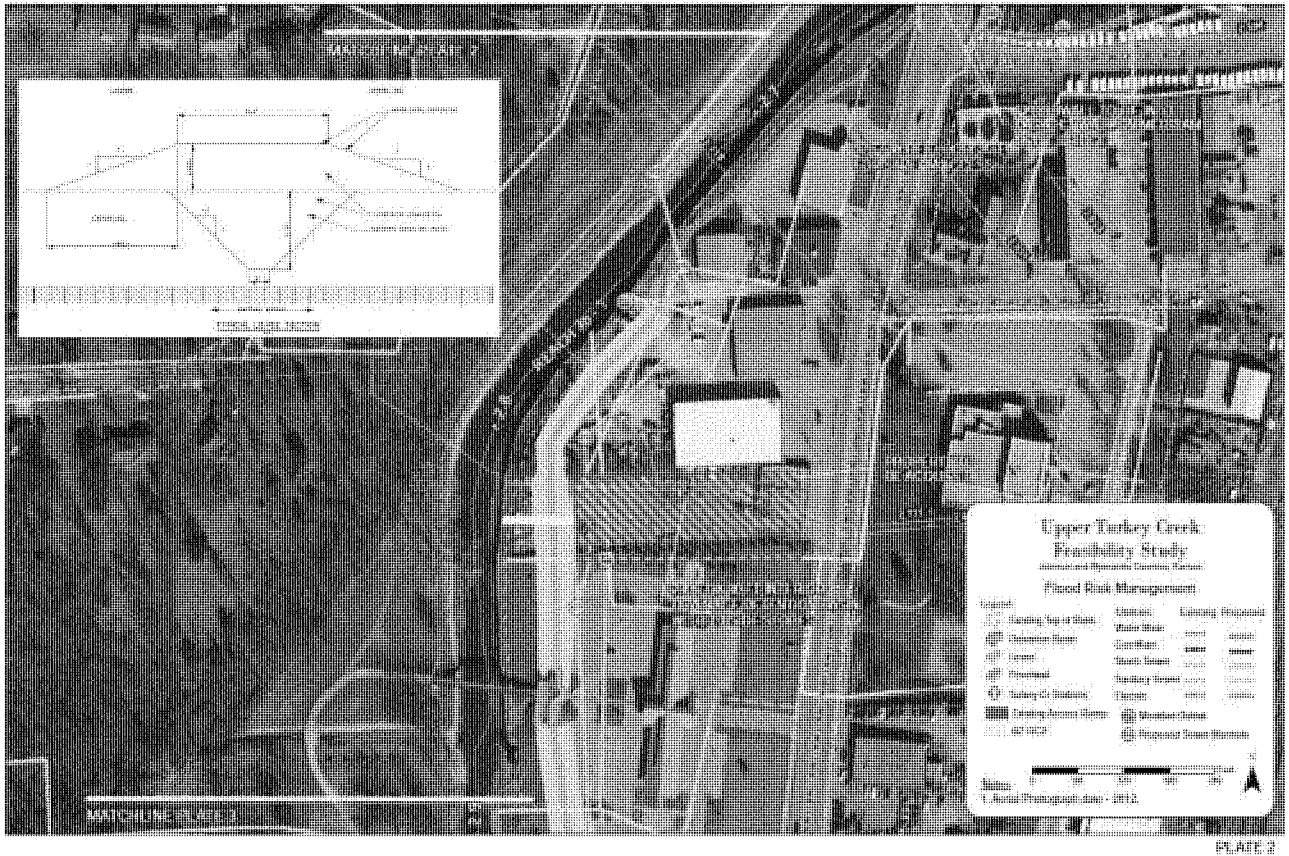


Figure 7-2: Recommended Plan (Alternative 2d) - Plate 2

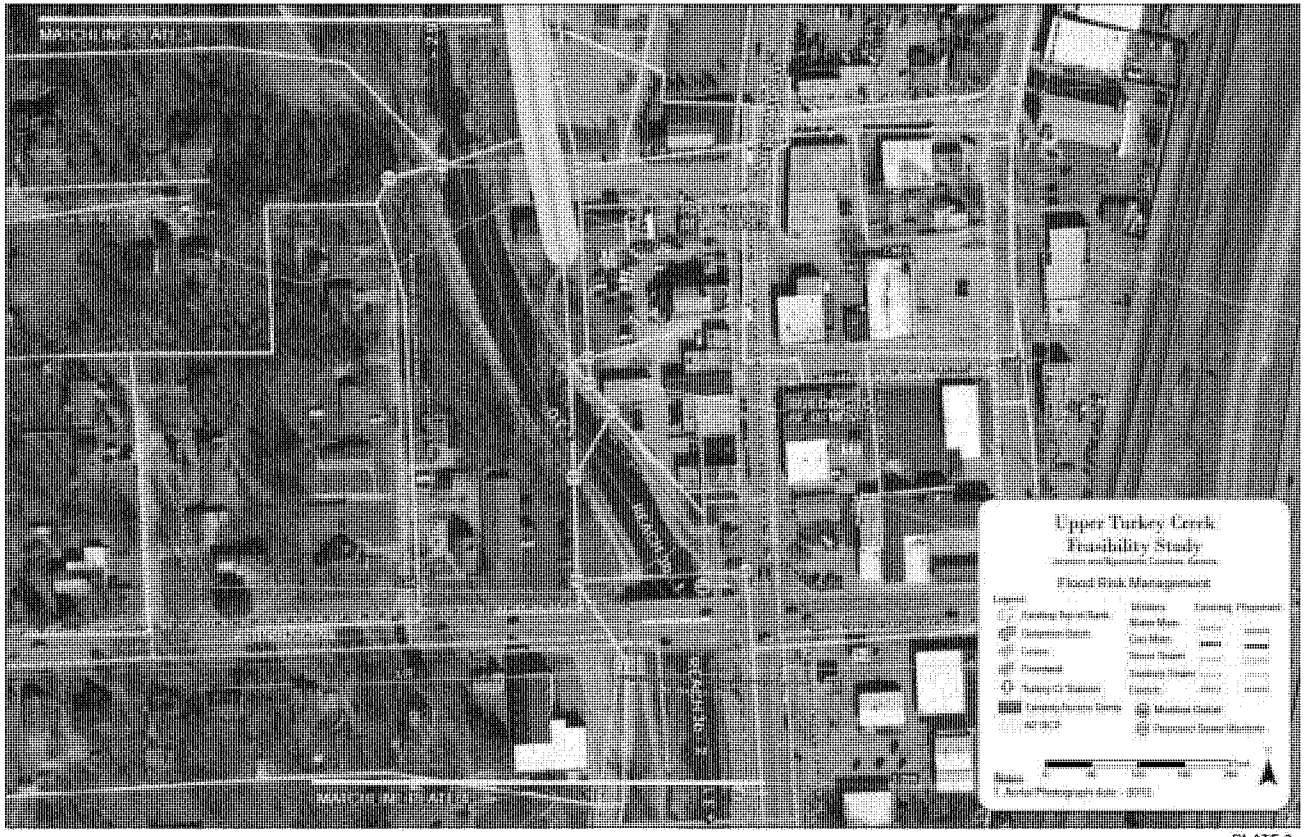


Figure 7-3: Recommended Plan (Alternative 2d) - Plate 3

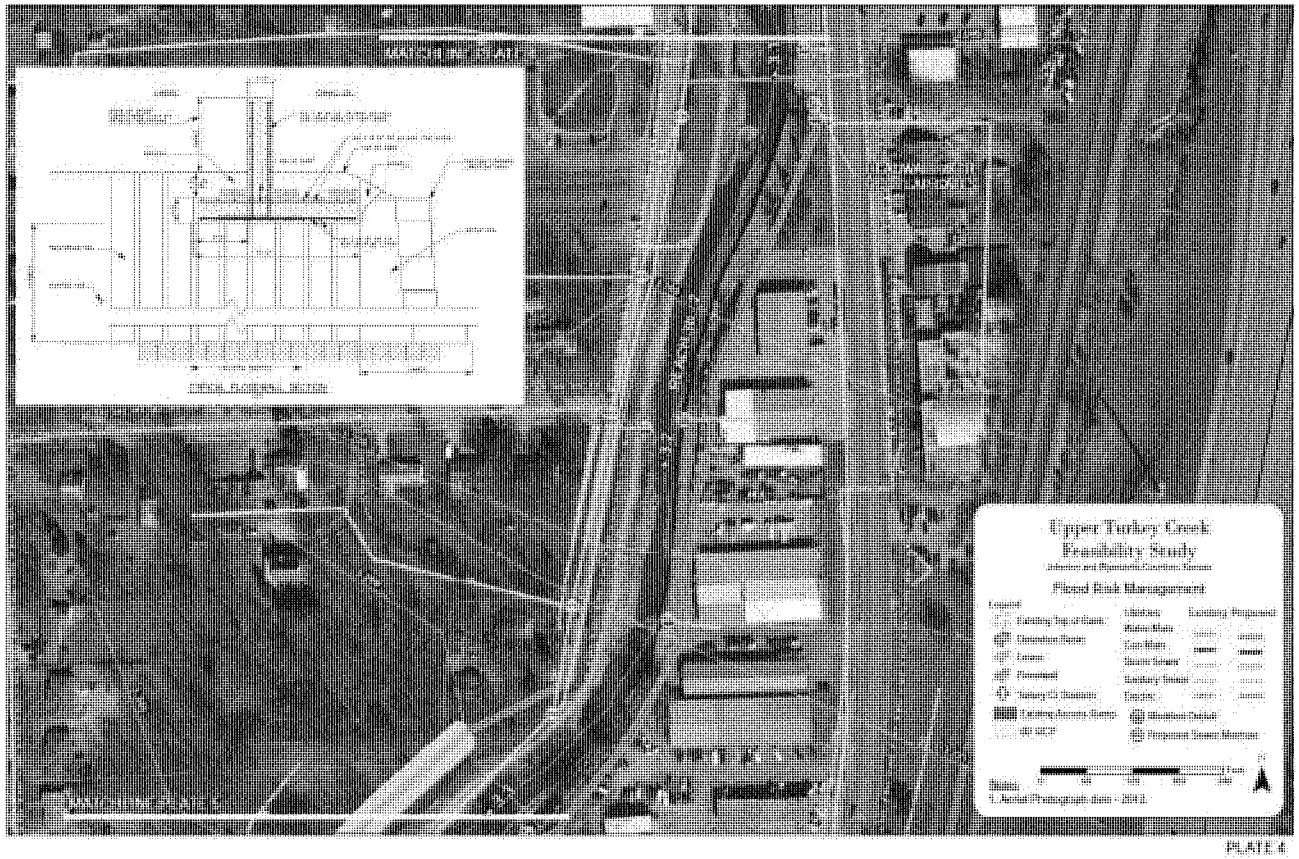


Figure 7-4: Recommended Plan (Alternative 2d) - Plate 4

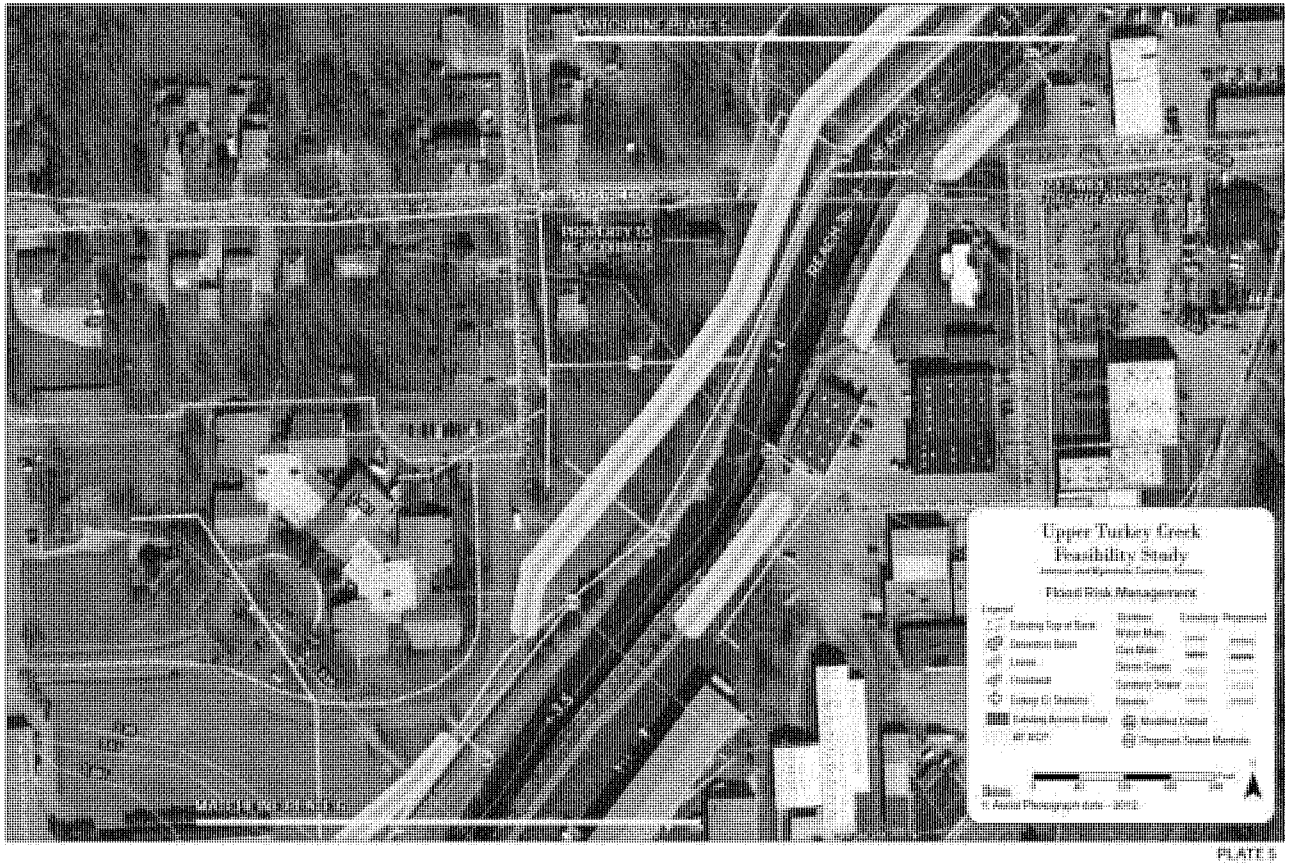


Figure 7-5: Recommended Plan (Alternative 2d) - Plate 5

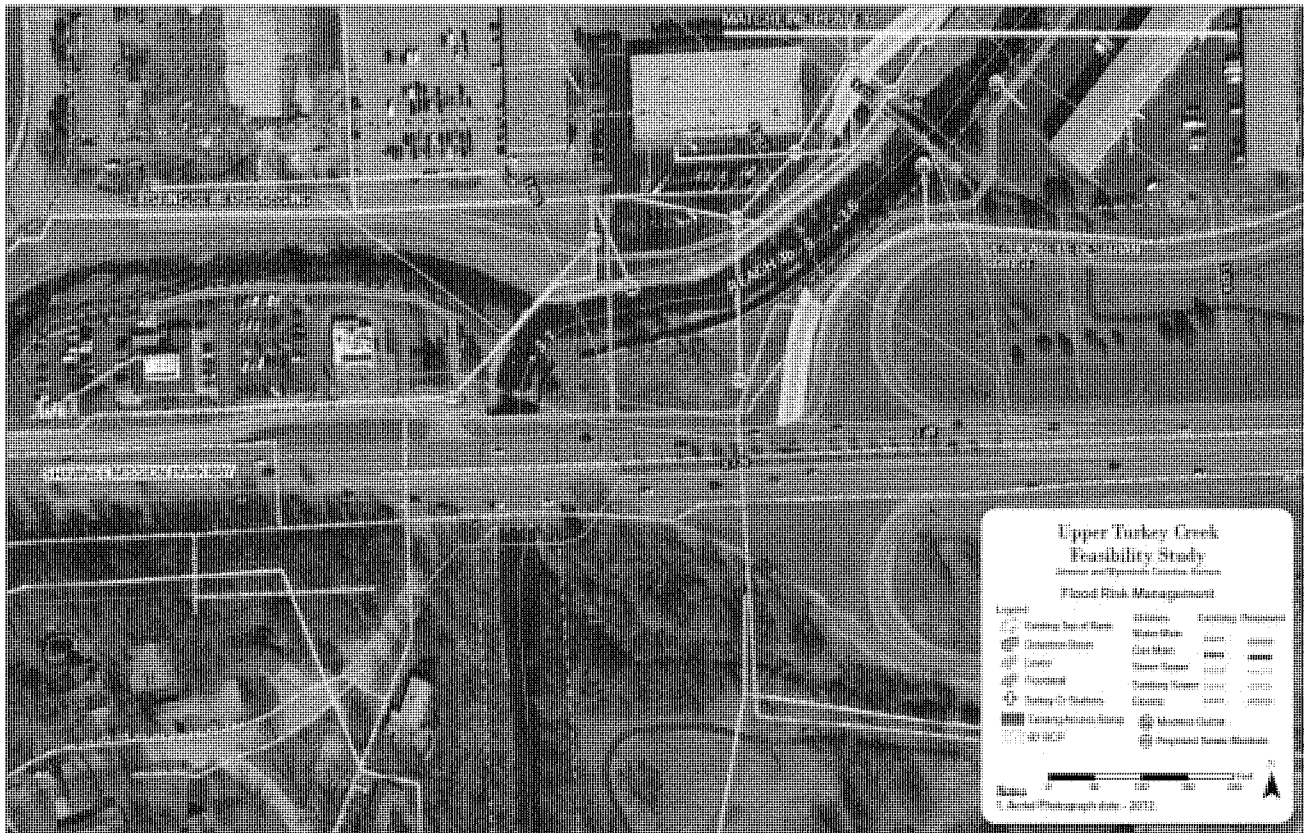


PLATE 6

Figure 7-6: Recommended Plan (Alternative 2d) - Plate 6

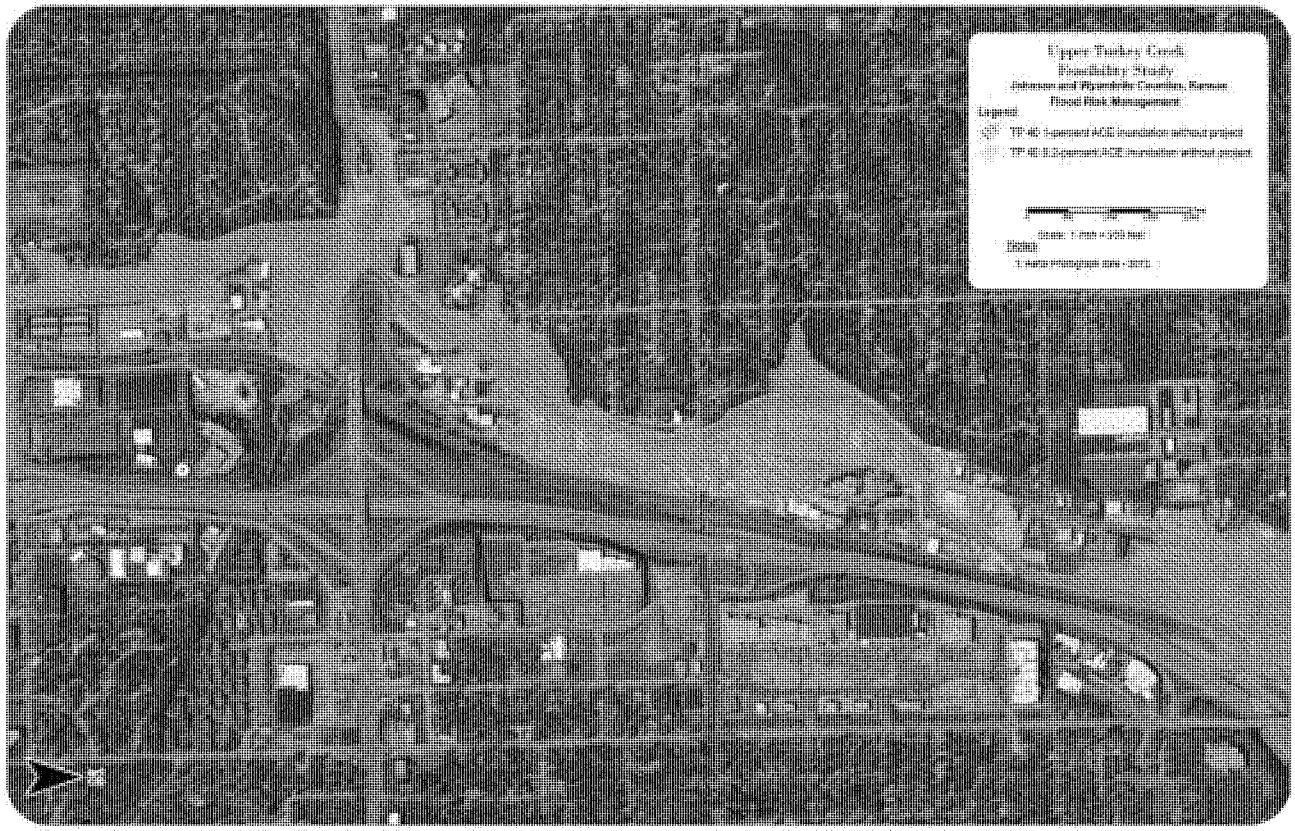
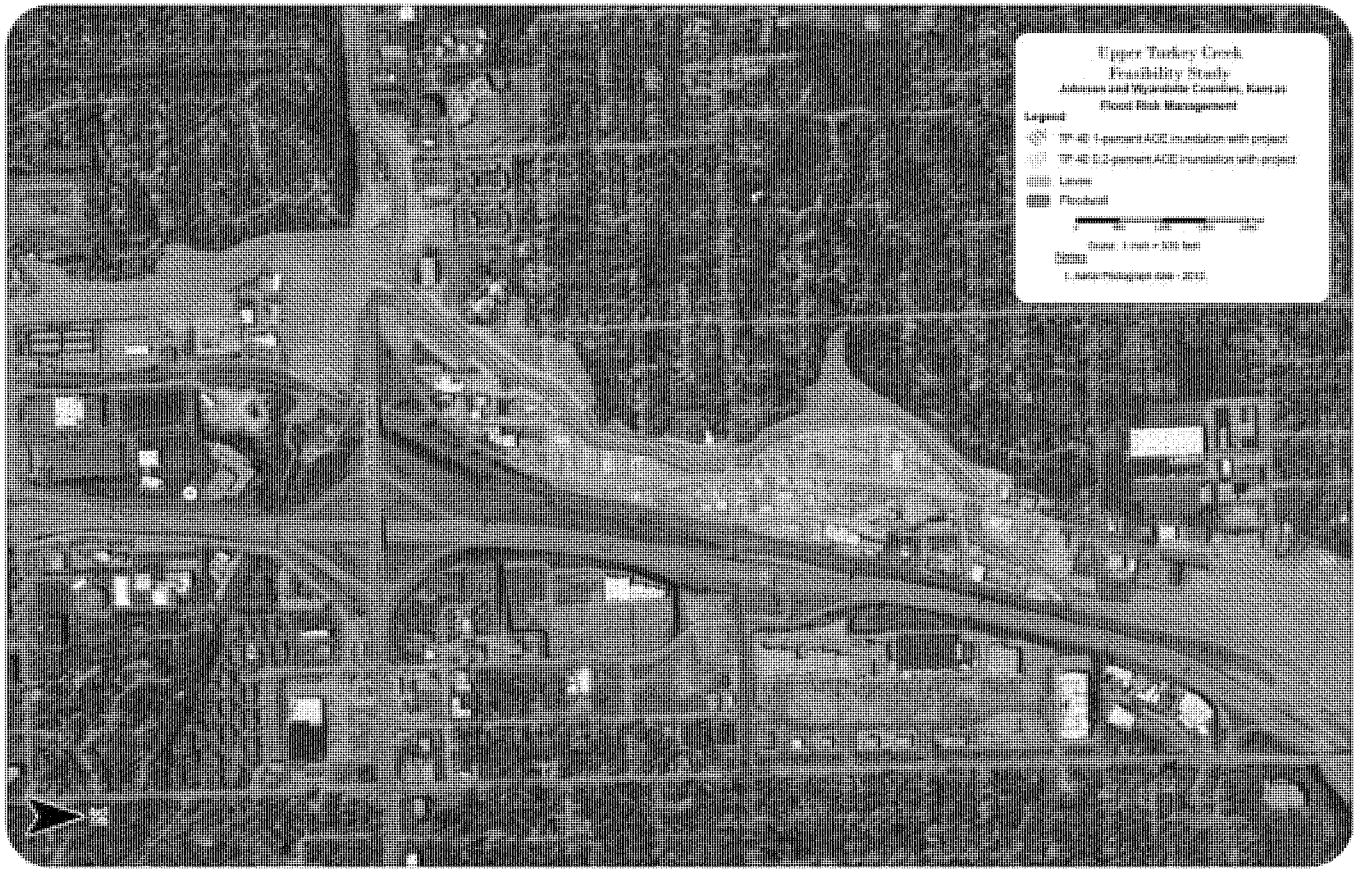


Figure 7-7: Inundation Map Without Project (TP-40) - Plate 7



7-8: Inundation Map With Project (TP-40) - Plate 8

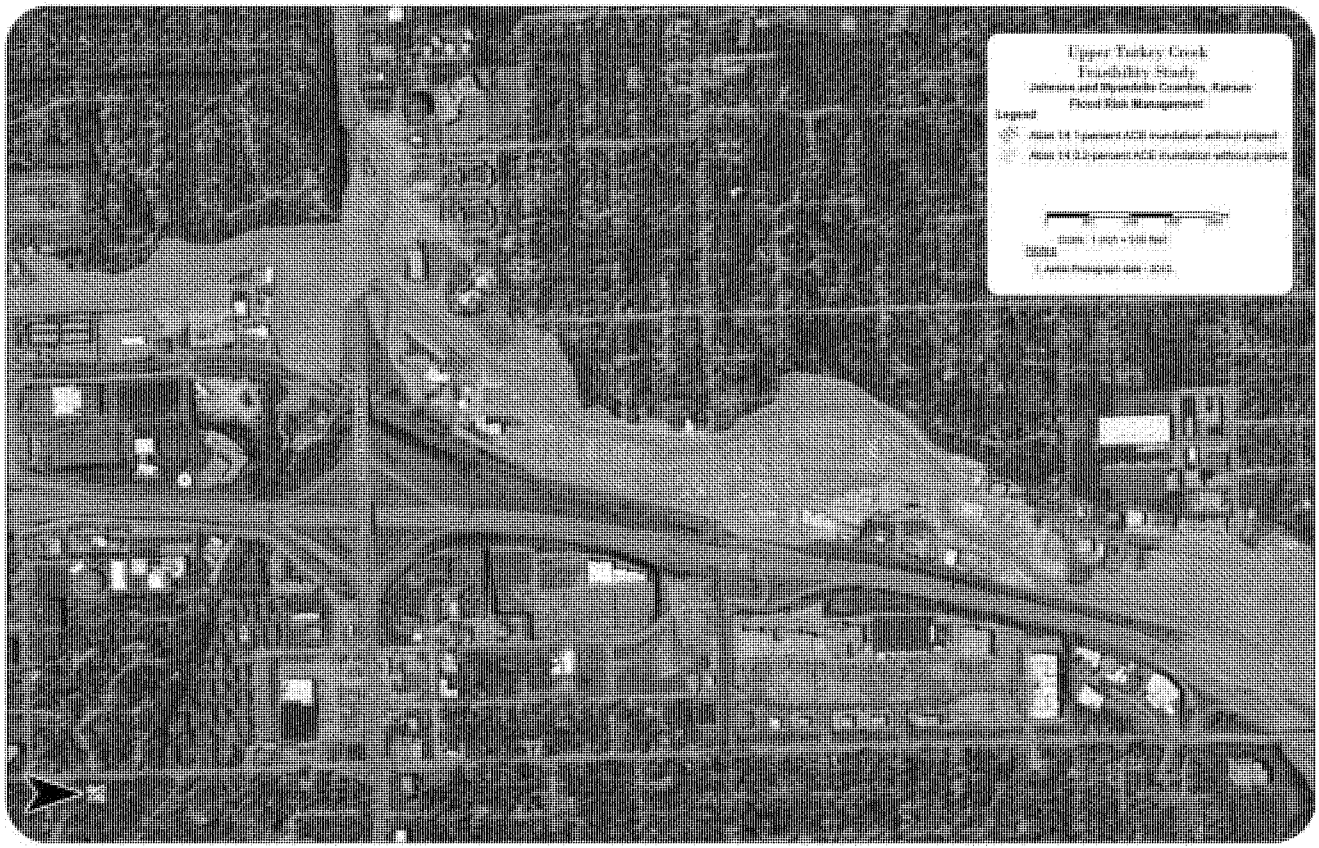


Figure 7-9: Inundation Map Without (Atlas 14) - Plate 9

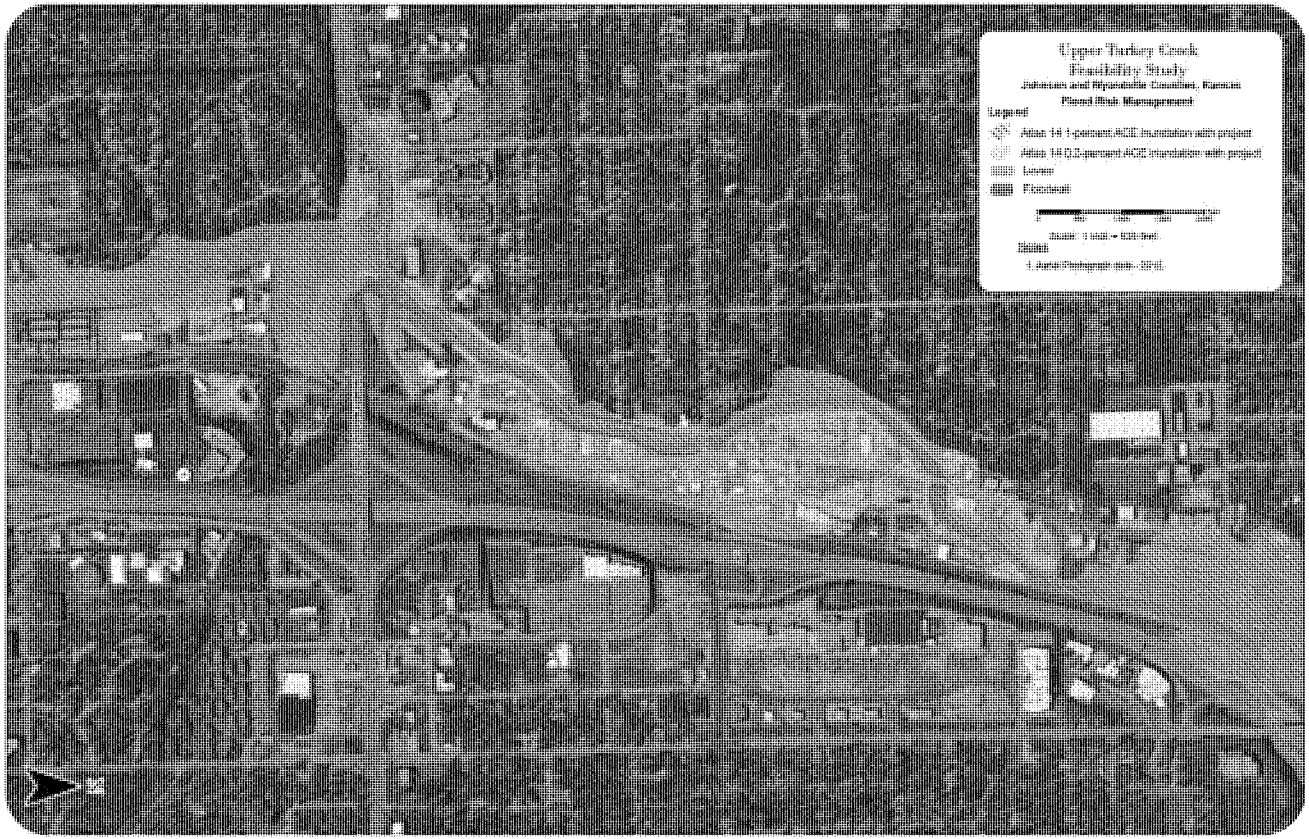


Figure 7-10: Inundation Map With (Atlas 14) - Plate 10

Table 7-1: Recommended Plan Features

Construction Features*	
Levees/Floodwalls: Left Bank	Reach 3b-1 - Merriam Downtown : • 160 feet floodwall downstream of Merriam • 75 feet of floodwall upstream of Merriam Drive • 168 feet of levee upstream of Merriam Drive Reach 3b-2 - Industrial and Railway Drive (West 61st Street): • 840 feet of floodwall begins at 300 feet upstream of Johnson Drive to 500 feet upstream of West 60th Street • 290 feet of levee from 500 feet upstream of West 60th Street to West 61st Street Reach 3b-3 - Parkway Vicinity: • 744 feet of levee from West 61st Street to 70 feet downstream of West 62nd Street • 200 feet of floodwall from 70 feet downstream of West 60th Street to 20 feet upstream of West 62nd Street • 320 feet of levee from 20 feet upstream of West 62nd Street to 60 feet upstream of pedestrian bridge (North side of Skate World Parking Lot) • 1,070 feet of floodwall from 60 feet upstream of pedestrian bridge , to south side of Skateland Parking lot, then along west 62nd Terrace
Levees/Floodwalls: Right Bank	Reach 3b-1 - Merriam Downtown: • 220 feet of floodwall downstream of Merriam Drive to Merriam Drive Parapet wall • 532 feet of floodwall from Merriam Drive Parapet wall to West 57th Street • 1051 feet of levee from West 57th Street to 180 feet South of Farmers Market Parking Lot • 595 feet of floodwall downstream of Johnson Drive Reach 3b-2 - Industrial and Railway Drive (West 61st Street): • 1,390 feet of floodwall south of Johnson Drive to 70 feet north of West 61st Street • 150 feet of levee to West 61st Street Reach 3b-3 - Parkway Vicinity: • 240 feet of levee from W 61st Street to190 feet north of W 62nd Street • 290 feet of floodwall from 190 feet north of W 62nd Street to W 62nd Street • 240 feet of levee from 62nd Street to 240 feet south of W 62nd Street • 890 feet of floodwall from 240 feet south of W 62nd Street to 130 feet north of Shawnee Mission Parkway • 180 feet of levee to Shawnee Mission Parkway • 560 feet of floodwall on W Side of Turkey Creek extending to North of Shawnee Mission Parkway and running along South side of drainage ditch the runs parallel to W. 62nd Terrace
Bridge Modifications/ Headwalls	Reach 3b-1 - Merriam Downtown: • Merriam Drive Bridge – approximately 4.5 to 6 foot high headwall (upstream/downstream) Reach 3b-3 - Parkway Vicinity: • Pedestrian Bridge located at River Mile/Station 3.568 - modification to span 175 feet across the new levee walls

Storm Sewer Modifications	Reach 3b-1 - Merriam Downtown: 7 Outfalls modified with flap gates. 4 Outfalls abandoned and combined with outfalls modified Detention Basin, including 2.14 acre-foot (80 feet wide by 250 feet long) grass detention basin and 60 in RCP outfall with flap gate, located in property north of the outdoor farmers' market. 3 Outfalls abandoned and combined with Detention Basin. Reach 3b-2 - Industrial and Railway Drive: 6 Outfalls modified with flap gates 2 Outfalls combined with outfalls modified 2 Headwall modifications with flap gates Reach 3b-3 - Parkway Vicinity: 7 Outfalls modified with flap gates 3 Outfalls combined with outfalls modified
Utility Impacts/ Relocations	Reach 3b-1 - Merriam Downtown: • 2 Domestic Water reconstructions • 1 Natural Gas reconstruction • 3 Sanitary Sewer reconstructions Reach 3b-2 - Industrial and Railway Drive: • 1 Domestic Water reconstruction • 2 Natural Gas reconstructions • 1 Sanitary Sewer reconstructions • 1 Overhead electric reconstruction Reach 3b-3 - Parkway Vicinity: • 1 Domestic Water reconstruction • 3 Sanitary Sewer reconstructions • 1 Domestic Water reconstruction
Notes: Merriam Downtown (includes farmers' market called Merriam Market Place) = Merriam Drive to Johnson Drive, RM/RS 2.623 to 3.05, *Reach 3b-1; Industrial and Railway Drive = Johnson Drive to West 61st Street, RM/RS 3.05 to 3.345, *Reach 3b-2; Parkway Vicinity = West 61st Street to Shawnee Mission Parkway, RM/RS 3.345 to 3.726 with the exception of Alternative 1 which extends from RM/RS 3.345 to RM/RS 3.855, *Reach 3b-3	

7.2.1 LEVEES AND FLOODWALLS

Earthen levees and concrete floodwalls will be constructed in the Merriam study area. Levees have been selected where existing structures have allowed flood protection to be placed greater than 1V on 2H behind the toe of the existing creek bank. Levee heights throughout the study area range from 3 to 6 feet and vary dependent upon location and water level protection needs. The levees were designed using Engineering Manual (EM) 1110-2-1913, which specifies that the minimum levee section shall have a crown width of at least 10 feet and a side slope flatter than or equal to 1V on 2H, and that 1V on 3H slope is the steepest slope that can be conveniently traversed with conventional mowing equipment and walked on during inspections. A homogeneous embankment (levee) is recommended with the landside slope at 3.0H: 1.0V and riverside slope at 3.0H: 1.0V, with vegetation or synthetic erosion control elements to protect the levee embankment side slopes. The general configuration of the levee is shown in Figure 7-9. The total amount of low to medium plasticity clay material needed for the levee is estimated to be 17,231 cubic yards. Landside seepage berms were not included due to the limited land area and the flashy nature

of Upper Turkey Creek. The flashy nature would not result in prolonged periods of flood impoundment, and as such, would not contribute significant seepage through the levee.

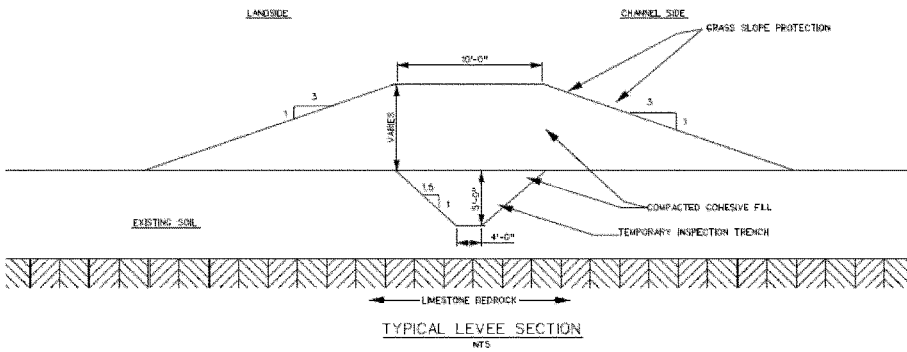


Figure 7-11: Typical Levee Cross Section

In areas where real estate acquisition was constrained because of the existing structures adjacent to Upper Turkey Creek, floodwalls were selected. The floodwall considered is a cantilevered T-type reinforced concrete floodwall with an 18-inch top width. The general configuration of the floodwall is shown in Figure 7-10. The soil beneath the floodwall will be modified with unreinforced auger cast piles, in sections of floodwall where the protected slope is steeper than 1:2 from the toe of the floodwall to the edge of the creek bed. This ground modification will provide improved global stability when the adjacent creek bank wall requires repair. An inspection trench will be completed below flood wall sections not supported on ground modified soil during construction phase. Where this inspection trench indicates soil that is inadequate to support the floodwall, it will be over-excavated and replaced with low plasticity clay. Based on the anticipated bearing elevation and the subsurface information, shallow foundations are adequate to provide bearing support for the flood wall. EM 1110-2-2502 was used for standard dimensions and construction materials. The proposed floodwall height varies depending on location.

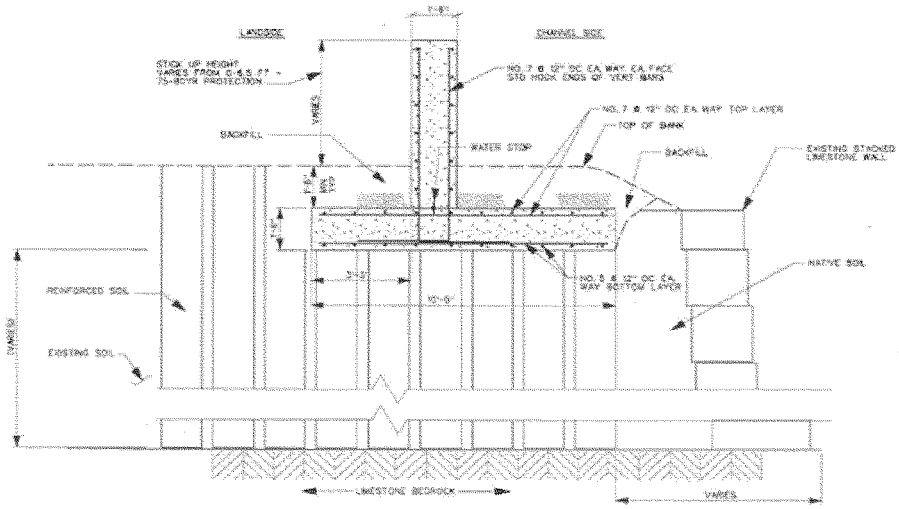


Figure 7-12: Typical Flood Wall

7.2.2 BRIDGE MODIFICATIONS

The proposed project area is bounded by the Shawnee Mission Parkway and Merriam Drive bridges. Major bridge modifications are not implemented under the Recommended Plan because there would be no additional benefit to this action. However, a 4.5 to 6-foot-high headwall (i.e., bridge parapet support structure) would be installed at the Merriam Drive Bridge crossing to maintain the flows in the river channel.

This bridge will require the installation of reinforced headwalls as a supplement to the levee and floodwall protection measure reducing the risk of overtopping at this bridge crossing during the higher intensity storm events. The planned project modifications raise the possibility of scour at the Merriam Drive Bridge. Pressure flow conditions which will occur under Merriam Bridge will have the potential to cause scour. Based on the one-dimensional steady state modeling which uses Atlas 14 flows, velocities will nearly double under pressurized conditions when compared to pre-project conditions. However, the bed material under Merriam Bridge is mostly exposed bedrock. Although the formation of a scour hole under the bridge is possible, it will take long term sustained high flows and velocities to form it and Turkey Creek is characterized mainly for its short duration floods. It is expected that if a scour hole under the bridge develops in the future, its formation will be slow and countermeasures to mitigate it would be implemented before placing the bridge stability in danger. The current surveillance program in the channel and at the bridges due to local maintenance requirements is performed periodically and is very diligent. Regular surveillance would continue and improve after project construction, being reinforced by the federal project sponsorship requirements and the project O&M Manual. The concern of contraction scour is also possible, and the addition of revetment upstream and downstream from the Merriam Drive Bridge was included in the cost risk analysis. During final design, a detailed analysis of the effects of increased velocities and potential scour as a result of the pressure flow through the bridges and downstream of the bridges will be performed in accordance with Federal Highway Administration Hydraulic Engineering Circular No. 18 Evaluating Scour at Bridges Fifth Edition, 2012, appropriate

bridge scour countermeasures consistent with FHWA Hydraulic Engineering Circular No. 23 Bridge Scour and Stream Instability Countermeasures Experience, Selection and Design Guidance Volumes 1 and 2, Third Edition 2009 and USACE EM 110-2-1601 Hydraulic Design of Flood Control Channels (1994). During the final design phase, a refined hydraulic model should be developed along this reach to confirm the effects of the pressurized flow condition and the velocity changes which may occur.

To minimize the induced damages upstream of Shawnee Mission Parkway, it was determined no headwall or parapet wall will be proposed for this bridge. Overtopping of the bridge will be required to prevent a rise in upstream water surface elevations. The bridge actually is lower in elevation than either abutment, as such the overtopping flow will remain within confines of the bridge and in the channel proper, and areas protected by levees and floodwalls in this vicinity will be protected as intended. At the 1 percent ACE event, in the without-project condition it is estimated that the bridge will overtop by approximately 3.5 feet at a velocity of approximately 4 feet per second. In the with-project condition, the overtopping depth at the bridge is estimated to be 3.6 feet at a velocity of approximately 4.1 feet per second. During final design, a reevaluation of the hydraulic model will be required if modifications to the bridge to prevent overtopping is desired. In addition, during final design an updated detailed topographic survey will be performed to assess any residual ponding on the downstream side of the Shawnee Mission Parkway bridge. The pedestrian bridge at RS 3.568 will be modified as part of the project to span 175 feet

7.2.3 DETENTION BASIN

A detention basin would be installed just north of the Farmers' Market in Merriam for internal drainage containing localized drainage during the peak stages of Upper Turkey Creek. The stored runoff volume would be released once the peak flow has progressed downstream from the study area. The detention basin is sized to hold 2.14 acre-feet of water, approximately 80 feet wide by 250 feet long, and have a maximum slope of 3:1 on all sides. Re-grading these areas will be necessary to provide drainage and ensure a ponding level of 905.5 feet, providing 0.5 foot of freeboard from the pond level to the road elevation. This amount of freeboard will be refined during design to ensure full compliance with the City of Merriam regulations.

7.2.4 UTILITY IMPACTS

Utilities impacted by this project include electric, domestic water, natural gas, sanitary sewers, and storm sewers. A summary of these impacts is presented below; complete descriptions are presented in Appendix B Chapter 1.

Overhead electrical lines require relocation when power poles conflict with project feature footprints or when lines cross with project features. When power poles conflict with project features and project features cannot be adjusted, power poles are relocated. When power lines cross project features vertical clearance required by the utility provider may not be maintained. This requires modification of the electric line relocation.

Domestic water lines located within the area subject to flooding or within the project features footprint were evaluated for modification. Where domestic water lines cross levees or floodwalls the lines are routed over the feature. This modification of the pressurized domestic water lines complies with Kansas City District criteria for utilities crossing flood protection. Appurtenances including vacuum breakers and manholes shall comply with Kansas City District criteria. Limited information is known about the construction material used in existing water lines within the flood corridor. The civil engineer and lead planner assumed that water lines will be replaced with ductile iron pipe. During the design phase additional investigations will be performed which may reduce the amount of waterline to be replaced.

Natural Gas lines located within the area subject to flooding or within the project features footprint were evaluated for modification. Where natural gas lines cross levees or floodwalls the lines are routed over the feature. This modification of the pressurized domestic water lines complies with Kansas City District criteria for utilities crossing flood protection. Welded steel pipe will be used for modified natural gas lines.

Pressurized sanitary sewer lines are not present within the limits of the recommended plan. Gravity sanitary sewer lines are within the proposed project limits. Sanitary sewer lines located under project feature footprints or within the flood corridor were considered for modification. The preferred location for relocated sanitary lines is landward of levees and floodwall. Where this is not possible, bolted manhole lids will be installed. Limited information is known regarding pipe material or condition throughout the plan limits. With limited information known regarding pipe material type and condition it is assumed that all lines would be replaced. During the design phase it may be determined that some lines may remain in service.

Only gravity storm sewer lines are located within selected plan limits. Storm sewer outfalls under proposed levee and flood walls require modification to ensure high water flows in Turkey Creek do not back flow through storm sewer systems. The back flow prevention system will include manholes installed on the landward side of the levee or floodwall. The storm sewers under the levee or floodwall will be replaced with reinforced concrete pipe (RCP) and on the creek side of the protection and junction boxes will be installed. Flap gates will be used within the junction boxes to prevent back flow. Throughout this reach there are cases of multiple storm sewer outfalls in close proximity. In these cases, the storm sewer lines will be combined landward of levees or floodwall and one outfall will be provided. The remaining inactive outfalls will be abandoned in place. Other lines will be routed to the detention basin. Replaced pipe will be RCP and have a minimum diameter of 24 inches. EM 1110-2-2902 recommends a minimum diameter of 48 inches for storm sewer lines under levees to facilitate installation, maintenance, and inspection. However, for this project, engineering judgment determined a minimum size of 24 inches is acceptable. Installation and inspection of 24 inch diameter pipes is readily performed using modern construction and inspection equipment. Manholes will be installed at the project limits to further facilitate inspection and maintenance activities. Storm sewer lines located under project feature footprints or within the flood corridor were considered for modification. As with sanitary sewer lines limited information is known about pipe material or condition. With limited information known regarding pipe material type and condition it is assumed all lines would be replaced. During the design phase further investigations should be made into the status of existing lines.

7.2.5 ENVIRONMENTAL MITIGATION

Mitigation actions for footprint impacts were based on the concept of replacing the value of the habitat lost with an equal or greater value of restored or improved habitat value. To evaluate the need for any compensatory mitigation that may be required for CWA Section 404 Authorization, the Habitat Evaluation Procedure (HEP) method was utilized. Specific Habitat Suitability Index (HSI) models used for this method were the green sunfish (*Lepomis cyanellus*) and the fox squirrel (*Sciurus niger*). Using the green sunfish model, the environmental specialist determined that no compensatory mitigation would be needed for the Recommended Plan for in-stream impacts. However, compensatory mitigation would be necessary for impacts to the riparian corridor as indicated by the fox squirrel model.

Numerous species are present in the project area that are tolerant of urban conditions and utilize the overall Turkey Creek riparian corridor. However, within the study area, most of the existing habitat consists of manicured grass and mast producing trees, primarily dominated by black walnut. The environmental specialist and planning team noted no large areas with undergrowth vegetation within the study area. Selection of the fox squirrel model best captures the habitat type, mast producing trees, which

would be impacted by the project. Other habitat models were reviewed, and environmental specialist determined that they would not pick up impacts caused by the project.

To compensate for riparian habitat lost as a result of implementing the Recommended Plan, hard mast producing trees, such as oak, walnut, and/or pecan would be planted. No trees would be planted within 15 feet of any levee or floodwall, complying with Engineering Technical Letter 1110-2-571, *Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures* (April 10, 2009).

The Recommended Plan would result in the removal of riparian trees that provide approximately 3.6 acres of canopy cover. Most of the canopy cover is overstory, with limited woody understory vegetation. Approximately 185 hard mast producing trees, such as oaks and walnut, would be planted over a 7-acre area to compensate for the loss of trees. For addressing environmental effects on the project, including cost effectiveness and incremental cost analysis (CE/ICA), Section 6.3 and Appendix M, *Clean Water Compensatory Mitigation CE/ICA*, contain a detailed analysis of the mitigation measures. Figures 3 and 4 in Appendix M show the locations that were coordinated with the sponsors.

Mitigation will occur concurrently with project construction within each construction contract. Trees will be planted during the first suitable planting season following award of the construction contract. Further details on planting rates, ensuring survival, monitoring and maintenances are located in Appendices M and O of this report. The planted trees will be monitored by the sponsor during an annual inspection by the project sponsor, and maintenance or replacement will be as specified in accordance with the project O&M manual which will be prepared during design phase. The inspection reports the survival and overall health of the trees, and whether the success goals are being met to ensure long-term success of mitigation planning. A mitigation plan is included as Appendix O.

7.3 DETAILED COST ESTIMATE (MCACES II)

The detailed construction cost estimate has been developed based a conceptual design of the Recommended Plan using the USACE Micro-Computer Aided Cost Estimating System MII (MCACES 2nd Generation) in accordance with guidance contained in ER 1110-2-1302, Civil Works Cost Engineering. The costs are allocated between the project's purposes. These costs, along with annual costs, annual benefits, net economic benefits and the benefits-to-cost ratios are shown in Table 5-9. These values are based on October 2014 price levels, an interest rate of 3.375 percent and a 50-year period of economic analysis. See Appendix L, *Cost Estimate and Cost and Schedule Risk Analysis*, for the MII construction cost estimate and output reports.

The MII costs, initial costs, investment costs, OMRR&R, and annual costs are discussed in detail in the sections below and are summarized in Table 7-2 and Table 7-3.

Table 7-2: Cost Estimate Summary (including contingencies)

Cost Account	Estimated Cost
Lands and Damages	$4,854,000
Relocations	$5,268,000
Fish & Wildlife Facilities (Mitigation Costs)	$15,000
Levee & Floodwalls (excluding EDC)	$22,565,000
Planning, Engineering, and Design (including EDC)	$3,066,000

Construction Management	$1,811,000
Project Cost Totals (Effective Price Level Date 1 Oct 14)	**$37,579,000**

Table 7-3: Annual Cost Calculation

Cost Account	Estimated Cost
Project Implementation Cost	$37,579,000
Interest During Construction	$3,003,900
Total Investment	$40,582,900
Annual Economic Cost	$1,691,400
Annual OMRR&R	$40,800
Total Average Annual Cost	**$1,732,200**

7.3.1 INITIAL COSTS

The NED costs of the recommended plan include the project first costs that will occur with project implementation. These costs include $2,787,000 for PED (excluding Engineering During Construction [EDC]), $24,655,000 for construction (including EDC and Supervision and Administration [S&A]), $15,000 for environmental mitigation, and $10,122,000 for lands, easements, right-of-way, relocations and disposal areas (LERRD).

7.3.2 INVESTMENT COSTS

All of the initial costs are included in the economic analysis. In addition to these costs interest during construction (IDC) ($3,003,900) was computed to describe the opportunity cost of the dollars spent on the project prior to its completion. The total investment cost of $40,582,900 was used in calculating the annual economic cost ($1,691,400) at the current FY15 Federal interest rate of 3.375 percent, October 2014 price level, and 50-year period of analysis. (This annual economic cost total is exclusive of annual OMRR&R costs.)

7.3.3 OPERATION, MAINTENANCE, REPAIR, REPLACEMENT, AND REHABILITATION COSTS

The analysis also includes all OMRR&R costs that the sponsors would be expected to incur based on any new proposed alternative. For the annual operations and maintenance (O&M) cost, unit costs and quantities for each alternative were estimated based on past project experience, and assumptions were made for quantities of line items for channel clearing and loading, hauling, and debris disposal. The unit costs for the drainage system maintenance were based on 10 percent of the particular drainage system costs for that level of intensity. Additionally, repairs, rehabilitation, and replacement unit costs were examined for each alternative. The planning team assumed that these percentages of the Recommended Plan would be repaired every 10 years, rehabilitated every 25 years, and replaced every 50 years. A specific percentage for each line item of each alternative in the initial screening is given in Appendix B, Chapter 4, paragraph 8. The OMRR&R costs for the recommended plan were then updated to the OCT 2014 price level using an appropriate index factor (CWCCIS 11: Levees & Floodwalls). A summary of these costs and how frequently they occur can be found in Table 7-4 below. The present value and the

average annual cost of each RR&R cost that would occur over the 50-year period of analysis was calculated using the FY2015 discount rate of 3.375 percent, and that value was added to the annual O&M cost ($28,000) to arrive at the average annual OMRR&R cost ($40,800) for the Recommended Plan. The existing channel and rock wall is maintained by the Merriam Drainage District (MDD), a district formed and constituted under Kansas state law for this purpose. This maintenance will continue in the with-project condition. The floodwall foundation and other features of the federal project are not dependent upon this rock wall for function. The City as project sponsor has agreed to all responsibilities that a Project Partnership Agreement (PPA) will require in order to maintain the federal project functional, safe and in good condition. Our knowledge of the City in working with them and in observing their relationship with MDD, both entities have demonstrated their ongoing ability to cooperate and have stated their intent to continue and increase their cooperation in maintenance of features in the project reach.

Table 7-4: OMRR&R Cost Summary

Items	Cost	Frequency
Operations and Maintenance	$28,000	Every year
Repairs	$49,000	Every 10
Rehabilitations	$104,000	Every 25
Replacements	$748,000	Every 50

7.3.4 ANNUAL COSTS

The total average annual cost of the Recommended Plan (including annual economic cost and annual OMRR&R costs) is $1,732,200.

7.3.5 COST ESTIMATE UNCERTAINTIES

A full CSRA was completed for the Recommended Plan. Contingencies used are intended to identify an estimated construction cost amount that is not likely to be exceeded, given the current project scope. Uncertainties that have been identified that could affect project costs and designs could affect design assumptions, pending a detailed design, include the following:

- Detailed design level soil and topography information (two borings and limited LiDAR are available);
- Unanticipated construction and phasing requirements;
- Variation in estimated quantities;
- Seasonal working condition uncertainties and extended schedule;
- Unanticipated utilities;
- Unexpected geotechnical issues;
- New design requirements;
- Delays in property, utility, and easement acquisition;
- Unexpected buried debris or unsuitable material

CSRA was performed for this project to determine the appropriate contingency factors for project features and is being coordinated with the Directory of Expertise for Civil Works Cost Engineering (Walla Walla District). The project CSRA is presented in Appendix L.

The screening alternative derivation of contingency included a general contingency of 20 percent plus construction risks associated with each alternative resulting in a range of 2 to 7 percent additional difference. Using CSRA on the selected plan, additional external risks were identified that would be consistent across all alternatives if adopted. The original construction related differences were accounted for in the alternative screening, and if CSRA was performed on the screening alternative, the additional associated risks would be relative across all alternatives.

7.4 DESIGN AND CONSTRUCTION CONSIDERATIONS

The creek along the study area is located a minimum of 15 feet from the existing residential and commercial properties, thus its impact to the existing structures during and after construction of the floodwall is expected to be minimal, if any. The majority of the structures along the creek bank are mostly one-story, warehouse-type structures. A Design Documentation Report will be completed during the development of plans and specifications with appropriate surveys and design-level detail to adjust exact proximity of features as needed. For this phase we have captured the major components, design criteria, features, and cost risks and contingencies as needed for a feasibility report.

Specific design and construction considerations for the Recommended Plan can be found in the individual engineering appendices. The design parameters used for floodwall design are considered to be reasonable at this planning stage. Site-specific subsurface conditions are based on visual observations given in boring logs. For the future design work, designers must conduct additional borings and laboratory testing to drive geotechnical design parameters, and a preliminary boring plan. A borrow site is not specifically located for this project; however, the volume of material to be imported for construction is relatively small. Based upon experience in this region on projects of a similar nature, and preliminary inquiries made specifically for this project, it was determined that it would be most cost effective to use a commercial borrow source. A local material supplier with an established permitted commercial borrow area within the 10 mile haul distance utilized for the baseline cost estimate would be able provide the volume of material that meets a design specification developed for the project contract.

Construction of the project, including land acquisition, will not begin until Congress authorizes and appropriates funds for it.

7.5 RISK AND UNCERTAINTY

Areas of risk and uncertainty are analyzed and described below so that decisions can be made with knowledge of the degree of reliability of the estimated benefits and costs of the effectiveness of alternative plans.

7.5.1 COST AND SCHEDULE RISK ANALYSIS

In compliance with Engineering Regulation (ER) 1110-2-1302 Civil Works Cost Engineering dated May 17, 2009, and developed by the Directory of Expertise for Civil Works Cost Engineering (Walla Walla District), CSRA was conducted on the Recommended Plan. CSRA was facilitated by CENWK-ED-DC with assistance from the study team and non-Federal sponsor. The purpose of this assessment was to establish an overall project contingency by identifying and measuring the cost and schedule impact of project uncertainties with respect to the estimated total project cost.

The draft CSRA report, as contained within the Appendix L, *Cost Estimate and Cost and Schedule Risk Analysis*, resulted in a contingency amount of 25 percent. The cost and schedule risk assessment for the

Recommended Plan was completed during the feasibility study. The most likely project cost (October 2014 price level) is estimated at approximately $37,579,000. The key cost risk drivers identified through sensitivity analysis were Market Conditions and Site Access. The key schedule risk driver identified through sensitivity analysis was Project Purpose – Height/Pump Plants, Site Access, and Numerous Separate Contracts. Details of CSRA are located in Appendix L, *Cost Estimate and Cost and Schedule Risk Analysis*. Significant effort and emphasis was placed in the development of the Recommended Plan details on determining the key features and cost factors for the project including foundation stability measures, drainage features, utility modifications, and relocations.

Recommendations to address cost and schedule risk include the implementation of cost and schedule contingencies, further iterative study of risks through the project life-cycle, potential mitigation throughout the design phase, and proactive monitoring and control of risk identified in this study.

7.5.2 RESIDUAL RISK

Although floodplain users and occupants may desire total protection from flooding, the planning team has emphasized that this is an unachievable goal during public outreach. Residual flood risk will remain after implementation of the Recommended Plan. The primary source of residual flood risk will be infrequent and extreme flood events that would overtop and/or flank the flood protection. The project will be designed using appropriate measures and factors of safety to ensure that the constructed system is robust and resilient. However, the City of Merriam, Merriam Drainage District, and Johnson County will express to the community on a periodic basis that a residual risk of exceedance of the system's design capacity exists, and this may be placed as a recurring action item in the floodplain management plan.

In the case of a flood event that exceeded the design capacity of the system, the levees and/or floodwalls of the Recommended Plan could be overtopped, allowing a sudden influx of flood water within the protected area. An overtopping or breach of a levee or failure of a control structure would allow flood water into the protected area during any subsequent flood event during which the breach remains unrepaired. The effects of the failure could be catastrophic depending on the magnitude and timing of the stage increases within the protected area. While the Recommended Plan is expected to reduce the risk of life loss from flooding due to the decreased probability of a flood event inundating the floodplain with short warning time, a residual risk to public safety associated with large flood events that could overtop the levees and/or floodwalls will remain.

Residual risk can be expressed by the probability of the project being exceeded over a certain number of years. Long-term risk indicates how well the project will contain floods under conditions of uncertainty and over a long period of time. The annual exceedance probability (AEP) of the NED plan design (probability of flooding in any given year with the project in place) in Reach 3b is 0.5 percent. Over a 10-year period, the probability of the top of project being exceeded is approximately 5.1 percent in Reach 3b. Over a 30-year period, the long-term risk is 12.2 percent, and it is 22.9 percent over a 50-year period. Additional information is included in Appendix F, *Socio-Economics*.

The planning team has assumed during formulation of the Recommended Plan that, during less frequent floods larger than the 1 percent ACE event, the local sponsor would continue operating the existing flood risk management features (such as the creek channel, storm sewer, bridges, etc.) and emergency preparedness and response measures within the protected area. In addition, an emergency action plan is important for the local sponsor to prepare and implement, including communication of this residual risk and the appropriate emergency measures to take during a flood event. An emergency action plan (EAP) is not the same as a floodplain management plan, and local creation of EAP is actually one action to be documented in the action items of a floodplain management plan. The local sponsor will prepare a floodplain management plan during design that will be useful as a flood risk management tool. This living

document will benefit the city by explaining numerous action items needed on a recurring basis, including risk communication, understanding roles and responsibilities of various departments at the city and the Merriam Drainage District. The floodplain management plan provides a framework for continued public outreach and information regarding flood risk, as well as reinforcement for ordinances and best practices for the City in the improved management of risk.

Communities in Johnson County, Kansas have an existing flood warning system called "Stormwatch." Originally developed by the City of Overland Park, but now utilized by many of the cities, the Stormwatch system and website presents users with data collected from a flood warning system consisting of remote weather stations located throughout the Kansas City Metropolitan area. The majority of the stations report real-time rainfall. Some stations also report stream levels, temperature, relative humidity, wind, pavement temperature, pavement state, and other weather data. All data is collected and stored into a database. The earliest stations were installed in the 1980s and information from those sites can be queried directly from this website. The City of Merriam, Johnson County, and the Kansas Department of Transportation (KDOT), as well as other responder agencies, local businesses and citizens monitor this system for rainfall data and flood threat. When the forecasts call for conditions of high risk, and rainfall intensities reach certain levels, this triggers a coordinated response by the City, County and KDOT for deployment of emergency response staff, emergency responder agencies, and closure of high risk streets and roads. KDOT manages traffic through the Kansas City Scout regional traffic management system. The KDOT System Manager will contact the Kansas State Highway Patrol based upon rainfall and stage data thresholds in the Stormwatch system in Turkey Creek watershed, and coordinate a response to include monitoring and closure of the high risk low lying locations, as appropriate. This robust and well coordinated response process supported by complementary plans in each jurisdiction, supported by the Stormwatch system, represents a significant measure in place to address current and residual risk. As such, at the end of this feasibility planning process, the final combination of flood risk management measures along with the formulation, design, construction and maintenance of the Recommended Plan components, constitute the decision process and public consensus for how floodwaters and the floodplain are being managed. The combination of these measures represents this community's decided approach and will serve to further reduce the risks associated with future flooding.

This Upper Turkey Creek feasibility study project manager is the Lead Silver Jackets Coordinator in Kansas and Missouri and has encouraged state attention to flood risks on Turkey Creek. The Silver Jackets Coordinator has participated regularly on the Kansas Hazard Mitigation Team since 2009, and worked closely with the state floodplain manager and state hazard mitigation officer through the interagency Silver Jackets Program to address flood risk management needs, including long-term local planning initiatives, risk identification and analysis, public awareness and outreach, and potential future nonstructural measures. Several USACE Silver Jackets interagency projects are currently underway in other areas of the state focused on the following:

- Flood inundation mapping for all levels of risk
- Hydraulic modeling work in concert with flood inundation mapping
- Floodplain management planning in protected and unprotected areas
- Extensive stakeholder and public involvement activities
- Assessment of unprotected residential areas for potentially effective nonstructural flood risk management measures.

These projects and coordination with the state floodplain manager at the Kansas Department of Agriculture Division of Water Resources (KDWR) has renewed focus on the full menu of measures for flood risk management. Several of the projects have emphasized the importance of presenting the flood risk management story regarding decisions on managing floodwaters and floodplains in a floodplain

management plan, especially tuned to having the public involved in the decision process for possible nonstructural, as well as structural, measures. The City of Merriam is also interested in establishing a floodplain management plan for the project, recognizing that the entire plan formulation process from the feasibility study is major piece of the community's floodplain management plan. This tool is considered a viable and essential component of an overall flood risk management planning effort by the State, including the ensemble of structural and nonstructural measures as unique to Turkey Creek. The floodplain management plan will further assist in driving down the risk for the protected areas and is also a vehicle through which USACE works in partnership to address residual risk. The floodplain management plan is also useful in clarifying the roles and responsibilities, which will be especially useful with the city's partnership with the Merriam Drainage District in sharing the responsibility of managing the flood risks. The appropriate state agencies have been kept aware of and have participated in planning meetings and discussions including regarding the Upper Turkey Creek flood risk management study and residual risk in Merriam, Kansas as well as areas up and downstream. This cooperation has set the stage very well for ongoing work involving the state floodplain manager at KDWR and state hazard mitigation officer at the Kansas Department of Emergency Management in working with the local partners, Johnson County, the City of Merriam and the Merriam Drainage District, in enhancing the engagement on all of the effective flood risk management measures going forward, in concert with the floodplain management plan development and implementation.

7.5.3 PRELIMINARY DESIGN UNCERTAINTY

The main source of uncertainty in the results of the hydraulic analysis is the absence of USGS stream gages on Turkey Creek. The base of this analysis is a HEC-RAS model which was originally provided by Johnson County. This model was initially produced by the Larkin Group Inc. for the Storm Management Program of Johnson County (JOCO Report) and the flows modeled were obtained from the Johnson County FEMA Flood Insurance Study (FIS). This model was reviewed and accepted by USACE engineers during the early stages of this feasibility study. Additional details about this study are provided in Appendix B, Chapter 3, Hydrologic and Hydraulic Conditions. For future design work, requirements to update the analysis for any changes in the watershed and or confirm the hydrology and hydraulic analysis are still valid are detailed in EM 1110-2-1416, Appendix C. Specific to this project, collection of detailed topographic surveys during design would provide an opportunity to update and or verify that the hydraulic model geometry and corresponding water surface profiles are still valid. Additionally, as the design progresses, final levee and floodwall configurations may also need to be updated in the hydraulic model to verify the water surface profiles and corresponding top of levee design is still valid. Due to the lack of stream gages in Turkey Creek, no further statistical analyses could be conducted to add validity to flow-frequency published in the Johnson County FIS and as updated in this study to include the updated precipitation frequency estimates from NOAA Atlas 14. However, another large flood event, if it were to occur during design, could provide an opportunity to collect additional data that can be used for hydrologic and or hydraulic model validation, and if warranted, re-calibration.

Limited preliminary geotechnical information is available on the soils in the region. Site-specific subsurface condition information on compactness/consistency and stratification of the soils is based on a generalized description given in boring logs based on visual observations of the subsurface deposits. The slope stability performed of the Upper Turkey Creek stream embankment determined general ideas of soil strengths and seepage potential in the study area. The Engineering Appendix (Appendix B) includes a list of preliminary design parameters and the assumed values necessary for the slope stability and the evaluation of the stability of the floodwalls. To compensate for this, the parameters as noted are on the conservative end, and likely a more economical design could be developed during the design phase after conducting additional geotechnical, survey, and site-specific hydrographic data. For the future design work, it is essential to conduct additional borings and laboratory testing to drive geotechnical design

parameters. Details on the types of geotechnical data that should be collected during design are included in Appendix B.

The information available for the existing stormwater system (ESS) located in the study area is limited. USACE requested ESS storm sewer plans from the City of Merriam, but these plans are not available. The only related information available is a GIS schematic illustrating the location of a fraction of pipelines and inlets. Not only is this a concern when determining the project cost and schedule, ESS was not considered in the hydrologic analysis of effective runoff and time of concentration due to lack of detailed information. However, not considering ESS for planning in this case is considered a conservative approach because its capacity was not included to estimate the detention volume. ESS will likely offer a small detention volume plus it will add some travel time to the flows potentially changing the time of concentration. Including ESS into a design analysis will most likely reduce the required size of the detention pond. ESS will be surveyed and detailed to a much greater degree during design phase. However the current cost and performance assumptions are considered reasonable for identification of the project cost and performance for a decision document

HTRW: An HTRW investigation of the study area was conducted consisting of a records search of past and present environmental activities and enforcement actions at properties adjacent to the creek. Based on findings from the records search performed, there are no known hazardous waste sites that will impact the proposed work. The property located north of the Merriam Market Place (or farmer's market) in downtown Merriam (5730 Merriam Drive) had three 560 gallon gasoline underground storage tanks removed from the property. There was no contamination observed during the underground storage tank removal and the site was remediated successfully so the likelihood of encountering fuel contamination is low. In addition, there is the possibility that properties along the channel may have buried debris, although there is no specific data or subsurface information to indicate such. If buried debris is excavated during construction activities, it will need to be properly disposed of at an off-site facility permitted to accept the material. Any specifications for work should include provisions to develop a contingency plan to address any hazardous waste encountered during construction. Based upon experience on other projects, provisions for the removal of some debris was included in the cost estimate and it was addressed in the cost risk analysis.

Climate Change: USACE published guidance for incorporating climate change impacts to inland hydrology in civil works studies, designs, and projects in Engineering and Construction Bulletin (ECB) No. 2014-10 on 02 May 2014. The guidance is similar to the preliminary guidance that was reviewed and applied during this feasibility study.

Climate Change Consideration and ECB No. 2014-10

Climate change information for hydrologic analyses includes direct changes to hydrology through changes in temperature, precipitation, and other climate variables, as well as subsequent basin responses such as sedimentation loadings potentially altered by changes in those primary climate drivers. ECB No. 2014-10 includes consideration of both past (observed) changes as well as potential future (projected) changes to relevant hydrologic inputs. In order to comply with ECB No. 2014-10, a qualitative analysis of available data was conducted. Two main sources of information were evaluated. A report published by NOAA National Environmental Satellite, Data and Information Service (NESDIS) and a long-term period of record weather station in the Kansas City, MO area.

NOAA NESDIS Model Report

Results from this model of future conditions for the central plains of the United States were published by NOAA NESDIS in January 2013. This report provides an assessment of climate trends and scenarios into

the next 50 to 100 years. The report states that over the period of record for the region of northeast Kansas, both temperature and precipitation has trended above normal, especially over the last 50 years. To account for climate change in the meteorological conditions of northeast Kansas, the future forecast for conditions in the region takes into consideration the past temperature and precipitation records, and then considers future modeled conditions in the area through 2070. According to this report, a warming trend of about 3-5 degrees Fahrenheit and a precipitation trend slightly toward wetter conditions can be expected through the next 50 years, but significant uncertainty is associated with these estimates. The NESDIS and other literature proffer slightly wetter future conditions in NE Kansas which could lead to slightly higher flood stages.

Long-Term Period of Record Weather Station

Daily total precipitation and daily maximum and minimum temperature data were obtained for NOAA weather station GHCND: USW00093972. The period of record extends from 1893 to 2014 and the data was obtained from the National Centers for Environmental Information formerly known as the National Climatic Data Center. The data from these 121 years were analyzed for linear trends that could indicate a discernible tendency in the annual maximum precipitation and in the temperature annual extremes.

The trend evaluation of the daily precipitation data was performed using four different sets: annual daily maximum, annual 2-day maximum, annual 3-day maximum and annual 5-day maximum. No definite trends were identified in any of the sets. Monthly daily maximum sets were briefly evaluated but the mild trends that could be identified were not consistent from month to month or season to season so the findings of this analysis were not considered relevant. A more defined trend was observed when analyzing daily maximum and minimum temperatures for the same period of record but at this time there is no clear correlation between the available precipitation and temperature data.

Additional Considerations

Although not prepared to address climate change, NOAA National Weather Service recently updated their precipitation atlas titled Hydro-meteorological Design Studies Center Frequency Data Server Atlas 14 (NOAA 2013). This document was published three months after the Recommended Plan was selected. The rainfall data used for analysis was based on a 2002 study completed by the University of Kansas working with the American Public Works Association (APWA) of Kansas City. A sensitivity analysis using the recently published updated rainfall atlas has been performed to help understand the implications of potentially increased extreme precipitation in the future and corresponding increases in peak flows. Based on a preliminary analysis, including re-running the hydrologic and hydraulic models with the 24-hr rainfall depths from Atlas 14 with an appropriate rainfall distribution, the team determined that Atlas 14 rainfall will result in increased flows (increased water surface elevations), increased damages in the without-project condition, and increased benefits in the with-project condition as compared to analysis performed with the 2002 precipitation study. Based on the alternatives analysis, the economic outputs were determined to be optimized for levee heights of alternative 2d. Taller levees will require significant changes and or full scale replacement of existing bridge, utility and road infrastructure. As documented in Chapter 5, economic outputs and benefit cost ratios are reduced for levees higher than the recommended plan for both precipitation frequency studies. Additionally, shorter levee heights were also shown to have reduced economic outputs from the recommended plan with both precipitation frequency studies. Therefore, based on the analysis of approximately a 15% increase in precipitation, future increases in precipitation frequency, if they were to occur due to climate change, are not expected to alter the

recommended plan. Residual risks could increase over time if climate change leads to an increased frequency of extreme precipitation events.

The data available and the results of plan formulation in this study indicate that increasing the level of structural risk reduction or altering structural project features to address the potential effects of climate change in the future is not warranted at this time. Periodic review of floodplain management activities, active and robust flood risk planning, preparedness and response, which is a characteristic in this study area that will be sustained and improved is the most appropriate response measure to account for uncertainties associated with elimate change. The floodplain management plan to be developed pursuant to the project will greatly support this recommendation.

Conclusions

The results of this qualitative and semi-quantitative analysis do not indicate a direct tendency in expected precipitation changes but may suggest a future tendency of temperature increases in the future. The lack of USGS gages in Turkey Creek prevents from a direct analysis of the effect of any potential climate change trend of the stream discharges. The impacts of a potential climate change trend are not expected to increase the current range of uncertainty considered in the hydrologic analysis.

7.6 REAL ESTATE REQUIREMENTS

7.6.1 LAND ACQUISITION – CATEGORIES

Required estates for project purposes will include permanent easements for flood protection, temporary work area easements, utility easements, and fee acquisition. The entire project will affect 121 tracts.

The non-federal sponsor will be responsible for providing information on property boundaries, specific estates to be acquired, facilities to be relocated, number of affected property owners, and zoning information for the area affected by the proposed project.

7.6.1.1 FEE

ER405-1-12 states that uneconomic remnants are required to be purchased in fee under Section 301 (9) of Public Law 91-646 (para 2-20) "If the acquisition of only a portion of a property would leave the owner with an uneconomic remnant, the head of the federal agency concerned shall offer to acquire that remnant. For the purposes of this Act, an uneconomic remnant is a parcel of real property in which the owner is left with an interest after the partial acquisition of the owner's property and which the head of the Federal agency concerned has determined has little or no value or utility to the owner." " During the Gross Appraisal process, four properties were identified as requiring a full take of the land and building that will require fee simple acquisition: parcels JP35000000-0009, JP28000033-0024D and JD241212-3003 will need to be acquired in fee due to the location of the buildings and the need for space for the levee/floodwall system. Parcel JF241212-3005 is where the detention basin will be constructed. The elevation of this property will be adjusted and will require removal of the building. The appraiser also identified a shed that will have to be acquired, but the remaining portion of the property will retain its highest and best use as a downtown row store. Details for the four properties are listed below:

- Property JP35000000-0009: This property described as a general office building.
- Property JD241212-3003: This property is a combination shop/warehouse structure.
- Property JF241212-3005: This property is a warehouse structure.
- Property JP28000033-0024D: This property is a residential house.

7.6.1.2 PERMANENT FLOOD PROTECTION EASEMENT

Permanent flood protection easement will be acquired for any land required for levees, floodwalls, and other permanent structures along with area needed for operation and management. The team's real estate specialist estimated that 8.6 acres will be required for the flood protection easement.

7.6.1.3 TEMPORARY EASEMENT

Temporary easements will be needed to provide adequate area for construction of the project and access to the work area. The real estate specialist estimated that 4.59 acres of temporary easement will be required for construction of the flood control structures of the project. All temporary easements were valued as 3-year easements.

7.6.1.4 MITIGATION LANDS

The team's environmental specialist has determined that 7 acres of mitigation land will be required for the project. Ideally the mitigation will be done on City-owned land; the City has stated public park land will be available for use.

7.6.2 LAND ACQUISITION – IDENTIFICATION OF LANDOWNERS

The real estate specialist determined that 121 parcels of land will be affected by the project. The City of Merriam owns in fee approximately 7.5 acres within the project footprint. The Merriam Drainage District (MDD) owns in fee more than 9.2 acres along the channel. The lands owned by the City of Merriam and MDD are available for use on the project. Most of the properties within the area are a mix of commercial/industrial businesses. The businesses include auto parts stores, used car sales lots, warehouses, car rental agencies, and other locally owned retail stores. The Real Estate Plan will list the landowners and easement requirements in more detail. Fee acquisition for project structures is approximately 1.5 acres, and permanent utility easement required is approximately 2.15 acres.

7.6.3 LAND ACQUISITION – IDENTIFICATION OF ACQUISITION ISSUES

The planning team determined that there will not be any issues with acquisition of lands, easements, and rights-of-ways for the project. USACE has worked with the non-federal sponsor to complete the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capabilities Checklist, and the non-Federal sponsor has been identified as being fully capable of acquiring the lands, easements, and rights-of-way for the project. The non-Federal sponsor has the legal authority to acquire and hold title to real property and condemnation authority and is fully capable of contracting for all real estate needs for the project. At this time, the non-federal sponsor will not require USACE assistance with acquiring real estate. Financial capability is addressed in Appendix I.

7.6.4 RELOCATION ASSISTANCE (PUBLIC LAW 91-646)

Relocation assistance will be required for the four properties being acquired in fee and the acquisition of one shed. The non-federal sponsor has been provided information on P.L. 91-646 and is aware of the obligation to ensure compliance. An estimate of the relocation costs has been included in the LERRDs cost estimate.

7.6.5 INDUCED DAMAGES

This alternative is not expected to have any substantial impact on the hydrology of the Turkey Creek watershed. The hydraulic modeling results show no increase in flooding upstream or downstream of the project reach. Upstream of Shawnee Mission Drive there is no appreciable increase in flooding in the with-project condition compared to without. Downstream of the Merriam Drive Bridge, the analysis showed that the flow with-project will remain within the channel. These results give reasonable confidence that the project will not induce additional damages upstream or downstream of its limits.

7.7 OPERATION AND MAINTENANCE CONSIDERATIONS

Section 3 of the Flood Control Act of 1936 and Section 103 of the Water Resource Development Act of 1986 (WRDA 1986) require that the non-federal sponsor (the City of Merriam), pay 100 percent of the costs for all OMRR&R of project features. The responsibilities of the non-federal sponsor in this regard are detailed in the OMRR&R Manual, which will be furnished to the non-federal sponsor at the completion of construction. Operation is those activities required for the safe and efficient functioning of the project to achieve the intended project benefits. Maintenance is the performance of those activities needed for proper care and efficient operation of the project. Repair is generally defined as including those activities that are of a routine nature and will maintain the project in a well-kept condition. Replacement covers those activities required to replace all or a portion of a worn out project element. Rehabilitation refers to those activities that are required to bring a deteriorated project back to original condition.

The following are typical operation requirements:

- Continual updating of the OMRR&R Manual and emergency response plans, including accounting for any modifications made to the system and updating all emergency contacts and suppliers
- Suggesting annual review of roles and responsibility between the City of Merriam and the Merriam Drainage District

The following are typical maintenance requirements:

- Regular mowing of grass areas
- Maintaining a 15-foot clear zone out from the toe of levees and face of floodwalls
- Eradicating burrowing animals and repairing any damage
- Spraying and removing woody brush and trees in riprap areas
- Removing siltation in drainage ways and detention pond
- Repairing any identified deficiencies pertinent to the project

For the annual O&M cost, unit costs and quantities for each alternative were estimated based on past project experience, and assumptions were made for quantities of line items for channel clearing and loading, hauling, and debris disposal. The unit costs for the drainage system maintenance were based on 10 percent of the particular drainage system costs for that level of intensity.

Additionally, repairs, rehabilitation, and replacement unit costs were estimated for each alternative. The team assumed that repairs would be required every 10 years, rehabilitation every 25 years, and replacement every 50 years. Details of how these costs were determined can be found in Appendix B, Chapter 4, paragraph 8. The OMRR&R costs for the recommended plan were then updated to the 1 Oct 2014 price level using an index factor from the current Civil Works Construction Cost Index System or CWCCIS (account 11: levees and floodwalls).

The present value and the average annual cost of each RR&R cost that would occur over the 50-year period of analysis was calculated using the FY2015 discount rate of 3.375 percent, and that value was added to the annual O&M cost to arrive at the average annual OMRR&R cost for each alternative.

Standard USACE procedures will be used to control invasive species. All District construction contracts contain language to prevent the spread of invasive species, and the OMRR&R Manual will contain information of controlling invasive species. Selection and use of any herbicides will be in accordance with all applicable laws, regulations, policies, and best management practices.

Continual inspections are required throughout the life of the project. All inspections of the system serve to identify any deficiencies that may have occurred since the last inspection. Inspections determine if the system is being maintained at an acceptable level. Types of inspection include the following:

- Annual inspections. An annual inspection is conducted by the USACE that results in a report. The annual inspection report identifies any deficiencies found during the inspection and provides individual and overall ratings.
- Mid-year inspections performed between each year's annual inspections. This inspection is conducted solely by the non-federal sponsor.
- Visual inspection by the non-federal sponsor of all discharge pipes every 5 years.
- Inspection by the non-federal sponsor before and after major flood events.

The non-federal sponsor would be responsible for coordinating all project modifications subsequent to completion of the construction project. Modifications to the system include any plans that impact the function or physical footprint. This includes any work not coordinated before its placement. All modifications impacting the system shall be submitted from the non-federal sponsor to USACE for review. Impacts include physical changes to the system, encroachments, and drainage system disruption.

The non-federal sponsor would be responsible for funding and carrying out annual operation and maintenance of the system and perform or ensure all relocations. Annual operations and maintenance costs that the non-federal sponsor would take on for the Recommended Plan were estimated based on past project experience, and assumptions were made for quantities on line items for channel clearing and loading, hauling, and debris disposal. The unit costs for the drainage system maintenance were based on 10 percent of the particular drainage system costs. Annual repairs, rehabilitation, and replacement costs assumed that repairs would occur every 10 years, rehabilitation every 25 years, and replacement every 50 years. Additional information is included in Appendix B. Their estimates include all labor, materials, and contracts necessary to maintain the system at an acceptable level.

The Recommended Plan has a total length of approximately 10,205 feet that comprises 6,822 feet of floodwalls and 3,383 feet of earthen levee. Existing pavement and mowing activities will minimize any new maintenance requirements by the non-federal sponsor in these areas.

7.8 SUMMARY OF ACCOUNTS

Implementation of the Recommended Plan would provide average annual NED benefits of approximately $3,444,700 in the form of reduced flood damages in the area protected by the levees and floodwalls. Average annual NED costs (including construction, LERRD, PED, S&A, EDC, environmental mitigation, IDC, and OMRR&R) would be approximately $1,732,200, resulting in net average annual NED benefits of $1,712,500.

Implementation of the Recommended Plan would also provide favorable Regional Economic Development (RED) effects due to the decreased probability of flood events inundating the floodplain. Existing businesses would be expected to continue their existing occupancy, and new businesses and investment would be more easily attracted to the area in the future if vacancies occur, resulting in a

stronger tax base. With decreased probability of flooding, business activity would be expected to remain relatively stable, barring unforeseen impacts from other sources. Additionally, temporary increases in employment would be expected during construction. The temporary presence of construction workers for the project may bring a temporary increase in demand for some services in the local area, but also a temporary increase in business volume, profits, and sales tax receipts at the local retail and service establishments.

The Recommended Plan would also likely reduce the risk of life loss from flooding, due to the decreased probability of a flood event inundating the floodplain with short warning time.

7.9 PROJECT IMPLEMENTATION REQUIREMENTS

To implement the Recommended Plan, several steps related to project authorization, funding, and regulatory approval need to be taken, including institutional requirements, division of responsibilities, a fully funded cost estimate, and permits.

7.9.1 INSTITUTIONAL REQUIREMENTS

PROJECT AUTHORIZATION

Project authorization will require approval of the feasibility report by Headquarters USACE, resulting in the transmission of the recommendation in the Report of the Chief of Engineers to the Office of the Assistant Secretary of the Army for Civil Works (ASA-CW), and then to the Office of Management and Budget (OMB) for approval. Then, the report is available to be authorized by inclusion by the United States Congress in a Water Resources Development Act that authorizes USACE Civil Works projects. The project would be considered for inclusion in the President's budget based upon national priorities, magnitude of the federal commitment, economic and environmental feasibility, level of local support, willingness of the non-federal sponsor to fund their share of the project cost, and the budget constraints that may exist at the time of funding.

PROJECT PARTNERSHIP AGREEMENT

Once Congress appropriates Federal construction funds, USACE and the non-federal sponsors would enter into a project partnership agreement (PPA), as required for all Civil Works design and construction projects. This PPA would define the federal and non-federal responsibilities for implementing, operating and maintaining the project. Items for cooperation under PPA can vary, depending on the mission area, or authorized purpose, of the project. This report is for the flood risk management mission area, also known as flood damage reduction. Recreation pieces can be accounted for under this, not requiring a separate or more detailed recreation authorization.

Items of cooperation for a structural flood damage reduction (single purpose) project that will be specifically authorized federal implementation of the Recommended Plan would be subject to the non-federal sponsor agreeing to comply with applicable federal laws and policies, including but not limited to the following basic items, where additional ones may also apply if any elements of the project were to change after the approval of the final report:

a. Provide a minimum of 35 percent, but not to exceed 50 percent of total project costs as further specified below:
    1. Provide the required non-federal share of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

2. Provide, during the first year of construction, any additional funds necessary to pay the full non-federal share of design costs;
3. Provide, during construction, a contribution of funds equal to 5 percent of total project costs;
4. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the project;
5. Provide, during construction, any additional funds necessary to make its total contribution equal to at least 35 percent of total project costs;

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

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

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

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

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

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

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

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

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

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

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

m. Comply with all applicable federal and state laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701 – 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c et seq.);

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

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

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

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

CERTIFICATION OF REAL ESTATE

USACE would officially request the non-federal sponsor to acquire the necessary real estate immediately after signing of the PPA and engineering and design has progressed to the point that all real estate

required can be identified. The non-Federal sponsor has been issued a risk letter explaining the risks of acquiring lands prior to the execution of the PPA and been advised to wait on coordination of the acquisition plan and notice to proceed with acquisition from the USACE Real Estate Office. The advertisement of the construction contracts would follow the certification of the real estate.

IMPLEMENTATION SCHEDULE

Subject to project authorization, funding, and regulatory approval, construction is scheduled to be completed in April 2024. The PED phase can begin once the Division Commander's transmittal has been sent, the Design Agreement has been signed by the City of Merriam as the non-Federal sponsor, and funds are available. The estimated schedule for project implementation is shown in Table 7-5.

Table 7-5: Project Implementation Schedule

Milestone	Start Date	Finish Date
PED	October 2016	September 2018
Initial Real Estate Acquisition	October 2018	September 2019
Project Construction		
Contract 1	October 2019	April 2021
Contract 2	May 2021	October 2022
Contract 3	November 2022	April 2024

The project team developed a detailed project schedule as part of this project, and this is included in Appendix L, *Cost Estimate and Cost and Schedule Risk Analysis*.

Costs, economic analyses, and milestones are periodically reviewed during future project phases and reevaluated as needed based on actual project progress and status. Each construction contract package will be reviewed for value engineering to limit the potential for future project cost growth.

7.9.2 PROJECT REVIEW PLAN

Project reviews are about comprehensive quality control and quality assurance of products. The USACE policy is that planning, engineering and scientific work will undergo an open, dynamic, and rigorous review process. Technical, scientific and engineering information that is relied upon to support recommendations in decision documents or form the basis of designs, specifications, and/or O&M requirements will be reviewed to ensure technical quality and practical application. This report has undergone extensive review, and a similar quality review is mandatory for the design and construction phase.

The EC 1165-2-209 "Civil Works Review Policy" establishes an accountable, comprehensive, life-cycle review strategy for Civil Works products by providing a seamless process for review of all Civil Works projects from initial planning through design, construction, and OMRR&R. EC provides the procedures for ensuring the quality and credibility of USACE decision, implementation, and O&M documents and work products.

This policy addresses OMB peer review requirements under the "Information Quality Act" and the Final Information Quality Bulletin for Peer Review by the OMB (referred to as the "OMB Peer Review

Bulletin"). It also provides guidance for the implementation of both Sections 2034 and 2035 of the WRDA of 2007 (P.L. 110-114).

7.9.3 PUBLIC-PRIVATE PARTNERSHIPS

The Merriam Drainage District (MDD) is a state authorized entity per the Kansas Watershed District Act. A three-person board of directors is elected periodically, and their mission is to apply funds collected from a mill levy to maintain a very small portion of Turkey Creek that is located entirely within the City of Merriam, Kansas. The city has no authorized control of this entity, but together MDD and the City's floodplain manager manage the floodplain. Additionally, the City is enrolled in the Federal Emergency Management Agency's National Flood Insurance Program (NFIP), and as a requirement, the City must fulfill the role of floodplain management, including actively reaching out to the MDD to satisfy conditions of enrollment in NFIP. Each of these watershed or drainage districts in Kansas is required to have a General Plan describing MDD's mission. Therefore, this public partnership is planning to use the floodplain management plan to cover the decision processes reached with this feasibility study, including the public outreach to the private land owners in the project area.

7.9.4 FULLY FUNDED COST ESTIMATE

The fully funded estimate for the Recommended Plan includes price escalation using Office of Management and Budget inflation factors. Project inflation factors, midpoint of construction features, and fully funded costs can be found in the total project cost summary in Table 7-6.

Table 7-6: Total Project Cost Summary

		Estimated Cost			Project First Cost	Total Project Cost (Fully Funded)		
WBS Number	**Feature Description**	**Cost ($K)**	**CNTG ($K)**	**CNTG (%)**	**Program Year (Budget EC): FY 2015 Effective Price Level Date: 1 Oct 14 ($K)**	**Cost ($K)**	**CNTG ($K)**	**Fully Funded plus CNTG ($K)**
01	Lands and Damages	$4,096	$758	19	$4,854	$4,557	$843	$5,400
02	Relocations	$4,214	$1,054	25	$5,268	$4,860	$1,215	$6,075
06	Fish & Wildlife Facilities	$12	$3	25	$15	$13	$3	$17
11	Levee & Floodwalls	$18,052	$4,513	25	$22,565	$20,810	$5,203	$26,013
30	Planning, Engineering, and Design	$2,453	$613	25	$3,066	$3,042	$761	$3,803
31	Construction Management	$1,449	$362	25	$1,811	$1,911	$478	$2,389
Project Cost Totals		**$30,276**	**$7,303**	**24**	**$37,579**	**$35,195**	**$8,502**	**$43,697**
Notes: All costs in the thousands ($1,000)								

7.9.5 DIVISION OF RESPONSIBILITIES

The non-federal sponsor will be required to sign a design agreement and PPA for implementation of the project. Pursuant to that, the sponsors shall provide 35 percent of the implementation cost of the project, which includes design, construction, project/construction management, and acquisition of all LERRDs, as required for implementation of the project. This will be a combination of cash and LERRD acquisition, with the sponsor required to provide a minimum of 5 percent of total project cost. The sponsor is directly responsible for all LERRD aequisition costs. The local sponsor shall be required to operate and maintain the project to provide the authorized performance for the life of the project.

USACE will provide for 65 percent of the implementation costs of the project and will generally solicit, award, and manage design and construction contracts for implementation. Upon notice by the District Commander to the sponsor of completion of construction of the project, the sponsor will assume the obligation to operate, maintain, repair, replace, and rehabilitate the project.

The apportionment of fully funded costs is shown in Table 7-7 (PED is preconstruction engineering and design).

Table 7-7: Apportionment of Cost

COST APPORTIONMENT	
Total Cost	$37,579,000
Federal Share	$24,426,000
Non-federal Share	$13,153,000
LERRD	$9,652,000
Non-federal Cash	$3,501,000

Price Level 1 Oct 2014

COST SHARING OF CONSTRUCTION AND LAND COSTS

The Federal share of the project will be limited to 65 percent of the Recommended Plan for the flood risk management features. This results in a federal cost of $24,426,000 which is 65 percent of the Recommended Plan for fully funded costs of $37,579,000. The non-federal sponsor is responsible for the costs of the lands, easements, right-of-way, relocations, and disposal areas (LERRDs), not to exceed 50 percent of the total project cost, and for a minimum cash contribution of 5 percent. LERRDs for the Recommended Plan are anticipated to cost $9,652,000 which is less than the project minimum 35 percent contribution that is required. The remaining non-federal share will be a cash contribution of $3,501,000; this exceeds the minimum cash contribution meaning no additional cash in needed. The statement of financial capability from the City is included as Appendix I. NOTE: LERRD costs include the Lands and Damages account and approximately 91% of the Relocations account. Costs not included from the Relocations account include pavement demolition and replacement.

Part of the Turkey Creek channel in the study area is operated and maintained by the Merriam Drainage District (MDD) under a state charter that provides MDD authorities independent of the City of Merriam or Johnson County. MDD has institutional responsibilities and real estate holdings in and near the Turkey Creek channel, where channel erosion repairs have been, and may be in the future, needed; therefore, involvement of MDD is a key element in assessing of future planning for Turkey Creek.

7.9.6 PERMITS

As part of implementing this project, the non-federal sponsors will be required to obtain all appropriate permits. The construction contractors will be responsible for acquiring all local licenses/permits required to comply with state and municipal laws, codes, and regulations (road, borrow, construction, etc.) and for acquiring the National Pollutant Discharge Elimination System (NPDES) permit from the Kansas Department of Health and Environment.

7.9.7 VIEWS OF NON-FEDERAL SPONSOR

The City of Merriam has continually expressed strong support for this project. The City of Merriam has expressed the desire to implement the project and sponsor project construction in accordance with the items of local cooperation set forth in Chapter 11. The non-federal sponsor has completed the necessary financial self-certifications to complete the feasibility report and enter into a Design Agreement. These certifications indicate that they are financially capable of moving forward with the selected plan. Additional financial certification will be necessary prior to beginning construction.

Johnson County, Kansas, has also expressed a desire to support the implementation of this project using funds from the county's Stormwater Management Program (SMP). SMP assists all of the cities in the county in planning, designing, and constructing large stormwater projects. This is an important funding mechanism for smaller cities in the county, such as Merriam. While the annual budget ranges between 10 and 20 million dollars, projects are carefully selected on specific criteria. Merriam's position downstream of several major cities has the burden of addressing resulting floodwaters, and this is one reason Merriam has received funding aid. This program is a significant part of the local cost share of this project.

MDD will also be an important cooperative and also likely a financial partner with the City in supporting future phases of design, construction, and especially the operation and maintenance of a federal cost-shared project on Upper Turkey Creek.

8 CHAPTER 8 – PUBLIC INVOLVEMENT, REVIEW AND CONSULTATION

8.1 PUBLIC INVOLVEMENT PROGRAM

A Public Involvement Program was developed by the Project Delivery Team (PDT) to help meet the requirements of ER 1105-2-100 and NEPA scoping requirements. The Upper Turkey Creek Feasibility Study PDT has regularly engaged the local sponsors and stakeholders throughout the entire process. Public input was sought during the Reconnaissance Phase (Appendix C, Exhibit 1), at the initiation of the Feasibility Study (Appendix C, Exhibit 2), and mid-way through Phase 2 of the Feasibility Study to receive feedback about identified alternatives. The public involvement goals have been to inform, engage and solicit input from stakeholders and the public to increase public awareness of the risk of flooding from Upper Turkey Creek in the City of Merriam and so that the Recommended Plan reflects that input, thus making the alternative acceptable to the public. The Recommended Plan reflects the views of the public and consultative input received from the local sponsor, other Federal and non-Federal agencies, and other affected stakeholders.

8.2 INSTITUTIONAL INVOLVEMENT

8.2.1 STUDY TEAM

A number of disciplines were represented on the PDT: engineering, biology, economics, real estate, planning and public outreach. Team members have interacted with their counterparts at non-Federal and Federal agencies as well as with local government officials and staff.

8.2.2 AGENCY PARTICIPATION

USACE and the project team have maintained regular contact throughout the study with the local sponsor, the City of Merriam. The City of Merriam established inter-local agreements with Johnson County, Kansas, and with the Unified Government of Wyandotte County and Kansas City, Kansas (e.g. Unified Government or UG) to cost-share the non-Federal portion of the study costs. External engagement has included interactions with elected officials as well as with professional staff from each interested jurisdiction.

The Merriam Drainage District operates and maintains part of the Upper Turkey Creek Channel under a state charter that gives the Drainage District Board authority independent of the City of Merriam and Johnson County. The District did not fund the study, but it was included in briefings and was informed of public meetings.

During the Reconnaissance phase, USACE had contact with numerous Non-Federal as well as Federal agencies (see Appendix C, Exhibit 5 for the complete list).

8.2.3 LOCAL AND REGIONAL INTERESTS

The Upper Turkey Creek study area includes numerous businesses along Merriam Drive, parallel to Upper Turkey Creek. The Downtown Merriam Partnership is an association of those businesses and it has been involved throughout the study process.

The Turkey Streamway Bike Trail parallels a section of Upper Turkey Creek between Johnson Drive and Antioch Road. Under the auspices of the Mid America Regional Council's (MARC) Metro Green Bike and Trail initiative, a coalition of public and private organizations have organized as the Turkey Creek Coalition. The coalition is an informal association interested in trail development along this segment of the creek. USACE is a member of the Coalition.

MARC, through other environmental programs, also has interests and acts as a convener of local governments in the region about stormwater and other water quality issues. MARC staff has participated in study briefings and public meetings.

8.3 INFORMATIONAL MATERIALS

The Public Involvement Program included media notices, public meetings, and outreach activities. The goal of the District was to increase public awareness of the risk of flooding and to focus media notices and public attention on the study at key points in the process. Outreach activities for the study were designed to educate the public of the existing flood hazard and associated flood damages and to provide the public with important project information and keep them informed about project activities and milestones and receive feedback. This feedback was then considered and used in the analysis of the study alternatives. The PDT utilized several communication tools to provide the public with study information including:

- Open Houses
- Workshops
- Public Meetings
- Press Releases
- Project Brochures
- Web Page

Information about the project was also made available on the Kansas City District's website at http://www.nwk.usace.army.mil/projects/utc/. The website is a mechanism to provide general information about the project and details about public meetings.

8.4 MEDIA RELEASES

Media releases were distributed to inform the public of upcoming events and of study milestones. Media releases throughout the study include:

- Reconnaissance Study, Notice of Initiation, July 2001 (Appendix C, Exhibit 1)
- Feasibility Study, Notice of Initiation, August 2002 (Appendix C, Exhibit 2)
- Turkey Creek Awareness Workshop, June 2003 (Appendix C, Exhibit 3)
- Upper Turkey Creek Concepts Workshop, September 2004 (Appendix C, Exhibit 4)
- Upper Turkey Creek Basin Feasibility Study, Notice of Public Meeting, September 2011 (Appendix C, Exhibit 6)
- Upper Turkey Creek Basin Feasibility Study, Public Notice of the Draft Feasibility Study with Integrated Environmental Assessment, June 2013 (Appendix C, Exhibit 7)

8.5 PUBLIC OPEN HOUSE AND MEETINGS

A series of meetings were held within the project area. The meetings allowed the PDT to present the existing flood risks and associated flood damages and to show the public flood risk management study alternatives and gather input on any issues that needed to be addressed prior to study initiation and throughout the study process.

- July 25, 2001 – a public workshop was held at Merriam City Hall in the City of Merriam to inform the public of the scope of the reconnaissance study. The workshop included a presentation of the existing flood risk, purpose of the analysis, potential benefits, and possible environmental impacts.
- July 17, 2003 –the Turkey Creek Awareness Workshop was held at the Antioch Public Library in Shawnee Mission, Kansas to inform the public of ongoing activities of the City, State, Federal, and other types of organizations to gather information for the future management of Turkey Creek.
- September 16, 2004 –the Upper Turkey Creek Concepts Workshop was held at the Community Center in the City of Merriam (Appendix C, Exhibit 6). The District presented the concepts developed at that time as opportunities for flood risk management for public consideration. The workshop was an opportunity for the public to ask questions and provide suggestions for improvement.
- October 19, 2011 – a public meeting was held at the Community Center in the City of Merriam to inform and receive input from the public about the identified alternatives. The public was informed about the planned meetings through numerous mechanisms: a 3 panel brochure describing the project, meeting information made available on the USACE District Website, postcards mailed to property owners within 1/8 mile of the creek and key partners, and on the City of Merriam's Facebook account.

  The meeting included a formal presentation titled "Solutions for Flood Hazard on Upper Turkey Creek" which included a discussion of study background, understanding flood risks (i.e. extent of floodwaters, velocity, proximity of population at risk, warning time, rate of rise) (Figure 8-1), , conceptual alternatives, other planning considerations, and next steps (Appendix C, Exhibit 6). The District presented its planning process, the alternatives evaluated, and the screening process used to arrive at the Recommended Plan for flood risk management. A question and answer period was held after the presentation where the project study team captured public comments made at the informational displays. Input was also collected from the public on comment cards provided to attendees in order to provide written feedback. The input collected allowed the project study team the opportunity to address any issues prior to the selection of the Recommended Plan.

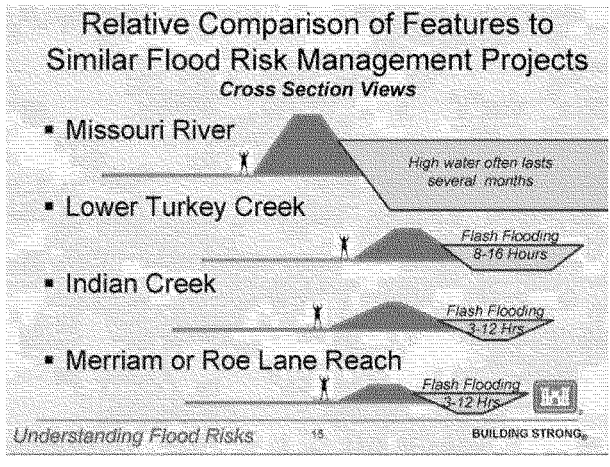


Figure 8-1: Public Hearing PowerPoint Slide 'Understanding Flood Risks"

- August 14, 2013 – a public meeting was held at the Merriam City Hall during the public review period of the Study to inform and receive input from the public about the Recommended Plan. This meeting explained the District's Recommended Plan for FRM. Comments were received on the draft report and are included in Appendix H.
- October 14, 2014 – The city held a meeting on the preliminary design. The USACE showed the levee/floodwall designed and explained how higher rainfall intensities called for a more robust approach over the last year. This was tied to an update from NOAA, National Weather Service, in their precipitation atlas called Atlas 14. This new flood risk was known in April 2013. The USACE

decided to address this in the design in November 2013. The meeting described the performance ability of the proposed low, 6-foot high levees and floodwall. Approximately ten people attended and offered good comments.

Upon the release of the Draft Feasibility Study with Integrated Environmental Assessment, a Public Notice was issued (see Appendix C Exhibit 7), the Study was made available for public review and another public meeting was held to obtain input on the recommended alternative.

8.6 PUBLIC VIEWS AND RESPONSES

A complete list of public comments and responses regarding the scoping process is contained in Appendix C, Public Outreach and Involvement. A complete list of public and private comments and responses to comments regarding the Draft Environmental Assessment is contained in Appendix H, Comments and Correspondence.

8.7 AGENCY CORRESPONDENCE

Agency correspondence and communications initiated during the scoping process and the views of the resource agencies are included in Appendix H, Comments and Correspondence.

The Draft Feasibility Report with Integrated Environmental Assessment was available by Public Notice for a 30 day public review period on June 27, 2013. The review period closed on August 21, 2013 after being extended by 26 days. The review period generated questions and comments on the Draft Feasibility Report with Integrated Environmental Assessment that covered a range of topics. These comments are provided in Appendix H, Comments and Correspondence.

The following is a list, summarizing the comments received during the review period for the Public Notice. Generally, they appear in the order in which they were received, and each is followed by the District response. Many of the responses provide a general overview and then direct the reader to the location within the Draft Feasibility Report with Integrated Environmental Assessment where more detailed information can be found.

1. **Letter from Kansas State Historic Preservation Office, Jennie Chinn, Executive Director and State Historic Preservation Officer, dated August 1, 2013**

   COMMENTS/CONCERNS

   A. The agency had previously reviewed the project and had cleared it in a letter to the USACE dated May 15, 2012. The agency concurred that the project should have no effect on properties listed in the National Register of Historic Places or otherwise listed in their files. The office continues to have no objection to implementation of the Upper Turkey Creek Basin Flood Risk Management Project.

      Response: Noted

2. **Electronic message from Kansas Department of Wildlife, Parks, and Tourism, Jason Luginbill, Aquatic Ecologist, Aquatic Services Section dated August 13, 2013**

   COMMENTS/CONCERNS

   A. The agency responded that no state-listed threatened or endangered species or crucial wildlife habitats should be significantly affected. No Department of Wildlife and Parks permits or special authorizations are needed.

      Response: Noted

   B. The agency provided the following design criteria:

- Avoidance of impacts to non-impacted riparian zones, wetlands, and native prairie and woodland areas
- Minimization of further instream construction activities particularly during general spawning dates of May 1 and August 31
- Incorporation of principles of Low Impact Development
- Implementation and maintenance of standard erosion control Best Management Practices
- Reseeding and landscaping of disturbed areas with indigenous species

Response: Each of these recommendations will be evaluated for incorporation in the design phase of the project.

3. **Letter from U.S. Environmental Protection Agency, Larry Shepard, NEPA Reviewer, dated August 21, 2013**

COMMENTS/CONCERNS

Floodplain Management

A. Comments ask for the inclusion of high water marks and projected flood levels on constructed flood walls, and signage to address flood hazards in the protected area. They also have asked for Floodplain Management Plan (FMP) deadlines to be completed in the PPA.

Response: The decision to provide water marks on floodwalls and signage in the protected area is a non-Federal sponsor decision. In addition to encouraging measures such as these, during the preparation and implementation of the FMP and project implementation, we will work with the sponsor to assist them with a range of flood risk management measures including continued risk information disclosure, flood preparedness and flood response. There are provisions in the clauses of the USACE Flood Risk Management PPA that requires preparation of a FMP including stipulation that it be completed prior to completion of construction. The FMP has been initiated during feasibility phase and it will be completed prior to project construction.

B. Comments ask for a City of Merriam commitment to identify structures and properties within the floodplain to acquire from willing sellers to further reduce flood risk in the area.

Response: We studied and identified the areas of highest flood risk to property and life along Upper Turkey Creek. The area identified as highest risk was located within the City of Merriam. As part of the feasibility report's consideration of alternatives, we evaluated evacuation of structures or buy-out from the floodplain as a detailed alternative (see Chapter 4, Section 4.6.2, Chapter 5, and Chapter 6. It was not selected as it was not the NED Plan. The City of Merriam as part of the FMP will be required to have in place or establish procedures that manage flood risk and protect Federal investment in this project. The FMP is discussed in Chapter 2, Section 2.6.3 and further discussion was added to Chapter 7, section 7.5.2. If the City of Merriam has justification, authority, and funding to implement property buy-outs in the future (which are beyond the scope of the Federal project), they will likely do so as they have done in the past.

C. Comments request the development of an FMP in a broader geographic context in order to provide a more "systems approach in the watershed".

Response: The USACE policy guidance expressly requires the non-Federal sponsor (City of Merriam) to prepare an FMP specifically for the study area. We are allowed to assist with it and are doing so. The capacity building and opportunities for participation in the FMP was presented to the key stakeholders, and included the importance of having a watershed

perspective and a systems approach. All planning work has been done in a watershed context, and the importance of this perspective will be part of the scope of the FMP. We will coordinate the FMP development with Johnson County and other stakeholders including FEMA, and the State of Kansas. We welcome this comment and would be pleased to include USEPA in the process.

Purpose and Need for Action

D. Comments expressed lack of a clearly-stated project purpose in the document. Comment questions whether the report is consistent with the charge to USACE in the Study Resolution from Congress, states the purpose of the report is addressed in the document but not the purpose of the project. The report addressed to a limited extent flood risk in the vicinity of the project, does not address fundamental causes of flood risk, nor flood risk remaining upstream and downstream of the project area.

Response: The study authority is for the Upper Turkey Creek basin, but it is not a watershed study authority. In scope it allows for basin wide flood risk planning in a watershed context. It asks the USACE to recommend modifications in the form of flood damage reduction (flood risk management) projects in the basin. We evaluated flood risk in the upper basin, and identified to the best of our ability the three most vulnerable areas with significant risk to life and property. Of these, one location was found to have technical and economic feasibility with a non-Federal sponsor willing to cost share in a project. However, that does not obviate the watershed based analyses that the study included, and the fact that the Recommended Plan was formulated and evaluated in a watershed context. The report, to a large degree, is a chronological summary of the study and its findings. The study was initiated by evaluating a broad array of flood risk management measures basin wide, including nonstructural measures, and also ecosystem restoration opportunities. As the study progressed, measures and alternatives were screened for feasibility and sponsorship.

In formulating, comparing, evaluating and selecting alternatives for the Upper Turkey Creek project, the purpose, or performance goal, that we have pursued has simply been to maximize flood risk reduction (or minimize residual risk) within the broader goals and constraints of economic efficiency, environmental considerations, and sponsor finances. Further clarification of the project purpose was added to the introduction section of Chapter 4.

The report in Sections 2.1 and 2.3.1 identifies the fundamental causes of increased flood risk and flood history, and identifies the significant flood hazard in Section 2.3.2. The project will not address the other areas of significant flood risk to life and property that were identified. However, those three areas are identified in Sections 4.1 and 4.3. Section 7.5 relates the residual flood risk which has also been disclosed at public meetings.

E. Comments asked for modification of objective one stated in Chapter 2, Section 2.4.1 to reflect the reduction of flood risk in the City of Merriam rather than in the watershed.

Response: The report is arranged largely in chronological sequence. Planning objective one in Section 2.4.1 was developed prior to screening and evaluation of measures and plans which is documented in Chapters 4 and 5 of the report. The USACE evaluated the threat to life and property in the watershed, and we found three areas of significant flood risk (see Chapter 4, Section 4.3.1). One area (City of Merriam) remained after screening criteria and sponsorship requirements were considered. The evaluation is included in Chapter 4, Section 4.5.1. The planning objective has been reviewed and approved at all levels in USACE as well

as formal Independent External Peer Review, and revision of the objective is not considered warranted.

Future Without Project Conditions

F. The study references existing channel capacity describing its capabilities at various AEP flows. It appears the study characterized channel capacity as conveying or containing the 20% AEP and in another place the 10% AEP (p. 2-5 and 2-6).

The report states that the 1-percent AEP flow would need to be reduced by 45-50 percent in order to remain within the existing channel. This indicates that the USACE could approach flood risk reduction by reducing the 1-percent AEP flow or expanding channel capacity. This concept is important to public understanding of design choices by the USACE but is under-emphasized throughout the report.

Response: The report evaluated measures in the watershed to reduce flood flows early in the study as discussed in Chapter 4, Section 4.5. The watershed is highly urbanized and our engineering analysis revealed that with the areas remaining that are undeveloped it is not feasible to control sufficient flows to have any meaningful flood peak reduction in the flood threatened areas as discussed in Chapter 4, section 4.5.2. The USACE has no authority to formulate watershed BMPs or stormwater reduction measures for implementation in the attempt to reduce peak flows. Our hydrologic modeling and experience indicates the effect of such measures on the magnitude of peak flood flows for large floods would be very limited. The results of evaluation and screening of measures are documented in Chapter 4, Section 4.5. Channel widening was retained and considered in detailed plan evaluation and was not the most cost effective or least impacting alternative, screening of channel widening is documented in Chapter 5. The study has resulted in a recommendation for a project to protect downtown Merriam from dangerous flash flooding, but this area was not the sole focus of the study.

At the Johnson Drive gage the channel capacity is able to convey approximately the 10-percent AEP at the top of bank. Elsewhere in the project reach the channel can pass up to the 20-percent AEP flow, with two areas limited to the 50-percent AEP (2-year event).

G. Section 3.3.11 recognizes the possibility that local businesses might move out of the floodplain as a result of repeated flooding without the recommended project, but does not include the possibility under "future without project conditions".

Response: Paragraph 3.3.11 states that the future without a flood risk management project would not be significantly different than that described under existing conditions. However, some business and industry may make the decision to move to other locations if flooding problems become too burdensome. There is a historic likelihood that individual businesses that move will be replaced by others.

Alternatives Analysis and Recommended Plan

H. The watershed still possesses some potential for precipitation retention (approximately 30% impervious surface) on a small scale, it is disappointing that the FR/IEA repeatedly references watershed approaches while quickly resorting to small-scale, localized alternatives based solely on "flood prevention" structures. A comprehensive, integrated solution to flood risk basin-wide with modular components addressing more localized issues should be developed, so as to find a full range of alternatives (including upstream and offline storage), and impacts to areas outside the City of Merriam would be fully considered. The notion of comprehensive, watershed-scale design for flood risk reduction should not be constrained by labeling it as "ecosystem restoration measures", as the FR/IEA appears to do.

Response: This project is expected to provide net annual benefits of approximately $1.7 million over the 50-year life of the project. The USACE recognizes that comprehensive watershed planning can make significant contributions to reducing flood risk while improving the environment in some instances. We did apply a watershed approach in formulation and did not unduly limit formulation in this study. The study started out being multi-purpose (ecosystem restoration and flood risk management) in approach using a watershed perspective. The watershed was evaluated for wetland and stream restoration sites while also being evaluated for various types of detention and storage opportunities. Opportunities for restoration sites that could also accomplish flood peak reduction were evaluated through site visits, evaluation of GIS and mapping, and in our hydrologic and hydraulic modeling. Detention or storage-type measures evaluated did not demonstrate capability of significantly reducing flood peaks at the damage areas in and downstream of Merriam and, therefore, would not provide significant flood risk management benefits. Similarly limited sites were available to provide significant wetland restoration opportunities. Any detention or storage measures that would be large enough to significantly reduce flood peaks would require costly buy-outs in improved areas, and / or disruptive construction of costly features in very adverse terrain, and would be very disruptive to the community as well. Ecosystem restoration measures were formulated that would have significant riparian and aquatic benefits, and are documented in Appendix J of the report. There were no sponsors willing to cost share and acquire land to implement these measures, but they could be implemented in the future. We recognize that recommending traditional structural flood risk management measures raises concerns about ensuring that a full range of alternatives were considered. In this case, a full-range of alternatives was considered, but in a very urbanized and impacted watershed the practical opportunities are limited. Measures and alternatives that could adequately address the flash flood threat were identified jointly by USACE and the cost-share sponsor, and were carried forward for full evaluation, including buyout of the floodplain. Incremental or partial buyouts were also evaluated but were not economically competitive with the recommended plan.

I. The document should have projected a 50-year (project life) increase following current precipitation trends to determine whether the recommended plan would provide adequate protection in the project area for the project's life.

Response: The USACE followed accepted practice and procedures in USACE and in the engineering profession for conduct of hydrologic analyses. We have incorporated consideration of the full period of flood history into our analyses and assessment of the flash flood risk. We did seek out the best information available regarding rainfall-runoff data during the study, and evaluated a 2002 University of Kansas update study. This study showed very close approximation of our hydrologic estimates which used traditional TP-40 methodology, and nothing in our investigation indicated that we should use alternative relationships or trends. Utilizing information from available climate trend reports and reasonable engineering assumptions, our best assessment is that there may be a slight increase in precipitation events and associated discharge frequency over the next 50 years, but these increases were considered to be within the bands of uncertainty in the hydrology analysis in this study. The National Weather Service has just published new precipitation frequency estimates in their Atlas 14 in March of 2013 which represents a very significant, long term and specialized body of work on this topic. Governmental agencies across the region must now consider what effect it will have and how to utilize it. It shows increases in the rainfall runoff relationships for some precipitation events. It would require significant effort in hydrologic analyses for us to determine definitive effects on the Recommended

Plan. Our preliminary evaluation indicates that more economic flood reduction benefits would result from a project, but that level of protection for the Recommended Plan could be lower. This recent information and the potential risk and uncertainty was raised and discussed at our August public meeting, and is discussed in the report in Chapter 7 under the section entitled "Risk and Uncertainty". We will consider more detailed design features during implement that are within the project scope and authority and that may be able to address new conditions based upon more detailed hydrologic analyses using Atlas 14 data. Flood risk management measures included in the FMP including public information and outreach, risk disclosure, flood response planning and risk management will continue through project implementation.

Environmental Consequences

J. Upstream and downstream impacts of constraining flood flows within the channel through the project site and possible elevation of flood stages outside of the project site have not been fully defined or analyzed to support the "no effects" statements. In addition, the study does not provide any analysis of how the recommended plan would affect the performance, present and future, of the USACE project in Lower Turkey Creek.

Response: Engineering analysis indicates that the project will not result in significant increases to water surface elevations upstream or downstream of the project area nor result in any noticeable effects to the Lower Turkey Creek project. Section 6.2.3 is being updated to better clarify our analysis of effects. The hydraulic analyses are summarized in Appendix B of the report.

K. The proposed structures will reduce public interaction with the Turkey Creek channel. The study should identify any reductions in recreational opportunities and aesthetics resulting from the installation of flood walls and levees.

Response: Impacts to recreation are described in Chapter 6 of the Draft Feasibility Study with Integrated Environmental Assessment. The public will continue to have access to the creek along the hiking and biking trail and pedestrian bridges, which were important considerations study. Most of the levee and floodwalls are on the bank opposite of the trail, and where required the project will accommodate the trail alignment.

Cumulative Impacts Analysis

L. The study should document in more detail the actions and impacts of each major change to the channel and floodplain. This project, although limited in scope, is one more alteration which contributes to the long-term decline in the quality and sustainability of the watershed. The study needs to account for each of these changes and their cumulative impacts.

Response: In our opinion the report addresses the environmental effects and cumulative impacts of the Recommended Plan sufficiently in Chapter 6, Section 6.4, and is in accordance with CEQ and USACE regulations. The proposed modifications are in a reach of previously modified channel with large limestone rock lining for most of its length, with a rock bottom in a fully urbanized area with heavy development and park like features. The existing conditions in the project area are documented in Chapter 6.

4. Electronic message from Delia Garcia, Ph.D., and Eliodora Chamberlain, Ph.D., dated August 21, 2013

COMMENTS/CONCERNS

A. The commenter expressed opposition to the recommended plan and the use of levees and floodwalls as flood control measures in place of management techniques that would provide more benefits to the ecosystem.

Response: Ecosystem restoration measures were considered early in the study and found to have merit for restoring habitat and channel stability. However there were no local sponsors identified with an interest in cost sharing ecosystem restoration features, and the study authority is for flood risk management. These measures remain available for further consideration by others and are documented in Appendix J of the report.

B. Recommendations were made to the Merriam Drainage District to work with other agencies and nongovernmental organizations to implement greener solutions to alleviate flood risk and promote workshops (e.g. rain gardens, rain barrels, pervious pavement) to homeowners and business organizations.

Response: Noted. The USACE will reinforce sound flood risk management beyond solely the construction of structural features through the development and implementation of the FMP in partnership with the City of Merriam and the MDD.

C. The recommended plan as proposed would lead to the further degradation of an already badly degraded environment.

Response: Impacts to natural resources for the entire area of impacts are described in Chapter 6 of the Draft Feasibility Study with Integrated Environmental Assessment. Unavoidable impacts will be offset by the proposed mitigation.

D. The commenter expressed concerns that the increased containment of flows with the Upper Turkey Creek will lead to increased water velocities to the Lower Turkey Creek and may create damages to the recently improved Lower Turkey Creek project.

Response: Engineering analysis indicates that the project will not result in significant increases to water surface elevations upstream or downstream of the project area nor result in any noticeable effects to the Lower Turkey Creek project. The hydraulic analyses are summarized in Appendix B of the report.

5. **Letter from U.S. Fish and Wildlife Service, Heather Whitlaw, Field Supervisor, dated August 21, 2013**

COMMENTS/CONCERNS

A. The U.S. Fish and Wildlife Service concurred with the USACE preliminary determination that the project will not affect species designated as threatened and endangered or adversely affect critical habitat and no Federally-listed threatened and endangered species occur in the project area.

Response: Noted

B. We believe that the description of current environmental conditions and Federal trust species, as well as the affects of the project on those resources, in the Draft Feasibility Study with Integrated Environmental Assessment is adequate.

Response: Noted

C. The project is likely to increase thermal pollution in Turkey Creek and downstream receiving waters increasing water temperatures that may further reduce habitat for aquatic and semi-aquatic species.

Response: The project area is located in a highly altered urban environment. There is very little shading of the channel occurring from existing vegetation as very few riparian trees are adjacent to the stream which has been heavily modified and lined with large rock as discussed in Chapter 3 and explained further in Chapter 6, Section 6.2.3. We believe the proposed project would not result in any significant change to the stream water temperatures relative to existing condition.

D. The mitigation plan does not adequately account for the removal of riparian vegetation, including trees, and the loss of the function of riparian vegetation to the health of the stream. Trees planted for mitigation for the loss of riparian vegetation should be along streams, preferably along Turkey Creek or tributaries to Turkey Creek.

Response: The proposed project will result in no significant loss of riparian vegetation as there is very limited riparian habitat or trees close to the stream. A majority of the riparian trees that are in the existing project footprint are located in park-like setting with manicured turf grass which provide very little habitat. In addition, the existing banks are very steep and comprised of large limestone blocks over much of the reach, which doesn't allow for significant riparian vegetation. By changing from the large limestone blocks to rip rap will allow for more growth of stream bank vegetation. Trees planted for mitigation will be planted near the stream when possible. Final locations for the planting will occur in the design phase. The existing conditions in the project area are documented in Chapter 3, Section 3.2. The effects of the project are located in Chapter 6, Section 6.2, and the project mitigation that is justified given project effects and allowable within USACE authority is documented in Section 6.3.

E. The agency recommends the use of the Kansas Stream Mitigation Guidance for the project.

Response: USACE Planning regulations requires the use of certified models in water resource planning studies. The KSMG has not been certified for use in USACE planning studies. The USFWS HEP that are certified for use in USACE planning studies were utilized as a means of comparing habitat units to determine mitigation needs. The HSI models used for HEP are more robust than the KSMG. As stated in the KSMG documentation, the KSMG is to be utilized when a more robust evaluation is not practical.

F. If mitigation is required for aquatic resources the mitigation plan should be developed in accordance with 33 CFR, Part 332 and 40 CFR 230, also known as the Mitigation Rule, and include the recommended sections.

Response: A 404(b)(1) analysis was performed and is included in Appendix B. USACE planning regulations require the replacement of an equal amount of habitat value, typically based on a Habitat Unit or equivalent which is annualized over the life of a project (i.e. AAHU). This process was used in the calculation of mitigation amounts for this project. As determined using a USFWS HSI model, no aquatic habitat mitigation would be required for the Recommended Plan.

G. The agency urges the USACE to evaluate and prioritize alternatives, mitigation, and restoration opportunities from a process-based approach that determines whether a proposal will further degrade, maintain, or enhance natural riverine processes.

Response: The USACE followed all applicable laws and regulations, including CEQ "Principles and Guidelines for Federal Water Resources Projects", P&Gs, and the USACE Planning Guidance Notebook (ER 1105-2-100), among others to develop and evaluate alternatives, including mitigation and restoration opportunities. Environmental impacts, both

positive and negative are utilized as a factor in the planning and selection of project alternatives. Chapter 6 presents the environmental effects of the Recommended Plan. The Recommended Plan will not result in additional significant degradation, either directly or cumulatively, of natural riverine processes in Turkey Creek.

H. If channel widening is considered again in the future, project planning should include the construction of a low flow/base flow channel which should emulate the natural stream pattern, profile, and dimensions.

Response: Noted. The USACE will continue to consider environmental design features during preliminary and final design of the project. The rock bed, confinement, and channel stability will likely limit construction of a low flow channel, but this will be considered as an option.

I. Recommend the use of native species planted on the levees.

Response: The use of native species for planting on the levees will be evaluated during the design phase to determine if and where it may be appropriate use of native vegetation.

J. The project should include erosion control that include BMPs to ensure sediment originating from the project does not enter the stream or migrate downstream. Additionally, instream sediment controls should be considered in sensitive areas or where upland controls may not be adequate.

Response: A stormwater pollution prevention plan will be developed as part of the Section 402 land disturbance permit. The appropriate BMPs will be incorporated into that plan to avoid sediment and other pollutants from entering Turkey Creek.

K. At a minimum the following should be included as a permit condition:

- All equipment brought on the site will be thoroughly washed to remove dirt, seeds, and plant parts.
- Any equipment that has been in any body of water within the past 30 days will by thoroughly cleaned with hot water greater than 140 degrees F and dried for a minimum of five days before being used at this project site.
- Before transporting equipment from the project site all visible mud, plants, and fish/animals will be removed, all water will be eliminated, and the equipment will be thoroughly cleaned.
- Anything that came in contact with water will be cleaned and dried following the above procedures.

Response: USACE construction specifications include those provisions as well as other conditions to prevent the spread of invasive species.

9 CHAPTER 9 – LIST OF PREPARERS

Name	Discipline	Experience	Role in Preparing Report
Brian Rast	Plan Formulation	20 years	Project Manager/Planner
Thomas Topi	Economics	6 years	Economics/Social
Meredith Harmon	Real Estate	6 years	Real Estate
Jesse Granet	Environmental Resources	15 years	EA Preparation, Impact Assessment and Mitigation Planning
Curtis Hoagland	Environmental Resources	17 years	EA Preparation, Impact Assessment and Mitigation Planning
William Otero	Hydraulic Engineering	14 years	Hydraulic and Hydrology Appendix
Timothy Meade	Archeologist/Cultural Resources	24 years	Cultural/Historical Section
Paul Speckin	Civil Engineer	27 years	HTRW Support
Eddie Fernandez	Structural Engineer	10 years	Lead Technical and Structural Engineering
Jim Mehnert	Geotechnical Engineer	25 years	Foundations
Jared Mewmaw	Civil Engineer	10 years	Civil / Site Development and Utilities
Lisa Hook	Geospatial Analysis	10 years	GIS and map-figures
Pat Miramontez	Cost Engineer	20 Years	Construction cost estimating and cost and schedule risk analysis
Lou Ragozzino	Civil Engineering/Hydraulic Analysis	29 years	Contractor/Civil Engineering/Hydraulic Analysis
Laura Totten	Ecologist/Project Management	14 years	Contractor/Project Manager/Main Report and Environmental Appendix
Michael Snyder	Environmental Scientist	13 years	Contractor/Main Report
David Halpern	Civil Engineer/Cost Estimator	10 years	Contractor/Cost Estimator
Dincer Egin	Geotechnical Engineer	30 years	Contractor/Geotechnical Engineer
Aaron Sylvia	Civil Engineering	9 years	Contractor/Cost Estimator/Engineering Appendix
Julie MacLachlan	Public Involvement/Facilitator	20 years	Contractor/Public Involvement Chapter and Appendix
Samantha Hogan	Environmental Scientist	6 years	Contractor/Preparing Maps and Figures
Coreen Johnson	Technical Editor	21 years	Contractor/Editorial Review

10 AGENCY COMPLIANCE WITH OTHER ENVIRONMENTAL LAWS

10.1 COMPLIANCE WITH OTHER ENVIRONMENTAL LAWS

Federal Polices	**Compliance**
Archeological Resources Protection Act, 16 U.S.C. 470, et seq.	Not Applicable
Clean Air Act, as amended, 42 U.S. C. 7401-7671g, et seq.	Full Compliance
Clean Water Act (Federal Water Pollution Control Act), 33 U.S.C. 1251, et seq.	Full Compliance
Coastal Zone Management Act, 16 U.S.C. 1451, et seq.	Not Applicable
Endangered Species Act, 16 U.S.C. 1531, et seq.	Full Compliance
Environmental Justice (Executive Order 12898)	Full Compliance
Estuary Protection Act, 16 U.S.C. 1221, et seq.	Not Applicable
Farmland Protection Policy Act, 7 U.S.C. 4201, et. seq.	Full Compliance
Federal Water Project Recreation Act, 16 U.S.C. 4601-12, et seq.	Full Compliance
Fish and Wildlife Coordination Act, 16 U.S.C. 661, et seq.	Full Compliance
Floodplain Management (Executive Order 11988, see Section 10.2)	Full Compliance
Invasive Species (Executive Order 13122)	Full Compliance
Land and Water Conservation Fund Act, 16 U.S.C. 4601-4, et seq.	Not Applicable
Marine Protection Research and Sanctuary Act, 33 U.S.C. 1401, et seq.	Not Applicable
Migratory Bird Treaty Act, as amended, 16 U.S.C. 703-712	Full Compliance
National Environmental Policy Act, 42 U.S.C. 4321, et seq.	Full Compliance
National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470a, et seq.	Full Compliance
Protection & Enhancement of the Cultural Environment (Executive Order 11593)	Full Compliance
Protection of Wetlands (Executive Order 11990)	Full Compliance
Rivers and Harbors Act, 33 U.S.C. 403, et seq.	Full Compliance

Watershed Protection and Flood Prevention Act, 16 U.S.C. 1001, et seq.	Full Compliance
Wild and Scenic River Act, 16 U.S.C. 1271, et seq.	Not Applicable

Notes:

a. Full compliance. Having met all requirements of the statute for the current stage of planning (either preauthorization or post authorization).

b. Partial compliance. Not having met some of the requirements that normally are met in the current stage of planning.

c. Noncompliance. Violation of a requirement of the statute.

d. Not applicable. No requirements for the statute required; compliance for the current stage of planning.

10.2 COMPLIANCE WITH EXECUTIVE ORDER 11988

Under this Executive Order, the USACE 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;
- Minimizes the impact of floods on human safety, health and welfare; and
- Restore and preserve the natural and beneficial values of the base floodplain.

Preauthorization studies, or feasibility studies, are one of the areas of the USACE Civil Works Program that must comply with the Executive Order. Where a floodplain may be affected, the policy and procedures of this regulation shall be incorporated in the multi-objective planning process (ER 1105-2-20, ER 1105-2-30) from the outset, to a scope and level of detail appropriate for preauthorization studies.

The project team followed the eight step decision-making process for helping to avoid long and short-term adverse impacts per the proposed actions that are in and that affect the floodplain in Merriam, Kansas. These eight steps are bulleted below and followed with project specific statements and should not be confused with the Six Step Planning Process used through the first seven chapters:

1. **Determine if the proposed action is in the base floodplain.**

The Selected Plan is in the base floodplain. The features also redefine the boundary of the floodway.

2. **Identify and evaluate practicable alternatives to locating in the base floodplain, including alternative sites outside of the floodplain.**

The project team considered a buyout of all structures and a greener floodplain. This is discussed in Section 4.6. After much discussion with the city and several meetings with stakeholders like Merriam Downtown Partners between 2006 and 2009, this is not acceptable to these businesses. If a portion of the channel happened to be owned by the city, this may have been an alternative worth pursuing. None of the property except at road rights-of-way belongs to the city. The conclusion was this is not a practicable alternative.

Another consideration is widening bridges. But two issues defeat this measure of wider bridge openings. First, a wider bridge typical requires commensurate widening of the channel, or the channel capacity

would become the next limiting factor for conveying the floodwaters. The real estate associated with widening the channel makes the bridge widening more costly. In addition, the Merriam Drive Bridge has a particularly high skew or a bend in the stream's alignment. Reducing the effects of the skew require more real estate as well. Also, benefits for improving just this one bridge are hard to realize when, during a flood, another bridge crossing is nearby that acts as an alternate and safer route for traffic.

3. **Provide for public review and involve the public in the decision process.**

Study finds that no other measure to alleviate the consequences of flooding will work, other than a feature built in the floodplain, and several opportunities, for the public to be involved the process leading to this realization, occurred. The public involvement chapter outlines this in detail. The stakeholders were engaged several times and with various tools, beginning in 2001. A full list of meetings is in Section 8.5. The project team organized a public meeting on October 19, 2011 to present a menu of measures and involve the public in the development of the alternatives from those measures. The project team was careful to clearly layout this menu of measures for reducing impacts of flooding. The measures covered tools for addressing floodplain management as well as those that adjust the floodwaters. The results for conducting plan formulation with the measures are presented in Section 4.5.5. The floodplain management measures discussed included both activities by the city and Merriam Drainage District and features, such as flood proofing and flood warning. Floodplain management measures will be continued in the floodplain management plan with the city's leadership. A list of action items will be maintained in the floodplain management plan.

4. **Identify beneficial and adverse impacts of the proposed action.**

    a. Impacts will vary depending on the Federal action

    b. Impacts on lives, property, and floodplain values

    c. Positive and negative; concentrated and dispersed; and short and long term

The negative impacts can be divided into floodwater and environmental impacts.

Regarding floodwater, the features of the Selected Plan will protect areas in the reach of stream that are on the same bank of the creek. Properties on banks without the levee or floodwall features will see a rise in water surface elevations and a change in the location of the floodway. The advancement of the floodwaters on to each property depends on topographic conditions: for example, a flat piece of land will see minimal advancement into the property for a similar property with steeper land slopes. A review of the lands, especially on the west bank of the creek, showed no structures will be impacted and risk of loss of life would not change.

Environmentally, the negative impacts are under the footprint of the features and the floodplain lands within the protected area that are cutoff from the water body. Ideally, the buyout alternative would offer the chance to return to a more vibrant stream corridor, however the private property owners are not on board with that. All of that land is developed behind the proposed levee. The land use has impervious surfaces. Thus no additional loss to the floodplain ecosystem is quantified. The project team was careful to assess needed compensatory mitigation for the terrestrial habitat impacted, and this is addressed in Appendix M.

Positive impacts are more notable. The area will not have impacts from the more frequent flood events. This includes damage, loss of life, and the suffering during recovery phases after flood events. The levee and flood walls require an interior drainage pond that offers an opportunity to improve water quality and water infiltration. Currently, Downtown Merriam discharges this stormwater directly. The dry pond area will act as a stormwater detention basin. Water held during the drainage holding time can percolate into

the soil. The green space alone offers and improvement compared to the amount of impermeable land cover currently in the area. If the city agrees to plant native plants, this could improve groundwater recharge. The same green area could be a recreational amenity as well, being used for removable soccer or volleyball equipment, directly compatible with the Merriam Downtown Marketplace park environment. This is a good example of the wise use of the floodplain.

With the levee in place, any poor water quality will be directed and controlled and routed to the interior drainage dry pond, which offers an opportunity for treatment if the city desires to pursue that with its own funding to address possible EPA requirements (NPDES).

5. **Examine the possibility of inducing development.**

The possibility of further inducing development is unlikely. The primary reason is that the area is already developed. The community leaders are focused on maintaining a stream corridor for the existing trail for pedestrians and bikers. The preference they have is that business re-development occurs at the tops of the nearby hills along the I-35 corridor and that the park setting be maintained.

6. **Revaluate the alternatives to minimize impacts**.

The re-evaluation has been done. Property owners wish to remain, and funds are not available to afford a buyout alternative. The study team considered means that other agencies offer. The team used the state hazard mitigation team network, through USACE Silver Jackets and looked at FEMA mitigation grants and HUD resiliency competitions. No funds were available through these, or the community simply was not eligible. The team considered a green way in conjunction with the EPA mechanisms, including the SAMP. Cost of bioengineering stream banks is high and the risk of failure during the root growth is too great. The solution to flooding is needed in the near term by 2020 according to the capital improvement plan.

7. **Issue findings and a public explanation**.

The study team looked at many possible solutions for years (2002-2014). The study has tried many different alternatives, from local to watershed-wide, from one agency to many. The Selected Plan is the result of a more than ten-year search. After including the public in the planning process, the city and USACE have presented updates, including one update focused on the increased flood risk found after applying the NOAA National Weather Service Atlas 14 higher rainfall intensities. The public understands the findings and has expressed desires to be worked into the design, such as preserving the trail.

8. **Recommend the plan most responsive to the planning objectives**.

The best plan was recommended per the requirements of the Executive Order 11988. The planning process established objectives and planning criteria for the decision process in Section 2.2 and Section 4.2, respectively. This planning effort sought to avoid the floodplain per measures evaluated in Section 4.5.2. As the only practicable alternative, the selected plan, Alternative 2d as modified for Atlas 14 flows, emerged in Section 5.3.2 and finalized in Chapter 7 as the best solution. That plan reduces the flash flood hazard and risk associated with floods in the best way. In alignment with the objectives of Executive Order, that plan minimizes the impact of floods on human safety, health, and welfare, as the proposed feature reduce the potential for loss of life and property damages. Finally, the planning process sought to restore and preserve the natural and beneficial values of the base floodplain. Specifically, environmental improvement was looked at to the degree possible under this study's authority, including identifying significant plan formulation of more than ten best management practices based on a watershed perspective (see Appendix J, Section 2 and 3). The final plan also includes environmental mitigation to meet the Executive Order's objectives on natural and beneficial values of the base floodplain (see Appendix M).

STATEMENT OF FINDINGS

The proposed levees and floodwalls are the best action for managing the flood risks for Merriam, Kansas, because of these features best address the flash flood risk in the this well developed area. The report documents the decision process that lead to this conclusion, and the reasons for why the proposed action must be located in the floodplain. The plan formulation process considered many alternatives before narrowing plans down to the determination to locate in the floodplain, and the many alternative sites and actions considered are presented in first several chapters of this report. The selected plan conforms to applicable State or local floodplain protection standards, including those of the National Flood Insurance Program as administered by the City of Merriam and the Kansas Department of Agriculture, Division of Water Resources, and the design phase will continue that effort. The selected plan will temporarily disrupt the natural and beneficial values of the floodplain, and the plan will also mitigate that environment. The plan will include steps to design or modify the proposed action to minimize potential harm to stakeholders in the area and within the floodplain, and much of this will be guided through a floodplain management plan. The City of Merriam and the Kansas Department of Agriculture, Division of Water Resources, the Lower Kansas River WRAPs, and the Turkey Creek Coalition have all been involved in the development of this plan.

11 CHAPTER 11 – 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 sponsor, 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. 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 NED Plan, which is Alternative 2d, as generally described in this report. The plan includes flood risk management features including 6,822 feet of floodwall up to 6.5 feet in height, 3,203 feet of levees up to 6.5 feet in height, with associated storm drainage modification and relocation work, and a 2.14 acre-foot detention area. These features are in the City of Merriam and extend approximately from Shawnee Mission Parkway to Merriam Drive, which is a stretch that includes Merriam's main downtown reach, as well as a commercial and industrial area just south of Johnson Drive. Most of the protected area is on the right bank of Turkey Creek. The total estimated first cost estimate at October 2014 price levels is $37,579,000, and a fully funded cost of $43,697,000, with the Federal and non-Federal shares of the total estimated at $28,403,000 and $15,294,000, respectively, and from that a LERRD requirement of $10,934,000, and estimated annual OMRR&R costs of $40,800. The selected plan has an overall benefit to cost ratio (BCR) of 2.0 to 1.

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

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

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

   (1) Provide the required non-Federal share of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

m. Comply with all applicable Federal and state laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled

"Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701 – 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c et seq.);

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

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

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

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

This 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 sponsor, the State of Kansas, interested Federal agencies, and other parties will be advised of any modifications and will be afforded the opportunity to comment further.

Andrew D. Sexton
Colonel, Corps of Engineers
District Commander

12 CHAPTER 12 – LIST OF RECIPIENTS

The following Federal, State, County, local and regional agencies; environmental organizations; and interested groups received notice of availability of this document:

- Kansas Division of Emergency Management (KDEM)
- Kansas Division of Water Resources, Kansas Department of Agriculture
- City of Merriam, Kansas
- Kansas House of Representatives
- USACE, Kansas City District
- Lower Kansas WRAPS
- Kansas Department of Health and Environment (KDHE)
- The Watershed Institute
- U.S. Environmental Protection Agency
- Downtown Merriam Partnership
- Merriam Drainage District
- Unified Government
- Kansas Department of Transportation (KDOT)
- Federal Emergency Management Agency (FEMA), Region VII
- Mid-America Regional Council
- Johnson County, Kansas
- Johnson County Public Works and Infrastructure-Urban Services Division
- City of Shawnee, Kansas
- City of Lenexa, Kansas
- City of Overland Park, Kansas
- City of Mission, Kansas
- City of Fairway, Kansas
- U.S. Geological Survey
- U.S. Fish and Wildlife Service
- Kansas Department of Wildlife, Parks, and Tourism
- Kansas State Historical Society (SHPO)
- Natural Resources Conservation Service (NRCS)
- Burrows Audubon Society
- Ducks Unlimited
- Federal Highway Administration
- Iowa Tribe of Kansas and Nebraska
- Kansas Water Office
- Kickapoo Tribe in Kansas
- Kansas Chapter Sierra Club
- Osage Tribe
- Ponca Tribe of Nebraska
- Pawnee Nation
- Sac and Fox Nation of Missouri in Kansas and Nebraska
- The Nature Conservancy

13 CHAPTER 13 – REFERENCES

13.1 PRIOR STUDIES AND REPORTS

The following previously conducted or ongoing studies are related to the Upper Turkey Creek Basin:

Design Memorandum No. 2, General Design Memorandum, Turkey Creek Diversion, USACE, Kansas City District, January 1956. The memorandum documents a proposed plan to raise the right bank levee on Turkey Creek by four feet from a point 200 feet upstream from the Turkey Creek Tunnel entrance to a point 4,000 feet upstream of the tunnel entrance. Also proposed was widening the bottom width of the channel to 90 feet with 1-on-2 side slopes from the Southwest Boulevard bridge to a point 100 feet downstream from the Frisco Railroad bridge. The design features discussed in the proposed plan were never constructed.

Flood Protection Project, Turkey Creek, Merriam, Kansas, USACE, September 1962. This Design Memorandum reevaluated the economic justification of a flood protection plan developed in 1946. The project was designed to alleviate flooding along Turkey Creek in Merriam, Kansas. The plan of improvement called for constructing levees along the banks, a short section of floodwall, a new channel through the entire length of the improvement area, and the modification of several bridges and roads. The report revised the recommendations for conditions, as of 1962, and provided a map of improvements and typical channel sections. This project was not constructed.

Letter Report for Proposed Inclusion of Turkey Creek Improvements, Modification of Local Protective Works, Kansas River, Kansas City, Kansas (Flood Control Act of 1962), USACE, Kansas City District, May 1968. The report described the Turkey Creek Flood Problem and proposed a solution for addressing flood hazards. The report recommended a new 28-foot-diameter tunnel to be driven adjacent to the existing tunnel, and an enlarged and deepened channel extending 11,400 feet upstream from the existing tunnel entrance. The proposed plan was never authorized or constructed.

Flood Plain Information Report for Turkey Creek in Metropolitan Kansas City, USACE, January 1974. The report was authorized by Section 206 of the 1960 Flood Control Act (Public Law 86-645) as amended. The report included an evaluation of the flooding hazards associated with Turkey Creek in the metropolitan Kansas City area. The report was prepared at the request of the Cities of Kansas City, Merriam, and Overland Park, Kansas, the Kansas Water Resources Board, and Kansas City, Missouri.

Turkey Creek Improvement, 75th Street and I-35 Interchange, January 1983. The report detailed the design for the improvement of 75th Street at the I-35 interchange. The design called for raising the grade of 75th Street 22 feet at the Turkey Creek crossing. The study examined the hydraulic feasibility of constructing the crossing on an embankment with a suitably sized culvert. The Kansas Department of Transportation (KDOT) chose to proceed with the channel improvements, the new structure at 75th Street, and the use of a reach upstream of the BNSF Railway bridge as both a borrow site and a detention basin.

Planning Aid Report for the Turkey Creek Basin, Kansas and Missouri Reconnaissance Study, U.S. Fish and Wildlife Service (USFWS), Kansas State Office, Manhattan, September 1987. During a reconnaissance phase to determine potential measures for managing flood risks within the Turkey Creek Basin, this report to the USACE provided five recommendations to conserve fish and wildlife habitat and two recommendations to enhance habitats.

Upper Turkey Creek
Johnson County and Wyandotte County, Kansas
Flood Risk Management Project
Feasibility Report with Integrated Environmental Assessment

Reconnaissance Report: Turkey Creek Basin, Kansas and Missouri, USACE, December 1987. The reconnaissance report presented the results of a reconnaissance study that examined various alternatives for flood damage reduction in the Turkey Creek Basin. The report included an assessment of the Federal Interest and local support for flood reduction measures. The report concluded that one or more plans to reduce flood damages and hazard to human life in the lower Turkey Creek basin had potential economic feasibility and therefore recommended a feasibility phase study.

Flood Insurance Study, City of Kansas City, Kansas, FEMA revision of January 1995. A study was performed to convert the City of Kansas City, Kansas, to the regular FEMA program of flood insurance. The program was then used by local and regional planners in their efforts to promote sound land use and flood plain management. Hydraulic analysis for the study was performed by the USACE, Kansas City District, and was completed in September 1977.

Design Concept Report Supplement: Burlington Northern Railroad at Turkey Creek, HNTB Corporation, August 1996. The report supplemented an earlier Design Concept Report that evaluated new alternatives for lowering flood levels along Turkey Creek near Merriam's Industrial Park. The report included new discharge values developed since the original report (1995). Based on the new discharge data, the investigation determined that the most feasible course of action was to widen the channel 20 feet downstream of the I-35 bridges, improve the channel between the existing railroad bridges and the I-35 bridges, and acquire four properties in the industrial park.

Draft Fish and Wildlife Coordination Act Report for the Turkey Creek, Kansas City, Kansas, and Kansas City, Missouri, Local Flood Protection Project, USFWS, Kansas State Office, Manhattan, April 1997. This report to the USACE identified the loss of 18 acres of riparian habitat and the physical alteration and channelization of 4,000 feet of Turkey Creek as the primary impacts caused by proposed flood risk management measures. The USFWS provided six recommendations to minimize and offset fish and wildlife habitat losses. The report was authorized under Section 205 of the Flood Control Act of 1948 and was designed to accompany the USACE Feasibility Study.

Use **Attainability Analysis of Turkey Creek, Johnson and Wyandotte Counties, Kansas, Gary E. Welker and Dr. Donald G. Huggins, USEPA, Environmental Services Division, Kansas City, Kansas and the Kansas Biological Division, University of Kansas, Lawrence, Kansas, July 1997.** The study included chemical and biological analyses of Turkey Creek to determine the use attainability for aquatic life and recreation use, future use attainment, and potential causes of non-attainment for Turkey Creek.

Final Fish and Wildlife Coordination Act Report for the Turkey Creek Flood Damage Reduction Project, Kansas City, Kansas, and Kansas City, Missouri, USFWS, Kansas State Office, Manhattan, October 1998. This report to the USACE identified the loss of 5.6 acres of riparian habitat and the physical alteration and channelization of 4,100 feet of Turkey Creek as the primary impacts caused by proposed flood risk management measures. USFWS provided six recommendations to minimize and offset fish and wildlife habitat losses. The report was authorized under Section 205 of the Flood Control Act of 1948 and was designed to accompany the USACE Feasibility Study.

Feasibility Report and Environmental Assessment, Turkey Creek Basin, Kansas City, Kansas and Missouri, Kansas City District, USACE, December 1998. The report included a recommendation for the construction of a downstream project consisting of a combination of channel modification and hillside interceptors. The preferred plan was authorized for construction in Section 101(a)(24) of Public Law 106-53, the Water Resources Development Act of 1999.

TMDLs for the Kansas - Lower Republican Basin, Kansas Department of Health & Environment, June 30, 1999. The report included the USEPA approved Total Maximum Daily Loads (TMDL) or

quantitative objectives and strategies needed to achieve water quality standards to fully support designated uses for the Kansas-Lower Republican River Watersheds, including Turkey Creek.

Upper Turkey Creek Basin, Johnson and Wyandotte Counties, Kansas: Section 905(b) Analysis, USACE, July 2001. This report evaluated the potential Federal interest in solutions to recurring flood damages, environmental degradation, and related water and land resource needs and opportunities in the Upper Turkey Creek Basin. A positive determination of Federal interest and recommended approval by the USACE District Engineer led to development of the 2002 Project Management Plan (PMP).

Draft Supplemental Final Fish and Wildlife Coordination Act Report for the proposed General Reevaluation Report and revised Environmental Assessment, Lower Turkey Creek flood damage reduction project – Kansas City, Kansas and Missouri, USFWS, March 29, 2002, Kansas State Office, Manhattan. This report is the draft supplement to the 1998 Final Fish & Wildlife Coordination Act Report and General Reevaluation Report. Due to the occurrence of a flood event exceeding the containment capability of the proposed channel modifications (1998 Feasibility Report), the USACE expanded the proposed project (General Reevaluation Report). Based on the proposed project expansion, the USFWS added four recommendations to the six previously identified measures to minimize and offset fish and wildlife habitat losses. USFWS also included one recommendation to enhance fish and wildlife habitat.

Final Supplemental Final Fish and Wildlife Coordination Act Report for the proposed General Reevaluation Report and revised Environmental Assessment, Lower Turkey Creek flood damage reduction project – Kansas City, Kansas and Missouri, USFWS, September 9, 2002, Kansas State Office, Manhattan. This report is the final supplement to the General Reevaluation Report. No changes were made from the previous "draft."

Stormwater Management Ordinance, Chapter 7, Article 1 of City code of ordinances, City of Merriam, June 24, 2002. This article establishes the stormwater run-off management criteria and standards for the city's secondary or major drainage system and its components. (Ord. No. 1400, §1, 3-26-01). The secondary or major system includes the primary/minor system, its overflow elements and all Turkey Creek tributaries and drainage structures both public and private that are not identified as part of the Turkey Creek regulatory floodplain located within the City of Merriam, Kansas.

Johnson County Flood Warning/Flood Forecasting: Feasibility Study, Johnson County Stormwater Management Program (SMP), August 2002. The Johnson County SMP completed a study to determine the feasibility of a flood warning/flood forecasting system in Johnson County, Kansas – and if determined to be feasible, develop an implementation plan and to identify the potential costs to develop such a system. The basis for the study was the existing rain and stream gage network in Johnson County. In 1999 the Johnson County SMP initiated a significant expansion to the existing rain and stream gage network that at the time was located primarily in Overland Park, Kansas and Jackson County, Missouri. The expansion covered a significant portion of Johnson County and was completed to provide a data collection system and the foundation for developing and implementing a flood warning system, if desired or required. The report concluded that based on the significant interest by Johnson County communities combined with the extent and capabilities of the existing rain and stream gage network in Johnson County, a flood warning/flood forecasting system is feasible and should be considered for Johnson County. The study identified several recommended system enhancements.

General Reevaluation Report and Environmental Assessment, Turkey Creek Basin, Kansas City, Kansas and Kansas City, Missouri, USACE, January 2003. This report presents the findings of a reevaluation of potential measures to reduce flood damages identified in USACE's 1998 Feasibility Report and Environmental Assessment. Reevaluation was necessary to include updated information from

a severe flood in October 1998. This report extends modification of the Turkey Creek channel an additional 4,000 feet upstream, widens the channel modifications approved in 1998, and upgrades the Turkey Creek tunnel. The plan provides flood damage reduction benefits to the same locations identified in the 1998 document.

Upper Turkey Creek Basin Environmental Restoration Report: Feasibility Phase – Draft, USACE, August 2004. The Upper Turkey Creek Basin Environmental Restoration Report-Feasibility Phase was prepared by HNTB and Kabbes Engineering. The purpose of the report was to identify strategies for environmental restoration within the basin. Nine strategies for environmental restoration were developed:

1. Stopping and possibly reversing the downcutting of the stream banks
2. Removing fish blockages or finding alternatives to divert fish around the blockages
3. Retrofitting stormwater basins and swales to improve water quality
4. Acquiring open space pertinent to aquatic resources
5. Removing enclosures on tributaries
6. Removing retaining walls and using bioengineering solutions to improve those locations and other eroded areas
7. Reconnecting the channel and the floodplain
8. Emphasizing stormwater and flood water storage and infiltration systems over stormwater and flood water conveyance systems
9. Implementing a public information and awareness campaign addressing regulatory programs, potential regulatory strategies, and negative environmental impacts on downstream flooding of stream enclosures and channel modifications, and available alternatives

The study provided designs for thirteen projects at twelve sites to address seven of the above-mentioned strategies. The report identifies the potential water quality, habitat, and benefits from flood risk management measures plus estimated restoration costs for each design.

Northeast Johnson County Watershed Study, Johnson County, Kansas. 2005. Johnson County Public Works is conducting a watershed study of the major creeks and streams in the Northeast corner of the County. The Northeast watershed is approximately 38.5 square miles and contains 5 watersheds (Brush Creek, Dykes Branch, Lake Quivira, Rock Creek, and Turkey Creek). The project includes data collection—channels, culverts, bridges, and low opening elevations on houses and business structures in or near flood-prone areas—public meetings, and development of a plan addressing future stormwater issues. The study will generate new floodplain maps, identify flood prone areas and other problems (stream erosion), alternative solutions will be considered.

Effects of Contaminant Sources on Streamwater Quality in Johnson County, Northeastern Kansas, October 2002 through June 2004, C.J. Lee, D.P. Mau, and T.J. Rasmussen. U.S. Geological Survey (USGS), Fact Sheet 2005–3080, August 2005. This fact sheet summarizes the results of a water-quality investigation conducted in Johnson County from October 2002 through June 2004. A minimum of three stormflow samples were collected from six sites located in the Blue River, Cedar Creek, Indian Creek, Kill Creek, Mill Creek, and Turkey Creek watersheds.

Effects of Nonpoint and Selected Point Contaminant Sources on Stream-Water Quality and Relation to Land Use in Johnson County, Northeastern Kansas, October 2002 through June 2004, C.J Lee, D.P. Mau, and T.J. Rasmussen, 2005, USGS, Scientific Investigations Report 2005–5144. USGS collected water and sediment samples in 12 Johnson County watersheds to determine the effects of nonpoint and selected point contaminant sources on stream-water quality and their relation to varying land use. The streams studied were located in urban areas of the county (Brush, Dykes Branch, Indian, Tomahawk, and Turkey Creeks), developing areas of the county (Blue River and Mill Creek), and in more rural areas of the county (Big Bull, Captain, Cedar, Kill, and Little Bull Creeks). Two base-flow synoptic surveys (73 total samples) were conducted in 11 watersheds, a minimum of three stormflow samples were collected in each of six watersheds, and 15 streambed-sediment sites were sampled in nine watersheds from October 2002 through June 2004.

Special Area Management Plan (SAMP), Upper Turkey Creek Watershed, Watershed Institute, Inc., 2007. The goal of a SAMP is to attain a balance between aquatic resource conservation, infrastructure maintenance, and sound economic development to minimize the individual and cumulative impacts of future projects. This report documents the first phase of the SAMP process for Upper Turkey Creek, which included documentation of past and present projects and planning efforts, existing information sources, relevant studies, existing conditions, preliminary goals and objectives, and additional information needs. Only phase 1 has been completed to date. The next three phases are identified as (2) Upper Turkey Creek Advisory Committee and issue identification, (3) development and prioritization of strategies, and (4) implementation, monitoring, and updating. The following five goals were identified for the Upper Turkey Creek Watershed SAMP in this report:

1. Establish an Upper Turkey Creek Advisory Committee
2. Improve Turkey Creek water quality to support native aquatic communities and enhance and maintain high-quality aquatic and terrestrial habitat in the Turkey Creek watershed.
3. Identify opportunities and mechanisms to educate and involve the public in enhancement of Turkey Creek.
4. Develop detailed comprehensive statements of policies, standards, and criteria to guide public and private uses of lands and waters as well as outline of mechanisms for implementation.
5. Establish a regulatory component addressing USACE 404 permits, stormwater permits, and USEPA regulatory information as well as other relevant regulatory components identified and agreed to through memorandum of understanding with the various agencies and stakeholders giving some sense of continuity and predictability based on a watershed area approach.

Rock Creek Watershed Planning Final Feasibility Report, USACE, August 2007. Rock Creek is an adjacent watershed to Upper Turkey Creek. This report includes a stream assessment methodology and results, recommended stream restoration projects, a presentation of BMP concepts, an implementation strategy for best management practices throughout the Rock Creek watershed and probable costs associated with these projects. A BMP implementation strategy was developed using probable life cycle costs, evaluation of water quality benefit, and a methodology to locate BMPs in appropriate sites.

Rock Creek Alternative Futures Study, USACE, August 2009. Rock Creek is an adjacent watershed to Upper Turkey Creek. The Alternative Futures Study, as an addition to the Rock Creek Watershed Study, compared the life-cycle cost and benefit of low impact development (LID) versus traditional redevelopment, analyzed the return on investment for LID and traditional redevelopment, and informed policy and ordinance recommendations for the City of Mission. The study identified key changes to the

City of Mission's municipal code to increase the use of LID practices in the City of Mission and to realize the water quality benefits outlined in the study.

Manual of Best Management Practices for Stormwater Quality, Mid-America Regional Council and American Public Works Association (APWA), Second Edition, August 2009.
The BMP Manual provides guidance for land development practices within the region, including the study area. Developers, engineers and planners can reference the manual's developing flexible tools to reduce the volume of stormwater discharge while conserving water quality at the same time. Development is on-going and will be refined as test sites produce results for the Metro Area. The manual provides specific guidance for planning and implementing BMPs, and describes how to assess alternative site-design approaches to maximize the benefits for individual sites. It also defines BMPs, provides performance goals for site development and describes methods for determining development impacts. The second section contains design criteria and more detailed design guidance for non-structural and structural BMPs. If local communities decide to provide a particular "level of service," the formulas and methodology outlined in the manual help define the technical parameters needed to meet local water quality goals. The manual can be accessed on the internet at http://www.marc.org/environment/water/bmp_manual.htm.

13.2 LITERATURE CITATIONS

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

City of Overland Park. 2012. Stormwatch. Johnson County Kansas Regional Weather. Accessed online on October 9, 2012 at: http://www.stormwatch.com/.

U.S. Environmental Protection Agency (EPA). 1998, Climate Change and Kansas, EPA 236-F-98-007i, 4 pp.

Kansas Department of Wildlife & Parks (KDWP). 2004. Subjective Evaluation of Aquatic Habitats. Developed By: Kansas Department of Wildlife & Parks, Environmental Services Section, 28 pp.

Larkin Group, Northeast Johnson County Watershed Study, May 2005.

NOAA (2013). National Weather Service Hydrometeorological Design Studies Center Precipitation Frequency Data Server Atlas 14. National Oceanic and Atmospheric Administration website. Available at http://hdsc.nws.noaa.gov/hdsc/pfds/.

Rast, Brian. Proceedings of the American Society of Civil Engineers Watershed Management Conference 2010 Innovations in Watershed Management Under Land Use and Climate Change. Madison. *Multi-Objective Management and Planning for Urban Watersheds*. 27 Aug 2010.

Rast, Brian. Proceedings of the Environmental & Water Resources Institute of the American Society of Civil Engineers World Environmental & Water Resources Congress 2009, Kansas City. *Nexus Projects in Kansas City's Suburban Watersheds*. 17 May 2009.

U.S. Census Bureau; American Community Survey, 2010 American Community Survey 5-Year Estimates, DP02, Selected Social Characteristics in the United States; generated by Thomas Topi. <http://factfinder2.census.gov>; (6 June 2012).

U.S. Census Bureau; American Community Survey, 2010 American Community Survey 5-Year Estimates, DP03, Selected Economic Characteristics; generated by Thomas Topi. <http://factfinder2.census.gov>; (6 June 2012).

U.S. Census Bureau; American Community Survey, 2010 American Community Survey 5-Year Estimates, DP04, Selected Housing Characteristics; generated by Thomas Topi. <http://factfinder2.census.gov>; (6 June 2012).

U.S. Census Bureau; American Community Survey, 2010 American Community Survey 5-Year Estimates, DP05, ACS Demographic and Housing Estimates; generated by Thomas Topi. <http://factfinder2.census.gov>; (6 June 2012).

U.S. Census Bureau; American Community Survey, 2010 American Community Survey 5-Year Estimates, S1701, Poverty Status in the Past 12 Months; generated by Thomas Topi. <http://factfinder2.census.gov>; (6 June 2012).

U.S. Census Bureau; Economic Census, CB0700CZ2, 2007 County Business Patterns: Zip Code Business Statistics: Zip Code Business Patterns by Employment Size Class: 2007; generated by Thomas Topi. <http://factfinder2.census.gov>; (7 November 2012).

U.S. Department of Agriculture (USDA). 1998. Stream Visual Assessment Protocol, National Water and Climate Center Technical Note 99-1. 42 pp.

U.S. Fish and Wildlife Service (USFWS). 1980. Habitat Evaluation Procedures (HEP) ESM 102, 130 pp.

Table of Contents

TAB 1 – APPENDIX A – PLAN FORMULATION AND EVALUATION

TAB 2 – APPENDIX B – ENGINEERING DESIGN AND MODELING

SECTION 1: CIVIL

SECTION 2: STRUCTURAL

SECTION 3: HYDROLOGY AND HYDRAULICS

SECTION 4: COST ENGINEERING

SECTION 5: GEOTECHNICAL

TAB 3 – APPENDIX C – PUBLIC OUTREACH AND INVOLVEMENT

EXHIBIT 1: RECONNAISSANCE STUDY, NOTICE OF INITIATION, JULY 2001

EXHIBIT 2: FEASIBILITY STUDY, NOTICE OF INITIATION, AUGUST 2002

EXHIBIT 3: TURKEY CREEK AWARENESS WORKSHOP, JUNE 2003

EXHIBIT 4: UPPER TURKEY CREED CONCEPTS WORKSHOP, SEPTEMBER 2004

EXHIBIT 5: FEDERAL AND NON-FEDERAL AGENCY INVOLVEMENT

EXHIBIT 6: UPPER TURKEY CREEK BASIN FEASIBILITY STUDY, PUBLIC MEETING, OCTOBER 2011

EXHIBIT 7: PUBLIC NOTICE OF THE DRAFT FEASIBILITY STUDY WITH INTEGRATED ENVIRONMENTAL ASSESSMENT, JUNE 2013

TAB 4 – APPENDIX D – CLEAN WATER ACT SECTION 404 (B) (1) EVALUATION

TAB 5 – APPENDIX E – USACE JURISDICTIONAL DETERMINATIONS

TAB 6 – APPENDIX F – SOCIO-ECONOMICS

TAB 7 – APPENDIX G – REAL ESTATE

TAB 8 – APPENDIX H – COMMENTS AND CORRESPONDENCE

TAB 9 – APPENDIX I – SELF-CERTIFICATION OF FINANCIAL CAPABILITY

TAB 10 – APPENDIX J – ENVIRONMENTAL

SECTION 1: EXISTING CONDITIONS

SECTION 2: ENVIRONMENTAL RESTORATION STRATEGIES-KABBES REPORT

SECTION 3: STREAM ASSESSMENTS

SECTION 4: WATER QUALITY

TAB 11 – APPENDIX K – CULTURAL RESOURCES

TAB 12 – APPENDIX L – TOTAL PROJECT COST SUMMARY, COST AND SHEDULE RISK ANALYSIS, COST REPORT, CONTRACT SCHEDULE

SECTION 1: TOTAL PROJECT COST SUMMARY

SECTION 2: PROJECT COST AND SCHEDULE RISK ANALYSIS

SECTION 3: COST REPORT

SECTION 4: CONTRACT SCHEDULE

TAB 13 – APPENDIX M – CE/ICA FOR MITIGATION

SECTION 1: CWA COMPENSATORY MITIGATION CE/ICA

TAB 14 – APPENDIX N – FINDING OF NO SIGNIFICANT IMPACT (FONSI)

TAB 15 – APPENDIX O – MITIGATION

Appendix A
Plan Formulation and Evaluation

UPPER TURKEY CREEK
Alternatives Screening Results
Oct '14 price level

12/23/2014

MERRIAM

Draft

For Official Use Only

Inter Rate: 3.375%
Per of time: 50
(r): 0.04167236

Index Point for Merriam
(Protected Area, Reach 3D): 3.299

Without Project Annual Damages
Reaches 3a, 3b, 3c City of Merriam

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Alternative Name	Old Alternative Naming Convention	Original Alternative Naming Convention	Alternative Description	Top of Levee at Index (ft msl)	1% event wsp elev at Index (ft msl)	Const Cost (Includes E&A)	PED Cost	LERRD Cost	Mitigation Cost (Compensatory Restoration)	Total First Cost	Federal Share of First Cost (65%) up to 65% of MED Plan	Local Share of First Cost, up 35% of MED Plan, then 100%	Interest During Construction	Total Investment Cost	Interest & Amortization of Initial Investment	Average Annual Induced Damages	Other Direct/ Indirect Costs	DMMP/IP	Total Average Annual Cost	Residual Damages With Project	Residual Damages as a % of Pot IND Prot Dmg	Avg. Ann Benefits	Net Annual Benefit	B/C Ratio at 3.375%, 50 yr pd of anal	Conditional Probability of Design Containing 1% Event
Future Without Proj Cond				NA	918.58															$ 4,749,600					0.001
UTC Alternative 2b	Alternative 2 Epsilon	UTC_A2_050_E_Merriam	Levee, existing bridges	920.05	918.77	$ 25,983,000	$ 2,712,000	$ 10,122,000	$ 15,000	$ 38,832,000	$ 25,673,800	$ 12,858,200	$ 2,946,400	$ 38,678,400	$ 1,653,700	$ -	$ -	$ 40,800	$ 1,894,500	$ 1,589,900	33%	$ 3,159,600	$ 1,466,100	1.3	0.644
UTC Alternative 2c	Alternative 2 Gamma	UTC_A2_100_E_Merriam	Levee, existing bridges	920.48	918.77	$ 24,261,000	$ 2,748,000	$ 10,122,000	$ 15,000	$ 37,146,000	$ 24,144,900	$ 13,001,100	$ 2,974,100	$ 40,120,100	$ 1,672,100	$ -	$ -	$ 40,800	$ 1,712,900	$ 1,437,300	30%	$ 3,312,100	$ 1,599,200	1.5	0.740
Modified 2012 Preferred Levee	**Alternative 2 Zeta**	UTC_A2_95%_E_Merriam	**Levee, existing bridges**	**920.98**	**918.77**	**$ 24,635,000**	**$ 2,787,000**	**$ 10,122,000**	**$ 15,000**	**$ 37,579,000**	**$ 24,426,400**	**$ 13,152,600**	**$ 3,003,900**	**$ 40,582,900**	**$ 1,691,400**	**$ -**	**$ -**	**$ 40,800**	**$ 1,732,200**	**$ 1,304,900**	**27%**	**$ 3,444,700**	**$ 1,712,500**	**2.0**	**0.828**
2014 Alpha14 Levee	N/A	N/A	Levee, existing bridges	922.60	918.58	$ 29,771,000	$ 2,987,000	$ 9,954,000	$ 15,000	$ 43,026,000	$ 27,968,900	$ 15,058,100	$ 4,021,100	$ 47,047,100	$ 1,960,800	$ -	$ -	$ 40,800	$ 2,001,600	$ 1,846,700	22%	$ 3,702,900	$ 1,701,300	1.8	0.995

Budget Interest Rate of 7% :

Budget Inter Rate: 7.000%
Per of time: 50
(r): 0.07245555

																								B/C Ratio at 7.000%, 50 yr pd of anal	
Future Without Proj Cond				NA	918.58															$ 4,749,600					0.001
UTC Alternative 2b	Alternative 2 Epsilon	UTC_A2_050_E_Merriam	Levee, existing bridges	920.05	918.77	$ 25,983,000	$ 2,712,000	$ 10,122,000	$ 15,000	$ 38,832,000	$ 25,673,800	$ 12,858,200	$ 6,499,400	$ 43,141,400	$ 3,126,600	$ -	$ -	$ 40,800	$ 3,167,000	$ 1,589,900	33%	$ 3,159,600	$ (407)	0.5666	0.644
UTC Alternative 2c	Alternative 2 Gamma	UTC_A2_100_E_Merriam	Levee, existing bridges	920.48	918.77	$ 24,261,000	$ 2,748,000	$ 10,122,000	$ 15,000	$ 37,146,000	$ 24,144,900	$ 13,001,100	$ 6,669,600	$ 43,815,600	$ 3,189,400	$ -	$ -	$ 40,800	$ 3,195,400	$ 1,437,300	30%	$ 3,312,100	$ 116,700	1.04	0.740
Modified 2012 Preferred Levee	**Alternative 2 Zeta**	UTC_A2_95%_E_Merriam	**Levee, existing bridges**	**920.98**	**918.77**	**$ 24,635,000**	**$ 2,787,000**	**$ 10,122,000**	**$ 15,000**	**$ 37,579,000**	**$ 24,426,400**	**$ 13,152,600**	**$ 6,534,400**	**$ 44,113,400**	**$ 3,196,500**	**$ -**	**$ -**	**$ 40,800**	**$ 3,237,300**	**$ 1,304,900**	**27%**	**$ 3,444,700**	**$ 213,300**	**1.07**	**0.828**
2014 Alpha14 Levee	N/A	N/A	Levee, existing bridges	922.60	918.58	$ 29,771,000	$ 2,987,000	$ 9,954,000	$ 15,000	$ 43,026,000	$ 27,968,900	$ 15,058,100	$ 8,754,500	$ 51,780,100	$ 3,753,000	$ -	$ -	$ 40,800	$ 3,793,800	$ 1,846,700	22%	$ 3,702,900	$ (84,100)	0.98	0.995

NOTES:

Appendix B
Civil, Structural, Hydrologic and Hydraulic Conditions, Cost, Geotechnical

Section 1 Civil

Upper Turkey Creek
Johnson County and Wyandotte County, Kansas
Flood Risk Management Project
Feasibility Study Report with Integrated Environmental Assessment

Table of Contents

1. INTRODUCTION 1
2. SURVEY 1
3. ACCESS ROADS 1
4. CONSTRUCTION STAGING 1
5. BORROW AREA 2
6. UTILITIES 2
6.1 ELECTRICAL 2
6.2 DOMESTIC WATER 2
6.3 NATURAL GAS 2
6.4 SANITARY SEWERS 3
6.5 STORM SEWER OUTFALLS 4
6.6 DETENTION BASIN 6
6.7 STORMWATCH GAGE 3010 7
7. BIKE TRAIL 7

1. INTRODUCTION

This section of the Engineering Appendix presents a discussion of the civil engineering considerations for the selected plan. Details covered in this section were not appropriate in the description of the selected plan in Chapter 7. This section covers assumptions used to develop the selected plan cost estimate. Recommendations for further investigations during Preconstruction Engineering and Design are also contained. Features described are located using one of two methods; the first method describes the location based on its relationship to existing features (i.e. north of Johnson Drive), the second method describes the location based on the channel stationing (i.e. STA 3.610). Channel stationing units are miles and correspond to the stationing used in the HEC-RAS Model. Channel stationing can be found in Figures 7-1 through 7-6 in Chapter 7.

2. SURVEY

During development of the alternatives using Atlas 14 flows two sources of information were used. The first source was GIS utility information developed by LBG. The second source of information is Johnson County Automated Information Mapping System (AIMS). Two foot contour information is available on this website.

These sources are adequate for planning studies but are not adequate for PED. During PED ground survey of the area is recommended. The project footprint and urban environment make land based survey preferable to aerial survey. The PED survey should capture existing topographic and planimetric features.

3. ACCESS ROADS

This project is located in a developed area of Merriam Kansas parallel to Interstate 35 (I-35). Two exits from I-35 are located near the project limits. The Shawnee Mission Parkway (Exit 228B) is located at the upstream end of the project limits. The Johnson Drive (Exit 229) exit is located near the midpoint of the project limits. Connecting I-35 to the project are three urban corridors; Shawnee Mission Parkway, Johnson Drive, and Merriam Drive. These urban corridors carry light industrial and retail traffic. Merriam Drive runs north/south connecting Shawnee Mission Parkway and Johnson Drive.

4. CONSTRUCTION STAGING

Construction and engineering division staff determined 2 acres is adequate construction staging. Four sites have been identified; one contains one half acre of hardstand while the remaining three contain at least two acres. The first site, located northwest of the intersection of Merriam Drive and Turkey Creek is being acquired for this project. This site is accessed from Merriam Drive and contains seven tenths of an acre for construction staging. This site contains one half acre of existing hardstand. The second site is a combination of the farmers market and an adjacent property acquired for the project. Aecess to this site is from Merriam Drive and contains 2.0 acres for construction staging. The third site combines a park and adjacent property acquired for this project. This site has access from West 61st Street via Mastin Street and Shawnee Mission Parkway and has 2.0 acres available for construction staging. The fourth site is an area bounded by Shawnee Mission Parkway and Merriam Drive. This area has access from Merriam Drive and has 3.6 acres available for construction staging.

5. BORROW AREA

LBG determined that sufficient borrow was not available on site or other sites owned by the sponsor. LBG then found a commercial source with available borrow. Cost estimates developed by LBG used quotes from this commercial source. USACE used borrow source information developed by LBG.

6. UTILITIES

6.1 ELECTRICAL

Overhead electrical lines cross project features at one location within the project limits. At this location (Sta. 3.350), levees are proposed on both banks of Turkey Creek. At this location both vertical and horizontal relocations are required. The vertical relocation is required to provide adequate vertical clearance between power line and top of levees. The horizontal relocation occurs on the left bank to accommodate levee alignment. Three hundred twenty five feet and one hundred feet of vertical and horizontal relocation are required respectively.

6.2 DOMESTIC WATER

STA 3.610: An existing DIP domestic water line crosses Turkey Creek, right bank levee and left bank floodwalls. The line will be relocated up and over the floodwalls and levee. The total relocation of six inch diameter water line is 240 feet comprised of 220 feet of horizontal and 20 feet of vertical relocation. The total relocation of eight inch diameter water line is 650 feet comprised of 610 feet of horizontal and 40 feet of vertical relocation. Both six and eight inch domestic waterlines will be excavated and replaced with restrained joint DIP. Because Turkey Creek invert is on bedrock it is assumed that waterline passing through the channel are concrete encased.

STA 3.100: An existing eight inch DIP domestic water line crosses Turkey Creek and right bank floodwall. The line will be relocated up and over the floodwall. The total relocation is 280 feet comprised of 260 feet of horizontal and 20 feet of vertical relocation. The domestic waterline will be excavated and replaced with eight inch restrained joint DIP. Because Turkey Creek invert is on bedrock it is assumed that waterline passing through the channel are concrete encased.

SAT 3.040: An existing one inch steel domestic water line crosses the right bank floodwall. The total length of relocation is 50 feet comprised of 30 feet of horizontal and 20 feet of vertical relocation. The domestic waterline will be excavated and replaced with one inch welded steel pipe.

STA 2.623: An existing eight inch DIP domestic water line crosses Turkey Creek and floodwall on both banks. This line is parallel to and behind the east Merriam Drive curb. The domestic water line will be relocated up and over the floodwalls. The total relocation is 190 feet comprised of 150 feet of horizontal and 40 feet of vertical relocation. The domestic waterline will be excavated and replaced with eight inch restrained joint DIP. Because Turkey Creek invert is on bedrock it is assumed that waterline passing through the channel are concrete encased.

6.3 NATURAL GAS

STA 3.190: An existing two inch gas line crosses left bank floodwall alignment. For this report it is assumed the existing pipe is Polyethylene (PE). At this location 320 feet of two inch PE pipe will be excavated and replaced with two inch PE pipe. Turkey Creek high water events have

durations of a few hours. Geotechnical engineering judgment determined that underseepage landward of floodwalls/levees is not a concern. If underseepage is not a concern then PE pipe does not risk flotation.

STA 2.070: An existing eight inch natural gas line crosses Turkey Creek and the right bank floodwall. This line is parallel to and behind the south Johnson Drive curb. The base mapping available does not indicate pipe material type. is located under the left bank floodwall footprint. This report recommends replacement of the line between Merriam Drive and Merriam Lane. At this location the natural gas line will be relocated up and over the floodwall. The total relocation is 270 feet comprised of 250 feet of horizontal and 20 feet of vertical relocation. The natural gas line will be welded steel and the vertical portion will be insulated.

STA 2.623: An existing four inch steel pipe is located under the left bank floodwall footprint. This line is parallel to and behind the east Merriam Drive curb. The steel line is attached to the Merriam Drive bridge deck across Turkey Creek. The portion of line attached to the bridge is insulated. At this location the natural gas line will be relocated up and over the floodwall on each bank. Each up and over is 50 feet of length comprised of 30 feet of horizontal and 20 feet of vertical relocation. The natural gas line will be welded steel and the vertical portion will be insulated.

6.4 SANITARY SEWERS

STA 3.664: The relocation at this station consists of Turkey Creek, left bank and right bank floodwall crossings. The base mapping does not indicate sanitary sewer line diameter or material type. For this report the line is assumed to be a twelve inch PVC line. This relocation requires a total installation of 330 feet of twelve inch RCP and three 48 inch diameter manholes.

STA 3.480: The relocation at this station consists of left bank relocation upstream to station 3.630. This relocation spans 0.15 mile, but is classified as one relocation because elements are contiguous. The base mapping does not indicate sanitary sewer line diameter or material type. For this report the line is assumed to be a twelve inch PVC line. This relocation requires installation of 970 feet of twelve inch RCP and eight 48 inch diameter manholes.

STA 3.400: The relocation at this station consists of left bank relocation where the existing sanitary sewer crosses the levee. The base mapping does not indicate sanitary sewer line diameter or material type. For this report the line is assumed to be a twelve inch PVC line. This relocation requires installation of 130 feet of twelve inch RCP and two 48 inch diameter manholes.

STA 3.104: The relocation at this station consists of left bank relocation upstream to station 3.282. This relocation spans 0.18 mile, but is classified as one relocation because elements are contiguous. The base mapping does not indicate sanitary sewer line diameter or material type. For this report the line is assumed to be a twelve inch PVC line. This relocation requires installation of 770 feet of twelve inch RCP and six 48 inch diameter manholes.

STA 3.045: The relocation at this station consists of a creek and right bank floodwall crossing. The base mapping does not indicate sanitary sewer line diameter or material type. For this report the line is assumed to be a twelve inch PVC line. This relocation requires a total installation of 220 feet of twelve inch RCP and three 48 inch diameter manholes.

STA 2.730: The relocation at this station consists of three creek crossings and right bank relocations upstream to station 3.010. This relocation spans 0.28 mile, but is classified as one relocation because elements are contiguous. The base mapping does not indicate sanitary sewer

line diameter or material type. For this report the line is assumed to be a twelve inch PVC line. This relocation requires installation of 1,670 feet of twelve inch RCP and twelve 48 inch diameter manholes.

STA 2.640: An existing sanitary sewer line crosses the left bank floodwall alignment. The base mapping does not indicate sanitary sewer line diameter or material type. For this report the line is assumed to be a twelve inch PVC line. At this location 100 feet of twelve inch PVC pipe will be excavated and replaced with twelve inch Reinforced Concrete Pipe (RCP). This relocation will require two 48 inch diameter manholes.

6.5 STORM SEWER OUTFALLS

Storm Sewer outfalls under proposed levee and flood walls require modification. Outfalls have to be modified to ensure high water flows in Turkey Creek do not back flow through storm sewer systems. The back flow prevention system includes a manhole installed on the landward side of the levee or flood wall. The storm sewer under the levee or floodwall is replaced with RCP and on the creek side of the protection a junction box is installed. A flap gate is installed within the junction box to prevent back flow. Under levees and floodwalls 83 and 35 feet of existing pipe is demolished and replaced with RCP respectively. Replaced pipe will have a minimum diameter of 24 inches. Kansas City District guidance indicates storm sewer lines under urban levees should be a minimum diameter of 48 inches. For this project the civil design section and geotechnical section determined that a minimum of 24 inches is acceptable. This decision requires inspection of these structures with video equipment in place of manual inspection. Drainage modifications are installed in the following locations.

STA 3.660 Left Bank: At this location a backflow prevention system will be installed. This system will replace a 24 inch CMP drainage structure which passes under proposed floodwall.

STA 3.578 Right Bank: At this location a backflow prevention system will be installed. This system will replace a 24 inch CMP drainage structure which passes under proposed floodwall.

STA 3.548 Right Bank: At this location a backflow prevention system will be installed. This system will replace an 18 inch CMP drainage structure which passes under proposed floodwall.

STA 3.520 Left Bank: At this location a backflow prevention system will be installed. This system will replace a 36 inch CMP drainage structure which passes under proposed floodwall.

STA 3.450 Left Bank: At this location a backflow prevention system will be installed. This system will replace a 36 inch CMP drainage structure which passes under proposed levee.

STA 3.422 Right Bank: At this location a backflow prevention system will be installed. This system will replace a 12 inch CMP drainage structure which passes under proposed floodwall. Nearby drainage structures will be routed to this structure to minimize levee/floodwall crossings. Existing right bank drainage structures to be combined include a 24 inch CMP at Sta 3.441 and a 12 inch CMP at Sta 3.465. Fifteen feet of the existing lines at Sta 3.441 and 3.456 will be removed to accommodate auger cast piles. The remainder of the existing lines at Sta 3.441 and 3.456 will be grout filled. The combined system will require a 36 inch RCP.

STA 3.350 Left Bank: At this location a backflow prevention system will be installed. This system will replace a 42 inch CMP drainage structure which passes under proposed levee. Nearby drainage structures will be routed to this structure to minimize levee/floodwall crossings. Existing left bank drainage structures to be combined include a 24 inch CMP at Sta 3.355. Fifteen feet of the existing line at Sta 3.355 will be removed to accommodate auger cast piles.

The remainder of the existing line at Sta 3.355 will be grout filled. The combined system will require a 42 inch RCP.

STA 3.299 Right Bank: At this location a backflow prevention system will be installed. This system will replace a 24 inch CMP drainage structure which passes under proposed floodwall.

STA 3.228 Right Bank: At this location a backflow prevention system will be installed. This system will replace a 24 inch CMP drainage structure which passes under proposed floodwall.

STA 3.194 Left Bank: At this location a backflow prevention system will be installed. This system will replace a 12 inch CMP drainage structure which passes under proposed floodwall. Nearby drainage structures will be routed to this structure to minimize levee/floodwall crossings. Existing left bank drainage structures to be combined include a 24 inch CMP at Sta 3.226. Fifteen feet of the existing line at Sta 3.226will be removed to accommodate auger cast piles. The remainder of the existing line at Sta 3.226 will be grout filled. The combined system will require a 24 inch RCP.

STA 3.190 Right Bank: At this location a backflow prevention system will be installed. This system will replace a 12 inch CMP drainage structure which passes under proposed levee. Nearby drainage structures will be routed to this structure to minimize levee/floodwall crossings. Existing right bank drainage structures to be combined include a 36 inch CMP at Sta 3.195. Fifteen feet of the existing line at Sta 3.195 will be removed to accommodate auger cast piles. The remainder of the existing line at Sta 3.195 will be grout filled. The combined system will require a 36 inch RCP.

STA 3.150 Left Bank: At this location a backflow prevention system will be installed. This system will replace a 36 inch CMP drainage structure which passes under proposed floodwall.

STA 3.112 Right Bank: At this location a 54 inch CMP drainage structure outlets at a headwall. At this location a new headwall will be installed and a flap gate will be installed at the headwall.

STA 3.109 Right Bank: At this location a triple seven foot by seven foot RCP passes under a proposed floodwall. At this location a different solution to prevent backflow is employed. At this location a new headwall will be installed and flap gates will be installed at the headwall.

STA 3.098 Right Bank: At this location a backflow prevention system will be installed. This system will replace a 12 inch CMP drainage structure which passes under proposed floodwall.

STA 3.042 Right Bank: At this location a backflow prevention system will be installed. This system will replace a 36 inch CMP drainage structure which passes under proposed floodwall.

STA 2.890 Right Bank: At this location a different solution provides backflow prevention system. This system drainage structure will be routed to the detention basin. This detention basin is discussed further below. This relocation will require 200ft of 18 inch RCP and one 48 inch manhole. Fifteen feet of the existing line will be removed to accommodate auger cast piles. The remainder of the existing system will be grout filled.

STA 2.854 Right Bank: At this location a different solution provides backflow prevention system. This system drainage structure will be routed to the detention basin. This detention basin is discussed further below. This relocation will require 125ft of 36 inch RCP and one 60 inch manhole. Fifteen feet of the existing line will be removed to accommodate auger cast piles. The remainder of the existing system will be grout filled.

STA 2.830 Right Bank: At this location a different solution provides backflow prevention system. This system drainage structure will be routed to the detention basin. This detention basin is

discussed further below. This relocation will require 125ft of 12 inch RCP and one 48 inch manhole. Fifteen feet of the existing line will be removed to accommodate auger cast piles. The remainder of the existing system will be grout filled.

STA 2.756 Right Bank: At this location a backflow prevention system will be installed. This system will replace a 24 inch CMP drainage structure which passes under proposed floodwall.

STA 2.655 Right Bank: At this location a backflow prevention system will be installed. This system will replace a 24 inch CMP drainage structure which passes under proposed floodwall.

STA 3.2.650 Left Bank: At this location a backflow prevention system will be installed. This system will replace a 12 inch CMP drainage structure which passes under proposed floodwall. Nearby drainage structures will be routed to this structure to minimize levee/floodwall crossings. Existing left bank drainage structures to be combined include a 24 inch CMP at Sta 2.668, an eight inch HDPE at Sta 2.662, an eight inch HDPE at Sta 2.659, and an eight inch HDPE at Sta 2.655. Fifteen feet of the existing lines at Sta 2.668, 2.662. 2.659 and 2.655 will be removed to accommodate auger cast piles. The remainder of the existing lines at Sta 2.668, 2.662. 2.659 and 2.655 will be grout filled. The combined system will require a 48 inch RCP.

STA 2.632 Right Bank: At this location a backflow prevention system will be installed. This system will replace a 12 inch CMP drainage structure which passes under proposed floodwall.

STA 2.632 Left Bank: At this location a backflow prevention system will be installed. This system will replace a 12 inch CMP drainage structure which passes under proposed floodwall.

STA 2.609 Right Bank: At this location a backflow prevention system will be installed. This system will replace a 12 inch CMP drainage structure which passes under proposed floodwall.

6.6 DETENTION BASIN

Drainage system modifications for Upper Turkey Creek were examined under Alternatives 1 through 3 as part of LBG's analysis. Drainage system modifications are required for the internal drainage of the City of Merriam because after the construction of floodwalls/levees, the drainage from the city would not be conveyed to Upper Turkey Creek in its current configuration. Drainage system modifications were broken down per storm intensity. The storm intensities analyzed are as follows: 10-percent AEP (10-year event), 2-percent AEP (50-year event), 1-percent AEP (100-year event), 0.5-percent AEP (200-year event), and 0.2-percent AEP (500-year event).

Initially, LBG developed a concept using two pump stations located in lower areas of Merriam. It was intended that the pumps would pump all drainage flows downstream of the project area past any potentially constructed levees or floodwalls. After submitting the conceptual design for the pump stations and associated drainage components, the USACE performed a value engineering analysis on the ability to use a less costly alternative to pumps. During the value engineering analysis, it was found that a detention basin could be installed adjacent to the Farmers' Market in Merriam. The detention basin was sized to hold 2.14 acre-feet of water and have a maximum slope of 3:1 on all sides. The design also called for a 60-inch reinforced concrete pipe outlet pipe from the detention basin through the levee into Turkey Creek in addition to the rerouting of all flows in the area to the detention basin.

Drainage system modifications were also assessed for the locally preferred alternative. This alternative is preferred by the local Merriam government and involves relocating the detention

basin to just north of the Farmers' Market. This particular option also included the demolition of a building located in the preferred detention basin location.

6.7 STORMWATCH GAGE 3010

An existing stormwatch gage is located at the southwest corner of Merriam Drive and Johnson Drive. The gage collects stage information only. The existing location is within the proposed floodwall footprint. The stormwatch gage will be relocated landward of the proposed floodwall.

7. BIKE TRAIL

An existing bike trail runs just landward of Turkey Creek banks. The trail is six feet wide and is paved with asphalt concrete. Replacement and relocation of this trail is required throughout the project limits. The replacement sections will be asphalt concrete six feet wide with six inches of aggregate base, three inches of base course and two inches of surface course. Information for replacements and relocations are provided below.

STA 3.569 Right Bank: At this location 100 feet of bike trail will be demolished during construction and will be replaced.

STA 3.569 Left Bank: At this location 370 feet of bike trail will be demolished during construction and will be replaced. This replacement will extend downstream to Sta 3.499

STA 3.349 Left Bank: At this location 100 feet of bike trail will be demolished during construction and will be relocated. Relocation is required to provide levee crossing. Since the relocation will be on the levee additional real estate is not required.

STA 3.250 Left Bank: At this location 700 feet of bike trail will be demolished during construction and will be replaced. This replacement will extend downstream to Sta 3.117

STA 2.679 Left Bank: At this location 200 feet of bike trail will be demolished and relocated. Two hundred and fifty feet of relocated bike trail is required to provide levee crossing. Since the relocation will be on property acquired in fee, additional real estate is not required.

8. QUANTITIES

Quantities were calculated as a joint effort of the civil, structural, geotechnical and cost engineers. The cost estimator led the effort to calculate and compile quantities. The civil engineer provided levee, utility relocation, bike trail and site work details to the cost estimator. The structural engineer provided floodwall information to the cost estimator. The geotechnical engineer provided inspection trench, foundation replacement and auger cast pile information to the cost estimator. Each discipline worked with the cost estimator and other disciplines as required to develop construction quantities and scheduling. The cost estimator provided this information to the Cost Mandatory Center of Expertise as part of the cost estimate certification process. Quantity estimates provided throughout this report are taken from the quantity estimate produced by the cost estimator to support the certified cost estimate.

Section 2 Structural

Upper Turkey Creek
Johnson County and Wyandotte County, Kansas
Flood Risk Management Project
Feasibility Study Report with Integrated Environmental Assessment

Table of Contents

1. INTRODUCTION B2-1
2. ANALYSIS B2-2
3. REFERENCES B2-3

Figures

FIGURE 2-1: TYPICAL FLOOD WALL CONFIGURATION B2-1

Tables

TABLE 2-1: DESIGN PARAMETER ASSUMPTIONS B2-2

Attachments

ATTACHMENT B2-A FLOODWALL CONFIGURATION ANALYSIS

1. INTRODUCTION

It was determined in Section I that the use of the inverted cantilever T-type wall would be best suited to provide adequate flood protection along upper Turkey Creek. However as a result of the Independent External Peer Review Process (IEPR), it was determined to use the higher Atlas 14 flows as described in Chapter 3. Upon revaluation of the floodwalls for the higher flows, the Sponsor agreed to the 1-percent AEP (100-year event) through downtown Merriam with an estimated assurance (conditional non-exceedance probability) of 82.9-percent (varying 0-6.5 ft tall floodwall) level of protection referred to as the Final NED Plan in this report. The existing stacked limestone retaining wall and its ability to provide adequate soil stability was suspect. This determination was made by way of historical documentation and photographs found within the Kansas City District that shows evidence of the piping of materials behind the wall. To mitigate the soil stability concerns and for the purposes of this analysis, the horizontal base of the floodwall will be supported by ground modified soil columns. A key will not be necessary for sliding as the base will be entrenched within the reinforcing soil on the land side of floodwall. The river side of the floodwall will be supported by the soil reinforcing and is weighted down by soil. Pore pressures from a high water event should have minimal effects for stability. The general configuration of the flood wall is given in Figure 2-1.

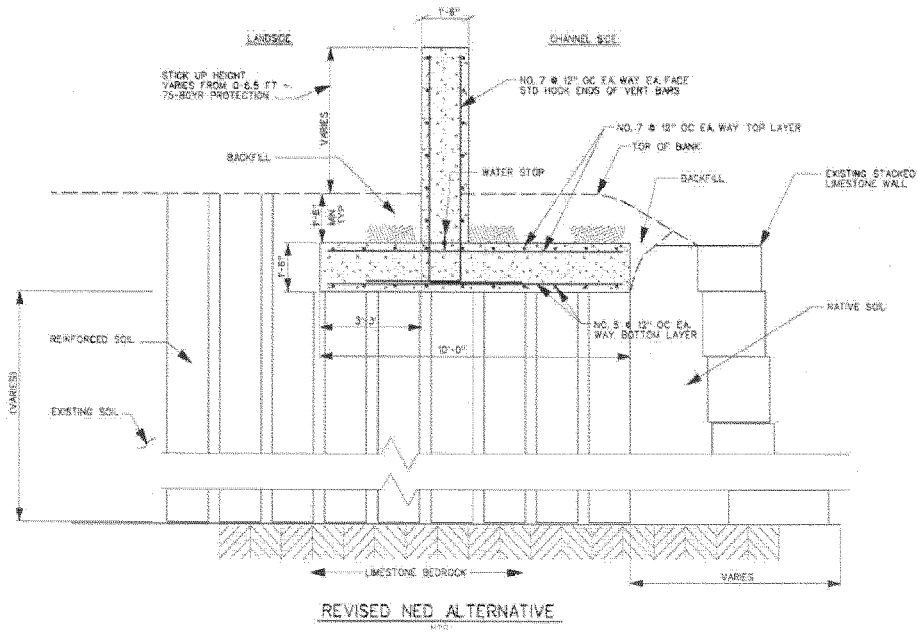


Figure 2-1: Typical Flood Wall

2. ANALYSIS

The flood walls have been preliminary designed for strength and stability. Assumptions are as follows:

• Wall Height. Civil section produced profiles were used to determine approximate wall heights. Incorporating required risk and uncertainty, the stickup height of the stems range from 0 to 6.5 ft high for the modified NED plan with Atlas 14 flows. A significant percentage of floodwall length has wall heights in the upper third of the stickup height range. For simplicity one wall height was chosen of the tallest wall.

• Stability Analysis and uplift. CTWALL CASE program was used for stability analysis. It assumes linear line of creep and seepage under the wall. In reality, the modified soil should have very low permeability that makes the pore pressure from a creek loading ineffectual. Thus the CTWALL analysis with seepage should be very conservative. To reduce the conservatism, the protected side groundwater elevation was arbitrarily chosen to be 6" above the bottom of the wall's foundation.

• Structure Classification. Due to an engineered soil modification, the factors of safety were taken from EM 1110-2-2100 based upon a well-defined site condition, critical structure.

• Shear strength. After discussing with a geotechnical engineer, a 35 degree angle of friction was selected as a low value for the modified soil. Drained conditions are expected to control due to high cohesive strengths of the modified soil. Backfill is assumed to have 30 degree angle of friction.

• Strength Analysis. A preliminary reinforced concrete strength design was used for shear and flexure of the wall in accordance with EM 1110-2-2104. An 18" stem and footer is adequate with No. 7 bars at 12" on-center (O.C.) for primary reinforcement. This is based on a strength analysis with 10 ft of head on the stem, 3 ft soil on the heel, 4000 psi concrete, and Grade 60 rebar.

Temperature and shrinkage (i.e. longitudinal steel) was taken the larger of EM 1110-2-2104 and ACI 350-06. ACI 350 controls, requiring No. 7 at 12" O.C. in the top of the footer and both sides of the stem, and No. 5 at 12" O.C. in the footer's bottom mat.

Table 2-1 includes a list of the preliminary design parameters and assumed values necessary for the slope stability and the evaluation of the stability of the retaining wall structures for this feasibility study. The parameters as noted are on the conservative end, and likely a more economical design could be developed during the design phase after conducting additional geotechnical, survey, and site specific hydrographic data.

Table 2-1: Design Parameter Assumptions

Parameter	Value	Unit
Concrete Strength	4,000	psi
Soil (natural) Density (moist)	120	pcf
Soil (natural) Density (submerged)	65	pcf
Concrete Density	150	pcf
Angle of Friction (improved soil mass)	35	degrees
Angle of Friction (compacted material)	30	degrees

REFERENCES

EM 1110-2-2100 Stability Analysis of Concrete Structures

EM 1110-2 2104 Strength Design for Reinforced Concrete Hydraulic Structures

ACI 318-11 Building Code Requirements for Structural Concrete and Commentary

ATTACHMENT B 2 – A

Floodwall Configuration Analysis

Reviewed: EHF 12/2014

TABLE A-2: H & H Impacts - Atlas 14 Alternative with 3-5x5 RCB

River Sta	W.S. Elev[1]	Rqd Freeboard[2]	Rqd Levee El.[3]	Levee El Left[4]	Left Delta[5]	Levee El Right[6]	Right Delta[7]	H	hH2Dh
mi	*ft*	*ft*	*ft*	*ft*	*ft*	*ft*	*ft*		
3.711 Shawnee Mission Parkway									
3.690	935.85	4	939.85	936.85	3.00				
3.665	934.49	3	937.49	935.31	2.18				
3.607	932.35	3	935.35	932.36	2.99			8'	4'
3.570	931.17	3	934.17	932.03	2.14			2'R	4'
3.568 Pedestrian Bridge									
3.560	930.86	3	933.86	930.82	3.04	930.82	3.04		
3.539	926.9	3	929.9	928.78	1.12	928.78	1.12		
3.481	925.73	3	928.73	927.83	0.9	927.83	0.9		
3.420	923.06	3	926.06	924.97	1.09	924.97	1.09	8'R	5'R
3.345	919.89	3	922.89	921.55	1.34	921.55	1.34	8'R	5'R
3.298	919.69	3	922.69	920.98	1.71	920.98	1.71		
3.231	919.12	3	922.12	920.38	1.74	920.38	1.74	8'	5'
3.230 Pedestrian Bridge									
3.225	919.11	3	922.11	920.37	1.74	920.37	1.74	8'	5'
3.165	916.2	3	919.2	917.53	1.67	917.53	1.67		
3.096	916.29	3	919.29			917.59	1.7		
3.070	916.88	4	920.88			918.16	2.72		
3.058 Johnson Drive Bridge									
3.040	916.16	4	920.16			917.65	2.51		
2.945	913.66	3	916.66			914.9	1.76		
2.813	913.5	3	916.5			914.75	1.75		
2.777	912.72	3	915.72			913.89	1.83		
2.719	911.5	3	914.5			912.74	1.76		
2.651	911.94	4	915.94	913	2.94	913	2.94		
2.636 Merriam Drive Bridge									
2.623	908.05	4	912.05	913.03	-0.98	913.03	-0.98		

[1] Water Surface Elevation Based on Atlas 14 rainfall and 3-5x5 RCB under Merriam Drive. (Source Otero)

[2] Rqd Freeboard per FEMA guidance. 4ft freeboard 100ft upstream and downstream of bridges and 3ft freeboard elsewhere. (Otero)

[3] Required Levee Elevation is water surface el. plus required freeboard.

[4] Left bank levee elevation from feasibility study selected alternative. Elevation set prior to incorporation of Atlas 14 rainfall data. (Otero)

[5] Left Delta is change in left bank levee height from feasibility study selected alternative to the Atlas 14 3-5x5 RCB alternative.

[6] Right bank levee elevation from feasibility study selected alternative. Elevation set prior to incorporation of Atlas 14 rainfall data. (Otero)

[7] Right Delta is change in right bank levee height from feasibility study selected alternative to the Atlas 14 3-5x5 RCB alternative.

* Values for WS El and existing levee elevation were interpolated from upstream and downstream values.

U.S. ARMY CORPS OF ENGINEERS - KANSAS CITY DISTRICT

Comp. By [illegible] Date _____ Project UTC REVISED NED VS ATLAS 14 Sheet ___ of ___

Reviewed: EHF 12/2014

Chkd. By _____ Date _____ Subject T WALL STRENGTH DESIGN Sheet 1 of 1

ASSUMED HEAD = 10'

STEM: $h = 18''$ ASSUME NO. 8 BAR

$d = 18'' - 3'' - 1.5(1'') = 13\frac{1}{2}''$

$F_u = 1.3 * 1.7\left(\frac{1}{2}(10')^2 \gamma_{H_2O}\right) = 6.9$ klf

$M_u = 10'/3\, F_u = 23$ k-ft/ft SOIL ADDS LITTLE MOMENT.

$\phi V_c = 0.75\left[2\sqrt{f'_c}\, bd\right] = 15k > F_u$ OK

$\rho_{req} = \dfrac{1 - \sqrt{1 - \dfrac{236\, M_u}{\phi\, bd^2 f'_c}}}{1.18\,(f_y/f'_c)} = 0.0024 \Rightarrow$ USE $\rho_{min} = 0.0032$

$A_{s\,req} = 0.52\ in^2/ft$ NO 7 OR 8 OK

HEEL:

$B = 6.5'$ (HEEL) ASSUME 3' SOIL LOAD:

(NET H_2O ACTS AS UPLIFT, IGNORE)

$F_u = 1.3 * 1.7\left[3'(125\,pcf)\, B\right] = 5.4$ klf

$M_u = \frac{1}{2}(6.5')\, F_u = 17.5$ k-ft/ft.

(STEM CONTROLS).

TOE: $q_{max} \approx 1$ ksf (ATLAS 14)

TOE WIDTH = 4.5'

FOR SIMPLICITY:

$F_u = 1.3 * 1.7 * q_{max} * 4.5' = 9.9$ klf $< \phi V_c$ OK

$M_u = \frac{1}{2}(4.5')\, F_u = 22$ k-ft/ft (STEM CONTROLS)

ALU: EM: $\frac{1}{2}(0.0028)\, bh = 0.30\ in^2/ft$

ACI 350: (TABLE 7.12.2.1) JTS 2.40'

$\frac{1}{2}(0.0005)\, bh = 0.54\ in^2/ft$ ($\frac{1}{2}$ in bottom → $0.27\ in^2$)

NO 7. NO 5

Reviewed: EHF 12/2014

ATLAS 14. UTC 8 ft wall stickup (9.5 ft stem).
Channel WSE at TOW. Unusual FS.
Ground EL reduced 0.5 ft on resisting side.
Resisting WSE 0.5' from bottom of foundation. Seepage pressures analyzed. In reality, soil mix should not transmit pore pressure from flashy stream.
Horizontal ground surfaces. No surcharges.
Average Drained phi = 35 deg foundation and 30 deg backfill.
Undrained assumed not to control.

Performed by Frederick Sheffield.

********** Echoprint of Input Data **********

Date: 2014/ 7/28 Time: 16.57.41

Structural geometry data:

Elevation of top of stem (ELTS)	=	111.00	ft
Height of stem (HTS)	=	9.50	ft
Thickness top of stem (TTS)	=	1.50	ft
Thickness bottom of stem (TBS)	=	1.50	ft
Dist. of batter at bot. of stem (TBSR)	=	0.00	ft
Depth of heel (THEEL)	=	1.50	ft
Distance of batter for heel (BTRH)	=	0.00	ft
Depth of toe (TTOE)	=	1.50	ft
Width of toe (TWIDTH)	=	4.50	ft
Distance of batter for toe (BTRT)	=	0.00	ft
Width of base (BWIDTH)	=	12.50	ft
Depth of key (HK)	=	0.00	ft
Width of bottom of key (TK)	=	0.00	ft
Dist. of batter at bot. of key (BTRK)	=	0.00	ft

Structure coordinates:

x (ft)	y (ft)
0.00	100.00
0.00	101.50
6.50	101.50
6.50	111.00
8.00	111.00
8.00	101.50
12.50	101.50
12.50	100.00

NOTE: X=0 is located at the left-hand side of the structure. The Y values correspond to the actual elevation used.

Reviewed: EHF 12/2014

Structural property data:
Unit weight of concrete = 0.150 kcf

Driving side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Delta (deg)	Elev. soil (ft)
30.00	0.000	0.120	0.125	0.00	103.00

Driving side soil geometry:

Soil point	Batter (in:1ft)	Distance (ft)
1	0.00	500.00
2	0.00	0.00
3	0.00	500.00

Driving side soil profile:

Soil point	x (ft)	y (ft)
1	-1493.50	103.00
2	6.50	103.00

Resisting side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Elev. soil (ft)	Batter (in:1ft)
30.00	0.000	0.120	0.125	102.50	0.00

Resisting side soil profile:

Soil point	x (ft)	y (ft)
1	8.00	102.50
2	508.00	102.50

Foundation property data:
phi for soil-structure interface = 35.00 (deg)
c for soil-structure interface = 0.000 (ksf)
phi for soil-soil interface = 35.00 (deg)
c for soil-soil interface = 0.000 (ksf)

Water data:
Driving side elevation = 111.00 ft

Reviewed: EHF 12/2014

```
  Resisting side elevation =   100.50 ft
  Unit weight of water     =   0.0624 kcf
  Seepage pressures computed by Line of Creep method.

Minimum required factors of safety:
  Sliding FS    =    1.33
  Overturning   =   75.00% base in compression

Crack options:
  o  Crack depth is to be calculated
  o  Computed cracks *will* be filled with water

Strength mobilization factor =   0.7500

At-rest pressures on the resisting side *are used*
in the overturning analysis.

Forces on the resisting side *are used* in the sliding analysis.

*Do* iterate in overturning analysis.



***** Summary of Results *****

***************     *** Satisfied ***
* Overturning *     Required base in comp. =  75.00 %
***************     Actual base in comp.   = 100.00 %
                    Overturning ratio      =   1.60

Xr (measured from toe) =   4.40 ft
Resultant ratio        = 0.3520
Stem ratio             = 0.3600
Base pressure at heel =    0.0548 ksf
Base pressure at toe  =    0.9225 ksf

***********     *** Satisfied ***
* Sliding *     Min. Required =   1.33
***********     Actual FS     =   1.43


********************** Output Results **********************

Date: 2014/ 7/28                                  Time: 16.57.41

***************************
**  Overturning Results  **
***************************
```

Reviewed: EHF 12/2014

```
Solution converged in  1 iterations.

SMF used to calculate K's =   0.7500
Alpha for the SMF          = -56.7876
Calculated earth pressure coefficients:
  Driving side at rest K    =   0.4313
  Driving side at rest Kc   =   0.6567
  Resisting side at rest K  =   0.5000
  Resisting side at rest Kc =   0.7071
  At-rest K's for resisting side calculated.

Depth of cracking =     0.00 ft

** Driving side pressures **

  Water pressures:
    Elevation    Pressure
      (ft)         (ksf)
    ======================
      111.00      0.0000
      103.00      0.4992
      100.00      0.5635

  Earth pressures:
    Elevation    Pressure
      (ft)         (ksf)
    ======================
      103.00      0.0000
      100.00      0.1340

** Resisting side pressures **

  Water pressures:
    Elevation    Pressure
      (ft)         (ksf)
    ======================
      100.50      0.0000
      100.00      0.0517

  Earth pressures:
    Elevation    Pressure
      (ft)         (ksf)
    ======================
      102.50      0.0000
      100.00      0.1254

** Uplift pressures **

  Water pressures:
     x-coord.    Pressure
      (ft)         (ksf)
```

Reviewed: EHF 12/2014

0.00	0.5635
12.50	0.0517

** Forces and moments **

Part	Force (kips) Vert.	Force (kips) Horiz.	Mom. Arm (ft)	Moment (ft-k)
Structure:				
Structure weight.....	4.950		-5.82	-28.80
Structure, driving side:				
Moist soil.....	0.000		0.00	0.00
Saturated soil.....	1.219		-9.25	-11.27
Water above structure.....	0.000		0.00	0.00
Water above soil.....	3.245		-9.25	-30.01
External vertical loads....	0.000		0.00	0.00
Ext. horz. pressure loads..		0.000	0.00	0.00
Ext. horz. line loads.....		0.000	0.00	0.00
Structure, resisting side:				
Moist soil.....	0.540		-2.25	-1.21
Saturated soil.....	0.000		0.00	0.00
Water above structure.....	0.000		0.00	0.00
Water above soil.....	0.000		0.00	0.00
Driving side:				
Effective earth loads.....		0.201	1.00	0.20
Shear (due to delta).....	0.000		0.00	0.00
Horiz. surcharge effects...		0.000	0.00	0.00
Water loads.....		3.591	3.80	13.66

Reviewed: EHF 12/2014

```
 Resisting side:
   Effective earth loads......                -0.157        0.83
-0.13
   Water loads................                -0.013        0.17
0.00
 Foundation:
   Vertical force on base.....   -6.108                   -4.40
26.88
   Shear on base..............                -3.622        0.00
0.00
   Uplift.....................   -3.845                   -7.98
30.70
=================================================================
=======
 ** Statics Check **   SUMS =     0.000       0.000
0.00

 Angle of base         =     0.00 degrees
 Normal force on base =    6.108 kips
 Shear force on base  =    3.622 kips
 Max. available shear force =    4.277 kips

 Base pressure at heel =   0.0548 ksf
 Base pressure at toe  =   0.9225 ksf

 Xr (measured from toe) =     4.40 ft
 Resultant ratio        =   0.3520
 Stem ratio             =   0.3600
 Base in compression    =   100.00 %
 Overturning ratio      =     1.60

 Volume of concrete =     1.22 cubic yds/ft of wall

 NOTE:  The engineer shall verify that the computed
 bearing pressures below the wall do not exceed the
 allowable foundation bearing pressure, or, perform a
 bearing capacity analysis using the program CBEAR.
 Also, the engineer shall verify that the base pressures
 do not result in excessive differential settlement of
 the wall foundation.



 ***********************
 **  Sliding Results  **
 ***********************

 Solution converged.  Summation of forces = 0.

            Horizontal   Vertical
```

Reviewed: EHF 12/2014

Wedge Number	Loads (kips)	Loads (kips)
1	0.000	1.003
2	1.997	3.245
3	0.000	0.000

Water pressures on wedges:

Wedge number	Top press. (ksf)	Bottom press. (ksf)	x-coord. (ft)	press. (ksf)
1	0.4992	0.5635		
2			0.0000	0.5635
2			12.5000	0.0517
3	0.0000	0.0517		

Points of sliding plane:
Point 1 (left), x = 0.00 ft, y = 100.00 ft
Point 2 (right), x = 12.50 ft, y = 100.00 ft

Depth of cracking = 0.00 ft

Wedge number	Failure angle (deg)	Total length (ft)	Weight of wedge (kips)	Submerged length (ft)	Uplift force (kips)
1	-56.189	3.611	0.377	3.611	1.919
2	0.000	12.500	6.709	12.500	3.845
3	34.036	4.467	0.556	0.893	0.023

Wedge number	Net force (kips)
1	-1.806
2	0.996
3	0.810
SUM =	0.000

Factor of safety = 1.429

****
** Bearing Results **
****

Reviewed: EHF 12/2014

Base width =	12.500	(ft)
Xr =	4.400	(ft)
Effective base width = (measured along slope)	8.801	(ft)
Base slope =	0.0000	(deg)
Phi =	35.000	(deg)
C =	0.000	(ksf)
Effective Gamma =	0.0626	(kcf)
Normal load =	6.108	(kips)
Load inclination =	30.667	(deg)
Load eccentricity =	1.850	(ft)
Surcharge =	0.2713	(kips)
Embedment =	2.500	(ft)
Ground slope =	0.0000	(deg)

Bearing Capacity Factors

	C	Q	G
Bearing	46.1236	33.2961	37.1524
Embedment	1.1091	1.0546	1.0546
Inclination	0.4346	0.4346	0.0153
Base Tilt	1.0000	1.0000	1.0000
Ground Slope	1.0000	1.0000	1.0000

Net ultimate bearing pressure = 4.1812 (ksf)

Factor of safety =	6.024

Reviewed: EHF 12/2014

NED. UTC 6.5 ft wall stickup (8 ft stem).
Channel WSE at TOW. Unusual FS.
Ground EL reduced 0.5 ft on resisting side.
Resisting WSE 0.5' from bottom of foundation. Seepage pressures analyzed. In reality, soil mix should not transmit pore pressure from flashy stream.
Horizontal ground surfaces. No surcharges.
Average Drained phi = 35 deg foundation and 30 deg backfill.
Undrained assumed not to control.

Performed by Frederick Sheffield.

********** Echoprint of Input Data **********

Date: 2014/ 7/28 Time: 17.05.44

Structural geometry data:

Elevation of top of stem (ELTS)	=	109.50	ft
Height of stem (HTS)	=	8.00	ft
Thickness top of stem (TTS)	=	1.50	ft
Thickness bottom of stem (TBS)	=	1.50	ft
Dist. of batter at bot. of stem (TBSR)	=	0.00	ft
Depth of heel (THEEL)	=	1.50	ft
Distance of batter for heel (BTRH)	=	0.00	ft
Depth of toe (TTOE)	=	1.50	ft
Width of toe (TWIDTH)	=	3.25	ft
Distance of batter for toe (BTRT)	=	0.00	ft
Width of base (BWIDTH)	=	10.00	ft
Depth of key (HK)	=	0.00	ft
Width of bottom of key (TK)	=	0.00	ft
Dist. of batter at bot. of key (BTRK)	=	0.00	ft

Structure coordinates:

x (ft)	y (ft)
0.00	100.00
0.00	101.50
5.25	101.50
5.25	109.50
6.75	109.50
6.75	101.50
10.00	101.50
10.00	100.00

NOTE: X=0 is located at the left-hand side of the structure. The Y values correspond to the actual elevation used.

Reviewed: EHF 12/2014

Structural property data:
Unit weight of concrete = 0.150 kcf

Driving side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Delta (deg)	Elev. soil (ft)
30.00	0.000	0.120	0.125	0.00	103.00

Driving side soil geometry:

Soil point	Batter (in:1ft)	Distance (ft)
1	0.00	500.00
2	0.00	0.00
3	0.00	500.00

Driving side soil profile:

Soil point	x (ft)	y (ft)
1	-1494.75	103.00
2	5.25	103.00

Resisting side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Elev. soil (ft)	Batter (in:1ft)
30.00	0.000	0.120	0.125	102.50	0.00

Resisting side soil profile:

Soil point	x (ft)	y (ft)
1	6.75	102.50
2	506.75	102.50

Foundation property data:
phi for soil-structure interface = 35.00 (deg)
c for soil-structure interface = 0.000 (ksf)
phi for soil-soil interface = 35.00 (deg)
c for soil-soil interface = 0.000 (ksf)

Water data:
Driving side elevation = 109.50 ft

Reviewed: EHF 12/2014

```
  Resisting side elevation =   100.50 ft
  Unit weight of water     =   0.0624 kcf
  Seepage pressures computed by Line of Creep method.

Minimum required factors of safety:
  Sliding FS   =    1.33
  Overturning  =   75.00% base in compression

Crack options:
  o  Crack depth is to be calculated
  o  Computed cracks *will* be filled with water

Strength mobilization factor =   0.7500

At-rest pressures on the resisting side *are used*
in the overturning analysis.

Forces on the resisting side *are used* in the sliding analysis.

*Do* iterate in overturning analysis.



***** Summary of Results *****

***************     *** Satisfied ***
* Overturning *     Required base in comp. =  75.00 %
***************     Actual base in comp.   = 100.00 %
                    Overturning ratio      =   1.66

Xr (measured from toe) =   3.39 ft
Resultant ratio        = 0.3388
Stem ratio             = 0.3250
Base pressure at heel =    0.0162 ksf
Base pressure at toe  =    0.9746 ksf

***********     *** Satisfied ***
* Sliding *     Min. Required =   1.33
***********     Actual FS     =   1.63


********************** Output Results **********************

Date: 2014/ 7/28                                  Time: 17.05.44

***************************
**  Overturning Results  **
***************************
```

Reviewed: EHF 12/2014

```
Solution converged in  1 iterations.

SMF used to calculate K's =   0.7500
Alpha for the SMF          = -56.8439
Calculated earth pressure coefficients:
  Driving side at rest K    =   0.4313
  Driving side at rest Kc   =   0.6567
  Resisting side at rest K  =   0.5000
  Resisting side at rest Kc =   0.7071
  At-rest K's for resisting side calculated.

Depth of cracking =     0.00 ft

** Driving side pressures **

  Water pressures:
    Elevation    Pressure
      (ft)         (ksf)
    ==================
      109.50      0.0000
      103.00      0.4056
      100.00      0.4680

  Earth pressures:
    Elevation    Pressure
      (ft)         (ksf)
    ==================
      103.00      0.0000
      100.00      0.1348

** Resisting side pressures **

  Water pressures:
    Elevation    Pressure
      (ft)         (ksf)
    ==================
      100.50      0.0000
      100.00      0.0520

  Earth pressures:
    Elevation    Pressure
      (ft)         (ksf)
    ==================
      102.50      0.0000
      100.00      0.1252

** Uplift pressures **

  Water pressures:
     x-coord.    Pressure
      (ft)         (ksf)
```

Reviewed: EHF 12/2014

0.00	0.4680
10.00	0.0520

** Forces and moments **

Part	Force (kips) Vert.	Force (kips) Horiz.	Mom. Arm (ft)	Moment (ft-k)
Structure:				
Structure weight.....	4.050		-4.56	-18.45
Structure, driving side:				
Moist soil.....	0.000		0.00	0.00
Saturated soil.....	0.984		-7.38	-7.26
Water above structure.....	0.000		0.00	0.00
Water above soil.....	2.129		-7.38	-15.70
External vertical loads....	0.000		0.00	0.00
Ext. horz. pressure loads..		0.000	0.00	0.00
Ext. horz. line loads.....		0.000	0.00	0.00
Structure, resisting side:				
Moist soil.....	0.390		-1.62	-0.63
Saturated soil.....	0.000		0.00	0.00
Water above structure.....	0.000		0.00	0.00
Water above soil.....	0.000		0.00	0.00
Driving side:				
Effective earth loads.....		0.202	1.00	0.20
Shear (due to delta).....	0.000		0.00	0.00
Horiz. surcharge effects...		0.000	0.00	0.00
Water loads.....		2.629	3.32	8.73

Reviewed: EHF 12/2014

```
 Resisting side:
   Effective earth loads......                -0.157        0.83
-0.13
   Water loads................                -0.013        0.17
0.00
 Foundation:
   Vertical force on base.....    -4.954                  -3.39
16.78
   Shear on base..............                -2.661        0.00
0.00
   Uplift.....................    -2.600                  -6.33
16.47

=================================================================
=======
 ** Statics Check **   SUMS =      0.000       0.000
0.00

 Angle of base          =      0.00 degrees
 Normal force on base =     4.954 kips
 Shear force on base  =     2.661 kips
 Max. available shear force =     3.469 kips

 Base pressure at heel =    0.0162 ksf
 Base pressure at toe  =    0.9746 ksf

 Xr (measured from toe) =      3.39 ft
 Resultant ratio        =    0.3388
 Stem ratio             =    0.3250
 Base in compression    =    100.00 %
 Overturning ratio      =      1.66

 Volume of concrete =      1.00 cubic yds/ft of wall

 NOTE:  The engineer shall verify that the computed
 bearing pressures below the wall do not exceed the
 allowable foundation bearing pressure, or, perform a
 bearing capacity analysis using the program CBEAR.
 Also, the engineer shall verify that the base pressures
 do not result in excessive differential settlement of
 the wall foundation.



 **********************
 **  Sliding Results  **
 **********************

 Solution converged.  Summation of forces = 0.

            Horizontal   Vertical
```

Reviewed: EHF 12/2014

Wedge Number	Loads (kips)	Loads (kips)
1	0.000	0.859
2	1.318	2.129
3	0.000	0.000

Water pressures on wedges:

Wedge number	Top press. (ksf)	Bottom press. (ksf)	x-coord. (ft)	press. (ksf)
1	0.4056	0.4680		
2			0.0000	0.4680
2			10.0000	0.0520
3	0.0000	0.0520		

Points of sliding plane:
Point 1 (left), x = 0.00 ft, y = 100.00 ft
Point 2 (right), x = 10.00 ft, y = 100.00 ft

Depth of cracking = 0.00 ft

Wedge number	Failure angle (deg)	Total length (ft)	Weight of wedge (kips)	Submerged length (ft)	Uplift force (kips)
1	-54.783	3.672	0.397	3.672	1.604
2	0.000	10.000	5.424	10.000	2.600
3	35.347	4.321	0.530	0.864	0.022

Wedge number	Net force (kips)
1	-1.545
2	0.807
3	0.738
SUM =	0.000

Factor of safety = 1.632

****
** Bearing Results **
****

Reviewed: EHF 12/2014

Base width =	10.000	(ft)
Xr =	3.388	(ft)
Effective base width = (measured along slope)	6.775	(ft)
Base slope =	0.0000	(deg)
Phi =	35.000	(deg)
C =	0.000	(ksf)
Effective Gamma =	0.0626	(kcf)
Normal load =	4.954	(kips)
Load inclination =	28.245	(deg)
Load eccentricity =	1.612	(ft)
Surcharge =	0.2713	(kips)
Embedment =	2.500	(ft)
Ground slope =	0.0000	(deg)

Bearing Capacity Factors

	C	Q	G
Bearing	46.1236	33.2961	37.1524
Embedment	1.1418	1.0709	1.0709
Inclination	0.4708	0.4708	0.0372
Base Tilt	1.0000	1.0000	1.0000
Ground Slope	1.0000	1.0000	1.0000

Net ultimate bearing pressure = 4.7319 (ksf)

Factor of safety = 6.472

Section 3 Hydrologic and Hydraulic Conditions

Table of Contents

1. SITE DESCRIPTION 1
1.1 STUDY AREA 1
1.2 UPPER TURKEY CREEK 2
1.3 DOWNSTREAM CHANNELS 3
1.3.1 LOWER TURKEY CREEK 3
1.3.2 KANSAS RIVER 3
2. SITE BACKGROUND 4
2.1 PURPOSE 4
2.2 FLOOD HISTORY 4
2.2.1 FLOOD OF 1961 4
2.2.2 FLOOD OF 1977 4
2.2.3 FLOOD OF 1993 5
2.2.4 FLOOD OF 1998 5
3. HYDROLOGY 6
3.1 EXISTING CONDITION OFFICIAL HYDROLOGIC STUDY 6
3.2 WATERSHED LOCATION AND DELINEATION 6
3.3 SOILS 6
3.4 SURFACE EXISTING CONDITIONS OF THE WATERSHED 8
3.5 FUTURE WITHOUT PROJECT HYDROLOGY 9
3.6 PRECIPITATION 9
3.7 UPDATED PRECIPITATION 9
3.8 STREAM FLOW 10
3.8.1 UPDATED DESIGN DISCHARGES 11
3.8.2 CLIMATE CHANGE CONSIDERATIONS 11
4. HYDRAULICS 16
4.1 BACKGROUND 16
4.2 EXISTING CONDITIONS HEC-RAS MODEL DEVELOPMENT 16
4.2.1 UPPER TURKEY CREEK REACHES 16
4.3 EXISTING CONDITIONS HEC-RAS MODEL – ATLAS 14 DISCHARGES 18
4.4 EXISTING CONDITIONS HEC-RAS MODEL – RESULTS 18

4.5 FUTURE CONDITIONS HYDRAULIC ASSUMPTIONS 18
5. PROPOSED CONDITIONS 19
5.1 INTRODUCTION 19
5.2 ALTERNATIVE NOMENCLATURE 19
5.3 DESCRIPTIONS OF ALTERNATIVES 20
5.3.1 FUTURE CONDITIONS WITHOUT PROJECT 20
5.3.2 ALTERNATIVE 1 – CHANNEL WIDENING 21
5.3.3 ALTERNATIVE 2 – LEVEE AND FLOOD WALL INSTALLATION 22
5.3.4 ALTERNATIVE 3 – COMBINATION OF CHANNEL WIDENING, LEVEES, AND FLOODWALLS 23
5.4 BRIDGE MODIFICATION 25
5.5 QUALITY CONTROL REVIEW 25
5.6 PREFERRED ALTERNATIVE MODEL RESULTS 26
5.6.1 DISCUSSION OF POTENTIAL INDUCED DAMAGES 29
5.6.2 RISK WARNING TIME 31
6. DATA CONVERSION FOR HEC-FDA ANALYSIS 34
6.1 RELIABLE LEVEL OF PROTECTION 35
6.2 NO RISE CERTIFICATION 35
6.3 STAGE UNCERTAINTY AND STANDARD ERROR 38
7. VALUE ENGINEERING OF INTERIOR DRAINAGE ALTERNATIVES 40
7.1 INTRODUCTION 40
7.2 HYDROLOGY 40
7.3 HYDRAULICS 47
7.4 ANALYSIS AND ALTERNATIVES 48
7.5 ALTERNATIVE 1: SURFACE DETENTION 48
7.6 ALTERNATIVE 2: UNDERGROUND DETENTION 51
8. REFERENCES 52

Figures

Figure 3-1. Upper and Lower Turkey Creek Drainage Basin 1

Figure 3-2. Turkey Creek Upper and Lower Reaches (Source Google ™ Earth ®, © 2012 Google) 2

Figure 3-3. Hyetograph illustrating the rainfall distribution over the 10-hour period that made up the largest percent of rainfall during the October 4, 1998 event 5

Figure 3-4. Illustration of soil types available on Turkey Creek (Modified from JOCO Figure 3-4) 7

Figure 3-5. Illustration of impervious surfaces on Turkey Creek (Modified from JOCO Figure 3-5) 8

Figure 3-6. Illustration of Turkey Creek Watershed with location of precipitation and stream gages (Modified from JOCO Figure 3-3) 11

Figure 3-7. Annual maximum and minimum daily temperatures at Kansas City, Missouri 12

Figure 3-8. Simulated difference in annual and seasonal mean precipitation (%) for the Great Plains Region (2041-2017 with respect to the reference period of 1971-2000). From NOAA 2013. 13

Figure 3-9. Maximum Annual Daily to Five Day Precipitation at Kansas City, MO 14

Figure 3-10. Illustration of 1% ACE Turkey Creek –TP-40 and Atlas 14 based flows - water surface profiles for the preferred alternative along reach TC-M80 (project reach) 28

Figure 3-11. Estimated stage hydrograph at the downstream end of the project reach (downstream of Merriam Drive) and precipitation during a 1% ACE event 31

Figure 3-12. Stage hydrographs and cumulative precipitation for StormWatch gages at Johnson Drive and the Antioch Ramp during the August 2007 event 32

Figure 3-13. Gage height hydrograph and cumulative precipitation for the StormWatch gage at Johnson Drive during the June 2010 event 33

Figure 3-14: Location Map and Aerial Photograph of the City of Merriam, Johnson County, Kansas 40

Figure 3-15: Topographic map of Merriam Reach and delineated watershed 41

Figure 3-16: Topographic map of Merriam Reach and delineated subwatersheds 42

Figure 3-17: Time of concentration worksheet for northern subwatershed SN 44

Figure 3-18: Time of concentration worksheet for southern subwatershed SS 45

Figure 3-19: Estimated runoff hydrograph for SN 46

Figure 3-20: Estimated runoff hydrograph for SS 46

Figure 3-21: Location of Cross Sections used to Model Merriam Reach 47

Figure 3-22: Location of Two Suggested Areas for Detention Basins on Subwatershed SN 50

Figure 3-23: Location of Two Suggested Areas for Detention Basins on Subwatershed SN 50

Figure 3-24: Location of Proposed Underground Retention Structure and Potential Inlet Locations 51

Tables

Table 3-1. Comparison of Rainfall Totals for Floods of 1997, 1993, and 1998 at NOAA Raing Gage in Shawnee, Kansas 4

Table 3-2. AEP and precipitation totals for 24 hour rainfall events based on TP-40 9

Table 3-3. AEP and precipitation totals for 24-hour rainfall events based on Atlas 14 10

Table 3-4. Turkey Creek Watershed Gages in the Storm Watch Gage Network 10

Table 3-5. Reaches included in the Upper Turkey Creek Existing Condition HEC-RAS Model 17

Table 3-6. Model Alternatives Nomenclature 20

Table 3-7. 90 Percent Reliability Level of Protection 35

Table 3-8. No Rise Water Surface Elevation Comparison 36

Table 3-9. 24-hour Rainfall Intensities and Total Precipitation for Johnson County, Kansas 43

Table 3-10. Frequency for Coincidental Occurrence (HEC_22, Table 7-3) 48

Table 3-11. Detention Volume Required and Pipe Diameter for Various Outflows 49

Table 3-12. Minimum Detention Volume and Pipe Diameter for the Total Watershed 51

Exhibits

Exhibit 1. Upper Turkey Creek HEC-RAS existing-condition model cross sections per reach in reference to Turkey Creek watershed

Exhibit 2. Design discharges based on TP-40 and Atlas 14 and flow change locations in the HEC-RAS model

Exhibit 3. Tabular results from Existing Condition HEC-RAS model - including reaches TC-M81, TC-M85, TC-M80a, TC-M80, and TC-M120

Exhibit 4. Water surface elevation profiles from Existing Condition HEC-RAS model for several events - including reaches TC-M81, TC-M85, TC-M80a, TC-M80, and TC-M120

Exhibit 5. Tabular results from Proposed Condition HEC-RAS model for the reach of interest TC-M80

Exhibit 6. Water surface elevation profiles from Proposed Condition HEC-RAS model for several events for the reach of interest TC-M80

Exhibit 7. Pre-project inundation mapping before and after publication of Atlas 14

Exhibit 8. With-project inundation map products

1. SITE DESCRIPTION

1.1 STUDY AREA

The study area covers approximately 23 square miles which comprises the Upper Turkey Creek drainage basin in Wyandotte and Johnson Counties, Kansas. The Turkey Creek channel starts at the headwaters in Lenexa, Kansas and stretches about 15 miles north following Interstate 35 to the confluence with the lower Kansas River. Within this area are the Cities of Lenexa, Shawnee, Merriam, Overland Park, Mission, Roeland Park, Westwood, and Kansas City, Kansas (largely urban commercial and residential).

The floodplain of Turkey Creek varies from 50 to 400 feet wide at segments. Elevations in the Turkey Creek basin vary from 1035 feet (NED 1/3, USGS) in the area surrounding the headwaters to 755 feet (NED 1/3, USGS) at the mouth of the Turkey Creek. There are 12 small tributary waterways that contribute to the flow of the Upper Turkey Creek. The major tributaries include: Quail Creek (Antioch Rd and I-35), Quaker Creek (North of 61st St.), Hickory Creek (Antioch Rd), Shawnee Creek (51st and Farley). Many other small creeks and drainage ways also contribute to the Turkey Creek, but they are smaller and unnamed. Figure 3-1 illustrates the Upper and Lower Turkey Creek drainage basins.

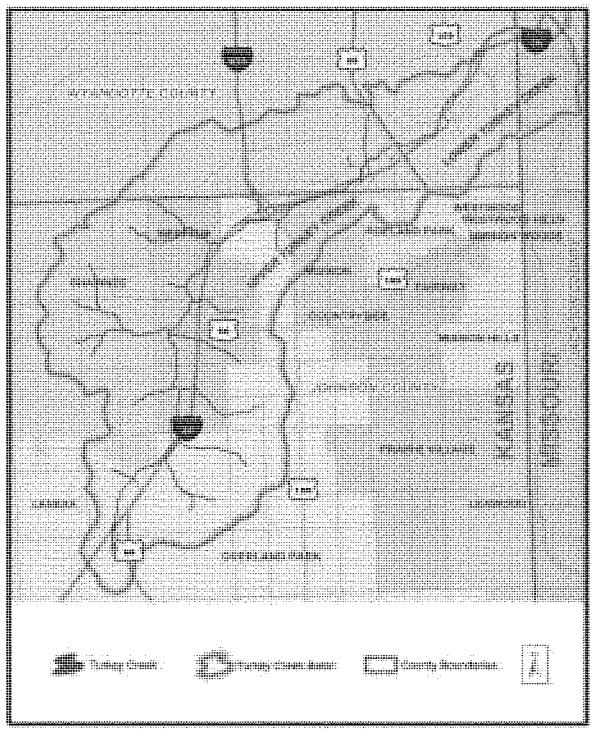


Figure 3-1. Upper and Lower Turkey Creek Drainage Basin

The Turkey Creek floodplain includes multiple downtown and commercial areas, residential neighborhoods, and industrial parks. The maximum floodplain is approximately 400 feet wide and most of these aforementioned areas are located directly next to the main Turkey Creek channel. The floodplain zone of Turkey Creek contains more than 40 residential structures and approximately 100 commercial and public facilities.

There are a total of 27 roadway bridge crossings on the Turkey Creek channel including large traffic roadways: Merriam Dr., Johnson Dr., Shawnee Mission Pkwy, W 67th St., W 75th St., Interstate 35 (three times), S 18th Expressway, Southwest Blvd, and S 7th St Trafficway. There are also four major rail crossings and two pedestrian bridges over Turkey Creek.

1.2 UPPER TURKEY CREEK

The headwaters of the Turkey Creek Basin originate in Lenexa, Kansas, just south of 89th Street. The portion of the watershed upstream of the 4.4 Burlington Northern Santa Fe (BNSF) Railroad Bridge near the river mile 2.12 is referred to in this study as Upper Turkey Creek. Lower Turkey is the downstream segment of the channel until the confluence with the lower Kansas River. This division of the two segments of the river and the surrounding area is shown in Figure 3-2. The Kansas Department of Transportation and Merriam Drainage District are currently in the construction phase of several projects to improve storm culverts and bridges susceptible to overtopping on the Upper Turkey Creek. Projects that have been completed in the Upper Turkey Creek in the past include: Antioch Bridge, BNSF 7.44 Railroad Bridge, Waterfall Park, and Johnson County Hazard Mitigation Projects.

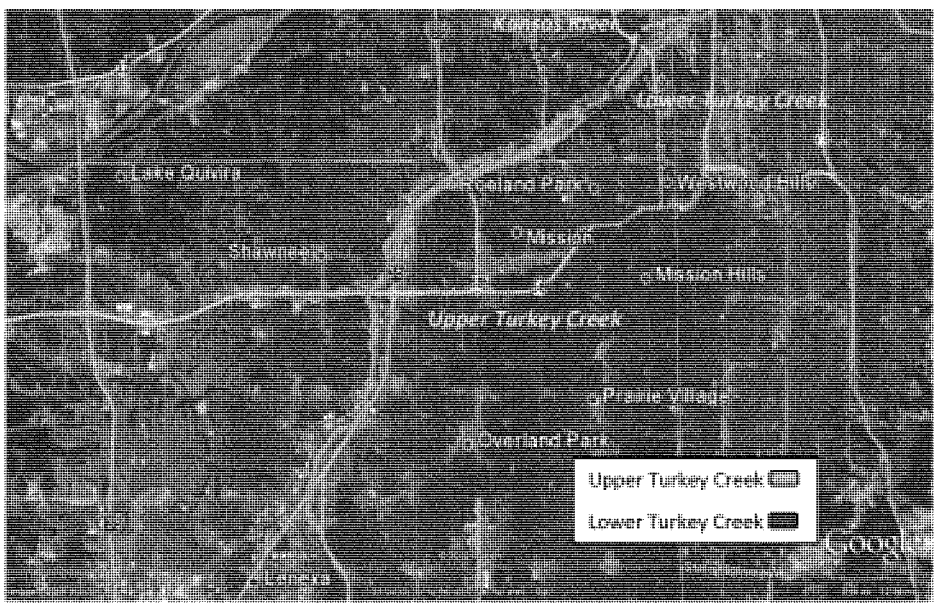


Figure 3-2. Turkey Creek Upper and Lower Reaches (Source Google ™ Earth ®, © 2012 Google)

1.3 DOWNSTREAM CHANNELS

The two channels located downstream of Upper Turkey Creek are Lower Turkey Creek and the Kansas River.

1.3.1 LOWER TURKEY CREEK

Lower Turkey Creek is the segment of Turkey Creek below the 4.4 BNSF Railroad Bridge to the confluence with the Kansas River. This segment stretches approximately 2.17 miles total and goes through the Turkey Creek tunnel for about 1,700 feet before discharging into the Kansas River. The tunnel was built in 1919 and its cross section is a horseshoe shape that is 28 feet in diameter. The lower portion has undergone many channel improvements and construction projects in the past. Currently, a large fraction of Lower Turkey Creek has been channelized. USACE recently completed the Turkey Creek Basin Construction Project, which included: 1,300 feet of improvements to the tunnel, bridge modification, channel widening, and enlargements to the hillside interceptors. The project was completed before the start of 2012.

1.3.2 KANSAS RIVER

The Kansas River Basin is located in northern Kansas, southern Nebraska, and Eastern Colorado. Major tributaries include the Big Blue, the Republican, the Saline, the Solomon, and the Smoky Hill Rivers. Much of the river's watershed is dammed for flood control, but the river is generally free-flowing and has only minor obstructions, including diversion weirs and one low impact hydroelectric dam. The Kansas River is formed by the convergence of the Republican and Smokey Hill Rivers at Junction City, Kansas. The top width of the Kansas River at the confluence of Turkey Creek is about 570 feet. The Kansas River Drainage Basin is approximately 60,000 square miles, above the confluence of the Turkey Creek.

2. SITE BACKGROUND

2.1 PURPOSE

This study was initiated in response to events observed in the Kansas City Metro area during the flooding of October 1998. As a result of urban expansion in the Turkey Creek river basin, and the heavy rains of October 1998 combined with the increased storm water flows of the urban area created a large flash flood event causing millions of dollars in damages to the local communities. Although this flood was the most devastating in recent memory, there were also many smaller scale flood events and floods that were larger in magnitude in the past. The following sections provide a discussion of the flood history of Turkey Creek and the surrounding river basin, including background information of the 1961, 1977, 1993, and 1998 flood events.

2.2 FLOOD HISTORY

Major floods on Turkey Creek are usually caused by a short-duration, high-intensity storm following an extended period of general rainfall on the basin. The rainfall preceding the heavy rains saturates the soil, preventing further infiltration of the water into the soil and forcing it to continue into the Turkey Creek channel, creating a higher than average flow. Since the Turkey Creek channel is so narrow and urbanized, it usually deals with flash flood events which are hard to prepare for and for the most part unexpected. Earlier flood events on Turkey Creek are known to have happened in 1844, 1951, 1958, 1961, and 1968, but very little information was documented on these events. Recent flood events that have available records and documentation include 1977, 1983, 1986, 1993, 1995, 1996, and 1998. However, the focus will be on the three largest flood events which were 1977, 1993, and 1998. These three flood's rainfall data taken on the same rain gauge at Shawnee, Kansas is shown below on Table 3-1. There is no uniform available data for flow or high water during these three major events.

Table 3-1. Comparison of Rainfall Totals for Floods of 1997, 1993, and 1998 at NOAA Raing Gage in Shawnee, Kansas

Flood Event Date	Peak Hour Rainfall (inches)	Total Flood Rainfall (inches)	Recorded Dates
1977	1.60	10.90	9/12/1977-9/13/1977
1993	1.50	6.00	7/10/1993
1998	3.51	5.61	10/4/1998

2.2.1 FLOOD OF 1961

A great flood event happened during June of 1961. However, very little documentation was kept regarding the nature, extent, and magnitude of the rainfall. Also no data is available that pertains to flood stages, flows, and the damages that resulted from this event.

2.2.2 FLOOD OF 1977

Locally known as the Plaza Flood, this was a flash flood event that occurred September 12-13, 1977 through the Kansas City Metro area. It was caused by a high intensity storm that followed a long period of light rain. Most of the focus was put on Brush Creek which travels through the Plaza and discharges into the Blue River. During this event there were 25 fatalities and 1000 automobiles totaled, along with millions of dollars in damages to the commercial and residential areas surrounding Brush Creek.

In the Turkey Creek area, $8.1 million in damages occurred due to flooding. Although damages were extensive, the Urban Study conducted following the flood determined that it was not feasible to implement a program for managing flood events along Turkey Creek.

2.2.3 FLOOD OF 1993

Extensive flooding occurred on July 10, 1993. Although this year was also a major flood year for the Missouri and Kansas Rivers in Kansas City, this was an unrelated flash flood event caused by high intensity storms on that date. When Turkey Creek flooded in 1993 it overtopped Interstate 35 at five different locations. The flooding that occurred during this event also caused one fatality. Damages from the 1993 event were estimated at $3.4 million in Merriam, Kansas and $20 million in the lower basin.

2.2.4 FLOOD OF 1998

The maximum flood of record for Turkey Creek occurred in October 1998 and resulted from the combined effects of saturated soil due to a week with 6 out of 7 days of rain and a high intensity storm that started in October 4, 1998. The storm covered the Kansas City Metro area with rain for the entire day with afternoon rainfall totals of 0.25 to 1.00 inch. Around 7:00 pm another round of storms produced an additional 3 to 5 inches of rain in a 2-hour period. This rainfall produced by this event exceeded the rainfall amount defined as the 1-percent annual exceedance probability (AEP) (100-year event) at the time. Although this flood had the least amount of total rainfall when compared to the 1977 and 1993 floods, it produced the highest amount of rainfall in the peak hour. To illustrate the rapidness of this event Figure 3-3, illustrates the 10 hours of highest rainfall intensity of the October 1998 rainfall event hyetograph. The worst damaged cause by this flood occurred at Merriam, Kansas near the midpoint of the Upper Turkey Creek reach. Multiple bridges and roadways were flooded during this event including Interstate 35 and the BNSF railroad tracks south of 75th St. The total cost of damages were estimated at $12.0 million in Merriam and $20 million in the lower basin area.

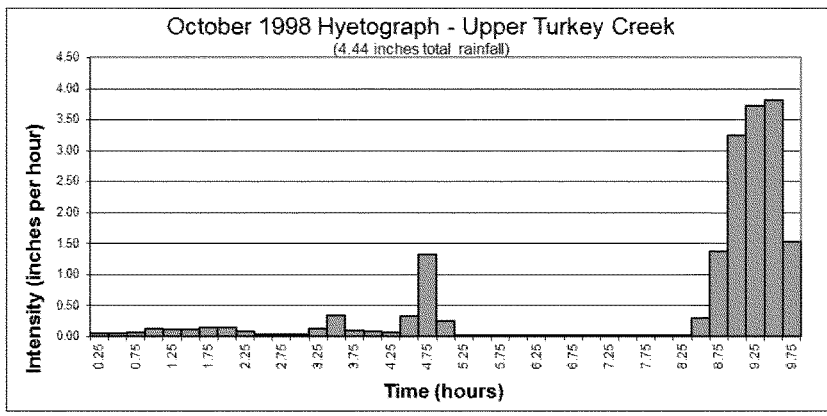


Figure 3-3. Hyetograph illustrating the rainfall distribution over the 10-hour period that made up the largest percent of rainfall during the October 4, 1998 event

3. HYDROLOGY

3.1 EXISTING CONDITION OFFICIAL HYDROLOGIC STUDY

In May 31, 2005, the Larkin Group Inc. (Larkin) completed a watershed study titled *Northeast Johnson County Watershed Study* (JOCO). The JOCO report was produced by Larkin for the Storm Management Program of Johnson County, Kansas. As part of the JOCO, Larkin developed a hydrologic model using the U.S. Army Corps of Engineers (USACE) software HEC-1. HEC-1 is computer software designed to simulate runoff response of a river basin to precipitation by representing the basin as an interconnected system of hydrologic and hydraulic components.

This HEC-1 model produced by Larkin included the complete watershed contributing to the upper portion of Turkey Creek, here on referred to as Upper Turkey Creek . During the early stage of the Upper Turkey Creek Feasibility Study it was decided to use Larkin's HEC-1 model (HEC-1 model) as the official existing conditions hydrologic model for the Upper Turkey Creek Feasibility Study. Most of the information included in this section was extracted from the JOCO report. The development of the JOCO HEC-1 model was documented in Section 6 of the JOCO report.

3.2 WATERSHED LOCATION AND DELINEATION

The Turkey Creek Watershed has headwaters starting near 89th Street and Bond, the creek flows in a northeasterly direction to the Johnson County Line near Lamar Avenue, which is the downstream end of this study. Downstream of the study limits, Turkey Creek flows east northeasterly about 3.4 miles to the Kansas River. The total drainage area of Turkey Creek to the confluence with the Kansas River is about 30 square miles and includes the drainage areas of both Upper Turkey Creek and Lower Turkey Creek in northeastern Johnson County, Kansas as well as drainage areas in Wyandotte County, Kansas, and Jackson County, Missouri.

Turkey Creek, in Johnson County has a main channel length of approximately 7.9 mi (41,700 feet) with an elevation drop of 191 feet. Elevations within the study area range from 1086 to 831 feet above mean sea level. The cities in the study area portion of the Turkey Creek watershed are Mission, Overland Park, Merriam, Lenexa, and Shawnee. An aerial photo illustrating the location of the Turkey Creek Watershed in reference to several highways and cities is attached.

3.3 SOILS

The two basic soil types present in the project area are silt loams and silty-clay loams. Approximately 70 percent of the watershed consists of the Sharpsburg soil unit, which is a silt loam. This soil is known for being deep, well drained and in the B hydrologic group. It is usually found in the uplands and has a range of slope from 3 to 8 percent. The soils data used for hydrologic analysis in the JOCO study is illustrated in Figure 3-4.

The other silt loams, covering approximately 15 percent of the area are the Grundy, Kennebec, and Ladoga soil units. The Grundy unit is deep, poorly drained, is in the C hydrologic group, has a slope range of 1 to 3 percent and is found in the uplands. The Ladoga unit, also found in the uplands is found to be deep, well drained, is in the B hydrologic group and has a slope range from 3 to 15 percent. The Kennebec unit, which has a significant amount of humus, is deep, well drained, in the B hydrologic group, and is found primarily in bottom lands.

The silty-clay loam found in this study is grouped into two categories, those with deep or shallow layers. These silt clay loams make up the remaining 15 percent of the soils in the watershed. The deep layers consist of the Martin, and Orthents soil units. Both of these units have similar characteristics in that they

both are well drained, in the C hydrologic group and are primarily found in the uplands. The Martin soils can have slopes up to 11 percent while the Orthents soil unit has slopes range from 3 to 6 percent.

The shallow layers of silty-clay loam are the Sogn and Vinland soil units. These soils are primarily detritus of limestone or shale rock layers. Both are excessively drained, found in the uplands, are in the D hydrologic group, and have slope ranges from 5 to 20 percent.

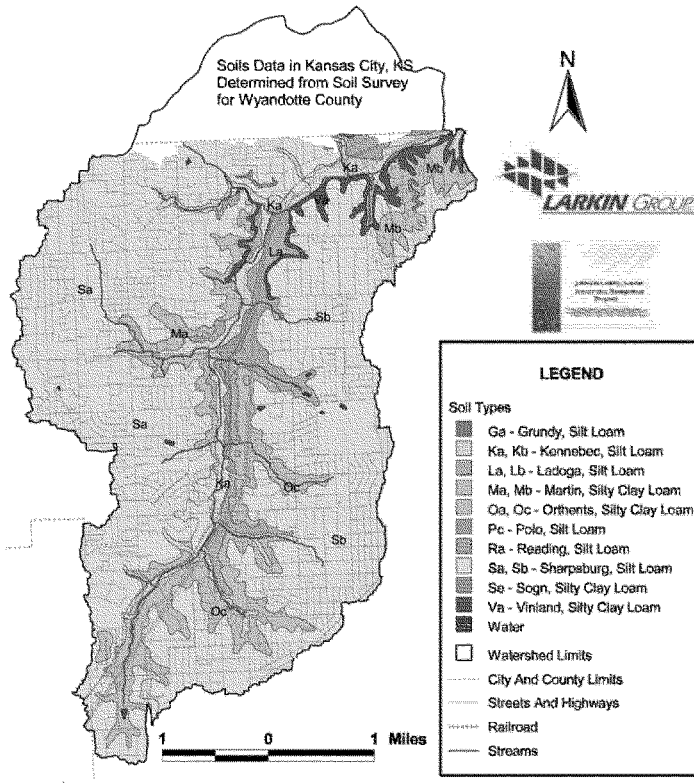


Figure 3-4. Illustration of soil types available on Turkey Creek (Modified from JOCO Figure 3-4)

3.4 SURFACE EXISTING CONDITIONS OF THE WATERSHED

The surface conditions (or land covering) are an important factor in determining the amount of precipitation that runs off the land. Analysis of surface conditions typically includes land uses, vegetation, and land conservation practices. The large majority of the JOCO study area is fully developed and urbanized including Turkey Creek Watershed (Figure 3-5). A quantitative analysis of existing land use was not required for the JOCO because the required hydrologic data was acquired from a detailed study of impervious surfaces. However, the study area can be roughly characterized as follows:

- About 36.0 square miles of the study area is urbanized and fully developed. About 0.5 square miles of undeveloped land, planned for future development is present in the Lake Quivira Watershed in western Shawnee. This undeveloped land is either pasture or woodlands. Open areas are also present in the community of Lake Quivira, but the planned use is for those areas to remain as wooded open space.
- About 60 to 70 percent of the urban area is residential usage (subdivisions of single-family homes, multi-family dwellings, and apartment complexes.
- About 20 to 25 percent of the land is used for commercial, business or institutional uses, including retail shopping, restaurants, entertainment, offices, hospitals, schools, churches and synagogues.
- Less than 5 percent of the urban land is used for light industries.
- The remainder of the urban land is open space (such as floodplain areas), parks, golf courses, or transportation corridors.
- The average percent imperviousness for the entire study area is approximately 38 percent.

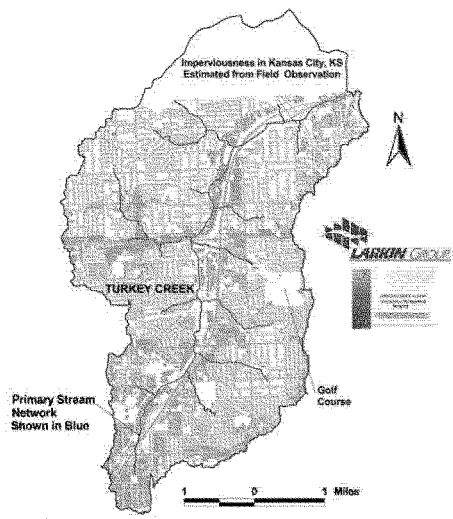


Figure 3-5. Illustration of impervious surfaces on Turkey Creek (Modified from JOCO Figure 3-5)

3.5 FUTURE WITHOUT PROJECT HYDROLOGY

The Turkey Creek watershed in the existing conditions analysis is fully urbanized and has been for some time. Therefore, any new development would essentially require demolition of existing developed areas. Additionally, according to the City of Merriam, when new developments are proposed, the City and County require that these businesses manage their stormwater using detention such that post project flows do not increase. For example, this was required of IKEA which is the most recent large project constructed in the Turkey Creek watershed. Therefore, no changes were made to the existing conditions hydrology study to account for future development.

3.6 PRECIPITATION

The precipitation values used in the HEC-1 model were determined using the 24-hour precipitation maps included in NOAA's Technical Paper Number 40 (TP-40). These values are summarized in Table 3-2. For hydrologic modeling purpose, a Soil Conservation Service (SCS) Type II temporal distribution was assumed.

Table 3-2. AEP and precipitation totals for 24 hour rainfall events based on TP-40

AEP (percentage)	Average Return Period (years)	24-hour Rainfall Amount (inches)
50	2	3.6
20	5	4.5
10	10	5.3
4	25	6.2
2	50	6.9
1	100	7.8
0.5	200	8.4
0.2	500	9.3

3.7 UPDATED PRECIPITATION

In April 2013, updated rainfall estimates for the Midwestern States were published by the National Oceanic and Atmospheric Administration (NOAA). The report is titled "NOAA Atlas 14 – Precipitation Frequency Atlas of the United States – Volume 8 – Version 2.0: Midwestern States" (Atlas 14). This publication coincided with the completion of the Alternative Formulation Briefing. By then, the feasibility level design had been completed and the project delivery team was preparing the report for the Independent External Peer Review (IEPR). One comment made by the IEPR team suggested that the hydrologic data used for design could be outdated and mentioned the recent publication of Atlas 14. This comment initiated an investigation of the potential impacts of the Atlas 14 precipitation values on the proposed NED project.

The changes in precipitation translated into modified flow-frequency relationships for the Upper Turkey Creek reach. Table 3-3 summarizes the frequency-precipitation relationship determined using Atlas 14. It should be emphasized that the Atlas 14 precipitation resulted in larger events for all frequencies especially for events with an AEP less than 2 percent. Although reformulation could not be attained, the NED plan was revised to ensure the level of protection proposed was not exceeded by the new resulting flows. Further details regarding the analysis conducted and the changes adopted in the Final NED Plan are summarized in Chapter 7

Table 3-3. AEP and precipitation totals for 24-hour rainfall events based on Atlas 14

AEP (percentage)	Average Return Period (years)	24-hour Rainfall Amount (inches)
50	2	3.7
20	5	4.7
10	10	5.5
4	25	6.8
2	50	7.8
1	100	8.8
0.5	200	9.9
0.2	500	11.4

3.8 STREAM FLOW

Johnson County, Kansas receives a mean annual rainfall of approximately 38 inches. This area is known to have intense thunderstorms between May and September that produce heavy rainfall. These storms can produce high stream flows and flooding in the area of study included in the JOCO Report. Some of these high stream flows have a short duration making Turkey Creek dangerous during these high events. Streams like Turkey Creek, that have the tendency to produce high flow and low duration peaks are referred to as flashy streams.

There is one U.S. Geological Survey (USGS) stream gage associated with the study area. This gage is identified as Gage 06893557 and is located near Ward Parkway in Kansas City, Missouri. It monitors Brush Creek downstream of the study area. The USGS has reported data for this gage since 1999 and the average annual mean stream flow for this gage is 10.31 cubic feet per second (cfs). Based on conversations with USGS Staff (Don Wilkinson) in 2002, the 100-year flow at this location has been estimated at approximately 16,000 cfs based on variety of source data, but not enough data has been collected from the gage to verify this estimate. Although this gage is not directly related to Turkey Creek, it was an important calibration tool for Larkin during the preparation of the JOCO HEC-1 model.

The Johnson County stream gage network (Storm Watch System) has four gage stations in the vicinity of the Turkey Creek watershed. These gages were only recently added in the late 1990's, and therefore, were not used as a basis for establishing the precipitation values for the hydrologic models. Two of these stream gage stations, identified as 3010 and 3020, are within the Turkey Creek Watershed (Table 3-4). These gauging stations are not set up for stream flow measurement, but collect precipitation and water level data. The location of these gages with respect to the Turkey Creek watershed is illustrated in Figure 3-6.

Table 3-4. Turkey Creek Watershed Gages in the Storm Watch Gage Network

Gage	Location	Oldest Available Record
3010	Johnson Drive	September 14, 1999
3020	65th Street	March 23, 2000

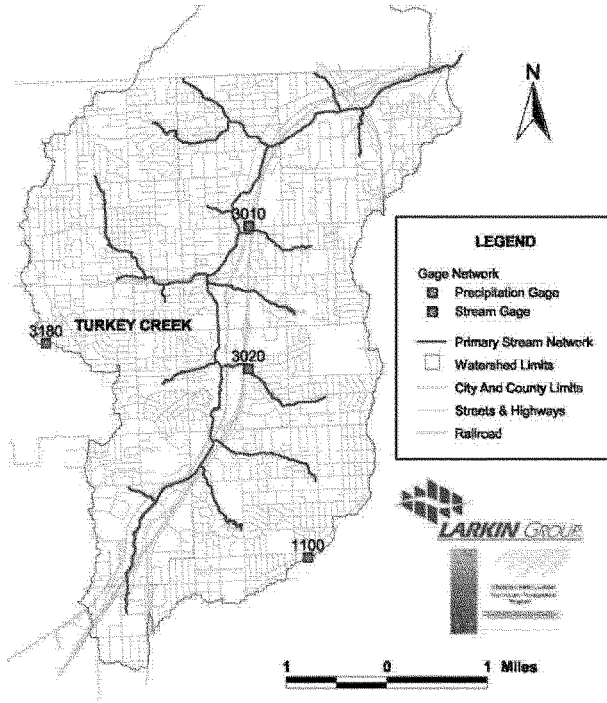


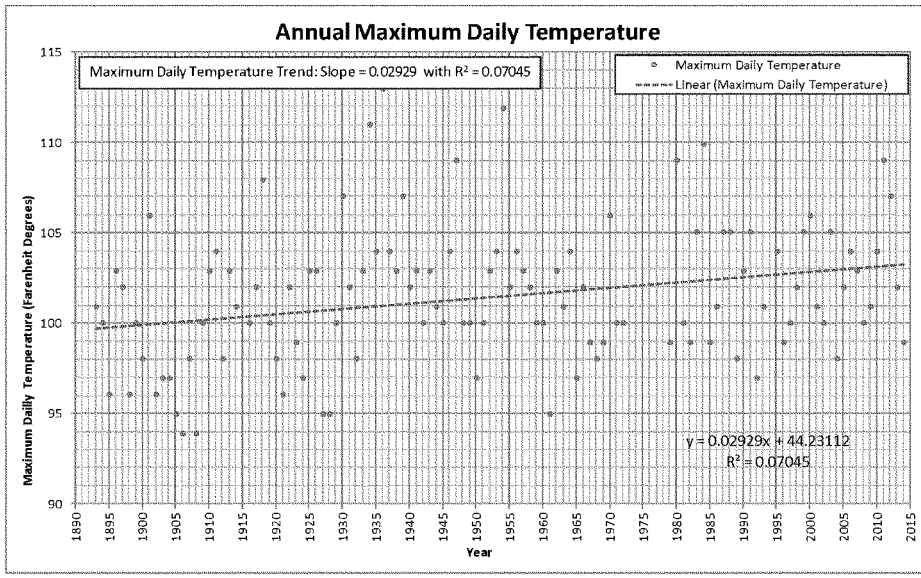
Figure 3-6. Illustration of Turkey Creek Watershed with location of precipitation and stream gages (Modified from JOCO Figure 3-3)

3.8.1 UPDATED DESIGN DISCHARGES

The design discharges were obtained from the HEC-1 model updated with the Atlas 14 precipitation values. Detailed discharge values used in the hydraulic model to determine the water surface profiles are presented in Exhibit 2.

3.8.2 CLIMATE CHANGE CONSIDERATIONS

In order to document expected changes in temperature and precipitation within the study location a trend analysis was conducted using the Kansas City weather station. This station was selected due to the long record dating back to October 1, 1893. First, annual daily maximum and minimum temperature records were analyzed to determine if temperature trends appear to be present within the study area. Figure 3-7 presents the temperature trend analysis.



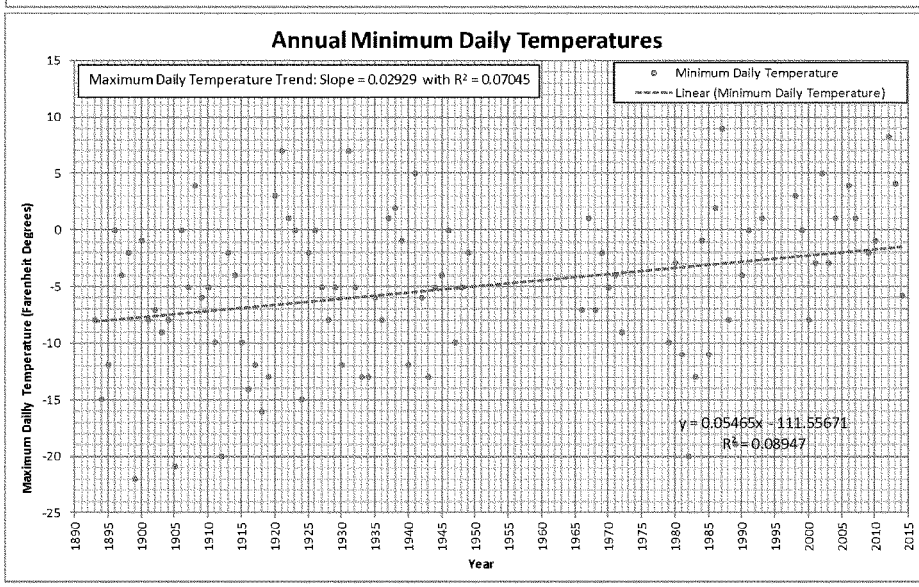


Figure 3-7. Annual maximum and minimum daily temperatures at Kansas City, Missouri

As seen in the figure, an increasing trend is present in the data. Recent studies have linked increasing temperature trends with increasing precipitation. Huntington (2006) reported recent meteorological models relating temperature and precipitation have shown a degree of proportionality between these two variables of approximately a 4.3% increase in precipitation per degree Kelvin, although this journal article was looking at mean values rather than extreme precipitation events.

Using the trendline for annual maximum temperature in Figure 3-7, an increase of 1.46 degrees Fahrenheit (0.81 Kelvin) is expected in the next 50 years. Available NOAA models suggest an average increase of 3 to 5 degrees Fahrenheit (1.6 to 2.8 Kelvin) over the next 70 years, while citing considerable uncertainty with these estimates. These projections in temperature coupled with the temperature-precipitation relationship from the Huntington (2006) study result in an estimated increase in precipitation of 3.5 to 12 percent. The NOAA model projections show less effect on annual mean precipitation with an estimated increase of less than a 5 percent with decreases modeled for summer when most major flood events occur. The largest increases are shown for winter season when few floods occur and more modest increases during spring and fall when some flood events historically occur in the Kansas City region. Figure 3-8 presents a graphic from the NOAA report which includes the state of Kansas. Climate change is discussed in more detail in Chapter 7 of the main report in accordance with ECB No. 2014-10.

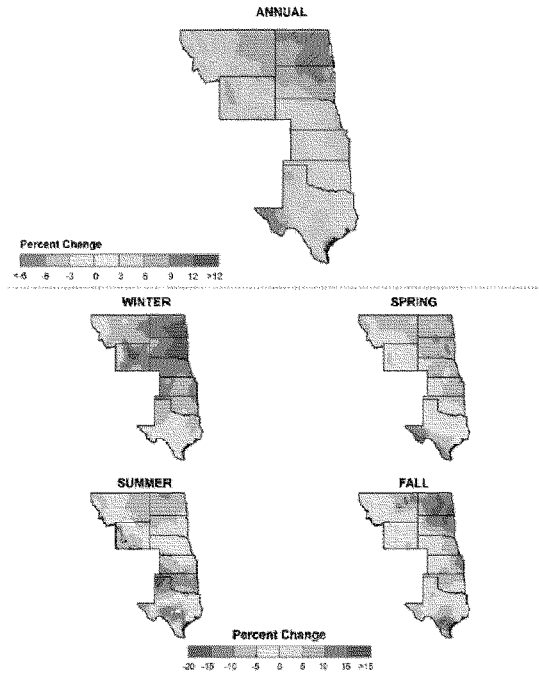


Figure 3-8. Simulated difference in annual and seasonal mean precipitation (%) for the Great Plains Region (2041-2017 with respect to the reference period of 1971-2000). From NOAA 2013.

Specific to the Upper Turkey Creek study, 24 hour precipitation values were utilized for analysis with a SCS Type II synthetic distribution. Figure 3-9 presents trend analysis for 1 to 5 day precipitation at Kansas City, Missouri.

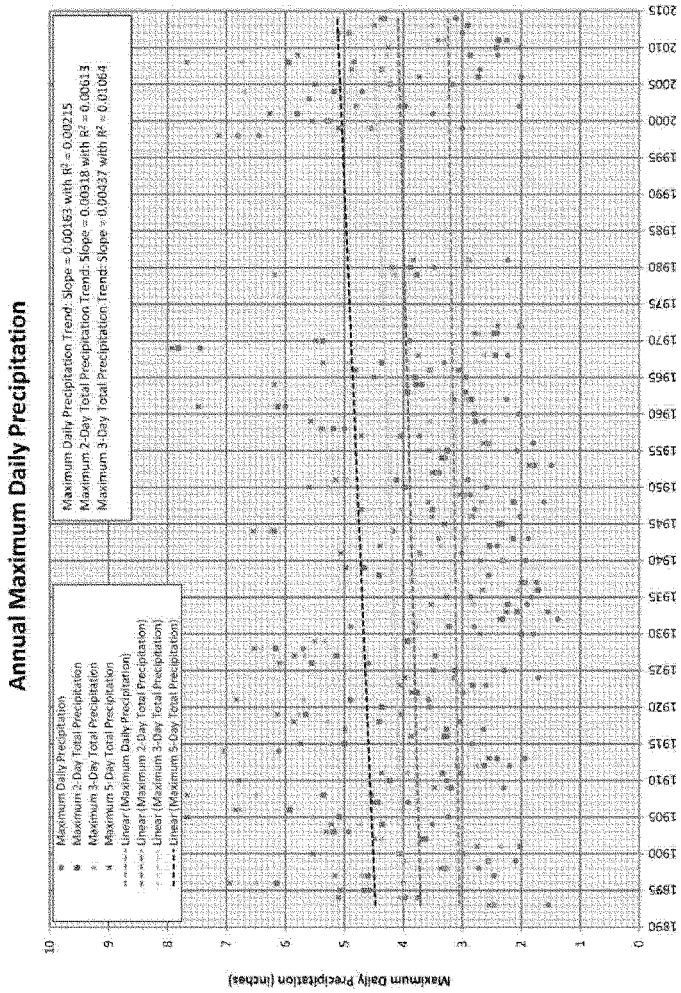


Figure 3-9. Maximum Annual Daily to Five Day Precipitation at Kansas City, MO

Figure 3-9 suggests that stronger trends are present in the five day precipitation values as compared to shorter precipitation durations. The linear trend analysis yields an increase of approximately 7%, 4.8%,

and 3.1% per degree Kelvin for the 5 day, 2 day, and 1 day durations, respectfully. Since 24 hour precipitation values with an SCS Type II distribution were utilized for the study,, the trends in 24 hour precipitation were considered the most important. Using a 3.1% increase per degree Kelvin against a range of 0.8 to 2.8 degree Kelvin increases would yield a potential difference in peak precipitation between 2.5 and 8.7 percent. This increase in precipitation could be considered proportional to the expected increases in peak flows. Considerable uncertainty exists in the trend analysis methodology as annual peak precipitation events are not necessarily coincident with periods of increased temperature, and the events are not evenly distributed. Additionally, longer term climate modeling show decreasing trends in mean precipitation during summer when most flood events occur. Generally speaking, changes less than 10% are considered within our ability to accurately measure streamflow, and the best estimate for the Kansas City area would be approximately 2.5 percent as it is based off of local trends in 24 hour precipitation versus annual maximum temperature trends. As mentioned previously, considerable uncertainty exists with this methodology.

However, while 24 hour values were used, much shorter duration intensities of precipitation are what drive peak streamflows for Turkey Creek. For example, approximately 3.5 inches of rain fell in 1 hour during the record 1998 event whereas the full storm was just over 5 inches. The SCS Type II storm distribution places over 3.9 inches of rain in one hour if using the 8.8 inch 24 hour intensity from Atlas 14, whereas the 1 hour value for Atlas 14 is 3.6 inches, indicating the methodology is already conservative by 12% for 1 hour durations. For longer durations, e.g. the three hour precipitation, the SCS Type II and Atlas 14 publication yield very similar depths. Given the way the calculations were made for Upper Turkey Creek, and the likely small projections of potential increases in extreme precipitation, the effects of climate change are expected to be insignificant for this study. Additionally, the hydrologic uncertainty analysis has considered much greater uncertainties associated with flows than are considered possible with projections from trend analysis and climate change models.

4. HYDRAULICS

4.1 BACKGROUND

Due to a recent period of rapid urban expansion Turkey Creek storm water flows have increased. The basin is now considered to be fully developed. In 1998 heavy rains caused millions of dollars in flood damage to the local communities. The existing stream-hydraulic conditions of Turkey Creek were modeled using the Hydrologic Engineering Center River Analysis System version 3.1.3 (HEC-RAS). HEC-RAS is a software developed by the USACE to conduct one dimensional steady flow river hydraulic calculations. The base of the existing Upper Turkey Creek Feasibility Study existing condition model was the JOCO hydraulic HEC-RAS model. This model was modified in 2003 by USACE engineers to incorporate the proposed new BNSF railroad bridge just downstream of Merriam.

As part of the Upper Turkey Creek Feasibility Study, the Louis Berger Group (LBG) used HEC-RAS flood models that were provided by both USACE and JOCO. The JOCO model, which was based on earlier USACE modeling efforts, was used for the Merriam portion of Turkey Creek because it had recently undergone review by the Federal Emergency Management Association (FEMA) and once approved the model would set the limits for 100-year FEMA firm mapping. The JOCO model was used for flood reduction improvements within the downtown Merriam area. This area sustained the most damage during the 1998 flood and was the focal point of the FDR study. The channel modifications within this area were predominantly bounded by the Shawnee Mission Parkway and Merriam Drive bridges. The USACE model was used to study flood reduction measures within the Roe Lane Industrial Park. This area is located at the downstream end of the Upper Turkey Creek reach in Wyandotte County between Route 69 and Roe Lane. This area not only floods from channel overtopping but also has back flooding problems through a rail opening in the route 69 bridge. Both models were combined into a single existing conditions model to establish a baseline to evaluate the proposed alternatives during the feasibility phase.

4.2 EXISTING CONDITIONS HEC-RAS MODEL DEVELOPMENT

The JOCO model was developed using the critical depth methodology without due consideration to the Wyandotte County cross-sections from an earlier USACE Turkey Creek model. As the areas evaluated by JOCO and USACE are contiguous, changes within either study area could potentially impact upstream and downstream areas. To eliminate any uncertainty of these potential impacts, USACE sought to create a model that incorporated the FEMA FIRM mapping efforts with the USACE modeling efforts to provide a comprehensive understanding of the two study areas. It was therefore necessary to integrate this portion of the model back into the USACE model, incorporate the Wyandotte County cross-sections into the new model, re-configure the baseline to reflect the findings of the JOCO model and model the conditions under eight different storm events (2, 5, 10, 20, 50, 100, 200, and 500-year).

4.2.1 UPPER TURKEY CREEK REACHES

This combined HEC-RAS model is considered the existing condition hydraulic model for the Upper Turkey Creek Feasibility Study. In this HEC-RAS model, the main channel reaches are identified in general as TC-M## and the tributaries as TR## (in which ## represents a two digit identification number). The model consists of 13 reaches of which five comprise Turkey Creek main channel, five comprise the two tributaries, and the others are used to model various split flows during high stage flood events. Table 3-5 includes all the reaches included in the existing model and Exhibit 1 illustrates the location of the reaches over an aerial photo.

Table 3-5. Reaches included in the Upper Turkey Creek Existing Condition HEC-RAS Model

Reach	Cross Sections	Remarks
TC-M120	7.508 to 5.647	Turkey Creek upstream reach
TC-M85	-0.073 to -0.504	Reach between I-35 Bypass and RR Bypass
TC-M81	-0.524 to -1.272	Turkey Creek along split with RR Bypass
TC-M80	5.513 to 0.217	Largest reach of Turkey Creek in model
TC-M80a	0.115 to 0.001	Turkey Creek along split with I-35 Bypass
TRIB88	6.771 to 6.756	Upstream of TRIB85
TRIB87	6.760 to 6.743	Upstream of TRIB85
TRIB85	6.712 to 5.855	Combined downstream with TRIB 81
TRIB81	6.708 to 5.649	Combined downstream with TRIB 85
TES-87	5.900 to 5.807	Floodplain cross section perpendicular to TC-M120 (Junction of TRIB81 and TRIB85)
I-35 Bypass	0.115 to 0.001	Split flow parallel to TC-M80a
RR Bypass	-0.525 to -0.590	Split flow parallel to TC-M81
ITC	-1.344 to -1.479	Turkey Creek downstream reach (discharge from RR-Bypass

Because the original JOCO model does not have reaches that terminate at the shared county line, some investigation of reach TC-M85 was required before merging the two models could be accomplished. In the JOCO model, this reach only contains three sections. One of these sections contains the downstream boundary condition. In the USACE model, the reach contains many more sections and continues downstream into Wyandotte County where it terminates into additional reaches. Because of this difference the three related sections from both models, stations -0.073, -0.132 and -0.206, were compared to ensure they contained identical geometry and coding. The resulting comparison indicated that the sections matched, the entire reach from the USACE model seamlessly replaced TC-M85 within the JOCO model allowing additional reaches within Wyandotte County to be imported. The JOCO boundary condition was changed to reflect the new downstream terminus station within the reach designated as ITC, river station -1.479. The downstream boundary condition was also changed from "critical depth" to "rating curve" in order to reference data created by the USACE which evaluates water surface dependant flow rates. Use of this rating curve more accurately portrays the connectivity with the Lower Turkey Creek river system.

Junction 9, which connects reaches I-35 Bypass and TC-M80a to TC-M85, was updated to include junction length data found in the USACE model. This data helps to minimize calculation errors associated with energy losses across complicated river junctions. Three additional areas within the Johnson County portion of the UTC-Existing model were updated with information from the USACE model: Piers within the bridge section at river station 0.061 in reach TC-M80a were repositioned so that they accurately reflected bridge deck coding; An ineffective area marker was added to the overbank area at station 2.312 of reach TC-M80. Terrain and bridge modifications between TC-M80 stations 2.002 to 2.12 were necessary to reflect the BNSF rail bridge reconstruction which required extensive recoding.

4.3 EXISTING CONDITIONS HEC-RAS MODEL – ATLAS 14 DISCHARGES

The results from the Atlas 14 based HEC-1 model translated into new flow-frequency relationships for the Upper Turkey Creek reach. The Q-break locations in the original model were evaluated to determine the correct expected channel discharges produced by the Atlas 14 updated rainfall values.

In general, the Atlas 14 discharges were higher than the original estimates. The minimum average increase in discharge was determined to be 2% for the 20-percent ACE event and the maximum average increase was approximately 17% for the 0.2-percent ACE event. Typically, the average increase augmented with lower frequencies except between the 50- percent and the 20-percent ACE events. The average flow increase for the 50-percent ACE event was 3% while the average flow increase for the 20-percent ACE event was 2%. Exhibit 2 summarizes the design discharges based on TP-40 and Atlas 14 and the flow change locations in the HEC-RAS model.

4.4 EXISTING CONDITIONS HEC-RAS MODEL – RESULTS

In addition to the flow updates, the HEC-RAS model version was also updated from version 3.1.3 to version 4.1.0. The tabular results from the HEC-RAS model are included in Exhibit 3. The 10%, 2%, 1%, and 0.2% ACE water surface profiles of the UTC main channel – which include model reaches TC-M81, TC-M85, TC-M80a, TC-M80, and TC-M120 – are illustrated in Exhibit 4.

4.5 FUTURE CONDITIONS HYDRAULIC ASSUMPTIONS

Potential future changes in the river morphology due to natural and or man made changes were considered to be negligible. Factors considered include:

1) Construction of new bridges, although none are currently known to be scheduled for replacement or construction, would be expected to occur with zero rise requirements due to the community's active participation in the national flood insurance program. Potential future development in the floodway would be limited for similar reasons, along with the presence of I-35 and park lands which would essentially make such development infeasible.

2) Final stages of construction of the Corps Lower Turkey Creek project are in progress. The project has a documented no rise certification dated November 18, 2014 from HNTB, and results in a drop of water surface that extends approximately 1,200 feet upstream of the project then converges with the pre-project profiles approximately 4 miles downstream of the Upper Turkey Creek Project.

3) The Merriam Drainage District has a strong operational budget and regularly performs maintenance of the channel within the project limits if any large deposits of rock or debris are observed.

5. PROPOSED CONDITIONS

5.1 INTRODUCTION

LBG initially attempted to store potential flood flows within upstream watershed areas of Turkey Creek by creating detention basins within certain existing or proposed over bank areas. After extensive work with both the HEC-1 and HEC-RAS models, it was determined that the available volume of flood storage was not sufficient to significantly reduce peak flood flows. Most of the available land was already being modeled as flood storage within the HEC-1 model and additional modifications in these areas did not provide sufficient storage volume to reduce flood levels within downtown Merriam. LBG also investigated the possibility of using a bypass tunnel. This concept was dismissed due to the extreme costs associated with this type of construction. Because the storage and bypass concepts were not feasible, LBG focused on methods of channel modification and widening to improve flood conditions. Three methods of flood protection were developed in the hydraulic analysis included: 1) channel widening; 2) levee and flood wall installation; and 3) a combination of channel widening, levees and flood walls.

Following the creation of the alternatives, data was extracted from the model and the water surface elevations were analyzed to determine the level of protection each alternative provided within the immediate project area. It was also required to demonstrate that the alternatives did not raise water surface profiles upstream of the project area. Following the creation of the various alternatives, the models were run, the data was extracted, and the extent of flooding was determined. Exhibit 1 displays the area of Upper Turkey Creek and its associated watershed versus the HEC-RAS configuration.

5.2 ALTERNATIVE NOMENCLATURE

For the purpose of distinguishing between the latest versions of the contiguous model data and previous models and GIS submissions, it was necessary to develop a unique file naming convention during the modeling process. The new convention had a 12 character limit due to HEC-RAS file name length restriction. The new naming convention, UTC_A#_###_A, consists of four variables separated by an underscore (example: UTC_A1_050_E). The first variable (UTC) denotes the project location as Upper Turkey Creek. The second variable (A#) denotes the alternative and number. The number represents the method of flood protection: (1) Channel Widening; (2) Levee and flood walls; or (3) Combination of channel widening and levee/flood walls. The third variable (###) represents the level of protection provided by the alternative for a given storm year. Three levels of protection have been formulated during this study; the 10-percent AEP (10-year event [010]), the 2-percent AEP (50-year event [050]), and the made to major bridge structures within the project areas. The alpha character will be either an M (Modified) or an E (Existing). In alternatives denoting the E, major bridges were not modified to accommodate storm flows. In alternatives with the M, only structures impeding storm flows for the desired level of protection were modified. Since the existing conditions contiguous model, also known as future without project, should keep the same nomenclature format the (A#) variable would be replaced with an EX to represent existing (example: UTC_EX_###_E). The last variable (A) represents whether modifications have been made to major bridge structures within the project areas. The alpha character will be either an M (Modified) or an E (Existing). In alternatives denoting the E, major bridges were not modified to accommodate storm flows. In alternatives with the M, only structures impeding storm flows for the desired level of protection were modified. Since the existing conditions contiguous model, also known as future without project, should keep the same nomenclature format the (A#) variable would be replaced with an EX to represent existing (example: UTC_EX_###_E).

5.3 DESCRIPTIONS OF ALTERNATIVES

The following flood damage reduction alternatives were analyzed using HEC-RAS 3.1.3. The alternatives were prepared for the 10-percent AEP (10-year event), 2-percent AEP (50-year event), and the 1-percent AEP (100-year event). For levee and flood wall alternatives and combination alternatives, 0.5-percent AEP (200-year event) and 0.2-percent AEP (500-year event) were also considered. Some alternatives require the replacement of a small foot bridge at river station 3.568, within reach TC-M80, to accommodate levee or channel widening. It should be noted that replacement of this minor bridge does not encompass the same level of effort or expense as modifying a major structure such as the Merriam Road bridge. Where channel widening is included in the proposed modifications, it was necessary to widen some bridge sections to accommodate excavation. Another modification to the alternatives was the removal of the inline structure at station 3.23. This structure does not appear to act as a channel restriction until the proposed channel shape modifications are performed. The 2006 aerial imagery was checked to confirm the location, type, and purpose of the structure prior to removal. Based on the aerial imagery, the channel has been relined with limestone blocks and no inline structures, weirs, large culvert openings, or tributary connections are located between sections 3.225 and 3.231. The location remains as a river mile station within the HEC-RAS model, however, the section elevation data for the structure was removed. Table 3-6 provides a summary of the HEC-RAS project model alternatives and respective nomenclature.

Table 3-6. Model Alternatives Nomenclature

Alternative	Type of Improvement	Annual Exceedance Probability
UTC_A1_010_E	Channel Widening	10-percent AEP (10-year event)
UTC_A1_050_E	Channel Widening	2-percent AEP (50-year event)
UTC_A1_050_M	Channel Widening	2-percent AEP (50-year event)
UTC_A1_100_E	Channel Widening	1-percent AEP (100-year event)
UTC_A1_100_M	Channel Widening	1-percent AEP (100-year event)
UTC_A2_10_E	Levee or Flood Wall	10-percent AEP (10-year event)
UTC_A2_50_E	Levee or Flood Wall	2-percent AEP (50-year event)
UTC_A2_100_E	Levee or Flood Wall	1-percent AEP (100-year event)
UTC_A2_200_E	Levee or Flood Wall	0.5 percent AEP (200-year event)
UTC_A2_500_E	Levee or Flood Wall	0.2 percent AEP (500-year event)
UTC_A3_010_E	Combination	10-percent AEP (10-year event)
UTC_A3_050_E	Combination	2-percent AEP (50-year event)
UTC_A3_050_M	Combination	2-percent AEP (50-year event)
UTC_A3_100_E	Combination	1-percent AEP (100-year event)
UTC_A3_100_M	Combination	1-percent AEP (100-year event)
UTC_A3_200_E	Combination	0.5 percent AEP (200-year event)
UTC_A3_500_E	Combination	0.2 percent AEP (500-year event)

5.3.1 FUTURE CONDITIONS WITHOUT PROJECT

The Future Conditions Without Project is the product of integrating two Turkey Creek HEC-RAS models into one contiguous model as discussed previously. This model simulates water surface elevations based on current stream configurations, channel shapes, overbank areas, and storm flow data. This model does

not simulate the effects of structural or channel modifications within the Turkey Creek river basin. The assumption was made that any river, creek, or tributary erosion or storm related damage would be addressed and fixed at the county level and that the basin systems and characteristics modeled would remain within a sufficient margin of deviation.

5.3.2 ALTERNATIVE 1 – CHANNEL WIDENING

Channel widening was considered in areas where over bank expansion was available. Because the majority of the channel currently has a hard slate bottom, channel bottom excavation was kept to a minimum. The proposed channel bottom width was kept constant, wherever possible, with a maximum side slope in most areas of 2H:1V, which requires the channels to be lined with either rip rap bio-stabilization or concrete block measures. These techniques are more ascetically appealing and less expensive than concrete channel hardening measures. Areas that require slopes in excess of 1H:1V (steeper) were treated with hardened revetments such as pre-cast retaining wall block or the local limestone blocks currently used in some downtown areas.

5.3.2.1 UTC_A1_010_E

Channel widening alternative using channel bottom widths ranging from 40 to 60 feet and 3H:1V side walls throughout downtown Merriam. The intent was to only to modify sections that could not accommodate the 10-percent AEP (10-year event). Through the Roe Lane Industrial Park, a narrower bottom width of 30 feet was used with a 1H:1V side slope because of limited available overbank area. The bottom of the channel was also modified to have an approximate slope of 0.0043 ft/ft to promote a consistent energy slope through the industrial park and reduce over bank flooding.

5.3.2.2 UTC_A1_050_E

Channel widening alternative using a channel bottom width of 60 feet and 2H:1V side slope for the reach between Shawnee Mission Drive and Merriam Drive. Sections 3.690 and 3.665, immediately upstream of Shawnee Mission Drive, have an increased channel bottom width to accommodate the main stem and tributary confluence of flows. In an effort to minimize excavation where possible, just the channel side slopes were modified to conform to the 2H:1V slope with rip rap bio-stabilization measures. The proposed channel through the Roe Lane Industrial Park has a bottom width of 50 feet with a 1H:1V sloped side wall. The bottom of the channel was excavated at an approximate slope of 0.0043 ft/ft to promote a consistent energy slope through the industrial park to reduce over bank flooding.

5.3.2.3 UTC_A1_050_M

For this alternative, the UTC_A1_050_E channel geometry was used with structural modifications made to the Shawnee Mission and Merriam Drive bridges. Some channel modifications were made upstream of Shawnee Mission, between sections 3.855 and 3.711, to improve the transition of the channel to the wider bridge opening. The four existing 14-foot wide culverts were removed and replaced with a 210-foot span supported by six piers spaced at 30-foot intervals. The lower bridge deck was raised 2.4 feet to enable the 2-percent AEP (50-year event) flow to pass through the bridge openings without overtopping. This bridge design also allows the 1-percent AEP (100-year event) flow to pass without overtopping the bridge deck while locally staying within the 2-percent AEP (50-year event) design channel. The existing culverts were a major restriction and caused the water surface to overtop the bridge at 5.77 feet above the top of culvert. The Merriam Drive bridge span was increased from 53 feet to 88 feet with four equally spaced piers. The bottom of the deck was raised one foot to accommodate the 2-percent AEP (50-year event) flows.

5.3.2.4 UTC_A1_100_E

Channel widening alternative utilizing 100-foot bottom widths and 2H:1V sloped side walls for the reach between Shawnee Mission Drive and Merriam Drive. Due to structural obstructions or topographical restrictions, some sections within this reach were coded to provide a transition to the proposed 100-foot

channel bottom width while maintaining the 2H:1V side slope. The pedestrian bridge at section 3.568 was modified to span 160 feet with a vertical clearance height of 4 feet which helped reduce flood levels by 6.87 feet at the upstream bridge section.

5.3.2.5 UTC_A1_100_M

Channel widening alternative using 100-foot bottom widths with 2H:1V sloped side walls for the reach between Shawnee Mission Drive and Merriam Drive. Due to structural obstructions or topographical restrictions, some sections within this reach were coded with less than the proposed 100-foot channel bottom width while maintaining the 2H:1V side slope. For the purpose of lowering water surface elevations in downtown Merriam, modifications were made to both the Shawnee Mission and Merriam Drive bridges. The Shawnee Mission Drive Bridge was enlarged to span 210 feet across six piers. The lower bridge deck was raised 2.85 feet to insure that the deck would not obstruct storm flows. Between sections 3.855 and 3.665, the channel bottom width transitioned to 200 feet to accommodate the new bridge openings. This proposed bridge and channel configuration reduced the upstream water surface by approximately 6 feet and reduced overtopping the road. The pedestrian bridge at section 3.568 was modified to span 160 feet with a vertical clearance height of four feet which helped reduce flood levels by 6.87 feet at the upstream bridge section. The Merriam Drive Bridge was enlarged to conform to the new channel shape. The proposed bridge spans 179 feet across seven piers. The lower bridge deck elevation was also raised by one foot. The alternative still required channel geometry modifications as found in alternative UTC_A1_100_E.

5.3.2.6 UTC_A1_200_E

The Channel widening alternative developed for the 0.5-percent AEP (200-year event) utilizes the same channel configuration as the 1-percent AEP (100-year event) channel alternative (UTC_A1_100_E) due to the limitations in land area required to create a wide enough channel that would contain the storm event. This configuration does not contain the entire 0.5-percent AEP (200-year event) at all locations within the project area, but it does reduce the 0.5-percent AEP (200-year event) water surface profile approximately 0.75 feet in the Merriam project area.

5.3.2.7 UTC_A1_500_E

The Channel widening alternative developed for the 0.2-percent AEP (500-year event) is utilizing the same channel configuration at the 1-percent AEP (100-year event) channel alternative (UTC_A1_100_E) due to the limitations in land area required to create a wide enough channel that would contain the storm event. This configuration does not contain the entire 0.2-percent AEP (500-year event) at all locations within the project area, but it does reduce the 0.2-percent AEP (500-year event) water surface profile approximately 0.68 feet in the Merriam project area.

5.3.3 ALTERNATIVE 2 – LEVEE AND FLOOD WALL INSTALLATION

Another flood abatement measure modeled was the installation of levees and flood walls. A levee wall is a compacted earthen mound that has 2 1/2H to 1V side slopes with a 10-foot crown regardless of levee height. Flood walls were used when space requirements for levees was greater than the available over bank area. The proposed flood walls would consist of a reinforced concrete retaining wall with a minimum thickness of two feet.

After hydrology was updated to incorporate Atlas 14, an additional alternative was formulated called Alternative 2G in the main body of the report as discussed in Section 5.3.3.2.

5.3.3.1 UTC_A2_010_E, UTC_A2_050_E, UTC_A2_100_E, UTC_A2_200_E, and UTC_A2_500_E

These alternatives involve the installation of concrete flood walls and/or earthen levees in the downtown Merriam area. Three levels of protection have been evaluated using flood prevention techniques in order to protect against 10-percent AEP (10-year event), 2-percent AEP (50-year event), 1-percent AEP (100-

year event), 0.5-percent AEP (200-year event), and the 0.2-percent AEP (500-year event). The coding within HEC-RAS does not distinguish between levee and flood walls, but does acknowledge the presence of a water retaining structure. Levee walls consist of an earthen embankment with a vegetative surface with 2 1/2H:1V side slopes and a 10-foot crown. The levee heights vary dependent upon location and water level protection needs, but a maximum levee height of eight feet was determine for the 0.2 percent AEP. Flood walls are reinforced concrete retaining wall structures which vary in height depending on location and water level protection requirements. As a supplement to the levee and flood wall protection measures, the inclusion of reinforced headwalls at bridge crossings reduced the risk of overtopping during flood events.

The downtown Merriam's levee system is bounded by the Shawnee Mission Parkway and Merriam Drive bridges. These bridges will require the installation of reinforced headwalls. Two of the UTC_A2 alternatives modified the pedestrian bridge located at station 3.568. Alternative UTC_A2_050_E requires a new bridge which spans 160 feet across the new levee walls. For Alternative UTC_A2_100_E, the proposed bridge would span 320 feet across the new levee walls. This alternative uses existing overbank area for floodway flow thus increasing the distance between the levee walls. If it is determined that additional structural support is required, piers could be added to shorten the overall span. However, placement of these piers would be limited to outside the main channel area. At a minimum, these bridges should provide a vertical clearance equal to that of the levee height in the area. The replacement of this bridge is necessary to reduce water surface elevations and the floodwall height in the area.

5.3.3.2 Alternative 2G (added after the hydrology update to Atlas 14)

A new alternative 2G was formulated following updates to Atlas 14 flows to provide a similar product to the pre-Atlas 14 tentative selected plan (TSP) 2D. Alternative 2D, which had 2.5 feet of freeboard above the 1% ACE event, happened to meet USACE reliability criteria for National Flood Insurance Program (NFIP) levee accreditation requirements by providing over 90% assurance of passing the 1% ACE event. In formulating Alternative 2G, freeboard requirements of FEMA were also considered relevant assuming a private engineering firm may perform the NFIP levee certification. FEMA requires a minimum 3 feet of freeboard above the 1% ACE event and an additional 1 foot of freeboard within 100 feet of bridges, which would include any headwalls on the bridges in this case. In order to pass these flows with feasible levee and bridge headwall heights, Alternative 2G required additional modeling and analysis of the Merriam Drive Bridge and the addition of a triple 5 feet by 5 feet box culvert on the right side of the existing bridge opening. The modeling approach utilized a new lateral structure at river station 2.718 connecting to the creek downstream of the bridge at river station 2.623. The triple 5x5 feet structure would be a 300 feet long box culvert with an upstream invert elevation of 897.9 feet and downstream invert of 896 feet. Mannings roughness was set at 0.013 for the culvert. This alternative generally resulted in a 2 feet higher floodwall for most of the reach as compared to Alternative 2D. Without the triple box culvert and only raising levees and bridge headwalls, water surfaces would increase approximately 5.2 feet just upstream of the Merriam Drive Bridge compared to the 1% ACE event TP40 based flow profiles, bringing the headwall to infeasible heights.

5.3.4 ALTERNATIVE 3 – COMBINATION OF CHANNEL WIDENING, LEVEES, AND FLOODWALLS

The combination alternative was created with the intent of minimizing the width increase of channel widening by introducing a levee wall where needed. It was anticipated that a combination of the two flood abatement measures would be more cost effective than levees or flood walls alone while providing better flood protection than channel widening alone.

5.3.4.1 UTC_A3_010_E

Combination alternative using a typical channel bottom width of 50 feet with 3H:1V sloped side walls through downtown Merriam. A few channel sections downstream of Shawnee Mission Parkway have an increased channel bottom width of 70 feet in order to accommodate the main stem and tributary confluence of flows. As with previous alternatives, this alternative followed the convention of modifying sections that could not accommodate the 10-percent (10-year event). Levee and flood wall systems were used between sections 3.231 and 2.651 to either contain flood flows or provide a minimum of two feet of freeboard protection. The pedestrian bridge at section 3.568 was modified to span 114 feet with a vertical clearance height of three feet above the bank elevation which reduced flood levels by 3.87 feet at the upstream bridge section.

5.3.4.2 UTC_A3_050_E

Combination alternative using a typical channel bottom width of 60 feet with 2H:1V side wall slopes through downtown Merriam. A few channel sections downstream of Shawnee Mission Parkway have been modified to 90 and 120 feet widths in order to accommodate the main stem and tributary confluence of flows. Wherever practical, the alternative followed the convention of only modifying sections that could not accommodate the 2-percent AEP (50-year event). Levee and flood wall systems were used between sections 3.420 and 2.440 to either contain flood flows or provide a minimum of two feet of freeboard protection. Protection heights generally remained at or below three feet. The pedestrian bridge at section 3.568 was modified to span 114 feet with a vertical clearance height of three feet above the bank elevation which reduced flood levels by 3.88 feet at the upstream bridge section.

5.3.4.3 UTC_A3_050_M

Combination alternative using a typical channel bottom width of 60 feet with 2H:1V side wall slopes through downtown Merriam. A few channel sections upstream and downstream of Shawnee Mission Parkway have been modified to transition to and from the modified 210-foot bridge opening. The bridge was enlarged to span 210 feet over six evenly spaced piers. The lower bridge deck was raise by 2.4 feet to accommodate storm flows. Downstream of the proposed bridge the channel transitions back to its existing shape over a tenth of a mile. The alternative geometry was typically the same as that found in alternative UTC_A3_050_E. The pedestrian bridge at section 3.568 was modified to span 114 feet with a vertical clearance height of three feet to reduce flood levels by 3.23 feet at the upstream bridge section. The Merriam Drive Bridge was enlarged to an 88-foot span supported by four piers. The channel sections immediately upstream and downstream of the bridge were enlarged to a 95-foot bottom with 1H:1V side wall slopes. Through Roe Lane, a bottom width of 50 feet was used with a 1H:1V side wall slope. The bottom of the channel was also modified to have an approximate slope of 0.0043 ft/ft to promote a consistent energy slope through the industrial park and reduce over bank flooding.

5.3.4.4 UTC_A3_100_E

Combination alternative using a typical channel bottom width of 100 feet with 2H:1V side wall slopes through downtown Merriam. The pedestrian bridge at section 3.568 was modified to span 167 feet with a vertical clearance height of four feet which reduced flood levels by 6.87 feet at the upstream bridge section.

5.3.4.5 UTC_A3_100_M

Combination alternative utilizing 100-foot bottom widths with 2H:1V sloped side walls for the reach between Shawnee Mission Drive and Merriam Drive. Due to structural obstructions or topographical restrictions, some sections within this reach were coded with less than the proposed 100-foot channel bottom width while maintaining the 2H:1V side slope. For the purpose of lowering water surface elevations in downtown Merriam, modifications were made to both the Shawnee Mission and Merriam Drive bridges. The Shawnee Mission Drive Bridge was enlarged to span 210 feet across six piers. The

lower bridge deck was raised by 2.40 feet to insure that the deck would not obstruct storm flows. Between sections 3.855 and 3.690, the channel bottom width transitioned to 200 feet to accommodate the new bridge openings. This proposed bridge and channel configuration reduced the immediate upstream water surface by an average of approximately four feet when compared to water surface elevations from UTC_A3_100_E. This bridge modification also reduced the upstream water surface by an average of 1.47 feet with the reduction affecting nearly a one-half mile of stream. The pedestrian bridge at section 3.568 was modified to span 160 feet with a vertical clearance height of four feet which reduced flood levels by 6.87 feet at the upstream bridge section in comparison to existing conditions. The Merriam Drive Bridge was enlarged to conform to the new channel shape. The proposed bridge spans 179 feet across seven piers. The lower bridge deck elevation was also raised by one foot. This modification reduced water surfaces an average of 2.23 feet for a distance of 0.65 miles upstream when compared to the existing structure used in alternative UTC_A3_100_E. The largest water surface drops can be found in the fourth of a mile immediately upstream of Merriam Drive. These reductions are as large as 3.44 feet below those found in the UTC_A3_100_E alternative. This bridge modification reduced the levee and flood wall protection heights throughout the Merriam Downtown area by an average of 2.23 feet, over a distance of approximately 0.68 miles.

5.3.4.6 UTC_A3_200_E

The Channel widening alternative developed for the 0.5-percent AEP (200-year event) utilizes the same channel configuration as the 1-percent AEP (100-year event) channel alternative (UTC_A3_100_E) due to the limitations in land area required to create a wide enough channel that would contain the storm event. This configuration does not contain the entire 0.5-percent AEP (200-year event) at all locations within the project area, but it does reduce the 0.5-percent AEP (200-year event) water surface profile approximately 0.75 feet in the Merriam project area. Additional levees along sections of the creek, required to contain the 0.5-percent AEP (200-year event), are included.

5.3.4.7 UTC_A3_500_E

The Channel widening alternative developed for the 0.2-percent AEP (500-year event) is utilizing the same channel configuration at the 1-percent AEP (100-year event) channel alternative (UTC_A3_100_E) due to the limitations in land area required to create a wide enough channel that would contain the storm event. This configuration does not contain the entire 0.2-percent AEP (500-year event) at all locations within the project area, but it does reduce the 0.2-percent AEP (500-year event) water surface profile approximately 0.68 feet in the Merriam project area. Additional levees along sections of the creek, required to contain the 0.2-percent AEP (500-year event).

5.4 BRIDGE MODIFICATION

A separate modeling scenario was created in addition to the scenarios described above. The plan incorporated the geometry of Alternative 2 and focused on the 1-percent AEP (100-year event) level of protection. The existing bridge at river station 2.636 was modified by having an increased width to prevent overtopping at Merriam Drive.

5.5 QUALITY CONTROL REVIEW

Following the coding of the various alternatives in each of the models, a quality control review was conducted to ensure that errors and omissions were removed from the modeling scenarios.

LBG performed a quality assurance/quality control (QA/QC) review of the Upper Turkey Creek HEC-RAS model on September 15-16, 2010. Personnel from LBG with experience with the HEC_RAS model were involved in the review to check the items listed as follows:

1. Project geometry for each HEC-RAS Plan to make sure each section was consistently representing conditions associated with each plan scenario.
2. Roughness coefficients for each section in each HEC-RAS Plan to make sure they consistently represented conditions associated with each plan scenario.
3. Bridge geometry for each HEC-RAS Plan to make sure each bridge was consistently representing conditions associated with each plan scenario.
4. Levee locations and heights for each plan scenario to make sure they had two feet of freeboard for each hydrologic condition.
5. Water surface elevations, energy grade lines, velocities, and Froude numbers in association with certain sections that were showing a slight increase in water surface elevations even though the channel was being widened. The geometry was verified to ensure accuracy and consistency.
6. Left bank, right bank, and main channel flow rates and where bank locations were set (to compare the effects of improved channels on overbank flow where there were slight increases due to reduced energy grade lines and velocities at certain cross section locations).
7. Excel spreadsheet showing comparison of water surface elevations for proposed conditions with existing conditions to make sure there were no errors in transporting data from HEC-RAS to the Excel spreadsheet. (It should be noted that initial inconsistencies were due to transposition errors in the original data provided to the USACE for review. This was subsequently discovered and corrected before this QA/QC review took place).
8. LBG corrected the roughness coefficients at one stream section (River Station 3.165) where there were inconsistent water surface elevation results.

5.6 PREFERRED ALTERNATIVE MODEL RESULTS

After the evaluating the proposed alternatives, Alternative 2 was selected as the preferred alternative. This alternative, originally designed for the TP-40 based flows, was found sufficient to maintain the Atlas 14 based flows within the channel banks. The proposed features are located along the HEC-RAS model reach identified as TC-M80 (reach of interest). Additional alternatives fully designed to accommodate the Atlas 14 based flows with reliability above 90% were also evaluated but found cost prohibitive and unacceptable aesthetically by the sponsors. The reliability of the current preferred alternative is under 90% and this was communicated to the sponsors. Figure 3-10 illustrates the 1% ACE water surface elevation profile obtained with the TP-40 based flows and the Atlas 14 based flows. A table summarizing the HEC-RAS model results for the reach of interest is included in Exhibit 5. Additionally, the 10%, 2%, 1%, and 0.2% ACE water surface profiles for the same reach are illustrated in Exhibit 6.

The design team acknowledges that, due to the presence of bridge headwalls, the pressure flow conditions which will occur under Merriam Bridge will have the potential to cause scour. Based on the model results, which uses Atlas 14 flows, velocities will nearly double under pressurized conditions when compared to pre-project conditions. However, the bed material under Merriam Bridge is mostly exposed bedrock.

Although the formation of a scour hole under the bridge is possible, it will take long term sustained high flows and velocities to form it and Turkey Creek is characterized mainly for its short duration floods. The team expects that if a scour hole under the bridge develops in the future, its formation will be slow and countermeasures to mitigate it could be implemented before placing the bridge stability in danger. The concern of contraction scour is also possible and addition of revetment upstream and downstream from

the Merriam Bridge was included in the cost risk analysis. The feasibility design team will recommend a detailed evaluation of the pressure flow conditions according to FHWA (2012) and appropriate bridge scour countermeasures consistent with FHWA(2012, 2009) and USACE EM 110-2-1601 Hydraulic Design of Flood Control Channels(1994). During the design phase a refined hydraulic model will be built along this reach to make sure a more robust understanding of the pressurized flow condition and the velocity changes is achieved.

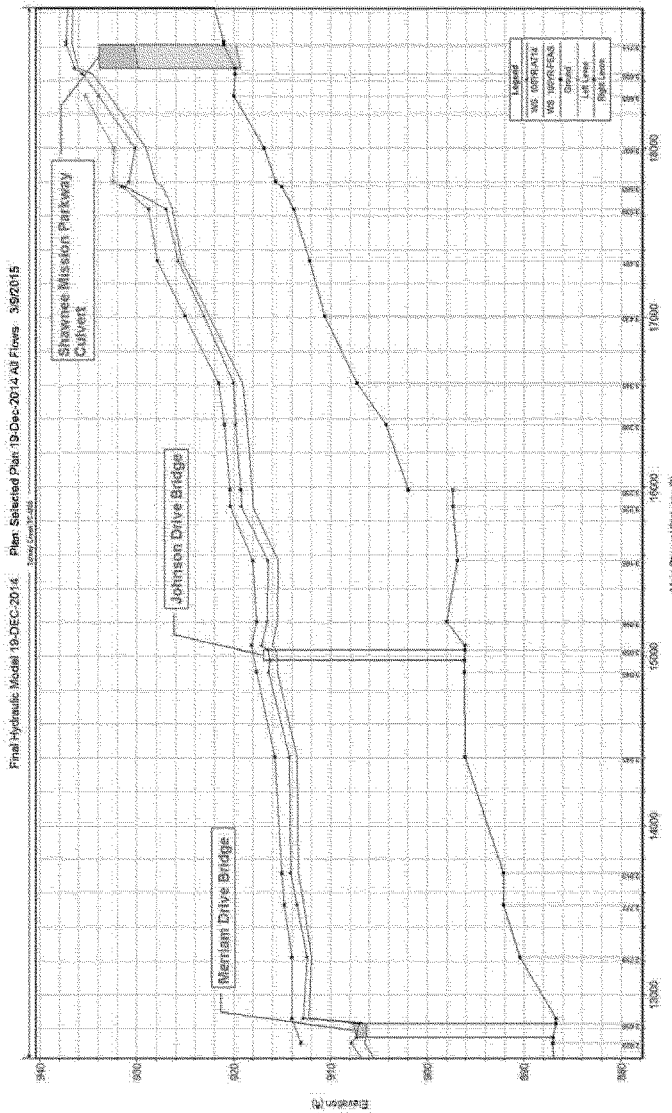


Figure 3-10. Illustration of 1% ACE Turkey Creek –TP-40 and Atlas 14 based flows - water surface profiles for the preferred alternative along reach TC-M80 (project reach)

5.6.1 DISCUSSION OF POTENTIAL INDUCED DAMAGES

Potential for induced damages is discussed in the following two sections for areas upstream and downstream of the proposed project.

5.6.1.1 Upstream Induced Damages

Induced damages upstream of levee projects tend to occur as a result of increased backwater effects. These backwater effects can cause increased flood heights within and immediately upstream of the project limits. In the specific situation at Upper Turkey Creek, the upstream end of the project ties into the embankments of Shawnee Mission Drive which are considered high ground. Areas downstream of Shawnee Mission Drive are either located on high ground or are protected by the proposed project. Accordingly, potential for induced damages would be located upstream of Shawnee Mission Drive.

Using Atlas 14 flows, the HEC-RAS model shows that the water surface profile increases 0.35 feet immediately downstream of Shawnee Mission Drive in the "with-project" condition during the 1/100 ACE event. Upstream of Shawnee Mission Drive, the maximum increase is 0.12 feet at cross section 3.726, with no difference in water surface elevations by cross section 4.099 located approximately 1,900 feet upstream of the bridge. For comparison, pre-project flow depth at cross section 3.726 is 16.1 feet during the 1/100 ACE event, compared to 16.2 feet depth with project. The results of the modeling were mapped using the most recent terrain data as shown in Exhibits 7 and 8. No appreciable change in inundation extent can be seen between the maps with and without project in this area. Additionally, even the 1/500 ACE event does not result in inundation of any buildings within the 1900-feet reach upstream of Shawnee Mission Drive. Events of this magnitude could result in overtopping of the proposed levee system and it is anticipated that larger events would result in overtopping of the proposed levee system. These larger events would be expected to have less impact on the water surface elevation upstream of Shawnee Mission Drive due to conveyance behind the levee. Considering the modeling results and comparison of inundation areas, induced damages are not expected upstream of the proposed project.

5.6.1.2 Downstream Induced Damages

Potential for induced damages downstream of a levee project occur only if the proposed levee system results in an obstruction that causes a loss of significant floodplain storage and reduction of the natural attenuation in the stream. In the case of Upper Turkey Creek (UTC), the majority of the flow is conveyed within the main channel and the leveed area is not anticipated to have significant effects; however, the only way to definitively answer the question would be through use of unsteady-state flow analysis.

Table 3-2 of EM 1110-2-1416 (EM) provides guidance for the type of models applicable at the different study phases. As seen in this table, for a feasibility study, the use of a gradually varied unsteady flow model (GVUSF) "... is possible, but unlikely, on most flood control studies." Table 3-4 of EM provides additional information for levees and channel projects stating that the typical analysis procedure is "GVSF (gradually varied steady flow) normally". For overbank flow, the EM states use as "GVSF normally, GVUSF/Multi-D for very wide floodplains or alluvial fans." In the case of UTC, the natural floodplain provides some conveyance but little storage. Therefore, using guidance from the EM, use of GVUSF models are more common to design phases of the project and the appropriate tool for analysis for a project such as UTC is a steady flow model.

In an attempt to address concerns regarding the potential induced downstream damages, a rough unsteady-state model was created to test sensitivity to unsteady flow routings with and without the levee. This model was created by 1) cropping the model to the UTC project limits only along Turkey Creek, 2) making the upstream boundary an unsteady flow hydrograph of the 1/100 ACE event and the downstream boundary a rating curve using elevations from the steady state model, and 3) removing the bridges and crudely modeling the bridge effects by adding ineffective flow areas. To generate the unsteady flow hydrograph in an HEC-DSS format for input in the HEC-RAS model, the HEC1 model was imported into HEC-HMS and modified to fix errors generated in the importing process with the most direct reasonable method without re-checking results against HEC-1 output. The resultant hydrograph was then scaled down slightly to provide water surface profiles just below levee overtopping. The flow at the upstream end of the model was input and routed downstream using geometry with and without levees. This model did not include lateral inflows. The analysis was set up to simply test change in attenuation with and without project. A full GVUSF analysis would require significant additional effort to reduce numerical instabilities and better model bridges and inflows, etc. This would include modeling storage benefits due to detention of the interior drainage area while the levee is loaded in the with-project case.

The simplified GVUSF analysis showed that in the without project case, flows entering the project reach attenuated 1.5 percent by the time they reach the downstream project limits. In the with-project case, flows attenuated 1.9 percent. Numeric instabilities were present in the maximum water surface profiles of the with-project condition as water surfaces are slightly higher and more backwater is present upstream of bridges which could explain why slightly more attenuation was shown in the with-project case. None-the-less, in the side by side comparison, the peak flows downstream matched within 0.4% and timing of the peak was less than five minutes sooner in the with-project case, indicating that the levee's effect on attenuation is negligible. This analysis does not take into account that the interior areas will detain local runoff while the levee is loaded, which could decrease peak flows slightly downstream. For floods in excess of the levee capacity, the likely effect is a temporary decrease in downstream flows while levee overtopping is occurring.

Therefore, the potential for downstream induced damages from UTC is considered negligible. Hydraulic analysis has been conducted in accordance with USACE design guidance.

5.6.2 RISK WARNING TIME

To estimate risk warning time with project, hydraulic model and available stage gages on Turkey Creek were analyzed. Using the hydraulic model, the 1% ACE event flow hydrograph was transformed to a stage hydrograph at cross section 2.623 just downstream of Merriam Drive Bridge. This bridge is located at the downstream end of the project reach. The obtained stage hydrograph was compared to the precipitation (Figure 3-11). Maximum rate of rise is approximately 7 feet per hour when the creek would rise approximately 9 feet in 1.25 hours. The peak would occur within 1.5 hours of the onset of the most intense period of precipitation, and within approximately 45 minutes of when the precipitation rate slows.

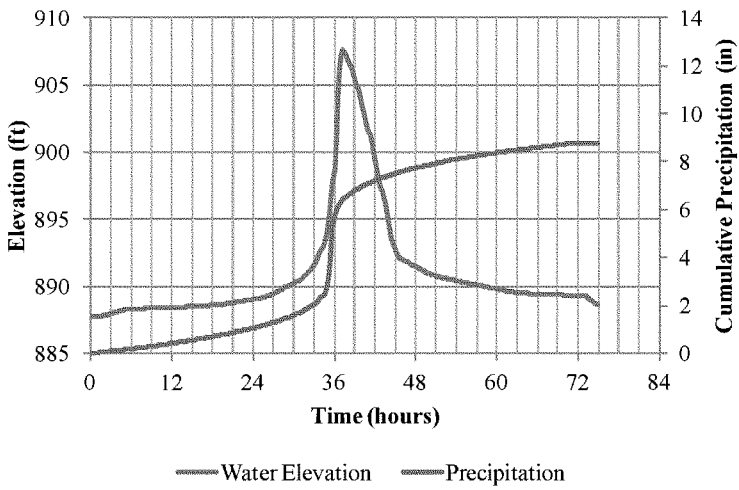


Figure 3-11. Estimated stage hydrograph at the downstream end of the project reach (downstream of Merriam Drive) and precipitation during a 1% ACE event

Also, available precipitation and stage data for two of the largest events measured on StormWatch gages along Turkey Creek were compiled. The events analyzed occurred on August 9, 2007 and June 13, 2010. Of greatest interest is the Gage 3010 at Johnson Drive located in the middle of the project reach, where in the August 2007 event approximately 1.75 inches of rain fell in 45 minutes with total rainfall of approximately 3.2 inches, whereas in the June 2010 event, approximately 2 inches of rain fell in 3 hours. Of secondary interest is the Antioch Ramp Gage 3090 located approximately 0.6 miles downstream of the project in the vicinity of Waterfall Park. For reference, the Antioch Ramp gage is located just downstream of a significant left bank tributary. Both gages came online after the record 1998 event occurred, with Johnson Drive coming online on 9/14/1999 and Antioch Road coming online on 10/6/2006. Figure 3-12 presents a plot of the 2007 hydrographs and precipitation measured at the Johnson Drive and Antioch Ramp gages. At both locations, the stream gages peaked within 1 hour and 15 minutes of the onset of the heaviest precipitation and within approximately 15 minutes of when precipitation stopped. Rate of rise of the August 2007 event was approximately 10 feet in 1 hour at Johnson Drive.

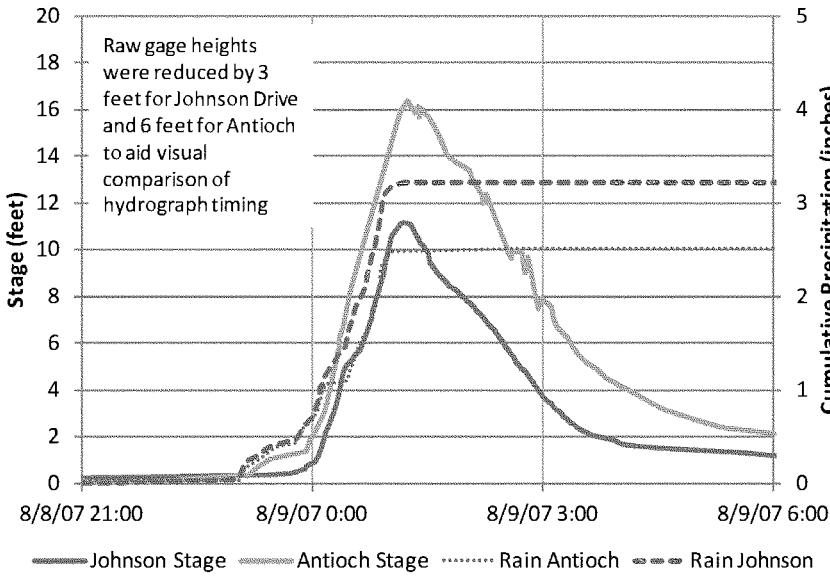


Figure 3-12. Stage hydrographs and cumulative precipitation for StormWatch gages at Johnson Drive and the Antioch Ramp during the August 2007 event

For the 2010 event, the storm intensity at Johnson Drive was more variable, with the most intense period having approximately 1 inch of rain in a 1 hour period after a little more than an inch of rain had already occurred. Figure 3-13 presents a plot of the gage heights and cumulative precipitation at Johnson Drive for the June 2010 event. In this event, the peak stage occurred within 40 minutes of the onset of the heaviest precipitation, and only 20 minutes after the rate of precipitation slowed and while it was still raining. Rate of rise of the June 2010 event was 3.5 feet in the last 20 minutes.

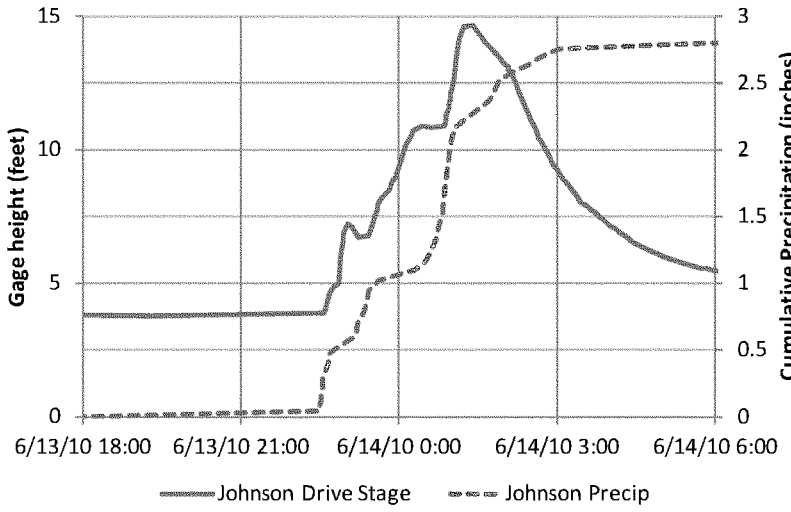


Figure 3-13. Gage height hydrograph and cumulative precipitation for the StormWatch gage at Johnson Drive during the June 2010 event

After considering the available model and StormWatch data for the project site, risk warning time is expected to be less than 1.5 hours and likely closer to an average of 30 minutes or less in most cases. Longer response times would require first responders to operate during periods of heavy precipitation. Rates of rise of 7 to 10 feet per hour can be expected to occur within the project reach.

6. DATA CONVERSION FOR HEC-FDA ANALYSIS

The results of a HEC-RAS model provide a one-dimensional simulation. Common industry belief is that this model, albeit a highly versatile tool, is not able to accurately model all dynamics of flood events, especially in a highly urbanized watershed. To supplement the results of HEC-RAS, the USACE applies the Hydrologic Engineering Center's Flood Damage Reduction Analysis (HEC-FDA, or FDA) model to statistically determine the expected flood damage associated with existing conditions, as well as proposed mitigation measures, for various flood events using hydrologic, hydraulic and economic relationships. The results of the FDA model serve as a decision support tool that allows stakeholders to have a better appreciation of the consequences of each flood event. The FDA model requires valuation data and associated flood elevations at each structure or cross-section in a very specific format. LBG was contracted by the USACE to provide reliable hydraulic output data using HEC-RAS and formatting the data for inclusion into the FDA model.

One particularly challenging aspect of this task was to organize the HEC-RAS output into a format that was consistent with the input form required by the FDA model. For the HEC-RAS modeling, Upper Turkey Creek was divided into multiple reaches with separating lines at points of confluence at tributaries. The output data from the HEC-RAS model is grouped by reach, from upstream to downstream, for all modeling events (e.g. TC-M120, 50- to 0.2-percent AEP [2- to 500-year event]) whereas the FDA model requires the data be grouped by modeling event (i.e. all reaches 50-percent AEP (2-year event), all reaches 20-percent AEP (5-year event), etc) with the downstream reaches first. Therefore, the output from the HEC-RAS model had to be reconfigured for input into the FDA model. The Upper Turkey Creek reaches had to first be combined to form one continuous reach and the order of the reaches reversed. The data was then arranged by modeling event. LBG used Visual Basic for Applications (VBA) coding to arrange the data in the necessary format for the FDA model.

Based on structure and/or channel geometry, water surface output from the HEC-RAS model rises and falls accordingly. In some cases, the water surface elevation at a particular structure or cross-section may be lower than that of the next downstream feature. The FDA model requires a smooth water surface elevation with a steadily decreasing water surface from upstream to downstream. The challenge is to smooth the water surface elevation without grossly altering the data. This was accomplished by beginning with the most downstream data point, evaluating each upstream data point, and adjusting the data point by 0.1-foot increments until a positive slope was achieved. The percentage of values within the combined Turkey Creek reach requiring modification ranged from eight percent to twenty-four percent with an average of seventeen percent of the data points requiring adjustment.

The FDA model input requires that the water surface elevation profiles became progressively higher with higher intensity storms. This hydraulic behavior is a tendency but not a rule since increases in velocity due to constricted higher flows can result in slightly lower water surface elevations for higher intensity storms. The results from the HEC-RAS model showed a few locations where higher flows resulted in a decrease in water surface elevation instead of an increase. In order to apply the FDA model for analysis, USACE instructed that the results from the model be modified to ensure increasing water surface elevations with higher storm intensities. For this, the HEC-RAS output for the 50-percent AEP (2-year event) was used as the baseline. Data for next event, the 20-percent AEP (5-year event), was compared to the 50-percent AEP (2-year event) data and adjusted, as necessary, to insure that the water surface elevation at each cross-section was greater than the previous modeling event. Similarly, each subsequent storm event was compared to the previous and adjusted as necessary (e.g. 10-percent AEP (10-year event) compared to the 20-percent AEP (5-year event), 2-percent AEP (20-year event) compared to the 10-percent AEP (10-year event), etc.).

6.1 RELIABLE LEVEL OF PROTECTION

Analysis of the FDA revealed that for Alternative 2, it was determined that there was an 86 percent reliable factor for the 1-percent AEP (100-year event) profile. Therefore, USACE instructed the AE to create a new modeling scenario that would achieve a reliable factor of at least 90 percent.

This additional modeling scenario was created that represented the 90 percent reliability factor for the levee/floodwall alternative. To accomplish this, a new modeling plan was defined in HEC-RAS and the levees in the HEC-RAS model were increased.

After executing the model, it was found that only the 0.5-percent AEP (200-year event) and 0.2-percent AEP (500-year event) profiles increased as a result of the increased levee height, as all other profiles were contain by the previous levee. Table 3-7 displays the cross sections that were modified, the levee heights associated at the respective river stations, and the water surface elevations generated during the 1-percent AEP (100-year event).

Table 3-7. 90 Percent Reliability Level of Protection

	Left Bank	Right Bank	
River Station	Top Of Wall/Levee	Top Of Wall/Levee	Water Surface Elevation
2.623	909.00	909.00	906.47
2.651	913.00	913.00	910.5
2.719	-	912.74	910.24
2.777	-	913.89	911.39
2.813	-	914.75	912.25
2.945	-	914.90	912.4
3.040	-	917.65	915.15
3.070	-	918.16	915.66
3.096	-	917.59	915.09
3.165	917.55	917.55	915.05
3.225	920.38	920.38	917.88
3.231	920.39	920.39	917.89
3.298	920.99	920.99	918.49
3.345	921.55	921.55	919.05
3.420	924.98	924.98	922.48
3.481	927.83	927.83	925.33
3.539	928.78	928.78	926.28
3.560	930.81	930.81	928.31
3.607	931.78	-	929.28
3.665	935.31	935.31	932.81
3.690	936.85	936.85	934.35

6.2 NO RISE CERTIFICATION

Based upon the results of the 90 percent reliability level of protection, water surface elevations for this alternative were compared to the existing conditions water surface elevations upstream of the project area.

The results of the water surface elevation comparison are shown in Table 3-8 below. As can be seen, the resultant water surface elevations upstream of the project area are at or below the existing water surface elevations for the same AEP.

Table 3-8. No Rise Water Surface Elevation Comparison

River Station	AEP Profile	UTC-Exist. WS El (Ft.)	UTC_A2_90% Alternative WS El (Ft.)	UTC_A2_90% Alternative WS El Change (Ft.)
3.726	10	934.51	934.41	0.1
3.726	2	936.29	936.37	-0.08
3.726	1	936.53	936.63	-0.1
3.726	0.2	937.47	937.6	-0.13
3.823	10	934.93	934.86	0.07
3.823	2	936.32	936.38	-0.06
3.823	1	936.5	936.58	-0.08
3.823	0.2	937.17	937.28	-0.11
3.855	10	935.14	935.08	0.06
3.855	2	936.59	936.64	-0.05
3.855	1	936.78	936.85	-0.07
3.855	0.2	937.51	937.6	-0.09
3.892	10	935.2	935.14	0.06
3.892	2	936.8	936.86	-0.06
3.892	1	937.03	937.09	-0.06
3.892	0.2	937.91	938	-0.09
3.921	10	936.16	936.13	0.03
3.921	2	937.8	937.82	-0.02
3.921	1	938.02	938.05	-0.03
3.921	0.2	938.93	938.96	-0.03
3.952	10	936.56	936.54	0.02
3.952	2	938.41	938.43	-0.02
3.952	1	938.68	938.7	-0.02
3.952	0.2	939.75	939.78	-0.03
3.990	10	936.48	936.45	0.03
3.990	2	938.54	938.55	-0.01
3.990	1	938.82	938.85	-0.03
3.990	0.2	940.01	940.03	-0.02
4.050	10	936.81	936.79	0.02
4.050	2	938.35	938.37	-0.02
4.050	1	938.6	938.62	-0.02
4.050	0.2	939.68	939.71	-0.03

River Station	AEP Profile	UTC-Exist. WS El (Ft.)	UTC_A2_90% Alternative WS El (Ft.)	UTC_A2_90% Alternative WS El Change (Ft.)
4.099	10	937.68	937.67	0.01
4.099	2	938.93	938.94	-0.01
4.099	1	939.13	939.13	0
4.099	0.2	940.25	940.25	0

The detention pond included within the protected area for internal drainage will contain localized flooding during the peak stages of Upper Turkey Creek and will only release a fraction of the accumulated volume during the 1-percent AEP (100-year event). This controlled release is not expected to alter the runoff characteristics downstream of the City of Merriam or significantly change the magnitude of the 1-percent AEP (100-year event) downstream of the project area.

The impacts of the Upper Turkey Creek flood control project beyond its upstream and downstream boundaries were evaluated through a qualitative review of the utilized HEC-RAS hydraulic model. The results obtained from this model suggest that, under current condition, most of the overtopping occurs along the Merriam Reach. The total overbank area flooded under current condition is approximately 0.12 acres (fully urbanized) through which flood waters move rapidly, eliminating the potential for discharge attenuation within the project reach. While outside-of-bank or overbank flooding within the project site alleviates flooding upstream and downstream, it is important to consider the volume of water "leaving" the channel during the overtopping event.

Modeling results also show some overbank flow under existing condition; however, due relative short duration of the Turkey Creek hydrographs (flashy nature) it can be inferred that this period of overtopping will be brief and will not result in a significant reduction of water volume moving downstream. Therefore, it is unlikely that the preferred plan will result in an increase in discharge downstream of the project area due to the reduction of overbank flow.

Additionally, is noted that the flow regime throughout the project reach and downstream is subcritical. Under subcritical flow, changes to the water surface elevation caused by decreases in the conveyance capacity of the channel will mainly propagate upstream (backwater). Also, the presence of a series of bridges upstream and downstream of the project reach will serve as flow-conveyance control structures maintaining the peak flow almost unchanged on the "with-project" condition.

The proposed project area is bounded by the Shawnee Mission Parkway and Merriam Drive bridges. Major bridge modifications are not implemented under the Recommended Plan because there would be no additional benefit to this action. However, a 4-foot high headwall (i.e., bridge parapet support structure) would be installed at the Merriam Drive Bridge crossing to maintain the flows in the river channel. This modification creates no increase in water surface elevation upstream of the bridge.

To minimize the induced damages upstream of Shawnee Mission Parkway, overtopping of the road will be required to remain, such that no rise in upstream water surface elevations will occur. During final design, a reevaluation of the hydraulic model will be required if modifications to the bridge to prevent overtopping is desired.

6.3 STAGE UNCERTAINTY AND STANDARD ERROR

According to EM 1110-2-1619 (EM 1619), the determination of stage-discharge uncertainty requires accounting for the uncertainty associated with factors affecting the stage-discharge relationship. These factors include bed forms, water temperature, debris or other obstructions, unsteady flow effects, variation in hydraulic roughness with season, sediment transport, channel scour or deposition, changes in channel shape during or as a result of flood events, as well as other factors. In some instances, uncertainty might be introduced into the stage-discharge curve due to measurement errors from instrumentation or method of flow measurement, waves, and other factors in the actual measurement of stage and discharge.

For Turkey Creek, factors like bed form, water temperature, and obstructions were neglected. The bed material of the creek is predominantly composed of gravels, cobbles, and sands. The bed load volume is not considered significant enough to produce bed formations of a scale that could impact the hydraulics of flood events with an annual chance of exceedance less than 50% (2-year event). Additionally, with future maintenance by the active drainage district, channel deposits of cobbles, if they do occur, will be removed and not allowed to accumulate. The lowest temperatures are experienced typically between November and March. During this cold season, the surface of Turkey Creek can freeze but the flows are traditionally the year lowest limiting the potential impact associated with temperature. Although the presence of woody debris in the lower portion of Turkey Creek is relatively common, there are not known records of issues caused by debris loads or blockages along the upper portion of Turkey Creek. Thus, stage changes induced by debris or obstructions were ignored for analysis. Variations in stage due to hydraulic roughness changes with season, potential channel scour or deposition, changes in channel shape during or as a result of flood events, as well as other factors were considered minor natural variations of the channel.

For ungaged streams like Turkey Creek, EM 1619 recommends the use of Equation 5-5. This equation is used as an upper bound estimate in the absence of other data. Equation 5-5 is stated as:

$$S = \left[0.07208 + 0.04936\, I_{Bed} - 2.2626 \times 10^{-7} A_{Basin} + 0.02164 H_{Range} + 1.4194 \times 10^{-5} Q_{100}\right]^2$$

where S is the standard deviation of uncertainty in meters, HRange is the maximum expected or observed stage range, ABasin is the basin area in square kilometers, Q100 is the 100-year estimated discharge in cubic meter per second, and IBed is a stream identifier for the size bed material which control the flow in the reach of interest. [Note: Q100 units were assumed to be cubic meters per second since EM 1110-2-1619 stated the units for this value as centimeters which is inconsistent with discharge]

The size bed materials which control the flow were identified as gravels and cobbles for the reach of interest. Accordingly, bed identifiers between 2 and 3 from Table 5-1 of EM 1619 were tested. Results of the roughness sensitivity analysis were used to estimate HRange using values of 1 meter, 0.67 meters, and 0.30 meters (equivalent to 3.28 feet, 2.20feet, and 0.98 feet respectively) . The watershed area of 59.60 square kilometer (23 square mile) utilized and Q100 equal to 491.2 cubic meters per second (equivalent to 17,348 cubic feet per second) at the downstream end of the proposed levee. This equation yields a standard deviation of less than 0.2 feet for all tries.

Considering that the hydraulic analysis for Turkey Creek was mostly based on a computer model without any stream gages available for calibration (only high water marks from a 1998 event), the methodology for determining uncertainty in stage for ungaged streams presented in EM 1110-2-1619 was applied.

Sensitivity checks were conducted using the "with project" model configuration to test the influence of changes in the channel roughness on the water surface elevation profiles of the 100-year event. These checks consisted on modifying the roughness coefficients in the model by plus or minus 20%. The stage

variance in the reach was found to be the greatest immediately upstream of the Merriam Drive Bridge and it ranged between a drop of 1.2 feet to an increase of 2.1 feet. The reach impacted represents approximately 11% of the reach of interest. The second greatest variance occurs upstream of Johnson Drive and it ranged from a drop of 1.1 feet to an increase of 1.1 feet representing 22% of the area of interest. For reaches out of bridge backwater influence, differences were generally within 0.5 feet.

Increasing and decreasing the roughness parameters by 20% yielded a range in channel roughness between 0.028 and 0.042 which was considered reasonable. Expanding the analysis beyond this range would result in channel roughness values uncharacteristic for this stream type. Sensitivity analysis showed that for a majority of the reach, water surface elevations of the 100-year event are generally insensitive to wide variations in channel roughness.

Bridges have much less effect on water surface profiles for flood events less frequent than the 100-year event. For example, for the 50-year event, a 20% increase in channel roughness shows only a 1-feet stage increase upstream of the Merriam Bridge as compared to the 2.1 feet increase for the 100-year event. Therefore, the location with the most sensitivity to water surface profiles is the downstream 11% of the proposed levee reach just upstream of Merriam Drive and only for events larger than a 50-year event. This location is also the desired initial overtopping location since it is the one with least likely impacts to damage large sections of the levee system or upstream properties. Flows would be able to quickly re-enter the creek along the right bank of the channel downstream of the proposed project.

Table 5-2 from EM 1619 was used to estimate uncertainty due to topographic information and confidence in estimated roughness parameters. The geometry used to develop the model is based mostly on 1998 aerial Planimetric data with 25 feet grid cells and breakline files supplemented with field surveys. Due to limited calibration data, coupled with sensitivity checks, confidence in the estimate of the roughness parameters is considered fair to porr. Accordingly, a standard deviation of approximately 1.0 feet was assumed.

Uncertainty due to natural variations as estimated using equation 5-5 is combined with values from Table 5-2 using equation 5-6 from EM 1619 to estimate standard deviation of total uncertainty as:

$$S_{Total} = \sqrt{S_{Natural}^2 + S_{Model}^2} = \sqrt{0.20^2 + 1.00^2} = 1.02 \text{ feet}$$

Based on these calculations a standard error value of 1 foot for stage uncertainty was adopted for all additional calculations including the FDA analysis. The sensitivity analysis supports this value as reasonable for the upper portion of Turkey Creek.

7. VALUE ENGINEERING OF INTERIOR DRAINAGE ALTERNATIVES

7.1 INTRODUCTION

An economic analysis of Alternative 2: Levee and Flood Wall Installation and Alternative 3: Combination of Channel widening, Levees, and Floodwalls was performed by the Planning Branch (PM-PF). Within these two alternatives, two pumping stations are proposed to be constructed to drain a small watershed with an approximate area of 36 acres and located in the City of Merriam, Johnson County, KS (Figure 3-14). This watershed possesses a relatively flat topography and it is proposed to protect it with a levee located along the right bank of the Turkey Creek reach. The use of these pump-stations carry an operation and maintenance cost that reduces the cost-benefit ratio of several of the proposed alternatives. As part of the economic analysis, the value engineering team (VET) was requested to find value engineering options to the use of pump for interior drainage.

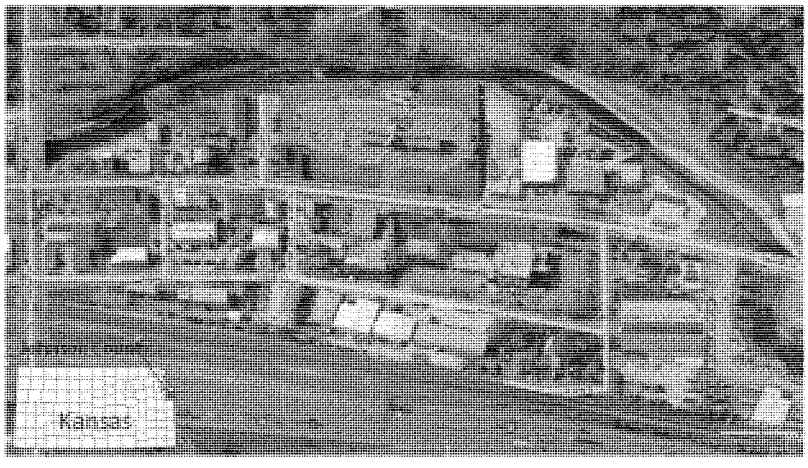


Figure 3-14: Location Map and Aerial Photograph of the City of Merriam, Johnson County, Kansas

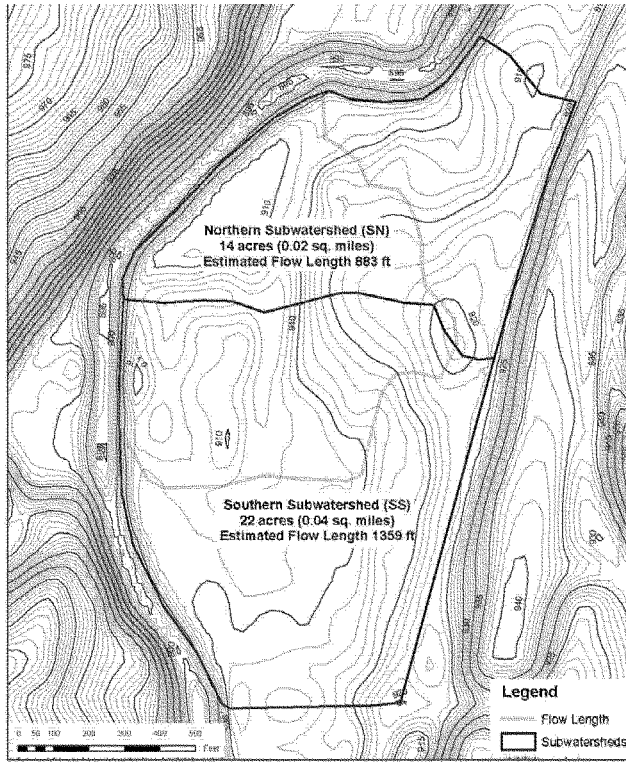
7.2 HYDROLOGY

Using a 3-meter digital elevation model, a 1-foot contour map of a portion of the city of Merriam was produced (Figure 3-15). Although the limitations of this approach are recognized, the lack of better topographical data and the flatness of the region influenced the decision to produce the contours at this density level. The contour map allowed the PDT to delineate the watershed based on best engineering judgment and previous information provided by LBG. The delineated watershed has an area of 36 acres equivalent to 0.06 square miles (mi^2).

Figure 3-15: Topographic map of Merriam Reach and delineated watershed

In order to parallel the current hydrologic analysis to the previous one from AE, it was decided to divide the watershed into two subwatersheds. The northern subwatershed (SN) has an area of 14 acres (0.02 mi^2) and the southern subwatershed (SS) an area of 22 acres (0.04 mi^2). These subwatersheds are illustrated in Figure 3-16. The methodology presented in the U.S. Department of Agriculture Technical Release 55 (TR-55, U.S. Department of Agriculture, 1986) was used to determine the effective runoff and time of concentration for these subwatersheds. Based on information from aerial pictures and considering soils traditionally found on the region, the curve number for each subwatershed were estimated at 96 for SN and 95 for SS. The USACE requested existing stormwater system (ESS) plans from the City of Merriam but these plans are not available. The only related information available is a GIS schematic illustrating the

location of a fraction of pipelines and inlets. This information is incomplete, unverified, and does not include additional information like diameters, inverts, flow direction, or slopes. Due to lack of detailed information, the existing stormwater drainage system was not considered in this analysis. Not considering the ESS for planning in this case is considered a conservative approach because its capacity was not included to estimate the detention volume. The ESS will likely offer a small detention volume plus it will add some travel time to the flows potentially changing the time of concentration. Including the ESS into a design analysis will most likely reduce the required size of the detention pond. It is strongly recommended to refine this study to include the ESS capacity in order to better estimate the required detention volume. It has been suggested, based on comparison with other small cities in the vicinity, that the capacity of the system should correspond to a 10-year runoff event but this information could not be verified.



Topographic Map of Merriam Reach and Delineated Subwatersheds
(1-foot contours obtained from 3-meters Digital Elevation Model)

Figure 3-16: Topographic map of Merriam Reach and delineated subwatersheds

It is possible that the changes to the stormwater system of the City of Merriam (i.e. detention) may have an impact in the timing and location of discharges when compared to the original model but these changes, if any, are expected to be negligible. The size of the watershed considered for interior drainage analysis in the value engineering is approximately 0.06 square miles while the size of the Upper Turkey Creek watershed upstream of the City of Merriam is approximately 20 square miles. It is expected that the timing and magnitude of the flows downstream of the City of Merriam will be controlled by Turkey Creek watershed and that the impact of the interior watershed would be too small to significantly alter the timing or peak magnitudes to downstream communities.

The TR-55 methodology requires the total precipitation from 24-hour design storms. In this case the 10-percent AEP (10-year event), 2-percent AEP (50-year event), and the 1-percent AEP (100-year event) were considered. The total precipitation for these events was calculated using rainfall intensities reported in the Kansas Department of Transportation Rainfall Intensity Tables for Kansas Counties (McEnroe, 1997). Table 3-9 shows the 24-hour rainfall intensities and total precipitation calculated for Johnson County.

Table 3-9. 24-hour Rainfall Intensities and Total Precipitation for Johnson County, Kansas

Return Period	Intensity (in/hr)	Precipitation (in)
10 year	0.22	5.4
50 year	0.29	7.0
100 year	0.32	7.9

After analyzing the subwatersheds and determining their flow length, the times of concentration were calculated using the travel time methodology presented in TR-55. The calculations showed a time of concentration for subwatershed SN of 8 minutes (min) and for subwatershed SS of 27 min. Figure 3-17 and Figure 3-18 illustrate the worksheets used to estimate the times of concentration and travel time. Assuming a free outlet at the discharge points for both subwatersheds, runoff hydrographs for the 10-percent AEP (10-year event), 2-percent AEP (50-year event), and the 1-percent AEP (100-year event) were obtained and are presented in Figure 3-19 and Figure 3-20. (Note: The total volume of runoff was estimated by integration of the hydrograph curves for each subwatershed).

Worksheet 3: Time of Concentration (T_c) or travel time (T_t)

Project	By	Date
UPPER TURKEY VALLEY ENGINEERING STUDY	VL OTERO	01/14/11
Location	**Checked**	**Date**
CITY OF MERRIAM, JOHNSON COUNTY, KS (SN)		

Check one: ☒ Present ☐ Developed — NORTHERN SUBWATERSHED

Check one: ☒ T_c ☐ T_t through subarea

Notes: Space for as many as two segments per flow type can be used for each worksheet. Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

	Segment ID	N1	
1. Surface description (table 3-1)		SMOOTH SURFACE	
2. Manning's roughness coefficient, n (table 3-1)		0.011	
3. Flow length, L (total L ≤ 300 ft) ft		30	
4. Two-year 24-hour rainfall, P_2 in		3.6	
5. Land slope, s ft/ft		0.004	
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ Compute T_t hr		0.030	+ ___ = 0.030

Shallow concentrated flow

	Segment ID	N2	
7. Surface description (paved or unpaved)		PAVED	
8. Flow length, L ft		203	
9. Watercourse slope, s ft/ft		0.013	
10. Average velocity, V (figure 3-1) ft/s		2.32	
11. $T_t = \frac{L}{3600\,V}$ Compute T_t hr		0.096	+ ___ = 0.096

Channel flow

* NO CHANNEL FLOW EXPECTED *

	Segment ID		
12. Cross sectional flow area, a ft^2			
13. Wetted perimeter, p_w ft			
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r ft			
15 Channel slope, s ft/ft			
16. Manning's roughness coefficient, n			
17. $V = \frac{1.49\,r^{2/3}\,s^{1/2}}{n}$ Compute V ft/s			
18. Flow length, L ft			
19. $T_t = \frac{L}{3600\,V}$ Compute T_t hr		___ + ___	= 0
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) Hr			0.126 (8 MIN)

(210-VI-TR-55, Second Ed., June 1986) D-3

Figure 3-17: Time of concentration worksheet for northern subwatershed SN

Worksheet 3: Time of Concentration (T_c) or travel time (T_t)

Project	By	Date
UPPER TURKEY VALUE ENGINEERING STUDY	W. OTERO	01/14/11
Location	**Checked**	**Date**
CITY OF MERRIAM, JOHNSON COUNTY, KS (SS)		

SOUTHERN SUBWATERSHED

Check one: ☒ Present ☐ Developed

Check one: ☒ T_c ☐ T_t through subarea

Notes: Space for as many as two segments per flow type can be used for each worksheet. Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

Segment ID	S1			
1. Surface description (table 3-1)	FALLOW			
2. Manning's roughness coefficient, n (table 3-1)	0.05			
3. Flow length, L (total L † 300 ft) ft	100			
4. Two-year 24-hour rainfall, P_2 in	3.6			
5. Land slope, s ft/ft	0.02			
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t hr	0.064	+		= 0.064

Segment ID	S2	S3		
7. Surface description (paved or unpaved)	PAVED	PAVED		
8. Flow length, L ft	459	800		
9. Watercourse slope, s ft/ft	0.023	0.001		
10. Average velocity, V (figure 3-1) ft/s	3.08	0.640		
11. $T_t = \frac{L}{3600\ V}$ Compute T_t hr	0.041	+ 0.346		= 0.387

Channel flow

* NO CHANNEL FLOW EXPECTED * Segment ID				
12. Cross sectional flow area, a ft^2				
13. Wetted perimeter, p_w ft				
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r ft				
15 Channel slope, s ft/ft				
16. Manning's roughness coefficient, n				
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V ft/s				
18. Flow length, L ft				
19. $T_t = \frac{L}{3600\ V}$ Compute T_t hr		+		= 0
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) Hr				0.451 (27 MIN)

(210-VI-TR-55, Second Ed., June 1986) D-3

Figure 3-18: Time of concentration worksheet for southern subwatershed SS

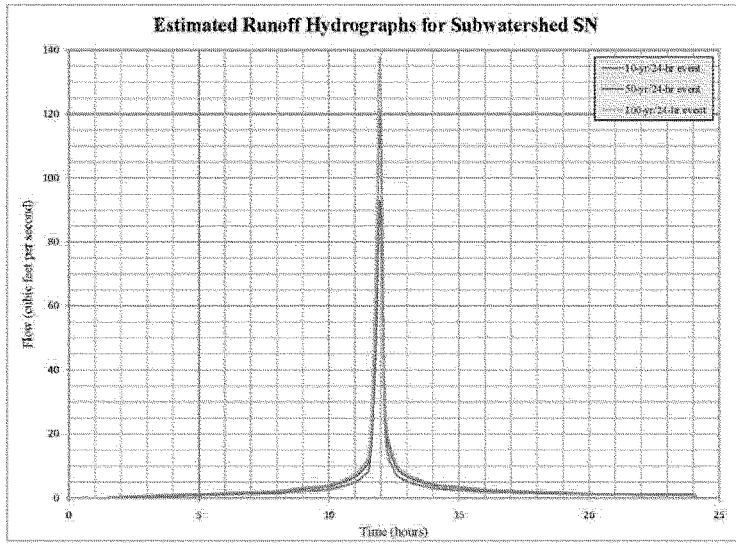


Figure 3-19: Estimated runoff hydrograph for SN

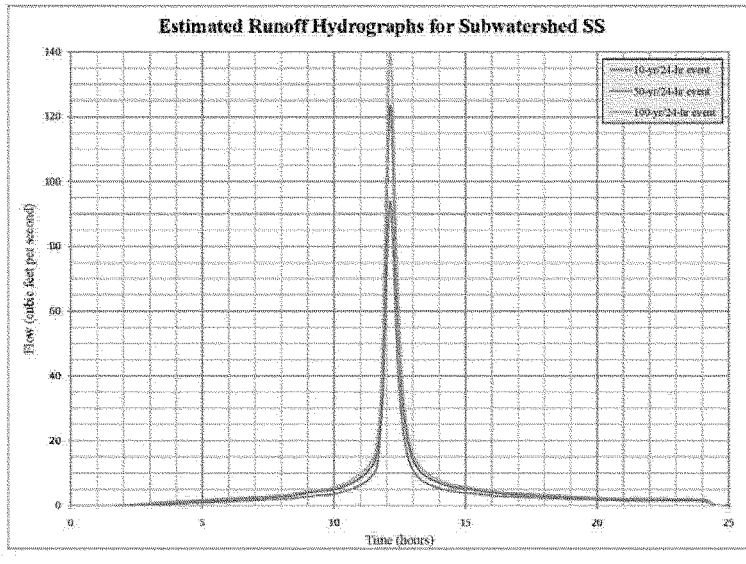


Figure 3-20: Estimated runoff hydrograph for SS

24-hour Rainfall Intensities and Total Precipitation for Johnson County, Kansas

Table 3-9. Runoff Volume and Peak Flow for the Studied Subwatersheds and Total Watershed

Watershed Unit	Event	Volume (ft3)	Volume (acre-ft)	Peak Flow (cfs)
SN	10-year	256003	6	92.9
	50-year	337964	8	121.4
	100-year	384778	9	137.3
SS	10-year	395696	9	93.8
	50-year	527718	12	123.3
	100-year	600919	14	139.6

7.3 HYDRAULICS

The steady state hydraulic model containing the alternatives developed by the AE was used to obtain water surface profiles for Turkey Creek. The model is assumed to be a representation of the hydraulic behavior of the reach after the levee construction. The reach of interest for this study is bounded upstream by cross section 3.07 (right upstream from the Johnson Drive Bridge) and downstream by cross section 2.507 (about 680 feet downstream from the Merriam Drive Bridge). Figure 3-21 illustrates the location of the cross sections used to model the Merriam Reach. The water surface profiles (WSPs) for the 10-percent AEP (10-year event), 2-percent AEP (50-year event), and the 1-percent AEP (100-year event) between these cross sections are included in the attachment.

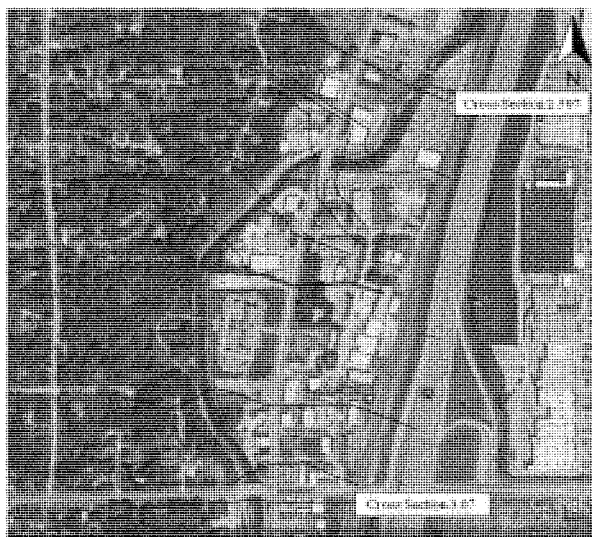


Figure 3-21: Location of Cross Sections used to Model Merriam Reach

7.4 ANALYSIS AND ALTERNATIVES

The purpose of the value engineering study was to find alternatives to the pumping stations. In this case the alternatives are basically limited to gravity driven drainage. From the analysis of the watershed, it is clear that a detention feature is necessary to store some of the runoff due to the flatness of the watershed under consideration. The other important design parameter is available head. After examining the WSPs from the model, it can be noticed that the water surface elevation (WSEL) drops drastically downstream of the Merriam Drive Bridge (cross section 2.507). This drop can be used to provide enough head from a detention feature to a discharge point into Turkey Creek. Additionally, if a comparison is made concerning the size of the watershed under consideration versus the area of the upper Turkey Creek watershed which is approximately 20 mi^2 (U.S. Army Corps of Engineers Kansas City District, 2009), the probability of having coincidental events from the watershed and on Turkey Creek is reduced. For urban drainage design purposes, the Federal Highway Administration in their Hydraulic Engineering Circular No. 22 (Federal Highway Administration, 1996) proposed a series of expected coincidental flows based on watershed area ratios (Table 3-10).

Considering the area of the Merriam Reach watershed versus the Upper Turkey Creek watershed we find a ratio of 1:350. Based on the information provided in 3-9 and conservatively assuming a ration of 1:100, when designing for a 10-percent AEP (10-year event) on the Merriam Reach watershed we should expect a 20-percent AEP (5-year event) on Turkey Creek and when designing for a 1-percent AEP (100-year event) on Merriam Reach we should expect a 4-percent AEP (25-year event) on Turkey Creek. Interpolating from these results we can also expect that for a 2-percent AEP (50-year event) on the Merriam Reach watershed, a 10-percent AEP (10-year event) should be expected on the Turkey Creek. Based on the information provided, the following alternatives are proposed for further investigation.

Table 3-10. Frequency for Coincidental Occurrence (HEC_22, Table 7-3)

Area Ratio	Frequency for Coincidental Occurrence			
	10-year Design		100-year Design	
	Main Stem	Tributary	Main Stem	Tributary
1,000 to 1	2 10	10 2	10 100	100 10
100 to 1	5 10	10 5	25 100	100 25
10 to 1	10 10	10 10	50 100	100 50

7.5 ALTERNATIVE 1: SURFACE DETENTION

The lowest ground elevation for most of the interior area protected by the levee is approximately 910 feet. This elevation is 5.2 feet higher than the WSEL at cross section 2.507 (i.e. 904.8 feet) for the 100-yeer event. This change in elevation can provide enough head for a culvert to drain the detention basins into Turkey Creek making unnecessary the use of the information presented in 3-10. For analysis purposes, the detention level can be set to be 910 feet. The proposed location for this outlet is illustrated in the attached exhibits. Assuming no head losses (friction and minor losses) between the detention level and the outlet invert, an estimation of an exit velocity for design as 18 feet per second (ft/s) can be made. It is likely that this velocity may be too high for a final design; nevertheless, it is likely that an increased in head losses will decrease this estimated velocity. Using this information and the design peak flow, pipe diameters and detention areas can be calculated. Table 3-11 presents various scenarios of detention volumes required for different peak flows. These results were obtained applying the methodology

presented in the TR-55 to estimate detention areas. An example of the calculations is included in the attached exhibits.

Table 3-11. Detention Volume Required and Pipe Diameter for Various Outflows

Subwatershed	Event	Peak Flow (cfs)	Outflow (cfs)	Pipe Diameter (ft)	Detention Volume (acre-ft)
SN	10	92.92	92.92	2.56	≈ 0
			70	2.23	1.22
			50	1.88	1.71
	50	121.39	121.39	2.93	≈ 0
			90	2.52	1.61
			60	2.06	2.38
	100	137.28	137.28	3.12	≈ 0
			100	2.66	1.86
			80	2.38	2.34
SS	10	93.79	93.79	2.58	≈ 0
			70	2.23	1.94
			50	1.88	2.71
	50	123.32	123.32	2.95	≈ 0
			90	2.52	2.58
			60	2.06	3.78
	100	139.6	139.6	3.14	≈ 0
			100	2.66	2.97
			80	2.38	3.72

Based on the results shown in Table 3-10 some locations for detention basins are suggested for further consideration and analysis. For subwatershed SN two locations are suggested and illustrated in Figure 3-22. The first one has an area of 3.9 acres but it is apparent from the aerial picture that it will require the relocation of several businesses. The second proposed location has an area of 1.9 acres and it is apparent from the aerial picture that it may require the relocation of one business. Regrading these areas will be necessary to provide drainage and assure a ponding level of 910 feet. The final design of the long culvert and its location will be left for further analysis during advanced stages of design.

Two locations are also suggested for subwatershed SS (Figure 3-23). The first one has an area of 3.9 acres and will possibly require the relocation of Merriam Marketplace. The second proposed location has an area of 1.5 acres and will possibly require the relocation of one business. Re-grading these areas will be necessary to provide drainage and assure a pond level of 910 feet. The pipe should have an invert elevation at the outlet of 904.8 feet and a minimum slope to ensure gravity flow. The final design of the long culvert and its location will be determined during advanced stages of design.

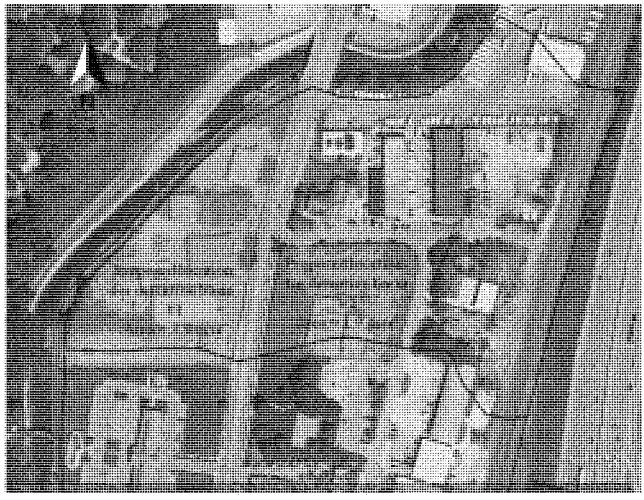


Figure 3-22: Location of Two Suggested Areas for Detention Basins on Subwatershed SN

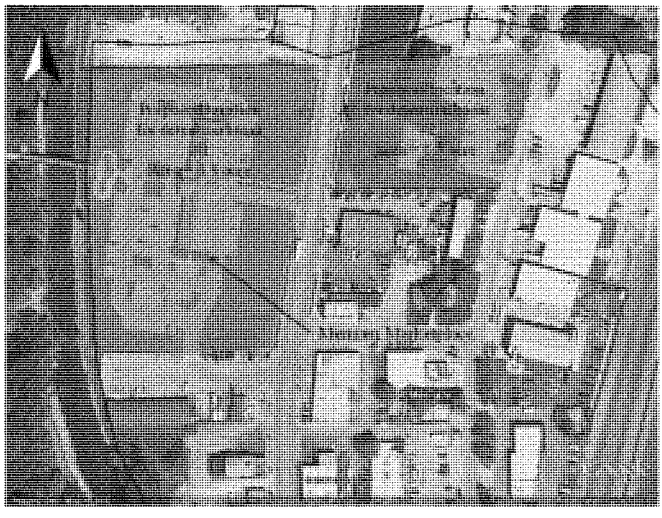


Figure 3-23: Location of Two Suggested Areas for Detention Basins on Subwatershed SN

Determining locations to provide detention for the whole watershed would require larger continuous areas or deeper basins to contain the required volume. If the frequency of coincidental occurrences is considered then it could be possible to find one location deep enough to provide detention for the whole watershed and still have room to provide a minimum slope to the outlet pipe.

7.6 ALTERNATIVE 2: UNDERGROUND DETENTION

During the construction of the levee along Turkey Creek it is also possible to bury a retention structure. This structure could be a concrete box with a series of inlets at ground level and should be placed parallel to the levee (Figure 3-24). This structure would provide a minimum storage but has the benefit of avoiding the relocation of most of the businesses otherwise affected. Table 3-12 summarizes preliminary results of the structure size and outlet pipe diameter required from different outflows. This alternative was evaluated only for the whole watershed but the concept can be extended to each subwatershed and the basic calculations have been attached. The underground detention approach will require structures ranging from 3.5 feet x 15 feet to 3.5 feet x 25 feet.

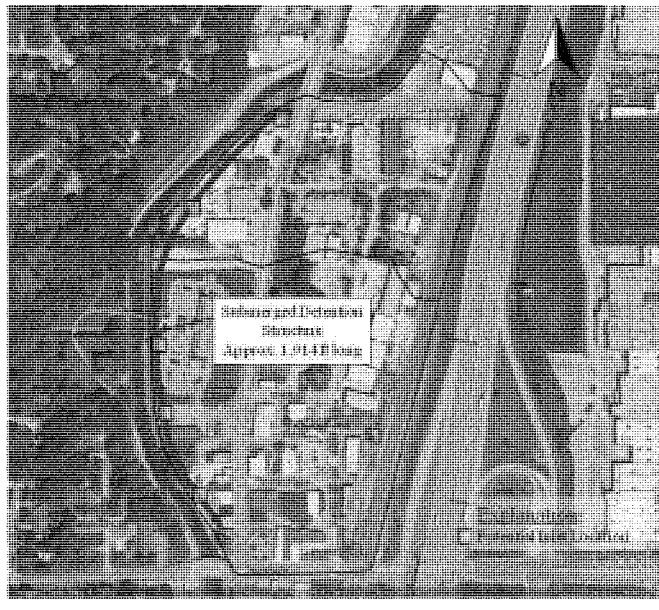


Figure 3-24: Location of Proposed Underground Retention Structure and Potential Inlet Locations

Table 3-12. Minimum Detention Volume and Pipe Diameter for the Total Watershed

Event	Peak Flow (cfs)	Length (ft)	Height (ft)	Width (ft)	Outflow (cfs)	Pipe Diameter (ft)	Detention Volume (acre-ft)
10	155.3	1914	3.5	15	147.5	3.2	2.3
50	203.24	1914	3.5	20	160.5	3.4	3.1
100	230.25	1914	3.5	25	172.8	3.5	3.8

8. REFERENCES

Federal Highway Administration, 1996, Urban Drainage Design Manual – Hydraulic Engineering Circular No. 22

Haan, C.A., 1977, Statistical Methods in Hydrology, The Iowa State University Press, Ames, Iowa.

Huntington, Thomas G. (2006). "Evidence for intensification of the global water cycle: Review and synthesis", Journal of Hydrology v. 319, p 83-95.

Larkin Group, Northeast Johnson County Watershed Study, May 2005.

McEnroe, B. M., 1997, Rainfall Intensity Tables for Kansas Counties, Kansas Department of Transportation

NOAA Technical Report NESDIS 142-4, "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment", Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service, Washington D.C., Jan. 2013.

U.S. Army Corps of Engineers, Turkey Creek Basin Feasibility Report and Environmental Assessment, December 1988.

U.S. Army Corps of Engineers, Turkey Creek Basin Kansas City Kansas and Missouri General Reevaluation Report, December 2003.

U.S. Army Corps of Engineers – Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package User's Manual, June 1998.

U.S. Army Corps of Engineers – Hydrologic Engineering Center, HEC-RAS River Analysis System User's Manual, November 2002.

U.S. Department of Agriculture, 1986, Urban Hydrology for Small Watersheds Technical Release 55

U.S. Weather Bureau (USWB), 1961, Rainfall Frequency Atlas of the United States, Technical Paper 40, Washington, D.C.

EXHIBITS

Exhibit 1

Exhibit 1. Upper Turkey Creek HEC-RAS existing-condition model cross sections per reach in reference to Turkey Creek watershed.
(Note: Reach RR-Bypass is not included in this illustration)

Base from the U.S. Department of Agriculture
2008 National Agricultural Imagery Program (NAIP)

0 1,500 3,000 6,000 9,000 Feet

Explanation

- TC-M120
- TC-M85
- TC-M80
- TC-M80a
- TC-M81
- TRIB88
- TRIB87
- TRIB85
- TRIB81
- I-35Bypass
- ITC
- TES-87
- Turkey Creek Main Channel
- Turkey Creek Watershed

Exhibit 2

Exhibit 2. Design discharges based on TP-40 and Atlas 14 and flow change locations in the HEC-RAS model

				Discharge for different annual chance of exceedance events (in cubic feet per second)							
			Flow	50% ACE Event	20% ACE Event	10% ACE Event	5% ACE Event	2% ACE Event	1% ACE Event	0.05% ACE Event	0.02% ACE Event
ID	Precipitation Source	Reach	Change Location*	(2-yr Event)	(5-yr Event)	(10-yr Event)	(20-yr Event)	(50-yr Event)	(100-yr Event)	(200-yr Event)	(500-yr Event)
1	ATLAS 14	TC-M120	7.508	572	759	924	1165	1348	1564	1779	2073
	TP-40			557	736	880	1027	1290	1368	1485	1712
2	ATLAS 14	TC-M120	7.182	1010	1357	1647	2047	2345	2653	2904	3207
	TP-40			982	1314	1570	1802	2253	2377	2546	2878
3	ATLAS 14	TC-M120	7.078	1318	1765	2128	2678	3104	3396	3697	4249
	TP-40			1281	1715	2022	2355	2965	3104	3289	3601
4	ATLAS 14	TC-M120	6.4	1908	2391	3115	4166	5033	5631	6272	7102
	TP-40			1875	2271	2946	3508	4768	5085	5424	6046
5	ATLAS 14	TC-M120	6.089	2135	2632	3295	4378	5182	6185	6913	7911
	TP-40			2092	2556	3084	3723	4933	5257	5833	6749
6	ATLAS 14	TC-M120	5.902	2201	2820	3474	4596	5586	6480	7220	8477
	TP-40			2116	2674	3273	3885	5278	5665	6154	7047
7	ATLAS 14	TRIB81	6.708	226	320	406	533	632	748	865	1025
	TP-40			218	308	383	455	600	642	706	829
8	ATLAS 14	TRIB81	6.4	376	541	689	904	1065	1251	1434	1679
	TP-40			363	520	649	772	1014	1082	1184	1377
9	ATLAS 14	TRIB81	5.969	544	769	987	1307	1543	1828	2115	2506
	TP-40			525	742	928	1109	1468	1567	1719	2026
10	ATLAS 14	TRIB81	5.838	852	1211	1511	2007	2402	2856	3296	3893
	TP-40			823	1198	1427	1658	2276	2443	2693	3160
11	ATLAS 14	TRIB88	6.771	432	620	789	1045	1237	1463	1691	2000
	TP-40			418	596	743	886	1176	1258	1380	1621
12	ATLAS 14	TRIB87	6.76	546	746	925	1188	1390	1627	1864	2189
	TP-40			530	722	877	1027	1325	1413	1540	1791
13	ATLAS 14	TRIB85	6.712	933	1308	1641	2142	2532	2991	3453	4086
	TP-40			903	1262	1551	1881	2407	2573	2824	3319
14	ATLAS 14	TRIB85	6.272	1131	1548	1933	2494	2903	3379	3848	4480
	TP-40			1095	1498	1828	2153	2773	2946	3206	3703
15	ATLAS 14	TES-87	5.9	1987	2397	2503	2937	3169	3446	3710	4061
	TP-40			1926	2354	2474	2651	3096	3194	3347	3652
16	ATLAS 14	TC-M80	5.513	2934	3872	4306	5873	7263	8764	9967	11498
	TP-40			2896	3742	4211	4800	6802	7434	8200	9662
17	ATLAS 14	TC-M80	5.394	2944	3862	4328	5845	7153	8524	9736	11282
	TP-40			2903	3727	4224	4766	6724	7227	8015	9400
18	ATLAS 14	TC-M80	5.023	3005	3931	4409	5897	7186	8625	9924	11511
	TP-40			2963	3795	4303	4846	6844	7279	8193	9556
19	ATLAS 14	TC-M80	4.634	3764	4768	5590	7313	8678	9980	11239	12759
	TP-40			3689	4604	5389	6063	8283	8785	9548	10838
20	ATLAS 14	TC-M80	4.516	3963	4976	5794	7460	8813	10144	11398	13005
	TP-40			3874	4809	5615	6251	8404	8909	9699	11018
21	ATLAS 14	TC-M80	4.234	3971	5032	5877	7505	8781	10047	11248	12846
	TP-40			3889	4876	5684	6332	8411	8875	9619	10883
22	ATLAS 14	TC-M80	3.726	4410	5595	6469	7890	9108	10381	11629	13363
	TP-40			4304	5447	6243	6963	8753	9212	9950	11247
23	ATLAS 14	TC-M80	3.665	6461	8918	10718	13007	14839	16855	18610	21037
	TP-40			6242	8596	10293	11585	14263	15007	16101	18115
24	ATLAS 14	TC-M80	3.07	6764	9291	11200	13593	15507	17691	19657	22293
	TP-40			6534	8957	10749	12124	14895	15699	16891	19091
25	ATLAS 14	TC-M80	2.813	6491	8890	10849	13309	15185	17348	19333	22087
	TP-40			6267	8576	10364	11815	14593	15379	16535	18744

				Discharge for different annual chance of exceedance events (in cubic feet per second)							
ID	Precipitation Source	Reach	Flow Change Location*	50% ACE Event (2-yr Event)	20% ACE Event (5-yr Event)	10% ACE Event (10-yr Event)	5% ACE Event (20-yr Event)	2% ACE Event (50-yr Event)	1% ACE Event (100-yr Event)	0.05% ACE Event (200-yr Event)	0.02% ACE Event (500-yr Event)
26	ATLAS 14	TC-M80	2.396	5621	7845	9843	12533	14448	16613	18641	21526
	TP-40			5434	7534	9322	10910	13853	14644	15801	18035
27	ATLAS 14	TC-M80	2.065	6047	8554	10894	14033	16224	18733	21068	24355
	TP-40			5837	8205	10275	12156	15549	16453	17804	20372
28	ATLAS 14	TC-M80	1.651	6049	8395	10294	13039	15699	18034	20597	23968
	TP-40			5841	8089	9850	11156	15003	15971	17152	19840
29	ATLAS 14	TC-M80	1.204	6419	8938	10981	13828	16834	19441	22341	26130
	TP-40			6200	8615	10489	11906	16022	17193	18537	21413
30	ATLAS 14	TC-M80	0.992	6538	9107	11201	13781	17035	19846	22744	26642
	TP-40			6312	8769	10692	12127	16097	17404	18862	21864
31	ATLAS 14	TC-M80	0.628	6683	9325	11463	14131	17355	20403	23434	27557
	TP-40			6451	8973	10926	12439	16464	17818	19416	22482
32	ATLAS 14	I-35 bypass	0.115	726	1013	336	1535	1885	2502	2545	4390
	TP-40			701	974	320	1351	1788	2185	2109	3581
33	ATLAS 14	TC-M80a	0.115	5957	8312	11127	12596	15470	17901	20889	23167
	TP-40			5750	7999	10606	11088	14676	15633	17307	18901
34	ATLAS 14	TC-M85	-0.073	6756	9408	11562	14251	17467	20624	23663	27865
	TP-40			6510	9054	11012	12552	16548	17833	19603	22708
35	ATLAS 14	TC-M85	-0.403	6510	9256	10437	14250	15582	20585	23595	27183
	TP-40			6260	8800	9940	12500	14700	17900	19500	22100
36	ATLAS 14	RR Bypass	-0.525	10	1768	2310	3762	4558	6325	7018	7995
	TP-40			0	0	0	0	0	0	0	0
37	ATLAS 14	RR Bypass	-0.529	10	312	1155	2280	2544	4025	6050	7380
	TP-40			0	0	0	0	0	0	0	0
38	ATLAS 14	RR Bypass	-0.56	45	416	609	1938	3392	5405	7260	8610
	TP-40			0	0	0	0	0	0	0	0
39	ATLAS 14	TC-M81	-0.524	6510	7488	8127	10488	11024	14260	16577	19803
	TP-40			6260	8900	9940	12500	14700	17900	19500	22100
40	ATLAS 14	TC-M81	-0.541	6614	7602	8295	10682	11236	14605	16940	20172
	TP-40			6360	9010	10100	12670	14900	18200	19800	22400
41	ATLAS 14	TC-M81	-0.77	6614	9058	10070	12768	13250	16905	18392	20049
	TP-40			6360	10410	11790	14500	16800	20200	21000	22400
42	ATLAS 14	TC-M81	-1.054	6739	9287	10700	12882	12720	15985	17182	19680
	TP-40			6513	10730	11870	14500	17100	20600	21000	23100
43	ATLAS 14	ITC	-1.344	6739	9287	10700	12882	12720	15985	17182	19680
	TP-40			6480	8930	10190	11300	12000	13900	14200	16000
44	ATLAS 14	ITC	-1.419	6802	9703	10784	14820	16112	21390	24442	28290
	TP-40			6540	9330	10270	13000	15200	18600	20200	23000
45	ATLAS 14	ITC	-1.479	6864	9797	10868	15048	16854	21505	24805	28782
	TP-40			6600	9420	10350	13200	15900	18700	20500	23400

* The flow change locations are identified as cross sections in the HEC-RAS model

Exhibit 3

Exhibit 3. Tabular results from Existing Condition HEC-RAS model - including reaches TC-M81, TC-M85, TC-M80a, TC-M80, and TC-M120

HEC-RAS Plan: PreProject

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M120	7.508	001YR	259.71	1009.34	1015.60	1011.80	1015.63	0.000204	1.41	183.99	50.01	0.13
TC-M120	7.508	002YR	572.00	1009.34	1017.28	1012.90	1017.35	0.000318	2.07	275.82	59.14	0.17
TC-M120	7.508	005YR	759.00	1009.34	1018.00	1013.39	1018.09	0.000364	2.38	318.41	63.01	0.18
TC-M120	7.508	010YR	924.00	1009.34	1019.27	1013.78	1019.36	0.000276	2.32	398.19	74.22	0.16
TC-M120	7.508	020YR	1165.00	1009.34	1022.37	1014.26	1022.41	0.000102	1.79	729.48	140.57	0.11
TC-M120	7.508	050YR	1348.00	1009.34	1025.27	1014.59	1025.30	0.000045	1.42	1176.37	172.81	0.07
TC-M120	7.508	100YR	1564.00	1009.34	1029.21	1014.94	1029.22	0.000017	1.05	2211.25	329.48	0.05
TC-M120	7.508	200YR	1779.00	1009.34	1033.28	1015.28	1033.29	0.000006	0.77	3912.44	504.31	0.03
TC-M120	7.508	500YR	2073.00	1009.34	1038.87	1015.70	1038.87	0.000002	0.49	7206.08	674.47	0.02
TC-M120	7.479	001YR	259.71	1010.50	1015.34		1015.51	0.001871	3.35	77.45	29.02	0.36
TC-M120	7.479	002YR	572.00	1010.50	1016.83		1017.17	0.002051	4.65	128.45	38.98	0.41
TC-M120	7.479	005YR	759.00	1010.50	1017.43		1017.87	0.002266	5.36	152.46	42.10	0.44
TC-M120	7.479	010YR	924.00	1010.50	1018.83		1019.19	0.001342	4.91	216.31	48.72	0.35
TC-M120	7.479	020YR	1165.00	1010.50	1022.12		1022.33	0.000459	3.83	420.37	87.14	0.22
TC-M120	7.479	050YR	1348.00	1010.50	1025.13		1025.26	0.000204	3.08	827.07	200.41	0.15
TC-M120	7.479	100YR	1564.00	1010.50	1029.16		1029.20	0.000066	2.11	1940.21	359.29	0.09
TC-M120	7.479	200YR	1779.00	1010.50	1033.26		1033.28	0.000025	1.50	3598.80	478.06	0.06
TC-M120	7.479	500YR	2073.00	1010.50	1038.86		1038.87	0.000008	1.00	6920.53	672.68	0.03
TC-M120	7.438	001YR	259.71	1010.26	1013.68	1013.68	1014.54	0.016146	7.44	34.90	20.36	1.00
TC-M120	7.438	002YR	572.00	1010.26	1014.94	1014.94	1016.14	0.014869	8.79	65.08	27.80	1.01
TC-M120	7.438	005YR	759.00	1010.26	1016.23		1017.03	0.007092	7.16	105.97	35.30	0.73
TC-M120	7.438	010YR	924.00	1010.26	1018.51		1018.84	0.001856	4.61	200.22	47.01	0.39
TC-M120	7.438	020YR	1165.00	1010.26	1022.08		1022.21	0.000457	2.91	400.21	65.34	0.21
TC-M120	7.438	050YR	1348.00	1010.26	1025.13		1025.20	0.000171	2.17	623.91	82.14	0.13
TC-M120	7.438	100YR	1564.00	1010.26	1029.15		1029.19	0.000059	1.66	1003.85	107.35	0.08
TC-M120	7.438	200YR	1779.00	1010.26	1033.25		1033.27	0.000025	1.32	1717.87	270.73	0.06
TC-M120	7.438	500YR	2073.00	1010.26	1038.86		1038.87	0.000008	0.93	3377.27	314.52	0.03
TC-M120	7.247	001YR	259.71	1003.58	1006.94	1005.64	1007.19	0.002028	4.01	64.64	25.11	0.44
TC-M120	7.247	002YR	572.00	1003.58	1012.51	1006.87	1012.61	0.000199	2.53	226.42	43.89	0.16
TC-M120	7.247	005YR	759.00	1003.58	1014.82	1007.45	1014.92	0.000143	2.57	295.81	51.40	0.14
TC-M120	7.247	010YR	924.00	1003.58	1015.25	1007.88	1015.39	0.000184	2.99	308.74	52.79	0.16
TC-M120	7.247	020YR	1165.00	1003.58	1015.99	1008.46	1016.18	0.000233	3.52	330.89	59.33	0.19
TC-M120	7.247	050YR	1348.00	1003.58	1016.38	1008.86	1016.62	0.000277	3.93	342.58	66.13	0.21
TC-M120	7.247	100YR	1564.00	1003.58	1016.70	1009.32	1017.01	0.000340	4.44	352.30	73.62	0.23
TC-M120	7.247	200YR	1779.00	1003.58	1016.99	1009.74	1017.37	0.000406	4.93	360.97	80.30	0.25
TC-M120	7.247	500YR	2073.00	1003.58	1017.30	1010.26	1017.78	0.000507	5.60	370.08	89.75	0.28
TC-M120	7.182	001YR	430.51	1000.80	1004.56		1005.36	0.009171	7.18	59.99	24.03	0.80
TC-M120	7.182	002YR	1010.00	1000.80	1012.32		1012.44	0.000894	2.84	361.25	64.32	0.19
TC-M120	7.182	005YR	1357.00	1000.80	1014.72		1014.82	0.000525	2.64	590.52	126.72	0.15
TC-M120	7.182	010YR	1647.00	1000.80	1015.13		1015.26	0.000626	2.97	644.79	137.52	0.17
TC-M120	7.182	020YR	2047.00	1000.80	1015.86		1016.00	0.000644	3.15	749.49	148.55	0.17
TC-M120	7.182	050YR	2345.00	1000.80	1016.24		1016.40	0.000681	3.32	807.90	162.49	0.18
TC-M120	7.182	100YR	2653.00	1000.80	1016.56		1016.73	0.000722	3.48	864.48	198.24	0.18
TC-M120	7.182	200YR	2904.00	1000.80	1016.85		1017.02	0.000718	3.53	924.96	214.23	0.18
TC-M120	7.182	500YR	3207.00	1000.80	1017.15		1017.33	0.000718	3.59	994.24	238.48	0.18
TC-M120	7.156	001YR	430.51	998.50	1003.80	1002.25	1004.35	0.004541	5.94	72.52	19.33	0.54
TC-M120	7.156	002YR	1010.00	998.50	1012.15	1004.52	1012.32	0.000653	3.33	305.50	41.22	0.20
TC-M120	7.156	005YR	1357.00	998.50	1014.56	1005.54	1014.73	0.000493	3.36	463.05	103.73	0.18
TC-M120	7.156	010YR	1647.00	998.50	1014.92	1006.29	1015.14	0.000624	3.86	502.40	113.76	0.20
TC-M120	7.156	020YR	2047.00	998.50	1015.63	1007.22	1015.87	0.000687	4.22	593.83	148.61	0.21
TC-M120	7.156	050YR	2345.00	998.50	1015.99	1007.85	1016.26	0.000749	4.49	650.83	167.72	0.22
TC-M120	7.156	100YR	2653.00	998.50	1016.28	1008.44	1016.56	0.000822	4.78	700.58	175.18	0.23
TC-M120	7.156	200YR	2904.00	998.50	1016.56	1008.88	1016.87	0.000848	4.92	750.57	182.00	0.24
TC-M120	7.156	500YR	3207.00	998.50	1016.85	1009.40	1017.18	0.000884	5.10	804.83	189.12	0.25
TC-M120	7.132		Culvert									
TC-M120	7.126	001YR	430.51	996.50	1001.70		1002.02	0.002257	4.48	96.13	25.68	0.41
TC-M120	7.126	002YR	1010.00	996.50	1003.64		1004.34	0.003614	6.72	150.35	30.47	0.53
TC-M120	7.126	005YR	1357.00	996.50	1004.64		1005.50	0.003856	7.44	182.29	32.97	0.56
TC-M120	7.126	010YR	1647.00	996.50	1005.30		1006.31	0.004101	8.06	204.56	35.84	0.58
TC-M120	7.126	020YR	2047.00	996.50	1006.16		1007.33	0.004171	8.71	237.93	41.72	0.60
TC-M120	7.126	050YR	2345.00	996.50	1006.74		1008.02	0.004092	9.11	263.53	45.48	0.60
TC-M120	7.126	100YR	2653.00	996.50	1006.94		1008.48	0.004772	10.01	272.43	46.74	0.65
TC-M120	7.126	200YR	2904.00	996.50	1007.34		1008.97	0.004744	10.34	291.61	49.36	0.65
TC-M120	7.126	500YR	3207.00	996.50	1008.29		1009.80	0.003805	10.00	341.67	55.63	0.60
TC-M120	7.078	001YR	571.51	996.37	999.54	999.54	1000.54	0.012875	8.14	73.11	36.89	0.96
TC-M120	7.078	002YR	1318.00	996.37	1001.30	1001.05	1002.70	0.008705	9.82	143.78	43.03	0.87
TC-M120	7.078	005YR	1765.00	996.37	1001.93	1001.80	1003.71	0.009262	11.16	171.12	44.98	0.92
TC-M120	7.078	010YR	2128.00	996.37	1002.46	1002.34	1004.46	0.009062	11.87	195.50	46.66	0.92
TC-M120	7.078	020YR	2678.00	996.37	1003.26	1003.09	1005.50	0.008479	12.64	233.74	49.11	0.91
TC-M120	7.078	050YR	3104.00	996.37	1003.88	1003.62	1006.24	0.007927	13.05	264.71	50.85	0.90
TC-M120	7.078	100YR	3396.00	996.37	1004.40	1003.97	1006.75	0.007177	13.07	291.49	52.34	0.87
TC-M120	7.078	200YR	3697.00	996.37	1004.70	1004.31	1007.21	0.007268	13.54	307.50	53.21	0.88
TC-M120	7.078	500YR	4249.00	996.37	1005.17	1004.85	1008.02	0.007678	14.48	332.62	54.55	0.91

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M120	7.020	001YR	571.51	992.89	997.02		997.66	0.005804	6.40	89.34	30.13	0.65
TC-M120	7.020	002YR	1318.00	992.89	998.84		1000.01	0.008486	8.67	152.08	39.10	0.77
TC-M120	7.020	005YR	1765.00	992.89	1000.16		1001.30	0.005854	8.60	208.27	46.46	0.67
TC-M120	7.020	010YR	2128.00	992.89	1000.76		1002.07	0.005802	9.22	237.39	49.96	0.68
TC-M120	7.020	020YR	2678.00	992.89	1001.01	1000.30	1002.89	0.007944	11.09	249.76	51.18	0.80
TC-M120	7.020	050YR	3104.00	992.89	1001.14	1000.89	1003.55	0.009884	12.56	256.58	51.84	0.90
TC-M120	7.020	100YR	3396.00	992.89	1001.25	1001.25	1004.03	0.011085	13.46	262.55	52.41	0.95
TC-M120	7.020	200YR	3697.00	992.89	1001.61	1001.61	1004.51	0.010803	13.79	281.45	54.18	0.95
TC-M120	7.020	500YR	4249.00	992.89	1002.26	1002.26	1005.33	0.010175	14.26	317.95	57.45	0.94
TC-M120	6.967	001YR	571.51	991.17	995.96		996.18	0.004080	3.75	152.37	90.69	0.51
TC-M120	6.967	002YR	1318.00	991.17	999.12		999.24	0.000658	2.86	466.97	108.87	0.24
TC-M120	6.967	005YR	1765.00	991.17	1000.55		1000.68	0.000467	2.89	628.37	116.77	0.21
TC-M120	6.967	010YR	2128.00	991.17	1001.26		1001.40	0.000463	3.10	712.54	120.66	0.21
TC-M120	6.967	020YR	2678.00	991.17	1001.80		1002.00	0.000561	3.59	778.72	123.68	0.24
TC-M120	6.967	050YR	3104.00	991.17	1002.22		1002.46	0.000619	3.92	831.58	126.11	0.25
TC-M120	6.967	100YR	3396.00	991.17	1002.47		1002.73	0.000664	4.15	882.69	127.52	0.26
TC-M120	6.967	200YR	3697.00	991.17	1002.69		1002.98	0.000713	4.38	891.71	128.98	0.27
TC-M120	6.967	500YR	4249.00	991.17	1003.09		1003.44	0.000797	4.78	943.77	132.11	0.29
TC-M120	6.903	001YR	571.51	989.18	995.13		995.35	0.001662	3.76	151.94	43.25	0.35
TC-M120	6.903	002YR	1318.00	989.18	998.72		998.97	0.000912	4.03	333.66	58.55	0.28
TC-M120	6.903	005YR	1765.00	989.18	1000.18		1000.46	0.000791	4.29	438.08	101.27	0.27
TC-M120	6.903	010YR	2128.00	989.18	1000.90		1001.19	0.000766	4.47	513.12	107.92	0.27
TC-M120	6.903	020YR	2678.00	989.18	1001.36		1001.74	0.000934	5.11	563.58	112.18	0.30
TC-M120	6.903	050YR	3104.00	989.18	1001.74		1002.17	0.001016	5.48	606.51	115.60	0.31
TC-M120	6.903	100YR	3396.00	989.18	1001.94		1002.42	0.001086	5.74	630.52	117.44	0.32
TC-M120	6.903	200YR	3697.00	989.18	1002.12		1002.66	0.001169	6.03	651.80	119.62	0.34
TC-M120	6.903	500YR	4249.00	989.18	1002.44		1003.07	0.001308	6.52	690.29	123.66	0.36
TC-M120	6.850	001YR	571.51	991.00	993.29	993.29	994.23	0.014669	7.78	73.49	38.75	1.00
TC-M120	6.850	002YR	1318.00	991.00	998.50	994.76	998.71	0.000843	3.69	362.84	102.78	0.28
TC-M120	6.850	005YR	1765.00	991.00	1000.12	995.45	1000.27	0.000405	3.04	566.52	143.20	0.20
TC-M120	6.850	010YR	2128.00	991.00	1000.86	995.94	1001.02	0.000333	2.95	679.59	162.22	0.19
TC-M120	6.850	020YR	2678.00	991.00	1001.32	996.61	1001.52	0.000392	3.33	762.39	203.19	0.21
TC-M120	6.850	050YR	3104.00	991.00	1001.72	997.06	1001.94	0.000386	3.41	846.27	215.74	0.21
TC-M120	6.850	100YR	3396.00	991.00	1001.94	997.35	1002.18	0.000392	3.50	895.85	230.49	0.21
TC-M120	6.850	200YR	3697.00	991.00	1002.14	997.65	1002.39	0.000401	3.59	941.97	233.91	0.21
TC-M120	6.850	500YR	4249.00	991.00	1002.49	998.99	1002.77	0.000411	3.73	1025.58	238.57	0.22
TC-M120	6.836		Culvert									
TC-M120	6.827	001YR	571.51	985.98	992.06	988.41	992.14	0.000421	2.28	250.77	56.72	0.19
TC-M120	6.827	002YR	1318.00	985.98	995.89	989.84	996.00	0.000305	2.66	496.20	74.31	0.18
TC-M120	6.827	005YR	1765.00	985.98	998.85	990.53	998.93	0.000189	2.32	773.10	141.20	0.14
TC-M120	6.827	010YR	2128.00	985.98	1000.28	991.03	1000.34	0.000118	2.04	1044.12	205.73	0.11
TC-M120	6.827	020YR	2678.00	985.98	1000.74	991.70	1000.83	0.000141	2.30	1140.73	210.09	0.13
TC-M120	6.827	050YR	3104.00	985.98	1001.29	992.19	1001.39	0.000137	2.35	1257.36	214.37	0.13
TC-M120	6.827	100YR	3396.00	985.98	1001.55	992.51	1001.67	0.000141	2.42	1315.90	216.42	0.13
TC-M120	6.827	200YR	3697.00	985.98	1001.78	992.82	1001.90	0.000148	2.51	1364.05	217.96	0.13
TC-M120	6.827	500YR	4249.00	985.98	1002.14	993.35	1002.29	0.000161	2.67	1442.51	220.37	0.14
TC-M120	6.767	001YR	571.51	986.09	991.97		992.02	0.000278	1.67	339.54	98.89	0.15
TC-M120	6.767	002YR	1318.00	986.09	995.87		995.92	0.000107	1.68	770.53	122.97	0.11
TC-M120	6.767	005YR	1765.00	986.09	998.84		998.88	0.000053	1.48	1174.99	157.71	0.08
TC-M120	6.767	010YR	2128.00	986.09	1000.25		1000.31	0.000044	1.46	1459.13	225.80	0.07
TC-M120	6.767	020YR	2678.00	986.09	1000.72		1000.79	0.000058	1.72	1565.49	236.50	0.09
TC-M120	6.767	050YR	3104.00	986.09	1001.27		1001.35	0.000063	1.85	1698.74	249.15	0.09
TC-M120	6.767	100YR	3396.00	986.09	1001.54		1001.63	0.000068	1.95	1767.14	255.40	0.09
TC-M120	6.767	200YR	3697.00	986.09	1001.76		1001.86	0.000074	2.05	1824.08	260.49	0.10
TC-M120	6.767	500YR	4249.00	986.09	1002.12		1002.24	0.000086	2.25	1918.84	276.19	0.11
TC-M120	6.699	001YR	571.51	986.02	991.69		991.82	0.001406	2.90	197.05	53.84	0.26
TC-M120	6.699	002YR	1318.00	986.02	995.70		995.84	0.000604	3.05	451.61	73.84	0.20
TC-M120	6.699	005YR	1765.00	986.02	998.74		998.84	0.000292	2.65	759.19	188.82	0.14
TC-M120	6.699	010YR	2128.00	986.02	1000.22		1000.28	0.000174	2.23	1094.76	247.52	0.11
TC-M120	6.699	020YR	2678.00	986.02	1000.67		1000.75	0.000206	2.49	1210.51	261.11	0.12
TC-M120	6.699	050YR	3104.00	986.02	1001.23		1001.31	0.000196	2.50	1357.91	269.95	0.12
TC-M120	6.699	100YR	3396.00	986.02	1001.50		1001.59	0.000198	2.55	1431.96	275.04	0.12
TC-M120	6.699	200YR	3697.00	986.02	1001.72		1001.82	0.000207	2.63	1492.91	279.48	0.13
TC-M120	6.699	500YR	4249.00	986.02	1002.07		1002.19	0.000222	2.78	1593.09	285.10	0.13
TC-M120	6.637	001YR	571.51	985.92	991.15	988.92	991.35	0.001443	3.51	162.91	45.51	0.31
TC-M120	6.637	002YR	1318.00	985.92	995.37	990.40	995.60	0.000802	3.85	342.55	65.88	0.25
TC-M120	6.637	005YR	1765.00	985.92	998.53	991.06	998.71	0.000437	3.44	515.12	115.43	0.20
TC-M120	6.637	010YR	2128.00	985.92	1000.11	991.57	1000.21	0.000273	2.49	844.94	135.55	0.14
TC-M120	6.637	020YR	2678.00	985.92	1000.52	992.29	1000.66	0.000350	2.90	911.49	176.60	0.16
TC-M120	6.637	050YR	3104.00	985.92	1001.07	992.82	1001.22	0.000348	3.00	1015.49	204.26	0.16
TC-M120	6.637	100YR	3396.00	985.92	1001.33	993.17	1001.50	0.000359	3.10	1076.00	255.19	0.17
TC-M120	6.637	200YR	3697.00	985.92	1001.55	993.52	1001.72	0.000377	3.22	1135.38	298.98	0.17

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M120	6.637	500YR	4249.00	985.92	1001.90	994.11	1002.08	0.000410	3.43	1252.51	370.48	0.18
TC-M120	6.621		Culvert									
TC-M120	6.611	001YR	571.51	983.19	986.38	986.31	987.34	0.013442	7.86	72.69	34.66	0.96
TC-M120	6.611	002YR	1318.00	983.19	988.03	987.90	989.51	0.011521	9.75	135.13	40.96	0.95
TC-M120	6.611	005YR	1765.00	983.19	988.95	988.66	990.54	0.009937	10.12	174.34	44.47	0.90
TC-M120	6.611	010YR	2128.00	983.19	989.50	989.19	991.27	0.009852	10.67	199.45	46.57	0.91
TC-M120	6.611	020YR	2678.00	983.19	990.25	989.94	992.27	0.009307	11.39	235.58	49.48	0.90
TC-M120	6.611	050YR	3104.00	983.19	990.74	990.42	992.97	0.009103	11.99	260.26	51.37	0.91
TC-M120	6.611	100YR	3396.00	983.19	991.04	990.77	993.43	0.009112	12.43	275.58	52.51	0.92
TC-M120	6.611	200YR	3697.00	983.19	991.33	991.10	993.89	0.009126	12.86	291.02	53.63	0.92
TC-M120	6.611	500YR	4249.00	983.19	991.79	991.70	994.68	0.009340	13.67	316.06	55.43	0.95
TC-M120	6.545	001YR	571.51	980.68	984.36	983.29	984.77	0.003891	5.10	112.04	40.72	0.54
TC-M120	6.545	002YR	1318.00	980.68	986.64	984.85	987.22	0.003003	6.10	216.80	50.87	0.51
TC-M120	6.545	005YR	1765.00	980.68	988.07	985.57	988.64	0.002131	6.11	293.61	57.16	0.45
TC-M120	6.545	010YR	2128.00	980.68	988.56	986.09	989.26	0.002336	6.76	322.26	59.37	0.48
TC-M120	6.545	020YR	2678.00	980.68	989.33	986.78	990.19	0.002468	7.51	369.28	62.83	0.50
TC-M120	6.545	050YR	3104.00	980.68	989.81	987.30	990.80	0.002623	8.09	400.12	65.23	0.52
TC-M120	6.545	100YR	3396.00	980.68	990.08	987.62	991.18	0.002773	8.51	417.75	66.57	0.54
TC-M120	6.545	200YR	3697.00	980.68	990.35	987.94	991.55	0.002910	8.92	435.84	67.91	0.56
TC-M120	6.545	500YR	4249.00	980.68	990.72	988.51	992.15	0.003264	9.74	461.60	69.78	0.59
TC-M120	6.484	001YR	571.51	978.81	981.47	981.47	982.48	0.014921	8.09	70.68	35.29	1.01
TC-M120	6.484	002YR	1318.00	978.81	986.12		986.47	0.001565	4.76	277.12	54.80	0.37
TC-M120	6.484	005YR	1765.00	978.81	987.69		988.04	0.001295	4.77	369.97	63.10	0.35
TC-M120	6.484	010YR	2128.00	978.81	988.13		988.57	0.001553	5.35	397.96	65.51	0.38
TC-M120	6.484	020YR	2678.00	978.81	988.87		989.42	0.001766	5.98	448.13	69.89	0.41
TC-M120	6.484	050YR	3104.00	978.81	989.32		989.97	0.001934	6.47	481.89	96.29	0.44
TC-M120	6.484	100YR	3396.00	978.81	989.56		990.29	0.002033	6.80	511.31	121.91	0.45
TC-M120	6.484	200YR	3697.00	978.81	989.86		990.62	0.002084	7.06	546.39	129.72	0.46
TC-M120	6.484	500YR	4249.00	978.81	990.23		991.11	0.002265	7.61	596.91	149.18	0.48
TC-M120	6.424	001YR	571.51	975.14	980.96	978.43	981.14	0.000938	3.12	183.35	50.59	0.28
TC-M120	6.424	002YR	1318.00	975.14	986.08	979.89	986.22	0.000306	2.98	442.46	75.94	0.18
TC-M120	6.424	005YR	1765.00	975.14	987.71	980.58	987.81	0.000263	2.68	690.18	166.02	0.16
TC-M120	6.424	010YR	2128.00	975.14	988.17	981.08	988.30	0.000290	2.92	773.07	183.16	0.17
TC-M120	6.424	020YR	2678.00	975.14	988.98	981.79	989.12	0.000280	3.04	929.27	202.18	0.17
TC-M120	6.424	050YR	3104.00	975.14	989.50	982.28	989.64	0.000275	3.13	1036.37	215.15	0.17
TC-M120	6.424	100YR	3396.00	975.14	989.79	982.62	989.94	0.000277	3.20	1100.43	222.54	0.18
TC-M120	6.424	200YR	3697.00	975.14	990.10	982.95	990.26	0.000273	3.24	1170.64	230.37	0.18
TC-M120	6.424	500YR	4249.00	975.14	990.53	983.50	990.71	0.000280	3.37	1272.22	240.17	0.18
TC-M120	6.415		Culvert									
TC-M120	6.406	001YR	571.51	975.03	979.24	976.97	979.38	0.000965	2.95	193.47	55.99	0.28
TC-M120	6.406	002YR	1318.00	975.03	980.98	978.26	981.29	0.001467	4.43	297.73	63.79	0.36
TC-M120	6.406	005YR	1765.00	975.03	981.87	978.89	982.25	0.001576	4.96	356.13	67.77	0.38
TC-M120	6.406	010YR	2128.00	975.03	983.33	979.35	983.66	0.001114	4.63	459.58	74.29	0.33
TC-M120	6.406	020YR	2678.00	975.03	985.07	979.98	985.38	0.000847	4.49	595.96	82.14	0.29
TC-M120	6.406	050YR	3104.00	975.03	986.30	980.44	986.61	0.000677	4.45	700.11	87.53	0.27
TC-M120	6.406	100YR	3396.00	975.03	987.08	980.74	987.38	0.000603	4.46	769.55	90.94	0.26
TC-M120	6.406	200YR	3697.00	975.03	987.85	981.03	988.15	0.000544	4.46	843.85	108.75	0.25
TC-M120	6.406	500YR	4249.00	975.03	988.79	981.52	989.09	0.000493	4.51	1011.78	224.48	0.24
TC-M120	6.400	001YR	1101.39	974.00	978.85		979.24	0.002368	5.02	219.57	55.85	0.45
TC-M120	6.400	002YR	1908.00	974.00	980.61		981.15	0.002312	5.87	324.86	63.62	0.46
TC-M120	6.400	005YR	2391.00	974.00	981.51		982.11	0.002265	6.23	383.90	67.58	0.46
TC-M120	6.400	010YR	3115.00	974.00	982.84		983.50	0.002082	6.52	477.81	73.44	0.45
TC-M120	6.400	020YR	4166.00	974.00	984.46		985.21	0.001877	6.92	602.44	80.50	0.44
TC-M120	6.400	050YR	5033.00	974.00	985.59		986.41	0.001734	7.29	695.60	85.19	0.43
TC-M120	6.400	100YR	5631.00	974.00	986.30		987.17	0.001669	7.53	757.22	88.04	0.43
TC-M120	6.400	200YR	6272.00	974.00	986.99		987.93	0.001627	7.79	819.51	90.82	0.43
TC-M120	6.400	500YR	7102.00	974.00	987.84		988.85	0.001584	8.10	900.37	108.43	0.43
TC-M120	6.351	001YR	1101.39	971.38	977.78		978.46	0.003662	6.62	166.41	35.85	0.54
TC-M120	6.351	002YR	1908.00	971.38	978.88		980.19	0.005660	9.19	208.59	41.45	0.69
TC-M120	6.351	005YR	2391.00	971.38	979.26	978.36	981.05	0.007066	10.75	224.89	43.44	0.78
TC-M120	6.351	010YR	3115.00	971.38	979.57	979.45	982.29	0.010039	13.26	238.72	44.89	0.94
TC-M120	6.351	020YR	4166.00	971.38	980.84	980.84	984.04	0.009363	14.50	299.07	50.89	0.94
TC-M120	6.351	050YR	5033.00	971.38	981.84	981.84	985.30	0.008666	15.17	352.50	55.98	0.92
TC-M120	6.351	100YR	5631.00	971.38	982.48	982.48	986.09	0.008273	15.57	389.82	60.05	0.91
TC-M120	6.351	200YR	6272.00	971.38	983.17	983.17	986.87	0.007793	15.86	432.71	64.44	0.89
TC-M120	6.351	500YR	7102.00	971.38	983.94	983.94	987.80	0.007469	16.33	484.09	69.47	0.89
TC-M120	6.306	001YR	1101.39	971.10	975.92	975.50	977.10	0.008978	8.75	128.23	54.91	0.84
TC-M120	6.306	002YR	1908.00	971.10	977.31	977.19	978.64	0.007447	9.63	227.27	86.76	0.80
TC-M120	6.306	005YR	2391.00	971.10	977.93	977.81	979.29	0.006669	9.94	284.00	94.39	0.77
TC-M120	6.306	010YR	3115.00	971.10	978.81	978.43	980.14	0.005598	10.11	369.33	100.84	0.73
TC-M120	6.306	020YR	4166.00	971.10	980.07		981.32	0.004221	9.98	514.43	137.02	0.65

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M120	6.306	050YR	5033.00	971.10	981.78		982.57	0.002195	8.29	788.70	181.73	0.49
TC-M120	6.306	100YR	5631.00	971.10	982.90		983.50	0.001499	7.41	1010.56	211.64	0.41
TC-M120	6.306	200YR	6272.00	971.10	983.70		984.23	0.001231	7.07	1186.64	225.58	0.38
TC-M120	6.306	500YR	7102.00	971.10	984.63		985.11	0.001015	6.77	1403.02	239.57	0.35
TC-M120	6.261	001YR	1101.39	968.71	975.60		975.91	0.002179	4.50	244.79	76.79	0.44
TC-M120	6.261	002YR	1908.00	968.71	977.26		977.60	0.001732	4.69	406.89	116.73	0.44
TC-M120	6.261	005YR	2391.00	968.71	977.90		978.28	0.001729	4.97	482.83	121.50	0.43
TC-M120	6.261	010YR	3115.00	968.71	978.78		979.22	0.001672	5.30	593.39	129.93	0.42
TC-M120	6.261	020YR	4166.00	968.71	980.06		980.54	0.001468	5.57	770.45	145.76	0.40
TC-M120	6.261	050YR	5033.00	968.71	981.72		982.13	0.000988	5.20	1024.96	161.81	0.33
TC-M120	6.261	100YR	5631.00	968.71	982.81		983.19	0.000794	5.03	1207.81	173.77	0.30
TC-M120	6.261	200YR	6272.00	968.71	983.59		983.97	0.000736	5.09	1347.84	184.65	0.29
TC-M120	6.261	500YR	7102.00	968.71	984.50		984.89	0.000685	5.19	1520.78	194.82	0.28
TC-M120	6.205	001YR	1101.39	968.18	974.80		975.22	0.002392	5.25	209.87	55.44	0.48
TC-M120	6.205	002YR	1908.00	968.18	976.50		976.99	0.002335	5.63	338.60	96.73	0.53
TC-M120	6.205	005YR	2391.00	968.18	977.08		977.64	0.002545	6.04	396.37	101.69	0.53
TC-M120	6.205	010YR	3115.00	968.18	977.96		978.60	0.002479	6.43	487.99	107.33	0.52
TC-M120	6.205	020YR	4166.00	968.18	979.32		980.00	0.002100	6.66	640.02	115.36	0.47
TC-M120	6.205	050YR	5033.00	968.18	981.22		981.78	0.001302	6.06	869.55	126.55	0.38
TC-M120	6.205	100YR	5631.00	968.18	982.39		982.90	0.001037	5.85	1021.97	133.54	0.34
TC-M120	6.205	200YR	6272.00	968.18	983.18		983.71	0.000979	5.96	1129.46	143.04	0.33
TC-M120	6.205	500YR	7102.00	968.18	984.09		984.64	0.000922	6.10	1270.52	160.75	0.32
TC-M120	6.148	001YR	1101.39	968.16	974.14		974.51	0.002230	4.89	225.09	55.56	0.43
TC-M120	6.148	002YR	1908.00	968.16	975.66		976.22	0.002803	6.02	317.09	65.40	0.48
TC-M120	6.148	005YR	2391.00	968.16	975.87		976.68	0.003928	7.21	331.44	66.71	0.57
TC-M120	6.148	010YR	3115.00	968.16	976.39	974.77	977.51	0.005100	8.49	367.01	69.60	0.65
TC-M120	6.148	020YR	4166.00	968.16	977.85		979.05	0.004673	8.79	473.85	77.69	0.63
TC-M120	6.148	050YR	5033.00	968.16	980.42		981.24	0.002256	7.29	699.11	101.28	0.45
TC-M120	6.148	100YR	5631.00	968.16	981.76		982.49	0.001652	6.91	844.10	113.43	0.40
TC-M120	6.148	200YR	6272.00	968.16	982.58		983.32	0.001522	7.01	938.83	119.00	0.39
TC-M120	6.148	500YR	7102.00	968.16	983.51		984.28	0.001422	7.18	1052.24	125.90	0.38
TC-M120	6.089	001YR	1305.01	968.16	971.57	971.57	972.90	0.013545	9.27	140.83	53.28	1.00
TC-M120	6.089	002YR	2135.00	968.16	972.62	972.62	974.41	0.012704	10.74	199.71	59.91	1.02
TC-M120	6.089	005YR	2632.00	968.16	973.69	973.69	974.98	0.007199	9.42	363.46	191.50	0.79
TC-M120	6.089	010YR	3295.00	968.16	974.16	974.16	975.59	0.007211	10.11	455.47	194.04	0.81
TC-M120	6.089	020YR	4378.00	968.16	977.79		978.17	0.001124	5.79	1194.39	213.46	0.35
TC-M120	6.089	050YR	5182.00	968.16	980.57		980.78	0.000474	4.54	1851.34	245.95	0.24
TC-M120	6.089	100YR	6185.00	968.16	981.90		982.11	0.000421	4.62	2181.52	250.95	0.23
TC-M120	6.089	200YR	6913.00	968.16	982.73		982.95	0.000402	4.71	2391.95	254.08	0.23
TC-M120	6.089	500YR	7911.00	968.16	983.68		983.91	0.000397	4.89	2633.88	257.73	0.23
TC-M120	6.038	001YR	1305.01	963.08	968.79		969.25	0.002874	5.43	240.37	61.32	0.48
TC-M120	6.038	002YR	2135.00	963.08	971.03		971.50	0.001847	5.49	389.73	71.43	0.41
TC-M120	6.038	005YR	2632.00	963.08	972.23		972.71	0.001502	5.56	477.89	76.06	0.38
TC-M120	6.038	010YR	3295.00	963.08	974.12		974.53	0.000974	5.26	731.05	159.03	0.32
TC-M120	6.038	020YR	4378.00	963.08	977.69		977.96	0.000441	4.45	1360.63	218.88	0.22
TC-M120	6.038	050YR	5182.00	963.08	980.50		980.69	0.000247	3.83	2010.78	244.58	0.17
TC-M120	6.038	100YR	6185.00	963.08	981.83		982.02	0.000238	3.98	2360.74	282.58	0.17
TC-M120	6.038	200YR	6913.00	963.08	982.67		982.86	0.000235	4.09	2605.52	302.09	0.17
TC-M120	6.038	500YR	7911.00	963.08	983.62		983.82	0.000238	4.26	2903.82	326.64	0.18
TC-M120	5.988	001YR	1305.01	963.00	968.14	966.56	968.52	0.002598	4.92	265.00	76.09	0.47
TC-M120	5.988	002YR	2135.00	963.00	970.76	967.49	971.06	0.001240	4.37	488.11	95.69	0.34
TC-M120	5.988	005YR	2632.00	963.00	972.06	967.98	972.35	0.000928	4.27	616.77	141.35	0.30
TC-M120	5.988	010YR	3295.00	963.00	974.04	968.58	974.29	0.000572	4.04	816.31	223.46	0.25
TC-M120	5.988	020YR	4378.00	963.00	977.64	969.44	977.85	0.000296	3.71	1180.02	295.11	0.19
TC-M120	5.988	050YR	5182.00	963.00	980.55	970.02	980.62	0.000092	2.40	2936.49	406.81	0.11
TC-M120	5.988	100YR	6185.00	963.00	981.89	970.73	981.95	0.000079	2.36	3487.46	414.19	0.10
TC-M120	5.988	200YR	6913.00	963.00	982.73	971.13	982.80	0.000074	2.35	3837.73	417.97	0.10
TC-M120	5.988	500YR	7911.00	963.00	983.69	971.68	983.75	0.000070	2.38	4239.14	422.81	0.10
TC-M120	5.968		Culvert									
TC-M120	5.944	001YR	1305.01	959.34	965.36	963.01	965.61	0.001397	4.01	336.17	114.11	0.35
TC-M120	5.944	002YR	2135.00	959.34	966.98	964.02	967.29	0.001165	4.57	505.48	148.95	0.34
TC-M120	5.944	005YR	2632.00	959.34	969.20	964.52	969.42	0.000549	3.91	759.99	163.49	0.24
TC-M120	5.944	010YR	3295.00	959.34	971.29	965.14	971.49	0.000372	3.76	1021.75	176.88	0.21
TC-M120	5.944	020YR	4378.00	959.34	972.66	965.94	972.92	0.000413	4.32	1204.74	188.05	0.23
TC-M120	5.944	050YR	5182.00	959.34	973.33	966.47	973.65	0.000469	4.78	1297.90	198.69	0.24
TC-M120	5.944	100YR	6185.00	959.34	973.85	967.09	974.26	0.000574	5.44	1370.65	205.36	0.27
TC-M120	5.944	200YR	6913.00	959.34	974.20	967.50	974.68	0.000648	5.89	1421.27	208.39	0.29
TC-M120	5.944	500YR	7911.00	959.34	974.62	968.05	975.20	0.000756	6.50	1481.62	211.96	0.31
TC-M120	5.902	001YR	1167.27	958.89	964.34	963.21	965.00	0.004292	6.56	199.29	133.07	0.60
TC-M120	5.902	002YR	2201.00	958.89	966.29		966.85	0.002504	6.63	487.35	159.14	0.49
TC-M120	5.902	005YR	2820.00	958.89	969.04		969.28	0.000731	4.66	957.55	183.04	0.28
TC-M120	5.902	010YR	3474.00	958.89	971.21		971.39	0.000417	4.10	1373.24	199.71	0.22

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M120	5.902	020YR	4596.00	958.89	972.59		972.80	0.000443	4.59	1661.20	218.98	0.23
TC-M120	5.902	050YR	5586.00	958.89	973.25		973.51	0.000521	5.15	1808.28	224.80	0.26
TC-M120	5.902	100YR	6480.00	958.89	973.77		974.08	0.000591	5.64	1925.78	228.57	0.27
TC-M120	5.902	200YR	7220.00	958.89	974.12		974.47	0.000658	6.06	2006.53	231.62	0.29
TC-M120	5.902	500YR	8477.00	958.89	974.51		974.96	0.000806	6.83	2098.45	235.42	0.32
TC-M120	5.842	001YR	1167.27	957.61	962.60	961.89	963.38	0.006161	7.15	180.74	109.11	0.70
TC-M120	5.842	002YR	2201.00	957.61	965.91		966.24	0.001270	5.20	592.50	135.87	0.36
TC-M120	5.842	005YR	2820.00	957.61	968.90		969.08	0.000462	4.03	1027.09	154.53	0.23
TC-M120	5.842	010YR	3474.00	957.61	971.11		971.27	0.000309	3.79	1385.22	170.04	0.20
TC-M120	5.842	020YR	4596.00	957.61	972.47		972.67	0.000355	4.37	1630.38	190.90	0.21
TC-M120	5.842	050YR	5586.00	957.61	973.10		973.36	0.000435	4.99	1752.27	196.47	0.24
TC-M120	5.842	100YR	6480.00	957.61	973.58		973.90	0.000509	5.53	1848.70	200.79	0.26
TC-M120	5.842	200YR	7220.00	957.61	973.90		974.27	0.000577	5.98	1913.54	203.64	0.28
TC-M120	5.842	500YR	8477.00	957.61	974.23		974.71	0.000731	6.82	1981.00	210.08	0.31
TC-M120	5.768	001YR	1167.27	955.72	961.60	960.66	962.29	0.002975	6.99	196.23	102.07	0.59
TC-M120	5.768	002YR	2201.00	955.72	965.86		965.99	0.000291	3.45	846.52	169.96	0.21
TC-M120	5.768	005YR	2820.00	955.72	968.90		968.97	0.000113	2.63	1393.19	192.53	0.14
TC-M120	5.768	010YR	3474.00	955.72	971.12		971.18	0.000079	2.47	1855.70	219.35	0.12
TC-M120	5.768	020YR	4596.00	955.72	972.48		972.56	0.000088	2.78	2160.85	227.59	0.13
TC-M120	5.768	050YR	5586.00	955.72	973.12		973.22	0.000108	3.16	2307.08	231.13	0.14
TC-M120	5.768	100YR	6480.00	955.72	973.62		973.74	0.000126	3.48	2421.86	233.87	0.15
TC-M120	5.768	200YR	7220.00	955.72	973.94		974.08	0.000142	3.75	2498.89	235.69	0.16
TC-M120	5.768	500YR	8477.00	955.72	974.28		974.47	0.000179	4.26	2579.60	237.58	0.18
TC-M120	5.703	001YR	1167.27	955.32	961.14		961.48	0.001525	5.09	278.70	125.33	0.43
TC-M120	5.703	002YR	2201.00	955.32	965.84		965.90	0.000146	2.55	1151.75	218.87	0.15
TC-M120	5.703	005YR	2820.00	955.32	968.89		968.93	0.000060	1.98	1870.37	250.93	0.10
TC-M120	5.703	010YR	3474.00	955.32	971.12		971.15	0.000042	1.85	2454.72	273.39	0.09
TC-M120	5.703	020YR	4596.00	955.32	972.49		972.53	0.000048	2.12	2836.90	285.85	0.09
TC-M120	5.703	050YR	5586.00	955.32	973.13		973.18	0.000060	2.41	3021.34	291.46	0.10
TC-M120	5.703	100YR	6480.00	955.32	973.62		973.69	0.000070	2.67	3166.96	296.62	0.11
TC-M120	5.703	200YR	7220.00	955.32	973.95		974.03	0.000080	2.88	3265.55	303.73	0.12
TC-M120	5.703	500YR	8477.00	955.32	974.29		974.40	0.000100	3.27	3372.41	316.99	0.14
TC-M120	5.647	001YR	1167.27	954.39	959.22	959.22	960.59	0.005911	10.26	143.81	61.12	0.85
TC-M120	5.647	002YR	2201.00	954.39	965.82		965.86	0.000088	2.28	1451.19	259.95	0.12
TC-M120	5.647	005YR	2820.00	954.39	968.89		968.91	0.000038	1.76	2300.08	290.55	0.08
TC-M120	5.647	010YR	3474.00	954.39	971.12		971.14	0.000027	1.64	2968.99	309.85	0.07
TC-M120	5.647	020YR	4596.00	954.39	972.48		972.51	0.000032	1.87	3400.76	321.53	0.08
TC-M120	5.647	050YR	5586.00	954.39	973.12		973.16	0.000040	2.15	3608.72	330.61	0.09
TC-M120	5.647	100YR	6480.00	954.39	973.62		973.67	0.000048	2.40	3774.58	339.30	0.10
TC-M120	5.647	200YR	7220.00	954.39	973.95		974.01	0.000055	2.60	3887.30	344.32	0.10
TC-M120	5.647	500YR	8477.00	954.39	974.29		974.37	0.000069	2.96	4006.56	348.47	0.12
TRIB81	6.708	001YR	69.02	1013.26	1014.97		1015.19	0.006791	3.73	18.52	16.21	0.61
TRIB81	6.708	002YR	226.00	1013.26	1016.09		1016.60	0.008504	5.74	39.36	21.00	0.74
TRIB81	6.708	005YR	320.00	1013.26	1016.50		1017.18	0.009680	6.63	48.23	22.73	0.80
TRIB81	6.708	010YR	406.00	1013.26	1016.77	1016.52	1017.63	0.011020	7.43	54.66	23.91	0.87
TRIB81	6.708	020YR	533.00	1013.26	1017.08	1017.01	1018.22	0.013266	8.56	62.25	25.23	0.96
TRIB81	6.708	050YR	632.00	1013.26	1017.34	1017.34	1018.65	0.014140	9.18	68.85	26.33	1.00
TRIB81	6.708	100YR	748.00	1013.26	1017.70	1017.70	1019.11	0.013834	9.53	78.50	27.85	1.00
TRIB81	6.708	200YR	865.00	1013.26	1018.02	1018.02	1019.53	0.013619	9.85	87.82	29.24	1.00
TRIB81	6.708	500YR	1025.00	1013.26	1018.44	1018.44	1020.06	0.013290	10.21	100.38	31.03	1.00
TRIB81	6.635	001YR	69.02	1010.46	1013.25		1013.39	0.003425	3.11	26.81	28.57	0.45
TRIB81	6.635	002YR	226.00	1010.46	1014.40		1014.63	0.003353	4.40	99.89	93.17	0.49
TRIB81	6.635	005YR	320.00	1010.46	1014.80		1015.06	0.003392	4.88	141.57	114.43	0.50
TRIB81	6.635	010YR	406.00	1010.46	1015.10		1015.38	0.003385	5.20	178.36	129.33	0.51
TRIB81	6.635	020YR	533.00	1010.46	1015.48		1015.77	0.003355	5.57	231.37	148.40	0.51
TRIB81	6.635	050YR	632.00	1010.46	1015.73		1016.02	0.003341	5.80	268.49	156.04	0.52
TRIB81	6.635	100YR	748.00	1010.46	1015.96		1016.27	0.003420	6.11	306.41	163.30	0.53
TRIB81	6.635	200YR	865.00	1010.46	1016.16		1016.50	0.003583	6.45	339.82	170.45	0.55
TRIB81	6.635	500YR	1025.00	1010.46	1016.41		1016.77	0.003824	6.91	382.21	180.53	0.57
TRIB81	6.595	001YR	69.02	1009.58	1012.09		1012.32	0.007920	3.85	17.91	16.57	0.65
TRIB81	6.595	002YR	226.00	1009.58	1013.31		1013.69	0.005853	5.11	56.28	48.84	0.63
TRIB81	6.595	005YR	320.00	1009.58	1013.82		1014.20	0.004766	5.35	84.91	63.39	0.59
TRIB81	6.595	010YR	406.00	1009.58	1014.22		1014.59	0.004020	5.41	113.63	78.46	0.55
TRIB81	6.595	020YR	533.00	1009.58	1014.74		1015.08	0.003212	5.39	163.41	132.61	0.51
TRIB81	6.595	050YR	632.00	1009.58	1015.09		1015.39	0.002740	5.30	217.06	167.54	0.48
TRIB81	6.595	100YR	748.00	1009.58	1015.38		1015.66	0.002483	5.30	268.61	185.15	0.46
TRIB81	6.595	200YR	865.00	1009.58	1015.58		1015.87	0.002481	5.46	307.21	196.96	0.46
TRIB81	6.595	500YR	1025.00	1009.58	1015.83		1016.12	0.002477	5.66	357.33	211.30	0.47
TRIB81	6.555	001YR	69.02	1008.13	1010.71	1010.30	1010.97	0.005581	4.38	23.20	23.80	0.54
TRIB81	6.555	002YR	226.00	1008.13	1012.15	1011.57	1012.57	0.005673	6.29	67.75	38.10	0.59
TRIB81	6.555	005YR	320.00	1008.13	1012.69	1012.05	1013.18	0.005946	7.08	89.61	43.42	0.62
TRIB81	6.555	010YR	406.00	1008.13	1013.02	1012.42	1013.61	0.006639	7.89	104.73	46.76	0.67
TRIB81	6.555	020YR	533.00	1008.13	1013.51	1012.89	1014.19	0.007032	8.72	128.80	51.85	0.70

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TRIB81	6.555	050YR	632.00	1008.13	1013.95	1013.21	1014.61	0.006499	8.87	154.63	78.65	0.68
TRIB81	6.555	100YR	748.00	1008.13	1014.82	1013.53	1015.15	0.003229	6.93	247.65	124.51	0.49
TRIB81	6.555	200YR	865.00	1008.13	1014.53	1014.31	1015.17	0.006158	9.26	213.33	113.09	0.67
TRIB81	6.555	500YR	1025.00	1008.13	1014.90	1014.59	1015.47	0.005464	9.09	258.35	127.86	0.64
TRIB81	6.553		Bridge									
TRIB81	6.551	001YR	69.02	1008.10	1010.53	1010.14	1010.79	0.005727	4.34	21.55	22.68	0.57
TRIB81	6.551	002YR	226.00	1008.10	1011.97		1012.40	0.005216	6.14	66.95	40.06	0.60
TRIB81	6.551	005YR	320.00	1008.10	1012.49		1013.00	0.005483	6.95	89.23	46.26	0.63
TRIB81	6.551	010YR	406.00	1008.10	1012.65		1013.36	0.007316	8.25	96.93	48.22	0.73
TRIB81	6.551	020YR	533.00	1008.10	1012.98	1012.74	1013.89	0.008804	9.55	113.46	52.17	0.82
TRIB81	6.551	050YR	632.00	1008.10	1013.23	1013.12	1014.25	0.009528	10.32	126.80	57.04	0.86
TRIB81	6.551	100YR	748.00	1008.10	1013.48	1013.46	1014.63	0.010299	11.12	141.70	62.25	0.90
TRIB81	6.551	200YR	865.00	1008.10	1014.16	1014.16	1014.79	0.005681	9.03	220.99	144.28	0.68
TRIB81	6.551	500YR	1025.00	1008.10	1014.37	1014.37	1015.00	0.005752	9.32	251.84	146.36	0.69
TRIB81	6.513	001YR	69.02	1006.68	1008.92	1008.71	1009.30	0.009939	4.99	15.10	15.46	0.76
TRIB81	6.513	002YR	226.00	1006.68	1010.09	1010.09	1010.92	0.010522	7.78	44.20	35.88	0.86
TRIB81	6.513	005YR	320.00	1006.68	1010.58	1010.58	1011.51	0.010090	8.58	64.11	45.48	0.87
TRIB81	6.513	010YR	406.00	1006.68	1011.09	1011.09	1011.91	0.007950	8.44	89.73	56.05	0.79
TRIB81	6.513	020YR	533.00	1006.68	1011.51	1011.51	1012.37	0.007686	8.95	115.95	67.02	0.79
TRIB81	6.513	050YR	632.00	1006.68	1011.80	1011.80	1012.65	0.007426	9.22	136.03	73.69	0.79
TRIB81	6.513	100YR	748.00	1006.68	1012.08	1012.08	1012.94	0.007294	9.53	157.45	80.17	0.79
TRIB81	6.513	200YR	865.00	1006.68	1012.30	1012.30	1013.19	0.007349	9.89	176.39	85.48	0.80
TRIB81	6.513	500YR	1025.00	1006.68	1012.55	1012.55	1013.51	0.007744	10.50	198.02	92.84	0.83
TRIB81	6.449	001YR	69.02	1002.84	1004.26	1004.26	1004.75	0.019324	5.62	12.29	12.99	1.01
TRIB81	6.449	002YR	226.00	1002.84	1005.43	1005.43	1006.34	0.014827	7.73	31.42	20.04	0.98
TRIB81	6.449	005YR	320.00	1002.84	1005.96	1005.96	1007.03	0.012853	8.45	43.04	24.40	0.95
TRIB81	6.449	010YR	406.00	1002.84	1006.39	1006.39	1007.57	0.011493	8.92	54.65	31.16	0.93
TRIB81	6.449	020YR	533.00	1002.84	1007.02	1007.02	1008.19	0.009294	9.15	78.37	42.89	0.86
TRIB81	6.449	050YR	632.00	1002.84	1007.38	1007.38	1008.60	0.008771	9.48	94.73	48.47	0.85
TRIB81	6.449	100YR	748.00	1002.84	1007.84	1007.84	1008.99	0.007449	9.43	119.91	60.84	0.80
TRIB81	6.449	200YR	865.00	1002.84	1008.22	1008.22	1009.31	0.006716	9.46	144.78	72.49	0.77
TRIB81	6.449	500YR	1025.00	1002.84	1008.59	1008.59	1009.68	0.006388	9.71	173.90	84.12	0.76
TRIB81	6.400	001YR	100.45	998.35	999.32	999.32	999.71	0.002751	5.00	20.10	25.92	1.00
TRIB81	6.400	002YR	376.00	998.35	1000.40	1000.40	1001.28	0.002183	7.51	50.08	28.53	1.00
TRIB81	6.400	005YR	541.00	998.35	1001.85	1000.90	1002.38	0.000670	5.82	92.92	30.70	0.59
TRIB81	6.400	010YR	689.00	998.35	1002.55	1001.30	1003.11	0.000581	6.00	114.76	32.05	0.56
TRIB81	6.400	020YR	904.00	998.35	1003.64	1001.82	1004.19	0.000457	5.97	151.48	35.26	0.51
TRIB81	6.400	050YR	1065.00	998.35	1004.37	1002.19	1004.92	0.000405	5.99	177.93	37.41	0.48
TRIB81	6.400	100YR	1251.00	998.35	1005.18	1002.59	1005.73	0.000357	5.98	209.12	39.99	0.46
TRIB81	6.400	200YR	1434.00	998.35	1005.70	1002.98	1006.30	0.000345	6.23	232.14	52.70	0.46
TRIB81	6.400	500YR	1679.00	998.35	1006.33	1003.44	1006.99	0.000333	6.56	272.55	74.66	0.46
TRIB81	6.388		Culvert									
TRIB81	6.373	001YR	100.45	996.87	997.85	997.85	998.31	0.019743	5.42	18.52	20.44	1.00
TRIB81	6.373	002YR	376.00	996.87	999.77	999.14	1000.34	0.008373	6.01	62.51	29.72	0.73
TRIB81	6.373	005YR	541.00	996.87	1001.54	999.85	1001.86	0.002526	4.50	120.16	68.01	0.43
TRIB81	6.373	010YR	689.00	996.87	1001.93	1000.26	1002.34	0.002991	5.14	134.01	75.38	0.47
TRIB81	6.373	020YR	904.00	996.87	1002.28	1000.78	1002.87	0.003906	6.14	148.73	103.66	0.55
TRIB81	6.373	050YR	1065.00	996.87	1002.33	1001.15	1003.12	0.005205	7.14	151.97	112.37	0.63
TRIB81	6.373	100YR	1251.00	996.87	1002.71	1001.54	1003.43	0.004692	7.10	244.37	135.37	0.61
TRIB81	6.373	200YR	1434.00	996.87	1002.99	1001.88	1003.75	0.004743	7.38	282.85	137.55	0.62
TRIB81	6.373	500YR	1679.00	996.87	1003.75	1002.78	1004.34	0.003392	6.77	389.75	143.94	0.53
TRIB81	6.356	001YR	100.45	995.33	997.68	997.14	997.86	0.000931	3.45	29.08	21.15	0.52
TRIB81	6.356	002YR	376.00	995.33	999.64	998.48	1000.02	0.001212	4.92	76.49	27.11	0.52
TRIB81	6.356	005YR	541.00	995.33	1001.48	999.07	1001.73	0.000636	4.05	154.00	87.46	0.35
TRIB81	6.356	010YR	689.00	995.33	1001.87	999.52	1002.18	0.000723	4.58	191.00	106.37	0.38
TRIB81	6.356	020YR	904.00	995.33	1002.22	1000.11	1002.64	0.000907	5.40	227.81	112.26	0.43
TRIB81	6.356	050YR	1065.00	995.33	1002.25	1000.53	1002.83	0.001229	6.31	230.79	112.62	0.50
TRIB81	6.356	100YR	1251.00	995.33	1002.56	1001.26	1003.21	0.001309	6.78	263.63	116.54	0.52
TRIB81	6.356	200YR	1434.00	995.33	1002.82	1001.77	1003.54	0.001398	7.23	291.61	119.09	0.54
TRIB81	6.356	500YR	1679.00	995.33	1003.54	1002.21	1004.18	0.001118	7.02	371.77	124.81	0.50
TRIB81	6.353		Bridge									
TRIB81	6.350	001YR	100.45	995.33	997.13	997.13	997.61	0.002566	5.54	18.13	18.97	1.00
TRIB81	6.350	002YR	376.00	995.33	998.47	998.47	999.49	0.002099	8.09	46.45	22.85	1.00
TRIB81	6.350	005YR	541.00	995.33	999.07	999.07	1000.31	0.001976	8.92	60.67	24.35	1.00
TRIB81	6.350	010YR	689.00	995.33	999.51	999.51	1000.95	0.001971	9.61	71.69	25.44	1.01
TRIB81	6.350	020YR	904.00	995.33	1000.14	1000.14	1001.78	0.001876	10.26	88.07	26.99	1.00
TRIB81	6.350	050YR	1065.00	995.33	1000.55	1000.55	1002.33	0.001841	10.71	99.45	28.01	1.00
TRIB81	6.350	100YR	1251.00	995.33	1001.01	1001.01	1002.93	0.001790	11.12	112.53	29.15	1.00
TRIB81	6.350	200YR	1434.00	995.33	1001.41	1001.41	1003.48	0.001731	11.54	125.90	38.02	0.99
TRIB81	6.350	500YR	1679.00	995.33	1001.98	1001.98	1004.15	0.001546	11.85	157.68	72.22	0.96

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TRIB81	6.289	001YR	100.45	991.26	993.03	993.03	993.71	0.002552	6.61	15.19	11.37	1.01
TRIB81	6.289	002YR	376.00	991.26	994.91	994.91	996.14	0.002170	8.93	42.11	17.26	1.01
TRIB81	6.289	005YR	541.00	991.26	995.63	995.63	997.12	0.001975	9.78	56.38	24.17	0.99
TRIB81	6.289	010YR	689.00	991.26	996.18	996.18	997.89	0.001817	10.49	71.98	32.52	0.98
TRIB81	6.289	020YR	904.00	991.26	996.96	996.96	998.87	0.001589	11.18	101.75	44.15	0.95
TRIB81	6.289	050YR	1065.00	991.26	997.43	997.43	999.52	0.001530	11.76	123.75	49.20	0.95
TRIB81	6.289	100YR	1251.00	991.26	997.97	997.97	1000.21	0.001437	12.24	152.31	55.44	0.93
TRIB81	6.289	200YR	1434.00	991.26	998.46	998.46	1000.84	0.001378	12.70	180.56	60.59	0.93
TRIB81	6.289	500YR	1679.00	991.26	999.04	999.04	1001.62	0.001340	13.34	217.12	66.71	0.93
TRIB81	6.224	001YR	100.45	986.01	987.78	987.78	988.46	0.002552	6.63	15.16	11.28	1.01
TRIB81	6.224	002YR	376.00	986.01	989.67	989.67	990.92	0.002176	8.97	41.92	17.03	1.01
TRIB81	6.224	005YR	541.00	986.01	990.43	990.43	991.90	0.001932	9.75	57.98	29.67	0.98
TRIB81	6.224	010YR	689.00	986.01	990.99	990.99	992.66	0.001767	10.43	77.03	38.56	0.97
TRIB81	6.224	020YR	904.00	986.01	991.75	991.75	993.62	0.001554	11.11	110.59	48.34	0.93
TRIB81	6.224	050YR	1065.00	986.01	992.21	992.21	994.25	0.001513	11.71	133.43	51.84	0.94
TRIB81	6.224	100YR	1251.00	986.01	992.75	992.75	994.93	0.001421	12.18	162.73	56.01	0.93
TRIB81	6.224	200YR	1434.00	986.01	993.06	993.06	995.56	0.001525	13.10	180.38	58.37	0.97
TRIB81	6.224	500YR	1679.00	986.01	993.77	993.77	996.37	0.001370	13.44	227.81	74.48	0.94
TRIB81	6.173	001YR	100.45	982.06	984.00	984.00	984.64	0.018402	6.38	15.73	12.56	1.00
TRIB81	6.173	002YR	376.00	982.06	985.73	985.73	986.78	0.015629	8.22	45.74	22.19	1.01
TRIB81	6.173	005YR	541.00	982.06	986.35	986.35	987.60	0.014243	8.97	60.60	26.10	1.00
TRIB81	6.173	010YR	689.00	982.06	986.79	986.79	988.24	0.013327	9.68	72.94	28.90	0.99
TRIB81	6.173	020YR	904.00	982.06	987.42	987.42	989.08	0.011981	10.42	91.85	31.92	0.97
TRIB81	6.173	050YR	1065.00	982.06	987.82	987.82	989.66	0.011485	10.96	105.21	33.89	0.97
TRIB81	6.173	100YR	1251.00	982.06	988.26	988.26	990.27	0.011069	11.52	120.38	36.00	0.96
TRIB81	6.173	200YR	1434.00	982.06	988.68	988.68	990.84	0.010560	11.96	136.21	38.71	0.96
TRIB81	6.173	500YR	1679.00	982.06	989.22	989.22	991.54	0.010002	12.48	157.93	42.45	0.95
TRIB81	6.100	001YR	100.45	977.60	979.59		979.89	0.005643	4.41	22.80	17.29	0.67
TRIB81	6.100	002YR	376.00	977.60	980.78	980.75	981.83	0.009849	8.27	47.26	26.68	0.97
TRIB81	6.100	005YR	541.00	977.60	981.59	981.44	982.68	0.006978	8.53	76.64	45.61	0.86
TRIB81	6.100	010YR	689.00	977.60	981.97	981.97	983.29	0.007304	9.45	95.81	53.91	0.90
TRIB81	6.100	020YR	904.00	977.60	982.61	982.61	984.02	0.006547	10.01	134.32	66.48	0.87
TRIB81	6.100	050YR	1065.00	977.60	982.99	982.99	984.49	0.006342	10.46	161.12	72.75	0.87
TRIB81	6.100	100YR	1251.00	977.60	983.41	983.41	984.99	0.006083	10.88	192.99	79.47	0.87
TRIB81	6.100	200YR	1434.00	977.60	983.77	983.77	985.43	0.005994	11.31	222.20	85.16	0.87
TRIB81	6.100	500YR	1679.00	977.60	984.23	984.23	985.96	0.005781	11.75	263.35	92.55	0.87
TRIB81	6.039	001YR	100.45	975.21	977.72		977.95	0.006139	3.84	27.73	34.09	0.59
TRIB81	6.039	002YR	376.00	975.21	979.10		979.46	0.004771	5.47	120.50	90.45	0.59
TRIB81	6.039	005YR	541.00	975.21	979.07	979.07	979.86	0.010349	7.99	117.88	89.41	0.87
TRIB81	6.039	010YR	689.00	975.21	979.38	979.38	980.25	0.010339	8.61	147.80	100.65	0.88
TRIB81	6.039	020YR	904.00	975.21	979.90	979.90	980.75	0.008816	8.85	205.74	122.64	0.84
TRIB81	6.039	050YR	1065.00	975.21	980.12	980.12	981.03	0.009015	9.33	233.53	124.29	0.85
TRIB81	6.039	100YR	1251.00	975.21	980.32	980.32	981.33	0.009644	10.00	258.70	125.76	0.89
TRIB81	6.039	200YR	1434.00	975.21	980.54	980.54	981.61	0.009803	10.45	286.15	127.35	0.91
TRIB81	6.039	500YR	1679.00	975.21	980.78	980.78	981.95	0.010281	11.12	317.22	129.06	0.94
TRIB81	5.969	001YR	168.25	971.49	973.68	973.68	974.49	0.012508	7.24	23.23	14.44	1.01
TRIB81	5.969	002YR	544.00	971.49	975.73	975.73	977.11	0.007601	9.64	71.25	36.42	0.90
TRIB81	5.969	005YR	769.00	971.49	977.11	977.11	977.73	0.002913	7.41	319.52	311.95	0.59
TRIB81	5.969	010YR	987.00	971.49	977.41	977.41	978.02	0.003044	7.87	413.93	321.74	0.60
TRIB81	5.969	020YR	1307.00	971.49	977.68	977.68	978.38	0.003594	8.85	503.35	328.65	0.66
TRIB81	5.969	050YR	1543.00	971.49	977.90	977.90	978.61	0.003727	9.25	576.21	334.18	0.68
TRIB81	5.969	100YR	1828.00	971.49	978.06	978.06	978.86	0.004281	10.09	629.04	338.13	0.73
TRIB81	5.969	200YR	2115.00	971.49	978.73		979.21	0.002683	8.57	859.25	354.82	0.59
TRIB81	5.969	500YR	2506.00	971.49	979.97		980.19	0.001214	6.47	1318.98	381.64	0.41
TRIB81	5.907	001YR	168.25	967.19	971.98	968.93	972.02	0.000296	1.52	110.59	34.96	0.15
TRIB81	5.907	002YR	544.00	967.19	974.94	970.45	975.02	0.000333	2.37	254.39	85.34	0.18
TRIB81	5.907	005YR	769.00	967.19	976.04	971.12	976.15	0.000341	2.70	365.45	113.08	0.18
TRIB81	5.907	010YR	987.00	967.19	976.80	971.69	976.93	0.000368	3.01	456.86	128.01	0.19
TRIB81	5.907	020YR	1307.00	967.19	976.62	972.37	976.87	0.000708	4.12	434.88	124.58	0.27
TRIB81	5.907	050YR	1543.00	967.19	976.87	972.85	977.18	0.000865	4.65	466.18	129.43	0.30
TRIB81	5.907	100YR	1828.00	967.19	977.62	973.32	977.93	0.000820	4.82	566.92	184.49	0.29
TRIB81	5.907	200YR	2115.00	967.19	978.43	973.74	978.74	0.000737	4.86	688.62	226.78	0.28
TRIB81	5.907	500YR	2506.00	967.19	979.62	974.32	979.91	0.000613	4.81	880.51	288.46	0.26
TRIB81	5.838	001YR	252.47	965.94	969.24		969.56	0.004114	4.59	55.01	23.75	0.53
TRIB81	5.838	002YR	852.00	965.94	971.47		972.22	0.004319	7.21	150.54	57.85	0.60
TRIB81	5.838	005YR	1211.00	965.94	972.32		973.26	0.004411	8.21	202.55	63.92	0.63
TRIB81	5.838	010YR	1511.00	965.94	973.66		974.39	0.002759	7.54	302.63	102.28	0.52
TRIB81	5.838	020YR	2007.00	965.94	975.57		975.68	0.000363	3.24	865.46	492.48	0.20
TRIB81	5.838	050YR	2402.00	965.94	976.59		976.64	0.000102	1.85	1400.52	554.56	0.11
TRIB81	5.838	100YR	2856.00	965.94	977.59		977.63	0.000044	1.30	1972.90	589.62	0.07
TRIB81	5.838	200YR	3296.00	965.94	978.49		978.52	0.000025	1.04	2508.81	598.75	0.05
TRIB81	5.838	500YR	3893.00	965.94	979.72		979.75	0.000014	0.83	3269.37	650.30	0.04
TRIB81	5.788	001YR	252.47	964.86	967.99		968.34	0.005188	4.79	52.71	25.77	0.59

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TRIB81	5.788	002YR	852.00	964.86	970.03		970.80	0.006881	7.01	121.48	41.48	0.72
TRIB81	5.788	005YR	1211.00	964.86	971.33		972.04	0.004250	6.75	182.33	52.27	0.60
TRIB81	5.788	010YR	1511.00	964.86	973.28		973.75	0.001687	5.55	300.38	69.16	0.40
TRIB81	5.788	020YR	2007.00	964.86	975.21		975.52	0.000867	4.80	509.41	151.75	0.30
TRIB81	5.788	050YR	2402.00	964.86	976.36		976.58	0.000489	3.95	703.75	184.21	0.23
TRIB81	5.788	100YR	2856.00	964.86	977.42		977.59	0.000313	3.40	926.84	342.20	0.19
TRIB81	5.788	200YR	3296.00	964.86	978.41		978.50	0.000220	3.04	1503.41	708.67	0.16
TRIB81	5.788	500YR	3893.00	964.86	979.68		979.74	0.000145	2.65	2438.98	749.25	0.13
TRIB81	5.739	001YR	252.47	963.03	967.72		967.82	0.000839	2.54	109.11	47.72	0.25
TRIB81	5.739	002YR	852.00	963.03	969.31		969.72	0.002345	5.29	196.41	57.78	0.44
TRIB81	5.739	005YR	1211.00	963.03	970.91		971.30	0.001641	5.25	293.21	65.13	0.38
TRIB81	5.739	010YR	1511.00	963.03	973.15		973.40	0.000750	4.41	484.45	142.90	0.27
TRIB81	5.739	020YR	2007.00	963.03	975.26		975.36	0.000244	2.94	904.41	256.26	0.16
TRIB81	5.739	050YR	2402.00	963.03	976.41		976.49	0.000132	2.32	1236.12	317.95	0.12
TRIB81	5.739	100YR	2856.00	963.03	977.46		977.53	0.000080	1.92	1589.17	352.84	0.10
TRIB81	5.739	200YR	3296.00	963.03	978.41		978.47	0.000055	1.67	1950.43	435.95	0.08
TRIB81	5.739	500YR	3893.00	963.03	979.68		979.72	0.000032	1.35	2654.39	597.70	0.06
TRIB81	5.688	001YR	252.47	961.55	967.66		967.69	0.000244	1.45	173.55	51.38	0.14
TRIB81	5.688	002YR	852.00	961.55	969.09		969.27	0.000952	3.35	255.97	57.74	0.29
TRIB81	5.688	005YR	1211.00	961.55	970.82		970.98	0.000593	3.31	409.74	143.13	0.24
TRIB81	5.688	010YR	1511.00	961.55	973.23		973.28	0.000113	1.82	918.71	271.74	0.11
TRIB81	5.688	020YR	2007.00	961.55	975.29		975.31	0.000038	1.22	1618.00	409.21	0.07
TRIB81	5.688	050YR	2402.00	961.55	976.44		976.46	0.000024	1.04	2131.67	487.04	0.05
TRIB81	5.688	100YR	2856.00	961.55	977.49		977.51	0.000017	0.91	2672.62	531.89	0.05
TRIB81	5.688	200YR	3296.00	961.55	978.43		978.45	0.000012	0.82	3184.21	548.54	0.04
TRIB81	5.688	500YR	3893.00	961.55	979.70		979.71	0.000009	0.73	3890.03	571.18	0.03
TRIB81	5.651	001YR	252.47	959.73	967.65	961.82	967.67	0.000063	1.18	272.49	84.78	0.08
TRIB81	5.651	002YR	852.00	959.73	969.04	963.73	969.15	0.000305	2.92	438.99	154.69	0.18
TRIB81	5.651	005YR	1211.00	959.73	970.84	964.57	970.90	0.000140	2.26	804.09	262.81	0.13
TRIB81	5.651	010YR	1511.00	959.73	973.24	965.14	973.26	0.000032	1.24	1575.93	382.06	0.06
TRIB81	5.651	020YR	2007.00	959.73	975.29	966.10	975.31	0.000014	0.92	2468.72	488.41	0.04
TRIB81	5.651	050YR	2402.00	959.73	976.44	966.75	976.45	0.000011	0.84	3065.53	559.96	0.04
TRIB81	5.651	100YR	2856.00	959.73	977.49	967.74	977.50	0.000008	0.78	3687.07	611.39	0.03
TRIB81	5.651	200YR	3296.00	959.73	978.44	969.42	978.45	0.000007	0.73	4274.27	628.19	0.03
TRIB81	5.651	500YR	3893.00	959.73	979.70	969.77	979.71	0.000005	0.67	5079.97	645.76	0.03
TRIB81	5.650		Culvert									
TRIB81	5.649	001YR	252.47	958.21	965.88	961.04	965.94	0.000180	1.96	129.08	73.23	0.13
TRIB81	5.649	002YR	852.00	958.21	968.15	963.19	968.22	0.000209	2.30	577.26	256.94	0.14
TRIB81	5.649	005YR	1211.00	958.21	970.85	964.23	970.87	0.000055	1.42	1417.91	382.80	0.08
TRIB81	5.649	010YR	1511.00	958.21	973.24	965.00	973.24	0.000016	0.87	2464.54	492.24	0.04
TRIB81	5.649	020YR	2007.00	958.21	975.28	966.20	975.29	0.000008	0.70	3571.43	593.87	0.03
TRIB81	5.649	050YR	2402.00	958.21	976.39	967.06	976.40	0.000007	0.65	4257.69	634.84	0.03
TRIB81	5.649	100YR	2856.00	958.21	977.48	967.30	977.49	0.000005	0.61	4957.27	643.88	0.03
TRIB81	5.649	200YR	3296.00	958.21	978.43	967.30	978.44	0.000005	0.59	5570.14	651.70	0.02
TRIB81	5.649	500YR	3893.00	958.21	979.67	968.23	979.67	0.000004	0.56	6383.17	661.97	0.02
TRIB88	6.771	001YR	118.04	983.96	988.03	986.00	988.08	0.001470	1.73	68.16	28.11	0.20
TRIB88	6.771	002YR	432.00	983.96	989.90	987.47	990.08	0.003860	3.39	127.89	35.87	0.31
TRIB88	6.771	005YR	620.00	983.96	990.62	988.09	990.88	0.004445	4.08	153.73	38.72	0.34
TRIB88	6.771	010YR	789.00	983.96	991.05	988.57	991.39	0.005280	4.73	169.95	40.44	0.37
TRIB88	6.771	020YR	1045.00	983.96	991.78	989.21	992.23	0.005790	5.43	198.39	43.34	0.40
TRIB88	6.771	050YR	1237.00	983.96	992.32	989.60	992.84	0.005932	5.84	220.34	45.49	0.41
TRIB88	6.771	100YR	1463.00	983.96	992.85	990.01	993.46	0.006239	6.33	242.72	47.61	0.43
TRIB88	6.771	200YR	1691.00	983.96	993.25	990.43	993.97	0.006818	6.87	260.02	49.21	0.45
TRIB88	6.771	500YR	2000.00	983.96	993.78	990.92	994.64	0.007431	7.53	283.45	51.31	0.48
TRIB88	6.756	001YR	118.04	985.60	987.21	987.21	987.66	0.019751	5.37	21.98	25.24	1.01
TRIB88	6.756	002YR	432.00	985.60	988.41	988.41	989.30	0.015371	7.60	56.81	31.68	1.00
TRIB88	6.756	005YR	620.00	985.60	988.93	988.93	990.02	0.014469	8.41	73.74	33.61	1.00
TRIB88	6.756	010YR	789.00	985.60	989.67		990.64	0.009542	7.89	99.97	36.40	0.84
TRIB88	6.756	020YR	1045.00	985.60	990.67		991.56	0.007760	7.57	138.00	40.47	0.72
TRIB88	6.756	050YR	1237.00	985.60	991.35		992.20	0.007335	7.42	166.65	43.45	0.67
TRIB88	6.756	100YR	1463.00	985.60	991.92		992.82	0.007484	7.62	192.20	53.43	0.65
TRIB88	6.756	200YR	1691.00	985.60	992.31	991.09	993.30	0.007496	8.03	219.80	79.87	0.66
TRIB88	6.756	500YR	2000.00	985.60	993.23		994.12	0.005376	7.68	302.63	98.19	0.58
TRIB87	6.760	001YR	212.00	983.35	985.88		986.06	0.002718	3.35	63.27	33.14	0.43
TRIB87	6.760	002YR	546.00	983.35	988.69		988.84	0.000957	3.09	176.65	47.24	0.28
TRIB87	6.760	005YR	746.00	983.35	989.54		989.72	0.000961	3.43	218.22	51.16	0.29
TRIB87	6.760	010YR	925.00	983.35	990.42		990.61	0.000809	3.53	265.07	55.13	0.27
TRIB87	6.760	020YR	1188.00	983.35	991.34		991.56	0.000775	3.85	317.49	59.23	0.27
TRIB87	6.760	050YR	1390.00	983.35	991.97		992.23	0.000759	4.07	356.25	62.14	0.28
TRIB87	6.760	100YR	1627.00	983.35	992.56		992.85	0.000785	4.38	393.41	64.85	0.28
TRIB87	6.760	200YR	1864.00	983.35	993.00		993.35	0.000843	4.72	422.70	66.90	0.30
TRIB87	6.760	500YR	2189.00	983.35	993.82		994.20	0.000826	4.98	479.00	70.84	0.30

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TRIB87	6.743	001YR	212.00	983.01	985.30		985.68	0.006409	5.00	42.41	22.32	0.64
TRIB87	6.743	002YR	546.00	983.01	988.38		988.71	0.001982	4.55	120.02	27.92	0.39
TRIB87	6.743	005YR	746.00	983.01	989.14		989.57	0.002289	5.28	143.53	42.00	0.42
TRIB87	6.743	010YR	925.00	983.01	990.04		990.48	0.001993	5.39	197.04	63.36	0.40
TRIB87	6.743	020YR	1188.00	983.01	990.95		991.44	0.001895	5.77	256.18	67.10	0.40
TRIB87	6.743	050YR	1390.00	983.01	991.58		992.11	0.001817	6.01	299.71	69.64	0.40
TRIB87	6.743	100YR	1627.00	983.01	992.14		992.72	0.001866	6.41	339.22	71.86	0.41
TRIB87	6.743	200YR	1864.00	983.01	992.54		993.20	0.002020	6.89	368.01	73.44	0.43
TRIB87	6.743	500YR	2189.00	983.01	993.36		994.06	0.001922	7.17	429.75	76.84	0.42
TRIB85	6.712	001YR	306.75	982.22	984.63	984.63	985.62	0.016157	7.99	38.40	19.63	1.01
TRIB85	6.712	002YR	933.00	982.22	986.88	986.88	988.57	0.014080	10.42	89.53	26.75	1.00
TRIB85	6.712	005YR	1308.00	982.22	988.69	988.69	989.53	0.006743	7.35	178.06	112.62	1.03
TRIB85	6.712	010YR	1641.00	982.22	990.12		990.44	0.003445	4.54	363.74	142.63	0.49
TRIB85	6.712	020YR	2142.00	982.22	991.09		991.38	0.002969	4.34	505.37	152.21	0.40
TRIB85	6.712	050YR	2532.00	982.22	991.75		992.03	0.002735	4.32	608.22	158.72	0.37
TRIB85	6.712	100YR	2991.00	982.22	992.34		992.64	0.002717	4.46	703.28	164.51	0.38
TRIB85	6.712	200YR	3453.00	982.22	992.77		993.11	0.002867	4.71	775.43	168.66	0.38
TRIB85	6.712	500YR	4086.00	982.22	993.61		993.95	0.002634	4.76	920.88	175.98	0.34
TRIB85	6.672	001YR	306.75	979.79	984.24		984.39	0.001164	3.16	96.99	26.78	0.29
TRIB85	6.672	002YR	933.00	979.79	987.06		987.47	0.001897	5.17	180.52	33.03	0.39
TRIB85	6.672	005YR	1308.00	979.79	988.46		988.97	0.001839	5.71	234.56	60.12	0.39
TRIB85	6.672	010YR	1641.00	979.79	989.70		990.20	0.001522	5.83	349.24	109.57	0.37
TRIB85	6.672	020YR	2142.00	979.79	990.48		991.12	0.001741	6.65	439.69	119.32	0.40
TRIB85	6.672	050YR	2532.00	979.79	991.06		991.77	0.001840	7.14	510.09	124.88	0.42
TRIB85	6.672	100YR	2991.00	979.79	991.52		992.36	0.002076	7.83	568.07	128.65	0.45
TRIB85	6.672	200YR	3453.00	979.79	991.75		992.78	0.002486	8.71	598.50	130.56	0.49
TRIB85	6.672	500YR	4086.00	979.79	992.55		993.64	0.002472	9.14	704.86	137.12	0.49
TRIB85	6.649	001YR	306.75	978.63	983.80	981.97	984.16	0.003027	4.77	64.25	17.88	0.44
TRIB85	6.649	002YR	933.00	978.63	985.53	984.69	986.94	0.008942	9.53	97.88	21.14	0.78
TRIB85	6.649	005YR	1308.00	978.63	986.61	985.85	988.40	0.009729	10.72	121.96	23.19	0.82
TRIB85	6.649	010YR	1641.00	978.63	989.30	986.72	989.96	0.002806	7.13	338.68	112.71	0.47
TRIB85	6.649	020YR	2142.00	978.63	990.20	988.68	990.88	0.002684	7.54	449.21	132.77	0.46
TRIB85	6.649	050YR	2532.00	978.63	990.84	989.11	991.53	0.002556	7.74	539.98	147.21	0.46
TRIB85	6.649	100YR	2991.00	978.63	991.32	989.62	992.07	0.002725	8.28	612.14	153.98	0.48
TRIB85	6.649	200YR	3453.00	978.63	991.53	990.08	992.44	0.003237	9.16	644.77	156.14	0.52
TRIB85	6.649	500YR	4086.00	978.63	992.43	990.63	993.29	0.002886	9.18	789.19	167.65	0.50
TRIB85	6.640		Bridge									
TRIB85	6.630	001YR	306.75	978.25	982.91		983.20	0.002475	4.30	71.36	21.27	0.41
TRIB85	6.630	002YR	933.00	978.25	985.82		986.48	0.003434	6.54	142.69	27.90	0.51
TRIB85	6.630	005YR	1308.00	978.25	986.94		987.80	0.003858	7.45	175.54	30.47	0.55
TRIB85	6.630	010YR	1641.00	978.25	987.76		988.79	0.004383	8.13	201.74	34.05	0.59
TRIB85	6.630	020YR	2142.00	978.25	988.75		990.01	0.005108	8.99	238.24	39.35	0.64
TRIB85	6.630	050YR	2532.00	978.25	989.40		990.82	0.005504	9.57	264.71	45.61	0.68
TRIB85	6.630	100YR	2991.00	978.25	990.05	988.14	991.65	0.005468	10.19	307.53	85.78	0.68
TRIB85	6.630	200YR	3453.00	978.25	990.69	988.95	992.39	0.005241	10.59	375.04	125.21	0.68
TRIB85	6.630	500YR	4086.00	978.25	991.57	990.08	993.22	0.004587	10.66	502.20	152.03	0.65
TRIB85	6.606	001YR	306.75	977.74	982.00		982.44	0.004847	5.32	57.65	21.72	0.58
TRIB85	6.606	002YR	933.00	977.74	984.90		985.62	0.004538	6.82	136.80	33.29	0.59
TRIB85	6.606	005YR	1308.00	977.74	986.16		986.96	0.003743	7.20	193.61	62.69	0.56
TRIB85	6.606	010YR	1641.00	977.74	987.02		987.90	0.003388	7.59	257.30	92.83	0.54
TRIB85	6.606	020YR	2142.00	977.74	988.14		989.04	0.002934	7.91	376.24	116.35	0.52
TRIB85	6.606	050YR	2532.00	977.74	988.90		989.79	0.002674	8.08	467.45	124.85	0.51
TRIB85	6.606	100YR	2991.00	977.74	989.68		990.59	0.002472	8.27	568.44	131.12	0.49
TRIB85	6.606	200YR	3453.00	977.74	990.42		991.33	0.002321	8.46	667.21	138.14	0.49
TRIB85	6.606	500YR	4086.00	977.74	991.35		992.27	0.002157	8.69	800.22	146.85	0.48
TRIB85	6.565	001YR	306.75	977.49	981.06		981.45	0.004070	4.97	61.74	22.82	0.53
TRIB85	6.565	002YR	933.00	977.49	984.00		984.72	0.003773	6.80	137.41	29.13	0.54
TRIB85	6.565	005YR	1308.00	977.49	985.29		986.16	0.003546	7.48	177.73	33.21	0.54
TRIB85	6.565	010YR	1641.00	977.49	986.02		987.09	0.003904	8.33	208.64	52.79	0.57
TRIB85	6.565	020YR	2142.00	977.49	986.91		988.26	0.004241	9.42	261.70	67.29	0.61
TRIB85	6.565	050YR	2532.00	977.49	987.43	985.38	989.02	0.004600	10.27	299.82	76.77	0.64
TRIB85	6.565	100YR	2991.00	977.49	987.94	986.54	989.80	0.005045	11.22	340.46	81.94	0.68
TRIB85	6.565	200YR	3453.00	977.49	988.43	987.44	990.54	0.005407	12.05	381.30	86.79	0.71
TRIB85	6.565	500YR	4086.00	977.49	989.06	988.31	991.48	0.005770	13.03	438.17	93.01	0.74
TRIB85	6.537	001YR	306.75	976.77	980.72		980.98	0.002241	4.07	75.96	25.42	0.41
TRIB85	6.537	002YR	933.00	976.77	983.68		984.27	0.002189	6.17	161.03	31.89	0.45
TRIB85	6.537	005YR	1308.00	976.77	984.98		985.73	0.002187	7.03	205.05	36.12	0.46
TRIB85	6.537	010YR	1641.00	976.77	985.64	982.86	986.61	0.002533	8.02	231.36	62.01	0.50
TRIB85	6.537	020YR	2142.00	976.77	986.48	983.86	987.74	0.002942	9.24	331.63	142.21	0.55
TRIB85	6.537	050YR	2532.00	976.77	987.06	984.58	988.44	0.003076	9.86	426.48	185.61	0.57
TRIB85	6.537	100YR	2991.00	976.77	987.84	985.33	989.14	0.002826	9.97	575.54	193.86	0.55
TRIB85	6.537	200YR	3453.00	976.77	988.60		989.81	0.002538	9.91	726.83	201.55	0.53
TRIB85	6.537	500YR	4086.00	976.77	989.56		990.66	0.002244	9.86	924.80	211.19	0.51

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TRIB85	6.478	001YR	306.75	976.05	979.96		980.23	0.002492	4.16	73.80	24.33	0.42
TRIB85	6.478	002YR	933.00	976.05	982.92		983.48	0.002792	6.05	154.55	32.35	0.47
TRIB85	6.478	005YR	1308.00	976.05	984.25		984.92	0.002821	6.59	207.82	45.10	0.48
TRIB85	6.478	010YR	1641.00	976.05	984.82		985.68	0.003251	7.46	239.25	71.24	0.53
TRIB85	6.478	020YR	2142.00	976.05	985.55		986.66	0.003691	8.56	297.10	84.33	0.57
TRIB85	6.478	050YR	2532.00	976.05	986.01		987.31	0.004064	9.37	336.56	90.11	0.61
TRIB85	6.478	100YR	2991.00	976.05	986.50	984.98	988.03	0.004441	10.22	382.32	97.30	0.64
TRIB85	6.478	200YR	3453.00	976.05	986.96	985.70	988.70	0.004738	10.97	429.35	109.12	0.67
TRIB85	6.478	500YR	4086.00	976.05	987.53	986.49	989.55	0.005141	11.94	505.62	151.90	0.71
TRIB85	6.443	001YR	306.75	975.62	979.18	978.25	979.60	0.004685	5.23	58.64	22.31	0.57
TRIB85	6.443	002YR	933.00	975.62	982.03		982.82	0.004429	7.15	130.47	28.08	0.58
TRIB85	6.443	005YR	1308.00	975.62	983.61		984.34	0.003505	6.94	224.92	92.02	0.53
TRIB85	6.443	010YR	1641.00	975.62	984.13		985.02	0.003914	7.76	279.01	120.28	0.57
TRIB85	6.443	020YR	2142.00	975.62	984.96		985.94	0.003792	8.36	391.86	145.57	0.57
TRIB85	6.443	050YR	2532.00	975.62	985.47		986.52	0.003791	8.79	469.25	153.01	0.58
TRIB85	6.443	100YR	2991.00	975.62	986.06		987.16	0.003732	9.20	561.61	163.94	0.59
TRIB85	6.443	200YR	3453.00	975.62	986.67		987.77	0.003521	9.40	663.29	171.01	0.58
TRIB85	6.443	500YR	4086.00	975.62	987.47		988.54	0.003215	9.55	804.05	180.73	0.56
TRIB85	6.394	001YR	306.75	974.10	976.56	976.56	977.52	0.015862	7.87	38.96	20.54	1.01
TRIB85	6.394	002YR	933.00	974.10	981.43		981.90	0.002423	5.53	168.58	34.47	0.44
TRIB85	6.394	005YR	1308.00	974.10	983.22		983.67	0.001605	5.49	283.86	82.80	0.38
TRIB85	6.394	010YR	1641.00	974.10	983.62		984.23	0.002014	6.40	318.76	88.38	0.43
TRIB85	6.394	020YR	2142.00	974.10	984.32		985.12	0.002378	7.41	383.89	97.93	0.47
TRIB85	6.394	050YR	2532.00	974.10	984.70		985.67	0.002755	8.24	421.54	102.15	0.51
TRIB85	6.394	100YR	2991.00	974.10	985.06		986.25	0.003227	9.18	459.32	105.62	0.56
TRIB85	6.394	200YR	3453.00	974.10	985.37		986.80	0.003727	10.10	492.17	108.35	0.60
TRIB85	6.394	500YR	4086.00	974.10	985.73	984.49	987.50	0.004431	11.32	532.13	111.52	0.66
TRIB85	6.348	001YR	306.75	970.99	976.06	973.65	976.21	0.001173	3.13	97.88	28.25	0.30
TRIB85	6.348	002YR	933.00	970.99	981.36	975.79	981.52	0.000477	3.19	320.08	82.26	0.21
TRIB85	6.348	005YR	1308.00	970.99	983.19	976.73	983.36	0.000400	3.40	500.06	107.56	0.20
TRIB85	6.348	010YR	1641.00	970.99	983.58	977.44	983.82	0.000532	4.04	543.69	111.24	0.23
TRIB85	6.348	020YR	2142.00	970.99	984.27	978.35	984.60	0.000692	4.83	625.54	128.47	0.27
TRIB85	6.348	050YR	2532.00	970.99	984.63	978.96	985.05	0.000844	5.46	674.05	139.90	0.30
TRIB85	6.348	100YR	2991.00	970.99	984.98	979.62	985.51	0.001037	6.18	724.24	150.60	0.33
TRIB85	6.348	200YR	3453.00	970.99	985.27	980.25	985.93	0.001239	6.88	768.83	156.56	0.36
TRIB85	6.348	500YR	4086.00	970.99	985.61	981.30	986.44	0.001519	7.77	823.72	161.14	0.41
TRIB85	6.338		Culvert									
TRIB85	6.317	001YR	306.75	971.68	975.68	973.82	975.87	0.000228	3.46	88.57	28.98	0.35
TRIB85	6.317	002YR	933.00	971.68	979.94	975.83	980.18	0.000113	3.92	241.44	49.56	0.27
TRIB85	6.317	005YR	1308.00	971.68	982.59	976.69	982.73	0.000049	3.26	588.41	178.13	0.19
TRIB85	6.317	010YR	1641.00	971.68	982.93	977.38	983.11	0.000063	3.79	649.85	185.96	0.22
TRIB85	6.317	020YR	2142.00	971.68	983.85	978.27	984.04	0.000063	4.03	831.61	207.40	0.22
TRIB85	6.317	050YR	2532.00	971.68	984.30	978.83	984.51	0.000069	4.34	925.87	217.70	0.23
TRIB85	6.317	100YR	2991.00	971.68	984.72	979.47	984.96	0.000077	4.69	1020.14	227.52	0.25
TRIB85	6.317	200YR	3453.00	971.68	985.07	980.13	985.34	0.000085	5.05	1100.87	235.61	0.26
TRIB85	6.317	500YR	4086.00	971.68	985.49	982.07	985.80	0.000096	5.50	1201.79	245.35	0.28
TRIB85	6.272	001YR	434.61	970.96	975.32	974.05	975.72	0.000504	5.07	85.77	29.01	0.52
TRIB85	6.272	002YR	1131.00	970.96	979.84	976.06	980.14	0.000135	4.40	291.18	78.22	0.30
TRIB85	6.272	005YR	1548.00	970.96	982.51	976.95	982.70	0.000063	3.79	608.10	162.61	0.22
TRIB85	6.272	010YR	1933.00	970.96	982.80	977.65	983.07	0.000087	4.52	655.80	169.75	0.26
TRIB85	6.272	020YR	2494.00	970.96	983.64	978.61	983.98	0.000101	5.16	808.22	193.47	0.28
TRIB85	6.272	050YR	2903.00	970.96	984.02	979.28	984.43	0.000117	5.71	884.01	205.30	0.31
TRIB85	6.272	100YR	3379.00	970.96	984.36	980.00	984.86	0.000139	6.35	955.62	216.73	0.34
TRIB85	6.272	200YR	3848.00	970.96	984.62	980.60	985.21	0.000163	6.98	1012.55	224.13	0.37
TRIB85	6.272	500YR	4480.00	970.96	984.90	981.18	985.64	0.000199	7.83	1078.90	231.44	0.41
TRIB85	6.255		Culvert									
TRIB85	6.241	001YR	434.61	970.39	972.98	972.98	973.98	0.002055	8.03	54.10	26.90	1.00
TRIB85	6.241	002YR	1131.00	970.39	974.82	974.82	976.44	0.001830	10.21	110.76	34.75	1.01
TRIB85	6.241	005YR	1548.00	970.39	975.67	975.67	977.52	0.001719	10.90	142.06	38.41	1.00
TRIB85	6.241	010YR	1933.00	970.39	977.47	976.34	978.70	0.000767	8.91	219.70	51.07	0.70
TRIB85	6.241	020YR	2494.00	970.39	978.94	977.16	980.13	0.000528	8.78	307.25	67.47	0.61
TRIB85	6.241	050YR	2903.00	970.39	979.51	977.71	980.84	0.000533	9.32	347.47	73.80	0.62
TRIB85	6.241	100YR	3379.00	970.39	980.03	978.31	981.55	0.000562	10.03	386.76	79.49	0.64
TRIB85	6.241	200YR	3848.00	970.39	980.56	978.88	982.24	0.000573	10.60	431.71	90.32	0.66
TRIB85	6.241	500YR	4480.00	970.39	981.22	979.59	983.10	0.000583	11.26	496.77	105.18	0.67
TRIB85	6.187	001YR	434.61	969.13	972.07	972.07	973.15	0.002074	8.31	52.30	24.78	1.01
TRIB85	6.187	002YR	1131.00	969.13	974.04	974.04	975.69	0.001819	10.32	109.57	33.56	1.01
TRIB85	6.187	005YR	1548.00	969.13	974.91	974.91	976.79	0.001728	11.00	140.77	37.61	1.00
TRIB85	6.187	010YR	1933.00	969.13	977.52		978.32	0.000410	7.41	349.92	143.62	0.53
TRIB85	6.187	020YR	2494.00	969.13	979.14		979.73	0.000244	6.69	593.84	162.52	0.42
TRIB85	6.187	050YR	2903.00	969.13	979.78		980.37	0.000233	6.89	700.82	172.51	0.42

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TRIB85	6.187	100YR	3379.00	969.13	980.37		981.00	0.000232	7.20	813.11	224.45	0.42
TRIB85	6.187	200YR	3848.00	969.13	981.00		981.60	0.000215	7.24	965.87	250.40	0.41
TRIB85	6.187	500YR	4480.00	969.13	981.78		982.36	0.000195	7.27	1166.13	263.57	0.40
TRIB85	6.151	001YR	434.61	967.08	970.18	969.53	970.73	0.000883	5.96	72.90	29.89	0.67
TRIB85	6.151	002YR	1131.00	967.08	972.93	971.36	973.62	0.000549	6.67	169.54	40.32	0.57
TRIB85	6.151	005YR	1548.00	967.08	975.44	972.19	975.91	0.000213	5.53	297.41	68.64	0.38
TRIB85	6.151	010YR	1933.00	967.08	977.71	972.87	978.07	0.000112	4.90	440.79	82.95	0.29
TRIB85	6.151	020YR	2494.00	967.08	979.23	973.71	979.59	0.000097	5.07	655.06	153.39	0.28
TRIB85	6.151	050YR	2903.00	967.08	979.85	974.29	980.24	0.000101	5.38	752.44	158.01	0.29
TRIB85	6.151	100YR	3379.00	967.08	980.44	974.94	980.87	0.000107	5.75	846.41	162.21	0.30
TRIB85	6.151	200YR	3848.00	967.08	981.05	975.49	981.51	0.000110	6.01	945.68	165.99	0.30
TRIB85	6.151	500YR	4480.00	967.08	981.80	976.19	982.29	0.000112	6.32	1072.11	170.68	0.31
TRIB85	6.139		Culvert									
TRIB85	6.130	001YR	434.61	966.38	969.64	969.44	970.55	0.001566	7.66	56.76	24.32	0.88
TRIB85	6.130	002YR	1131.00	966.38	971.60	971.48	973.18	0.001618	10.08	112.17	32.16	0.95
TRIB85	6.130	005YR	1548.00	966.38	974.30	972.37	975.13	0.000467	7.34	215.90	46.95	0.55
TRIB85	6.130	010YR	1933.00	966.38	975.55	973.08	976.39	0.000362	7.40	280.38	55.97	0.50
TRIB85	6.130	020YR	2494.00	966.38	976.24	973.91	977.37	0.000429	8.60	320.93	60.97	0.55
TRIB85	6.130	050YR	2903.00	966.38	976.60	974.49	977.97	0.000492	9.50	343.27	63.56	0.60
TRIB85	6.130	100YR	3379.00	966.38	977.00	975.15	978.65	0.000558	10.46	368.83	73.21	0.64
TRIB85	6.130	200YR	3848.00	966.38	977.80	975.75	979.51	0.000517	10.71	456.94	120.48	0.63
TRIB85	6.130	500YR	4480.00	966.38	979.09	976.56	980.57	0.000399	10.28	629.85	140.88	0.56
TRIB85	6.078	001YR	434.61	965.97	968.94	968.94	970.02	0.002056	8.35	52.08	24.27	1.00
TRIB85	6.078	002YR	1131.00	965.97	971.32	970.93	972.66	0.001331	9.28	121.84	34.38	0.87
TRIB85	6.078	005YR	1548.00	965.97	974.29		974.90	0.000400	6.27	246.80	51.38	0.50
TRIB85	6.078	010YR	1933.00	965.97	975.59		976.17	0.000301	6.11	319.32	60.19	0.45
TRIB85	6.078	020YR	2494.00	965.97	976.33		977.08	0.000334	6.97	365.47	65.27	0.48
TRIB85	6.078	050YR	2903.00	965.97	976.72		977.62	0.000371	7.64	391.61	68.15	0.51
TRIB85	6.078	100YR	3379.00	965.97	977.16		978.23	0.000406	8.34	422.44	71.80	0.54
TRIB85	6.078	200YR	3848.00	965.97	977.98		979.09	0.000367	8.50	484.42	81.23	0.53
TRIB85	6.078	500YR	4480.00	965.97	979.23		980.25	0.000288	8.28	646.47	147.25	0.48
TRIB85	6.011	001YR	434.61	964.52	967.81	967.61	968.67	0.002028	8.27	52.57	24.62	1.00
TRIB85	6.011	002YR	1131.00	964.52	971.44	969.60	972.04	0.000436	6.26	187.15	62.15	0.52
TRIB85	6.011	005YR	1548.00	964.52	974.35	970.44	974.69	0.000136	4.87	388.51	141.57	0.31
TRIB85	6.011	010YR	1933.00	964.52	975.70	971.15	975.96	0.000094	4.52	735.37	208.00	0.27
TRIB85	6.011	020YR	2494.00	964.52	976.49	972.05	976.80	0.000106	5.09	918.45	245.97	0.29
TRIB85	6.011	050YR	2903.00	964.52	976.93	972.59	977.28	0.000116	5.49	1029.46	257.16	0.31
TRIB85	6.011	100YR	3379.00	964.52	977.43	973.15	977.82	0.000124	5.86	1161.76	270.07	0.32
TRIB85	6.011	200YR	3848.00	964.52	978.28	973.66	978.66	0.000111	5.83	1403.60	296.35	0.30
TRIB85	6.011	500YR	4480.00	964.52	979.52	974.30	979.85	0.000093	5.73	1805.84	362.68	0.28
TRIB85	5.997		Culvert									
TRIB85	5.989	001YR	434.61	962.67	967.25	965.69	967.50	0.001765	4.00	108.61	39.05	0.42
TRIB85	5.989	002YR	1131.00	962.67	970.09	967.47	970.42	0.001276	4.61	245.29	57.66	0.39
TRIB85	5.989	005YR	1548.00	962.67	971.09	968.24	971.49	0.001287	5.11	302.84	64.20	0.40
TRIB85	5.989	010YR	1933.00	962.67	973.22	968.84	973.54	0.000626	4.49	430.69	78.20	0.29
TRIB85	5.989	020YR	2494.00	962.67	975.25	969.61	975.49	0.000483	3.95	647.60	120.53	0.26
TRIB85	5.989	050YR	2903.00	962.67	976.38	970.08	976.61	0.000383	3.88	816.53	181.79	0.24
TRIB85	5.989	100YR	3379.00	962.67	977.44	970.60	977.66	0.000318	3.82	1042.15	245.78	0.22
TRIB85	5.989	200YR	3848.00	962.67	978.39	971.07	978.58	0.000264	3.72	1336.40	446.09	0.20
TRIB85	5.989	500YR	4480.00	962.67	979.66	971.62	979.79	0.000169	3.21	2017.77	579.86	0.17
TRIB85	5.915	001YR	434.61	960.86	966.91	964.13	967.04	0.000664	2.84	152.83	44.10	0.27
TRIB85	5.915	002YR	1131.00	960.86	969.81	965.98	970.02	0.000616	3.72	325.37	98.21	0.28
TRIB85	5.915	005YR	1548.00	960.86	970.85	966.61	971.08	0.000581	4.01	451.52	142.19	0.28
TRIB85	5.915	010YR	1933.00	960.86	973.21	967.44	973.30	0.000190	2.82	943.23	259.91	0.17
TRIB85	5.915	020YR	2494.00	960.86	975.27	968.20	975.33	0.000087	2.20	1521.45	445.00	0.12
TRIB85	5.915	050YR	2903.00	960.86	976.43	968.72	976.47	0.000063	2.00	1891.18	609.47	0.10
TRIB85	5.915	100YR	3379.00	960.86	977.49	969.48	977.53	0.000051	1.91	2246.29	713.36	0.09
TRIB85	5.915	200YR	3848.00	960.86	978.44	970.31	978.47	0.000044	1.86	2574.48	751.46	0.09
TRIB85	5.915	500YR	4480.00	960.86	979.68	970.87	979.72	0.000037	1.80	3015.58	756.72	0.08
TRIB85	5.882	001YR	434.61	960.55	966.83	963.53	966.93	0.000471	2.57	168.85	43.27	0.23
TRIB85	5.882	002YR	1131.00	960.55	969.77	965.38	969.90	0.000397	3.08	430.67	217.87	0.22
TRIB85	5.882	005YR	1548.00	960.55	970.88	966.23	970.95	0.000188	2.36	738.30	320.56	0.16
TRIB85	5.882	010YR	1933.00	960.55	973.24	966.90	973.26	0.000026	1.08	1827.29	425.72	0.06
TRIB85	5.882	020YR	2494.00	960.55	975.29	967.74	975.30	0.000011	0.81	2588.24	718.52	0.04
TRIB85	5.882	050YR	2903.00	960.55	976.44	968.30	976.45	0.000008	0.74	3174.05	813.30	0.04
TRIB85	5.882	100YR	3379.00	960.55	977.50	970.00	977.51	0.000007	0.72	3733.45	839.83	0.03
TRIB85	5.882	200YR	3848.00	960.55	978.45	970.24	978.46	0.000006	0.71	4243.73	857.83	0.03
TRIB85	5.882	500YR	4480.00	960.55	979.69	970.57	979.70	0.000005	0.70	4921.77	862.84	0.03
TRIB85	5.866		Culvert									
TRIB85	5.855	001YR	434.61	960.14	965.85	962.86	965.97	0.000467	2.83	153.76	61.69	0.23

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TRIB85	5.855	002YR	1131.00	960.14	968.11	964.48	968.26	0.000480	3.31	414.17	207.86	0.24
TRIB85	5.855	005YR	1548.00	960.14	970.84	965.26	970.86	0.000073	1.67	1358.48	546.76	0.10
TRIB85	5.855	010YR	1933.00	960.14	973.24	965.91	973.25	0.000012	0.79	2885.26	742.13	0.04
TRIB85	5.855	020YR	2494.00	960.14	975.28	966.83	975.29	0.000005	0.58	4542.75	861.77	0.03
TRIB85	5.855	050YR	2903.00	960.14	976.39	967.44	976.40	0.000004	0.53	5512.29	885.45	0.02
TRIB85	5.855	100YR	3379.00	960.14	977.49	968.01	977.49	0.000003	0.50	6490.16	900.49	0.02
TRIB85	5.855	200YR	3848.00	960.14	978.43	968.49	978.44	0.000003	0.49	7347.20	907.15	0.02
TRIB85	5.855	500YR	4480.00	960.14	979.67	968.93	979.68	0.000002	0.48	8470.67	907.15	0.02
TES-87	5.90	001YR	1302.30	958.07	965.88	961.99	965.94	0.000031	1.97	660.80	291.61	0.17
TES-87	5.90	002YR	1987.00	958.07	968.15	962.56	968.21	0.000018	1.91	1038.35	904.10	0.14
TES-87	5.90	005YR	2397.00	958.07	970.82	962.85	970.86	0.000008	1.60	1509.03	1977.90	0.10
TES-87	5.90	010YR	2503.00	958.07	973.21	962.91	973.24	0.000004	1.30	1937.29	2345.55	0.07
TES-87	5.90	020YR	2937.00	958.07	975.26	963.24	975.28	0.000003	1.29	2303.04	2419.20	0.06
TES-87	5.90	050YR	3169.00	958.07	976.36	963.39	976.39	0.000003	1.28	2501.22	2484.19	0.06
TES-87	5.90	100YR	3446.00	958.07	977.46	963.56	977.48	0.000003	1.29	2697.02	2531.37	0.06
TES-87	5.90	200YR	3710.00	958.07	978.40	963.73	978.43	0.000002	1.31	2866.29	2594.14	0.06
TES-87	5.90	500YR	4061.00	958.07	979.64	963.93	979.67	0.000002	1.33	3087.74	2594.14	0.06
TES-87	5.826		Culvert									
TES-87	5.807	001YR	1302.30	956.00	959.91	959.91	961.17	0.003712	9.00	144.65	936.38	1.00
TES-87	5.807	002YR	1987.00	956.00	965.90	961.19	966.00	0.000069	2.49	792.43	1888.57	0.17
TES-87	5.807	005YR	2397.00	956.00	968.97	961.51	969.04	0.000027	2.01	1168.42	1920.68	0.11
TES-87	5.807	010YR	2503.00	956.00	971.20	961.60	971.25	0.000015	1.69	1440.96	1943.01	0.09
TES-87	5.807	020YR	2937.00	956.00	972.48	961.92	972.53	0.000014	1.79	1598.98	2410.23	0.09
TES-87	5.807	050YR	3169.00	956.00	973.12	962.08	973.18	0.000014	1.83	1676.07	2417.89	0.09
TES-87	5.807	100YR	3446.00	956.00	973.62	962.30	973.68	0.000015	1.92	1737.04	2422.71	0.09
TES-87	5.807	200YR	3710.00	956.00	973.95	962.49	974.02	0.000016	2.02	1777.63	2425.93	0.09
TES-87	5.807	500YR	4061.00	956.00	974.30	962.69	974.38	0.000018	2.16	1820.52	2430.30	0.10
TC-M80	5.513	001YR	1367.54	953.10	958.21	957.11	959.44	0.005463	8.93	153.13	30.01	0.70
TC-M80	5.513	002YR	2934.00	953.10	964.97	959.65	965.78	0.001593	7.32	420.01	800.30	0.41
TC-M80	5.513	005YR	3872.00	953.10	968.12	961.39	968.84	0.001004	6.99	590.26	1042.08	0.34
TC-M80	5.513	010YR	4306.00	953.10	970.49	962.05	971.08	0.000673	6.40	717.93	1313.02	0.29
TC-M80	5.513	020YR	5873.00	953.10	972.49	964.28	972.50	0.000041	1.72	6200.40	1408.40	0.07
TC-M80	5.513	050YR	7263.00	953.10	973.15	965.60	973.15	0.000018	1.17	11258.02	1437.17	0.05
TC-M80	5.513	100YR	8764.00	953.10	973.65	966.82	973.65	0.000022	1.31	11979.89	1449.61	0.05
TC-M80	5.513	200YR	9967.00	953.10	973.98	967.71	973.99	0.000025	1.41	12465.69	1457.92	0.06
TC-M80	5.513	500YR	11498.00	953.10	974.33	968.78	974.34	0.000029	1.55	12982.49	1460.47	0.06
TC-M80	5.499		Bridge									
TC-M80	5.486	001YR	1367.54	953.10	957.19	957.19	958.97	0.010515	10.72	127.55	35.73	1.00
TC-M80	5.486	002YR	2934.00	953.10	960.33	959.75	962.38	0.007068	11.48	255.49	47.79	0.88
TC-M80	5.486	005YR	3872.00	953.10	961.92	960.97	963.95	0.005712	11.44	347.96	70.17	0.81
TC-M80	5.486	010YR	4306.00	953.10	962.66	961.52	964.59	0.005543	11.22	404.04	82.80	0.80
TC-M80	5.486	020YR	5873.00	953.10	964.55	963.37	966.34	0.004816	10.94	644.72	294.13	0.76
TC-M80	5.486	050YR	7263.00	953.10	966.36	965.43	967.35	0.002342	8.82	1603.30	687.36	0.55
TC-M80	5.486	100YR	8764.00	953.10	968.50		968.89	0.000863	6.28	3197.68	806.95	0.35
TC-M80	5.486	200YR	9967.00	953.10	970.03		970.27	0.000494	5.22	4496.20	887.14	0.27
TC-M80	5.486	500YR	11498.00	953.10	971.49		971.66	0.000345	4.72	5861.44	1001.28	0.23
TC-M80	5.417	001YR	1367.54	949.84	956.49	953.67	956.92	0.001425	5.25	260.38	51.37	0.41
TC-M80	5.417	002YR	2934.00	949.84	960.04	955.99	960.64	0.001316	6.22	471.75	67.55	0.41
TC-M80	5.417	005YR	3872.00	949.84	961.69	957.09	962.36	0.001240	6.57	589.14	74.63	0.41
TC-M80	5.417	010YR	4306.00	949.84	962.43	957.55	963.12	0.001146	6.69	650.88	100.00	0.40
TC-M80	5.417	020YR	5873.00	949.84	964.23	959.04	965.08	0.001105	7.45	909.43	186.41	0.41
TC-M80	5.417	050YR	7263.00	949.84	965.85	960.19	966.75	0.000996	7.78	1287.58	313.45	0.39
TC-M80	5.417	100YR	8764.00	949.84	967.59	961.24	968.44	0.000822	7.73	1876.94	347.30	0.37
TC-M80	5.417	200YR	9967.00	949.84	969.15	962.00	969.90	0.000667	7.48	2431.90	364.25	0.34
TC-M80	5.417	500YR	11498.00	949.84	970.62	962.99	971.34	0.000595	7.51	2976.84	380.24	0.32
TC-M80	5.407		Bridge									
TC-M80	5.394	001YR	1410.94	948.77	956.40		956.73	0.001000	4.63	304.95	56.76	0.35
TC-M80	5.394	002YR	2944.00	948.77	959.97		960.44	0.000926	5.53	532.70	70.89	0.36
TC-M80	5.394	005YR	3862.00	948.77	961.62		962.16	0.000905	5.89	655.17	77.42	0.36
TC-M80	5.394	010YR	4328.00	948.77	962.36		962.94	0.000899	6.06	713.77	80.36	0.36
TC-M80	5.394	020YR	5845.00	948.77	964.19		964.87	0.000881	6.66	929.27	159.35	0.36
TC-M80	5.394	050YR	7153.00	948.77	965.85		966.51	0.000735	6.72	1235.59	232.44	0.34
TC-M80	5.394	100YR	8524.00	948.77	967.63		968.17	0.000536	6.29	1817.44	393.60	0.30
TC-M80	5.394	200YR	9736.00	948.77	969.25		969.61	0.000353	5.49	2479.43	421.74	0.25
TC-M80	5.394	500YR	11282.00	948.77	970.74		971.02	0.000266	5.07	3116.45	439.69	0.22
TC-M80	5.373	001YR	1410.94	947.97	956.27	952.26	956.61	0.001211	4.70	300.43	47.57	0.33
TC-M80	5.373	002YR	2944.00	947.97	959.70	954.61	960.29	0.001443	6.13	480.13	57.07	0.37
TC-M80	5.373	005YR	3862.00	947.97	961.28	955.76	961.98	0.001526	6.73	573.70	61.43	0.39
TC-M80	5.373	010YR	4328.00	947.97	961.99	956.29	962.75	0.001566	7.01	617.81	63.39	0.40
TC-M80	5.373	020YR	5845.00	947.97	963.63	957.88	964.64	0.001805	8.06	730.13	78.94	0.43
TC-M80	5.373	050YR	7153.00	947.97	965.09	959.03	966.24	0.001773	8.61	858.90	94.18	0.44

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	5.373	100YR	8524.00	947.97	966.60	960.16	967.85	0.001678	9.06	1014.65	132.67	0.43
TC-M80	5.373	200YR	9736.00	947.97	968.08	961.08	969.29	0.001452	9.03	1357.39	323.87	0.41
TC-M80	5.373	500YR	11282.00	947.97	969.86	962.19	970.78	0.001066	8.33	2077.82	416.82	0.36
TC-M80	5.367		Bridge									
TC-M80	5.361	001YR	1410.94	947.55	955.83		956.39	0.002218	6.00	235.13	39.97	0.44
TC-M80	5.361	002YR	2944.00	947.55	958.87		959.86	0.002814	7.98	368.80	47.93	0.51
TC-M80	5.361	005YR	3862.00	947.55	960.24		961.45	0.003056	8.84	436.92	51.51	0.53
TC-M80	5.361	010YR	4328.00	947.55	960.84		962.16	0.003182	9.24	468.30	53.08	0.55
TC-M80	5.361	020YR	5845.00	947.55	961.79		963.75	0.004370	11.24	520.11	55.58	0.65
TC-M80	5.361	050YR	7153.00	947.55	962.69		965.13	0.004936	12.52	571.42	58.12	0.70
TC-M80	5.361	100YR	8524.00	947.55	963.55		966.49	0.005331	13.75	623.48	65.77	0.73
TC-M80	5.361	200YR	9736.00	947.55	964.31	962.33	967.63	0.005538	14.65	677.09	74.61	0.76
TC-M80	5.361	500YR	11282.00	947.55	964.41	963.37	968.79	0.007223	16.83	684.66	76.70	0.86
TC-M80	5.307	001YR	1410.94	947.95	955.37		955.76	0.001617	5.02	281.09	51.92	0.38
TC-M80	5.307	002YR	2944.00	947.95	958.39		959.04	0.001852	6.45	456.15	63.17	0.42
TC-M80	5.307	005YR	3862.00	947.95	959.77		960.54	0.001933	7.07	546.36	67.86	0.44
TC-M80	5.307	010YR	4328.00	947.95	960.36		961.21	0.002006	7.37	587.56	70.50	0.45
TC-M80	5.307	020YR	5845.00	947.95	961.12		962.41	0.002883	9.10	643.08	80.14	0.54
TC-M80	5.307	050YR	7153.00	947.95	962.01		963.58	0.003159	10.06	732.31	126.65	0.58
TC-M80	5.307	100YR	8524.00	947.95	963.00		964.74	0.003127	10.69	867.17	146.60	0.58
TC-M80	5.307	200YR	9736.00	947.95	964.08	960.41	965.72	0.002692	10.60	1187.87	342.78	0.55
TC-M80	5.307	500YR	11282.00	947.95	964.07	961.59	966.28	0.003632	12.30	1183.96	342.60	0.64
TC-M80	5.268	001YR	1410.94	947.74	954.77		955.33	0.002686	6.00	235.23	48.96	0.48
TC-M80	5.268	002YR	2944.00	947.74	957.73		958.59	0.002450	7.45	403.63	69.82	0.49
TC-M80	5.268	005YR	3862.00	947.74	959.11		960.10	0.002259	8.05	520.94	98.23	0.49
TC-M80	5.268	010YR	4328.00	947.74	959.72		960.78	0.002197	8.31	584.24	110.12	0.48
TC-M80	5.268	020YR	5845.00	947.74	959.88		961.69	0.003760	10.99	601.61	113.50	0.63
TC-M80	5.268	050YR	7153.00	947.74	960.30	959.07	962.72	0.004762	12.75	652.84	128.53	0.72
TC-M80	5.268	100YR	8524.00	947.74	960.61	960.14	963.75	0.005994	14.60	693.95	139.41	0.81
TC-M80	5.268	200YR	9736.00	947.74	960.86	960.86	964.67	0.007109	16.16	729.02	148.18	0.89
TC-M80	5.268	500YR	11282.00	947.74	963.02	963.02	965.49	0.003989	13.74	1256.63	302.38	0.69
TC-M80	5.213	001YR	1410.94	946.75	951.84	951.84	953.73	0.012676	11.02	128.04	33.99	1.00
TC-M80	5.213	002YR	2944.00	946.75	954.37	954.37	957.07	0.011594	13.17	223.55	41.56	1.00
TC-M80	5.213	005YR	3862.00	946.75	955.59	955.59	958.62	0.012137	13.97	276.64	47.08	1.00
TC-M80	5.213	010YR	4328.00	946.75	956.18	956.18	959.31	0.011651	14.21	306.08	51.67	0.99
TC-M80	5.213	020YR	5845.00	946.75	958.74	958.74	960.45	0.004914	11.37	762.94	249.14	0.68
TC-M80	5.213	050YR	7153.00	946.75	959.32	959.32	961.15	0.005122	12.13	910.11	253.61	0.70
TC-M80	5.213	100YR	8524.00	946.75	959.82	959.82	961.81	0.005440	12.95	1036.91	257.52	0.73
TC-M80	5.213	200YR	9736.00	946.75	960.76		962.41	0.004279	12.21	1285.98	268.76	0.66
TC-M80	5.213	500YR	11282.00	946.75	962.02		963.32	0.003142	11.27	1635.09	291.35	0.58
TC-M80	5.130	001YR	1410.94	942.00	950.37		950.91	0.002527	5.93	237.93	47.45	0.47
TC-M80	5.130	002YR	2944.00	942.00	953.59		954.39	0.002219	7.20	412.66	61.06	0.47
TC-M80	5.130	005YR	3862.00	942.00	955.14		956.06	0.001994	7.75	516.76	76.56	0.46
TC-M80	5.130	010YR	4328.00	942.00	955.62		956.65	0.002089	8.21	556.70	101.27	0.47
TC-M80	5.130	020YR	5845.00	942.00	956.53		958.01	0.002703	9.93	663.93	124.13	0.54
TC-M80	5.130	050YR	7153.00	942.00	957.12		959.01	0.003246	11.29	739.35	129.22	0.60
TC-M80	5.130	100YR	8524.00	942.00	957.69	955.65	960.00	0.003765	12.57	814.01	134.21	0.65
TC-M80	5.130	200YR	9736.00	942.00	958.09	956.93	960.82	0.004298	13.74	869.24	155.58	0.70
TC-M80	5.130	500YR	11282.00	942.00	958.50	957.79	961.80	0.005014	15.19	936.46	173.29	0.76
TC-M80	5.066	001YR	1410.94	942.00	949.60		950.11	0.002161	5.71	247.18	46.19	0.43
TC-M80	5.066	002YR	2944.00	942.00	952.82		953.62	0.002315	7.15	411.95	56.99	0.47
TC-M80	5.066	005YR	3862.00	942.00	954.48		955.36	0.002077	7.54	549.13	176.60	0.46
TC-M80	5.066	010YR	4328.00	942.00	954.98		955.91	0.002086	7.85	651.85	231.61	0.46
TC-M80	5.066	020YR	5845.00	942.00	955.80	952.37	957.05	0.002594	9.27	849.33	250.71	0.52
TC-M80	5.066	050YR	7153.00	942.00	956.31	953.51	957.84	0.003060	10.42	981.94	263.72	0.57
TC-M80	5.066	100YR	8524.00	942.00	956.92	955.84	958.63	0.003307	11.25	1146.03	276.02	0.60
TC-M80	5.066	200YR	9736.00	942.00	957.40	956.56	959.26	0.003496	11.90	1279.64	280.88	0.62
TC-M80	5.066	500YR	11282.00	942.00	957.89	957.20	959.97	0.003819	12.79	1417.97	285.48	0.65
TC-M80	5.023	001YR	1458.58	942.00	949.31		949.67	0.001430	4.86	300.41	52.62	0.36
TC-M80	5.023	002YR	3005.00	942.00	952.49		953.11	0.001770	6.30	477.29	59.30	0.39
TC-M80	5.023	005YR	3931.00	942.00	954.14		954.84	0.002051	6.71	669.65	253.94	0.39
TC-M80	5.023	010YR	4409.00	942.00	954.66		955.38	0.002065	6.95	822.23	319.13	0.40
TC-M80	5.023	020YR	5897.00	942.00	955.47		956.38	0.002507	8.04	1094.51	351.86	0.44
TC-M80	5.023	050YR	7186.00	942.00	955.97		957.05	0.002899	8.93	1275.83	354.45	0.48
TC-M80	5.023	100YR	8625.00	942.00	956.60		957.78	0.003082	9.57	1509.62	377.41	0.50
TC-M80	5.023	200YR	9924.00	942.00	957.10		958.36	0.003231	10.08	1699.69	384.37	0.52
TC-M80	5.023	500YR	11511.00	942.00	957.64		958.99	0.003414	10.67	1908.50	399.20	0.53
TC-M80	4.986	001YR	1458.58	942.00	948.23	946.80	949.15	0.004706	7.71	189.08	40.43	0.63
TC-M80	4.986	002YR	3005.00	942.00	951.10		952.50	0.004708	9.48	316.91	48.74	0.66
TC-M80	4.986	005YR	3931.00	942.00	952.76	950.33	954.16	0.005127	9.59	497.25	239.27	0.62
TC-M80	4.986	010YR	4409.00	942.00	953.67	950.87	954.83	0.003626	8.37	841.64	344.76	0.51
TC-M80	4.986	020YR	5897.00	942.00	954.85	953.93	955.80	0.003475	8.82	1193.96	374.22	0.51

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	4.986	050YR	7186.00	942.00	955.32		956.40	0.003889	9.64	1373.33	389.95	0.54
TC-M80	4.986	100YR	8625.00	942.00	956.00		957.08	0.003812	9.97	1647.50	417.74	0.54
TC-M80	4.986	200YR	9924.00	942.00	956.53		957.62	0.003800	10.29	1873.60	439.35	0.54
TC-M80	4.986	500YR	11511.00	942.00	957.09		958.22	0.003826	10.67	2128.06	461.98	0.55
TC-M80	4.964	001YR	1458.58	941.56	946.27	946.27	948.20	0.012857	11.15	130.85	33.98	1.00
TC-M80	4.964	002YR	3005.00	941.56	949.18	948.76	951.63	0.009732	12.56	239.18	40.72	0.91
TC-M80	4.964	005YR	3931.00	941.56	950.68	950.03	953.28	0.008743	12.92	304.15	45.58	0.88
TC-M80	4.964	010YR	4409.00	941.56	951.47	950.59	954.06	0.008103	12.93	340.94	48.13	0.86
TC-M80	4.964	020YR	5897.00	941.56	953.87	953.87	955.33	0.003775	10.50	797.46	341.55	0.61
TC-M80	4.964	050YR	7186.00	941.56	954.96	954.40	956.02	0.002651	9.48	1223.88	462.05	0.52
TC-M80	4.964	100YR	8625.00	941.56	955.79		956.69	0.002179	9.05	1615.35	479.50	0.48
TC-M80	4.964	200YR	9924.00	941.56	956.37		957.23	0.002011	9.00	1898.72	490.20	0.46
TC-M80	4.964	500YR	11511.00	941.56	956.96		957.82	0.001938	9.12	2189.48	508.88	0.46
TC-M80	4.912	001YR	1458.58	937.00	945.48		946.14	0.002711	6.53	223.45	38.54	0.48
TC-M80	4.912	002YR	3005.00	937.00	948.83		949.89	0.002944	8.25	364.38	45.56	0.51
TC-M80	4.912	005YR	3931.00	937.00	950.27		951.56	0.003149	9.09	432.35	48.58	0.54
TC-M80	4.912	010YR	4409.00	937.00	951.00		952.38	0.003269	9.41	468.77	51.58	0.55
TC-M80	4.912	020YR	5897.00	937.00	952.42	948.84	954.16	0.003717	10.66	683.72	363.36	0.60
TC-M80	4.912	050YR	7186.00	937.00	953.28	950.11	955.10	0.003706	11.25	1050.30	468.41	0.60
TC-M80	4.912	100YR	8625.00	937.00	953.97	953.74	955.84	0.003749	11.79	1379.12	481.01	0.61
TC-M80	4.912	200YR	9924.00	937.00	954.58	954.30	956.42	0.003662	12.07	1677.17	502.46	0.61
TC-M80	4.912	500YR	11511.00	937.00	955.18	954.96	957.03	0.003668	12.47	1990.64	529.72	0.62
TC-M80	4.874	001YR	1458.58	937.00	945.08		945.62	0.002107	5.90	247.41	42.02	0.43
TC-M80	4.874	002YR	3005.00	937.00	948.42		949.30	0.002324	7.54	398.38	48.34	0.46
TC-M80	4.874	005YR	3931.00	937.00	949.83		950.92	0.002563	8.38	468.86	51.76	0.49
TC-M80	4.874	010YR	4409.00	937.00	950.53		951.71	0.002741	8.71	506.36	55.88	0.51
TC-M80	4.874	020YR	5897.00	937.00	951.85	947.83	953.39	0.003272	10.02	663.66	341.83	0.57
TC-M80	4.874	050YR	7186.00	937.00	952.66	949.06	954.34	0.003358	10.71	961.13	390.77	0.58
TC-M80	4.874	100YR	8625.00	937.00	953.23	950.50	955.09	0.003642	11.55	1187.31	401.25	0.61
TC-M80	4.874	200YR	9924.00	937.00	953.91	953.57	955.69	0.003440	11.68	1462.71	410.19	0.60
TC-M80	4.874	500YR	11511.00	937.00	954.46	954.13	956.31	0.003543	12.22	1688.87	415.96	0.61
TC-M80	4.851	001YR	1458.58	936.00	944.66		945.32	0.002757	6.53	223.35	39.95	0.49
TC-M80	4.851	002YR	3005.00	936.00	947.95		948.98	0.002943	8.15	368.62	48.44	0.52
TC-M80	4.851	005YR	3931.00	936.00	949.31		950.57	0.003163	8.99	437.31	51.99	0.55
TC-M80	4.851	010YR	4409.00	936.00	949.99		951.34	0.003215	9.32	473.09	53.74	0.55
TC-M80	4.851	020YR	5897.00	936.00	951.25	948.06	952.97	0.003603	10.63	680.64	392.85	0.60
TC-M80	4.851	050YR	7186.00	936.00	952.49	949.31	953.89	0.002825	10.18	1197.83	442.72	0.54
TC-M80	4.851	100YR	8625.00	936.00	953.17	952.55	954.58	0.002832	10.60	1505.20	462.47	0.54
TC-M80	4.851	200YR	9924.00	936.00	953.91		955.19	0.002558	10.50	1855.52	482.41	0.52
TC-M80	4.851	500YR	11511.00	936.00	954.47		955.79	0.002605	10.91	2133.41	497.66	0.53
TC-M80	4.815	001YR	1458.58	935.00	944.51		944.89	0.001273	4.94	295.23	44.11	0.34
TC-M80	4.815	002YR	3005.00	935.00	947.76		948.46	0.001677	6.71	447.74	50.07	0.40
TC-M80	4.815	005YR	3931.00	935.00	949.10		949.99	0.001978	7.59	521.49	70.48	0.43
TC-M80	4.815	010YR	4409.00	935.00	949.81		950.75	0.001922	7.83	593.52	156.07	0.43
TC-M80	4.815	020YR	5897.00	935.00	951.32		952.27	0.001747	8.19	922.33	270.05	0.42
TC-M80	4.815	050YR	7186.00	935.00	952.51		953.33	0.001460	7.99	1298.73	362.92	0.39
TC-M80	4.815	100YR	8625.00	935.00	953.10		954.02	0.001603	8.63	1538.86	456.33	0.42
TC-M80	4.815	200YR	9924.00	935.00	953.83		954.69	0.001466	8.55	1878.54	470.89	0.40
TC-M80	4.815	500YR	11511.00	935.00	954.38		955.28	0.001514	8.91	2140.50	481.82	0.41
TC-M80	4.767	001YR	1458.58	934.27	943.91		944.46	0.002112	5.96	244.61	39.32	0.42
TC-M80	4.767	002YR	3005.00	934.27	946.87		947.89	0.002771	8.11	373.74	71.39	0.50
TC-M80	4.767	005YR	3931.00	934.27	948.24		949.39	0.002636	8.76	574.81	178.73	0.50
TC-M80	4.767	010YR	4409.00	934.27	949.26		950.24	0.002094	8.35	774.22	216.65	0.45
TC-M80	4.767	020YR	5897.00	934.27	950.99		951.81	0.001643	8.19	1239.36	301.18	0.41
TC-M80	4.767	050YR	7186.00	934.27	952.25		952.94	0.001360	7.94	1640.40	336.82	0.38
TC-M80	4.767	100YR	8625.00	934.27	952.82		953.60	0.001513	8.61	1835.63	346.30	0.40
TC-M80	4.767	200YR	9924.00	934.27	953.54		954.30	0.001470	8.77	2087.55	357.98	0.40
TC-M80	4.767	500YR	11511.00	934.27	954.03		954.88	0.001613	9.39	2267.58	367.75	0.42
TC-M80	4.722	001YR	1458.58	934.20	943.59		944.01	0.001489	5.14	283.70	46.24	0.37
TC-M80	4.722	002YR	3005.00	934.20	946.57		947.29	0.001737	6.89	455.45	69.97	0.41
TC-M80	4.722	005YR	3931.00	934.20	947.97		948.80	0.001711	7.50	576.96	110.71	0.42
TC-M80	4.722	010YR	4409.00	934.20	949.00		949.78	0.001447	7.36	709.76	154.20	0.39
TC-M80	4.722	020YR	5897.00	934.20	950.62		951.46	0.001397	7.93	1014.92	214.94	0.39
TC-M80	4.722	050YR	7186.00	934.20	951.73		952.61	0.001375	8.33	1276.25	256.44	0.40
TC-M80	4.722	100YR	8625.00	934.20	952.05		953.19	0.001768	9.59	1357.23	263.63	0.45
TC-M80	4.722	200YR	9924.00	934.20	952.62		953.88	0.001906	10.22	1511.75	276.85	0.47
TC-M80	4.722	500YR	11511.00	934.20	952.72		954.36	0.002472	11.70	1540.48	279.24	0.54
TC-M80	4.675	001YR	1458.58	933.41	943.29		943.65	0.001245	4.85	300.61	45.79	0.33
TC-M80	4.675	002YR	3005.00	933.41	946.16		946.84	0.001785	6.67	474.60	101.98	0.41
TC-M80	4.675	005YR	3931.00	933.41	947.64		948.35	0.001562	6.98	647.32	132.67	0.40
TC-M80	4.675	010YR	4409.00	933.41	948.79		949.39	0.001203	6.60	814.76	160.38	0.35
TC-M80	4.675	020YR	5897.00	933.41	950.43		951.08	0.001138	7.05	1129.92	225.24	0.35
TC-M80	4.675	050YR	7186.00	933.41	951.55		952.24	0.001133	7.46	1437.14	317.45	0.36

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	4.675	100YR	8625.00	933.41	951.83		952.70	0.001437	8.51	1525.86	321.36	0.40
TC-M80	4.675	200YR	9924.00	933.41	952.44		953.34	0.001474	8.87	1730.94	407.33	0.41
TC-M80	4.675	500YR	11511.00	933.41	952.46		953.67	0.001962	10.25	1741.02	408.68	0.47
TC-M80	4.634	001YR	2087.32	933.76	942.19	939.54	943.13	0.003300	7.79	267.86	40.10	0.53
TC-M80	4.634	002YR	3764.00	933.76	944.43	941.97	946.10	0.004621	10.39	362.43	44.36	0.64
TC-M80	4.634	005YR	4768.00	933.76	945.54	943.22	947.61	0.005082	11.54	415.17	54.33	0.68
TC-M80	4.634	010YR	5590.00	933.76	946.30	944.13	948.68	0.005347	12.41	464.78	84.96	0.70
TC-M80	4.634	020YR	7313.00	933.76	948.78	947.39	950.54	0.003283	11.32	801.73	297.29	0.57
TC-M80	4.634	050YR	8678.00	933.76	950.51	948.67	951.82	0.002249	10.24	1112.89	381.79	0.48
TC-M80	4.634	100YR	9980.00	933.76	949.80	949.32	952.04	0.003970	13.14	980.05	348.11	0.64
TC-M80	4.634	200YR	11239.00	933.76	950.36	949.91	952.68	0.003996	13.56	1085.36	375.06	0.65
TC-M80	4.634	500YR	12759.00	933.76	952.55	950.55	953.15	0.001208	8.23	2680.13	716.81	0.36
TC-M80	4.605	001YR	2087.32	933.62	941.86	939.16	942.67	0.002926	7.26	287.70	44.97	0.51
TC-M80	4.605	002YR	3764.00	933.62	944.00	941.44	945.45	0.004073	9.67	389.13	49.76	0.61
TC-M80	4.605	005YR	4768.00	933.62	945.08	942.58	946.86	0.004771	10.68	446.33	55.71	0.67
TC-M80	4.605	010YR	5590.00	933.62	945.83	943.43	947.85	0.005314	11.42	489.49	60.26	0.71
TC-M80	4.605	020YR	7313.00	933.62	948.71	945.25	949.99	0.002832	9.51	921.48	238.53	0.54
TC-M80	4.605	050YR	8678.00	933.62	950.51	947.97	951.44	0.001782	8.44	1305.07	292.19	0.44
TC-M80	4.605	100YR	9980.00	933.62	949.81	948.63	951.36	0.003158	10.78	1149.80	267.11	0.58
TC-M80	4.605	200YR	11239.00	933.62	950.38	949.12	952.00	0.003150	11.14	1275.28	287.06	0.58
TC-M80	4.605	500YR	12759.00	933.62	951.31	949.67	952.83	0.002776	11.02	1516.19	406.42	0.55
TC-M80	4.602		Bridge									
TC-M80	4.600	001YR	2087.32	932.60	941.65	939.15	942.55	0.003538	7.61	274.36	46.17	0.55
TC-M80	4.600	002YR	3764.00	932.60	943.76	941.61	945.26	0.004923	9.84	382.61	56.60	0.67
TC-M80	4.600	005YR	4768.00	932.60	944.79	942.84	946.59	0.005236	10.78	442.48	59.32	0.70
TC-M80	4.600	010YR	5590.00	932.60	945.41	943.71	947.52	0.005714	11.64	480.26	60.92	0.73
TC-M80	4.600	020YR	7313.00	932.60	946.24	945.16	949.17	0.007254	13.74	541.01	106.91	0.83
TC-M80	4.600	050YR	8678.00	932.60	946.49	946.49	950.36	0.009228	15.81	569.46	118.58	0.94
TC-M80	4.600	100YR	9980.00	932.60	948.40	948.40	951.21	0.005505	13.93	973.72	285.80	0.75
TC-M80	4.600	200YR	11239.00	932.60	949.05	949.05	951.88	0.005325	14.24	1144.72	309.43	0.75
TC-M80	4.600	500YR	12759.00	932.60	949.72	949.72	952.61	0.005219	14.66	1334.63	336.19	0.75
TC-M80	4.58	001YR	2087.32	933.50	941.42	938.97	942.02	0.002547	6.22	335.76	64.25	0.48
TC-M80	4.58	002YR	3764.00	933.50	943.60	940.87	944.54	0.002639	7.81	486.25	74.31	0.51
TC-M80	4.58	005YR	4768.00	933.50	944.67	941.79	945.80	0.002629	8.56	569.91	82.33	0.53
TC-M80	4.58	010YR	5590.00	933.50	945.34	942.44	946.64	0.002747	9.21	637.60	152.64	0.54
TC-M80	4.58	020YR	7313.00	933.50	946.33	943.66	947.96	0.003081	10.47	860.83	313.84	0.59
TC-M80	4.58	050YR	8678.00	933.50	946.73	944.62	948.71	0.003646	11.69	968.42	338.87	0.64
TC-M80	4.58	100YR	9980.00	933.50	947.04	946.57	949.38	0.004217	12.83	1055.31	364.65	0.69
TC-M80	4.58	200YR	11239.00	933.50	947.29	947.29	950.00	0.004791	13.89	1131.23	376.31	0.74
TC-M80	4.58	500YR	12759.00	933.50	948.00	948.00	950.69	0.004573	14.15	1356.19	408.48	0.73
TC-M80	4.516	001YR	2271.29	933.47	940.36		941.02	0.004825	6.52	348.29	69.94	0.51
TC-M80	4.516	002YR	3963.00	933.47	942.62		943.54	0.004668	7.70	514.38	77.54	0.53
TC-M80	4.516	005YR	4976.00	933.47	943.73		944.79	0.004660	8.25	602.89	81.51	0.53
TC-M80	4.516	010YR	5794.00	933.47	944.35	941.40	945.57	0.005015	8.86	653.63	83.70	0.56
TC-M80	4.516	020YR	7460.00	933.47	945.57		946.77	0.004445	9.11	936.78	279.33	0.54
TC-M80	4.516	050YR	8813.00	933.47	946.02	943.41	947.32	0.004699	9.67	1066.81	306.13	0.56
TC-M80	4.516	100YR	10144.00	933.47	946.46		947.80	0.004744	10.02	1203.08	320.60	0.56
TC-M80	4.516	200YR	11398.00	933.47	946.87		948.22	0.004633	10.18	1338.86	331.50	0.56
TC-M80	4.516	500YR	13005.00	933.47	947.42		948.75	0.004364	10.23	1524.70	357.59	0.55
TC-M80	4.448	001YR	2271.29	931.63	939.18		939.76	0.002559	6.09	372.72	74.27	0.48
TC-M80	4.448	002YR	3963.00	931.63	941.54		942.32	0.002412	7.09	558.91	84.32	0.49
TC-M80	4.448	005YR	4976.00	931.63	942.69		943.57	0.002369	7.52	670.67	128.91	0.49
TC-M80	4.448	010YR	5794.00	931.63	943.49		944.34	0.002101	7.58	884.80	382.33	0.47
TC-M80	4.448	020YR	7460.00	931.63	945.43		945.88	0.001029	6.12	1738.99	506.38	0.34
TC-M80	4.448	050YR	8813.00	931.63	945.90		946.39	0.001077	6.46	1985.50	533.94	0.35
TC-M80	4.448	100YR	10144.00	931.63	946.36		946.85	0.001085	6.67	2235.05	553.55	0.35
TC-M80	4.448	200YR	11398.00	931.63	946.80		947.29	0.001058	6.76	2483.44	566.01	0.35
TC-M80	4.448	500YR	13005.00	931.63	947.38		947.86	0.001000	6.79	2816.85	582.30	0.35
TC-M80	4.368	001YR	2271.29	931.16	937.91		938.67	0.002488	7.01	323.82	65.19	0.55
TC-M80	4.368	002YR	3963.00	931.16	940.28		941.29	0.002344	8.07	491.05	78.02	0.56
TC-M80	4.368	005YR	4976.00	931.16	941.42		942.56	0.002266	8.57	581.28	84.81	0.56
TC-M80	4.368	010YR	5794.00	931.16	942.23	939.31	943.42	0.002092	8.83	718.61	259.64	0.55
TC-M80	4.368	020YR	7460.00	931.16	944.95		945.50	0.000803	6.64	1692.23	434.46	0.36
TC-M80	4.368	050YR	8813.00	931.16	945.29		945.94	0.000955	7.39	1841.24	458.80	0.39
TC-M80	4.368	100YR	10144.00	931.16	945.61		946.37	0.001089	8.05	1993.65	482.41	0.42
TC-M80	4.368	200YR	11398.00	931.16	945.95		946.79	0.001181	8.54	2162.27	507.25	0.44
TC-M80	4.368	500YR	13005.00	931.16	946.45		947.36	0.001243	9.01	2421.78	543.28	0.45
TC-M80	4.302	001YR	2271.29	929.79	937.47		937.96	0.001398	5.63	403.44	73.36	0.42
TC-M80	4.302	002YR	3963.00	929.79	939.88		940.57	0.001424	6.69	592.72	83.79	0.44
TC-M80	4.302	005YR	4976.00	929.79	941.05		941.85	0.001413	7.17	698.96	138.20	0.45
TC-M80	4.302	010YR	5794.00	929.79	941.90		942.74	0.001356	7.42	836.68	202.72	0.45
TC-M80	4.302	020YR	7460.00	929.79	944.92		945.22	0.000450	4.93	2067.21	575.12	0.27

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	4.302	050YR	8813.00	929.79	945.27		945.61	0.000516	5.39	2268.17	587.92	0.29
TC-M80	4.302	100YR	10144.00	929.79	945.61		945.99	0.000567	5.77	2469.95	598.53	0.30
TC-M80	4.302	200YR	11398.00	929.79	945.97		946.38	0.000592	6.02	2688.18	609.79	0.31
TC-M80	4.302	500YR	13005.00	929.79	946.49		946.92	0.000593	6.20	3011.64	626.12	0.31
TC-M80	4.254	001YR	2271.29	929.00	937.14	934.08	937.55	0.001635	5.12	443.99	83.81	0.39
TC-M80	4.254	002YR	3963.00	929.00	939.60	935.72	940.14	0.001605	5.93	668.81	99.54	0.40
TC-M80	4.254	005YR	4976.00	929.00	940.80	936.53	941.41	0.001586	6.27	793.52	107.42	0.41
TC-M80	4.254	010YR	5794.00	929.00	941.65	937.11	942.32	0.001579	6.53	887.69	116.41	0.41
TC-M80	4.254	020YR	7460.00	929.00	944.67	938.23	945.06	0.000765	5.32	1855.77	461.26	0.30
TC-M80	4.254	050YR	8813.00	929.00	944.94	939.02	945.42	0.000930	5.97	1981.83	465.33	0.33
TC-M80	4.254	100YR	10144.00	929.00	945.21	939.74	945.78	0.001077	6.54	2108.57	469.39	0.36
TC-M80	4.254	200YR	11398.00	929.00	945.52	940.37	946.16	0.001168	6.94	2256.86	474.89	0.37
TC-M80	4.254	500YR	13005.00	929.00	946.02	941.15	946.69	0.001209	7.27	2501.24	531.33	0.38
TC-M80	4.244		Bridge									
TC-M80	4.234	001YR	2199.13	928.98	936.58		937.10	0.002323	5.80	379.47	77.04	0.46
TC-M80	4.234	002YR	3971.00	928.98	938.95		939.70	0.002265	6.91	574.41	87.13	0.47
TC-M80	4.234	005YR	5032.00	928.98	940.11		940.96	0.002262	7.42	677.84	92.04	0.48
TC-M80	4.234	010YR	5877.00	928.98	940.91		941.86	0.002237	7.81	752.81	95.41	0.49
TC-M80	4.234	020YR	7505.00	928.98	942.31		943.27	0.001928	8.06	1037.80	222.18	0.46
TC-M80	4.234	050YR	8781.00	928.98	943.02		944.03	0.001899	8.40	1197.71	228.85	0.47
TC-M80	4.234	100YR	10047.00	928.98	943.50		944.61	0.002004	8.90	1308.67	233.81	0.48
TC-M80	4.234	200YR	11248.00	928.98	943.91		945.12	0.002099	9.34	1406.79	239.14	0.50
TC-M80	4.234	500YR	12846.00	928.98	944.35		945.71	0.002285	10.00	1511.56	245.20	0.52
TC-M80	4.169	001YR	2199.13	928.27	935.49		936.15	0.002991	6.50	338.14	69.68	0.52
TC-M80	4.169	002YR	3971.00	928.27	937.80		938.74	0.002991	7.78	510.64	79.86	0.54
TC-M80	4.169	005YR	5032.00	928.27	938.91		940.00	0.003007	8.36	602.27	84.75	0.55
TC-M80	4.169	010YR	5877.00	928.27	939.68		940.88	0.003053	8.79	668.94	88.94	0.56
TC-M80	4.169	020YR	7505.00	928.27	940.81	937.90	942.27	0.003292	9.69	790.37	216.18	0.60
TC-M80	4.169	050YR	8781.00	928.27	941.53	938.70	943.04	0.003160	10.05	990.50	293.03	0.60
TC-M80	4.169	100YR	10047.00	928.27	942.07	939.43	943.62	0.003111	10.37	1151.13	303.82	0.60
TC-M80	4.169	200YR	11248.00	928.27	942.41	940.15	944.08	0.003256	10.87	1258.62	316.89	0.61
TC-M80	4.169	500YR	12846.00	928.27	942.95	942.30	944.65	0.003230	11.22	1432.64	336.71	0.62
TC-M80	4.099	001YR	2199.13	927.41	934.21		934.97	0.003357	7.02	313.38	62.50	0.55
TC-M80	4.099	002YR	3971.00	927.41	936.22		937.45	0.003922	8.92	445.20	68.77	0.62
TC-M80	4.099	005YR	5032.00	927.41	937.21		938.70	0.003944	9.79	516.15	75.21	0.63
TC-M80	4.099	010YR	5877.00	927.41	937.79		939.52	0.004170	10.59	563.25	103.19	0.66
TC-M80	4.099	020YR	7505.00	927.41	938.54	936.93	940.74	0.004808	12.07	685.20	184.95	0.72
TC-M80	4.099	050YR	8781.00	927.41	939.08	939.07	941.51	0.005043	12.86	787.84	194.91	0.74
TC-M80	4.099	100YR	10047.00	927.41	939.75	939.75	942.15	0.004737	13.06	926.60	237.65	0.73
TC-M80	4.099	200YR	11248.00	927.41	940.39	940.39	942.67	0.004312	12.99	1095.86	277.22	0.70
TC-M80	4.099	500YR	12846.00	927.41	940.97	940.97	943.27	0.004245	13.35	1261.42	301.82	0.70
TC-M80	4.050	001YR	2199.13	927.18	932.57		933.82	0.005614	8.99	244.70	63.21	0.80
TC-M80	4.050	002YR	3971.00	927.18	934.83		936.37	0.004250	9.95	400.59	74.42	0.74
TC-M80	4.050	005YR	5032.00	927.18	936.13	934.59	937.72	0.003539	10.15	501.95	98.70	0.70
TC-M80	4.050	010YR	5877.00	927.18	936.95	935.23	938.55	0.003138	10.29	626.96	179.26	0.67
TC-M80	4.050	020YR	7505.00	927.18	937.87	937.23	939.62	0.003076	11.02	804.17	202.55	0.67
TC-M80	4.050	050YR	8781.00	927.18	938.53	937.96	940.33	0.002969	11.39	942.99	218.21	0.67
TC-M80	4.050	100YR	10047.00	927.18	939.22	938.50	940.98	0.002746	11.51	1098.21	234.72	0.65
TC-M80	4.050	200YR	11248.00	927.18	939.88		941.54	0.002456	11.38	1261.66	258.92	0.62
TC-M80	4.050	500YR	12846.00	927.18	940.70		942.25	0.002162	11.23	1487.18	289.41	0.59
TC-M80	3.990	001YR	2199.13	925.40	931.46		932.22	0.003806	7.01	313.52	69.45	0.58
TC-M80	3.990	002YR	3971.00	925.40	934.16		935.07	0.002931	7.69	516.48	81.14	0.54
TC-M80	3.990	005YR	5032.00	925.40	935.61		936.57	0.002647	7.86	641.76	117.86	0.52
TC-M80	3.990	010YR	5877.00	925.40	936.66		937.53	0.002057	7.57	894.80	301.53	0.47
TC-M80	3.990	020YR	7505.00	925.40	937.94		938.64	0.001564	7.26	1293.37	335.11	0.42
TC-M80	3.990	050YR	8781.00	925.40	938.75		939.39	0.001351	7.14	1591.40	420.74	0.39
TC-M80	3.990	100YR	10047.00	925.40	939.53		940.11	0.001169	6.97	1944.65	503.04	0.37
TC-M80	3.990	200YR	11248.00	925.40	940.21		940.75	0.001034	6.82	2330.64	596.37	0.35
TC-M80	3.990	500YR	12846.00	925.40	941.05		941.54	0.000893	6.64	2851.49	630.33	0.33
TC-M80	3.952	001YR	2199.13	923.68	931.48		931.79	0.000778	4.45	494.06	82.17	0.32
TC-M80	3.952	002YR	3971.00	923.68	934.19		934.65	0.000848	5.43	733.44	130.04	0.35
TC-M80	3.952	005YR	5032.00	923.68	935.69		936.17	0.000714	5.61	1074.35	344.92	0.33
TC-M80	3.952	010YR	5877.00	923.68	936.74		937.21	0.000623	5.64	1443.95	358.96	0.31
TC-M80	3.952	020YR	7505.00	923.68	937.87		938.40	0.000649	6.17	1856.15	371.52	0.32
TC-M80	3.952	050YR	8781.00	923.68	938.61		939.19	0.000674	6.56	2133.68	378.25	0.33
TC-M80	3.952	100YR	10047.00	923.68	939.31		939.93	0.000686	6.87	2444.92	531.88	0.34
TC-M80	3.952	200YR	11248.00	923.68	939.94		940.57	0.000683	7.08	2811.69	617.20	0.34
TC-M80	3.952	500YR	12846.00	923.68	940.74		941.37	0.000664	7.25	3314.87	640.97	0.34
TC-M80	3.921	001YR	2199.13	924.12	931.14		931.61	0.001297	5.50	399.76	70.43	0.41
TC-M80	3.921	002YR	3971.00	924.12	933.76		934.43	0.001754	6.60	622.05	118.91	0.43
TC-M80	3.921	005YR	5032.00	924.12	935.28		935.99	0.001454	6.80	880.63	207.54	0.40
TC-M80	3.921	010YR	5877.00	924.12	936.33		937.04	0.001298	6.92	1105.53	223.38	0.38

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	3.921	020YR	7505.00	924.12	937.33		938.20	0.001455	7.80	1337.49	240.55	0.41
TC-M80	3.921	050YR	8781.00	924.12	937.96		938.97	0.001594	8.47	1493.55	252.14	0.44
TC-M80	3.921	100YR	10047.00	924.12	938.57		939.70	0.001694	9.03	1649.82	263.01	0.45
TC-M80	3.921	200YR	11248.00	924.12	939.08		940.32	0.001792	9.55	1787.16	272.23	0.47
TC-M80	3.921	500YR	12846.00	924.12	939.72		941.11	0.001910	10.18	1964.16	283.68	0.49
TC-M80	3.892	001YR	2199.13	924.24	930.09		931.19	0.005343	8.41	261.60	55.51	0.68
TC-M80	3.892	002YR	3971.00	924.24	932.36		933.91	0.005437	9.97	398.47	65.96	0.71
TC-M80	3.892	005YR	5032.00	924.24	934.14		935.56	0.004141	9.58	525.20	78.04	0.65
TC-M80	3.892	010YR	5877.00	924.24	935.39	932.64	936.68	0.003287	9.19	761.16	250.69	0.59
TC-M80	3.892	020YR	7505.00	924.24	936.35	933.88	937.82	0.003449	10.00	1008.07	261.95	0.61
TC-M80	3.892	050YR	8781.00	924.24	936.94	935.57	938.57	0.003604	10.66	1163.50	266.38	0.63
TC-M80	3.892	100YR	10047.00	924.24	937.56		939.29	0.003602	11.11	1330.48	271.29	0.63
TC-M80	3.892	200YR	11248.00	924.24	938.07		939.90	0.003659	11.56	1469.62	276.11	0.64
TC-M80	3.892	500YR	12846.00	924.24	938.72		940.68	0.003699	12.08	1650.86	282.09	0.65
TC-M80	3.855	001YR	2199.13	923.69	929.66		930.40	0.002553	6.93	317.18	66.07	0.56
TC-M80	3.855	002YR	3971.00	923.69	932.07		933.06	0.002501	8.00	496.44	81.96	0.57
TC-M80	3.855	005YR	5032.00	923.69	934.03		934.90	0.001787	7.50	680.25	124.63	0.50
TC-M80	3.855	010YR	5877.00	923.69	935.33		936.16	0.001372	7.34	861.79	152.36	0.45
TC-M80	3.855	020YR	7505.00	923.69	936.20		937.28	0.001579	8.41	1003.01	168.24	0.49
TC-M80	3.855	050YR	8781.00	923.69	936.70		938.01	0.001787	9.27	1088.75	171.92	0.52
TC-M80	3.855	100YR	10047.00	923.69	937.23		938.74	0.001934	10.00	1180.54	175.97	0.55
TC-M80	3.855	200YR	11248.00	923.69	937.64		939.36	0.002104	10.70	1253.29	179.23	0.58
TC-M80	3.855	500YR	12846.00	923.69	938.08		940.12	0.002379	11.69	1332.69	206.61	0.62
TC-M80	3.823	001YR	2199.13	923.59	928.91		929.85	0.003828	7.81	281.75	67.37	0.67
TC-M80	3.823	002YR	3971.00	923.59	931.54		932.60	0.002836	8.27	480.20	83.77	0.61
TC-M80	3.823	005YR	5032.00	923.59	933.74		934.58	0.001818	7.36	683.42	101.60	0.50
TC-M80	3.823	010YR	5877.00	923.59	935.12		935.90	0.001484	7.07	832.21	113.74	0.46
TC-M80	3.823	020YR	7505.00	923.59	935.96		936.97	0.001792	8.10	930.03	120.75	0.50
TC-M80	3.823	050YR	8781.00	923.59	936.42		937.66	0.002043	8.96	987.00	126.07	0.54
TC-M80	3.823	100YR	10047.00	923.59	936.91		938.37	0.002212	9.68	1054.26	160.83	0.57
TC-M80	3.823	200YR	11248.00	923.59	937.29		938.96	0.002408	10.38	1124.28	211.47	0.60
TC-M80	3.823	500YR	12846.00	923.59	937.69	935.10	939.66	0.002703	11.31	1220.73	275.68	0.64
TC-M80	3.726	001YR	2431.05	921.00	925.41	924.48	926.37	0.013785	7.84	309.94	81.30	0.68
TC-M80	3.726	002YR	4410.00	921.00	930.18	926.07	930.83	0.003575	6.48	680.61	114.38	0.39
TC-M80	3.726	005YR	5595.00	921.00	932.82	926.90	933.44	0.002383	6.31	886.60	162.09	0.33
TC-M80	3.726	010YR	6469.00	921.00	934.74	927.44	935.04	0.001303	4.62	1505.51	359.01	0.23
TC-M80	3.726	020YR	7890.00	921.00	935.81	928.29	936.04	0.001075	4.02	2035.03	461.21	0.20
TC-M80	3.726	050YR	9108.00	921.00	936.43	928.96	936.67	0.000974	3.95	2332.21	491.47	0.19
TC-M80	3.726	100YR	10381.00	921.00	937.11	929.66	937.35	0.000843	3.80	2675.74	517.74	0.18
TC-M80	3.726	200YR	11629.00	921.00	937.64	930.30	937.88	0.000785	3.75	2955.16	538.55	0.17
TC-M80	3.726	500YR	13363.00	921.00	938.22	931.17	938.49	0.000760	3.79	3277.78	565.01	0.17
TC-M80	3.711		Culvert									
TC-M80	3.690	001YR	2431.05	919.85	924.84	923.66	925.77	0.005089	7.72	314.78	71.53	0.65
TC-M80	3.690	002YR	4410.00	919.85	929.39	925.39	929.97	0.002269	6.12	721.01	123.48	0.45
TC-M80	3.690	005YR	5595.00	919.85	931.29	926.29	931.81	0.001563	5.78	968.16	136.24	0.38
TC-M80	3.690	010YR	6469.00	919.85	932.40	926.98	932.91	0.001330	5.77	1127.54	179.05	0.36
TC-M80	3.690	020YR	7890.00	919.85	933.28	928.01	933.89	0.001375	6.29	1307.27	227.37	0.37
TC-M80	3.690	050YR	9108.00	919.85	934.05	929.04	934.65	0.001274	6.40	1596.38	628.96	0.36
TC-M80	3.690	100YR	10381.00	919.85	935.19	929.61	935.56	0.000747	5.28	2238.45	803.74	0.28
TC-M80	3.690	200YR	11629.00	919.85	936.06	930.12	936.36	0.000488	4.50	2801.34	907.09	0.23
TC-M80	3.690	500YR	13363.00	919.85	937.03	930.79	937.27	0.000339	3.95	3432.70	1047.68	0.20
TC-M80	3.665	001YR	2357.80	920.00	923.67	923.24	924.84	0.008619	8.68	271.50	79.97	0.83
TC-M80	3.665	002YR	6461.00	920.00	927.22	926.29	929.06	0.006801	10.90	592.81	103.74	0.80
TC-M80	3.665	005YR	8918.00	920.00	928.99	927.70	930.95	0.006303	11.24	793.49	125.74	0.79
TC-M80	3.665	010YR	10718.00	920.00	930.14	928.68	932.11	0.005265	11.31	986.14	252.33	0.74
TC-M80	3.665	020YR	13007.00	920.00	931.73	930.48	933.29	0.003425	10.40	1410.37	300.18	0.62
TC-M80	3.665	050YR	14839.00	920.00	932.92	931.10	934.20	0.002492	9.65	1854.01	478.22	0.54
TC-M80	3.665	100YR	16855.00	920.00	934.17	931.74	935.20	0.001800	8.87	2492.40	713.96	0.46
TC-M80	3.665	200YR	18610.00	920.00	935.16	932.36	936.06	0.001440	8.39	3071.19	806.95	0.42
TC-M80	3.665	500YR	21037.00	920.00	936.17	932.92	937.00	0.001237	8.19	3713.10	871.93	0.40
TC-M80	3.607	001YR	2357.80	916.87	921.39	920.71	922.47	0.006761	8.34	282.84	74.52	0.75
TC-M80	3.607	002YR	6461.00	916.87	924.88	923.85	926.94	0.006787	11.52	560.84	89.57	0.81
TC-M80	3.607	005YR	8918.00	916.87	926.61	925.43	928.98	0.006164	12.36	721.72	95.87	0.79
TC-M80	3.607	010YR	10718.00	916.87	927.30	926.37	930.17	0.006867	13.60	788.34	98.11	0.85
TC-M80	3.607	020YR	13007.00	916.87	928.69	927.46	931.74	0.006244	14.02	927.52	101.96	0.82
TC-M80	3.607	050YR	14839.00	916.87	928.95	928.25	932.71	0.007481	15.56	953.93	102.67	0.90
TC-M80	3.607	100YR	16855.00	916.87	929.30	929.09	933.80	0.008635	17.02	990.76	108.69	0.97
TC-M80	3.607	200YR	18610.00	916.87	929.84	929.84	934.74	0.008863	17.78	1049.96	111.12	0.99
TC-M80	3.607	500YR	21037.00	916.87	931.53	931.53	935.89	0.006562	16.91	1312.05	341.53	0.87
TC-M80	3.570	001YR	2357.80	915.68	919.69	919.32	920.95	0.008743	9.00	261.85	74.71	0.85
TC-M80	3.570	002YR	6461.00	915.68	923.90	922.40	925.70	0.005222	10.76	600.68	86.39	0.72
TC-M80	3.570	005YR	8918.00	915.68	925.69	923.85	927.83	0.005012	11.74	760.24	96.54	0.72

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	3.570	010YR	10718.00	915.68	925.94	924.85	928.85	0.006635	13.69	784.75	103.25	0.83
TC-M80	3.570	020YR	13007.00	915.68	926.28	926.06	930.23	0.006673	15.95	821.55	112.58	0.96
TC-M80	3.570	050YR	14839.00	915.68	927.67	927.67	931.28	0.006675	15.38	1034.40	196.57	0.86
TC-M80	3.570	100YR	16855.00	915.68	929.02	929.02	932.11	0.005054	14.57	1345.02	250.42	0.76
TC-M80	3.570	200YR	18610.00	915.68	929.62	929.62	932.72	0.004861	14.78	1497.61	317.72	0.75
TC-M80	3.570	500YR	21037.00	915.68	930.29	930.29	933.49	0.004795	15.23	1675.67	386.22	0.76
TC-M80	3.560	001YR	2357.80	915.00	919.66		920.58	0.005235	7.68	307.05	74.92	0.67
TC-M80	3.560	002YR	6461.00	915.00	923.90		925.43	0.004105	9.94	650.06	87.26	0.64
TC-M80	3.560	005YR	8918.00	915.00	925.69		927.56	0.004034	10.99	814.36	102.24	0.65
TC-M80	3.560	010YR	10718.00	915.00	925.94		928.49	0.005330	12.82	840.71	106.59	0.75
TC-M80	3.560	020YR	13007.00	915.00	926.31	925.47	929.74	0.006838	14.89	881.96	118.41	0.86
TC-M80	3.560	050YR	14839.00	915.00	926.87	926.87	930.74	0.007196	15.88	953.74	137.96	0.89
TC-M80	3.560	100YR	16855.00	915.00	929.07	929.07	931.15	0.003274	12.24	1572.45	384.47	0.62
TC-M80	3.560	200YR	18610.00	915.00	929.42	929.42	931.57	0.003278	12.48	1709.43	401.24	0.62
TC-M80	3.560	500YR	21037.00	915.00	929.81	929.81	932.11	0.003376	12.93	1868.20	419.84	0.63
TC-M80	3.539	001YR	2357.80	913.76	919.11	917.55	919.92	0.003922	7.22	326.60	68.70	0.58
TC-M80	3.539	002YR	6461.00	913.76	923.24	920.95	924.85	0.004106	10.19	634.54	85.64	0.64
TC-M80	3.539	005YR	8918.00	913.76	925.40	922.54	926.90	0.003098	10.12	934.77	204.57	0.57
TC-M80	3.539	010YR	10718.00	913.76	925.60	923.96	927.59	0.004011	11.67	976.72	215.36	0.65
TC-M80	3.539	020YR	13007.00	913.76	926.17	926.17	928.44	0.004305	12.55	1108.02	244.62	0.68
TC-M80	3.539	050YR	14839.00	913.76	926.68	926.68	929.05	0.004224	12.83	1239.46	270.99	0.68
TC-M80	3.539	100YR	16855.00	913.76	927.15	927.15	929.68	0.004176	13.12	1374.91	301.65	0.68
TC-M80	3.539	200YR	18610.00	913.76	927.51	927.51	930.19	0.004169	13.38	1485.13	331.45	0.69
TC-M80	3.539	500YR	21037.00	913.76	928.20	928.20	930.86	0.003639	12.99	1730.93	600.77	0.65
TC-M80	3.481	001YR	2357.80	912.13	917.19	916.38	918.36	0.006463	8.69	271.18	63.77	0.74
TC-M80	3.481	002YR	6461.00	912.13	920.84	919.91	923.17	0.006976	12.24	527.67	77.25	0.83
TC-M80	3.481	005YR	8918.00	912.13	921.71	921.55	925.18	0.009273	14.95	597.85	89.22	0.96
TC-M80	3.481	010YR	10718.00	912.13	924.13	924.13	926.29	0.004325	12.30	1010.41	261.61	0.69
TC-M80	3.481	020YR	13007.00	912.13	925.01	925.01	927.09	0.003945	12.44	1267.75	320.92	0.67
TC-M80	3.481	050YR	14839.00	912.13	925.76	925.76	927.60	0.003333	11.96	1534.69	385.61	0.62
TC-M80	3.481	100YR	16855.00	912.13	926.10	926.10	928.09	0.003503	12.49	1656.38	387.98	0.64
TC-M80	3.481	200YR	18610.00	912.13	926.37	926.37	928.50	0.003626	12.91	1756.45	389.93	0.65
TC-M80	3.481	500YR	21037.00	912.13	926.68	926.68	929.05	0.003887	13.58	1867.57	392.09	0.68
TC-M80	3.420	001YR	2357.80	910.56	915.18	914.37	916.25	0.006337	8.33	283.19	69.89	0.73
TC-M80	3.420	002YR	6461.00	910.56	918.43	917.64	920.81	0.007520	12.37	522.36	78.70	0.85
TC-M80	3.420	005YR	8918.00	910.56	920.46	920.46	922.56	0.005185	12.06	923.68	303.52	0.73
TC-M80	3.420	010YR	10718.00	910.56	921.35	921.35	923.27	0.004518	12.01	1221.85	360.96	0.69
TC-M80	3.420	020YR	13007.00	910.56	922.13	922.13	924.01	0.004284	12.32	1519.88	429.29	0.68
TC-M80	3.420	050YR	14839.00	910.56	922.55	922.55	924.52	0.004394	12.83	1695.18	537.21	0.69
TC-M80	3.420	100YR	16855.00	910.56	922.98	922.98	925.03	0.004501	13.33	1878.00	566.80	0.71
TC-M80	3.420	200YR	18610.00	910.56	923.29	923.29	925.45	0.004676	13.83	2008.38	578.95	0.72
TC-M80	3.420	500YR	21037.00	910.56	923.73	923.73	925.99	0.004776	14.34	2204.77	596.54	0.74
TC-M80	3.345	001YR	2357.80	907.25	911.17	911.17	912.81	0.012357	10.26	229.71	69.90	1.00
TC-M80	3.345	002YR	6461.00	907.25	914.36	914.36	917.26	0.010652	13.65	473.19	82.81	1.01
TC-M80	3.345	005YR	8918.00	907.25	916.21	916.21	919.24	0.008067	14.02	659.69	142.05	0.91
TC-M80	3.345	010YR	10718.00	907.25	918.14	918.14	920.11	0.004279	11.92	1155.03	480.46	0.69
TC-M80	3.345	020YR	13007.00	907.25	919.09	919.09	920.82	0.003606	11.68	1593.92	580.10	0.64
TC-M80	3.345	050YR	14839.00	907.25	919.60	919.60	921.26	0.003424	11.76	1857.07	606.06	0.63
TC-M80	3.345	100YR	16855.00	907.25	919.94	919.94	921.69	0.003575	12.27	2040.36	613.40	0.65
TC-M80	3.345	200YR	18610.00	907.25	920.23	920.23	922.05	0.003673	12.66	2194.71	619.11	0.66
TC-M80	3.345	500YR	21037.00	907.25	921.59	920.58	922.78	0.002258	10.70	2935.89	645.33	0.53
TC-M80	3.298	001YR	2357.80	904.24	909.00	908.15	910.01	0.007804	8.06	292.53	73.94	0.71
TC-M80	3.298	002YR	6461.00	904.24	911.79	911.32	914.28	0.010818	12.68	509.70	81.91	0.90
TC-M80	3.298	005YR	8918.00	904.24	913.85	912.80	916.48	0.008566	13.02	685.11	87.81	0.82
TC-M80	3.298	010YR	10718.00	904.24	915.13	913.78	917.81	0.007496	13.24	871.87	396.49	0.78
TC-M80	3.298	020YR	13007.00	904.24	916.59	916.48	918.60	0.005091	12.08	1313.10	508.80	0.66
TC-M80	3.298	050YR	14839.00	904.24	917.70	916.97	919.30	0.003772	11.13	1664.67	551.73	0.58
TC-M80	3.298	100YR	16855.00	904.24	918.58	917.42	920.05	0.003250	10.85	1955.82	574.17	0.54
TC-M80	3.298	200YR	18610.00	904.24	919.48	917.80	920.79	0.002709	10.38	2274.75	602.62	0.50
TC-M80	3.298	500YR	21037.00	904.24	921.27	918.20	922.22	0.001710	8.98	2960.87	629.59	0.41
TC-M80	3.231	001YR	2357.80	901.95	905.33	904.95	906.40	0.011354	8.33	283.11	90.34	0.83
TC-M80	3.231	002YR	6461.00	901.95	910.67	907.64	911.70	0.003366	8.14	793.95	97.87	0.50
TC-M80	3.231	005YR	8918.00	901.95	913.13	908.93	914.29	0.002815	8.62	1034.63	97.87	0.47
TC-M80	3.231	010YR	10718.00	901.95	914.47	909.76	915.75	0.002739	9.12	1228.12	432.56	0.47
TC-M80	3.231	020YR	13007.00	901.95	915.65	910.74	917.02	0.002686	9.62	1514.32	449.31	0.47
TC-M80	3.231	050YR	14839.00	901.95	916.75	911.51	918.06	0.002394	9.58	1798.42	465.03	0.45
TC-M80	3.231	100YR	16855.00	901.95	917.61	912.31	918.95	0.002332	9.83	2028.69	477.20	0.45
TC-M80	3.231	200YR	18610.00	901.95	918.57	912.97	919.86	0.002111	9.75	2299.39	499.29	0.43
TC-M80	3.231	500YR	21037.00	901.95	920.53	915.68	921.58	0.001530	8.97	2928.19	550.92	0.37
TC-M80	3.230		Inl Struct									
TC-M80	3.225	001YR	2357.80	897.35	905.22	901.81	905.55	0.001439	4.55	518.26	85.22	0.33
TC-M80	3.225	002YR	6461.00	897.35	910.66	904.76	911.31	0.001440	6.44	1002.87	92.76	0.35

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	3.225	005YR	8918.00	897.35	913.12	906.14	913.93	0.001552	7.20	1238.07	104.88	0.36
TC-M80	3.225	010YR	10718.00	897.35	914.46	907.09	915.39	0.001611	7.75	1439.10	372.15	0.38
TC-M80	3.225	020YR	13007.00	897.35	915.64	908.20	916.73	0.001743	8.47	1683.36	409.31	0.40
TC-M80	3.225	050YR	14839.00	897.35	916.68	909.02	917.83	0.001715	8.80	1920.51	423.56	0.40
TC-M80	3.225	100YR	16855.00	897.35	917.44	909.91	918.72	0.001813	9.35	2101.95	432.76	0.41
TC-M80	3.225	200YR	18610.00	897.35	918.33	910.64	919.65	0.001769	9.58	2321.02	444.32	0.41
TC-M80	3.225	500YR	21037.00	897.35	920.21	911.60	921.41	0.001454	9.31	2816.46	472.30	0.38
TC-M80	3.165	001YR	2357.80	896.85	904.42	901.14	905.01	0.001433	6.17	382.38	56.00	0.41
TC-M80	3.165	002YR	6461.00	896.85	909.04	905.07	910.52	0.002033	9.84	677.61	71.65	0.52
TC-M80	3.165	005YR	8918.00	896.85	911.16	907.02	913.04	0.002115	11.16	841.04	84.85	0.54
TC-M80	3.165	010YR	10718.00	896.85	912.46	908.33	914.48	0.002079	11.78	1052.19	296.30	0.55
TC-M80	3.165	020YR	13007.00	896.85	912.37	909.81	915.41	0.003151	14.45	1034.81	290.30	0.67
TC-M80	3.165	050YR	14839.00	896.85	912.72	910.93	916.33	0.003672	15.85	1101.52	313.21	0.73
TC-M80	3.165	100YR	16855.00	896.85	913.66	913.66	917.25	0.003499	16.12	1287.44	364.61	0.72
TC-M80	3.165	200YR	18610.00	896.85	913.88	913.77	918.00	0.003973	17.34	1332.11	366.27	0.77
TC-M80	3.165	500YR	21037.00	896.85	913.88	913.77	919.33	0.005221	19.88	1332.73	380.03	0.88
TC-M80	3.096	001YR	2357.80	898.00	903.36	901.94	904.24	0.003181	7.53	313.30	66.96	0.61
TC-M80	3.096	002YR	6461.00	898.00	908.37	905.47	909.66	0.002421	9.12	708.13	91.78	0.58
TC-M80	3.096	005YR	8918.00	898.00	910.73	907.08	912.13	0.002082	9.50	939.38	103.49	0.55
TC-M80	3.096	010YR	10718.00	898.00	912.31	908.13	913.59	0.001625	9.29	1444.41	466.35	0.50
TC-M80	3.096	020YR	13007.00	898.00	911.88	909.33	914.05	0.002859	11.99	1287.54	464.16	0.66
TC-M80	3.096	050YR	14839.00	898.00	912.13	910.20	914.73	0.003349	13.19	1380.55	465.46	0.72
TC-M80	3.096	100YR	16855.00	898.00	913.31	912.53	915.56	0.002677	12.65	1810.68	471.46	0.65
TC-M80	3.096	200YR	18610.00	898.00	914.26	913.09	916.28	0.002258	12.24	2163.19	476.35	0.61
TC-M80	3.096	500YR	21037.00	898.00	915.13	913.73	917.11	0.002113	12.38	2482.66	480.76	0.59
TC-M80	3.070	001YR	2543.90	896.11	903.68	899.71	903.89	0.000524	3.73	682.56	111.20	0.27
TC-M80	3.070	002YR	6764.00	896.11	908.84	902.28	909.26	0.000536	5.19	1304.02	129.35	0.29
TC-M80	3.070	005YR	9291.00	896.11	911.23	903.51	911.73	0.000535	5.73	1622.09	137.72	0.29
TC-M80	3.070	010YR	11200.00	896.11	912.67	904.36	913.25	0.000559	6.13	1872.03	347.04	0.30
TC-M80	3.070	020YR	13593.00	896.11	912.60	905.37	913.47	0.000837	7.49	1847.17	321.02	0.37
TC-M80	3.070	050YR	15507.00	896.11	912.99	906.08	914.04	0.000996	8.25	1992.26	404.26	0.41
TC-M80	3.070	100YR	17691.00	896.11	913.88	906.90	915.01	0.000999	8.63	2421.61	544.99	0.41
TC-M80	3.070	200YR	19657.00	896.11	914.68	907.58	915.82	0.000962	8.80	2857.38	549.20	0.41
TC-M80	3.070	500YR	22293.00	896.11	915.49	908.45	916.68	0.000962	9.12	3306.29	553.30	0.41
TC-M80	3.058		Bridge									
TC-M80	3.040	001YR	2543.90	896.15	903.50		903.73	0.000563	3.82	665.31	110.10	0.27
TC-M80	3.040	002YR	6764.00	896.15	908.65		909.08	0.000566	5.30	1276.49	127.65	0.30
TC-M80	3.040	005YR	9291.00	896.15	911.01		911.54	0.000564	5.85	1588.14	135.73	0.30
TC-M80	3.040	010YR	11200.00	896.15	912.46		913.03	0.000547	6.13	1888.26	249.37	0.30
TC-M80	3.040	020YR	13593.00	896.15	912.26		913.14	0.000859	7.61	1838.09	235.05	0.38
TC-M80	3.040	050YR	15507.00	896.15	912.53		913.61	0.001024	8.42	1906.75	252.99	0.41
TC-M80	3.040	100YR	17691.00	896.15	913.31		914.47	0.001035	8.80	2114.16	277.26	0.42
TC-M80	3.040	200YR	19657.00	896.15	913.97		915.17	0.001030	9.06	2313.60	363.11	0.42
TC-M80	3.040	500YR	22293.00	896.15	914.65		915.92	0.001045	9.41	2573.62	397.62	0.43
TC-M80	2.945	001YR	2543.90	896.09	901.12	900.68	902.66	0.006462	9.97	255.22	61.23	0.86
TC-M80	2.945	002YR	6764.00	896.09	905.35		907.83	0.004964	12.65	534.75	71.04	0.81
TC-M80	2.945	005YR	9291.00	896.09	907.15	905.96	910.16	0.004940	13.94	666.44	75.38	0.83
TC-M80	2.945	010YR	11200.00	896.09	909.35	907.09	911.88	0.003446	12.96	919.75	233.81	0.71
TC-M80	2.945	020YR	13593.00	896.09	911.19		912.45	0.001632	9.93	1645.98	457.62	0.50
TC-M80	2.945	050YR	15507.00	896.09	912.00		913.03	0.001238	9.03	2017.09	462.75	0.44
TC-M80	2.945	100YR	17691.00	896.09	912.98		913.83	0.000897	8.06	2482.93	487.96	0.38
TC-M80	2.945	200YR	19657.00	896.09	913.75		914.52	0.000747	7.62	2681.12	553.03	0.35
TC-M80	2.945	500YR	22293.00	896.09	914.51		915.25	0.000654	7.37	3330.26	616.61	0.33
TC-M80	2.813	001YR	2484.66	892.15	899.64		900.28	0.001776	6.39	388.89	69.58	0.48
TC-M80	2.813	002YR	6491.00	892.15	904.51		905.55	0.001663	8.21	807.59	109.82	0.49
TC-M80	2.813	005YR	8890.00	892.15	906.80		907.91	0.001434	8.59	1207.41	365.79	0.47
TC-M80	2.813	010YR	10849.00	892.15	909.65		910.43	0.000641	6.74	2559.32	499.69	0.33
TC-M80	2.813	020YR	13309.00	892.15	911.01		911.60	0.000628	7.06	3151.15	520.81	0.33
TC-M80	2.813	050YR	15185.00	892.15	911.69		912.32	0.000643	7.37	3510.70	531.43	0.34
TC-M80	2.813	100YR	17348.00	892.15	912.65		913.27	0.000614	7.50	4027.41	549.56	0.33
TC-M80	2.813	200YR	19333.00	892.15	913.39		914.03	0.000607	7.70	4443.88	566.00	0.33
TC-M80	2.813	500YR	22087.00	892.15	914.11		914.80	0.000645	8.15	4856.43	587.21	0.35
TC-M80	2.777	001YR	2484.66	892.15	898.42	897.29	899.71	0.004310	9.12	272.42	54.83	0.72
TC-M80	2.777	002YR	6491.00	892.15	903.01		905.00	0.003818	11.32	573.63	75.53	0.72
TC-M80	2.777	005YR	8890.00	892.15	905.36		907.41	0.003529	11.51	772.42	93.79	0.71
TC-M80	2.777	010YR	10849.00	892.15	909.50		910.28	0.000801	6.96	1546.51	236.87	0.36
TC-M80	2.777	020YR	13309.00	892.15	910.64		911.45	0.000831	7.53	1873.06	386.07	0.37
TC-M80	2.777	050YR	15185.00	892.15	911.45		912.19	0.000690	7.15	2239.05	524.80	0.34
TC-M80	2.777	100YR	17348.00	892.15	912.57		913.17	0.000458	6.14	2838.10	543.40	0.28
TC-M80	2.777	200YR	19333.00	892.15	913.36		913.93	0.000370	5.71	3274.88	562.16	0.25
TC-M80	2.777	500YR	22087.00	892.15	914.11		914.69	0.000333	5.59	3701.63	581.26	0.24
TC-M80	2.719	001YR	2484.66	890.42	895.56	895.56	897.78	0.008870	11.97	207.64	47.22	1.01

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	2.719	002YR	6491.00	890.42	900.29	899.68	903.40	0.006275	14.16	458.35	60.24	0.90
TC-M80	2.719	005YR	8890.00	890.42	903.12		906.07	0.004765	13.79	644.77	71.49	0.81
TC-M80	2.719	010YR	10849.00	890.42	908.21		909.84	0.001880	10.23	1060.46	91.78	0.53
TC-M80	2.719	020YR	13309.00	890.42	908.68		910.91	0.002460	12.01	1127.93	154.83	0.61
TC-M80	2.719	050YR	15185.00	890.42	908.69	905.59	911.58	0.003192	13.69	1129.49	155.06	0.69
TC-M80	2.719	100YR	17348.00	890.42	909.56	906.68	912.63	0.003143	14.23	1278.05	197.14	0.70
TC-M80	2.719	200YR	19333.00	890.42	910.70	907.47	913.47	0.002631	13.77	1528.33	256.04	0.65
TC-M80	2.719	500YR	22087.00	890.42	911.49	911.49	914.26	0.002554	14.07	1808.33	414.80	0.64
TC-M80	2.651	001YR	2484.66	886.70	895.11	892.18	895.71	0.001499	6.20	400.85	63.29	0.43
TC-M80	2.651	002YR	6491.00	886.70	900.80	895.69	901.85	0.001399	8.25	786.82	72.46	0.44
TC-M80	2.651	005YR	8890.00	886.70	903.46	897.36	904.72	0.001377	9.02	985.52	76.76	0.44
TC-M80	2.651	010YR	10849.00	886.70	908.32	898.56	909.18	0.000819	7.56	1530.77	326.48	0.35
TC-M80	2.651	020YR	13309.00	886.70	909.01	900.02	910.03	0.000943	8.37	1763.49	349.12	0.38
TC-M80	2.651	050YR	15185.00	886.70	909.22	901.03	910.45	0.001124	9.22	1840.09	360.90	0.41
TC-M80	2.651	100YR	17348.00	886.70	910.56	902.14	911.48	0.000815	8.31	2408.33	496.23	0.36
TC-M80	2.651	200YR	19333.00	886.70	911.78	903.10	912.47	0.000578	7.33	3051.53	560.61	0.31
TC-M80	2.651	500YR	22087.00	886.70	912.57	904.31	913.24	0.000528	7.22	3511.77	599.09	0.29
TC-M80	2.636		Bridge									
TC-M80	2.623	001YR	2484.66	887.04	894.63		895.12	0.001407	5.60	443.74	78.27	0.41
TC-M80	2.623	002YR	6491.00	887.04	899.84		900.70	0.001225	7.46	870.41	85.63	0.41
TC-M80	2.623	005YR	8890.00	887.04	902.09		903.16	0.001291	8.30	1071.47	92.88	0.43
TC-M80	2.623	010YR	10849.00	887.04	904.45		905.54	0.001131	8.35	1299.85	100.64	0.41
TC-M80	2.623	020YR	13309.00	887.04	905.55		906.93	0.001356	9.42	1412.40	104.25	0.45
TC-M80	2.623	050YR	15185.00	887.04	906.33		907.94	0.001473	10.17	1494.80	107.58	0.47
TC-M80	2.623	100YR	17348.00	887.04	907.82		909.53	0.001377	10.50	1687.07	192.41	0.47
TC-M80	2.623	200YR	19333.00	887.04	909.75		911.24	0.001073	10.01	2515.57	589.19	0.42
TC-M80	2.623	500YR	22087.00	887.04	910.82	902.68	912.31	0.001040	10.25	3212.22	699.30	0.42
TC-M80	2.594	001YR	2484.66	886.89	893.81		894.68	0.003488	7.46	333.13	60.94	0.56
TC-M80	2.594	002YR	6491.00	886.89	898.82		900.24	0.003122	9.57	678.21	76.55	0.57
TC-M80	2.594	005YR	8890.00	886.89	900.98		902.67	0.003107	10.46	849.87	82.93	0.58
TC-M80	2.594	010YR	10849.00	886.89	903.53		905.14	0.002262	10.17	1071.06	90.20	0.51
TC-M80	2.594	020YR	13309.00	886.89	904.24		906.40	0.002828	11.80	1135.95	92.16	0.57
TC-M80	2.594	050YR	15185.00	886.89	904.65		907.29	0.003325	13.06	1173.67	93.28	0.62
TC-M80	2.594	100YR	17348.00	886.89	906.09		908.89	0.003092	13.46	1311.03	97.26	0.61
TC-M80	2.594	200YR	19333.00	886.89	908.35	902.70	910.74	0.002260	12.63	1877.73	396.49	0.53
TC-M80	2.594	500YR	22087.00	886.89	908.87	903.83	911.67	0.002590	13.79	2109.32	494.73	0.57
TC-M80	2.507	001YR	2484.66	885.68	892.43		893.17	0.002949	6.93	358.56	65.40	0.52
TC-M80	2.507	002YR	6491.00	885.68	897.78		898.92	0.002383	8.57	757.67	83.86	0.50
TC-M80	2.507	005YR	8890.00	885.68	899.97		901.33	0.002377	9.36	950.25	91.43	0.51
TC-M80	2.507	010YR	10849.00	885.68	902.92		904.12	0.001686	8.79	1234.69	101.46	0.44
TC-M80	2.507	020YR	13309.00	885.68	903.45		905.11	0.002206	10.34	1288.70	103.36	0.51
TC-M80	2.507	050YR	15185.00	885.68	903.66		905.75	0.002723	11.61	1310.21	104.13	0.57
TC-M80	2.507	100YR	17348.00	885.68	905.32		907.46	0.002378	11.75	1488.28	110.63	0.54
TC-M80	2.507	200YR	19333.00	885.68	907.86	900.82	909.69	0.001673	10.96	1993.19	398.15	0.46
TC-M80	2.507	500YR	22087.00	885.68	908.24	901.99	910.47	0.001999	12.15	2157.83	480.65	0.51
TC-M80	2.484	001YR	2484.66	884.92	892.05	889.81	892.81	0.002938	7.00	354.79	62.74	0.52
TC-M80	2.484	002YR	6491.00	884.92	897.37	893.39	898.60	0.002521	8.93	727.18	77.27	0.51
TC-M80	2.484	005YR	8890.00	884.92	899.48	895.06	901.01	0.002619	9.91	896.74	83.05	0.53
TC-M80	2.484	010YR	10849.00	884.92	902.54	896.29	903.89	0.001849	9.33	1163.47	91.96	0.46
TC-M80	2.484	020YR	13309.00	884.92	902.85	897.70	904.79	0.002566	11.17	1198.05	144.84	0.54
TC-M80	2.484	050YR	15185.00	884.92	902.78	898.70	905.33	0.003404	12.82	1187.87	129.25	0.62
TC-M80	2.484	100YR	17348.00	884.92	905.02	899.76	907.17	0.002414	11.98	1721.88	332.54	0.54
TC-M80	2.484	200YR	19333.00	884.92	908.31	900.70	909.27	0.001023	8.88	3566.61	642.58	0.36
TC-M80	2.484	500YR	22087.00	884.92	908.89	901.85	909.93	0.001098	9.38	3947.61	656.01	0.38
TC-M80	2.479		Bridge									
TC-M80	2.471	001YR	2484.66	884.98	891.57		892.34	0.002986	7.04	352.95	60.53	0.51
TC-M80	2.471	002YR	6491.00	884.98	896.52		897.96	0.003075	9.65	672.75	70.14	0.55
TC-M80	2.471	005YR	8890.00	884.98	898.40		900.27	0.003459	10.98	809.82	75.36	0.59
TC-M80	2.471	010YR	10849.00	884.98	899.51		901.79	0.003916	12.12	894.94	78.43	0.63
TC-M80	2.471	020YR	13309.00	884.98	901.21		903.79	0.003911	12.90	1031.56	82.11	0.64
TC-M80	2.471	050YR	15185.00	884.98	902.59	898.45	905.32	0.003594	13.26	1152.90	113.23	0.62
TC-M80	2.471	100YR	17348.00	884.98	904.76	899.61	907.14	0.002687	12.62	1680.66	345.68	0.55
TC-M80	2.471	200YR	19333.00	884.98	906.93	900.54	908.61	0.001772	11.15	2713.63	621.79	0.46
TC-M80	2.471	500YR	22087.00	884.98	905.31	901.71	908.70	0.003733	15.21	1877.28	431.09	0.66
TC-M80	2.438	001YR	2484.66	883.99	890.80		891.71	0.003556	7.67	323.88	56.97	0.57
TC-M80	2.438	002YR	6491.00	883.99	895.70		897.33	0.003442	10.25	633.97	69.58	0.59
TC-M80	2.438	005YR	8890.00	883.99	897.33		899.53	0.003753	11.92	750.88	73.88	0.64
TC-M80	2.438	010YR	10849.00	883.99	897.75		900.79	0.004920	14.00	782.19	74.99	0.73
TC-M80	2.438	020YR	13309.00	883.99	898.17	897.02	902.41	0.006549	16.55	813.81	75.96	0.85
TC-M80	2.438	050YR	15185.00	883.99	898.66	898.04	903.73	0.007412	18.09	851.71	77.03	0.91
TC-M80	2.438	100YR	17348.00	883.99	899.14	899.14	905.24	0.008493	19.87	888.78	78.05	0.98
TC-M80	2.438	200YR	19333.00	883.99	900.18	900.18	906.60	0.008079	20.42	970.66	80.68	0.97

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	2.438	500YR	22087.00	883.99	904.81	904.81	907.99	0.003081	15.30	2344.76	529.18	0.63
TC-M80	2.396	001YR	1906.91	883.61	890.72		891.07	0.001293	4.75	401.50	68.19	0.34
TC-M80	2.396	002YR	5621.00	883.61	895.80		896.52	0.001703	6.81	825.05	97.41	0.41
TC-M80	2.396	005YR	7845.00	883.61	897.62		898.56	0.001930	7.77	1010.25	105.95	0.44
TC-M80	2.396	010YR	9843.00	883.61	898.19		899.50	0.002514	9.20	1070.53	108.46	0.51
TC-M80	2.396	020YR	12533.00	883.61	898.79		900.69	0.003365	11.06	1136.51	111.15	0.59
TC-M80	2.396	050YR	14448.00	883.61	899.58		901.76	0.003526	11.87	1225.65	114.68	0.61
TC-M80	2.396	100YR	16613.00	883.61	900.48	897.13	902.95	0.003618	12.64	1330.87	134.81	0.63
TC-M80	2.396	200YR	18641.00	883.61	900.04		903.39	0.005144	14.72	1278.96	116.66	0.75
TC-M80	2.396	500YR	21526.00	883.61	901.23	898.96	904.83	0.004918	15.32	1518.44	312.55	0.74
TC-M80	2.312	001YR	1906.91	882.92	890.37		890.60	0.000783	3.87	492.94	80.15	0.27
TC-M80	2.312	002YR	5621.00	882.92	895.32		895.87	0.001130	5.91	958.23	165.50	0.35
TC-M80	2.312	005YR	7845.00	882.92	897.22		897.84	0.001087	6.48	1415.98	286.97	0.36
TC-M80	2.312	010YR	9843.00	882.92	897.69		898.55	0.001422	7.63	1555.65	298.81	0.41
TC-M80	2.312	020YR	12533.00	882.92	898.18		899.38	0.001916	9.11	1704.90	310.44	0.48
TC-M80	2.312	050YR	14448.00	882.92	899.23		900.40	0.001742	9.20	2040.27	332.42	0.46
TC-M80	2.312	100YR	16613.00	882.92	900.43		901.55	0.001536	9.17	2460.44	365.59	0.44
TC-M80	2.312	200YR	18641.00	882.92	899.62		901.36	0.002533	11.31	2172.10	342.20	0.56
TC-M80	2.312	500YR	21526.00	882.92	901.52		902.93	0.001817	10.49	2878.23	400.03	0.48
TC-M80	2.208	001YR	1906.91	882.53	889.42	886.56	889.91	0.002068	5.62	339.48	64.71	0.43
TC-M80	2.208	002YR	5621.00	882.53	893.93	890.55	894.91	0.002655	7.95	707.47	500.81	0.52
TC-M80	2.208	005YR	7845.00	882.53	895.67	892.11	896.90	0.002602	8.91	885.36	567.46	0.53
TC-M80	2.208	010YR	9843.00	882.53	897.47	893.38	897.80	0.000825	5.68	3020.89	670.67	0.31
TC-M80	2.208	020YR	12533.00	882.53	897.97	894.75	898.39	0.001027	6.53	3357.21	681.64	0.35
TC-M80	2.208	050YR	14448.00	882.53	899.21	895.56	899.54	0.000752	6.00	4219.55	708.87	0.30
TC-M80	2.208	100YR	16613.00	882.53	900.54	896.44	900.81	0.000571	5.60	5179.68	737.77	0.27
TC-M80	2.208	200YR	18641.00	882.53	899.67	897.21	900.13	0.001023	7.17	4550.41	719.36	0.35
TC-M80	2.208	500YR	21526.00	882.53	901.74	897.21	902.06	0.000616	6.15	6084.40	764.78	0.28
TC-M80	2.132	001YR	1906.91	882.42	888.21	886.32	888.89	0.003109	6.58	289.99	59.37	0.52
TC-M80	2.132	002YR	5621.00	882.42	891.63	890.10	893.36	0.005401	10.56	532.38	412.10	0.73
TC-M80	2.132	005YR	7845.00	882.42	893.09	891.70	895.32	0.005643	11.98	655.37	481.59	0.76
TC-M80	2.132	010YR	9843.00	882.42	894.20	892.86	896.87	0.005661	13.13	754.25	605.98	0.78
TC-M80	2.132	020YR	12533.00	882.42	897.85	894.21	898.04	0.000503	4.93	4796.87	867.51	0.25
TC-M80	2.132	050YR	14448.00	882.42	899.12	895.10	899.28	0.000374	4.54	5956.77	980.33	0.22
TC-M80	2.132	100YR	16613.00	882.42	900.48	896.24	900.61	0.000286	4.22	7315.41	1023.34	0.19
TC-M80	2.132	200YR	18641.00	882.42	899.55	897.05	899.77	0.000519	5.46	6382.52	996.42	0.26
TC-M80	2.132	500YR	21526.00	882.42	901.66	897.05	901.83	0.000318	4.69	8662.73	1183.31	0.20
TC-M80	2.12	001YR	1906.91	882.14	886.38	886.38	887.74	0.013097	9.35	204.37	77.09	1.00
TC-M80	2.12	002YR	5621.00	882.14	889.25	889.25	891.90	0.009965	13.17	444.50	87.71	0.98
TC-M80	2.12	005YR	7845.00	882.14	890.61	890.61	893.85	0.009241	14.65	565.36	90.79	0.98
TC-M80	2.12	010YR	9843.00	882.14	891.71	891.71	895.43	0.008779	15.75	666.65	281.11	0.98
TC-M80	2.12	020YR	12533.00	882.14	893.06	893.06	897.38	0.008343	17.02	794.84	569.84	0.98
TC-M80	2.12	050YR	14448.00	882.14	894.06	894.06	898.64	0.007792	17.60	902.81	668.05	0.96
TC-M80	2.12	100YR	16613.00	882.14	896.25	895.34	900.09	0.005199	16.32	1245.19	809.81	0.81
TC-M80	2.12	200YR	18641.00	882.14	899.46	896.00	899.68	0.000468	5.70	7179.54	1247.41	0.25
TC-M80	2.12	500YR	21526.00	882.14	901.64	897.44	901.77	0.000252	4.56	10019.92	1366.12	0.19
TC-M80	2.065	001YR	1860.30	874.00	880.56	876.83	880.76	0.000743	3.57	521.38	93.37	0.27
TC-M80	2.065	002YR	6047.00	874.00	885.15	880.00	885.72	0.001193	6.08	994.69	112.81	0.36
TC-M80	2.065	005YR	8554.00	874.00	887.61	881.42	888.30	0.001152	6.66	1284.72	414.62	0.36
TC-M80	2.065	010YR	10894.00	874.00	889.75	882.62	890.51	0.001091	6.99	1559.53	875.73	0.36
TC-M80	2.065	020YR	14033.00	874.00	892.05	884.03	892.92	0.001016	7.49	1873.76	1012.98	0.36
TC-M80	2.065	050YR	16224.00	874.00	894.38	884.95	895.23	0.000804	7.40	2192.92	1208.86	0.33
TC-M80	2.065	100YR	18733.00	874.00	896.60	885.92	897.47	0.000695	7.50	2497.32	1297.38	0.31
TC-M80	2.065	200YR	21068.00	874.00	898.22	886.76	899.15	0.000662	7.75	2718.59	1321.39	0.31
TC-M80	2.065	500YR	24355.00	874.00	900.11	887.88	901.15	0.000653	8.18	2978.77	1337.38	0.31
TC-M80	2.049		Bridge									
TC-M80	2.035	001YR	1860.30	872.42	878.94	875.37	879.17	0.000871	3.83	485.53	87.79	0.29
TC-M80	2.035	002YR	6047.00	872.42	884.56	878.67	885.10	0.000994	5.78	1045.88	133.38	0.33
TC-M80	2.035	005YR	8554.00	872.42	886.97	880.16	887.62	0.001025	6.47	1322.09	274.76	0.34
TC-M80	2.035	010YR	10894.00	872.42	889.05	881.37	889.79	0.001025	6.88	1582.49	682.78	0.35
TC-M80	2.035	020YR	14033.00	872.42	891.28	882.85	892.14	0.000998	7.46	1880.71	910.95	0.35
TC-M80	2.035	050YR	16224.00	872.42	892.66	883.77	893.62	0.000972	7.84	2068.41	991.20	0.35
TC-M80	2.035	100YR	18733.00	872.42	894.12	884.76	895.18	0.000957	8.27	2265.19	1075.43	0.36
TC-M80	2.035	200YR	21068.00	872.42	895.36	885.67	896.53	0.000952	8.65	2434.37	1178.54	0.36
TC-M80	2.035	500YR	24355.00	872.42	896.96	886.82	898.27	0.000956	9.19	2650.45	1222.60	0.37
TC-M80	2.020	001YR	1860.30	870.78	878.88	874.99	879.09	0.000764	3.63	512.10	88.72	0.27
TC-M80	2.020	002YR	6047.00	870.78	884.51	878.32	885.01	0.000954	5.67	1067.20	125.61	0.32
TC-M80	2.020	005YR	8554.00	870.78	886.89	879.75	887.52	0.001051	6.38	1340.00	169.33	0.34
TC-M80	2.020	010YR	10894.00	870.78	888.98	881.01	889.69	0.001071	6.76	1612.12	621.70	0.35
TC-M80	2.020	020YR	14033.00	870.78	891.21	882.47	892.04	0.000996	7.31	1925.98	809.79	0.34
TC-M80	2.020	050YR	16224.00	870.78	892.61	883.40	893.52	0.000967	7.67	2127.07	878.33	0.34
TC-M80	2.020	100YR	18733.00	870.78	894.06	884.42	895.07	0.000949	8.07	2337.94	1002.63	0.35

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	2.020	200YR	21068.00	870.78	895.32	885.32	896.42	0.000941	8.43	2519.22	1084.43	0.35
TC-M80	2.020	500YR	24355.00	870.78	896.92	886.60	898.15	0.000943	8.93	2750.80	1128.32	0.35
TC-M80	2.016		Bridge									
TC-M80	2.012	001YR	1860.30	870.45	878.52	875.50	878.91	0.001590	4.97	374.55	71.01	0.38
TC-M80	2.012	002YR	6047.00	870.45	883.78	879.45	884.66	0.001858	7.53	803.21	88.12	0.44
TC-M80	2.012	005YR	8554.00	870.45	885.96	881.07	887.09	0.001972	8.56	999.74	118.05	0.46
TC-M80	2.012	010YR	10894.00	870.45	887.88	882.36	889.20	0.001979	9.21	1182.43	302.15	0.47
TC-M80	2.012	020YR	14033.00	870.45	889.85	883.90	891.46	0.002063	10.17	1381.50	629.13	0.49
TC-M80	2.012	050YR	16224.00	870.45	891.08	884.93	892.88	0.002063	10.77	1516.93	685.39	0.49
TC-M80	2.012	100YR	18733.00	870.45	892.37	886.01	894.38	0.002068	11.40	1670.38	739.97	0.50
TC-M80	2.012	200YR	21068.00	870.45	893.51	886.97	895.69	0.002060	11.91	1821.00	845.19	0.50
TC-M80	2.012	500YR	24355.00	870.45	895.07	888.27	897.41	0.002003	12.44	2054.00	996.46	0.50
TC-M80	2.002	001YR	1860.30	871.00	878.47	875.32	878.83	0.001413	4.81	386.97	70.87	0.36
TC-M80	2.002	002YR	6047.00	871.00	883.71	879.17	884.58	0.001806	7.48	808.29	89.90	0.44
TC-M80	2.002	005YR	8554.00	871.00	885.89	880.86	886.99	0.001921	8.45	1012.40	128.05	0.46
TC-M80	2.002	010YR	10894.00	871.00	887.82	882.21	889.09	0.001903	9.02	1208.32	357.14	0.47
TC-M80	2.002	020YR	14033.00	871.00	889.81	883.87	891.33	0.001923	9.88	1421.46	542.28	0.48
TC-M80	2.002	050YR	16224.00	871.00	891.05	884.89	892.74	0.001906	10.44	1557.53	617.91	0.48
TC-M80	2.002	100YR	18733.00	871.00	892.34	885.99	894.24	0.001904	11.05	1703.40	690.70	0.49
TC-M80	2.002	200YR	21068.00	871.00	893.48	886.96	895.55	0.001902	11.57	1836.36	769.06	0.50
TC-M80	2.002	500YR	24355.00	871.00	895.00	888.21	897.31	0.001896	12.23	2016.13	903.49	0.50
TC-M80	1.946		Bridge									
TC-M80	1.927	001YR	1860.30	869.70	877.28		877.53	0.001067	3.96	469.92	71.14	0.27
TC-M80	1.927	002YR	6047.00	869.70	881.14		882.13	0.002758	7.97	758.82	78.65	0.45
TC-M80	1.927	005YR	8554.00	869.70	882.65		884.12	0.003605	9.72	879.80	81.59	0.52
TC-M80	1.927	010YR	10894.00	869.70	884.21		885.97	0.005313	10.64	1023.62	113.95	0.63
TC-M80	1.927	020YR	14033.00	869.70	885.99		888.01	0.005255	11.41	1229.85	117.13	0.62
TC-M80	1.927	050YR	16224.00	869.70	887.18		889.35	0.005199	11.85	1369.59	119.38	0.62
TC-M80	1.927	100YR	18733.00	869.70	888.54		890.82	0.004703	12.14	1588.18	230.19	0.60
TC-M80	1.927	200YR	21068.00	869.70	890.26		892.16	0.003460	11.34	2074.44	325.27	0.52
TC-M80	1.927	500YR	24355.00	869.70	892.41	886.55	893.79	0.002307	10.14	2876.88	433.92	0.44
TC-M80	1.878	001YR	1860.30	869.00	877.10		877.30	0.000602	3.61	514.77	69.12	0.23
TC-M80	1.878	002YR	6047.00	869.00	880.54		881.52	0.002018	7.94	761.44	74.77	0.44
TC-M80	1.878	005YR	8554.00	869.00	881.68		883.25	0.002917	10.08	848.96	80.67	0.55
TC-M80	1.878	010YR	10894.00	869.00	882.53		884.70	0.003740	11.84	920.31	87.78	0.64
TC-M80	1.878	020YR	14033.00	869.00	883.62		886.50	0.004601	13.62	1031.72	109.69	0.77
TC-M80	1.878	050YR	16224.00	869.00	884.00	882.04	887.56	0.005556	15.14	1074.16	112.63	0.84
TC-M80	1.878	100YR	18733.00	869.00	884.51	883.81	888.80	0.006485	16.63	1132.51	115.82	0.90
TC-M80	1.878	200YR	21068.00	869.00	884.85	884.64	889.94	0.007527	18.12	1171.85	117.92	0.96
TC-M80	1.878	500YR	24355.00	869.00	885.85	885.85	891.51	0.007844	19.13	1293.97	124.77	0.97
TC-M80	1.849	001YR	1860.30	868.97	876.91	872.70	877.18	0.000996	4.13	450.46	69.74	0.29
TC-M80	1.849	002YR	6047.00	868.97	879.87	876.59	881.08	0.003686	8.91	715.88	127.25	0.53
TC-M80	1.849	005YR	8554.00	868.97	880.78	878.33	882.64	0.005078	11.16	840.26	146.21	0.63
TC-M80	1.849	010YR	10894.00	868.97	881.45	880.36	883.93	0.006325	13.01	942.46	159.82	0.71
TC-M80	1.849	020YR	14033.00	868.97	882.11	882.05	885.52	0.008141	15.38	1053.18	173.37	0.81
TC-M80	1.849	050YR	16224.00	868.97	883.14	883.14	886.52	0.007406	15.56	1241.69	189.31	0.79
TC-M80	1.849	100YR	18733.00	868.97	883.93	883.93	887.52	0.007432	16.25	1392.81	195.66	0.80
TC-M80	1.849	200YR	21068.00	868.97	884.60	884.60	888.39	0.007464	16.84	1526.03	201.10	0.80
TC-M80	1.849	500YR	24355.00	868.97	885.44	885.44	889.53	0.007589	17.67	1697.82	207.90	0.82
TC-M80	1.814	001YR	1860.30	868.97	876.47		876.91	0.001912	5.35	350.84	109.70	0.40
TC-M80	1.814	002YR	6047.00	868.97	879.37		880.30	0.003728	8.54	908.29	237.83	0.54
TC-M80	1.814	005YR	8554.00	868.97	880.48		881.57	0.003871	9.51	1181.83	254.54	0.56
TC-M80	1.814	010YR	10894.00	868.97	881.45		882.62	0.003770	10.05	1432.86	264.95	0.56
TC-M80	1.814	020YR	14033.00	868.97	882.59		883.88	0.003624	10.60	1740.27	271.77	0.56
TC-M80	1.814	050YR	16224.00	868.97	883.28		884.66	0.003605	11.01	1929.81	275.84	0.57
TC-M80	1.814	100YR	18733.00	868.97	883.95		885.46	0.003696	11.57	2114.08	280.23	0.58
TC-M80	1.814	200YR	21068.00	868.97	884.53		886.17	0.003766	12.04	2278.53	284.43	0.59
TC-M80	1.814	500YR	24355.00	868.97	885.16		887.03	0.004029	12.86	2462.24	301.20	0.61
TC-M80	1.767	001YR	1860.30	868.69	874.88	874.73	876.00	0.007762	8.68	239.31	118.30	0.79
TC-M80	1.767	002YR	6047.00	868.69	878.09		879.24	0.005089	9.88	809.95	227.29	0.70
TC-M80	1.767	005YR	8554.00	868.69	879.13		880.49	0.005062	10.93	1051.65	236.59	0.71
TC-M80	1.767	010YR	10894.00	868.69	879.94		881.53	0.005258	11.95	1250.77	252.65	0.74
TC-M80	1.767	020YR	14033.00	868.69	880.99		882.79	0.005291	13.00	1532.12	281.69	0.76
TC-M80	1.767	050YR	16224.00	868.69	881.95		883.67	0.004522	12.86	1813.79	299.39	0.71
TC-M80	1.767	100YR	18733.00	868.69	882.78		884.51	0.004164	13.00	2061.91	304.79	0.69
TC-M80	1.767	200YR	21068.00	868.69	883.46		885.24	0.003956	13.20	2273.08	308.48	0.68
TC-M80	1.767	500YR	24355.00	868.69	883.95		886.02	0.004372	14.26	2423.93	310.96	0.72
TC-M80	1.702	001YR	1860.30	867.59	873.94		874.37	0.002560	5.58	403.05	137.16	0.47
TC-M80	1.702	002YR	6047.00	867.59	877.54		878.02	0.001888	6.60	1284.81	279.48	0.44
TC-M80	1.702	005YR	8554.00	867.59	878.53		879.17	0.002171	7.73	1565.89	294.57	0.48
TC-M80	1.702	010YR	10894.00	867.59	879.27		880.07	0.002496	8.79	1792.57	319.26	0.53

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	1.702	020YR	14033.00	867.59	880.44		881.33	0.002365	9.32	2176.28	330.05	0.52
TC-M80	1.702	050YR	16224.00	867.59	881.57		882.41	0.001968	9.13	2552.10	336.05	0.48
TC-M80	1.702	100YR	18733.00	867.59	882.42		883.30	0.001910	9.45	2837.87	340.64	0.48
TC-M80	1.702	200YR	21068.00	867.59	883.12		884.06	0.001893	9.78	3078.40	344.45	0.49
TC-M80	1.702	500YR	24355.00	867.59	883.54		884.69	0.002203	10.78	3223.95	346.74	0.53
TC-M80	1.651	001YR	2131.17	866.55	873.45	870.66	873.84	0.001497	5.06	436.87	141.70	0.38
TC-M80	1.651	002YR	6049.00	866.55	876.63	874.28	877.47	0.001987	7.87	1094.94	321.27	0.47
TC-M80	1.651	005YR	8395.00	866.55	877.37	875.67	878.49	0.002548	9.41	1343.51	345.93	0.54
TC-M80	1.651	010YR	10294.00	866.55	878.36	875.92	879.42	0.002277	9.49	1688.14	388.38	0.52
TC-M80	1.651	020YR	13039.00	866.55	879.82	877.89	880.77	0.001854	9.35	2212.01	488.27	0.48
TC-M80	1.651	050YR	15699.00	866.55	881.00	878.52	881.92	0.001675	9.46	2643.07	579.35	0.46
TC-M80	1.651	100YR	18034.00	866.55	881.92	879.02	882.84	0.001586	9.63	2984.98	638.15	0.45
TC-M80	1.651	200YR	20597.00	866.55	882.59	879.51	883.59	0.001652	10.13	3237.80	646.65	0.47
TC-M80	1.651	500YR	23968.00	866.55	882.83	880.13	884.11	0.002066	11.46	3331.70	649.81	0.52
TC-M80	1.607	001YR	2131.17	865.15	871.05	871.05	872.93	0.012184	11.01	193.63	51.46	1.00
TC-M80	1.607	002YR	6049.00	865.15	875.22	875.22	876.70	0.005237	10.83	838.35	325.32	0.72
TC-M80	1.607	005YR	8395.00	865.15	876.63	876.25	877.79	0.003723	10.33	1352.37	453.87	0.63
TC-M80	1.607	010YR	10294.00	865.15	877.97	876.73	878.81	0.002446	9.24	1861.95	530.83	0.52
TC-M80	1.607	020YR	13039.00	865.15	879.60	877.35	880.27	0.001743	8.65	2496.80	593.65	0.45
TC-M80	1.607	050YR	15699.00	865.15	880.84	877.86	881.48	0.001488	8.56	2996.13	621.15	0.42
TC-M80	1.607	100YR	18034.00	865.15	881.79	878.30	882.42	0.001352	8.56	3396.32	647.44	0.41
TC-M80	1.607	200YR	20597.00	865.15	882.61	878.74	883.15	0.000729	6.60	5005.56	709.80	0.30
TC-M80	1.607	500YR	23968.00	865.15	883.15	879.28	883.56	0.000858	7.27	5249.55	735.94	0.33
TC-M80	1.560	001YR	2131.17	863.94	870.07	868.60	870.89	0.004196	7.27	293.04	65.63	0.61
TC-M80	1.560	002YR	6049.00	863.94	874.39	872.56	875.43	0.002743	8.73	997.32	363.20	0.54
TC-M80	1.560	005YR	8395.00	863.94	876.42	874.68	877.08	0.001564	7.65	1753.56	461.59	0.42
TC-M80	1.560	010YR	10294.00	863.94	877.79	875.29	878.33	0.001173	7.21	2290.71	522.31	0.37
TC-M80	1.560	020YR	13039.00	863.94	879.47	876.02	879.92	0.000887	6.86	2986.89	597.46	0.33
TC-M80	1.560	050YR	15699.00	863.94	880.87	876.63	881.17	0.000574	5.90	4310.97	730.30	0.27
TC-M80	1.560	100YR	18034.00	863.94	881.87	877.10	882.13	0.000474	5.60	5074.18	775.95	0.25
TC-M80	1.560	200YR	20597.00	863.94	882.75	877.58	883.00	0.000411	5.41	5761.30	782.89	0.23
TC-M80	1.560	500YR	23968.00	863.94	883.06	878.18	883.38	0.000481	5.94	6019.35	785.57	0.26
TC-M80	1.512	001YR	2131.17	861.92	869.03	867.32	869.86	0.003881	7.29	292.32	61.56	0.59
TC-M80	1.512	002YR	6049.00	861.92	874.02	872.00	874.77	0.001916	7.61	1104.26	284.22	0.46
TC-M80	1.512	005YR	8395.00	861.92	876.15	873.51	876.71	0.001220	7.04	1734.44	310.30	0.38
TC-M80	1.512	010YR	10294.00	861.92	877.55	874.16	878.05	0.000978	6.83	2184.37	408.91	0.35
TC-M80	1.512	020YR	13039.00	861.92	879.25	874.93	879.71	0.000786	6.69	2782.45	551.65	0.32
TC-M80	1.512	050YR	15699.00	861.92	880.69	875.68	881.03	0.000558	6.02	3934.62	689.96	0.27
TC-M80	1.512	100YR	18034.00	861.92	881.72	876.22	882.02	0.000456	5.68	4672.55	728.13	0.25
TC-M80	1.512	200YR	20597.00	861.92	882.62	876.78	882.90	0.000402	5.53	5348.13	765.61	0.23
TC-M80	1.512	500YR	23968.00	861.92	882.92	877.44	883.26	0.000477	6.09	5578.99	766.93	0.26
TC-M80	1.395	001YR	2131.17	859.54	866.84	864.91	867.63	0.003374	7.15	298.19	57.50	0.55
TC-M80	1.395	002YR	6049.00	859.54	871.46	868.75	873.09	0.003666	10.23	592.07	283.42	0.62
TC-M80	1.395	005YR	8395.00	859.54	873.27	870.54	875.34	0.003718	11.59	734.50	343.42	0.64
TC-M80	1.395	010YR	10294.00	859.54	874.71	871.77	876.87	0.003293	11.91	885.24	422.54	0.61
TC-M80	1.395	020YR	13039.00	859.54	876.66	874.31	878.74	0.002537	11.59	1143.53	522.30	0.55
TC-M80	1.395	050YR	15699.00	859.54	878.15	875.75	880.25	0.002039	11.13	1389.03	606.21	0.50
TC-M80	1.395	100YR	18034.00	859.54	879.67	876.77	881.28	0.001991	11.35	1513.90	633.29	0.50
TC-M80	1.395	200YR	20597.00	859.54	879.08	877.59	882.11	0.002389	12.54	1549.90	635.19	0.55
TC-M80	1.395	500YR	23968.00	859.54	882.89	878.21	883.07	0.000133	3.41	7283.73	817.29	0.13
TC-M80	1.362	001YR	2131.17	859.24	866.38	863.85	867.09	0.002563	6.82	317.84	82.04	0.48
TC-M80	1.362	002YR	6049.00	859.24	870.89	868.08	872.47	0.003234	10.30	617.39	346.46	0.58
TC-M80	1.362	005YR	8395.00	859.24	872.59	869.88	874.68	0.003701	11.93	750.00	377.58	0.63
TC-M80	1.362	010YR	10294.00	859.24	873.60	871.19	876.18	0.004102	13.31	838.63	399.83	0.68
TC-M80	1.362	020YR	13039.00	859.24	874.73	872.66	878.03	0.004712	15.15	950.25	468.01	0.74
TC-M80	1.362	050YR	15699.00	859.24	875.92	874.97	879.57	0.004738	16.10	1091.69	548.49	0.75
TC-M80	1.362	100YR	18034.00	859.24	876.96	876.94	880.65	0.004458	16.37	1246.93	625.62	0.74
TC-M80	1.362	200YR	20597.00	859.24	878.19	878.19	881.55	0.003740	15.78	1469.60	704.11	0.68
TC-M80	1.362	500YR	23968.00	859.24	879.57	878.92	882.70	0.003032	14.98	1731.83	710.70	0.62
TC-M80	1.296	001YR	2131.17	858.77	865.19	863.23	866.03	0.003592	7.34	290.41	74.83	0.56
TC-M80	1.296	002YR	6049.00	858.77	869.28	867.37	871.16	0.004214	11.17	572.90	239.78	0.66
TC-M80	1.296	005YR	8395.00	858.77	871.03	869.26	873.30	0.004149	12.47	744.09	330.84	0.67
TC-M80	1.296	010YR	10294.00	858.77	871.77	870.63	874.61	0.004809	14.04	829.80	366.93	0.73
TC-M80	1.296	020YR	13039.00	858.77	873.13	872.44	876.33	0.004847	15.19	1005.57	400.64	0.75
TC-M80	1.296	050YR	15699.00	858.77	874.77	873.75	877.86	0.004148	15.22	1241.50	454.79	0.71
TC-M80	1.296	100YR	18034.00	858.77	875.82	874.66	879.04	0.004016	15.70	1406.07	494.12	0.70
TC-M80	1.296	200YR	20597.00	858.77	877.82	876.91	880.09	0.002592	13.67	1866.67	805.29	0.58
TC-M80	1.296	500YR	23968.00	858.77	879.70	877.76	881.51	0.001796	12.18	2322.27	957.48	0.49
TC-M80	1.248	001YR	2131.17	858.02	862.46	862.46	864.38	0.012360	11.12	191.59	49.58	1.00
TC-M80	1.248	002YR	6049.00	858.02	866.89	866.55	869.66	0.007676	13.60	469.14	77.26	0.87
TC-M80	1.248	005YR	8395.00	858.02	868.81	868.28	871.88	0.006929	14.50	637.51	103.44	0.85
TC-M80	1.248	010YR	10294.00	858.02	870.27	869.97	873.27	0.005767	14.58	805.51	122.83	0.79
TC-M80	1.248	020YR	13039.00	858.02	872.20	871.23	875.03	0.004556	14.49	1056.89	138.15	0.72

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	1.248	050YR	15699.00	858.02	874.13	872.31	876.74	0.003577	14.13	1349.67	256.82	0.66
TC-M80	1.248	100YR	18034.00	858.02	875.10	873.21	877.95	0.003674	14.96	1536.32	347.12	0.67
TC-M80	1.248	200YR	20597.00	858.02	876.69	874.21	879.34	0.003117	14.72	1897.05	485.65	0.63
TC-M80	1.248	500YR	23968.00	858.02	879.12	874.80	881.02	0.001991	12.85	2565.07	710.62	0.51
TC-M80	1.204	001YR	2212.26	854.31	861.99	859.65	862.73	0.002890	6.94	318.99	56.73	0.52
TC-M80	1.204	002YR	6419.00	854.31	866.35	863.96	868.05	0.004261	10.44	614.56	78.58	0.66
TC-M80	1.204	005YR	8938.00	854.31	868.22	865.83	870.32	0.004468	11.62	769.65	289.61	0.69
TC-M80	1.204	010YR	10981.00	854.31	869.55	867.11	871.92	0.004391	12.37	891.61	333.72	0.69
TC-M80	1.204	020YR	13828.00	854.31	871.35	868.69	873.99	0.003931	13.09	1077.34	388.45	0.68
TC-M80	1.204	050YR	16834.00	854.31	872.90	870.06	875.85	0.003759	13.91	1256.05	427.03	0.67
TC-M80	1.204	100YR	19441.00	854.31	873.02	871.24	876.87	0.004852	15.90	1270.77	429.82	0.77
TC-M80	1.204	200YR	22341.00	854.31	873.42	872.54	878.16	0.005742	17.64	1321.68	439.17	0.84
TC-M80	1.204	500YR	26130.00	854.31	874.11	874.11	879.85	0.006572	19.50	1410.26	455.17	0.90
TC-M80	1.136	001YR	2212.26	854.59	860.69	859.14	861.52	0.003912	7.37	306.09	71.85	0.59
TC-M80	1.136	002YR	6419.00	854.59	865.40	863.03	866.67	0.002882	9.42	749.46	117.17	0.56
TC-M80	1.136	005YR	8938.00	854.59	867.68	864.59	868.98	0.002240	9.67	1035.84	134.17	0.51
TC-M80	1.136	010YR	10981.00	854.59	869.25	865.80	870.59	0.001989	9.94	1254.95	404.66	0.49
TC-M80	1.136	020YR	13828.00	854.59	871.36	867.00	872.72	0.001687	10.15	1580.19	559.02	0.46
TC-M80	1.136	050YR	16834.00	854.59	873.12	868.17	874.56	0.001561	10.58	1874.46	607.75	0.46
TC-M80	1.136	100YR	19441.00	854.59	873.37	869.07	875.21	0.001982	11.97	1918.70	614.71	0.51
TC-M80	1.136	200YR	22341.00	854.59	873.99	870.04	876.16	0.002256	13.08	2030.14	631.82	0.55
TC-M80	1.136	500YR	26130.00	854.59	874.63	871.23	877.30	0.002659	14.54	2149.63	670.61	0.60
TC-M80	1.091	001YR	2212.26	854.02	859.89	858.13	860.63	0.003393	6.88	321.74	65.84	0.55
TC-M80	1.091	002YR	6419.00	854.02	864.40	861.78	865.88	0.003712	9.75	658.54	84.22	0.61
TC-M80	1.091	005YR	8938.00	854.02	866.54	863.47	868.27	0.003586	10.53	848.98	93.98	0.62
TC-M80	1.091	010YR	10981.00	854.02	868.03	864.71	869.93	0.003330	11.06	1004.13	120.67	0.61
TC-M80	1.091	020YR	13828.00	854.02	870.58	866.22	872.23	0.002259	10.56	1489.64	238.44	0.52
TC-M80	1.091	050YR	16834.00	854.02	872.82	867.63	874.14	0.001591	9.86	2046.61	261.83	0.45
TC-M80	1.091	100YR	19441.00	854.02	872.99	869.76	874.69	0.002008	11.17	2092.76	265.12	0.50
TC-M80	1.091	200YR	22341.00	854.02	873.65	871.24	875.55	0.002166	11.93	2272.40	305.74	0.53
TC-M80	1.091	500YR	26130.00	854.02	874.35	872.20	876.55	0.002421	12.98	2469.99	360.63	0.56
TC-M80	1.074		Bridge									
TC-M80	1.055	001YR	2212.26	853.83	858.66	857.57	859.47	0.004871	7.23	306.06	78.60	0.65
TC-M80	1.055	002YR	6419.00	853.83	862.66	860.80	864.13	0.004321	9.75	658.21	97.41	0.66
TC-M80	1.055	005YR	8938.00	853.83	863.79	862.26	865.87	0.005312	11.58	771.70	102.74	0.74
TC-M80	1.055	010YR	10981.00	853.83	865.60	863.32	867.61	0.004179	11.38	967.09	117.11	0.68
TC-M80	1.055	020YR	13828.00	853.83	866.23	864.63	868.99	0.005338	13.35	1043.97	129.81	0.77
TC-M80	1.055	050YR	16834.00	853.83	868.07	865.90	870.65	0.004051	13.11	1404.97	244.11	0.69
TC-M80	1.055	100YR	19441.00	853.83	870.07	867.81	872.00	0.002614	11.76	1967.06	315.81	0.57
TC-M80	1.055	200YR	22341.00	853.83	871.98	869.07	873.42	0.001750	10.53	2619.05	396.29	0.48
TC-M80	1.055	500YR	26130.00	853.83	874.15	870.15	875.25	0.001174	9.44	3410.01	483.85	0.40
TC-M80	1.017	001YR	2212.26	848.40	858.26	855.07	858.75	0.001808	5.63	393.27	68.37	0.41
TC-M80	1.017	002YR	6419.00	848.40	862.42	859.11	863.23	0.002032	7.71	1036.69	461.41	0.47
TC-M80	1.017	005YR	8938.00	848.40	863.96	862.33	864.66	0.001510	7.44	1536.49	493.58	0.41
TC-M80	1.017	010YR	10981.00	848.40	866.08	862.94	866.52	0.000801	6.15	2230.84	519.41	0.31
TC-M80	1.017	020YR	13828.00	848.40	867.00	863.60	867.52	0.000860	6.70	2547.55	547.82	0.33
TC-M80	1.017	050YR	16834.00	848.40	868.86	864.20	869.33	0.000651	6.36	3202.51	653.02	0.29
TC-M80	1.017	100YR	19441.00	848.40	870.63	864.68	871.05	0.000497	5.99	3868.10	810.52	0.26
TC-M80	1.017	200YR	22341.00	848.40	872.35	865.16	872.75	0.000402	5.76	4534.04	866.59	0.24
TC-M80	1.017	500YR	26130.00	848.40	874.39	865.73	874.78	0.000331	5.60	5335.82	932.66	0.22
TC-M80	0.992	001YR	2247.76	847.82	858.15		858.51	0.001307	4.82	465.95	79.46	0.35
TC-M80	0.992	002YR	6538.00	847.82	862.61		862.93	0.000798	5.33	1924.24	584.15	0.30
TC-M80	0.992	005YR	9107.00	847.82	864.17		864.42	0.000576	5.00	2892.13	645.15	0.26
TC-M80	0.992	010YR	11201.00	847.82	866.22		866.37	0.000299	4.02	4260.71	681.10	0.19
TC-M80	0.992	020YR	13781.00	847.82	867.20		867.35	0.000295	4.18	4928.24	691.48	0.19
TC-M80	0.992	050YR	17035.00	847.82	869.03		869.18	0.000260	4.25	6253.27	842.36	0.19
TC-M80	0.992	100YR	19846.00	847.82	870.80		870.93	0.000189	3.88	7782.09	984.33	0.16
TC-M80	0.992	200YR	22744.00	847.82	872.52		872.64	0.000147	3.64	9349.92	930.81	0.14
TC-M80	0.992	500YR	26642.00	847.82	874.57		874.67	0.000115	3.44	11281.68	955.58	0.13
TC-M80	0.991	001YR	2247.76	847.60	858.13	853.89	858.38	0.000790	4.01	560.39	86.22	0.28
TC-M80	0.991	002YR	6538.00	847.60	861.98	857.16	862.77	0.001571	7.14	915.39	98.18	0.41
TC-M80	0.991	005YR	9107.00	847.60	862.95	858.68	864.21	0.002191	9.01	1012.43	101.07	0.49
TC-M80	0.991	010YR	11201.00	847.60	864.83	859.78	866.18	0.001896	9.37	1206.93	106.62	0.47
TC-M80	0.991	020YR	13781.00	847.60	865.16	861.03	867.11	0.002621	11.21	1242.67	107.61	0.56
TC-M80	0.991	050YR	17035.00	847.60	866.48	862.42	868.69	0.002854	12.51	1387.28	111.53	0.59
TC-M80	0.991	100YR	19846.00	847.60	868.00	863.50	870.63	0.002717	13.08	1560.12	116.04	0.59
TC-M80	0.991	200YR	22744.00	847.60	869.65	864.52	872.34	0.002457	13.31	1877.63	228.25	0.57
TC-M80	0.991	500YR	26642.00	847.60	871.92	865.92	874.40	0.002011	13.09	2415.42	246.38	0.52
TC-M80	0.965		Bridge									
TC-M80	0.945	001YR	2247.76	844.50	856.32		856.65	0.001133	4.61	487.09	78.49	0.33
TC-M80	0.945	002YR	6538.00	844.50	860.12		861.15	0.002038	8.14	809.97	89.99	0.46

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	0.945	005YR	9107.00	844.50	860.68		862.45	0.003269	10.70	860.18	91.72	0.59
TC-M80	0.945	010YR	11201.00	844.50	862.78		864.58	0.002599	10.83	1059.63	98.30	0.55
TC-M80	0.945	020YR	13781.00	844.50	861.45		864.93	0.005824	15.01	932.22	94.15	0.80
TC-M80	0.945	050YR	17035.00	844.50	862.23	861.53	866.83	0.007022	17.27	1006.88	96.61	0.89
TC-M80	0.945	100YR	19846.00	844.50	863.20	862.67	868.46	0.007265	18.52	1101.15	99.62	0.92
TC-M80	0.945	200YR	22744.00	844.50	864.04	863.69	870.05	0.007629	19.81	1186.58	102.27	0.95
TC-M80	0.945	500YR	26642.00	844.50	865.38	865.38	872.08	0.007539	20.98	1325.96	106.46	0.96
TC-M80	0.940	001YR	2247.76	844.49	856.21		856.54	0.001114	4.63	485.22	77.66	0.33
TC-M80	0.940	002YR	6538.00	844.49	859.95		860.92	0.001990	7.92	849.77	117.50	0.46
TC-M80	0.940	005YR	9107.00	844.49	860.39		862.08	0.003275	10.49	902.44	122.33	0.60
TC-M80	0.940	010YR	11201.00	844.49	862.66		864.20	0.002300	10.14	1210.77	149.71	0.52
TC-M80	0.940	020YR	13781.00	844.49	860.84	860.03	864.32	0.006368	15.09	958.90	127.31	0.84
TC-M80	0.940	050YR	17035.00	844.49	861.51	861.51	866.08	0.007743	17.36	1045.68	135.32	0.94
TC-M80	0.940	100YR	19846.00	844.49	862.73	862.73	867.50	0.007077	17.85	1220.43	150.50	0.91
TC-M80	0.940	200YR	22744.00	844.49	863.87	863.87	868.81	0.006591	18.31	1399.91	163.26	0.90
TC-M80	0.940	500YR	26642.00	844.49	865.19	865.19	870.40	0.006235	19.00	1624.22	175.46	0.88
TC-M80	0.897	001YR	2247.76	844.30	854.30	854.30	855.90	0.007360	11.34	250.28	72.51	0.74
TC-M80	0.897	002YR	6538.00	844.30	858.80	858.80	860.23	0.004517	12.28	777.58	329.73	0.63
TC-M80	0.897	005YR	9107.00	844.30	859.62	859.62	861.15	0.004890	13.36	1049.85	335.19	0.66
TC-M80	0.897	010YR	11201.00	844.30	863.13		863.55	0.000961	6.98	2256.91	364.89	0.31
TC-M80	0.897	020YR	13781.00	844.30	861.19		862.60	0.004013	13.10	1582.90	342.37	0.61
TC-M80	0.897	050YR	17035.00	844.30	862.59		863.77	0.002878	11.81	2066.16	348.83	0.53
TC-M80	0.897	100YR	19846.00	844.30	863.78		864.84	0.002257	10.99	2496.20	374.03	0.47
TC-M80	0.897	200YR	22744.00	844.30	864.59		865.68	0.002114	10.98	2804.57	385.43	0.46
TC-M80	0.897	500YR	26642.00	844.30	865.76		866.85	0.001865	10.76	3263.28	401.65	0.44
TC-M80	0.830	001YR	2247.76	845.36	852.00		852.76	0.003012	6.99	321.71	57.57	0.52
TC-M80	0.830	002YR	6538.00	845.36	857.09		857.93	0.001917	8.06	1048.14	267.49	0.45
TC-M80	0.830	005YR	9107.00	845.36	858.80		859.53	0.001498	7.93	1512.07	276.84	0.41
TC-M80	0.830	010YR	11201.00	845.36	863.00		863.30	0.000431	5.23	2731.46	306.02	0.23
TC-M80	0.830	020YR	13781.00	845.36	860.82		861.64	0.001421	8.59	2082.26	289.25	0.41
TC-M80	0.830	050YR	17035.00	845.36	862.16		863.01	0.001323	8.83	2476.84	299.03	0.40
TC-M80	0.830	100YR	19846.00	845.36	863.35		864.22	0.001211	8.89	2839.50	308.93	0.39
TC-M80	0.830	200YR	22744.00	845.36	864.12		865.08	0.001258	9.35	3080.20	315.69	0.40
TC-M80	0.830	500YR	26642.00	845.36	865.26		866.30	0.001259	9.76	3446.20	327.93	0.41
TC-M80	0.750	001YR	2247.76	844.35	849.64	848.80	850.90	0.006551	9.01	249.56	56.00	0.75
TC-M80	0.750	002YR	6538.00	844.35	853.35	852.89	856.23	0.008582	13.61	480.22	117.47	0.91
TC-M80	0.750	005YR	9107.00	844.35	855.64	855.64	858.22	0.005977	13.26	763.83	230.49	0.79
TC-M80	0.750	010YR	11201.00	844.35	856.64	856.64	859.28	0.005640	13.71	931.81	320.69	0.78
TC-M80	0.750	020YR	13781.00	844.35	858.17	857.52	860.51	0.004301	13.22	1202.50	371.80	0.70
TC-M80	0.750	050YR	17035.00	844.35	859.79	858.49	862.02	0.003493	13.05	1506.22	417.19	0.64
TC-M80	0.750	100YR	19846.00	844.35	861.22	859.25	863.33	0.002921	12.80	1786.72	471.96	0.60
TC-M80	0.750	200YR	22744.00	844.35	861.42	859.96	864.07	0.003601	14.35	1828.33	482.30	0.67
TC-M80	0.750	500YR	26642.00	844.35	862.38	860.83	865.27	0.003625	15.03	2041.06	535.24	0.68
TC-M80	0.693	001YR	2247.76	842.33	847.53	846.75	848.61	0.008572	8.34	269.56	69.41	0.75
TC-M80	0.693	002YR	6538.00	842.33	852.31	850.28	853.89	0.005124	10.12	651.20	146.51	0.65
TC-M80	0.693	005YR	9107.00	842.33	854.41	851.86	856.15	0.004155	10.72	890.41	248.93	0.61
TC-M80	0.693	010YR	11201.00	842.33	855.80	853.17	857.65	0.003767	11.17	1079.22	351.95	0.59
TC-M80	0.693	020YR	13781.00	842.33	857.29	854.55	859.25	0.003454	11.63	1306.01	504.81	0.58
TC-M80	0.693	050YR	17035.00	842.33	858.90	856.00	860.97	0.003218	12.16	1571.21	543.02	0.57
TC-M80	0.693	100YR	19846.00	842.33	860.40	857.21	862.45	0.002845	12.23	1839.41	589.20	0.54
TC-M80	0.693	200YR	22744.00	842.33	862.77	858.10	863.06	0.000462	5.41	5605.72	749.55	0.22
TC-M80	0.693	500YR	26642.00	842.33	863.93	859.24	864.22	0.000399	5.25	6482.75	756.51	0.21
TC-M80	0.628	001YR	2270.85	839.11	846.16	844.17	846.93	0.002943	7.00	324.32	61.04	0.54
TC-M80	0.628	002YR	6683.00	839.11	850.48	848.15	852.33	0.003992	10.92	611.95	111.22	0.67
TC-M80	0.628	005YR	9325.00	839.11	852.19	850.06	854.60	0.004539	12.46	749.54	176.42	0.73
TC-M80	0.628	010YR	11463.00	839.11	853.36	851.53	856.14	0.004559	13.45	873.27	404.97	0.75
TC-M80	0.628	020YR	14131.00	839.11	854.71	853.33	857.81	0.004347	14.30	1040.07	460.55	0.75
TC-M80	0.628	050YR	17355.00	839.11	856.59	854.93	859.70	0.003655	14.52	1292.62	495.02	0.70
TC-M80	0.628	100YR	20403.00	839.11	858.22	856.17	861.32	0.003193	14.67	1532.13	545.39	0.67
TC-M80	0.628	200YR	23434.00	839.11	858.32	857.25	862.33	0.004098	16.69	1547.76	550.65	0.76
TC-M80	0.628	500YR	27557.00	839.11	860.47	860.47	863.63	0.002883	15.31	2058.26	701.46	0.65
TC-M80	0.571	001YR	2270.85	838.44	845.69	842.49	846.18	0.001709	5.62	403.86	65.16	0.40
TC-M80	0.571	002YR	6683.00	838.44	849.71	846.44	851.17	0.003037	9.73	690.06	140.62	0.56
TC-M80	0.571	005YR	9325.00	838.44	851.24	848.27	853.30	0.003511	11.57	821.25	306.20	0.62
TC-M80	0.571	010YR	11463.00	838.44	852.27	849.54	854.61	0.003858	12.89	916.19	451.02	0.66
TC-M80	0.571	020YR	14131.00	838.44	853.36	851.12	856.51	0.004282	14.40	1023.34	466.61	0.70
TC-M80	0.571	050YR	17355.00	838.44	854.45	852.75	858.36	0.004817	16.12	1138.96	486.33	0.76
TC-M80	0.571	100YR	20403.00	838.44	855.27	854.21	859.93	0.005381	17.69	1232.02	502.17	0.81
TC-M80	0.571	200YR	23434.00	838.44	857.57	857.57	861.02	0.003480	15.66	1645.76	663.42	0.67
TC-M80	0.571	500YR	27557.00	838.44	858.45	858.45	862.19	0.003534	16.31	1834.43	695.18	0.68
TC-M80	0.514	001YR	2270.85	838.44	844.98	842.51	845.56	0.002437	6.10	372.14	71.46	0.47
TC-M80	0.514	002YR	6683.00	838.44	848.46	846.35	850.13	0.003811	10.41	658.81	120.84	0.64
TC-M80	0.514	005YR	9325.00	838.44	849.80	848.04	852.10	0.004361	12.30	789.69	216.62	0.70

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	0.514	010YR	11463.00	838.44	850.79	849.32	853.52	0.004613	13.50	897.18	279.33	0.73
TC-M80	0.514	020YR	14131.00	838.44	851.59	850.71	855.04	0.005338	15.24	991.10	329.58	0.79
TC-M80	0.514	050YR	17355.00	838.44	852.61	852.26	856.75	0.005808	16.83	1120.35	405.21	0.84
TC-M80	0.514	100YR	20403.00	838.44	853.56	853.56	858.21	0.006023	17.99	1251.70	496.37	0.87
TC-M80	0.514	200YR	23434.00	838.44	856.63	856.63	858.92	0.002570	13.49	2156.95	871.12	0.59
TC-M80	0.514	500YR	27557.00	838.44	857.23	857.23	859.69	0.002677	14.09	2397.93	878.86	0.60
TC-M80	0.445	001YR	2270.85	839.00	843.61	842.46	844.38	0.004397	7.05	331.11	100.93	0.62
TC-M80	0.445	002YR	6683.00	839.00	847.37	845.72	848.69	0.003530	9.57	798.88	280.54	0.62
TC-M80	0.445	005YR	9325.00	839.00	849.03	847.16	850.51	0.003160	10.37	1071.10	440.54	0.61
TC-M80	0.445	010YR	11463.00	839.00	850.34	848.11	851.87	0.002793	10.67	1307.84	504.89	0.59
TC-M80	0.445	020YR	14131.00	839.00	851.34	849.16	853.13	0.002934	11.64	1499.89	554.36	0.61
TC-M80	0.445	050YR	17355.00	839.00	852.82	850.25	854.68	0.002682	12.07	1808.00	672.59	0.59
TC-M80	0.445	100YR	20403.00	839.00	854.17	851.19	855.92	0.002293	11.93	2165.99	752.97	0.56
TC-M80	0.445	200YR	23434.00	839.00	856.41	852.19	856.65	0.000324	4.94	6164.83	764.60	0.22
TC-M80	0.445	500YR	27557.00	839.00	857.78	853.99	858.01	0.000264	4.71	7216.71	771.24	0.20
TC-M80	0.369	001YR	2270.85	837.00	842.53	840.46	842.91	0.002632	5.00	473.92	117.28	0.41
TC-M80	0.369	002YR	6683.00	837.00	846.54	843.23	847.34	0.002537	7.42	995.15	168.45	0.44
TC-M80	0.369	005YR	9325.00	837.00	848.21	844.51	849.23	0.002605	8.45	1241.69	248.67	0.46
TC-M80	0.369	010YR	11463.00	837.00	849.57	845.42	850.70	0.002490	8.96	1455.45	322.37	0.46
TC-M80	0.369	020YR	14131.00	837.00	850.45	846.49	851.86	0.002865	10.09	1609.95	563.41	0.50
TC-M80	0.369	050YR	17355.00	837.00	852.21	847.65	853.52	0.002334	9.94	2005.57	735.37	0.46
TC-M80	0.369	100YR	20403.00	837.00	853.73	848.69	854.95	0.001860	9.49	2370.12	743.52	0.42
TC-M80	0.369	200YR	23434.00	837.00	856.31	849.78	856.53	0.000283	4.09	6379.89	752.49	0.17
TC-M80	0.369	500YR	27557.00	837.00	857.70	852.08	857.91	0.000235	3.91	7424.54	756.66	0.15
TC-M80	0.295	001YR	2270.85	834.55	840.80	839.46	841.48	0.005216	6.63	342.69	85.00	0.58
TC-M80	0.295	002YR	6683.00	834.55	844.45	842.65	845.88	0.005510	9.67	728.15	137.58	0.64
TC-M80	0.295	005YR	9325.00	834.55	846.04	844.20	847.76	0.005333	10.72	943.92	169.38	0.65
TC-M80	0.295	010YR	11463.00	834.55	848.49	845.17	849.67	0.002778	9.17	1393.52	427.56	0.49
TC-M80	0.295	020YR	14131.00	834.55	849.51	846.38	850.76	0.002605	9.43	1618.99	507.61	0.48
TC-M80	0.295	050YR	17355.00	834.55	851.65	848.59	852.72	0.001582	8.21	2108.85	679.28	0.39
TC-M80	0.295	100YR	20403.00	834.55	853.24	849.21	854.34	0.001221	7.75	2488.77	732.96	0.35
TC-M80	0.295	200YR	23434.00	834.55	855.18	849.73	856.26	0.000871	7.08	2965.30	753.27	0.30
TC-M80	0.295	500YR	27557.00	834.55	856.37	850.37	857.65	0.000862	7.36	3265.17	757.79	0.30
TC-M80	0.217	001YR	2270.85	833.53	838.42	837.39	839.32	0.005205	7.60	298.89	74.21	0.67
TC-M80	0.217	002YR	6683.00	833.53	842.23	841.01	843.80	0.004598	10.32	692.67	158.73	0.68
TC-M80	0.217	005YR	9325.00	833.53	844.73	842.48	846.10	0.002820	9.87	1042.08	208.00	0.56
TC-M80	0.217	010YR	11463.00	833.53	847.85	843.39	848.82	0.001416	8.44	1538.16	438.19	0.42
TC-M80	0.217	020YR	14131.00	833.53	848.72	844.43	849.91	0.001608	9.40	1703.31	490.39	0.45
TC-M80	0.217	050YR	17355.00	833.53	851.09	845.52	852.16	0.001166	8.91	2170.32	516.03	0.39
TC-M80	0.217	100YR	20403.00	833.53	852.81	846.38	853.88	0.000996	8.81	2531.70	520.81	0.37
TC-M80	0.217	200YR	23434.00	833.53	854.90	847.76	855.90	0.000781	8.40	2978.91	524.85	0.33
TC-M80	0.217	500YR	27557.00	833.53	856.10	849.00	857.27	0.000822	8.97	3241.12	527.12	0.35
I-35 bypass	.115	001YR	246.62	840.00	846.58	841.55	846.59	0.000008	0.40	745.84	457.96	0.03
I-35 bypass	.115	002YR	725.78	840.00	847.35	842.64	847.36	0.000024	0.75	1083.57	509.70	0.06
I-35 bypass	.115	005YR	1012.70	840.00	847.70	843.10	847.71	0.000031	0.88	1246.64	533.04	0.06
I-35 bypass	.115	010YR	336.09	840.00	846.76	841.82	846.77	0.000012	0.48	821.87	470.22	0.04
I-35 bypass	.115	020YR	1534.63	840.00	848.28	843.75	848.29	0.000035	1.00	1633.10	554.80	0.07
I-35 bypass	.115	050YR	1884.63	840.00	848.65	844.11	848.67	0.000036	1.05	1840.26	556.75	0.07
I-35 bypass	.115	100YR	2502.24	840.00	849.21	844.77	849.24	0.000038	1.14	2155.29	559.72	0.07
I-35 bypass	.115	200YR	2544.94	840.00	849.77	844.81	849.80	0.000025	0.97	2470.11	562.66	0.06
I-35 bypass	.115	500YR	4389.75	840.00	851.32	845.98	851.36	0.000028	1.15	3377.19	594.18	0.07
I-35 bypass	.080	001YR	246.62	845.59	846.55	845.99	846.58	0.000129	1.45	170.66	182.38	0.26
I-35 bypass	.080	002YR	725.78	845.59	847.25	846.40	847.34	0.000174	2.44	299.98	185.90	0.33
I-35 bypass	.080	005YR	1012.70	845.59	847.56	846.60	847.69	0.000189	2.86	358.42	187.47	0.36
I-35 bypass	.080	010YR	336.09	845.59	846.71	846.08	846.76	0.000139	1.68	201.05	183.21	0.28
I-35 bypass	.080	020YR	1534.63	845.59	848.09	846.91	848.27	0.000196	3.41	457.60	462.12	0.38
I-35 bypass	.080	050YR	1884.63	845.59	848.43	847.10	848.64	0.000190	3.66	523.81	467.26	0.38
I-35 bypass	.080	100YR	2502.24	845.59	848.95	847.41	849.21	0.000191	4.10	623.28	474.89	0.40
I-35 bypass	.080	200YR	2544.94	845.59	849.59	847.44	849.77	0.000110	3.49	748.29	484.08	0.31
I-35 bypass	.080	500YR	4389.75	845.59	851.03	848.24	851.33	0.000115	4.39	1040.16	508.99	0.33
I-35 bypass	.061		Bridge									
I-35 bypass	.0425	001YR	246.62	845.09	845.53	845.51	845.71	0.014621	3.43	71.96	166.15	0.92
I-35 bypass	.0425	002YR	725.78	845.09	845.94	845.94	846.36	0.013851	5.15	140.82	169.17	1.00
I-35 bypass	.0425	005YR	1012.70	845.09	846.15	846.15	846.66	0.013094	5.77	175.55	170.67	1.00
I-35 bypass	.0425	010YR	336.09	845.09	845.60	845.60	845.85	0.016612	4.02	83.50	166.66	1.00
I-35 bypass	.0425	020YR	1534.63	845.09	846.47	846.47	847.16	0.012186	6.63	231.51	369.84	1.01
I-35 bypass	.0425	050YR	1884.63	845.09	846.69	846.69	847.45	0.011285	7.01	268.78	376.82	1.00
I-35 bypass	.0425	100YR	2502.24	845.09	848.10	847.01	848.46	0.002218	4.80	528.95	421.22	0.49
I-35 bypass	.0425	200YR	2544.94	845.09	849.32	847.03	849.50	0.000705	3.41	767.22	463.94	0.29
I-35 bypass	.0425	500YR	4389.75	845.09	850.66	847.86	850.94	0.000802	4.37	1043.25	643.09	0.33
I-35 bypass	.001	001YR	246.62	843.99	844.44	844.44	844.65	0.002407	3.69	66.84	157.00	1.00
I-35 bypass	.001	002YR	725.78	843.99	844.90	844.90	845.32	0.001923	5.23	138.65	158.93	0.99

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
I-35 bypass	001	005YR	1012.70	843.99	845.10	845.10	845.64	0.001892	5.91	171.25	159.80	1.01
I-35 bypass	001	010YR	336.09	843.99	844.54	844.54	844.80	0.002247	4.08	82.43	157.42	0.99
I-35 bypass	001	020YR	1534.63	843.99	845.45	845.45	846.16	0.001734	6.74	227.81	161.30	1.00
I-35 bypass	001	050YR	1884.63	843.99	846.68	845.66	846.96	0.000323	4.41	431.33	371.55	0.48
I-35 bypass	001	100YR	2502.24	843.99	848.10	846.00	848.32	0.000133	3.77	677.04	411.96	0.33
I-35 bypass	001	200YR	2544.94	843.99	849.31	846.02	849.45	0.000056	2.93	896.32	452.86	0.22
I-35 bypass	001	500YR	4389.75	843.99	850.64	846.89	850.88	0.000078	3.99	1176.43	555.89	0.27
TC-M80a	0.115	001YR	2024.24	832.00	838.76		839.17	0.001521	5.17	391.42	65.57	0.37
TC-M80a	0.115	002YR	5957.23	832.00	842.48		843.70	0.002456	9.03	759.62	127.83	0.51
TC-M80a	0.115	005YR	8312.30	832.00	844.73		846.10	0.002172	9.77	1077.97	155.34	0.50
TC-M80a	0.115	010YR	11126.91	832.00	847.39		848.77	0.001763	10.07	1534.31	186.20	0.47
TC-M80a	0.115	020YR	12596.37	832.00	848.43		849.88	0.001718	10.41	1734.78	200.07	0.46
TC-M80a	0.115	050YR	15470.37	832.00	850.61		852.12	0.001552	10.80	2213.07	245.07	0.45
TC-M80a	0.115	100YR	17900.76	832.00	852.41		853.84	0.001359	10.77	2671.45	258.43	0.43
TC-M80a	0.115	200YR	20889.06	832.00	854.52		855.87	0.001168	10.70	3223.53	263.69	0.40
TC-M80a	0.115	500YR	23167.25	832.00	855.93		857.26	0.001086	10.76	3598.79	267.17	0.39
TC-M80a	0.080	001YR	2024.24	831.00	838.68	834.65	838.91	0.001045	4.20	603.02	117.49	0.27
TC-M80a	0.080	002YR	5957.23	831.00	842.48	838.15	843.17	0.001839	7.37	1078.19	133.36	0.39
TC-M80a	0.080	005YR	8312.30	831.00	844.77	839.48	845.59	0.001769	8.19	1400.02	147.10	0.39
TC-M80a	0.080	010YR	11126.91	831.00	847.43	840.87	848.34	0.001586	8.75	1808.07	159.57	0.38
TC-M80a	0.080	020YR	12596.37	831.00	848.47	841.50	849.45	0.001601	9.16	1976.08	164.84	0.39
TC-M80a	0.080	050YR	15470.37	831.00	850.64	842.69	851.72	0.001527	9.69	2347.25	176.62	0.39
TC-M80a	0.080	100YR	17900.76	831.00	852.36	843.72	853.50	0.001473	10.07	2658.72	186.53	0.39
TC-M80a	0.080	200YR	20889.06	831.00	854.39	844.89	855.60	0.001410	10.48	3050.01	200.28	0.38
TC-M80a	0.080	500YR	23167.25	831.00	855.74	845.68	857.03	0.001403	10.86	3330.28	213.11	0.39
TC-M80a	0.061		Bridge									
TC-M80a	0.043	001YR	2024.24	830.00	837.34		837.65	0.001079	4.49	451.21	72.85	0.32
TC-M80a	0.043	002YR	5957.23	830.00	840.30		841.47	0.002505	8.73	742.44	132.08	0.51
TC-M80a	0.043	005YR	8312.30	830.00	841.44		843.13	0.003149	10.61	899.29	142.81	0.59
TC-M80a	0.043	010YR	11126.91	830.00	842.81		844.99	0.003507	12.18	1103.17	153.57	0.63
TC-M80a	0.043	020YR	12596.37	830.00	844.48		846.41	0.002684	11.66	1365.27	161.61	0.57
TC-M80a	0.043	050YR	15470.37	830.00	846.13		848.24	0.002571	12.35	1638.82	169.38	0.57
TC-M80a	0.043	100YR	17900.76	830.00	847.38		849.65	0.002522	12.91	1853.81	175.22	0.57
TC-M80a	0.043	200YR	20889.06	830.00	848.31		850.96	0.002762	14.03	2019.84	179.63	0.60
TC-M80a	0.043	500YR	23167.25	830.00	849.71		852.34	0.002507	14.09	2275.48	186.28	0.58
TC-M80a	0.001	001YR	2024.24	830.00	836.96		837.35	0.001528	5.03	402.58	72.91	0.38
TC-M80a	0.001	002YR	5957.23	830.00	838.77	837.42	840.53	0.005377	10.74	635.38	201.50	0.73
TC-M80a	0.001	005YR	8312.30	830.00	840.76		842.32	0.003795	10.54	1049.81	214.27	0.64
TC-M80a	0.001	010YR	11126.91	830.00	842.31		843.99	0.003453	11.24	1388.71	224.16	0.62
TC-M80a	0.001	020YR	12596.37	830.00	844.30		845.56	0.002134	9.96	1847.96	237.13	0.51
TC-M80a	0.001	050YR	15470.37	830.00	846.09		847.35	0.001851	10.18	2261.93	248.76	0.48
TC-M80a	0.001	100YR	17900.76	830.00	847.42		848.71	0.001720	10.43	2618.84	257.42	0.47
TC-M80a	0.001	200YR	20889.06	830.00	848.43		849.89	0.001816	11.19	2881.25	263.98	0.49
TC-M80a	0.001	500YR	23167.25	830.00	849.89		851.30	0.001585	11.07	3275.86	273.53	0.46
TC-M85	-0.073	001YR	2327.15	828.00	834.00	834.00	836.30	0.011956	12.18	191.02	41.49	1.00
TC-M85	-0.073	002YR	6756.00	828.00	838.37	838.09	839.30	0.003236	9.89	1181.33	392.37	0.58
TC-M85	-0.073	005YR	9408.00	828.00	841.18	838.73	841.55	0.001031	6.69	2256.90	432.46	0.34
TC-M85	-0.073	010YR	11562.00	828.00	842.97	839.16	843.26	0.000693	6.03	3021.78	547.68	0.29
TC-M85	-0.073	020YR	14251.00	828.00	844.76	839.66	845.03	0.000585	6.02	3942.22	677.63	0.27
TC-M85	-0.073	050YR	17467.00	828.00	846.62	840.19	846.86	0.000433	5.59	4943.05	898.32	0.24
TC-M85	-0.073	100YR	20624.00	828.00	847.99	840.66	848.23	0.000389	5.57	5681.73	919.97	0.23
TC-M85	-0.073	200YR	23663.00	828.00	849.11	841.11	849.37	0.000371	5.66	6287.77	1014.35	0.22
TC-M85	-0.073	500YR	27865.00	828.00	850.54	841.67	850.81	0.000354	5.80	7064.50	1025.87	0.22
TC-M85	-0.132	001YR	2327.15	826.00	832.77	831.37	833.05	0.001776	5.29	665.47	248.03	0.38
TC-M85	-0.132	002YR	6756.00	826.00	838.68	833.42	838.81	0.000370	3.84	2406.13	359.84	0.20
TC-M85	-0.132	005YR	9408.00	826.00	841.16	834.25	841.33	0.000307	3.98	3262.59	416.57	0.19
TC-M85	-0.132	010YR	11562.00	826.00	842.94	834.71	843.09	0.000287	4.16	3948.04	566.10	0.18
TC-M85	-0.132	020YR	14251.00	826.00	844.72	835.29	844.88	0.000253	4.19	4679.82	602.96	0.17
TC-M85	-0.132	050YR	17467.00	826.00	846.57	835.89	846.75	0.000234	4.30	5441.69	844.00	0.17
TC-M85	-0.132	100YR	20624.00	826.00	847.93	836.48	848.13	0.000237	4.53	6004.16	848.54	0.17
TC-M85	-0.132	200YR	23663.00	826.00	849.04	836.98	849.27	0.000246	4.77	6465.15	860.51	0.18
TC-M85	-0.132	500YR	27865.00	826.00	850.46	837.65	850.72	0.000257	5.09	7055.79	871.93	0.18
TC-M85	-0.206	001YR	2327.15	822.00	831.70	827.93	832.29	0.001809	6.14	378.75	54.55	0.41
TC-M85	-0.206	002YR	6756.00	822.00	837.53	833.12	838.43	0.002268	7.60	888.66	114.07	0.48
TC-M85	-0.206	005YR	9408.00	822.00	840.02	835.20	840.98	0.002020	7.85	1198.16	158.10	0.46
TC-M85	-0.206	010YR	11562.00	822.00	841.80	836.39	842.77	0.001626	7.95	1516.10	272.22	0.43
TC-M85	-0.206	020YR	14251.00	822.00	843.59	837.61	844.59	0.001389	8.16	1879.18	308.10	0.41
TC-M85	-0.206	050YR	17467.00	822.00	845.41	838.96	846.47	0.001249	8.47	2253.21	534.25	0.40
TC-M85	-0.206	100YR	20624.00	822.00	846.65	840.14	847.84	0.001273	9.04	2510.76	636.70	0.40
TC-M85	-0.206	200YR	23663.00	822.00	847.61	841.50	848.95	0.001335	9.63	2713.35	660.91	0.42
TC-M85	-0.206	500YR	27865.00	822.00	848.83	842.74	850.38	0.001416	10.40	2971.34	717.42	0.44
TC-M85	-0.281	001YR	2327.15	820.00	830.88	826.52	831.54	0.001962	6.53	356.27	45.98	0.41

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M85	-0.281	002YR	6756.00	820.00	834.80	832.09	837.04	0.004742	12.03	564.44	238.07	0.67
TC-M85	-0.281	005YR	9408.00	820.00	836.19	834.41	839.48	0.005867	14.60	663.41	347.39	0.76
TC-M85	-0.281	010YR	11562.00	820.00	838.15	836.01	841.49	0.004936	14.90	858.73	437.95	0.72
TC-M85	-0.281	020YR	14251.00	820.00	838.63	838.63	843.21	0.008514	17.52	916.61	454.89	0.83
TC-M85	-0.281	050YR	17467.00	820.00	840.00	840.00	845.10	0.006613	18.81	1097.66	514.82	0.85
TC-M85	-0.281	100YR	20624.00	820.00	842.93	842.93	846.73	0.004223	16.91	1625.70	698.35	0.70
TC-M85	-0.281	200YR	23663.00	820.00	843.80	843.80	847.81	0.004327	17.66	1810.81	719.40	0.72
TC-M85	-0.281	500YR	27865.00	820.00	844.83	844.83	849.17	0.004516	18.69	2032.66	740.80	0.74
TC-M85	-0.352	001YR	2327.15	820.00	830.40	825.68	830.88	0.001371	5.56	419.21	59.79	0.36
TC-M85	-0.352	002YR	6756.00	820.00	833.65	830.66	835.45	0.003252	10.92	675.71	109.77	0.59
TC-M85	-0.352	005YR	9408.00	820.00	835.38	832.98	837.51	0.003331	12.22	944.99	247.32	0.61
TC-M85	-0.352	010YR	11562.00	820.00	833.82	833.82	838.89	0.008972	18.33	694.62	113.58	0.98
TC-M85	-0.352	020YR	14251.00	820.00	837.62	836.56	840.14	0.003457	13.90	1321.09	260.00	0.64
TC-M85	-0.352	050YR	17467.00	820.00	837.67	837.67	841.41	0.005096	16.93	1330.85	260.31	0.78
TC-M85	-0.352	100YR	20624.00	820.00	839.70	838.65	842.87	0.003826	15.99	1679.62	271.55	0.69
TC-M85	-0.352	200YR	23663.00	820.00	840.63	839.47	844.05	0.003901	16.74	1841.58	276.72	0.70
TC-M85	-0.352	500YR	27865.00	820.00	841.61	840.56	845.52	0.004212	18.03	2012.07	282.14	0.74
TC-M85	-.403	001YR	1925.24	819.50	830.50		830.62	0.000256	2.80	717.57	104.04	0.17
TC-M85	-.403	002YR	6510.40	819.50	834.09		834.69	0.000839	6.38	1136.89	127.36	0.32
TC-M85	-.403	005YR	9256.00	819.50	835.80		836.68	0.001044	7.77	1363.20	136.77	0.37
TC-M85	-.403	010YR	10437.00	819.50	835.96		837.04	0.001275	8.65	1384.02	137.58	0.41
TC-M85	-.403	020YR	14250.00	819.50	837.78		839.25	0.001504	10.19	1644.41	147.36	0.45
TC-M85	-.403	050YR	15582.00	819.50	838.07		839.75	0.001680	10.90	1687.10	148.92	0.48
TC-M85	-.403	100YR	20585.00	819.50	839.58		841.90	0.002092	12.90	1918.43	157.77	0.54
TC-M85	-.403	200YR	23595.00	819.50	840.35		843.08	0.002347	14.05	2042.85	168.06	0.58
TC-M85	-.403	500YR	27183.00	819.50	841.28		844.46	0.002582	15.23	2206.18	180.68	0.61
TC-M85	-.423	001YR	1925.24	817.10	830.49	822.99	830.60	0.000218	2.72	773.48	138.75	0.16
TC-M85	-.423	002YR	6510.40	817.10	834.05	827.10	834.61	0.000746	6.23	1299.18	155.96	0.30
TC-M85	-.423	005YR	9256.00	817.10	835.77	828.96	836.57	0.000934	7.57	1574.17	164.25	0.35
TC-M85	-.423	010YR	10437.00	817.10	835.92	829.55	836.90	0.001144	8.43	1597.96	164.94	0.38
TC-M85	-.423	020YR	14250.00	817.10	837.76	832.03	839.08	0.001352	9.90	1910.36	173.84	0.43
TC-M85	-.423	050YR	15582.00	817.10	838.05	832.63	839.56	0.001512	10.59	1960.79	175.24	0.45
TC-M85	-.423	100YR	20585.00	817.10	839.58	834.63	841.65	0.001881	12.51	2235.27	182.64	0.51
TC-M85	-.423	200YR	23595.00	817.10	840.38	835.64	842.78	0.002097	13.58	2381.68	186.46	0.54
TC-M85	-.423	500YR	27183.00	817.10	841.35	836.84	844.12	0.002294	14.68	2565.16	191.15	0.57
TC-M85	-.45		Bridge									
TC-M85	-.471	001YR	1925.24	818.00	829.37		829.49	0.000222	2.73	744.63	97.33	0.16
TC-M85	-.471	002YR	6510.40	818.00	832.67		833.29	0.000849	6.51	1224.66	162.55	0.32
TC-M85	-.471	005YR	9256.00	818.00	834.21		835.12	0.001097	7.99	1481.29	169.86	0.37
TC-M85	-.471	010YR	10437.00	818.00	834.16		835.32	0.001417	9.05	1471.90	169.59	0.42
TC-M85	-.471	020YR	14250.00	818.00	835.74		837.33	0.001745	10.77	1745.14	177.06	0.48
TC-M85	-.471	050YR	15582.00	818.00	835.81		837.70	0.002047	11.70	1758.75	177.42	0.52
TC-M85	-.471	100YR	20585.00	818.00	836.68		839.50	0.002890	14.41	1915.31	181.55	0.62
TC-M85	-.471	200YR	23595.00	818.00	836.94		840.48	0.003578	16.19	1981.09	182.74	0.69
TC-M85	-.471	500YR	27183.00	818.00	837.18	835.95	841.69	0.004485	18.30	2006.29	183.90	0.77
TC-M85	-.504	001YR	1925.24	817.40	829.36	821.18	829.44	0.000174	2.38	904.24	251.93	0.14
TC-M85	-.504	002YR	6510.40	817.40	832.86	825.30	833.07	0.000371	4.31	2513.32	604.18	0.21
TC-M85	-.504	005YR	9256.00	817.40	834.61	827.11	834.81	0.000327	4.41	3670.35	691.51	0.20
TC-M85	-.504	010YR	10437.00	817.40	834.68	827.80	834.92	0.000403	4.90	3717.15	691.74	0.23
TC-M85	-.504	020YR	14250.00	817.40	836.59	831.24	836.80	0.000334	4.84	5030.12	698.17	0.21
TC-M85	-.504	050YR	15582.00	817.40	836.84	831.65	837.07	0.000363	5.10	5202.21	699.01	0.22
TC-M85	-.504	100YR	20585.00	817.40	838.33	832.80	838.59	0.000376	5.50	6233.09	704.00	0.23
TC-M85	-.504	200YR	23595.00	817.40	839.05	833.37	839.34	0.000393	5.76	6740.57	706.45	0.23
TC-M85	-.504	500YR	27183.00	817.40	839.95	834.19	840.26	0.000399	5.99	7370.76	709.48	0.24
RR Bypass	-.525	001YR	10.40	830.00	830.57	830.57	830.70	0.003897	2.89	3.60	13.93	1.00
RR Bypass	-.525	002YR	10.40	830.00	830.57	830.57	830.70	0.003897	2.89	3.60	13.93	1.00
RR Bypass	-.525	005YR	1768.00	830.00	833.93	833.93	835.40	0.001720	9.79	186.98	68.11	1.00
RR Bypass	-.525	010YR	2310.00	830.00	834.52	834.52	836.25	0.001591	10.62	228.15	70.61	0.99
RR Bypass	-.525	020YR	3762.00	830.00	835.88	835.88	838.22	0.001416	12.41	327.79	76.32	0.98
RR Bypass	-.525	050YR	4558.00	830.00	836.52	836.52	839.17	0.001368	13.24	377.70	79.02	0.99
RR Bypass	-.525	100YR	6325.00	830.00	838.50	837.86	841.15	0.000926	13.34	542.53	87.36	0.85
RR Bypass	-.525	200YR	7018.00	830.00	839.10	838.33	841.86	0.000874	13.64	595.93	89.90	0.84
RR Bypass	-.525	500YR	7995.00	830.00	839.94		842.82	0.000810	14.01	672.16	93.40	0.82
RR Bypass	-.527	001YR	10.40	829.00	829.60	829.60	829.75	0.003690	3.10	3.36	11.19	1.00
RR Bypass	-.527	002YR	10.40	829.00	829.60	829.60	829.75	0.003690	3.10	3.36	11.19	1.00
RR Bypass	-.527	005YR	1768.00	829.00	833.39	833.39	834.95	0.001651	10.33	198.60	68.59	1.00
RR Bypass	-.527	010YR	2310.00	829.00	834.02	834.02	835.86	0.001560	11.26	242.40	71.45	1.00
RR Bypass	-.527	020YR	3762.00	829.00	835.47	835.47	837.94	0.001409	13.18	350.71	78.08	1.00
RR Bypass	-.527	050YR	4558.00	829.00	836.18	836.18	838.94	0.001348	13.99	407.27	81.32	1.00
RR Bypass	-.527	100YR	6325.00	829.00	837.58	837.58	840.94	0.001260	15.52	526.22	87.75	1.00
RR Bypass	-.527	200YR	7018.00	829.00	838.10	838.10	841.65	0.001227	16.02	572.32	90.12	1.00
RR Bypass	-.527	500YR	7995.00	829.00	838.78	838.78	842.61	0.001197	16.70	634.72	93.23	1.00

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
RR Bypass	-.528	001YR	10.40	828.00	828.13	828.13	828.19	0.004959	1.99	5.22	42.28	1.00
RR Bypass	-.528	002YR	10.40	828.00	828.13	828.13	828.19	0.004959	1.99	5.22	42.28	1.00
RR Bypass	-.528	005YR	1768.00	828.00	831.11	831.11	832.44	0.001733	9.33	198.45	80.84	0.99
RR Bypass	-.528	010YR	2310.00	828.00	831.65	831.65	833.21	0.001601	10.12	243.69	85.20	0.98
RR Bypass	-.528	020YR	3762.00	828.00	832.89	832.89	834.98	0.001419	11.78	355.62	95.13	0.97
RR Bypass	-.528	050YR	4558.00	828.00	833.49	833.49	835.83	0.001354	12.51	414.24	99.94	0.97
RR Bypass	-.528	100YR	6325.00	828.00	834.69	834.69	837.51	0.001253	13.84	540.17	109.56	0.97
RR Bypass	-.528	200YR	7018.00	828.00	835.11	835.11	838.11	0.001236	14.33	586.11	112.86	0.97
RR Bypass	-.528	500YR	7995.00	828.00	835.69	835.69	838.92	0.001199	14.92	653.01	117.51	0.97
RR Bypass	-0.529	001YR	10.40	824.00	824.16	822.22	824.22	0.022540	3.23	547.99	483.90	1.99
RR Bypass	-0.529	002YR	10.40	824.00	824.16	822.22	824.22	0.022247	3.22	548.46	483.98	1.98
RR Bypass	-0.529	005YR	312.00	824.00	825.23	825.23	825.57	0.003273	4.73	1112.74	574.60	1.06
RR Bypass	-0.529	010YR	1155.00	824.00	823.42	823.42	823.79	6766.169000		237.84	334.34	0.00
RR Bypass	-0.529	020YR	2280.00	824.00	823.89	823.89	824.35	5796.226000		419.76	444.17	0.00
RR Bypass	-0.529	050YR	2544.00	824.00	823.97	823.97	824.45	5798.912000		455.62	462.76	0.00
RR Bypass	-0.529	100YR	4025.00	824.00	827.57	827.57	828.87	0.001817	9.15	2673.23	750.10	1.01
RR Bypass	-0.529	200YR	6050.00	824.00	828.37	828.37	830.07	0.001666	10.49	3291.16	785.58	1.01
RR Bypass	-0.529	500YR	7380.00	824.00	828.85	828.85	830.79	0.001592	11.20	3668.16	792.75	1.01
RR Bypass	-0.530	001YR	10.40	822.00	822.07		822.07	0.002477	0.63	115.50	511.19	0.42
RR Bypass	-0.530	002YR	10.40	822.00	822.07		822.07	0.002493	0.63	115.40	511.19	0.42
RR Bypass	-0.530	005YR	312.00	822.00	822.60	822.43	822.73	0.003266	3.02	388.50	520.27	0.69
RR Bypass	-0.530	010YR	1155.00	822.00	823.30		823.69	0.003489	5.22	755.69	532.23	0.81
RR Bypass	-0.530	020YR	2280.00	822.00	823.80	823.72	824.60	0.004524	7.41	1027.91	540.92	0.97
RR Bypass	-0.530	050YR	2544.00	822.00	823.89	823.85	824.80	0.004818	7.88	1074.66	542.40	1.01
RR Bypass	-0.530	100YR	4025.00	822.00	824.52	824.52	825.79	0.004596	9.33	1420.49	553.23	1.04
RR Bypass	-0.530	200YR	6050.00	822.00	825.33	825.33	826.95	0.004086	10.59	1871.77	567.04	1.02
RR Bypass	-0.530	500YR	7380.00	822.00	825.78	825.78	827.64	0.003957	11.34	2129.90	574.79	1.03
RR Bypass	-0.540	001YR	10.40	820.00	820.23	820.23	820.29	0.011992	1.93	5.38	46.37	1.00
RR Bypass	-0.540	002YR	10.40	820.00	820.23	820.23	820.29	0.011992	1.93	5.38	46.37	1.00
RR Bypass	-0.540	005YR	312.00	820.00	820.96	820.90	821.14	0.005523	3.38	92.18	192.02	0.86
RR Bypass	-0.540	010YR	1155.00	820.00	821.52	821.52	821.95	0.006291	5.24	220.28	262.42	1.01
RR Bypass	-0.540	020YR	2280.00	820.00	822.03	822.03	822.62	0.005702	6.16	380.61	661.40	1.01
RR Bypass	-0.540	050YR	2544.00	820.00	822.13	822.13	822.75	0.005541	6.35	443.26	665.65	1.01
RR Bypass	-0.540	100YR	4025.00	820.00	822.59	822.59	823.39	0.004982	7.20	758.51	686.63	1.00
RR Bypass	-0.540	200YR	6050.00	820.00	823.11	823.11	824.12	0.004678	8.09	1120.36	709.95	1.01
RR Bypass	-0.540	500YR	7380.00	820.00	823.43	823.43	824.54	0.004449	8.49	1346.49	724.14	1.00
RR Bypass	-0.550	001YR	10.40	818.00	818.06		818.06	0.002683	0.58	17.99	308.86	0.42
RR Bypass	-0.550	002YR	10.40	818.00	818.06		818.06	0.002768	0.58	17.82	308.78	0.43
RR Bypass	-0.550	005YR	312.00	818.00	818.31	818.31	818.46	0.008743	3.07	101.77	347.18	1.00
RR Bypass	-0.550	010YR	1155.00	818.00	818.72	818.72	819.04	0.006821	4.50	256.66	408.65	1.00
RR Bypass	-0.550	020YR	2280.00	818.00	819.10	819.10	819.56	0.006122	5.43	419.75	464.68	1.01
RR Bypass	-0.550	050YR	2544.00	818.00	819.17	819.17	819.66	0.005982	5.58	455.81	476.17	1.01
RR Bypass	-0.550	100YR	4025.00	818.00	819.54	819.54	820.15	0.005547	6.27	641.61	531.49	1.01
RR Bypass	-0.550	200YR	6050.00	818.00	819.96	819.96	820.70	0.005149	6.91	875.95	593.96	1.00
RR Bypass	-0.550	500YR	7380.00	818.00	820.18	820.18	821.01	0.005021	7.30	1010.45	618.13	1.01
RR Bypass	-0.560	001YR	44.72	816.00	816.15	816.15	816.22	0.046764	2.13	20.99	153.74	1.02
RR Bypass	-0.560	002YR	44.72	816.00	816.15	816.15	816.22	0.045254	2.11	21.22	154.07	1.00
RR Bypass	-0.560	005YR	416.00	816.00	816.59	816.59	816.82	0.031046	3.78	110.03	250.63	1.01
RR Bypass	-0.560	010YR	609.00	816.00	816.73	816.73	817.00	0.029306	4.13	147.41	281.54	1.01
RR Bypass	-0.560	020YR	1938.00	816.00	817.35	817.35	817.79	0.024651	5.32	364.20	417.91	1.00
RR Bypass	-0.560	050YR	3392.00	816.00	817.79	817.79	818.35	0.022816	5.99	566.27	513.38	1.01
RR Bypass	-0.560	100YR	5405.00	816.00	818.21	818.21	818.92	0.021512	6.74	801.67	582.37	1.01
RR Bypass	-0.560	200YR	7260.00	816.00	818.54	818.54	819.36	0.020342	7.29	995.44	616.31	1.01
RR Bypass	-0.560	500YR	8610.00	816.00	818.82	818.75	819.65	0.017641	7.34	1172.54	645.78	0.96
RR Bypass	-0.570	001YR	44.72	805.00	807.28		807.36	0.003789	2.33	19.17	11.83	0.32
RR Bypass	-0.570	002YR	44.72	805.00	806.94		807.07	0.006957	2.91	15.37	10.83	0.43
RR Bypass	-0.570	005YR	416.00	805.00	810.73	809.06	810.77	0.002986	1.45	285.92	334.06	0.28
RR Bypass	-0.570	010YR	609.00	805.00	810.97	810.28	811.01	0.003021	1.66	366.08	352.85	0.29
RR Bypass	-0.570	020YR	1938.00	805.00	811.68	810.86	812.00	0.004058	2.68	723.61	426.69	0.36
RR Bypass	-0.570	050YR	3392.00	805.00	812.50	811.34	812.68	0.004525	3.41	1014.82	521.91	0.40
RR Bypass	-0.570	100YR	5405.00	805.00	813.06	811.86	813.35	0.005575	4.35	1329.01	616.06	0.46
RR Bypass	-0.570	200YR	7260.00	805.00	813.19	812.27	813.67	0.008561	5.56	1414.47	639.27	0.58
RR Bypass	-0.570	500YR	8610.00	805.00	813.28		813.91	0.010927	6.40	1469.56	653.80	0.65
RR Bypass	-0.580	001YR	44.72	803.00	804.30	804.19	804.68	0.030272	4.93	9.08	8.91	0.86
RR Bypass	-0.580	002YR	44.72	803.00	805.15		805.25	0.004698	2.52	17.73	11.46	0.36
RR Bypass	-0.580	005YR	416.00	803.00	807.06	807.06	808.39	0.032531	9.26	44.94	17.17	1.01
RR Bypass	-0.580	010YR	609.00	803.00	808.20	808.20	808.38	0.065363	3.41	178.71	591.48	1.09
RR Bypass	-0.580	020YR	1938.00	803.00	808.58	808.58	808.93	0.042593	4.75	407.89	594.37	1.01
RR Bypass	-0.580	050YR	3392.00	803.00	808.88	808.88	809.40	0.040059	5.83	582.28	596.57	1.04
RR Bypass	-0.580	100YR	5405.00	803.00	809.36	809.23	809.96	0.026672	6.20	872.41	600.21	0.91
RR Bypass	-0.580	200YR	7260.00	803.00	810.22		810.64	0.010418	5.23	1388.08	607.48	0.61
RR Bypass	-0.580	500YR	8610.00	803.00	810.89		811.24	0.006258	4.79	1798.18	615.19	0.49
RR Bypass	-0.590	001YR	44.72	801.00	804.47		804.47	0.000067	0.17	264.55	446.37	0.04

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
RR Bypass	-0.590	002YR	44.72	801.00	805.22		805.22	0.000004	0.08	599.81	449.26	0.01
RR Bypass	-0.590	005YR	416.00	801.00	805.96		805.96	0.000087	0.45	935.55	452.13	0.05
RR Bypass	-0.590	010YR	609.00	801.00	806.37		806.38	0.000102	0.55	1121.90	453.72	0.06
RR Bypass	-0.590	020YR	1938.00	801.00	806.90		806.93	0.000545	1.44	1361.56	455.75	0.15
RR Bypass	-0.590	050YR	3392.00	801.00	807.11		807.20	0.001329	2.36	1459.68	456.58	0.23
RR Bypass	-0.590	100YR	5405.00	801.00	808.58		808.69	0.000970	2.58	2135.07	462.92	0.21
RR Bypass	-0.590	200YR	7260.00	801.00	809.48		809.61	0.000977	2.91	2552.96	467.41	0.22
RR Bypass	-0.590	500YR	8610.00	801.00	810.27		810.41	0.000888	3.02	2922.75	473.19	0.21
TC-M81	-.524	001YR	4877.81	815.70	829.27	824.52	829.43	0.000400	3.97	1736.98	694.63	0.21
TC-M81	-.524	002YR	6510.40	815.70	832.99	825.82	833.01	0.000067	1.96	6224.55	1120.00	0.09
TC-M81	-.524	005YR	7488.00	815.70	834.74	826.33	834.75	0.000038	1.60	8181.96	1120.00	0.07
TC-M81	-.524	010YR	8127.00	815.70	834.83	826.52	834.85	0.000043	1.71	8291.88	1120.00	0.07
TC-M81	-.524	020YR	10488.00	815.70	836.72	827.22	836.74	0.000035	1.65	10409.52	1120.00	0.07
TC-M81	-.524	050YR	11024.00	815.70	836.99	827.35	837.01	0.000035	1.68	10704.49	1120.00	0.07
TC-M81	-.524	100YR	14260.00	815.70	838.49	828.14	838.51	0.000037	1.81	12387.84	1120.00	0.07
TC-M81	-.524	200YR	16577.00	815.70	839.23	828.63	839.26	0.000041	1.94	13217.65	1120.00	0.07
TC-M81	-.524	500YR	19803.00	815.70	840.14	829.30	840.17	0.000046	2.11	14237.57	1120.00	0.08
TC-M81	-.530		Bridge									
TC-M81	-.541	001YR	4964.44	815.80	828.26	823.76	828.93	0.001310	6.86	769.70	511.93	0.38
TC-M81	-.541	002YR	6614.40	815.80	830.10	824.82	830.95	0.001306	7.65	979.23	969.28	0.39
TC-M81	-.541	005YR	7602.40	815.80	833.61	825.42	833.81	0.000307	4.40	2896.30	996.12	0.20
TC-M81	-.541	010YR	8295.00	815.80	833.51	825.82	833.76	0.000383	4.89	2839.90	995.34	0.22
TC-M81	-.541	020YR	10681.80	815.80	836.50	827.14	836.63	0.000189	3.87	4510.84	1029.98	0.16
TC-M81	-.541	050YR	11236.00	815.80	836.78	827.43	836.91	0.000190	3.92	4668.94	1038.73	0.16
TC-M81	-.541	100YR	14605.00	815.80	838.24	831.75	838.39	0.000200	4.23	5504.07	1078.20	0.17
TC-M81	-.541	200YR	16940.00	815.80	838.97	832.26	839.14	0.000217	4.51	5924.27	1081.40	0.17
TC-M81	-.541	500YR	20172.00	815.80	839.86	832.83	840.06	0.000241	4.88	6438.38	1085.31	0.18
TC-M81	-.556	001YR	4964.44	817.41	827.94		828.80	0.001640	7.50	699.71	90.22	0.43
TC-M81	-.556	002YR	6614.40	817.41	829.81		830.83	0.001558	8.23	945.14	175.60	0.43
TC-M81	-.556	005YR	7602.40	817.41	833.43		833.77	0.000470	5.43	2945.34	629.45	0.25
TC-M81	-.556	010YR	8295.00	817.41	833.28		833.71	0.000596	6.07	2848.69	624.35	0.28
TC-M81	-.556	020YR	10681.80	817.41	836.37		836.60	0.000320	5.05	4934.90	726.64	0.21
TC-M81	-.556	050YR	11236.00	817.41	836.64		836.89	0.000324	5.13	5137.79	735.83	0.21
TC-M81	-.556	100YR	14605.00	817.41	838.10		838.37	0.000350	5.61	6243.02	784.00	0.22
TC-M81	-.556	200YR	16940.00	817.41	838.82		839.11	0.000383	6.01	6814.82	807.79	0.23
TC-M81	-.556	500YR	20172.00	817.41	839.69		840.03	0.000428	6.53	7532.89	836.72	0.25
TC-M81	-.569	001YR	4964.44	817.70	826.68	825.10	828.54	0.004710	11.04	481.35	80.44	0.69
TC-M81	-.569	002YR	6614.40	817.70	828.55	826.43	830.57	0.003945	11.64	658.49	119.68	0.66
TC-M81	-.569	005YR	7602.40	817.70	833.30	827.27	833.73	0.000682	6.31	2598.56	532.50	0.29
TC-M81	-.569	010YR	8295.00	817.70	833.10	827.73	833.66	0.000869	7.14	2488.50	531.31	0.33
TC-M81	-.569	020YR	10681.80	817.70	836.30	829.84	836.58	0.000427	5.66	4221.46	549.74	0.24
TC-M81	-.569	050YR	11236.00	817.70	836.58	831.64	836.87	0.000432	5.75	4373.62	551.33	0.24
TC-M81	-.569	100YR	14605.00	817.70	838.02	832.59	838.35	0.000467	6.30	5174.90	559.63	0.25
TC-M81	-.569	200YR	16940.00	817.70	838.73	833.13	839.09	0.000514	6.77	5571.88	563.69	0.27
TC-M81	-.569	500YR	20172.00	817.70	839.56	833.78	840.00	0.000580	7.40	6054.40	568.59	0.29
TC-M81	-.575		Bridge									
TC-M81	-.581	001YR	4964.44	817.90	826.65		827.99	0.004398	9.29	534.36	84.83	0.65
TC-M81	-.581	002YR	6614.40	817.90	828.70		829.98	0.003351	9.14	780.41	204.64	0.59
TC-M81	-.581	005YR	7602.40	817.90	829.95		831.07	0.002499	8.67	1100.43	311.14	0.52
TC-M81	-.581	010YR	8295.00	817.90	830.55		831.63	0.002256	8.61	1371.17	464.32	0.50
TC-M81	-.581	020YR	10681.80	817.90	832.49		833.27	0.001477	7.90	2287.24	483.77	0.42
TC-M81	-.581	050YR	11236.00	817.90	832.84		833.60	0.001399	7.85	2458.63	486.87	0.41
TC-M81	-.581	100YR	14605.00	817.90	835.11		835.70	0.000970	7.37	3575.84	495.22	0.35
TC-M81	-.581	200YR	16940.00	817.90	836.18		836.75	0.000918	7.53	4096.17	498.67	0.34
TC-M81	-.581	500YR	20172.00	817.90	837.52		838.12	0.000862	7.73	4778.77	503.14	0.34
TC-M81	-.639	001YR	4964.44	815.21	825.18		826.64	0.004340	9.70	511.95	75.63	0.66
TC-M81	-.639	002YR	6614.40	815.21	827.75		829.04	0.002795	9.14	768.14	210.87	0.55
TC-M81	-.639	005YR	7602.40	815.21	829.44		830.38	0.001733	8.11	1196.15	261.36	0.44
TC-M81	-.639	010YR	8295.00	815.21	830.12		831.00	0.001539	7.97	1376.03	265.63	0.42
TC-M81	-.639	020YR	10681.80	815.21	832.09		832.86	0.001190	7.82	1909.46	277.72	0.38
TC-M81	-.639	050YR	11236.00	815.21	832.43		833.20	0.001167	7.88	2004.05	279.07	0.38
TC-M81	-.639	100YR	14605.00	815.21	834.66		835.39	0.000962	7.93	2636.48	287.99	0.35
TC-M81	-.639	200YR	16940.00	815.21	835.65		836.44	0.000977	8.32	2923.71	291.95	0.36
TC-M81	-.639	500YR	20172.00	815.21	836.95		837.81	0.000986	8.79	3306.44	297.15	0.37
TC-M81	-.696	001YR	4964.44	811.84	824.71		825.53	0.001762	7.27	682.80	76.66	0.43
TC-M81	-.696	002YR	6614.40	811.84	827.42		828.26	0.001325	7.37	902.54	85.45	0.39
TC-M81	-.696	005YR	7602.40	811.84	829.08		829.92	0.001100	7.38	1050.20	92.17	0.36
TC-M81	-.696	010YR	8295.00	811.84	829.70		830.60	0.001118	7.65	1107.54	94.91	0.37
TC-M81	-.696	020YR	10681.80	811.84	831.15		832.35	0.001308	8.86	1250.07	101.41	0.40
TC-M81	-.696	050YR	11236.00	811.84	831.37		832.66	0.001375	9.17	1272.96	102.42	0.41
TC-M81	-.696	100YR	14605.00	811.84	832.96		834.71	0.001646	10.72	1440.85	108.99	0.46
TC-M81	-.696	200YR	16940.00	811.84	833.35		835.59	0.002042	12.12	1483.92	110.54	0.51

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M81	-.696	500YR	20172.00	811.84	833.61		836.68	0.002747	14.20	1512.67	111.55	0.60
TC-M81	-0.711	001YR	4964.44	815.70	824.53	822.00	825.35	0.002711	7.24	685.52	112.43	0.52
TC-M81	-0.711	002YR	6614.40	815.70	827.40	822.97	828.04	0.001489	6.41	1032.07	129.00	0.40
TC-M81	-0.711	005YR	7602.40	815.70	829.13	823.52	829.69	0.001111	6.02	1263.49	138.97	0.35
TC-M81	-0.711	010YR	8295.00	815.70	829.77	823.88	830.35	0.001091	6.13	1353.04	142.65	0.35
TC-M81	-0.711	020YR	10681.80	815.70	831.29	825.03	832.01	0.001108	6.79	1577.36	150.63	0.36
TC-M81	-0.711	050YR	11236.00	815.70	831.54	825.24	832.29	0.001139	6.98	1614.09	151.88	0.37
TC-M81	-0.711	100YR	14605.00	815.70	833.24	826.65	834.20	0.001193	7.86	1880.67	160.52	0.39
TC-M81	-0.711	200YR	16940.00	815.70	833.74	827.52	834.93	0.001412	8.76	1960.81	163.16	0.42
TC-M81	-0.711	500YR	20172.00	815.70	834.18	828.61	835.75	0.001794	10.09	2032.84	165.41	0.48
TC-M81	-.730		Bridge									
TC-M81	-.739	001YR	4964.44	811.70	820.75	820.57	822.82	0.009948	11.54	430.21	93.88	0.95
TC-M81	-.739	002YR	6614.40	811.70	825.26	821.62	826.06	0.001790	7.19	958.15	610.42	0.44
TC-M81	-.739	005YR	7602.40	811.70	827.09	822.19	827.76	0.001172	6.66	1216.93	661.09	0.37
TC-M81	-.739	010YR	8295.00	811.70	827.71	822.55	828.41	0.001129	6.80	1306.61	670.70	0.37
TC-M81	-.739	020YR	10681.80	811.70	829.16	823.73	830.03	0.001196	7.62	1518.16	708.51	0.39
TC-M81	-.739	050YR	11236.00	811.70	829.38	823.99	830.30	0.001242	7.86	1550.30	731.82	0.40
TC-M81	-.739	100YR	14605.00	811.70	830.98	825.35	832.17	0.001364	8.94	1789.49	799.81	0.42
TC-M81	-.739	200YR	16940.00	811.70	831.33	826.19	832.83	0.001683	10.10	1841.37	800.46	0.47
TC-M81	-.739	500YR	20172.00	811.70	831.46	827.24	833.55	0.002312	11.91	1860.78	800.71	0.55
TC-M81	-0.770	001YR	2532.91	814.00	819.70		820.90	0.005949	8.80	287.89	62.77	0.72
TC-M81	-0.770	002YR	6614.40	814.00	822.51	822.51	824.98	0.007104	13.10	643.64	453.76	0.85
TC-M81	-0.770	005YR	9058.40	814.00	823.75	823.75	826.64	0.007064	14.50	837.99	536.37	0.87
TC-M81	-0.770	010YR	10069.50	814.00	824.22	824.22	827.26	0.007043	15.00	911.48	567.39	0.88
TC-M81	-0.770	020YR	12768.00	814.00	825.33	825.33	828.79	0.007094	16.27	1087.59	607.82	0.90
TC-M81	-0.770	050YR	13250.00	814.00	825.51	825.51	829.05	0.007101	16.48	1117.32	611.63	0.90
TC-M81	-0.770	100YR	16905.00	814.00	827.12	826.80	830.90	0.006490	17.35	1375.56	644.52	0.89
TC-M81	-0.770	200YR	18392.00	814.00	827.93	827.31	831.64	0.005918	17.31	1507.59	661.17	0.86
TC-M81	-0.770	500YR	20049.00	814.00	828.79	827.83	832.46	0.005445	17.35	1647.61	678.70	0.83
TC-M81	-0.816	001YR	2532.91	814.00	817.59	817.58	819.14	0.012393	9.99	253.66	81.36	1.00
TC-M81	-0.816	002YR	6614.40	814.00	820.46	820.46	822.78	0.008465	12.61	652.15	420.32	0.92
TC-M81	-0.816	005YR	9058.40	814.00	821.95	821.66	824.37	0.006792	13.13	908.49	629.92	0.85
TC-M81	-0.816	010YR	10069.50	814.00	822.70	822.14	825.01	0.005800	12.94	1044.46	651.74	0.80
TC-M81	-0.816	020YR	12768.00	814.00	824.62	823.20	826.70	0.004118	12.56	1410.61	687.18	0.70
TC-M81	-0.816	050YR	13250.00	814.00	824.94	823.34	826.99	0.003926	12.52	1474.12	690.86	0.68
TC-M81	-0.816	100YR	16905.00	814.00	827.20	824.63	829.13	0.002959	12.39	1939.92	759.94	0.61
TC-M81	-0.816	200YR	18392.00	814.00	828.07	825.09	829.97	0.002697	12.37	2126.56	791.69	0.59
TC-M81	-0.816	500YR	20049.00	814.00	828.98	825.58	830.86	0.002481	12.39	2326.01	824.84	0.58
TC-M81	-0.888	001YR	2532.91	808.00	812.84	812.74	814.67	0.011014	10.87	232.95	59.19	0.97
TC-M81	-0.888	002YR	6614.40	808.00	817.26	816.32	819.64	0.006743	12.32	537.09	76.81	0.82
TC-M81	-0.888	005YR	9058.40	808.00	819.13	817.92	821.84	0.006321	13.22	685.11	83.27	0.81
TC-M81	-0.888	010YR	10069.50	808.00	819.91	818.53	822.70	0.006030	13.41	750.96	86.03	0.80
TC-M81	-0.888	020YR	12768.00	808.00	821.86	820.01	824.81	0.005396	13.79	925.67	507.66	0.77
TC-M81	-0.888	050YR	13250.00	808.00	822.18	820.26	825.16	0.005273	13.87	955.66	558.20	0.76
TC-M81	-0.888	100YR	16905.00	808.00	824.37	822.02	827.62	0.004446	14.50	1208.37	685.83	0.73
TC-M81	-0.888	200YR	18392.00	808.00	825.17	822.66	828.54	0.004247	14.78	1304.18	689.90	0.72
TC-M81	-0.888	500YR	20049.00	808.00	825.94	823.38	829.48	0.004158	15.18	1396.49	693.79	0.72
TC-M81	-0.959	001YR	2532.91	802.36	811.82	808.87	812.59	0.002567	7.06	358.56	55.76	0.49
TC-M81	-0.959	002YR	6614.40	802.36	815.46	813.12	817.46	0.004520	11.30	585.59	67.84	0.68
TC-M81	-0.959	005YR	9058.40	802.36	816.94	815.00	819.64	0.005415	13.17	687.82	71.98	0.75
TC-M81	-0.959	010YR	10069.50	802.36	817.59	815.71	820.51	0.005560	13.70	735.01	73.71	0.76
TC-M81	-0.959	020YR	12768.00	802.36	818.98	817.36	822.57	0.006236	15.21	839.60	77.33	0.81
TC-M81	-0.959	050YR	13250.00	802.36	819.25	817.65	822.93	0.006287	15.39	860.76	78.03	0.82
TC-M81	-0.959	100YR	16905.00	802.36	821.11	819.61	825.44	0.006987	16.70	1012.02	557.28	0.86
TC-M81	-0.959	200YR	18392.00	802.36	821.76	820.37	826.35	0.007324	17.20	1069.55	786.59	0.88
TC-M81	-0.959	500YR	20049.00	802.36	822.33	821.31	827.27	0.007587	17.86	1141.59	909.92	0.90
TC-M81	-1.023	001YR	2532.91	803.46	811.21	808.20	811.78	0.001983	6.07	417.18	68.31	0.43
TC-M81	-1.023	002YR	6614.40	803.46	814.34	811.79	815.96	0.003854	10.22	647.02	78.43	0.63
TC-M81	-1.023	005YR	9058.40	803.46	815.42	813.45	817.79	0.005076	12.35	733.51	81.91	0.73
TC-M81	-1.023	010YR	10069.50	803.46	816.05	814.07	818.60	0.005205	12.82	785.70	84.28	0.74
TC-M81	-1.023	020YR	12768.00	803.46	816.71	815.60	820.26	0.007590	15.13	844.01	92.41	0.88
TC-M81	-1.023	050YR	13250.00	803.46	816.77	815.84	820.55	0.008099	15.60	849.25	106.25	0.91
TC-M81	-1.023	100YR	16905.00	803.46	818.57	818.17	822.69	0.009332	16.30	1037.30	659.20	0.96
TC-M81	-1.023	200YR	18392.00	803.46	819.39	818.95	823.46	0.009237	16.19	1135.81	764.84	0.95
TC-M81	-1.023	500YR	20049.00	803.46	819.99	819.63	824.23	0.009534	16.51	1214.33	861.09	0.96
TC-M81	-1.033	001YR	2532.91	804.38	811.16	809.10	811.60	0.002240	5.37	471.98	106.53	0.45
TC-M81	-1.033	002YR	6614.40	804.38	814.54	811.76	815.43	0.002468	7.56	874.54	125.50	0.50
TC-M81	-1.033	005YR	9058.40	804.38	815.81	812.91	816.99	0.002764	8.74	1036.32	421.71	0.55
TC-M81	-1.033	010YR	10069.50	804.38	816.51	813.35	817.74	0.002648	8.93	1127.58	580.87	0.54
TC-M81	-1.033	020YR	12768.00	804.38	817.42	814.43	819.04	0.003127	10.22	1249.79	702.79	0.59
TC-M81	-1.033	050YR	13250.00	804.38	817.54	814.61	819.24	0.003238	10.47	1265.60	712.39	0.60
TC-M81	-1.033	100YR	16905.00	804.38	819.41	815.92	821.28	0.003301	10.98	1541.89	866.19	0.62

HEC-RAS Plan: PreProject (Continued)

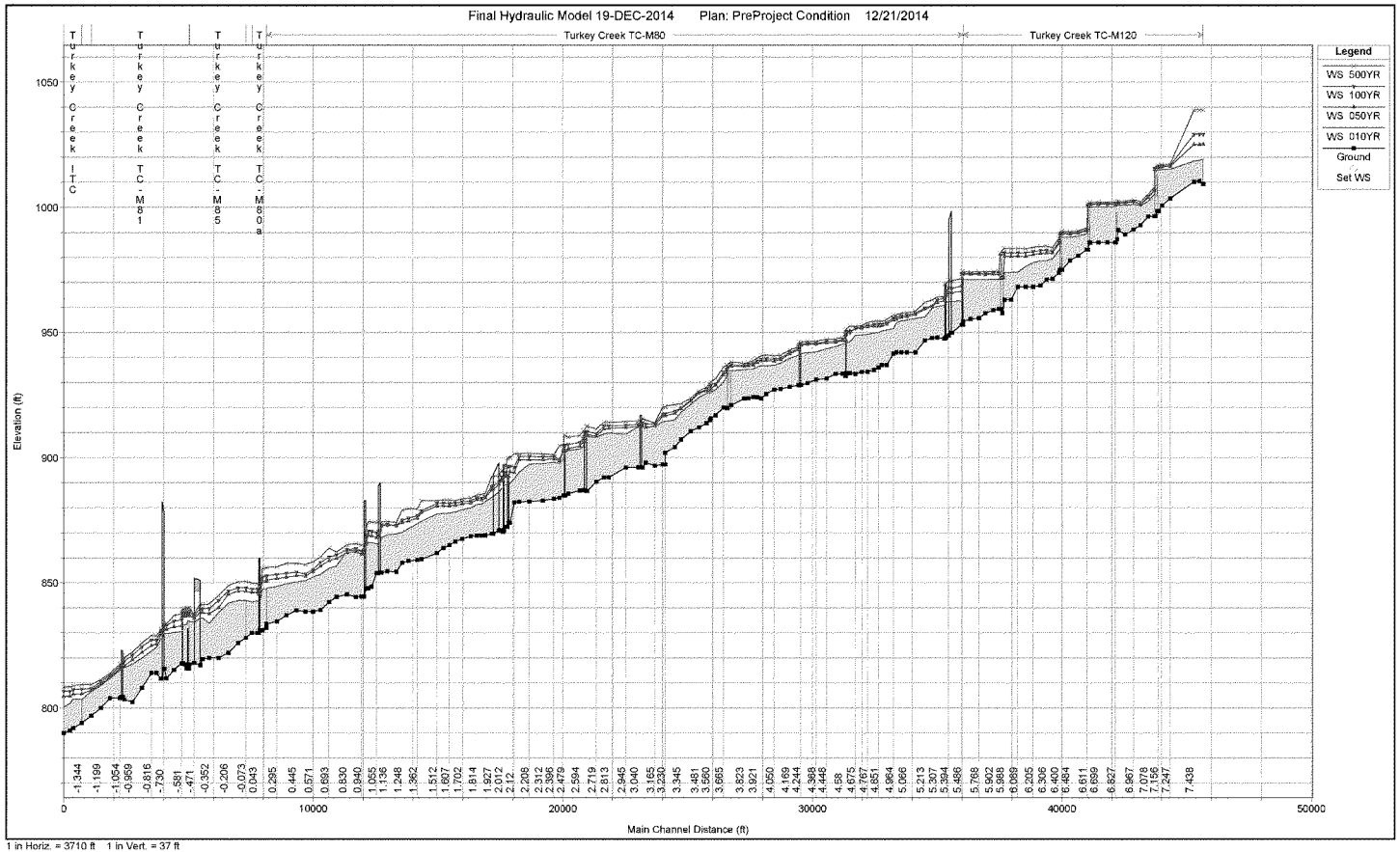
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M81	-1.033	200YR	18392.00	804.38	820.21	816.41	822.10	0.003012	11.05	1669.89	908.46	0.60
TC-M81	-1.033	500YR	20049.00	804.38	820.84	816.94	822.84	0.002950	11.37	1772.40	971.18	0.60
TC-M81	-1.035		Bridge									
TC-M81	-1.045	001YR	2532.91	804.38	810.79	809.09	811.32	0.002899	5.85	433.04	104.32	0.51
TC-M81	-1.045	002YR	6614.40	804.38	814.07	811.76	815.02	0.002711	7.94	916.98	628.32	0.53
TC-M81	-1.045	005YR	9058.40	804.38	815.18	813.06	816.44	0.002990	9.20	1107.31	647.12	0.57
TC-M81	-1.045	010YR	10069.50	804.38	815.93	813.47	817.19	0.002683	9.25	1237.53	659.85	0.55
TC-M81	-1.045	020YR	12768.00	804.38	816.34	814.47	818.15	0.003657	11.14	1309.70	678.17	0.65
TC-M81	-1.045	050YR	13250.00	804.38	815.85	814.65	818.08	0.004785	12.29	1224.89	658.62	0.73
TC-M81	-1.045	100YR	16905.00	804.38	816.65	815.81	819.59	0.005683	14.20	1364.82	693.99	0.81
TC-M81	-1.045	200YR	18392.00	804.38	816.87	816.26	820.17	0.006189	15.05	1404.16	705.24	0.85
TC-M81	-1.045	500YR	20049.00	804.38	817.64	816.74	820.92	0.005607	15.07	1539.37	743.69	0.82
TC-M81	-1.054	001YR	2484.03	803.96	810.69	808.46	811.17	0.002198	5.55	447.94	93.61	0.45
TC-M81	-1.054	002YR	6739.20	803.96	813.72	811.40	814.83	0.002975	8.66	962.76	628.50	0.56
TC-M81	-1.054	005YR	9287.20	803.96	814.64	813.12	816.18	0.003618	10.32	1172.12	644.25	0.63
TC-M81	-1.054	010YR	10699.50	803.96	815.09	813.75	816.87	0.003930	11.14	1274.46	651.45	0.66
TC-M81	-1.054	020YR	12882.00	803.96	815.73	814.55	817.86	0.004357	12.28	1420.15	661.69	0.70
TC-M81	-1.054	050YR	12720.00	803.96	815.69	814.50	817.79	0.004329	12.20	1409.54	660.94	0.70
TC-M81	-1.054	100YR	15985.00	803.96	816.55	815.59	819.17	0.004893	13.75	1606.07	693.06	0.75
TC-M81	-1.054	200YR	17182.00	803.96	816.84	815.96	819.64	0.005089	14.29	1671.78	707.28	0.77
TC-M81	-1.054	500YR	19680.00	803.96	817.40	816.66	820.60	0.005485	15.35	1799.96	734.96	0.81
TC-M81	-1.131	001YR	2484.03	803.92	807.58	807.43	808.94	0.027525	9.36	265.33	85.84	0.94
TC-M81	-1.131	002YR	6739.20	803.92	810.67	810.67	812.24	0.021992	10.57	795.65	560.76	0.81
TC-M81	-1.131	005YR	9287.20	803.92	811.57	811.57	813.29	0.020883	11.44	1088.35	562.69	0.81
TC-M81	-1.131	010YR	10699.50	803.92	811.94	811.94	813.79	0.021335	12.02	1210.32	563.49	0.82
TC-M81	-1.131	020YR	12882.00	803.92	812.47	812.47	814.51	0.021891	12.82	1383.70	564.62	0.85
TC-M81	-1.131	050YR	12720.00	803.92	812.44	812.44	814.46	0.021827	12.76	1372.00	564.54	0.84
TC-M81	-1.131	100YR	15985.00	803.92	813.16	813.16	815.44	0.022394	13.79	1609.96	566.09	0.87
TC-M81	-1.131	200YR	17182.00	803.92	813.40	813.40	815.78	0.022669	14.16	1688.60	566.60	0.88
TC-M81	-1.131	500YR	19680.00	803.92	813.87	813.87	816.46	0.023286	14.89	1841.92	567.58	0.90
TC-M81	-1.199	001YR	2484.03	800.00	804.73	803.27	805.32	0.004670	6.17	407.61	122.67	0.56
TC-M81	-1.199	002YR	6739.20	800.00	807.74	806.41	808.42	0.003299	7.23	1240.75	576.84	0.51
TC-M81	-1.199	005YR	9287.20	800.00	808.64	807.67	809.34	0.003102	7.66	1652.81	579.71	0.50
TC-M81	-1.199	010YR	10699.50	800.00	809.08	807.99	809.80	0.003027	7.87	1854.14	580.64	0.50
TC-M81	-1.199	020YR	12882.00	800.00	809.69	808.42	810.45	0.002949	8.18	2138.02	581.94	0.50
TC-M81	-1.199	050YR	12720.00	800.00	809.65	808.40	810.40	0.002956	8.16	2117.43	581.84	0.50
TC-M81	-1.199	100YR	15985.00	800.00	810.49	808.94	811.30	0.002868	8.58	2505.76	583.50	0.50
TC-M81	-1.199	200YR	17182.00	800.00	810.67	809.13	811.54	0.003016	8.91	2586.87	583.82	0.52
TC-M81	-1.199	500YR	19680.00	800.00	811.27	809.49	812.18	0.002915	9.14	2865.19	584.94	0.51
TC-M81	-1.272	001YR	2484.03	796.95	802.74	801.32	803.61	0.004128	7.47	337.65	87.44	0.61
TC-M81	-1.272	002YR	6739.20	796.95	805.56	805.56	806.95	0.004561	10.33	939.58	525.64	0.68
TC-M81	-1.272	005YR	9287.20	796.95	806.33	806.33	807.90	0.005036	11.46	1199.60	527.10	0.73
TC-M81	-1.272	010YR	10699.50	796.95	806.68	806.68	808.35	0.005294	12.03	1320.51	527.84	0.75
TC-M81	-1.272	020YR	12882.00	796.95	807.18	807.18	809.00	0.005638	12.80	1490.60	528.88	0.78
TC-M81	-1.272	050YR	12720.00	796.95	807.14	807.14	808.96	0.005607	12.74	1479.28	528.81	0.78
TC-M81	-1.272	100YR	15985.00	796.95	807.79	807.79	809.84	0.006109	13.82	1700.54	530.15	0.82
TC-M81	-1.272	200YR	17182.00	796.95	808.59	807.99	810.26	0.004598	12.65	1977.63	538.38	0.72
TC-M81	-1.272	500YR	19680.00	796.95	809.39	808.39	811.00	0.004072	12.56	2265.75	549.08	0.69
ITC	-1.344	001YR	2484.03	794.00	799.13	799.13	801.00	0.012027	10.97	226.39	61.07	1.00
ITC	-1.344	002YR	6739.20	794.00	802.35	802.35	803.58	0.005676	10.36	979.26	365.19	0.75
ITC	-1.344	005YR	9287.20	794.00	803.10	802.99	804.44	0.005936	11.20	1233.26	369.19	0.77
ITC	-1.344	010YR	10699.50	794.00	803.38	803.29	804.86	0.006393	11.86	1331.50	370.72	0.81
ITC	-1.344	020YR	12882.00	794.00	804.83	803.72	805.83	0.003606	9.99	1859.52	409.95	0.62
ITC	-1.344	050YR	12720.00	794.00	805.65	803.70	806.34	0.002224	8.37	2171.56	414.11	0.50
ITC	-1.344	100YR	15985.00	794.00	807.53	804.26	808.11	0.001468	7.74	2901.66	432.52	0.42
ITC	-1.344	200YR	17182.00	794.00	808.65	804.48	809.15	0.001100	7.16	3357.87	456.45	0.37
ITC	-1.344	500YR	19680.00	794.00	809.41	804.91	809.95	0.001102	7.47	3686.14	478.53	0.37
ITC	-1.419	001YR	1955.92	792.00	797.18	795.99	797.69	0.003772	5.87	365.81	169.13	0.55
ITC	-1.419	002YR	6801.60	792.00	802.28	799.22	802.57	0.000905	5.03	1877.12	916.31	0.31
ITC	-1.419	005YR	9703.20	792.00	803.29	799.99	803.68	0.001087	5.96	2258.18	922.47	0.35
ITC	-1.419	010YR	10783.50	792.00	803.62	800.49	804.05	0.001146	6.26	2383.06	924.49	0.36
ITC	-1.419	020YR	14820.00	792.00	804.72	801.41	805.29	0.001335	7.28	2801.70	931.26	0.40
ITC	-1.419	050YR	16112.00	792.00	805.44	801.66	805.99	0.001188	7.18	3075.33	935.89	0.38
ITC	-1.419	100YR	21390.00	792.00	807.23	802.62	807.86	0.001129	7.72	3753.74	946.87	0.38
ITC	-1.419	200YR	24442.00	792.00	808.26	803.11	808.92	0.001080	7.94	4143.06	959.02	0.37
ITC	-1.419	500YR	28290.00	792.00	808.93	803.67	809.71	0.001199	8.63	4396.93	978.76	0.40
ITC	-1.432	001YR	1955.92	791.00	795.93	795.37	796.94	0.007465	8.08	242.19	71.58	0.77
ITC	-1.432	002YR	6801.60	791.00	799.68	799.50	802.03	0.007590	12.46	618.92	175.30	0.86
ITC	-1.432	005YR	9703.20	791.00	801.61	801.61	803.23	0.004454	11.30	1392.06	807.13	0.69
ITC	-1.432	010YR	10783.50	791.00	801.89	801.89	803.58	0.004585	11.72	1517.39	810.78	0.70
ITC	-1.432	020YR	14820.00	791.00	803.47	802.78	804.87	0.003488	11.43	2234.74	837.56	0.63
ITC	-1.432	050YR	16112.00	791.00	804.70	803.04	805.69	0.002265	9.93	2812.03	898.02	0.52

HEC-RAS Plan: PreProject (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
ITC	-1.432	100YR	21390.00	791.00	806.73	803.96	807.61	0.001746	9.72	3776.92	954.38	0.47
ITC	-1.432	200YR	24442.00	791.00	807.85	804.47	808.69	0.001547	9.85	4310.03	966.12	0.44
ITC	-1.432	500YR	28290.00	791.00	808.49	805.00	809.46	0.001687	10.37	4617.56	973.58	0.47
ITC	-1.479	001YR	1966.21	790.00	793.93	793.41	795.03	0.007723	6.41	233.69	67.21	0.79
ITC	-1.479	002YR	6864.00	790.00	798.01	797.97	800.25	0.006533	12.27	727.31	782.07	0.82
ITC	-1.479	005YR	9796.60	790.00	799.78	799.61	801.26	0.003999	11.15	1469.46	836.34	0.66
ITC	-1.479	010YR	10667.50	790.00	800.37	799.89	801.71	0.003445	10.81	1736.01	864.38	0.62
ITC	-1.479	020YR	15048.00	790.00	803.49	800.89	804.14	0.001375	8.27	3187.49	943.46	0.41
ITC	-1.479	050YR	16654.00	790.00	804.63	801.24	805.19	0.001106	7.67	3718.24	985.10	0.38
ITC	-1.479	100YR	21505.00	790.00	806.67	802.03	807.20	0.000912	7.84	4677.24	1000.38	0.35
ITC	-1.479	200YR	24605.00	790.00	807.77	802.53	808.33	0.000862	8.06	5193.53	1009.64	0.35
ITC	-1.479	500YR	26782.00	790.00	808.39	803.10	809.06	0.001003	8.81	5486.76	1015.37	0.37

Exhibit 4

Exhibit 4. Water surface elevation profiles from Existing Condition HEC-RAS model for several events - including reaches TC-M81, TC-M85, TC-M80a, TC-M80, and TC-M120



1 in Horiz. = 3710 ft 1 in Vert. = 37 ft

Exhibit 5

Exhibit 5. Tabular results from Proposed Condition HEC-RAS model for the reach of interest TC-M80

HEC-RAS Plan: Pref2012Mod River: Turkey Creek Reach: TC-M80

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	5.513	010YR	4306.00	953.10	970.49	962.05	971.08	0.000673	6.40	717.93	1313.02	0.29
TC-M80	5.513	050YR	7263.00	953.10	973.15	965.60	973.15	0.000018	1.17	11258.02	1437.17	0.05
TC-M80	5.513	100YR	8764.00	953.10	973.65	966.82	973.65	0.000022	1.31	11979.89	1449.61	0.05
TC-M80	5.513	500YR	11498.00	953.10	974.33	968.78	974.34	0.000029	1.55	12982.49	1460.47	0.06
TC-M80	5.499		Bridge									
TC-M80	5.486	010YR	4306.00	953.10	962.66	961.52	964.59	0.005543	11.22	404.04	82.80	0.80
TC-M80	5.486	050YR	7263.00	953.10	966.36	965.43	967.35	0.002342	8.82	1603.30	687.36	0.55
TC-M80	5.486	100YR	8764.00	953.10	968.50		968.89	0.000863	6.28	3197.68	806.85	0.35
TC-M80	5.486	500YR	11498.00	953.10	971.49		971.66	0.000345	4.72	5861.44	1001.28	0.23
TC-M80	5.417	010YR	4306.00	949.84	962.43	957.55	963.12	0.001146	6.69	650.88	100.00	0.40
TC-M80	5.417	050YR	7263.00	949.84	965.85	960.19	966.75	0.000996	7.78	1287.58	313.45	0.39
TC-M80	5.417	100YR	8764.00	949.84	967.59	961.24	968.44	0.000822	7.73	1876.94	347.30	0.37
TC-M80	5.417	500YR	11498.00	949.84	970.62	962.99	971.34	0.000595	7.51	2976.84	380.24	0.32
TC-M80	5.407		Bridge									
TC-M80	5.394	010YR	4328.00	948.77	962.36		962.94	0.000899	6.06	713.77	80.36	0.36
TC-M80	5.394	050YR	7153.00	948.77	965.85		966.51	0.000735	6.72	1235.59	232.44	0.34
TC-M80	5.394	100YR	8524.00	948.77	967.63		968.17	0.000536	6.29	1817.44	393.60	0.30
TC-M80	5.394	500YR	11282.00	948.77	970.74		971.02	0.000266	5.07	3116.45	439.69	0.22
TC-M80	5.373	010YR	4328.00	947.97	961.99	956.29	962.75	0.001566	7.01	617.81	63.39	0.40
TC-M80	5.373	050YR	7153.00	947.97	965.09	959.03	966.24	0.001773	8.61	858.90	94.18	0.44
TC-M80	5.373	100YR	8524.00	947.97	966.60	960.16	967.85	0.001678	9.06	1014.65	132.67	0.43
TC-M80	5.373	500YR	11282.00	947.97	969.86	962.19	970.78	0.001066	8.33	2077.82	416.82	0.36
TC-M80	5.367		Bridge									
TC-M80	5.361	010YR	4328.00	947.55	960.84		962.16	0.003182	9.24	468.30	53.08	0.55
TC-M80	5.361	050YR	7153.00	947.55	962.69		965.13	0.004936	12.52	571.42	58.12	0.70
TC-M80	5.361	100YR	8524.00	947.55	963.55		966.49	0.005331	13.75	623.46	65.77	0.73
TC-M80	5.361	500YR	11282.00	947.55	964.41	963.37	968.79	0.007223	16.83	684.66	76.70	0.86
TC-M80	5.307	010YR	4328.00	947.95	960.36		961.21	0.002006	7.37	587.56	70.50	0.45
TC-M80	5.307	050YR	7153.00	947.95	962.01		963.58	0.003159	10.06	732.31	126.65	0.58
TC-M80	5.307	100YR	8524.00	947.95	963.00		964.74	0.003127	10.69	867.17	146.60	0.58
TC-M80	5.307	500YR	11282.00	947.95	964.07	961.59	966.28	0.003632	12.30	1183.96	342.60	0.64
TC-M80	5.268	010YR	4328.00	947.74	959.72		960.76	0.002197	8.31	584.24	110.12	0.48
TC-M80	5.268	050YR	7153.00	947.74	960.30	959.07	962.72	0.004762	12.75	652.84	128.53	0.72
TC-M80	5.268	100YR	8524.00	947.74	960.61	960.14	963.75	0.005994	14.60	693.95	139.41	0.81
TC-M80	5.268	500YR	11282.00	947.74	963.02	963.02	965.49	0.003989	13.74	1256.63	302.38	0.69
TC-M80	5.213	010YR	4328.00	946.75	956.18	956.18	959.31	0.011651	14.21	306.08	51.67	0.99
TC-M80	5.213	050YR	7153.00	946.75	959.32	959.32	961.15	0.005122	12.13	910.11	253.61	0.70
TC-M80	5.213	100YR	8524.00	946.75	959.82	959.82	961.81	0.005440	12.95	1036.91	257.52	0.73
TC-M80	5.213	500YR	11282.00	946.75	962.02		963.32	0.003142	11.27	1635.09	291.35	0.58
TC-M80	5.130	010YR	4328.00	942.00	955.62		956.65	0.002089	8.21	556.70	101.27	0.47
TC-M80	5.130	050YR	7153.00	942.00	957.12		959.01	0.003248	11.29	739.35	129.22	0.60
TC-M80	5.130	100YR	8524.00	942.00	957.89	955.65	960.00	0.003765	12.57	814.01	134.21	0.65
TC-M80	5.130	500YR	11282.00	942.00	958.50	957.79	961.80	0.005014	15.19	936.46	173.29	0.76
TC-M80	5.066	010YR	4328.00	942.00	954.98		955.91	0.002086	7.85	651.85	231.61	0.46
TC-M80	5.066	050YR	7153.00	942.00	956.31	953.51	957.84	0.003060	10.42	981.94	263.72	0.57
TC-M80	5.066	100YR	8524.00	942.00	956.92	955.84	958.63	0.003307	11.25	1146.03	276.02	0.60
TC-M80	5.066	500YR	11282.00	942.00	957.89	957.20	959.97	0.003819	12.79	1417.97	285.48	0.65
TC-M80	5.023	010YR	4409.00	942.00	954.66		955.38	0.002065	6.95	822.23	319.13	0.40
TC-M80	5.023	050YR	7186.00	942.00	955.97		957.05	0.002899	8.93	1275.83	364.45	0.48
TC-M80	5.023	100YR	8625.00	942.00	956.60		957.78	0.003062	9.57	1509.62	377.41	0.50
TC-M80	5.023	500YR	11511.00	942.00	957.64		958.99	0.003414	10.67	1908.50	399.20	0.53
TC-M80	4.986	010YR	4409.00	942.00	953.87	950.87	954.83	0.003626	8.37	841.64	344.76	0.51
TC-M80	4.986	050YR	7186.00	942.00	955.32		956.40	0.003889	9.64	1373.33	389.95	0.54
TC-M80	4.986	100YR	8625.00	942.00	956.00		957.08	0.003812	9.97	1647.50	417.74	0.54
TC-M80	4.986	500YR	11511.00	942.00	957.09		958.22	0.003826	10.67	2128.06	461.98	0.55
TC-M80	4.964	010YR	4409.00	941.56	951.47	950.59	954.06	0.008103	12.93	340.94	48.13	0.86
TC-M80	4.964	050YR	7186.00	941.56	954.96	954.40	956.02	0.002651	9.48	1223.88	462.05	0.52
TC-M80	4.964	100YR	8625.00	941.56	955.79		956.69	0.002179	9.05	1615.35	479.50	0.48
TC-M80	4.964	500YR	11511.00	941.56	956.96		957.82	0.001938	9.12	2189.48	508.88	0.46
TC-M80	4.912	010YR	4409.00	937.00	951.00		952.38	0.003269	9.41	468.77	51.58	0.55
TC-M80	4.912	050YR	7186.00	937.00	953.28	950.11	955.10	0.003706	11.25	1050.30	468.41	0.60
TC-M80	4.912	100YR	8625.00	937.00	953.97	953.74	955.84	0.003749	11.79	1379.12	481.01	0.61

HEC-RAS Plan: Pref2012Mod River: Turkey Creek Reach: TC-M80 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	4.912	500YR	11511.00	937.00	955.18	954.96	957.03	0.003668	12.47	1990.64	529.72	0.62
TC-M80	4.874	010YR	4409.00	937.00	950.53		951.71	0.002741	8.71	506.36	55.88	0.51
TC-M80	4.874	050YR	7186.00	937.00	952.66	949.06	954.34	0.003358	10.71	961.13	390.77	0.58
TC-M80	4.874	100YR	8625.00	937.00	953.23	950.50	955.09	0.003642	11.55	1187.31	401.25	0.61
TC-M80	4.874	500YR	11511.00	937.00	954.46	954.13	956.31	0.003543	12.22	1688.87	415.96	0.61
TC-M80	4.851	010YR	4409.00	936.00	949.99		951.34	0.003215	9.32	473.09	53.74	0.55
TC-M80	4.851	050YR	7186.00	936.00	952.49	949.31	953.89	0.002825	10.18	1197.83	442.72	0.54
TC-M80	4.851	100YR	8625.00	936.00	953.17	952.55	954.58	0.002832	10.60	1505.20	462.47	0.54
TC-M80	4.851	500YR	11511.00	936.00	954.47		955.79	0.002605	10.91	2133.41	497.66	0.53
TC-M80	4.815	010YR	4409.00	935.00	949.81		950.75	0.001922	7.83	593.52	156.07	0.43
TC-M80	4.815	050YR	7186.00	935.00	952.51		953.33	0.001460	7.99	1298.73	362.92	0.39
TC-M80	4.815	100YR	8625.00	935.00	953.10		954.02	0.001603	8.63	1538.86	456.33	0.42
TC-M80	4.815	500YR	11511.00	935.00	954.38		955.28	0.001514	8.91	2140.50	481.82	0.41
TC-M80	4.767	010YR	4409.00	934.27	949.26		950.24	0.002094	8.35	774.22	216.65	0.45
TC-M80	4.767	050YR	7186.00	934.27	952.25		952.94	0.001360	7.94	1640.40	336.82	0.38
TC-M80	4.767	100YR	8625.00	934.27	952.82		953.60	0.001513	8.61	1835.63	346.30	0.40
TC-M80	4.767	500YR	11511.00	934.27	954.03		954.88	0.001613	9.39	2267.58	367.75	0.42
TC-M80	4.722	010YR	4409.00	934.20	949.00		949.78	0.001447	7.36	709.76	154.20	0.39
TC-M80	4.722	050YR	7186.00	934.20	951.73		952.61	0.001375	8.33	1276.25	256.44	0.40
TC-M80	4.722	100YR	8625.00	934.20	952.05		953.19	0.001768	9.59	1357.23	263.63	0.45
TC-M80	4.722	500YR	11511.00	934.20	952.72		954.36	0.002472	11.70	1540.48	279.24	0.54
TC-M80	4.675	010YR	4409.00	933.41	948.79		949.39	0.001203	6.60	814.76	160.38	0.35
TC-M80	4.675	050YR	7186.00	933.41	951.55		952.24	0.001133	7.46	1437.14	317.45	0.36
TC-M80	4.675	100YR	8625.00	933.41	951.83		952.70	0.001437	8.51	1525.86	321.36	0.40
TC-M80	4.675	500YR	11511.00	933.41	952.46		953.67	0.001962	10.25	1741.02	408.68	0.47
TC-M80	4.634	010YR	5590.00	933.76	946.30	944.13	948.68	0.005347	12.41	464.78	84.96	0.70
TC-M80	4.634	050YR	8678.00	933.76	950.51	948.67	951.82	0.002249	10.24	1112.89	381.79	0.48
TC-M80	4.634	100YR	9980.00	933.76	949.80	949.32	952.04	0.003970	13.14	980.05	348.11	0.64
TC-M80	4.634	500YR	12759.00	933.76	952.55	950.55	953.15	0.001208	8.23	2680.13	716.81	0.36
TC-M80	4.605	010YR	5590.00	933.62	945.83	943.43	947.85	0.005314	11.42	489.49	60.26	0.71
TC-M80	4.605	050YR	8678.00	933.62	950.51	947.97	951.44	0.001782	8.44	1305.07	292.19	0.44
TC-M80	4.605	100YR	9980.00	933.62	949.81	948.63	951.36	0.003158	10.78	1149.80	267.11	0.58
TC-M80	4.605	500YR	12759.00	933.62	951.31	949.67	952.83	0.002776	11.02	1516.19	406.42	0.55
TC-M80	4.602		Bridge									
TC-M80	4.600	010YR	5590.00	932.60	945.41	943.71	947.52	0.005714	11.64	480.26	60.92	0.73
TC-M80	4.600	050YR	8678.00	932.60	946.49	946.49	950.36	0.009228	15.81	569.46	118.58	0.94
TC-M80	4.600	100YR	9980.00	932.60	948.40	948.40	951.21	0.005505	13.93	973.72	285.80	0.75
TC-M80	4.600	500YR	12759.00	932.60	949.72	949.72	952.61	0.005219	14.66	1334.63	336.19	0.75
TC-M80	4.58	010YR	5590.00	933.50	945.34	942.44	946.64	0.002747	9.21	637.60	152.64	0.54
TC-M80	4.58	050YR	8678.00	933.50	946.73	944.62	948.71	0.003646	11.69	968.42	338.87	0.64
TC-M80	4.58	100YR	9980.00	933.50	947.04	946.57	949.38	0.004217	12.83	1055.31	364.65	0.69
TC-M80	4.58	500YR	12759.00	933.50	948.00	948.00	950.69	0.004573	14.15	1356.19	408.48	0.73
TC-M80	4.516	010YR	5794.00	933.47	944.35	941.40	945.57	0.005015	8.86	653.63	83.70	0.56
TC-M80	4.516	050YR	8813.00	933.47	946.02	943.41	947.32	0.004699	9.67	1066.81	306.13	0.56
TC-M80	4.516	100YR	10144.00	933.47	946.46		947.80	0.004744	10.02	1203.08	320.60	0.56
TC-M80	4.516	500YR	13005.00	933.47	947.42		948.75	0.004364	10.23	1524.70	357.59	0.55
TC-M80	4.448	010YR	5794.00	931.63	943.49		944.34	0.002101	7.58	884.80	382.33	0.47
TC-M80	4.448	050YR	8813.00	931.63	945.90		946.39	0.001077	6.46	1985.50	533.94	0.35
TC-M80	4.448	100YR	10144.00	931.63	946.36		946.85	0.001085	6.67	2235.05	553.55	0.35
TC-M80	4.448	500YR	13005.00	931.63	947.38		947.86	0.001000	6.79	2816.85	582.30	0.35
TC-M80	4.368	010YR	5794.00	931.16	942.23	939.31	943.42	0.002092	8.83	718.61	259.64	0.55
TC-M80	4.368	050YR	8813.00	931.16	945.29		945.94	0.000955	7.39	1841.24	458.80	0.39
TC-M80	4.368	100YR	10144.00	931.16	945.61		946.37	0.001089	8.05	1993.65	482.41	0.42
TC-M80	4.368	500YR	13005.00	931.16	946.45		947.36	0.001243	9.01	2421.78	543.26	0.45
TC-M80	4.302	010YR	5794.00	929.79	941.90		942.74	0.001356	7.42	836.68	202.72	0.45
TC-M80	4.302	050YR	8813.00	929.79	945.27		945.61	0.000516	5.39	2268.17	587.92	0.29
TC-M80	4.302	100YR	10144.00	929.79	945.61		945.99	0.000567	5.77	2469.95	598.53	0.30
TC-M80	4.302	500YR	13005.00	929.79	946.49		946.92	0.000593	6.20	3011.64	626.12	0.31
TC-M80	4.254	010YR	5794.00	929.00	941.65	937.11	942.32	0.001579	6.53	887.69	116.41	0.41
TC-M80	4.254	050YR	8813.00	929.00	944.94	939.02	945.42	0.000930	5.97	1981.83	465.33	0.33
TC-M80	4.254	100YR	10144.00	929.00	945.21	939.74	945.78	0.001077	6.54	2108.57	469.39	0.36
TC-M80	4.254	500YR	13005.00	929.00	946.02	941.15	946.69	0.001209	7.27	2501.24	531.33	0.38

HEC-RAS Plan: Pref2012Mod River: Turkey Creek Reach: TC-M80 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	4.244		Bridge									
TC-M80	4.234	010YR	5877.00	928.98	940.91		941.86	0.002237	7.81	752.81	95.41	0.49
TC-M80	4.234	050YR	8781.00	928.98	943.02		944.03	0.001898	8.40	1197.80	228.86	0.47
TC-M80	4.234	100YR	10047.00	928.98	943.50		944.61	0.002004	8.90	1308.67	233.81	0.48
TC-M80	4.234	500YR	12846.00	928.98	944.35		945.71	0.002285	10.00	1511.57	245.20	0.52
TC-M80	4.169	010YR	5877.00	928.27	939.68		940.88	0.003053	8.79	668.93	88.94	0.56
TC-M80	4.169	050YR	8781.00	928.27	941.52	938.70	943.04	0.003170	10.06	988.75	292.91	0.60
TC-M80	4.169	100YR	10047.00	928.27	942.07	939.43	943.62	0.003111	10.37	1151.15	303.82	0.60
TC-M80	4.169	500YR	12846.00	928.27	942.95	942.30	944.65	0.003231	11.22	1432.62	336.71	0.62
TC-M80	4.099	010YR	5877.00	927.41	937.79		939.52	0.004170	10.59	563.23	103.16	0.66
TC-M80	4.099	050YR	8781.00	927.41	939.09	939.07	941.51	0.005019	12.84	789.72	195.04	0.74
TC-M80	4.099	100YR	10047.00	927.41	939.75	939.75	942.15	0.004737	13.06	926.60	237.65	0.73
TC-M80	4.099	500YR	12846.00	927.41	940.97	940.97	943.27	0.004245	13.35	1261.42	301.82	0.70
TC-M80	4.050	010YR	5877.00	927.18	936.95	935.23	938.55	0.003140	10.29	626.84	179.24	0.67
TC-M80	4.050	050YR	8781.00	927.18	938.57	937.97	940.34	0.002918	11.32	950.25	218.99	0.66
TC-M80	4.050	100YR	10047.00	927.18	939.25	938.50	940.99	0.002704	11.44	1105.19	235.79	0.65
TC-M80	4.050	500YR	12846.00	927.18	940.72		942.26	0.002149	11.21	1491.04	289.90	0.59
TC-M80	3.990	010YR	5877.00	925.40	936.68		937.53	0.002058	7.57	894.43	301.50	0.47
TC-M80	3.990	050YR	8781.00	925.40	938.79		939.41	0.001326	7.09	1605.56	422.41	0.39
TC-M80	3.990	100YR	10047.00	925.40	939.55		940.13	0.001153	6.93	1957.80	512.67	0.37
TC-M80	3.990	500YR	12846.00	925.40	941.06		941.55	0.000888	6.63	2858.92	630.62	0.33
TC-M80	3.952	010YR	5877.00	923.68	936.74		937.21	0.000623	5.64	1443.57	358.95	0.31
TC-M80	3.952	050YR	8781.00	923.68	938.64		939.22	0.000666	6.53	2146.06	379.13	0.33
TC-M80	3.952	100YR	10047.00	923.68	939.34		939.95	0.000679	6.85	2458.98	534.49	0.34
TC-M80	3.952	500YR	12846.00	923.68	940.75		941.38	0.000661	7.24	3323.21	641.15	0.34
TC-M80	3.921	010YR	5877.00	924.12	936.33		937.03	0.001299	6.92	1105.23	223.36	0.38
TC-M80	3.921	050YR	8781.00	924.12	938.00		939.00	0.001571	8.43	1503.90	252.84	0.43
TC-M80	3.921	100YR	10047.00	924.12	938.60		939.72	0.001675	9.00	1658.56	263.61	0.45
TC-M80	3.921	500YR	12846.00	924.12	939.74		941.12	0.001900	10.16	1969.04	283.99	0.49
TC-M80	3.892	010YR	5877.00	924.24	935.39	932.64	936.68	0.003291	9.19	760.49	250.64	0.59
TC-M80	3.892	050YR	8781.00	924.24	937.04		938.62	0.003447	10.50	1190.35	267.14	0.62
TC-M80	3.892	100YR	10047.00	924.24	937.64		939.32	0.003483	10.98	1352.17	272.05	0.62
TC-M80	3.892	500YR	12846.00	924.24	938.76		940.69	0.003640	12.02	1662.64	282.47	0.65
TC-M80	3.855	010YR	5877.00	923.69	935.32		936.15	0.001373	7.34	861.39	152.31	0.45
TC-M80	3.855	050YR	8781.00	923.69	936.81		938.08	0.001721	9.17	1106.43	172.66	0.52
TC-M80	3.855	100YR	10047.00	923.69	937.31		938.79	0.001878	9.90	1195.30	176.63	0.54
TC-M80	3.855	500YR	12846.00	923.69	938.11	935.44	940.14	0.002356	11.65	1340.37	242.47	0.62
TC-M80	3.823	010YR	5877.00	923.59	935.12		935.89	0.001486	7.07	831.88	113.71	0.46
TC-M80	3.823	050YR	8781.00	923.59	936.53		937.75	0.001952	8.84	1001.84	127.47	0.53
TC-M80	3.823	100YR	10047.00	923.59	937.01		938.43	0.002132	9.58	1070.58	173.82	0.56
TC-M80	3.823	500YR	12846.00	923.59	937.74	935.10	939.68	0.002651	11.24	1234.79	280.70	0.63
TC-M80	3.726	010YR	6469.00	921.00	934.74	927.44	935.04	0.001306	4.62	1504.08	358.29	0.23
TC-M80	3.726	050YR	9108.00	921.00	936.58	928.96	936.81	0.000887	3.80	2408.26	497.38	0.18
TC-M80	3.726	100YR	10381.00	921.00	937.23	929.66	937.45	0.000788	3.69	2736.97	522.37	0.17
TC-M80	3.726	500YR	13363.00	921.00	938.27	931.17	938.54	0.000740	3.75	3306.40	567.78	0.17
TC-M80	3.711		Culvert									
TC-M80	3.690	010YR	6469.00	919.85	932.39	926.98	932.91	0.001334	5.77	1126.51	178.71	0.36
TC-M80	3.690	050YR	9108.00	919.85	934.46	929.04	934.92	0.000974	5.75	1814.03	693.39	0.32
TC-M80	3.690	100YR	10381.00	919.85	935.54	929.61	935.83	0.000579	4.74	2450.78	857.90	0.25
TC-M80	3.690	500YR	13363.00	919.85	937.17	930.79	937.39	0.000310	3.80	3528.85	1051.95	0.19
TC-M80	3.665	010YR	10718.00	920.00	930.14	928.69	932.11	0.005248	11.29	979.28	197.55	0.74
TC-M80	3.665	050YR	14839.00	920.00	932.71	930.84	934.33	0.003081	10.58	1582.01	355.61	0.59
TC-M80	3.665	100YR	16855.00	920.00	933.90	931.50	935.33	0.002431	10.14	2072.85	450.40	0.54
TC-M80	3.665	500YR	21037.00	920.00	936.34	932.82	937.14	0.001187	8.09	3826.09	881.32	0.39
TC-M80	3.607	010YR	10718.00	916.87	927.30	926.37	930.17	0.006866	13.60	788.37	98.11	0.85
TC-M80	3.607	050YR	14839.00	916.87	928.97	928.26	932.71	0.007423	15.51	956.45	102.74	0.90
TC-M80	3.607	100YR	16855.00	916.87	930.12	929.11	933.92	0.006665	15.66	1081.39	112.39	0.88
TC-M80	3.607	500YR	21037.00	916.87	931.03	931.03	935.96	0.007766	17.87	1201.24	139.01	0.94
TC-M80	3.570	010YR	10718.00	915.68	925.98	924.84	928.86	0.006522	13.61	789.79	104.58	0.83
TC-M80	3.570	050YR	14839.00	915.68	927.95	927.95	931.29	0.006002	14.85	1092.26	216.75	0.82
TC-M80	3.570	100YR	16855.00	915.68	930.79	929.03	932.55	0.002562	11.42	1810.59	277.55	0.56
TC-M80	3.570	500YR	21037.00	915.68	930.29	930.29	933.49	0.004797	15.23	1675.42	269.78	0.78

HEC-RAS Plan: Pref2012Mod River: Turkey Creek Reach: TC-M80 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	3.560	010YR	10718.00	915.00	925.99	924.24	928.51	0.005237	12.74	846.04	107.45	0.75
TC-M80	3.560	050YR	14839.00	915.00	927.32	926.98	930.78	0.006106	15.07	1026.73	196.87	0.82
TC-M80	3.560	100YR	16855.00	915.00	931.19	929.09	932.05	0.001033	7.65	2424.13	408.05	0.36
TC-M80	3.560	500YR	21037.00	915.00	929.86	929.86	932.10	0.003269	12.75	1882.44	399.80	0.62
TC-M80	3.539	010YR	10718.00	913.76	925.36	924.36	927.78	0.004848	12.62	863.47	123.24	0.72
TC-M80	3.539	050YR	14839.00	913.76	926.23	926.23	929.88	0.006475	15.45	983.36	146.75	0.84
TC-M80	3.539	100YR	16855.00	913.76	926.92	926.92	930.84	0.006320	15.93	1085.46	146.75	0.84
TC-M80	3.539	500YR	21037.00	913.76	928.79	928.79	930.93	0.002731	11.60	1951.67	619.01	0.57
TC-M80	3.481	010YR	10718.00	912.13	923.99	923.99	926.29	0.004638	12.62	968.74	230.04	0.71
TC-M80	3.481	050YR	14839.00	912.13	925.30	925.30	927.79	0.004490	13.50	1274.53	234.43	0.72
TC-M80	3.481	100YR	16855.00	912.13	925.74	925.74	928.45	0.004670	14.13	1377.43	234.43	0.73
TC-M80	3.481	500YR	21037.00	912.13	927.45	926.59	929.91	0.003426	13.28	1778.36	234.43	0.64
TC-M80	3.420	010YR	10718.00	910.56	920.76	920.76	923.70	0.006844	14.16	853.70	154.10	0.84
TC-M80	3.420	050YR	14839.00	910.56	922.44	922.44	925.72	0.006386	15.35	1129.62	171.21	0.83
TC-M80	3.420	100YR	16855.00	910.56	923.06	923.06	926.58	0.006467	16.05	1235.54	171.21	0.85
TC-M80	3.420	500YR	21037.00	910.56	924.24	924.24	928.25	0.006584	17.32	1437.87	171.21	0.87
TC-M80	3.345	010YR	10718.00	907.25	917.59	917.59	920.19	0.005818	13.35	916.50	194.92	0.80
TC-M80	3.345	050YR	14839.00	907.25	919.01	919.01	921.99	0.005744	14.67	1194.41	194.92	0.81
TC-M80	3.345	100YR	16855.00	907.25	919.97	919.57	922.81	0.004998	14.53	1380.48	194.92	0.77
TC-M80	3.345	500YR	21037.00	907.25	921.87	920.63	922.95	0.002021	10.27	3095.40	652.67	0.50
TC-M80	3.298	010YR	10718.00	904.24	915.44	913.78	917.93	0.006646	12.76	893.20	185.48	0.74
TC-M80	3.298	050YR	14839.00	904.24	918.48	916.75	920.34	0.003749	11.59	1468.81	189.65	0.58
TC-M80	3.298	100YR	16855.00	904.24	919.77	917.38	921.51	0.003121	11.31	1714.85	189.65	0.54
TC-M80	3.298	500YR	21037.00	904.24	921.55	918.52	922.45	0.001608	8.81	3071.07	631.38	0.40
TC-M80	3.231	010YR	10718.00	901.95	914.87	909.76	916.07	0.002457	8.83	1257.69	170.09	0.44
TC-M80	3.231	050YR	14839.00	901.95	917.90	911.51	919.13	0.001990	9.20	1814.02	188.52	0.41
TC-M80	3.231	100YR	16855.00	901.95	919.22	912.31	920.46	0.001829	9.32	2064.13	188.52	0.40
TC-M80	3.231	500YR	21037.00	901.95	920.87	913.86	921.86	0.001425	8.76	3040.61	553.34	0.36
TC-M80	3.230		Inl Struct									
TC-M80	3.225	010YR	10718.00	897.35	914.86	907.09	915.73	0.001461	7.49	1500.60	181.23	0.36
TC-M80	3.225	050YR	14839.00	897.35	917.89	909.02	918.84	0.001297	8.06	2065.24	187.02	0.35
TC-M80	3.225	100YR	16855.00	897.35	919.22	909.91	920.21	0.001236	8.28	2313.41	187.02	0.35
TC-M80	3.225	500YR	21037.00	897.35	920.54	911.60	921.70	0.001368	9.14	2909.51	475.89	0.37
TC-M80	3.165	010YR	10718.00	896.85	912.83	908.33	914.85	0.001968	11.66	992.51	98.74	0.53
TC-M80	3.165	050YR	14839.00	896.85	915.24	910.89	917.83	0.002127	13.41	1251.78	114.19	0.57
TC-M80	3.165	100YR	16855.00	896.85	916.43	912.09	919.18	0.002093	13.91	1387.70	114.19	0.57
TC-M80	3.165	500YR	21037.00	896.85	920.49	913.77	921.20	0.000584	8.39	3804.08	561.46	0.31
TC-M80	3.096	010YR	10718.00	898.00	912.65	908.12	914.01	0.001584	9.37	1183.14	131.90	0.50
TC-M80	3.096	050YR	14839.00	898.00	915.29	910.19	916.91	0.001441	10.30	1536.81	136.30	0.49
TC-M80	3.096	100YR	16855.00	898.00	916.54	911.09	918.25	0.001369	10.65	1755.41	224.95	0.49
TC-M80	3.096	500YR	21037.00	898.00	920.41	912.76	920.95	0.000443	7.06	4853.15	596.97	0.29
TC-M80	3.070	010YR	11200.00	896.11	913.10	904.40	913.65	0.000509	5.93	1903.09	178.78	0.29
TC-M80	3.070	050YR	15507.00	896.11	915.82	906.12	916.52	0.000507	6.72	2395.36	183.17	0.30
TC-M80	3.070	100YR	17691.00	896.11	917.10	906.92	917.86	0.000503	7.05	2630.54	188.20	0.30
TC-M80	3.070	500YR	22293.00	896.11	920.47	908.46	920.86	0.000256	5.68	6230.40	658.37	0.22
TC-M80	3.056		Bridge									
TC-M80	3.040	010YR	11200.00	896.15	912.87	904.37	913.44	0.000513	6.06	1853.16	152.18	0.29
TC-M80	3.040	050YR	15507.00	896.15	915.32	906.09	916.09	0.000550	7.03	2231.94	156.97	0.31
TC-M80	3.040	100YR	17691.00	896.15	916.38	906.90	917.24	0.000572	7.49	2398.03	159.02	0.32
TC-M80	3.040	500YR	22293.00	896.15	920.01	908.46	920.32	0.000174	4.70	5037.01	497.82	0.18
TC-M80	2.945	010YR	11200.00	896.09	910.11	907.12	912.42	0.002815	12.27	951.42	147.26	0.64
TC-M80	2.945	050YR	15507.00	896.09	913.18	910.78	915.23	0.001882	11.79	1412.06	152.68	0.55
TC-M80	2.945	100YR	17691.00	896.09	914.21	911.58	916.38	0.001796	12.06	1569.65	154.40	0.54
TC-M80	2.945	500YR	22293.00	896.09	920.03	912.91	920.19	0.000077	3.10	7115.51	818.26	0.12
TC-M80	2.813	010YR	10849.00	892.15	910.12	903.44	911.03	0.000834	7.79	1541.24	171.54	0.38
TC-M80	2.813	050YR	15185.00	892.15	913.06	905.65	914.14	0.000788	8.65	2055.29	178.15	0.38
TC-M80	2.813	100YR	17348.00	892.15	914.07	906.57	915.28	0.000822	9.19	2236.82	180.11	0.39
TC-M80	2.813	500YR	22087.00	892.15	919.86	908.35	920.11	0.000180	5.22	9077.75	1013.44	0.19
TC-M80	2.777	010YR	10849.00	892.15	909.49	904.38	910.79	0.001387	9.15	1203.71	114.94	0.47
TC-M80	2.777	050YR	15185.00	892.15	912.45	906.57	913.92	0.001193	9.85	1605.01	145.60	0.45
TC-M80	2.777	100YR	17348.00	892.15	913.43	907.46	915.06	0.001206	10.34	1748.91	148.32	0.46
TC-M80	2.777	500YR	22087.00	892.15	919.94	909.35	920.06	0.000039	2.33	8057.51	914.81	0.09

HEC-RAS Plan: Pref2012Mod River: Turkey Creek Reach: TC-M80 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	2.719	010YR	10849.00	890.42	908.86	903.02	910.32	0.001570	9.69	1120.82	95.41	0.49
TC-M80	2.719	050YR	15185.00	890.42	911.62	905.63	913.47	0.001538	10.98	1438.55	124.60	0.50
TC-M80	2.719	100YR	17348.00	890.42	912.42	906.73	914.57	0.001671	11.85	1539.97	127.18	0.52
TC-M80	2.719	500YR	22087.00	890.42	919.85	908.84	920.04	0.000112	3.97	6643.11	672.70	0.15
TC-M80	2.651	010YR	10849.00	886.70	908.92	898.60	909.76	0.000734	7.36	1496.87	134.34	0.33
TC-M80	2.651	050YR	15185.00	886.70	911.90	901.07	912.85	0.000677	7.97	1976.15	164.62	0.33
TC-M80	2.651	100YR	17348.00	886.70	912.81	902.17	913.87	0.000708	8.43	2126.62	164.62	0.34
TC-M80	2.651	500YR	22087.00	886.70	919.90	904.39	919.99	0.000034	2.30	9327.07	864.27	0.08
TC-M80	2.636		Bridge									
TC-M80	2.623	010YR	10849.00	887.04	904.45	897.42	905.54	0.001131	8.35	1299.85	100.64	0.41
TC-M80	2.623	050YR	15185.00	887.04	906.33	899.59	907.94	0.001473	10.17	1494.80	107.58	0.47
TC-M80	2.623	100YR	17348.00	887.04	907.81	900.61	909.53	0.001381	10.51	1659.49	121.32	0.47
TC-M80	2.623	500YR	22087.00	887.04	910.07	902.71	912.18	0.001422	11.66	1935.90	122.39	0.48
TC-M80	2.594	010YR	10849.00	886.89	903.53		905.14	0.002262	10.17	1071.06	90.20	0.51
TC-M80	2.594	050YR	15185.00	886.89	904.65		907.29	0.003325	13.06	1173.67	93.28	0.62
TC-M80	2.594	100YR	17348.00	886.89	906.09		908.89	0.003092	13.46	1311.03	97.26	0.61
TC-M80	2.594	500YR	22087.00	886.89	908.87	903.83	911.67	0.002590	13.79	2109.32	494.73	0.57
TC-M80	2.507	010YR	10849.00	885.68	902.92		904.12	0.001686	8.79	1234.69	101.46	0.44
TC-M80	2.507	050YR	15185.00	885.68	903.66		905.75	0.002723	11.61	1310.21	104.13	0.57
TC-M80	2.507	100YR	17348.00	885.68	905.32		907.46	0.002378	11.75	1488.28	110.63	0.54
TC-M80	2.507	500YR	22087.00	885.68	908.24	901.99	910.47	0.001999	12.15	2157.83	480.65	0.51
TC-M80	2.484	010YR	10849.00	884.92	902.54	896.29	903.89	0.001849	9.33	1163.47	91.96	0.46
TC-M80	2.484	050YR	15185.00	884.92	902.78	898.70	905.33	0.003404	12.82	1187.87	129.25	0.62
TC-M80	2.484	100YR	17348.00	884.92	905.02	899.76	907.17	0.002414	11.98	1721.88	332.54	0.54
TC-M80	2.484	500YR	22087.00	884.92	908.89	901.85	909.93	0.001098	9.38	3947.61	656.01	0.38
TC-M80	2.479		Bridge									
TC-M80	2.471	010YR	10849.00	884.98	899.51		901.79	0.003916	12.12	894.94	78.43	0.63
TC-M80	2.471	050YR	15185.00	884.98	902.59	898.45	905.32	0.003594	13.26	1152.90	113.23	0.62
TC-M80	2.471	100YR	17348.00	884.98	904.76	899.61	907.14	0.002687	12.62	1660.66	345.68	0.55
TC-M80	2.471	500YR	22087.00	884.98	905.31	901.71	908.70	0.003733	15.21	1877.28	431.09	0.66
TC-M80	2.438	010YR	10849.00	883.99	897.75		900.79	0.004920	14.00	782.19	74.99	0.73
TC-M80	2.438	050YR	15185.00	883.99	898.66	898.04	903.73	0.007412	18.09	851.71	77.03	0.91
TC-M80	2.438	100YR	17348.00	883.99	899.14	899.14	905.24	0.008493	19.87	888.78	78.05	0.98
TC-M80	2.438	500YR	22087.00	883.99	904.81	904.81	907.99	0.003081	15.30	2344.76	529.18	0.63
TC-M80	2.396	010YR	9843.00	883.61	898.19		899.50	0.002514	9.20	1070.53	108.46	0.51
TC-M80	2.396	050YR	14448.00	883.61	899.58		901.76	0.003526	11.87	1225.65	114.68	0.61
TC-M80	2.396	100YR	16613.00	883.61	900.48	897.13	902.95	0.003618	12.64	1330.87	134.81	0.63
TC-M80	2.396	500YR	21526.00	883.61	901.23	898.96	904.83	0.004918	15.32	1518.44	312.55	0.74
TC-M80	2.312	010YR	9843.00	882.92	897.69		898.55	0.001422	7.63	1555.65	298.81	0.41
TC-M80	2.312	050YR	14448.00	882.92	899.23		900.40	0.001742	9.20	2040.27	332.42	0.46
TC-M80	2.312	100YR	16613.00	882.92	900.43		901.55	0.001536	9.17	2460.44	365.59	0.44
TC-M80	2.312	500YR	21526.00	882.92	901.52		902.93	0.001817	10.49	2878.23	400.03	0.48
TC-M80	2.208	010YR	9843.00	882.53	897.47	893.38	897.80	0.000825	5.68	3020.89	670.67	0.31
TC-M80	2.208	050YR	14448.00	882.53	899.21	895.56	899.54	0.000752	6.00	4219.55	708.87	0.30
TC-M80	2.208	100YR	16613.00	882.53	900.54	896.44	900.81	0.000571	5.60	5179.68	737.77	0.27
TC-M80	2.208	500YR	21526.00	882.53	901.74	897.21	902.06	0.000616	6.15	6084.40	764.78	0.28
TC-M80	2.132	010YR	9843.00	882.42	894.20	892.86	896.87	0.005661	13.13	754.25	605.98	0.78
TC-M80	2.132	050YR	14448.00	882.42	899.12	895.10	899.28	0.000374	4.54	5956.77	980.33	0.22
TC-M80	2.132	100YR	16613.00	882.42	900.48	896.24	900.61	0.000286	4.22	7315.41	1023.34	0.19
TC-M80	2.132	500YR	21526.00	882.42	901.68	897.05	901.83	0.000318	4.69	8662.73	1183.31	0.20
TC-M80	2.12	010YR	9843.00	882.14	891.71	891.71	895.43	0.008779	15.75	666.65	281.11	0.98
TC-M80	2.12	050YR	14448.00	882.14	894.06	894.06	898.64	0.007792	17.60	902.81	688.05	0.96
TC-M80	2.12	100YR	16613.00	882.14	896.25	895.34	900.09	0.005199	16.32	1245.19	809.81	0.81
TC-M80	2.12	500YR	21526.00	882.14	901.64	897.44	901.77	0.000252	4.56	10019.92	1366.12	0.19
TC-M80	2.065	010YR	10894.00	874.00	889.75	882.62	890.51	0.001091	6.99	1559.53	875.73	0.36
TC-M80	2.065	050YR	16224.00	874.00	894.38	884.95	895.23	0.000804	7.40	2192.92	1208.86	0.33
TC-M80	2.065	100YR	18733.00	874.00	896.60	885.92	897.47	0.000695	7.50	2497.32	1297.38	0.31
TC-M80	2.065	500YR	24355.00	874.00	900.11	887.88	901.15	0.000653	8.18	2978.77	1337.38	0.31
TC-M80	2.049		Bridge									
TC-M80	2.035	010YR	10894.00	872.42	889.05	881.37	889.79	0.001025	6.88	1582.49	682.78	0.35
TC-M80	2.035	050YR	16224.00	872.42	892.66	883.77	893.62	0.000972	7.84	2068.41	991.20	0.35
TC-M80	2.035	100YR	18733.00	872.42	894.12	884.76	895.18	0.000957	8.27	2265.19	1075.43	0.36

HEC-RAS Plan: Pref2012Mod River: Turkey Creek Reach: TC-M80 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	2.035	500YR	24355.00	872.42	896.96	886.82	898.27	0.000956	9.19	2650.45	1222.60	0.37
TC-M80	2.020	010YR	10894.00	870.78	888.98	881.01	889.69	0.001071	6.76	1612.12	621.70	0.35
TC-M80	2.020	050YR	16224.00	870.78	892.61	883.40	893.52	0.000967	7.67	2127.07	878.33	0.34
TC-M80	2.020	100YR	18733.00	870.78	894.06	884.42	895.07	0.000949	8.07	2337.94	1002.63	0.35
TC-M80	2.020	500YR	24355.00	870.78	896.92	886.60	898.15	0.000943	8.93	2750.80	1128.32	0.35
TC-M80	2.016		Bridge									
TC-M80	2.012	010YR	10894.00	870.45	887.88	882.36	889.20	0.001979	9.21	1182.43	302.15	0.47
TC-M80	2.012	050YR	16224.00	870.45	891.08	884.93	892.88	0.002063	10.77	1516.93	685.39	0.49
TC-M80	2.012	100YR	18733.00	870.45	892.37	886.01	894.38	0.002068	11.40	1670.38	739.97	0.50
TC-M80	2.012	500YR	24355.00	870.45	895.07	888.27	897.41	0.002003	12.44	2054.00	996.46	0.50
TC-M80	2.002	010YR	10894.00	871.00	887.82	882.21	889.09	0.001903	9.02	1208.32	357.14	0.47
TC-M80	2.002	050YR	16224.00	871.00	891.05	884.89	892.74	0.001906	10.44	1557.53	617.91	0.48
TC-M80	2.002	100YR	18733.00	871.00	892.34	885.99	894.24	0.001904	11.05	1703.40	690.70	0.49
TC-M80	2.002	500YR	24355.00	871.00	895.00	888.21	897.31	0.001896	12.23	2016.13	903.49	0.50
TC-M80	1.946		Bridge									
TC-M80	1.927	010YR	10894.00	869.70	884.21		885.97	0.005313	10.64	1023.62	113.95	0.63
TC-M80	1.927	050YR	16224.00	869.70	887.18		889.35	0.005199	11.85	1369.59	119.38	0.62
TC-M80	1.927	100YR	18733.00	869.70	888.54		890.82	0.004703	12.14	1588.18	230.19	0.60
TC-M80	1.927	500YR	24355.00	869.70	892.41	886.55	893.79	0.002307	10.14	2876.88	433.92	0.44
TC-M80	1.878	010YR	10894.00	869.00	882.53		884.70	0.003740	11.84	920.31	87.78	0.64
TC-M80	1.878	050YR	16224.00	869.00	884.00	882.04	887.56	0.005556	15.14	1074.16	112.63	0.84
TC-M80	1.878	100YR	18733.00	869.00	884.51	883.81	888.60	0.006485	16.63	1132.51	115.82	0.90
TC-M80	1.878	500YR	24355.00	869.00	885.85	885.85	891.51	0.007844	19.13	1293.97	124.77	0.97
TC-M80	1.849	010YR	10894.00	868.97	881.45	880.36	883.93	0.006325	13.01	942.46	159.82	0.71
TC-M80	1.849	050YR	16224.00	868.97	883.14	883.14	886.52	0.007406	15.56	1241.69	189.31	0.79
TC-M80	1.849	100YR	18733.00	868.97	883.93	883.93	887.52	0.007432	16.25	1392.81	195.66	0.80
TC-M80	1.849	500YR	24355.00	868.97	885.44	885.44	889.53	0.007589	17.67	1697.82	207.90	0.82
TC-M80	1.814	010YR	10894.00	868.97	881.45		882.62	0.003770	10.05	1432.66	264.95	0.56
TC-M80	1.814	050YR	16224.00	868.97	883.28		884.66	0.003605	11.01	1929.81	275.84	0.57
TC-M80	1.814	100YR	18733.00	868.97	883.95		885.46	0.003696	11.57	2114.08	280.23	0.58
TC-M80	1.814	500YR	24355.00	868.97	885.16		887.03	0.004029	12.86	2462.24	301.20	0.61
TC-M80	1.767	010YR	10894.00	868.69	879.94		881.53	0.005258	11.95	1250.77	252.65	0.74
TC-M80	1.767	050YR	16224.00	868.69	881.95		883.67	0.004522	12.86	1813.79	299.39	0.71
TC-M80	1.767	100YR	18733.00	868.69	882.78		884.51	0.004164	13.00	2061.91	304.79	0.69
TC-M80	1.767	500YR	24355.00	868.69	883.95		886.02	0.004372	14.26	2423.93	310.96	0.72
TC-M80	1.702	010YR	10894.00	867.59	879.27		880.07	0.002496	8.79	1792.57	319.26	0.53
TC-M80	1.702	050YR	16224.00	867.59	881.57		882.41	0.001968	9.13	2552.10	336.05	0.48
TC-M80	1.702	100YR	18733.00	867.59	882.42		883.30	0.001910	9.45	2837.87	340.64	0.48
TC-M80	1.702	500YR	24355.00	867.59	883.54		884.69	0.002203	10.78	3223.95	346.74	0.53
TC-M80	1.651	010YR	10294.00	866.55	878.36	875.92	879.42	0.002277	9.49	1688.14	388.38	0.52
TC-M80	1.651	050YR	15699.00	866.55	881.00	878.52	881.92	0.001675	9.46	2643.07	579.35	0.46
TC-M80	1.651	100YR	18034.00	866.55	881.92	879.02	882.84	0.001586	9.63	2984.98	638.15	0.45
TC-M80	1.651	500YR	23968.00	866.55	882.83	880.13	884.11	0.002066	11.46	3331.70	649.81	0.52
TC-M80	1.607	010YR	10294.00	865.15	877.97	876.73	878.81	0.002446	9.24	1861.95	530.83	0.52
TC-M80	1.607	050YR	15699.00	865.15	880.84	877.86	881.48	0.001488	8.56	2996.13	621.15	0.42
TC-M80	1.607	100YR	18034.00	865.15	881.79	878.30	882.42	0.001352	8.56	3396.32	647.44	0.41
TC-M80	1.607	500YR	23968.00	865.15	883.15	879.28	883.56	0.000858	7.27	5249.55	735.94	0.33
TC-M80	1.560	010YR	10294.00	863.94	877.79	875.29	878.33	0.001173	7.21	2290.71	522.31	0.37
TC-M80	1.560	050YR	15699.00	863.94	880.87	876.63	881.17	0.000574	5.90	4310.97	730.30	0.27
TC-M80	1.560	100YR	18034.00	863.94	881.87	877.10	882.13	0.000474	5.60	5074.18	775.95	0.25
TC-M80	1.560	500YR	23968.00	863.94	883.08	878.18	883.38	0.000481	5.94	6019.35	785.57	0.26
TC-M80	1.512	010YR	10294.00	861.92	877.55	874.16	878.05	0.000978	6.83	2184.37	408.91	0.35
TC-M80	1.512	050YR	15699.00	861.92	880.69	875.68	881.03	0.000556	6.02	3934.62	689.96	0.27
TC-M80	1.512	100YR	18034.00	861.92	881.72	876.22	882.02	0.000456	5.68	4672.55	728.13	0.25
TC-M80	1.512	500YR	23968.00	861.92	882.92	877.44	883.26	0.000477	6.09	5578.99	766.93	0.26
TC-M80	1.395	010YR	10294.00	859.54	874.71	871.77	876.87	0.003293	11.91	885.24	422.54	0.61
TC-M80	1.395	050YR	15699.00	859.54	878.15	875.75	880.25	0.002039	11.13	1389.03	606.21	0.50
TC-M80	1.395	100YR	18034.00	859.54	878.87	876.77	881.28	0.001991	11.35	1513.90	633.29	0.50
TC-M80	1.395	500YR	23968.00	859.54	882.89	878.21	883.07	0.000133	3.41	7283.73	817.29	0.13
TC-M80	1.362	010YR	10294.00	859.24	873.60	871.19	876.18	0.004102	13.31	838.63	399.83	0.68
TC-M80	1.362	050YR	15699.00	859.24	875.92	874.97	879.57	0.004738	16.10	1091.69	548.49	0.75
TC-M80	1.362	100YR	18034.00	859.24	876.96	876.94	880.65	0.004458	16.37	1246.93	625.62	0.74

HEC-RAS Plan: Pref2012Mod River: Turkey Creek Reach: TC-M80 (Continued)

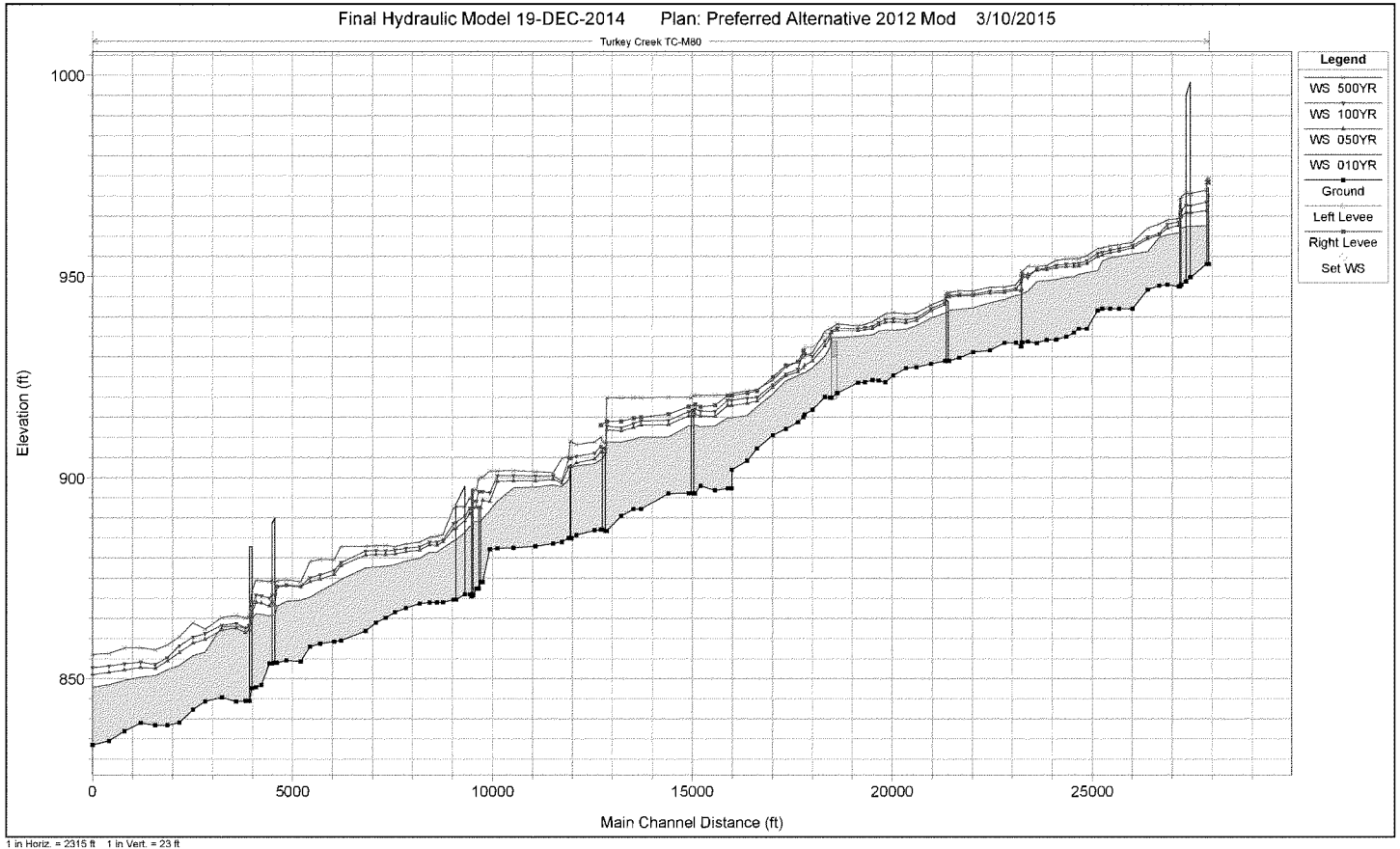
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	1.362	500YR	23968.00	859.24	879.57	878.92	882.70	0.003032	14.98	1731.83	710.70	0.62
TC-M80	1.296	010YR	10294.00	858.77	871.77	870.63	874.61	0.004809	14.04	829.80	366.93	0.73
TC-M80	1.296	050YR	15699.00	858.77	874.77	873.75	877.86	0.004148	15.22	1241.50	454.79	0.71
TC-M80	1.296	100YR	18034.00	858.77	875.82	874.66	879.04	0.004018	15.70	1406.07	494.12	0.70
TC-M80	1.296	500YR	23968.00	858.77	879.70	877.76	881.51	0.001796	12.18	2322.27	957.48	0.49
TC-M80	1.248	010YR	10294.00	858.02	870.27	869.97	873.27	0.005767	14.58	805.51	122.83	0.79
TC-M80	1.248	050YR	15699.00	858.02	874.13	872.31	876.74	0.003577	14.13	1349.67	256.82	0.66
TC-M80	1.248	100YR	18034.00	858.02	875.10	873.21	877.95	0.003674	14.96	1536.32	347.12	0.67
TC-M80	1.248	500YR	23968.00	858.02	879.12	874.80	881.02	0.001991	12.85	2565.07	710.62	0.51
TC-M80	1.204	010YR	10981.00	854.31	869.55	867.11	871.92	0.004391	12.37	891.61	333.72	0.69
TC-M80	1.204	050YR	16834.00	854.31	872.90	870.06	875.85	0.003759	13.91	1256.05	427.03	0.67
TC-M80	1.204	100YR	19441.00	854.31	873.02	871.24	876.87	0.004852	15.90	1270.77	429.82	0.77
TC-M80	1.204	500YR	26130.00	854.31	874.11	874.11	879.85	0.006572	19.50	1410.26	455.17	0.90
TC-M80	1.136	010YR	10981.00	854.59	869.25	865.80	870.59	0.001989	9.94	1254.95	404.66	0.49
TC-M80	1.136	050YR	16834.00	854.59	873.12	868.17	874.56	0.001581	10.58	1874.46	607.75	0.46
TC-M80	1.136	100YR	19441.00	854.59	873.37	869.07	875.21	0.001982	11.97	1918.70	614.71	0.51
TC-M80	1.136	500YR	26130.00	854.59	874.63	871.23	877.30	0.002659	14.54	2149.63	670.61	0.60
TC-M80	1.091	010YR	10981.00	854.02	868.03	864.71	869.93	0.003330	11.06	1004.13	120.67	0.61
TC-M80	1.091	050YR	16834.00	854.02	872.82	867.63	874.14	0.001591	9.86	2046.61	261.83	0.45
TC-M80	1.091	100YR	19441.00	854.02	872.99	868.76	874.69	0.002008	11.17	2092.76	265.12	0.50
TC-M80	1.091	500YR	26130.00	854.02	874.35	872.20	876.55	0.002421	12.98	2469.99	360.63	0.56
TC-M80	1.074		Bridge									
TC-M80	1.055	010YR	10981.00	853.83	865.60	863.32	867.61	0.004179	11.38	967.09	117.11	0.68
TC-M80	1.055	050YR	16834.00	853.83	868.07	865.90	870.85	0.004051	13.11	1404.97	244.11	0.69
TC-M80	1.055	100YR	19441.00	853.83	870.07	867.81	872.00	0.002614	11.76	1967.06	315.81	0.57
TC-M80	1.055	500YR	26130.00	853.83	874.15	870.15	875.25	0.001174	9.44	3410.01	483.85	0.40
TC-M80	1.017	010YR	10981.00	848.40	866.08	862.94	868.52	0.000801	6.15	2230.84	519.41	0.31
TC-M80	1.017	050YR	16834.00	848.40	868.86	864.20	869.33	0.000651	6.36	3202.51	653.02	0.29
TC-M80	1.017	100YR	19441.00	848.40	870.63	864.68	871.05	0.000497	5.99	3868.10	810.52	0.26
TC-M80	1.017	500YR	26130.00	848.40	874.39	865.73	874.78	0.000331	5.60	5335.82	932.66	0.22
TC-M80	0.992	010YR	11201.00	847.82	866.22		866.37	0.000299	4.02	4260.71	681.10	0.19
TC-M80	0.992	050YR	17035.00	847.82	869.03		869.18	0.000260	4.25	6253.27	842.36	0.19
TC-M80	0.992	100YR	19846.00	847.82	870.80		870.93	0.000189	3.88	7782.09	884.33	0.16
TC-M80	0.992	500YR	26642.00	847.82	874.57		874.67	0.000115	3.44	11281.68	955.58	0.13
TC-M80	0.991	010YR	11201.00	847.60	864.83	859.78	866.18	0.001896	9.37	1206.93	106.62	0.47
TC-M80	0.991	050YR	17035.00	847.60	866.48	862.42	868.89	0.002854	12.51	1387.28	111.53	0.59
TC-M80	0.991	100YR	19846.00	847.60	868.00	863.50	870.63	0.002717	13.08	1560.12	116.04	0.59
TC-M80	0.991	500YR	26642.00	847.60	871.92	865.92	874.40	0.002011	13.09	2415.42	246.38	0.52
TC-M80	0.965		Bridge									
TC-M80	0.945	010YR	11201.00	844.50	862.78		864.58	0.002599	10.83	1059.63	98.30	0.55
TC-M80	0.945	050YR	17035.00	844.50	862.23	861.53	866.83	0.007022	17.27	1006.88	96.61	0.89
TC-M80	0.945	100YR	19846.00	844.50	863.20	862.67	868.46	0.007265	18.52	1101.15	99.62	0.92
TC-M80	0.945	500YR	26642.00	844.50	865.38	865.38	872.08	0.007539	20.98	1325.96	106.46	0.96
TC-M80	0.940	010YR	11201.00	844.49	862.66		864.20	0.002300	10.14	1210.77	149.71	0.52
TC-M80	0.940	050YR	17035.00	844.49	861.51	861.51	866.08	0.007743	17.36	1045.68	135.32	0.94
TC-M80	0.940	100YR	19846.00	844.49	862.73	862.73	867.50	0.007077	17.85	1220.43	150.50	0.91
TC-M80	0.940	500YR	26642.00	844.49	865.19	865.19	870.40	0.006235	19.00	1624.22	175.46	0.88
TC-M80	0.897	010YR	11201.00	844.30	863.13		863.55	0.000961	6.98	2256.91	364.89	0.31
TC-M80	0.897	050YR	17035.00	844.30	862.59		863.77	0.002878	11.81	2066.16	348.83	0.53
TC-M80	0.897	100YR	19846.00	844.30	863.78		864.84	0.002257	10.99	2496.20	374.03	0.47
TC-M80	0.897	500YR	26642.00	844.30	865.76		866.85	0.001865	10.76	3263.28	401.65	0.44
TC-M80	0.830	010YR	11201.00	845.36	863.00		863.30	0.000431	5.23	2731.46	306.02	0.23
TC-M80	0.830	050YR	17035.00	845.36	862.16		863.01	0.001323	8.83	2476.84	299.03	0.40
TC-M80	0.830	100YR	19846.00	845.36	863.35		864.22	0.001211	8.89	2839.50	308.93	0.39
TC-M80	0.830	500YR	26642.00	845.36	865.26		866.30	0.001259	9.76	3446.20	327.93	0.41
TC-M80	0.750	010YR	11201.00	844.35	856.64	856.64	859.28	0.005640	13.71	931.81	320.69	0.78
TC-M80	0.750	050YR	17035.00	844.35	859.79	858.49	862.02	0.003493	13.05	1506.22	417.19	0.64
TC-M80	0.750	100YR	19846.00	844.35	861.22	859.25	863.33	0.002921	12.80	1786.72	471.96	0.60
TC-M80	0.750	500YR	26642.00	844.35	862.38	860.83	865.27	0.003625	15.03	2041.06	535.24	0.68
TC-M80	0.693	010YR	11201.00	842.33	855.80	853.17	857.85	0.003767	11.17	1079.23	351.96	0.59
TC-M80	0.693	050YR	17035.00	842.33	858.90	856.00	860.97	0.003218	12.16	1571.21	543.02	0.57
TC-M80	0.693	100YR	19846.00	842.33	860.40	857.21	862.45	0.002845	12.23	1839.41	589.20	0.54

HEC-RAS Plan: Pref2012Mod River: Turkey Creek Reach: TC-M80 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
TC-M80	0.693	500YR	26642.00	842.33	863.93	859.24	864.22	0.000399	5.25	6482.75	756.51	0.21
TC-M80	0.628	010YR	11463.00	839.11	853.36	851.53	856.14	0.004559	13.45	873.28	404.98	0.75
TC-M80	0.628	050YR	17355.00	839.11	856.59	854.93	859.70	0.003655	14.52	1292.62	495.02	0.70
TC-M80	0.628	100YR	20403.00	839.11	858.22	856.17	861.32	0.003193	14.67	1532.13	545.39	0.67
TC-M80	0.628	500YR	27557.00	839.11	860.47	860.47	863.63	0.002863	15.31	2056.26	701.46	0.65
TC-M80	0.571	010YR	11463.00	838.44	852.27	849.54	854.81	0.003858	12.89	916.18	451.02	0.66
TC-M80	0.571	050YR	17355.00	838.44	854.45	852.75	858.36	0.004817	16.12	1138.96	486.33	0.76
TC-M80	0.571	100YR	20403.00	838.44	855.27	854.21	859.93	0.005381	17.69	1232.02	502.17	0.81
TC-M80	0.571	500YR	27557.00	838.44	858.45	858.45	862.19	0.003534	16.31	1834.43	695.18	0.68
TC-M80	0.514	010YR	11463.00	838.44	850.79	849.32	853.52	0.004613	13.50	897.21	279.34	0.73
TC-M80	0.514	050YR	17355.00	838.44	852.61	852.26	856.75	0.005808	16.83	1120.35	405.21	0.84
TC-M80	0.514	100YR	20403.00	838.44	853.56	853.56	858.21	0.006023	17.99	1251.70	496.37	0.87
TC-M80	0.514	500YR	27557.00	838.44	857.23	857.23	859.69	0.002677	14.09	2397.93	878.86	0.60
TC-M80	0.445	010YR	11463.00	839.00	850.34	848.11	851.87	0.002792	10.67	1307.94	504.92	0.59
TC-M80	0.445	050YR	17355.00	839.00	852.82	850.25	854.68	0.002682	12.07	1808.00	672.59	0.59
TC-M80	0.445	100YR	20403.00	839.00	854.17	851.19	855.92	0.002293	11.93	2165.99	752.97	0.56
TC-M80	0.445	500YR	27557.00	839.00	857.78	853.99	858.01	0.000264	4.71	7216.71	771.24	0.20
TC-M80	0.369	010YR	11463.00	837.00	849.57	845.42	850.70	0.002489	8.96	1455.59	322.42	0.46
TC-M80	0.369	050YR	17355.00	837.00	852.21	847.65	853.52	0.002334	9.94	2005.57	735.37	0.46
TC-M80	0.369	100YR	20403.00	837.00	853.73	848.69	854.95	0.001860	9.49	2370.12	743.52	0.42
TC-M80	0.369	500YR	27557.00	837.00	857.70	852.08	857.91	0.000235	3.91	7424.54	756.66	0.15
TC-M80	0.295	010YR	11463.00	834.55	848.50	845.17	849.68	0.002774	9.16	1394.16	427.78	0.49
TC-M80	0.295	050YR	17355.00	834.55	851.65	848.59	852.72	0.001582	8.21	2108.85	679.28	0.39
TC-M80	0.295	100YR	20403.00	834.55	853.24	849.21	854.34	0.001221	7.75	2488.77	732.96	0.35
TC-M80	0.295	500YR	27557.00	834.55	856.37	850.37	857.65	0.000862	7.36	3265.17	757.79	0.30
TC-M80	0.217	010YR	11463.00	833.53	847.86	843.39	848.82	0.001414	8.43	1538.80	438.61	0.42
TC-M80	0.217	050YR	17355.00	833.53	851.09	845.52	852.16	0.001166	8.91	2170.32	516.03	0.39
TC-M80	0.217	100YR	20403.00	833.53	852.81	846.38	853.88	0.000996	8.81	2531.70	520.81	0.37
TC-M80	0.217	500YR	27557.00	833.53	856.10	849.00	857.27	0.000822	8.97	3241.12	527.12	0.35

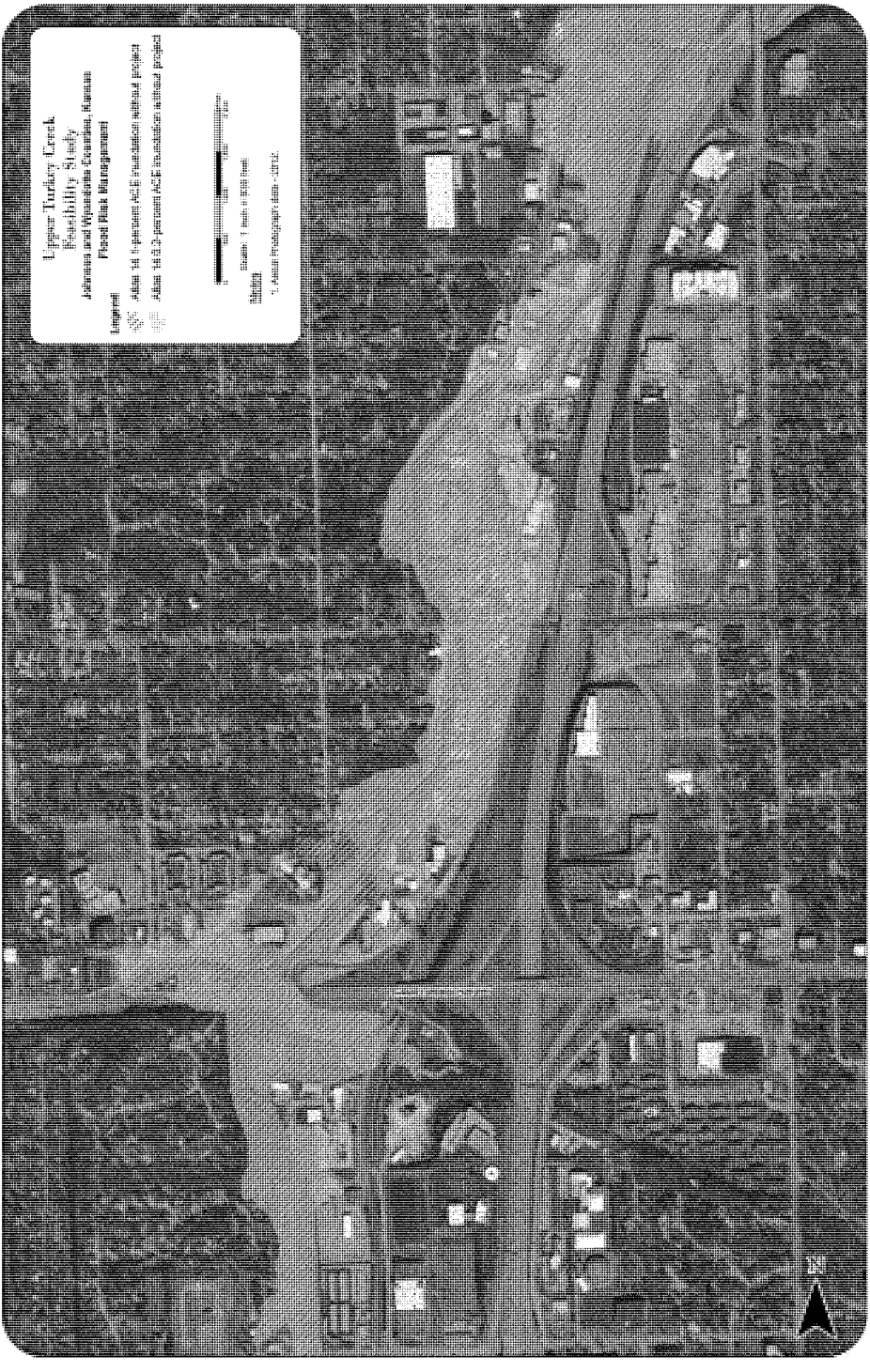
Exhibit 6

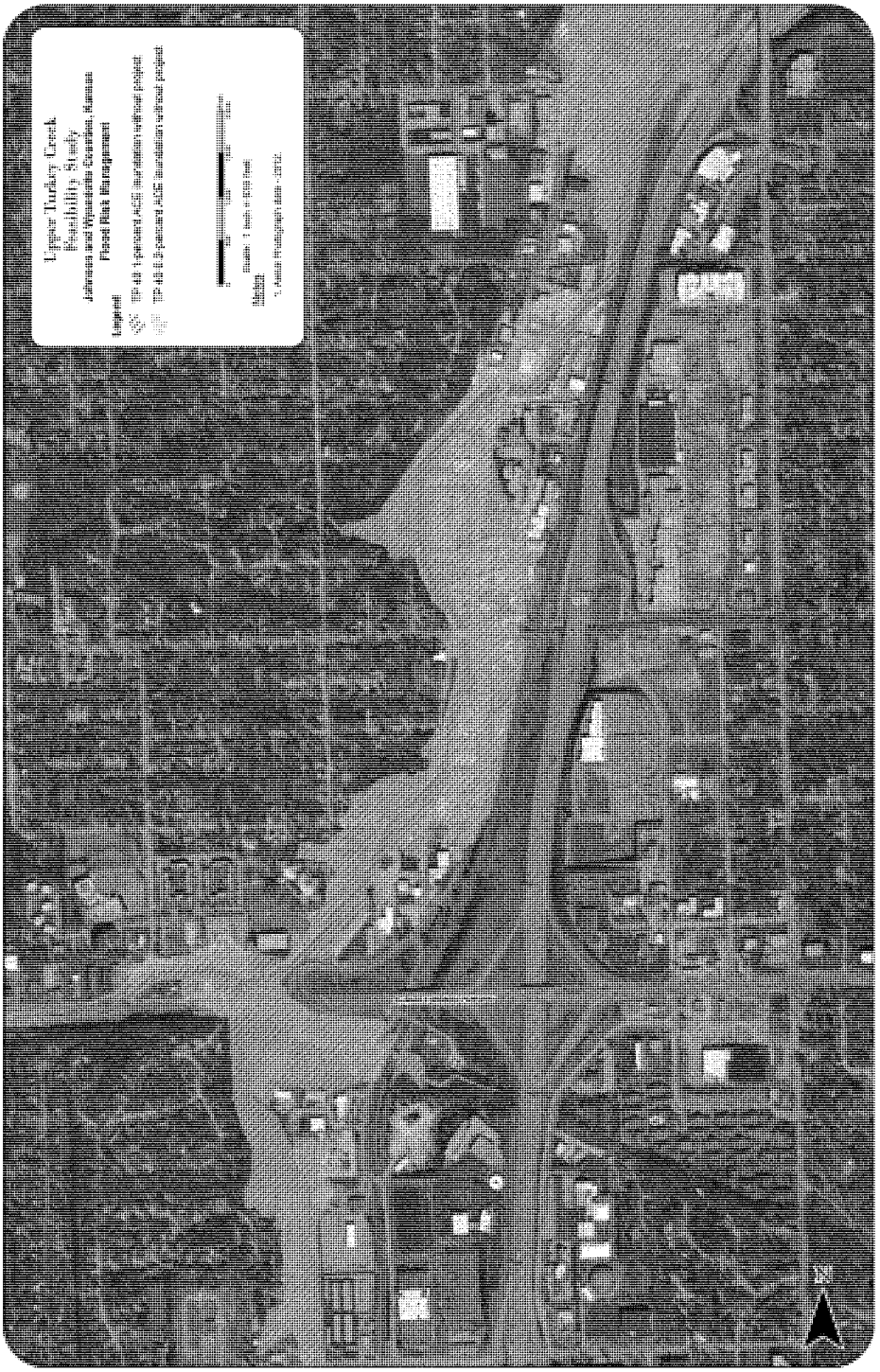
Exhibit 6. Water surface elevation profiles from Proposed Condition HEC-RAS model for several events for the reach of interest TC-M80



1 in Horiz. = 2315 ft 1 in Vert. = 23 ft

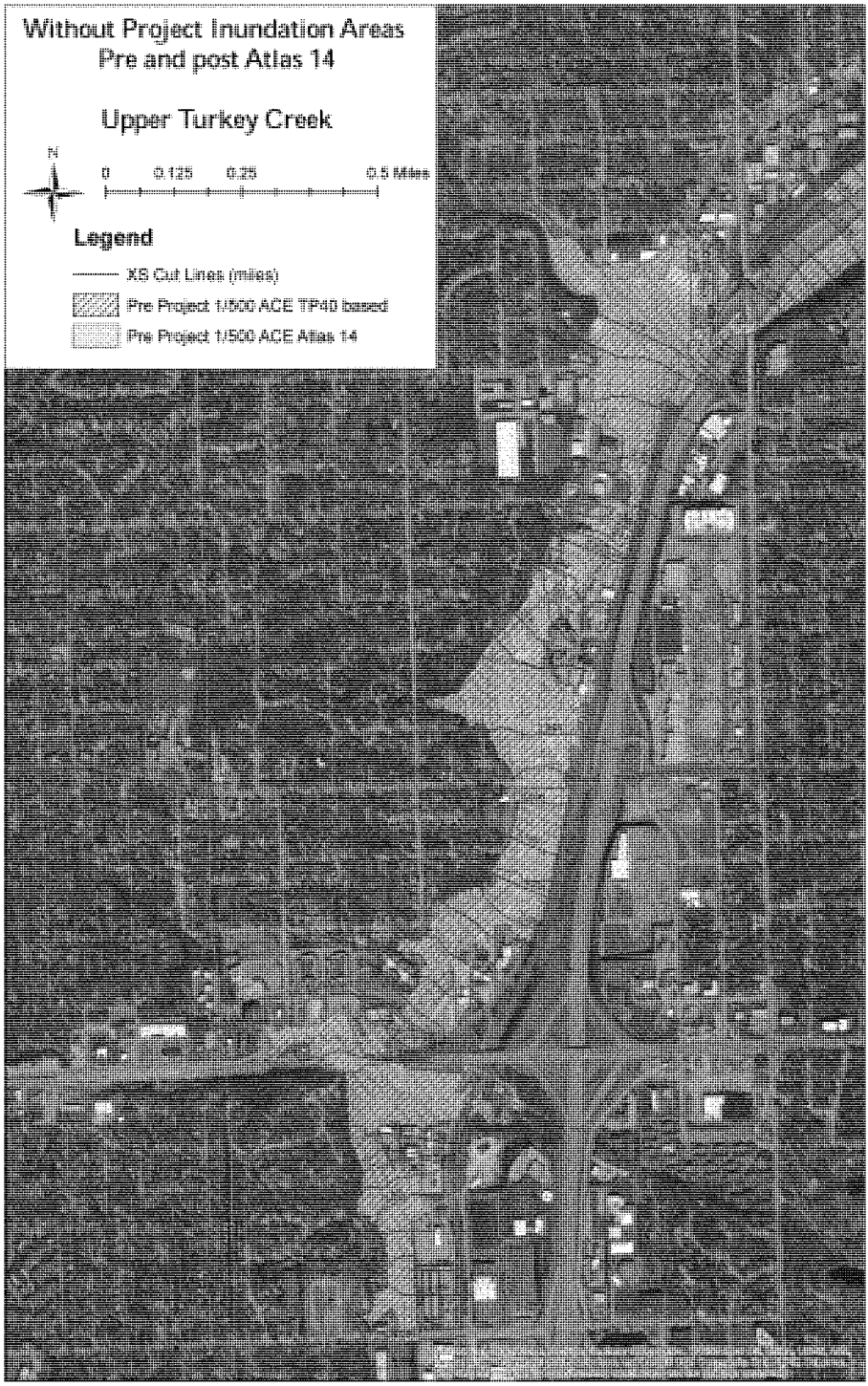
Exhibit 7


Upper Turkey Creek
Feasibility Study
Legend
N


Upper Turkey Creek
Feasibility Study
Johnson and Wyandotte Counties, Kansas
Flood Risk Management
Legend
TP 48 1-percent ACE inundation without project
TP 48 0.5-percent ACE inundation without project
Notes
1. Aerial Photograph date - 2012.
N

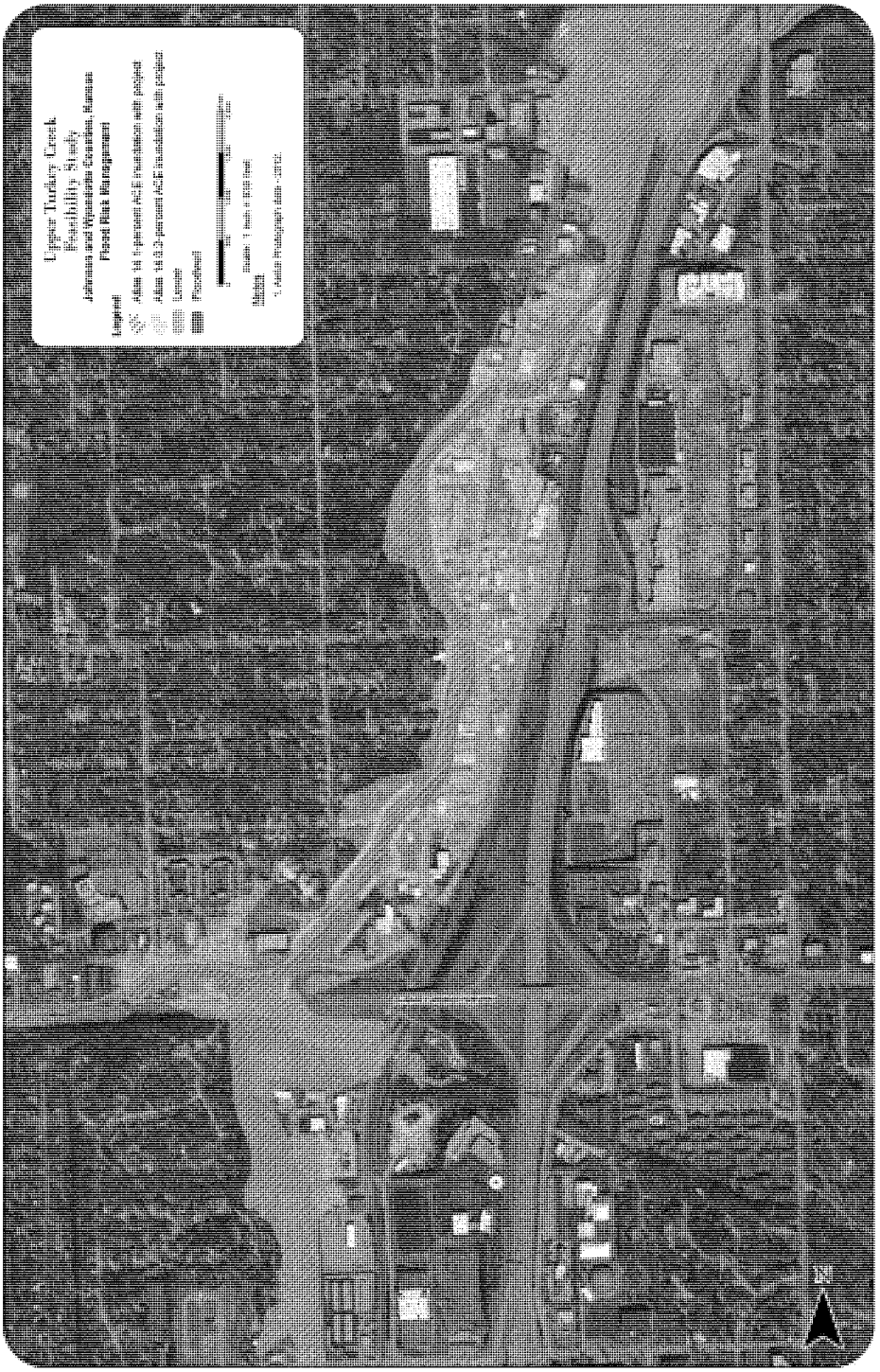
Without Project Inundation Areas
Pre and post Atlas 14
Upper Turkey Creek
N
0
0.125
0.25
0.5 Miles
Legend
XS Cut Lines (miles)
Pre Project 1/100 ACE TP40 based
Pre Project 1/100 ACE Atlas 14

Without Project Inundation Areas
Pre and post Atlas 14
Upper Turkey Creek
N
0
0.125
0.25
0.5 Miles
Legend
XS Cut Lines (miles)
Pre Project 1%00 ACE TP40 based
Pre Project 1%00 ACE Atlas 14


Without Project Inundation Areas
Pre and post Atlas 14
Upper Turkey Creek
N
0
0.125
0.25
0.5 Miles
Legend
XS Cut Lines (miles)
Pre Project 1/500 ACE TP40 based
Pre Project 1/500 ACE Atlas 14

Without Project Inundation Areas
Pre and post Atlas 14
Upper Turkey Creek
N
0
0.125
0.25
0.5 Miles
Legend
XS Cut Lines (miles)
Pre Project 1/500 ACE TP40 based
Pre Project 1/500 ACE Atlas 14

Exhibit 8


Upper Turkey Creek
Feasibility Study
Johnson and Wyandotte Counties, Kansas
Flood Risk Management
Legend
Alias 1st 1-percent ACE inundation with project
Alias 1st 0.2-percent ACE inundation with project
Levee
Floodwall
Notes
1. Aerial Photograph date - 2012.
N

Upper Turkey Creek
Feasibility Study
Flood Risk Management
Legend
Levee
Floodwall
N

Section 4 Cost Engineering

Table of Contents

1. INTRODUCTION B4-1
2. ALTERNATIVES BREAKDOWN B4-1
3. CHANNELIZATION UNIT COST DEVELOPMENT B4-2
4. LEVEE AND FLOODWALL UNIT COST DEVELOPMENT B4-3
5. UTILITY CROSSINGS UNIT COST DEVELOPMENT B4-3
6. DRAINAGE SYSTEM MODIFICATIONS UNIT COST DEVELOPMENT B4-3
7. OPERATIONS AND MAINTENANCE UNIT COST DEVELOPMENT B4-4
8. REPAIRS, REHABILITATION, AND REPLACEMENT UNIT COST DEVELOPMENT B4-4
9. GENERAL CONTINGENCY & VARYING RISK CONTINGENCY B4-5

Tables

TABLE 4-1: PROJECT NOMENCLATURE B4-2

Attachments

ATTACHMENT B4-A COST ESTIMATES TABLES

1. INTRODUCTION

The purpose of this chapter is to describe the approach used in developing the preliminary cost estimates for the various alternatives developed for the Upper Turkey Creek Feasibility Study.

2. ALTERNATIVES BREAKDOWN

The Louis Berger Group, Inc. (LBG) analysis is for the three different alternatives developed for the project. Alternative 1 includes channelization of Upper Turkey Creek with bank stabilization by means of rip rap stabilization and the use of biostabilization (which includes rip rap with joint plantings). Alternative 2 includes the use of levees and flood walls, and Alternative 3 includes a combination of both channelization and levees and flood walls. Each alternative was evaluated for a number of different annual exceedance probabilities (AEP). The cost estimates developed for all alternatives were based upon a parametric cost approach, such that a unit cost per common unit of improvement was developed for each alternative and then multiplied by the quantity of the improvement. A detailed explanation of the unit cost development is included within the cost estimating spreadsheets.

Alternative 1 was evaluated for the 10-year AEP (10-year event), 2-percent AEP (50-year event) existing, 2-percent AEP (5-year event) modified, 1-percent AEP (100-year event) existing, and the 1-percent AEP (100-year event) modified. The existing and modified alternatives vary in that in the existing, all bridges in the design area were left in their existing condition while in the modified the bridges were raised and/or widened requiring additional earthwork and structural costs.

Alternative 2 was evaluated for the 10-year AEP (10-year event), 2-percent AEP (50-year event), 1-percent AEP (100-year event), 0.5-percent AEP (200-year event), and the 0.2-percent AEP (500-year event). In addition a 90-percent alternative was compiled by taking the 1-percent AEP (100-year event) alternative and raising the levee and flood wall height by 6 inches. Further, the locally preferred alternative was developed by taking the 90-percent alternative and relocating the detention basin to a location preferred by the City of Merriam government.

Alternative 3 was evaluated for the 10-percent AEP (10-year event), 2-percent AEP (50-year event) existing, 2-percent AEP (50-year event) modified, 1-percent AEP (100-year event) existing, 1-percent AEP (100-year event) modified, 0.5-percent AEP (200-year event), and the 0.2-percent AEP (500-year event). The existing and modified alternatives vary in that in the existing, all bridges in the design area were left in their existing condition while in the modified the bridges were raised and/or widened acquiring additional earthwork and structural costs.

Subsequent to the development of the cost estimates, the naming convention of the alternatives was changed to remove any reference to the flood risk mitigation AEP and only reflects an alpha numeric identification reference with no reference to AEP. The table below presents a cross reference between the previous nomenclature and the current array of alternatives.

Table 4-1: Project Nomenclature

Alternative Name	Original Alternative Naming Convention	Alternative Description
Future Without Project Condition		
UTC Alternative 1a	UTC_A1_010_E_Merriam_PureNED	Channelization, existing bridges
UTC Alternative 1b	UTC_A1_050_E_Merriam_PureNED	Channelization, existing bridges
UTC Alternative 1c	UTC_A1_050_M_Merriam_PureNED	Channelization, with modified bridges
UTC Alternative 1d	UTC_A1_100_E_Merriam_PureNED	Channelization, existing bridges
UTC Alternative 1e	UTC_A1_100_M_Merriam_PureNED	Channelization, with modified bridges
UTC Alternative 2a	UTC_A2_010_E_Merriam	Levee, existing bridges
UTC Alternative 2b	UTC_A2_050_E_Merriam	Levee, existing bridges
UTC Alternative 2c	UTC_A2_100_E_Merriam	Levee, existing bridges
UTC Alternative 2d	**UTC_A2_90%_E_Merriam**	**Levee, existing bridges**
UTC Alternative 2e	UTC_A2_200_E_Merriam	Levee, existing bridges
UTC Alternative 2f	UTC_A2_500_E_Merriam	Levee, existing bridges
UTC Alternative 3a	UTC_A3_010_E_Merriam_PureNED	Channelization with a levee, existing bridges
UTC Alternative 3b	UTC_A3_050_E_Merriam_PureNED	Channelization with a levee, existing bridges
UTC Alternative 3c	UTC_A3_050_M_Merriam_PureNED	Channelization with a levee, and modified bridges
UTC Alternative 3d	UTC_A3_100_E_Merriam_PureNED	Channelization with a levee, existing bridges
UTC Alternative 3e	UTC_A3_100_M_Merriam_PureNED	Channelization with a levee, and modified bridges
UTC Alternative 4 Property Buyouts	UTC_A4_100_Buyout_Merriam	Buyout of the base-flood properties
UTC Locally Preferred Plan	**UTC_A2_Locally Preferred Alternative_E_Merriam**	**Levee, existing bridges**

3. CHANNELIZATION UNIT COST DEVELOPMENT

Channelization options of Upper Turkey Creek were examined for Alternatives 1 and 3 as part of LBG's analysis. Quantities were developed using average end area methods, as well as quantities developed from the Hydrologic Engineering Center-River Analysis System (HEC-RAS) model and typical cross sections. Unit costs were obtained from RS Means (a published construction unit cost database) using the Kansas City, Missouri, localizing factor of 640; some quantities were obtained from local vendors. Also the U.S. Army Corps of Engineers (USACE) Civil Works Construction Cost Index System, or Engineering Manual 1110-2-1304, for channelization was used to escalate the costs from 2010 to 2011 dollars.

LBG further broke down channelization into rip rap stabilization, biostabilization, hardening, bank fill, and bank excavation sub-items. For each of these sub-items a conversion factor (or quantity) was used to convert the cost per unit from RS Means into one cost per common unit. For rip rap stabilization, biostabilization, and hardening, a common unit of square feet was chosen. For bank fill and bank excavation a common unit of bank cubic yard was chosen. The conversion factor included within the cost estimating spreadsheet converts the costs for each line item to a cost per common unit. This cost per common unit was then applied to the quantities of each channelization item. A cost for standard general conditions (including bonding, permits, and mobilization/demobilization) multiplier of 15 percent was also included.

4. LEVEE AND FLOODWALL UNIT COST DEVELOPMENT

Levee and flood wall options of Upper Turkey Creek were examined for Alternatives 2 and 3 as part of LBG's analysis. While most of the unit costs were obtained from RS Means using the Kansas City localizing factor of 640, some were obtained from local vendors. Also Engineering Manual 1110-2-1304 for levees and floodwalls was used to escalate the costs from 2006 to 2011 dollars.

For the levee, LBG developed a unit cost per linear foot of earthen levee ranging in height from one foot to nine feet. For each different height of levee, LBG developed the area of a typical cross section that has a top width of 10 feet and side slopes of 3H to 1V. These typical levee sections were developed in accordance with Engineering Manual 1110-2-1913 and were used to calculate a conversion factor to convert the cost per units given in RS Means to the cost per linear foot of that particular levee height. A side slope of 3H to 1V was used for the typical levee cross section. Landside seepage berms were not included due to the limited land area and the flashy nature of Upper Turkey Creek. The flashy nature would not result in prolonged periods of flood impoundment and, therefore, would not contribute to extensive seepage through the levee.

For the flood wall, LBG calculated a unit cost per linear foot of a typical flood wall for a number of height ranges. These ranges are as follows: 0–2 feet, 2–4 feet, 4–6 feet, 6–8 feet, 8–10 feet, and 10–12 feet. The floodwall considered is a cantilevered T-type reinforced concrete floodwall with an 18-inch top width and tapered back face. The wall foundation also was considered to be 3.5 feet below grade. Although detailed structural calculations were not performed for this phase of the project, Engineering Manual 1110-2-2502 was used for standard dimensions and construction materials included within the cost estimates.

For each different height range, the quantity of each line item per flood wall linear foot was estimated; from there, the quantity per linear foot (conversion factor) was developed. It also was assumed that the prime contractor would hire a subcontractor to complete the work for the flood wall. For this reason a "prime markup" of 15 percent was applied to the costs for items related to concrete work. Because ledge is fairly shallow in the project area (observed at the channel invert), sheet piling was not included as a foundation item within the floodwall estimate.

5. UTILITY CROSSINGS UNIT COST DEVELOPMENT

Utility crossings for Upper Turkey Creek were examined for Alternatives 1through 3 as part of LBG's analysis. While most of the unit costs were obtained from RS Means using the Kansas City localizing factor of 640, some were obtained from local vendors. Also Engineering Manual 1110-2-1304 was used to escalate the costs from 2010 to 2011 dollars for buildings, grounds, and utilities.

LBG developed a unit cost for each utility crossing. For each line item necessary to construct a typical utility crossing, LBG estimated quantities based on past experience. These quantities were then multiplied by the unit cost obtained from RS Means to develop the cost for each utility crossing for that particular line item. Line items that LBG assumed would be constructed by a subcontractor were marked up with a "prime markup" of 15 percent. The line items were then summed and an additional 15 percent charge was applied to account for mobilization/demobilization.

6. DRAINAGE SYSTEM MODIFICATIONS UNIT COST DEVELOPMENT

Drainage system modifications for Upper Turkey Creek were examined for Alternatives 1through 3 as part of LBG's analysis. While most of the unit costs were obtained from RS Means using the Kansas City localizing factor of 640, some were obtained from local vendors. The drainage system modifications were broken down per storm intensity. The storm intensities analyzed are as follows: 10-percent AEP (10-year

event), 2-percent AEP (50-year event), 1-percent AEP (100-year event), 0.5-percent AEP (200-year event), and the 0.2-percent AEP (500-year event).

LBG developed a unit cost for the drainage system modifications that pertain to each AEP as described above. For each line item necessary to construct drainage system modifications, quantities were estimated based on a review of the topography of the project area. These quantities were then multiplied by the unit cost obtained from RS Means to develop the cost for drainage system modifications for that particular line item.

Most line item costs and quantities remained the same from each successive storm intensity; however, the size of the flap gates for the 1-percent AEP (100-year event), 0.5-percent AEP (200-year event), and the 0.2-percent AEP (500-year event) increased when compared to the 10-percent AEP (10-year event) and the 2-percent AEP (50-year event). The line items were then summed and an additional 15 percent charge was applied to account for mobilization/demobilization.

7. OPERATIONS AND MAINTENANCE UNIT COST DEVELOPMENT

Operations and maintenance unit costs for Upper Turkey Creek were examined for Alternatives 1through 3 as part of LBG's analysis. Different AEPs were studied that correlate with the same storm intensities as described above: 10-percent AEP (10-year event), 2-percent AEP (50-year event), 1-percent AEP (100-year event), 0.5-percent AEP (200-year event), and the 0.2-percent AEP (500-year event).

Unit costs and quantities for these items were estimated based on past project experience, and assumptions were made for quantities of line items for channel clearing and loading, hauling, and debris disposal. The unit costs for the drainage system maintenance were based on 10 percent of the particular drainage system costs for that level of intensity. Quantities also increased for each successive AEP.

8. REPAIRS, REHABILITATION, AND REPLACEMENT UNIT COST DEVELOPMENT

Repairs, rehabilitation, and replacement unit costs for Upper Turkey Creek were examined for Alternatives 1 through 3 as part of LBG's analysis. Assumptions were made as to what percentage of each alternative needed to be repaired, rehabilitated, or replaced for each AEP: 10-percent AEP (10-year event), 2-percent AEP (50-year event), 1-percent AEP (100-year event), 0.5-percent AEP (200-year event), and 0.2-percent AEP (500-year event). Further, it was assumed that these percentages of each alternative would be repaired every 10 years, rehabilitated every 25 years, and replaced every 50 years.

For Alternative 1, it was assumed that 10 percent of the rip rap, or biostabilization, and 10 percent of the flap gates would be repaired. For Alternative 2, it was assumed that 5 percent of the levees and flood walls and 10 percent of the flap gates would be repaired. For Alternative 3, it was assumed that 10 percent of the rip rap, or biostabilization; 5 percent of the levees and flood wall; and 10 percent of the flap gates would be repaired.

For Alternative 1, it was assumed that 25 percent of the rip rap, or biostabilization, and 25 percent of the flap gates would be rehabilitated. For Alternative 2, it was assumed that 10 percent of the levees and flood walls and 25 percent of the flap gates would be rehabilitated. For Alternative 3 it was assumed that 25 percent of the rip rap, or biostabilization; 10 percent of the levees and flood walls; and 25 percent of the flap gates would be rehabilitated.

For Alternative 1, it was assumed that 25 percent of the rip rap, or biostabilization; 10 percent of the block; and 50 percent of the flap gates would be replaced. For Alternative 2, it was assumed that 25 percent of the levees and flood walls, 50 percent of the drainage system and detention basin, and 50 percent of the flap gates would be replaced. For Alternative 3, it was assumed that 25 percent of the rip

rap, or biostabilization; 10 percent of the block; 25 percent of the levees and flood walls; 50 percent of the drainage system and detention basin; and 50 percent of the flap gates would be replaced.

9. GENERAL CONTINGENCY & VARYING RISK CONTINGENCY

General contingency and varying risk contingency were applied to Alternatives 1 through 3 as part of LBG's analysis. General contingency was carried for each alternative at 20 percent of the capital cost to allow for undetermined items not yet accounted for during this feasibility study phase of the project. Additionally a risk contingency was provided for each alternative, and this risk contingency varies per alternative and ranges from two percent to seven percent of the capital cost. The varying risk contingency is greater for those alternatives that contain construction elements that are more susceptible to failure during flooding, such as channelization improvements, which include stabilization with live stake plantings versus one that is stabilized by hardened block.

ATTACHMENT B 4 – A

Cost Estimate Tables

THE Louis Berger Group, INC.

December 20, 2012

Upper Turkey Creek

Preliminary Opinion of Probable Construction Costs

UTC Alternative 1a
(UTC_A1_010_E_Merriam_PureNED)

Item	Unit	Unit Price	Quantity	Amount
Channel Modification				
Excavation	CY	$11.07	64,072	$709,004
Fill	CY	$7.83	5,115	$40,049
Overbank Rehabilitation	SF	$3.87	96,239	$372,302
Bank Rehabilitation				
Hardening	SF	$28.98	7,180	$208,104
RipRap Stabilization	SF	$9.00	264,320	$2,379,874
Easement Repairs	SF	$0.99	162,420	$161,539
Utility Crossing	EA	$81,497.77	6	$488,987
Drainage System Modifications	LS	$689,333.29	1	$689,333

Capital Cost	**$5,049,193**
Risk Contingency 2%	**$95,716**
General Contingency (20%)	**$1,009,900**
Subtotal	**$6,154,808**
Preconstruction Eng. And Design (10%)	**$615,481**
Engineering During Construction (1%)	**$61,548**
Supervision and Administration (6.5%)	**$400,063**
Total Capital Cost (2011$)	**$7,231,900**

Operation and Maintenance (1YR)	**$74,467**
Repair (10YR)	**$164,066**
Rehabilitation (25YR)	**$410,166**
Replacement (50YR)	**$442,225**

THE Louis Berger Group, INC.

December 20, 2012

Upper Turkey Creek

Preliminary Opinion of Probable Construction Costs

UTC Alternative 1b
(UTC_A1_050_E_Merriam_PureNED)

Item	Unit	Unit Price	Quantity	Amount
Channel Modification				
Excavation	CY	$11.07	95,646	$1,058,398
Fill	CY	$7.83	5,552	$43,463
Overbank Rehabilitation	SF	$3.87	155,509	$601,593
Bank Rehabilitation				
Hardening	SF	$28.98	-	$0
RipRap Stabilization	SF	$9.00	344,687	$3,103,482
Easement Repairs	SF	$0.99	220,500	$219,304
Utility Crossing	EA	$81,497.77	6	$488,987
Drainage System Modifications	LS	$777,066.62	1	$777,067

Capital Cost	**$6,292,294**
Risk Contingency 2%	**$110,186**
General Contingency (20%)	**$1,258,500**
Subtotal	**$7,660,980**
Preconstruction Eng. And Design (10%)	**$766,098**
Engineering During Construction (1%)	**$76,610**
Supervision and Administration (6.5%)	**$497,964**
Total Capital Cost (2011$)	**$9,001,651**

Operation and Maintenance (1YR)	**$91,353**
Repair (10YR)	**$218,883**
Rehabilitation (25YR)	**$547,207**
Replacement (50YR)	**$574,207**

THE Louis Berger Group, INC.

December 20, 2012

Upper Turkey Creek

Preliminary Opinion of Probable Construction Costs

UTC Alternative 1c
(UTC_A1_050_M_Merriam_PureNED)

Item	Unit	Unit Price	Quantity	Amount
Channel Modification				
Excavation	CY	$11.07	132,651	$1,467,883
Fill	CY	$7.83	6,576	$51,484
Overbank Rehabilitation	SF	$3.87	129,331	$500,321
Bank Rehabilitation				
Hardening	SF	$28.98	25,888	$750,303
RipRap Stabilization	SF	$9.00	333,900	$3,006,361
Easement Repairs	SF	$0.99	255,980	$254,592
Bridge Modification				
Shawnee Mission Pkwy	LS	$2,823,130	1	$2,823,130
Merriam Drive	LS	$1,512,352	1	$1,512,352
Utility Crossing	EA	$81,497.77	6	$488,987
Drainage System Modifications	LS	$777,066.62	1	$777,067

Capital Cost	**$11,632,479**
Risk Contingency 2%	**$226,967**
General Contingency (20%)	**$2,326,500**
Subtotal	**$14,185,946**
Preconstruction Eng. And Design (10%)	**$1,418,595**
Engineering During Construction (1%)	**$141,859**
Supervision and Administration (6.5%)	**$922,087**
Total Capital Cost (2011$)	**$16,668,487**

Operation and Maintenance (1YR)	**$91,353**
Repair (10YR)	**$237,371**
Rehabilitation (25YR)	**$630,927**
Replacement (50YR)	**$1,132,957**

THE Louis Berger Group, INC.

December 20, 2012

Upper Turkey Creek

Preliminary Opinion of Probable Construction Costs

UTC Alternative 1d

(UTC_A1_100_E_Merriam_PureNED)

Item	Unit	Unit Price	Quantity	Amount
Channel Modification				
Excavation	CY	$11.07	203,748	$2,254,624
Fill	CY	$7.83	11,714	$91,712
Overbank Rehabilitation	SF	$3.87	59,690	$230,914
Bank Rehabilitation				
Hardening	SF	$28.98	-	$0
RipRap Stabilization	SF	$9.00	459,461	$4,136,884
Easement Repairs	SF	$0.99	235,920	$234,641
Pedestrian Bridge	LS	$104,491	1	$104,491
Utility Crossing	EA	$81,497.77	6	$488,987
Drainage System Modifications	LS	$777,066.62	1	$777,067

Capital Cost	**$8,319,320**
Risk Contingency 3%	**$234,634**
General Contingency (20%)	**$1,663,900**
Subtotal	**$10,217,853**
Preconstruction Eng. And Design (10%)	**$1,021,785**
Engineering During Construction (1%)	**$102,179**
Supervision and Administration (6.5%)	**$664,160**
Total Capital Cost (2011$)	**$12,005,978**

Operation and Maintenance (YR)	**$106,353**
Repair (10YR)	**$288,170**
Rehabilitation (25YR)	**$720,426**
Replacement (50YR)	**$747,426**

THE Louis Berger Group, INC.

December 20, 2012

Upper Turkey Creek

Preliminary Opinion of Probable Construction Costs

UTC Alternative 1e
(UTC_A1_100_M_Merriam_PureNED)

Item	Unit	Unit Price	Quantity	Amount
Channel Modification				
Excavation	CY	$11.07	234,850	$2,598,788
Fill	CY	$7.83	12,062	$94,430
Overbank Rehabilitation	SF	$3.87	110,909	$429,055
Bank Rehabilitation				
Hardening	SF	$28.98	-	$0
RipRap Stabilization	SF	$9.00	494,351	$4,451,019
Easement Repairs	SF	$0.99	275,800	$274,305
Bridge Modification				
Shawnee Mission Pkwy	LS	$2,823,130	1	$2,823,130
Merriam Drive	LS	$2,601,015	1	$2,601,015
Pedestrian Bridge	LS	$104,491	1	$104,491
Utility Crossing	EA	$81,497.77	6	$488,987
Drainage System Modifications	LS	$777,066.62	1	$777,067

Capital Cost	**$14,642,286**
Risk Contingency 2%	**$269,322**
General Contingency (20%)	**$2,928,500**
Subtotal	**$17,840,108**
Preconstruction Eng. And Design (10%)	**$1,784,011**
Engineering During Construction (1%)	**$178,401**
Supervision and Administration (6.5%)	**$1,159,607**
Total Capital Cost (2011$)	**$20,962,127**

Operation and Maintenance (1YR)	**$106,353**
Repair (10YR)	**$334,233**
Rehabilitation (25YR)	**$823,083**
Replacement (50YR)	**$1,300,083**

THE Louis Berger Group, INC.

December 20, 2012

Upper Turkey Creek

Preliminary Opinion of Probable Construction Costs

UTC Alternative 2a
(UTC_A2_010_E_Merriam)

Item	Unit	Unit Price	Quantity	Amount
Levee				
2 ft	LF	$37.88	-	$0
3 ft	LF	$58.24	1,910	$111,248
4 ft	LF	$83.04	998	$82,872
5 ft	LF	$112.29	-	$0
6 ft	LF	$145.97	-	$0
Flood Wall				
0-2 ft	LF	$477.45	2,218	$1,058,783
2-4 ft	LF	$583.82	3,692	$2,155,495
4-6 ft	LF	$690.20	53	$36,443
6-8 ft	LF	$810.92	-	$0
8-12 ft	LF	$1,011.86		$0
Easement Repairs	SF	$0.99	177,409	$176,447
Utility Crossing	EA	$81,497.77	6	$488,987
Drainage System Modification	LS	$689,333.29	1	$689,333
Detention Basin	LS	$1,510,222.72	1	$1,510,223

Capital Cost		**$6,309,830**
Risk Contingency	*3%*	**$205,514**
General Contingency (20%)		**$1,262,000**
Subtotal		**$7,777,344**
Preconstruction Eng. And Design (10%)		**$777,734**
Engineering During Construction (1%)		**$77,773**
Supervision and Administration (6.5%)		**$505,527**
Total Capital Cost (2011$)		**$9,138,379**

Operation and Maintenance (1YR)	**$144,444**
Repair (10YR)	**$169,125**
Rehabilitation (25YR)	**$340,499**
Replacement (50YR)	**$2,007,439**

THE Louis Berger Group, INC.

December 20, 2012

Upper Turkey Creek

Preliminary Opinion of Probable Construction Costs

UTC Alternative 2b
(UTC_A2_050_E_Merriam)

Item	Unit	Unit Price	Quantity	Amount
Levee				
2 ft	LF	$37.88	359	$13,601
3 ft	LF	$58.24	876	$51,049
4 ft	LF	$83.04	354	$29,378
5 ft	LF	$112.29	2,001	$224,699
6 ft	LF	$145.97	190	$27,746
Flood Wall				
0-2 ft	LF	$477.45	-	$0
2-4 ft	LF	$583.82	4,768	$2,783,618
4-6 ft	LF	$690.20	1,505	$1,038,612
6-8 ft	LF	$810.92	-	$0
8-12 ft	LF	$1,011.86		$0
Easement Repairs	SF	$0.99	201,064	$199,974
Pedestrian Bridge	LS	$104,491.33	1	$104,491
Utility Crossing	EA	$81,497.77	6	$488,987
Drainage System Modification	LS	$777,066.62	1	$777,067
Detention Basin	LS	$1,510,222.72	1	$1,510,223

Capital Cost		**$7,249,443**
Risk Contingency	*3%*	**$248,108**
General Contingency (20%)		**$1,449,900**
Subtotal		**$8,947,451**
Preconstruction Eng. And Design (10%)		**$894,745**
Engineering During Construction (1%)		**$89,475**
Supervision and Administration (6.5%)		**$581,584**
Total Capital Cost (2011$)		**$10,513,255**
Operation and Maintenance (1YR)		**$153,218**
Repair (10YR)		**$232,168**
Rehabilitation (25YR)		**$469,736**
Replacement (50YR)		**$2,304,484**

THE Louis Berger Group, INC.

December 20, 2012

Upper Turkey Creek

Preliminary Opinion of Probable Construction Costs

UTC Alternative 2c
(UTC_A2_100_E_Merriam)

Item	Unit	Unit Price	Quantity	Amount
Levee				
2 ft	LF	$37.88	306	$11,601
3 ft	LF	$58.24	808	$47,051
4 ft	LF	$83.04	306	$25,432
5 ft	LF	$112.29	1,104	$123,910
6 ft	LF	$145.97	195	$28,517
Flood Wall				
0-2 ft	LF	$477.45	438	$209,236
2-4 ft	LF	$583.82	5,074	$2,962,408
4-6 ft	LF	$690.20	3,231	$2,230,282
6-8 ft	LF	$810.92	-	$0
8-12 ft	LF	$1,011.86	-	$0
Easement Repairs	SF	$0.99	229,259	$228,016
Pedestrian Bridge	LS	$104,491.33	1	$104,491
Utility Crossing	EA	$81,497.77	6	$488,987
Drainage System Modification	LS	$777,066.62	1	$777,067
Detention Basin	LS	$1,510,222.72	1	$1,510,223

Capital Cost		**$8,747,220**
Risk Contingency	*4%*	**$322,997**
General Contingency (20%)		**$1,749,500**
Subtotal		**$10,819,716**
Preconstruction Eng. And Design (10%)		**$1,081,972**
Engineering During Construction (1%)		**$108,197**
Supervision and Administration (6.5%)		**$703,282**
Total Capital Cost (2011$)		**$12,713,166**

Operation and Maintenance (1YR)	**$153,218**
Repair (10YR)	**$302,119**
Rehabilitation (25YR)	**$620,438**
Replacement (50YR)	**$2,681,241**

THE Louis Berger Group, INC.

December 20, 2012

Upper Turkey Creek

Preliminary Opinion of Probable Construction Costs

UTC Alternative 2d
(UTC_A2_90%_E_Merriam)

Item	Unit	Unit Price	Quantity	Amount
Levee				
2 ft	LF	$37.88	306	$11,601
3 ft	LF	$58.24	-	$0
4 ft	LF	$83.04	306	$25,432
5 ft	LF	$112.29	935	$104,938
6 ft	LF	$145.97	496	$72,448
7 ft	LF	$178.36	0	$0
Flood Wall				
0-2 ft	LF	$477.45	359	$171,422
2-4 ft	LF	$583.82	3,672	$2,143,983
4-6 ft	LF	$690.20	4,578	$3,159,567
6-8 ft	LF	$810.92	496	$402,477
8-12 ft	LF	$1,011.86	-	$0
Easement Repairs	SF	$0.99	222,976	$221,767
Pedestrian Bridge	LS	$104,491.33	1	$104,491
Utility Crossing	EA	$81,497.77	6	$488,987
Drainage System Modification	LS	$777,066.62	1	$777,067
Detention Basin	LS	$1,510,222.72	1	$1,510,223

Capital Cost		**$9,194,401**
Risk Contingency	*4%*	**$345,356**
General Contingency (20%)		**$1,838,900**
Subtotal		**$11,378,657**
Preconstruction Eng. And Design (10%)		**$1,137,866**
Engineering During Construction (1%)		**$113,787**
Supervision and Administration (6.5%)		**$739,613**
Total Capital Cost (2011$)		**$13,369,922**
Operation and Maintenance (1YR)		**$153,218**
Repair (10YR)		**$309,993**
Rehabilitation (25YR)		**$636,187**
Replacement (50YR)		**$2,720,611**

THE Louis Berger Group, INC.

December 20, 2012

Upper Turkey Creek

Preliminary Opinion of Probable Construction Costs

UTC Alternative 2e
(UTC_A2_200_E_Merriam)

Item	Unit	Unit Price	Quantity	Amount
Levee				
2 ft	LF	$37.88	-	$0
3 ft	LF	$58.24	306	$17,836
4 ft	LF	$83.04	808	$67,087
5 ft	LF	$112.29	-	$0
6 ft	LF	$145.97	1056	$154,145
Flood Wall				
0-2 ft	LF	$477.45	612	$292,426
2-4 ft	LF	$583.82	4,162	$2,429,822
4-6 ft	LF	$690.20	4,727	$3,262,599
6-8 ft	LF	$810.92	195	$158,422
8-12 ft	LF	$1,011.86	-	$0
Easement Repairs	SF	$0.99	237,338	$236,051
Pedestrian Bridge	LS	$104,491.33	1	$104,491
Utility Crossing	EA	$81,497.77	6	$488,987
Drainage System Modification	LS	$777,066.62	1	$777,067
Detention Basin	LS	$1,510,222.72	1	$1,510,223

Capital Cost	**$9,499,155**
Risk Contingency 4%	**$360,593**
General Contingency (20%)	**$1,899,900**
Subtotal	**$11,759,648**
Preconstruction Eng. And Design (10%)	**$1,175,965**
Engineering During Construction (1%)	**$117,596**
Supervision and Administration (6.5%)	**$764,377**
Total Capital Cost (2011$)	**$13,817,586**
Operation and Maintenance (1YR)	**$153,218**
Repair (10YR)	**$329,258**
Rehabilitation (25YR)	**$674,717**
Replacement (50YR)	**$2,816,936**

THE Louis Berger Group, INC.

December 20, 2012

Upper Turkey Creek

Preliminary Opinion of Probable Construction Costs

UTC Alternative 2f
(UTC_A2_500_E_Merriam)

Item	Unit	Unit Price	Quantity	Amount
Levee				
2 ft	LF	$37.88	42	$1,600
3 ft	LF	$58.24	-	$0
4 ft	LF	$83.04	306	$25,432
5 ft	LF	$112.29	502	$56,323
6 ft	LF	$145.97	306	$44,702
Flood Wall				
0-2 ft	LF	$477.45	-	$0
2-4 ft	LF	$583.82	2,307	$1,347,088
4-6 ft	LF	$690.20	4,377	$3,021,140
6-8 ft	LF	$810.92	4,694	$3,806,408
8-12 ft	LF	$1,011.86	-	$0
Easement Repairs	SF	$0.99	250,696	$249,337
Pedestrian Bridge	LS	$104,491.33	1	$104,491
Utility Crossing	EA	$81,497.77	6	$488,987
Drainage System Modification	LS	$777,066.62	1	$777,067
Detention Basin	LS	$1,510,222.72	1	$1,510,223

Capital Cost		**$11,432,797**
Risk Contingency	*4%*	**$457,275**
General Contingency (20%)		**$2,286,600**
Subtotal		**$14,176,673**
Preconstruction Eng. And Design (10%)		**$1,417,667**
Engineering During Construction (1%)		**$141,767**
Supervision and Administration (6.5%)		**$921,484**
Total Capital Cost (2011$)		**$16,657,590**
Operation and Maintenance (1YR)		**$153,218**
Repair (10YR)		**$417,838**
Rehabilitation (25YR)		**$841,076**
Replacement (50YR)		**$3,232,834**

THE Louis Berger Group, INC.

December 20, 2012

Upper Turkey Creek

Preliminary Opinion of Probable Construction Costs

UTC Alternative 3a
(UTC_A3_010_E_Merriam_PureNED)

Item	Unit	Unit Price	Quantity	Amount
Levee				
1 ft	LF	$21.96	-	$0
2 ft	LF	$37.88	803	$30,402
3 ft	LF	$58.24	248	$14,454
4 ft	LF	$83.04	-	$0
5 ft	LF	$112.29	-	$0
6 ft	LF	$145.97	-	$0
7 ft	LF	$184.09	-	$0
8 ft	LF	$226.66	-	$0
Flood Wall				
0-2 ft	LF	$477.45	2,160	$1,031,053
2-4 ft	LF	$583.82	523	$305,176
4-6 ft	LF	$690.20	-	$0
6-8 ft	LF	$810.92	-	$0
8-12 ft	LF	$1,011.86	-	$0
Channel Modification				
Excavation	CY	$11.07	41,171	$455,584
Fill	CY	$7.83	6,284	$49,199
Overbank Rehabilitation	SF	$3.87	96,239	$372,302
Bank Rehabilitation				
Hardening	SF	$28.98	19,331	$560,269
RipRap Stabilization	SF	$6.04	186,153	$1,123,780
Easement Repairs	SF	$0.99	236,019	$234,740
Utility Crossing	EA	$81,497.77	6	$488,987
Drainage System Modification	LS	$689,333.29	1	$689,333
Detention Basin	LS	$1,510,222.72	1	$1,510,223

Capital Cost	**$6,865,501**
Risk Contingency 3%	**$200,009**
General Contingency (20%)	**$1,373,200**
Subtotal	**$8,438,709**
Preconstruction Eng. And Design (10%)	**$843,871**
Engineering During Construction (1%)	**$84,387**
Supervision and Administration (6.5%)	**$548,516**
Total Capital Cost (2011$)	**$9,915,483**

Operation and Maintenance (1YR)	**$149,978**
Repair (10YR)	**$185,932**
Rehabilitation (25YR)	**$430,304**
Replacement (50YR)	**$1,804,520**

THE Louis Berger Group, INC.

December 20, 2012

Upper Turkey Creek

Preliminary Opinion of Probable Construction Costs

UTC Alternative 3b
(UTC_A3_050_E_Merriam_PureNED)

Item	Unit	Unit Price	Quantity	Amount
Levee				
1 ft	LF	$21.96	-	$0
2 ft	LF	$37.88	-	$0
3 ft	LF	$58.24	354	$20,604
4 ft	LF	$83.04	660	$54,809
5 ft	LF	$112.29	840	$94,267
6 ft	LF	$145.97	-	$0
7 ft	LF	$184.09	803	$147,746
8 ft	LF	$226.66	-	$0
Flood Wall				
0-2 ft	LF	$477.45	681	$325,198
2-4 ft	LF	$583.82	2,276	$1,328,593
4-6 ft	LF	$690.20	3,519	$2,428,949
6-8 ft	LF	$810.92	106	$85,633
8-12 ft	LF	$1,011.86	-	$0
Channel Modification				
Excavation	CY	$11.07	87,191	$964,833
Fill	CY	$7.83	22,624	$177,125
Overbank Rehabilitation	SF	$3.87	373,808	$1,446,090
Bank Rehabilitation				
Hardening	SF	$28.98	-	$0
RipRap Stabilization	SF	$6.04	351,797	$2,123,750
Easement Repairs	SF	$0.99	405,249	$403,052
Utility Crossing	EA	$81,497.77	6	$488,987
Drainage System Modification	LS	$777,066.62	1	$777,067
Detention Basin	LS	$1,510,222.72	1	$1,510,223

Capital Cost	**$12,376,925**
Risk Contingency 3%	**$361,905**
General Contingency (20%)	**$2,475,400**
Subtotal	**$15,214,230**
Preconstruction Eng. And Design (10%)	**$1,521,423**
Engineering During Construction (1%)	**$152,142**
Supervision and Administration (6.5%)	**$988,925**
Total Capital Cost (2011$)	**$17,876,720**

Operation and Maintenance (1YR)	**$166,864**
Repair (10YR)	**$447,465**
Rehabilitation (25YR)	**$1,006,518**
Replacement (50YR)	**$2,850,032**

THE Louis Berger Group, INC.

December 20, 2012

Upper Turkey Creek

Preliminary Opinion of Probable Construction Costs

UTC Alternative 3c
(UTC_A3_050_M_Merriam_PureNED)

Item	Unit	Unit Price	Quantity	Amount
Levee				
1 ft	LF	$21.96	-	$0
2 ft	LF	$37.88	660	$25,002
3 ft	LF	$58.24	354	$20,604
4 ft	LF	$83.04	84	$7,016
5 ft	LF	$112.29	1,336	$149,997
6 ft	LF	$145.97	306	$44,702
7 ft	LF	$184.09	-	$0
8 ft	LF	$226.66	-	$0
Flood Wall				
0-2 ft	LF	$477.45	1,119	$534,433
2-4 ft	LF	$583.82	3,010	$1,757,352
4-6 ft	LF	$690.20	1,321	$911,946
6-8 ft	LF	$810.92	-	$0
8-12 ft	LF	$1,011.86	-	$0
Channel Modification				
Excavation	CY	$11.07	132,651	$1,467,883
Fill	CY	$7.83	6,576	$51,484
Overbank Rehabilitation	SF	$3.87	206,324	$798,171
Bank Rehabilitation				
Hardening	SF	$28.98	25,968	$752,618
RipRap Stabilization	SF	$6.04	334,044	$2,016,579
Easement Repairs	SF	$0.99	417,161	$414,899
Bridge Modification				
Shawnee Mission Pkwy	LS	$2,823,129.72	1	$2,823,130
Merriam Drive	LS	$1,512,352.09	1	$1,512,352
Utility Crossing	EA	$81,497.77	6	$488,987
Drainage System Modification	LS	$777,066.62	1	$777,067
Detention Basin	LS	$1,510,222.72	1	$1,510,223

Capital Cost	**$16,064,444**
Risk Contingency 3%	**$421,920**
General Contingency (20%)	**$3,212,900**
Subtotal	**$19,699,264**
Preconstruction Eng. And Design (10%)	**$1,969,926**
Engineering During Construction (1%)	**$196,993**
Supervision and Administration (6.5%)	**$1,280,452**
Total Capital Cost (2011$)	**$23,146,636**

Operation and Maintenance (1YR)	**$166,864**
Repair (10YR)	**$410,010**
Rehabilitation (25YR)	**$976,250**
Replacement (50YR)	**$3,139,814**

THE Louis Berger Group, INC.

December 20, 2012

Upper Turkey Creek

Preliminary Opinion of Probable Construction Costs

UTC Alternative 3d
(UTC_A3_100_E_Merriam_PureNED)

Item	Unit	Unit Price	Quantity	Amount
Levee				
1 ft	LF	$21.96	-	$0
2 ft	LF	$37.88	396	$15,001
3 ft	LF	$58.24	306	$17,836
4 ft	LF	$83.04	-	$0
5 ft	LF	$112.29	190	$21,343
6 ft	LF	$145.97	-	$0
7 ft	LF	$184.09	-	$0
8 ft	LF	$226.66	-	$0
Flood Wall				
0-2 ft	LF	$477.45	1,806	$862,152
2-4 ft	LF	$583.82	982	$573,360
4-6 ft	LF	$690.20	697	$481,041
6-8 ft	LF	$810.92	-	$0
8-12 ft	LF	$1,011.86	-	$0
Channel Modification				
Excavation	CY	$11.07	202,222	$2,237,734
Fill	CY	$7.83	12,275	$96,105
Overbank Rehabilitation	SF	$3.87	98,810	$382,250
Bank Rehabilitation				
Hardening	SF	$28.98	-	$0
RipRap Stabilization	SF	$6.04	464,130	$2,801,891
Easement Repairs	SF	$0.99	323,462	$321,709
Pedestrian Bridge	LS	$104,491.33	1	$104,491
Utility Crossing	EA	$81,497.77	6	$488,987
Drainage System Modification	LS	$777,066.62	1	$777,067
Detention Basin	LS	$1,510,222.72	1	$1,510,223

Capital Cost		**$10,691,189**
Risk Contingency	*3%*	**$354,728**
General Contingency (20%)		**$2,138,300**
Subtotal		**$13,184,217**
Preconstruction Eng. And Design (10%)		**$1,318,422**
Engineering During Construction (1%)		**$131,842**
Supervision and Administration (6.5%)		**$856,974**
Total Capital Cost (2011$)		**$15,491,455**

Operation and Maintenance (1YR)	**$181,864**
Repair (10YR)	**$389,526**
Rehabilitation (25YR)	**$924,546**
Replacement (50YR)	**$2,390,801**

THE Louis Berger Group, INC.

December 20, 2012

Upper Turkey Creek

Preliminary Opinion of Probable Construction Costs

UTC Alternative 3e
(UTC_A3_100_M_Merriam_PureNED)

Item	Unit	Unit Price	Quantity	Amount
Levee				
1 ft	LF	$21.96	306	$6,725
2 ft	LF	$37.88	586	$22,202
3 ft	LF	$58.24	-	$0
4 ft	LF	$83.04	-	$0
5 ft	LF	$112.29	-	$0
6 ft	LF	$145.97	-	$0
7 ft	LF	$184.09	-	$0
8 ft	LF	$226.66	-	$0
Flood Wall				
0-2 ft	LF	$477.45	1,061	$506,703
2-4 ft	LF	$583.82	216	$126,386
4-6 ft	LF	$690.20	-	$0
6-8 ft	LF	$810.92	-	$0
8-12 ft	LF	$1,011.86	-	$0
Channel Modification				
Excavation	CY	$11.07	296,542	$3,281,455
Fill	CY	$7.83	14,685	$114,973
Overbank Rehabilitation	SF	$3.87	104,301	$403,492
Bank Rehabilitation				
Hardening	SF	$28.98	-	$0
RipRap Stabilization	SF	$6.04	492,995	$2,976,144
Easement Repairs	SF	$0.99	313,742	$312,041
Bridge Modification	EA			
Shawnee Mission Pkwy	LS	$2,823,129.72	1	$2,823,130
Merriam Drive	LS	$2,601,015.08	1	$2,601,015
Pedestrian Bridge	LS	$104,491.33	1	$104,491
Utility Crossing	EA	$81,497.77	6	$488,987
Drainage System Modification	LS	$777,066.62	1	$777,067
Detention Basin	LS	$1,510,222.72	1	$1,510,223

Capital Cost	**$16,055,032**
Risk Contingency 2%	**$395,747**
General Contingency (20%)	**$3,211,100**
Subtotal	**$19,661,878**
Preconstruction Eng. And Design (10%)	**$1,966,188**
Engineering During Construction (1%)	**$196,619**
Supervision and Administration (6.5%)	**$1,278,022**
Total Capital Cost (2011$)	**$23,102,707**

Operation and Maintenance (1YR)	**$181,864**
Repair (10YR)	**$366,515**
Rehabilitation (25YR)	**$937,238**
Replacement (50YR)	**$2,607,185**

THE Louis Berger Group, INC.

December 20, 2012

Upper Turkey Creek

Preliminary Opinion of Probable Construction Costs

UTC Alternative 3f
(UTC_A3_200_E_Merriam_PureNED)

Item	Unit	Unit Price	Quantity	Amount
Levee				
1 ft	LF	$21.96	-	$0
2 ft	LF	$37.88	-	$0
3 ft	LF	$58.24	1104	$64,272
4 ft	LF	$83.04	306	$25,432
5 ft	LF	$112.29	-	$0
6 ft	LF	$145.97	190	$27,746
7 ft	LF	$184.09	-	$0
8 ft	LF	$226.66	-	$0
Flood Wall				
0-2 ft	LF	$477.45	581	$277,300
2-4 ft	LF	$583.82	2,001	$1,168,299
4-6 ft	LF	$690.20	913	$630,456
6-8 ft	LF	$810.92	-	$0
8-12 ft	LF	$1,011.86	-	$0
Channel Modification				
Excavation	CY	$11.07	202,222	$2,237,734
Fill	CY	$7.83	12,275	$96,105
Overbank Rehabilitation	SF	$3.87	98,810	$382,250
Bank Rehabilitation				
Hardening	SF	$28.98	-	$0
RipRap Stabilization	SF	$6.04	464,130	$2,801,891
Easement Repairs	SF	$0.99	337,824	$335,992
Pedestrian Bridge	LS	$104,491.33	1	$104,491
Utility Crossing	EA	$81,497.77	6	$488,987
Drainage System Modification	LS	$777,066.62	1	$777,067
Detention Basin	LS	$1,510,222.72	1	$1,510,223

Capital Cost	**$10,928,243**
Risk Contingency 3%	**$364,295**
General Contingency (20%)	**$2,185,700**
Subtotal	**$13,478,237**
Preconstruction Eng. And Design (10%)	**$1,347,824**
Engineering During Construction (1%)	**$134,782**
Supervision and Administration (6.5%)	**$876,085**
Total Capital Cost (2011$)	**$15,836,929**

Operation and Maintenance (1YR)	**$194,364**
Repair (10YR)	**$418,090**
Rehabilitation (25YR)	**$990,386**
Replacement (50YR)	**$2,489,996**

THE Louis Berger Group, INC.

December 20, 2012

Upper Turkey Creek

Preliminary Opinion of Probable Construction Costs

UTC Alternative 3g
(UTC_A3_500_E_Merriam_PureNED)

Item	Unit	Unit Price	Quantity	Amount
Levee				
1 ft	LF	$21.96	-	$0
2 ft	LF	$37.88	-	$0
3 ft	LF	$58.24	950	$55,354
4 ft	LF	$83.04	-	$0
5 ft	LF	$112.29	708	$79,445
6 ft	LF	$145.97	-	$0
7 ft	LF	$184.09	306	$56,377
8 ft	LF	$226.66	190	$43,083
Flood Wall				
0-2 ft	LF	$477.45	-	$0
2-4 ft	LF	$583.82	2,108	$1,230,791
4-6 ft	LF	$690.20	1,299	$896,486
6-8 ft	LF	$810.92	993	$804,955
8-12 ft	LF	$1,011.86	-	$0
Channel Modification				
Excavation	CY	$11.07	202,222	$2,237,734
Fill	CY	$7.83	12,275	$96,105
Overbank Rehabilitation	SF	$3.87	98,810	$382,250
Bank Rehabilitation				
Hardening	SF	$28.98	-	$0
RipRap Stabilization	SF	$6.04	464,130	$2,801,891
Easement Repairs	SF	$0.99	366,998	$365,009
Pedestrian Bridge	LS	$104,491.33	1	$104,491
Utility Crossing	EA	$81,497.77	6	$488,987
Drainage System Modification	LS	$777,066.62	1	$777,067
Detention Basin	LS	$1,510,222.72	1	$1,510,223

Capital Cost	**$11,930,245**
Risk Contingency 3%	**$413,390**
General Contingency (20%)	**$2,386,100**
Subtotal	**$14,729,735**
Preconstruction Eng. And Design (10%)	**$1,472,973**
Engineering During Construction (1%)	**$147,297**
Supervision and Administration (6.5%)	**$957,433**
Total Capital Cost (2011$)	**$17,307,438**

Operation and Maintenance (1YR)	**$214,364**
Repair (10YR)	**$447,159**
Rehabilitation (25YR)	**$1,039,813**
Replacement (50YR)	**$2,678,969**

THE Louis Berger Group, INC.

December 20, 2012

Upper Turkey Creek

Preliminary Opinion of Probable Construction Costs

UTC Locally Preferred Plan
(UTC_A2_Locally Preferred Alternative_E_Merriam)

Item	Unit	Unit Price	Quantity	Amount
Levee				
2 ft	LF	$37.88	306	$11,601
3 ft	LF	$58.24	-	$0
4 ft	LF	$83.04	306	$25,432
5 ft	LF	$112.29	935	$104,938
6 ft	LF	$145.97	496	$72,448
7 ft	LF	$178.36	0	$0
Flood Wall				
0-2 ft	LF	$477.45	359	$171,422
2-4 ft	LF	$583.82	3,672	$2,143,983
4-6 ft	LF	$690.20	4,578	$3,159,567
6-8 ft	LF	$810.92	496	$402,477
8-12 ft	LF	$1,011.86	-	$0
Easement Repairs	SF	$0.99	222,976	$221,767
Pedestrian Bridge	LS	$104,491.33	1	$104,491
Utility Crossing	EA	$81,497.77	6	$488,987
Drainage System Modification	LS	$777,066.62	1	$777,067
Detention Basin	LS	$1,599,348.64	1	$1,599,349

Capital Cost	**$9,283,527**
Risk Contingency 4%	**$345,356**
General Contingency (20%)	**$1,856,800**
Subtotal	**$11,485,683**
Preconstruction Eng. And Design (10%)	**$1,148,568**
Engineering During Construction (1%)	**$114,857**
Supervision and Administration (6.5%)	**$746,569**
Total Capital Cost (2011$)	**$13,495,677**

Operation and Maintenance (1YR)	**$153,218**
Repair (10YR)	**$309,993**
Rehabilitation (25YR)	**$636,187**
Replacement (50YR)	**$2,765,174**

Section 5 Geotechnical

Table of Contents

1. INTRODUCTION B5-1
2. SUBSURFACE CONDITIONS B5-1
2.1 REGIONAL GEOLOGY B5-1
2.2 SITE SPECIFIC SUBSURFACE CONDITIONS B5-3
2.3 SEISMIC CONSIDERATIONS B5-4
2.4 SOIL VOLUME AND RECOMMENDED LEVEE STRUCTURE B5-4
3. SLOPE STABILITY ANALYSIS B5-5
3.1 EMBANKMENT SLOPE STABILITY B5-6
3.1.1 STABILITY OF THE EXISTING CHANNEL WITH THE NEW LEVEE STRUCTURE B5-7
3.1.2 INTERNAL STABILITY OF THE LEVEE STRUCTURE B5-7
3.2 STREAM BANK SLOPE STABILITY B5-7
4. Addendum. Geotechnical updates to October 2013 NED Plan B5-16

Figures

FIGURE 5-1: TYPICAL LEVEE CROSS SECTION B5-5
FIGURE 5-2: EXISTING CHANNEL PHOTOGRAPH B5-8
FIGURE 5-3: TYPICAL CHANNEL CROSS SECTION WITHIN THE MERRIAM PROJECT AREA B5-9
FIGURE 5-4: CRITICAL CHANNEL CROSS SECTION, RIVER STATION 2.813 ..... B5-10
FIGURE 5-5: CRITICAL CHANNEL CROSS SECTION, RIVER STATION 3.298 ..... B5-11
FIGURE 5-6: CRITICAL CHANNEL CROSS SECTION, RIVER STATION 3.481 ..... B5-12
FIGURE 5-7: CRITICAL CHANNEL CROSS SECTION, RIVER STATION 2.813 ..... B5-13
FIGURE 5-8: CRITICAL CHANNEL CROSS SECTION, RIVER STATION 3.298 ..... B5-14
FIGURE 5-9: CRITICAL CHANNEL CROSS SECTION, RIVER STATION 3.481 ..... B5-15

Tables

TABLE 5-1: NRCS SOILS SERIES WITHIN MERRIAM PROJECT AREA B5-2
TABLE 5-2: SOIL PARAMETERS FOR CONCEPTUAL PRELIMINARY DESIGN B5-4
TABLE 5-3: EFFECTIVE AND TOTAL SHEAR STRENGTH PARAMETERS B5-6
TABLE 5-4: SECANT SHAFT WALL SUMMARY B5-17
TABLE 5-5: NED FLOODWALL SECTIONS SLATED FOR GROUND MODIFICATION AND RISK REDUCTION ... B5-18

Attachments

ATTACHMENT B5-A: GEOTECHNICAL BORING AND SOILS INFORMATION
ATTACHMENT B5-B: SLOPE STABILITY CALCULATIONS

Upper Turkey Creek
Johnson County and Wyandotte County, Kansas
Flood Risk Management Project
Feasibility Study Report with Integrated Environmental Assessment

1. INTRODUCTION

The purpose of this chapter is to summarize the regional and site specific geologic, soil, and geotechnical conditions, to derive parameters, to conduct preliminary stability assessment of the levee and the existing critical channel structures, and to describe the approach used in assessment of geotechnical conditions and material required for the various alternatives developed for the Upper Turkey Creek Feasibility Study. A detailed description of the alternative evaluation and comparison, the formulation of the final array of alternatives, and the evaluation of final array of alternatives can be found in Chapter 5 of the body of the feasibility report.

The Recommended Plan is a levee and floodwall plan in the City of Merriam. These features would extend approximately from Shawnee Mission Parkway to Merriam Drive, which is a stretch that includes Merriam's main downtown reach. Most of the protected area is on the right bank of Turkey Creek. The features are designed for a small urban watershed with levees not exceeding seven feet in height. The plan includes 6,035 feet of floodwall up to 6 feet in height, 2,740 feet of levees up to 6 feet in height, a total 3,340 feet of storm drainage work, and a 2.14 acre-foot detention area.

The Upper Turkey Creek floodplain is 50 to 400 feet in width in most locations due to manmade activities. Bank heights along Upper Turkey Creek vary from 10 to 20 feet and the stream width averages 25 feet within the project area. The Recommended Plan would pass the 1-percent AEP (100-year event) through downtown Merriam with an estimated assurance (conditional nonexceedance probability) of 95.7 percent. The creek along the project area is located a minimum of 15 feet from the existing residential and commercial properties, thus its impact to the existing structures during and after construction of the flood walls is expected to be minimal, if any. The majority of the structures along the creek bank are mostly one story, warehouse type structures. For a majority of the project length, there is a stone masonry gravity wall constructed by stacking plates of rocks along both banks of the stream. The impact of the stone masonry gravity wall to the stability of the levee is discussed in the proceeding paragraphs.

Limited preliminary geotechnical information is available on the soils in the region. Site-specific subsurface condition information on compactness/consistency and stratification of the soils is based on a generalized description given in boring logs based on visual observations of the subsurface deposits. The slope stability performed of the Upper Turkey Creek stream embankment determined general ideas of soil strengths and seepage potential in the study area. A list of preliminary design parameters and the assumed values necessary for the slope stability and the evaluation of the stability of the floodwalls are included below. To compensate for this, the parameters as noted are on the conservative end, and likely a more economical design could be developed during the design phase after conducting additional geotechnical, survey, and site-specific hydrographic data. For the future design work, it is essential to conduct additional borings and laboratory testing to drive geotechnical design parameters. Additionally, the final geotechnical investigation data would include laboratory strength testing to determine strength parameters.

2. SUBSURFACE CONDITIONS

2.1 REGIONAL GEOLOGY

The study area is part of the Osage Plains physiographic section of western Missouri and eastern Kansas. The topography was developed on Pennsylvanian shale interspersed with sandstone and thin beds of limestone, which was formed as a result of the transgression of the Absaroka Sea. The transgressive and regressive sea movements also formed the Morrowan, the Atokan, the Desmoinsian, the Missourian and the Virgilian series of rocks. Most of these rocks are shale, sandstones and clays, although thin limestone and coals are also common. Pennsylvanian strata are the dominant rock north of the

Missouri River and in the Osage Plains region; they exist as hilltop outliers even over much of the Ozark uplift, often resting unconformably on Ordovician rocks. Even though the Pennsylvanian deposits are quite extensive, they form usually thin to medium bedded layers of distinctive composition, called *cyclothems*. A cyclothem results when a sea transgresses and regresses very rapidly along a coastal area, and in a repeating pattern. Often, this pattern consists of a sandstone (beach); silty shale or siltstone (tidal); freshwater limestone (lagoon); underclay (terrestrial); coal (terrestrial swampy forest); shale (nearshore tidal); limestone (shallow marine); and black shale (deep marine).

Tertiary and Quaternary (Cenozoic Era) alluvial (stream deposited) clays, sand and gravels (with a few poorly consolidated sandstones); glacial (ice deposited) tillites and gravels, and eolian (wind blown) clays and loess (an extremely fine "rock flour") overlies the Pennsylvanian era rocks.

The surface/near surface geology of the project area consists of Holocene alluvium, and Virgilian Lane Shale and Wyandotte Limestone of the Kansas City Group. The two basic soil types present in the project area are silt loams and silty-clay loams. Approximately 70 percent of the watershed consists of the Sharpsburg soil unit, which is a silt loam. This soil is known for being deep, well drained and in the B hydrologic group. It is usually found in the uplands and has a range of slope from 3 to 8 percent. The other silt loams, covering approximately 15 percent of the area are the Grundy, Kennebec, and Ladoga soil units. The Grundy unit is deep, poorly drained, is in the C hydrologic group, has a slope range of 1 to 3 percent and is found in the uplands. The Ladoga unit, also found in the uplands is found to be deep, well drained, is in the B hydrologic group and has a slope range from 3 percent to 15 percent. The Kennebec unit, which has a significant amount of humus, is deep, well drained, in the B hydrologic group, and is found primarily in bottom lands. The silty-clay loam found in this study is grouped into two categories, those with deep or shallow layers. These silt clay loams make up the remaining 15 percent of the soils in the watershed. The deep layers consist of the Martin, and Orthents soil units. Both of these units have similar characteristics in that they both are well drained, in the C hydrologic group and are primarily found in the uplands. The Martin soils can have slopes up to 11 percent while the Orthents soil unit has slopes range from 3 to 6 percent. The shallow layers of silty-clay loam are the Sogn and Vinland soil units. These soils are primarily detritus of limestone or shale rock layers. Both are excessively drained, found in the uplands, are in the D hydrologic group, and have slope ranges from 5 to 20 percent. Information obtained from the United States Department of Agriculture, Natural Resource Conservation Service (NRCS), reports the soils in the Merriam project area to be predominantly the Kennebec silt loam (91.2 percent) which trace amounts of Ladoga silt loam (1.4 percent), Oska-Martin complex (1.7 percent), and Vinland-Rock outcrop complex (5.7 percent). A copy of the NRCS soils information is included in Table 5-1 below. Also included are copies of the soils series maps indicating the soil types within the Merriam project area.

Table 5-1: NRCS Soils Series within Merriam Project Area

Johnson County, Kansas (KS091)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
7050	Kennebec silt loam, occasionally flooded	5.9	91.2%
7285	Ladoga silt loam, 3 to 8 percent slopes	0.1	1.4%
7462	Oska-Martin complex, 4 to 8 percent slopes	0.1	1.7%
7658	Vinland-Rock outcrop complex, 15 to 45 percent slopes	0.4	5.7%
Totals for Area of Interest		6.5	100.0%

2.2 SITE SPECIFIC SUBSURFACE CONDITIONS

Prior to the initiation of the feasibility study, USACE drilled two boreholes, and retained a contractor to conduct soils/sediment sampling. That investigation program concentrated on the surface and near surface sampling of sediments within Upper Turkey Creek between 51st Street and 75th Street. Also, three (3) boreholes were drilled to depths ranging from 26 feet and 38 feet below the existing grade. During the sampling program, it appears that shallow hand augured samples were taken within the stream channel within this reach.

The soil laboratory tests performed by Geotechnology, Inc. (Geotechnology) are included in Attachment B5-A to this Chapter. Surface and near surface samples and samples from the upper parts of the boreholes indicated soils mostly belonged to Silty gravelly very stiff Clay (CL, CH), according to the Unified Soil Classification System (USCS). The clayey soils have very high consistency (i.e. very stiff) which may point to their residual nature (i.e. formed due to weathering and disintegration of bedrock).

Soils and rocks below grade in the vicinity of the Upper Turkey Creek, based on the USACE borings DC-4, DC-5 and DC-6, site consisted of: 1) Fill (mostly clay and silt) underlain by; 2) Clay, Sandy silty Clay, and Silt, over; 3) Bedrock (Shale and Limestone).

The Standard Penetration Test (ASTM D 1586) (SPT) "N" values given in the boring logs indicate generally very stiff clay is underlained by stiff, locally to medium clay. No laboratory tests on the samples collected from the boreholes were included in the Geotechnology Report. Generalized descriptions of these subsurface deposits, as observed in the test borings (top to bottom), are presented as follows:

Stratum 1: Fill: The uppermost soil materials in all three boreholes consisted of reddish brown, gray, to black and stiff to very stiff silty, sandy, gravelly CLAY with pieces of boulders, concrete, glass, and other foreign materials. Its thickness ranged from about 4 feet (in DC4) to 6-1/2 feet (in DC5).

Stratum 2: Silty Clay, Gravelly Clay: This stratum mostly consisted of gray to dark brown, stiff, Silty CLAY a Lean CLAY and was recorded immediately below the fill. This stratum appears to be missing in the boring DC4, while it has an average thickness of about 10 feet (ranging between 6 to 10 feet) in the other two boreholes. Based on the description of the soils, it appears that this stratum may be formed as a result of the weathering/disintegration of the underlying shale bedrock.

Stratum 3: Bedrock (Shale and Limestone): This stratum mostly consisted generally of the alternating layers of SHALE and LIMESTONE which were observed between about 4 feet and 18 feet below the existing grade. Shale consisted of greenish gray highly weathered locally disintegrated (into stiff clay) rock. The upper 10-12 feet of the samples were collected by a SPT sampler indicating its soil-grade consistency. The Rock Quality Designation (RQD %) and the Total Core Recovery (TCR percent) in shale ranged from RQD= 0 to 80 percent and, TCR=60 to 100 percent from those samples collected at depths (about 20 feet below the existing grade).

The Limestone consisted of gray, fine grained thinly to moderately thickly bedded, moderately weathered, fossilferous and argillaceous rock with Rock Quality Designation (RQD%) and the Total Core Recovery (TCR percent) ranged from RQD=70 to 100 percent and, TCR= 80 to 100. All three borings were terminated with bedrock at depths 26 feet to 38 feet below the existing grade.

As noted above, the above stratification is based on visual observations given in the boring logs. For the future design work, it is essential to conduct additional borings and laboratory testing to derive geotechnical design parameters. As an example, a minimum of one borehole to an average depth of 25 feet must be drilled at every 200 feet along the alignment to collect design subsurface data. During boring

both disturbed and undisturbed samples should be collected, and the samples should be tested for classification, index, strength and consolidation properties. Strength tests should include consolidated, undrained conditions to evaluate rapid draw down conditions.

In earthwork and for the conceptual preliminary design, the following soil parameters can be used:

Table 5-2: Soil Parameters for Conceptual Preliminary Design

Parameters/ Soil type	Stratum 1 Fill	Stratum 2, Silty Clay, Gravelly Clay	Stratum 4 Bedrock
Angle of Internal Friction (ϕ^0)	32	0	38
Cohesion (psf)	-	2,000	-
Unit Weight (pcf)	125	125	150
Unit Weight, submerged (pcf)	-	60	90
Coefficient of Passive Resistance, Kp	3.25	1.5	4.20
Coefficient of Active Pressure, Ka	0.31	0.5	0.23
Coefficient of interface friction-ultimate	0.30	0.30	0.40

2.3 SEISMIC CONSIDERATIONS

Seismic design parameters should conform to the requirements of the USACE Design Manuals, the International Building Code (IBC), and ASCE Section 7, according to which, the site is classified for seismic design as *"Site Class D"*, Stiff Soil Profile. Because of the stiff to very stiff clay, over shale and limestone bedrock, the site is classified as *"Liquefaction Unlikely"* under seismic loading

Based on the data collected from the USCG's *US Seismic Design Map Web Applications*, in design, and site coefficients (S_s) of 0.057, and ($S_{1)}$ of 0.157 can be used.

2.4 SOIL VOLUME AND RECOMMENDED LEVEE STRUCTURE

Levee and Floodwall options of Upper Turkey Creek were examined for Alternative 2 as part of LBG's analysis. For the levee, LBG used a homogeneous earthen levee. The levee concepts were based on EM 1110-2-1913 which specifies a top width of 10 feet and side slopes of 3H: 1V (Figure 5-1). Levee heights throughout the project area range from 2 to 6 feet high. Landside seepage berms were not included due to the limited land area and the flashy nature of Upper Turkey Creek. The flashy nature would not result in prolonged periods of flood impoundment, and as such, would not contribute to extensive seepage through the levee.

The subsurface below the proposed levee structure would consist of very stiff clay (fill), underlain by stiff clay and silt (likely residual soil), over the bedrock shale. Because the soils and the bedrock below the levee are low permeability, and relatively impervious, seepage below the levee is not considered to be a concern for this project, and no impervious barrier, (i.e. sheet pile, slurry wall cut off, etc.) is required as long as the levee foundation subgrade is prepared satisfactorily and that the levee sits on either compacted stiff to very stiff clay, or cleaned bedrock shale.

The volume of soil required for Alternative 2, the Levee/Floodwall for the 1-percent AEP (100-year event) with 90 percent reliability has been calculated to be approximately 17,231 cubic yards. The laboratory test report (by Geotechnology) indicates all surface, near surface, and the sediment and soils belong to low to high plasticity clay (CL, CH) and locally, poorly graded sand (SP). Mining of clay from nearby pits may present challenges in terms of excavation (because they are stiff to very stiff), handling and storing. Since no borrow site was specifically located for this project and, the volume of material is relatively small, commercial material sources are recommended to be considered for this project.

Alternatively, the Kansas City District indicated that excess materials from a project on the Lower Turkey Creek, could be available for this project which may be used for the levee construction. However, no geotechnical information has been provided to determine if the material would be suitable for use on the project.

Because of the small cross sectional area of the levee, when combined with the workability and sensitivity a homogeneous embankment (levee) structure is recommended. Materials consisting of low to medium plasticity clay (CL) would be suitable to construct the embankment. Because both fill (Stratum 1) and the underlying silty clay (Stratum 2) can be considered low permeability soils, a cut off wall below the embankment will not be required, provided the subgrade is prepared properly. The homogeneous levee structure can be designed with the landside slope at 3H: 1V and stream-side slope at 3H: 1V, with riprap protection (stream side), and vegetation, or synthetic erosion control elements to protect the landside levee (Figure 5-1).

Long term consolidation settlement under the levee loads are expected to be on the order of magnitude of less than one inch.

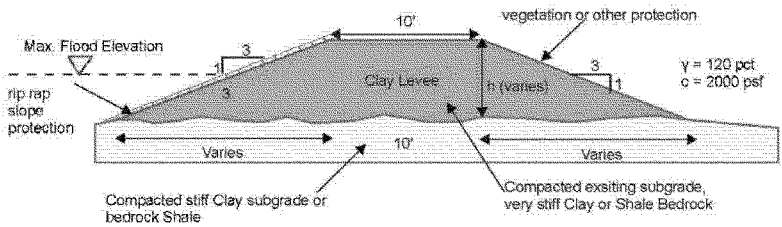


Figure 5-1: Typical Levee Cross Section

3. SLOPE STABILITY ANALYSIS

As indicated in the paragraph above, levee heights throughout the project area range from 2 to 6 feet high.

The levee section was developed based upon a preliminary geological investigation, the borehole data collected by the USACE which includes at a minimum:

a. Collection and study of

(1) Topographic, soil, and geological maps.

(2) Aerial photographs.

(3) Boring logs and well data.

(4) Information on existing engineering projects.

b. Field survey: Observations and geology of area, documented by written notes and photographs, including such features as:

(1) Riverbank slopes, rock outcrops, earth and rock cuts or fills.

(2) Surface materials.

(3) Poorly drained areas.

(4) Evidence of instability of foundations and slopes.

(5) Emerging seepage.

(6) Natural and man-made physiographic features.

(7) The existing structures and its potential impact to the proposed flood wall

3.1 EMBANKMENT SLOPE STABILITY

In the construction of new levees, the slope stability depends on the type of materials proposed for use in the levee construction. As previously discussed in Section 2.4 of this report, the volume of soil required for the Recommended Plan is approximately 10,000 cubic yards. Since no borrow site was specifically located for this project, and the volume of material is relatively small, it is anticipated that a local material supplier would provide the volume of material which meets a design specification developed for the project. Based on the USACE's recommendations, for conceptual design and preliminary cost estimates a homogeneous clay (CL) earthen levee with side slope gradients of 3H: 1V is evaluated. The relatively low gradient side slopes would also resist the rapid draw-down conditions with an adequate factor of safety (See Attachment B5-B).

3.1.1 STABILITY OF THE EXISTING CHANNEL WITH THE NEW LEVEE STRUCTURE

The stability analysis at three most critical sections with the levee structure was carried out using XSABL-An Integrated Slope Stability Analysis Program, Version 5.2, Interactive Software Designs, Inc. (Attachment B5-B) The analysis is based on general limit equilibrium methods using Janbu's generalized procedure of slices and Bishop's Method of analysis and the failure surfaces were generated using random technique option of generating non-circular slip surfaces. Those critical slip surfaces are also shown in the schematic sections in Attachment B5-B.

Based on the analysis the overall slope global stability in normal operating conditions, a minimum safety factor calculated as 4.3 was estimated in the most critical section, River Station 2.813, where the proposed detention basin for interior drainage will be located on the landside of the levee. The factors of safety in the other two sections were 6.5 (River Station 3.298) and 5.2 (River Station 3.481). Because the laboratory test data for shear strength parameters required for rapid draw down analysis (the consolidated undrained R-tests) were not available, stability of the existing channel with the levee structure was analyzed for rapid draw down conditions based on the following assumed effective and total strength parameters.

Table 5-3: Effective and Total Shear Strength Parameters

Parameter	Stratum 2a (Upper parts) Very Stiff gravelly Clay	Stratum 2b (lower parts) Stiff lean Clay
γ_{soil} (pcf)	135 (Assumed saturated)	125
c_T (psf)	60	60
φ_T (degrees)	25	23

The results of the rapid draw down slope stability analysis are given in Attachment B5-B. The rapid draw down conditions also assumed the new levee structure as 720 psf surcharge. The existing channel has an adequate factor of safety of 1.9 in the most critical section in a rapid draw down event at river station 2.813 where the proposed detention basin for interior drainage will be located on the landside of the

levee. The factors of safety in the other two sections were 2.5 (River Station 3.298) and 2.7 (River Station 3.481).

3.1.2 INTERNAL STABILITY OF THE LEVEE STRUCTURE

The following parameters were used for the stability of the levee (embankment) structure:

Levee (Embankment) Material: Clay, Silty Clay, Sandy, Gravelly Clay

- Unit Weight = 125 pcf
- Submerged Unit Weight = 60 pcf
- Angle of Friction = 30^0
- Cohesion =100 psf
- Proposed side slopes at 3H: 1V

At the time of the preparation of this feasibility study, the type of the levee structure was not selected. In the stability analysis, therefore a conservative angle of friction is selected. In considering the long term stability of a clay levee, the analysis would be valid as the long term stability of the clay slopes is governed by the residual strength expressed in "the angle of shearing resistance" (See, Skempton A.W, 1964. *Long-Term Stability of Clay Slopes*, Fourth Rankine Lecture)

Because this is a feasibility study the levee analysis additional stability analysis were made using the chart solutions to evaluate after construction, rapid drawdown cases, and empirical data provided in the Design of Small Dams, the US Department of Interior, the USACE's EM1110-2-1902, Slope Stability: Chart Solutions for Embankment Slopes, and Stability Charts for Earth Slopes During Rapid Drawdown (by N. Morgenstern, The Institution of Civil Engineers, Geotechnique, June 1963, pp121-131).

Additional slope stability analysis was conducted. The results of those analyses along with the assumed conditions/parameters are given in Attachment B5-B), according to which:

A factor of safety of 2.5 is obtained after construction, under normal operating conditions. A surcharge of 300 psf was introduced (for construction traffic, soil stockpile, etc.) to evaluate the stability, for which the factor of safety is reduced to 2.3.

In rapid drawdown (extreme) conditions, the factor of safety is reduced to 1.2 which can be considered adequate because A) conservative parameters were used, B) the critical circle is tangent to the base of the levee, and other levee analysis would lead to a higher factor of safety. In the rapid drawdown assessment, a levee height of 7 feet, maximum water elevation of 6 feet, and a rapid drawdown to base level were considered (Attachment B5-B).

3.2 STREAM BANK SLOPE STABILITY

The stability of the existing channel with a stone masonry wall was also evaluated using the typical sections given in Figures 5-3 through 5-9. These sections were chosen as critical sections within the project area, either due to the height of the existing gravity stone wall and its proximity of the proposed flood risk mitigation features (River Station 2.813), changes in the channel geometry, such as flattening or steepening of the existing side slopes (River Station 3.298), and at a section where development has encroached to the top of the bank of the existing channel (River Station 3.481). During the stability analysis relatively conservative soil parameters were developed using the USACE boring logs. The parameters used in the assessment of the stability and the typical channel section geometry are marked on Figure 5-3. The subsurface conditions in the area of the existing stream bank, consists generally of stiff to very stiff silt and clay, underlain by the bedrock. The stability analysis conducted at three different slopes showed that the stability of the stream bank is maintained with an adequate factor of safety, a typical

section shown in Figure 5-3 where the side slope is 1.71H:1.0V gave a factor of safety of 4.4, while a steeper slope gradient which represents the steepest side slopes in all critical sections at 0.83H:1.0V gave a factor of safety of 2.1 (Attachment B 5-B). The existing stream bank and channel contains armor rock slope protection (i.e. the stone masonry wall) which provides additional slope support. (See Figures 5-2 and 5-3 below). Figures 5-4 through 5-9 indicate the geometry and location of the cross sections analyzed in the project area.

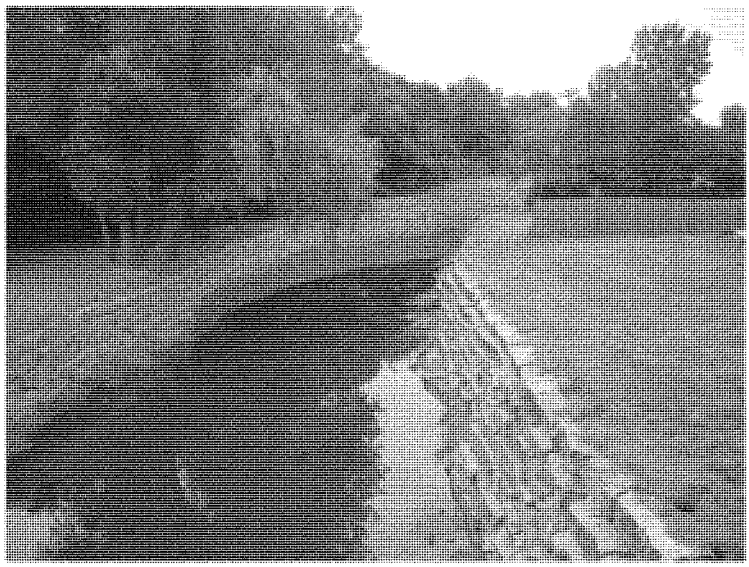


Figure 5-2: Existing Channel Photograph

The stability analysis of the existing stone stacked masonry wall shown in Figure 5.2, was conducted based on a geometry provided by the MDD engineering consultant, Delich, Roth, and Goodwille, P.A., and is provided in Attachment B5-B. The attachment also includes the soil and groundwater conditions and the assumed surcharge due to the new levee structure. The stability analysis indicates that the stone masonry wall has a factor of safety of 2.2 against global stability failure, 2.58 against overturning, and 2.66 against sliding. The critical failure surfaces are also included on the critical cross sections included in the stability analysis.

The proposed levee system would be set back from the bank of the channel and the top of the slope as indicated on a typical channel cross section within the Merriam project area included in Figure 5-3.

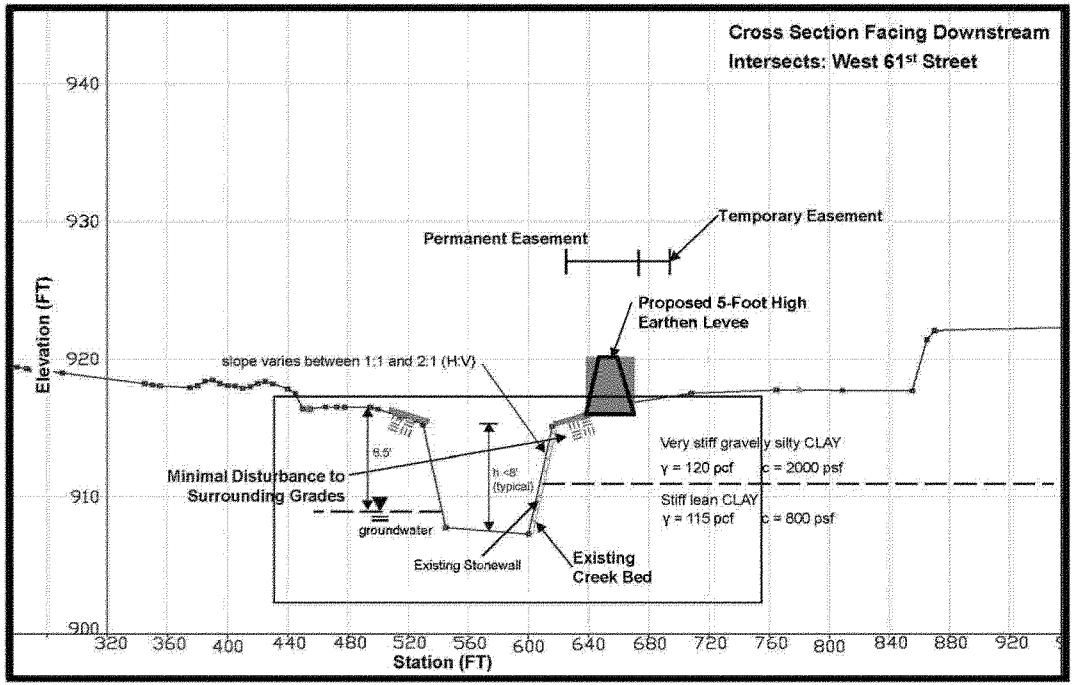


Figure 5-3: Typical Channel Cross Section within the Merriam Project Area

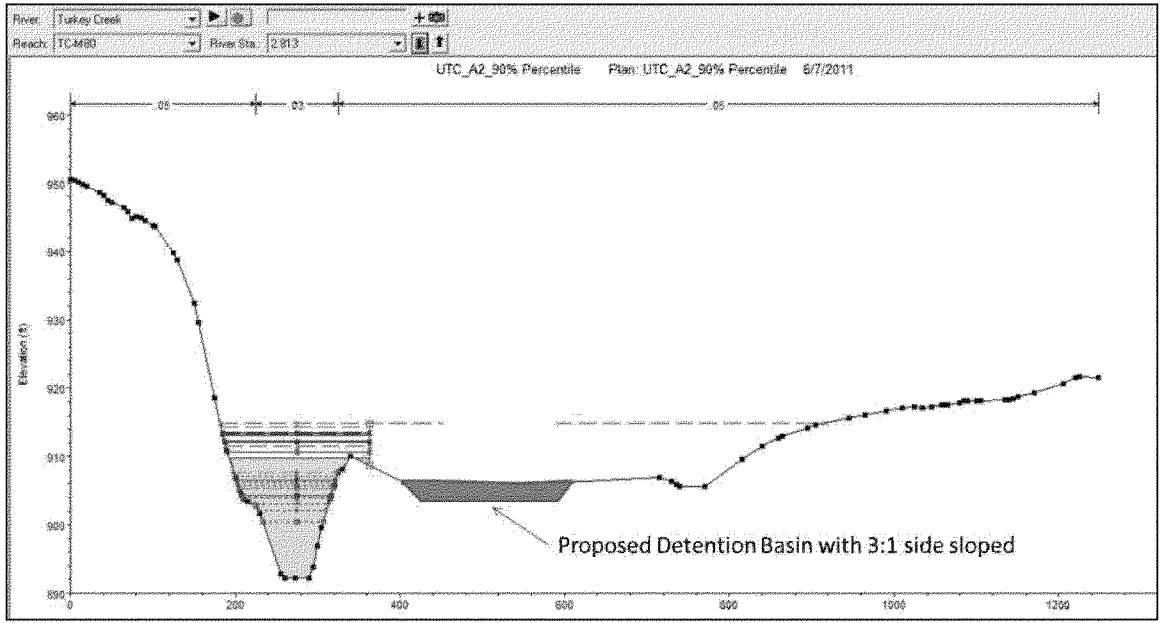


Figure 5-4: Critical Channel Cross Section, River Station 2.813

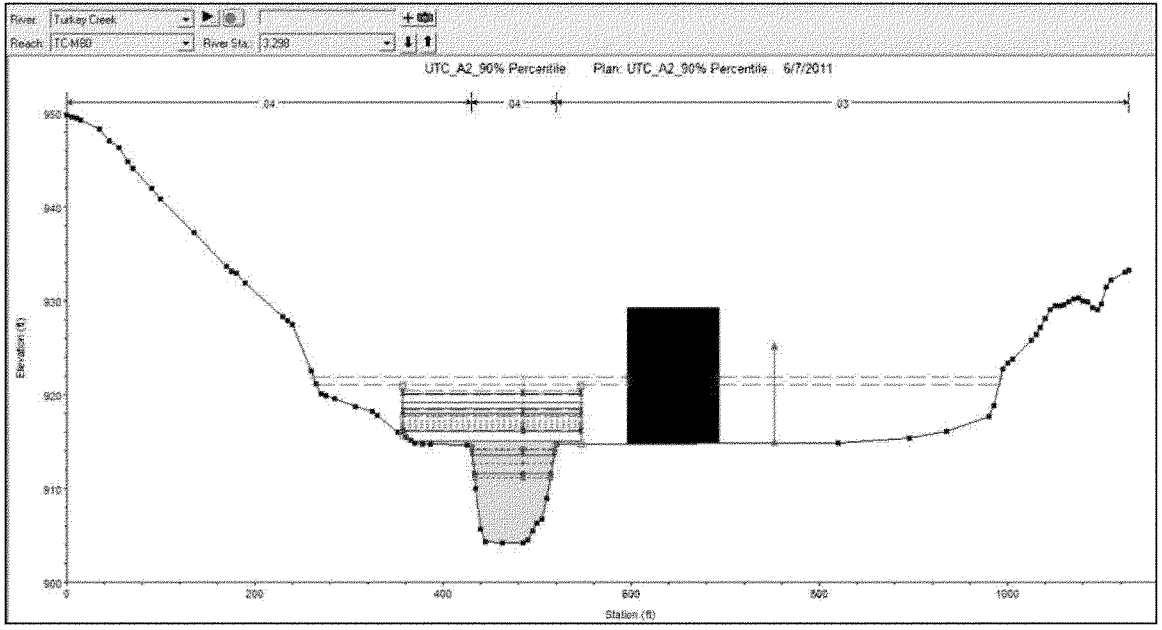


Figure 5-5: Critical Channel Cross Section, River Station 3.298

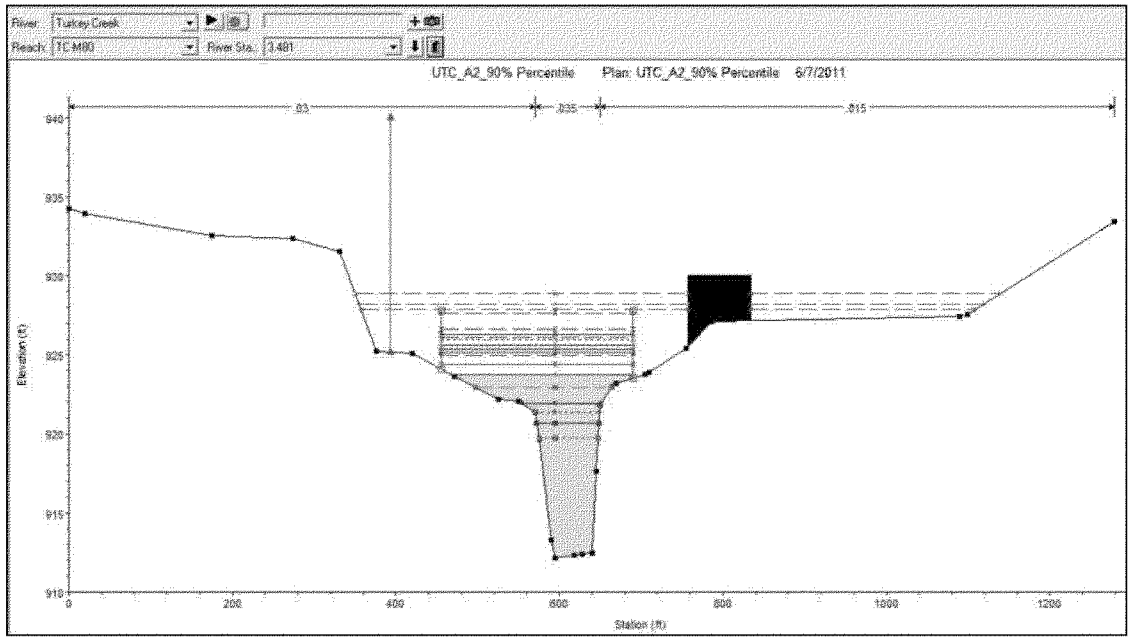


Figure 5-6: Critical Channel Cross Section, River Station 3.481

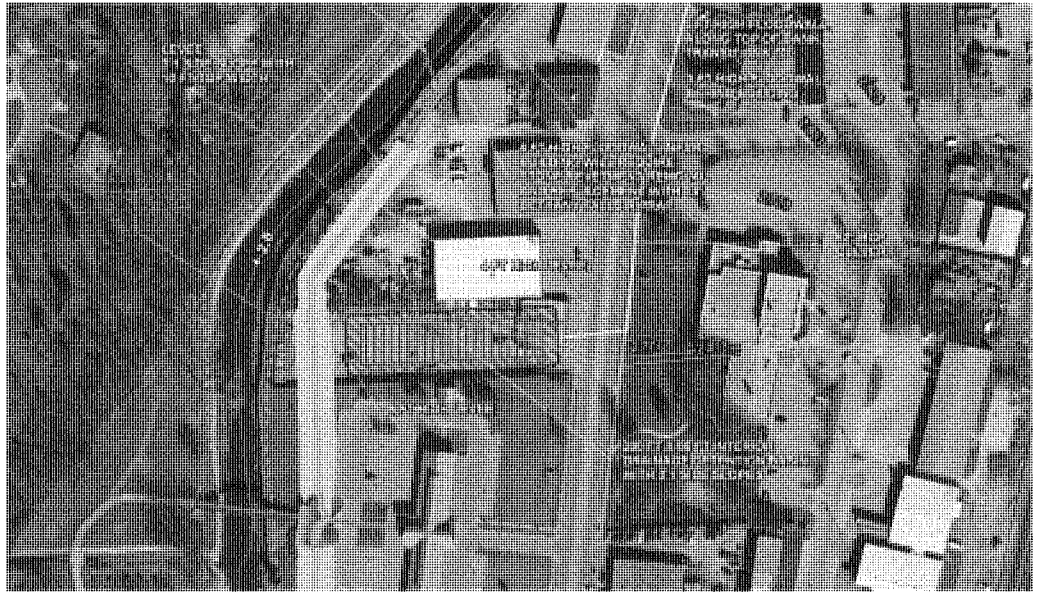


Figure 5-7: Critical Channel Cross Section, River Station 2.813

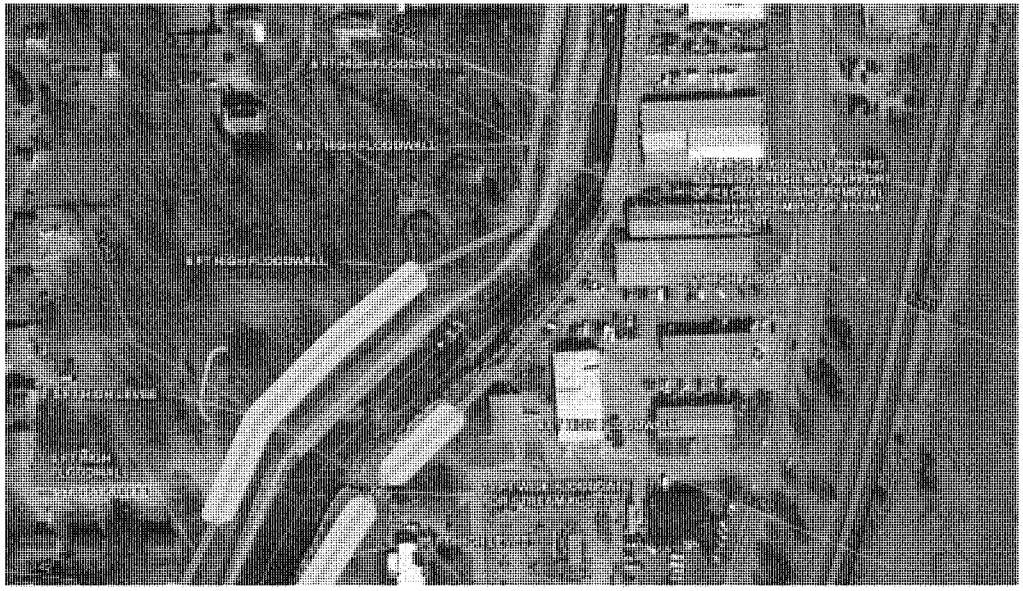


Figure 5-8: Critical Channel Cross Section, River Station 3.298

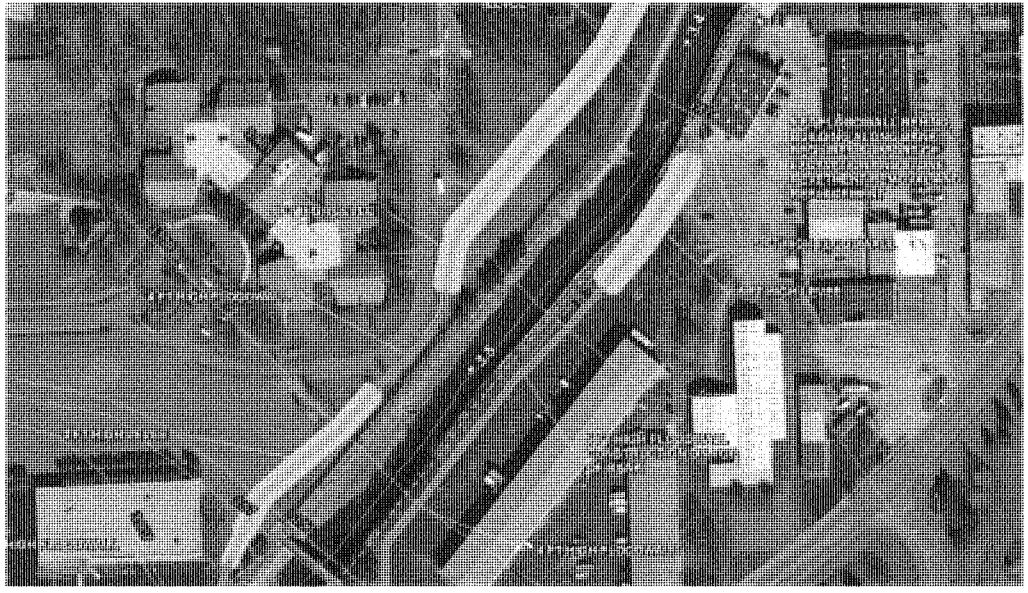


Figure 5-9: Critical Channel Cross Section, River Station 3.481

4.0 ADDENDUM – GEOTECHNICAL UPDATES TO OCTOBER 2013 NED PLAN

An evaluation of Atlas 14 precipitation impacts on the NED plan was performed after the Architect-Engineering (AE) firm that developed the feasibility study was released from contract. Because the AE had been released, USACE performed the evaluation of Atlas 14 precipitation impacts. All information in sections 1.0 through 3.0 in this chapter was developed by the AE. The analysis USACE performed was limited to the evaluation of two levee heights corresponding to Atlas 14 nominal 100-year flows with a 95% and 83% confidence of not overtopping.

During the re-evaluation of the NED plan, USACE discovered that the existing limestone block wall that supports the creek bank has experienced regular failures along the proposed flood protection reach. The failures consist of short sections (roughly 100 ft long or less) of the creek bank wall completely collapsing into the creek. The cause of the failures is unknown, but the wall is not an engineered structure. When these failures occur the City of Merriam, the future sponsor, rebuilds the section of failed creek bank wall with the original limestone blocks. Several visits to inspect the existing creek bank wall then took place and observations were made regarding the existing stacked limestone block creek bank walls that are adjacent to the proposed flood protection. As was documented in Section 3.2, this wall had been found to be stable during an engineering analysis performed by the AE. However, during the site visit by USACE the walls were observed to have locations where retained soil was migrating through the limestone blocks. Additional discussions with the project Sponsor after the site visit indicated that sections of the wall are periodically replaced due to failures. Based on the recent information, it became apparent that the original engineering evaluation did not properly account for the condition and stability of the stacked block walls. The walls, based on visual inspection and recent performance history, are not capable of providing support to the proposed adjacent flood protection system. Several alternatives were considered that either provided stabilization to the bank or provided a foundation for the project that did not rely on the creek bank's continued stability.

The first of the alternatives investigated was to remove the existing creek bank wall, replace it with a new modular gravity wall system (gabion basket wall, etc.) and then construct the originally proposed floodwalls on the existing creek bank. A modular gravity wall would require bottom-up construction. This option was screened out due to excessive cost associated with construction in the wet and need for temporary shoring during construction. Temporary shoring would be needed due to the close proximity of buildings and other infrastructure to the existing creek bank wall (on average 15-ft tall).

Next two alternatives were evaluated to provide a floodwall foundation that did not rely on the stability provided by the limestone block supported creek bank. In order to keep construction costs lower and maintain the park like creek aesthetics, both of the alternatives assumed the existing limestone block creek bank would not be modified. It is anticipated the existing wall will continue to have failures and be maintained/repaired by the local sponsor; however failure of the wall will not affect either of these alternatives.

The first of these alternatives consisted of a secant drilled shafts that would directly support a cast in place floodwall (I-wall). This alternative was evaluated for levee heights corresponding to Atlas 14 flows with a 95% confidence of not overtopping and was eliminated due to cost. The drilled shafts would be installed to form a secant pile wall landward of the existing limestone block wall and then an I-wall would be formed and structurally tied to the drilled shafts. Tie-backs were considered as a means to reduce shaft

size of the secant pile wall alternative (cantilever wall); however construction of tie backs would require the expense of the removal of the existing creek bank wall.

Analysis of the secant wall was executed using ENSOFT's LPILE software. Two floodwall heights were evaluated to analyze the requirements for each of the flow scenarios being evaluated during the re-evaluation. A typical wall section was developed to take the place of both the creek wall and flood wall. This section was based on a flood wall section 7-ft in height and a creek wall 14.4-ft in height. The secant shaft wall consisted of 30-inch drilled shafts that transitioned to a reinforced concrete I-wall. The secant shaft wall would consist of primary and secondary shafts. Primary shafts were assumed to have a 5-ft rock socket and secondary shafts were assumed to extend to 6-inches above the top of bedrock. The analysis of the typical section is included as an attachment to this chapter of Appendix B. Table 5-4 provides a summary of secant shaft wall analysis results. For this alternative, future stability and maintenance of the stacked block walls is not required adjacent to the secant shaft wall. While the secant shaft wall alternative is very robust and can be constructed in the dry, it is very expensive and is not economically feasible

Table 5-4. Secant Shaft Wall Summary

Wall ht above bank (ft)	Primary Shaft Length (ft)	Secondary Shaft Length (ft)	Drilled Shaft Diameter (inches)	Wall Section width (inches)	Primary Shaft Rock Socket (ft)	Secondary Shaft Rock Socket (ft)	Top of Shaft Max. Deflection (inches)	Top of Wall Max. Deflection (inches)
7	19.9	13.9	30	15	5	0	1.2	0.8

- Both wall and primary shafts were assumed to be reinforced with 8 #10 bars

Next a ground modification alternative was investigated. The proposed alternative investigated included ground modification landward of the creek bank to support a shallow foundation floodwall. Ground improvement was provided where the projected slope was steeper than 1:2 between the floodwall toe and creek bed. The ground modification provides stability to the floodwall foundation during localized failure and repair of the existing creek bank wall.

The ground improvement consisted of unreinforced 16-inch diameter, concrete, soil replacement columns extending to the top of bedrock. The columns will be spaced approximately 2-ft on center in an equilateral triangular pattern. Soil properties used in the analysis are the same as for alternative 1. The concrete columns were assumed to have a strength of 4,000-psf at a replacement ratio (As) of 0.40. This alternative was developed for both flow scenarios. The width of the required ground improvement was determined to be 15-ft, centered on the floodwall footing. The ground modification analysis is included as Attachment C. Flood wall sections slated for ground modification are identified in Table 5-5. While small failures and isolated areas of disrepair of the stacked block wall would not cause levee failure with the modified foundation, this alternative requires that the Sponsor continue to perform reasonable maintenance on the existing stacked block wall. This alternative provided the lowest project cost, and is the selected alternative.

Table 5-5. NED Floodwall Sections Slated for Ground Modification for Risk Reduction

Wall I.D.	Downstream River Station of wall Section	Side of Creek bank (left or right)	Length of wall section to be supported on Ground Modification
R2	2.610	Right	120-ft
R4	2.645	Right	80-ft
R6	2.670	Right	60-ft
R9-R14	2.724	Right	880-ft
R15	3.065	Right	1,140-ft
L5	3.132	Left	200-ft
L6	3.186	Left	100-ft
L7	3.204	Left	340-ft
R15	3.065	Right	250-ft
R22-R24	3.383	Right	290-ft
R25-R28	3.460	Right	470-ft
R33-R35	3.581	Right	190-ft

Appendix C
Public Outreach and Involvement

Exhibit 1
Reconnaissance Study, Notice of Initiation, July 2001

US Army Corps of Engineers

NOTICE OF INITIATION
Upper Turkey Creek Basin
Johnson and Wyandotte Counties, Kansas
RECONNAISSANCE STUDY#

#

JULY 2001

#

The Kansas City District Corps of Engineers is conducting a reconnaissance of potential flood damage reduction alternatives and related natural resource issues in the Upper Turkey Creek Basin of Johnson and Wyandotte Counties in Kansas. The study area for this reconnaissance is upstream of the authorized flood damage reduction project. A resolution of the Committee on Transportation and Infrastructure of the United States House of Representatives adopted February 16, 2000, authorized this study of the upper basin. The study was requested by the City of Merriam, Kansas, the Merriam Drainage District, the Unified Government of Wyandotte County and Kansas City, Kansas, and Johnson County, Kansas.

Upper Turkey Creek Basin

Public Workshop
July 25

Merriam City Hall

The study funded entirely by the Federal Government includes an expedited analysis as described in Section 905(b) of the 1986 Water Resources Development Act. The purpose of the analysis is to quickly determine whether the planning process should proceed into the more detailed feasibility phase based on Federal interest in implementing a solution. The analysis considers estimated costs, potential benefits, and possible environmental impacts of the preliminary alternatives. Any future Feasibility Study would be cost-shared on a 50-50 basis between the Federal Government and at least one non-Federal sponsor.

Turkey Creek has produced significant flood damages throughout the basin in 1961, 1977, 1993, and 1998. The flood of July 1993 caused one fatality and damages estimated at $3.4 million in Merriam, Kansas, and $20 million in the lower basin. The flood of October 1998 caused damages in Merriam, Kansas, estimated at $12.0 million, and damages in the lower basin equivalent to those experienced in 1993. The primary

#

Please share this notice with anyone interested in the study.

overflow points along Upper Turkey Creek in the 1998 flood were: vicinity of 75th street, downtown Merriam, I-35 at vicinity of Lamar Ave., and Roe Lane Industrial Park.

This study provides an opportunity to focus on comprehensive water and related land resource measures in the upper portion of the basin. Potential measures include: structural flood damage reduction measures, flood proofing measures, flood warning, detention, relocation, and zoning. Environmentally focused concepts could include wetland or habitat restoration, water quality improvements, and bioengineering to enhance the watershed environment along Turkey Creek and its tributaries. Several local agencies are focused on Turkey Creek Basin problems and are expressing interest in developing a basin-wide, multi-jurisdictional approach. Federal and State agencies have also expressed a desire to cooperate in this effort. We welcome your participation in the reconnaissance study.

An initial public workshop on the scope of the reconnaissance study will be held Wednesday, July 25, 2001, at 7 p.m. in the Council Chambers, Merriam City Hall, 9000 W. 62nd Terrace, Merriam, Kansas

If you have questions or wish to express your concerns about the study in writing, please address your correspondence to:

U.S. Army Corps of Engineers
Formulation Section (PM-PF)
ATTN: Mike Wolfender
601 E. 12th Street
Kansas, City, MO 64106-2896

#

#

Please share this notice with anyone interested in the study.

Exhibit 2
Feasibility Study, Notice of Initiation, August 2002

US Army Corps
of Engineers

NOTICE OF INITIATION

Upper Turkey Creek Basin Johnson and Wyandotte Counties, Kansas

FEASIBILITY STUDY

AUGUST 27 2002

In cooperation with the City of Merriam, Kansas, the Kansas City District Corps of Engineers is conducting a Feasibility Study of potential flood damage reduction alternatives and environmental restoration opportunities in the Upper Turkey Creek Basin of Johnson and Wyandotte Counties in Kansas. The Unified Government of Wyandotte County and Kansas City, Kansas, and Johnson County, Kansas, joined in the request for this study and are key participants on the study team.

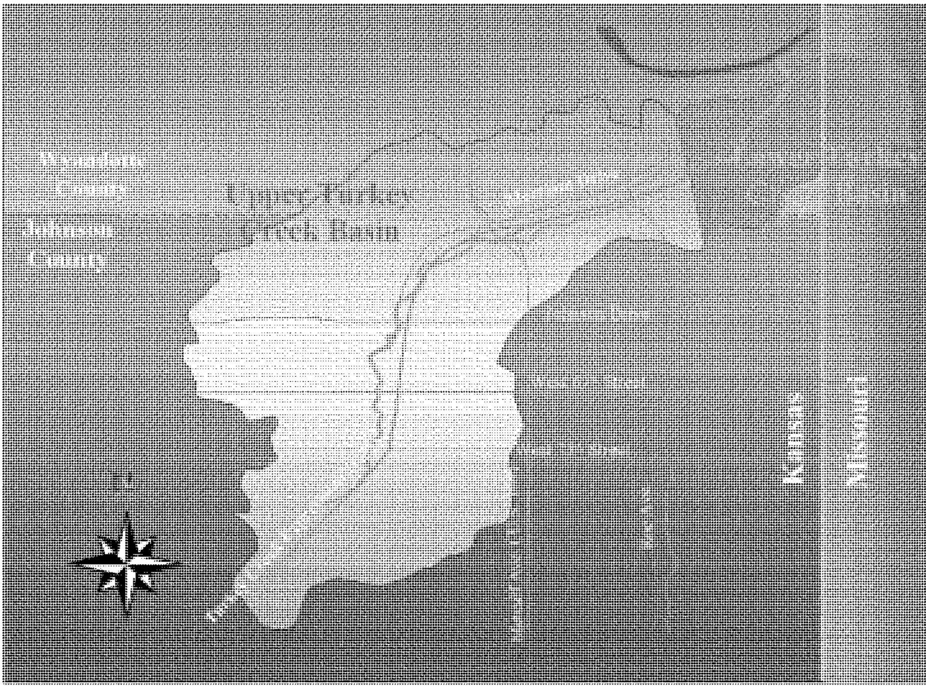
The study area for this Feasibility Study begins at the upstream limit of the Turkey Creek flood damage reduction project authorized for construction in the 1999 Water Resources Development Act and encompasses the remainder of the basin. A map on the reverse of this announcement shows the study area. A resolution of the Committee on Transportation and Infrastructure of the United States House of Representatives adopted February 16, 2000, authorized this study of the upper basin.

The study made the transition to a Feasibility Study on June 24, 2002, with signing of a cost-sharing agreement by the City of Merriam and the Government. Prior to that signing, the Kansas City District had completed an expedited reconnaissance study at 100-percent Federal cost and worked with the study team members to develop the cost sharing agreement. The agreement calls for a study cost of slightly less than $2.5 million with part of the non-Federal share to be provided as in-kind work rather than cash. The Federal Government and the non-Federal sponsor will share the total Feasibility Study cost equally.

The study team plans one or more public workshops to provide further details of the Feasibility Study and to accept public input to the study process. The date and location have not been established but the location will be within the study area and the date will probably be after October 1. In the interim, you may direct questions or comments on the Feasibility Study to Mike Wolfender, Project Manager, Kansas City District, Corps of Engineers, ATTN: PM-PF, 601 E. 12th Street, Kansas City, Missouri 64106*2896, phone (816) 983-3108 or e-mail michael.j.wolfender@usace.army.mil.

Please share this notice with anyone interested in the study.

Upper Turkey Creek Basin Feasibility Study Area



DEPARTMENT OF THE ARMY
KANSASCITY DISTRICT,CORPS OF ENGINEERS
700 FEDERAL BUILDING
601 E. 12TH ST.
KANSAS CITY, MO 64106-2896

OFFICIAL BUSINESS

Please share this notice with anyone interested in the study.

Exhibit 3
Turkey Creek Awareness Workshop, June 2003

#

Turkey Creek Awareness Workshop

June 17, 2003

The future Turkey Creek will be different from what it is today, perhaps better, perhaps not, depending on the plans we're making now. Visiting the Awareness Workshop would be a convenient way to learn about the activities now underway by City, State, Federal and other types of organizations to gather information and turn it into useful plans for the future restoration and management of Turkey Creek.

Turkey Creek flows generally north and east from near 90th Street in Oveland Park and follows the Interstate Highway 35 corridor until it enters a tunnel that takes it to the Kansas River. The water in Turkey Creek drains from the eastern part of Shawnee, the northwest corner of Overland Park, The northeast corner of Lenexa, all of Merriam, the southwest corner of Kansas City, Kansas, and small parts of Mission and Roeland Park.

Some of the activities now underway affect:

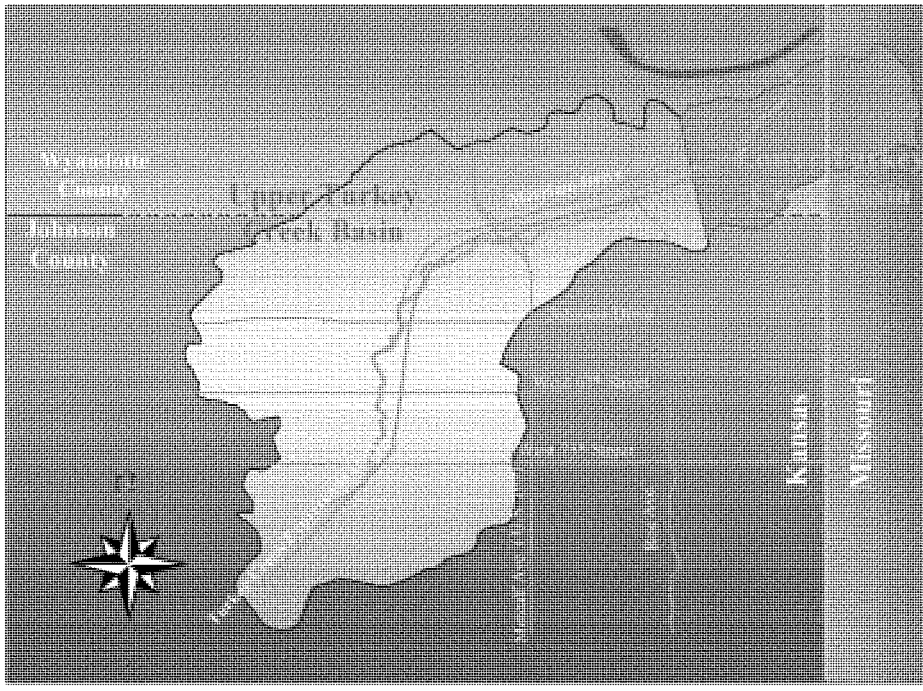
- Stormwater
- Wastewater
- Interstate Highway 35
- Recurring flood damage
- Natural habitat and resources
- Trails and parks
- Water Quality

The workshop will be open from 3 until 7 p.m. at the Antioch Public Library, 8700 West 63rd Street, Shawnee Mission, Kansas. A brief presentation will begin at 6 p.m.

You may direct questions or comments to Mike Wolfender, Project Manager, Kansas City District, Corps of Engineers, ATTN: PM-PF, 601 E. 12th Street, Kansas City, Missouri 64106-2896, phone (816) 983-3108 or e-mail michael.j.wolfender@usace.army.mil.

Please share this notice with anyone interested in Turkey Creek.

Upper Turkey Creek Basin Feasibility Study Area

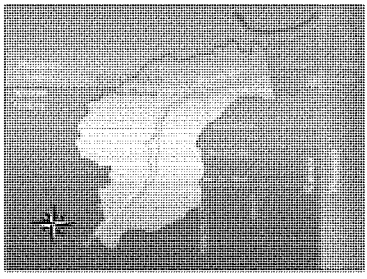


DEPARTMENT OF THE ARMY
KANSASCITY DISTRICT,CORPS OF ENGINEERS
700 FEDERAL BUILDING
601 E. 12TH ST.
KANSAS CITY, MO 64106-2896

OFFICIAL BUSINESS#

Please share this notice with anyone interested in Turkey Creek.

Exhibit 4
Upper Turkey Creek Concepts Workshop, September 2004



Upper Turkey Creek Concepts Workshop

September 16, 2004

Merriam Community Center

Since July of 2002, the Kansas City District Corps of Engineers and the City of Merriam, Kansas, assisted by Johnson County and the Unified Government of Kansas City Kansas and Wyandotte County have investigated opportunities to reduce flood damages in Merriam and in the Roe Lane Industrial Park. As part of the study, we are looking at ways to protect and restore the vitality of Turkey Creek as a living stream that residents can appreciate and enjoy. The current study is far from complete, but we have produced some example solutions for consideration and refinement. This workshop is an opportunity for you to ask questions about the examples and make suggestions for improving them.

We have posted general information on the Upper Turkey Creek basin study on the worldwide web at http://www.nwk.usace.army.mil/projects/utc/.

The workshop will be open from 3 until 8 p.m. in room 128 of the Merriam Community Center, 5701 Merriam Drive, Merriam, Kansas. A brief presentation will begin at 6 p.m.

You may direct questions or comments to Mike Wolfender, Project Manager, Kansas City District, Corps of Engineers, ATTN: PM-PF, 601 E. 12th Street, Kansas City, MO 64106-2896, phone (816) 983-3108 or e-mail michael.j.wolfender@usace.army.mil.

US Army Corps of Engineers®

City of Merriam KANSAS

UNIFIED GOVERNMENT • Wyandotte County • Kansas City, Kansas

Please share this notice with anyone interested in Turkey Creek.

Exhibit 5
Federal and Non-Federal Agency Involvement

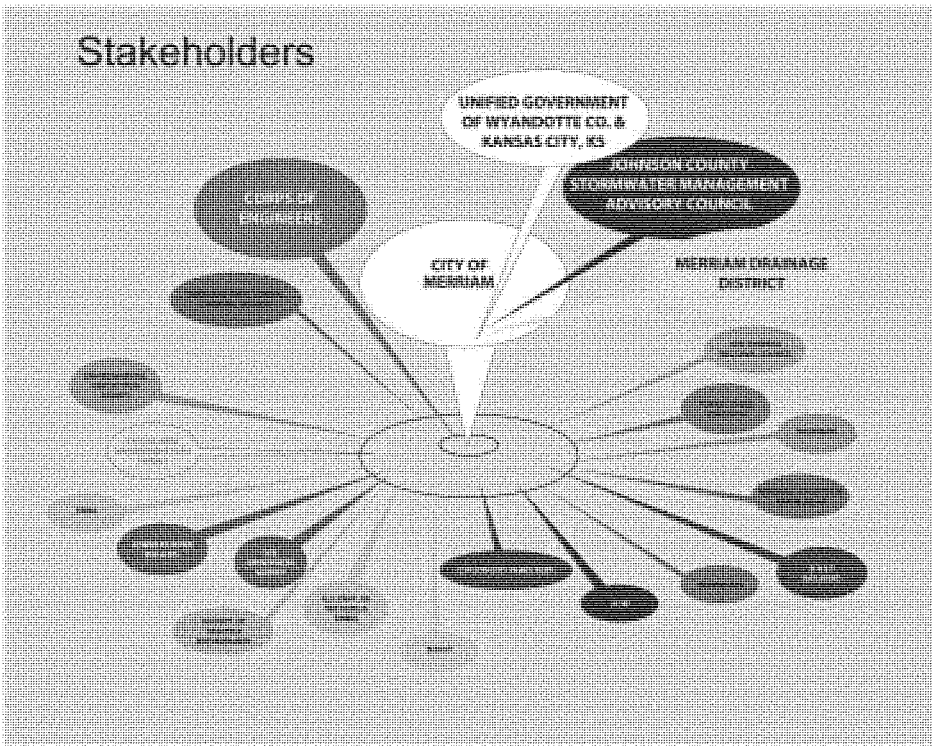

Stakeholders
UNIFIED GOVERNMENT OF WYANDOTTE CO. & KANSAS CITY, KS
JOHNSON COUNTY STORMWATER MANAGEMENT ADVISORY COUNCIL
CITY OF MERRIAM
MERRIAM DRAINAGE DISTRICT

Exhibit 6
Upper Turkey Creek Basin Feasibility Study, Public Meeting, October 2011

October 2011 Public Meeting Notice

Notice of Public Meeting

U.S. Army Corps of Engineers
Kansas City District

Issue Date: September 15, 2011

Upper Turkey Creek Basin Feasibility Study

In cooperation with the City of Merriam, Kansas, the Unified Government of Wyandotte County and the City of Kansas City, Kansas, and the U.S. Army Corps of Engineers, Kansas City District, is conducting a public meeting for the Upper Turkey Creek Basin Feasibility Study. The purpose of the study is to identify opportunities to improve flood risk management along Turkey Creek from upstream of the Boulevard Drive-In Theater in Wyandotte County, Kansas into Johnson County, Kansas. This study will result in a feasibility report that recommends improvements for flood risk management, and an environmental assessment as required by the National Environmental Policy Act (NEPA) and U.S. Army Corps of Engineers regulations.

Major flooding of Turkey Creek occurred in 1961, 1977, 1993, and 1998. Sadly, the flood of 1993 resulted in a fatality. The City of Merriam is particularly prone to damage during flood events. The 1998 flood resulted in an estimated $12 million in damages within Merriam alone. For these reasons, improved flood risk management is desired along Turkey Creek.

The Feasibility Study has focused on three project sites:

- The Roe Lane Industrial Park in Kansas City, Kansas
- Interstate-35
- Downtown Merriam, Kansas

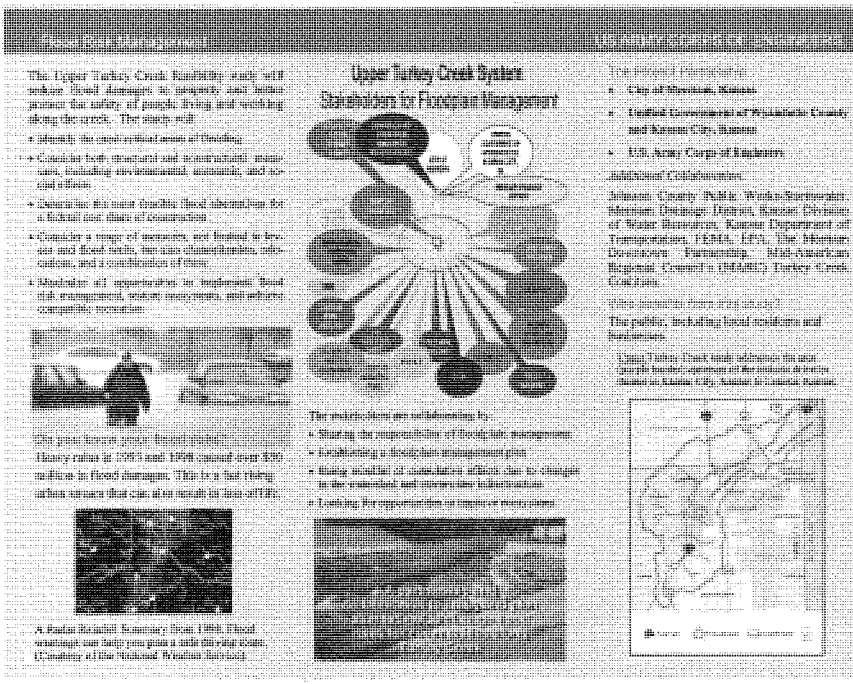
The purpose of the public meeting is to share various alternatives that have been developed, provide an opportunity for public feedback on the alternatives, and to allow for public input concerning Clean Water Act Section 404 compliance.

The public meeting will be held on **October 19, 2011 from 5:00 - 8:00 pm**, at the Irene B. French Community Center, 5701 Merriam Drive, Merriam, Kansas, 66203. Additional information about the Upper Turkey Creek Basin study is located on the web at http://www.nwk.usace.army.mil/projects/utc/.

Questions may be directed to the Upper Turkey Creek Project Manager by clicking on the Comments link located at http://www.nwk.usace.army.mil/projects/utc/ or by calling (816) 389-2000.

October 2011 Public Meeting Brochure

Public Meeting, October 2011
Solutions to Flood Risks along Upper Turkey Creek Basin
U.S. Army Corps of Engineers


Upper Turkey Creek System
Stakeholders for Floodplain Management

October 2011 Public Meeting Mailing List

Upper Turkey Creek

Major Stakeholder Mailing List

Name	Org	Address
Jake Gray	Kansas Division of Emergency Management (KDEM)	2800 SW Topeka Blvd., Topeka, KS 66611
Tom Morey	Kansas Division of Water Resources, Kansas Department of Agriculture	109 SW 9th Street, 2nd Floor, Topeka, Kansas 66612-1283
Hye Jin Lee	City of Merriam	City Hall, 8997 W. 62nd Terrace, Merriam, KS 66202-2815
Bryan Dyer	City of Merriam	City Hall, 8997 W. 62nd Terrace, Merriam, KS 66202-2816
Phil Lammers	City of Merriam	City Hall, 8997 W. 62nd Terrace, Merriam, KS 66202-2817
Judy Deverey	City of Merriam	City Hall, 8997 W. 62nd Terrace, Merriam, KS 66202-2818
Dave Smothers	City of Merriam	City Hall, 8997 W. 62nd Terrace, Merriam, KS 66202-2819
Randy Carroll	City of Merriam	City Hall, 8997 W. 62nd Terrace, Merriam, KS 66202-2819
Ken Sissom	City of Merriam	City Hall, 8997 W. 62nd Terrace, Merriam, KS 66202-2819
Ronnie Metsker	KANSAS House of Representatives	?
Brian Rast	US Army Corps of Engineers, Kansas City District	Richard Bolling Federal Building, Suite 529, 601 East 12th Street, Kansas City, Missouri 64106-2896
John Grothaus	US Army Corps of Engineers, Kansas City District	Richard Bolling Federal Building, Suite 529, 601 East 12th Street, Kansas City, Missouri 64106-2897
David Combs	US Army Corps of Engineers, Kansas City District	Richard Bolling Federal Building, Suite 529, 601 East 12th Street, Kansas City, Missouri 64106-2898
Steve Iverson	US Army Corps of Engineers, Kansas City District	Richard Bolling Federal Building, Suite 529, 601 East 12th Street, Kansas City, Missouri 64106-2899
Anthony Hofmann, Colonel, District Engineer	US Army Corps of Engineers, Kansas City District	Richard Bolling Federal Building, Suite 529, 601 East 12th Street, Kansas City, Missouri 64106-2900
Rick Davis	Lower Kansas WRAPS	1109 SW Red Oaks Ct., Topeka, KS 66615
Amanda Reed	KDHE	Bureau of Water, Watershed Management Section, 1000 S.W. Jackson St., Suite 420, Topeka, KS 66612-1367
Scott Satterwaite	KDHE	Bureau of Water, Watershed Management Section, 1000 S.W. Jackson St., Suite 420, Topeka, KS 66612-1368
Frank Austenfeld	The Watershed Institute	
Mandy Whitsitt	U.S. Environmental Protection Agency	Region 7, WWPD/WPIB, 901 N. 5th St., Kansas City, Kansas 66101
Jeff Robichaud	U.S. Environmental Protection Agency	Region 7, WWPD/WPIB, 901 N. 5th St., Kansas City, Kansas 66101
Terry Harris	Downtown Merriam Partnership	5701 Merriam Dr., Merriam, KS 66203
Ted Derks	Downtown Merriam Partnership	Box 7081, Kansas City, MO 64113
Joe Roth	Delich, Roth & Goodwillie	913 Sheidley Avenue, Suite 110, Bonner Springs, KS 66012
Jim Wymer	Merriam Drainage District	(913) 831-4061
Gerry Becker	Merriam Drainage District	5546 Goodman St., Merriam, KS 66202
Jim Orr	Merriam Drainage District	4800 Rainbow Boulevard, Suite 200, Westwood, KS 66205-1932
Bill Leap	Merriam Drainage District	5525 Noland Road, Shawnee, KS 66216
Bob Roddy	Unified Government	701 N. 7th St., 7th Floor, Kansas City, KS 66101
Burt Morey	Kansas Department of Transportation	1290 S. Enterprise Drive, Olathe, KS 66061
You Jen Tsai	FEMA, Region VII	9221 Ward Parkway, Suite 300, Kansas City, Missouri 64114
Tom Jacobs	Mid-America Regional Council	600 Broadway St., Suite 300, Kansas City, MO 64105-1554
Aaron Bartlett	Mid-America Regional Council	600 Broadway St., Suite 300, Kansas City, MO 64105-1554

	Kassie Shelton	Mid-America Regional Council	600 Broadway St., Suite 300, Kansas City, MO 64105-1554		
	Kent Lage	Johnson County Public Works & Infrastructure - Urban Services Division	1800 W. 56 Highway, Olathe, Kansas 66061		
	Heather Schmidt	Johnson County Public Works	1800 W. 56 Highway, Olathe, Kansas 66061		
	Doug Wesselschmidt	City of Shawnee			
	Mike Gregory	Shawnee	City Hall, 11110 Johnson Dr., Shawnee, KS 66203		
	Tom Jacobs	City of Lenexa			
	Dan Miller	City of Overland Park			
	Steve Weeks	City of Mission			
	Jerry Wiley	City of Fairway	CITY HALL, 4210 Shawnee Mission Parkway, Suite 100 Fairway, KS 66205		
		USGS			

FID	AREA	PROP_ID	KUPN	C_ACRE	D_ACRE	PF	OWNER1	OWNER2	S_STREET	S_STTYPE	S_DIR	S_NUMBER	LU	CLASS	I_VALUE	L_VALUE	T_VALUE	ZONING	S_ADDR	S_ZIP	O_ADDR1	O_ADDR2	UNIQID	SHPCOUNT
3235	14692.59	JP7200000	05613020 02005.00 0	0.34	0	P	SCHOENS TADT, JULIA P. TRUSTEE	SCHOENS TADT, JULIA P. TRUST	ROBIN HOOD	DR		6349	111	RU	31940	133060	165000		6349 ROBIN HOOD DR	66203	6349 ROBIN HOOD DR	MERRIAM , KS 66203	24310	1
3239	48694.45	JF241213-:	05613020 02027.04 0	1.12	1.25	F	MULLIN, MARK	MULLIN, DARLENE	NS	NT		0	511	CU	48830	251170	300000		N/A	66203	5050 WOODLA ND DR	SHAWNEE , KS 66218	24308	1
3244	23215.35	JF241213-:	05613020 02029.00 0	0.53	0	F	CITY OF MERRIAM		NS	NT		0	650	EM	100	0	100		N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	24305	1
3245	22674.27	JP7200000	05613020 04006.00 0	0.52	0	P	EUBANK, CAROL TRUSTEE	EUBANK TRUST	ROBIN HOOD	DR		6350	111	RU	36410	123390	159800		6350 ROBIN HOOD DR	66203	6350 ROBIN HOOD DR	MERRIAM , KS 66203	24304	1
3254	19366.52	JP7200000	05613020 02004.00 0	0.44	0	P	RABINOFF , WALT CO-TRUSTEE	RABINOFF , SANDRA H. CO-TRUSTEE	ROBIN HOOD	DR		6351	111	RU	34560	111640	146200		6351 ROBIN HOOD DR	66203	6351 ROBIN HOOD DR	MERRIAM , KS 66203	24300	1
3265	13724.64	JF241213-:	05613020 02030.00 0	0.32	0	F	CITY OF MERRIAM		63RD	TER	W	9719	735	EM	2810	0	2810		9719 W 63RD TER	66203	9000 W 62ND TER	MERRIAM , KS 66202	24298	1
3272	15783.66	JP7200000	05613020 02003.00 0	0.36	0	P	NANNEY, SHAWN T.	NANNEY, REBEKAH R.	ROBIN HOOD	DR		6353	111	RU	32550	135650	168200		6353 ROBIN HOOD DR	66203	6353 ROBIN HOOD DR	MERRIAM , KS 66203	24293	1
3273	20854.24	JP7200000	05613020 04002.00 0	0.48	0	P	SMITH, MAX D. JR		ROBIN HOOD	DR		6306	111	RU	35390	120010	155400		6306 ROBIN HOOD DR	66203	6306 ROBIN HOOD DR	MERRIAM , KS 66203	24292	1
3274	21682.78	JP7200000	05613020 04001.00 0	0.5	0	P	HONDERICK, EDWINA E.		ROBIN HOOD	DR		6302	111	RU	35860	128740	164600		6302 ROBIN HOOD DR	66203	6302 ROBIN HOOD DR	MERRIAM , KS 66203	24291	1
3280	24998.33	JF241213-:	05613020 02034.00 0	0.57	0	F	CITY OF MERRIAM		63RD	TER	W	9709	735	EM	3390	0	3390		9709 W 63RD TER	66203	9000 W 62ND TER	MERRIAM , KS 66202	24288	1
3281	20001.42	JF241213-:	05613020 02033.00 0	0.46	0	F	CITY OF MERRIAM		63RD	TER	W	9713	735	EM	3130	0	3130		9713 W 63RD TER	66203	9000 W 62ND TER	MERRIAM , KS 66202	24287	1
3283	37497.26	JF241213-:	05613020 02032.00 0	0.86	0	F	CITY OF MERRIAM		63RD	TER	W	9717	735	EM	4020	0	4020		9717 W 63RD TER	66203	9000 W 62ND TER	MERRIAM , KS 66202	24286	1
3293	44466.17	JF241213-:	05613020 02031.00 0	1.02	1	F	CITY OF MERRIAM		63RD	TER	W	9720	735	EM	4380	0	4380		9720 W 63RD TER	66203	9000 W 62ND TER	MERRIAM , KS 66202	24285	1
3300	13365.74	JD7200000	00000000 00000.00 0	0.31	0	D									0	0	0						24284	1
3329	29238.01	JP7200000	05613020 03003.00 0	0.67	0	P	LANDERS, KAY J. TRUSTEE	LANDERS, KAY J. REV TRUST	ROBIN HOOD	DR		6305	111	RU	40090	164810	204900		6305 ROBIN HOOD DR	66203	6305 ROBIN HOOD DR	MERRIAM , KS 66203	24272	1
3330	21076.78	JP7200000	05613020 03002.00 0	0.48	0	P	GARIETY, HARVEY J.	GARIETY, GAIL H.	ROBIN HOOD	DR		6303	111	RU	35520	123380	158900		6303 ROBIN HOOD DR	66203	6303 ROBIN HOOD DR	MERRIAM , KS 66203	24271	1
3331	28202.72	JP7200000	05613020 03001.00 0	0.65	0	P	BASGALL, JAMES L.		ROBIN HOOD	DR		6301	111	RU	39510	120390	159900		6301 ROBIN HOOD DR	66203	6301 ROBIN HOOD DR	MERRIAM , KS 66203	24270	1
3332	235992.9	JD7200000	00000000 00000.00 0	5.42	0	D									0	0	0						24269	1

3333	20702.52	JP7200000	05613020 02002.00 0	0.48	0	P	YOUNG, MARTHA J. TRUSTEE	YOUNG, FRANCIS TRUSTEE	ROBIN HOOD	DR		6355	111	RU	35310	95590	130900		6355 ROBIN HOOD DR	66203	6355 ROBIN HOOD DR	MERRIAM , KS 66203	24268	1
3350	636642.9	JF241213-:	05613020 02001.00 0	14.62	15.4	F	KESSLER, GEO E.		NS	NT		0	458P	VU	0	0	0		N/A	66203	9700 W 63RD ST	MERRIAM , KS 66203	24265	1
3367	6044.288	JP2800003	00000000 00000.00 0	0.14	0	P	JOHNSON COUNTY		NS	NT		0	458	EC	0	0	0		N/A	66203	111 S CHERRY ST	OLATHE, KS 66061-3441	24249	1
3368	6245.22	JP2800003	05112030 11048.00 0	0.14	0	P	STAMBAUGH, RAY W.		NS	NT		0	458P	VU	0	0	0		N/A	66203	NS NT	MERRIAM , KS 66203	24248	1
3370	6263.997	JP2800003	05112030 11049.00 0	0.14	0	P	STAMBAUGH, RAY W.	+	NS	NT		0	458P	VU	0	0	0		N/A	66203	NS NT	MERRIAM , KS 66203	24247	1
3371	6264.008	JP2800003	05112030 11050.00 0	0.14	0	P	STAMBAUGH, RAY W.		NS	NT		0	458P	VU	0	0	0		N/A	66203	NS NT	MERRIAM , KS 66203	24246	1
3374	6264.019	JP2800003	05112030 11051.00 0	0.14	0	P	STAMBAUGH, RAY W.		NS	NT		0	458P	VU	0	0	0		N/A	66203	NS NT	MERRIAM , KS 66203	24245	1
3375	6264.011	JP2800003	05112030 11052.00 0	0.14	0	P	STAMBAUGH, RAY W.		NS	NT		0	458P	VU	0	0	0		N/A	66203	NS NT	MERRIAM , KS 66203	24244	1
3376	6767.917	JP2800003	05112030 11053.00 0	0.16	0	P	JOHNSON, JAS A.		NS	NT		0	458P	VU	0	0	0		N/A	66203	NS NT	MERRIAM , KS 66203	24243	1
3378	6245.087	JP2800003	05112030 11055.00 0	0.14	0	P	STAMBAUGH, RAY W.		NS	NT		0	458P	VU	0	0	0		N/A	66203	NS NT	MERRIAM , KS 66203	24242	1
3379	6245.26	JP2800003	05112030 11056.00 0	0.14	0	P	POTTER, JAMES	ETAL	NS	NT		0	458P	VU	0	0	0		N/A	66203	2711 SOUTHWEST BLV	KANSAS CITY, MO 64108	24241	1
3380	6264.743	JP2800003	05112030 11057.00 0	0.14	0	P	POTTER, JAMES	ETAL	NS	NT		0	458P	VU	0	0	0		N/A	66203	2711 SOUTHWEST BLV	KANSAS CITY, MO 64108	24240	1
3381	6262.569	JP2800003	05112030 11058.00 0	0.14	0	P	POTTER, JAMES	ETAL	NS	NT		0	458P	VU	0	0	0		N/A	66203	2711 SOUTHWEST BLV	KANSAS CITY, MO 64108	24239	1
3382	6264.71	JP2800003	05112030 11059.00 0	0.14	0	P	POTTER, JAMES	ETAL	NS	NT		0	458P	VU	0	0	0		N/A	66203	2711 SOUTHWEST BLV	KANSAS CITY, MO 64108	24238	1
3383	6263.079	JP2800003	05112030 11060.00 0	0.14	0	P	POTTER, JAMES	ETAL	NS	NT		0	458P	VU	0	0	0		N/A	66203	2711 SOUTHWEST BLV	KANSAS CITY, MO 64108	24237	1
3385	37545.99	JP2800003	00000000 00000.00 0	0.86	0	P	CITY OF MERRIAM		NS	NT		0	458	EM	0	0	0		N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	24236	2
3386	153961.5	JD450000C	00000000 00000.00 0	3.53	0	D									0	0	0						24235	1
3388	6251.691	JC241212-:	00000000 00000.00 0	0.14	0	C									0	0	0						24233	1
3389	37945.21	JP4500000	05112030 11031.00 0	0.87	0	P	ENTERPRISE LEASING COMPANY		63RD	ST	W	10000	552	CU	265620	214910	480530		10000 W 63RD ST	66203	7815 FLOYD ST	OVERLAND PARK, KS 66204	24232	1
3390	27365.71	JP4500000	05112030 11036.00 0	0.63	0	P	LINTON, ROBERT F. TRUSTEE	LINTON, ROBERT F. TRUST	63RD	ST	W	9900	583	CU	191560	109930	301490		9900 W 63RD ST	66203	PO BOX 14026	LEXINGTON, KY 40512-4026	24231	1
3391	6511.975	JP2800003	05112030 11061.00 0	0.15	0	P	TAYLOR, B. S.		NS	NT		0	458P	VU	0	0	0		N/A	66203	0 NS NT	MERRIAM , KS 00000	24230	1

3392	35931.94	JP4500000	05112030 11034.00 0 00000000 00000.00	0.82	0	P	ENTERPRISE LEASING COMPANY	NS	NT	0	500	VU	0	0	0	N/A	66203	7815 FLOYD ST	OVERLAND PARK, KS 66204	24229	1
3393	6525.356	JP2800003	0 00000000 00000.00	0.15	0	P	CITY OF MERRIAM	NS	NT	0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	24228	1
3397	6700.307	JP2800003	0 00000000 00000.00	0.15	0	P	CITY OF MERRIAM	NS	NT	0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	24226	1
3399	14618.87	JP2800003	0 00000000 00000.00	0.34	0	P	JOHNSON COUNTY	NS	NT	0	458	EC	0	0	0	N/A	66203	111 S CHERRY ST	OLATHE, KS 66061-3441	24225	1
3400	13450.37	JD2800000	0 05112030 11062.00 0 00000000 00000.00	0.31	0	D							0	0	0					24224	1
3401	5872.1	JP2800003	0 00000000 00000.00	0.13	0	P	TAYLOR, B. S.	NS	NT	0	458P	VU	0	0	0	N/A	66203	0 NS NT	MERRIAM, KS 00000	24223	1
3402	45925.82	JP2800003	0 00000000 00000.00	1.05	0	P	CITY OF MERRIAM	NS	NT	0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	24222	2
3405	6029.562	JP2800003	0 05112030 11037.00 0	0.14	0	P	CITY OF MERRIAM	NS	NT	0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	24220	1
3406	437.0309	JP2800003	0	0.01	0	P	MOLEY, FRANK P. MOLEY, MARIE	NS	NT	0	458P	VU	0	0	0	N/A	66203	RR 2 BOX 244	SPRING HILL, KS 66083	24219	3
3408	54214.56	JP4500000	0 05112030 11032.00 0	1.24	0	P	MERRIAM DRAINAGE DISTRICT	NS	NT	0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	24217	1
3409	8102.852	JP4500000	0 05112030 11031.01 0 00000000 00000.00	0.19	0	P	COACHLITE SKATE CENTER WEST, INC.	NS	NT	0	500	VU	0	0	0	N/A	66203	9800 W 62ND TER	MERRIAM, KS 66203	24216	1
3410	3217.523	JC241212-	0 00000000 00000.00	0.07	0	C							0	0	0					24215	1
3411	6037.268	JP2800003	0 00000000 00000.00	0.14	0	P	JOHNSON COUNTY	NS	NT	0	458	EC	0	0	0	N/A	66203	111 S CHERRY ST	OLATHE, KS 66061-3441	24214	1
3412	37778.29	JP2800003	0 00000000 00000.00	0.87	0	P	CITY OF MERRIAM	NS	NT	0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	24213	1
3417	12439.53	JP2800003	0 00000000 00000.00	0.29	0	P	CITY OF MERRIAM	NS	NT	0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	24209	1
3420	12314	JR2800003	0 00000000 00000.00	0.28	0	R							0	0	0					24207	1
3422	6634.916	JP2800003	0 00000000 00000.00	0.15	0	P	CITY OF MERRIAM	NS	NT	0	458	EK	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	24206	1
3425	6700.199	JP2800003	0 00000000 00000.00	0.15	0	P	CITY OF MERRIAM	NS	NT	0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	24203	1
3428	11380.48	JP2800003	0 05112030 11037.00 0	0.26	0	P	CITY OF MERRIAM	NS	NT	0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	24202	1
3429	2360.684	JP2800003	0	0.05	0	P	MOLEY, FRANK P. MOLEY, MARIE	NS	NT	0	458P	VU	0	0	0	N/A	66203	RR 2 BOX 244	SPRING HILL, KS 66083	24201	3

3437	10249.14	JP2800003	00000000 00000.00 0	0.24	0	P	CITY OF MERRIAM		NS	NT		0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	24194	1
3440	46173.89	JD2800000	00000000 00000.00 0	1.06	0	D									0	0	0					24193	1
3445	21629.69	JP2800003	05112030 11037.02 0	0.5	0	P	CITY OF MERRIAM	MOLEY, FRANK P.	NS	NT		0	458P	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	24191	1
3446	8313.189	JP2800003	05112030 11037.00 0	0.19	0	P	MOLEY, FRANK P.	MOLEY, MARIE	NS	NT		0	458P	VU	0	0	0	N/A	66203	RR 2 BOX 244	SPRING HILL, KS 66083	24190	3
3448	5222.5	JP2800003	05112030 11041.00 0	0.12	0	P	JOH-MEN COMPANY		NS	NT		0	500	VU	1000	0	1000	N/A	66203	9836 BELINDER RD	LEAWOO D, KS 66206	24189	1
3449	5436.268	JP2800003	00000000 00000.00 0	0.12	0	P	CITY OF MERRIAM		NS	NT		0	458	EK	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	24188	1
3451	5438.143	JP2800003	00000000 00000.00 0	0.12	0	P	JOHNSON COUNTY		NS	NT		0	458	EC	0	0	0	N/A	66203	111 S CHERRY ST	OLATHE, KS 66061-3441	24187	1
3452	2466.423	JP2800003	05112030 11054.00 0	0.06	0	P	TFC PARTNERS HIP		NS	NT		0	458	VU	0	0	0	N/A	66203	4400 SHAWNEE MISSION PKY	FAIRWAY, KS 66205	24186	1
3455	11468.36	JP2800003	00000000 00000.00 0	0.26	0	P	CITY OF MERRIAM		NS	NT		0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	24185	1
3457	17310.42	JP2800003	05112030 11038.00 0	0.4	0	P	TRIANGLE INDUSTRI AL PARK		NS	NT		0	5121	CU	0	0	0	N/A	66203	1948 E SANTA FE ST	OLATHE, KS 66062	24184	1
3460	42837.76	JP2800003	05112030 11040.00 0	0.98	0	P	TRIANGLE INDUSTRI AL PARK		MERRIAM	DR		6220	512	CU	277130	1096770	1373900	6220 MERRIAM DR	66203	1948 E SANTA FE ST	OLATHE, KS 66062	24181	1
3475	87969.83	JP2800003	05112030 11030.00 0	2.02	0	P	COACHLIT E SKATE CENTER WEST,	INC.	62ND	TER	W	9800	726	CU	79180	352800	431980	9800 W 62ND TER	66203	9800 W 62ND TER	MERRIAM , KS 66203	24174	1
3477	6717.614	JD2800000	00000000 00000.00 0	0.15	0	D									0	0	0					24173	1
3488	909.6537	JP2800003	05112030 10010.00 0	0.02	0	P	STAMBAU GH, RAY W.		NS	NT		0	458P	VU	0	0	0	N/A	66203	0 NS NT	MERRIAM , KS 00000	24162	1
3494	2714.313	JP2800003	05112030 10009.00 0	0.06	0	P	STAMBAU GH, RAY W.		NS	NT		0	458P	VU	0	0	0	N/A	66203	NS NT	MERRIAM , KS 66203	24157	1
3499	14828.55	JP2800003	05112030 10005.00 0	0.34	0	P	ASH, ROBERT M. JR		MERRIAM	DR		6200	514	CU	44490	104090	148580	6200 MERRIAM DR	66203	6200 MERRIAM DR	MERRIAM , KS 66203	24153	1
3500	4518.315	JP2800003	05112030 10008.00 0	0.1	0	P	STAMBAU GH, RAY W.		NS	NT		0	458P	VU	0	0	0	N/A	66203	NS NT	MERRIAM , KS 66203	24154	1
3502	19181.42	JP2800003	05112030 11039.00 0	0.44	0	P	TRIANGLE INDUSTRI AL PARK		NS	NT		0	5121	CU	0	0	0	N/A	66203	1948 E SANTA FE ST	OLATHE, KS 66062	24151	1
3503	34047.04	JD2800000	00000000 00000.00 0	0.78	0	D									0	0	0					24150	1
3506	80625.99	JP2800003	05112030 11028.00 0	1.85	0	P	CITY OF MERRIAM		NS	NT		0	6591	RU	0	0	0	N/A	66203	9700 W 62ND ST	MERRIAM , KS 66202	24149	1

3507	145129	JP4500000	05112030 11033.00 0	3.33	0	P	RM 14 FK CORP	MASTIN	ST		6231	581	CU	580520	408980	989500	6231 MASTIN ST	66203	PO BOX 852800	RICHARDSON, TX 75085-2800	24148	1
3508	1732.521	JP2800003	05112030 10004.00 0	0.04	0	P	KNICKERBOCKER, WILLIAM J. TR	KNICKERBOCKER, KATHLEEN A. TR	NS	NT	0	6391	CU	0	0	0	N/A	66203	6144 MERRIAM DR	MERRIAM, KS 66203	24147	1
3509	126158.9	JP4670000	05112030 11029.00 0	2.9	0	P	MERRIAM CENTER ASSOCIATES	62ND	TER	W	9900	638	CU	378480	678040	1056520	9900 W 62ND TER	66203	7180 W 107TH ST, #7	OVERLAND PARK, KS 66212	24146	1
3510	1332.802	JP2800003	05112040 09003.00 0	0.03	0	P	JOHNSTON, ROBERT M.	ETAL	NS	NT	0	458P	VU	0	0	0	N/A	66203	6142 MERRIAM DR	MERRIAM, KS 66203	24145	1
3513	14618.31	JP2800003	05112030 10006.00 0	0.34	0	P	KNICKERBOCKER, WILLIAM J. TR	KNICKERBOCKER, KATHLEEN A. TR	NS	NT	0	6391	CU	0	0	0	N/A	66203	6144 MERRIAM DR	MERRIAM, KS 66203	24144	1
3521	639.0339	JP2800003	05112040 09004.00 0	0.01	0	P	STAMBAUGH, RAY W.		NS	NT	0	458P	VU	0	0	0	N/A	66203	0 NS NT	MERRIAM, KS 00000	24139	1
3523	36076.24	JP2800003	05112030 10003.00 0	0.83	0	P	JOH-MEN COMPANY	MERRIAM	DR		6210	514	CU	72150	303110	375260	6210 MERRIAM DR	66203	9836 BELINDER RD	LEAWOOD, KS 66206	24137	1
3525	7694.573	JP2800003	05112030 10007.00 0	0.18	0	P	KNICKERBOCKER, WILLIAM J. TR	KNICKERBOCKER, KATHLEEN A. TR	MERRIAM	DR	6144	639	CU	60120	105110	165230	6144 MERRIAM DR	66203	6144 MERRIAM DR	MERRIAM, KS 66203	24135	1
3538	1219.137	JP2800003	05112040 09002.00 0	0.03	0	P	JOHNSTON, ROBERT M.	ETAL	NS	NT	0	458P	VU	0	0	0	N/A	66203	6142 MERRIAM DR	MERRIAM, KS 66203	24124	1
3539	34320.41	JP2800003	00000000 00000.00 0	0.79	0	P	JOHNSON COUNTY		NS	NT	0	458	EC	0	0	0	N/A	66203	111 S CHERRY ST	OLATHE, KS 66061-3441	24123	1
3540	35763.43	JP2800003	05112030 11026.00 0	0.82	0	P	CITY OF MERRIAM		NS	NT	0	6591	RU	0	0	0	N/A	66203	9700 W 62ND ST	MERRIAM, KS 66203	24122	1
3542	14144.68	JP2800003	05112030 11043.00 0	0.32	0	P	TEN MASTIN, INC.		NS	NT	0	100F	VU	0	0	0	N/A	66203	0 NS NT	MERRIAM, KS 00000	24120	1
3543	100722.8	JP2800003	05112030 11042.00 0	2.31	0	P	TRIANGLE INDUSTRIAL PARK		NS	NT	0	5121	CU	0	0	0	N/A	66203	1948 E SANTA FE ST	OLATHE, KS 66062	24119	1
3549	27627.3	JP2800003	05112030 10002.00 0	0.63	0	P	HOWE, ELSIE RAE TRUSTEE	ETAL	62ND	ST	W 9513	511	CU	69070	136530	205600	9513 W 62ND ST	66203	9705 MONROVIA ST, #318	LENEXA, KS 66215	24117	1
3553	10839.96	JP2800003	05112030 10001.00 0	0.25	0	P	JOHNSTON, ROBERT M.	ETAL	MERRIAM	LN	6130	638	CU	27100	84000	111100	6130 MERRIAM LN	66203	6142 MERRIAM DR	MERRIAM, KS 66203	24114	1
3555	18651.12	JP2800003	05112040 09001.00 0	0.43	0	P	JOHNSTON, ROBERT M.	ETAL	MERRIAM	DR	6134	511	CU	56550	228250	284800	6134 MERRIAM DR	66203	6142 MERRIAM DR	MERRIAM, KS 66203	24112	1
3557	9004.787	JP2800003	05112040 09005.00 0	0.21	0	P	STAMBAUGH, RAY W.		NS	NT	0	458P	VU	0	0	0	N/A	66203	RR 1	SHAWNEE MISSION, KS 66203	24111	1

3566	14391.23	JP4500000	05112030 11022.00 0	0.33	0	P	EL CON INVESTMENTS, INC.	CORTEZ	ST		6105	119	RU	520000	2895100	3415100	6105 CORTEZ ST	66203	6105 CORTEZ ST	MERRIAM, KS 66203	24104	3
3578	1823.57	JP2800003	05112030 11006.03 0	0.04	0	P	CITY OF MERRIAM	NS	NT		0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	24097	1
3581	33751.25	JP2800003	05112030 11006.00 0	0.77	0	P	PORTER, TIMOTHY J.	PORTER, EVELYN E.	NS	NT		0	100F	VU	8770	0	8770	N/A	66203	1205 N CURTIS ST	OLATHE, KS 66061	24096	3
3582	10940.84	JP4500000	05112030 11022.00 0	0.25	0	P	EL CON INVESTMENTS, INC.	CORTEZ	ST		6105	119	RU	520000	2895100	3415100	6105 CORTEZ ST	66203	6105 CORTEZ ST	MERRIAM, KS 66203	24095	3
3584	22300.5	JF241212-;	05112030 11023.00 0	0.51	0	F	CITY OF MERRIAM	NS	NT		0	6591	RU	0	0	0	N/A	66203	9700 W 62ND ST	MERRIAM, KS 66202	24094	1
3585	194908.9	JF241212-;	05112030 11027.00 0	4.47	0	F	CITY OF MERRIAM	62ND	ST	W	9700	659	EB	667120	3014280	3681400	9700 W 62ND ST	66203	9700 W 62ND ST	MERRIAM, KS 66203	24093	1
3588	10445.14	JP2800003	05112030 11044.00 0	0.24	0	P	MERRIAM DRAINAGE DISTRICT	NS	NT		0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	24090	1
3590	6508.317	JP2800003	05112030 11006.00 0	0.15	0	P	PORTER, TIMOTHY J.	PORTER, EVELYN E.	NS	NT		0	100F	VU	8770	0	8770	N/A	66203	1205 N CURTIS ST	OLATHE, KS 66061	24088	3
3591	5740.072	JP2800003	05112030 11006.00 0	0.13	0	P	PORTER, TIMOTHY J.	PORTER, EVELYN E.	NS	NT		0	100F	VU	8770	0	8770	N/A	66203	1205 N CURTIS ST	OLATHE, KS 66061	24087	3
3593	264251.9	JP4500000	05112030 11022.00 0	6.07	0	P	EL CON INVESTMENTS, INC.	CORTEZ	ST		6105	119	RU	520000	2895100	3415100	6105 CORTEZ ST	66203	6105 CORTEZ ST	MERRIAM, KS 66203	24086	3
3594	6722.374	JP2800003	05112030 09005.00 0	0.15	0	P	MERRIAM DRAINAGE DISTRICT	NS	NT		0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	24085	1
3596	39435.81	JP2800003	05112030 09006.00 0	0.91	0	P	ODDO, ANTHONY V. TRUSTEE	ODDO, MARILYN E. TRUSTEE	MERRIAM	LN		6126	512	CU	81040	299960	381000	6126 MERRIAM LN	66203	6325 ROBIN HOOD DR	MERRIAM, KS 66203	24083	1
3597	1086.522	JP2800003	05112030 09007.00 0	0.02	0	P	ODDO, ANTHONY V. TRUSTEE	ODDO, MARILYN E. TRUSTEE	NS	NT		0	5121	CU	0	0	0	N/A	66203	6325 ROBIN HOOD LN	MERRIAM, KS 66203	24082	1
3599	6604.289	JP2800003	05112030 09008.00 0	0.15	0	P	PATCH, DANIEL D. TRUSTEE	PATCH, KATHY E. TRUSTEE	MERRIAM	LN		6110	511	CU	19810	64890	84700	6110 MERRIAM LN	66203	11935 W 72ND TER	SHAWNEE, KS 66216	24080	1
3600	408.4182	JP2800003	05112030 11002.01 0	0.01	0	P	FURMAN, JARED W.	FURMAN, FAITH A.	NS	NT		0	100F	VU	190	0	190	N/A	66203	6109 KNOX ST	MERRIAM, KS 66203	24079	1
3601	456.5071	JP2800003	05112030 11047.00 0	0.01	0	P	MERRIAM DRAINAGE DISTRICT	NS	NT		0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	24078	1
3604	5201.392	JP2800003	05112030 11002.00 0	0.12	0	P	FURMAN, JARED W.	FURMAN, FAITH A.	NS	NT		0	100F	VU	610	0	610	N/A	66203	6109 KNOX ST	MERRIAM, KS 66203	24076	1
3605	8603.251	JF241212-;	05112030 11008.00 0	0.2	0	F	GEBHART, JEFFREY C.	KNOX	ST		6114	112	RU	21010	85990	107000	6114 KNOX ST	66203	3660 W 96TH ST	OVERLAND PARK, KS 66206	24075	1

3607	44296.85	JP2800003	05112040 08002.00 0	1.02	0	P	SHAWNEE WELDING CO., INC.		MERRIAM	DR		6124	333	CU	132890	417210	550100	6124 MERRIAM DR	66203	6124 MERRIAM DR	MERRIAM , KS 66203	24073	1
3617	12368.97	JP2800003	05112030 11005.00 0	0.28	0	P	FURMAN, JARED W.	FURMAN, FAITH A.	KNOX	ST		6109	111	RU	21840	101160	123000	6109 KNOX ST	66203	6109 KNOX ST	MERRIAM , KS 66203	24069	1
3625	14622.39	JP2800003	05112030 09004.00 0	0.34	0	P	MERRIAM DRAINAGE DISTRICT		NS	NT		0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	24064	1
3638	13401.45	JF241212-:	05112030 11015.00 0	0.31	0	F	FENNERN, PAUL D.		61ST	ST	W	9813	111	RU	22060	89940	112000	9813 W 61ST ST	66203	9813 W 61ST ST	MERRIAM , KS 66203	24052	1
3639	13391.42	JF241212-:	05112030 11014.00 0	0.31	0	F	MCPHERSON, LAWRENCE D.		61ST	ST	W	9807	111	RU	22060	81140	103200	9807 W 61ST ST	66203	9807 W 61ST ST	MERRIAM , KS 66203	24051	1
3640	13392.7	JF241212-:	05112030 11013.00 0	0.31	0	F	BLACKMER, JEFFERY S.	SCOTT, SHEILA I.	61ST	ST	W	9803	111	RU	22060	75440	97500	9803 W 61ST ST	66203	9803 W 61ST ST	MERRIAM , KS 66203	24050	1
3642	15032.25	JF241212-:	05112030 11012.00 0	0.35	0	F	TRABON, WILLIAM J. TRUSTEE		NS	NT		0	111	RU	22420	60580	83000	N/A	66203	9914 W 61ST ST	MERRIAM , KS 66203	24048	1
3643	15031.67	JF241212-:	05112030 11011.00 0	0.35	0	F	HOFFMAN , JAMES L.	HOFFMAN , LAURIE A.	61ST	ST	W	9715	111	RU	22420	90180	112600	9715 W 61ST ST	66203	9715 W 61ST ST	MERRIAM , KS 66203	24047	1
3646	15024.98	JF241212-:	05112030 11010.00 0	0.34	0	F	WALKER, RITA A.		61ST	ST	W	9709	111	RU	22420	84780	107200	9709 W 61ST ST	66203	9709 W 61ST ST	MERRIAM , KS 66203	24044	1
3649	7369.083	JP2800003	05112030 11004.00 0	0.17	0	P	COLLINS, GARY E.	COLLINS, CHERYL A.	61ST	ST	W	9695	111	RU	20740	117860	138600	9695 W 61ST ST	66203	9695 W 61ST ST	MERRIAM , KS 66203	24041	1
3650	10882.94	JF241212-:	05112030 11009.00 0	0.25	0	F	BELAUSTEGUI, JUAN M.	HOURNOU, IVONNE	KNOX	ST		6102	112	RU	21510	137290	158800	6102 KNOX ST	66203	6102 KNOX ST	MERRIAM , KS 66203	24040	1
3651	9568.972	JP2800003	05112030 11003.00 0	0.22	0	P	BALLARD, JASON	MARTINEK-BALLARD, HEATHER	61ST	ST	W	9685	111	RU	21220	86780	108000	9685 W 61ST ST	66203	9685 W 61ST ST	MERRIAM , KS 66203	24039	1
3652	11651.72	JP2800003	05112030 11001.00 0	0.27	0	P	JESTER, MICHAEL		61ST	ST	W	9675	111	RU	21680	89620	111300	9675 W 61ST ST	66203	9675 W 61ST ST	MERRIAM , KS 66203	24038	1
3658	23367.77	JD2800000	00000000 00000.00 0	0.54	0	D									0	0	0					24034	1
3663	10397.84	JP2800003	00000000 00000.00 0	0.24	0	P	CITY OF MERRIAM		NS	NT		0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	24033	1
3664	11309.04	JP2800003	05112030 09003.00 0	0.26	0	P	MERRIAM DRAINAGE DISTRICT		NS	NT		0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	24032	1
3665	14411.36	JP2800003	05112030 09002.00 0	0.33	0	P	MERRIAM DRAINAGE DISTRICT		NS	NT		0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	24031	1

		05112030 09001.00			MCMENEMY,											6108 MERRIAM		9619 W	MERRIAM				
3666	27355.02	JP2800003	0 00000000 00000.00	0.63	0 P	LEONA A.		MERRIAM	LN		6108	649	CU	68390	65340	133730	LN	66203	57TH ST	, KS 66203	24030	1	
3667	108963.9	JD280000C	0	2.5	0 D									0	0	0					24029	1	
		05112040 08001.00			ORSER,	ORSER,										6100 MERRIAM		10408	OVERLAND PARK,				
3669	58405.41	JP2800003	0 00000000 00000.00	1.34	0 P	CARL E.	CAROL B.	MERRIAM	DR		6100	552	CU	136010	53960	189970	DR	66203	CODY ST	KS 66214	24027	1	
3670	40037.49	JD241212-	0 00000000 00000.00	0.92	0 D	STATE HIGHWAY								0	0	0					24026	1	
3671	49352.95	JF241212-	0 00000000 00000.00	1.13	3.6 F	#10		NS	NT		0	458	EK	0	0	0	N/A	66203	STATE HOUSE	TOPEKA, KS 66612	24025	2	
3677	5834.524	JD241212-	0 00000000 00000.00	0.13	0 D									0	0	0					24021	1	
3683	95376.87	JP8300000	0	2.19	0 P	CITY OF MERRIAM		NS	NT		0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	24019	1	
3690	17426.5	JF241212-	05112030 07011.00 0 00000000 00000.00	0.4	0 F	GIANNOTTI, DAVID J.		KNOX	ST		6045	111	RU	22950	81250	104200	6045 KNOX ST	66203	6045 KNOX ST	MERRIAM, KS 66203	24012	1	
3702	297115.2	JD830000C	0	6.82	0 D									0	0	0					24002	1	
3711	14411.56	JF241212-	05112030 06030.00 0 05112030 06031.00	0.33	0 F	BENEFICIAL MORTGAGE CO.	OF KANSAS, INC.	61ST	ST	W	9706	111	RU	22290	84110	106400	9706 W 61ST ST	66203	961 WEIGEL DR	ELMHURST, IL 60126	23997	1	
3714	7161.034	JF241212-	05112030 06031.01 0 05112030 07010.00	0.16	0 F	WALKER, EARL J.		61ST	ST	W	9700	112	RU	12000	78400	90400	9700 W 61ST ST	66203	13402 W 67TH ST	SHAWNEE, KS 66216	23994	1	
3716	5150.87	JF241212-	0 05112030 07010.00	0.12	0.12 F	WALKER, CINDY L.		61ST	ST	W	9702	112	RU	11140	80960	92100	9702 W 61ST ST	66203	9702 W 61ST ST	MERRIAM, KS 66203	23992	1	
3722	15399.38	JF241212-	0	0.35	0 F	PARKS, DIANE	ETAL	KNOX	ST		6041	111	RU	22500	105900	128400	6041 KNOX ST	66203	6041 KNOX ST	MERRIAM, KS 66203	23990	1	
3727	1230.009	JF241212-	05112040 05012.00 0	0.03	0 F	MERRIAM DRAINAGE DISTRICT		NS	NT		0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23985	1	
3728	31135.95	JF241212-	05112040 05011.00 0	0.71	0 F	MACEK, VICTOR M. JR TRUSTEE		MERRIAM	LN		6059	511	CU	46700	168500	215200	6059 MERRIAM LN	66203	13625 MIDLAND DR	SHAWNEE, KS 66216	23986	1	
3730	22350.09	JF241212-	05112040 05013.00 0	0.51	0 F	MACEK, VICTOR M. JR TRUSTEE		MERRIAM	LN		6032	511	CU	78230	145970	224200	6032 MERRIAM LN	66203	6032 MERRIAM DR	MERRIAM, KS 66203	23984	1	
3733	17445.88	JF241212-	05112030 06029.00 0	0.4	0 F	WILLIAMSON, TERRY L.	WILLIAMSON, SHARON R.	61ST	ST	W	9712	111	RU	22950	82350	105300	9712 W 61ST ST	66203	9712 W 61ST ST	MERRIAM, KS 66203	23983	1	
3737	17000.55	JF241212-	05112030 06032.00 0 00000000 00000.00	0.39	0 F	BERNAL, RAYMOND A.	PRUNEDA, BONITTA L.	KNOX	ST		6034	111	RU	22860	86640	109500	6034 XNOX ST	66203	6034 KNOX ST	MERRIAM, KS 66203	23980	1	
3738	8759.126	JD241212-	0	0.2	0 D									0	0	0					23979	1	

3741	15399.55	JF241212-;	05112030 07009.00 0	0.35	0 F	PAIDA, DWIGHT I.	PAIDA, SANDRA M.	KNOX	ST		6037	111	RU	22500	84600	107100	6037 KNOX ST	66203	6037 KNOX ST	MERRIAM , KS 66203	23978	1
3743	92836.77	JF241212-;	05112030 07012.00 0	2.13	2 F	MERRIAM DRAINAGE DISTRICT		NS	NT		0	735	EM	48380	0	48380	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23976	2
3744	3917.472	JF241212-;	05112030 07012.00 0	0.09	2 F	MERRIAM DRAINAGE DISTRICT		NS	NT		0	735	EM	48380	0	48380	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23975	2
3755	12467.43	JP1800000	05112030 07013.00 0	0.29	0 P	MERRIAM DRAINAGE DISTRICT		NS	NT		0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23966	1
3757	5792.633	JF241212-;	05112030 07014.00 0	0.13	0 F	MERRIAM DRAINAGE DISTRICT		NS	NT		0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23964	1
3762	16687.6	JP1800000	05112030 07008.00 0	0.38	0 P	ERICKSON, ELDON L. CO-TRUSTEE	ERICKSON, NYONA V. CO-TRUSTEE	KNOX	ST		6017	112	RU	22790	87510	110300	6017 KNOX ST	66203	12916 W 66TH TER	SHAWNEE , KS 66216	23959	1
3763	23673.58	JP1800000	05112030 06033.00 0	0.54	0 P	FARAGE, CHESTER OWEN JR	FARAGE, SHANNON MICHELLE	KNOX	ST		6030	111	RU	24320	79280	103600	6030 KNOX ST	66203	6030 KNOX ST	MERRIAM , KS 66203	23958	1
3768	18037.35	JF241212-;	05112040 05010.00 0	0.41	0 F	MERRIAM DRAINAGE DISTRICT		NS	NT		0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23955	1
3769	49881.71	JF241212-;	05112030 06028.00 0	1.15	1.1 F	MEIS, MICHAEL A.	MEIS, MELANIE J.	61ST	ST	W	9804	111	RU	30090	130910	161000	9804 W 61ST ST	66203	9804 W 61ST ST	MERRIAM , KS 66203	23954	1
3772	28978.46	JF241212-;	05112040 05014.00 0	0.67	0 F	MACEK, VICTOR M. JR TRUSTEE		NS	NT		0	511	CU	86930	269270	356200	N/A	66203	13625 MIDLAND DR	SHAWNEE , KS 66215	23952	1
3773	121.2035	JF241212-;	05112030 07015.01 0	0	0.01 F	CITY OF MERRIAM		NS	NT		0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23951	1
3784	9971.451	JF241212-;	05112030 07015.00 0	0.23	0.27 F	LYNN, ERIC B.	LYNN, PEGGY S.	MERRIAM	LN		6036	111	RU	21310	45390	66700	6036 MERRIAM LN	66203	6028 CAMPBELL ST	MERRIAM , KS 66203	23944	1
3787	16648.63	JP1800000	05112030 07007.00 0	0.38	0 P	ERICKSON, ELDON L. CO-TRUSTEE	ERICKSON, NYONA V. CO-TRUSTEE	KNOX	ST		6021	112	RU	22780	91320	114100	6021 KNOX ST	66203	12916 W 66TH TER	SHAWNEE , KS 66216	23941	1
3791	22399.34	JP1800000	05112030 06034.00 0	0.51	0 P	GRANGER, RICHARD A.	GRANGER, GEORGIA L.	KNOX	ST		6024	111	RU	24040	81660	105700	6024 KNOX ST	66203	6024 KNOX ST	MERRIAM , KS 66203	23937	1
3812	15518	JF241212-;	05112030 07016.00 0	0.36	0 F	LYNN, ERIC B.	LYNN, PEGGY S.	CAMPBELL	LN	W	6028	111	RU	22530	75370	97900	6028 W CAMPBELL LN	66203	6028 W CAMPBELL LN	MERRIAM , KS 66203	23921	1
3813	19577.93	JP1800000	05112030 07006.00 0	0.45	0 P	FREE, STEPHEN D.	FREE, AMANDA S.	KNOX	ST		6015	111	RU	23420	89680	113100	6015 KNOX ST	66203	6015 KNOX ST	MERRIAM , KS 66203	23920	1

3817	22402.2	05112030 06035.00 JP1800000 0	0.51	0 P	MCDOWELL, CLYDE E.	MCDOWELL, LOLA J.	KNOX	ST		6018	111	RU	24040	77860	101900	6018 KNOX ST	66203	6018 KNOX ST	MERRIAM, KS 66203	23918	1
3819	19912.25	05112040 05009.00 JF241212- 0	0.46	0 F	MERRIAM DRAINAGE DISTRICT		MERRIAM	LN		6023	650	EM	0	0	0	6023 MERRIAM LN	66203	9000 W 62ND TER	MERRIAM, KS 66202	23916	1
3821	32690.06	05112040 05015.00 JF241212- 0	0.75	0 F	PETERSON, RUTH M. TRUSTEE	PETERSON, RUTH M. REV TRUST	MERRIAM	LN		6002	532	CU	47170	217230	264400	6002 MERRIAM LN	66203	26690 NEW LANCASTER RD	LOUISBURG, KS 66053	23915	1
3831	18900.73	05112030 07001.00 JP1800000 0	0.43	0 P	DAVEY, DANICE A.	ETAL	NS	NT		0	100	VU	6990	0	6990	N/A	66203	9515 W 60TH ST	MERRIAM, KS 66203	23909	1
3853	32668.4	05112040 05005.00 JF241212- 0	0.75	0 F	PETERSON, RUTH M. TRUSTEE	PETERSON, RUTH M. REV TRUST	NS	NT		0	5321	CU	0	0	0	N/A	66203	26690 NEW LANCASTER RD	LOUISBURG, KS 66053	23891	1
3855	68015.8	05112030 07002.00 JP1800000 0	1.56	0 P	DAVEY, DANICE A.		60TH	ST	W	9515	111	RU	34080	83520	117600	9515 W 60TH ST	66203	9515 W 60TH ST	MERRIAM, KS 66203	23890	1
3890	20571.51	05112040 05004.00 JF241212- 0	0.47	0 F	HEPKER, KATHLEEN M. TRUSTEE	HEPKER, KATHLEEN M. TRUST	MERRIAM	DR		5948	511	CU	14230	72270	86500	5948 MERRIAM DR	66203	4401 W 82ND ST	PRAIRIE VILLAGE, KS 66208	23856	1
3895	22912.63	05112030 07005.00 JP1800000 0	0.53	0 P	GIPSON, MARNE B.		60TH	ST	W	9615	111	RU	24160	45940	70100	9615 W 60TH ST	66203	1030 W 45TH ST	KANSAS CITY, MO 64111	23854	1
3898	22912.44	05112030 07004.00 JP1800000 0	0.53	0 P	GIPSON, MARNE B.		60TH	ST	W	9611	111	RU	24160	55940	80100	9611 W 60TH ST	66203	1030 W 45TH ST	KANSAS CITY, MO 64111	23852	1
3902	15999.94	05112030 07003.00 JP1800000 0	0.37	0 P	PROCK, GEORGE L. III	MIXEY, AMANDA R.	60TH	ST	W	9521	111	RU	22640	83560	106200	9521 W 60TH ST	66203	9521 W 60TH ST	MERRIAM, KS 66203	23848	1
3906	15460.51	05112030 08003.00 JP1800000 0	0.35	0 P	BURGE, EUGENE L.	ETAL,	60TH	ST	W	9509	111	RU	22520	88080	110600	9509 W 60TH ST	66203	9509 W 60TH ST	MERRIAM, KS 66203	23845	1
3908	15578.39	05112030 08002.00 JP1800000 0	0.36	0 P	VANKAM, EMILE E.		60TH	ST	W	9503	111	RU	22540	79060	101600	9503 W 60TH ST	66203	9503 W 60TH ST	MERRIAM, KS 66203	23843	1
3909	15724.54	05112030 08001.00 JP1800000 0	0.36	0 P	WHEELER, GRADY H.	WHEELER, MILDRED	60TH	ST	W	9421	111	RU	22580	68920	91500	9421 W 60TH ST	66203	9421 W 60TH ST	MERRIAM, KS 66203	23842	1
3910	3856.277	00000000 00000.00 JD241212- 0	0.09	0 D									0	0	0					23841	1
3911	57740.2	00000000 00000.00 JD1800000 0	1.33	0 D									0	0	0					23840	1
3913	5538.563	00000000 00000.00 JD1300000 0	0.13	0 D									0	0	0					23838	1
3928	30959.67	05112040 05003.00 JF241212- 0	0.71	0 F	PLATEL, LOIC J.	PLATEL, CLAUDINE D.	MERRIAM	DR		5930	511	CU	54580	146320	200900	5930 MERRIAM DR	66203	11742 GARNETT ST	OVERLAND PARK, KS 66210	23827	1
3936	34037.24	05112040 06010.00 JF241212- 0	0.78	0 F	BRIDGES, JACK L. TRUSTEE	BRIDGES, JOHNNY ANN TRUSTEE	MERRIAM	DR		5957	511	CU	35740	255260	291000	5957 MERRIAM DR	66203	2230 SW WATERFALL PL	LEES SUMMIT, MO 64081	23820	1
3951	6250.771	05112030 01028.00 JP1300000 0	0.14	0.17 P	HOESCH, CANDICE A.		60TH	ST	W	9520	111	RU	21760	65540	87300	9520 W 60TH ST	66203	9520 W 60TH ST	MERRIAM, KS 66203	23812	2

3962	8290.355	JF241212-0	05112040 06009.00 0	0.19	0	F	HEPKER, KATHLEEN M. TRUSTEE	HEPKER, KATHLEEN M. TRUST	MERRIAM	DR		5947	649	CU	8700	28820	37520	5947 MERRIAM DR	66203	4401 W 82ND ST	PRAIRIE VILLAGE, KS 66208	23803	1
3966	5784.449	JP1300000	05112030 01028.00 0	0.13	0.17	P	HOESCH, CANDICE A.		60TH	ST	W	9520	111	RU	21760	65540	87300	9520 W 60TH ST	66203	9520 W 60TH ST	MERRIAM , KS 66203	23799	2
3967	17981.31	JF241212-0	05112030 01027.00 0	0.41	0	F	CANSLER, MICHAEL D.	CANSLER, KATHLEEN D.	60TH	ST	W	9604	112	RU	23070	88230	111300	9604 W 60TH ST	66203	9604 W 60TH ST	MERRIAM , KS 66203	23798	1
3968	15070.01	JP1300000	05112030 01030.00 0	0.35	0	P	ROLLER, RICHARD D.	ROLLER, LORI L.	60TH	ST	W	9516	111	RU	22430	96570	119000	9516 W 60TH ST	66203	9516 W 60TH ST	MERRIAM , KS 66203	23797	1
3969	139309.7	JP1200001	00000000 00000.00 0	3.2	0	P	CITY OF MERRIAM		NS	NT		0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23796	1
3971	111146.9	JD1200000	00000000 00000.00 0	2.55	0	D									0	0	0					23794	1
3972	14998.28	JP1300000	05112030 01031.00 0	0.34	0	P	ONEAL, PEGGY G.	ONEAL, CHARLES T. SR	60TH	ST	W	9508	111	RU	22420	71280	93700	9508 W 60TH ST	66203	9508 W 60TH ST	MERRIAM , KS 66203	23793	1
3974	14997.7	JP1300000	05112030 01032.00 0	0.34	0	P	VANKAM, EMILE		60TH	ST	W	9502	111	RU	22420	80680	103100	9502 W 60TH ST	66203	9502 W 60TH ST	MERRIAM , KS 66203	23791	1
3976	18085.15	JP1300000	05112030 01033.00 0	0.42	0	P	RUDD, WARREN P.		60TH	ST	W	9422	111	RU	23100	92000	115100	9422 W 60TH ST	66203	9422 W 60TH ST	MERRIAM , KS 66203	23789	1
3983	1384.715	JF241212-0	05112040 05002.01 0	0.03	0.03	F	CITY OF MERRIAM		NS	NT		0	500	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23783	1
3984	9043.016	JF241212-0	05112040 06008.00 0	0.21	0	F	COLE, GERALD E.	COLE, WANDA L.	MERRIAM	DR		5943	534	CU	9500	106580	116080	5943 MERRIAM DR	66203	10706 W 71ST PL	SHAWNEE , KS 66203	23782	1
3988	34994.64	JF241212-0	05112040 05002.00 0	0.8	0.87	F	OSIPIK, DARRYL G.	OSIPIK, LAURIE L.	MERRIAM	DR		5920	511	CU	63540	112860	176400	5920 MERRIAM DR	66203	5920 MERRIAM DR	MERRIAM , KS 66203	23778	1
4003	11844.91	JF241212-0	05112040 06007.00 0	0.27	0	F	MCMENEMY, JOHN P. TRUSTEE	MCMENEMY, JOHN P. TRUST	MERRIAM	DR		5937	534	CU	12440	43960	56400	5937 MERRIAM DR	66203	9117 W 72ND ST	MERRIAM , KS 66204	23763	1
4009	15542.57	JF241212-0	05112030 01021.00 0	0.36	0	F	DAUGHERTY, LEE A.	DAUGHERTY, KARRIE L.	59TH	TER	W	9605	111	RU	22540	102660	125200	9605 W 59TH TER	66203	9605 W 59TH TER	MERRIAM , KS 66203	23758	1
4012	14815.81	JP0025000	05112030 15001.00 0	0.34	0	P	ANDERSON, CHRISTOPHER L.	ANDERSON, LYNN H.	59TH	TER	W	9521	111	RU	22380	148820	171200	9521 W 59TH TER	66203	9521 W 59TH TER	MERRIAM , KS 66203	23755	1
4013	10259.5	JP1300000	05112030 01019.00 0	0.24	0	P	BALDWIN, RANDY L.	BALDWIN, KELLY D.	59TH	TER	W	9515	111	RU	21370	71130	92500	9515 W 59TH TER	66203	9515 W 59TH TER	MERRIAM , KS 66203	23754	1
4018	16223.76	JP1300000	05112030 01018.00 0	0.37	0	P	ELLIOTT, RUSSELL C.	ELLIOTT, MARILYN	59TH	TER	W	9507	111	RU	22690	86710	109400	9507 W 59TH TER	66203	9507 W 59TH TER	MERRIAM , KS 66203	23750	1
4022	9546.248	JD1300000	00000000 00000.00 0	0.22	0	D									0	0	0					23747	1
4024	24703.87	JF241212-0	05112040 06006.00 0	0.57	0	F	HAMIL, SHARON TRUSTEE	HAMIL, SHARON LIV TRUST	MERRIAM	DR		5921	531	CU	25940	73560	99500	5921 MERRIAM DR	66203	9930 FONTANA LN	OVERLAND PARK, KS 66207	23745	1
4025	14238.71	JD1300000	00000000 00000.00 0	0.33	0	D									0	0	0					23744	1

		00000000 00000.00																						
4036	8706.705	JD1400000	0	0.2	0	D									0	0	0						23733	1
4047	13922.01	JP1300000	05112030 01015.00 0	0.32	0	P	COLE, VIRGINIA L.		59TH	TER	W	9520	111	RU	22180	86020	108200	9520 W 59TH TER	66203	9520 W 59TH TER	MERRIAM , KS 66203	23726	1
4048	18666.59	JF2412124	05112030 01034.00 0	0.43	0	F	MERRIAM CHRISTIAN CHURCH, INC.		NS	NT		0	670	ER	23220	9390	32610	N/A	66203	9401 JOHNSON DR	MERRIAM , KS 66203	23725	1
4050	11694.77	JP1300000	05112030 01016.00 0	0.27	0	P	SCHROEGER, MATTHEW V.	SCHROEGER, MARY A.	NS	NT		0	100	VU	21690	0	21690	N/A	66203	9511 JOHNSON DR	MERRIAM , KS 66203	23723	1
4051	74930.1	JP1300000	05112030 01017.00 0	1.72	0	P	MERRIAM CHRISTIAN CHURCH		NS	NT		0	670	ER	35600	10120	45720	N/A	66203	9401 JOHNSON DR	MERRIAM , KS 66203	23722	1
4052	3115.563	JF2412124	05112030 01035.00 0	0.07	0	F	MERRIAM CHRISTIAN CHURCH		NS	NT		0	670	ER	19800	0	19800	N/A	66203	9401 JOHNSON DR	MERRIAM , KS 66203	23721	1
4061	23579.04	JP1400000	05112040 04004.00 0	0.54	0	P	PIETERS, MAURICE H.	PIETERS, MARTHA M.	MERRIAM	DR		5911	532	CU	27700	89600	117300	5911 MERRIAM DR	66203	9309 JOHNSON DR	MERRIAM , KS 66203	23712	1
4062	3925.158	JP1400000	05112040 04005.00 0	0.09	0	P	PIETERS, MAURICE H.	PIETERS, MARTHA M.	NS	NT		0	5321	CU	0	0	0	N/A	66203	9309 JOHNSON DR	MERRIAM , KS 66203	23710	1
4069	33569.77	JP1400000	00000000 00000.00 0	0.77	0	P	CITY OF MERRIAM		NS	NT		0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23704	1
4075	275801.4	JD4500000	00000000 00000.00 0	6.33	0	D									0	0	0						23698	1
4098	12960.25	JP4600000	05112030 01007.00 0	0.3	0	P	ENLOW, ARTHUR D.	ENLOW, DEBRA S.	JOHNSON	DR		9605	124	RU	19760	60140	79900	9605 JOHNSON DR	66203	929 NE 87TH TER	KANSAS CITY, MO 64155	23676	1
4101	10124.15	JP4600000	05112030 01005.00 0	0.23	0	P	POTTER, NANCY J.		JOHNSON	DR		9519	111	RU	19190	40810	60000	9519 JOHNSON DR	66203	9519 JOHNSON DR	MERRIAM , KS 66203	23673	1
4104	18088.28	JP4600000	05112030 01004.00 0	0.42	0	P	SCHROEGER, MATTHEW V.	SCHROEGER, MARY A.	JOHNSON	DR		9511	111	RU	20790	95810	116600	9511 JOHNSON DR	66203	9511 JOHNSON DR	MERRIAM , KS 66203	23670	1
4105	1439.465	JP4600000	00000000 00000.00 0	0.03	0	P	CITY OF MERRIAM		NS	NT		0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23669	1
4107	10347.85	JP4600000	05112030 01006.00 0	0.24	0	P	VANDEPUTTE, RICK C.	VANDEPUTTE, CHRISTIE A.	JOHNSON	DR		9523	111	RU	19240	61360	80600	9523 JOHNSON DR	66203	9523 JOHNSON DR	MERRIAM , KS 66203	23667	1
4109	19842.71	JP4600000	05112030 01003.00 0	0.46	0	P	MERRIAM CHRISTIAN CHURCH		JOHNSON	DR		9503	111	ER	21140	47460	68600	9503 JOHNSON DR	66203	9401 JOHNSON DR	MERRIAM , KS 66203	23665	1
4110	6748.982	JP4600000	05112030 01002.00 0	0.15	0	P	ROEBUCK, RICHARD K.		JOHNSON	DR		9417	111	RU	18520	61280	79800	9417 JOHNSON DR	66203	9417 JOHNSON DR	MERRIAM , KS 66203	23664	1

		05112030 01001.00				MERRIAM CHRISTIAN CHURCH		JOHNSON	DR	9401	670	ER	79160	365090	444250	9401 JOHNSON DR	66203	9401 JOHNSON DR	MERRIAM, KS 66203	23660	1
4114	15830.85	JP4600000	0	0.36	0 P																
		05112040 04003.00				TRACKWELL, LEO	TRACKWELL, PEARL	MERRIAM	LN	5903	537	CU	34560	152240	186800	5903 MERRIAM LN	66203	11405 W 71ST ST	SHAWNEE, KS 66216	23659	1
4115	12799.09	JP1400000	0	0.29	0 P																
		05112040 04002.00				PIETERS, MAURICE H.	PIETERS, MARTHA M.	JOHNSON	DR	9309	531	CU	16030	165870	181900	9309 JOHNSON DR	66203	9309 JOHNSON DR	MERRIAM, KS 66203	23658	2
4116	8105.339	JP1400000	0	0.19	0 P																
		05112040 04002.00				PIETERS, MAURICE H.	PIETERS, MARTHA M.	JOHNSON	DR	9309	531	CU	16030	165870	181900	9309 JOHNSON DR	66203	9309 JOHNSON DR	MERRIAM, KS 66203	23657	2
4117	802.3048	JP1400000	0	0.02	0 P																
		00000000 00000.00				CITY OF MERRIAM		NS	NT	0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23654	1
4119	1098.461	JP1400000	0	0.03	0 P																
		00000000 00000.00				CITY OF MERRIAM		NS	NT	0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23653	1
4120	8093.501	JP4600000	0	0.19	0 P																
		00000000 00000.00				CITY OF MERRIAM		NS	NT	0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23652	2
4121	704.0075	JP1400000	0	0.02	0 P																
		00000000 00000.00				CITY OF MERRIAM		NS	NT	0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23650	2
4123	67.38786	JP1400000	0	0	0 P																
		00000000 00000.00											0	0	0					23649	1
4124	8066.05	JD4600000	0	0.19	0 D																
		00000000 00000.00				CITY OF MERRIAM		NS	NT	0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23648	1
4125	369.1025	JP1400000	0	0.01	0 P																
		05112040 04001.00				HODGDON, J. B. TRUSTEE	ETAL	JOHNSON	DR	9301	531	CU	13090	85810	98900	9301 JOHNSON DR	66203	6231 ROBINSON ST	OVERLAND PARK, KS 66202	23647	1
4126	8725.47	JP1400000	0	0.2	0 P																
		00000000 00000.00											0	0	0					23645	1
4128	3445.444	JD4600000	0	0.08	0 D																
		00000000 00000.00											0	0	0					23644	1
4129	13172.9	JD241212-	0	0.3	0 D																
		00000000 00000.00				MERRIAM DRAINAGE DISTRICT		MERRIAM	LN	5909	458	EM	0	0	0	5909 MERRIAM LN	66203	9000 W 62ND TER	MERRIAM, KS 66202	23643	1
4130	41739.92	JF241212-	0	0.96	0 F																
		00000000 00000.00				CITY OF MERRIAM		NS	NT	0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23642	1
4131	2600.101	JF241212-	0	0.06	0 F																
		00000000 00000.00				STATE HIGHWAY #10		NS	NT	0	458	EK	0	0	0	N/A	66203	STATE HOUSE	TOPEKA, KS 66612	23641	2
4132	190915.9	JF241212-	0	4.38	3.6 F																
		00000000 00000.00				CITY OF MERRIAM		NS	NT	0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23640	1
4133	809.8889	JP4600000	0	0.02	0 P																
		00000000 00000.00											0	0	0					23638	1
4135	9303.669	JD1400000	0	0.21	0 D																
		00000000 00000.00											0	0	0					23636	1
4137	300075.4	JD241212-	0	6.89	0 D																
		00000000 00000.00				CITY OF MERRIAM		NS	NT	0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23635	1
4138	474.1132	JP8400000	0	0.01	0 P																

4139	9802.382	JD480000C	00000000 00000.00 0	0.23	0 D									0	0	0						23634	2
4140	2327.922	JD241212-	00000000 00000.00 0	0.05	0 D									0	0	0						23633	1
4141	32185.68	JF241212<	00000000 00000.00 0	0.74	0 F	SEC OF TRANSPORTATION	STATE OF KANSAS	NS	NT	0	458	EK	0	0	0	N/A	66203	STATE HOUSE	TOPEKA, KS 66612	23632	1
4142	404.8837	JD480000C	00000000 00000.00 0	0.01	0 D									0	0	0						23631	1
4145	55034.88	JD140000C	00000000 00000.00 0	1.26	0 D									0	0	0						23628	1
4149	899.4409	JP8400001	00000000 00000.00 0	0.02	0 P	KALSYD ASSOCIATES		NS	NT	0	458P	VU	0	0	0	N/A	66203	9320 JOHNSON DR	MERRIAM, KS 66202	23624	1
4168	5308.245	JP8400001	05112010 08010.00 0	0.12	0 P	CITY OF MERRIAM		MERRIAM	DR	5871	458	VU	0	0	0	5871 MERRIAM DR	66203	9000 W 62ND TER	MERRIAM, KS 66202	23608	1
4169	89.9612	JP8400001	05112010 08010.01 0	0	0 P	KALSYD ASSOCIATES		NS	NT	0	5321	CU	0	0	0	N/A	66203	9320 JOHNSON DR	MERRIAM, KS 66202	23607	1
4178	17615.56	JP4700000	05112020 14007.00 0	0.4	0 P	HUSONG, JAMES O. JR		JOHNSON	DR	9650	111	RU	20690	114310	135000	9650 JOHNSON DR	66203	9650 JOHNSON DR	MERRIAM, KS 66203	23602	1
4181	1836.235	JP8400000	00000000 00000.00 0	0.04	0 P	MERRIAM DRAINAGE DISTRICT		NS	NT	0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23600	1
4182	3142.871	JP8400000	00000000 00000.00 0	0.07	0 P	MERRIAM DRAINAGE DISTRICT		NS	NT	0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23599	1
4183	17547.15	JP4700000	05112020 14008.00 0	0.4	0 P	ROSS, JOHN D.	ROSS-ANTHOFER, LISA M.	JOHNSON	DR	9600	111	RU	20680	83920	104600	9600 JOHNSON DR	66203	9600 JOHNSON DR	MERRIAM, KS 66203	23598	1
4184	1300.13	JP8400000	05112001 07013.00 0	0.03	0 P	CITY OF MERRIAM		MERRIAM	DR	5868	650	EM	0	0	0	5868 MERRIAM DR	66203	9000 W 62ND TER	MERRIAM, KS 66202	23597	1
4186	4916.495	JD480000C	00000000 00000.00 0	0.11	0 D									0	0	0						23595	1
4187	21477.87	JP4800000	05112020 14013.00 0	0.49	0 P	KELLEY, CONNIE K.		JOHNSON	DR	9516	111	RU	21470	89430	110900	9516 JOHNSON DR	66203	9516 JOHNSON DR	MERRIAM, KS 66203	23594	1
4190	897.018	JP8400000	00000000 00000.00 0	0.02	0 P	MERRIAM DRAINAGE DISTRICT		NS	NT	0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23591	1
4191	15414.09	JP4800000	05112020 14014.00 0	0.35	0 P	KEIM, WAYNE V.	KEIM, RUTH A.	JOHNSON	DR	9500	111	RU	20250	75450	95700	9500 JOHNSON DR	66203	9500 JOHNSON DR	MERRIAM, KS 66203	23590	1
4192	2145.08	JP8400000	05112001 07012.00 0	0.05	0 P	CITY OF MERRIAM		MERRIAM	DR	5854	531	CU	12870	60330	73200	5854 MERRIAM DR	66203	9000 W 62ND TER	MERRIAM, KS 66202	23589	1
4193	5400.04	JP8400001	05112010 08009.00 0	0.12	0 P	KALSYD ASSOCIATES		MERRIAM	DR	5853	552	CU	11340	73860	85200	5853 MERRIAM DR	66203	9320 JOHNSON DR	MERRIAM, KS 66203	23588	1

4194	9900.106	JP8400001	05112010 08011.00 0	0.23	0	P	KALSYD ASSOCIATES		JOHNSON	DR	9320	513	CU	103960	314680	418640	9320 JOHNSON DR	66203	9320 JOHNSON DR	MERRIAM, KS 66203	23587	1
4195	10801.34	JP8400001	05112010 08012.00 0	0.25	0	P	SUGAR, L.C.		JOHNSON	DR	9214	5131	CU	0	0	0	9214 JOHNSON DR	66203	9320 JOHNSON DR	MERRIAM, KS 66204	23586	1
4196	1214.707	JD480000C	00000000 00000.00 0	0.03	0	D								0	0	0					23585	1
4198	7549.91	JP8400000	05112010 06006.00 0	0.17	0	P	MERRIAM DRAINAGE DISTRICT		NS	NT	0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23583	1
4200	13219.47	JP8400000	05112010 06003.00 0	0.3	0	P	W. W. C. PARTNERSHIP		JOHNSON	DR	9424	111	RU	19810	85290	105100	9424 JOHNSON DR	66203	7005 GLADSTONE AVE	SHAWNEE, KS 66218	23581	1
4201	2255.329	JP8400000	00000000 00000.00 0	0.05	0	P	CITY OF MERRIAM		NS	NT	0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23580	1
4203	397.6818	JP8400000	05112010 06001.00 0	0.01	0	P	TRENARY, LARRY K.		GRANT	ST	5815	111	RU	23880	76120	100000	5815 GRANT ST	66203	5815 GRANT ST	MERRIAM, KS 66203	23578	2
4204	267.3811	JP8400000	00000000 00000.00 0	0.01	0	P	MERRIAM DRAINAGE DISTRICT		NS	NT	0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23577	1
4205	15183.26	JP8400000	05112010 06004.00 0	0.35	0	P	OCONNELL, ALVIN H.	OCONNELL, MARY A.	JOHNSON	DR	9400	533	CU	91100	154000	245100	9400 JOHNSON DR	66203	9901 JOHNSON DR	MERRIAM, KS 66203	23576	1
4206	5412.443	JP8400000	05112010 06005.00 0	0.12	0	P	MERRIAM DRAINAGE DISTRICT		NS	NT	0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23575	1
4207	3562.646	JP8400000	05112010 07011.00 0	0.08	0	P	LEAP, DANIEL D.		MERRIAM	DR	5848	531	CU	14300	96700	111000	5848 MERRIAM DR	66203	5848 MERRIAM DR	MERRIAM, KS 66203	23574	1
4211	11025.15	JP4800000	05112020 14015.00 0	0.25	0	P	DAICY, ERIC M.		GRANT	ST	5812	111	RU	21540	61460	83000	5812 GRANT ST	66203	5812 GRANT ST	MERRIAM, KS 66203	23570	1
4212	5641.556	JP8400001	05112010 08008.00 0	0.13	0	P	LEAP, BILLY D.	LEAP, KATHLEEN S.	MERRIAM	DR	5847	531	CU	6770	78730	85500	5847 MERRIAM DR	66203	5525 NOLAND RD	SHAWNEE, KS 66216	23569	1
4213	358.3367	JP8400001	05112010 08005.00 0	0.01	0	P	TRUE AUTO PARTS, INC.		MERRIAM	DR	5837	534	CU	7630	158090	165720	5837 MERRIAM DR	66203	5837 MERRIAM DR	SHAWNEE MSN, KS 66203	23568	3
4215	5853.449	JP8400000	05112010 07010.00 0	0.13	0	P	CITY OF MERRIAM		MERRIAM	DR	5844	531	CU	40970	37730	78700	5844 MERRIAM DR	66203	9000 W 62ND TER	MERRIAM, KS 66202	23566	1
4216	439.1093	JP8400000	05112010 07009.02 0	0.01	0	P	CITY OF MERRIAM		NS	NT	0	531	CU	28680	121920	150600	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23565	2
4217	13650.48	JP4800000	05112020 14009.00 0	0.31	0	P	TESSON, EUGENE A.	TESSON, GAIL R.	CARTER	ST	5824	111	RU	22120	106580	128700	5824 CARTER ST	66203	5824 CARTER ST	MERRIAM, KS 66203	23564	1
4219	14876.32	JP4800000	05112020 14012.00 0	0.34	0	P	MEDITZ, FRED	MEDITZ, MARY J.	CARTER	ST	5821	111	RU	22390	130810	153200	5821 CARTER ST	66203	5821 CARTER ST	MERRIAM, KS 66203	23562	1
4221	3000.145	JP8400001	05112010 08005.00 0	0.07	0	P	TRUE AUTO PARTS, INC.		MERRIAM	DR	5837	534	CU	7630	158090	165720	5837 MERRIAM DR	66203	5837 MERRIAM DR	SHAWNEE MSN, KS 66203	23560	3

4226	3342.057	JP8400000	00000000 00000.00 0	0.08	0	P	MERRIAM DRAINAGE DISTRICT		NS	NT		0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23555	1
4227	20473.78	JP4800000	05112020 14006.00 0	0.47	0	P	YOUNG, RANDALL W.	YOUNG, KIM H.	KNOX	ST		5825	111	RU	23620	102680	126300	5825 KNOX ST	66203	5825 KNOX ST	MERRIAM, KS 66203	23554	1
4228	7168.89	JP8400000	05112010 07009.02 0	0.16	0	P	CITY OF MERRIAM		NS	NT		0	531	CU	28680	121920	150600	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23553	2
4229	513.4156	JP8400000	05112010 07009.01 0	0.01	0	P	TRUE AUTO PARTS, INC.		NS	NT		0	500	VU	100	0	100	N/A	66203	5836 MERRIAM DR	MERRIAM, KS 66203	23552	1
4230	3000.118	JP8400001	05112010 08005.00 0	0.07	0	P	TRUE AUTO PARTS, INC.		MERRIAM	DR		5837	534	CU	7630	158090	165720	5837 MERRIAM DR	66203	5837 MERRIAM DR	SHAWNEE MSN, KS 66203	23551	3
4231	5848.917	JD4800000	00000000 00000.00 0	0.13	0	D									0	0	0					23550	1
4232	4200.339	JP8400001	05112010 08003.00 0	0.1	0	P	ZUCK, JOE M.	ETAL	NS	NT		0	500	VU	23400	0	23400	N/A	66203	6734 RILEY ST	OVERLAND PARK, KS 66204	23549	2
4234	3600.357	JP8400001	05112010 08003.00 0	0.08	0	P	ZUCK, JOE M.	ETAL	NS	NT		0	500	VU	23400	0	23400	N/A	66203	6734 RILEY ST	OVERLAND PARK, KS 66204	23547	2
4235	3599.76	JP8400001	05112010 08002.00 0	0.08	0	P	ZUCK, JOE M.	ETAL	58TH	TER	W	9215	500	VU	10800	0	10800	9215 W 58TH TER	66203	6734 RILEY ST	OVERLAND PARK, KS 66204	23546	1
4237	7200.751	JP8400001	05112010 08001.00 0	0.17	0	P	MILLER, DONALD K.	MILLER, LINDA	58TH	TER	W	9203	513	CU	21600	82000	103600	9203 W 58TH TER	66203	9 GREENES PT	GRAVOIS MILLS, MO 65037-8020	23544	1
4239	1993.522	JP8400000	00000000 00000.00 0	0.05	0	P	MERRIAM DRAINAGE DISTRICT		NS	NT		0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23542	1
4241	4582.077	JP8400000	05112010 07008.00 0	0.11	0	P	TRUE AUTO PARTS, INC.		MERRIAM	DR		5836	531	CU	18330	81570	99900	5836 MERRIAM DR	66203	5836 MERRIAM DR	MERRIAM, KS 66203	23541	1
4242	175.6978	JP8400000	05112010 07007.00 0	0	0	P	K.C. STRINGS VIOLIN SHOP, INC.		NS	NT		0	5311	CU	0	0	0	N/A	66203	5826 MERRIAM DR	MERRIAM, KS 66203	23540	1
4249	5849.09	JP8400000	05112010 10001.00 0	0.13	0	P	BUTLER ENTERPRISES, INC.		KESSLER	ST		5747	511	CU	158380	277220	435600	5747 KESSLER ST	66203	5747 KESSLER ST	MERRIAM, KS 66203	23536	15
4250	1714.591	JP8400000	00000000 00000.00 0	0.04	0	P	MERRIAM DRAINAGE DISTRICT		NS	NT		0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	SHAWNEE MSN, KS 66202	23535	1
4251	13650.64	JP4800000	05112020 14010.00 0	0.31	0	P	MENDOZA, JOSE E.	MENDOZA, MICHELLE D.	CARTER	ST		5820	111	RU	22120	125580	147700	5820 CARTER ST	66203	5820 CARTER ST	MERRIAM, KS 66203	23534	1

4252	5787.414	JP8400000	05112010 07005.00 0	0.13	0	P	K.C. STRINGS VIOLIN SHOP, INC.		MERRIAM	DR		5826	531	CU	9400	79000	88400	5826 MERRIAM DR	66203	5826 MERRIAM DR	MERRIAM , KS 66203	23533	2
4253	13648.98	JP4800000	05112020 14011.00 0	0.31	0	P	ARTHUR, DENNIS B.	ANDERSON, LESLEE C.	CARTER	ST		5815	111	RU	22120	112580	134700	5815 CARTER ST	66203	5815 CARTER ST	MERRIAM , KS 66203	23532	1
4256	17787.62	JP4800000	05112020 14016.00 0	0.41	0	P	WILIKER, L. ERNESTINE, TRUSTEE	WILIKER, VERNON H.	GRANT	ST		5800	111	RU	23030	107370	130400	5800 GRANT ST	66203	5800 GRANT ST	MERRIAM , KS 66203	23529	1
4259	1874.47	JP8400000	05112010 07005.00 0	0.04	0	P	K.C. STRINGS VIOLIN SHOP, INC.		MERRIAM	DR		5826	531	CU	9400	79000	88400	5826 MERRIAM DR	66203	5826 MERRIAM DR	MERRIAM , KS 66203	23526	2
4265	8415.385	JP4800000	05112020 14017.00 0	0.19	0	P	SOBANEK, DONALD	SOBANEK, TAMELLA K.	GRANT	ST		5790	111	RU	20970	96630	117600	5790 GRANT ST	66203	5790 GRANT ST	MERRIAM , KS 66203	23524	1
4269	2902.23	JP8400000	00000000 00000.00 0	0.07	0	P	MERRIAM DRAINAGE DISTRICT		NS	NT		0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23520	1
4273	26530.5	JP8400000	05112010 07003.00 0	0.61	0	P	PITTMAN, ROBERT	PITTMAN, MARGE	MERRIAM	DR		5820	511	CU	27860	118640	146500	5820 MERRIAM DR	66203	5820 MERRIAM DR	MERRIAM , KS 66203	23516	1
4274	3600.054	JP8400000	05112010 09007.00 0	0.08	0	P	WEAVER, GEORGE J.	WEAVER, MARTY J.	58TH	TER	W	9236	631	CU	10800	38400	49200	9236 W 58TH TER	66203	5825 MERRIAM DR	MERRIAM , KS 66203	23515	1
4278	14174.2	JF241212-1	05112010 09006.00 0	0.33	0	F	WEAVER, GEORGE J.		MERRIAM	DR		5825	531	CU	14880	157720	172600	5825 MERRIAM DR	66203	5825 MERRIAM DR	MERRIAM , KS 66203	23513	1
4279	17999.75	JP8400000	05112010 09008.00 0	0.41	0	P	MERRIAM COMM. ASSN.		58TH	TER	W	9214	511	CU	13500	131300	144800	9214 W 58TH TER	66203	9309 JOHNSON DR	MERRIAM , KS 66203	23512	1
4281	4208.65	JD480000C	00000000 00000.00 0	0.1	0	D									0	0	0					23510	1
4282	31046.99	JP4800000	05112020 14005.00 0	0.71	0	P	STEWART, THOMAS R.	MORGAN, CAROL D.	HOCKER	DR		9617	111	RU	25950	254650	280600	9617 HOCKER DR	66203	9617 HOCKER DR	MERRIAM , KS 66203	23509	1
4283	16727.62	JP4800000	05112020 14004.00 0	0.38	0	P	STEWART, THOMAS R.	MORGAN, CAROL D.	NS	NT		0	100	VU	22800	0	22800	N/A	66203	9617 HOCKER DR	MERRIAM , KS 66203	23508	1
4284	4725.238	JP8400000	05112010 10001.00 0	0.11	0	P	BUTLER ENTERPRISES, INC.		KESSLER	ST		5747	511	CU	158380	277220	435600	5747 KESSLER ST	66203	5747 KESSLER ST	MERRIAM , KS 66203	23507	15
4285	4722.495	JP8400000	05112010 10001.00 0	0.11	0	P	BUTLER ENTERPRISES, INC.		KESSLER	ST		5747	511	CU	158380	277220	435600	5747 KESSLER ST	66203	5747 KESSLER ST	MERRIAM , KS 66203	23506	15
4286	3151.553	JP8400000	05112010 10001.00 0	0.07	0	P	BUTLER ENTERPRISES, INC.		KESSLER	ST		5747	511	CU	158380	277220	435600	5747 KESSLER ST	66203	5747 KESSLER ST	MERRIAM , KS 66203	23505	15
4287	11398.27	JP4800000	05112020 14003.00 0	0.26	0	P	GRANT, JOHN R.	GRANT, MERLINDA	HOCKER	DR		9515	111	RU	21620	125180	146800	9515 HOCKER DR	66203	9515 HOCKER DR	MERRIAM , KS 66203	23504	1

4289	225.0463	05112010 10001.00 JP8400000 0	0.01	0	P	BUTLER ENTERPRISES, INC.		KESSLER	ST		5747	511	CU	158380	277220	435600	5747 KESSLER ST	66203	5747 KESSLER ST	MERRIAM , KS 66203	23502	15
4291	21940.29	05112020 14002.00 JP4800000 0	0.5	0	P	BOATMAN, JANE A.		HOCKER	DR		9509	111	RU	23940	106560	130500	9509 HOCKER DR	66203	9509 HOCKER DR	MERRIAM , KS 66203	23500	1
4295	8419.375	05112020 14001.00 JP4800000 0	0.19	0	P	CANTRELL, J. CREGG	CANTRELL, SANDRA A.	GRANT	ST		5780	111	RU	20970	101930	122900	5780 GRANT ST	66203	5780 GRANT ST	MERRIAM , KS 66203	23496	1
4297	21262.01	05112010 06001.00 JP8400000 0	0.49	0	P	TRENARY, LARRY K.		GRANT	ST		5815	111	RU	23880	76120	100000	5815 GRANT ST	66203	5815 GRANT ST	MERRIAM , KS 66203	23494	2
4298	17096.8	05112010 06007.00 JP8400000 0	0.39	0	P	MERRIAM DRAINAGE DISTRICT		NS	NT		0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23493	1
4300	27857.19	00000000 00000.00 JD241212-0	0.64	0	D									0	0	0					23492	1
4301	3101.877	05112010 09002.00 JP8400000 0	0.07	0	P	SUTER, KIM W.	SUTER, CHERYL J.	MERRIAM	DR		5807	533	CU	16200	313500	329700	5807 MERRIAM DR	66203	7524 FRONTAGE RD	OVERLAND PARK, KS 66204	23491	4
4304	8781.689	05112010 07002.00 JF241212-0	0.2	0	F	ROBERTS, LONNIE D.	ROBERTS, SALLY I.	MERRIAM	DR		5816	511	CU	7900	116700	124600	5816 MERRIAM DR	66203	5816 MERRIAM DR	MERRIAM , KS 66203	23490	1
4305	4297.361	05112010 07001.00 JF241212-0	0.1	0	F	CANSLER, MELVIN L.	CANSLER, MARTHA L.	MERRIAM	DR		5816	533	CU	15040	21960	37000	5816 MERRIAM DR, #A	66203	12610 W 55TH ST	SHAWNEE , KS 66216	23489	1
4306	351.5762	00000000 00000.00 JF241212-0	0.01	0	F	CITY OF MERRIAM		NS	NT		0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23488	1
4313	3004.692	05112010 09002.00 JP8400000 0	0.07	0	P	SUTER, KIM W.	SUTER, CHERYL J.	MERRIAM	DR		5807	533	CU	16200	313500	329700	5807 MERRIAM DR	66203	7524 FRONTAGE RD	OVERLAND PARK, KS 66204	23481	4
4314	7199.373	05112010 09009.00 JP8400000 0	0.17	0	P	POUNDS, ROBERT L.		KESSLER	LN		5804	274	CU	7560	30840	38400	5804 KESSLER LN	66203	5804 KESSLER LN	MERRIAM , KS 66203	23480	1
4319	3688.256	00000000 00000.00 JD241212-0	0.08	0	D									0	0	0					23477	1
4320	8464.558	05112010 13021.00 JF241212-0	0.19	0	F	CITY OF MERRIAM		NS	NT		0	458P	VU	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23476	1
4321	20717.46	00000000 00000.00 JD241212-0	0.48	0	D									0	0	0					23475	1
4322	5720.03	05112010 09002.00 JP8400000 0	0.13	0	P	SUTER, KIM W.	SUTER, CHERYL J.	MERRIAM	DR		5807	533	CU	16200	313500	329700	5807 MERRIAM DR	66203	7524 FRONTAGE RD	OVERLAND PARK, KS 66204	23474	4
4323	5174.42	00000000 00000.00 JD480000C 0	0.12	0	D									0	0	0					23473	1
4324	3600.096	05112010 09002.00 JP8400000 0	0.08	0	P	SUTER, KIM W.	SUTER, CHERYL J.	MERRIAM	DR		5807	533	CU	16200	313500	329700	5807 MERRIAM DR	66203	7524 FRONTAGE RD	OVERLAND PARK, KS 66204	23472	4
4325	7201.035	05112010 09001.00 JP8400000 0	0.17	0	P	DEAN & DEBBIE, INC.		58TH	ST	W	9207	511	CU	7560	111540	119100	9207 W 58TH ST	66203	9207 W 58TH ST	MERRIAM , KS 66203	23471	1

4327	3599.92	JP8400000	05112010 10001.00 0	0.08	0	P	BUTLER ENTERPRISES, INC.	KESSLER	ST	5747	511	CU	158380	277220	435600	5747 KESSLER ST	66203	5747 KESSLER ST	MERRIAM, KS 66203	23470	15
4337	47862.13	JD4800000	00000000 00000.00 0	1.1	0	D							0	0	0					23463	1
4339	5021.841	JF241212-0	05112010 05022.00 0	0.12	0	F	CARREL, SHIRLEY M. HORNBECK, DONALD L. HORNBECK, DONALD L.	TRUSTEE HORNBECK, KATHERINE E.	MERRIAM	DR	5810	511	CU	5270	117830	123100	5810 MERRIAM DR	66203	16336 W BRIARWOOD CT	OLATHE, KS 66062	23461	1
4340	6378.972	JP4800000	05112020 15012.00 0	0.15	0	P		HORNBECK, KATHERINE E.	HOCKER	DR	9620	111	RU	22220	150780	173000	9620 HOCKER DR	66203	9620 HOCKER DR	MERRIAM, KS 66203	23460	3
4341	5166.952	JP4800000	05112020 15012.00 0	0.12	0	P		HORNBECK, KATHERINE E.	HOCKER	DR	9620	111	RU	22220	150780	173000	9620 HOCKER DR	66203	9620 HOCKER DR	MERRIAM, KS 66203	23459	3
4342	2577.202	JP4800000	05112020 15012.00 0	0.06	0	P		HORNBECK, KATHERINE E.	HOCKER	DR	9620	111	RU	22220	150780	173000	9620 HOCKER DR	66203	9620 HOCKER DR	MERRIAM, KS 66203	23458	3
4347	66714.53	JD4800000	00000000 00000.00 0	1.53	0	D							0	0	0					23453	1
4357	4710.211	JF241212-0	05112010 11005.00 0	0.11	0	F	BRYANT, SYLVIA M.	ETAL	MERRIAM	DR	5757	532	CU	5420	53680	59100	5757 MERRIAM DR	66203	5757 MERRIAM DR	MERRIAM, KS 66203	23445	1
4358	444.3262	JF241212-0	05112010 11004.00 0	0.01	0	F	BRYANT, SYLVIA M.	ETAL	NS	NT	0	5321	CU	0	0	0	N/A	66203	5757 MERRIAM DR	MERRIAM, KS 66203	23444	1
4361	3749.911	JP4800000	05112020 15009.00 0	0.09	0	P	SCHLEICHER, ROCHELLE M.	SCHLEICHER, DANIEL L.	HOCKER	DR	9610	111	RU	34970	189030	224000	9610 HOCKER DR	66203	9610 HOCKER DR	MERRIAM, KS 66203	23441	15
4363	7499.764	JP4800000	05112020 15009.00 0	0.17	0	P	SCHLEICHER, ROCHELLE M.	SCHLEICHER, DANIEL L.	HOCKER	DR	9610	111	RU	34970	189030	224000	9610 HOCKER DR	66203	9610 HOCKER DR	MERRIAM, KS 66203	23440	15
4365	9224.906	JP4800000	05112020 15009.00 0	0.21	0	P	SCHLEICHER, ROCHELLE M.	SCHLEICHER, DANIEL L.	HOCKER	DR	9610	111	RU	34970	189030	224000	9610 HOCKER DR	66203	9610 HOCKER DR	MERRIAM, KS 66203	23438	15
4368	4498.968	JP4800000	05112020 15009.00 0	0.1	0	P	SCHLEICHER, ROCHELLE M.	SCHLEICHER, DANIEL L.	HOCKER	DR	9610	111	RU	34970	189030	224000	9610 HOCKER DR	66203	9610 HOCKER DR	MERRIAM, KS 66203	23437	15
4369	4500.056	JP4800000	05112020 15016.00 0	0.1	0	P	WALLACE, JOAN		HOCKER	DR	9516	111	RU	26440	118060	144500	9516 HOCKER DR	66203	9516 HOCKER DR	MERRIAM, KS 66203	23436	6
4370	9345.098	JP4800000	05112020 15016.00 0	0.21	0	P	WALLACE, JOAN		HOCKER	DR	9516	111	RU	26440	118060	144500	9516 HOCKER DR	66203	9516 HOCKER DR	MERRIAM, KS 66203	23435	6
4371	7500.061	JP4800000	05112020 15016.00 0	0.17	0	P	WALLACE, JOAN		HOCKER	DR	9516	111	RU	26440	118060	144500	9516 HOCKER DR	66203	9516 HOCKER DR	MERRIAM, KS 66203	23434	6
4372	3658.335	JP4800000	05112020 15016.00 0	0.08	0	P	WALLACE, JOAN		HOCKER	DR	9516	111	RU	26440	118060	144500	9516 HOCKER DR	66203	9516 HOCKER DR	MERRIAM, KS 66203	23433	6
4373	3841.71	JP4800000	05112020 15016.01 0	0.09	0	P	CITY OF MERRIAM		NS	NT	0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23432	10
4374	7500.029	JP4800000	05112020 15016.01 0	0.17	0	P	CITY OF MERRIAM		NS	NT	0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23431	10

4376	9345.014	JP4800000	05112020 15016.01 0	0.21	0	P	CITY OF MERRIAM	NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23430	10
4379	5197.367	JP4800000	05112020 15016.01 0	0.12	0	P	CITY OF MERRIAM	NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23427	10
4389	6825.135	JP4800000	05112020 15009.00 0	0.16	0	P	SCHLEICHER, ROCHELLE M.	SCHLEICHER, DANIEL L.	HOCKER	DR	9610	111	RU	34970	189030	224000	9610 HOCKER DR	66203	9610 HOCKER DR	MERRIAM , KS 66203	23419	15
4390	1499.817	JP4800000	05112020 15009.00 0	0.03	0	P	SCHLEICHER, ROCHELLE M.	SCHLEICHER, DANIEL L.	HOCKER	DR	9610	111	RU	34970	189030	224000	9610 HOCKER DR	66203	9610 HOCKER DR	MERRIAM , KS 66203	23418	15
4391	1513.31	JP4800000	05112020 15016.00 0	0.03	0	P	WALLACE, JOAN	HOCKER	DR		9516	111	RU	26440	118060	144500	9516 HOCKER DR	66203	9516 HOCKER DR	MERRIAM , KS 66203	23417	6
4392	5369.399	JP6800000	05112010 11007.00 0	0.12	0	P	SMITH, ROBERT L.	KESSLER	LN		5748	111	RU	20300	2700	23000	5748 KESSLER LN	66203	14333 JOHNSON DR	SHAWNEE , KS 66216	23416	1
4395	6769.881	JP4800000	05112020 15016.00 0	0.16	0	P	WALLACE, JOAN	HOCKER	DR		9516	111	RU	26440	118060	144500	9516 HOCKER DR	66203	9516 HOCKER DR	MERRIAM , KS 66203	23413	6
4398	10212.37	JF241212-(	05112010 11006.00 0	0.23	0	F	BRYANT, SYLVIA M. ETAL	58TH	ST	W	9224	111	RU	21360	32040	53400	9224 W 58TH ST	66203	5757 MERRIAM DR	MERRIAM , KS 66203	23410	1
4399	6814.782	JP4800000	05112020 15016.01 0	0.16	0	P	CITY OF MERRIAM	NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23409	10
4400	1710.427	JP4800000	05112020 15016.01 0	0.04	0	P	CITY OF MERRIAM	NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23408	10
4405	6824.581	JP4800000	05112020 15009.00 0	0.16	0	P	SCHLEICHER, ROCHELLE M.	SCHLEICHER, DANIEL L.	HOCKER	DR	9610	111	RU	34970	189030	224000	9610 HOCKER DR	66203	9610 HOCKER DR	MERRIAM , KS 66203	23405	15
4407	1499.747	JP4800000	05112020 15009.00 0	0.03	0	P	SCHLEICHER, ROCHELLE M.	SCHLEICHER, DANIEL L.	HOCKER	DR	9610	111	RU	34970	189030	224000	9610 HOCKER DR	66203	9610 HOCKER DR	MERRIAM , KS 66203	23404	15
4409	1556.409	JP4800000	05112020 15016.01 0	0.04	0	P	CITY OF MERRIAM	NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23402	10
4411	6807.474	JP4800000	05112020 15016.01 0	0.16	0	P	CITY OF MERRIAM	NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23401	10
4413	7017.709	JP4800000	05112020 15016.01 0	0.16	0	P	CITY OF MERRIAM	NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23400	10
4414	1790.037	JP4800000	05112020 15016.01 0	0.04	0	P	CITY OF MERRIAM	NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23399	10
4418	933.4105	JP4800000	05112020 15017.00 0	0.02	0	P	MERRIAM DRAINAGE DISTRICT	OF JOHNSON CO KANSAS	NS	NT		0	483	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23395	4
4419	4055.741	JP4800000	05112020 15017.00 0	0.09	0	P	MERRIAM DRAINAGE DISTRICT	OF JOHNSON CO KANSAS	NS	NT		0	483	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23394	4
4420	4674.349	JP4800000	05112020 15009.00 0	0.11	0	P	SCHLEICHER, ROCHELLE M.	SCHLEICHER, DANIEL L.	HOCKER	DR	9610	111	RU	34970	189030	224000	9610 HOCKER DR	66203	9610 HOCKER DR	MERRIAM , KS 66203	23393	15

4421	4148.035	JP4800000	05112020 15017.00 0	0.1	0	P	MERRIAM DRAINAGE DISTRICT	OF JOHNSON CO KANSAS	NS	NT		0	483	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23392	4
4422	1057.303	JP4800000	05112020 15017.00 0	0.02	0	P	MERRIAM DRAINAGE DISTRICT	OF JOHNSON CO KANSAS	NS	NT		0	483	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23391	4
4423	4173.558	JP4800000	05112020 15009.00 0	0.1	0	P	SCHLEICHER, ROCHELLE M.	SCHLEICHER, DANIEL L.	HOCKER	DR		9610	111	RU	34970	189030	224000	9610 HOCKER DR	66203	9610 HOCKER DR	MERRIAM, KS 66203	23390	15
4425	2643.127	JP4800000	05112020 15003.00 0	0.06	0	P	JESTER, ALAN F.	JESTER, EDE M.	57TH	ST	W	9615	111	RU	27370	105630	133000	9615 W 57TH ST	66203	9615 W 57TH ST	MERRIAM, KS 66203	23389	18
4426	1519.174	JP4800000	05112020 15003.00 0	0.03	0	P	JESTER, ALAN F.	JESTER, EDE M.	57TH	ST	W	9615	111	RU	27370	105630	133000	9615 W 57TH ST	66203	9615 W 57TH ST	MERRIAM, KS 66203	23388	18
4428	607.0497	JP4800000	05112020 15018.01 0	0.01	0	P	CARAVELLO, TONY	CARAVELLO, LISA R.	NS	NT		0	100X	VU	1670	0	1670	N/A	66203	9613 W 57TH ST	MERRIAM, KS 66203	23386	4
4430	1261.703	JP4800000	05112020 15018.01 0	0.03	0	P	CARAVELLO, TONY	CARAVELLO, LISA R.	NS	NT		0	100X	VU	1670	0	1670	N/A	66203	9613 W 57TH ST	MERRIAM, KS 66203	23384	4
4434	1463.165	JP4800000	05112020 15019.01 0	0.03	0	P	CITY OF MERRIAM		NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23380	17
4435	29244.35	JF241212-0	05112010 11002.00 0	0.67	0.52	F	WILIKER, L. ERNESTINE TRUSTEE	WILIKER, VERNON	MERRIAM	DR		5745	511	CU	53920	95980	149900	5745 MERRIAM DR	66203	5800 GRANT ST	MERRIAM, KS 66203	23379	2
4437	2771.798	JP4800000	05112020 15019.01 0	0.06	0	P	CITY OF MERRIAM		NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23377	17
4438	701.8834	JP4800000	05112020 15019.01 0	0.02	0	P	CITY OF MERRIAM		NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23376	17
4440	1562.84	JF241212-0	05112010 11002.00 0	0.04	0.52	F	WILIKER, L. ERNESTINE TRUSTEE	WILIKER, VERNON	MERRIAM	DR		5745	511	CU	53920	95980	149900	5745 MERRIAM DR	66203	5800 GRANT ST	MERRIAM, KS 66203	23374	2
4444	22765.11	JP0530000	05112020 15011.00 0	0.52	0	P	LOCKE, HALE H.	LOCKE, VERA A.	KNOX	ST		5757	111	RU	24120	133180	157300	5757 KNOX ST	66203	5757 KNOX ST	MERRIAM, KS 66203	23370	1
4445	2158.207	JP6800000	05112010 11001.00 0	0.05	0	P	CITY OF MERRIAM		MERRIAM	DR		5701	692	EM	224120	911570	1135690	5701 MERRIAM DR	66203	9000 W 62ND TER	MERRIAM, KS 66202	23369	2
4446	4971.888	JP4800000	05112020 15009.00 0	0.11	0	P	SCHLEICHER, ROCHELLE M.	SCHLEICHER, DANIEL L.	HOCKER	DR		9610	111	RU	34970	189030	224000	9610 HOCKER DR	66203	9610 HOCKER DR	MERRIAM, KS 66203	23368	15
4448	1283.906	JP4800000	05112020 15008.00 0	0.03	0	P	ERNLUND, NINA W.		KNOX	ST		5719	111	RU	21490	106910	128400	5719 KNOX ST	66203	5719 KNOX ST	MERRIAM, KS 66203	23367	3
4450	4162.76	JP4800000	05112020 15009.00 0	0.1	0	P	SCHLEICHER, ROCHELLE M.	SCHLEICHER, DANIEL L.	HOCKER	DR		9610	111	RU	34970	189030	224000	9610 HOCKER DR	66203	9610 HOCKER DR	MERRIAM, KS 66203	23366	15
4452	2637.727	JP4800000	05112020 15003.00 0	0.06	0	P	JESTER, ALAN F.	JESTER, EDE M.	57TH	ST	W	9615	111	RU	27370	105630	133000	9615 W 57TH ST	66203	9615 W 57TH ST	MERRIAM, KS 66203	23364	18

4455	1524.621	JP4800000	05112020 15003.00 0	0.04	0	P	JESTER, ALAN F.	JESTER, EDE M.	57TH	ST	W	9615	111	RU	27370	105630	133000	9615 W 57TH ST	66203	9615 W 57TH ST	MERRIAM , KS 66203	23363	18
4457	1494.827	JP4800000	05112020 15018.01 0	0.03	0	P	CARAVELL O, TONY	CARAVELL O, LISA R.	NS	NT		0	100X	VU	1670	0	1670	N/A	66203	9613 W 57TH ST	MERRIAM , KS 66203	23362	4
4460	4521.956	JP4800000	05112020 15018.01 0	0.1	0	P	CARAVELL O, TONY	CARAVELL O, LISA R.	NS	NT		0	100X	VU	1670	0	1670	N/A	66203	9613 W 57TH ST	MERRIAM , KS 66203	23360	4
4462	2308.145	JP4800000	05112020 15019.01 0	0.05	0	P	CITY OF MERRIAM		NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23358	17
4465	6931.176	JP4800000	05112020 15019.01 0	0.16	0	P	CITY OF MERRIAM		NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23356	17
4466	1756.099	JP4800000	05112020 15019.01 0	0.04	0	P	CITY OF MERRIAM		NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23355	17
4476	469.5354	JP4800000	05112020 15019.01 0	0.01	0	P	CITY OF MERRIAM		NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23346	17
4477	6824.885	JP4800000	05112020 15008.00 0	0.16	0	P	ERNLUND, NINA W.		KNOX	ST		5719	111	RU	21490	106910	128400	5719 KNOX ST	66203	5719 KNOX ST	MERRIAM , KS 66203	23345	3
4479	4162.69	JP4800000	05112020 15009.00 0	0.1	0	P	SCHLEICHER, ROCHELLE M.	SCHLEICHER, DANIEL L.	HOCKER	DR		9610	111	RU	34970	189030	224000	9610 HOCKER DR	66203	9610 HOCKER DR	MERRIAM , KS 66203	23343	15
4480	2673.493	JP4800000	05112020 15003.00 0	0.06	0	P	JESTER, ALAN F.	JESTER, EDE M.	57TH	ST	W	9615	111	RU	27370	105630	133000	9615 W 57TH ST	66203	9615 W 57TH ST	MERRIAM , KS 66203	23342	18
4482	1488.903	JP4800000	05112020 15003.00 0	0.03	0	P	JESTER, ALAN F.	JESTER, EDE M.	57TH	ST	W	9615	111	RU	27370	105630	133000	9615 W 57TH ST	66203	9615 W 57TH ST	MERRIAM , KS 66203	23340	18
4486	1511.392	JP4800000	05112020 15019.00 0	0.03	0	P	CARAVELL O, TONY	CARAVELL O, LISA R.	NS	NT		0	100X	VU	9740	0	9740	N/A	66203	9613 W 57TH ST	MERRIAM , KS 66203	23336	12
4488	6345.155	JP4800000	05112020 15019.00 0	0.15	0	P	CARAVELL O, TONY	CARAVELL O, LISA R.	NS	NT		0	100X	VU	9740	0	9740	N/A	66203	9613 W 57TH ST	MERRIAM , KS 66203	23334	12
4489	88.2752	JP4800000	05112020 15019.00 0	0	0	P	CARAVELL O, TONY	CARAVELL O, LISA R.	NS	NT		0	100X	VU	9740	0	9740	N/A	66203	9613 W 57TH ST	MERRIAM , KS 66203	23333	12
4490	2685.444	JP4800000	05112020 15008.00 0	0.06	0	P	ERNLUND, NINA W.		KNOX	ST		5719	111	RU	21490	106910	128400	5719 KNOX ST	66203	5719 KNOX ST	MERRIAM , KS 66203	23332	3
4491	6897.596	JP4800000	05112020 15019.01 0	0.16	0	P	CITY OF MERRIAM		NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23331	17
4492	1796.963	JP4800000	05112020 15019.01 0	0.04	0	P	CITY OF MERRIAM		NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23330	17
4495	4112.385	JP4800000	05112020 15007.00 0	0.09	0	P	SIMMONS , DOROTHEE L. TRUSTEE	ABBOTT, DORLA J. TRUSTEE	KNOX	ST		5715	111	RU	21520	104080	125600	5715 KNOX ST	66203	5715 KNOX ST	MERRIAM , KS 66203	23328	2
4497	4162.62	JP4800000	05112020 15009.00 0	0.1	0	P	SCHLEICHER, ROCHELLE M.	SCHLEICHER, DANIEL L.	HOCKER	DR		9610	111	RU	34970	189030	224000	9610 HOCKER DR	66203	9610 HOCKER DR	MERRIAM , KS 66203	23327	15
4498	2700.417	JP4800000	05112020 15003.00 0	0.06	0	P	JESTER, ALAN F.	JESTER, EDE M.	57TH	ST	W	9615	111	RU	27370	105630	133000	9615 W 57TH ST	66203	9615 W 57TH ST	MERRIAM , KS 66203	23326	18
4501	1462.026	JP4800000	05112020 15003.00 0	0.03	0	P	JESTER, ALAN F.	JESTER, EDE M.	57TH	ST	W	9615	111	RU	27370	105630	133000	9615 W 57TH ST	66203	9615 W 57TH ST	MERRIAM , KS 66203	23325	18

4502	1537.993	JP4800000	05112020 15019.00 0	0.04	0	P	CARAVELLO, TONY	CARAVELLO, LISA R.	NS	NT		0	100X	VU	9740	0	9740	N/A	66203	9613 W 57TH ST	MERRIAM, KS 66203	23324	12
4505	6787.067	JP4800000	05112020 15019.00 0	0.16	0	P	CARAVELLO, TONY	CARAVELLO, LISA R.	NS	NT		0	100X	VU	9740	0	9740	N/A	66203	9613 W 57TH ST	MERRIAM, KS 66203	23322	12
4506	1551.848	JP4800000	05112020 15019.00 0	0.04	0	P	CARAVELLO, TONY	CARAVELLO, LISA R.	NS	NT		0	100X	VU	9740	0	9740	N/A	66203	9613 W 57TH ST	MERRIAM, KS 66203	23321	12
4508	5373.209	JP4800000	05112020 15019.01 0	0.12	0	P	CITY OF MERRIAM		NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23320	17
4509	1782.96	JP4800000	05112020 15019.01 0	0.04	0	P	CITY OF MERRIAM		NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23319	17
4519	6807.17	JP4800000	05112020 15007.00 0	0.16	0	P	SIMMONS, DOROTHEE L. TRUSTEE	ABBOTT, DORLA J. TRUSTEE	KNOX	ST		5715	111	RU	21520	104080	125600	5715 KNOX ST	66203	5715 KNOX ST	MERRIAM, KS 66203	23310	2
4521	4151.676	JP4800000	05112020 15009.00 0	0.1	0	P	SCHLEICHER, ROCHELLE M.	SCHLEICHER, DANIEL L.	HOCKER	DR		9610	111	RU	34970	189030	224000	9610 HOCKER DR	66203	9610 HOCKER DR	MERRIAM, KS 66203	23309	15
4522	2701.691	JP4800000	05112020 15003.00 0	0.06	0	P	JESTER, ALAN F.	JESTER, EDE M.	57TH	ST	W	9615	111	RU	27370	105630	133000	9615 W 57TH ST	66203	9615 W 57TH ST	MERRIAM, KS 66203	23308	18
4523	21685.71	JF241212-0	05112010 05021.00 0	0.5	0	F	MERRIAM DRAINAGE DISTRICT	JO CO	NS	NT		0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23307	1
4524	1460.8	JP4800000	05112020 15003.00 0	0.03	0	P	JESTER, ALAN F.	JESTER, EDE M.	57TH	ST	W	9615	111	RU	27370	105630	133000	9615 W 57TH ST	66203	9615 W 57TH ST	MERRIAM, KS 66203	23306	18
4525	1539.322	JP4800000	05112020 15019.00 0	0.04	0	P	CARAVELLO, TONY	CARAVELLO, LISA R.	NS	NT		0	100X	VU	9740	0	9740	N/A	66203	9613 W 57TH ST	MERRIAM, KS 66203	23305	12
4527	6785.714	JP4800000	05112020 15019.00 0	0.16	0	P	CARAVELLO, TONY	CARAVELLO, LISA R.	NS	NT		0	100X	VU	9740	0	9740	N/A	66203	9613 W 57TH ST	MERRIAM, KS 66203	23303	12
4528	3486.654	JP4800000	05112020 15019.00 0	0.08	0	P	CARAVELLO, TONY	CARAVELLO, LISA R.	NS	NT		0	100X	VU	9740	0	9740	N/A	66203	9613 W 57TH ST	MERRIAM, KS 66203	23302	12
4529	3444.904	JP4800000	05112020 15019.01 0	0.08	0	P	CITY OF MERRIAM		NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23301	17
4531	1786.531	JP4800000	05112020 15019.01 0	0.04	0	P	CITY OF MERRIAM		NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23299	17
4533	196468	JF241212-0	05112010 05023.00 0	4.51	4.5	F	CITY OF MERRIAM		MERRIAM	DR		5750	799	EM	510350	432760	943110	5750 MERRIAM DR	66203	9000 W 62ND TER	MERRIAM, KS 66202	23297	1
4537	6824.835	JP4800000	05112020 15006.00 0	0.16	0	P	WAUGAMAN, LARRY R.	WAUGAMAN, SONJA M.	KNOX	ST		5711	111	RU	22120	99080	121200	5711 KNOX ST	66203	5711 KNOX ST	MERRIAM, KS 66203	23293	2
4541	4162.559	JP4800000	05112020 15004.00 0	0.1	0	P	MCMENEMY, LEONA A.		NS	NT		0	100	VU	22790	0	22790	N/A	66203	9619 W 57TH ST	MERRIAM, KS 66203	23292	4
4542	2686.345	JP4800000	05112020 15003.00 0	0.06	0	P	JESTER, ALAN F.	JESTER, EDE M.	57TH	ST	W	9615	111	RU	27370	105630	133000	9615 W 57TH ST	66203	9615 W 57TH ST	MERRIAM, KS 66203	23291	18
4545	1476.192	JP4800000	05112020 15003.00 0	0.03	0	P	JESTER, ALAN F.	JESTER, EDE M.	57TH	ST	W	9615	111	RU	27370	105630	133000	9615 W 57TH ST	66203	9615 W 57TH ST	MERRIAM, KS 66203	23290	18

4547	1517.89	JP4800000	05112020 15019.00 0	0.03	0	P	CARAVELL O, TONY	CARAVELL O, LISA R.	NS	NT		0	100X	VU	9740	0	9740	N/A	66203	9613 W 57TH ST	MERRIAM , KS 66203	23289	12
4549	6807.123	JP4800000	05112020 15019.00 0	0.16	0	P	CARAVELL O, TONY	CARAVELL O, LISA R.	NS	NT		0	100X	VU	9740	0	9740	N/A	66203	9613 W 57TH ST	MERRIAM , KS 66203	23288	12
4551	5376.483	JP4800000	05112020 15019.00 0	0.12	0	P	CARAVELL O, TONY	CARAVELL O, LISA R.	NS	NT		0	100X	VU	9740	0	9740	N/A	66203	9613 W 57TH ST	MERRIAM , KS 66203	23287	12
4552	1499.174	JP4800000	05112020 15019.01 0	0.03	0	P	CITY OF MERRIAM		NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23286	17
4553	1768.057	JP4800000	05112020 15019.01 0	0.04	0	P	CITY OF MERRIAM		NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23285	17
4555	82.78728	JP4800000	05112020 15019.01 0	0	0	P	CITY OF MERRIAM		NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23284	17
4558	6825.275	JP4800000	05112020 15006.00 0	0.16	0	P	WAUGAM AN, LARRY R.	WAUGAM AN, SONJA M.	KNOX	ST		5711	111	RU	22120	99080	121200	5711 KNOX ST	66203	5711 KNOX ST	MERRIAM , KS 66203	23281	2
4559	27693.38	JP4800000	05112010 12005.00 0	0.64	0	P	BIVINS, T. J.	BIVINS, PATRICIA A.	KESSLER	LN		5717	645	CU	69230	156820	226050	5717 KESSLER LN	66203	500 E 6TH ST	WELLSVIL LE, KS 66092	23280	1
4560	4162.606	JP4800000	05112020 15004.00 0	0.1	0	P	MCMENE MY, LEONA A.		NS	NT		0	100	VU	22790	0	22790	N/A	66203	9619 W 57TH ST	MERRIAM , KS 66203	23279	4
4561	2670.999	JP4800000	05112020 15003.00 0	0.06	0	P	JESTER, ALAN F.	JESTER, EDE M.	57TH	ST	W	9615	111	RU	27370	105630	133000	9615 W 57TH ST	66203	9615 W 57TH ST	MERRIAM , KS 66203	23278	18
4562	4499.947	JF241212-:	05112010 05020.00 0	0.1	0	F	MERRIAM DRAINAGE DISTRICT		NS	NT		0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23277	1
4563	1491.586	JP4800000	05112020 15003.00 0	0.03	0	P	JESTER, ALAN F.	JESTER, EDE M.	57TH	ST	W	9615	111	RU	27370	105630	133000	9615 W 57TH ST	66203	9615 W 57TH ST	MERRIAM , KS 66203	23276	18
4565	6824.989	JP4800000	05112020 15001.00 0	0.16	0	P	CARAVELL O, TONY	CARAVELL O, LISA R.	57TH	ST	W	9613	111	RU	28210	83490	111700	9613 W 57TH ST	66203	9613 W 57TH ST	MERRIAM , KS 66203	23274	6
4566	6881.42	JP4800000	05112020 15001.00 0	0.16	0	P	CARAVELL O, TONY	CARAVELL O, LISA R.	57TH	ST	W	9613	111	RU	28210	83490	111700	9613 W 57TH ST	66203	9613 W 57TH ST	MERRIAM , KS 66203	23273	6
4568	47585.07	JF241212-:	05112010 05024.00 0	1.09	0	F	MUEHLBERGER, ROBERT J.	MUEHLBERGER, KAYE	MERRIAM	DR		5726	511	CU	99930	86170	186100	5726 MERRIAM DR	66203	5726 MERRIAM DR	MERRIAM , KS 66203	23272	1
4569	1384.253	JP4800000	05112020 15019.01 0	0.03	0	P	CITY OF MERRIAM		NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23271	17
4572	6824.459	JP4800000	05112020 15005.00 0	0.16	0	P	MCMENE MY, LEONA A.		57TH	ST	W	9619	111	RU	22150	116450	138600	9619 W 57TH ST	66203	9619 W 57TH ST	MERRIAM , KS 66203	23269	2
4575	4162.131	JP4800000	05112020 15004.00 0	0.1	0	P	MCMENE MY, LEONA A.		NS	NT		0	100	VU	22790	0	22790	N/A	66203	9619 W 57TH ST	MERRIAM , KS 66203	23267	4
4577	2664.932	JP4800000	05112020 15003.00 0	0.06	0	P	JESTER, ALAN F.	JESTER, EDE M.	57TH	ST	W	9615	111	RU	27370	105630	133000	9615 W 57TH ST	66203	9615 W 57TH ST	MERRIAM , KS 66203	23266	18
4580	1497.7	JP4800000	05112020 15003.00 0	0.03	0	P	JESTER, ALAN F.	JESTER, EDE M.	57TH	ST	W	9615	111	RU	27370	105630	133000	9615 W 57TH ST	66203	9615 W 57TH ST	MERRIAM , KS 66203	23264	18

4583	6824.966	JP4800000	05112020 15001.00 0	0.16	0	P	CARAVELLO, TONY	CARAVELLO, LISA R.	57TH	ST	W	9613	111	RU	28210	83490	111700	9613 W 57TH ST	66203	9613 W 57TH ST	MERRIAM, KS 66203	23262	6
4586	6905.171	JP4800000	05112020 15001.00 0	0.16	0	P	CARAVELLO, TONY	CARAVELLO, LISA R.	57TH	ST	W	9613	111	RU	28210	83490	111700	9613 W 57TH ST	66203	9613 W 57TH ST	MERRIAM, KS 66203	23260	6
4597	13992.23	JP6800000	05112010 12004.00 0	0.32	0	P	KASCHT, HARVEY	KASCHT, ELIZABETH M.	KESSLER	LN		5713	534	CU	34990	62290	97280	5713 KESSLER LN	66203	5713 KESSLER LN, #101	MERRIAM, KS 66203	23249	1
4599	6951.174	JP4800000	05112020 15005.00 0	0.16	0	P	MCMENEMY, LEONA A.		57TH	ST	W	9619	111	RU	22150	116450	138600	9619 W 57TH ST	66203	9619 W 57TH ST	MERRIAM, KS 66203	23247	2
4601	4232.719	JP4800000	05112020 15004.00 0	0.1	0	P	MCMENEMY, LEONA A.		NS	NT		0	100	VU	22790	0	22790	N/A	66203	9619 W 57TH ST	MERRIAM, KS 66203	23246	4
4603	2704.926	JP4800000	05112020 15003.00 0	0.06	0	P	JESTER, ALAN F.	JESTER, EDE M.	57TH	ST	W	9615	111	RU	27370	105630	133000	9615 W 57TH ST	66203	9615 W 57TH ST	MERRIAM, KS 66203	23244	18
4604	1523.182	JP4800000	05112020 15003.00 0	0.03	0	P	JESTER, ALAN F.	JESTER, EDE M.	57TH	ST	W	9615	111	RU	27370	105630	133000	9615 W 57TH ST	66203	9615 W 57TH ST	MERRIAM, KS 66203	23243	18
4605	4522.274	JD4800000	00000000 00000.00 0	0.1	0	D									0	0	0					23242	2
4607	6917.018	JP4800000	05112020 15001.00 0	0.16	0	P	CARAVELLO, TONY	CARAVELLO, LISA R.	57TH	ST	W	9613	111	RU	28210	83490	111700	9613 W 57TH ST	66203	9613 W 57TH ST	MERRIAM, KS 66203	23241	6
4609	6996.569	JP4800000	05112020 15001.00 0	0.16	0	P	CARAVELLO, TONY	CARAVELLO, LISA R.	57TH	ST	W	9613	111	RU	28210	83490	111700	9613 W 57TH ST	66203	9613 W 57TH ST	MERRIAM, KS 66203	23240	6
4611	76648.95	JF241212-:	00000000 00000.00 0	1.76	1.64	F	SEC OF TRANSPORTATION	STATE OF KANSAS	NS	NT		0	458	EK	0	0	0	N/A	66203	STATE HOUSE	TOPEKA, KS 66612	23239	1
4613	265781.8	JD4800000	00000000 00000.00 0	6.1	0	D									0	0	0					23238	1
4615	9992.976	JP6800000	05112010 12003.00 0	0.23	0	P	BLY, HERBERT H.	BLY, JULIE I.	KESSLER	LN		5709	631	CU	24980	48750	73730	5709 KESSLER LN	66203	5701 KESSLER LN	MERRIAM, KS 66203	23237	1
4624	8633.925	JF241212-:	00000000 00000.00 0	0.2	0.23	F	CITY OF MERRIAM		NS	NT		0	458	VU	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23230	1
4627	11828.22	JD241212-:	00000000 00000.00 0	0.27	0	D									0	0	0					23227	1
4631	41769.71	JF241212-:	00000000 00000.00 0	0.96	1	F	CITY OF MERRIAM		NS	NT		0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23225	3
4632	149330.6	JP6800000	05112010 11001.00 0	3.43	0	P	CITY OF MERRIAM		MERRIAM	DR		5701	692	EM	224120	911570	1135690	5701 MERRIAM DR	66203	9000 W 62ND TER	MERRIAM, KS 66202	23224	2
4633	10531.47	JP6800000	05112010 12001.00 0	0.24	0	P	BLY, HERBERT H.	BLY, JULIE I.	KESSLER	LN		5701	111	RU	21430	41370	62800	5701 KESSLER LN	66203	5701 KESSLER LN	MERRIAM, KS 66203	23223	1
4636	13299.58	JF241212-:	05112010 05019.01 0	0.31	0.15	F	CITY OF MERRIAM		NS	NT		0	500	VU	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23222	1
4637	2394.595	JP7000000	00000000 00000.00 0	0.05	0	P	CITY OF MERRIAM		NS	NT		0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23221	1
4639	81105.26	JF241212-:	05112010 05019.00 0	1.86	1.63	F	SWANSON, LARRY V.	REZABEK, JANICE G.	NS	NT		0	5141	CU	0	0	0	N/A	66203	3208 NE 42 CT	FT. LAUDERDALE, FL 33308	23219	1

4641	215503.9	JF241212-0	00000000 00000.00 0	4.95	0	F	FRISCO RAILROAD		NS	NT		0	411	UR	0	0	0	N/A	66203	PO BOX 961089	FORT WORTH, TX 76161-0089	23217	1
4644	20757.19	JF241212-0	05112010 05025.00 0	0.48	0	F	SWANSON, LARRY V.	REZABEK, JANICE G.	MERRIAM	DR		5700	514	CU	122240	515460	637700	5700 MERRIAM DR	66203	3208 NE 42 CT	FT. LAUDERDALE, FL 33308	23215	1
4652	16800.49	JP2100000	05112020 02024.00 0	0.39	0	P	BELL, JAMES C.	BELL, VICKI	57TH	ST	W	9620	111	RU	22810	110590	133400	9620 W 57TH ST	66203	9620 W 57TH ST	MERRIAM, KS 66203	23211	1
4655	2371.056	JD7000000	00000000 00000.00 0	0.05	0	D									0	0	0					23210	1
4662	15806.43	JP2100000	05112020 02031.00 0	0.36	0	P	COOK, TONY J.	COOK, VESTA J.	57TH	PL	W	9500	111	RU	22590	112210	134800	9500 W 57TH PL	66203	9500 W 57TH PL	MERRIAM, KS 66203	23206	1
4663	65126.95	JD6800000	00000000 00000.00 0	1.5	0	D									0	0	0					23205	1
4674	1197.679	JF241212-0	00000000 00000.00 0	0.03	0.01	F	CITY OF MERRIAM		NS	NT		0	458	VU	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23204	1
4675	16327.41	JP2100000	05112020 02025.00 0	0.37	0	P	TOBUREN, MERRILL W.	TOBUREN, MARTHA J.	57TH	ST	W	9610	111	RU	22710	84890	107600	9610 W 57TH ST	66203	9510 W 57TH ST	MERRIAM, KS 66203	23203	1
4676	18151.37	JP2100000	05112020 02026.00 0	0.42	0	P	KOETTING, CHRISTOPHER T.	KOETTING, VALERIE L.	57TH	ST	W	9512	111	RU	23110	116190	139300	9512 W 57TH ST	66203	9512 W 57TH ST	MERRIAM, KS 66203	23202	1
4677	12626.61	JP3600000	05112010 05026.00 0	0.29	0	P	MASTERS, RAYMOND C.	MASTERS, CYNTHIA M.	MERRIAM	DR		5654	532	CU	21400	212600	234000	5654 MERRIAM DR	66203	4714 EBY ST	MERRIAM, KS 66203	23201	2
4680	20500.18	JP2100000	05112020 02023.00 0	0.47	0	P	BURKE, GARY L.	BURKE, MARY J.	KNOX	ST		5651	111	RU	23630	105670	129300	5651 KNOX ST	66203	5651 KNOX ST	MERRIAM, KS 66203	23198	1
4683	15027.87	JD2100000	00000000 00000.00 0	0.34	0	D									0	0	0					23195	1
4686	15545.24	JP2100000	05112020 02030.00 0	0.36	0	P	BAILEY, WILLIAM A.	BAILEY, VERSA W.	57TH	PL	W	9504	111	RU	22540	105560	128100	9504 W 57TH PL	66203	9504 W 57TH PL	MERRIAM, KS 66203	23192	1
4692	13965.45	JP3600000	05112010 05028.00 0	0.32	0	P	PERKOVIC, IVAN	PERKOVIC, COLETTE	MERRIAM	DR		5646	514	CU	59650	150000	209650	5646 MERRIAM DR	66203	11108 W 119TH TER	OVERLAND PARK, KS 66213	23186	2
4693	554.423	JP3600000	00000000 00000.00 0	0.01	0	P	CITY OF MERRIAM		NS	NT		0	458	EK	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23185	1
4698	18736.37	JP6800000	05112010 04011.00 0	0.43	0	P	FIRST CHURCH OF CHRIST	SCIENTIST	57TH	ST	W	9224	670	ER	65580	151090	216670	9224 W 57TH ST	66203	5868 MERRIAM DR	MERRIAM, KS 66203	23182	1
4701	40948.53	JF241212-0	00000000 00000.00 0	0.94	0.95	F	CITY OF MERRIAM		NS	NT		0	458	VU	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	23179	1
4707	23099.08	JP2100000	05112020 02022.00 0	0.53	0	P	LAY, J. WILLIAM	LAY, ROBERTA C.	KNOX	ST		5647	111	RU	24200	113400	137600	5647 KNOX ST	66203	5647 KNOX ST	MERRIAM, KS 66203	23176	1
4708	45864.23	JF241212-0	05112010 05018.00 0	1.05	1.2	F	ROBERTS, LONNIE D.	ROBERTS, SALLY I.	HAYES	ST		5636	111	RU	29210	53190	82400	5636 HAYES ST	66203	12818 W 65TH ST	SHAWNEE, KS 66216	23175	1

4710	24600.93	JP2100000	05112020 02027.00 0	0.56	0	P	TOBUREN, MERRILL W.	TOBUREN, MARTHA A.	57TH	PL	W	9510	111	RU	24530	133970	158500	9510 W 57TH PL	66203	9510 W 57TH PL	MERRIAM , KS 66203	23174	1
4713	54293.54	JP3600000	05112010 05026.00 0	1.25	0	P	MASTERS, RAYMOND C.	MASTERS, CYNTHIA M.	MERRIAM	DR		5654	532	CU	21400	212600	234000	5654 MERRIAM DR	66203	4714 EBY ST	MERRIAM , KS 66203	23172	2
4717	15520.42	JP2100000	05112020 02028.00 0	0.36	0	P	MIDDLETON, PAUL A.		57TH	PL	W	9508	111	RU	22530	131870	154400	9508 W 57TH PL	66203	9508 W 57TH PL	MERRIAM , KS 66203	23171	1
4718	15858.08	JP3600000	05112010 05028.00 0	0.36	0	P	PERKOVIC, IVAN	PERKOVIC, COLETTE	MERRIAM	DR		5646	514	CU	59650	150000	209650	5646 MERRIAM DR	66203	11108 W 119TH TER	OVERLAND PARK, KS 66213	23170	2
4719	553.8984	JD360000C	00000000 00000.00 0	0.01	0	D									0	0	0					23169	1
4720	16488.32	JP2100000	05112020 02029.00 0	0.38	0	P	LYTLE, FLOYD D. LIVING TRUST	LYTLE, ONA M. LIVING TRUST	57TH	PL	W	9506	111	RU	22740	113160	135900	9506 W 57TH PL	66203	9506 W 57TH PL	MERRIAM , KS 66203	23168	1
4724	11116.93	JP6800000	05112010 04010.00 0	0.26	0	P	DOTY, JOHNIE	DOTY, ROSALIE	MERRIAM	DR		5645	511	CU	17830	140370	158200	5645 MERRIAM DR	66203	5645 MERRIAM DR	MERRIAM , KS 66203	23166	1
4725	3553.6	JD680000C	00000000 00000.00 0	0.08	0	D									0	0	0					23165	1
4728	50168.6	JP6800000	05112010 04014.00 0	1.15	0	P	KESSLER I-35 BUSINESS CENTER		57TH	ST	W	9150	514	CU	100340	676460	776800	9150 W 57TH ST	66203	5039A MERRIAM DR	MERRIAM , KS 66203	23162	1
4731	47042.05	JP6800000	05112010 04015.00 0	1.08	0	P	CAMPBELL, RUSSELL E. JR	CAMPBELL, MARY ANN	57TH	ST	W	9108	645	CU	94080	83710	177790	9108 W 57TH ST	66203	6120 CLARE RD	SHAWNEE , KS 66226	23160	1
4732	5865.833	JF241212-0	05112010 04009.00 0	0.13	0.14	F	DOTY, JOHNIE	DOTY, ROSALIE	NS	NT		0	5111	CU	0	0	0	N/A	66203	5645 MERRIAM DR	MERRIAM , KS 66203	23159	1
4734	348.5457	JF241212-0	00000000 00000.00 0	0.01	0.01	F	CITY OF MERRIAM		NS	NT		0	458	VU	0	0	0	N/A	66202	9000 W 62ND TER	MERRIAM , KS 66202	23157	1
4740	21173.07	JP3500000	05112010 05030.00 0	0.49	0	P	SINGH, HARBHAJAN	KAUR, KAMALJIT	NS	NT		0	100F	VU	1540	0	1540	N/A	66203	5623 HAYES ST	MERRIAM , KS 66203	23152	1
4752	39004.56	JF241212-0	00000000 00000.00 0	0.9	0	F	CITY OF MERRIAM		NS	NT		0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23142	1
4753	10096.79	JP0900000	05112020 02016.00 0	0.23	0	P	HOLLOWAY, DONNA R. TRUSTEE	HOLLOWAY, DONNA R. REV TRUST	56TH	TER	W	9515	111	RU	21340	102660	124000	9515 W 56TH TER	66203	9515 W 56TH TER	MERRIAM , KS 66203	23141	1
4754	10696.01	JP0900000	05112020 02015.00 0	0.25	0	P	CHRISTESEN, DOLORES C.		56TH	TER	W	9509	111	RU	21470	129230	150700	9509 W 56TH TER	66203	9509 W 56TH TER	MERRIAM , KS 66203	23140	1
4755	14856.1	JP0900000	05112020 02014.00 0	0.34	0	P	LEEDHAM, ROBERT C. CO-TRUSTEE	LEEDHAM, MARIE A. CO-TRUSTEE	56TH	TER	W	9503	111	RU	22380	115820	138200	9503 W 56TH TER	66203	9503 W 56TH TER	MERRIAM , KS 66203	23139	1
4757	31181.29	JP3500000	05112010 05017.00 0	0.72	0	P	FRAZEE, JULIET L.		HAYES	ST		5628	111	RU	25980	43820	69800	5628 HAYES ST	66203	5140 LOWELL ST	OVERLAND PARK, KS 66202	23138	1

4758	14130.19	05112020 02017.00 JP0900000 0	0.32	0	P	SEATON, PHILLIP W.	SEATON, SHARON M.	56TH	TER	W	9605	111	RU	22230	100670	122900	9605 W 56TH TER	66203	9605 W 56TH TER	MERRIAM , KS 66203	23137	1
4759	782.8622	05112010 05032.01 JP3500000 0	0.02	0	P	CITY OF MERRIAM		NS	NT		0	650	EM	100	0	100	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23136	1
4761	13476.02	05112020 02018.00 JP0900000 0	0.31	0	P	FISACKERLY, IRA G. JR	FISACKERLY, NANCY A.	56TH	TER	W	9611	111	RU	22080	101020	123100	9611 W 56TH TER	66203	9611 W 56TH TER	MERRIAM , KS 66203	23135	1
4773	19834.72	05112010 05032.00 JP3500000 0	0.46	0	P	SINGH, HARBHAJAN	KAUR, KAMALJIT	HAYES	ST		5621	112	RU	23480	132920	156400	5621 HAYES ST	66203	5623 HAYES ST	MERRIAM , KS 66203	23128	1
4779	41792.48	05112010 05031.00 JP3500000 0	0.96	0	P	MERRIAM DRAINAGE DISTRICT		NS	NT		0	650	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23123	1
4781	18498.66	05112010 04008.00 JF241212-0	0.42	0	F	DOTY, JOHNIE HD	DOTY, ROSALIE	NS	NT		0	500	VU	0	0	0	N/A	66203	5645 MERRIAM DR	MERRIAM , KS 66203	23121	1
4783	466463.5	05112010 17002.00 JP4950000 0	10.71	0	P	DEVELOPMENT OF MARYLAND,	INC.	ANTIOCH	RD		5700	541	CU	2798780	3359320	6158100	5700 ANTIOCH RD	66202	PO BOX 105842	ATLANTA, GA 30348-5842	23119	1
4785	594.0323	05112010 05034.03 JP3500000 0	0.01	0	P	CITY OF MERRIAM		NS	NT		0	500	VU	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23118	1
4787	35992.64	00000000 00000.00 JD0900000 0	0.83	0	D									0	0	0					23117	1
4788	10153.15	05112020 02013.00 JP0900000 0	0.23	0	P	SNOW, WILLIAM D.	SNOW, VAL M.	56TH	TER	W	9500	111	RU	21350	101450	122800	9500 W 56TH TER	66203	9500 W 56TH TER	MERRIAM , KS 66203	23116	1
4792	4159.642	05112010 05033.00 JP3500000 0	0.1	0	P	CARREL, WINTON K.	ETAL	HAYES	ST		5615	112	RU	11020	59480	70500	5615 HAYES ST	66203	5615 HAYES ST	MERRIAM , KS 66203	23115	1
4793	31072.24	05112010 05016.00 JP3500000 0	0.71	0	P	CLARK, JULIANNE		HAYES	ST		5612	111	RU	25950	64250	90200	5612 HAYES ST	66203	5612 HAYES ST	MERRIAM , KS 66203	23114	1
4806	9316.131	05112010 05033.01 JP3500000 0	0.21	0	P	BLECHA, MARILYN S.		HAYES	ST		5613	112	RU	11640	59460	71100	5613 HAYES ST	66203	5613 HAYES ST	MERRIAM , KS 66203	23101	1
4808	30252.96	05112010 05034.00 JP3500000 0	0.69	0	P	JENKINS & ASSOCIATES, INC.		MERRIAM	DR		5600	631	CU	105890	179610	285500	5600 MERRIAM DR	66203	5602 MERRIAM DR	MERRIAM , KS 66203	23099	1
4809	3124.382	00000000 00000.00 JP3500000 0	0.07	0	P	CITY OF MERRIAM		NS	NT		0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23098	1
4814	10021.48	05112020 02010.00 JP0900000 0	0.23	0	P	MOORE, JOHN M.	MOORE, KATHLEEN C.	56TH	TER	W	9512	111	RU	21320	92180	113500	9512 W 56TH TER	66203	9512 W 56TH TER	MERRIAM , KS 66203	23094	1
4815	10642.89	05112020 02011.00 JP0900000 0	0.24	0	P	HERRIN, WILLIAM J.	HERRIN, LAWANNA F.	56TH	TER	W	9508	111	RU	21460	111940	133400	9508 W 56TH TER	66203	9508 W 56TH TER	MERRIAM , KS 66203	23093	1
4816	15080.87	05112020 02012.00 JP0900000 0	0.35	0	P	VANLERBERGHE, PAUL F. TRUSTEE	VANLERBERGHE, ADRIANA M. TTEE	56TH	TER	W	9504	111	RU	22430	115770	138200	9504 W 56TH TER	66203	9504 W 56TH TER	MERRIAM , KS 66203	23092	1
4819	10023.2	00000000 00000.00 JF241212-0	0.23	0	F	CITY OF MERRIAM		NS	NT		0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23090	1

4824	34258.93	JF241212-0	05112010 04007.00	0.79	0	F	PERKINS, EDWARD J.	PERKINS, LYNDA K.	MERRIAM	DR		5605	532	CU	102780	222320	325100	5605 MERRIAM DR	66203	5605 MERRIAM DR	MERRIAM , KS 66203	23086	1
4827	29244.53	JP3500000	05112010 05015.00	0.67	0	P	BROOM, VIRGINIA	ETAL	HAYES	ST		5604	111	RU	25550	60850	86400	5604 HAYES ST	66203	5604 HAYES ST	MERRIAM , KS 66203	23083	1
4837	14710.5	JP3500000	05112010 05037.00	0.34	0	P	DAVEY, DOUGLAS K.		HAYES	ST		5605	111	RU	22350	47550	69900	5605 HAYES ST	66203	5605 HAYES ST	MERRIAM , KS 66203	23077	1
4838	5228.288	JP3500000	05112010 05036.00	0.12	0	P	RONAN, MICHAEL T.		NS	NT		0	5111	CU	0	0	0	N/A	66203	5568 MERRIAM DR	MERRIAM , KS 66203	23076	1
4845	23710.46	JP3500000	05112010 05035.00	0.54	0	P	RONAN, MICHAEL T.		MERRIAM	DR		5568	511	CU	136820	120540	257360	5568 MERRIAM DR	66203	5568 MERRIAM DR	MERRIAM , KS 66203	23068	1
4846	3123.252	JP3500000	00000000 00000.00	0.07	0	P	CITY OF MERRIAM		NS	NT		0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	23067	1
4860	7596.963	JP3500000	05112010 05038.00	0.17	0	P	LEWIS, REDIE		HAYES	ST		5547	111	RU	20790	38910	59700	5547 HAYES ST	66203	7907 HALL ST	LENEXA, KS 66219	23058	1
4863	10150.92	JP3500000	05112010 05039.00	0.23	0	P	RONAN, MICHAEL T.		NS	NT		0	5111	CU	0	0	0	N/A	66203	5568 MERRIAM DR	MERRIAM , KS 66203	23055	1
4864	15079.2	JP6700000	05112020 02002.00	0.35	0	P	BRANDON , DANIEL S.	BRANDON , MARY K.	56TH	ST	W	9513	111	RU	22430	119670	142100	9513 W 56TH ST	66203	9513 W 56TH ST	MERRIAM , KS 66203	23054	1
4865	33075.32	JP3500000	05112010 05014.00	0.76	0	P	MEDINA, MICHAEL W.		HAYES	ST		5548	111	RU	26390	90610	117000	5548 HAYES ST	66203	5548 HAYES ST	MERRIAM , KS 66203	23053	1
4867	15210.42	JP6700000	05112020 02001.00	0.35	0	P	SAMBOL, CONSTANCE M.	SAMBOL, RICHARD L.	56TH	ST	W	9505	111	RU	22460	116140	138600	9505 W 56TH ST	66203	9505 W 56TH ST	MERRIAM , KS 66203	23051	1
4871	35126.73	JF241212-0	05112010 04016.00	0.81	0.89	F	MYERS, RAYMOND I.	MYERS, JUDITH B.	MERRIAM	DR		5601	511	CU	116630	188470	305100	5601 MERRIAM DR	66203	5601 MERRIAM DR	MERRIAM , KS 66203	23048	1
4872	3750.075	JF241212-0	05112010 04006.01	0.09	0.09	F	MYERS, RAYMOND I.	MYERS, JUDITH B.	NS	NT		0	5111	CU	0	0	0	N/A	66203	5601 MERRIAM DR	MERRIAM , KS 66203	23046	1
4879	11157.3	JP3500000	05112010 05041.00	0.26	0	P	DENTON, RALPH L.		HAYES	ST		5545	111	RU	21570	38030	59600	5545 HAYES ST	66203	8819 W 47TH TER	MERRIAM , KS 66203	23042	1
4885	15534.33	JP3500000	05112010 05013.00	0.36	0	P	NEALY, M. DAVID	NEALY, JUDITH A.	56TH	ST	W	9500	111	RU	22530	94170	116700	9500 W 56TH ST	66203	9500 W 56TH ST	MERRIAM , KS 66203	23039	1
4888	15546.95	JP3500000	05112010 05012.00	0.36	0	P	SANDNES, MARTHA L.	SANDNES, RONALD W.	HAYES	ST		5540	111	RU	22540	86560	109100	5540 HAYES ST	66203	5540 HAYES ST	MERRIAM , KS 66203	23036	1
4898	12453.48	JP3500000	05112010 05042.00	0.29	0	P	WRIGHT, CHARLES W.	ETAL	HAYES	ST		5541	111	RU	21860	77940	99800	5541 HAYES ST	66203	PO BOX 7194	KANSAS CITY, KS 64113	23032	1
4905	25000.98	JF241212-0	05112010 04006.00	0.57	0	F	H & R PROPERTIES OF JOHNSON	COUNTY, L.L.C.	NS	NT		0	533	CU	75000	104700	179700	N/A	66203	5541 MERRIAM DR	MERRIAM , KS 66203	23026	1
4911	185352.9	JF241212-0	05112010 04016.01	4.26	4.21	F	KINCAID, GRAYDON J. JR.	KINCAID, PATRICIA A.	NS	NT		0	423	CU	278030	179170	457200	N/A	66203	2353 GUILFORD LN	SHAWNEE MISSION, KS 66208-1120	23020	1
4918	28648.68	JP3500000	05112010 05011.00	0.66	0	P	LOPEZ, MARIA F.	ETAL	HAYES	ST		5538	111	RU	25420	57180	82600	5538 HAYES ST	66203	5538 HAYES ST	MERRIAM , KS 66203	23014	1

4925	12721.07	JP3500000	05112010 05043.00 0	0.29	0	P	WRIGHT, LEWIS H. SR	ETAL	HAYES	ST		5537	111	RU	21920	60080	82000	5537 HAYES ST	66203	PO BOX 7194	KANSAS CITY, MO 64113	23008	1
4930	21503.28	JF241212-(	05112010 04005.00 0	0.49	0	F	ANACO TRANSMISSION REPAIR SHOP		MERRIAM	DR		5537	511	CU	64510	171490	236000	5537 MERRIAM DR	66203	9800 BLUE RIDGE	KANSAS CITY, MO 64138	23005	1
4940	31616.7	JP3500000	05112010 05009.00 0	0.73	0	P	SHARON, JESSE J.		HAYES	ST		5528	111	RU	26070	55030	81100	5528 HAYES ST	66203	5528 HAYES ST	MERRIAM, KS 66203	23002	1
4942	17497.58	JP3500000	05112010 05044.00 0	0.4	0	P	WRIGHT, LEWIS H. SR	ETAL	HAYES	ST		5529	100	VU	22970	0	22970	5529 HAYES ST	66203	PO BOX 7194	KANSAS CITY, MO 64113	22999	1
4944	66295.79	JP3500000	05112010 05040.00 0	1.52	0	P	MERRIAM PROPERTIES		MERRIAM	DR		5538	511	CU	232040	150460	382500	5538 MERRIAM DR	66203	3516 W 97TH PL	LEAWOOD, KS 66206	22997	1
4959	29303.45	JP3500000	05112010 05045.00 0	0.67	0	P	WRIGHT, LEWIS H.	ETAL	HAYES	ST		5521	111	RU	25560	53440	79000	5521 HAYES ST	66203	PO BOX 7194	KANSAS CITY, MO 64113	22988	1
4961	22659.26	JP3500000	05112010 05046.00 0	0.52	0	P	COLLINS, HOMER M.	COLLINS, ROMA J.	MERRIAM	DR		5500	553	CU	79310	34480	113790	5500 MERRIAM DR, #A	66203	5500 MERRIAM DR	MERRIAM, KS 66203	22986	1
4991	94888.99	JD3400000	00000000 00000.00 0	2.18	0	D									0	0	0					22963	1
4993	144908.7	JF241212-(	05112010 04004.00 0	3.33	3.3	F	KINCAID, GRAYDON J. JR	KINCAID, PATRICIA A.	NS	NT		0	638	CU	217360	218080	435440	N/A	66203	2353 GUILFORD LN	MISSION HILLS, KS 66208	22962	1
5009	43790.74	JD3500000	00000000 00000.00 0	1.01	0	D									0	0	0					22950	1
5010	34115.42	JP3500000	05112010 05004.00 0	0.78	0	P	FROST, EUGENE R.	FROST, ALETHA B.	HAYES	ST		5517	111	RU	26620	67080	93700	5517 HAYES ST	66203	5517 HAYES ST	MERRIAM, KS 66203	22949	1
5012	34420.61	JP3500000	05112010 05002.00 0	0.79	0	P	COLLINS, HOMER M.	COLLINS, ROMA J.	55TH	ST	W	9209	111	RU	26690	51310	78000	9209 W 55TH ST	66203	5500 MERRIAM DR	MERRIAM, KS 66203	22947	1
5013	19289.24	JP3500000	05112010 05001.00 0	0.44	0	P	COLLINS, HOMER M.	COLLINS, ROMA J.	MERRIAM	DR		5500	553	CU	67510	34780	102290	5500 MERRIAM DR	66203	5500 MERRIAM DR	MERRIAM, KS 66203	22946	1
5014	1828.121	JP3500000	00000000 00000.00 0	0.04	0	P	CITY OF MERRIAM		NS	NT		0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	22945	1
5015	38515.94	JD3500000	00000000 00000.00 0	0.88	0	D									0	0	0					22944	1
5016	97298.43	JD241212-(	00000000 00000.00 0	2.23	0	D									0	0	0					22943	1
5019	140605.9	JP6900000	00000000 00000.00 0	3.23	0	P	MERRIAM TOWN CENTER LTD.		NS	NT		0	458	EM	0	0	0	N/A	66203	34555 CHAGRIN BLV	MORELAND HILLS, OH 44022	22942	1
5020	23576.57	JD6900000	00000000 00000.00 0	0.54	0	D									0	0	0					22941	1
5022	93255.57	JF241212-(	05112010 04002.00 0	2.14	0	F	LAIRD, WILLIAM W.		MERRIAM	DR		5513	552	CU	93720	59430	153150	5513 MERRIAM DR	66203	5501 MERRIAM DR	MERRIAM, KS 66203	22940	1
5024	104072.8	JF241212-(	05112010 04017.00 0	2.39	0	F	FRISCO RAILROAD		NS	NT		0	411	UR	0	0	0	N/A	66203	PO BOX 961089	FORT WORTH, TX 76161-0089	22939	1

5025	3397.821	00000000 00000.00 JD241212~ 0	0.08	0	D								0	0	0						22938	1
5026	16325.74	05101040 10002.00 JF241201~ 0	0.37	0	F	CITY OF MERRIAM	NS	NT	0	458	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM , KS 66202	14436	1
5039	1783041	05112010 17001.00 JP4950000 0	40.93	0	P	MERRIAM TOWN CENTER, LTD.	ANTIOCH	RD	5500	541	CU	9806730	26974870	36781600	5500 ANTIOCH RD	66202	3300 ENTERPRISE PKY	BEACHWOOD, OH 44122	22937	1
5050	50855.36	00000000 00000.00 JD241201~ 0	1.17	0	D								0	0	0				14426	1
5052	2308.373	05101040 13005.00 JP0300000 0	0.05	0	P	INTERSTATE SIGNS, INC.	NS	NT	0	500	VU	6920	0	6920	N/A	66202	ONE WEST ARMOUR BLVD	KANSAS CITY, MO 64111	14425	1
5067	25214.7	05101040 09011.01 JF241201~ 0	0.58	0.56	F	T & B, JR ACCESS	NS	NT	0	500	VU	50430	0	50430	N/A	66203	7730 HEDGE LANE TER	SHAWNEE , KS 66227	14417	1
5096	45079.57	05101040 11021.02 JF241201~ 0	1.03	1.02	F	CAPITAL CORPORATION	MERRIAM	DR	5439	512	CU	94670	421030	515700	5439 MERRIAM DR	66203	5439 MERRIAM DR	MERRIAM , KS 66203	14391	1
5108	81482.66	05101040 11021.00 JF241201~ 0	1.87	2.33	F	MYERS, R. RICHARD ETAL	NS	NT	0	399	CU	36130	2930	39060	N/A	66203	1053 SNOW LILLY CT	CASTLE ROCK, CO 80104	14388	1
5111	41074.1	05101040 13006.00 JP0300000 0	0.94	0	P	TWO J ENTERPRISES, L.L.C.	ANTIOCH	RD	5428	514	CU	123220	409980	533200	5428 ANTIOCH RD	66202	1200 12TH AVE SW	LEMARS, IA 51031	14387	1
5114	37267.36	05101040 09011.00 JF241201~ 0	0.86	1.6	F	T & B	MERRIAM	DR	5440	583	CU	111800	187160	298960	5440 MERRIAM DR	66203	7730 HEDGE LANE TER	SHAWNEE , KS 66227	14384	1
5116	15988.28	05101040 11021.01 JF241201~ 0	0.37	0.36	F	LEPISTO, JAMES E. LEPISTO, CHERYL N. A. E.	MERRIAM	DR	5435	513	CU	33570	92030	125600	5435 MERRIAM DR	66203	5435 MERRIAM DR	MERRIAM , KS 66203	14382	1
5164	23746.75	05101040 09012.00 JF241201~ 0	0.55	0	F	ROBISON, INC.	MERRIAM	DR	5400	511	CU	83110	176790	259900	5400 MERRIAM DR	66203	14890 S EVENING STAR RD	EUDORA, KS 66025	14357	1
5168	42272.03	05101040 13007.00 JP0300000 0	0.97	0	P	REED, WILLIAM B. SR TRUSTEE REED, WILLIAM B. SR TRUST	ANTIOCH	RD	5424	514	CU	105680	268320	374000	5424 ANTIOCH RD	66202	14735 W 50TH ST	SHAWNEE , KS 66216	14354	1
5178	14148.45	05101040 13008.00 JP0300000 0	0.32	0	P	HORST, GEORGE H. HORST, LOIS J.	ANTIOCH	RD	5422	274	CU	35370	157770	193140	5422 ANTIOCH RD	66202	5422 ANTIOCH RD	MERRIAM , KS 66202	14343	1
5207	33536.94	05101040 09013.00 JF241201~ 0	0.77	0	F	MERRIAM INDUSTRIAL PARK	MERRIAM	DR	5360	511	CU	117380	285420	402800	5360 MERRIAM DR	66203	PO BOX 28928	ST. LOUIS, MO 63132	14332	1
5212	33294.75	05101040 13009.00 JP0300000 0	0.76	0	P	DARLING, ALBERT DAVIS, JOHN F.	ANTIOCH	RD	5420	514	CU	83240	272960	356200	5420 ANTIOCH RD	66202	810 BALTIMORE AVE	KANSAS CITY, MO 64105-1706	14330	1
5227	4503.098	05101040 13010.00 JP0300000 0	0.1	0	P	5400 ANTIOCH, INC.	ANTIOCH	DR	5400	2621	CU	0	0	0	5400 ANTIOCH DR, #B	66203	5400 ANTIOCH DR	MERRIAM , KS 66202	14316	1
5230	84940.97	05101040 11020.00 JF241201~ 0	1.95	1.9	F	ENTERPRISE LEASING COMPANY OF KANSAS	NS	NT	0	532	CU	169880	265740	435620	N/A	66203	7815 FLOYD ST	OVERLAND PARK, KS 66204	14315	1
5233	197932.7	05101040 09010.00 JF241201~ 0	4.54	4.58	F	T & S CO.	NS	NT	0	500	VU	247420	0	247420	N/A	66203	9400 W 55TH ST	MERRIAM , KS 66203	14312	1

5250	41642.71	JF241201-	05101040 09014.00 0	0.96	0	F	MERRIAM INDUSTRIAL PARK L.L.C.	MERRIAM	DR		5338	511	CU	145750	450450	596200	5338 MERRIAM DR	66203	2600 GRAND BLV, #700	KANSAS CITY, MO 64108-4615	14300	1
5253	4031.153	JP0300000	05101040 13013.00 0	0.09	0	P	5400 ANTIOCH, INC.	ANTIOCH	DR		5400	2621	CU	0	0	0	5400 ANTIOCH DR, #C	66202	5400 ANTIOCH DR	MERRIAM, KS 66202	14297	1
5256	56885.3	JP0300000	05101040 13011.00 0	1.31	0	P	5400 ANTIOCH, INC.	ANTIOCH	DR		5400	262	CU	220460	959340	1179800	5400 ANTIOCH DR, #A	66202	5400 ANTIOCH DR	MERRIAM, KS 66202	14296	1
5259	79783.05	JD0300000	00000000 00000.00 0	1.83	0	D								0	0	0					14291	1
5274	1738.963	JF241201-	05101040 13014.00 0	0.04	0	F	STATE OF KANSAS	NS	NT		0	458	EK	0	0	0	N/A	66202	STATE HOUSE	TOPEKA, KS 66612	14284	1
5293	329122.8	JF241201-	05101040 13004.00 0	7.56	7.29	F	STATE OF KANSAS	NS	NT		0	458	EK	0	0	0	N/A	66203	STATE HOUSE	TOPEKA, KS 66612	14271	1
5295	26609.17	JF241201-	05101040 13004.01 0	0.61	0.74	F	STATE OF KANSAS	NS	NT		0	458	EK	0	0	0	N/A	66202	STATE HOUSE	TOPEKA, KS 66612	14270	1
5324	20343.21	JF241201-	05101040 11019.00 0	0.47	0	F	ENTERPRISE LEASING COMPANY OF KANSAS	NS	NT		0	5321	CU	0	0	0	N/A	66203	7815 FLOYD ST	OVERLAND PARK, KS 66204	14258	1
5339	13274.9	NP5360000	06306030 04046.00 0	0.3	0	P	ANTIOCH FAMILY WORSHIP CENTER	53RD	ST	W	8520	112	RU	21390	64410	85800	8520 W 53RD ST	66202	5055 ANTIOCH RD	OVERLAND PARK, KS 66202	55301	1
5361	2249.281	NR0130000	00000000 00000.00 0	0.05	0	R								0	0	0					55286	1
5362	97552.67	JF241201-	05101040 09001.00 0	2.24	3.8	F	MERRIAM INDUSTRIAL PARK L.L.C.	MERRIAM	DR		5300	511	CU	117060	945840	1062900	5300 MERRIAM DR	66203	2600 GRAND BLV, #700	KANSAS CITY, MO 64108-4615	14231	1
5369	26323.35	JD241201-	00000000 00000.00 0	0.6	0	D								0	0	0					14222	1
5370	102988.4	JD241201-	00000000 00000.00 0	2.36	0	D								0	0	0					14221	1
5371	2475.81	JF241201-	00000000 00000.00 0	0.06	0	F	STATE HIGHWAY DEPARTMENT	NS	NT		0	458	EK	0	0	0	N/A	66203	STATE HOUSE	TOPEKA, KS 66612	14220	1
5372	150604.4	JC241201-	00000000 00000.00 0	3.46	0	C								0	0	0					14218	1
5374	6248.418	JP7300000	05101040 08020.00 0	0.14	0	P	UNITED KANSAS BANK & TRUST	NS	NT		0	458P	VU	0	0	0	N/A	66203	PO BOX 419147	KANSAS CITY, MO 64141-6147	14216	1
5380	206566.1	JF241201-	05101040 13003.00 0	4.74	4.7	F	STATE OF KANSAS	NS	NT		0	458	EK	0	0	0	N/A	66203	STATE HOUSE	TOPEKA, KS 66612	14215	1
5381	478883.9	JF241201-	05101040 11018.00 0	10.99	9.4	F	ENTERPRISE LEASING COMPANY OF KANSAS	MERRIAM	DR		5305	532	CU	390740	348970	739710	5305 MERRIAM DR	66203	7815 FLOYD ST	OVERLAND PARK, KS 66204	14213	1

5362	14343.71	JD241201-	00000000 00000.00 0	0.33	0	D									0	0	0						14212	1
5387	27811.08	NF251206-	00000000 00000.00 0	0.64	0	F	STATE OF KANSAS		NS	NT		0	458	EK	0	0	0	N/A	66202	STATE HOUSE	TOPEKA, KS 66612	55271	1
5432	13872.27	JP7300000	05101040 08021.00 0	0.32	0	P	TYLER, WILLIAM E.	TYLER, LAURA I.	MERRIAM	DR		5240	584	CU	20060	181230	201290	5240 MERRIAM DR	66203	PO BOX 519	PLEASANT ON, KS 66075	14165	2
5433	5230.798	JP7300000	05101040 08021.00 0	0.12	0	P	TYLER, WILLIAM E. ENTERPRISE	TYLER, LAURA I.	MERRIAM	DR		5240	584	CU	20060	181230	201290	5240 MERRIAM DR	66203	PO BOX 519	PLEASANT ON, KS 66075	14164	2
5441	34108.64	JP7300000	05101040 11017.00 0	0.78	0	P	LEASING COMPANY OF ENTERPRISE	KANSAS	MERRIAM	DR		5263	5321	CU	0	0	0	5263 MERRIAM DR	66203	7815 FLOYD ST	OVERLAND PARK, KS 66204	14155	2
5444	32120.61	JP7300000	05101040 11017.00 0	0.74	0	P	LEASING COMPANY OF ENTERPRISE	KANSAS	MERRIAM	DR		5263	5321	CU	0	0	0	5263 MERRIAM DR	66203	7815 FLOYD ST	OVERLAND PARK, KS 66204	14152	2
5453	16503.13	JP7300000	05101040 11016.02 0	0.38	0	P	LEASING COMPANY OF	KANSAS	NS	NT		0	5321	CU	0	0	0	N/A	66203	7815 FLOYD ST	OVERLAND PARK, KS 66204	14145	1
5475	3673.839	JF241201-	05101040 08022.00 0	0.08	0	F	FOUR D'S INVESTMENTS L.L.C.		MERRIAM	DR		5238	511	CU	30560	129840	160400	5238 MERRIAM DR	66203	8600 W 63RD ST, #301	MERRIAM, KS 66202	14136	2
5478	19137.37	JP7300000	05101040 11016.01 0	0.44	0	P	LEASING COMPANY OF	KANSAS	NS	NT		0	5321	CU	0	0	0	N/A	66203	7815 FLOYD ST	OVERLAND PARK, KS 66204	14134	1
5483	22866.8	NF251206-	00000000 00000.00 0	0.52	0	F	STATE OF KANSAS		NS	NT		0	458	EK	0	0	0	N/A	66203	STATE HOUSE	TOPEKA, KS 66612	55223	1
5485	47259.96	JF241201-	05101040 08022.00 0	1.08	0	F	FOUR D'S INVESTMENTS L.L.C.		MERRIAM	DR		5238	511	CU	30560	129840	160400	5238 MERRIAM DR	66203	8600 W 63RD ST, #301	MERRIAM, KS 66202	14130	2
5486	3489.176	JF241201-	05101040 08023.00 0	0.08	0	F	PERRY, FRANK S.	PERRY, CHERYL J.	NS	NT		0	460	CU	8130	3050	11180	N/A	66203	2800 W 118TH ST	LEAWOOD, KS 66211	14128	2
5487	3281.405	JF241201-	05101040 08023.00 0	0.08	0	F	PERRY, FRANK S.	PERRY, CHERYL J.	NS	NT		0	460	CU	8130	3050	11180	N/A	66203	2800 W 118TH ST	LEAWOOD, KS 66211	14129	2
5488	28925.63	JP7300000	05101040 11014.00 0	0.66	0	P	DEFEO, DAVID L.	DEFEO, SAUNDRA G.	NS	NT		0	6361	CU	0	0	0	N/A	66203	5245 MERRIAM DR	MERRIAM, KS 66203	14127	1
5489	102804.5	JP7300000	05101040 13002.00 0	2.36	0	P	STATE OF KANSAS		NS	NT		0	458	EK	0	0	0	N/A	66203	STATE HOUSE	TOPEKA, KS 66612	14126	1
5504	33846.99	JP7300000	05101040 11016.00 0	0.78	0	P	DEFEO, DAVID L.		MERRIAM	DR		5245	636	CU	43830	66430	110260	5245 MERRIAM DR	66203	5245 MERRIAM DR	MERRIAM, KS 66203	14112	1
5506	30095.62	JF241201-	05101040 11011.00 0	0.69	0	F	CITY OF MERRIAM		52ND	ST	W	8812	699	EM	22570	3440	26010	8812 W 52ND ST	66203	9000 W 62ND TER	MERRIAM, KS 66202	14099	1
5526	28924.62	JP7300000	05101040 11015.00 0	0.66	0	P	DEFEO, DAVID L.	DEFEO, SAUNDRA G.	NS	NT		0	500	VU	21690	0	21690	N/A	66203	5245 MERRIAM DR	MERRIAM, KS 66203	14083	1

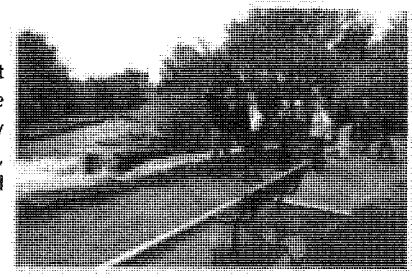
5541	525867.2	NP013000	06306030 04010.00 0	12.07	0	P	ANTIOCH FAMILY WORSHIP CENTER,	INC.	ANTIOCH	RD		5201	670	ER	1051730	2268400	3320130	5201 ANTIOCH RD	66202	5055 ANTIOCH RD	OVERLAND PARK, KS 66202	55194	1
5554	20816.77	NP189400	06306030 11001.00 0	0.48	0	P	LOWE, JAMES B.	ETAL	HADLEY	ST		5229	119	RU	224000	1235000	1459000	5229 HADLEY ST	66202	922 WALNUT	KANSAS CITY, MO 64106	55183	15
5564	52319.35	JF241201	05101040 11013.00 0	1.2	1.2	F	CITY OF MERRIAM		MERRIAM	DR		5201	460	EM	39240	9410	48650	5201 MERRIAM DR	66203	9000 W 62ND TER	MERRIAM, KS 66202	14034	1
5568	38071.19	JF241201	05101040 11010.00 0	0.87	0	F	CITY OF MERRIAM		52ND	ST	W	8810	460	EM	28550	41240	69790	8810 W 52ND ST	66203	9000 W 62ND TER	MERRIAM, KS 66202	14030	1
5569	13758.86	JF241201	05101040 11012.00 0	0.32	0	F	CITY OF MERRIAM		NS	NT		0	458P	VU	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	14029	1
5570	2074.148	JF241201	05101040 11009.01 0	0.05	0.23	F	CITY OF MERRIAM		NS	NT		0	458P	EM	0	0	0	N/A	66203	9000 W 62ND TER	MERRIAM, KS 66202	14028	1
5598	60474.95	JF241201	05101040 08026.00 0	1.39	0	F	VOELK, GERALD E.	VOELK, JOHN W.	NS	NT		0	552	CU	25730	83980	109710	N/A	66203	5234 MERRIAM DR	MERRIAM, KS 66203	13977	2
5621	55525.58	JF241201	05101040 11009.00 0	1.27	1.3	F	CITY OF MERRIAM		MERRIAM	DR		5191	699	EM	41640	114430	156070	5191 MERRIAM DR	66203	9000 W 62ND TER	MERRIAM, KS 66202	13963	1
5625	14625.7	JF241201	05101040 08030.00 0	0.34	0	F	BAMFORD FIRE SPRINKLER	COMPANY, INC.	MERRIAM	DR		5144	511	CU	16950	50650	67600	5144 MERRIAM DR	66203	5134 MERRIAM DR	MERRIAM, KS 66203	13958	1
5646	94776.08	JP7300000	05101040 13001.00 0	2.18	0	P	STATE OF KANSAS		NS	NT		0	458	EK	0	0	0	N/A	66203	STATE HOUSE	TOPEKA, KS 66612	13939	1
5655	12181.11	JP7300001	05101040 08033.00 0	0.28	0	P	BAMFORD FIRE SPRINKLER	COMPANY, INC.	MERRIAM	DR		5134	511	CU	14080	223820	237900	5134 MERRIAM DR	66203	5134 MERRIAM DR	MERRIAM, KS 66203	13929	1
5658	24600.44	JD7300000	00000000 00000.00 0	0.56	0	D									0	0	0					13928	1
5712	11249.5	JF241201	05101040 11001.00 0	0.26	0	F	CARLSON, BRANDON	CARLSON, JANELLE	BENSON	ST		5132	111	RU	18900	38200	57100	5132 BENSON ST	66203	5132 BENSON ST	MERRIAM, KS 66203	13886	1
5713	152349.4	JF241201	05101040 11008.00 0	3.5	3.5	F	METROPOLITAN MERRIAM, L.L.C.		MERRIAM	DR		5127	514	CU	159970	1475030	1635000	5127 MERRIAM DR	66203	2600 GRAND AVE, #700	KANSAS CITY, MO 64108-4600	13883	1
5715	3124.94	JF241201	05101040 11002.00 0	0.07	0	F	DUVALL, THOMAS D.	DUVALL, DONNA G.	BENSON	ST		5130	552	CU	9380	48600	57980	5130 BENSON ST	66203	12412 W 68TH TER	SHAWNEE, KS 66216	13877	2
5746	64206.35	JF241201	05101040 11007.00 0	1.47	1.4	F	ROBERTS, LONNIE D.	ROBERTS, SALLY I.	MERRIAM	DR		5125	111	RU	28130	58070	86200	5125 MERRIAM DR	66203	5816 MERRIAM DR	MERRIAM, KS 66203	13845	1
5779	24595.97	JD7550000	00000000 00000.00 0	0.56	0	D									0	0	0					13809	1
5880	50514.6	NC251206	00000000 00000.00 0	1.16	0	C									0	0	0					55081	1
5893	100398.4	NF251206	00000000 00000.00 0	2.3	13.1	F	STATE OF KANSAS		NS	NT		0	458	EK	0	0	0	N/A	66203	STATE HOUSE	TOPEKA, KS 66612	55077	2

5896	721163.1	NF251206-	00000000 00000.00 0 00000000 00000.00	16.56	8	F	STATE HIGHWAY COMMISS ION OF	KANSAS	NS	NT	0	458	EK	0	0	0	N/A	66202	STATE HOUSE	TOPEKA, KS 66612	55076	2
6518	2083898	JD730000C	0	47.84	0	D								0	0	0					12921	1

October 2011 Public Meeting Postcard Mailing

You are invited to attend the Upper Turkey Creek Public Workshop to discuss the potential solutions for flood hazards along Turkey Creek in Johnson County and Wyandotte County, Kansas.

Please come and share information about flood concerns that should be part of the US Army Corps of Engineers' planning study with a focus on the Merriam Reach, between Shawnee Mission Parkway and Antioch Avenue.



Please visit our website to preview the study:
www.nwk.usace.army.mil/projects/utc/

This meeting gives *you* an opportunity to

- Discuss integrating environment enhancements, flooding, and socio-economic opportunities, including biking and walking trails.
- Give feedback on possible measures for addressing flooding.

Upper Turkey Creek Basin Public Workshop

Wednesday, October 19, 2011
5:00—8:00 p.m.

US Army Corps of Engineers
Kansas City District

MERRIAM

Upper Creek Basin Public Workshop

Wednesday, October 19, 2011 5:00—8:00 p.m.

Irene B. French Community Center,
5701 Merriam Drive, Merriam, Kansas, 66203
Questions? Call: (816) 398-8658

October 2011 Public Meeting Sign-In Sheet

US Army Corps of Engineers.

MERRIAM just right

Upper Turkey Creek Feasibility Study
Wednesday, October 19, 2011, 5:00 – 8:00 p.m.
5701 Merriam Drive, Merriam, Kansas 66203

Sign-in Sheet

	Name	Organization/Affiliation	Email	Phone
1.	Joseph C. Roth	DRG Engineers	jroth@drgengineers.com	913.441.1100
2.	David Johnson		davekcmo@gmail.com	816.305.5817
3.	Al Frisby	City of Merriam (Council)	afrisbyii@kc.rr.com	
4.	Rochelle Schleicter	Home owner	Rochellsch@msn.com	913.677.3589
5.	Chad Rowe	Merriam City Council	chard@merriam.org	913.484.2446
6.	Vera Locke	Creekside Resident	Vera0112@att.net	913.722.1821
7.	Gerald Becker	Merriam Drainage District	GBECKER5@kc.rr.com	816.590.2472
8.	Charles McAllister	Johnson Co. Stormwater		
9.	Dave Smothers	City of Merriam	daves@merriam.org	913.322.5550
10.	Susan Hayden	City of Merriam	shayden@merriam.org	913.322.5550
11.	Larry Shepard	U.S. EPA KC	Shepard.larry@epa.gov	913.551.7441
12.	Larry O'Donnell	LBRWC (Little Blue River Watershed Coalition)	Turttle5@aol.com	816.356.4040
13.	Cris Siebenlist	KC Bike Club	cpigsfly@mindspring.com	913.362.6361
14.	Tom Poer	HNTB	tpoer@hntb.com	816.527.2357
15.	David Williams	ESI Contracting	dwilliams@esicontractingcorp.com	816.523.5081
16.	Chris Evans Hands	Merriam Council	Chrish@merriam.org	913.384.5340
17.	Kent Lage	JoCo Public Works and Infrastructure	Kent.Lage@jocogov.org	

NOTE: Jim Wymer of the Merriam and Monticello Drainage District was in attendance but did not sign in. Upper Turkey Creek Feasibility Study

October 2011 Public Meeting Agenda

Upper Turkey Creek Feasibility Study

Wednesday, October 19, 2011, 5:00 PM – 8:00 PM
5701 Merriam Drive, Merriam, Kansas 66203

US Army Corps of Engineers. MERRIAM

AGENDA:

5:00 p.m.	START
5:10 p.m.	Project Overview Presentation
5:25 p.m.	Open House
6:15 p.m.	OPTIONAL round table discussion in Hocker Grove Room
6:30 p.m.	Project Overview Presentation
6:45 p.m.	Open House
7:30 p.m.	OPTIONAL round table discussion in Hocker Grove room
8:00 p.m.	Workshop concludes

Stations:

Station 1: Background and History

Station 2: PowerPoint Presentation

Station 3: Three Alternative Concepts (overview)

Station 4: Conceptual Alternative 1: Channelization

Station 5: Conceptual Alternative 2: Levees and Floodwalls

Station 6: Conceptual Alternative 3: Combination

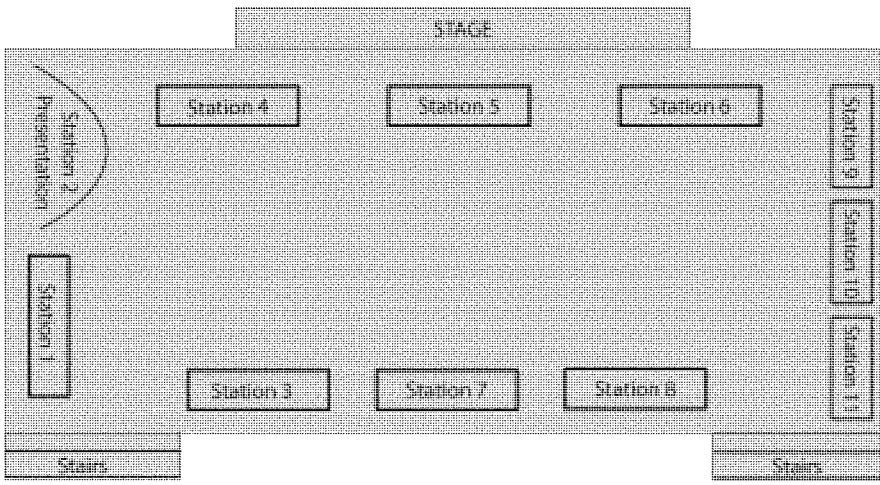
Station 7: Nonstructural Conceptual Alternative: Floodplain Buyout

Station 8: Real Estate Information Table

Station 9: Ecosystem Restoration Opportunities

Station 10: Floodplain Management Plan

Station 11: Exit



October 2011 Public Meeting Presentation

Gallery session for the residents and businesses

Solutions for Flood Hazards on Upper Turkey Creek

Brian T. Rast, PE, CFM, PMP

Project Manager

Kansas City District

October 19, 2011

US Army Corps of Engineers

BUILDING STRONG®

MERRIAM

just right

Briefing Outline

- *Introduction and Background*
- *Understanding Flood Risks*
- *Conceptual Alternatives*
- *Other Planning Considerations*
- *Next Steps*
- *Questions / Discussion*

Introduction and Background

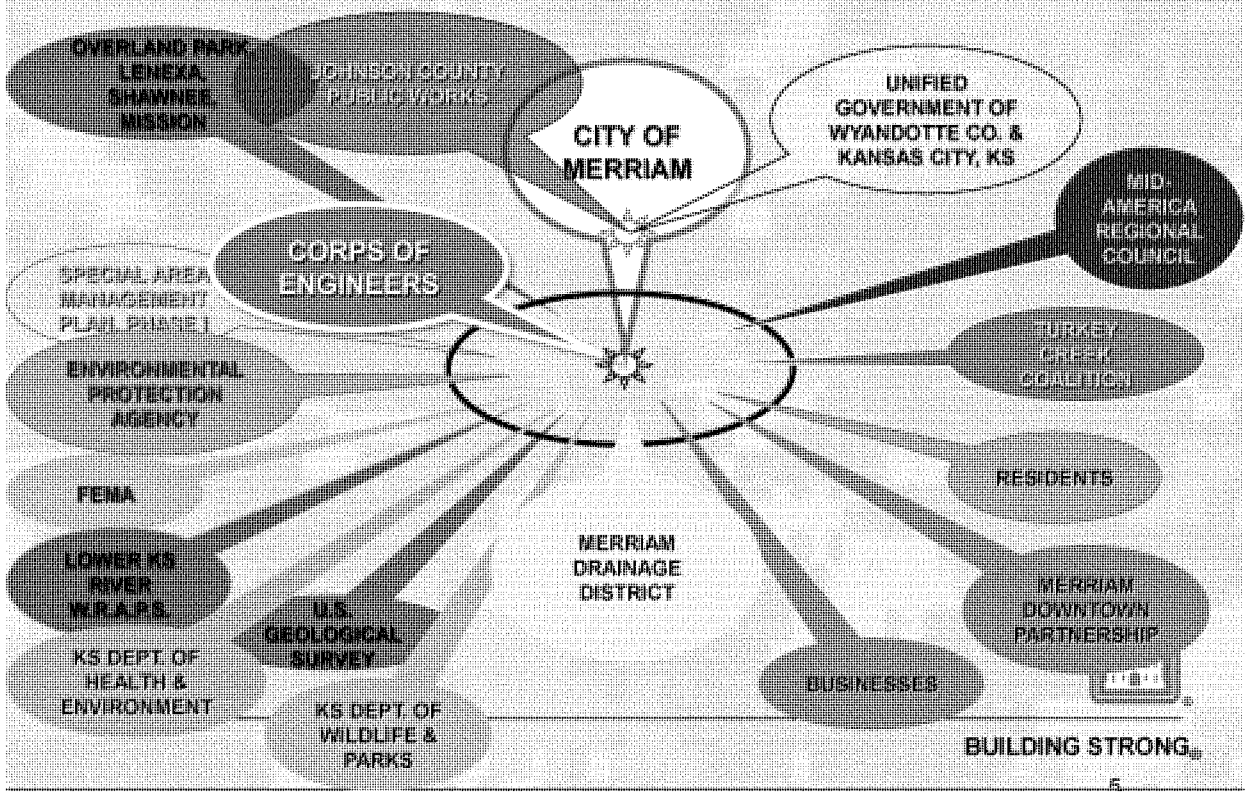
Upper Turkey Creek
Feasibility Study

BUILDING STRONG®

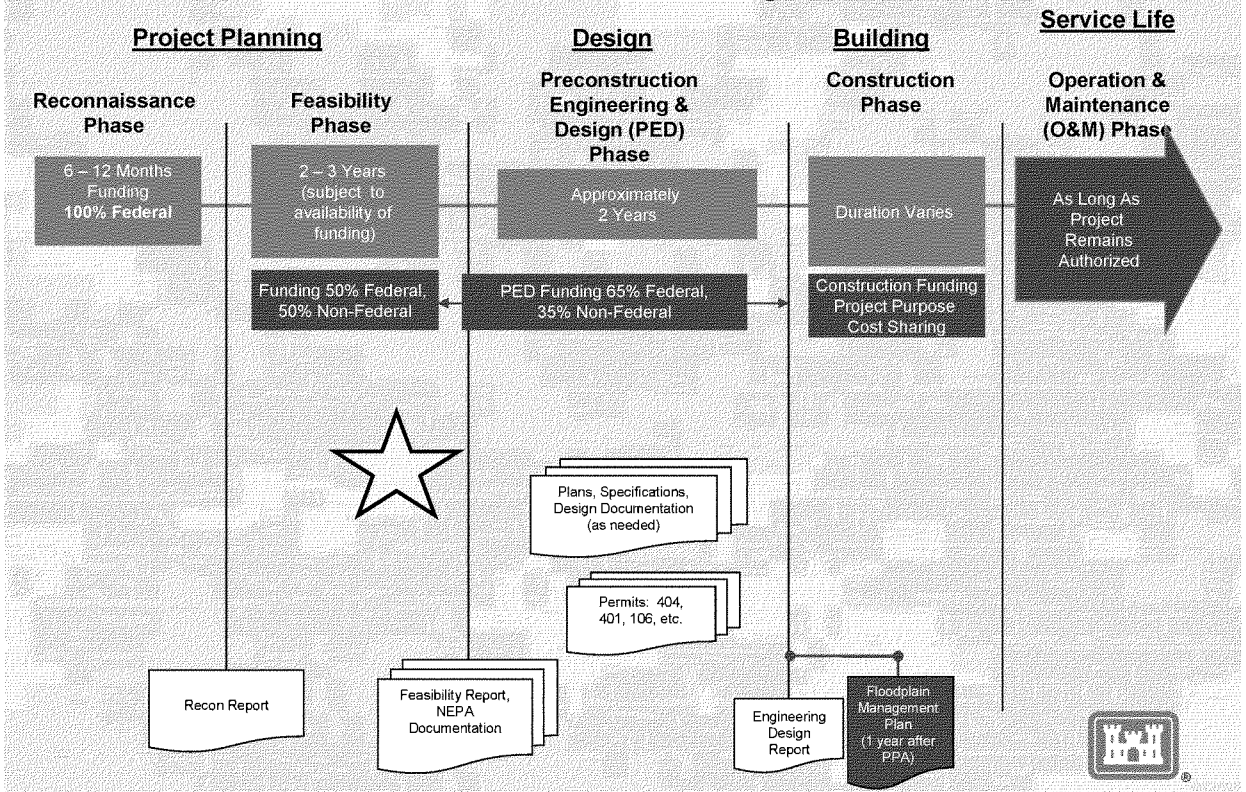
What is the purpose?

- Feasibility Phase
- Feasibility Report
- Federal interest in construction
  - Feasible?
  - or not?

Upper Turkey Creek Stakeholders & Partnerships

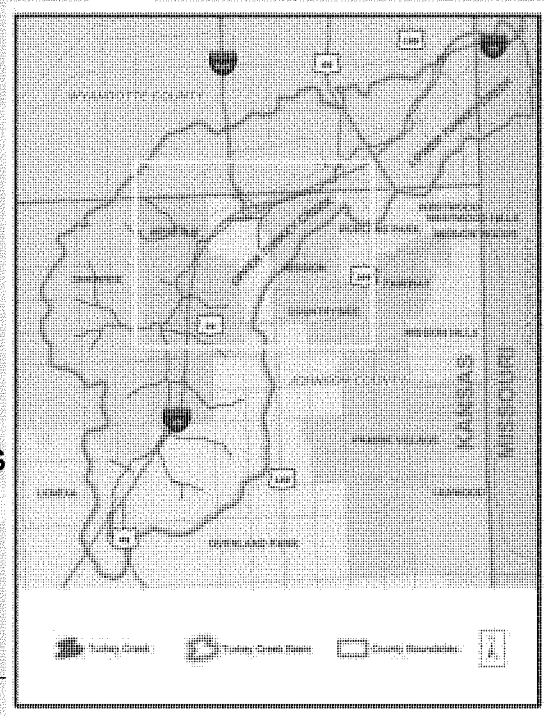


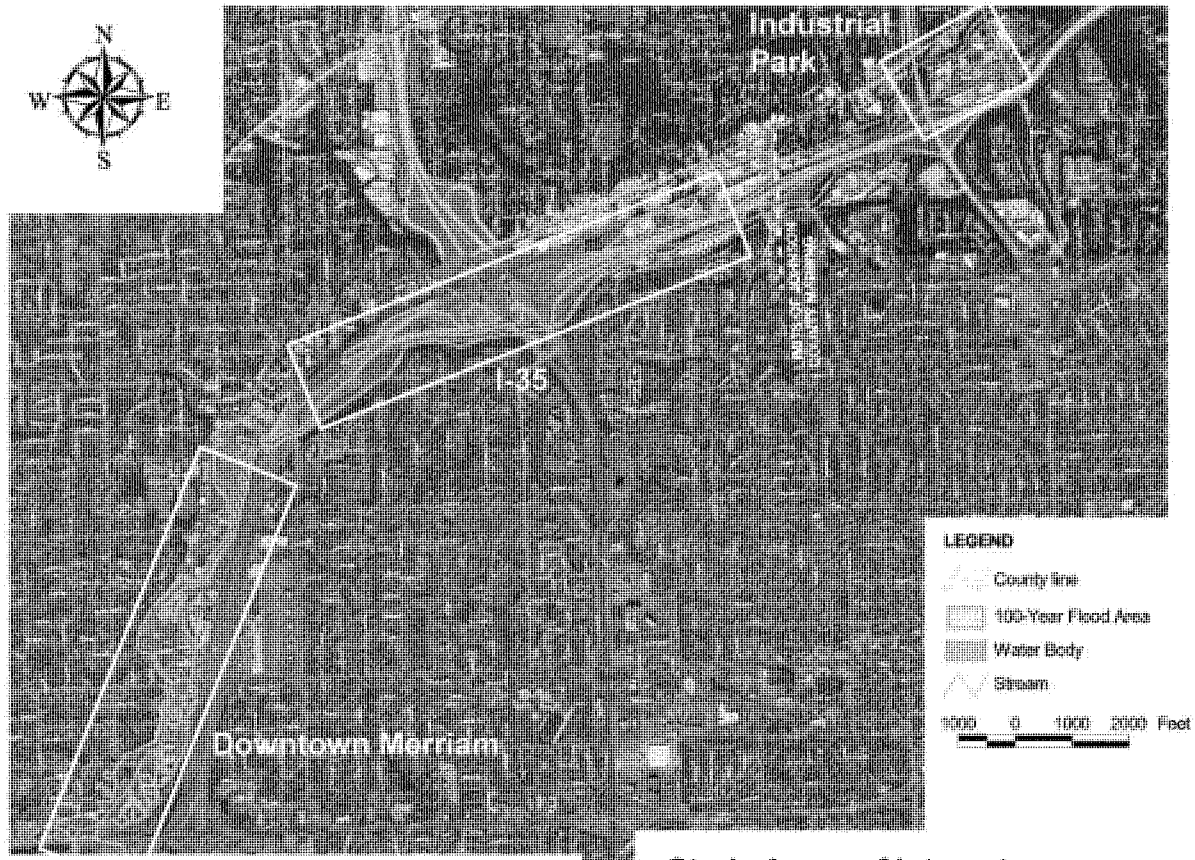
Corps' Civil Works Project Phases



Purpose and Scope

- Congressional authority for **flood risk management**
- The Corps is using a systems approach
  - Floodplain management plan
  - Watershed-level collaborative planning,
  - Multipurpose considerations (environmental degradation and recreation)

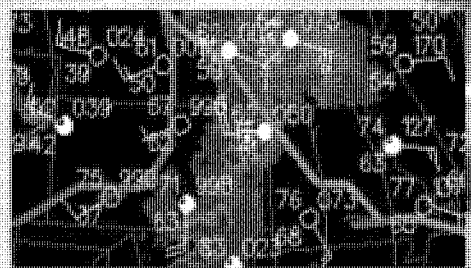




Study Areas of Interest

History

- Flooding in and around Johnson County led to presidential disaster declarations in **1993 and 1998**. The estimated cost of these disasters exceeded **$50 million dollars**.
- Heavy rains in 1998 produced flooding that caused several million dollars in damage to businesses and overtopped Interstate-35 in several locations.
- The storm of October 1998 **exceeded the 100-year return frequency for both the 24-hour and 60-minute** rainfall amounts.



Timeline for Turkey Creek

1967 - Merriam Drainage District modifies channel

1972 - MDD completes channel

1980s - MDD completes stream bank armoring between Shawnee Mission Parkway and Antioch Road

1988 - Kansas Department of Transportation completes Antioch Rd. bridge

1993 - Flood event, 1 fatality, $3.4 million in flood damages in Merriam

1998 - Monday night football flood event, $12 million in flood damages in Merriam

1998 - Corps completes planning work for current construction project downstream of the Drive-In Theater

Timeline for Turkey Creek

2001 -Reconnaissance study completed for Upper Turkey

2002 - Feasibility study begins for Upper Turkey

2002 - First public meeting for Upper Turkey

2005 - KDOT begins constructing channel-widening between Mission Road and Rainbow Boulevard on Lower Turkey

2009 - Flood insurance rate maps updated in Johnson County, Kansas

2009 - Corps completes repairs to 1,300-ft., 28-ft. diameter tunnel between Interstate-35 and Kansas River

2009 - MARC Turkey Creek Coalition cities and counties to sign resolution supporting bicycle / pedestrian trail

Understanding Flood Risks

Upper Turkey Creek
Feasibility Study

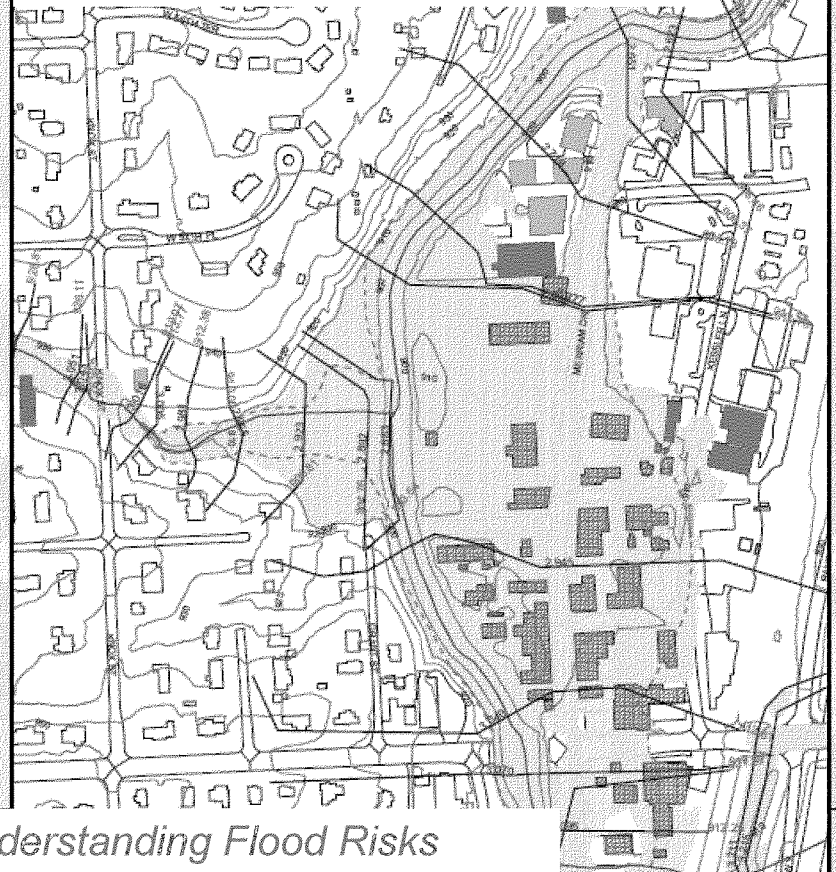
BUILDING STRONG®

Understand Your Flood Risks

Flood hazards that need to be discussed

- **Depth** and maps of extents of floodwaters
- **Velocity**
- Proximity of the population at risk
- **Warning time**
- **Rate of rise**

Upper Turkey Creek FIRM (2009 draft)



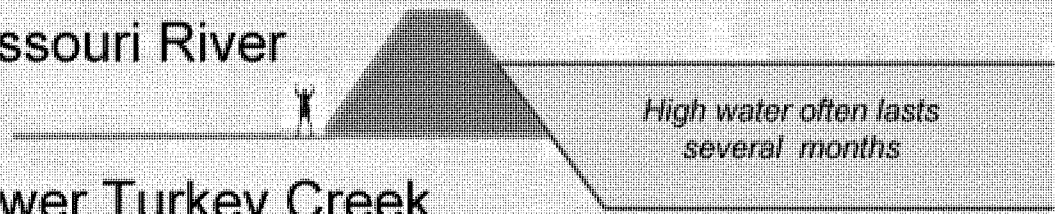
Understanding Flood Risks

BUILDING STRONG®

Relative Comparison of Features to Similar Flood Risk Management Projects

Cross Section Views

- Missouri River



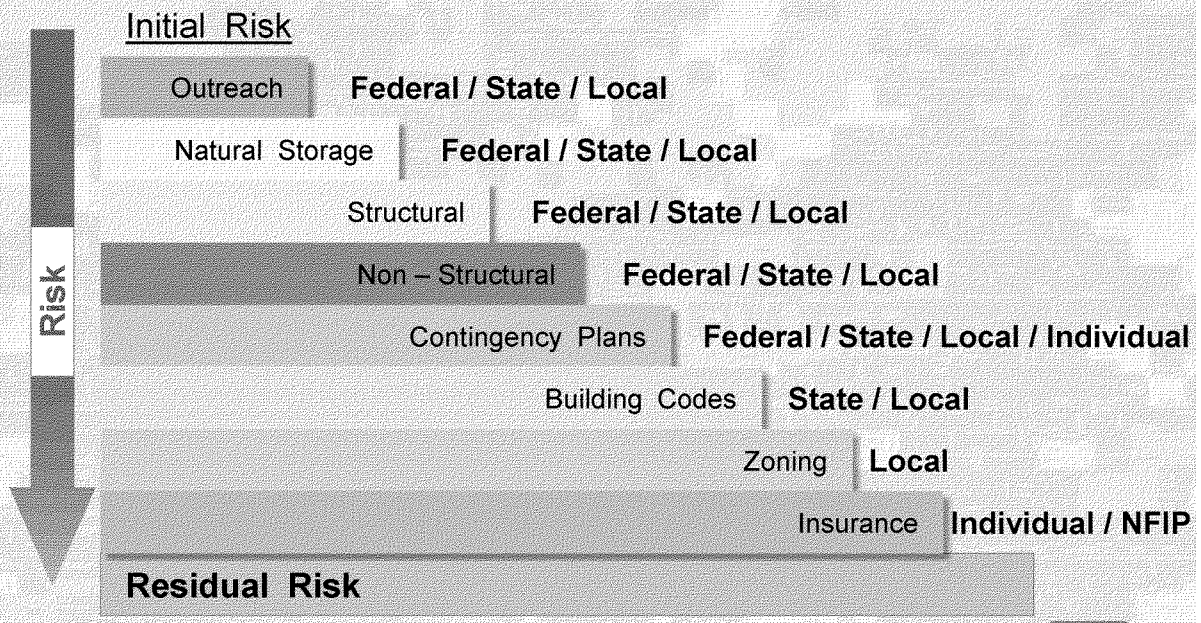
- Lower Turkey Creek

- Indian Creek

- Merriam or Roe Lane Reach

Shared Flood Risk Management

Measures for Driving Down Flood Risks



All Stakeholders contribute to reducing risk!

BUILDING STRONG®

Conceptual Alternatives

Upper Turkey Creek
Feasibility Study

Features for Conceptual Solutions

What features can we use to reduce damages?

STRUCTURAL

- Dams
- Reservoirs
- Floodwalls
- Levees
- Channels
- Straightening

- Clearing and snagging
- Closure structures
- Bridge modifications
- Conveyance modifications
- Pumping
- Land treatment
- Channel diversions

Features and Activities for Conceptual Solutions

What measures can we use to reduce damages?

NON-STRUCTURAL

- Sanitary and well codes
- Evacuation
- Floodproofing
  - Raising
  - Window and door seals
- Information and education
- Emergency preparedness
- Flood warning and preparedness
- Development codes/regulations

A drive by of a [illegible] home in Tehama, CA.

- Tax adjustments
- Animal refuge area
- Relocation (Corps provides assistance)
- Public Acquisition

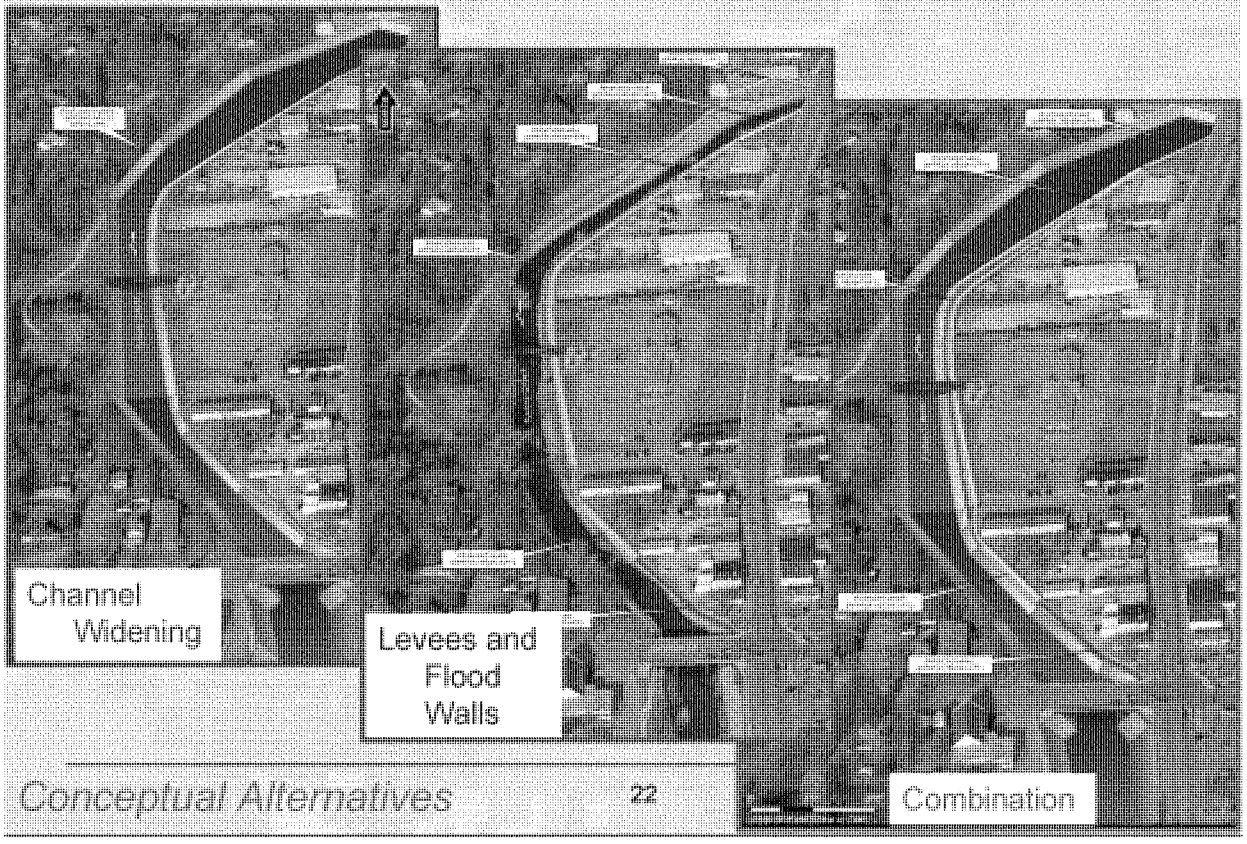
Conceptual Alternatives Evaluated With Bridges and Without

BUILDING STRONG®

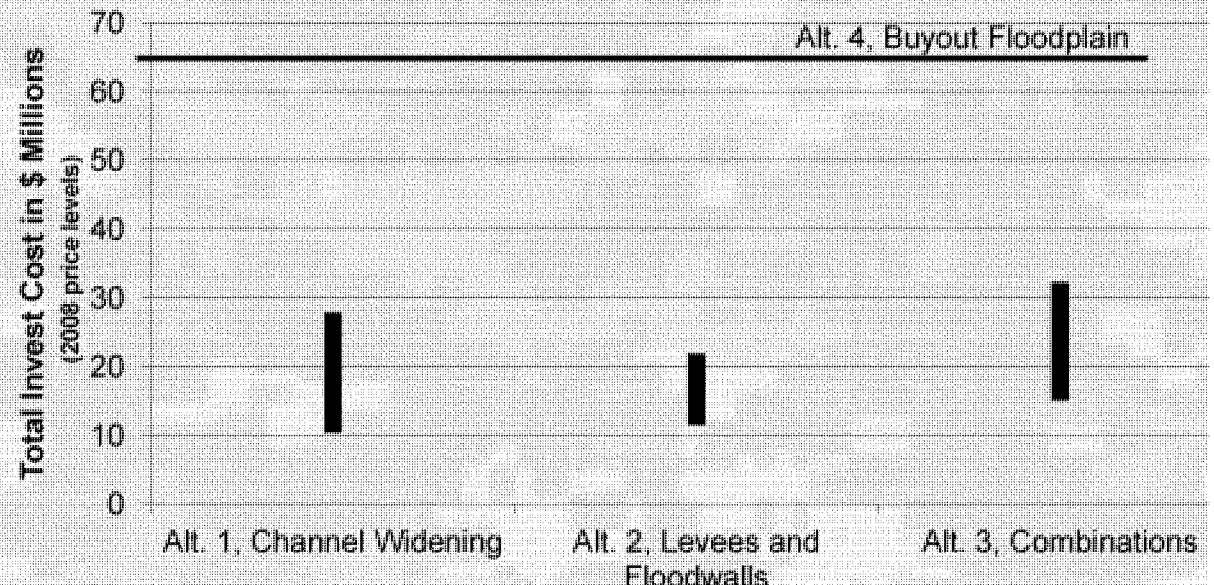
Conceptual Plan Formulation for Flood Risk Management

- Alternative 1: Channel Widening
- Alternative 2: Levees and Flood Walls
- Alternative 3: Combination of Channel Widening with Levees and Floodwalls
- Alternative 4: Floodplain Buyout

Alternative Themes for Screening



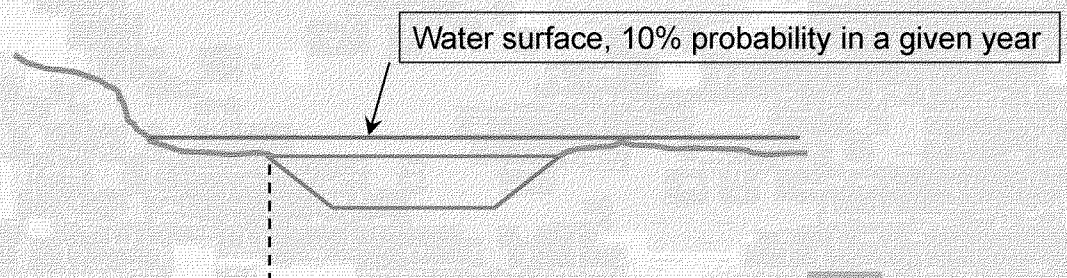
Comparison of Rough Cost Estimates for the Conceptual Alternatives



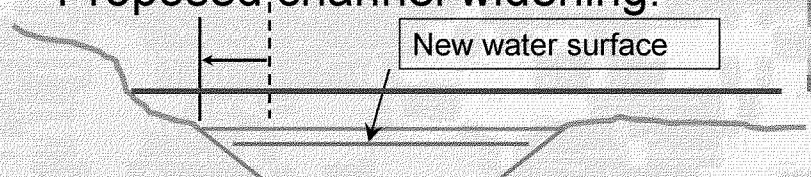
Residual Risk Example

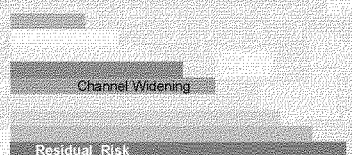
Cross Sectional View Near Farmer's Market

- Current channel capacity:



- Proposed channel widening:





Other Planning Considerations

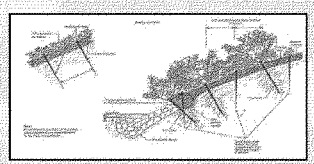
Upper Turkey Creek Feasibility Study

BUILDING STRONG®

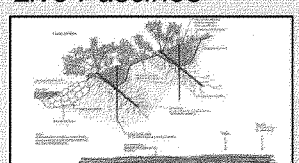
Multi-Objective Enhancements: Environmental and Recreational

- **Hike/Bike Trail by Mid-America Regional Council**
- **Bank Stabilization Measures**
- **Fish Habitat Improvement**
- **Riffle-Pool Complexes**
- **Development of Riparian Habitat**
- **Water Quality Improvement**

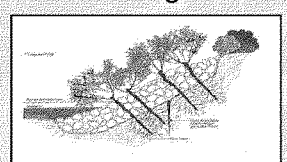
Brush Mattresses

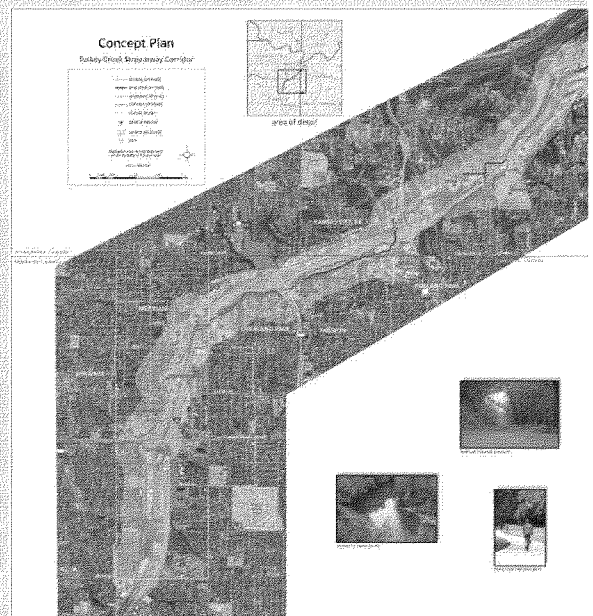


Live Fascines



Riprap with Joint Plantings



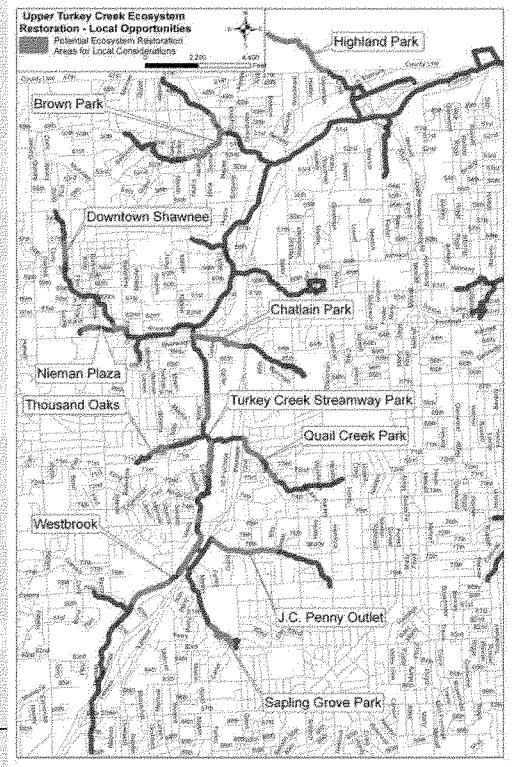


Other Planning Considerations

BUILDING STRONG®

Opportunities For Local Implementation

- 106 reaches on the Upper Turkey Creek
- 33 stream reaches analyzed
- 11 opportunity areas identified
- Site Vicinities
  - Highland Park
  - Brown Park
  - Downtown Shawnee
  - Nieman Plaza
  - Chatlain Park
  - Turkey Creek Streamway Park
  - Thousand Oaks
  - Quail Creek
  - Westbrook
  - JC Penney Outlet
  - Sapling Grove Park



Other Planning Considerations

Next Steps

Upper Turkey Creek
Feasibility Study

BUILDING STRONG®

Next Steps

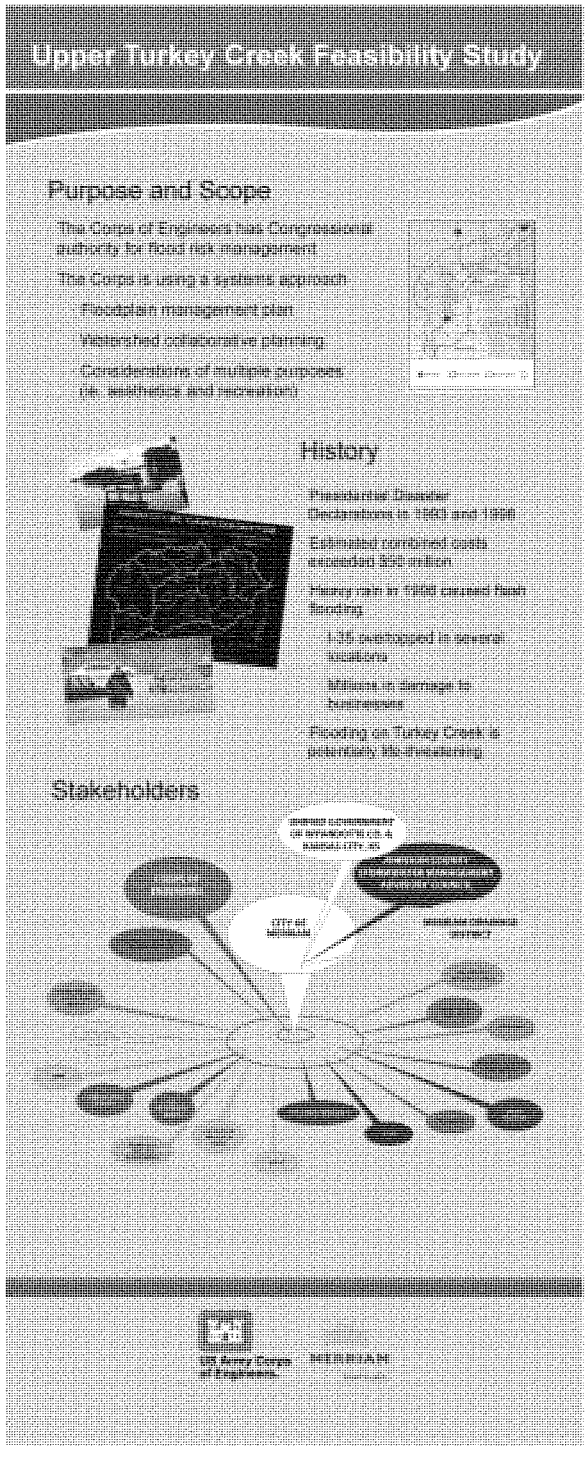
- Planners begin a Floodplain Management Plan
- Follow up public meeting in early 2012
- Begin real estate planning work in spring 2012
- Draft Feasibility Report, 2012
- Federal decision point: Chief of Engineer's Report, 2013
- Design Phase 2014 to 2015
- Construction in 2016

Your Questions

For More Information

www.nwk.usace.army.mil/projects/utc

October 2011 Public Meeting Banners


Upper Turkey Creek Feasibility Study
Purpose and Scope
The Corps of Engineers has Congressional authority for flood risk management
The Corps is using a systems approach
Floodplain management plan
Watershed collaborative planning
Considerations of multiple purposes (ie. aesthetics and recreation)
History
Presidential Disaster Declarations in 1993 and 1998
Estimated combined costs exceeded $50 million
Heavy rain in 1998 caused flash flooding
I-35 overtopped in several locations
Millions in damage to businesses
Flooding on Turkey Creek is potentially life-threatening
Stakeholders
US Army Corps of Engineers
MERRIAM

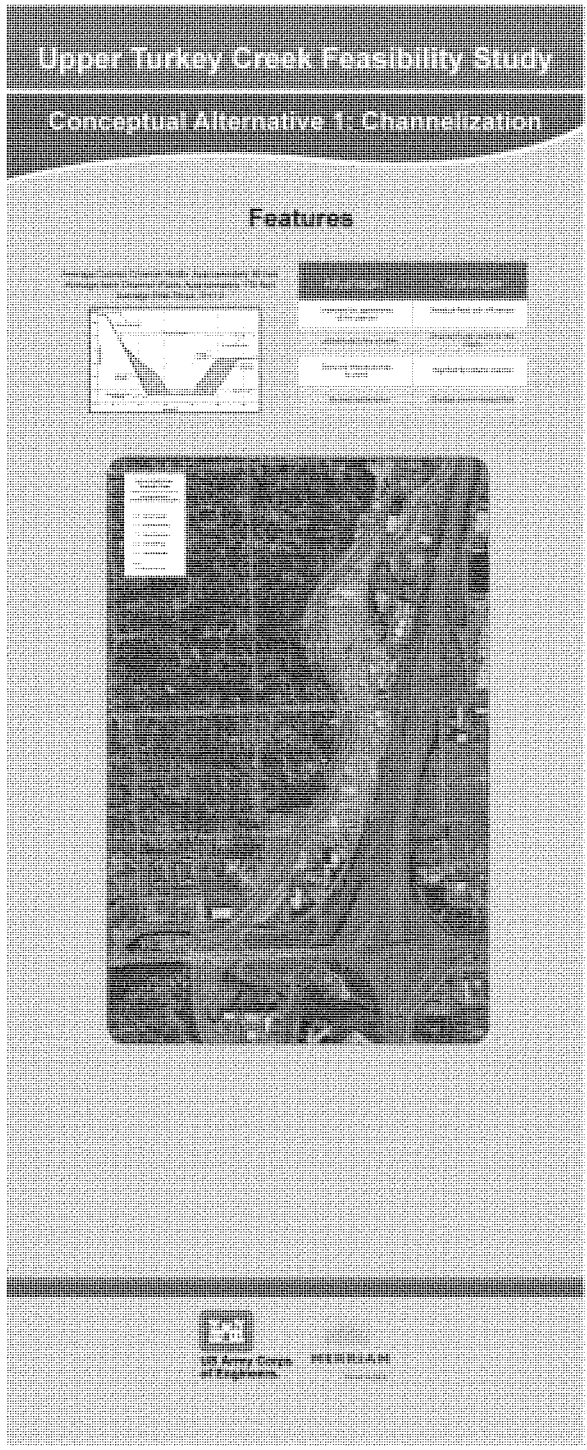
Initial Plan Formulation

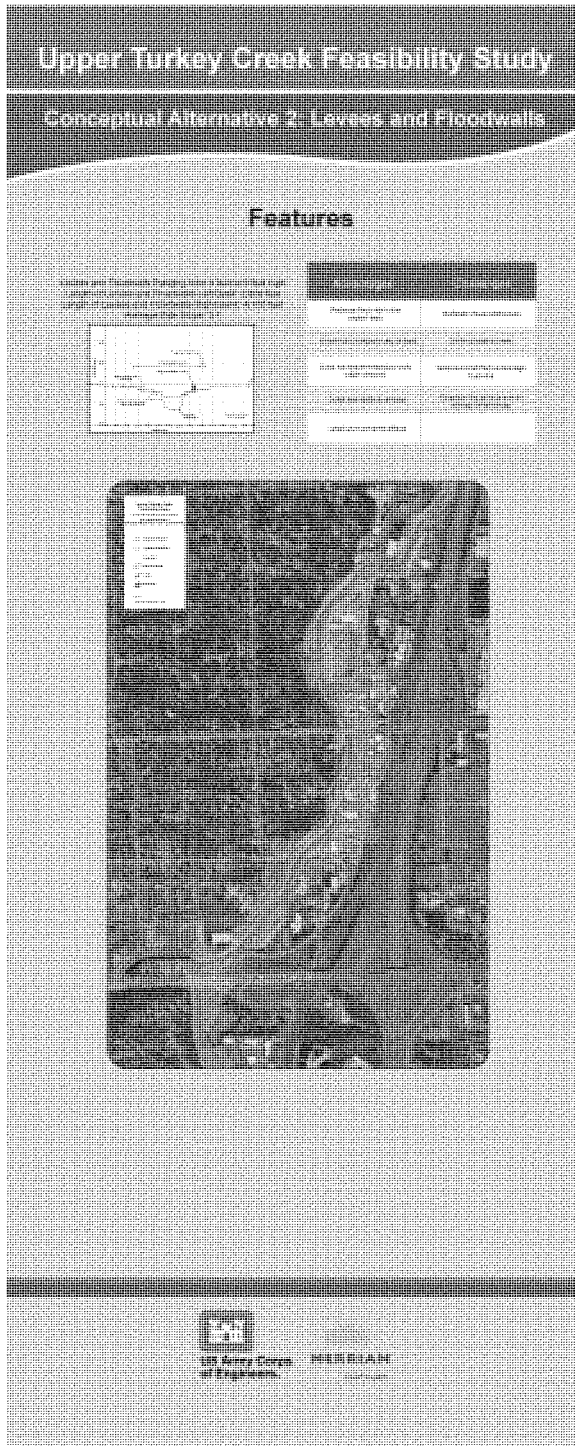
Conceptual alternatives were developed that could manage the flood risk and potentially meet other purposes like recreation and aesthetics.

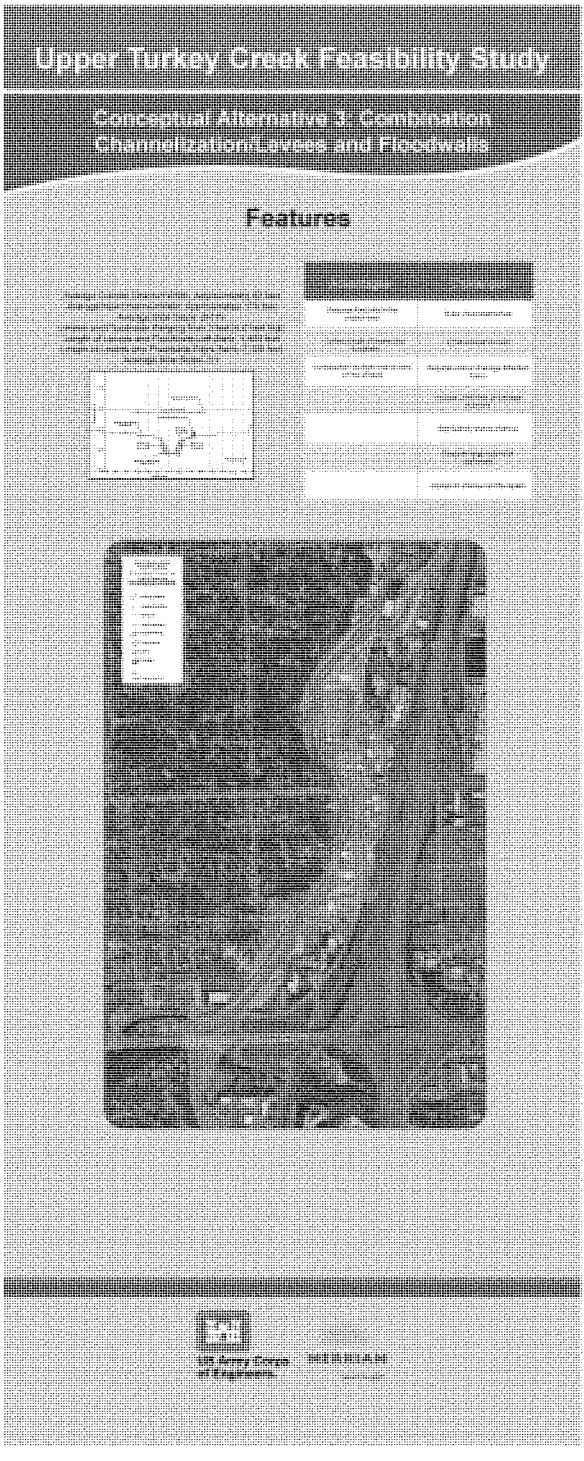
The conceptual alternatives include structural and nonstructural flood reduction measures, consistent with flood risk authorization of the National Economic Development (NED) plan.

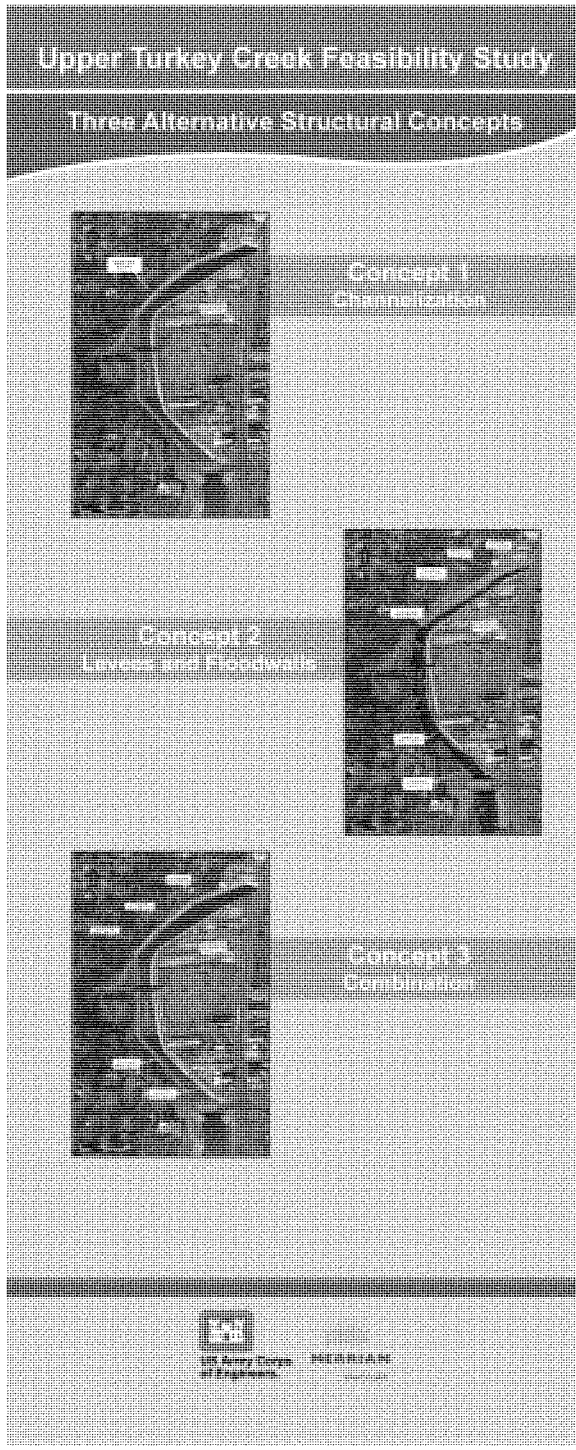
The initial plan formulation for the three Conceptual Alternatives for flood reduction evaluated structural protection and channel modification in 3 areas:

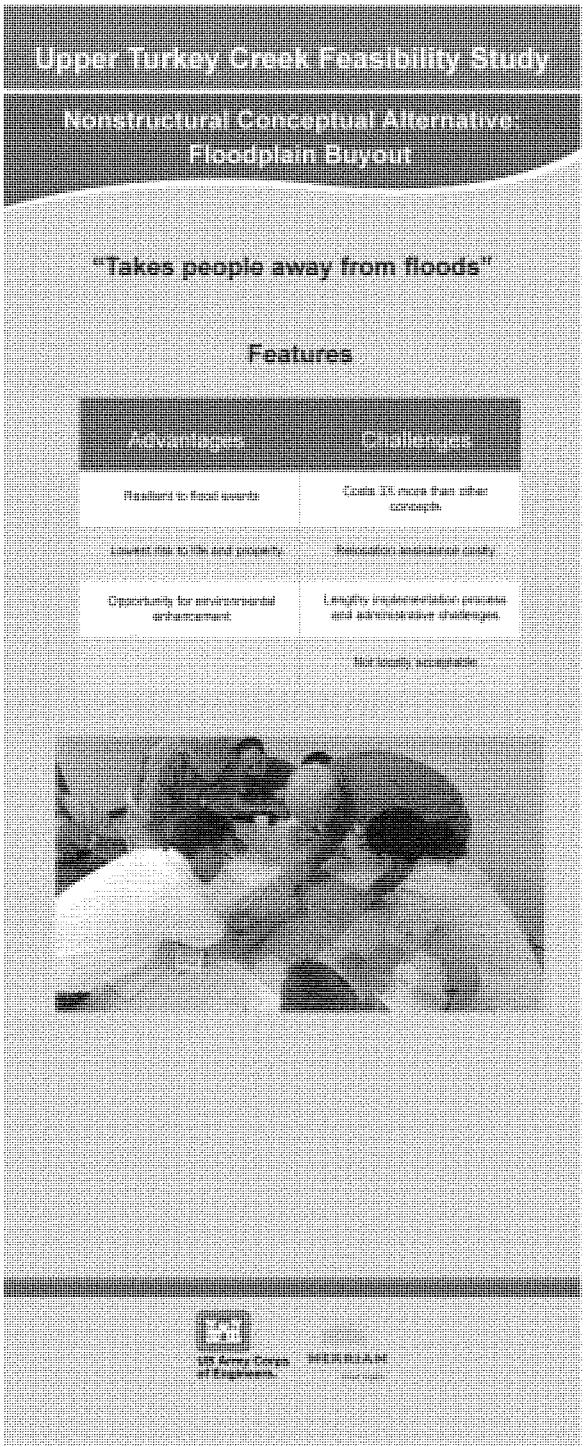
- **City of Merriam:**
  - Models indicated the majority of the Turkey Creek channel through Merriam can contain a 5-year storm flow. However, two areas flood at the 5-year flow.
  - As estimated, a 45-50% reduction in the current 100 year flows is needed for Turkey Creek to remain in its channel.
- **Interstate 35:**
  - Overtops in 2 locations
  - Floods into nearby buildings
- **Roe Lane Industrial Park:**
  - Floods primarily between the creek and railroad tracks


Upper Turkey Creek Feasibility Study
Conceptual Alternative 1: Channelization
Features
US Army Corps of Engineers
MERIDIAN


Upper Turkey Creek Feasibility Study
Conceptual Alternative 2: Levees and Floodwalls
Features
US Army Corps of Engineers
MERRIAM


Upper Turkey Creek Feasibility Study
Conceptual Alternative 3: Combination Channelization/Levees and Floodwalls
Features
US Army Corps of Engineers
MERIDIAN


Upper Turkey Creek Feasibility Study
Three Alternative Structural Concepts
Concept 1
Channelization
Concept 2
Levees and Floodwalls
Concept 3
Combination
US Army Corps of Engineers
MERRIAN

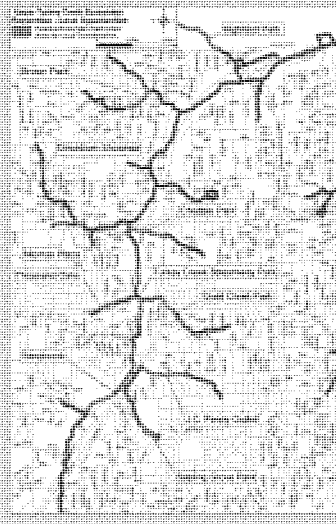

Upper Turkey Creek Feasibility Study
Nonstructural Conceptual Alternative:
Floodplain Buyout
"Takes people away from floods"
Features
Advantages
Challenges
Resilient to flood events
Costs 3X more than other concepts
Lowest risk to life and property
Relocation assistance costly
Opportunity for environmental enhancement
Lengthy implementation process and administrative challenges
Not locally acceptable
US Army Corps of Engineers
MERRIAM

Upper Turkey Creek Feasibility Study

Potential Ecosystem Restoration Opportunities For Local Implementation

Opportunities:

- Bank Stabilization Measures
- Fish Habitat Improvement
- Riffle-Pool Complexes
- Instream Habitat
- Development of Riparian Habitat
- Water Quality Improvement



October 2011 Public Meeting Summary of Public Comments

US Army Corps of Engineers

MERRIAM just right

Upper Turkey Creek Feasibility Study
Wednesday, October 19, 2011, 5:00 – 8:00 p.m.
5701 Merriam Drive, Merriam, Kansas 66203

Public Comments Recorded at Stations with Flipcharts

Station #1: History and Purpose

No comments recorded.

Station #3: Overview of Three Structural Conceptual Alternatives

- Concern raised about the effects of the alternatives to the current trail.
- Question of ownership of the new levees and future use for recreation.

Station #4: Structural Conceptual Alternative #1 – Channelization

- Concern that the widening could affect the existing trail (Parks Department).
- Costly/O&M; earthen berm more reliable.
- Concrete armoring is costly to maintain.
- Putting water back into the g.w. through green stabilization.
- Likes the bio-stabilization/improving appearance depends on what you use to stabilize.
- Trail access – would use an off-stream trail (Limited multi-modal access from downtown to Merriam).
- Johnson Drive improvement – heavy traffic – at grade intersection – grades to get over railroad very problematic.
- Coordination and future planning – think ahead.

Station #5 – Structural Conceptual Alternative #2 – Levees and Floodwalls

- Looking into buying out property on north of Farmer's Market for detention. Detention area at Market is former channel, which has been filled.
- Impact on trail, left of Turkey Creek (close to Farmer's Market).
- Visual showing graph of time (hyd).
- Mods to scenic walkway.
- Floodwall visuals (material, aesthetic effect).
- Update aerial photos.
- Campbell St/Campbell Lane → Floodwall aesthetics (tight).
- Trail relocation.

Station #6 – Structural Conceptual Alternative #3 – Combination

- Impact on Campbell Lane/access to church.
- Budget for long-term O&M.

Station #7 – Nonstructural Alternative: Floodplain buy-out

No comments recorded.

US Army Corps of Engineers

MERRIAM just right

Upper Turkey Creek Feasibility Study
Wednesday, October 19, 2011, 5:00 – 8:00 p.m.
5701 Merriam Drive, Merriam, Kansas 66203

Evaluation of Meeting

1. Advance notice of the meeting was timely.

   Agree - 9 Neutral Disagree - 1

   Comments:
   - It may have had good advance notice but I just happened to hear about it through an email at 3:30 p.m. (*In evaluation of information, writer indicates interest in bike trail north and east through KCK)*
   - Wonderful
   - Saw Tweet from Merriam just today

2. Technical information was clear.

   Agree - 10 Neutral - 2 Disagree

   Comments:
   - But no details

3. Questions were answered in plain language.

   Yes - 11 No - 1

   Comments:

4. Next steps for the project are clear.

   Agree – 7 Neutral - 3 Disagree

   Comments:
   - Did not give details on costs of possible alternatives.
   - Encourage the least disruption to streamway trail as possible and would prefer option of detention not being on Farmers Market property.
   -

Exhibit 7
Public Notice of the Draft Feasibility Study with Integrated Environmental Assessment, May 2013

PUBLIC NOTICE

US Army Corps of Engineers
Kansas City District

Permit No. 2013-554
Issue Date: June 27, 2013
Expiration Date: July 26, 2013

30-Day Notice

JOINT PUBLIC NOTICE: This public notice is issued jointly with the Kansas Department of Health and Environment. The Kansas Department of Health and Environment will use the comments to this notice in deciding whether to grant Section 401 water quality certification. Commenters are requested to furnish a copy of their comments to the Kansas Department of Health and Environment, Bureau of Water - Watershed Management Section, 1000 SW Jackson Street, Suite 420, Topeka, Kansas 66612-1367.

APPLICANT: Kansas City District, Corps of Engineers
635 Federal Building
Kansas City, Missouri 64106-2896

PROJECT LOCATION: The project is located along Turkey Creek in Merriam, Kansas, from approximately Shawnee Mission Parkway to Merriam Drive in Johnson County, Kansas. It is in Section 12 of Township 12 South, Range 24 East. Turkey Creek in this area flows north to south and parallels I-35. A map of the project area is included in Chapter 5 of the Draft Feasibility Report with Integrated Environmental Assessment.

AUTHORITY: Section 404 of the Clean Water Act (33 USC 1344). The feasibility study was authorized by Resolution of the Committee on Transportation and Infrastructure, U.S. House of Representatives, Docket 2616, adopted February 16, 2000.

> Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That the Secretary of the Army is requested to review the report of the Chief of Engineers on the Turkey Creek Basin, Kansas and Missouri, dated June 21, 1999, and other pertinent reports, to determine whether any modifications of the recommendations contained therein are advisable at the present time in the interest of flood damage reduction for areas of Turkey Creek Basin in Johnson and Wyandotte Counties, Kansas, upstream of the project for flood damage reduction authorized in section 101(a)(24) of Public Law 106-53, the Water Resources Development Act of 1999.

ACTIVITY: The U.S. Army Corps of Engineers - Kansas City District, in cooperation with the City of Merriam, Kansas, propose a levee and floodwall project along Turkey Creek in Johnson County, Kansas. The purpose of this project is to address flooding risks along Turkey Creek within Merriam, Kansas. In addition, sections of the existing limestone revetment stream bank retaining wall would be replaced with rip rap in several locations within the project area to maintain bank stability.

The National Economic Development (NED) plan involves the installation of concrete floodwalls and earthen levees in the project area. The Merriam downtown or Farmers' Market area would require construction of 280 feet of floodwall 5 feet high upstream of Merriam Drive on the left bank of Upper Turkey Creek. On the right bank of the creek, the alternative includes 550 feet of floodwall 5 to 6 feet high from Merriam Drive upstream to West 57th Street, then 990 feet of levee 6 feet high, and 550 feet of floodwall 6 feet high downstream of Johnson Drive. Two flap gates would be required on drainage structures discharging to the creek, and the Merriam Drive Bridge would require the incorporation of an approximately 4-foot high headwall. Storm sewer modifications would include 500 feet of storm drainage replacement, and an additional 830 feet of pipe rework, a 2,100-foot storm sewer trunk line, and a 2.14-acre/feet grass detention basin approximately 80 feet wide by 360 feet long located north of the Farmers' Market for internal drainage. Impacts to utilities would include reconstruction of a sanitary sewer line at the crossing south of the Farmers' Market.

The Industrial and Railway Drive area would require construction of 800 feet of floodwall 4 to 6 feet high beginning 300 feet upstream of Johnson Drive to 500 feet upstream of West 60th Street, then 440 feet of levee 5 feet high along the bike path to 100 feet north of West 61st Street on the left bank of the creek. On the right bank of the creek, the alternative includes 1,100 feet of floodwall 4 to 6 feet high south of Johnson Drive to 400 feet north of West 61st Street, then 400 feet of levee 5 feet high to West 61st Street. Three flap gates would be required on a triple culvert south of Johnson Drive.

The Parkway vicinity would require construction of 725 feet of floodwall 5 feet high from 100 feet south of West 61st Street along the bike path to Knox Avenue where it joins West 62nd Street, then 700 feet of levee 3 to 5 feet high from West 62nd Street to West 62nd Terrace, and 930 feet of floodwall 3 feet high along West 62nd Terrace to Shawnee Mission Parkway on the left bank of the creek. On the right bank of the creek, the alternative includes 1,000 feet of floodwall 5 feet high from West 61st Street to 400 feet north of Shawnee Mission Parkway, then 300 feet of levee 5 feet high, and 100 feet of floodwall 4 feet high to Shawnee Mission Parkway. Six flap gates would be required on drainage structures discharging to the creek, and the pedestrian bridge near West 62nd Terrace would require modification to span 175 feet. Impacts to utilities would include reconstruction of a sanitary sewer and water line at and near Shawnee Mission Parkway.

Direct project related impacts to waters of the U.S. would result from the replacement of existing limestone revetment blocks that line the channel banks and replacing it with 24-inch Bethany Falls riprap. Approximately 1,000 cubic yards of riprap will be placed below the ordinary high water mark of Turkey Creek in the following locations: the right descending bank from river mile (RM) 2.69 to 2.75, RM 2.93 to 3.03, RM 3.14 to 3.28, RM 3.39 to 3.42, RM 3.59 to 3.62, and the left descending bank from RM 3.60 to 3.64. The 50% annual flood chance flood event

(2-yr return interval) was used to represent the ordinary high water mark, which represents a conservative (slightly high) estimate of fill below ordinary high water mark. Project Drawings are included as Chapter 5 of the Draft Feasibility Report with Integrated Environmental Assessment.

WETLANDS/AQUATIC HABITAT: There were no wetlands identified within or adjacent to the project area. The Habitat Evaluation Procedures (HEP) green sunfish Habitat Suitability Index (HSI) model was used to assess the impacts to waters of the U.S. as part of CWA Section 404 authorizations. This model has been certified for use by the National Ecosystem Planning Center of Expertise. The current HSI value for the green sunfish in the project area is 0.52, which results in 3.7 habitat units for the project area. The recommended plan would result in no change in HSI scores or habitat units, thus there would be no long-term adverse impact resulting from the proposed project on waters of the U.S. To evaluate the affect of the proposed project on the riparian floodplain area, the fox squirrel HSI model was utilized. The existing HSI score for the fox squirrel was 0.12, resulting in 3.18 habitat units over a 26.5 acre area. These habitat units would be lost under the proposed project from the removal of trees in the project footprint. This loss of riparian trees would be mitigated by the planting of 238 hard mast producing trees would be planted in the Upper Turkey Creek watershed. A DRAFT Section 404 (b)(1) Evaluation (40 CFR 230) has been prepared (See Appendix D in Draft Feasibility Report with Integrated Environmental Assessment).

STATEMENT OF AVOIDANCE, MINIMIZATION, AND COMPENSATORY MITIGATION FOR UNAVOIDABLE IMPACTS TO AQUATIC RESOURCES: Impacts to downstream receiving waters will be minimized by incorporating on-site best management practices. Alternatives with significant impacts to the ecosystem were screened out in the initial planning process. Unavoidable impacts of the project to riparian floodplain area will be offset by planting of 238 hard mast producing trees in the Upper Turkey Creek watershed.

NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) OF 1969, as amended: The Corps has made a preliminary determination that the proposed project would not result in significant degradation of the human environment and therefore the proposed project would support a Finding of No Significant Impact (FONSI). The Corps has prepared a Draft Feasibility Report with Integrated Environmental Assessment (EA) for the project; this draft document may be requested as described below under "Additional Information" and is available for review at the Corps of Engineers office and online at the Corps' web page at: http://www.nwk.usace.army.mil/regulatory/CurrentPN/currentnotices.htm. The Corps will utilize comments received in response to this Public Notice and the Draft Feasibility Report with Intergated EA to complete our evaluation of the project for compliance with the requirements of NEPA, and other Federal, state, and local regulations, including this review for project compliance with the requirements of Section 404 of the Clean Water Act. The Corps has made a preliminary determination that the project as proposed would not be contrary to the public interest and is in compliance with the Section 404(b)(1) Guidelines (Appendix D of Draft Feasibility Report with Integrated Environmental Assessment).

ADDITIONAL INFORMATION: Additional information about this application may be obtained by contacting Curtis Hoagland at (816) 389-3401 or curtis.r.hoagland@usace.army.mil. All comments to this public notice should be directed to U.S. Army Corps of Engineers, ATTN: Curtis Hoagland, 635 Federal Building, Kansas City, Missouri 64106.

CULTURAL RESOURCES: The proposed project has been reviewed in compliance with the National Historic Preservation Act of 1966 (Public Law 89-665) including a check of the National Register of Historic Places (NRHP) and supplements thereto. No sites were identified within the project area. A survey of the project area was conducted on December 2, 2012. The survey found no new sites or NRHP eligible properties in the area. The results of the research and survey were coordinated by letter with State Historic Preservation Officer (SHPO). In that letter, the Corps requested concurrence that any proposed work in the project area would have no effect on historical properties and that any work could proceed without any further coordination, unless in the unlikely event that archeological materials were discover during construction. SHPO concurred with this recommendation.

ENDANGERED SPECIES: In compliance with the Endangered Species Act, a preliminary determination has been made that the described work will not affect species designated as threatened or endangered or adversely affect critical habitat. The U.S. Fish and Wildlife Service concurred with this determination in previous correspondence.

FLOODPLAINS: This activity is being reviewed in accordance with Executive Order 11988, Floodplain Management, which discourages direct or indirect support of floodplain development whenever there is a practicable alternative. By this public notice, comments are requested from individuals and agencies that believe the described work will adversely impact the floodplain.

WATER QUALITY CERTIFICATION: Section 401 of the Clean Water Act (33 USC 1341) requires that all discharges of dredged or fill material must be certified by the appropriate state agency as complying with applicable effluent limitations and water quality standards. This public notice serves as an application to the state in which the discharge site is located for certification of the discharge. The discharge must be certified before Department of the Army authorization can be issued. Certification, if issued, expresses the state's opinion that the discharge will not violate applicable water quality standards.

PUBLIC INTEREST REVIEW: The decision to issue authorization will be based on an evaluation of the probable impact including the cumulative impacts of the proposed activity on the public interest. That decision will reflect the national concern for both protection and utilization of important resources. The benefits which reasonably may be expected to accrue from the proposal must be balanced against its reasonably foreseeable detriments. All factors which may be relevant to the proposal will be considered including the cumulative effects thereof; among those are conservation, economics, aesthetics, general environmental concerns, wetlands, cultural values, fish and wildlife values, flood hazards, floodplain values, land use, navigation, shoreline erosion and accretion, recreation, water supply and conservation, water quality, energy needs, safety, food and fiber production, mineral needs and, in general, the needs and welfare of the people. The evaluation of the impact of the activity on the public interest will include application of the guidelines promulgated by the Administrator, Environmental

Protection Agency under authority of Section 404(b) of the Clean Water Act (33 USC 1344). The Corps of Engineers is soliciting comments from the public; Federal, state, and local agencies and officials; Indian Tribes; and other interested parties in order to consider and evaluate the impacts of this proposed activity. Any comments received will be considered by the Corps of Engineers to determine whether to issue, modify, condition or deny an authorization for this proposal. To make this decision, comments are used to address impacts on endangered species, historic properties, water quality, general environmental effects, and other public interest factors listed above.

COMMENTS: This notice is provided to outline details of the above-described activity so this District may consider all pertinent comments prior to determining if issuance of an authorization would be in the public interest. Any interested party is invited to submit to this office written facts or objections relative to the activity on or before the public notice expiration date. Comments both favorable and unfavorable will be accepted and made a part of the record and will receive full consideration in determining whether it would be in the public interest to issue the Department of the Army authorization. Copies of all comments, including names and addresses of commenters may be published in the Final Feasibility Report. Comments should be mailed to: U.S. Army Corps of Engineers, ATTN: Curtis Hoagland, 635 Federal Building, Kansas City, Missouri 64106.

PUBLIC MEETING: A public meeting will be held on Monday July 22, 2013, from 5:30-6:45 PM at the Merriam City Hall, 6200 Eby Street, Merriam, Kansas 66202.

PUBLIC NOTICE

US Army Corps
of Engineers
Kansas City District

Permit No. 2013-554
Date: July 15, 2013

AMENDMENT

PURPOSE: The purpose of this amendment to the original Public Notice dated June 27, 2013 is to make a change through addendum to the main feasibility report, make a change in the public meeting date and times, and extend the public comment period.

ADDENDUM TO DRAFT FEASIBILITY REPORT WITH INTEGRATED ENVIRONMENTAL ASSESSMENT: On page 7-21 of the main report, Section 7.8.1.2, item a. 1. Replace "Provide 25 percent of design cost..." with "Provide the required non-Federal share of design costs..."

PUBLIC MEETING: The date of the public meeting has been changed from Monday, July 22, 2013 to Wednesday, August 14, 2013 from 5:30-7:00 PM at the Merriam City Hall, 6200 Eby Street, Merriam, Kansas 66202. There will be no meeting on July 22, 2013. **Note**: If you require special accommodations (i.e. qualified interpreter, hearing assistance, etc.) in order to attend this meeting, please contact the City Clerk's office 913-322-5500 at least 48 hours in advance.

COMMENT DATE EXTENSION: The closing date for submitting public comments has been extended from July, 26, 2013 to August 21, 2013.

ADDITIONAL INFORMATION: Additional information about this application may be obtained by contacting Curtis Hoagland, (816) 389-3401 or curtis.r.hoagland@usace.army.mil. All comments to this public notice should be directed to U.S. Army Corps of Engineers, ATTN: Curtis Hoagland, 635 Federal Building, Kansas City, Missouri 64106.

Appendix D
Clean Water Act Section 404 (b)(1) Evaluation

CLEAN WATER ACT 404(b)(1) EVALUATION

APPENDIX D

UPPER TURKEY CREEK BASIN
Johnson and Wyandotte Counties, KS
Flood Risk Management Project
Feasibility Study

May 2013

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

Table of Contents

1.0 INTRODUCTION 1
1.1 LOCATION 1
1.2 PROPOSED PROJECT 1
1.3 AUTHORITY 1
2.0 REVIEW OF COMPLIANCE (§ 230.10 a-d) 2
2.1 ALTERNATIVES 2
2.2 WATER QUALITY STANDARDS/T&E SPECIES/MARINE SANCTUARIES 2
2.3 WATERS OF THE U.S. 2
2.4 MINIMIZATION OF IMPACTS 3
3.0 TECHNICAL EVALUATION FACTORS (SUBPARTS C-F) 3
3.1 POTENTIAL IMPACTS ON PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE AQUATIC ECOSYSTEM (SUBPART C) 3
3.1.1 SUBSTRATE 3
3.1.2 SUSPENDED PARTICULATES/TURBIDITY 4
3.1.3 WATER 4
3.1.4 CURRENT PATTERNS AND WATER CIRCULATION 4
3.1.5 NORMAL WATER FLUCTUATIONS 4
3.1.6 SALINITY GRADIENTS 4
3.2 POTENTIAL IMPACTS TO THE BIOLOGICAL CHARACTERISTICS OF THE AQUATIC ECOSYSTEM (SUBPART D) 4
3.2.1 THREATENED AND ENDANGERED SPECIES 5
3.2.2 FISH, CRUSTEACEANS, MOLLUSKS, AND OTHER AQUATIC ORGANISMS IN THE FOOD WEB5
3.2.3 OTHER WILDLIFE 5
3.3 POTENTIAL IMPACTS ON SPECIAL AQUATIC SITES (SUBPART E) 5
3.3.1 SANCTUARIES AND REFUGES 5
3.3.2 WETLANDS 5
3.3.3 MUD FLATS 5
3.3.4 VEGETATED SHALLOWS 6
3.3.5 CORAL REEFS 6

3.3.6 RIFFLE AND POOL COMPLEXES 6

3.4 POTENTIAL EFFECTS ON HUMAN USE CHARACTERISTICS (SUBPART F) 6

3.4.1 MUNICIPAL AND PRIVATE WATER SUPPLIES 6

3.4.2 RECREATIONAL AND COMMERCIAL FISHERIES 6

3.4.3 WATER-RELATED RECREATION 6

3.4.4 AESTHETICS 6

3.4.5 PARKS, NATIONAL AND HISTORIC MONUMENTS, NATIONAL SEASHORES, WILDERNESS AREAS, RESEARCH SITES, AND SIMILAR PRESERVES 6

4.0 EVALUATION OF DREDGED OR FILL MATERIAL (SUBPART G) 7

4.1 GENERAL EVALUATION OF DREDGED OR FILL MATERIAL 7

4.2 CHEMICAL, BIOLOGICAL, AND PHYSICAL EVALUATION AND TESTING 7

5.0 DISPOSAL SITE DELINEATION (§230.11f) 7

6.0 ACTIONS TO MINIMIZE ADVERSE EFFECTS (SUBPART H) 7

7.0 FACTUAL DETERMINATIONS (§230.11) 8

8.0 FINDINGS (§230.12) 8

FIGURE 1: RECOMMENDED PLAN (ALTERNATIVE 2d)-PLATE 1 10

FIGURE 2: RECOMMENDED PLAN (ALTERNATIVE 2d)-PLATE 2 11

FIGURE 3: RECOMMENDED PLAN (ALTERNATIVE 2d)-PLATE 3 12

FIGURE 4: RECOMMENDED PLAN (ALTERNATIVE 2d)-PLATE 4 13

FIGURE 5: RECOMMENDED PLAN (ALTERNATIVE 2d)-PLATE 5 14

FIGURE 6: RECOMMENDED PLAN (ALTERNATIVE 2d)-PLATE 6 15

1.0 INTRODUCTION

1.1 LOCATION

The headwaters of the Turkey Creek Basin are in Lenexa, Kansas, just south of 89th Street, and the portion of the watershed upstream of the 4.4 Burlington Northern Santa Fe (BNSF) railroad bridge referred to in this study as Upper Turkey Creek and Lower Turkey Creek is the downstream portion. The entire basin drains 23 square miles before passing through a quarter-mile-long tunnel to the Kansas River. Turkey Creek is approximately 15 miles long and flows parallel to I-35 for almost its entire length. The Turkey Creek drainage basin overlaps the common boundary of Johnson and Wyandotte Counties, Kansas. Countyline Road passes east-west through the basin separating Johnson County to the south from Wyandotte County to the north. This report is focused on the Upper Turkey Creek Basin, or sometimes referred to as UTC, and is defined as the basin upstream of an authorized flood risk management construction project in the downstream 8,700 feet of the Turkey Creek channel known as Lower Turkey Creek in this report. The primary sites considered for flood risk management plan formulation were a) in the City of Merriam, Kansas b) in the Unified Government of Wyandotte County and Kansas City, Kansas at an industrial park called Roe Lane; and c) on a flood prone segment of highway, Interstate 35 in Johnson County running generally between Merriam and downstream into the Unified Government area. Only the City of Merriam site was carried forward.

1.2 PROPOSED PROJECT

The Recommended Plan is a levee and floodwall plan in the City of Merriam. These features would extend approximately from Shawnee Mission Parkway to Merriam Drive, which is a 1.5-mile stretch that includes Merriam's main downtown reach. Most of the protected area is on the right bank of Turkey Creek while much of the left bank remains as an unoccupied floodplain. The features are designed for a small urban watershed with levees no more than 6.5 feet high. The Recommended Plan includes 6,822 feet of floodwall up to 6.5 feet high, 3,383 feet of levees up to 6 feet high, utility modifications, approximately 12,427 Auger Grout Piles, and a 2.14 acre-foot detention area (Figures 1 through 6).

An overview of major construction features is included below:

- Levees and floodwalls
- Ground Modification
- Drainage system modifications
- Bridge modifications/headwalls
- Utility modifications
- Environmental mitigation

1.3 AUTHORITY

This study was authorized by Resolution of the Committee on Transportation and Infrastructure, U.S. House of Representatives, Docket 2616, adopted February 16, 2000.

> Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That the Secretary of the Army is requested to review the report

of the Chief of Engineers on the Turkey Creek Basin, Kansas and Missouri, dated June 21, 1999, and other pertinent reports, to determine whether any modifications of the recommendations contained therein are advisable at the present time in the interest of flood damage reduction for areas of Turkey Creek Basin in Johnson and Wyandotte Counties, Kansas, upstream of the project for flood damage reduction authorized in section 101(a)(24) of Public Law 106-53, the Water Resources Development Act of 1999.

2.0 REVIEW OF COMPLIANCE (§ 230.10 a-d)

2.1 ALTERNATIVES

In addition to the recommended plan identified above a wide array of alternatives with varying scales of channel widening, levees and floodwalls, combinations of widening with levees and floodwalls, and property buyouts were considered. Alternatives were examined and compared considering the Federal criteria for completeness, efficiency, effectiveness, and acceptability. As alternatives passed through this evaluation and screening process, the economic analysis of each alternative's incremental cost was used as a ranking factor in the final selection. Out of the alternatives having passed review for engineering adequacy, environmental and public acceptability, and other evaluation criteria as described below, the alternative with the highest net benefits to the national economy was identified as the overall recommended NED plan. The final array of alternatives consisted of the No Action Alternative, 1d – Channel Widening to the 1-percent AEP (100-year event), 2d - Levees and Floodwalls to meet the 1-percent AEP, 3d – Combination of Channel Widening and Levees/Floodwalls, and 4 – Property Buyout. More detailed information on the alternatives and screening process can be found in Chapter 5 of this feasibility report. Both alternative 1d and 3d which includes channel widening, results in a much higher impact to waters of the US. The property buyout would involve 94 properties making them difficult to obtain and result in a much lower cost to benefit ratio and would still leave existing utilities, railroads, and roads at risk for future flood damage, making this not a practicable alternative in terms of 404 (b)(1). The levees and floodwalls alternative 2d is considered the least damaging practicable alternative. Additional information on the impact of each of the alternatives on waters of the US can be found in Chapter 6 of this feasibility report.

2.2 WATER QUALITY STANDARDS/T&E SPECIES/MARINE SANCTUARIES

The proposed project would not result in a violation of any applicable state water standard. A Clean Water Act Section 401 State Water Quality Certification would be required prior to beginning any construction. The proposed project would also not violate any applicable toxic effluent standard or prohibition under Section 307 of the Clean Water Act. The construction contractor would be required to obtain a Section 402 National Pollution Discharge Elimination System (NPDES) stormwater permit from Kansas Department of Health and the Environment (KDHE) prior to beginning any construction. No Federally-listed species, candidate species, or designated critical habitats are located in or adjacent to the project area. No marine sanctuaries exist within or near the project area.

2.3 WATERS OF THE U.S.

The proposed project would not cause or contribute to significant degradation of waters of the U.S. Early in the planning process a stream quality assessment was performed for the Upper Turkey Creek watershed based on a combination of the Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers

(Barbour et al. 1999), and the USDA, Natural Resources Conservation Service (NRCS), Stream Visual Assessment Protocol (USDA 1998). Seventeen different variables were used to characterize physical stream conditions, habitat characteristics, and the biological community. Each variable was scored on a scale of 1 to 10. Poor conditions for a given variable would result in a low score, while good conditions would result in a higher score. The three reaches evaluated in the project area were all categorized as poor with scores being amongst the lowest in the entire Upper Turkey Creek Watershed. At times, the Turkey Creek channel within the project area becomes dominated with filamentous algae. Emergent aquatic vegetation is virtually non-existent. Additionally, as an indicator of the condition of the aquatic habitat, the U.S. Fish and Wildlife Service's Habitat Evaluation Procedure (HEP) method was utilized to calculate a Habitat Suitability Index (HSI) score and determine the existing number of Habitat Units (HUs) for green sunfish (*Lepomis cyanellus*) within the downtown Merriam reach of the project area. Within this reach, the HSI for green sunfish was 0.52, resulting in 3.7 HUs for this reach of the river. Approximately 25% of the floodplain riparian area has tree canopy cover. These areas typically consist of manicured lawn under the canopy cover. To evaluate the existing condition of the riparian corridor for compliance with Section 404 of the CWA, the HEP method was used to calculate an HSI score and determine the existing number of habitat units for the fox squirrel (*Sciurus niger*). Within this reach, the HSI score for the fox squirrel was 0.10, resulting in 2.7 HUs over a 26.5-acre area. A HEP analysis was then performed on the proposed project to determine if there would be any impact on green sunfish and fox squirrel. The proposed project would only result in short-term minor impacts to waters of the U.S. during construction of the levees and floodwalls. The proposed project would not result in any impact to the green sunfish, but would result in the loss of 2.7 Average Annual Habitat Units (AAHUs) for fox squirrel from the removal of approximatley3.6 acres of trees. This impact would be offset by the planting of trees over a 7 acre area. The proposed project would not cause an adverse impact to human health, life stages of organisms dependent on aquatic ecosystems, ecosystem diversity, productivity and stability, recreational, aesthetic, and economic values. A detailed evaluation of the recommended plan can be found in chapter 6 of this report.

2.4 MINIMIZATION OF IMPACTS

Appropriate and practical steps have been taken which will minimize potential adverse impacts on the aquatic ecosystem. Alternatives with significant impacts to the ecosystem were screened out in the initial planning process. The proposed detention pond should reduce sediment entering the Upper Turkey Creek by capturing runoff and sediment and other debris from surrounding urban properties (see Figures 1-2).

3.0 TECHNICAL EVALUATION FACTORS (SUBPARTS C-F)

3.1 POTENTIAL IMPACTS ON PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE AQUATIC ECOSYSTEM (SUBPART C)

3.1.1 SUBSTRATE

There may be some minor short term impacts to the substrate during construction activities from equipment working in the channel. The impact will be minimized by the use of Best Management Practices (BMPs) during construction activities. Following construction, the channel substrate should return to the pre-construction state. Most of the structural alterations (additions of levees and floodwalls) would take place outside of the channel. Due to past channelization in the project area, the creek bed is down to bedrock in many areas and the sides of the channel are lined with large limestone blocks. There

are several areas where these blocks are not providing or will not be providing adequate protection and will be replaced with 24" riprap (see Figures 1-6).

3.1.2 SUSPENDED PARTICULATES/TURBIDITY

The proposed plan would result in minor short-term impacts to suspended particulates and an inerease in turbidity during project construction. This would result from disturbing the existing sand/silt substrate near the construction location. There would be a minor long-term decrease in suspended sediments and subsequently turbidity from the addition of the detention pond which would allow sediments to settle out before entering the stream. The levees and flood walls would also limit the direct runoff into the stream channel which should also allow for a decrease in relative turbidity levels, particularly following the large rainfall events.

3.1.3 WATER

The Recommended Plan would have minor, short-term construction related impacts to water quality due to activities occurring within the creek channel and on the creek banks in order to construct the levees and floodwalls. Additionally, two sewer lines and two waterlines that currently cross under Turkey Creek would be replaced. Replacement of these lines should reduce potential future water quality impacts from the breakage of those lines. Upper Turkey Creek has existing poor water quality issues from a variety of point and non-point sources. This has lead to some areas where filamentous green algae are dominant, and emergent aquatic vegetation is non-existent. This project would not result in a long-term impact to water quality.

3.1.4 CURRENT PATTERNS AND WATER CIRCULATION

The addition of floodwalls and levees in the recommended plan would constrict very high flows to within the leveed/floodwalled area. This would alter the current patterns and circulation at these high flow levels. At high flows under the existing conditions the water would flow out onto the floodplain which would slow the relative speed of the water. The current pattern and water circulation patterns would be unaffected during flows of bankfull or less.

3.1.5 NORMAL WATER FLUCTUATIONS

The Upper Turkey Creek project area is already an altered system with surrounding areas being highly developed with large amounts of impervious surface. This has created an unnatural hydrograph that allows for a rapid runoff of water; that under undeveloped conditions, large portions of precipitation would soak into the ground prior to reaching the creek. The addition of levees/floodwalls and a detention basin will slow water from reaching the creek channel. Water within the channel however will be at a relatively higher level and velocity during high flow events due to being constricted within a narrower floodplain area created by the levees/floodwalls. The altered water level fluctuations of Upper Turkey Creek will continue to be altered following construction.

3.1.6 SALINITY GRADIENTS

The proposed project would not impact any salinity gradients.

3.2 POTENTIAL IMPACTS TO THE BIOLOGICAL CHARACTERISTICS OF THE AQUATIC ECOSYSTEM (SUBPART D)

3.2.1 THREATENED AND ENDANGERED SPECIES

The recommended plan would have no effect on any Federally-listed threatened or endangered species, candidate species, or designated critical habitat. No Federally-listed species, candidate species, or designated critical habitats are located in or adjacent to the project area.

3.2.2 FISH, CRUSTEACEANS, MOLLUSKS, AND OTHER AQUATIC ORGANISMS IN THE FOOD WEB

The recommended plan would cause minor short-term construction related impacts to aquatic organisms from the direct displacement of organisms, and potential decreases in water quality during construction that may negatively impact species that are not tolerant of these changes. BMPs, as described in Section 6 of the feasibility report, would help minimize impacts to water quality. Any organisms that would flee the project area as a result of direct displacement would be expected to either return to the area after construction has been completed or use similar habitat types in locations adjacent to the project. A HEP analysis was done utilizing the green sunfish HSI model to compare between the existing habitat and the recommended plan, the result of this analysis determined that AAHUs remained the same under the recommended plan. There would be no long-term adverse impacts to fish, crustaceans, mollusks, or other aquatic organisms in the food web.

3.2.3 OTHER WILDLIFE

As the project is in a highly developed area, wildlife habitat is somewhat limited with species consisting mostly of those that can survive within an urban environment. However, there would be a removal of approximately 3.6 acres of trees creating a minor long-term impact to wildlife. To mitigate for the loss of these trees, approximately 185 hard mast producing trees would be planted in the Upper Turkey Creek watershed. A minor, long-term impact to wildlife would be that the levees and flood walls may physically restrict access to Turkey Creek. However, the 15- to 20-foot vertical drop along the creek banks due to the channelization with limestone blocks already limits wildlife access to Turkey Creek. To comply with the Migratory Bird Treaty Act, the taking of migratory birds, their eggs, and nests would be avoided by conducting field surveys if construction were to take place during the migratory bird nesting season, generally considered to be from April 1 to July 15. Additionally short-term impacts from construction-related noise and activity may displace wildlife from the project area. It is anticipated that animals displaced by noise would return to the project area following construction.

3.3 POTENTIAL IMPACTS ON SPECIAL AQUATIC SITES (SUBPART E)

3.3.1 SANCTUARIES AND REFUGES

No Federal, state or locally managed sanctuary or refuge is located in or adjacent to propose project location. There would be no impacts to sanctuaries or refuges from the proposed project.

3.3.2 WETLANDS

No wetlands were identified in or adjacent to the project area. There would be no impacts to wetlands from the proposed project.

3.3.3 MUD FLATS

No mud flats would be impacted by the proposed project.

3.3.4 VEGETATED SHALLOWS

No vegetated shallows would be impacted by the proposed project. No rooted aquatic vegetation is located within the project area.

3.3.5 CORAL REEFS

No coral reefs would be impacted by the proposed project. No coral reefs are located in the project area.

3.3.6 RIFFLE AND POOL COMPLEXES

Upper Turkey Creek is highly altered within the project area. A few poorly developed riffle pool complexes are present in the area. The proposed project would not result in any long-term adverse affect to riffle pool complexes.

3.4 POTENTIAL EFFECTS ON HUMAN USE CHARACTERISTICS (SUBPART F)

3.4.1 MUNICIPAL AND PRIVATE WATER SUPPLIES

Two municipal water lines would be replaced during the project. This may cause a slight disruption to those serviced by those lines but this would provide for more stable supply in the future. No water intakes are located in or near the project area.

3.4.2 RECREATIONAL AND COMMERCIAL FISHERIES

The proposed project would not negatively affect the suitability of any recreational or commercial fisheries. Lack of stream access in the project area as well as limited water quality is already limiting the suitability of the recreational fishery.

3.4.3 WATER-RELATED RECREATION

There is little to no water-related recreation within the channel of the Upper Turkey Creek. A trail is located along Turkey Creek in Streamway Park (Figures 1-6), efforts will be made during the detailed design phase to retain the trail along the creek. The proposed project would also result in an approximate 1 acre loss to Merriam Marketplace and Campbell Park within the footprint of the levees and floodwalls. These would result in a minor long-term impact to recreational area near the stream.

3.4.4 AESTHETICS

Aesthetics associated with the aquatic ecosystem consist of the perception of beauty by one or a combination of the senses of sight, hearing, touch, and smell. The proposed project area is located in an industrial and commercial corridor, with most areas not lending themselves to natural aesthetic values. Several park areas are located within the downtown Merriam area. The placement of levees and floodwalls would obstruct the view shed of the creek from many of these businesses and park areas, as well as the parallel portions of I-35. Due to the already highly developed nature of the watershed, it is unlikely the proposed project would lead to additional development affecting the aesthetics of the area.

3.4.5 PARKS, NATIONAL AND HISTORIC MONUMENTS, NATIONAL SEASHORES, WILDERNESS AREAS, RESEARCH SITES, AND SIMILAR PRESERVES

The proposed project would require the use of approximately 1 acre of the Merriam Market Place and the adjacent Campbell Park for the placement of the levee and floodwalls (Figures 1-6). The construction of

levees or floodwalls in these areas would affect the view of the stream from the park areas. The Turkey Creek Streamway Park which includes a paved trail that parallels the creek channel could be impacted by the proposed project. However, efforts would be made during the more detailed engineering and design phase of any project to retain a trail adjacent to Turkey Creek throughout the project area. No other parks, National and historic monuments, National seashores, wilderness areas, research sites, and similar preserves would be adversely impacted by the proposed project.

4.0 EVALUATION OF DREDGED OR FILL MATERIAL (SUBPART G)

4.1 GENERAL EVALUATION OF DREDGED OR FILL MATERIAL

Fill material placed below the ordinary high water mark would consist of 24-inch Bethany Falls riprap obtained from a commercial source. The riprap would replace the current limestone revetment blocks lining the channel banks (Figures 1-6). This would only occur in several areas along the project reach where the current limestone blocks would not be compatible with the levee/floodwall or is failing to provide adequate bank protection. No fill would be placed on the stream bed. Replaced limestone revetment blocks would be hauled away by the contractor and disposed of outside of the floodplain. This same type of commercial fill material has been successfully used on other nearby projects, resulting in a product that is free from chemical, biological, or other pollutants.

4.2 CHEMICAL, BIOLOGICAL, AND PHYSICAL EVALUATION AND TESTING

The commercial fill material would meet the testing exclusion as Bethany Falls riprap has been used on multiple projects in the nearby area including other projects on Turkey Creek with no harmful effects. There is no reason to believe that this fill would contain harmful contaminants.

5.0 DISPOSAL SITE DELINEATION (§230.11f)

Fill locations would consist of the bank areas along Turkey Creek. The approximate location of fill placement include the right descending bank from river mile (RM) 2.69 to 2.75, RM 2.93 to 3.03, RM 3.14 to 3.28, RM 3.39 to 3.42, RM 3.59 to 3.62, and the left descending bank from RM 3.60 to 3.64 (Figures 1-6) . As almost the entire stream bank in the project area is lined with limestone rock revetment blocks with high steep walls, a delineation of the ordinary high water mark using tradition means (drift lines, etc.) would be difficult if not impossible. Due to availability of the computed water surface profiles, the 50-percent annual chance flood event (2-yr return interval) was selected for analysis to generate a conservative (slightly high) estimate of fill below ordinary high water. Based on this level, approximately 1,000 cubic yards of clean rip rap fill would be spread over the stream segments listed above. The limestone revetment blocks currently in these locations would be removed and replaced by the rip rap resulting in a net zero balance of fill below the ordinary high water mark.

6.0 ACTIONS TO MINIMIZE ADVERSE EFFECTS (SUBPART H)

As part of the planning process, alternatives that included channel widening were analyzed as potential alternatives. These would have required a much higher impact to the stream during construction. The preferred alternative minimizes construction related impacts relative to channel widening. To offset the

2.7 AAHU loss of riparian corridor habitat, 7 acres of hard mast producing trees would be planted on nearby lands owned by the city, resulting in approximately 3.1 AAHU over a 50 year period of analysis. The construction contractor would be required to obtain a Section 402 NPDES stormwater permit from Kansas Department of Health and Environement. As part of the NPDES permit, Best Management Practices (BMPs) would be required to minimize the incidental fallback of material into the waterway and to minimize the introduction of fuel, petroleum products, or other deleterious material from entering the waterway. Such measures could include the use of erosion control fences; storing equipment, solid waste, and petroleum products above the ordinary high water mark and away from areas prone to runoff; and requiring that all equipment be clean and free of leaks. Additional measures to minimize adverse effects would include using clean rock fill with minimal fines, stabilizing the earthen material with rock, using appropriate construction equipment, minimizing the amount of time that equipment would be in the river channel, and not placing fill in the river during unusual high water events.

7.0 FACTUAL DETERMINATIONS (§230.11)

A review of the information in sections 2 through 6 above indicate there is minimal potential for long-term environmental effects of the proposed discharge. There should be a minor long-term positive benefit to sedimentation from the off channel detention basin. There would be a change to several areas of the physical substrate of the channel sidewalls from limestone revetment blocks to 24 inch riprap, however this would not have an adverse effect on stream quality. The water circulation, fluctuation, and salinity levels would remain nearly the same for all but the highest flow levels where out of bank flows would be confined within the levee floodwalls. The suspended particulates/turbidity would have a small adverse effect during construction activities from equipment working in the channel; however, there should be a minor benefit (reduction) to turbidity levels from the off-channel detention basin capturing runoff. The proposed riprap has been used on other nearby projects without any contaminant issues so this project should have no impact to contaminants. There will be localized minor short-term impacts on the aquatic ecosystems and organisms during construction but following construction aquatic ecosystem should return to similar pre-construction conditions. Best management practices will be used during construction to limit contaminants and other deleterious materials from entering the waterway. No significant cumulative or secondary are anticipated for the proposed project.

8.0 FINDINGS (§230.12)

The proposed Upper Turkey Creek Project has been evaluated and determined to be in compliance with Clean Water Act Section 404(b)(1) guidelines, with the inclusion of appropriate and practical conditions to minimize pollution and adverse effects on the aquatic ecosystem.

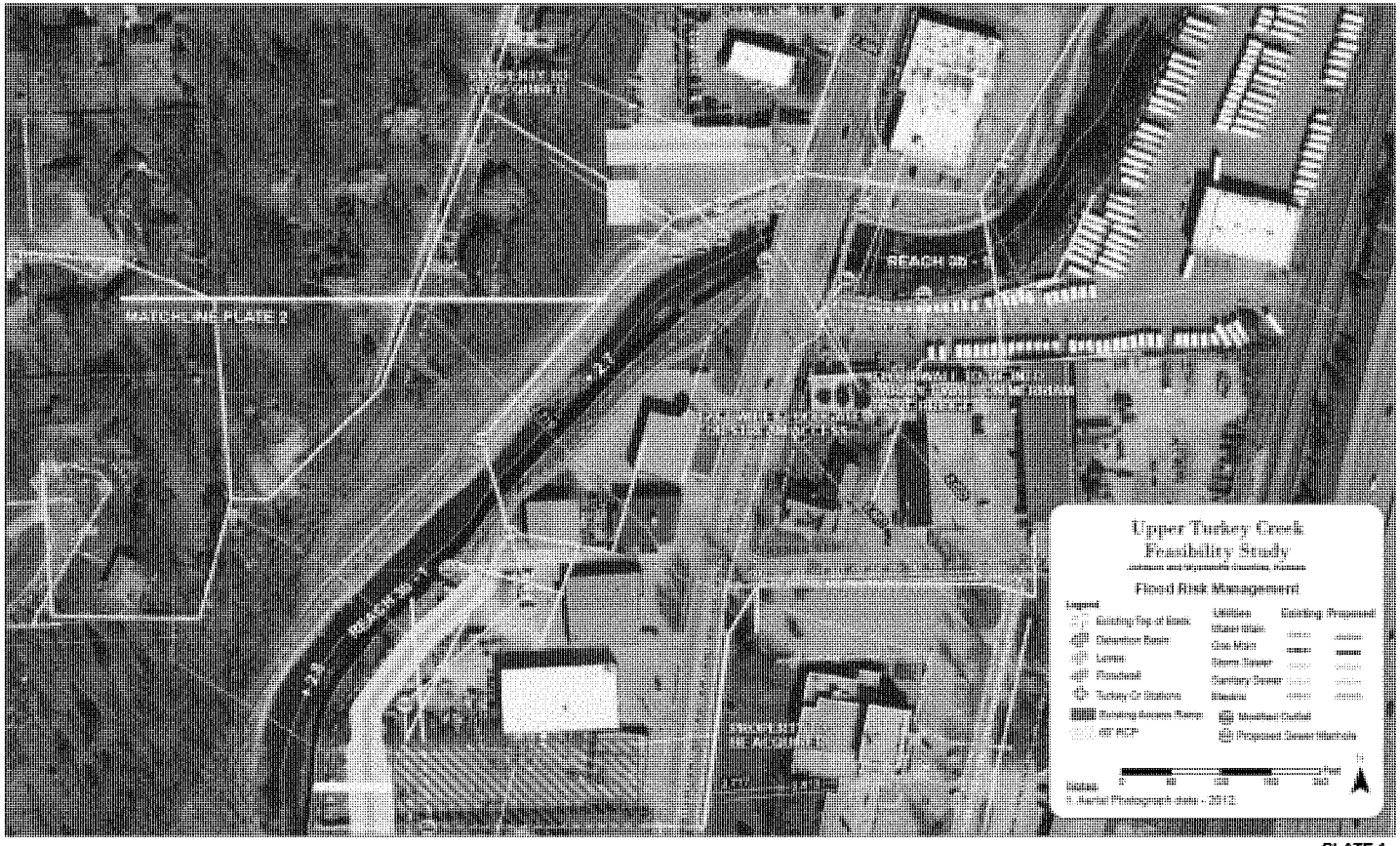


Figure 1: Recommended Plan (Alternative 2d) – Plate 1

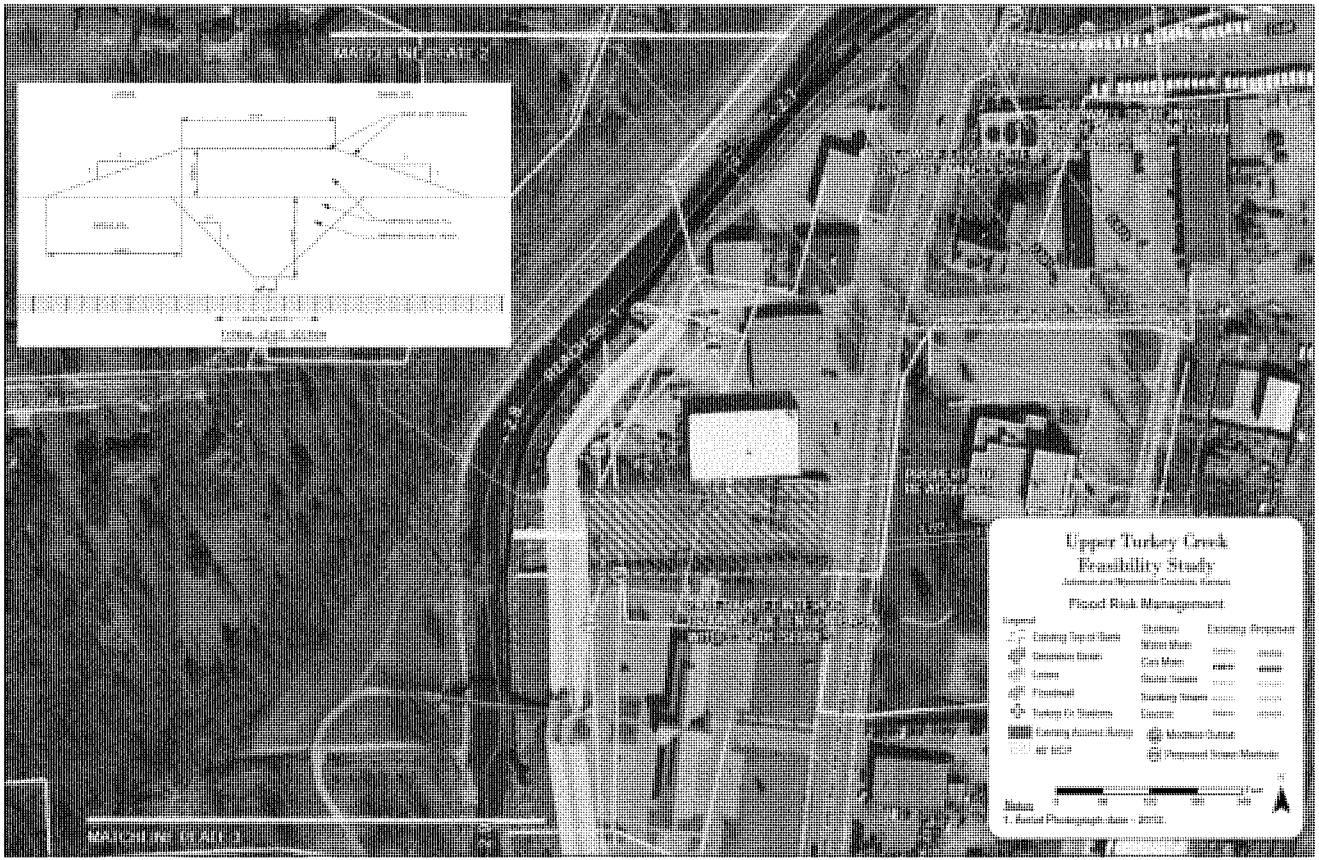


PLATE 2

Figure 2: Recommended Plan (Alternative 2d) – Plate 2

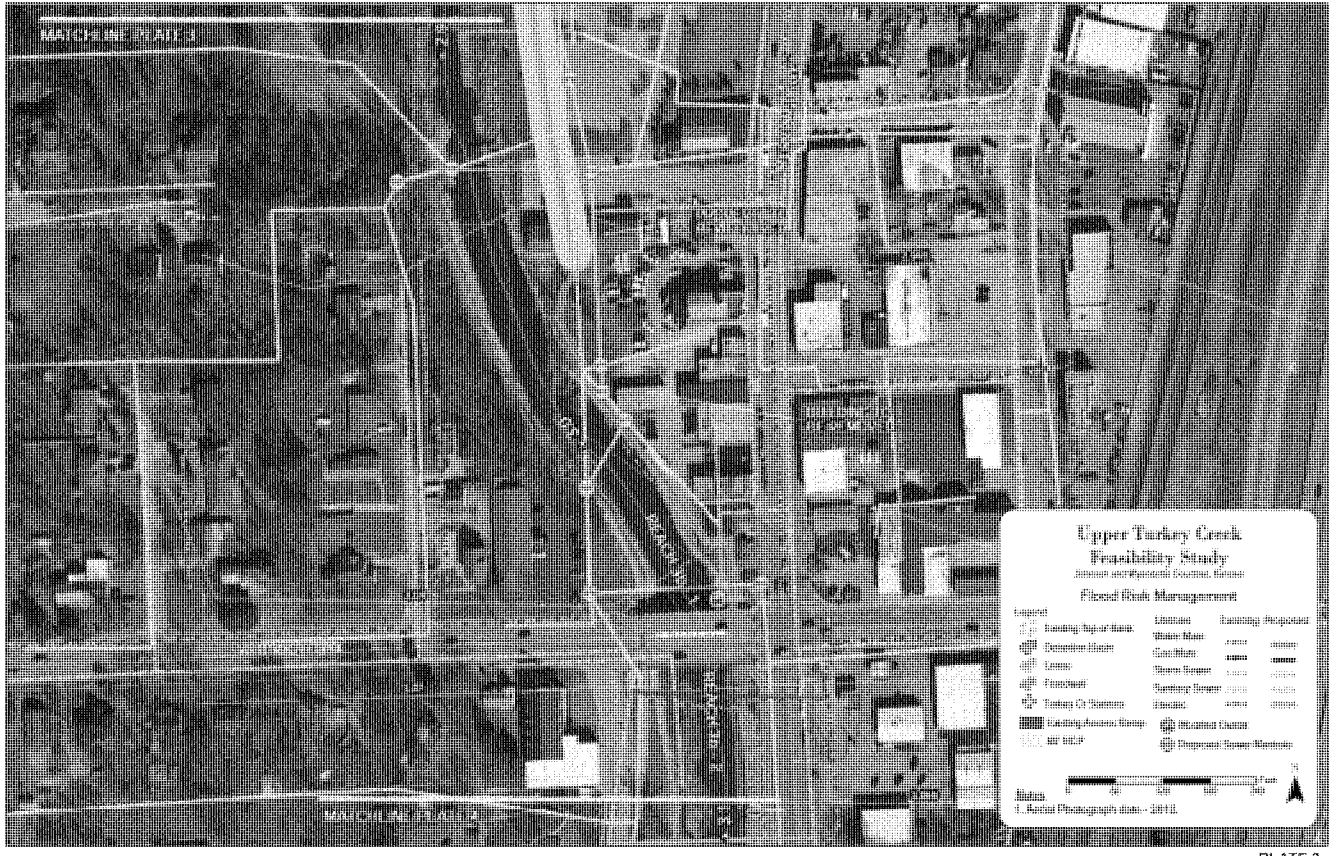


Figure 3: Recommended Plan (Alternative 2d) – Plate 3

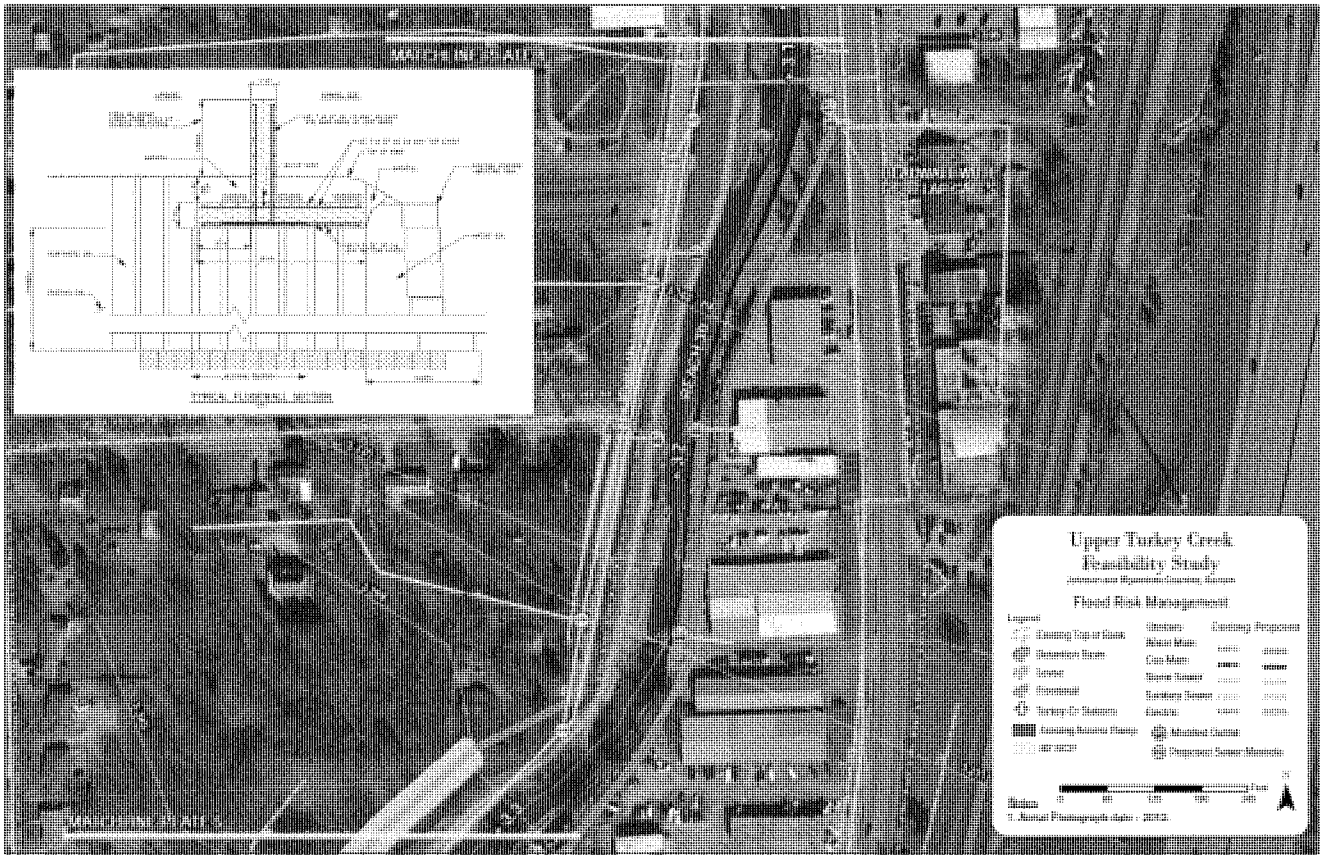


Figure 4: Recommended Plan (Alternative 2d) – Plate 4

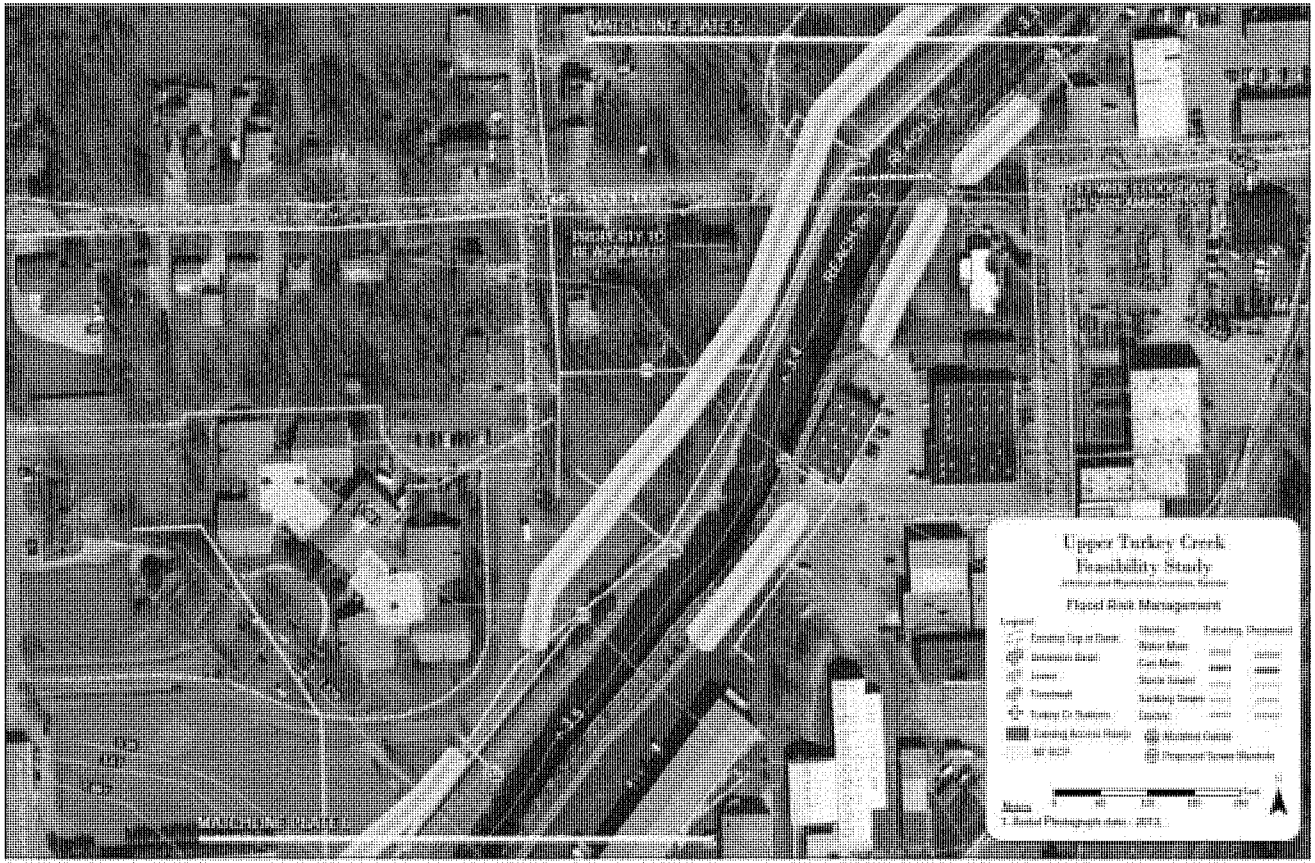


PLATE 5

Figure 5: Recommended Plan (Alternative 2d) – Plate 5

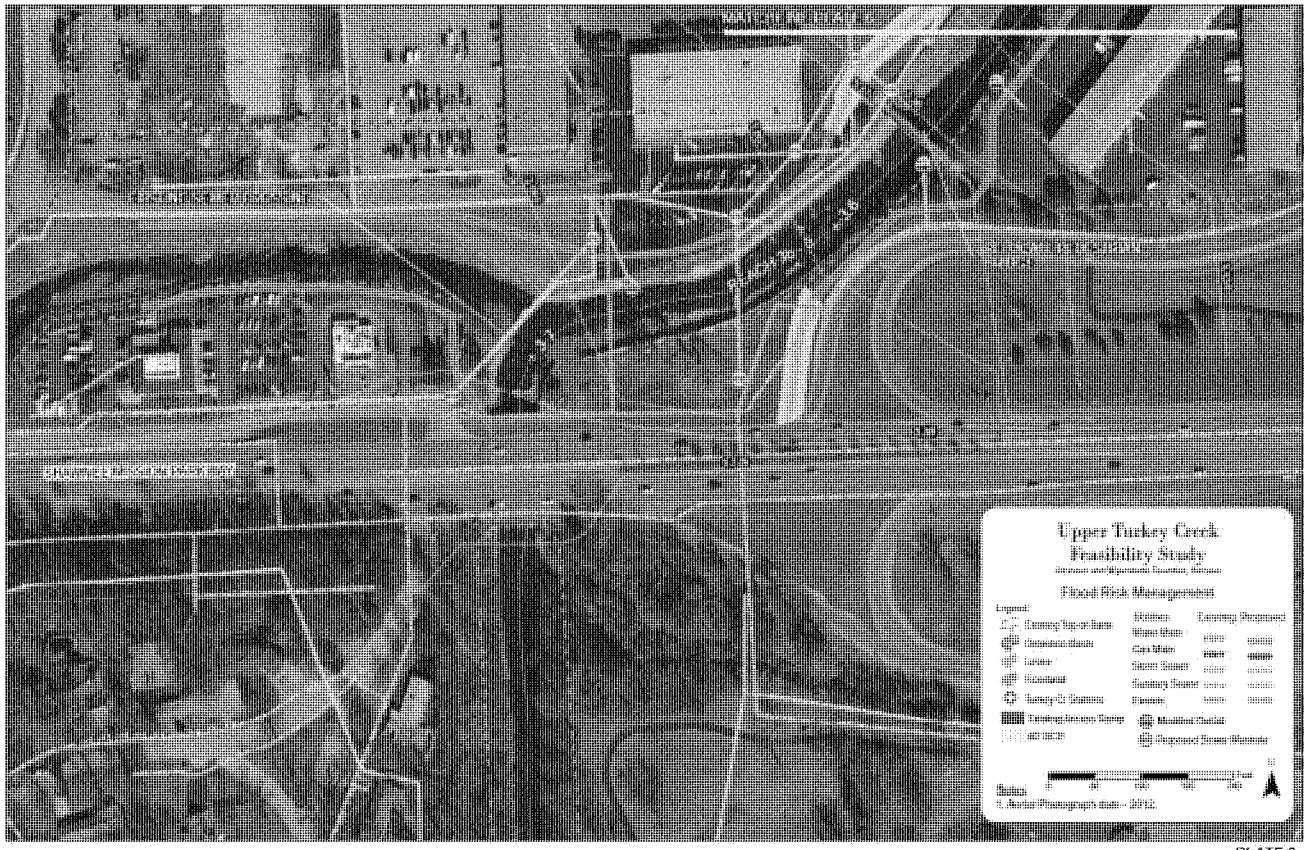


PLATE 6

Figure 6: Recommended Plan (Alternative 2d) – Plate 6

Bureau of Water
Watershed Management Section
1000 SW Jackson, Suite 420
Topeka, KS 66612-1367

Kansas

Phone: 785-296-4195
Fax: 785-296-5509
nps@kdheks.gov
www.kdheks.gov/nps

Robert Moser, MD, Secretary Department of Health & Environment Sam Brownback, Governor

December 8, 2014

Mr. Curtis R. Hoagland
Environmental Resources Specialist
Kansas City District
U.S. Army Corps of Engineers
635 Federal Building
Kansas City, Missouri 64106-2896

Section 401 Water Quality Certification

RE: PN2013-554: Applicant: Kansas City District, U.S. Army Corps of Engineers, 635 Federal Building Kansas City, Missouri 64106-2896

Mr. Hoagland:

On December 4, 2014, the Kansas Department of Health and Environment (KDHE) received, from the U.S. Army Corps of Engineers (USACE), Kansas City District, a request for Section 401 Water Quality Certification for the proposed Section 404 project. However, according to USACE, "Some minor modifications have occurred since the PN as described below. *There are no longer any project features upstream of Shawnee Mission Parkway. In Addition the foundations for the flood walls have been widened to add stability due to change in H&H rainfall data. This has reduced our impact to removal of trees from 4 acres to 3.6 acres. This decreased our loss of Average Annual Habitat Units from 3.2 to 2.7 AAHUs. As a result our mitigation will be the planting of 185 trees over 7 acres".* **The final report and EA will be posted on their website after they are approved by USACE HQ and finalized. The USACE will send KDHE a copy of the final feasibility report and EA/FONSI. Information concerning the Turkey Creek Project is located at:** http://www.nwk.usace.army.mil/Missions/CivilWorks/CivilWorksProgramsandProjects/UpperTurkeyCreek.aspx

Description from the U.S. Army Corps of Engineers, Kansas City District/KDHE Joint Public Notice dated June 27, 12013: "**Proposed**: The U.S. Army Corps of Engineers - Kansas City District, in cooperation with the City of Merriam, Kansas, propose a levee and floodwall project along Turkey Creek in Johnson County, Kansas. The purpose of this project is to address flooding risks along Turkey Creek within Merriam, Kansas. In addition, sections of the existing limestone revetment stream bank retaining wall would be replaced with rip rap in several locations within the project area to maintain bank stability. The National Economic Development (NED) plan involves the installation of concrete floodwalls and earthen levees in the project area. The Merriam downtown or Farmers' Market area would require construction of 280 feet of floodwall 5 feet high upstream of Merriam Drive on the left bank of Upper Turkey Creek. On the right bank of the creek, the alternative includes 550 feet of floodwall 5 to 6 feet high from Merriam Drive upstream to West 57th Street, then 990 feet of levee 6 feet high, and 550 feet of floodwall 6 feet high downstream of Johnson Drive. Two flap gates would be required on drainage structures discharging to the creek, and the Merriam Drive Bridge would require the incorporation of an approximately 4-foot high headwall. Storm sewer modifications would include 500 feet of storm drainage replacement, and an additional 830 feet of pipe rework, a 2,100-foot storm sewer trunk line, and a 2.14-acre/feet grass detention basin approximately 80 feet wide by 360 feet long located north of the Farmers' Market for internal drainage. Impacts to utilities would include reconstruction of a sanitary sewer line at the crossing south of the Farmers' Market. The Industrial and Railway Drive area would

require construction of 800 feet of floodwall 4 to 6 feet high beginning 300 feet upstream of Johnson Drive to 500 feet upstream of West 60th Street, then 440 feet of levee 5 feet high along the bike path to 100 feet north of West 61st Street on the left bank of the creek. On the right bank of the creek, the alternative includes 1,100 feet of floodwall 4 to 6 feet high south of Johnson Drive to 400 feet north of West 61st Street, then 400 feet of levee 5 feet high to West 61st Street. Three flap gates would be required on a triple culvert south of Johnson Drive. The Parkway vicinity would require construction of 725 feet of floodwall 5 feet high from 100 feet south of West 61st Street along the bike path to Knox Avenue where it joins West 62nd Street, then 700 feet of levee 3 to 5 feet high from West 62nd Street to West 62nd Terrace, and 930 feet of floodwall 3 feet high along West 62nd Terrace to Shawnee Mission Parkway on the left bank of the creek. On the right bank of the creek, the alternative includes 1,000 feet of floodwall 5 feet high from West 61st Street to 400 feet north of Shawnee Mission Parkway, then 300 feet of levee 5 feet high, and 100 feet of floodwall 4 feet high to Shawnee Mission Parkway. Six flap gates would be required on drainage structures discharging to the creek, and the pedestrian bridge near West 62nd Terrace would require modification to span 175 feet. Impacts to utilities would include reconstruction of a sanitary sewer and water line at and near Shawnee Mission Parkway. Direct project related impacts to waters of the U.S. would result from the replacement of existing limestone revetment blocks that line the channel banks and replacing it with 24-inch Bethany Falls riprap. Approximately 1,000 cubic yards of riprap will be placed below the ordinary high water mark of Turkey Creek in the following locations: the right descending bank from river mile (RM) 2.69 to 2.75, RM 2.93 to 3.03, RM 3.14 to 3.28, RM 3.39 to 3.42, RM 3.59 to 3.62, and the left descending bank from RM 3.60 to 3.64. The 50% annual flood chance flood event (2-yr return Interval) was used to represent the ordinary high water mark, which represents a conservative (slightly high) estimate of fill below ordinary high water mark. Project Drawings are included as Chapter 5 of the Draft Feasibility Report with Integrated Environmental Assessment. The project is located along Turkey Creek in Merriam, Kansas, from approximately Shawnee Mission Parkway to Merriam Drive in Johnson County, Kansas. It is in Section 12 of Township 12 South, Range 24 East. Turkey Creek in this area flows north to south and parallels I-35. A map of the project area is included in Chapter 5 of the Draft Feasibility Report with Integrated Environmental Assessment.

WETLANDS/AQUATIC HABITAT: There were no wetlands identified within or adjacent to the project area. The Habitat Evaluation Procedures (HEP) green sunfish Habitat Suitability Index (HSI) model was used to assess the impacts to waters of the U.S. as part of CWA Section 404 authorizations. This model has been certified for use by the National Ecosystem Planning Center of Expertise. The current HSI value for the green sunfish in the project area is 0.52, which results in 3.7 habitat units for the project area. The recommended plan would result in no change in HSI scores or habitat units, thus there would be no long-term adverse impact resulting from the proposed project on waters of the U.S. To evaluate the affect of the proposed project on the riparian floodplain area, the fox squirrel HSI model was utilized. The existing HSI score for the fox squirrel was 0.12, resulting in 3.18 habitat units over a 26.5 acre area. These habitat units would be lost under the proposed project from the removal of trees in the project footprint. This loss of riparian trees would be mitigated by the planting of 238 hard mast producing trees would be planted in the Upper Turkey Creek watershed. A Draft Section 404 (b)(1) Evaluation (40 CFR 230) has been prepared (See Appendix D in Draft Feasibility Report with Integrated Environmental Assessment).

STATEMENT OF AVOIDANCE, MINIMIZATION, AND COMPENSATORY MITIGATION FOR UNAVOIDABLE IMPACTS TO AQUATIC RESOURCES: Impacts to downstream receiving waters will be minimized by incorporating on-site best management practices. Alternatives with significant impacts to the ecosystem were screened out in the initial planning process. Unavoidable impacts of the project to riparian floodplain area will be offset by planting of 238 hard mast producing trees in the Upper Turkey Creek watershed."

The KDHE has reviewed the USACE provided material and determined the project has the following potential water pollutant discharge sources:

1. Construction and excavation activities including grading and filling, equipment and materials storage, equipment fueling and maintenance, etc.
2. Stabilizing of the creek bank
3. Significant disturbance of riparian area.

Discharges from these sources if not minimized or otherwise controlled may cause violations of the provisions of Kansas Water Quality Standards found at KAR 28-16-28 et seq. The Kansas Surface Water Register [KAR 28-16-28b(g)] documents this segment of (Upper)Turkey Creek being designated for uses including: Primary contact recreation stream segment is by law or written permission of the landowner open to and accessible by the public, aquatic life support, food procurement, domestic water supply, ground water recharge, industrial water supply, irrigation use and livestock watering.

The KDHE has reviewed the certification request materials and associated documents, in response to the joint public notice of the project and find there is a potential for significant water quality impacts. Therefore, KDHE issues this Section 401 Water Quality Certification subject to the conditions enumerated throughout this letter.

1) **This certification shall be posted on site through the duration of the project.**

2) The U.S Army Corps of Engineers shall avoid or control the discharge of suspended solids from riparian activities **so that the project does not cause:**

    a. Any surface waters of the state within and below the project area to contain discarded solid material, including trash, garbage rubbish, offal, grass clippings, discarded building or construction materials, car bodies, tires, wire and other unwanted or discarded materials [KAR 28-16-28e(b)(3)].

    b. Any surface waters of the state within and below the project to have floating debris, scum, foam, froth and other floating materials directly or indirectly attributable to the project [KAR 28-16-28e(b)(4)].

    c. Any surface waters of the state within or below the project to have of deposits of sludge or fine solids [KAR 28-16-28e(b)(6)].

    d. The concentration of dissolved oxygen in Turkey Creek to be lower than 5.0 mg/L, Kansas Surface Water Quality Standards [KAR 28-16-28e(d)] in table1g, found in a separate document found at: http://www.kdhe.state.ks.us/water/download/swqs_numeric_criteria.pdf .

    e. Addition of suspended solids to Turkey Creek in amounts and concentrations that will interfere with the behavior, reproduction, physical habitat, or other factors related to the survival and propagation of aquatic or semiaquatic life or terrestrial wildlife [KAR 28-16-28e(2)(B)].

3) Construction activities disturbing one acre or more are subject to the National Pollutant Discharge Elimination System (N.P.D.E.S.) storm water permit requirements of 40 C.F.R. 122.26. The U.S Army Corps of Engineers shall contact Mr. Larry Hook at 785/296-5549, lhook@kdheks.gov; Bureau of Water - Industrial Programs (BOW IP) for instructions or visit KDHE's website: www.kdheks.gov/stormwater. This permit requires a Stormwater Pollution Prevention Plan (SWP3) be prepared and retained on site.

4) The U.S Army Corps of Engineers shall avoid or control the discharge of toxic substances, oil and grease and other fluids from riparian activities, **so that the project does not canse:**

    a. Any surface waters of the state within and below the project area to have a public health hazard, nuisance condition or impairments of designed uses [KAR 28-16-28e(b)(1)].

    b. Any surface waters of the state within and below the project area to have a visible oil and grease film or sheen on the water surface or on submerged substrate or adjoining shore lines, nor have a sludge or emulsion deposit below the water surface of adjoining shorelines [KAR 28-16-28e(b)(5)].

    c. Any surface waters of the state within and below the project to contain taste and odor producing substances at concentrations which interfere with the production of potable water by conventional water treatment processes, impart an unpalatable flavor to edible aquatic or semi-aquatic life or terrestrial wildlife or that result in noticeable odors in the vicinity [KAR 28-16-28e(b)(7).

    d. The concentration of dissolved oxygen in Turkey Creek to be lower than 5.0 mg/L, Kansas Surface Water Quality Standards [KAR 28-16-28e(d)] in table1g, found in a separate document found at: http://www.kdhe.state.ks.us/water/download/swqs_numeric_criteria.pdf.

    e. The pH in Turkey Creek to be below 6.5 or above 8.5 including effects by concentrations of toxic substances. Refer to Surface Water Quality Standards [KAR 28-16-28e(d)] in table1g, a separate document found at: http://www.kdhe.state.ks.us/water/download/swqs_numeric_criteria.pdf

    f. Concentrations of toxic substances listed in Tables 1a, 1b, and 1c [KAR 28-16-28e(d)] in Turkey Creek to exceed the criteria set out in these tables [KAR 28-16-28e(c)(2)(D) & KAR 28-16-28e(c)(4)(A)].

    g. In Turkey Creek harmful concentrations of any substance alone or in combination with other substances causing toxic, carcinogenic, teratogenic, or mutagenic effects in humans [KAR 28-16-28e(c)(3)(C)].

    h. Concentrations of substances that bio-accumulate in the tissues of edible organisms to exceed a cancer risk level of (10^{-6}) in persons consuming organisms taken from Turkey Creek [KAR 28-16-28e(c)(4)(B)].

5) The activity shall avoid or control the discharge of plant nutrients from wetland removal, removal of permanent riparian vegetation, **so that the project does not cause:**

a. Accelerated succession or replacement of aquatic biota or the production of undesirable quantities or kinds of aquatic life in Turkey Creek [KAR 28-16-28e(c)(2)(A)].

b. Cause the development of objectionable concentrations of algae or algal by-products or nuisance growths of submersed, floating, emergent aquatic vegetation in Turkey Creek [KAR 28-16-28e(c)(7)(A)].

c. The concentration of dissolved oxygen in Turkey Creek to be lower than 5.0 mg/L, Kansas Surface Water Quality Standards [KAR 28-16-28e(d)] in table1g, found in a separate document found at: http://www.kdhe.state.ks.us/water/download/swqs_numeric_criteria.pdf.

6) The U.S Army Corps of Engineers shall avoid or control the discharge of *Escherichia-coli* bacteria from the project sites, especially human sanitation or housekeeping activities and surface runoff so that the project does not cause the *Escherichia-coli* bacteria concentration of Turkey Creek to exceed a geometric mean of 427 organisms per 100 milliliters during the period of April through October 31 and geometric mean of 3,843 organisms per 100 milliliters during the period of November 1 through March 31. [KAR 28-16-28e(c)(7)(D)].

7) The U.S Army Corps of Engineers shall prepare a water quality protection plan describing the actions that will be taken to comply with Certification Conditions 2-6. The SWPP referenced in condition 3 above will suffice. The applicant is strongly encouraged to also address the following items in the SWPP plan:

a. **Riparian Areas:** Minimize removal or disturbance of riparian areas (areas adjacent to water bodies). Strongly consider using native vegetation endemic to the area.

b. **Erosion and sediment control**: Maintain practices to minimize or avoid soil loss and sedimentation.

c. **Solid Waste:** All waste materials produced by the construction project shall be disposed of in accordance with the provisions of the Kansas solid waste management statutes and regulations (K.S.A. 65-3401 and K.A.R. 28-29-1 et. seq.) or applicable local rules. Good housekeeping including personal refuse such as food containers, sacks etc. shall be addressed.

d. **Fuels, Chemicals and Maintenance Areas:** All fuels and chemicals necessary to complete the project shall be stored in such a manner that accidental spillage is minimized or can be temporarily contained before reaching the water body. Equipment maintenance areas shall also be located in this manner.

e. **Spills:** Should a spill of fuel or discharge of pollutants occur, the local emergency staff should be contacted first by dialing 911. The Kansas Department of Health and Environment shall then be notified immediately: (785) 296-1679 (24 hours a day.) These incidences should also be reported to the National Spill Response Center (*1-800-424-8802). Hazardous materials spills and air releases that meet federal reportable quantities must also be reported to Kansas Division of Emergency Management (800-275-0297)."* These reporting numbers shall be posted in several locations around the site. A Spill Prevention and Response Plan should be prepared. This should include reportable quantity limits (see www.kansas.gov/kdem).

f. **Floating Debris:** The applicant shall take appropriate measures to capture any floating debris released to surface waters as a result of this project.

g. **Materials** used to stabilize stream banks area shall be free of pollutants which can wash or leach into waters of the state.

8) If the applicant believes the conditions of this certification will result in impairment of important widespread social and economic development, the applicant is advised of the variance provisions of KAR 28-16-28b(lll) and KAR 28-16-28f(e).

Questions concerning this certification may be directed to Mr. Scott Satterthwaite, 785-296-5573.

Sincerely,

Scott L. Satterthwaite

Scott L. Satterthwaite, M.S.
Non-point Source Pollution Control Specialist
Bureau of Water-Watershed Management Section

EC: KDHE- Rowlands, Stiles, Hook
KDA DWR- Phillips

Appendix E
USACE Jurisdictional Determination

PRELIMINARY JURISDICTIONAL DETERMINATION FORM

BACKGROUND INFORMATION

A. REPORT COMPLETION DATE FOR PRELIMINARY JURISDICTIONAL DETERMINATION (JD): April 26, 2013

B. NAME AND ADDRESS OF PERSON REQUESTING PRELIMINARY JD:

C. DISTRICT OFFICE, FILE NAME, AND NUMBER: Kansas City District, Upper Turkey Creek Feasibility Study, 2013-554

D. PROJECT LOCATION(S) AND BACKGROUND INFORMATION: The Corps of Engineers in conjunction with the local project sponsor, the City of Merriam conducted a feasibility study on decreasing the flood risk along Turkey Creek in Merriam, Kansas. The proposed project is a series of levees and floodwall approximately from Shawnee Mission Parkway to Merriam Drive (see attached maps). The plan includes approximately 6,035 feet of floodwall up to six feet in height, 2,740 feet of levees up to five feet in height, a total of 3,340 feet of storm drainage work, and a 2.14 acre-foot detention area. The project may also include some replacement of existing large stone retaining wall blocks with riprap within the channel to enhance stability.

(USE THE ATTACHED TABLE TO DOCUMENT MULTIPLE WATERBODIES AT DIFFERENT SITES)

State: Kansas County/parish/borough: Johnson and Wyandotte Counties
City: Merriam
Center coordinates of site (lat/long in degree decimal format): Lat. 39.020886° N, Long. 94.694782° **W**.
Universal Transverse Mercator: 15 S 353262 E 4320423
Name of nearest waterbody: Turkey Creek

Identify (estimate) amount of waters in the review area:
Non-wetland waters: Approximately 7,030 linear feet: 20 to 60 (~25ft average) width (ft) and/or acres.
Cowardin Class:
Stream Flow: Approximately 5 cfs
Wetlands: acres.
Cowardin Class:

Name of any water bodies on the site that have been identified as Section 10 waters:
Tidal: None
Non-Tidal: None

E. REVIEW PERFORMED FOR SITE EVALUATION (CHECK ALL THAT APPLY):

☒ Office (Desk) Determination. Date: April 26, 2013

☐ Field Determination. Date(s):

1. The Corps of Engineers believes that there may be jurisdictional waters of the United States on the subject site, and the permit applicant or other affected party who requested this preliminary JD is hereby advised of his or her option to request and obtain an approved jurisdictional determination (JD) for that site. Nevertheless, the permit applicant or other person who requested this preliminary JD has declined to exercise the option to obtain an approved JD in this instance and at this time.

2. In any circumstance where a permit applicant obtains an individual permit, or a Nationwide General Permit (NWP) or other general permit verification requiring "pre-construction notification" (PCN), or requests verification for a non-reporting NWP or other general permit, and the permit applicant has not requested an approved JD for the activity, the permit applicant is hereby made aware of the following: (1) the permit applicant has elected to seek a permit authorization based on a preliminary JD, which does not make an official determination of jurisdictional waters; (2) that the applicant has the option to request an approved JD before accepting the terms and conditions of the permit authorization, and that basing a permit authorization on an approved JD could possibly result in less compensatory mitigation being required or different special conditions; (3) that the applicant has the right to request an individual permit rather than accepting the terms and conditions of the NWP or other general permit authorization; (4) that the applicant can accept a permit authorization and thereby agree to comply with all the terms and conditions of that permit, including whatever mitigation requirements the Corps has determined to be necessary; (5) that undertaking any activity in reliance upon the subject permit authorization without requesting an approved JD constitutes the applicant's acceptance of the use of the preliminary JD, but that either form of JD will be processed as soon as is practicable; (6) accepting a permit authorization (e.g., signing a proffered individual permit) or undertaking any activity in reliance on any form of Corps permit authorization based on a preliminary JD constitutes agreement that all wetlands and other water bodies on the site affected in any way by that activity are jurisdictional waters of the United States, and precludes any challenge to such jurisdiction in any administrative or judicial compliance or enforcement action, or in any administrative appeal or in any Federal court; and (7) whether the applicant elects to use either an approved JD or a preliminary JD, that JD will be processed as soon as is practicable. Further, an approved JD, a proffered individual permit (and all terms and conditions contained therein), or individual permit denial can be administratively appealed pursuant to 33 C.F.R. Part 331, and that in any administrative appeal, jurisdictional issues can be raised (see 33 C.F.R. 331.5(a)(2)). If, during that administrative appeal, it becomes necessary to make an official determination whether CWA jurisdiction exists over a site, or to provide an official delineation of jurisdictional waters on the site, the Corps will provide an approved JD to accomplish that result, as soon as is practicable.

This preliminary JD finds that there *"may be"* waters of the United States on the subject project site, and identifies all aquatic features on the site that could be affected by the proposed activity, based on the following information:

SUPPORTING DATA. Data reviewed for preliminary JD (check all that apply - checked items should be included in case file and, where checked and requested, appropriately reference sources below):

☒ Maps, plans, plots or plat submitted by or on behalf of the applicant/consultant: US Army Corps of Engineers.

☐ Data sheets prepared/submitted by or on behalf of the applicant/consultant.
- ☐ Office concurs with data sheets/delineation report.
- ☐ Office does not concur with data sheets/delineation report.

☐ Data sheets prepared by the Corps: .

☐ Corps navigable waters' study: .

☒ U.S. Geological Survey Hydrologic Atlas: Online National Map Site.
- ☒ USGS NHD data.
- ☒ USGS 8 and 12 digit HUC maps.

☐ U.S. Geological Survey map(s). Cite scale & quad name: .

☐ USDA Natural Resources Conservation Service Soil Survey. Citation: .

☒ National wetlands inventory map(s). Cite name: Online NWI Mapper.

☐ State/Local wetland inventory map(s): .

☐ FEMA/FIRM maps: .

☐ 100-year Floodplain Elevation is: (National Geodectic Vertical Datum of 1929)

☐ Photographs: ☒ Aerial (Name & Date):2012, 2011, 2010, 2008, 2006.
or ☐ Other (Name & Date): .

☐ Previous determination(s). File no. and date of response letter: .

☐ Other information (please specify): .

<u>IMPORTANT NOTE: The information recorded on this form has not necessarily been verified by the Corps and should not be relied upon for later jurisdictional determinations.</u>

Signature and date of Regulatory Project Manager (REQUIRED)	Signature and date of person requesting preliminary JD (REQUIRED, unless obtaining the signature is impracticable)

SAMPLE

Site number	**Latitude**	**Longitude**	**Cowardin Class**	**Estimated amount of aquatic resource in review area**	**Class of aquatic resource**
1					
2					
3					
4					

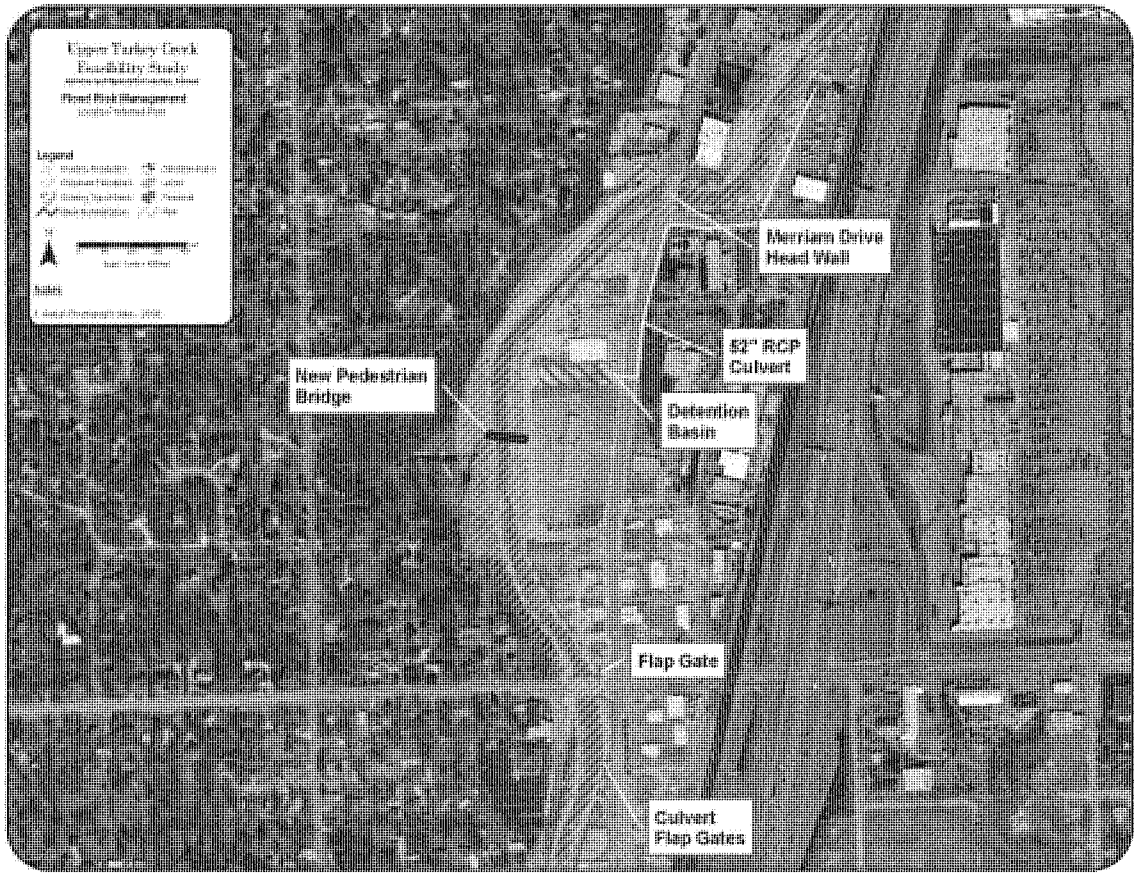


Figure ES-1: NED Plan-Northern Portion

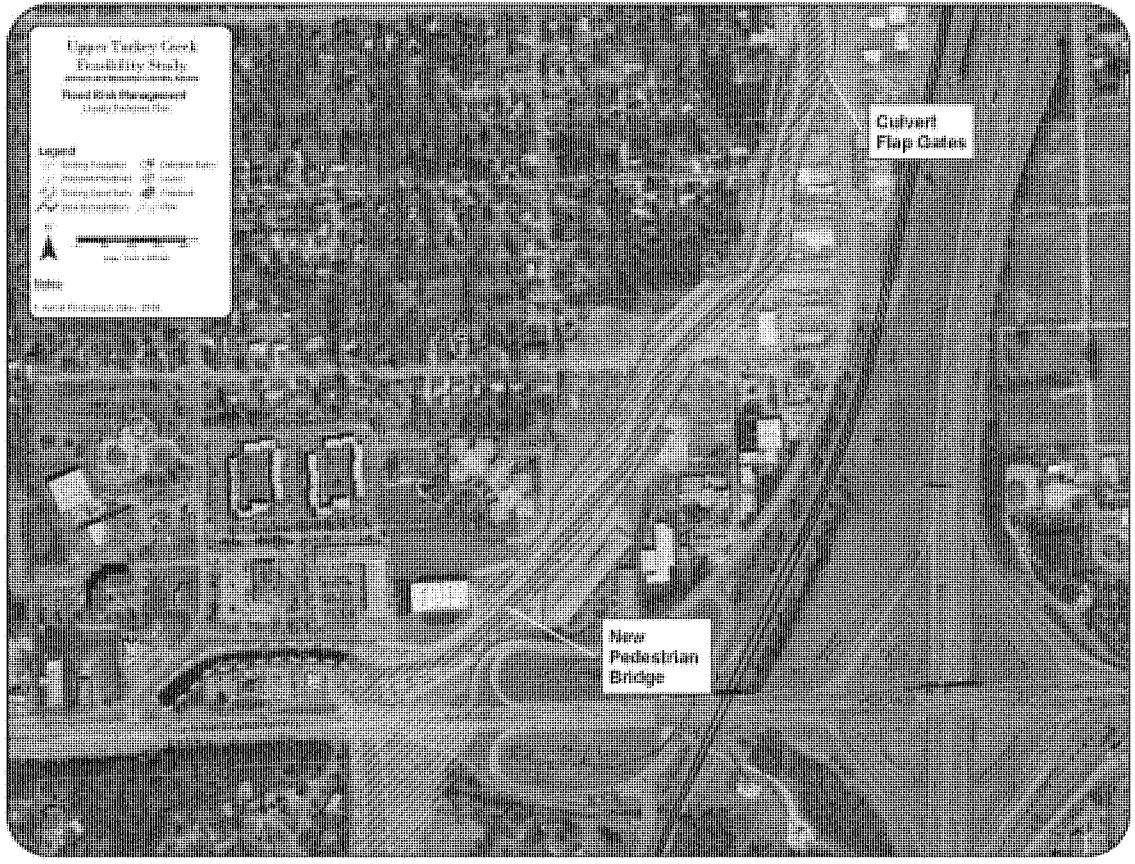


Figure ES-2: NED Plan-Southern Portion

Appendix F
Socioeconomics

SOCIOECONOMICS

APPENDIX F

UPPER TURKEY CREEK BASIN
Johnson and Wyandotte Counties, KS
Flood-Risk Management Project
Feasibility Study

January 2015

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

TABLE OF CONTENTS

1.0 INTRODUCTION 5

1.1 Purpose and Scope 5
1.2 References 5

2.0 STUDY AREA BACKGROUND 6

2.1 Study Area Location 6
2.2 Study Area Economy and Access 6
2.3 Study Area Socioeconomic Characteristics 6
2.4 Historical Flood Events and Damages 7

3.0 WITHOUT-PROJECT CONDITION ANALYSIS 9

3.1 Mapping 9
3.2 Study Reaches 9
3.2.1 Reach 1a 9
3.2.2 RR Bypass Reach 9
3.2.3 Reach 1b 10
3.2.4 Reach 2 10
3.2.5 Reach 3a 10
3.2.6 Reach 3b 10
3.2.7 Reach 3c 10
3.2.8 Reach 4 10
3.2.9 Reach 5 10
3.2.10 Tributary 81 Reach 10
3.2.11 Tributary 85 Reach 10
3.3 Economic Data Collection 10
3.3.1 Field Survey and Interviews 10
3.3.2 Descriptive and Location Data 11
3.3.3 Structure and Content Investment Values 11
3.3.4 Damageability and Uncertainties 12
3.3.5 Investment in Roads, Elevations, Damageability 14
3.4 Study Area Investment 14
3.4.1 Summary of Study Area Investment 14
3.4.2 Reach 3a 15
3.4.3 Reach 3b 15
3.4.4 Reach 3c 15
3.5 Physical Damages and Other Costs of Flooding 15
3.5.1 Analysis Years 15
3.5.2 Damage Categories 16
3.5.3 Damage Calculation Methodologies and Uncertainties 16
3.6 Results of Damage Analysis for Existing (Without-Project) Condition 18
3.6.1 Beginning Damage Elevations 18
3.6.2 Integration of Stage-Damage and Stage-Discharge-Frequency Relationships 19
3.6.3 Exceedance Probability-Damage (including risk and uncertainty) for the Interim Feasibility Report Units 23
3.7 Existing Condition Engineering Performance 28
3.7.1 Annual Performance and Equivalent Long-term Risk of the Existing Project 28
3.7.2 Alternative Display of Annual Performance and Equivalent Long-Term Risk of the Existing Project 28
3.7.3 Conditional Probability of Design Non-Exceedance. 29

3.8 Future Without-Project Condition 29
3.8.1 National Economic Development, Regional Economic Development Impacts, and Other Social Effects Without Project 29

4.0 WITH-PROJECT CONDITION ANALYSIS 30

4.1 NED Analysis of Benefits and Costs 30
4.2 Residual Damages and Benefits of Screening Alternatives 30
4.3 Costs of Screening Alternatives 31
4.3.1 Annual Project Costs 31
4.3.2 Annual OMRR&R Costs 35
4.3.3 Other Direct and Associated Costs of Implementation 36
4.3.4 Total Annual Costs 36
4.4 Summary of Economic Screening of Alternatives Considered 37
4.5 Economic Performance with Uncertainty for Screening Alternatives Considered . 37
4.6 Engineering Performance of Screening Alternatives Considered 38
4.6.1 Annual Performance and Eq uivalent Long-term Risk 38
4.6.2 Conditional Probability of Design Non-Exceedance 40
4.7 RED Impacts With Project 40
4.8 Other Social Effects With Project 41

5.0 NED PLAN 42

6.0 INCREMENTAL ANALYSIS 42

7.0 UPDATED WATER-SURFACE PROFILES AND SENSITIVITY ANALYSIS 43

8.0 THE NED PLAN 46

8.1 NED Plan Costs 47
8.2 NED PLAN Performance 48
8.2.1 BENEFITS AND COSTS 48
8.2.2 Damage Reduction by Category and Event 49
8.2.3 Engineering Performance (Assurance) 50
8.2.4 RED and OSE Effects 51
8.3 Residual Risk 51
8.3.1 Residual Damages 51
8.3.2 Risk of Project Capacity Exceedance 52

9.0 PLAN FOR ECONOMIC UPDATES 52

10.0 CONCLUSION 54

LIST OF FIGURES

Figure 4-1: Planning Set "CEICA Analysis 2" Cost and Output 34
Figure 4-2: Planning Set "CEICA Analysis 2" Incremental Cost and Output 34

LIST OF TABLES

Table 2-1: Population, Employment, and Housing Characteristics, 2010 7
Table 2-2: Turkey Creek Flood History 8
Table 3-1: Initial Study Reaches 9
Table 3-2: Study Area Investment 15
Table 3-3: Example Depth-Percent Damage Function Report for "AMASONRY" Auto Repairs and Auto Parts – "Other" Damage Category 17
Table 3-4: Example Stage-Damage Report Without Project Commercial Damage Category 18
Table 3-5: Significant Damage Events and Elevations 19
Table 3-6: Exceedance Probability-Discharge Function Report for Damage Reach 3b 20
Table 3-7: Stage-Discharge Report for Damage Reach 3b 21
Table 3-8: Exceedance Probability-Damage Function Report for Damage Reach 3b 22
Table 3-9: Existing Without Project Condition Primary Damages (with Risk and Uncertainty) 23
Table 3-10: Existing Condition Primary Damages (with Risk and Uncertainty) by Category for Selected Events 24
Table 3-11: Minimum Number of Structures/Groups of Structures Affected 25
Table 3-12: Existing Condition Primary Damages (with Risk and Uncertainty) for Structures, Contents, and Other for Selected Events 26
Table 3-13: Existing Condition (Without Project) Annual Damages 27
Table 3-14: Existing Condition (Without Project) Other Costs of Flooding (Clean-Up) 27
Table 3-15: Annual Performance and Equivalent Long-Term Risk, Existing Condition 28
Table 3-16: Alternative Display of Annual Performance and Equivalent Long-term Risk, Existing Condition 28
Table 3-17: Conditional Probability of Design Non-Exceedance, Existing Condition 29
Table 4-1: Equivalent Annual Benefits and Residual Damages With and Without Project 31
Table 4-2: Detailed Breakdown of Project First Costs by Alternative 32
Table 4-3: Results of IWR Planning Suite Cost Effectiveness Analysis 33
Table 4-4: Results of IWR Planning Suite Incremental Cost Analysis 33
Table 4-5: Evaluation of Best Buy Options against Minimum Mitigation Requirement 35
Table 4-6: Mitigation Options and Mitigation Costs Used in Economic Screening 35
Table 4-7: Detailed Cost Breakdown for Screening Alternatives for Merriam 36
Table 4-8: Screening Summary With-Project Annual Benefits, Costs, and Net Benefits 37
Table 4-9: Economic Performance with Uncertainty for Merriam Alternatives 38
Table 4-10: Annual Performance and Equivalent Long-term Risk for Merriam Reach 3b 39
Table 4-11: Conditional Probability of Design Non-Exceedance 40
Table 5-1: Summary With-Project Annual Benefits, Costs, and Net Benefits for NED Plan and Locally Preferred Plan 42
Table 7-1: Sensitivity Analysis - Equivalent Annual Benefits and Residual Damages With and Without Project 44

Table 7-2: Sensitivity Analysis - Detailed Breakdown of Project First Costs by Alternative.....44
Table 7-3: Sensitivity Analysis - Detailed Cost Breakdown for Alternatives Considered.....45
Table 7-4: Sensitivity Analysis - Annual Benefits, Costs, and Net Benefits of Alternatives.....45
Table 7-5: Economic Performance with Uncertainty for Merriam Alternatives.....45
Table 7-6: Annual Performance and Equivalent Long-term Risk for Merriam Reach 3b 46
Table 7-7: Conditional Probability of Design Non-Exceedance.....46
Table 8-1: Detailed Breakdown of Project First Costs for NED Plan.....47
Table 8-2: Detailed Breakdown of Annual Costs for NED Plan.....48
Table 8-3: Summary of With- and Without-Project Annual Damages, Benefits and Costs 48
Table 8-4: Probabilistic Economic Performance of NED Plan 48
Table 8-5: Future With and Without Project Condition EAD by Category 49
Table 8-6: Single-Event Exceedance Probability-Damage with NED Plan.....50
Table 8-7: Annual Performance and Equivalent Long-term Risk for NED Plan (Merriam Reach 3b) 50
Table 8-8: Annual Performance and Equivalent Long-Term Risk for NED Plan (Merriam Reach 3b) 51
Table 8-9: Conditional Probability of Design Non-Exceedance 51

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of this economic analysis is to identify the extent of the economic impact from flooding and, on a comparable basis, evaluate the range of plans considered in the study. The analysis requires a risk-based analysis of the flood problem under the existing condition. The existing, future without-project, and future with-project conditions are established, and a risk-based evaluation in terms of benefits, costs, and performance of the various alternatives under the with-project condition is presented. The analysis encompasses all flood-prone properties within the study area.

1.2 REFERENCES

The analysis was accomplished under the procedures outlined in the following:

- Economic and Environmental Principles and Guidelines for Water and Related Resources Implementation Studies (P&G) -- Water Resources Council, 1983;
- Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook -- 22 April 2000;
- ER 1105-2-101, Risk Analysis for Flood Damage Reduction Studies -- 3 January 2006;
- Engineering Manual (EM) 1110-2-1619, Risk-Based Analysis for Flood Damage Reduction Studies -- 1 August 1996;
- HEC-FDA Flood Damage Reduction Analysis User's Manual (Version 1.2.4) -- Hydrologic Engineering Center, USACE Institute for Water Resources, November 2008.
- Economic Guidance Memorandum (EGM) 04-01, Generic Depth-Damage Relationships for Residential Structures With Basements – USACE Institute for Water Resources, 10 October 2003.
- Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios in Support of the Lower Atchafalaya Reevaluation and Morganza to the Gulf, Louisiana Feasibility Studies – USACE-MVN (New Orleans District), May 1997;
- IWR Report 96-R-12, Analysis of Non-residential Content Value and Depth-Damage Data for Flood Damage Reduction Studies -- Jack C. Kiefer and J. Scott Willett (Planning & Management Consultants Ltd., Carbondale IL), May 1996;
- EGM 09-04, Generic Depth-Damage Relationships for Vehicles -- 22 Jun 2009;
- Water Resources Development Act (WRDA) of 1990, Section 308;
- Residential Cost Handbook -- Marshall & Swift, various updates 2002-2010;
- EM 1110-2-1304, Civil Works Construction Cost Index System (CWCCIS) – version of 30 September 2013.
- Engineer Circular 1165-2-209, Civil Works Review Policy -- 31 January 2010.

Other references pertinent to the analysis include the following:

- 1993 Interagency Floodplain Management Review Committee Report (Galloway Report);
- *Impacts of the Great Flood of 1993*, U.S. Army Corps of Engineers Lower Mississippi Valley Division, May 1996;
- Flood Plain Management Assessment of the Upper Mississippi River and Lower Missouri Rivers and Tributaries, U. S. Army Corps of Engineers June 1995.

2.0 STUDY AREA BACKGROUND

2.1 STUDY AREA LOCATION

Turkey Creek is a right bank tributary of the lower Kansas River. The Upper Turkey Creek Basin study area is located in northeastern Johnson and southeastern Wyandotte Counties in Kansas and is a part of the Kansas City Metropolitan Statistical Area (MSA). The initial study area boundaries were Upper Turkey Creek stream miles (RM) -1.119 to 7.508. RM 0 is at the boundary between Johnson and Wyandotte Counties. The basin contains a highly developed urban area in the Kansas portion of the Kansas City MSA. Portions of the Kansas cities of Merriam, Lenexa, Overland Park, and Kansas City are located in the basin study area. The focus of the screening is on the Merriam reaches (RM 2.035 to 5.394) because this is the only area that has both very significant investment in the floodplain and interest from the local sponsor in a flood risk management project.

2.2 STUDY AREA ECONOMY AND ACCESS

The Upper Turkey Creek study area is part of the Kansas City MSA, which has a diverse and varied economic base. As a centrally located market, the Kansas City metropolitan area is a major warehouse and distribution center and a leading agribusiness center. It ranks first in the nation as a farm distribution center and as a market for hard wheat. In addition to its agribusiness activities, the Kansas City metropolitan area has major industrial activities, such as auto and truck assembly, steel and metal fabrication, and food processing. The Kansas City metropolitan area also fosters a growing non-manufacturing sector. Wholesale and retail industries and service organizations are now chief employers in the area. The initial Upper Turkey Creek study area (RM -1.119 to 7.508) contains approximately 105 businesses, including about 90 commercial and industrial buildings in the Merriam reaches that are the focus of the analysis (RM 2.035 to 5.394). Types of businesses range from light manufacturing, construction and earthwork, auto repair, auto sales, and tool and die manufacturing to retail and service businesses.

The Kansas City metropolitan area has a major network of interstates and major highways that provide excellent access to the study area. The area is easily accessed by Interstate 35 (I-35), which runs parallel to Turkey Creek and the study area. Kansas City International Airport, some 20 miles north of the study area, is easily accessible via the interstate system. Major rail service also is available to the study area.

2.3 STUDY AREA SOCIOECONOMIC CHARACTERISTICS

Census 2010 data for 14 tracts encompassing the overall study area were compiled to describe the socioeconomic characteristics of the study area. Census 2010 data were also compiled for counties in the study area and for the Kansas City, Missouri, and Kansas MSA. Although census tracts cover areas that may typically be somewhat larger than the study area, tract data are considered to be generally representative of study area characteristics. The overall study area includes portions of Kansas Census tracts (KCT) numbers 434, 450, 502, 503.01, 504, 511, 519.03, 519.06, 519.07, 520.01, 520.04, 521.01, 522.01, and 9800.02. The Merriam project area includes portions of five Johnson County tracts. These include KCT numbers 519.06, 520.01, 520.04, 521.01, and 522.01.

The 2010 population of the overall study area's 14 census tracts was 42,503, and the population of the Merriam reaches was 14,857, which equates to about 2.1 percent and 0.7 percent of population of the Kansas City MSA, respectively. Approximately 20.5 percent of the overall study area population and 19.0 percent of the Merriam reaches population were 17 years of age or younger. Approximately 12.1 percent of the overall study area's population and 12.6 percent of the population of the Merriam reaches was over the age of 65. There were 19,801 households in the census tracts in the overall study area with an average household size of 2.1. The 6,804 households in the Merriam reaches have an average household size of 2.1, compared with an average household size of 2.2 for Merriam. There were 21,907 housing units in the overall study area, 46.7 percent of which were owner occupied, 43.6 percent renter occupied, and the remaining 9.6 percent vacant. In

the Merriam reaches, there were 7,440 housing units, of which, 42.9 percent were owner occupied, 48.6 percent were renter occupied, and 8.5 percent were vacant.

The two primary economic indicators in the study area are employment and income. The indicators show the number and the quality of the jobs available to the study area population. At the time data were collected for the 2010 census, the census tracts in the overall study area experienced unemployment of 6.1 percent, which was significantly below the national average of 7.9 percent. The 3.9 percent unemployment rate for the census tracts in the Merriam project area was even lower. The range of median household income is $37,744 to $59,486 for the census tracts in the overall study area and $41,910 to $59,486 for the census tracts in the Merriam project area. For comparison, the median population for the United States is in the middle of these ranges at $51,914.

Table 2-1 displays the population, employment, and housing characteristics for the study area census tracts, Johnson and Wyandotte Counties, and the Kansas City MSA.

Table 2-1: Population, Employment, and Housing Characteristics, 2010

	Overall Study Area Census Tracts	Merriam Project Area Census Tracts	Merriam, Kansas	Johnson County, Kansas	Wyandotte County, Kansas	Kansas City (MO-KS) MSA	Kansas	United States
Population 2010	42,503	14,857	11,107	531,228	155,462	1,999,718	2,809,329	303,965,272
Households 2010	19,801	6,804	5,125	210,278	57,207	789,432	1,101,672	114,235,996
Average number of persons per household	2.1	2.1	2.2	2.5	2.7	2.5	2.5	2.6
% Under age 18	20.5%	19.0%	18.6%	26.7%	28.2%	25.8%	25.5%	24.4%
% Over age 65	12.1%	12.6%	13.4%	10.6%	10.7%	11.7%	13.1%	12.7%
Unemployment	6.1%	3.9%	5.2%	4.6%	12.2%	6.8%	6.0%	7.9%
Median[a] household income	$37,744 to $59,486	$41,910 to $59,486	$49,957	$73,733	$38,503	$55,749	$49,424	$51,914
Housing vacancy rate	9.6%	8.5%	6.3%	5.4%	14.4%	9.6%	9.9%	12.2%
Median[a] house value	$73,600 to $159,000	$148,300 to $158,000	$155,000	$209,900	$97,600	$158,000	$122,600	$188,400

Source: U.S. Census American Community Survey 2010 5-year estimates

[a] Median values are given as the range of median values among the census tracts, excluding Census Tract 9800.02, which did not have enough houses or households to provide a meaningful median.

2.4 HISTORICAL FLOOD EVENTS AND DAMAGES

Repeated flooding by Turkey Creek has caused severe physical flood damages and loss of revenues during periods of flooding. It also has significantly impacted transportation access in the area. Significant damage in the basin has occurred most recently in 1961, 1977, 1993, 1998, and 1999. Damages reported for the July 1993 flood in Merriam were about $3.4 million (approximately $6.4 million in October 2014 dollars, using the ENR Construction Cost Index or CCI to adjust). In October 1998, estimated flood damages in Merriam totaled $12 million (approximately $19.8 million in October 2014 dollars based on the CCI), and I-35, which runs parallel to Turkey Creek, was overtopped at five different locations. The U.S. Army Corps of Engineers (USACE), Kansas City District, hydrology and hydraulics staff estimates that the 1998 flood event was a 1-percent event, but there is a high degree of uncertainty for this estimate since Upper Turkey Creek is an ungaged stream. It is also important to note that reported damages are often not wholly representative of actual total damages incurred during flood events because many people and businesses do not report damages to officials and post-flood surveys are often less than comprehensive. Table 2-2 lists known flood events in both the upper and lower portions of the

Turkey Creek Basin, including a description of the flooding and estimated damages if known. (The mentions of Rosedale refer to a neighborhood downstream of the Upper Turkey Creek study area.) Specific historical flood damage data were collected during interviews of businesses in the study area and noted in the structure inventory data.

Table 2-2: Turkey Creek Flood History

Event	Description of Flooding	Estimated Damages (price level based on year of occurrence)
May 5–6, 1904	Not available.	Unknown
October 21–22, 1908	Not available.	Unknown
September 6–7, 1914	Not available.	Unknown
June 1, 1935	Flood depths up to 7 feet occurred with estimated discharge of 13,650 cfs. Commercial, industrial, and railroad damages were experienced in Merriam, Rosedale, and along Southwest Boulevard.	Unknown
April 21–22, 1944	Not available.	
July 30–31, 1958	Flood damage at Merriam and along Southwest Boulevard, at least 69 buildings damaged. Railroad tracks washed out west of Roe. Estimated discharge of 4,400 cfs at Merriam.	$155,000
September 12–13, 1961	Flooding damaged at least 82 buildings; No. 10 Fire Station was flooded to 1 foot depth, and I-35 was under water.	$240,000
July 21, 1968	Not available.	Unknown
September 12–13, 1977	Significant damage occurred along Southwest Blvd in the Rosedale District (estimated discharge of 11,700 cfs) and in Merriam; numerous buildings were damaged.	$8,100,000
April 1, 1983	Rosedale District and the state line area experienced severe flooding. Flood depths reached an estimated 4–6 feet in the state line area (estimated 12,500 cfs discharge).	Unknown
September 17, 1986	Rosedale District experienced severe damage with many buildings flooded. I-35 northbound lanes under water and other transportation damages occurred. Damages to city infrastructure (e.g., bridges, sewers, and streets).	Unknown
July 10, 1993	Largest flood on record. Damages in Rosedale, state line, and the Kansas City Central Industrial District. One fatality, but loss of life could have been greater had flood occurred during business hours rather than in the early morning hours.	$22,000,000 (partial estimate)
October 4–5, 1998	Severe flash flooding in Merriam and along Southwest Boulevard, numerous flooded buildings, mud and debris deposits. Flood depths and extents of flooding were very similar to the 1993 event. I-35 was closed for a few hours.	$25,000,000 (rough partial estimate)
June 27–28, 1999	Some businesses along Southwest Boulevard flooded (approximately 1-foot depth); people rescued from cars stalled in high water; street intersections closed; I-35 closed at 18th Street, and at Lamar, for a couple of hours.	Unknown
August 28, 2004	Limited flooding; buildings downstream along Southwest Boulevard were evacuated.	Unknown

3.0 WITHOUT-PROJECT CONDITION ANALYSIS

3.1 MAPPING

Electronic mapping data files were obtained from local government sources, and Kansas City District GIS staff compiled detailed aerial maps of the study area with 2-foot contours. GIS staff also obtained electronic files from local cities and counties that contained structure footprints and land parcel data (including parcel valuation). Kansas City District economics staff completed the data collection for commercial, residential, and public investment in the study area.

3.2 STUDY REACHES

For purposes of the analysis, the initial study area along Upper Turkey Creek was divided into nine reaches, including a split-flow reach that runs parallel to the main channel. A reach also was designated for each of two Upper Turkey Creek tributaries. Table 3-1 below lists the study reaches, their river mile boundaries, and the designated index point location for each reach. The reach index point is used to aggregate the stage damage relationships for the different categories of investment in each reach at a common location.

Table 3-1: Initial Study Reaches

Damage Reach Name	Beginning Station (RM)	Ending Station (RM)	Bank	Index Location Station (RM)
Reach 1a	-1.199	-0.730	Both	-0.816
RR Bypass Reach	-0.590	-0.525	Both	-0.560
Reach 1b	-0.730	0	Both	-0.206
Reach 2	0	2.035	Both	.897
Reach 3a	2.035	2.593	Both	2.120
Reach 3b	2.593	3.855	Both	3.298
Reach 3c	3.855	5.394	Both	4.767
Reach 4	5.394	7.247	Both	6.038
Reach 5	7.402	7.508	Both	7.479
Tributary 81 Reach	5.649	6.708	Both	6.1
Tributary 85 Reach	5.855	6.712	Both	6.187

3.2.1 REACH 1A

Reach 1a is located in Wyandotte County. The downstream reach limit is RM –1.199, located slightly east of the intersection of Roe Lane and Merriam Lane. The upstream limit is RM –0.730, which is the boundary of a potential Roe Lane project area. Because of lack of interest from the local sponsors, Reach 1a was not evaluated in detail with the Hydrologic Engineering Center-Flood Damage Reduction Analysis (HEC-FDA) software to screen alternatives.

3.2.2 RR BYPASS REACH

The RR Bypass Reach is a split-flow reach that runs parallel to Reach 1a of Upper Turkey Creek. Structures in the RR Bypass Reach are subject to flooding from both RR Bypass Reach and Reach 1a. Similar to Reach 1a, the RR Bypass Reach was not evaluated in detail with the HEC-FDA software to screen alternatives, due to lack of interest from local sponsors.

3.2.3 REACH 1B

Reach 1b is located between the potential Roe Lane project area (RM –0.730) and the county line at RM 0. Reach 1b was not evaluated in detail with the HEC-FDA software.

3.2.4 REACH 2

Reach 2 is within Johnson County, Kansas, extending from RM 0 to 2.035, flowing through portions of Mission and Overland Park between Merriam and the county line. Reach 2 was not evaluated in detail with the HEC-FDA software.

3.2.5 REACH 3A

Reach 3a is just downstream of the potential project area in Merriam, between RM 2.035 near Antioch Road and RM 2.593 near 55th Street. Reach 3a was evaluated in detail with the HEC-FDA software.

3.2.6 REACH 3B

Reach 3b is the potential project area in Merriam between RM 2.593 near 55th Street and RM 3.855 near 63rd Street (Shawnee Mission Parkway). Reach 3b was evaluated in detail with the HEC-FDA software, and its boundaries are shown in Figures 5-1 through 5-4 of Chapter 5.

3.2.7 REACH 3C

Reach 3c is located between the potential Merriam project area (RM 3.855) and 75th Street (RM 5.394). Reach 3c was evaluated in detail with the HEC-FDA software.

3.2.8 REACH 4

Reach 4 extends from RM 5.394 to 7.247 just north of 87th Street Parkway. Reach 4 was not evaluated in detail with the HEC-FDA software.

3.2.9 REACH 5

Reach 5 is located between RM 7.247 to 7.508 in the area of 87th Street Parkway. Reach 5 was not evaluated in detail using the HEC-FDA software.

3.2.10 TRIBUTARY 81 REACH

Tributary 81 Reach is located at Turkey Creek RM 5.649 (confluence) and extends slightly more than 1 mile upstream to tributary mile 6.708. Tributary 81 was not evaluated in detail with the HEC-FDA software.

3.2.11 TRIBUTARY 85 REACH

Tributary 85 Reach is located at Turkey Creek RM 5.855 (confluence) and extends approximately nine-tenths of a mile upstream to tributary mile 6.712. Tributary 85 was not evaluated in detail with the HEC-FDA software.

3.3 ECONOMIC DATA COLLECTION

Economic data collection efforts for the small number of residential structures were based on visual observation during the field survey. Data obtained for the commercial, industrial, and public facilities were based on a mix of direct interviews of typical businesses in the study area and visual field observation.

3.3.1 FIELD SURVEY AND INTERVIEWS

Kansas City District staff conducted a windshield survey of all development in the study area to identify individual businesses and entities subject to flood damage. A survey form recently approved by Office of Management and Budget for use in data collection efforts for another Kansas City District study was used for the field survey data collection efforts in the Upper Turkey Creek study. A sample of the survey form is included as Attachment 1. Based on visual observation

during the windshield survey, a mix of businesses representative of typical businesses in the study area was identified for interviews conducted by Kansas City District economics staff.

Completed interview survey forms provided detailed information about property values, location of damageable investment, and damage susceptibility of the investment at various depths of flooding. Data included the type of business, depreciated replacement structure value, and investment values by physical location (basement, first floor, second floor) for inventory, office equipment, production equipment, and other contents. Survey data also included estimates of potential damage to structure, inventory, equipment, and other contents with various potential depths of flooding. Information on historical flood events and historical damages was obtained in some cases. However, many respondents indicated that they were not occupants of the area during the last major damage event.

The 32 interviews accounted for about 32 percent of the estimated total commercial investment. The earlier survey data were augmented and updated by additional windshield surveys conducted in 2007 and 2012 to identify any significant changes in investment in the study area.

3.3.2 DESCRIPTIVE AND LOCATION DATA

Visual observation during the windshield survey and review of aerial survey maps were used to develop descriptive and location data for structures, including: name and address of business occupant, as available; type of business; number of buildings; first floor above ground height and low entry elevations; type of construction material; estimated effective age; and condition of the building -- all noted during the windshield survey. The ground elevation for each structure was determined based on the aerial maps with 2-foot contours and spot elevations. Where similar structure/investment entity types were located adjacently and at similar elevations, such structures/investments were grouped and entered into HEC-FDA as a single entry. For identification purposes, each structure or group of structures was assigned a structure number corresponding to the aerial map structure number and a river mile location based on the cross-sections on the maps. Square footage data for each structure were obtained from GIS data files. The GIS square footage data were checked during the windshield survey in order to minimize square footage calculation errors from roof overhangs, multiple structure groupings, or multiple story buildings. Vehicles and any outdoor inventories and equipment were usually assumed to have the same ground elevation as the associated structure.

3.3.3 STRUCTURE AND CONTENT INVESTMENT VALUES

Commercial values - Data provided by business owners and representatives were used for the businesses that were interviewed. For businesses that were not interviewed, depreciated replacement values developed using Marshall & Swift data were computed for each structure, based on the descriptive data obtained during the windshield survey (type of business, class of structure, exterior walls make, effective age and condition). For purposes of determining business content values for the businesses that were not interviewed, the interviewed businesses in the study area were grouped by general business type, based on information obtained during the interview. A typical dollar value per square foot was developed for each group of similar business types based on study area interview data. Then, for businesses not interviewed, the typical dollar value per square foot was multiplied by the square footage of the structure to determine an estimated content value.

The commercial "other" category in this analysis is used only for those businesses with equipment and inventory stored outside. The only such businesses that are characterized with a value for the "other" category are the auto and transportation-related businesses such as garages and dealerships. For these businesses, the "other" category is used to account for external inventory in the form of cars, trucks, and other vehicles on the lot. For most of these businesses, vehicle counts were estimated at each business affected during the original field survey and subsequent updates. As such, these estimates are site-specific and non-generic. For auto and transportation-related businesses where no site-specific data were available, we used an other-to-structure value ratio (OSVR) of 30 percent. This is a very conservative ratio considering that the OSVRs from the auto

businesses that do have site-specific data are substantially higher than 30 percent in virtually all cases. The commercial "other" category in this analysis does not include landscaping or employee vehicles

Residential values - Residential values make a relatively slight contribution to investment and EAD in this analysis. There are only nine homes in the study area, and they tend to be situated on relatively high ground and subject to damage only in larger flood events. Consequently, residential values account for only about 4 percent of total investment and 1.3 percent of EAD.

For residential structures, the Residential Cost Handbook from Marshall & Swift was used to develop depreciated replacement values for residences based on type of structure, square footage, effective age, and condition. These values were input into the HEC-FDA software program for residential structures.

Residential content values were set at 100 percent in each residential occupancy used in HEC-FDA, with no error specified. This procedure follows the guidance established in EGM 04-01 for use of the EGM's residential depth-damage functions within HEC-FDA.

For the Residential "other" category in HEC-FDA, the value for each home was assumed to equal 20 percent of structure value. This percentage is meant to account for items outside the home that would typically be found at most residences, including a car, one or more utility outbuildings with contents, and landscaping. Each residential unit was assumed to have one vehicle of average value, one or more utility outbuildings, and typical landscaping subject to damage. Most families today own more than one vehicle, but with imminent threat of flooding and little warning time, it is likely that a family would load belongings into one of the vehicles and evacuate the area. Thus, for purposes of the study, vehicles assumed to be subject to flood damage were limited to one per residential structure. (If most homes are assumed to have more than one vehicle, with one evacuated and one left behind as assumed here, this assumption comports fairly well with the vehicle evacuation data found in EGM 09-04, which indicates that in flash-flooding situations with less than six hours of warning time, about 50 percent of vehicles are evacuated.) All homes in the protected areas have at least one utility outbuilding, with multiple outbuildings at most of the residences, and most if not all of the homes have typical shrub plantings, lawns, and gardens that also would be damaged by flooding. The other-to-structure value (OSVR) ratio of 20 percent would of course vary considerably from home to home in reality, as would the individual values of cars, outbuildings, and landscaping, so the analysis is not based on assumptions regarding the specific average value of cars, outbuildings and contents, and landscaping. The only assumption in the analysis is that these diverse items, which are rolled up into a single category due to limitations of the HEC-FDA analysis (since FDA categories are limited to structure, contents, and other value), collectively amount to an average of 20 percent of residential structure value.

3.3.4 DAMAGEABILITY AND UNCERTAINTIES

Depth Damage Relationships

Depth-damage relationships used in this study were obtained from the following sources:

- IWR residential functions;
- Information provided by business/property owner representatives working in the study area;
- Commercial/public functions developed by the New Orleans District.

Commercial - Application of the depth-damage relationships depended on the business/property category, construction characteristics, and the source and quantity of survey data available for the particular type of business/ property. When completed, site-specific survey form data had been provided, the depth-damage relationships provided by the business/property representative were used. Site-specific data were available for 25 of the 90 businesses in the study area. When site-specific survey data were not available, the analysis utilized depth-damage functions developed by the New Orleans District Corps of Engineers, which has accomplished a great deal of analysis over several major studies concerning typical content values and depth-damage functions for both

structures and contents in a broad range of industries. The data used in this analysis were published in the report "Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios in Support of the Lower Atchafalaya Reevaluation and Morganza to the Gulf, Louisiana Feasibility Studies." This source was recommended by national Corps subject experts for use in previous NWK flood risk management economic analyses. Several data sets were contained in the referenced report. Structure depth-damage functions used in this study came from the expert elicitation data for freshwater flooding and included three categories: masonry-bearing, wood and steel frame, and metal frame. Depth-damage functions for contents came from the dataset based on post-flood interviews with business owner/operators. Development of the owner/ operator data for each business category included interviews with 10 businesses, usually representing several specific types of business within each broad category. The content functions were based on eight broadly defined non-residential categories commonly found in virtually any community, including eating and recreation, warehousing and contractors, professional offices, retail and personal services, grocers and gas stations, repair and home use, public and semi-public, and multi-family housing (not used in this study since there are no applicable properties).

The Planning Guidance Notebook (ER 1105-2-100, Appendix E, para. E-19q(2)) requires that when "comparable floodplain data" (i.e., generic data) are used, the study must justify the applicability of the data to local conditions. Although the New Orleans curves originated in a different geographical context, they transfer well to the Upper Turkey Creek basin context for the following reasons: (1) they are based on inland, freshwater flooding (not saltwater flooding, it should be emphasized); (2) the structure types used as a basis for the expert elicitation dataset are commonly found in almost any community; (3) the eight categories of non-residential contents functions are also based on broad categories found in almost any community.

The New Orleans functions were used for the 65 commercial structures for which site-specific data were not available. For structure depth-damage, each business/property in this analysis was classified using the three different construction types defined in the New Orleans data. For content and other depth-damages, the standardized national industrial classification codes assigned to each business/property were used to classify each structure into the appropriate business/property category as defined in the New Orleans report."

Risk and uncertainty is accounted for in the New Orleans depth-damage functions by median, maximum, and minimum values for each category that serve as the basis for triangular damage uncertainty distributions in the risk analysis for Upper Turkey Creek.

Residential - Residential damages in this analysis are based on depth-damage percentages released in Economic Guidance Memorandum 04-01, "Generic Depth-Damage Relationships for Residential Structures Without Basements," dated 10 October 2003. This EGM summarized data developed by the Institute for Water Resources (IWR) using post-flood residential damage claim records provided by the Federal Emergency Management Agency (FEMA). The functions account for both structural and content damage to homes. Based as they are on post-flood damage claims data, the functions should also account for any emergency flood avoidance actions taken by residents such as evacuation or flood proofing. The IWR functions pertain to the three residential occupancy types for this analysis: 1-story without basement, 1 1/2-story without basement, and 2-story without basement. Only the curves that assumed no basement were used since none of the nine homes in the study area have basements.

The pattern of flood risk for Upper Turkey Creek is primarily related to flash flooding. Available data on streamflow at both Johnson Drive and Antioch Road indicate that the creek can rise approximately 10 feet within 1 hour. Rises of this magnitude do not allow adequate time for businesses to move significant amounts of property (including vehicles) out of the floodplain in response to flood events.

Uncertainties

Economic uncertainties used in the HEC-FDA model are associated with structure and content values, structure elevations, and depth-percent damage relationships. Uncertainties were developed as described below.

Commercial structure value uncertainties were determined by completing a set of Marshall & Swift valuations for the businesses interviewed. The Marshall & Swift valuations were compared to the values that the business owners provided, and a standard deviation was computed. The businesses of interviewed owners were representative of the various types of structures located within the study area, and the process considered such factors as type of business, size, building effective age, and construction material. A normal distribution was selected with a standard deviation of approximately 41.8 percent. This standard deviation was used as the depreciated structure value uncertainty for all commercial and public structures within the study area for which survey data were not directly provided by the owners.

Uncertainties about residential structure values were determined using the ranges of values provided by Marshall & Swift for lower and higher quality residential structure types. Residential content to structure value ratios were chosen based on the particular structure depth percent damage curve used for the structure. If the IWR without-basement curves were used, the ratio was set at 100 percent of structure value. If other with-basement curves were used, the ratios and standard deviations from Table 6-4 of EM 1110-2-1619, *Risk Based Analysis for Flood Damage Reduction Studies*, were used as appropriate for the type of residential structure.

Ground elevation uncertainties were assigned in accordance with Table 6-5, EM 1110-2-1619, dated 1 August 1996. Based on the contour interval of available mapping, the recommended standard deviation of 0.3 foot and a normal distribution were assigned.

Uncertainties about depth-damage relationships were assigned by entering the estimates of minimum, maximum, and most likely damages provided by business owners interviewed or as presented in the IWR and New Orleans depth percent damage curves.

Three of the commercial structures in the inventory of the Upper Turkey Creek floodplain were identified as vacant, and 5 of the 24 interviewed commercial occupants had moved to the area after the 1998 flood. As is typically the case for flood-risk management studies in commercial and industrial areas, the variability in commercial occupancy that is likely to occur over the period of analysis is another source of uncertainty.

3.3.5 INVESTMENT IN ROADS, ELEVATIONS, DAMAGEABILITY

Damages to roads in each reach are included in the public category of damage. Miles of roads by type and elevation for each reach were determined from study area maps. Estimates of the investment per mile for the various types of roads were developed from typical road construction cost estimates obtained from the Missouri Department of Transportation and from representatives of Kansas City highway engineering firms. These estimates were applied to the estimated miles of roadways by type in each reach subject to flooding. Uncertainties in investment value were determined based on the ranges of values provided for the different types of roads. The analysis uses a 35 percent maximum or minimum variation for arterial and local/collector streets. Depth-percent damage relationships for roads in the study area were based on previously developed Kansas City District curves. These curves were developed by obtaining typical costs per mile for minor maintenance such as regrading and resurfacing as well as for more major reconstruction to compare against the costs of new construction. In general, it is assumed that lower levels of inundation will result in relatively minor damage requiring repairs amounting to regrading and/or resurfacing, while more severe inundation levels will require much more expensive repairs that would be comparable to reconstruction. The resurfacing and reconstruction costs per mile obtained were divided by the new construction costs per mile to produce the generalized depth-damage percentages.

3.4 STUDY AREA INVESTMENT

3.4.1 SUMMARY OF STUDY AREA INVESTMENT

During a survey of the overall study area, 105 commercial structures and 10 residential structures were identified from RM –1.199 to 7.508. (See section 3.2 above for reach demarcation.) Of these, 91 commercial structures and 9 residential structures are in the Merriam reaches. Total investment

in the study area was estimated at $113.7 million in FY 2012 prices for the screening process. This total has been updated to $120.6 million in FY 2015 prices. Table 3-2 below shows total investment relative to both price levels. The subsequent discussion of existing and future without-project damages, as well as the discussion of screening of alternatives, is presented in terms of the FY 2012 price level, while the NED plan discussion is based on the FY 2015 price level.

The depreciated replacement value for buildings and infrastructure in the study area is estimated to be approximately $48.4 million (October 2011 price level). The study area businesses and residences have approximately $65.2 million worth of investment in contents and "other" investment that is subject to flood damage. Business contents include inventory, office equipment, computers, production equipment and machinery, and other miscellaneous contents. "Other" investment includes outdoor items such as residential vehicles and landscaping and commercial equipment and inventory stored outdoors. Residential and non-residential investment is not broken out in Table 3-2 since the investment in this study area is overwhelmingly non-residential (about 97.7 percent of total investment).

3.4.2 REACH 3A

Reach 3a, with 20 structures, has commercial and public investment of approximately $8.5 million for structures and $14.8 million for contents/other for a total of approximately $23.3 million.

3.4.3 REACH 3B

Reach 3b has 78 structures, with commercial, residential, and public investment of approximately $28.6 million for structures and $42.6 million for contents/other for a total of approximately $71.2 million.

3.4.4 REACH 3C

Reach 3c, with 2 structures, has commercial investment of approximately $11.4 million for structures and $7.8 million for contents/other for a total of approximately $19.2 million.

Table 3-2: Study Area Investment

Reach	# Structures/ groups of structures	1 Oct 11 prices ($1,000s)			1 Oct 14 prices ($1,000s)		
		Structure / infrastructure investment	Contents Investment*	Reach Totals	Structure / infrastructure investment	Contents Investment*	Reach Totals
Reach 3a	20	$8,500.0	$14,800.0	$23,300.0	$9,300.0	$15,600.0	$24,900.0
Reach 3b	78	$28,600.0	$42,600.0	$71,200.0	$29,500.0	$45,500.0	$75,000.0
Reach 3c	2	$11,400.0	$7,800.0	$19,200.0	$12,400.0	$8,300.0	$20,700.0
Study Area Totals	**100**	**$48,400.0**	**$65,200.0**	**$113,700.0**	**$51,200.0**	**$69,400.0**	**$120,600.0**

3.5 PHYSICAL DAMAGES AND OTHER COSTS OF FLOODING

Primary damages for the Upper Turkey Creek Basin study consist of physical inundation damage to the commercial, residential, and public structures and their contents and damages to roads in the study area. Clean-up costs also were calculated as a separate damage category in the HEC-FDA.

3.5.1 ANALYSIS YEARS

Analysis years selected for the study configuration in the HEC-FDA model define damage and project performance information for specific periods during the life of a project. The analysis year represents a static period or year for which the hydrologic engineering and economic data must be

developed for the analyses. The existing conditions analysis is based on conditions of 2012. The base year for the Upper Turkey Creek Basin study is 2018. The year 2043 was used as the "future condition year" in HEC-FDA. However, hydrologic and economic conditions were assumed to be the same for existing, base and future years in HEC-FDA. The conditions are assumed to be identical because no changes in existing hydrologic/hydraulic conditions (including those conditions forecasted using Atlas 14 data) or existing property inventory are projected for the entire installation period and period of analysis – largely because the existing floodplain is developed. In addition, no abnormal population increases are projected for the area through the period of analysis.

3.5.2 DAMAGE CATEGORIES

Physical Damages - The predominant land uses and investment in the study area are, as described above, commercial, public, and residential. Potential flood damages are based on damages to structures and damages to contents, including inventory and equipment for commercial properties. Additionally, there would be damages to public infrastructure (roads).

Other Costs of Flooding - Reduction of the physical damages would be the primary basis for the benefits of a project in the study area. However, benefits of providing flood protection in the study area can also include avoidance of other costs, such as emergency flood-fighting costs, flood insurance administration costs, overtime costs related to business evacuations, and clean-up costs. These costs associated with flood avoidance measures are an important issue in the Turkey Creek Basin because of the frequency of actual and threatened flooding. Significant revenue losses can occur as businesses remain closed to clean up and refurbish. However, these types of costs do not usually represent a change in the National Economic Development (NED) benefits. Traffic diversion costs and utilities damages were also not included in the analyses. Although these costs are expected to continue to be a factor in the without-project condition and the significance of their impact should be noted, most non-physical categories were not quantitatively evaluated.

The exception is clean-up costs, which were calculated in HEC-FDA. Cumulative clean-up expenses under conditions of frequent flooding are severe. Clean-up costs are, to a large extent, a reassignment of workers from productive duties. A stage-damage relationship was developed by taking 2 percent of the total value of inundated investment for various flood events, based on preliminary runs of the HEC-FDA. This is consistent with other approved studies in the USACE, Kansas City District, that used actual data collected after the 1993 flood event on the Missouri and Mississippi Rivers. Published reports that were researched for that effort included the *1993 Interagency Floodplain Management Review Committee Report* (Galloway Report); *Impacts of the Great Flood of 1993*, U.S. Army Corps of Engineers Lower Mississippi Valley Division, May 1996; and the *Flood Plain Management Assessment of the Upper Mississippi River and Lower Missouri Rivers and Tributaries,* U. S. Army Corps of Engineers June 1995.

3.5.3 DAMAGE CALCULATION METHODOLOGIES AND UNCERTAINTIES

The feasibility phase analysis for the Upper Turkey Creek Basin study uses the HEC-FDA software program (certified version 1.2.4) developed by the Hydrologic Engineering Center, for incorporation of risk and uncertainty in the analysis of alternatives. Eight water surface profiles were entered into the HEC-FDA model. The eight profiles included the 0.50, 0.20, 0.10, 0.05, 0.02, 0.01, 0.005, and 0.002 probability events. For successful operation of the HEC-FDA model, some water surface profiles were "smoothed" prior to data entry by adjusting elevations by as much as 0.2 foot where "blips" in the profiles appeared. In addition to specific economic data uncertainties, uncertainties in the discharge-exceedance probability function for each reach and in the stage-discharge function for each reach are included in the model to produce the aggregated stage-damage functions by category for each reach. HEC-FDA risk-based analyses incorporate those uncertainties in the integration of the hydrologic and hydraulic engineering and economic analysis of the with- and without-project conditions using Monte Carlo simulation techniques.

Primary flood damages for various flood events are computed based on the level of investment subject to flooding, the beginning damage elevation, and the estimated damage to that investment

with various depths of flooding. Values of investment subject to flooding, structure elevations, and foundation heights (to indicate the elevation at which first floor flood damages would be estimated to occur) along with associated uncertainties were entered into the HEC-FDA model for each structure or groups of structures in the study area. Damage susceptibility functions and associated uncertainties for the various types of structures and contents determined as described in preceding paragraphs were also entered into the HEC-FDA model. The HEC-FDA program references each structure's first floor elevation or beginning damage elevation to the corresponding frequency event elevation at the reach index point. Individual stage-damage relationships at each structure for each investment category are then computed with risk and aggregated to the reach index location in the program for integration of the economic and hydrologic engineering data. Use of HEC-FDA for the analysis facilitates the assessment of the tradeoff between risks and costs.

An example of a depth-percent damage function, with error limits, for the content investment category is displayed in Table 3-3 below. An example stage primary damage (at the reach index point) report is provided in Table 3-4 below.

Table 3-3: Example Depth-Percent Damage Function Report for "AMASONRY" Auto Repairs and Auto Parts – "Other" Damage Category

Depth (feet)	Damage (percent)	Error Limit Curves (normal) Damage (percent)			
		-2 SD	-1 SD	+1 SD	+2 SD
0.00	0.0	0.0	0.0	0.0	0.0
0.50	5.9	0.0	0.0	25.1	44.3
1.00	25.1	0.0	8.3	41.9	58.7
2.00	42.9	16.5	29.7	56.1	69.3
3.00	58.6	41.6	50.1	67.1	75.6
4.00	72.3	61.7	67.0	77.6	82.9
5.00	83.9	71.5	77.7	90.1	96.3
6.00	93.2	65.6	79.4	100.0	100.0
7.00	97.4	69.8	83.6	100.0	100.0
8.00	99.5	71.9	85.7	100.0	100.0
9.00	100.0	72.4	86.2	100.0	100.0
10.00	100.0	72.4	86.2	100.0	100.0

Note: SD – standard deviation

Table 3-4: Example Stage-Damage Report Without Project Commercial Damage Category

Plan Name: Without Project Condition
Stream Name: Upper Turkey Creek
Damage Reach Name: Reach 3b
Damage Category Name: Commercial

Stage (feet)	Damage ($1,000s)	Error Limit Curves (Normal)			
		Damage (October 2011 prices, $1,000s)			
		-2 SD	-1 SD	+1 SD	+2 SD
905.0	$0	$0	$0	$0	$0
906.0	$0	$0	$0	$0	$0
907.0	$0	$0	$0	$0	$0
908.0	$0	$0	$0	$0	$0
909.0	$0	$0	$0	$0	$0
910.0	$0	$0	$0	$0	$0
911.0	$28.2	$0	$0	$62.8	$97.4
912.0	$180.5	$91.5	$136.0	$225.0	$269.5
913.0	$478.3	$0	$230.1	$726.5	$974.7
914.0	$2,948.2	$1,132.7	$2,040.4	$3,855.9	$4,763.6
915.0	$11,390.3	$7,845.1	$9,617.7	$13,162.9	$14,935.5
916.0	$15,397.8	$10,951.5	$13,174.6	$17,620.9	$19,844.1
917.0	$18,471.2	$13,437.1	$15,954.2	$20,988.3	$23,505.4
918.0	$22,635.0	$16,899.9	$19,767.4	$25,502.5	$28,370.0
919.0	$30,340.2	$22,704.4	$26,522.3	$34,158.1	$37,976.0
920.0	$37,900.8	$28,330.9	$33,115.8	$42,685.7	$47,470.7
921.0	$43,159.3	$32,585.0	$37,872.2	$48,446.5	$53,733.7
922.0	$46,470.2	$35,310.0	$40,890.1	$52,050.4	$57,630.5
923.0	$48,609.2	$37,030.2	$42,819.7	$54,398.7	$60,188.2
924.0	$50,478.8	$38,464.7	$44,471.8	$56,485.9	$62,492.9

Note: SD – standard deviation

3.6 RESULTS OF DAMAGE ANALYSIS FOR EXISTING (WITHOUT-PROJECT) CONDITION

3.6.1 BEGINNING DAMAGE ELEVATIONS

Stage damage curves developed with risk and uncertainty at the reach index point indicate that significant physical damages (>$5,000) to structures in the Upper Turkey Creek project occur with very high frequency. In Reach 3a, significant damage begins at index point elevation 889.50, the 40 annual chance exceedance (ACE) event. Reach 3b begins to incur significant damages around the 60 percent ACE event (elevation 910.85 at the index point). Reach 3c begins to incur significant damages around the 10 percent ACE event (elevation 949.45 at the index point). Table 3-4 displays the events and elevations at which significant damage begins in each reach.

Table 3-5 below provides a summary by reach of the frequency events and corresponding elevations at which significant physical damages (>$5,000) are estimated to begin to occur based on evaluation of the existing conditions.

Table 3-5: Significant Damage Events and Elevations

Unit	Index Point	Elevation at Reach Index Point	Frequency of Event
Reach 3a	2.120	889.50	40%
Reach 3b	3.298	910.85	60%
Reach 3c	4.767	949.45	10%

3.6.2 INTEGRATION OF STAGE-DAMAGE AND STAGE-DISCHARGE-FREQUENCY RELATIONSHIPS

Hydrologic and hydraulic uncertainties include uncertainties about the stage-discharge-exceedance probability relationships. Discharge-exceedance probability functions were developed in the HEC-FDA program by the graphical exceedance probability method using the water surface profiles and a 30-year period of record. Uncertainty in stage-discharge functions was also developed in HEC-FDA using a standard deviation of error of 1 foot provided by the USACE hydrologic engineering staff. Tables 3-6, 3-7, and 3-8 display examples of discharge-exceedance probability, stage-discharge, and exceedance probability-damage functions (including risk and uncertainty). The functions were generated in the HEC-FDA program after specification and input of the above-described uncertainties about the economic, hydrologic and hydraulic data. Integration of the depth damage relationships with the stage-frequency data in HEC-FDA provided estimates of total damages for flood events with various chances of occurrence for the existing without project conditions.

Table 3-6: Exceedance Probability-Discharge Function Report for Damage Reach 3b

Plan Name: Without Project Condition
Stream Name: Upper Turkey Creek
Damage Reach Name: Reach 3b

Exceedance Probability	Discharge (feet)
0.9990	1,649
0.9900	2,036
0.9500	3,005
0.9000	3,603
0.8000	4,398
0.7000	5,047
0.6000	5,643
0.5000	6,244
0.4750	6,399
0.4500	6,557
0.4250	6,719
0.4000	6,886
0.3750	7,059
0.3500	7,241
0.3000	7,637
0.2750	7,858
0.2500	8,098
0.2250	8,363
0.2000	8,659
0.1750	8,994
0.1500	9,378
0.1250	9,829
0.1000	10,374
0.0750	11,070
0.0500	12,060
0.0400	12,624
0.0250	13,841
0.0200	14,423
0.0150	15,173
0.0100	16,206
0.0090	16,470
0.0080	16,770
0.0070	17,103
0.0060	17,489
0.0050	17,947
0.0040	18,502
0.0020	20,395
0.0010	22,359
0.0001	25,152

Table 3-7: Stage-Discharge Report for Damage Reach 3b

Plan Name: Without Project Condition
Stream Name: Upper Turkey Creek
Damage Reach Name: Reach 3b

Discharge (cfs)	Stage (feet)	Error Limit Curves Stage (feet)			
		-2 SD	-1 SD	+1 SD	+2 SD
0	904.24	904.24	904.24	905.24	906.24
6242	911.61	909.61	910.61	912.61	913.61
8596	913.58	911.58	912.58	914.58	915.58
10293	914.86	912.86	913.86	915.86	916.86
11585	915.68	913.68	914.68	916.68	917.68
14263	917.37	915.37	916.37	918.37	919.37
15007	917.80	915.80	916.80	918.80	919.80
16101	918.27	916.27	917.27	919.27	920.27
18115	919.24	917.24	918.24	920.24	921.24

Note: cfs – cubic feet per second, SD – standard deviation

Table 3-8: Exceedance Probability-Damage Function Report for Damage Reach 3b

Plan Name: Without Project Condition
Stream Name: Upper Turkey Creek
Damage Reach Name: Reach 3b

Exceedance Probability	Primary Damage by Damage Category (October 2011 prices, $1,000s)				
	Cleanup	Commercial	Public	Residential	Total Damage
0.9900	$0.0	$0.0	$0.0	$0.0	$0.0
0.9500	$0.0	$0.0	$0.0	$0.0	$0.0
0.9000	$0.0	$0.0	$0.0	$0.0	$0.0
0.8000	$0.0	$0.1	$0.0	$0.0	$0.1
0.7000	$0.2	$3.3	$0.0	$0.1	$3.6
0.6000	$1.8	$29.5	$0.2	$0.5	$32.0
0.5000	$7.3	$119.9	$0.8	$2.2	$130.1
0.4750	$9.1	$149.1	$1.0	$2.7	$161.8
0.4500	$11.0	$181.1	$1.2	$3.3	$196.6
0.4250	$13.3	$217.9	$1.4	$3.9	$236.5
0.4000	$16.1	$265.7	$1.7	$4.8	$287.3
0.3750	$20.1	$329.8	$2.2	$6.0	$358.0
0.3500	$25.3	$415.3	$2.7	$7.5	$450.9
0.3250	$31.9	$523.7	$3.4	$9.4	$568.5
0.3000	$41.2	$675.4	$4.4	$12.2	$733.2
0.2750	$56.1	$920.4	$6.1	$16.6	$999.2
0.2500	$82.8	$1,358.3	$8.9	$24.5	$1,474.5
0.2250	$117.7	$1,932.2	$12.7	$34.8	$2,097.5
0.2000	$161.9	$2,657.9	$17.5	$47.9	$2,885.2
0.1750	$234.2	$3,843.5	$25.3	$69.3	$4,172.3
0.1500	$367.5	$6,032.4	$39.7	$108.8	$6,548.4
0.1250	$530.8	$8,712.4	$57.3	$157.1	$9,457.6
0.1000	$687.3	$11,280.8	$74.2	$203.4	$12,245.7
0.0750	$827.4	$13,580.6	$89.3	$244.9	$14,742.2
0.0500	$985.2	$16,169.7	$106.4	$291.6	$17,552.7
0.0400	$1,064.4	$17,471.1	$114.9	$315.0	$18,965.5
0.0250	$1,230.6	$20,198.1	$132.9	$364.2	$21,925.7
0.0200	$1,316.2	$21,602.8	$142.1	$389.5	$23,450.6
0.0150	$1,437.9	$23,601.1	$155.2	$425.6	$25,619.8
0.0100	$1,634.2	$26,821.9	$176.4	$483.6	$29,116.1
0.0090	$1,685.1	$27,658.4	$181.9	$498.7	$30,024.1
0.0080	$1,741.6	$28,658.4	$188.0	$515.4	$31,031.2
0.0070	$1,805.1	$29,627.7	$194.9	$534.2	$32,161.9
0.0060	$1,876.4	$30,797.2	$202.6	$555.3	$33,431.4
0.0050	$2,109.3	$34,619.8	$227.7	$624.2	$37,581.0
0.0040	$2,550.7	$41,864.9	$275.4	$754.9	$45,445.8
0.0020	$3,433.5	$56,355.1	$370.7	$1,016.1	$61,175.4
0.0010	$3,874.9	$63,600.2	$418.3	$1,146.8	$69,040.2

3.6.3 EXCEEDANCE PROBABILITY-DAMAGE (INCLUDING RISK AND UNCERTAINTY) FOR THE INTERIM FEASIBILITY REPORT UNITS

Primary Damages (including risk and uncertainty) vs. Frequencies

0.10 ACE Event—A flood event of this magnitude and frequency could impact approximately 58 structures. Reach 3a would incur an estimated $211,000 in damages with a maximum depth of 1.4 feet to structures, approximately $2,000 in damages to roads, and approximately $10,000 in clean-up costs. Reach 3b would incur approximately $8.2 million in damages with a maximum depth of 5.1 feet to structures, approximately $53,000 in damages to roads, and $456,000 in clean-up costs. Reach 3c would incur approximately $2,000 in road damages.

0.01 ACE Event—A flood event of this magnitude and frequency could impact an estimated 86 structures. Reach 3a would incur approximately $6.1 million in damages with a maximum depth of 5.3 feet to structures, approximately $57,000 in damages to roads, and approximately $234,000 in clean-up costs. Reach 3b would incur approximately $17.6 million in damages with a maximum depth of 6.3 feet to structures, approximately $109,000 in damages to roads, and nearly $1 million in clean-up costs. Reach 3c would incur approximately $2.6 million in damages with a maximum depth of 1.8 feet to structures, approximately $22,000 in road damages, and approximately $258,000 in clean-up costs.

0.002 ACE Event—A flood event of this frequency and magnitude could impact an estimated 98 structures. Reach 3a would incur approximately $13.1 million in damages with a maximum depth of 8.9 feet to structures, approximately $70,000 in damages to roads, and approximately $509,000 in clean-up costs. Reach 3b would incur approximately $27.2 million in damages with a maximum depth of 7.5 feet to structures, approximately $183,000 in damages to roads, and approximately $1.5 million in clean-up costs. Reach 3c would incur approximately $4.1 million in damages with a maximum depth of 2.3 feet to structures, approximately $28,000 in road damages, and approximately $416,000 in clean-up costs.

Table 3-9 displays the existing condition primary damages by ACE event for the reaches in the study area. Table 3-10 displays existing condition primary damages, by category, flood frequency event and reach. Table 3-11 shows the number of structures/groups of structures affected by each flood event by reach and damage category. Table 3-12 shows the existing condition primary damage by flood frequency event and reach for the structural, contents, and other categories.

Table 3-9: Existing Without Project Condition Primary Damages (with Risk and Uncertainty)

Reach	ACE Event	Existing Condition			
		2012 Discharge (cfs)	2012 Stage (feet)	Max. Struc. Depth 2012[a]	2012 Primary Damages (October 2011 prices, $1,000s)
Reach 3a	.1	9,322	891.43	1.4	$223.2
	.05	10,910	892.25	2.3	$567.2
	.02	13,853	893.76	4.7	$3,857.1
	.01	14,644	894.60	5.3	$6,368.3
	.002	18,035	898.91	8.9	$13,724.8
Reach 3b	.1	10,293	914.86	5.1	$8,721.3
	.05	11,585	915.68	5.6	$12,061.7
	.02	14,263	917.37	6.1	$17,135.1
	.01	15,007	917.80	6.3	$18,670.1
	.002	18,115	919.24	7.5	$28,902.7
Reach 3c	.1	4,303	949.03	NA	$2.1
	.05	4,846	949.81	NA	$3.5
	.02	6,844	951.85	1.7	$2,239.3
	.01	7,279	952.33	1.8	$2,846.3
	.002	9,556	953.33	2.3	$4,556.7
Study Area Total	.1	NA	NA	5.1	$8,946.6
	.05	NA	NA	5.6	$12,632.4
	.02	NA	NA	6.1	$23,231.5
	.01	NA	NA	6.3	$27,884.7
	.002	NA	NA	8.9	$47,184.2

Note: cfs – cubic feet per second

[a] Based on lowest structure; does not include street elevations.

Table 3-10: Existing Condition Primary Damages (with Risk and Uncertainty) by Category for Selected Events

Damage Category	Existing Condition (2012) Primary Damages (October 2011 prices, $1,000s)		
	.1 ACE Event	.01 ACE Event	.002 ACE Event
Reach 3a			
Commercial	$211.2	$6,077.2	$13,145.7
Public	$1.8	$57.1	$70.4
Residential	$0.0	$0.0	$0.0
Clean-up	$10.1	$234.0	$508.6
Total	$223.2	$6,368.3	$13,724.8
Reach 3b			
Commercial	$8,036.1	$17,182.8	$26,698.4
Public	$53.3	$109.3	$183.0
Residential	$176.0	$390.2	$501.6
Clean-up	$455.9	$987.8	$1,519.7
Total	$8,721.3	$18,670.1	$28,902.7
Reach 3c			
Commercial	$0.0	$2,566.1	$4,112.4
Public	$2.1	$22.2	$28.3
Residential	$0.0	$0.0	$0.0
Cleanup	$0.0	$258.0	$416.1
Total	$2.1	$2,846.3	$4,556.7
Study Area Total			
Commercial	$8,247.3	$25,826.1	$43,956.5
Public	$57.2	$188.6	$281.7
Residential	$176.0	$390.2	$501.6
Cleanup	$466.0	$1,479.8	$2,444.4
Total	$8,946.6	$27,884.7	$47,184.2

Note: Any discrepancies are due to rounding.

Table 3-11: Minimum Number of Structures/Groups of Structures Affected

Damage Category	Existing Condition (2012) Cumulative (at or below specific flood elevation)		
	.1 ACE Event	.01 ACE Event	.002 ACE Event
Reach 3a			
Commercial	2	13	19
Residential	0	0	0
Total	2	13	19
Reach 3b			
Commercial	47	60	68
Residential	7	7	8
Total	54	67	76
Reach 3c			
Commercial	0	2	2
Residential	0	0	0
Total	0	2	2
Study Area Total			
Commercial	49	75	89
Residential	7	7	8
Total	56	82	97

Table 3-12: Existing Condition Primary Damages (with Risk and Uncertainty) for Structures, Contents, and Other for Selected Events

Damage Category	Existing Condition (2012) Primary Damages (October 2011 prices, $1,000s)		
	0.1 ACE Event	0.01 ACE Event	0.002 ACE Event
Reach 3a			
Structural	$31.3	$1,819.0	$3,605.6
Contents	$176.0	$4,139.0	$9,243.0
Other	$15.9	$410.3	$876.2
Total	$223.2	$6,368.3	$13,724.8
Reach 3b			
Structural	$1,930.4	$4,474.6	$7,144.8
Contents	$4,583.3	$10,744.3	$17,704.6
Other	$2,207.6	$3,451.2	$4,053.2
Total	$8,721.3	$18,670.1	$28,902.7
Reach 3c			
Structural	$2.1	$1,646.4	$2,394.7
Contents	$0.0	$1,199.9	$2,162.0
Other	$0.0	$0.0	$0.0
Total	$2.1	$2,846.3	$4,556.7
Study Area Total			
Structural	$1,963.8	$7,940.0	$13,145.1
Contents	$4,759.3	$16,083.2	$29,109.6
Other	$2,223.5	$3,861.5	$4,929.4
Total	$8,946.6	$27,884.7	$47,184.2

Notes: Clean-up costs included with structural. Any discrepancies are due to rounding.

Expected Annual Damages (EAD) for the Existing Condition

The HEC-FDA program calculated (with risk and uncertainty) the expected (average) annual damages (EAD) from flooding for the existing condition (2012), using the exceedance probability functions, stage-discharge functions, and structure inventory data. Tables 3-13 and 14 provide a detailed breakdown of the damages by category for each reach and for the total study area.

Table 3-13: Existing Condition (Without Project) Annual Damages

(October 2011 prices, $1,000s)

Reach	Clean-up	Commercial	Public	Residential	Total
Reach 3a	$14.1	$409.1	$3.2	$0.0	$426.4
Reach 3b	$161.7	$2,654.6	$17.5	$47.9	$2,881.6
Reach 3c	$10.8	$136.2	$1.6	$0.0	$148.6
Study Area Total	$186.6	$3,199.9	$22.3	$47.9	$3,456.7

Notes: Any discrepancy due to rounding. 50-year period of analysis, FY12 federal interest rate of 4.000%

Table 3-14: Existing Condition (Without Project) Other Costs of Flooding (Clean-Up)

	Existing Condition Expected Annual Non-Physical (Clean-Up) Costs of Flooding (October 2011 Prices, $1,000s)		
	Clean-up	As a % of Physical Damages	As a % of Total Damages (Physical + Non-Physical)
Reach 3a	$14.1	3%	3%
Reach 3b	$161.7	6%	5%
Reach 3c	$10.8	8%	7%
Study Area Total	$186.6	6%	5%

Notes: Any discrepancy due to rounding. 50-year period of analysis, FY12 federal interest rate of 4.000%

3.7 EXISTING CONDITION ENGINEERING PERFORMANCE

3.7.1 ANNUAL PERFORMANCE AND EQUIVALENT LONG-TERM RISK OF THE EXISTING PROJECT

Long-term risk refers to the flood risk over a long period of time, given uncertainty. Table 3-15 below shows the long-term risk for each reach over periods of 10, 30, and 50 years.

Table 3-15: Annual Performance and Equivalent Long-Term Risk, Existing Condition

Reach	Target Stage	Target Stage Annual Exceedance Probability		Equivalent Long-Term Risk (Probability of Exceedance) Over the Indicated Time Period		
		Median	Expected	10 Years	30 Years	50 Years
Reach 3a	891.70	0.079	0.107	0.6781	0.0412	0.9965
Reach 3b	913.17	0.245	0.269	0.9563	0.9998	1.0000
Reach 3c	950.58	0.035	0.045	0.3713	0.6866	0.9018

3.7.2 ALTERNATIVE DISPLAY OF ANNUAL PERFORMANCE AND EQUIVALENT LONG-TERM RISK OF THE EXISTING PROJECT

Table 3-16 displays long-term risk under existing conditions in other terms. Annual performance is shown in terms of the annual probability that the existing condition design will NOT be exceeded (will not flood). The long-term risk is stated in terms of the chance of the project design being exceeded in a specified number of years (chance of flooding in a specified number of years).

Table 3-16: Alternative Display of Annual Performance and Equivalent Long-term Risk, Existing Condition

Reach	Target Stage	Annual Non-Exceedance Probability	Equivalent Long-Term Risk (chance of design being exceeded over the indicated time period)		
			10 Years	30 Years	50 Years
Reach 3a	891.70	0.893	1 in 1.5	1 in 1.1	1 in1.0
Reach 3b	913.17	0.731	1 in 1.0	1 in 1.0	1 in1.0
Reach 3c	950.58	0.955	1 in 2.7	1 in 1.5	1 in1.1

3.7.3 CONDITIONAL PROBABILITY OF DESIGN NON-EXCEEDANCE.

Table 3-17 below shows the probability that the target stage associated with the existing condition will not be exceeded, given the occurrence of an event of the specified annual exceedance probability.

Table 3-17: Conditional Probability of Design Non-Exceedance, Existing Condition

Reach	Top of Levee/ Floodwall Elevation (at index point)	Conditional Probability of Design Containing Indicated Event					
		10%	4%	2%	1%	0.4%	0.2%
Reach 3a	NA	0.5900	0.2457	0.0872	0.0603	0.0288	0.0146
Reach 3b	NA	0.0997	0.0187	0.0034	0.0020	0.0008	0.0005
Reach 3c	NA	0.9246	0.6108	0.1543	0.0966	0.0291	0.0124

3.8 FUTURE WITHOUT-PROJECT CONDITION

The future without-project condition is the basis of comparison for all of the other alternatives, and the difference in damages with and without a project is the basis for benefits of each alternative. Conditions in the floodplain are not expected to change significantly between the existing (2012), base (2018) and future (2043) years. Economically, the communities within the floodplain are participants in the National Flood Insurance Program, thus limiting new, unprotected development within the 1 percent floodplain. Also, most of the open space in the Merriam reaches has been developed, so the consequences of flooding should not be expected to differ greatly between these reference years. Base and future year hydrologic conditions in the basin are also expected to be very similar to the existing condition. The basin is highly urbanized and water surface profiles and stage uncertainties are not expected to change significantly in the absence of a federal project. Thus, the base year and future year without-project conditions are assumed to be identical to those of the existing condition in this analysis.

Since the three reference conditions are identical, the economic (EAD) and project performance results presented above in Tables 3-13 through 3-17 also serve to characterize the future without-project condition.

3.8.1 NATIONAL ECONOMIC DEVELOPMENT, REGIONAL ECONOMIC DEVELOPMENT IMPACTS, AND OTHER SOCIAL EFFECTS WITHOUT PROJECT

The benefit evaluation process involves analysis of the economic losses to the subject study area from flooding, and the potential gains to the study area from the successful prevention of flooding. Some impacts with and without a flood control project may be of major significance to a metropolitan area or community, but may not have any net impact on the national economy. For example, if a flood interrupts production at a given business in one community, that community suffers a loss. However, if the lost production is simply transferred to another plant elsewhere in the country, the loss to the local community does not represent a net loss to the national economy. These Regional Economic Development (RED) impacts are not included in determining the NED benefits and costs, but they do receive separate consideration in the decision-making process. Other RED impacts include the potential effects on the tax base if businesses leave the area after future flood events. Other social effects (OSE) relevant to the future-without project condition include the risk to human life, especially given the fast-rising nature of Upper Turkey Creek flood events.

4.0 WITH-PROJECT CONDITION ANALYSIS

Alternatives considered in the economic analysis include channelization projects (Alternative 1); levee and floodwall projects (Alternative 2); projects that combine channelization, levees, and floodwalls (Alternative 3); and a floodplain buyout (Alternative 4). Several scales of each alternative type were evaluated for Alternatives 1, 2, and 3. Alternative 4 included a single scale, a floodplain buyout of the 1 percent ACE event. The protected area for the alternatives that included levees and floodwalls matched the boundaries of Reach 3b for both sides of Upper Turkey Creek.

Although not shown in the detailed evaluation of alternatives below, some additional consideration was given to more limited buyout alternatives, focused on areas with the highest concentrations of expected flood damages. It was determined that these alternatives would offer significantly less in net economic benefit than the structural alternatives and would not be locally acceptable due to the economic void that would be left in downtown Merriam.

4.1 NED ANALYSIS OF BENEFITS AND COSTS

Economic costs and benefits resulting from a project are evaluated in terms of their impacts on national wealth, without regard to where in the United States the impacts may occur. NED benefits must result directly from a project and must represent net increases in the economic value of goods and services to the national economy. NED costs represent the costs of diverting resources from other uses in implementing a flood risk management project, as well as the costs of economic losses resulting from detrimental effects of a project. These detrimental effects could include, for example, induced flooding in areas other than the project study area.

4.2 RESIDUAL DAMAGES AND BENEFITS OF SCREENING ALTERNATIVES

For the screening of alternatives, which was accomplished during FY 2012, the future condition with- and without-project equivalent annual damages (EAD) were calculated with risk and uncertainty in HEC-FDA to reflect October 2011 prices and the FY 2012 federal interest rate of 4.000 percent. Table 4-1 shows the benefits of each alternative and the with-project equivalent residual annual damages that would be expected to occur if each alternative considered were in place. EAD under the future without-project condition are also shown for comparison purposes.

Section 308 of the Water Resources Development Act (WRDA) of 1990 requires that structures built after July 1, 1991, be excluded from economic benefits if their first floors are built below the 1 percent flood elevation. Section 308 was considered during the economic analysis; however, Johnson County land records show the structures in the Upper Turkey Creek floodplain as being constructed prior to 1991, typically much earlier.

Table 4-1: Equivalent Annual Benefits and Residual Damages With and Without Project

(October 2011 Prices, 4.000% Interest Rate, 50-Year Period of Analysis, $1,000s)

Alternative	Equivalent Annual Flood Damages in Reach 3a	Equivalent Annual Flood Damages in Reach 3b	Equivalent Annual Flood Damages in Reach 3c	Total Equivalent Annual Damages/Residual Damages in Reaches 3a, 3b, and 3c	Total Benefits from FRM Alternatives in Merriam
Future Without Project	$ 426.4	$ 2,881.6	$ 148.6	$ 3,456.7	NA
Alternative 1a	$ 426.0	$ 1,965.9	$ 148.6	$ 2,540.5	$ 916.2
Alternative 1b	$ 426.4	$ 1,928.4	$ 148.6	$ 2,503.4	$ 953.3
Alternative 1c	$ 426.4	$ 1,203.5	$ 148.4	$ 1,778.2	$ 1,678.5
Alternative 1d	$ 426.4	$ 850.6	$ 148.4	$ 1,425.4	$ 2,031.3
Alternative 1e	$ 426.4	$ 381.2	$ 148.4	$ 955.9	$ 2,500.8
Alternative 2a	$ 426.4	$ 1,130.7	$ 148.6	$ 1,705.7	$ 1,751.0
Alternative 2b	$ 426.4	$ 230.2	$ 148.6	$ 805.2	$ 2,651.5
Alternative 2c	$ 426.4	$ 225.2	$ 148.6	$ 800.2	$ 2,656.5
Alternative 2d	$ 426.4	$ 69.6	$ 148.6	$ 655.6	$ 2,812.1
Alternative 2e	$ 426.4	$ 47.8	$ 148.6	$ 622.8	$ 2,833.9
Alternative 2f	$ 426.4	$ 7.0	$ 148.6	$ 582.1	$ 2,874.6
Alternative 3a	$ 426.0	$ 559.1	$ 148.6	$ 1,133.7	$ 2,323.0
Alternative 3b	$ 426.4	$ 390.0	$ 148.6	$ 965.0	$ 2,491.7
Alternative 3c	$ 426.4	$ 327.7	$ 148.4	$ 902.5	$ 2,554.2
Alternative 3d	$ 426.4	$ 87.0	$ 148.4	$ 661.7	$ 2,795.0
Alternative 3e	$ 426.4	$ 61.9	$ 148.4	$ 636.6	$ 2,820.1
Alternative 4– Property Buyouts	$ 14.6	$ 32.9	$ 12.1	$ 59.7	$ 3,397.0

Note: Any discrepancies are due to rounding.

4.3 COSTS OF SCREENING ALTERNATIVES

4.3.1 ANNUAL PROJECT COSTS

The Louis Berger Group provided screening cost estimates (October 2011 price level) and estimated construction periods for each of the alternatives. The interest during construction for each alternative was calculated based on the total first cost for each alternative, the starting and completion dates for each phase beginning with PED, assumed equal monthly expenditures during each phase, and the FY12 federal interest rate of 4.000 percent. Ongoing federal funding issues were not considered in the starting and completion dates of the phases; appropriate funding was assumed available for each phase. Total first cost for each alternative includes the estimated construction cost, cost for lands, easements and rights of way, preconstruction engineering and design cost, environmental mitigation cost, supervision and administration cost, and contingencies. The interest during construction calculated for each alternative was then added to the total first cost to derive the economic cost of each alternative. The economic cost was then annualized based on a 50-year life and a 4.000 percent interest rate.

Table 4-2: Detailed Breakdown of Project First Costs by Alternative

(October 2011 Prices, 4.000% Interest Rate, 50-Year Period of Analysis, $1,000s)

Alternative	Construction Cost (includes EDC and S&A)	PED Cost	LERRD Cost	Mitigation Cost (Compensatory Restoration)	Total First Cost
Future Without Project	NA	NA	NA	NA	NA
Alternative 1a	$ 6,616.4	$ 615.5	$ 3,241.1	$ 29.3	$ 10,502.3
Alternative 1b	$ 8,235.6	$ 766.1	$ 4,744.7	$ 29.3	$ 13,775.7
Alternative 1c	$ 15,249.9	$ 1,418.6	$ 4,744.7	$ 29.3	$ 21,442.5
Alternative 1d	$ 10,984.2	$ 1,021.8	$ 5,652.2	$ 29.3	$ 17,687.5
Alternative 1e	$ 19,178.1	$ 1,784.0	$ 5,652.2	$ 29.3	$ 26,643.6
Alternative 2a	$ 8,360.6	$ 777.7	$ 2,369.3	$ 24.0	$ 11,531.6
Alternative 2b	$ 9,618.5	$ 894.7	$ 3,943.3	$ 24.0	$ 14,480.5
Alternative 2c	$ 11,631.2	$ 1,082.0	$ 3,963.5	$ 24.0	$ 16,700.7
Alternative 2d	$ 12,232.1	$ 1,137.9	$ 3,963.5	$ 24.0	$ 17,357.5
Alternative 2e	$ 12,641.6	$ 1,176.0	$ 3,963.5	$ 24.0	$ 17,805.1
Alternative 2f	$ 15,239.9	$ 1,417.7	$ 3,963.5	$ 24.0	$ 20,645.1
Alternative 3a	$ 9,071.6	$ 843.9	$ 3,901.6	$ 29.3	$ 13,846.4
Alternative 3b	$ 16,355.3	$ 1,521.4	$ 4,191.7	$ 29.3	$ 22,097.7
Alternative 3c	$ 21,176.7	$ 1,969.9	$ 4,168.6	$ 29.3	$ 27,344.5
Alternative 3d	$ 14,173.0	$ 1,318.4	$ 4,872.8	$ 29.3	$ 20,393.5
Alternative 3e	$ 21,136.5	$ 1,966.2	$ 5,189.2	$ 29.3	$ 28,321.2
Alternative 4—Property Buyouts	$ -	$ -	$ 58,232.5	$ -	$ 58,232.5

Note: Any discrepancies are due to rounding; EDC – Engineering During Construction, LERRD – Land, Easement, Rights-of-way, Relocations, and Disposal, PED – Preconstruction Engineering and Design, S&A – Supervision and Administration

Derivation of Mitigation Costs (Compensatory Restoration)

The environmental team formulated 18 options for mitigation. Each of the mitigation options was mutually exclusive from the others. Therefore, no additional permutations or combinations of options were evaluated under the cost effectiveness and incremental cost analysis (CE/ICA). The certified IWR (Institute for Water Resources) Planning Suite program was used to determine which of the options were cost effective and which options were best buys. Cost effective options are those options for which there is no other option that achieves greater output at a lesser cost (identified in Table 4-3). The best buy options are the full array of cost-effective options for which the average cost for the *incremental* output is strictly increasing (identified in Table 4-4). The first best buy option is always the "No Action" (in this case "No Mitigation") option, followed by the option that produces output at the lowest average cost, followed by the next option that produces additional/incremental output at the lowest average cost, followed again by the next option that produces further incremental output at the lowest average cost, and so on, with the option that produces the most output always being the final option in the array of best buys. The output used for CE/ICA was fox squirrel Average Annual Habitat Units (AAHU). The cost used for CE/ICA was average annual cost, including the cost of purchasing trees, installation, preconstruction engineering and design (PED), and real estate. The full calculation of costs can be found in Appendix M, "Cost Effective Incremental Cost Analysis CE-ICA." In addition to Tables 4-3 and 4-4, the results of CE/ICA are also displayed graphically in Figures 4-1 and 4-2.

Table 4-3: Results of IWR Planning Suite Cost Effectiveness Analysis

Mitigation Option	Total Cost	Average Annual Cost	Fox Squirrel AAHU Gain	Cost Effective?
No Mitigation	$0	$0	0.00	Yes
Mitigation Option 1	$14,802	$689	2.26	Yes
Mitigation Option 2	$13,851	$645	2.23	Yes
Mitigation Option 3	$13,323	$620	2.18	Yes
Mitigation Option 4	$30,483	$1,419	2.78	No
Mitigation Option 5	$25,612	$1,192	2.71	No
Mitigation Option 6	$22,906	$1,066	2.58	No
Mitigation Option 7	$20,722	$965	3.16	Yes
Mitigation Option 8	$19,392	$903	3.12	Yes
Mitigation Option 9	$18,652	$868	3.06	Yes
Mitigation Option 10	$42,676	$1,987	3.89	No
Mitigation Option 11	$35,857	$1,669	3.80	No
Mitigation Option 12	$32,069	$1,493	3.61	No
Mitigation Option 13	$26,643	$1,240	4.06	Yes
Mitigation Option 14	$24,932	$1,161	4.01	Yes
Mitigation Option 15	$23,982	$1,116	3.93	Yes
Mitigation Option 16	$54,870	$2,554	5.00	No
Mitigation Option 17	$46,102	$2,146	4.88	No
Mitigation Option 18	$41,232	$1,919	4.64	No
Mitigation Option 19	$32,564	$1,516	4.97	Yes
Mitigation Option 20	$30,473	$1,419	4.90	Yes
Mitigation Option 21	$29,311	$1,364	4.80	Yes
Mitigation Option 22	$67,063	$3,122	6.12	Yes
Mitigation Option 23	$56,347	$2,623	5.97	Yes
Mitigation Option 24	$50,394	$2,346	5.67	No

Notes: The average annual cost was determined using an October 2011 price level and the FY2012 federal interest rate of 4.000% over a 50-year period of analysis.
AAHU – Average Annual Habitat Unit

Table 4-4: Results of IWR Planning Suite Incremental Cost Analysis

Mitigation Option	Average Annual Cost	Fox Squirrel AAHU Gain	Best Buy?
No Mitigation	$0	0.00	Yes
Mitigation Option 1	$689	2.26	No
Mitigation Option 2	$645	2.23	No
Mitigation Option 3	$620	2.18	No
Mitigation Option 7	$965	3.16	No
Mitigation Option 8	$903	3.12	No
Mitigation Option 9	$868	3.06	Yes
Mitigation Option 13	$1,240	4.06	No
Mitigation Option 14	$1,161	4.01	No
Mitigation Option 15	$1,116	3.93	Yes
Mitigation Option 19	$1,516	4.97	No
Mitigation Option 20	$1,419	4.90	Yes
Mitigation Option 21	$1,364	4.80	Yes
Mitigation Option 22	$3,122	6.12	Yes
Mitigation Option 23	$2,623	5.97	Yes
Mitigation Option 24	$2,346	5.67	No

Note: The average annual cost was determined using an October 2011 price level and the FY2012 federal interest rate of 4.000% over a 50-year period of analysis.
AAHU – Average Annual Habitat Unit

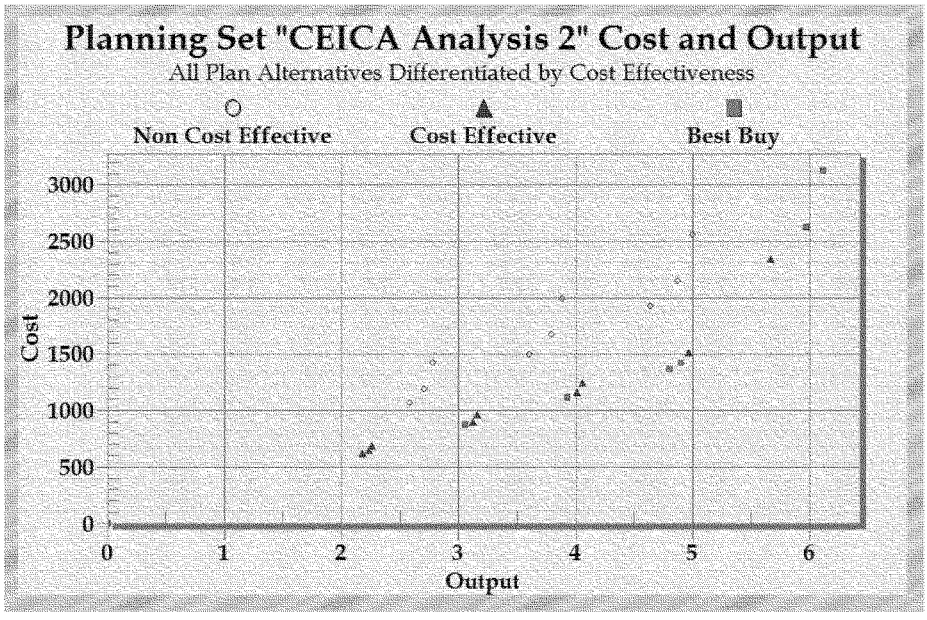


Figure 4-1: Planning Set "CEICA Analysis 2" Cost and Output

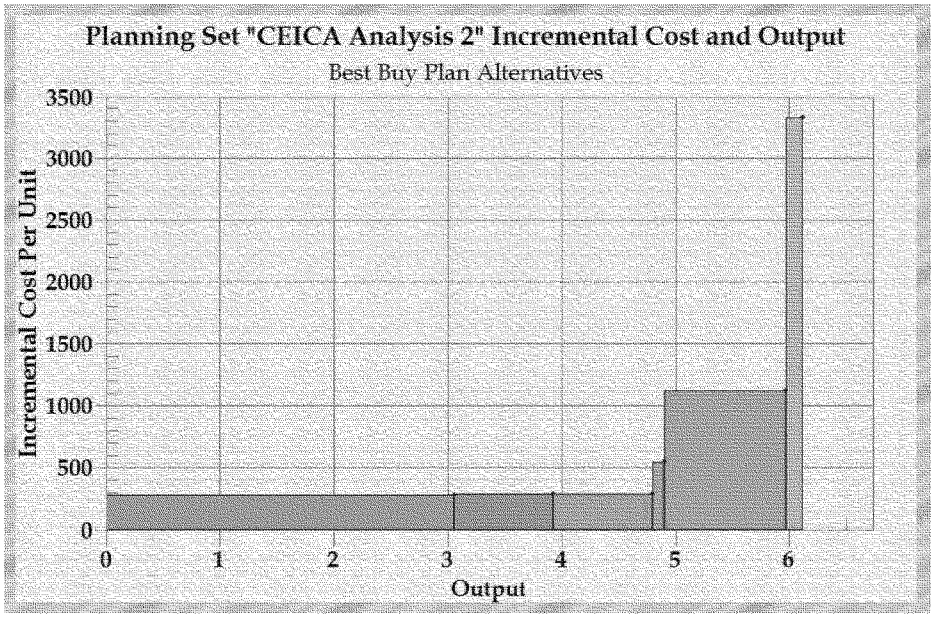


Figure 4-2: Planning Set "CEICA Analysis 2" Incremental Cost and Output

The criteria for determining which mitigation option(s) would be used in the economic screening were that the option:

1. Is a best buy option as determined by CE/ICA;
2. Meets the minimum mitigation requirement for a given alternative;
3. Is the lowest-cost option of the options that meet criteria 1 and 2.

The best buy options are evaluated for criteria 2 in Table 4-5. The final results of all criteria are shown in Table 4-6. Mitigation Option 21 was used for Alternatives 1 and 3. Mitigation Option 15 was used for Alternative 2. No mitigation was assumed for the property buyouts in Alternative 4.

Table 4-5: Evaluation of Best Buy Options against Minimum Mitigation Requirement

Mitigation Option (re-ordered by ascending cost and output)	Fox Squirrel AAHU Gain	Meets Minimum Mitigation Requirement for Alt 1 (3.94)	Meets Minimum Mitigation Requirement for Alt 2 (3.18)	Meets Minimum Mitigation Requirement for Alt 3 (4.23)	Meets Minimum Mitigation Requirement for Alt 4 (3.18)	Meets Minimum Mitigation Requirement for Alt 5 (0.00)
No Mitigation	0.00	No	No	No	No	Yes
Mitigation Option 9	3.06	No	No	No	No	Yes
Mitigation Option 15	3.93	No	Yes	No	Yes	Yes
Mitigation Option 21	4.80	Yes	Yes	Yes	Yes	Yes
Mitigation Option 20	4.90	Yes	Yes	Yes	Yes	Yes
Mitigation Option 23	5.97	Yes	Yes	Yes	Yes	Yes
Mitigation Option 22	6.12	Yes	Yes	Yes	Yes	Yes

Note: AAHU – Average Annual Habitat Unit

Table 4-6: Mitigation Options and Mitigation Costs Used in Economic Screening

Alternative	Mitigation Option Used in Economic Screening	Total Cost
Alternative 1: Channel Widening	Mitigation Option 21	$29,311
Alternative 2: Levees and Floodwalls	Mitigation Option 15	$23,982
Alternative 3: Combination Widening and Levees and Floodwalls	Mitigation Option 21	$29,311
Alternative 4: Property Buy-Outs	No Mitigation	$0

Note: October 2011 price level

4.3.2 ANNUAL OMRR&R COSTS

The costs for operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) were estimated in October 2011 prices for each alternative and were based on a life-cycle cost analysis. The analysis included all OMRR&R costs that the sponsors would be expected to incur based on any new proposed alternative. The analysis considered and accounted for the OMRR&R in each year of occurrence, and then computed a present worth value of the future OMRR&R costs. The present worth value was then annualized using a federal interest rate of 4.000 percent and a 50-year period of analysis.

4.3.3 OTHER DIRECT AND ASSOCIATED COSTS OF IMPLEMENTATION

Induced damages created by a proposed flood risk alternative must be included as costs in the economic screening; however, based on results from the HEC-FDA and discussions with hydrology and hydraulics engineering staff, the alternatives evaluated for Upper Turkey Creek would not induce significant damages on adjacent stream reaches. Any indication of induced damages is only based on rounding errors or internal HEC-FDA iterative computations, not on actual induced damages.

4.3.4 TOTAL ANNUAL COSTS

The total annual cost of each alternative that will be compared with the benefits of the project is the sum of the direct project costs: annual economic cost (design, real estate and construction costs) and annual OMRR&R costs. Table 4-7 provides a detailed breakdown of costs for the alternatives considered.

Table 4-7: Detailed Cost Breakdown for Screening Alternatives for Merriam

(October 2011 Prices, 4.000% Interest, 50-Year Period of Analysis, $1,000s)

Alternative	Project First Cost	Interest During Constr.	Total Investment Cost	Annual Economic Cost	Annual OMRR&R Cost	Annual Induced Damages	Total Average Annual Cost
Future Without Project	NA	NA	NA	NA	NA	NA	NA
Alternative 1a	$ 10,502.3	$ 497.4	$ 10,999.7	$ 512.0	$ 100.9	$ 0.0	$ 612.9
Alternative 1b	$ 13,775.7	$ 853.3	$ 14,629.0	$ 681.0	$ 126.5	$ 0.0	$ 807.5
Alternative 1c	$ 21,442.5	$ 1,516.8	$ 22,959.3	$ 1,068.8	$ 133.7	$ 0.0	$ 1,202.5
Alternative 1d	$ 17,687.5	$ 1,135.1	$ 18,822.6	$ 876.2	$ 152.5	$ 0.0	$ 1,028.7
Alternative 1e	$ 26,643.6	$ 2,344.0	$ 28,987.6	$ 1,349.4	$ 162.5	$ 0.0	$ 1,511.9
Alternative 2a	$ 11,531.6	$ 520.8	$ 12,052.4	$ 561.0	$ 179.9	$ 0.0	$ 740.9
Alternative 2b	$ 14,480.5	$ 897.3	$ 15,377.8	$ 715.8	$ 198.9	$ 0.0	$ 914.7
Alternative 2c	$ 16,700.7	$ 1,007.7	$ 17,708.4	$ 824.3	$ 210.8	$ 0.0	$ 1,035.1
Alternative 2d	$ 17,357.5	$ 1,040.1	$ 18,397.6	$ 856.4	$ 212.1	$ 0.0	$ 1,068.5
Alternative 2e	$ 17,805.1	$ 1,306.4	$ 19,111.5	$ 889.6	$ 215.3	$ 0.0	$ 1,104.9
Alternative 2f	$ 20,645.1	$ 1,760.4	$ 22,405.5	$ 1,043.0	$ 229.4	$ 0.0	$ 1,272.4
Alternative 3a	$ 13,846.4	$ 642.5	$ 14,488.9	$ 674.5	$ 187.6	$ 0.0	$ 862.1
Alternative 3b	$ 22,097.7	$ 1,284.3	$ 23,382.0	$ 1,088.4	$ 247.0	$ 0.0	$ 1,335.4
Alternative 3c	$ 27,344.5	$ 1,897.5	$ 29,242.0	$ 1,361.2	$ 245.0	$ 0.0	$ 1,606.2
Alternative 3d	$ 20,393.5	$ 1,232.1	$ 21,625.6	$ 1,006.7	$ 252.2	$ 0.0	$ 1,258.9
Alternative 3e	$ 28,321.2	$ 2,435.7	$ 30,756.9	$ 1,431.7	$ 252.0	$ 0.0	$ 1,683.7
Alternative 4—Property Buyouts	$ 58,232.5	$ 0.0	$ 58,232.5	$ 2,710.7	$ 0.0	$ 0.0	$ 2,710.7

Note: Any discrepancies are due to rounding.

4.4 SUMMARY OF ECONOMIC SCREENING OF ALTERNATIVES CONSIDERED

Table 4-8 displays a summary of total annual costs (including OMRR&R costs), annual benefits, residual damages, and net benefits for each alternatives evaluated. The benefit/cost ratio and the net benefits for the alternatives considered are also shown.

Table 4-8: Screening Summary With-Project Annual Benefits, Costs, and Net Benefits

(October 2011 Prices, 4.000% Interest Rate, 50-Year Period of Analysis, $1,000s)

Reach Alternative	Total Annual Costs of Project[a]	Annual Benefits	Residual Damages	B/C Ratio	Net Benefits
Future Without Project	NA	NA	$ 3,456.7	NA	NA
Alternative 1a	$ 612.9	$ 916.2	$ 2,540.5	1.5	$ 303.3
Alternative 1b	$ 807.5	$ 953.3	$ 2,503.4	1.2	$ 145.8
Alternative 1c	$ 1,202.5	$ 1,678.5	$ 1,778.2	1.4	$ 476.0
Alternative 1d	$ 1,028.7	$ 2,031.3	$ 1,425.4	2.0	$ 1,002.6
Alternative 1e	$ 1,511.9	$ 2,500.8	$ 955.9	1.7	$ 988.9
Alternative 2a	$ 740.9	$ 1,751.0	$ 1,705.7	2.4	$ 1,010.1
Alternative 2b	$ 914.7	$ 2,651.5	$ 805.2	2.9	$ 1,736.8
Alternative 2c	$ 1,035.1	$ 2,656.5	$ 800.2	2.6	$ 1,621.4
Alternative 2d	$ 1,068.5	$ 2,812.1	$ 655.6	2.6	$ 1,743.6
Alternative 2e	$ 1,104.9	$ 2,833.9	$ 622.8	2.6	$ 1,729.0
Alternative 2f	$ 1,272.4	$ 2,874.6	$ 582.1	2.3	$ 1,602.2
Alternative 3a	$ 862.1	$ 2,323.0	$ 1,133.7	2.7	$ 1,460.9
Alternative 3b	$ 1,335.4	$ 2,491.7	$ 965.0	1.9	$ 1,156.3
Alternative 3c	$ 1,606.2	$ 2,554.2	$ 902.5	1.6	$ 948.0
Alternative 3d	$ 1,258.9	$ 2,795.0	$ 661.7	2.2	$ 1,536.1
Alternative 3e	$ 1,683.7	$ 2,820.1	$ 636.6	1.7	$ 1,136.4
Alternative 4—Property Buyouts	$ 2,710.7	$ 3,397.0	$ 59.7	1.3	$ 686.3

Note: Any discrepancies are due to rounding.

[a] Includes PED (Preconstruction Engineering and Design); LERRD (Lands, Easements, Rights-of-way, Relocations, and Disposal); construction; EDC (Engineering During Construction); S&A (Supervision and Administration); environmental mitigation; interest during construction; and OMRR&R (Operation, Maintenance, Repair, Rehabilitation, and Replacement).

4.5 ECONOMIC PERFORMANCE WITH UNCERTAINTY FOR SCREENING ALTERNATIVES CONSIDERED

The economic performance and effectiveness of the alternatives are compared in Table 4-9 below. The table displays the expected value and probabilistic values of equivalent annual damage (EAD) and EAD reduced, thus showing the impact of uncertainty in evaluation of project benefits. The damages reduced represent the project benefits, and are shown in terms of annualized equivalent values as computed in HEC-FDA.

Table 4-9: Economic Performance with Uncertainty for Merriam Alternatives

(October 2011 Prices, 4.000% Interest Rate, 50-Year Period of Analysis, $1,000s)

Plan	Top of Levee/ Floodwall Elev. (feet)	Expected Value and Probabilistic Values of EAD and EAD Reduced					
		EAD			Probability EAD Reduced Exceeds Indicated Amount		
		Without Plan	With Plan	Damage Reduced	.75	.50	.25
Future Without Project	NA	$ 3,456.7	$ 3,456.7	NA	NA	NA	NA
Alternative 1a	NA	$ 3,456.7	$ 2,540.5	$ 916.2	$ 621.0	$ 964.1	$1,224.7
Alternative 1b	NA	$ 3,456.7	$ 2,503.4	$ 953.3	$ 604.2	$ 953.2	$1,275.4
Alternative 1c	NA	$ 3,456.7	$ 1,778.2	$ 1,678.5	$ 921.4	$1,544.2	$2,267.7
Alternative 1d	NA	$ 3,456.7	$ 1,425.4	$ 2,031.3	$1,085.4	$1,863.6	$2,765.3
Alternative 1e	NA	$ 3,456.7	$ 955.9	$ 2,500.8	$1,176.3	$2,194.4	$3,395.8
Alternative 2a	917.11	$ 3,456.7	$ 1,705.7	$ 1,751.0	$1,001.5	$1,564.2	$2,391.6
Alternative 2b	920.05	$ 3,456.7	$ 805.2	$ 2,651.5	$1,222.3	$2,250.6	$3,653.5
Alternative 2c	920.49	$ 3,456.7	$ 800.2	$ 2,656.5	$1,231.1	$2,261.4	$3,665.0
Alternative 2d	920.99	$ 3,456.7	$ 655.6	$ 2,812.1	$1,256.0	$2,291.8	$3,791.0
Alternative 2e	921.21	$ 3,456.7	$ 622.8	$ 2,833.9	$1,262.1	$2,299.2	$3,800.6
Alternative 2f	922.78	$ 3,456.7	$ 582.1	$ 2,874.6	$1,289.3	$2,332.4	$3,839.9
Alternative 3a	916.36	$ 3,456.7	$ 1,133.7	$ 2,323.0	$1,162.1	$2,132.1	$3,071.3
Alternative 3b	917.80	$ 3,456.7	$ 965.0	$ 2,491.7	$1,209.1	$2,206.1	$3,317.3
Alternative 3c	916.86	$ 3,456.7	$ 902.5	$ 2,554.2	$1,215.6	$2,231.1	$3,412.3
Alternative 3d	916.64	$ 3,456.7	$ 661.7	$ 2,795.0	$1,252.1	$2,287.0	$3,786.5
Alternative 3e	915.93	$ 3,456.7	$ 636.6	$ 2,820.1	$1,267.2	$2,305.5	$3,808.4
Alternative 4 – Property Buyouts	NA	$ 3,456.7	$ 59.7	$ 3,397.0	$1,503.5	$2,715.7	$4,590.1

Notes: Any discrepancies are due to rounding.

EAD – equivalent annual damages

4.6 ENGINEERING PERFORMANCE OF SCREENING ALTERNATIVES CONSIDERED

How well a new federal flood-risk management project performs is indicated by the probability that, in a certain number of years, flows would be expected to exceed the capacity of the stream's channel and, if a levee/floodwall project exists, the water-surface elevation will exceed the top of the levee/floodwall.

4.6.1 ANNUAL PERFORMANCE AND EQ UIVALENT LONG-TERM RISK

Long-term risk indicates how successfully the project protects against flooding under conditions of uncertainty and over a long period of time. Table 4-10 shows, for the without-project condition and each alternative considered, the long-term risk or probability of the project being exceeded in a 10-, 30-, and 50-year period.

Table 4-10: Annual Performance and Equivalent Long-term Risk for Merriam Reach 3b

Plan	Top of Levee/ Floodwall Elevation (feet)	Annual Performance (annual probability of design being exceeded)	Equivalent Long-term Risk (probability of exceedance over the indicated time period)		
			10 Years	30 Years	50 Years
Future Without Project	NA	0.2688	0.9563	0.9996	1.0000
Alternative 1a	NA	0.1497	0.8024	0.9826	0.9997
Alternative 1b	NA	0.1168	0.7112	0.9552	0.9980
Alternative 1c	NA	0.1169	0.7117	0.9554	0.9980
Alternative 1d	NA	0.0617	0.4713	0.7968	0.9587
Alternative 1e	NA	0.0419	0.3485	0.6574	0.8826
Alternative 2a	917.11	0.0387	0.3263	0.6275	0.8613
Alternative 2b	920.05	0.0048	0.0474	0.1143	0.2155
Alternative 2c	920.49	0.0045	0.0439	0.1061	0.2009
Alternative 2d	920.99	0.0012	0.0119	0.0294	0.0580
Alternative 2e	921.21	0.0008	0.0079	0.0197	0.0391
Alternative 2f	922.78	0.0001	0.0010	0.0025	0.0050
Alternative 3a	916.36	0.0199	0.1817	0.3943	0.6331
Alternative 3b	917.80	0.0094	0.0903	0.2107	0.3771
Alternative 3c	916.86	0.0100	0.0955	0.2218	0.3945
Alternative 3d	916.64	0.0024	0.0239	0.0586	0.1138
Alternative 3e	915.93	0.0023	0.0226	0.0555	0.1079
Alternative 4–Property Buyouts	NA	0.2678	0.9557	0.9996	1.0000

4.6.2 CONDITIONAL PROBABILITY OF DESIGN NON-EXCEEDANCE

Table 4-11 shows the probability that the target stage associated with each plan will not be exceeded, given the occurrence of the 1 percent ACE event.

Table 4-11: Conditional Probability of Design Non-Exceedance

Plan	Top of Levee/ Floodwall Elevation (feet)	Conditional Probability of Design Containing 1% ACE Event
Future Without Project	NA	0.002
Alternative 1a	NA	0.030
Alternative 1b	NA	0.044
Alternative 1c	NA	0.043
Alternative 1d	NA	0.200
Alternative 1e	NA	0.296
Alternative 2a	917.11	0.252
Alternative 2b	920.05	0.847
Alternative 2c	920.49	0.856
Alternative 2d	920.99	0.956
Alternative 2e	921.21	0.971
Alternative 2f	922.78	0.996
Alternative 3a	916.36	0.505
Alternative 3b	917.80	0.703
Alternative 3c	916.86	0.687
Alternative 3d	916.64	0.917
Alternative 3e	915.93	0.921
Alternative 4–Property Buyouts	NA	0.002

4.7 RED IMPACTS WITH PROJECT

Construction of any of the alternatives considered would contribute to the long-term stability of the project area. Alternative 1 does not require significant acquisition or relocation of residents or businesses. Alternatives 2 and 3 would require a buyout of two businesses (three buildings), slightly reducing the local tax base. With decreased probability of flood events inundating the floodplain, existing businesses would be expected to continue their occupancy in Reach 3b, and new businesses and investment would be more easily attracted to the area in the future if vacancies occur, resulting in a stronger tax base. With decreased probability of flooding, business activity would be expected to remain relatively stable, barring impacts from other sources. Because Alternatives 2 and 3 generally are more effective than Alternative 1 in reducing residual damages and the probability of flood events inundating the floodplain, they would be expected to have greater benefits of this type. Additionally, temporary increases in employment would be expected during construction. The temporary presence of construction workers for the project may bring a temporary increase in demand for some services in the local area, but also a temporary increase in business volume, profits, and sales tax receipts at the local retail and service establishments. Alternative 4 would be characterized by a buyout of all the homes and commercial buildings that would be inundated by the 1 percent flood event, greatly reducing the local tax base due to the demolition and removal of structures.

4.8 OTHER SOCIAL EFFECTS WITH PROJECT

Implementation of any of the structural and non-structural alternatives considered would contribute to the safety of those living or working in the project area. Risk is defined as the probability of an event and the consequences if that event does occur. As shown in Table 4-10, the structural alternatives (Alternatives 1, 2, and 3) reduce flood risk and the attendant threat to human life. The alternatives that include levees and floodwalls (Alternatives 2 and 3) generally are more effective than Alternative 1 (channelization only) in reducing this aspect of flood risk. Alternative 4 does not change the probability of flooding relative to the future without-project condition; however, by removing homes, businesses, and people from the floodplain, Alternative 4 reduces the population that would be threatened by floodwaters, thus reducing the consequences of future flood events.

Public safety is a particular social concern in the Upper Turkey Creek basin because the nature of flood risk here is generally flash flooding, given that the creek channel is very urbanized and narrow in the study area. Upper Turkey Creek can rise very rapidly: available data on stream flow at both Johnson Drive and Antioch Road indicate that the creek rise approximately 10 feet within an hour during a flood event, and this is consistent with anecdotal experience noted during the more recent Upper Turkey Creek flood events. The rapidity with which flood events develop on this stream usually allows little if any advance warning of possible overbank flows, particularly in this upper portion of the basin where early warning systems could easily be outrun by a developing flash flood event. Two deaths occurred in the Upper Turkey Creek basin during a flood event in October 1998, and at least one other death has occurred downstream of the study area in previous flood events.

A primary metric of the threat of flooding to human life is population at risk (PAR), which is anchored by those who live and work in the area. There are only a few homes in the floodplain of this study area, but the total PAR related to residents and workers at the 91 study area companies is estimated to be about 1,500 – nearly all workers. This figure does not tell the entire story, however, as PAR also includes those who are in the area temporarily, such as customers of area businesses or drivers and passengers traveling through the area. This transitory portion of the PAR is difficult to estimate with any accuracy and is heavily dependent upon judgment, but one point of reference is traffic counts. Average daily traffic counts as estimated by the Kansas Department of Transportation are available for one location within the study area: Merriam Drive at 60th Street, just south of Johnson Drive, where the average daily traffic count is 4,495. This works out to an hourly average of 187 vehicles per hour. However, the count at this location probably is not fully representative of study area traffic in light of the average daily traffic counts in excess of 9,000 (approaching 400 per hour) that can be seen nearby (just outside the study area floodplain) on Antioch Road near Johnson Drive and on Merriam Drive near the Johnson/Wyandotte County line. Factoring in the likelihood for vehicles to carry multiple passengers along with the driver brings the transitory portion of PAR at any given time to perhaps 500. The total PAR for the study area, including residents, workers, and drivers, is therefore estimated to be approximately 2,000.

5.0 NED PLAN

The NED plan is the scale of alternative that reasonably maximizes expected net NED benefits. Net NED benefits are the difference between the NED benefits and the NED costs. The plan with the highest net benefits (not necessarily the highest benefit-cost ratio) is considered the NED plan, assuming technical feasibility, environmental soundness, and public acceptability. This was the basis for selecting Alternative 2d as the NED plan. Based on the economic screening of the array of alternatives, as shown in Table 4-8 above, Table 5-1 displays annual costs, benefits, net benefits, and residual damages for the NED plan (Alternative 2d) and the two alternatives with net NED benefits within 1 percent of the NED plan.

Table 5-1: Summary With-Project Annual Benefits, Costs, and Net Benefits for NED Plan and Locally Preferred Plan

(October 2011 Prices, 4.000% Interest Rate, 50-Year Period of Analysis, $1,000s)

Reach Alternative	Total Annual Costs of Project[a]	Annual Benefits	Residual Damages	B/C Ratio	Net Benefits
Alternative 2b	$ 914.7	$ 2,651.5	$ 805.2	2.9	$ 1,736.8
Alternative 2d (NED plan)	$ 1,068.5	$ 2,812.1	$ 655.6	2.6	$ 1,743.6
Alternative 2e	$ 1,104.9	$ 2,833.9	$ 622.8	2.6	$ 1,729.0
Locally Preferred Plan	$ 1,126.9	$ 2,820.9	$ 635.8	2.5	$ 1,694.0

Notes: Any discrepancies are due to rounding.

[a] Includes PED (Preconstruction Engineering, and Design), LERRD (Land, Easement, Rights-of-way, Relocations, and Disposal), construction, environmental mitigations, interest during construction, and OMRR&R (Operation, Maintenance, Repair, Rehabilitation, and Replacement).

6.0 INCREMENTAL ANALYSIS

In water resources planning, the plan that maximizes net NED benefits is the best plan from an economic perspective. The economic analysis also examines increments of plans or project features to determine their incremental costs and incremental benefits. Increments of plans may be, for example, increments of added levee heights or separate features that are added to the plan. Increments of plans continue to be added and evaluated as long as the incremental benefits exceed the incremental costs. In comparison to all of the alternatives that provide less gross NED benefits than the NED plan, the incremental benefits of the NED plan exceed the incremental costs. However, for the alternatives that provide more gross NED benefits than the NED plan, their incremental benefits above the NED plan do not exceed the incremental costs. This results in the NED plan, Alternative 2d, having the greatest net NED benefit, albeit narrowly over Alternatives 2b and 2e.

Three alternatives from the screening array Alternative 2 series (2b, 2d, and, 2e), all levee and floodwall plans, are narrowly separated in terms of net annual economic benefits. They also have very similar social and environmental effects and requirements for implementation. Throughout several iterations of analyses conducted in the process of adjusting economic and cost data, these three alternatives have remained narrowly separated; nevertheless, Alternative 2d, the NED plan, has consistently remained the plan with the maximum net annual benefits. Alternative 2d would pass the 1-percent ACE event through downtown Merriam with an estimated assurance (conditional non-exceedance probability) of 95.7 percent. In comparing the three alternatives, 2b is approximately $2.88 million cheaper in first costs than 2d but has significantly less benefits and retains significantly greater residual risk, providing an estimated assurance of passing the 1-percent ACE event of 84.7 percent and allowing more structures to be damaged at a higher level. Alternative 2e, on the other hand, provides an estimated 97.1 percent assurance in passing the 1-

percent ACE event, but is more expensive than 2d by $447,600. It provides very similar flood risk reduction to the structures in Merriam relative to 2d.

Table 4-1 shows that selection of Alternative 2b would reduce annual damages for Reach 3b to $230,200, about 8 percent of without-project condition damages. Alternative 2d, while entailing higher project costs, would reduce residual damages for Reach 3b to $69,600, or 2.4 percent of without-project damages, and Alternative 2e, the most expensive of these three alternatives, would further reduce residual damages to 1.7 percent of without-project damages ($47,800). Alternatives 2b, 2d, and 2e all have identical environmental consequences and require identical mitigation measures. Local acceptability is greatest for Alternative 2d, as the incremental reduction in residual risk (as compared to 2b) is viewed as being worth the incremental cost.

7.0 UPDATED WATER-SURFACE PROFILES AND SENSITIVITY ANALYSIS

The study's Independent External Peer Review (IEPR) brought to light that the National Oceanographic and Atmospheric Administration (NOAA) had recently published updated hydrologic information (Atlas 14), which would change the probability of flooding in the Upper Turkey Creek study area. An updated HEC-RAS model based on the Atlas 14 hydrologic data showed flood probabilities that were generally higher than previous estimates. This meant that any with-project alternative would have both greater benefits and greater residual damages than previously estimated. Given that preliminary screening showed levees to be far more effective and efficient than channelization, the sensitivity analysis focused on whether or not a levee project was still justified and what the recommended levee height should be. In consultation with the vertical team, including the HQUSACE Office of Water Policy Review, a new plan, designated the Atlas-14 Sensitivity-Analysis Plan, was formulated for the sensitivity analysis. The Atlas-14 Sensitivity-Analysis Plan was designed to achieve a level of reliability similar to what had been previously estimated for the NED plan based on the older hydrology. Benefits and costs also were updated from the screening-level FY 12 price level and interest rate to FY 15 for the sensitivity analysis. The updated benefits and costs of the NED Plan (with top-of-levee elevation of 920.98 at the index point) were compared against the Atlas-14 Sensitivity-Analysis Plan (with top-of-levee elevation of 922.69 at the index point), and both plans were compared with the future without-project condition.

In addition to the NED Plan and the Atlas-14 Sensitivity-Analysis Plan, the sensitivity analysis also included Alternatives 2b and 2c, which were similar to the NED plan. Note that Alternative 2c was included in the sensitivity analysis rather than 2e, even though in the screening, 2e was closer to 2d in net benefits (within 1 percent of net benefits, as discussed in sections 5.0 and 6.0) than was 2c. However, 2e was also more expensive than 2d, and the vertical team (again, including HQUSACE Office of Water Policy Review) wanted to focus on the two alternatives smaller in scale than 2d to ensure that 2d remained on the rising portion of the net benefits curve, and was therefore still the NED plan, in the Atlas 14 context.

The update factors used included a 9.4 percent increase for structures using the Construction Cost Index (CCI), a 5.5 percent increase for roads using the Civil Works Construction Cost Index System for "Roads" (CWCCIS 08), and a 6.5 percent increase for contents, cleanup, and other using the Consumer Price Index (CPI). So the increase in annual damages from the previous estimate (e.g. $3,456,700 for the FY 2012 estimate of Future Without Project to $4,749,600 for the FY 2015 estimate, an increase of 37.4 percent) was caused in part by an increase in price level, but mostly by a change in H&H conditions under Atlas 14.

Based on the updated costs and benefits from the Atlas-14 update, Tables 7-1 through 7-7 display costs, benefits, net benefits, and residual damages for the NED plan (Alternative 2d), two alternatives similar to 2d (Alternatives 2b and 2c), and the Atlas-14 Sensitivity-Analysis Plan.

First, Table 7-1 shows the benefits of each alternative and the with-project equivalent residual annual damages that would be expected to occur if each alternative considered were in place.

Table 7-1: Sensitivity Analysis - Equivalent Annual Benefits and Residual Damages With and Without Project

(October 2014 Prices, 3.375% Interest Rate, 50-Year Period of Analysis, $1,000s)

Alternative	Equivalent Annual Flood Damages in Reach 3a	Equivalent Annual Flood Damages in Reach 3b	Equivalent Annual Flood Damages in Reach 3c	Total Equivalent Annual Damages/Residual Damages in Reaches 3a, 3b, and 3c	Total Benefits from FRM Alternatives in Merriam
Future Without Project	$ 702.9	$ 3,709.6	$ 337.4	$ 4,749.6	NA
Alternative 2b	$ 702.9	$ 549.0	$ 337.4	$ 1,589.0	$ 3,160.6
Alternative 2c	$ 702.9	$ 397.4	$ 337.4	$ 1,437.5	$ 3,312.1
Alternative 2d (NED Plan)	$ 702.9	$ 264.9	$ 337.4	$ 1,304.9	$ 3,444.7
Atlas-14 Sensitivity-Analysis Plan	$ 702.9	$ 6.7	$ 337.4	$ 1,046.7	$ 3,702.9

Note: Any discrepancies are due to rounding.

Table 7-2 shows project first costs for each of the alternatives. The updated construction costs shown include engineering during construction and supervision & administration, but not PED. The LERRD costs shown include lands & damages, as well as relocations.

Table 7-2: Sensitivity Analysis - Detailed Breakdown of Project First Costs by Alternative

(October 2014 Prices, 3.375% Interest Rate, 50-Year Period of Analysis, $1,000s)

Alternative	Construction Cost (includes EDC and S&A)	PED Cost	LERRD Cost	Mitigation Cost (Compensatory Restoration)	Total First Cost
Future Without Project	NA	NA	NA	NA	NA
Alternative 2b	$ 23,883.0	$ 2,712.0	$ 10,122.0	$ 15.0	$ 36,732.0
Alternative 2c	$ 24,261.0	$ 2,748.0	$ 10,122.0	$ 15.0	$ 37,146.0
Alternative 2d (NED Plan)	$ 24,655.0	$ 2,787.0	$ 10,122.0	$ 15.0	$ 37,579.0
Atlas-14 Sensitivity-Analysis Plan	$ 29,771.0	$ 3,287.0	$ 9,954.0	$ 15.0	$ 43,209.0

Note: Any discrepancies are due to rounding; EDC – Engineering During Construction, LERRD – Land, Easement, Rights-of-way, Relocations, and Disposal, PED – Preconstruction Engineering and Design, S&A – Supervision and Administration

Table 7-3 provides a detailed breakdown of the updated average annual cost of each alternative. For this update, each alternative's annual cost (as well as IDC) was calculated using a Federal interest rate of 3.375 percent and a 50-year period of analysis.

Table 7-3: Sensitivity Analysis - Detailed Cost Breakdown for Alternatives Considered

(October 2014 Prices, 3.375% Interest, 50-Year Period of Analysis, $1,000s)

Alternative	Project First Cost	Interest During Constr.	Total Investment Cost	Annual Economic Cost	Annual OMRR&R Cost	Annual Induced Damages	Total Average Annual Cost
Future Without Project	NA	NA	NA	NA	NA	NA	NA
Alternative 2b	$ 36,732.0	$ 2,946.4	$ 39,678.4	$ 1,653.7	$ 40.8	$ 0.0	$ 1,694.5
Alternative 2c	$ 37,146.0	$ 2,974.1	$ 40,120.1	$ 1,672.1	$ 40.8	$ 0.0	$ 1,712.9
Alternative 2d (NED Plan)	$ 37,579.0	$ 3,003.9	$ 40,582.9	$ 1,691.4	$ 40.8	$ 0.0	$ 1,732.2
Atlas-14 Sensitivity-Analysis Plan	$ 43,026.0	$ 4,021.1	$ 47,047.1	$ 1,960.8	$ 40.8	$ 0.0	$ 2,001.6

Note: Any discrepancies are due to rounding.

Table 7-4 displays an updated summary of total annual costs (including OMRR&R costs), annual benefits, residual damages, and net benefits for each alternative. The benefit/cost ratio and the net benefits for the alternatives considered are also shown.

Table 7-4: Sensitivity Analysis - Annual Benefits, Costs, and Net Benefits of Alternatives

(October 2014 Prices, 3.375% Interest Rate, 50-Year Period of Analysis, $1,000s)

Reach Alternative	Total Annual Costs of Project[a]	Annual Benefits	Residual Damages	B/C Ratio	Net Benefits
Future Without Project	NA	NA	$ 4,749.6	NA	NA
Alternative 2b	$ 1,694.5	$ 3,160.6	$ 1,589.0	1.9	$ 1,466.1
Alternative 2c	$ 1,712.9	$ 3,312.1	$ 1,437.5	1.9	$ 1,599.2
Alternative 2d (NED Plan)	$ 1,732.2	$ 3,444.7	$ 1,304.9	2.0	$ 1,712.5
Atlas-14 Sensitivity-Analysis Plan	$ 2,001.6	$ 3,702.9	$ 1,046.7	1.8	$ 1,701.3

Note: Any discrepancies are due to rounding.

[a] Includes PED (Preconstruction Engineering and Design); LERRD (Lands, Easements, Rights-of-way, Relocations, and Disposal); construction; EDC (Engineering During Construction); S&A (Supervision and Administration); environmental mitigation; interest during construction; and OMRR&R (Operation, Maintenance, Repair, Rehabilitation, and Replacement).

Table 7-5 shows expected values and probabilistic values of equivalent annual damage and reduction in equivalent annual damage for each of the alternatives.

Table 7-5: Economic Performance with Uncertainty for Merriam Alternatives

(October 2014 Prices, 3.375% Interest Rate, 50-Year Period of Analysis, $1,000s)

Plan	Top of Levee/ Floodwall Elev. (feet)	Expected Value and Probabilistic Values of EAD and EAD Reduced					
		EAD			Probability EAD Reduced Exceeds Indicated Amount		
		Without Plan	With Plan	Damage Reduced	.75	.50	.25
Future Without Project	NA	$ 4,749.6	$ 4,749.6	NA	NA	NA	NA
Alternative 2b	920.05	$ 4,749.6	$ 1,589.0	$ 3,160.6	$ 1,706.4	$ 2,835.7	$ 4,262.1
Alternative 2c	920.49	$ 4,749.6	$ 1,437.5	$ 3,312.1	$ 1,727.0	$ 2,938.8	$ 4,445.8
Alternative 2d (NED Plan)	920.98	$ 4,749.6	$ 1,304.9	$ 3,444.7	$ 1,749.1	$ 2,986.1	$ 4,620.3
Atlas-14 Sens.-Analysis Plan	922.69	$ 4,749.6	$ 1,046.7	$ 3,702.9	$ 1,811.3	$ 3,062.2	$ 4,891.1

Notes: Any discrepancies are due to rounding.

EAD – equivalent annual damages

Table 7-6 shows (for each alternative) the long-term risk or probability of the project being exceeded in a 10-, 30-, and 50-year period, under conditions of uncertainty.

Table 7-6: Annual Performance and Equivalent Long-term Risk for Merriam Reach 3b

Plan	Top of Levee/ Floodwall Elevation (feet)	Annual Performance (annual probability of design being exceeded)	Equivalent Long-term Risk (probability of exceedance over the indicated time period)		
			10 Years	30 Years	50 Years
Future Without Project	NA	0.283	0.9640	0.9998	1.0000
Alternative 2b	920.05	0.011	0.1086	0.2498	0.4371
Alternative 2c	920.49	0.008	0.0777	0.1831	0.3326
Alternative 2d (NED Plan)	920.98	0.005	0.0507	0.1220	0.2292
Atlas-14 Sensitivity-Analysis Plan	922.69	0.0001	0.0011	0.0028	0.0055

Table 7-7 shows the probability that the target stage associated with each plan will not be exceeded, given the occurrence of the 1-percent ACE event.

Table 7-7: Conditional Probability of Design Non-Exceedance

Plan	Top of Levee/ Floodwall Elevation (feet)	Conditional Probability of Design Containing 1% ACE Event
Future Without Project	NA	0.002
Alternative 2b	920.05	0.644
Alternative 2c	920.49	0.740
Alternative 2d (NED Plan)	920.98	0.829
Atlas-14 Sensitivity-Analysis Plan	922.69	0.995

8.0 THE NED PLAN

The USACE Planning Guidance Notebook, ER 1105-2-100 states, "A plan that reasonably maximizes net national economic development benefits, consistent with the Federal objective, is to be formulated. This plan is to be identified as the NED plan

During the final iteration of the planning process the study team continued to analyze data on stream hydraulics, hydrology, interior drainage, economics, engineering design and costs, and real-estate costs to refine and optimize alternatives. In this process of optimizing the concept alternatives wherever possible, all costs for Alternative 2 (levee and floodwalls) and Alternative 3 – (combination of channel widening and levee/floodwalls) were re-evaluated. Recommendations for refining the alternatives included relocation of the detention basin from the area east of the Farmer's Market to a property located on the north of the Farmer's Market for all Alternative 2 and Alternative 3 concept alternatives. Although this property was always considered ideal from a hydraulic and engineering stand point, the real estate acquisition of the lot was not considered possible during the initial alternative conceptualization. The revised alternatives became the final Alternative 2 (levee and floodwalls) and Alternative 3 (combination of channel widening and levee/floodwalls) concept alternatives.

Further analysis revealed that the relocation of the detention basin to the north of the Farmers' Market is the more acceptable alternative for the local community. The Farmers' Market is a community event pavilion housing many special events and programs, and the local sponsor has expressed concerns and a desire to avoid impacts to the Farmers' Market area. In addition to the local acceptability issue, the construction of the detention basin east of the Farmers' Market pavilion would have required relocation of the entrance road to the Farmers' Market in order to provide a continuous pond and maximize the available space for detention while keeping mild slopes for maintenance. This change could have had impacts on the future use of the Farmer's Market. From an engineering perspective, the location north of the Farmers' Market is also a more ideal location (lower) than the proposed site east of the Farmers' Market and is closer to Turkey Creek, requiring less pipe (culvert) installation from the ponding area to the proposed outlet point. There is potential for nuisance flooding to occur if the constructed detention basin east of the Farmers' Market were to exceed its capacity during a storm event. This nuisance flooding is not expected with the relocation of the detention basin to north of the Farmers' Market as this site is at a lower elevation than the surrounding area.

All of the Alternative 2 and Alternative 3 concept alternatives are similar structural projects involving channel widening and levee/floodwalls that are distinguished only by differing project scales and the costs associated with these scales. For that reason, changes in cost estimates or other factors would most likely have a similar effect on all of the Alternative 2 and Alternative 3 concept alternatives rather than creating any ranking shifts compelling enough to necessitate a new economic analysis.

Based on the current economic analysis and information, Alternative 2d is the plan that reasonably maximizes the net national economic development benefits and is the most effective at addressing the planning objectives, and is therefore the NED plan. Alternative 2d would pass the 1-percent ACE event through downtown Merriam with an estimated assurance (conditional non-exceedance probability) of 82.9 percent, and provide greater net annual benefits in reduction of flood damages than the other Alternative 2 and Alternative 3 concept alternatives, in addition to meeting the needs of the local community.

8.1 NED PLAN COSTS

The NED costs of the recommended plan include the project first costs shown in Table 8-1 (design, construction, environmental mitigation, and LERRD costs) that will occur with project implementation. All of these costs are included in the economic analysis. The total annual cost (including interest during construction, and OMRR&R costs) for the NED plan was computed at the current FY15 Federal interest rate of 3.375 percent, October 2014 price level, and 50-year period of analysis. Table 8-2 displays the total annual cost of implementing the NED Plan.

Table 8-1: Detailed Breakdown of Project First Costs for NED Plan

(October 2014 Prices, 3.375% Interest Rate, 50-Year Period of Analysis, $1,000s)

Alternative	Construction Cost (Includes EDC and S&A)	PED Cost	LERRD Cost	Mitigation Cost (compensatory restoration)	Total First Cost
Alternative 2d	$ 24,655.0	$ 2,797.0	$ 10,122.0	$ 15.0	$ 37,579.0

Notes: Any discrepancies are due to rounding.

EDC – Engineering During Construction, PED – Preconstruction Engineering and Design, LERRD – Lands, Easements, Rights-of-way, Relocations, and Disposal Areas, S&A –Supervision & Administration

Table 8-2: Detailed Breakdown of Annual Costs for NED Plan

(October 2014 Prices, 3.375% Interest, 50-yr Period of Analysis, $1,000s)

Alternative	Project First Cost	Interest During Const.	Total Investment Cost	Annual Economic Cost	Annual OMRR&R Cost	Annual Induced Damages	Total Average Annual Cost
Alternative 2d	$ 37,579.0	$ 3,003.9	$ 40,582.9	$ 1,691.4	$ 40.8	$ 0.0	$ 1,732.2

Note: Any discrepancies are due to rounding.

8.2 NED PLAN PERFORMANCE

8.2.1 BENEFITS AND COSTS

Implementation of the NED plan would provide significant flood-risk management benefits. Table 8-3 displays the annual benefits, residual damages, annual cost, and net benefits for the NED plan.

Table 8-3: Summary of With- and Without-Project Annual Damages, Benefits and Costs

(October 2014 Prices, 3.375% Interest Rate, 50-Year Period of Analysis, $1,000s)

Reach Alternative	Total Annual Costs of Project *	Annual Benefits	Residual Damages	B/C Ratio	Net Benefits
Future Without Project	NA	NA	$ 4,749.6	NA	NA
Alternative 2d	$ 1,732.2	$ 3,444.7	$ 1,304.9	2.0	$ 1,712.5

Note: Any discrepancies are due to rounding.

* Includes PED, LERRD, Construction, Environmental Mitigations, Interest During Construction, and OMRR&R.

The risk and uncertainty-based economic performance and effectiveness of the NED plan is summarized in Table 8-4. The table displays the expected value and other probabilistic values of EAD and EAD reduced, thus showing the impact of uncertainty in evaluation of project benefits. For Alternative 2d, the mean/average estimate, given uncertainties, of the damage reduced is $3,444,700. However, there is a 75-percent chance that the damage reduced will be more than $1,749,100, a 50-percent chance that the damage reduced will be more than $2,986,100, and a 25-percent chance that the damage reduced will be more than $4,620,300. The damages reduced represent the project benefits, and are shown in terms of annualized equivalent values as computed in HEC-FDA.

Table 8-4: Probabilistic Economic Performance of NED Plan

October 2014 Prices, 3.375% Interest Rate, 50-Year Period of Analysis, $1,000s

Plan	Top of Levee/ Floodwall Elevation (feet)	Expected Value and Probabilistic Values of EAD and EAD Reduced					
		Equivalent Annual Damage			Probability EAD Reduced Exceeds Indicated Amount		
		Without Plan	With Plan	Damage Reduced	.75	.50	.25
Future Without Project	NA	$4,749.6	$4,749.6	NA	NA	NA	NA
Alternative 2d	920.00	$4,749.6	$ 1,304.9	$3,444.7	$1,749.1	$2,986.1	$4,620.3

Note: Any discrepancies are due to rounding.

EAD – equivalent annual damages

8.2.2 DAMAGE REDUCTION BY CATEGORY AND EVENT

Flooding will occur significantly less frequently in Reach 3b with implementation of the NED plan, and thus total EAD in Merriam is reduced by approximately 73 percent. Table 8-5 displays the NED plan and without-project EAD (physical and non-physical) by category of damage.

Table 8-5: Future With and Without Project Condition EAD by Category

(October 2014 Prices, 3.375% Interest Rate, 50-Year Period of Analysis, $1,000s)

Equivalent Annual Physical Damages		
Reach	Without Project	NED Plan
Commercial EAD	$ 4,411.1	$ 1,240.3
Commercial EAD Reduced	NA	$ 3,170.8
Public EAD	$ 30.6	$ 12.6
Public EAD Reduced	NA	$ 18.0
Residential EAD	$ 63.8	$ 4.8
Residential EAD Reduced	NA	$ 59.0
Clean-up EAD	$ 244.1	$ 47.3
Clean-up EAD Reduced	NA	$ 196.8
Total EAD	$ 4,749.6	$ 1,305.0
Total EAD Reduced	NA	$ 3,444.7

Note: Any discrepancies are due to rounding.

EAD – equivalent annual damages

Table 8-6 displays river discharge, river stage, maximum structure depth, and damage that could occur with a flood event of the specified exceedance probability with implementation of the NED plan. The NED plan features levees and floodwalls that are designed to protect Reach 3b against flood stages up to approximately the 0.0052 ACE event, preventing damage to Reach 3b for the events listed. Reaches 3a and 3c are unaffected by the project, and their EAD is the same as in the without-project condition.

Table 8-6: Single-Event Exceedance Probability-Damage with NED Plan

ACE Event	Discharge (cfs)	Stage (feet)	Max. Struc Depth[a]	Damage (October 2014 prices, $1,000s)	No. of Structures Affected
3a					
.1	9,843	891.71	1.7	$321.2	4
.01	16,613	896.61	6.6	$12,328.4	16
.002	21,526	901.64	11.6	$17,685.9	20
3b					
.1	10,718	915.44	NA	$0	0
.01	16,855	919.77	NA	$0	0
.002	21,037	921.55	14.0	$46,448.4	75
3c					
.1	4,409	949.26	NA	$2.7	0
.01	8,625	952.82	2.1	$4,312.7	2
.002	11,511	954.03	3.0	$6,262.3	2
Study Area Total					
.1	NA	NA	1.7	$323.9	4
.01	NA	NA	6.6	$16,641.1	18
.002	NA	NA	14.0	$64,760.6	97

Note: cfs – cubic feet per second

[a] Based on lowest structure.

8.2.3 ENGINEERING PERFORMANCE (ASSURANCE)

How well the NED plan would perform is indicated by the probability of the project being exceeded over a certain number of years. Long-term risk indicates how well the project will contain floods under conditions of uncertainty and over a long period of time. Table 8-7 shows the long-term risk or probability of the project being exceeded in a 10-, 30-, and 50-year period. The AEP (annual exceedance probability) of the NED plan design (probability of flooding in any given year with the project in place) in Reach 3b is 0.0052. Over a 10-year period, the probability of the top of project being exceeded is 0.0507 in Reach 3b. Over a 30-year period, the long-term risk is 0.1220, and it is 0.2292 over a 50-year period.

Table 8-7: Annual Performance and Equivalent Long-term Risk for NED Plan (Merriam Reach 3b)

Plan	Top of Levee/ Floodwall Elevation (feet)	Annual Performance (annual probability of design being exceeded)	Equivalent Long-term Risk (probability of exceedance over the indicated time period)		
			10 Years	30 Years	50 Years
Future Without Project	NA	0.2827	0.9646	0.9998	1.0000
Alternative 3d	920.98	0.0052	0.0507	0.1220	0.2292

As shown in Table 8-8, long-term risk can be alternatively described in terms of chance of flooding in any given year or in a specified time period. The equivalent long-term residual risk with the NED plan in place can be characterized as follows: There is a 1 in 3.5 chance that Reach 3b would flood in any year under the future without project condition. With the NED plan, Reach 3b has a 1 in 192 chance of flooding in any year, a significant reduction in the probability of flooding. Over 50 years, there is a 1 in 4 chance that the capacity of the project to protect against flooding would be exceeded one or more times. This shows a significant improvement over the near certainty of capacity exceedance in the future without project condition over 50 years. Over 30 years, there is a

1 in 8 chance of the project design capacity being exceeded (flooding), again a significant improvement over the near certainty of exceedance under the future without project condition. Over 10 years, there is a 1 in 20 chance with the NED plan, compared with a 1 in 1.04 chance under the future without project condition.

Table 8-8: Annual Performance and Equivalent Long-Term Risk for NED Plan (Merriam Reach 3b)

Plan	Top of Levee Floodwall Elevation (feet)	Annual Performance (annual probability of design being exceeded)	Equivalent Long-term Risk (probability of exceedance over the indicated time period)		
			10 Years	30 Years	50 Years
Future Without Project	NA	1 in 3.5	1 in 1.04	~ 1 in 1	~ 1 in 1
Alternative 3d	920.98	1 in 160	1 in 20	1 in 8	1 in 4

One metric used to characterize the performance of a flood risk management project is overall project reliability against the 1-percent ACE event. Table 8-9 displays, for the NED plan, the with-project conditional non-exceedance probability given the occurrence of a 1-percent ACE event. The table also displays the top of levee margins above the nominal 1 percent and below the nominal 0.2 percent ACE event water surface profiles.

Table 8-9: Conditional Probability of Design Non-Exceedance

Plan	Top of Levee/Flood Wall Elev. at Index Point (feet msl)	Overtopping Margin (feet) above 1% ACE Event Water Surface Profile	Overtopping Margin (feet) in comparison to 0.2% ACE Event Water Surface Profile	Conditional Probability of Design Containing 1% ACE Event
Alternative 3d	920.98	+1.21	-0.57	0.829

8.2.4 RED AND OSE EFFECTS

Implementation of the NED plan would provide RED benefits due to the decreased probability of flood events inundating the floodplain, as shown in Table 4-11. Existing businesses would be expected to continue their occupancy in Reach 3b, and new businesses and investment would be more easily attracted to the area in the future if vacancies occur, resulting in a stronger tax base. With reduced probability of flooding, business activity would be expected to remain relatively stable, barring unforeseen impacts from other sources. Additionally, temporary increases in employment would be expected during construction. The temporary presence of construction workers for the project may bring a temporary increase in demand for some services in the local area, but also a temporary increase in business volume, profits, and sales tax receipts at the local retail and service establishments.

The NED plan would also likely reduce the risk of life loss from flooding, due to the decreased probability of a flood event inundating the floodplain with short warning time.

8.3 RESIDUAL RISK

8.3.1 RESIDUAL DAMAGES

The total residual damage for the project is $1,304,900 per year, which is approximately 27 percent of the future without-project damages. All of the reduced damage takes place in Reach 3b, which has residual damage of $264,920, approximately 7.1 percent of the Reach 3b future without-project damages of $3,709,600. Residual damage for the project is $702,850 for Reach 3a and $337,170 for Reach 3c, both of which are unchanged from the future without-project condition.

8.3.2 RISK OF PROJECT CAPACITY EXCEEDANCE

Although floodplain users and occupants may desire 100 percent protection from flooding, this is an unachievable goal. No flood-risk management project can guarantee 100 percent elimination of flooding. With any flood-risk management project, it is important for floodplain users and occupants to be aware of the level of flood risk that remains even after implementation of a recommended project (see Tables 8-4 and 8-7 above). The probability and occurrence of flooding would be less frequent with the implementation of the recommended plan in the Merriam Project area. However, during major flood events, residents and other floodplain occupants may still be ordered to evacuate and move to higher ground. If levees and/or floodwalls failed or overtopped during these events, flood depths could reach more than 14 feet in the Merriam Project Area, causing significant damages. The probability that a flood event will overtop the levees and/or floodwalls in Reach 3b is approximately 0.52 percent in a given year and 22.9 percent over a 50-year period. The probability of flood events inundating Reach 3a or Reach 3c would be unchanged from the future without-project condition. For Reach 3a this probability would be approximately 11 percent in a given year and over 99 percent over a 50-year period, and for Reach 3c the probability would be approximately 8.6 percent in a given year and approximately 99 percent over a 50-year period.

9.0 PLAN FOR ECONOMIC UPDATES

ER 1105-2-100, para. D-4, requires a plan for conducting updates of the project economic justification. Economic updates, revisiting estimated damages, benefits, costs, affected population, and residual risk, will be required every three years. Updates are not intended to involve major economic analyses or extensive reworking of the feasibility study analysis. They are intended to verify the continuing validity of important assumptions on which the economic justification is founded as well as to convert data to current price levels. It is currently expected that the first economic update would be required in FY 2018.

If there have been only modest changes in the study area's economic base since the previous approved update, and there have been no changes in engineering data or plan formulation, it may be concluded that the changes in the economic base do not challenge the fundamental economic development assumptions that supported the previous economic analysis. In this case, the update can be a Level 1 update consisting of a simple reaffirmation of the benefits from the previous analysis and involving no structure inventory revision and new benefit calculations.

If significant changes have occurred in the area's economic base since the previous approved update, but there have been no changes in the supporting engineering data or the plan formulation, a Level 2 update will be called for. The Level 2 update will entail revising the structure inventory and recalculating benefits. If there have also been changes in the engineering data and/or the plan formulation in addition to the economic base changes, a Level 3 update will be required involving structure inventory revision, new economic modeling, and recalculation of the benefit-cost ratio.

Task 1: Data gathering -- The first task for the economic update for all levels will be data gathering to evaluate changes since the last approved economic analysis in the economic base and the population at risk. A brief windshield survey including all major portions of the study area will be carried out to initially identify major changes in the scale or condition of residential and nonresidential properties and transportation networks. Local city and Chamber of Commerce staff will be consulted to further help identify major changes of the previous three years pertaining to the economic structure inventory and particularly to major nonresidential properties. Discussions will encompass verification of continuing operations at major properties, identification of significant changes in operational scale at major businesses and facilities, and identification of significant new development including major new businesses, public facilities, residential developments, and roads and streets. Business operators may also be consulted briefly for general information on operational

scale. Additional research on the internet will also be carried out in judging the extent of economic changes.

Task 1 (data gathering) estimated labor: 32 hours.

Task 2: Structure inventory and population at risk revisions – This task will not be required for Level 1 updates. For Level 2 or 3 updates, an updated structure inventory will be necessary. For all businesses and public facilities, new updated depreciated replacement structure values will be calculated using RS Means cost per square foot values and appropriate individual depreciation rates. Contents will be adjusted as appropriate based on information gathered from the first task. Since there are only a few homes in the floodplain, residential updating will also involve calculation of new depreciated replacement structure values for all homes using RS Means cost per square foot values and appropriate individual depreciation rates. For roads, streets and railroads, updated average replacement costs per mile, as well as average depreciation factors, will be used to bring depreciated replacement values up to date for each type of road. Estimates of affected population and population at risk also will be updated if significant new block or block-level Census data are available.

Task 2 (structure inventory revision) estimated labor: 28 hours (Level 2 & 3 only)

Task 3: Economic modeling – This task will not be required for Level 1. For Level 2 updates, the HEC-FDA model will be loaded with the updated structure inventory. For Level 3 updates, it will be necessary to revise the HEC-FDA model using new engineering data and/or new plan formulation in addition to loading the updated structure inventory.

Task 3 (economic modeling) estimated labor: 8 hours (Level 2); 24 hours (Level 3)

Task 4: Computation of updated benefits -- The revised HEC-FDA model will be used to calculate new benefit estimates for Level 2 or 3 updates.

Task 4 (benefits computation) estimated labor: 8 hours (Level 2 & 3 only)

Task 5: Costs and B/C ratio – An updated cost estimate will be prepared by engineering staff (labor not included here) and annualized. Benefit-cost ratios and net benefits will be calculated based on the updated benefits (for Level 2 or 3 updates) and costs (for all levels).

Task 5 (BCR) – 2 hours (all levels)

Task 6: Documentation -- A report will be prepared documenting the tasks completed and the results of the updated analysis. This will be a brief report for Level 1 updates, more extensive for Level 2 or 3 updates.

Task 6 (report preparation) – 8 hours (Level 1); 24 hours (Level 2 & 3)

Total estimated labor:

Level 1 economic update: 42 hours

Level 2 economic update: 102 hours

Level 3 economic update: 118 hours

10.0 CONCLUSION

The feasibility-level socioeconomics analysis of the Upper Turkey Creek flood risk management project has found that a strong Federal interest exists in the NED plan. The plan exhibits very strong economic justification with a benefit-cost ratio of 2.0. With net benefits of $1,712,500, the project represents a strong contribution to national economic outputs. The plan also would make important contributions to public safety considerations.

Annual benefits	**$3,444,700**
First costs	**$37,579,000**
Annual costs	**$1,732,200**
Benefit-cost ratio	**2.0**
Net benefits	**$1,712,500**

Appendix G
Real Estate

Upper Turkey Creek
Johnson County and Wyandotte County, Kansas
Flood Risk Management Project
Feasibility Study Report with Integrated Environmental Assessment

Real Estate Plan (REP)

1. Purpose:

This Real Estate Plan (REP) is presented in support of the Feasibility Study Report with Integrated Environmental Assessment dated October 2014. A previous REP for this project was a part of the October 2013 Feasibility Report with Integrated Environmental Assessment and was sent through Northwest Division for Headquarters USACE. HQUSACE completed a review of the previous plan and provided comments December 2013. These concerns have been addressed and are a part of this report. Additional information from the Atlas 14 Precipitation Frequency Data Server caused a change in the scope of the project and reexamination of the real estate required.

This Real Estate Plan was developed in support of the Feasibility Report authorized by Resolution of the Committee on Transportation and Infrastructure, U.S. House of Representatives, Docket 2616, adopted February 16, 2000, Section 101(A)(24) of Public Law 106-53, the Water Resources Development Act of 1999. The purpose of this plan is to include information on any real estate activities that may be involved for the identified project. The project is located in the Turkey Creek Basin, in Johnson and Wyandotte Counties, Kansas. The Turkey Creek is a right bank tributary of the lower Kansas River.

The Non Federal Sponsor (NFS), the City of Merriam, requested Corps assistance to develop and construct a flood risk management project. Potential for flooding that could result in loss of life and/or property damage in the Upper Turkey Creek basin creates a need for this project. Flooding in and around Johnson County, Kansas, led to presidential disaster declaration in 1993 and 1998. Heavy rains in 1998 produced flooding that caused several million dollars in damage to businesses and public property along Turkey Creek in Johnson and Wyandotte Counties, Kansas.

Urbanization and ongoing development in the Upper Turkey Creek watershed has resulted in degradation of environmental resources associated with the creek. The creek has been deepening and widening its channel as a result of high runoff volumes and flow rates associated with urbanization in the watershed. In response, much of the creek channel has been enclosed in culverts, lined with concrete, or otherwise hardened to address channel instability. Stream reaches where the channel has been enclosed or hardened with concrete provide little or no habitat value and represent impassable biological dead zones for most of the fish and other aquatic wildlife in Turkey Creek. Failure of Turkey Creek to attain its designated recreation and aquatic life uses is, in part, a result of these channel modifications.

The Real Estate Plan is tentative in nature; it is for planning purposes only and both the final real property acquisition lines and the real estate cost estimates provided are subject to change even after approval of the Feasibility Report. This REP is an update to the plan completed in April 2013.

Access to, from and across the project area will be by way of city streets. Access may also be requested from landowners adjacent to the project areas of interest if needed.

2. Description of Lands, Easements, Rights of Way, Relocation and Disposal (LERRD):

Most all the properties associated with the project are located in a mixed commercial/industrial area with a few areas of residential housing. Improvements include auto parts stores, used car sales lots, warehouses, City of Merriam buildings, car rental agencies, and other locally owned retail stores.

Required estates for project purposes will include permanent easements for flood protection, temporary work area easements, flood protection easements, fee acquisition, and utility easements. Four properties will be acquired in fee due to the fact that acquisition of only a portion of the property would leave an uneconomic remnant. The entire project will affect 121 tracts. Parcels JP35000000-0009, JP28000033-0024D and JD241212-3006 will need to be acquired in fee due to the location of the buildings and the need for space for the levee and/or floodwall. Parcel JF241212-3005 is where the detention basin will be constructed. The elevation of this property will be adjusted and will require removal of the building. No disposal action is needed for this project.

TABLE 2.1 – Real Estate Required for Project		
Type of Acquisition	Approximate Acreage	Estimated Costs
Temporary Construction Easement	4.59	$54,042.00
Permanent Flood Protection Easement	8.6	$1,068,052.00
Fee Acquisition- due to project structures	1.5	$1,151,810.00
Fee Acquisition- Mitigation	7	$35,000.00
Utility Easement (Permanent)	2.15	$182,524.00

For further detail regarding tract ownership, and footprint for the project structures, please see Exhibit B. Mitigation land is not shown in Exhibit A or B. The exact City parks which will be used for mitigation are still in discussion.

Required estates for project purposes will include permanent easements for flood protection, temporary work area easements, drainage ditch Easements, flowage easement and utility relocation.

Temporary Work Area Easement:
A temporary easement and right-of-way in, on, over and across (the land to be described) for a period not to exceed three (3) years, beginning with the date of possession by the NFS, for use by the United States, the Sponsor, its representatives, agents, and contractors as a temporary ingress and egress route, construction area, and work area, including the right to move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the Emergency Streambank Protection Project together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way, and the right to clear, borrow, excavate and remove soil, dirt and other materials; 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 and highways, public utilities, railroads and pipelines.

Flood Protection Easement (Permanent):
A perpetual and assignable right and easement to construct, maintain, repair, operate, patrol and replace a flood protection levee, including all appurtenances thereto, and a right of ingress and egress; reserving however, to the owners, their heirs and assigns, all such rights and privileges in the land 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.

Pipeline (Utility) 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 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, railroads and pipelines.

Fee:
The fee simple title to (the land described in_____Schedule A) (Tracts Nos. _____, _____ and _____), Subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

ER405-1-12 states that uneconomic remnants are required to be purchased in fee under Section 301 (9) of Public Law 91-646 (para 2-20) "If the acquisition of only a portion of a property would leave the owner with an uneconomic remnant, the head of the Federal agency concerned shall offer to acquire that remnant. For the purposes of this Act, an uneconomic remnant is a parcel of real property in which the owner is left with an interest after the partial acquisition of the owner's property and which the head of the Federal agency concerned has determined has little or no value or utility to the owner".

3. Land Owned by the Non-Federal Sponsor:
The City of Merriam owns fee over approximately 7.5 acres along the project area. These lands are available for the project but not sufficient to cover all improvements, so additional real estate acquisitions are required. The City has also granted the use of City parks in the area to mitigate tree loss. The Merriam Drainage District also owns fee over 9.2 acres along the channel and will be available for use on the project.

As per ER 405-1-12, Chapter 12, paragraph 12-38 "The non-Federal sponsor shall not receive credit for the value of any LER, including incidental costs that have been provided previously as an item of cooperation for another Federal project." At this time none of the lands identified as belonging to the NFS have been provided previously for another Federal Project. Credit will be received for previous and newly acquired LERRD.

4. Non-Standard Estates:
No non-standard estates have been identified for this project.

5. Existing Federal Projects:
There are no existing Federal Projects within the proposed project area. However, there is a project on the lower portion of the creek that is an authorized USACE Turkey Creek Basin, Kansas City, Kansas and Missouri, flood damage reduction project that includes a combination of improvements to the tunnel, bridge modifications, channel widening, and a series of enlargements to the hillside interceptors. A portion of this project has been completed and the rest is in various stages of the process.

6. Federally Owned Land:
There are currently no federally owned lands within the project area.

7. Navigational Servitude:
The Federal Navigational Servitude doctrine arises from two related components: navigation power which is derived from the commerce clause of the U.S. Constitution giving Congress regulatory power over navigable waters; and navigation servitude which provides that certain private property may be taken, without compensation to the landowner, if the taking is necessary to exercise the navigation power. Private ownership of land below navigable or tidal waters is acquired and held subject to the dominant public right of navigation. This dominant public right may be exercised by Congress without giving rise to a compensable taking. Turkey Creek is not navigable therefore exercise of Federal Navigational Servitude is not applicable to the project.

8. Real Estate Maps:
Project maps are included as Exhibit A. Real Estate mapping depicts the project area, tract boundaries required to support the project, significant utilities to be relocated and known or potential HTRW lands.

9. Flooding Induced by Project:
The feasibility study requires the analysis of any induced damages due to raises in the water surface profile caused by raises of the studied levee unit. There is no shown induced flooding due to the construction of this project.

10. Baseline Cost Estimate on Acquisition of LERRD:

For a summary of total real estate costs see table 10.1. Temporary work area easements, permanent flood protection levee easements, flowage easement and pipeline easement will be required and are included in the cost estimate along with incidental costs for the NFS and in-house Federal administrative costs. There are four properties that will require fee acquisition and one shed will have to be acquired. The estimated cost includes the estimate for the purchase of these properties and an estimated cost for P.L. 91-646 relocation costs. When there was an absence of specific information relating to suspect contaminated area, for this cost estimate, it was prudent to value the land as clean. Known areas of contamination will be avoided to the fullest extent possible. The non-federal sponsor will be responsible for all clean up of environmental contamination and is aware of this fact.

Below is a summary table of the Real Estate Baseline Cost Estimate for Land costs, Utility and Facility Relocations, PL91-646 Relocations and Administrative costs for the NFS. Land cost values are based on a Cost Estimate conducted and approved by Kevin Keller of the Kansas City District Corps of Engineers Office November 2014. The Utility and Facility Relocation costs were provided by cost estimators at the Kansas City District Corps of Engineers.

TABLE 10.1 - Baseline Cost Estimate	
Type of Costs	**Total Costs**
Land Acquisition Costs	
Temporary Construction Easement	$54,042.00
Permanent Flood Protection Easement	$1,068,052.00
Fee Simple for Project Structures	$1,151,810.00
Fee Simple for Mitigation lands	$35,000.00
Utility Easement (Permanent)	$182,524.00
P.L. 91-646 Relocations	$250,000.00
Total Real Estate Acquisition Costs	$2,741,428.00
20% Contingency	$548,286.00
Total Real Estate Acquisition Costs w/ Contingency	$3,289,714.00
Utility/Facility Relocation Costs	
Utility Relocation	$3,254,351.00
Pedestrian Bridge and Trail Relocation	$584,011.00
Total Utility/Facility Relocation	$3,838,362.00
25% Contingency	$959,591.00
Total Utility/Facility Relocation w/ Contingency	$4,797,953.00
LERRD Administrative Costs	
Non-Federal Sponsor Incidental Costs	$1,264,500.00
Federal Incidental Costs	$90,000.00
Total Incidental Costs	$1,354,500.00
15% Contingency	$203,175.00
Total Incidental Costs w/ Contingency	$1,557,675.00
Total LERRDS Costs for Project	$9,645,342.00

11. Relocation Assistance (P.L. 91-646):
The non-federal sponsor has been provided information on P.L. 91-646 and is aware of the obligation to ensure compliance. During planning, there has been coordination with engineering impact as few parcels as necessary. However, five parcels within the project footprint will likely require P.L. 91-646 assistance. (See table 11.1 for a list of properties that were identified as a possible disruption to business or residence).

Table 11.1 – Relocation Assistance (P.L. 91-646)

Property ID	Full Take Included in Appraisal Cost	Comments	Estimated Relocation Costs
JF241212-3005	Yes	The placement of the levee along the creek and plans for a detention basin on this commercial property makes a full take required. Estimated relocation costs include, moving expenses, searching for replacement property costs, and reestablishment costs.	$60,000
JP35000000-0009	Yes	The placement of a floodwall and levee will go through the center of the commercial property, including the existing structure. Estimated relocation costs include, moving expenses, searching for replacement property costs, and reestablishment costs.	$60,000
JF241212-3006	Yes	Improvement on this commercial property currently sets within feet of the bank leaving little room for the proposed construction of a floodwall and levee. Estimated relocation costs include, moving expenses, searching for replacement property costs, and reestablishment costs.	$60,000
JP28000033-0024D	Yes	The placement of the levee will impact the residential property to the extent that a full take is required. Estimated relocation costs include, replacement housing and moving expenses.	$55,000
JF84000009-0001A	Taking of Shed Only	A small storage building located within feet of the creek bank. A flood wall is planned for this tract. It is estimated that this building will have to be acquired with the remaining portion of the property retaining its' highest and best use. The estimated relocation costs for the shed are moving expenses.	$15,000

12. Mineral Activity Impacted Present/Future:
There is no current or anticipated mineral activity or timber value impact in the vicinity of the proposed project.

13. Assessment of Non-Federal Sponsor Legal Capability:
The Corps has worked with the City of Merriam to complete the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capabilities Checklist (See Exhibit C). The non-federal sponsor has the legal authority to acquire and hold

title to real property and condemnation authority and is fully capable of contracting for all real estate needs for the project. The sponsor will not require USACE assistance with acquiring real estate. Financial capability is addressed in the main report.

14. Zoning Ordinances Considered in Support of LERRD Requirements:
Predominate zoning within the boundaries of the project is commercial, light industrial, and business industrial. All land associated with the project are located within a flood zone. Zoning issues are not anticipated for this project.

15. Real Estate Acquisition Schedule:
The project sponsor is responsible for acquiring real estate interests required for the project. A time frame for land acquisition has been outlined for the area of interest ranging from 6 months to 1 year and can begin when final plans and specs have been completed and the PPA has been executed. The Project Manager and Real Estate Division will formulate the milestone schedule upon project approval to meet dates for advertisement and award of a construction contract.

16. Facility/Utility Relocation:
The pedestrian bridge in Reach 3, (shown on Plate 6 of Exhibit A) will require a modification consisting of widening the bridge to span across the new levee walls.

The Feasibility Study examined the utilities crossing affected by the project for the Upper Turkey Creek. Together with Civil Engineering and Cost Estimating the plan was scrutinized to estimate costs of relocation or removal of functioning and/or abandoned utilities. The Baseline Cost Estimate captures these assumptions. The Government will make a final determination of the relocations necessary for the construction, and operation, or maintenance of the project during the design phase and approval of final attorney's opinions of compensability for each of the impacted utilities and facilities.

The utilities that will be relocated are: storm and sanitary sewer, Electric lines, and gas lines. All are shown in Exhibit A. A description of the planned relocations can be found in Appendix B, Chapter 1, Paragraph 6 of the Feasibility Study.

"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."

17. Impact of HTRW:
A general records search of hazardous, toxic, and radioactive waste (HTRW) sites was conducted in 2011 by the Corps of Engineers along the Upper Turkey Creek corridor. This included the EPS Enviromapper, EPA Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS) database, KDHE Identified Sites list, KDHE aboveground storage tanks and underground storage tanks assessment database, and KDHE database of registered underground storage tanks.

Findings from the records search indicate that there are no known hazardous waste sites within or adjacent to the project area. In addition, no solid waste facilities, such as former landfills, were identified. There are many records of leaking underground storage tanks throughout the Upper Turkey Creek watershed. Some of these tanks were located near the downstream portion of the proposed project area at 5639 Merriam Drive, Merriam, Kansas. This facility is used as a school bus station. The leaking tanks were used to store waste oil and diesel fuel. The storage tanks were removed along with approximately 170 cubic yards of contaminated soil, which was disposed of in accordance with environmental procedure. Additional underground storage tanks are currently registered at this location, although they are not known to be leaking.

18. Opposition/Support of Project by Local Landowners:
Input was received through coordination with public and other agencies on the draft and interim products during workshops and public meetings during the Reconnaissance Phase, initiation of the Feasibility Study and mid-way through Phase 2 of the Feasibility Study to receive feedback on the possible alternatives. The recommended plan reflects the views of the public received during the workshops and public meeting and therefore is accepted and supported by the local landowners.

19. Notification to Non-Federal Sponsor of Early Acquisition of LERRD:
The Non-Federal Sponsors have been advised in writing of the risks associated with advance land acquisition activities. A risk letter was mailed to the Non-Federal Sponsor 25 April 2013. The risks outlined in the letter include but are not limited to:

- Congress may not appropriate funds to construct the proposed project;
- The proposed project may otherwise not be funded or approved for construction;
- A project partnership agreement (PPA) mutually agreeable to the Non-Federal Sponsor and the government may not be executed and implemented;
- The Non-Federal Sponsors may incur liability and expense by virtue of their ownership of contaminated lands, or interests therein, whether such liability arising out of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended;
- The Non-Federal Sponsors may acquire interests or estates that are later determined by the government to be inappropriate, insufficient, or otherwise not required for the project;
- The Non-Federal Sponsors may initially acquire insufficient or excessive real property acreage, which may result in additional negotiations and/or benefit payments under public law (P.L.) 91-646, as well as the payment of additional fair market value to affected landowners which could have been avoided by delaying acquisition until after PPA execution and the government's notice to commence acquisition and performance of LERRD; and
- The Non-Federal Sponsors may incur costs or expenses in connection with their decision to acquire or perform LERRD in advance of the executed PPA and the government's notice to proceed, which may not be creditable under the provisions of P.L. 99-662 or the PPA.

20. All other Real Estate Issues:
Cultural Resources, District Archeologists have researched and performed field surveys of the areas of interest. Coordination with the Missouri State Historic Preservation Office (SHPO) is ongoing. It has been determined that the project will result in no known adverse effects on historic properties, but appropriate measures will be taken to avoid, minimize or mitigate any effects.

Unidentified public utilities could be an issue as most of the areas of interest are heavily developed and have been for close to one hundred years. PDT members are working closely with sponsors to identify possible problem areas and avoid or address any utilities in question.

This report was prepared by Meredith Harmon, March 2015

CENWK-OC 9 March 2015

MEMORANDUM FOR CENWK-RE

SUBJECT: Upper Turkey Creek Real Estate Plan (REP) Legal Sufficiency Review Revised

I have revised my 10 December 2014 review of the "Real Estate Plan (REP)" for the "Upper Turkey Creek Johnson County and Wyandotte County, Kansas Flood Risk Management Project Feasibility Study Report with Integrated Environmental Assessment" for legal sufficiency and have found the following issues which are required by ER 405-1-12:

1. Paragraph 16 states that there is a pedestrian bridge that will require a modification consisting of widening the bridge to span across the new levee walls. There is no identification of the owners of this affected facility, whether these owners have a compensable interest in the land on which the impacted portion of the facility is located, nor has there been a Preliminary or Final Attorney's Opinion of Compensability completed in support of this relocation or modification determination.
2. Paragraph 16 continues to state there are "storm and sanitary sewer, electric lines, and gas lines" that "will be relocated." Again, however, there is no identification of owners, no indication whether they have a compensable interest in the land on which the impacted portion of the utilities is located, nor is there any completed Preliminary or Final Attorney's Opinions of Compensability.

Alice J. Edwards

Alice J. Edwards

Assistant District Counsel

Kansas City District

U.S. Army Corps of Engineers

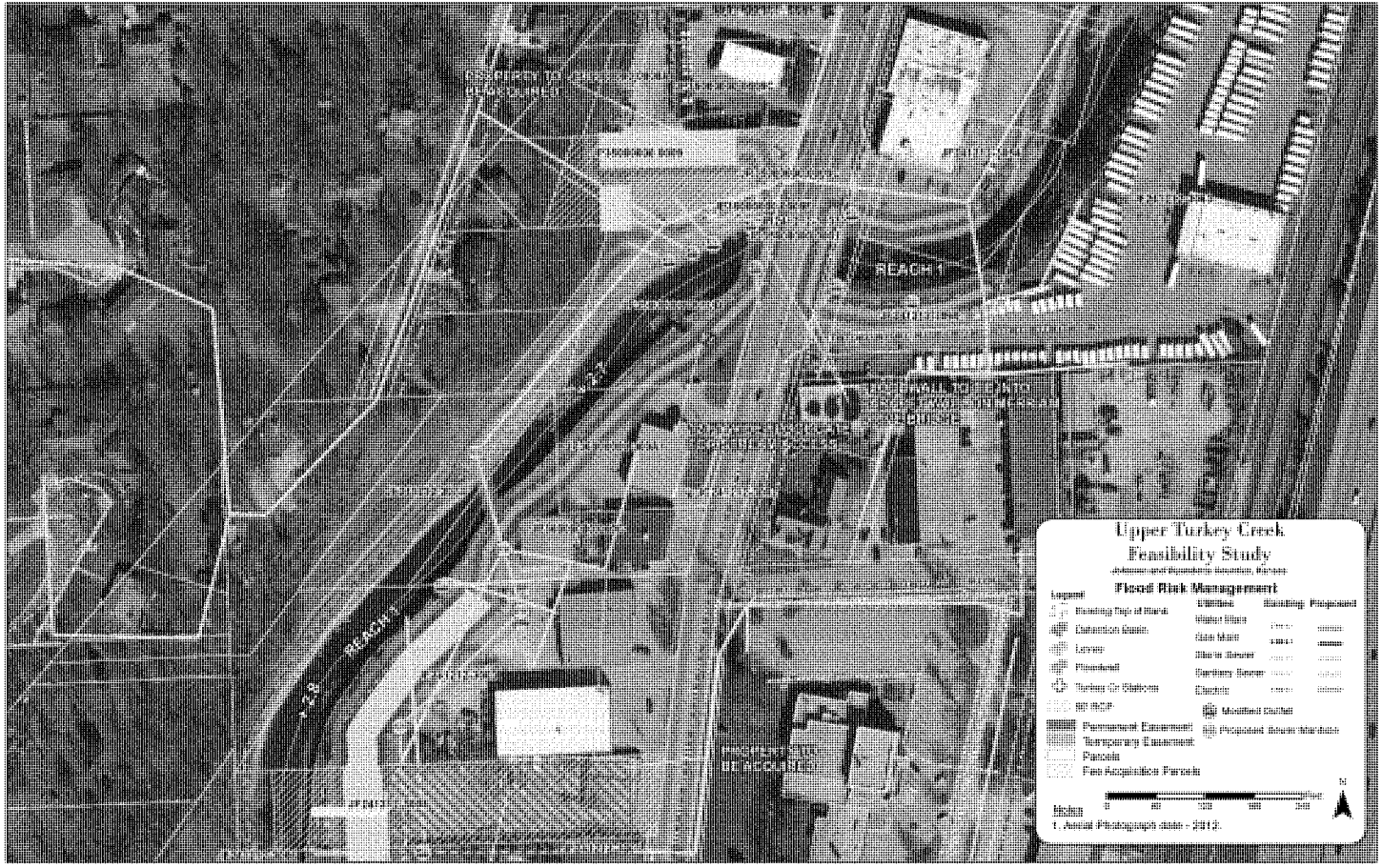


Exhibit A

PLATE 1

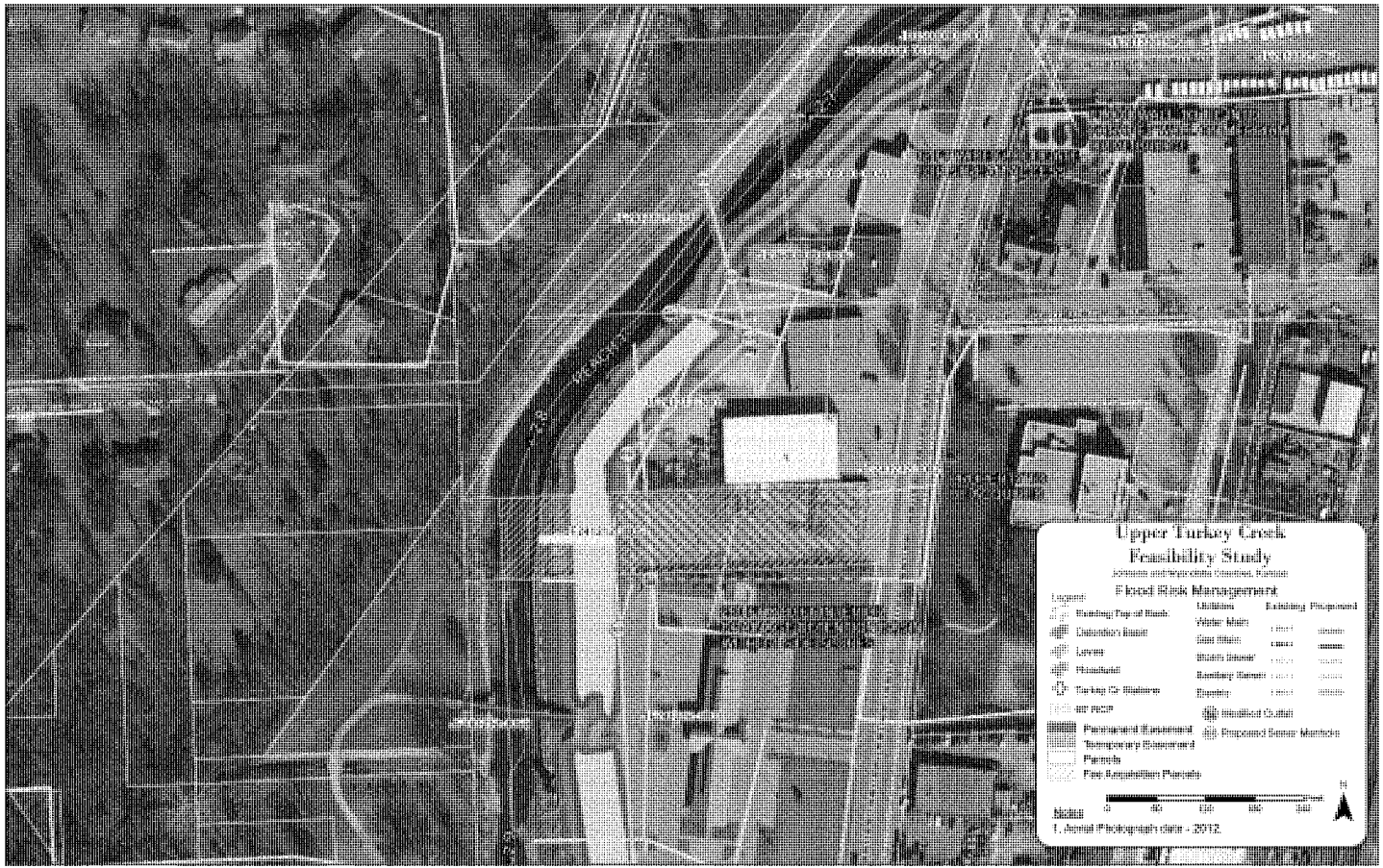


PLATE 2

Exhibit A

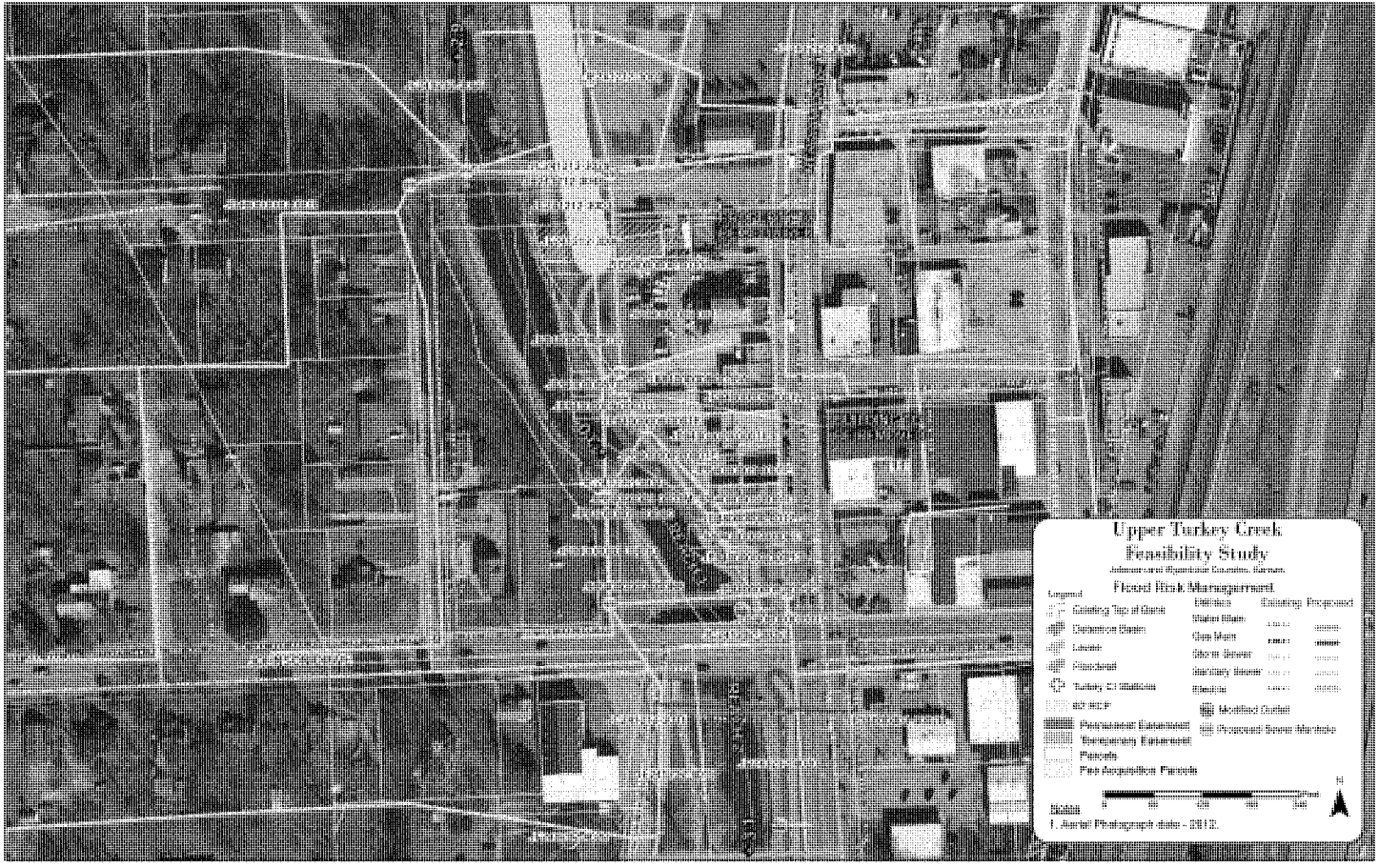


Exhibit A

PLATE 3

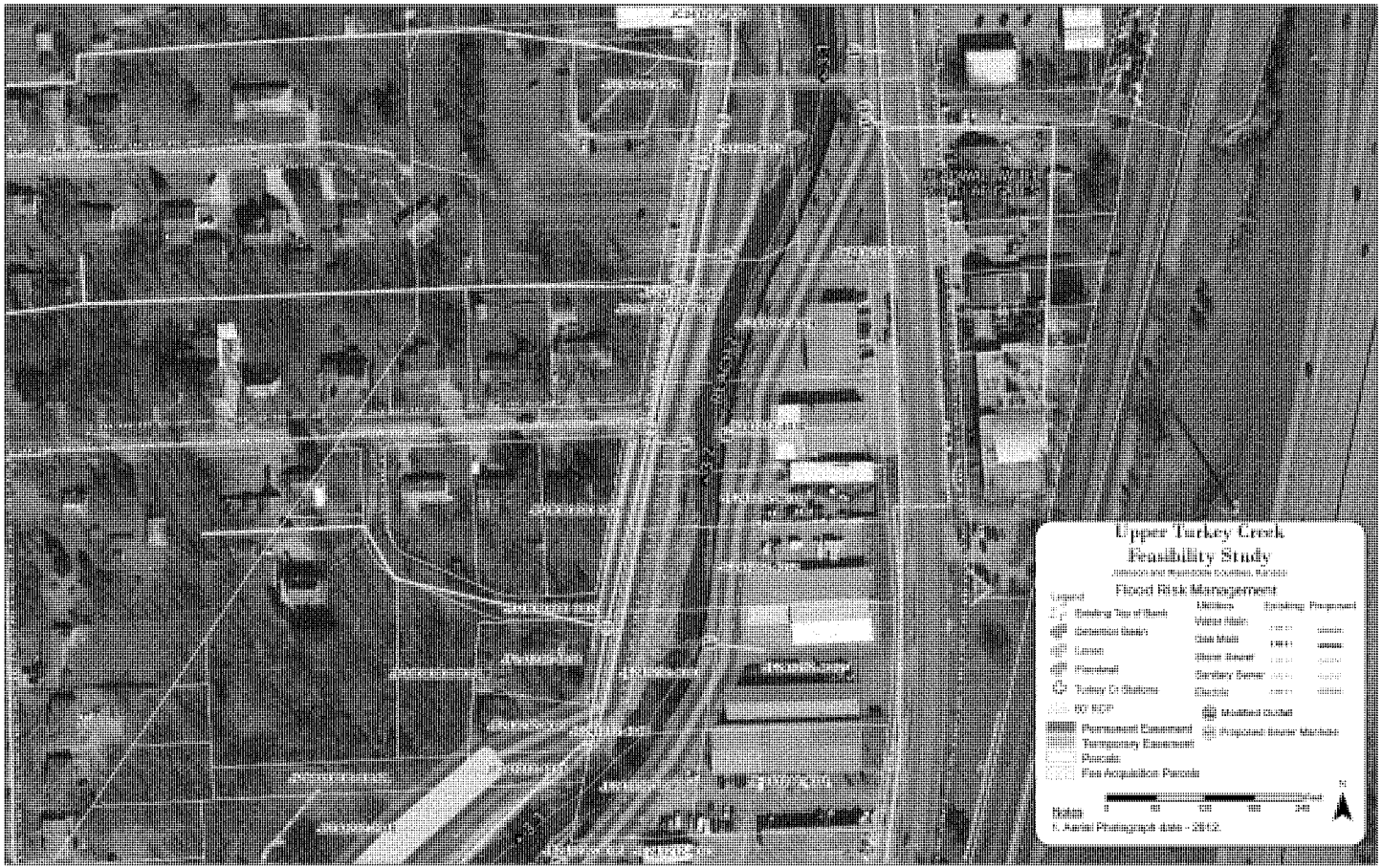


Exhibit A

PLATE 4

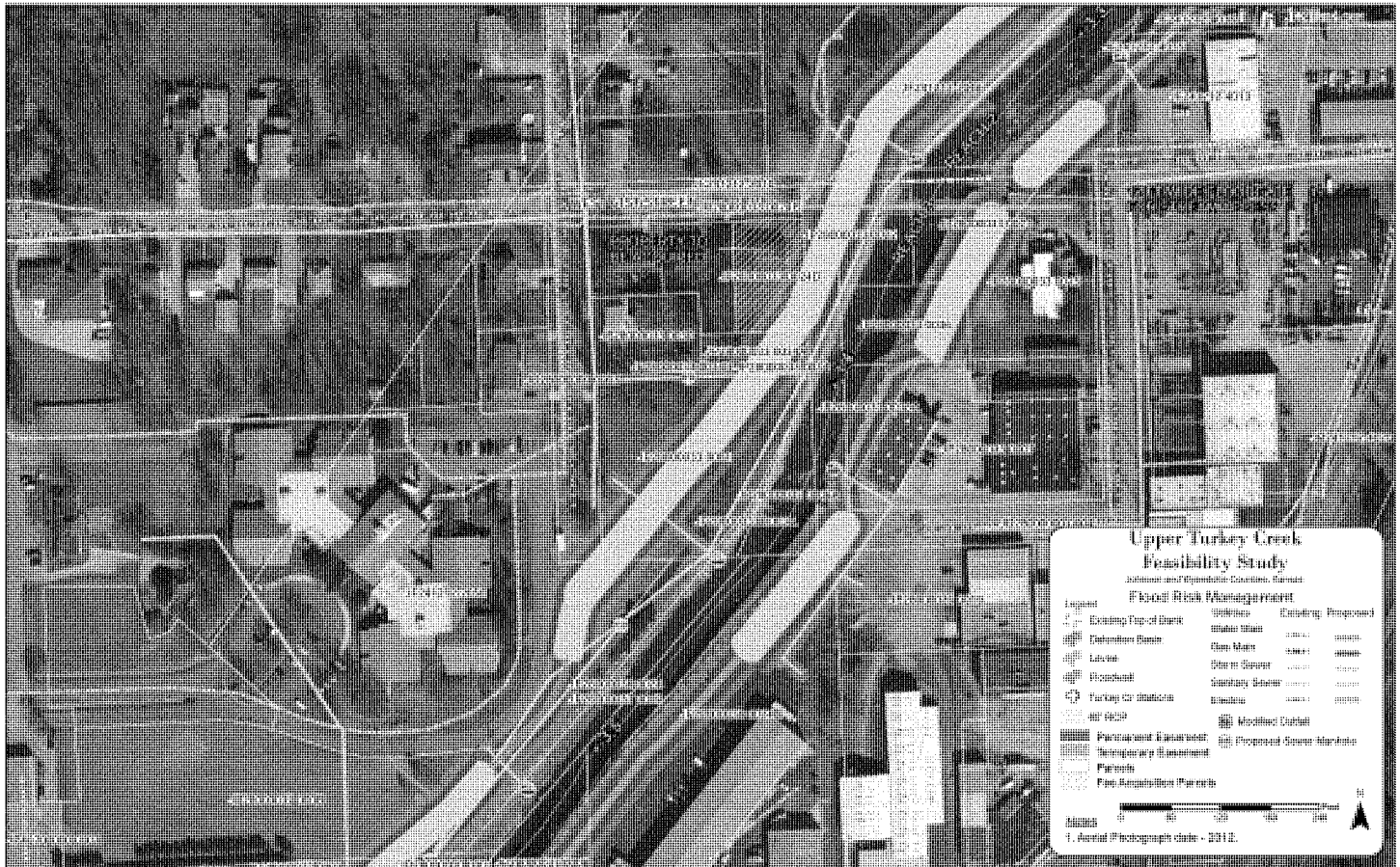


Exhibit A

PLATE 5

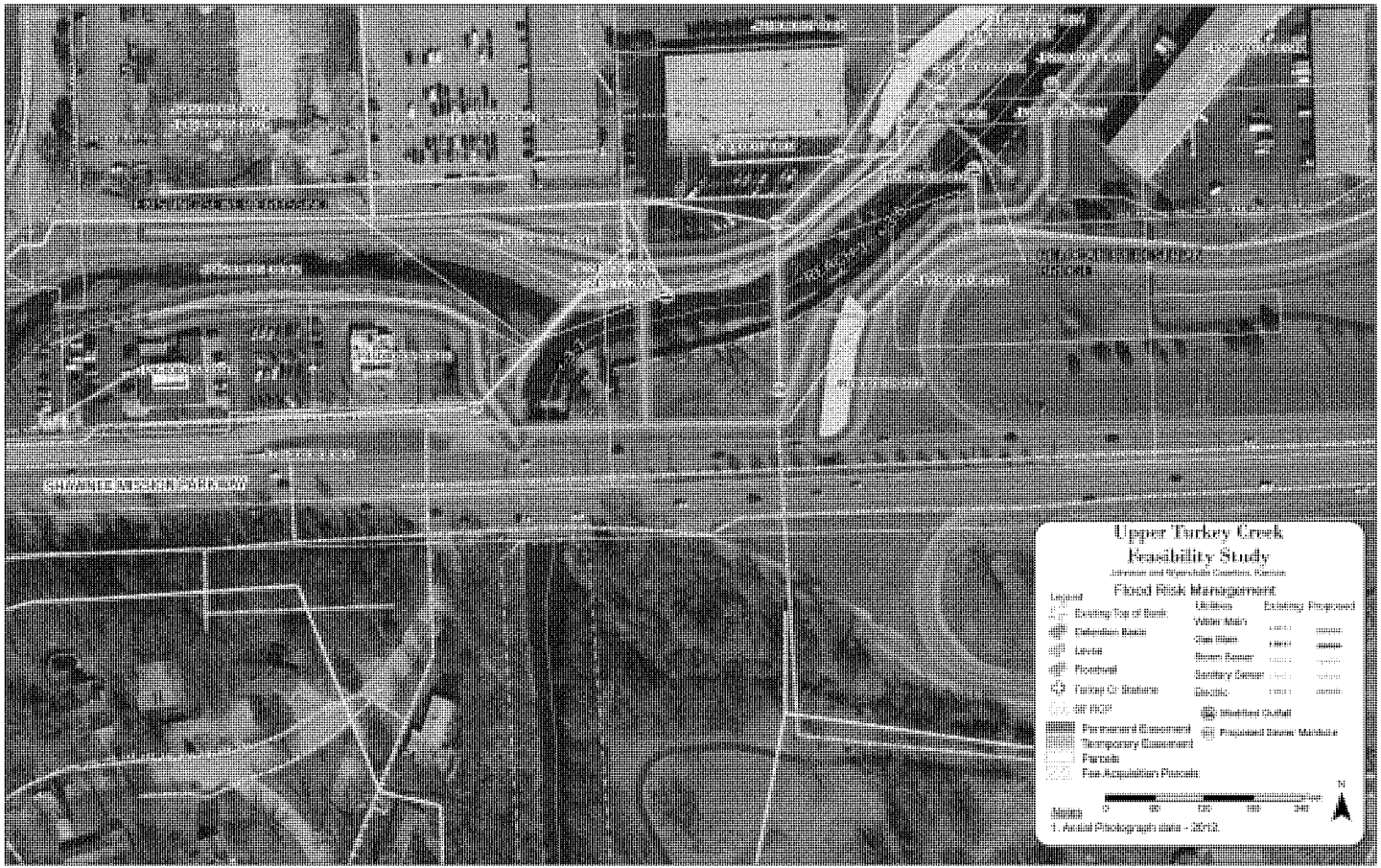


PLATE 6

Exhibit A

	A	B	C	G	H	I	J	K	L
1	Parcel	Acquisition Type	PROPERTY ID	Area Sq ft of acquisition	Ownership Information	Fee Acquisition	Permenant Flood Protection Easement	Temporary Construction Easement	Utility Easement
2	1	Floodwall_perm	JC241212-2002	929.9927495			1859.985499	1238.760793	494.9698337
3		Floodwall_perm	JC241212-2002	929.9927495					
4		Floodwall_temp	JC241212-2002	619.3803967					
5		Floodwall_temp	JC241212-2002	619.3803967					
6		Sewer_Utilities	JC241212-2002	8.85715846					
7		Sewer_Utilities	JC241212-2002	8.85715846					
8		Sewer_Utilities	JC241212-2002	238.6277584					
9		Sewer_Utilities	JC241212-2002	238.6277584					
10	2	Levee_Perm	JC241212-2010	1157.463911			2052.160327	677.3350433	286.0896564
11		Levee_Perm	JC241212-2010	894.6964163					
12		Levee_Temp	JC241212-2010	146.8937112					
13		Levee_Temp	JC241212-2010	378.8677734					
14		Levee_Temp	JC241212-2010	151.5735587					
15		Electric_Utilities	JC241212-2010	286.0896564					
16	3	Gas_Utilities	JC241212-2011	300.5383695					300.5383695
17	4	Floodwall_perm	JC241212-3002	3785.843605			3785.843605	1177.269594	452.3098322
18		Floodwall_temp	JC241212-3002	1177.269594					
19		Storm_Utilities	JC241212-3002	158.3045387					
20		Gas_Utilities	JC241212-3002	0.001868631					
21		Storm_Utilities	JC241212-3002	129.5147189					
22		Gas_Utilities	JC241212-3002	53.37417615					
23		Storm_Utilities	JC241212-3002	1.157789184					
24		Gas_Utilities	JC241212-3002	1.157789184					
25		Gas_Utilities	JC241212-3002	54.39947572					
26		Storm_Utilities	JC241212-3002	54.39947572					
27	5	Levee_Perm	JC241212-3003	2631.81229			2631.81229	811.3916515	104.732174
28		Levee_Temp	JC241212-3003	811.3916515					
29		Sewer_Utilities	JC241212-3003	104.732174					

Exhibit B

	A	B	C	G	H	I	J	K	L
30	6	Floodwall_perm	JC241212-3004	1605.912452			1605.912452	1621.703239	2309.414078
31		Floodwall_temp	JC241212-3004	1621.703239					
32		Sewer_Utilities	JC241212-3004	1108.2284					
33		Sewer_Utilities	JC241212-3004	1201.185679					
34	7	Floodwall_perm	JC241212-3005	220.0445014			220.0445014	481.5594796	
35		Floodwall_temp	JC241212-3005	481.5594796					
36	8	Levee_Perm	JC241212-3029	766.2540887			766.2540887	236.1940817	1310.352611
37		Levee_Temp	JC241212-3029	236.1940817					
38		Sewer_Utilities	JC241212-3029	97.1796758					
39		Sewer_Utilities	JC241212-3029	1213.172935					
40	9	Floodwall_perm	JD13000000 0004	49.36521762			49.36521762	931.9878635	707.0197869
41		Floodwall_temp	JD13000000 0004	931.9878635					
42		Sewer_Utilities	JD13000000 0004	431.9190804					
43		Storm_Utilities	JD13000000 0004	275.1007065					
44	10	Floodwall_perm	JD18000000 0002	1777.282378			1777.282378	2482.136332	2293.069953
45		Floodwall_temp	JD18000000 0002	2482.136332					
46		Storm_Utilities	JD18000000 0002	2063.265288					
47		Gas_Utilities	JD18000000 0002	229.4183592					
48		Storm_Utilities	JD18000000 0002	0.193152503					
49		Gas_Utilities	JD18000000 0002	0.193152503					
50	11	Levee_Perm	JD28000000 0001	30.34280879			30.34280879	684.5103481	1366.571312
51		Levee_Temp	JD28000000 0001	684.5103481					
52		Sewer_Utilities	JD28000000 0001	1366.571312					
53	12	Levee_Perm	JD28000000 0003	649.1228849			649.1228849	609.5687941	
54		Levee_Temp	JD28000000 0003	609.5687941					
55	13	Floodwall_perm	JD28000000 0004	1252.245537			9612.798131	3044.031138	1088.17026
56		Floodwall_temp	JD28000000 0004	1006.523839					
57		Floodwall_temp	JD28000000 0004	27.2513647					
58		Levee_Perm	JD28000000 0004	2685.110018					
59		Levee_Perm	JD28000000 0004	5675.442577					
60		Levee_Temp	JD28000000 0004	508.3222122					
61		Levee_Temp	JD28000000 0004	577.4556374					

Exhibit B

	A	B	C	G	H	I	J	K	L
62		Levee_Temp	JD28000000 0004	145.7034307					
63		Levee_Temp	JD28000000 0004	778.7746539					
64		Storm_Utilities	JD28000000 0004	680.6571596					
65		Electric_Utilities	JD28000000 0004	349.2635172					
66		Sewer_Utilities	JD28000000 0004	58.24958293					
67	14	Floodwall_perm	JD35000000 0001	916.4883329			916.4883329	2162.332592	4.924923615
68		Floodwall_temp	JD35000000 0001	836.4277123					
69		Floodwall_temp	JD35000000 0001	1325.904879					
70		Storm_Utilities	JD35000000 0001	4.924923615					
71	15	Floodwall_perm	JD45000000 0005	2156.130879			2156.130879	2251.526093	4517.338142
72		Floodwall_temp	JD45000000 0005	2251.526093					
73		Water_Utilities	JD45000000 0005	1886.998982					
74		Water_Utilities	JD45000000 0005	1258.874266					
75		Sewer_Utilities	JD45000000 0005	88.28415987					
76		Sewer_Utilities	JD45000000 0005	1283.180734					
77	16	Sewer_Utilities	JD48000000 0003	669.1144609					669.1144609
78	17	Floodwall_perm	JD48000000 0012	118.2734711			118.2734711	178.8097383	
79		Floodwall_temp	JD48000000 0012	178.8097383					
80	18	Levee_Perm	JD84000000 0010	880.233602			880.233602	331.8604883	
81		Levee_Temp	JD84000000 0010	331.8604883					
82	19	Sewer_Utilities	JD84000000 0011	214.9945518					214.9945518
83	20	Floodwall_perm	JD84000000 0015	0.000730257			0.000730257	67.67202118	
84		Floodwall_temp	JD84000000 0015	67.67202118					
85	21	Floodwall_perm	JF241212-2046	1190.104923	Merriam Drainage District		25730.9114	8895.747931	2161.045071
86		Floodwall_temp	JF241212-2046	803.2043524					
87		Levee_Perm	JF241212-2046	6005.55475					
88		Levee_Perm	JF241212-2046	18535.25173					
89		Levee_Temp	JF241212-2046	2966.073662					
90		Levee_Temp	JF241212-2046	1912.286244					
91		Levee_Temp	JF241212-2046	3214.183672					
92		Storm_Utilities	JF241212-2046	140.9648109					
93		Electric_Utilities	JF241212-2046	1390.909944					

Exhibit B

	A	B	C	G	H	I	J	K	L
94		Storm_Utilities	JF241212-2046	629.1703164					
95	22	Floodwall_perm	JF241212-2058	3316.967788	Private Landowner		10818.11454	4059.292277	374.1240681
96		Floodwall_temp	JF241212-2058	132.4563778					
97		Floodwall_temp	JF241212-2058	1409.226602					
98		Levee_Perm	JF241212-2058	7501.146749					
99		Levee_Temp	JF241212-2058	2.032552507					
100		Levee_Temp	JF241212-2058	1147.559878					
101		Levee_Temp	JF241212-2058	1368.016867					
102		Storm_Utilities	JF241212-2058	37.20769558					
103		Sewer_Utilities	JF241212-2058	336.9163726					
104	23	Levee_Perm	JF241212-3001	10740.96198	City of Merriam		28706.1199	10533.58815	8502.282506
105		Levee_Perm	JF241212-3001	17965.15792					
106		Levee_Temp	JF241212-3001	6278.762488					
107		Levee_Temp	JF241212-3001	4254.825658					
108		Sewer_Utilities	JF241212-3001	2047.372726					
109		Storm_Utilities	JF241212-3001	6408.584435					
110		Sewer_Utilities	JF241212-3001	15.18660639					
111		Sewer_Utilities	JF241212-3001	15.5693696					
112		Storm_Utilities	JF241212-3001	15.5693696					
113	24	Floodwall_perm	JF241212-3003	576.1145115	Private Landowner		14631.63157	5579.25164	5919.661168
114		Floodwall_temp	JF241212-3003	319.0678205					
115		Floodwall_temp	JF241212-3003	57.83178515					
116		Levee_Perm	JF241212-3003	14055.51706					
117		Levee_Temp	JF241212-3003	5202.352034					
118		Sewer_Utilities	JF241212-3003	5089.739543					
119		Storm_Utilities	JF241212-3003	161.2442552					
120		Storm_Utilities	JF241212-3003	668.6773706					
121	25	Floodwall_perm	JF241212-3054	4125.300803	Private Landowner		4125.300803	3010.34251	
122		Floodwall_temp	JF241212-3054	3010.34251					
123	26	Sewer_Utilities	JF241212-3056	6.635345998	Merriam Drainage District				6.635345998
124		Floodwall_perm	JF241212-3060	6023.901186	Private				

Exhibit B

	A	B	C	G	H	I	J	K	L
125	27	Floodwall_temp	JF241212-3060	4087.720632	Private Landowner		6023.901186	4087.720632	1.428910283
126		Storm_Utilities	JF241212-3060	1.428910283					
127	28	Floodwall_perm	JF241212-3063	18.17722916	Private Landowner		18.17722916	474.671719	376.2858582
128		Floodwall_temp	JF241212-3063	474.671719					
129		Storm_Utilities	JF241212-3063	376.2858582					
130	29	Sewer_Utilities	JF241212-3073	931.0970109	City of Merriam				931.0970109
131	30	Floodwall_perm	JF241212-4009	3496.42425	Private Landowner		3887.696364	1853.352638	195.6358944
132		Floodwall_temp	JF241212-4009	1698.071688					
133		Levee_Perm	JF241212-4009	391.2721136					
134		Levee_Temp	JF241212-4009	155.28095					
135		Sewer_Utilities	JF241212-4009	195.6358944					
136	31	Floodwall_perm	JF241212-4010	2885.533588	Merriam Drainage District		5181.821182	3289.975908	61.76918041
137		Floodwall_perm	JF241212-4010	2296.287593					
138		Floodwall_temp	JF241212-4010	1625.298634					
139		Floodwall_temp	JF241212-4010	1664.677274					
140		Storm_Utilities	JF241212-4010	49.45435099					
141		Sewer_Utilities	JF241212-4010	12.31482941					
142	32	Floodwall_temp	JF241212-4011	59.03986319	Private Landowner			59.03986319	
143	33	Floodwall_perm	JF241212-4012	2585.934609	Private Landowner		2585.934609	1589.402093	613.9674034
144		Floodwall_temp	JF241212-4012	1589.402093					
145		Storm_Utilities	JF241212-4012	613.9674034					
146	34	Floodwall_perm	JF241212-4013	1669.413939	Private Landowner		1669.413939	1396.559843	129.8890456
147		Floodwall_temp	JF241212-4013	1315.525479					
148		Levee_Temp	JF241212-4013	81.03436441					
149		Storm_Utilities	JF241212-4013	129.8890456					
150	35	Floodwall_perm	JF241212-4019	4184.063845	Merriam Drainage District		4184.063845	3187.493146	3811.589328
151		Floodwall_temp	JF241212-4019	3187.493146					
152		Gas_Utilities	JF241212-4019	934.3363133					
153		Water_Utilities	JF241212-4019	1885.876586					
154		Sewer_Utilities	JF241212-4019	814.7219302					

Exhibit B

	A	B	C	G	H	I	J	K	L
155		Storm_Utilities	JF241212-4019	176.654498					
156	36	Water_Utilities	JF241212-4028	260.320454	Private Landowner				260.320454
157	37	Floodwall_perm	JF241212-4029	3948.737572	Private Landowner		8543.986848	4921.130128	26.89988528
158		Floodwall_perm	JF241212-4029	4595.249276					
159		Floodwall_temp	JF241212-4029	1690.990955					
160		Floodwall_temp	JF241212-4029	3230.139173					
161		Storm_Utilities	JF241212-4029	26.89988528					
162	38	Floodwall_perm	JF241212-4030	3003.103639	Private Landowner		6391.435295	3411.296207	1957.691556
163		Floodwall_perm	JF241212-4030	3388.331656					
164		Floodwall_temp	JF241212-4030	1153.008583					
165		Floodwall_temp	JF241212-4030	2258.287624					
166		Storm_Utilities	JF241212-4030	1591.940292					
167		Storm_Utilities	JF241212-4030	365.7512638					
168	39	Floodwall_perm	JF241212-4031	1559.603204	Private Landowner		3662.13351	2094.116568	
169		Floodwall_perm	JF241212-4031	2102.530306					
170		Floodwall_temp	JF241212-4031	692.4494902					
171		Floodwall_temp	JF241212-4031	1401.667078					
172	40	Floodwall_perm	JF241212-4032	2264.224362	Private Landowner		5299.016365	3048.528342	
173		Floodwall_perm	JF241212-4032	3034.792004					
174		Floodwall_temp	JF241212-4032	1025.409405					
175		Floodwall_temp	JF241212-4032	2023.118938					
176	41	Floodwall_perm	JF241212-4033	1024.292764	Private Landowner		1024.292764	1223.123651	583.5831098
177		Floodwall_temp	JF241212-4033	1223.123651					
178		Gas_Utilities	JF241212-4033	583.5831098					
179	42	Floodwall_perm	JF241212-4035	800.3563511	Merriam Drainage		800.3563511	329.8922591	
180		Floodwall_temp	JF241212-4035	329.8922591					
181	43	Floodwall_perm	JF241212-4036	4911.973963	Merriam Drainage District		4911.973963	3215.517187	52.54102261
182		Floodwall_temp	JF241212-4036	3215.517187					
183		Sewer_Utilities	JF241212-4036	52.54102261					
184	44	Floodwall_perm	JF241212-4037	400.9577879	Merriam Drainage		2178.625026	634.8164633	
185		Floodwall_temp	JF241212-4037	528.6763046					

	A	B	C	G	H	I	J	K	L
186	44	Levee_Perm	JF241212-4037	1777.667248	Drainage District		2176.625036	624.8164652	
187		Levee_Temp	JF241212-4037	96.14015865					
188	45	Floodwall_perm	JF241212-4048	2.335628912	City of Merriam		2.335628912	113.5435539	5.323336484
189		Floodwall_temp	JF241212-4048	113.5435539					
190		Sewer_Utilities	JF241212-4048	5.323336484					
191	46	Floodwall_perm	JF241212-4049	547.2009392	City of Merriam		547.2009392	812.8330765	24.72698587
192		Floodwall_temp	JF241212-4049	812.8330765					
193		Sewer_Utilities	JF241212-4049	24.72698587					
194	47	Gas_Utilities	JP14000003 0002B	292.6008719	Private Landowner				292.6008719
195	48	Storm_Utilities	JP18000000 0001	45.31668693	Private Landowner				45.31668693
196	49	Levee_Perm	JP18000000 0004	34.11147329	Private Landowner		34.11147329	238.8420967	
197		Levee_Temp	JP18000000 0004	238.8420967					
198	50	Levee_Perm	JP18000000 0004A	1288.228459	Merriam Drainage		1288.228459	652.0287118	
199		Levee_Temp	JP18000000 0004A	652.0287118					
200	51	Levee_Perm	JP28000033 0001	17242.04062	Private Landowner		17242.04062	5308.088248	2148.820797
201		Levee_Temp	JP28000033 0001	2385.632627					
202		Levee_Temp	JP28000033 0001	2922.455621					
203		Storm_Utilities	JP28000033 0001	1483.387161					
204		Sewer_Utilities	JP28000033 0001	665.4336357					
205	52	Storm_Utilities	JP28000033 0003A	147.3225231	City of Merriam				147.3225231
206	53	Levee_Perm	JP28000033 0006A	590.6392294	Merriam Drainage District		590.6392294	596.5865902	25.40354654
207		Levee_Temp	JP28000033 0006A	596.5865902					
208		Sewer_Utilities	JP28000033 0006A	25.40354654					
209	54	Floodwall_perm	JP28000033 0007	705.5651635	Private Landowner		798.6267519	1832.505833	850.6863365
210		Floodwall_temp	JP28000033 0007	1692.183516					
211		Levee_Perm	JP28000033 0007	93.06158847					
212		Levee_Temp	JP28000033 0007	140.3223168					
213		Storm_Utilities	JP28000033 0007	850.6863365					
214		Levee_Perm	JP28000033 0015	325.5543249					

Exhibit B

	A	B	C	G	H	I	J	K	L
215	55	Levee_Perm	JP28000033 0015	1744.857795	Private Landowner		2070.41212	2132.866808	1132.221406
216		Levee_Temp	JP28000033 0015	1542.464154					
217		Levee_Temp	JP28000033 0015	590.402654					
218		Electric_Utilities	JP28000033 0015	1132.221406					
219	56	Levee_Perm	JP28000033 0021	833.4486492	Merriam Drainage District		6182.712702	2272.367321	1232.999853
220		Levee_Perm	JP28000033 0021	5349.264053					
221		Levee_Temp	JP28000033 0021	1847.237711					
222		Levee_Temp	JP28000033 0021	425.1296102					
223		Electric_Utilities	JP28000033 0021	1232.999853					
224	57	Levee_Perm	JP28000033 0022	3335.080329	Merriam Drainage District		3335.080329	1358.187755	778.3178108
225		Levee_Temp	JP28000033 0022	1358.187755					
226		Electric_Utilities	JP28000033 0022	778.3178108					
227	58	Sewer_Utilities	JP28000033 0030	78.78165032	Private Landowner				78.78165032
228	59	Levee_Perm	JP28000033 0034	23.57290052	Merriam Drainage District		23.57290052	224.3498416	194.6046353
229		Levee_Temp	JP28000033 0034	224.3498416					
230		Sewer_Utilities	JP28000033 0034	194.6046353					
231	60	Levee_Perm	JP28000033 0034A	3215.477498	Private Landowner		3215.477498	609.6637712	7.996351191
232		Levee_Temp	JP28000033 0034A	577.9638716					
233		Levee_Temp	JP28000033 0034A	31.69989962					
234		Sewer_Utilities	JP28000033 0034A	7.996351191					
235	61	Sewer_Utilities	JP28000033 0034B	69.80047372	Private Landowner				69.80047372
236	62	Floodwall_perm	JP28000033 0036	556.5162886	Merriam Drainage District		5626.299426	1738.513314	
237		Floodwall_temp	JP28000033 0036	504.319648					
238		Levee_Perm	JP28000033 0036	5069.783138					
239		Levee_Temp	JP28000033 0036	1100.930908					
240		Levee_Temp	JP28000033 0036	133.2627573					
241	63	Floodwall_perm	JP28000033 0038A	4251.591652	Merriam Drainage District		4251.591652	1307.249799	
242		Floodwall_temp	JP28000033 0038A	876.6891487					
243		Floodwall_temp	JP28000033 0038A	430.5606502					
244		Levee_Perm	JP28000036 0019	437.8082764					

	A	B	C	G	H	I	J	K	L
245	64	Levee_Temp	JP28000036 0019	514.1387972	Private Landowner		437.8082764	514.1387972	751.6544014
246		Storm_Utilities	JP28000036 0019	493.6074243					
247		Storm_Utilities	JP28000036 0019	258.0469772					
248	65	Storm_Utilities	JP28000036 0024	209.0165582	Private Landowner				578.4838134
249		Storm_Utilities	JP28000036 0024	369.4672552					
250	66	Floodwall_perm	JP28000036 0024A	8243.916918	Private Landowner		17451.33832	8186.607497	1412.494195
251		Floodwall_temp	JP28000036 0024A	2993.644522					
252		Floodwall_temp	JP28000036 0024A	2530.581116					
253		Levee_Perm	JP28000036 0024A	9207.4214					
254		Levee_Temp	JP28000036 0024A	1375.437815					
255		Levee_Temp	JP28000036 0024A	1286.944044					
256		Storm_Utilities	JP28000036 0024A	504.016788					
257		Storm_Utilities	JP28000036 0024A	885.4316813					
258		Storm_Utilities	JP28000036 0024A	11.52286279					
259		Storm_Utilities	JP28000036 0024A	11.52286279					
260	67	Floodwall_perm	JP28000037 0001	9828.601616	Private Landowner		16981.94102	6993.375611	4652.936695
261		Floodwall_temp	JP28000037 0001	5208.850591					
262		Levee_Perm	JP28000037 0001	7153.339408					
263		Levee_Temp	JP28000037 0001	1249.858154					
264		Levee_Temp	JP28000037 0001	534.6668656					
265		Sewer_Utilities	JP28000037 0001	2132.724285					
266		Water_Utilities	JP28000037 0001	460.6110536					
267		Water_Utilities	JP28000037 0001	1172.168988					
268		Sewer_Utilities	JP28000037 0001	503.413971					
269		Storm_Utilities	JP28000037 0001	314.8862218					
270		Water_Utilities	JP28000037 0001	34.56608797					
271		Sewer_Utilities	JP28000037 0001	34.56608797					
272	68	Floodwall_perm	JP28000037 0007	808.4756108	City of Merriam		1593.42965	2901.375514	1201.940927
273		Floodwall_temp	JP28000037 0007	1614.391662					
274		Levee_Perm	JP28000037 0007	784.9540388					
275		Levee_Temp	JP28000037 0007	107.3958129					
276		Levee_Temp	JP28000037 0007	1179.588039					
277		Storm_Utilities	JP28000037 0007	39.55621319					

Exhibit B

	A	B	C	G	H	I	J	K	L
278		Storm_Utilities	JP28000037 0007	334.5109529					
279		Sewer_Utilities	JP28000037 0007	827.873761					
280	69	Floodwall_perm	JP28000037 0008	4211.25033	Private Landowner		4211.25033	2807.513562	95.46505721
281		Floodwall_temp	JP28000037 0008	997.3251303					
282		Floodwall_temp	JP28000037 0008	1810.188432					
283		Storm_Utilities	JP28000037 0008	95.46505721					
284	70	Floodwall_perm	JP28000037 000B	691.7422458	Private Landowner		7674.822385	2042.974641	0.064008286
285		Floodwall_temp	JP28000037 000B	137.2843566					
286		Levee_Perm	JP28000037 000B	6983.080139					
287		Levee_Temp	JP28000037 000B	1887.286775					
288		Levee_Temp	JP28000037 000B	18.40350921					
289		Storm_Utilities	JP28000037 000B	0.064008286					
290	71	Floodwall_perm	JP28000038 0017	2469.540374	Private Landowner		2469.540374	1750.390281	184.9009965
291		Floodwall_temp	JP28000038 0017	1400.624816					
292		Floodwall_temp	JP28000038 0017	349.765465					
293		Storm_Utilities	JP28000038 0017	184.9009965					
294	72	Levee_Perm	JP28000038 0023	30.09892859	Private Landowner		30.09892859	354.4093833	
295		Levee_Temp	JP28000038 0023	354.4093833					
296	73	Levee_Temp	JP35000000 0008A	9.276118086	Private Landowner			9.276118086	
297	74	Floodwall_perm	JP35000000 0009F	329.8988198	City of Merriam		329.8988198	140.2946028	89.44876287
298		Floodwall_temp	JP35000000 0009F	140.2946028					
299		Storm_Utilities	JP35000000 0009F	89.44876287					
300	75	Floodwall_perm	JP35000000 0010B	7256.653645	Merriam Drainage District		7256.653645	4100.256578	4042.862114
301		Floodwall_temp	JP35000000 0010B	1328.499288					
302		Floodwall_temp	JP35000000 0010B	2771.757289					
303		Storm_Utilities	JP35000000 0010B	154.7607918					
304		Storm_Utilities	JP35000000 0010B	878.2025208					
305		Storm_Utilities	JP35000000 0010B	1620.11517					
306		Storm_Utilities	JP35000000 0010B	1389.783631					
307	76	Floodwall_perm	JP36000000 000A1	4632.070239	Private Landowner		4632.070239	3091.76576	
308		Floodwall_temp	JP36000000 000A1	1948.668177					

Exhibit B

	A	B	C	G	H	I	J	K	L
309		Floodwall_temp	JP36000000 000A1	1143.097583	Landowner				
310	77	Floodwall_perm	JP36000000 000C	4964.332475	Private Landowner		4964.332475	3345.080883	2107.124788
311		Floodwall_temp	JP36000000 000C	1321.934047					
312		Floodwall_temp	JP36000000 000C	2006.429132					
313		Levee_Temp	JP36000000 000C	16.71770358					
314		Sewer_Utilities	JP36000000 000C	1124.84184					
315		Storm_Utilities	JP36000000 000C	227.6094636					
316		Storm_Utilities	JP36000000 000C	754.6734843					
317	78	Floodwall_perm	JP45000005 0002A	8052.889729	Private Landowner		16105.77946	6485.153439	
318		Floodwall_perm	JP45000005 0002A	8052.889729					
319		Floodwall_temp	JP45000005 0002A	3242.576719					
320		Floodwall_temp	JP45000005 0002A	3242.576719					
321	79	Floodwall_perm	JP45000005 0004A	2028.186708	Private Landowner		2028.186708	2289.428712	
322		Floodwall_temp	JP45000005 0004A	2289.428712					
323	80	Floodwall_perm	JP45000005 0004B	7982.926294	Merriam Drainage District		8970.230662	8866.850126	1720.241589
324		Floodwall_perm	JP45000005 0004B	987.3043675					
325		Floodwall_temp	JP45000005 0004B	4091.737275					
326		Floodwall_temp	JP45000005 0004B	4775.11285					
327		Sewer_Utilities	JP45000005 0004B	1720.241589					
328	81	Floodwall_perm	JP45000005 0004C	5255.885737	Private Landowner		5255.885737	3083.736403	0.248141428
329		Floodwall_temp	JP45000005 0004C	3083.736403					
330		Sewer_Utilities	JP45000005 0004C	0.248141428					
331	82	Floodwall_perm	JP45000005 0004D	3835.521579	Private Landowner		3835.521579	2272.694836	406.0103087
332		Floodwall_temp	JP45000005 0004D	2272.694836					
333		Sewer_Utilities	JP45000005 0004D	406.0103087					
334	83	Floodwall_perm	JP46700000 0001	4349.819548	Private Landowner		4349.819548	2274.489501	336.4758182
335		Floodwall_temp	JP46700000 0001	2274.489501					
336		Sewer_Utilities	JP46700000 0001	336.4758182					
337	84	Floodwall_perm	JP84000000 000B7	640.2771929	Merriam Drainage		640.2771929	355.9247666	
338		Floodwall_temp	JP84000000 000B7	355.9247666					

Exhibit B

	A	B	C	G	H	I	J	K	L
339	85	Sewer_Utilities	JP84000000 000B8	1608.649592	Merriam Drainage District				1608.649592
340	86	Sewer_Utilities	JP84000000 00B10	171.1932944	Merriam Drainage				615.2770429
341		Sewer_Utilities	JP84000000 00B10	444.0837485					
342	87	Floodwall_perm	JP84000008 0011	2104.560478	Private Landowner		2183.90789	1688.747432	1984.741847
343		Floodwall_temp	JP84000008 0011	1657.034546					
344		Levee_Perm	JP84000008 0011	79.34741229					
345		Levee_Temp	JP84000008 0011	31.71288664					
346		Sewer_Utilities	JP84000008 0011	1984.741847					
347	88	Floodwall_perm	JP84000008 0012	1725.21872	Merriam Drainage		1725.21872	815.9364344	
348		Floodwall_temp	JP84000008 0012	815.9364344					
349	89	Floodwall_perm	JP84000008 0016A	61.14107007	Private Landowner		61.14107007	338.5198922	52.36618646
350		Floodwall_temp	JP84000008 0016A	338.5198922					
351		Sewer_Utilities	JP84000008 0016A	52.36618646					
352	90	Floodwall_perm	JP84000008 0019A	928.7268109	Merriam Drainage		928.7268109	328.1054534	
353		Floodwall_temp	JP84000008 0019A	328.1054534					
354	91	Floodwall_perm	JP84000009 0001A	54.98266866	Private Landowner		54.98266866	321.0576697	
355		Floodwall_temp	JP84000009 0001A	321.0576697					
356	92	Floodwall_perm	JP84000009 0001D	30.93554724	Private Landowner		30.93554724	293.607797	
357		Floodwall_temp	JP84000009 0001D	293.607797					
358	93	Floodwall_perm	JP84000009 0001E	855.5352261	Private Landowner		855.5352261	389.5088751	36.70302579
359		Floodwall_temp	JP84000009 0001E	3.026020257					
360		Floodwall_temp	JP84000009 0001E	386.4828549					
361		Sewer_Utilities	JP84000009 0001E	36.70302579					
362	94	Floodwall_perm	JP84000009 0001F	1550.586085	Merriam Drainage District		1550.586085	600.6196662	75.14285879
363		Floodwall_temp	JP84000009 0001F	600.6196662					
364		Sewer_Utilities	JP84000009 0001F	75.14285879					
365	95	Floodwall_perm	JP84000009 0001G	907.0459646	Merriam Drainage		907.0459646	313.1403805	
366		Floodwall_temp	JP84000009 0001G	313.1403805					
367	96	Floodwall_perm	JP84000009 0001I	347.1326363	Private Landowner		347.1326363	641.3682548	
368		Floodwall_temp	JP84000009 0001I	641.3682548					

Exhibit B

	A	B	C	G	H	I	J	K	L
369	97	Floodwall_temp	JP84000009 0001J	7.373625975	Private Landowner			7.373625975	
370	98	Floodwall_perm	JP84000009 0001L	35.60528752	Merriam Drainage		35.60528752	226.8286347	
371		Floodwall_temp	JP84000009 0001L	226.8286347					
372	99	Floodwall_perm	JP84000009 0001M	459.9229529	Merriam Drainage		459.9229529	79.94542802	
373		Floodwall_temp	JP84000009 0001M	79.94542802					
374	100	Floodwall_perm	JP84000009 0001N	575.9616239	Private Landowner		575.9616239	216.2765853	
375		Floodwall_temp	JP84000009 0001N	216.2765853					
376	101	Floodwall_perm	JP84000009 0003C	11.18820073	Private Landowner		11.18820073	45.30879005	
377		Floodwall_temp	JP84000009 0003C	45.30879005					
378	102	Floodwall_perm	JP84000009 0004C	267.3784565	Merriam Drainage		267.3784565	0.016682262	
379		Floodwall_temp	JP84000009 0004C	0.016682262					
380	103	Floodwall_perm	JP84000009 0006A	90.25442866	City of Merriam		90.25442866	18.16323759	
381		Floodwall_temp	JP84000009 0006A	18.16323759					
382	104	Floodwall_perm	JP84000009 0006B	736.6431021	City of Merriam		736.6431021	204.6917747	
383		Floodwall_temp	JP84000009 0006B	204.6917747					
384	105	Floodwall_perm	JP84000009 0006C	1259.66758	Merriam Drainage District		1259.66758	733.4548508	204.2751746
385		Floodwall_temp	JP84000009 0006C	733.4548508					
386		Sewer_Utilities	JP84000009 0006C	204.2751746					
387	106	Floodwall_perm	JP84000009 0006D	325.9231167	Merriam Drainage		325.9231167	300.6193748	
388		Floodwall_temp	JP84000009 0006D	300.6193748					
389	107	Floodwall_perm	JP84000009 0006E	755.6661849	Private Landowner		755.6661849	609.726608	
390		Floodwall_temp	JP84000009 0006E	609.726608					
391	108	Floodwall_perm	JP84000009 0006F	62.92944638	City of Merriam		62.92944638		
392	109	Floodwall_perm	JP84000009 0006G	0.077345136	Private Landowner		0.077345136	29.86757207	
393		Floodwall_temp	JP84000009 0006G	29.86757207					
394	110	Floodwall_perm	JR241212-3033	1955.33226	City of Merriam		1955.33226	1697.203011	589.9387071
395		Floodwall_temp	JR241212-3033	1697.203011					
396		Storm_Utilities	JR241212-3033	390.7969486					
397		Storm_Utilities	JR241212-3033	71.95890165					
398		Storm_Utilities	JR241212-3033	99.07259659					

Exhibit B

	A	B	C	G	H	I	J	K	L
399		Gas_Utilities	JR241212-3033	14.05513013					
400		Storm_Utilities	JR241212-3033	14.05513013					
401	111	Levee_Perm	JR241212-3048	1710.108387	City of Merriam		1710.108387	527.1695685	1697.489559
402		Levee_Temp	JR241212-3048	527.1695685					
403		Sewer_Utilities	JR241212-3048	193.2332152					
404		Sewer_Utilities	JR241212-3048	1504.256343					
405	112	Floodwall_perm	JR241212-4020	14122.2255	State Highway #10		14122.2255	9637.138326	5254.763974
406		Floodwall_temp	JR241212-4020	9637.138326					
407		Storm_Utilities	JR241212-4020	95.67270848					
408		Storm_Utilities	JR241212-4020	80.6534992					
409		Gas_Utilities	JR241212-4020	2715.231869					
410		Water_Utilities	JR241212-4020	2363.205898					
411	113	Electric_Utilities	JR28000033 0024B	329.9866576	City of Merriam				329.9866576
412	114	Floodwall_perm	JR28000038 0001	1758.421444	State Highway Commission		10290.64483	5637.181804	13188.22744
413		Floodwall_temp	JR28000038 0001	454.8939954					
414		Floodwall_temp	JR28000038 0001	371.0491049					
415		Floodwall_temp	JR28000038 0001	769.1984002					
416		Levee_Perm	JR28000038 0001	8532.223388					
417		Levee_Temp	JR28000038 0001	4042.040304					
418		Water_Utilities	JR28000038 0001	9840.59573					
419		Sewer_Utilities	JR28000038 0001	3184.928546					
420		Storm_Utilities	JR28000038 0001	162.703163					
421	115	Floodwall_perm	JR28000038 0014	3317.995113	City of Merriam		3317.995113	2923.908391	129.2104635
422		Floodwall_temp	JR28000038 0014	1867.845402					
423		Floodwall_temp	JR28000038 0014	1056.062989					
424		Storm_Utilities	JR28000038 0014	129.2104635					
425	116	Floodwall_perm	JR28000038 0019	1296.884432	City of Merriam		5770.124718	4093.26663	790.2880907
426		Floodwall_perm	JR28000038 0019	4462.879639					
427		Floodwall_temp	JR28000038 0019	1764.764517					
428		Floodwall_temp	JR28000038 0019	516.8293839					
429		Floodwall_temp	JR28000038 0019	1628.330091					
430		Levee_Perm	JR28000038 0019	10.3606474					

Exhibit B

	A	B	C	G	H	I	J	K	L
431		Levee_Temp	JR28000038 0019	183.3426379					
432		Storm_Utilities	JR28000038 0019	790.2880907					
433	117	Floodwall_perm	JR35000000 0009C	447.9465611	City of Merriam		447.9465611	501.3813841	343.8992004
434		Floodwall_temp	JR35000000 0009C	501.3813841					
435		Sewer_Utilities	JR35000000 0009C	0.002114403					
436		Storm_Utilities	JR35000000 0009C	83.28176927					
437		Sewer_Utilities	JR35000000 0009C	130.3076584					
438		Storm_Utilities	JR35000000 0009C	130.3076584					
439	118	Fee	JF241212-3005	47,585.43	Private Landowner	47,585.43			
440	119	Fee	JP35000000 0009	4,111.48	Private Landowner	4,111.48			
441	120	Fee	JF241212-3006	8,781.66	Private Landowner	8,781.66			
442	121	Fee	JP28000033 0024D	5,069.70	Private Landowner	5,069.70			
443									
444					**Total Sq Ft:**	**65,548.27**	**374,754.98**	**200,157.01**	**93,602.29**
445					**Total Acres:**	**1.5**	**8.6**	**4.59**	**2.15**

Exhibit B

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

City of Merriam
Upper Turkey Creek
Flood Risk Management Project
Johnson County and Wyandotte County, Kansas

I. Legal Authority:

a. Does the sponsor have the legal authority to acquire and hold title to real property for project purposes? **Yes**

b. Does the sponsor have the power of eminent domain for this project? **Yes**

c. Does the sponsor have "quick take" authority for this project? **Yes**

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary? **No**

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? **No**

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirement of Federal projects including P.L. 91-646, as amended? **No**

b. If the answer to II.a. is "yes", has a reasonable plan been developed to provide such training? **N/A**

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? **Yes**

D. Is the sponsor's projected in-house staffing level sufficient considering its other work load, if any, and the project schedule? **Yes (at this time)**

e. Can the sponsor obtain contractor support, if required, in a timely fashion? **Yes**

ExhibitC

f. Will the sponsor likely request USACE assistance in acquiring real estate? **No**

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? **Yes**

b. Has the sponsor approved the project/real estate schedule/milestones? **(It is too early in the feasibility study to project real estate milestones. The sponsor will be consulted when it is time to set these milestones)**

IV. Overall Assessment:

a. Has the sponsor performed satisfactorily on other USACE projects? **(This is the first project working with this sponsor)**

b. With regard to this project, the sponsor is anticipated to be: (Highly, Fully, Moderate, Marginally capable) **Fully Capable**

V. Coordination:

a. Has this assessment been coordinated with the sponsor? **Yes**

b. Does the sponsor concur with this assessment? **Yes**

Prepared by: _____
Carla J. Buatte, Real Estate Specialist

Reviewed by: Patty Richardson
Patty Richardson, Team Leader

Approved by: 4/29/13
Gregory G. Wilson,
Chief, Real Estate Division
Date: _____

Exhibit C

Appendix H
Comments and Correspondence

Exhibit 1
Agency Correspondence

DEPARTMENT OF THE ARMY
KANSAS CITY DISTRICT, CORPS OF ENGINEERS
635 FEDERAL BUILDING
KANSAS CITY, MISSOURI 64106-2896

May 9, 2012

REPLY TO
ATTENTION OF

Environmental Resources Section
Planning Branch

Ms. Jennie A. Chinn
Executive Director, State Historic Preservation Officer
Kansas State Historical Society
6425 S. W. 6th Avenue
Topeka, Kansas 66615-1099

Dear Ms. Chinn:

The attached report Archeologieal Survey of Upper Turkey Creek Basin Flood Risk Management Projeet Johnson County, Kansas details the results of an areheological survey conducted by the Kansas City District, Corps of Engineers (Corps). This correspondence initiates Section 106 consultation for the proposed project.

The archeological survey was conducted by David Cain, an archeological intern. Mr. Cain meets the Secretary of Interiors standards for conducting archeological investigations. In sum, the survey found no archeological sites or artifacts during the survey. The former Ft. Leavenworth-Ft. Scott military road is mapped bisecting the project area. The former road is marked by a sign in the project area, but no trace of the road remains due to the severe urban development in the area. I have reviewed the report and concur with his recommendations that no historic properties will be effected by the proposed undertaking. At this time, I request your review and concurrence as well.

Thank you for your consideration in this matter. If you have any questions or have need of further information please contact me at timothy.m.meade@usace.army.mil or at (816) 389-3138.

Sincerely,

Timothy Meade
District Archeologist

Enclosure

KSR&C No. 12-OS-134

6425 SW 6th Avenue
Topeka, KS 66615

Kansas

phone: 785-272-8681
fax: 785-272-8682
cultural_resources@kshs.org

Kansas Historical Society

Sam Brownback, Governor
Jennie Chinn, Executive Director

May 15, 2012

Timothy Meade
Cultural Resource Manager
Kansas City District, Corps of Engineers
700 Federal Building
Kansas City, Missouri 64106-2896

RE: Flood Risk Management Project
Upper Turkey Creek Basin
Johnson County

Dear Mr. Meade:

In accordance with 36 CFR 800, the Kansas State Historic Preservation Office has reviewed a report entitled *Archeological Survey of Upper Turkey Creek Basin, Flood Risk Management Project Johnson County, Kansas*, by David I. Cain. We find the report to be acceptable and concur with the recommendation that the project as proposed should have no effect on properties listed in the National Register of Historic Places or otherwise identified in our files. This office has no objection to implementation of the flood risk management project.

This information is provided at your request to assist you in identifying historic properties, as specified in 36 CFR 800 for Section 106 consultation procedures. If you have questions or need additional information regarding these comments, please contact Tim Weston at 785-272-8681 (ext. 214) or Kim Gant at 785-272-8681 (ext.225).

Sincerely,

Jennie Chinn, Executive Director and
State Historic Preservation Officer

Timothy Weston for

Patrick Zollner
Deputy SHPO

Totten, Laura

From:	Granet, Jesse J NWK <Jesse.J.Granet@usace.army.mil>
Sent:	Thursday, April 12, 2012 9:04 AM
To:	Mike_LeValley@fws.gov
Cc:	Michele McNaulty; eric.johnson@ksoutdoors.com; Rast, Brian T NWK; Grothaus, John J NWK; Switzer, Jennifer L NWK; Covington, William G NWK
Subject:	RE: Upper Turkey Creek CAR (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Mike and Eric,

Thank you. I really appreciate you taking the time to look at the existing conditions of the project area and come to this conclusion.

I will be sure to contact you when we are prepared to put the document out for comment, which should be sometime this summer or fall.

Thanks again,
Jesse

Jesse Granet
Environmental Resources Specialist
U.S. Army Corps of Engineers
Kansas City District
Environmental Resources Section
USACE Phone: (816) 389-3470

-----Original Message-----
From: Mike_LeValley@fws.gov [mailto:Mike_LeValley@fws.gov]
Sent: Thursday, April 12, 2012 8:52 AM
To: Granet, Jesse J NWK
Cc: Michele McNaulty; eric.johnson@ksoutdoors.com
Subject: Re: Upper Turkey Creek CAR (UNCLASSIFIED)

Jesse: I've discussed this project with Eric Johnson of the KDWPT. Given the urban location of the project, limited habitat benefits for federal and state trust resources, past modifications to stream hydrology and morphology, and the proposed alternatives (channelization/floodwalls etc.), we do not think a formal Fish and Wildlife Coordination Act Report is warranted. We can provide FWCA comments through the 404 permit process, include FWCA comments in our NEPA review, or both.

Michael J. LeValley
Kansas Ecological Services Field Office Supervisor U.S. Fish and Wildlife Service
2609 Anderson Avenue

Manhattan, KS 66502
785-539-3474, Ext. 105
785-539-8567, Fax
Inactive hide details for "Granet, Jesse J NWK" <Jesse.J.Granet@usace.army.mil>"Granet, Jesse J NWK" <Jesse.J.Granet@usace.army.mil>

"Granet, Jesse J NWK" <Jesse.J.Granet@usace.army.mil>

04/03/2012 11:05 AM

To

Michele McNaulty <Michele_McNulty@fws.gov>, "Mike_LeValley@fws.gov" <Mike_LeValley@fws.gov>

cc

Subject

Upper Turkey Creek CAR (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Hi Michele & Mike,

We talked some time ago about your office preparing a CAR for the Upper Turkey Creek project in Johnson County. I've attached a concise description of each of the alternatives that will be considered in our Integrated Feasibility Report and Environmental Assessment. As we discussed previously, the project is in a highly urbanized/disturbed location and the creek has previously been modified throughout the project area.

I'm currently in the process of using two HSI models to determine project impacts and how these can best be offset. I'm using the fox squirrel model for terrestrial impacts, and the green sunfish model for aquatic impacts. I can share these results with you once I've completed the analysis.

What is the best way to proceed with complying with the Fish and Wildlife Coordination Act?

Thanks,
Jesse

Jesse Granet
Environmental Resources Specialist

U.S. Army Corps of Engineers
Kansas City District
Environmental Resources Section
USACE Phone: (816) 389-3470

Classification: UNCLASSIFIED
Caveats: NONE

[attachment "Upper Turkey Creek Project Area in Merriam.docx" deleted by Mike LeValley/R6/FWS/DOI] [attachment "03-29-12 UTC_COMPARISON OF FINAL ALTERNATIVES SECTION.docx" deleted by Mike LeValley/R6/FWS/DOI]

Classification: UNCLASSIFIED
Caveats: NONE

Exhibit 2
Draft Feasibility Report with Integrated Environmental Assessment Comments Received, August 2013

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 7
11201 Renner Boulevard
Lenexa, Kansas 66219

AUG 2 1 2013

Mr. Curtis Hoagland
U.S. Army Corps of Engineers
Kansas City District
635 Federal Building
Kansas City, MO 64106

Dear Mr. Hoagland:

Thank you for the opportunity to review the draft Feasibility Report with Integrated Environmental Assessment for the Upper Turkey Creek Flood Risk Management Project (the Project) prepared by the U.S. Army Corps of Engineers, Kansas City District (the Corps). This Feasibility Study was authorized by resolution of the Committee on Transportation and Infrastructure, U.S. House of Representatives, in 2000. The Corps was directed to evaluate opportunities for flood damage reduction for areas of the Upper Turkey Creek watershed within Wyandotte and Johnson Counties in Kansas.

Turkey Creek begins in Lenexa, Kansas, in Johnson County, and flows nominally along Interstate 35 in a northeasterly direction to its confluence with the Kansas River in Wyandotte County, Kansas. Turkey Creek is approximately 15 miles long and its watershed drains 23 square miles in both Johnson and Wyandotte Counties. The watershed is heavily urbanized with "nearly 30% of the watershed [consisting] of constructed impervious services." In addition, in many locations, development along Turkey Creek lines an armored channel which has become incised as a result of high energy storm flows. The Corps has, for purposes of past and current flood risk reduction studies, approached Turkey Creek as Lower and Upper Turkey Creek. The Corps has organized its projects such that the 4.4 Burlington Northern Santa Fe railroad bridge, in Wyandotte County, serves as the boundary between Upper and Lower Turkey Creek. Recently, the Corps has completed portions of an on-going flood risk reduction project along Lower Turkey Creek. The Congressional authorization is for a flood risk reduction study for Upper Turkey Creek, although the Corps has decided to carry forward for recommendation an alternative limited to the City of Merriam along a small portion of Upper Turkey Creek.

I have reviewed the FR/IEA and offer the following comments regarding document content and the overall approach to flood risk reduction within the Turkey Creek watershed, in general, and the Upper Turkey Creek watershed, specifically, of which this Corps project is a significant component.

Floodplain Management

As part of the Corps' responsibilities under Executive Order 11988, I would encourage the Corps to include provisions in its Project Partnership Agreement (PPA) with the project sponsor requiring the City to identify on constructed floodwalls, public structures and area signage "past and probable flood height in order to enhance public awareness of and knowledge about flood hazards" consistent with Section 3(c) of the Executive Order. I would also suggest that the Corps include specific requirements and deadlines for completion of a Floodplain Management Plan by the City in its PPA. It would be

Printed on Recycled Paper

appropriate for the City to commit, in its FMP, to identifying those structures and properties within the floodplain which will be prioritized for acquisition from willing sellers as part of their effort to further reduce flood risk in the area and, thereby, increase the probability of protection at less frequent AEP flows (e.g., 1%, 0.2%).

In order to secure a more "systems approach in the watershed" as is discussed in section 2.6.4, the FMP should be developed in a much broader geographic context than just the City of Merriam. The development of an FMP to address flood risk reduction in the Upper Turkey Creek watershed should be more logically undertaken by Johnson County, in cooperation with Wyandotte County, or by the Mid-America Regional Council.

Project Purpose and Need for Action

The Executive Summary states that the purpose of the study is "to determine the federal interest in constructing a flood risk management project in the City of Merriam." This appears to be a mischaracterization of the charge to the Corps by the House Committee which identified the Turkey Creek watershed upstream of the existing Corps project in Lower Turkey Creek. Chapter 1, section 1.1, identifies the purpose of the feasibility study and the purpose of the report, but the document does not clearly identify the purpose of the project. The lack of clarity regarding the purpose of the project contributes to further confusion regarding the appropriate scope of the project (i.e., watershed or City of Merriam). Section 1.1 references the Committee's resolution which "favored a watershed perspective to future water resource development proposals" and that "A successful plan must fit a broad range of community goals for the whole Turkey Creek watershed to ensure the resulting project would be sustainable…". Although the recommended plan addresses, to a limited extent, flood risk in the immediate area of the project sponsor, it does not address the fundamental causes of increased flood risk in Upper Turkey Creek nor flood risk remaining up- and downstream from the project site. The FR/IEA does not adequately address how the recommended plan affects flood risk along Turkey Creek outside of the project site.

Chapter 2, section 2.4.1, identifies three objectives which could serve as project purpose, but these objectives are not clearly labeled as 'project purpose.' For clarification, objective one is described as pertaining to the "Upper Turkey Creek" watershed rather than the more narrowly designed 'project site.' This objective should be modified to reflect the reduction of flood risk in only a small portion of the watershed rather than throughout the watershed as is presently stated.

Future without Project Conditions

The FR/IEA references existing channel capacity describing its capabilities at various AEP flows. It appears the Report characterizes channel capacity as conveying or containing the 20% AEP and in another place the 10% AEP (p. 2-5 and 2-6). The Report also states that the 1% AEP flow would have to be reduced by 45 to 50% in order to remain within the existing channel. That important statement subtly suggests that the Corps could approach flood risk reduction through the City of Merriam by either reducing the 1% AEP flow or expanding channel capacity. This concept is important to public understanding of project design choices by the Corps, but is under-emphasized throughout the FR/IEA. In addition, this statement confirms, although not so clearly to the public, that the focus of the project is on flood risk reduction only in this short segment of Upper Turkey Creek.

Section 3.3.11 recognizes the possibility that local businesses might move out of the floodplain as a result of repeated flooding without the recommended project, but does not include this possibility under

'without project conditions.' Instead, the FR/IEA assumes continued economic losses and impacts to business with repeated flooding.

Alternatives Analysis and Recommended Plan

Recognizing the limitations to flood risk reduction within a developed watershed, but noting that the watershed still possesses some potential for precipitation retention (approximately 30% impervious surface) on a small scale, it is disappointing that the FR/IEA repeatedly references watershed approaches while quickly resorting to small-scale, localized alternatives based solely on "flood prevention" structures. With any alternatives addressing flood risk reduction on a watershed scale quickly eliminated from analysis, the FR/IEA focuses on the reduction of flood risk to only downtown Merriam. A more useful approach would have designed a comprehensive, integrated solution to flood risk for the entire Upper Turkey Creek watershed with modular components addressing more localized issues dependent upon local sponsor support. This approach would then communicate the need for watershed-scale solutions and multiple project integration to fully address flood risk comprehensively in the long-term. The notion of a comprehensive, watershed-scale design for flood risk reduction should not be constrained by labeling it as "ecosystem restoration measures," as the FR/IEA appears to do.

It appears from the FR/IEA description of how off-line and on-line flood storage alternatives were evaluated that this evaluation was conducted such that all the necessary flood reductions must be captured solely with this approach. The Report does not include, within its alternatives development process, any alternatives which might include small-scale or piece-meal improvements in the watershed which would augment flood risk reduction achieved with structures within the project site. The Report thoroughly describes the limited availability of green space for comprehensive reductions in flood flows (i.e., <u>all</u> of the 40 to 50% reduction in the 1% AEP flow), but does not consider any smaller scale projects which would incrementally reduce flood risk in the watershed outside the project footprint and, in combination with site structures, in the City of Merriam.

Section 3.3.2 recognizes the current climate trend and the possibility that continued increases in precipitation would likely lead to increased flooding in this urbanized watershed. Section 7.4.3 addresses uncertainty and states that projected influences of climate change are not addressed in the FR/IEA because "no accepted methods are currently available to incorporate such global predictions at a local scale." Despite recognizing that current climate trends, not future projections, indicate the real possibility that the 1% AEP flow will increase in the future, the FR/IEA does not characterize the risk of increased flooding with project improvements in both the project site and the surrounding watershed. The FR/IEA should have projected a 50-year (project life) increase following current precipitation trends to determine whether the recommended plan would provide adequate protection in the project area for the project's life.

Environmental Consequences

Section 6.2.3 addresses the consequences of the range of measures specific to Turkey Creek hydraulics and hydrology. With the exception of a general statement about Alternatives 2d, 3d and the Locally Preferred Plan not causing "substantial impacts to the hydrology of Turkey Creek," the FR/IEA does not appear to address possible elevation of flood stages outside of the project site resulting from constraining flows within control structures. It is not unreasonable to assume that outside-of-bank flooding within the project site alleviates flooding up- and downstream. Constraining flood flows within the channel through the project site would seem to simply convey those flows to downstream areas. There did not appear to be any detailed analysis to support the generic 'no effect' statements. In

addition, the FR/IEA did not provide any analysis of how the recommended plan would affect the performance, present and future, of the Corps project in Lower Turkey Creek.

With construction of flood walls and levees under the recommended plan, public interaction with the Turkey Creek channel will be reduced. The recreational trail paralleling Turkey Creek provides a unique experience for the public in an urban environment. The FR/IEA should identify any reductions in recreational opportunities and aesthetics resulting from the installation of flood walls and levees.

Cumulative Impacts Analysis

The analysis of cumulative impacts in section 6.4 addresses historic degradation of the Turkey Creek watershed and the immediate environment of the Turkey Creek channel and floodplain since the early twentieth century. Changes in land use within the watershed producing dramatic changes in the coverage of impervious surfaces and encroachment upon the floodplain and channel have had devastating impacts on the natural and human environment. The FR/IEA includes many citations to studies documenting the contemporary status of the environmental quality of Turkey Creek. Changes in the watershed and to the channel in the beginning of the previous century have destroyed any record of a natural Turkey Creek ecosystem which might serve as a reference point for comparison. However, without a baseline condition against which to compare recent and proposed changes to the Creek, studies such as this one tend to simply acknowledge an apparently irreversibly degraded condition which makes further degradation, or the lack of measured ecological restoration, acceptable.

Recent and planned changes to the Lower Turkey Creek channel by the Corps, under separate authorization, resulted in additional loss of riparian and channel habitat in an urban setting which can little afford such losses. This FR/IEA should, at least, document, in more detail, the actions and impacts of each major change to the channel and floodplain. In essence, this project, although limited in geographic scope and apparent impact, is one more alteration which contributes to the long-term decline in the quality and sustainability of the watershed. Without a full accounting of each these changes and their cumulative impacts, the consequences of multiple, incremental changes in land use and hydrology in an already degraded environment will never affect public decision-making and public awareness. Given the limited scope of this and other past projects in an continually degrading system, it is only in the analysis of "individually minor, but collectively significant actions taking place over a period of time" (40 CFR 1508.7) that the spirit of NEPA can be fully addressed.

Section 6.4 also references preparation of an FMP for the Upper Turkey Creek watershed. As previously stated in these comments, we believe an FMP designed for the entire watershed and by entities responsible for the management of the entire floodplain across county boundaries is critical to developing a sustainable approach to both flood risk reduction and watershed restoration in the long-term.

Thank you for the opportunity to comment on the draft Feasibility Report with Integrated Environmental Assessment. If you have any questions regarding these comments, please contact me at (913) 551-7441 or shepard.larry@epa.gov.

Sincerely,

Larry Shepard
NEPA Reviewer

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Kansas Ecological Services Field Office
2609 Anderson Avenue
Manhattan, Kansas 66502

August 21, 2013

Curtis Hoagland
Kansas City District, Corps of Engineers
635 Federal Building
Kansas City, MO 64106

RE: CENWK-CO-RW (2013-554) FWS Tracking # 2013-CPA-0402

Dear Mr. Hoagland:

This letter is in response to your request for comments on the Draft Feasibility Report with Integrated Environmental Assessment for Upper Turkey Creek in Johnson County (Draft Report) to address flooding risks. The U.S. Army Corps of Engineers – Kansas City District (Corps), in cooperation with the City of Merriam, Kansas (Merriam) have chosen the alternative of a levee and floodwall project as the National Economic Development (NED) plan. The NED plan would also include replacing sections of the existing limestone revetment stream bank retaining wall with riprap in several locations within the project area to maintain bank stability; storm sewer modifications in the Merriam Farmer's Market area including a 2.14-acre/feet grass detention basin approximately 80 feet wide by 360 feet long located north of the Farmer's Market for internal drainage; modifying the pedestrian bridge near West 62nd Terrace to span 175 feet. The project is located in the City of Merriam, the Industrial and Railway Drive area and the Parkway vicinity all within Johnson County, Kansas.

Direct project related impacts to waters of the U.S. would result from the replacement of existing limestone revetment blocks that line the channel banks and replacing it with 24-inch Bethany Falls riprap. Approximately 1,000 cubic yards of riprap would be placed below the ordinary high water marks of Turkey Creek in the following locations: the right descending bank form river mile (RM) 2.69 to 2.75; RM 2.93 to 3.03; RM 3.14 to 3.28; RM 3.39 to 3.42; RM 3.59 to 3.62; and the left descending bank from RM 3.60 to 3.64. The 50% annual flood event (2-year return interval) was used to represent the ordinary high water mark.

There were no wetlands identified within or adjacent to the project area. The Habitat Evaluation Procedures (HEP) green sunfish Habitat Suitability Index (HSI) model was used to assess the impacts to waters of the U.S. as part of CWA Section 404 authorizations. The current HSI value for the green sunfish in the project area is 0.52, which results in 3.7 habitat units for the project area. The public notice states that the recommended plan would result in no change in HSI scores or habitat units, thus there would be on long-term adverse impact resulting from the proposed project on water of the U.S. To evaluate the affect of the proposed project on the

riparian floodplain area, the fox squirrel HSI model was utilized. The existing HSI score for the fox squirrel was 0.12, resulting in 3.18 habitat units over a 26.5 acre area. These habitat units would be lost under the proposed project from the removal of trees in the project footprint. This loss of riparian trees would be mitigated by the planning of 238 hard mast producing trees planted in the Upper Turkey Creek watershed.

We have reviewed the permit application pursuant to our authorities under the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.); section 404(b) of the Clean Water Act (33 U.S.C 1344); the Migratory Bird Treaty Act of 1918 (MBTA), as amended (16 U.S.C. 703 *et seq*); the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*); and executive orders 11990 (wetland protection) and 11988 (floodplain management).

Endangered Species Comments

The Public Notice stated that we previously concurred with your preliminary determination that the described work will not affect species designated as threatened or endangered or adversely affect critical habitat. Although we did not find such correspondence in our records or in Appendix H of the Draft Report, we do agree with your determination as there should be no federally listed threatened or endangered species in the project area.

Fish and Wildlife Coordination Act Comments

We believe that the descriptions of current environmental conditions and federal trust species, as well as the affects of the project on those resources, in the Draft Report is adequate.

We have the following comments.

The project is likely to increase thermal pollution in Turkey Creek and in downstream receiving waters. Thermal pollution could be increased by the installation of riprap in the creek and the removal of shading riparian vegetation. Many aquatic species are sensitive to changes in water temperatures so increasing water temperatures may further reduce habitat for aquatic and semi-aquatic species.

The removal of riparian vegetation, including the trees, and the proposal to mitigate the loss of trees by planting trees in park areas doesn't account for the function of riparian vegetation to the health of the stream. Riparian vegetation filters surface water runoff, improves bank stabilization, and supplies detritus to the aquatic system which is the foundation of the aquatic food chain. Trees and other vegetation provide shade over the creek which moderates water temperatures. Debris from the riparian vegetation, especially woody debris, provides structure in the stream and habitat for wildlife. Trees planted for mitigation for the loss of riparian vegetation in the project area should be along streams, preferably along Turkey Creek or tributaries to Turkey Creek.

The Corps of Engineers, Kansas City District Regulatory Program has adopted the Kansas Stream Mitigation Guidance (KSMG) as a method to calculate debits for impacts to streams and credits for mitigation. We recommend that the KSMG be used for this project.

If it is determined that mitigation for aquatic resources is needed the mitigation plan should be developed in accordance with 33 CFR, Part 332 and 40 CFR 230, also known as the Mitigation Rule, and include the following sections:

1. Mitigation Objectives
2. Site Selection
3. Site Protection Instrument
4. Baseline Information
5. Determination of Credits
6. Mitigation Work Plan
7. Operation and Maintenance Plan
8. Performance Standards (use quantitative measurements)
9. Monitoring Requirements
10. Long-term Management Plan
11. Adaptive Management Plan
12. Financial Assurances

Natural processes that create and sustain habitat in the aquatic system are often damaged by flood control projects. These processes include a natural range of variability of flows, channel meandering and flood plain storage, large woody debris recruitment and sediment routing and transport. Such processes are important to retain or restore because native aquatic species have adapted to them and cannot thrive when they are damaged. Many of these processes have been significantly altered in the Turkey Creek Watershed. We urge the Corps to evaluate and prioritize alternatives, mitigation, and restoration opportunities from a process-based approach that determines whether a proposal will further degrade, maintain, or enhance natural riverine processes.

The Draft Report discussed alternatives that include channel widening. Although it is not a part of the NED at this time, it may be discussed again in the future. If channel widening occurs it would spread the base flow over more area leading to a decrease in water depth. This would likely increase thermal pollution and create a physical, and possibly a behavioral, barrier to aquatic organism passage. Should channel widening be considered, project planning should include the construction of a low flow/base flow channel which should emulate the natural stream pattern, profile, and dimensions.

We did not find a discussion in the Draft Report about the types of vegetation to be planted on the levees. Non-native fescue or brome grass species are typically proposed for these types of projects. These grass species are generally invasive and are detrimental to the remaining native riparian vegetation and wildlife. We recommend the use of native species. The USDA – Natural Resource Conservation Service's Plants Database (http://plants.usda.gov/java/) lists three species of fescue that are native to Kansas: clustered fescue (*Festuca paradoxa*), nodding fescue (*Festuca subverticillata*), and Rocky Mountain fescue (*Festuca saximontana*). Other native grasses which might be suitable for use on the levees include buffalo grass (*Bouteloua dactyloides*) and western wheat grass (*Pascopyrum smithii*).

Erosion controls should be an integral component of the project to ensure that sediment originating from the project does not enter the stream or migrate downstream. Erosion controls should include on-land best management practices, such as mulching bare areas, properly maintaining silt fences, hay bales, or coir mats, and reseeding disturbed areas as-soon-as-possible. Good information on BMPs for erosion control can be found at http://www.dot.ca.gov/hq/construc/stormwater/BMP_Field_Master_FullSize_Final-Jan03.pdf, and http://www.fws.gov/midwest/fisheries/streamcrossings/ErosionControl.htm. In addition, in-stream sediment controls should also be considered in sensitive areas or where upland erosion controls may not be adequate. These practices should be properly maintained for the life of the project. Before removing any in-stream structures, the accumulated silt should be carefully removed, so as not to disturb the natural substrate or vegetation of the stream and to prevent the downstream migration of sediments that have accumulated behind the structure.

Invasive Species

Invasive species have been identified as a major factor in the decline of native flora and fauna and impact aquatic resources. Executive order 13112 Section 2 (3) directs Federal agencies to not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere and to ensure that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions. Tools to perform Hazard Analysis and Critical Control Points (HACCP) planning for invasive species control are available at http://haccp-nrm.org/. HACCP planning focuses attention on critical control points where non-target species can be removed. Documenting risks and methods used to remove non target species gives managers a strategic method to make consistent decisions based on identified risks. Planning builds a logical framework of information to weigh risks for species spread against management benefits. Invasive species of particular concern in Kansas include the zebra mussel (*Dreissena polymorpha*), Eurasian watermilfoil (*Myriophyllum spicatum*), purple loosestrife (*Lythrum salicaria*), Johnson grass (*Sorghum halepense*), sericea lespedeza (*Lespedeza cuneata*), salt cedar (*Tamarix spp.*), and reed canary grass (*Phalaris arundinacea*). Additional information on aquatic invasive species in Kansas can be found on KDWP's website http://www.kdwp.state.ks.us/news/fishing/aquatic_nuisance_species. Human actions are the primary means of invasive species introductions. Prevention of introductions is the first and most cost-effective option for dealing with invasive species. We strongly encourage the inclusion of best management practices for the prevention of invasive species transfer in all mitigation plans. At the minimum the following should be included as a permit condition:

> All equipment brought on site will be thoroughly washed to remove dirt, seeds, and plant parts. Any equipment that has been in any body of water within the past 30 days will be thoroughly cleaned with hot water greater 140° F (typically the temperature found at commercial truck washes) and dried for a minimum of five days before being used at this project site. In addition, before transporting equipment from the project site all visible mud, plants and fish/animals will be removed, all water will be eliminated, and the equipment will be thoroughly cleaned. Anything that came in contact with water will be cleaned and dried following the above procedure.

Thank you for the opportunity to comment on this project. If you have any questions, please contact me or Susan Blackford of my staff at (785) 539-3474.

Sincerely,

Heather Whitlaw
Field Supervisor

cc: EPA, Kansas City, KS (Wetland Protection Section)
KDWP, Pratt, KS (Environmental Services)
KDHE, Topeka, KS (Bureau of Water)

HW/shb

JUL - 8 2013

KSR&C No. 12-05-134

6425 SW 6th Avenue
Topeka, KS 66615

Kansas

phone: 785-272-8681
fax: 785-272-8682
cultural_resources@kshs.org

Kansas Historical Society

Sam Brownback, Governor
Jennie Chinn, Executive Director

July 1, 2013

Curtis Hoagland
U.S. Army Corps of Engineers
635 Federal Building
Kansas City, MO 64106

RE: Upper Turkey Creek Basin Flood Risk Management
Permit No. 2013-554
Johnson County

Dear Mr. Hoagland:

The Kansas State Historic Preservation Office has reviewed your public notice and attached documentation regarding the above-referenced project dated June 27, 2013. According to our records, we have already reviewed and cleared this project in a letter to Timothy Meade of the Kansas City District Corps of Engineers dated May 15, 2012. Archeological survey was conducted and our office concurred that the project should have no effect on properties listing in the National Register of Historic Places or otherwise listed in our files. Since we see no significant differences in the current plans, our original clearance can stand. This office continues to have no objection to implementation of the Upper Turkey Creek Basin Flood Risk Management Project.

This information is provided at your request to assist you in identifying historic properties, as specified in 36 CFR 800 for Section 106 consultation procedures. If you have questions or need additional information regarding these comments, please contact Tim Weston at 785-272-8681 (ext. 214) or Kim Gant at 785-272-8681 ext. 225. Please refer to the Kansas Review & Compliance number (KSR&C#) above on all future correspondence relating to this project.

Sincerely,

Jennie Chinn
Executive Director and
State Historic Preservation Officer

Timothy Weston for

Patrick Zollner
Deputy State Historic Preservation Officer

From: Luginbill, Jason
Sent: Tuesday, August 13, 2013 2:08 PM
To: Hoagland, Curtis R NWK
Cc: Environmental Services
Subject: [EXTERNAL] KDWPT review (20130928 & 20130928-2) for City of Merriam, KS, Turkey Creek Levee and Floodwall Project

Project: City of Merriam, KS, Turkey Creek Levee and Floodwall Project Tracking No.: 20130928 & 20130928-2 Legals: T12S, R24E, Sec. 12

Dear Mr. Hoagland:

The referenced project was reviewed for potential impacts on crucial wildlife habitats, current state-listed threatened and endangered species and species in need of conservation, and Kansas Department of Wildlife, Parks, and Tourism managed areas for which this agency has administrative authority.

No state-listed threatened or endangered species or crucial wildlife habitats should be significantly affected. No Department of Wildlife and Parks permits or special authorizations are needed.

* Avoid impacts to non-impacted riparian zones, wetlands, and native prairie and woodland areas.

* Minimize any / all further instream construction activities particularly during general spawning dates of May 1 through August 31.
* Incorporate principles of Low Impact Development, such as permeable asphalt pavement, swales, bioretention, raingardens, and on-site phytoremediation.
* Implement and maintain standard erosion control Best Management Practices such as silt fencing, hay bale ditch checks, erosion control blankets, storm drain inlet protection and temporary weed-free seeding/mulching to protect water quality during construction.
* Reseed and landscape with indigenous warm season grasses, forbs, shrubs and trees to permanently revegetate all areas disturbed by construction.

Please consider this email our official review of this project. If you have any questions or concerns please feel free to contact me.

Thank you,

Jason S. Luginbill

Jason S. Luginbill, Aquatic Ecologist
Ecological Services Section, KDWPT
512 SE 25th Ave.
Pratt, KS 67124
Office: 620-672-0795
Cell: 620-450-8311
Fax: 620-672-2972

From: Delia Garcia

Hello,

We are writing this email to express our opposition to the preferred alternative presented for the Upper Turkey Creek Flood Risk Management Program. The proposed levees and flood walls are a rather antiquated way of dealing with flood control, when there are other management techniques that can be implemented that would provide more benefits to the ecosystem. The Merriam Drainage District needs to make an effort to work with other agencies and nongovernmental organizations to implement greener solutions that could help alleviate the risk of flooding. It should also spend some of the funds it receives from our taxes to sponsor and promote workshops (e.g. rain gardens, rain barrels, pervious pavement) that homeowners and business organizations can voluntarily implement.

Instead of focusing on restoring an ecosystem that has been badly degraded by years of mismanagement (bank stabilization through hard surfaces that have led to further erosion of downstream banks), this alternative as proposed will lead to the further degradation of the environment. Increased channelization of flows within the Upper Turkey Creek, will lead to increased water velocities traveling to the Lower Turkey Creek. It would be a shame that all of the money and effort that has been spent in trying to improve the ecosystem in the Lower Turkey Creek, could be undone by high water velocities that would occur if the Upper Turkey Creek is further channelized.

Merriam needs to embrace the environmental and aesthetic benefits that an improved ecosystem could do for the City's image. Stop treating Turkey Creek as though it is just a pipe whose only purpose is to move water downstream as fast as possible.

We are completely opposed to both our federal and local taxes being spent on further degrading the environment. Our taxes would be better spent on our elected officials taking a trip to Portalnd, Oregon or other cities where they value their natural resources and have spent money on green infrastructure rather than gray infrastructure.

Delia Garcia, Ph.D.

Appendix I
Self-Certification of Financial Capability

MERRIAM

CITY OF MERRIAM

February 11, 2013

COL Anthony J. Hofmann
Commander, Kansas City District
U.S. Army Corps of Engineers
Attn: CENWK-PM-PF (Grothaus)
Bolling Federal Building, Room 538
601 E. 12th Street
Kansas City, MO 64106-2896

Dear COL Hofmann:

This is to express our support for the Upper Turkey Creek Flood Risk Management project. We understand as the local sponsor we will be required to sign a Preconstruction Engineering and Design (PED) Agreement which will require us to provide 25 percent share of design costs during the PED phase. We understand the PED phase is the effort required to prepare plans, specifications and associated design documentation for the first construction contract, and that subsequent design effort for remaining project features would be performed during construction. We understand that PED costs will be rolled into the total construction cost and shared at 65 percent federal, 35 percent local under the Project Partnership Agreement (PPA).

We understand that in order to move into construction it will require approval of the feasibility report, project authorization in a Water Resources Development Act (WRDA), and the appropriations in the Construction Account of the Energy & Water Development Bill. We understand local sponsorship requires signing a PPA and provision of 35 percent of project cost in the form of cash, lands, easements, rights of way, relocations and disposal areas (LERRD). We understand that as currently estimated, the total project first cost for the Locally Preferred Plan (LPP) is approximately $19,023,000, of which the local sponsor share will need to provide approximately $7,412,000, which includes the fully non-federally funded buy-up of $1,160,000 over the local cost share required for National Economic Development (NED) Plan. This additional local cost is to enable moving the interior ponding area to maintain our Farmer's Market free from direct impact.

We understand that local sponsorship includes local acquisition or provision of all LERRD, currently estimated at $5,174,000 for the LPP, and that land values are based upon the appraised fair market value. This leaves approximately $2,238,000 for the local cash requirement which exceeds the 5 percent minimum. We understand that ownership, operation and maintenance of the project after construction and acceptance of work is the local sponsor's responsibility. The flood threat is a serious risk to loss of life as well as a severe economic impact, and we desire to move forward as expeditiously as possible. We look forward to working in partnership with the Corps of Engineers on this project.

Sincerely,

Mayor Ken Sissom
City of Merriam

CITY OF MERRIAM
9000 W. 62nd Terrace • Merriam, Kansas 66202-2815
Phone: 913-322-5500 • Fax: 913-322-5505
www.merriam.org

NON-FEDERAL SPONSOR'S
SELF-CERTIFICATION OF FINANCIAL CAPABILITY
FOR DECISION DOCUMENTS

I, Cynthia Ehart, do hereby certify that I am the Chief Financial Officer [OR TITLE OF EQUIVALENT OFFICIAL] of the City of Merriam, Kansas (the "Non-Federal Sponsor"); that I am aware of the financial obligations of the Non-Federal Sponsor for the Upper Turkey Creek Flood Risk Management Project; and that the Non-Federal Sponsor will have the financial capability to satisfy the Non-Federal Sponsor's obligations for that project. I understand that the Government's acceptance of this self-certification shall not be construed as obligating either the Government or the Non-Federal Sponsor to implement a project.

IN WITNESS WHEREOF, I have made and executed this certification this 11th day of February, 2013.

BY: Cynthia L Ehart

TITLE: Finance Director

DATE: 2/11/13

Appendix J
Environmental
HTRW, Environmental Restoration Strategies – Kabbes Report, Stream Assessments, Water Quality

Section 1
HTRW

ENVIRONMENTAL LAWS AND REGULATIONS

Various Federal and State legislation regulates the proper use, disposal, and clean up of hazardous materials and waste.

Resource Conservation and Recovery Act (RCRA)

Passed by Congress in 1976, this law gives the Environmental Protection Agency the authority to regulate hazardous waste disposal. This is accomplished by tracking the hazardous waste from its generation to its disposal. In 1984, there were several amendments made to this act, called the Hazardous and Solid Waste Act (HSWA). The amendments were enacted to include underground storage tank regulation, all releases of hazardous waste to the environment, and mandates for corrective action at hazardous waste facilities.

Toxic Substance Control Act (TSCA)

Also enacted by Congress in 1976, this law deals with all chemicals produced or imported into the United States. It requires that the chemical be adequately tested for toxicity prior to its commercial release to the public. In 1979, this act was amended to include the prohibition of the manufacture and distribution polychlorinated biphenyls (PCBs). PCBs are required to be labeled and disposed of properly. In the Statutes of Kansas, K.A.R. 28-55-5 states that PCB treatment, storage and disposal facilities shall comply with all applicable requirements of 40 CFR 761 subpart D, as in effect on November I, 1986 and 40 CFR 264 subparts B, C, D, G and H, as in effect on November 1, 1986.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

Nicknamed Superfund, this law was enacted to start a trust fund for the payment of remediation at abandoned hazardous waste sites. This law was passed in 1980. The issue of abandoned or uncontrolled sites has grown through the years. The EPA manages the National Priority List, which lists certain CERCLA sites of the highest priority. By law, the State of Kansas also maintains a registry list of all abandoned and uncontrolled hazardous waste sites within the state. Superfund Amendments and Reauthorization Act (SARA) amended CERCLA in 1984. The amendments included more state and community involvement in the remediation process, increased focus on human health problems posed by contaminated sites, selection of remedies that permanently cleaned the site, and consideration of standards and other requirements in State and other Federal laws and regulations.

Federal Facility Compliance Act (FFCA)

In 1992, Congress passed the Federal Facility Act, which requires the Department of Energy (DOE) to develop and submit Site Treatment Plans for the development of capacity and technologies for treating mixed waste. All facilities that the DOE stores or generates these wastes must have such a plan. It also requires schedules for bringing new treatment facilities into operation.

State Regulations

The State of Kansas provides regulations for the use, management, and disposal of hazardous waste. These regulations are found in Article 31 on Hazardous Waste Management with additional statutes on Public Health in Chapter 65 and Hazardous Waste in Regulation Article 34. Environmental Use Controls are mentioned in K.S.A 65-1, 221 to 65-1, 235 and gives the state authority to assist existing programs to help address environmental contamination in a cost effective manner and restrict the use of land where controls exist. It also empowers the State to enforce the regulations, defines hazardous waste, and controls the management, treatment, and disposal of hazardous waste. Statute Article 34 Solid Waste and Regulation Article 55 establishes criteria for facilities that handle and dispose of PCB waste. Article 28 contains regulations pertaining to the protection of surface waters and the water supply from environmental contamination and establishes water quality standards.

SITE INVESTIGATION

The HTRW investigations at this stage of the project consisted primary of a records search of past and present environmental activities and enforcement actions at properties adjacent to the creek. The information sources reviewed as part of this records search included:

- USEPA Enviromapper - GIS database identifying Superfund sites, sites were hazardous releases have occurred, and facilities regulated by the USEPA that handle materials designated as hazardous waste.

- USEPA CERCLIS Database - The Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) database contains general information on sites across the nation and US territories including location, status, contaminants, and actions taken. It provides information on sites being assessed under the Superfund Program, hazardous waste sites and potential hazardous waste sites.

- KDHE Identified Sites – Contaminated sites managed by the Bureau of Remediation (except for leaking underground or above ground petroleum storage tanks) are included in the Identfied Sites List (ISL).

- KDHE AST and UST Assessment Database – this database provides information on site were leaks have occurred or a tank has been closed.

- KDHE Database of Registered USTs

The areas focused on during this investigation included properties adjacent to Turkey Creek and its' tributaries where a potential for soil disturbance is identified.

Below are the findings from the records search:

Superfund Sites

There were no Superfund sites identified in areas of potential soil disturbance

Sites identified on CERCLIS Database

The CERCLIS Database identified no sites being investigated or remediated for hazardous waste within the areas of potential soil disturbance

KDHE Identified Sites

Figure I shows locations of KDHE Identified sites in the proximity of Turkey Creek. There were three sites identified that are relatively close to proposed work. These are listed below.

- Site 1: CEPA L.C., 7700 Wedd Rd, Overland Park, KS – contaminated with chlorinated solvents from adjacent Site 2. A railroad track exists between the site and the channel. Site should not impact work.
- Site 2: Electronics Research Company, 7618 Wedd Rd, Overland Park, KS – contaminated from a chlorinated solvent spill. A railroad track exists between the site and the channel. Site should not impact work.
- Site 4: Security Storage, 11015 W 62nd St, Shawnee, KS – this property is being impacted by a release from a leaking UST on an adjacent property. Channel work adjacent to this property is minimal so there should be no impact to the project.

Solid Waste Facilities

There is one solid waste facility identified near the project area. It is facility number 16 on Figure 2. The name of the facility is Planet Marrs Recycling located at 2701 Roe Lane, Kansas City, KS. Information from the KDHE database indicates it is a composting operation, therefore it poses no risk to encountering any hazardous substances.

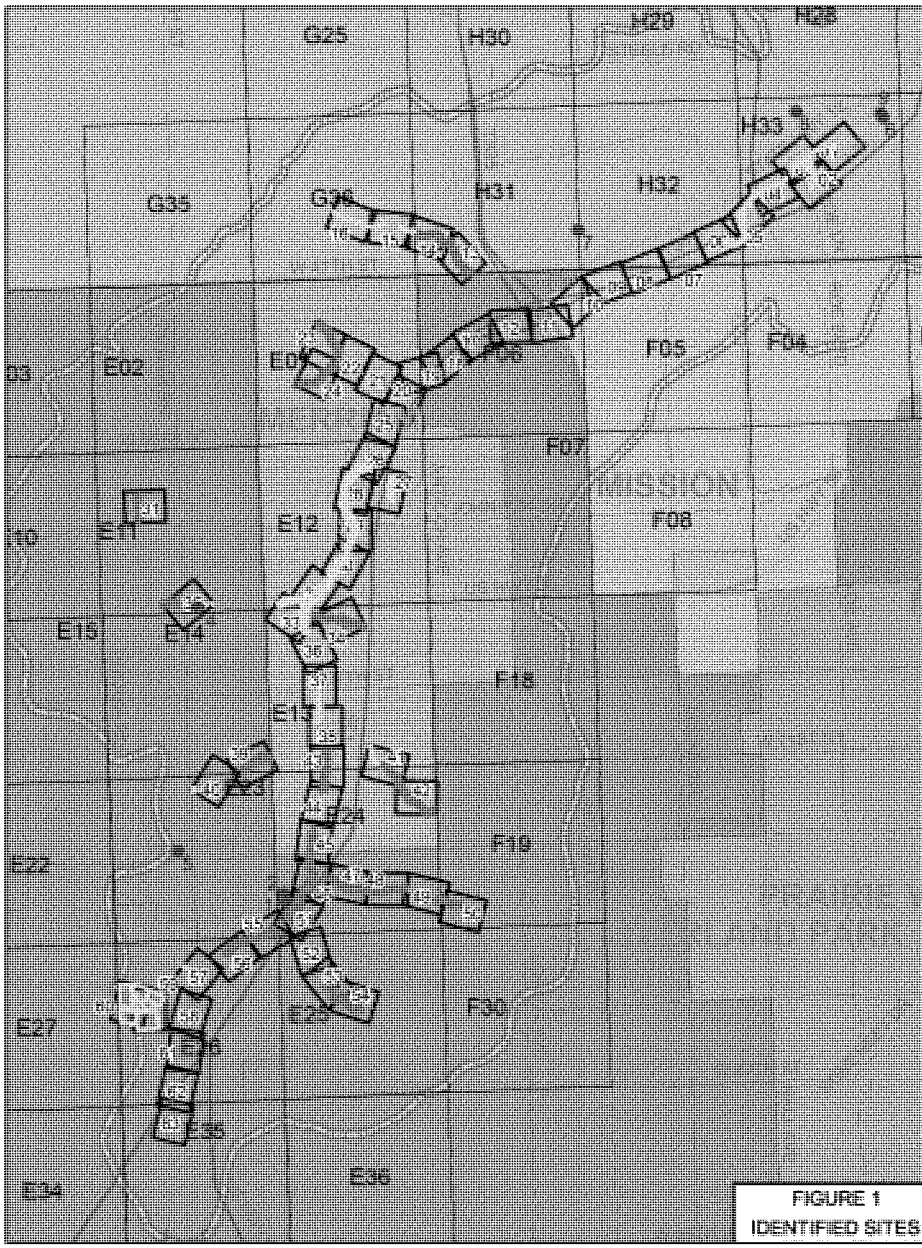


FIGURE 1
IDENTIFIED SITES

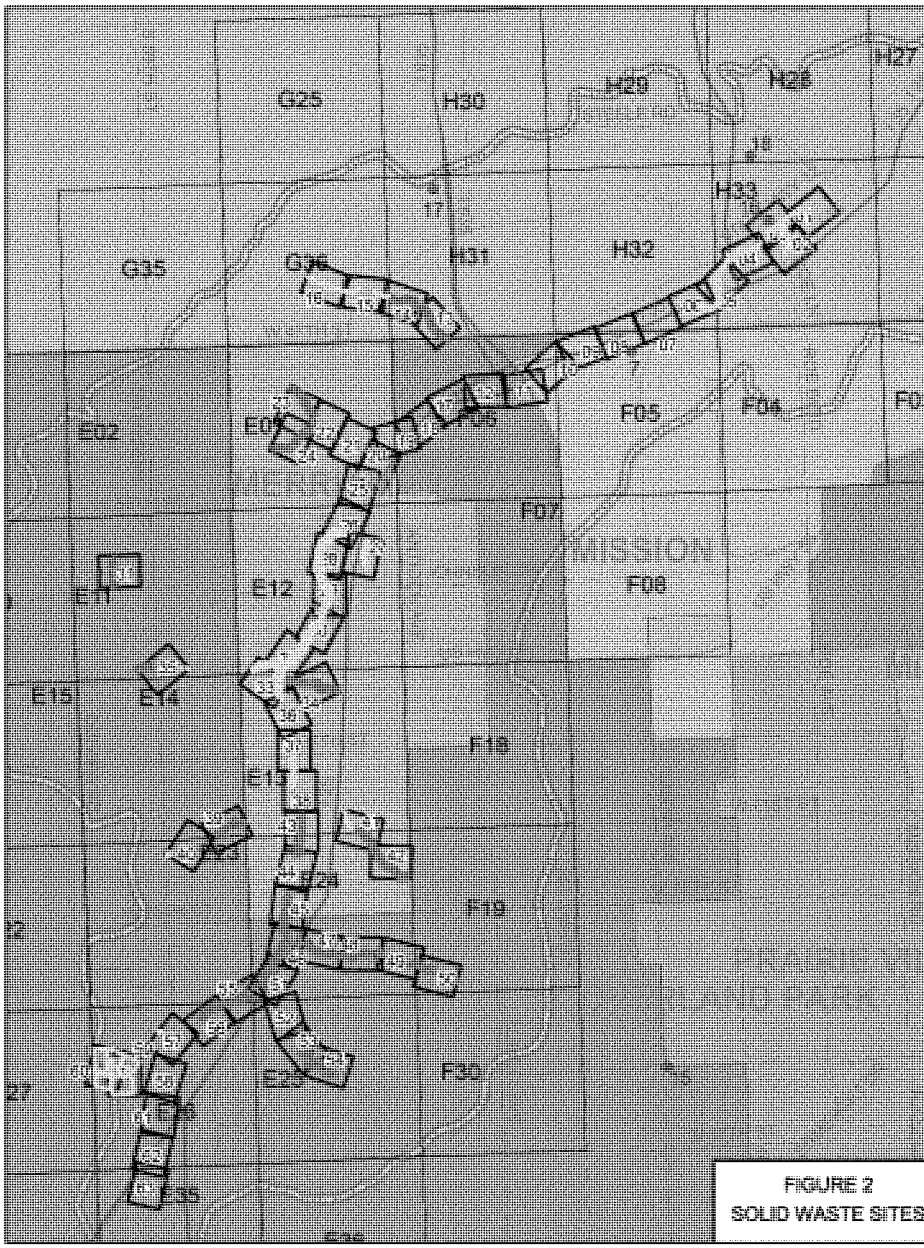


FIGURE 2
SOLID WASTE SITES

Leaking or Closed Storage Tank Sites

There are a large number of historical leaking UST sites near the project. These sites are plotted on Figure 3. Although many of the site appear close to the proposed channel work, a closer look at the specific properties found that only four sites (3, 4, 7, and 24) are immediately adjacent to the channel. Based on remarks in the KDHE database, it appears all of the contamination associated with the leaking tanks on these properties was adequately remediated. However, recommend contingency plans be developed to address any fuel contaminated soil if it is encountered.

- Site 3: Harrington Roofing Co, 2820 Roe Lane, Kansas City, KS - 1-4000 gallon gasoline underground storage tank & 1-3000 gallon diesel underground storage tank was removed 7-12-96. Line assess not done, but dispenser appears to have been adjacent to underground storage tanks. 356 yds of soil removed from basin.
- Site 4: Rohrer Contracting, 2820 Roe Lane, Kansas City, KS - Field tests showed a maximum of 1500 ppm total petroleum hydrocarbons. Removed an estimated 25 yards of sand and backfilled. Leakage from all sources of past operation.
- Site 7: Kansas City, Maintenance. Shop, 4801 Shawnee Drive, Kansas City, KS - 1 1000 gal diesel and 1 1000 gal gasoline USTs removed. there was contaminated soil surrounding the tanks. They transported 100 yds of contaminated soil to Miami co landfill.
- Site 24: School Services & Leasing, 5639 Merriam Drive, Merriam, KS - 1-300 waste oil UST & lines removed. Tank had minor staining, ~20 yrds removed. 1-10000 gas, 1-2000 diesel USTs & lines removed from 2nd excav. fill stained, excav= +2500 ppm tph. overexcavated, ~150 yrds removed. closed.
- Site 25: Marley Pump Company, 5730 Merriam Drive, Merriam KS – 3-560 gallon gasoline USTs were removed in 1992. There was no contamination noted.

Facilities Handling Hazardous Waste

There are numerous facilities located along the Turkey Creek channel that handle or produce hazardous wastes. These facilities are regulated by USEPA. Although they handle hazardous wastes, there have been no reported spills or areas requiring cleanup they would have an impact on the project.

Registered Underground Storage Tanks

Registered USTs near the proposed Turkey Creek project are shown on Figure 4. Two of these USTs are on properties immediately adjacent to the channel where work is proposed. The exact location of these tanks and piping will need to be identified during the design phase to ensure they are located in the specific area to be disturbed. The properties adjacent to the channel with registered USTs are:

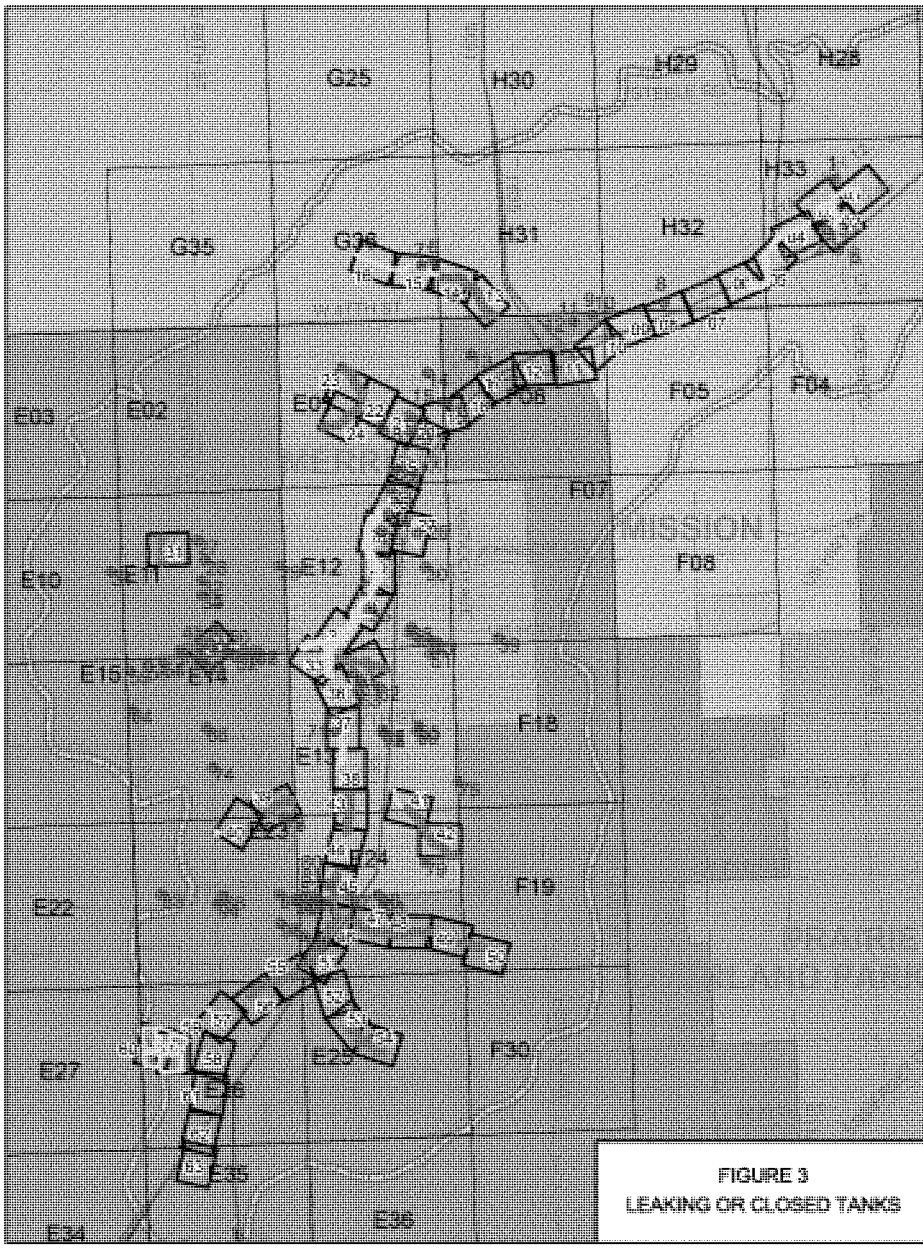


FIGURE 3
LEAKING OR CLOSED TANKS

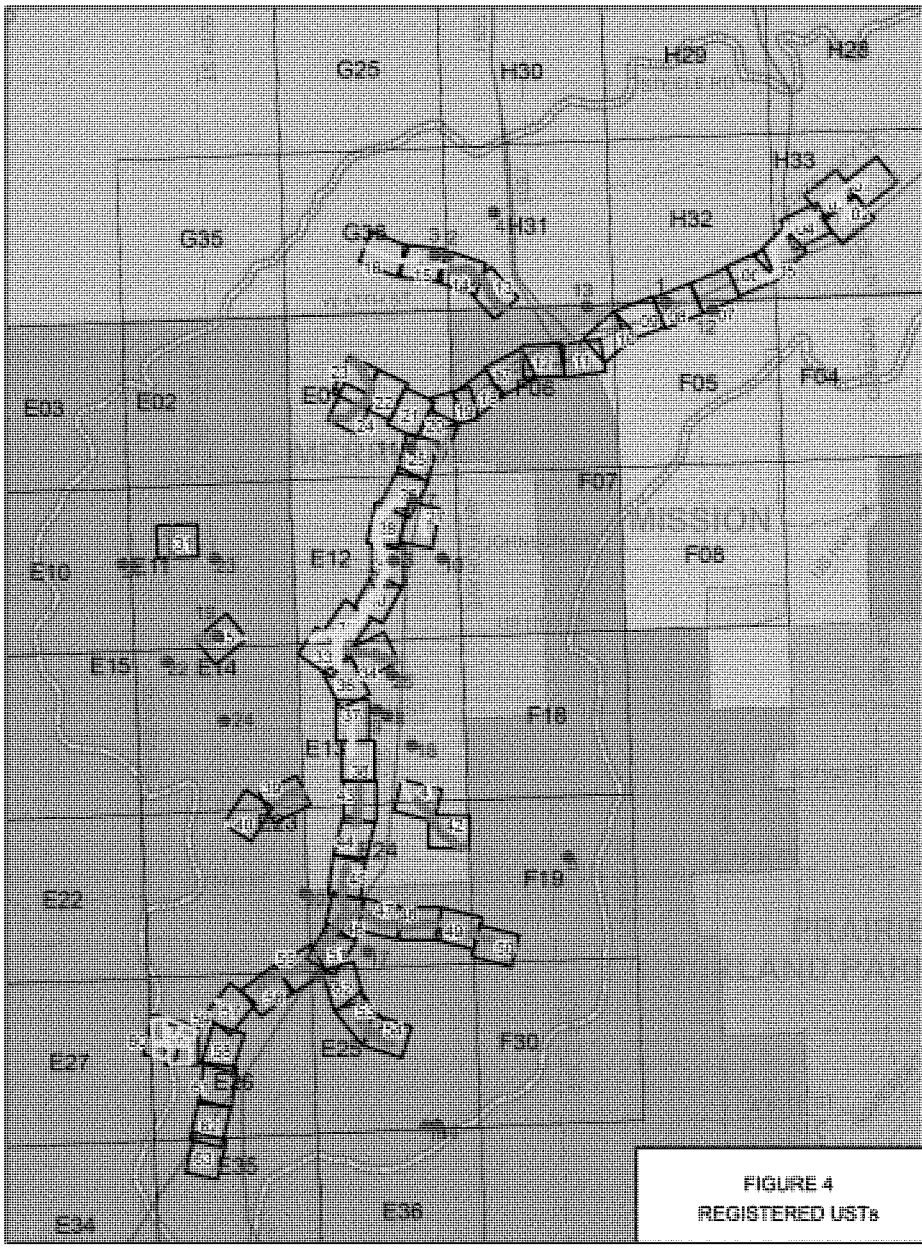


FIGURE 4
REGISTERED USTs

- Site 3: Street Maintenance Dept Buildings, 4801 Shawnee Drive, Kansas City, KS –
- Site 7: Durham School Services, 5639 Merriam Drive, Merriam, KS – the 2010 registration for this tank identifies the property as First Student, Inc.

CONCLUSION/RECOMMENDATIONS

Based upon the findings from the records search performed, there are no known hazardous waste sites that will impact the proposed channel work. In addition, no solid waste facilities, such as former landfills, were identified at locations that would impact the project. There are three properties immediately adjacent to the channel that had leaking underground storage tanks. These are at 2820 Roe Lane, 4801 Shawnee Drive, and 5639 Merriam Drive. It appears the contamination associated with these leaking tanks was adequately addressed, so it is unlikely fuel contaminated soil will be encountered. There are also two properties adjacent to the channel that have current registered USTs. These are at 4801 Shawnee Drive and 5639 Merriam Drive. It is recommended the specific location of these tanks be identified during the design phase of the project so they can be avoided. In addition, any specifications developed for the work, should include provisions to develop a contingency plan to address any hazardous waste or fuel contaminated soils if encountered during construction.

The property located north of the Farmer's Market in downtown Merriam (5730 Merriam Drive) had 3-560 gallon gasoline USTs removed from the property. There was no contamination observed during the UST removal. In addition, there are reports that the property contains a significant amount of buried debris. If buried debris is excavated during construction activities it will need to be properly disposed of at an off-site facility permitted to accept the material.

Section 2 Environmental Restoration Strategies – Kabbes Report

U.S. Army Corps of Engineers
Kansas City District

Upper Turkey Creek Basin Environmental Restoration Report
Feasibility Phase

***DRAFT* REPORT**

Prepared by:

HNTB
ARCHITECTS ENGINEERS PLANNERS

KEI

August 2004

TABLE OF CONTENTS

FINAL REPORT

EXECUTIVE SUMMARY.....I

STUDY AREA MAP.....III

FOREWORD.....IV

TASK 1: STOP STREAM DOWNCUTTING

Brown Park

Title Sheet..... 1.1
Task Objective..... 1.2
Site Selection Criteria..... 1.2
Site Conditions/Site Analysis..... 1.2
Restoration Description..... 1.3
Design Procedures..... 1.4
Water Quality Benefits..... 1.5
Habitat Benefits..... 1.6
Maintenance Requirements and Expected Design Life..... 1.6
Value Engineering Alternatives..... 1.6
References..... 1.6
Cost Estimate..... 1.7
Location Sketch..... 1.8
Site Photos..... 1.9
Plan View..... 1.10
Profile View..... 1.11
Typical Riffle Detail..... 1.12

75th Street

Title Sheet..... 1.13
Task Objective..... 1.14
Site Selection Criteria..... 1.14
Site Conditions/Site Analysis..... 1.14
Restoration Description..... 1.14
Water Quality Benefits..... 1.16
Habitat Benefits..... 1.16
Maintenance Requirements and Expected Design Life..... 1.17
Value Engineering Alternatives..... 1.17
References..... 1.17
Cost Estimate..... 1.18
Location Sketch..... 1.19
Site Photos..... 1.20
Plan View..... 1.21
Profile View..... 1.22
Typical Riffle Detail..... 1.23

TASK 2: REMOVE OBSTRUCTIONS TO FISH AND WILDLIFE PASSAGE

75th Street

Title Sheet..... 2.1
Task Objective..... 2.2
Site Selection Criteria..... 2.2
Site Conditions/Site Analysis..... 2.2
Restoration Description..... 2.3
Water Quality Benefits..... 2.5
Habitat Benefits..... 2.6
Maintenance Requirements and Expected Design Life..... 2.9
Value Engineering Alternatives..... 2.9
References..... 2.10
Cost Estimate..... 2.11
Site Photos..... 2.12

TASK 3: RETROFIT STORMWATER BASINS FOR WATER QUALITY BENEFITS

Merriam Town Center

Title Sheet..... 3.1
Task Objective..... 3.2
Site Selection Criteria..... 3.2
Site Conditions/Site Analysis..... 3.2
Restoration Description..... 3.3
Detention Basin Riser Hydraulics..... 3.3
Water Quality Benefits..... 3.4
Habitat Benefits..... 3.4
Flood Reduction Impact..... 3.4
Maintenance Requirements and Expected Design Life..... 3.4
Value Engineering Alternatives..... 3.5
References..... 3.5
Cost Estimate..... 3.6
Location Sketch..... 3.7
Site Photos..... 3.8
Plan View..... 3.9
Profile View..... 3.10
Outlet Structure Detail..... 3.11
Planting Plan..... 3.12
Section A Detail..... 3.13

Pine Ridge West Business Park

Title Sheet..... 3.15
Task Objective..... 3.16
Site Selection Criteria..... 3.16
Site Conditions/Site Analysis..... 3.16
Restoration Description..... 3.17
Water Quality Benefits..... 3.17
Habitat Benefits..... 3.18

Flood Reduction Impact..... 3.18
Maintenance Requirements and Expected Design Life..... 3.18
Value Engineering Alternatives..... 3.19
References..... 3.19
Cost Estimate..... 3.21
Location Sketch..... 3.22
Site Photos..... 3.23
Plan View..... 3.24
Section A Detail..... 3.25
Section B Detail..... 3.26
Section C Detail..... 3.27

TASK 4: ACQUIRE AREAS OF OPEN SPACE WITH IMPORTANT AQUATIC RESOURCES

Title Sheet.....
Task Objective.....
Site Selection Criteria.....

TASK 5: OPEN UP CHANNEL ENCLOSURES ON TRIBUTARIES
Enclosed System in Kansas City, Kansas

Title Sheet..... 5.1
Task Objective..... 5.2
Site Selection Criteria..... 5.2
Site Conditions/Site Analysis..... 5.2
Reference Stream Survey..... 5.3
Restoration Description..... 5.3
Water Quality Benefits..... 5.3
Habitat Benefits..... 5.4
Flood Reduction Impact..... 5.4
Operation and Maintenance and Life Expectancy..... 5.5
Value Engineering Alternatives..... 5.5
References..... 5.5
Cost Estimate..... 5.6
Location Sketch..... 5.7
Site Photos..... 5.8
Existing Conditions Upstream..... 5.9
Existing Conditions Downstream..... 5.10
Plan View Upstream..... 5.11
Plan View Dowstream..... 5.12
Cross Section..... 5.13
Planting Plan..... 5.14

TASK 6: DESIGN A BIOENGINEERING SOLUTION TO STABILIZE STREAMBANKS

Kansas City, Kansas Maintenance Facility

Title Sheet..... 6.1
Task Objective..... 6.2
Site Selection Criteria..... 6.2

Site Conditions/Site Analysis..... 6.2
Restoration Description..... 6.3
Water Quality Benefits..... 6.3
Habitat Benefits..... 6.3
Operation and Maintenance and Life Expectancy..... 6.4
Value Engineering Alternatives..... 6.4
References..... 6.4
Cost Estimate..... 6.5
Location Sketch..... 6.6
Site Photos..... 6.7
Plan View..... 6.8
Profile View..... 6.9
Typical Creek Section..... 6.10

62nd Street and Ballentine

Title Sheet..... 6.11
Task Objective..... 6.12
Site Selection Criteria..... 6.12
Site Conditions/Site Analysis..... 6.12
Restoration Description..... 6.13
Water Quality Benefits..... 6.13
Habitat Benefits..... 6.13
Operation and Maintenance and Life Expectancy..... 6.14
Value Engineering Alternatives..... 6.14
References..... 6.14
Cost Estimate..... 6.15
Location Sketch..... 6.16
Site Photos..... 6.17
Plan View..... 6.18
Profile View..... 6.19
Typical Creek Section..... 6.20

TASK 7: RECONNECT CHANNEL AND FLOODPLAIN FOR WATER QUALITY BENEFITS

67th Street and Knox

Title Sheet..... 7.1
Task Objective..... 7.2
Site Selection Criteria..... 7.2
Site Conditions/Site Analysis..... 7.2
Restoration Description..... 7.2
Water Quality Benefits..... 7.3
Habitat Benefits..... 7.3
Flood Reduction Impact..... 7.3
Operation and Maintenance and Life Expectancy..... 7.3
Value Engineering Alternatives..... 7.3
References..... 7.3
Cost Estimate..... 7.4
Location Sketch..... 7.5
Site Photos..... 7.6

Plan View..... 7.7
Planting Plan..... 7.8

TASK 8: EMPHASIZE STORMWATER AND FLOODWATER INFILTRATION OVER CONVEYANCE SYSTEMS

Quail Creek Park

Title Sheet..... 8.1
Task Objective..... 8.2
Site Selection Criteria..... 8.2
Site Conditions/Site Analysis..... 8.2
Reference Stream Survey..... 8.2
Restoration Description..... 8.3
Water Quality Benefits..... 8.3
Habitat Benefits..... 8.4
Flood Reduction Impact..... 8.4
Maintenance Requirements and Expected Design Life..... 8.4
Value Engineering Alternatives..... 8.4
Cost Estimate..... 8.5
Location Sketch..... 8.6
Site Photos..... 8.7
Plan View..... 8.8
Cross Section..... 8.9

71st Street and Nieman Road

Title Sheet..... 8.10
Task Objective..... 8.11
Site Selection Criteria..... 8.11
Site Conditions/Site Analysis..... 8.11
Restoration Description..... 8.12
Water Quality Benefits..... 8.12
Flood Reduction Impact..... 8.12
Maintenance Requirements and Expected Design Life..... 8.13
Value Engineering Alternatives..... 8.13
Cost Estimate..... 8.14
Location Sketch..... 8.15
Site Photos..... 8.16
Plan View..... 8.17
Detention Outlet Structure Detail..... 8.17A

PARKING LOT MEDIAN

Title Sheet..... 8.18
Task Objective..... 8.19
Site Selection Criteria..... 8.19
Site Conditions/Site Analysis..... 8.19
Restoration Description..... 8.19
Water Quality Benefits..... 8.19
Habitat Benefits..... 8.20
Flood Reduction Impact..... 8.20
Maintenance Requirements and Expected Design Life..... 8.20

Value Engineering Alternatives..... 8.20
References..... 8.20
Cost Estimate..... 8.21
Location Sketch..... 8.22
Site Photos..... 8.23
Grading Plan..... 8.24
Planting Plan..... 8.25
Basin Section..... 8.26

EXECUTIVE SUMMARY

Upper Turkey Creek is an urban watershed still undergoing development. In response to urbanization, the stream system has been deepening and widening. The response has been in many places to enclose the channels in culverts or line the channels with concrete. These concrete and enclosed channel sections become generally impassible biological dead zones for most of the fish and wildlife in Turkey Creek.

The Turkey Creek channel and floodplain has been part of the Kansas City metropolitan infrastructure since the 1800s. The relatively flat valley among the rolling hills offered a good place to build a railroad heading southwest from the busy community at the confluence of the Kansas and Missouri Rivers. The Southwest Highway and Interstate 35 and associated development in time paralleled the railroad taking advantage of the relatively flat terrain of the Turkey Creek floodplain. To provide good drainage and impacts from flooding, the railway and roadway beds were raised and adjacent land filled for businesses, homes and public uses.

Because of the favorable elevations, the creek system is the common location for utilities. The Turkey Creek channel and floodplain thus became the public infrastructure, transportation, utilities, drainage and development gateway of the southwest Kansas City metropolitan area. The channel deepening and widening has resulted in a number of exposed sewer lines crossing the creek or paralleling the creek. Urban stormwater runoff has added pollutants to the stream system. The loss of stream riffles, vegetated stream banks and floodplain has limited natural methods to remove pollutants.

A downstream historic flood control project has cut off the creek's natural connection to a larger water body. Continued development has resulted in filling along creek banks and the filling in of on-stream lakes. Channel downcutting has in some areas eroded below the shale and cobble substrate to expose fine sediment such as clays. The fisheries that dominate the stream are primarily small species that do not require significant stretches of stream to live and reproduce. Yet, studies indicate that Turkey Creek has a good potential for restoration.

Upper Turkey Creek, in general, has water quality that is acceptable for human contact and a good physical substrate to support a healthy ecosystem. Recent fisheries studies indicate larger fish finding their way to Upper Turkey Creek, perhaps in response to improvements in the quality of wastewater treatment plant discharges. An existing and planned future trail system is inviting people to enjoy the Upper Turkey Creek corridor.

The Kansas City District geographics information system (GIS) based inventory of Upper Turkey Creek and tributaries has provided a valuable snapshot of the current status of the system and areas that need to be addressed. This report presents a number of potential projects to deal with the ongoing degradation of Turkey Creek to provide tools for restoring the system.

The reconnaissance report listed nine strategies for environmental restoration. These strategies included:

- Stopping and if possible reversing the downcutting of the stream system, which leads to further bank erosion problems and blockages to fish passage.
- Removing the blockages to fish passage or finding ways to get fish around or over those blockages.
- Retrofitting stormwater basins and swales for water quality benefits.
- Acquiring areas of remaining open space with important aquatic resources.
- Opening up channel enclosures on tributaries.
- Removing retaining walls and addressing those locations and other bank erosion areas with bioengineering solutions.

- Reconnecting the channel and the floodplain for water quality, habitat and potential flood control benefits and recreation corridors for greenways and trails.
- Emphasizing stormwater and floodwater storage and infiltration systems over stormwater and floodwater conveyance systems.
- Implementing a public information/awareness campaign concerning existing regulatory programs, potential regulatory strategies, and the negative environmental impacts on downstream flooding of stream enclosures and channel modifications and available alternatives.

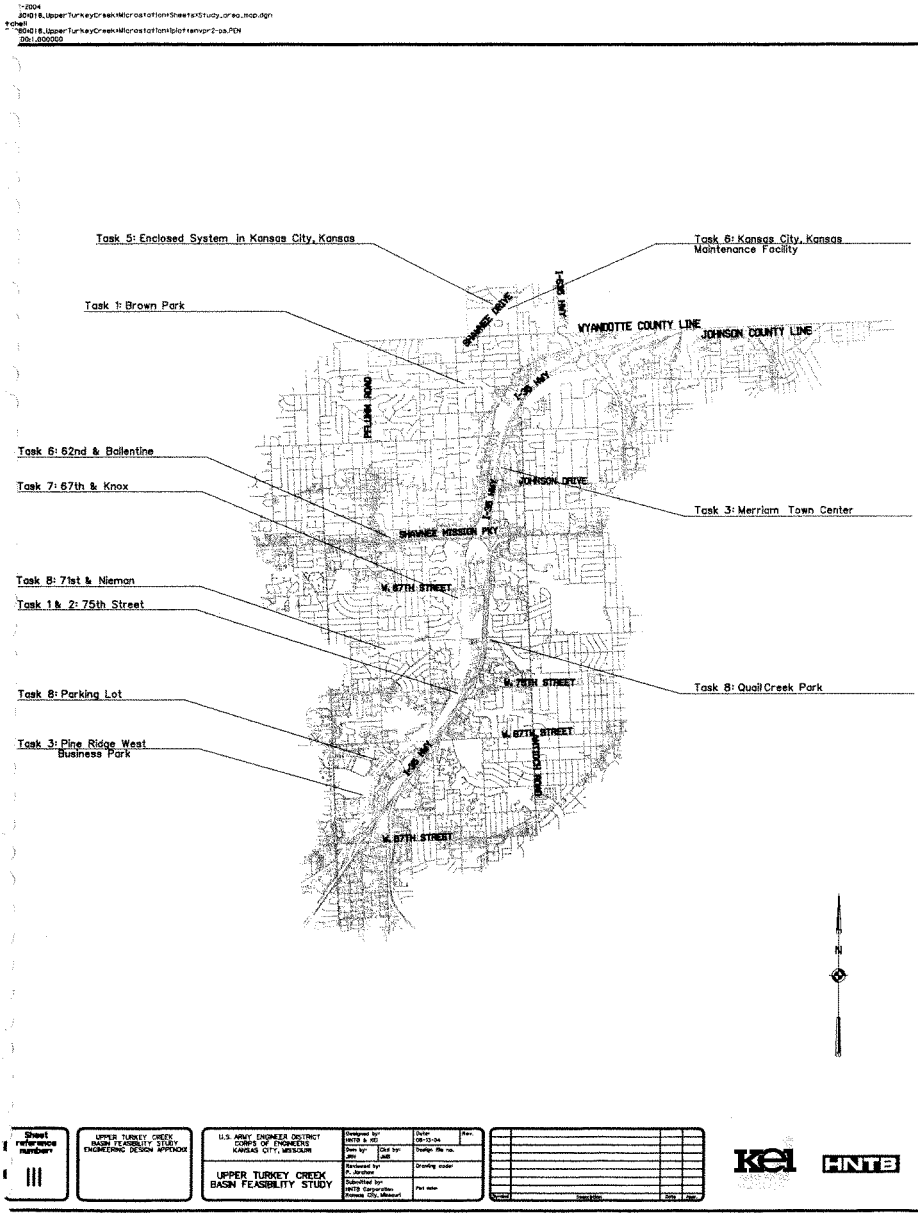
This report provides designs for thirteen projects at twelve sites to address seven of the strategies. The potential benefits of water quality, habitat and flood control and cost of each measure is included in the following table.

Environmental restoration, or undoing the impact of many of the previous actions taken is not inexpensive. Economics of scales of by improving entire reaches can be achieved making the measures more cost-effective. Through additional modeling and in working together with flood protection measures, costs for some of these measures may be able to be further reduced improving the quality of life for area residents.

SUMMARY OF MEASURES, BENEFITS AND COSTS

Site	Task Objective	No. Sites Inventoried	WQ Benefits	Habitat Benefits	Flood Benefit	Maintenance Costs	Demonstration Site Cost
Brown Park	(I) Prevent Channel Downcutting	83*	TSS DO NH_3	Fisheries Benthics		Low	$60,000
75th Street	(I) Prevent Channel Downcutting	83*	TSS DO NH_3	Fisheries Benthics		Low	$110,000 (measures combined)
75th Street	(II) Remove Fish Obstructions	79	TSS DO NH_3	Fisheries Benthics		Low	$110,000 (measures combined)
Merriam Town Center	(III) Retrofit SW Basins for WQ	22	P HC CO TSS Metals Organics	Birds	Yes	Medium	$290,000
Pine Ridge West	(III) Retrofit SW Basins for WQ	22	P N NO_3 HC CO TSS Metals	Fisheries (possible)	Yes	Medium	$40,000
KCK Sewer Day lighting	(V) Daylight Enclosed Channel	71	DO P N	Fisheries Benthics	Yes	Medium	$610,000
KCK Maintenance Facility	(VI) Bioengineer Streambank Stabilization	66	TSS DO P N Metals Organics	Fisheries Benthics		Medium	$110,000
Ballentine	(VI) Bioengineer Streambank Stabilization	66	TSS DO	Fisheries Benthics		Low	$210,000
67th & Knox	(VII) Reconnect Channel & Floodplain	53**	TSS DO NO_3 pH Temp	Fisheries Birds	Yes	Low	$390,000***
Quail Creek Park	(VIII) Remove Concrete Channel Lined	45	DO NH_3 TSS Temp pH NO_3	Fisheries Benthic	Yes	Low	$60,000
71st & Neiman	(VIII) Increase Stormwater & Floodwater Storage	53	TSS N Metals P NO_2 HC	Birds Fisheries (indirect) Benthic (indirect)	Yes	Medium	$70,000
Parking Lot Median	(VIII) Increase Infiltration	**	Cu Pb Zn P N NH_3 NO_2	Fisheries (indirect) Benthic (indirect)	Yes	Medium	$40,000

* Including fish obstruction sites.
** Not specified
*** Costs can be further reduced by reducing scope of project.


Task 5: Enclosed System in Kansas City, Kansas
Task 6: Kansas City, Kansas Maintenance Facility
Task 1: Brown Park
WYANDOTTE COUNTY LINE
JOHNSON COUNTY LINE
SHAWNEE DRIVE
I-635 HWY
I-35 HWY
PELLMAN ROAD
Task 6: 62nd & Ballentine
Task 7: 67th & Knox
JOHNSON DRIVE
Task 3: Merriam Town Center
SHAWNEE MISSION PKY
W. 67TH STREET
Task 8: 71st & Nieman
Task 1 & 2: 75th Street
W. 75TH STREET
Task 8: Quail Creek Park
Task 8: Parking Lot
W. 67TH STREET
Task 3: Pine Ridge West Business Park
I-35 HWY
W. 67TH STREET
N
Sheet reference number
III
UPPER TURKEY CREEK BASIN FEASIBILITY STUDY ENGINEERING DESIGN APPENDIX
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS KANSAS CITY, MISSOURI
UPPER TURKEY CREEK BASIN FEASIBILITY STUDY
Designed by: HNTB & KEI
Date: 08-13-04
Rev.
Dwn by: JRH
Ckd by: JMB
Drawing code:
Reviewed by: P. Jordan
Submitted by: HNTB Corporation Kansas City, Missouri
Plot date:
Symbol
Description
Date
Appr.
KEI
HNTB

FOREWORD

Upper Turkey Creek is an urban watershed still undergoing development. In response to urbanization, the stream system has been deepening and widening. The response has been in many places to enclose the channels in culverts or line the channels with concrete. These concrete and enclosed channel sections become generally impassible biological dead zones for most of inhabitants of Turkey Creek.

Because of the favorable elevations, the creek system is the common location for utilities. The channel deepening and widening has resulted in a number of exposed sewer lines crossing the creek or paralleling the creek. Urban stormwater runoff has added pollutants to the stream system. The loss of stream riffles and vegetated stream banks has limited natural methods to remove pollutants.

A downstream historic flood control project has cut off the creek's natural connection to a larger water body. Continued development has resulted in filling along creek banks and the filling in of on stream lakes. Channel downcutting has in some areas eroded below the shale and cobble substrate to expose fine sediment such as clays. The fisheries that dominate the stream are primarily small species that do not require significant stretches of stream to live and reproduce. Yet, studies indicate that Turkey Creek has a good potential for restoration.

Upper Turkey Creek, in general, has water quality that is acceptable for human contact and a good physical substrate to support a healthy ecosystem. Recent fisheries studies have found larger fish finding their way to Upper Turkey Creek, perhaps in response to improvements in the quality of wastewater treatment plant discharges. An exciting and planned future trail system is inviting people to enjoy the Upper Turkey Creek corridor.

The Kansas City Corps of Engineers District geographics information system (GIS) based inventory of Upper Turkey Creek and tributaries has provided a valuable snapshot of the current status of the system and areas that need to be addressed. This report presents a number of potential projects to deal with the ongoing degradation of Turkey Creek to provide tools for restoring the system.

TASK 1: STOP STREAM DOWNCUTTING BROWN PARK

BROWN PARK

TASK OBJECTIVE

The task objective is to design a system to prevent downcutting of the channel.

SITE SELECTION CRITERIA

The criteria in selecting a site for this task was to determine a suitable location, which is representative of other locations within the Upper Turkey Creek watershed. The demonstration site is ideally an average representation, based on condition, accessibility, utility and development conflicts.

This site is representative of some of the tributaries to Turkey Creek that are experiencing downcutting. Two streams come together in Brown Park to form a tributary to Turkey Creek. Brown Park is a publicly owned local facility. The two tributaries are undergoing active stream downcutting and headcutting. The site was noted and photographed in the Upper Turkey Creek Feasibility Study Environmental Field Assessment provided by the Kansas City District as one of the stream downcutting sites.

The exposure of three utility crossings on the two tributaries are good indicators of stream downcutting. The exposure of the utility crossings by stream downcutting is a common problem noted through out the Turkey Creek watershed. This particular site included two (2) exposed sanitary sewer encasements and one (1) exposed abandoned waterline. Should downcutting continue in the future, this will significantly lower the stream bottom downstream of the road crossing culverts. The culverts may be subject to failure because of the eroded foundation or require corrective action to repair the downcutting. Should the streams continue to downcut downstream of the culverts, the culverts will become obstructions to fish passage.

SITE CONDITIONS/SITE ANALYSIS

The site is located in the South Park residential subdivision of the City of Merriam, Kansas. The site limits include 50th Terrace to the north; Knox Avenue to the west; Booker Drive to the east; and 51st Street to the south. The channel sections used in the restoration design include the North Tributary from the culvert under 50th Terrace and the South Tributary from the culvert under 51st Street to the Brown Park pedestrian bridge which is located downstream of the junction of the two tributaries.

Brown Park had previously benefited by construction of a bioengineering project. However, stream downcutting had undermined the bank protection work. Should downcutting continue in the future, this will significantly lower the stream bottom downstream of the road crossing culverts, causing the culverts to become obstructions to fish passage.

The channel bottom width of the South Tributary is approximately 15 – 25 feet wide and the top of bank averages 10-feet high. The eroded side slopes are approximately 1H:1V and moderately vegetated. Heavy vegetation grows on the upper side slopes. The channel bottom consists primarily of shale rock. During dry periods, the water depth averages less than 6-inches with localized ponding areas up to 2-feet deep.

Downcutting was evidenced by the exposed encased 18-inch sanitary sewer pipe crossing the channel and a retired 4-inch water main.

The North Tributary bottom sediments appeared to consist of primarily silt and clays. Active headcutting of the North Tributary on the site is resulting in excessive bank erosion, sediment release and downstream deposition. An 18-inch concrete encased sanitary sewer crossing was found exposed. The stream had downcut to below the bottom of the encasement.. The channel upstream and downstream of 50th Terrace had eroded to below the upstream and downstream inverts of the triple – 10' x 6' RCB box culvert crossing. The headcutting of the North Tributary could in the future endanger the structural integrity of the downstream side of the culverts.

Stream downcutting and headcutting are theorized to be the result of the stream attempting to deepen and widen itself to carry increased annual flows due to urbanization of the upstream watershed and the loss of stormwater infiltration and storage. Another possible cause of channel downcutting is potential stream deepening due to downstream construction activities resulting in a lowering of the stream downstream and headcutting upstream.

The two tributaries at the site have a combined drainage area of 811 acres. As reported in the HEC-RAS provided by the District, the 2-year flow for the North Tributary (Trib 32 in the model) is 256 cfs. The 2-year flow for the South Tributary (Trib 31 in the model) is 592 cfs. Downstream of the junction of the two tributaries the HEC-RAS model reports the 2-year frequency flow as 1033 cfs for the downstream reach (Trib 35 in the model) of the site at the pedestrian bridge. The 2-year channel depth in the North Tributary is approximately 2.5 feet, the 2-year channel depth in the South Tributary ranges from approximately 2.5 and 5 feet over the project area. The approximate 2-year depth after the two channels combine is 7.7 feet. The 2-year frequency flow top width is 48-62 feet. The channel slopes are 0.006 feet/feet - 0.009 feet/feet.

The Kansas City District USACOE obtained sediment distribution information for the bottom sediments from Geotechnology, Inc. The results of that sampling are included in the Appendix and this site is noted as specimen 1-2. The results indicate that the d_{84} for the Brown Park site was 2.5 mm, which means that 84% of the stream bottom sediments collected at the site were smaller than 2.5 mm. The d_{75} was 0.8 mm and the d_{50} was 0.024 mm. No d_{16} was reported. For the South Tributary, a variety of cobbles were visible, some as large as 150 to 600 mm in size that appeared to have been moved by the stream.

RESTORATION DESCRIPTION

To stop stream downcutting and headcutting in a fashion that provides both fish and wildlife benefits and water quality benefits, installation of a series of rock riffles is proposed. Design allows for effective vertical flow conveyance, expansion and contraction upstream and downstream based on coefficients reported by V. T. Chow in "Open Channel Hydraulics" (1). The riffles are designed to also allow for fish passage by further flattening the downstream slope per the recommended design by Dr. Robert W. Newbury in "Stream Analysis and Fish Habitat Design" (2). The riffle rock was initially sized based on Lane's equation as referenced in the "Field Manual of Urban Stream Restoration" (3).

DESIGN PROCEDURES

Area topography at two feet. intervals was made available for the site by Johnson County. Limited field surveying to determine current channel inverts in the reach was performed by HNTB. The HEC-RAS model prepared by Johnson County and augmented by 1- and 2- year return frequency flows by the Kansas City District was also used as well as the sediment data on the stream sediment analyzed by Geotechnology, Inc., and provided by the District.

Comparing the survey work performed by HNTB to the Johnson County topography and the HEC-RAS model, the stream had downcut in the area of the utility crossing approximately 3 to 7 feet exposing the utilities. The headcuts appeared to be moving upstream, potentially endangering upstream roadway culvert crossings in the future.

The initial design approach was to construct a series of rock riffles to act as fish passable grade control structures and stop the upward migration of the stream's headcutting. In nature, rock riffles are usually found at the crossover point in a meandering stream where the stream changes from convex to concave. These rock riffles were placed to cover the exposed utility lines on the North and South Tributaries.

Riffles store potential energy that then helps erode or scour downstream pools in a natural pool riffle sequence. Therefore, it was important to check the area downstream of the riffles for erosion potential. Another riffle was placed downstream of the pedestrian bridge to help mitigate the potential impacts of erosion of the riffles on the bridge abutments. Riffles were also placed downstream of the culvert crossings at 50th Terrace and 51st Street to help protect the crossings.

The riffle heights were chosen so as to cover the exposed pipe encasements. Riffle elevations that were chosen to cover an existing blockage were designed to pass the design flow (two-year flow) assuming critical depth over the riffle. Critical depth and flow calculations for each riffle can be found in the Appendix. Riffles that were chosen to cover a blockage were checked to verify that the design flow or greater could pass at critical depth. This initial design check was used to help design riffles that would not increase flood elevations at design flows. Riffle elevations for the riffles downstream of the culverts were chosen to match the downstream invert of the culverts. The elevation of the riffle downstream of the pedestrian bridge was chosen to back up water through the structure. To help arrest downcutting, the riffles were designed to back up water on the downstream slope of the next upstream riffle.

A future check was made of the proposed riffle complex using the existing conditions HEC-RAS model. The stream headcutting was not reflected in the model so the survey data collected by HNTB was used to define a new channel bottom elevation in the proposed conditions model. The model indicated that the channel was found to be carrying the 100-year frequency flows in the channel. Carrying flows in excess of the 2-year frequency events generally cause increased channel bank erosion as the channel is no longer connected to its floodplain and the channel scour is increased. To further stabilize the channel, it was evaluated as to whether or not the overbank could be excavated to provide out of bank flows at the 2-year frequency event. Because of the existing utilities in the area, only minimal excavation could occur in the overbank.

The riffles were then placed in the proposed conditions model. The existing and proposed HEC-RAS analysis is included in the Appendix along with a table comparing the existing and proposed elevations for the 10- and 100-year frequency events. The proposed riffles did not increase 10- and 100- year frequency elevations at the upstream limits of the project reach. Localized increases in elevations were generally within 0.5 feet, with a few exceptions, and did not appear to impact structures.

The rock for the riffles was sized using Lane equations to calculate rock size based on tractive force. The existing channels were incised, carrying close to the 100-year flood flow before spilling out into the floodplain. The rock sizes calculated for the riffles were very large. Crest stone rock sizes were calculated to be approximately 5 feet in diameter. Crest stone rock used in riffles will need to be buried in to the channel bottom and channel banks. The rock used to fill in around the crest stones should be of varying gradation. The rock sizing calculations can be found in the Appendix.

Using the sediment transport functions of HEC-RAS and the sediment analysis data, the sediment transport capacity of the channel and riffles were analyzed so as to determine the riffles' ability to pass sediment flows. The model was prepared using the sediment gradation diameters provided by the District. However, as noted previously site field observations indicate that much larger diameter material is likely being moved by the channel flows. The sediment transport equations chosen were Toffaleti and Yang because of the particle and channel sizes used in those investigators' field and flume experiments. In many cases they provided similar answers for low flow events and suggested that the system with riffles would be able to pass significant sediment loads in the range of 2,000 tons/day of sediment concentrations for the two tributaries combined for the 2-year flow event. The North and South Tributaries can pass a widely varying sediment concentration of approximately 200 to over 1,000 tons per day of sediment for the 2-year event.

Because of the active state of headcutting at the site, the limited survey information and recent channel re-construction at the downstream end of the project site, additional survey information will be required before construction plans and specifications are prepared for this site. At that time, current sediment data can also be obtained. When the additional information is collected, the design assumptions should be checked and the design modified, if necessary.

WATER QUALITY BENEFITS

Construction of riffles helps reduce the sediment load to the stream by stopping channel downcutting. Actual calculation of the in channel sediment load due to downcutting was measured to be 1.5 CY per running feet per year for the North Tributary and 0.2 CY per running feet per year for the -South Tributary . Assuming the same erosion rates occur throughout the project site, the construction of the riffles will reduce sediment load to the stream by 1.5 CY to 0.2 CY per running feet per year. One of the differences, noted in the "Use Attainability Analysis of Turkey Creek, Johnson and Wyandotte Counties, Kansas" (4) between Turkey Creek and the higher quality reference streams, was the relative high percentage of clay fines on the Turkey Creek substrates due to point and nonpoint sources. Stopping channel downcutting can help reduce one source of clay fines to the stream system.

Other sources noted water quality benefits due to the construction of rock riffles. Rock riffles help aerate water and increase Dissolved Oxygen (DO) levels per USEPA publication entitled, "Ecological Restoration," (5) and can provide habitat for benthic organisms that reduce ammonia (NH_3) to nitrate (NO_3) per conversation with Don Roseboom, co-author of "Field Manual of Urban Stream Restoration." Riffles can increase DO levels in a stream and reduce NH_3 levels.

HABITAT BENEFITS

Continual stream incision will expose and erode more clay fines creating unstable clay and silt channel bottoms generally associated with poorer habitat condition and less species richness and diversity. This area, particularly in the riffle pool, provides habitat for the small size fisheries found in the stream system in the riffle pool area. Discussion with Kansas Department of Parks and Wildlife biologist, Kristen Hase, referenced the need for more pool habitats for Upper Turkey Creek fisheries. The rock riffles provide a valuable substrate for benthic organisms important to a healthy ecosystem.

MAINTENANCE REQUIREMENTS AND EXPECTED DESIGN LIFE

Generally constructed riffles require no maintenance if properly constructed by burying the end rocks back into the channel banks to stop water from cutting around the riffles.

There is no life expectancy limit noted in the literature. Performance over time can be enhanced as riffle rock attract biological life on the rocks that result in improvement in the food chain and aid in denitrifying ammonia in the water.

VALUE ENGINEERING ALTERNATIVES

The site is actively downcutting. The model and the survey data is not adequate to try a number of different scenarios at this time.

REFERENCES

1. Ven Te Chow, Ph.D., "Open-Channel Hydraulics," McGraw-Hill, Inc., 1959.
2. Dr. Robert W. Newbury and Marc N. Gaboury, "Stream Analysis and Fish Habitat Design," A Field Manual, Newbury Hydraulics Ltd., Gibsons, British Columbia, Canada, 1993.
3. Dr. Robert W. Newbury, et al, "Field Manual of Urban Stream Restoration," Illinois State Water Survey, Champaign, IL, 1998.
4. Gary E. Welker and Dr. Donald G. Huggins, "Use Attainability Analysis of Turkey Creek, Johnson and Wyandotte Counties, Kansas", U.S. Environmental Protection Agency, Environmental Services Division, Kansas City, Kansas, Kansas Biological Division, University of Kansas, Lawrence, Kansas, July 1997.
5. United States Environmental Protection Agency, "Ecological Restoration – EPA 841-F-95-007", U.S. Environmental Protection Agency, November 1995.

United States Army Corps of Engineers
Upper Turkey Creek
Task 1 Brown Park

HNTB

Engineer's Estimate of Probable Costs

8/12/2004

No.	Item	Quantity	Unit of Measure		Unit Cost		Cost
1	Clearing	0.04	Acre	$	1,200.00	$	48.00
2	Construction limit fence	744	L. F.	$	1.00	$	744.00
3	Construction access road	2	Each	$	500.00	$	1,000.00
4	Rock (2ft)	819	Ton	$	20.00	$	16,380.00
5	Rock (3ft)	841	Ton	$	30.00	$	25,230.00
6	Native grasses	0.11	Acre	$	4,000.00	$	440.00
7	Erosion control fabric	250	S. Y.	$	2.00	$	500.00
8	Mobilization	1	Lump Sum	$	2,000.00	$	2,000.00
					Subtotal:	$	46,342.00
					20% Contingency	$	9,268.40
					Total:	$	55,610.40
					Use:	**$**	**60,000.00**

Notes:

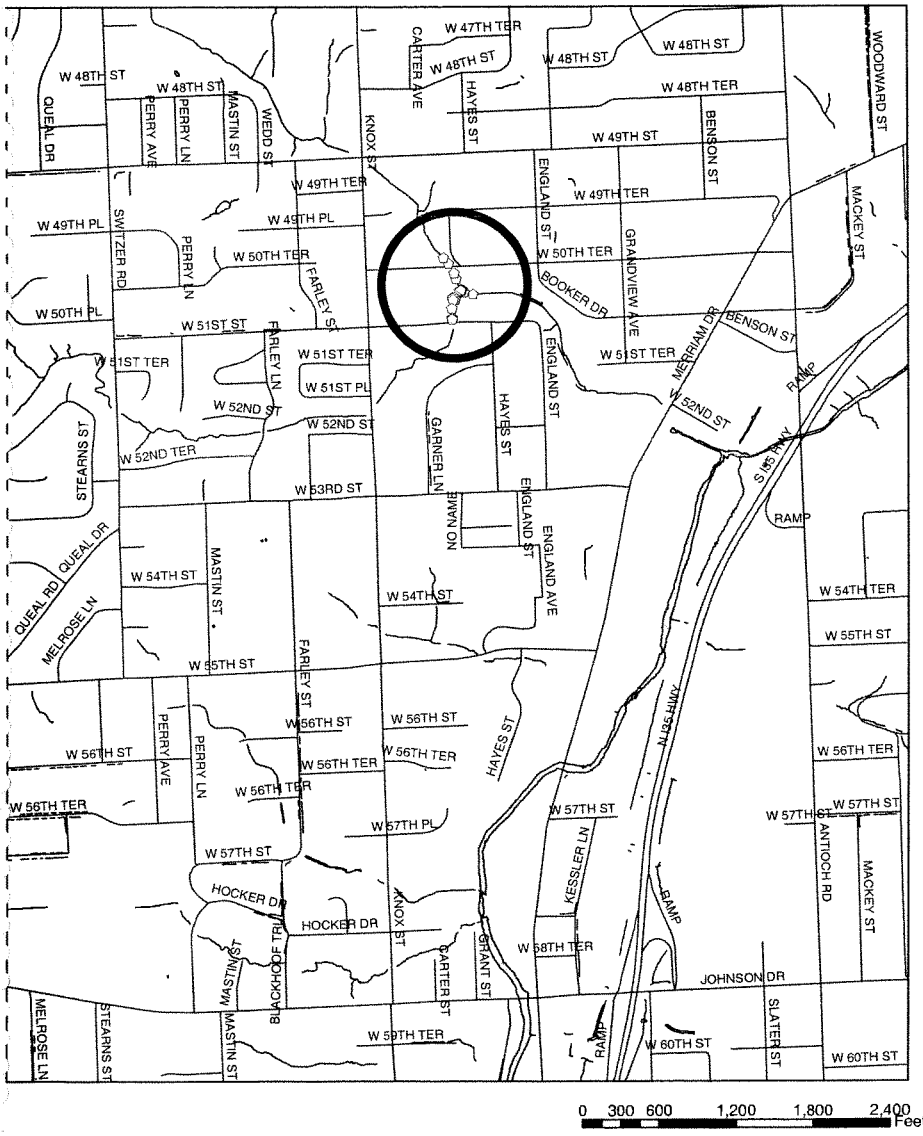
1. The costs shown above represent an estimate of probable cost prepared in good faith and with reasonable care. HNTB has no control over the costs of construction labor, materials or equipment, or over any competitive bidding or negotiating methods.

2. KEI suggested to include permanent signage to display the environmental improvements constructed at each site.

F:\32080\D18_UpperTurkeyCreek\Report\Appendix\[Cost_Estimate.xls]1-3-1 Brown Park

Task 1-3-1 Brown Park

Location Map



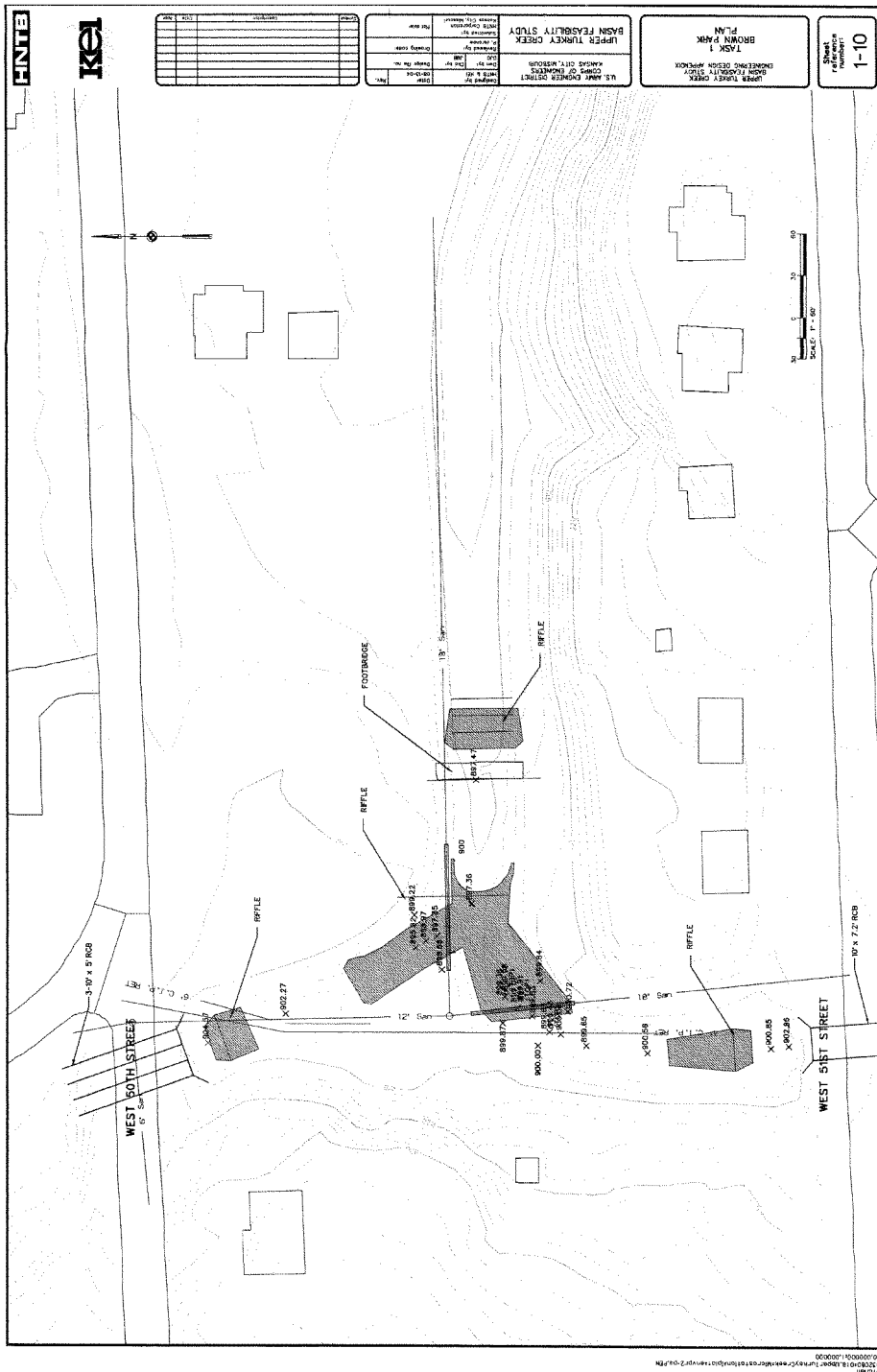
Task 1: Brown Park

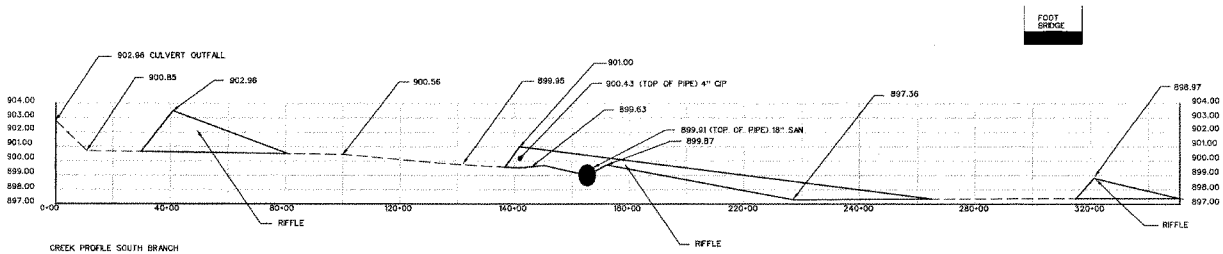
Upper Turkey Creek

Encased sanitary sewer

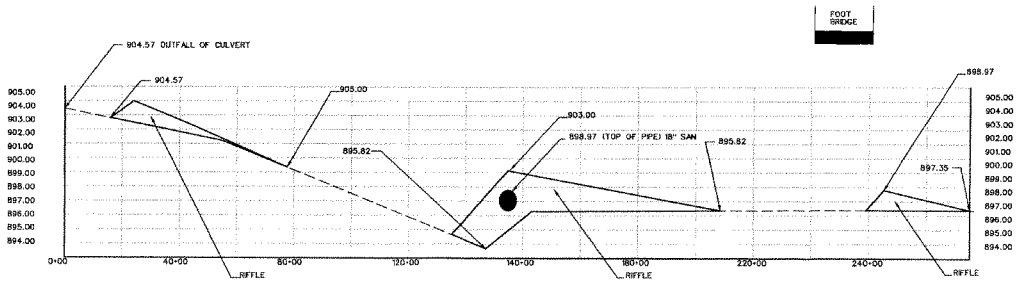
View of main tributary upstream west of pedestrian bridge

Encased sanitary sewer and abandoned water line, in southern tributary


UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI
TASK 1
BROWN PARK
PLAN
Sheet reference number:
1-10
FOOTBRIDGE
RIFFLE
RIFFLE
RIFFLE
RIFFLE
WEST 50TH STREET
WEST 51ST STREET
3-10' x 5' RCB
10' x 7.2' RCB
12' San
18' San
SCALE: 1" = 60'



CREEK PROFILE SOUTH BRANCH



CREEK PROFILE NORTH BRANCH

HNTB

KEI

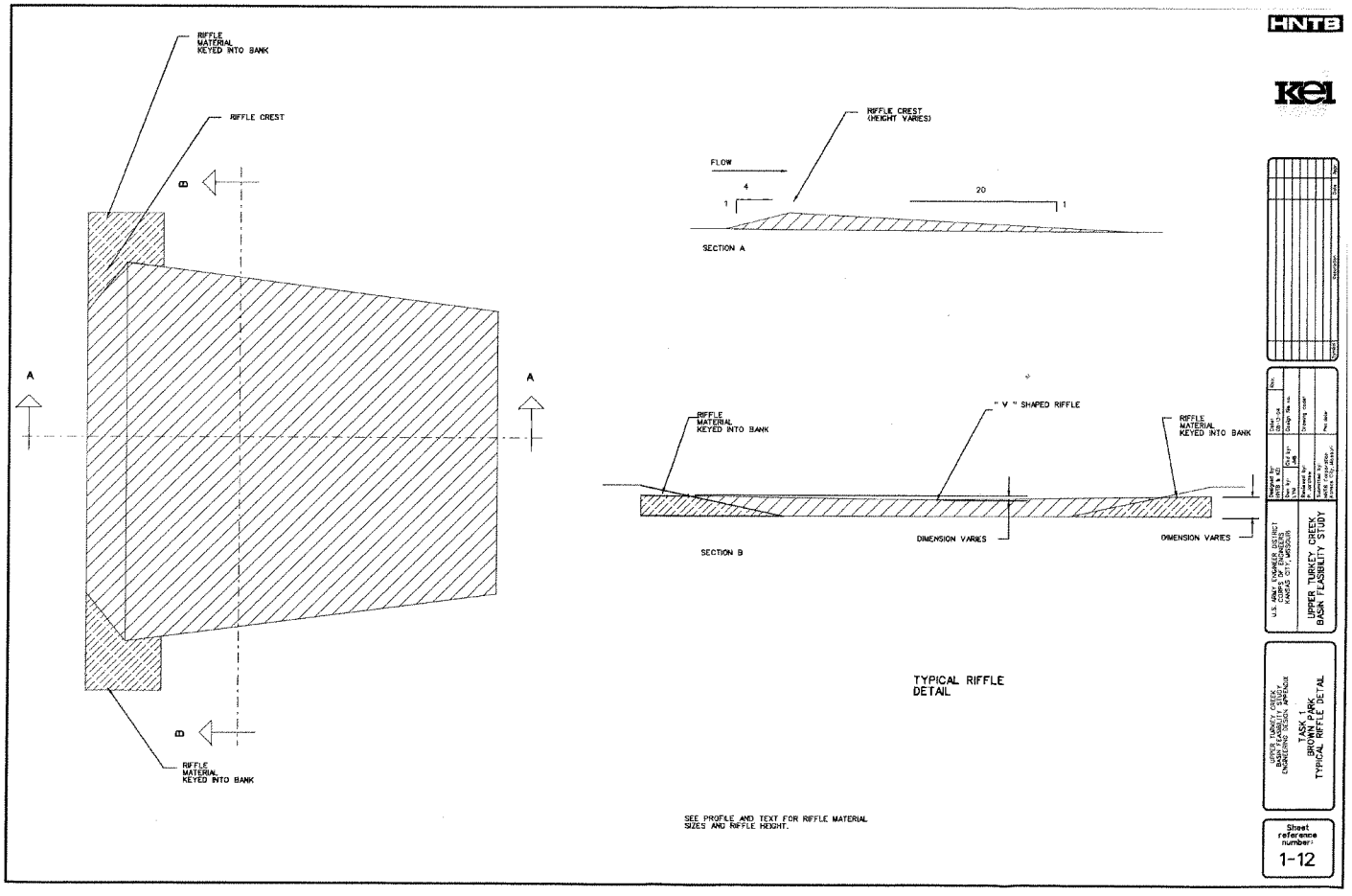
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX

TASK
BROWN PARK
PROFILES

Sheet reference number:
1-11


RIFFLE MATERIAL KEYED INTO BANK
RIFFLE CREST
B
A
A
B
RIFFLE MATERIAL KEYED INTO BANK
RIFFLE CREST (HEIGHT VARIES)
FLOW
4
1
20
1
SECTION A
RIFFLE MATERIAL KEYED INTO BANK
" V " SHAPED RIFFLE
RIFFLE MATERIAL KEYED INTO BANK
DIMENSION VARIES
DIMENSION VARIES
SECTION B
TYPICAL RIFFLE DETAIL
SEE PROFILE AND TEXT FOR RIFFLE MATERIAL SIZES AND RIFFLE HEIGHT.
HNTB
kel
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS KANSAS CITY, MISSOURI
UPPER TURKEY CREEK BASIN FEASIBILITY STUDY
UPPER TURKEY CREEK BASIN FEASIBILITY STUDY ENGINEERING DESIGN APPENDIX
TASK 1 BROWN PARK TYPICAL RIFFLE DETAIL
Sheet reference number:
1-12

TASK 1: STOP STREAM DOWNCUTTING

75TH STREET

TASK OBJECTIVE

The task objective is to design a system to prevent downcutting of the channel.

SITE SELECTION CRITERIA

The most fundamental criteria in selecting a site for this task was to determine a suitable location which is representative to other similar locations within the Upper Turkey Creek watershed. The demonstration site is ideally the average representation, based on condition, accessibility, utility and development conflicts.

The site was noted as a downcutting site on Turkey Creek in the Upper Turkey Creek Feasibility Study Environmental Field Assessment provided by the Kansas City District and was photographed and inventoried. The site included entirely exposed utility crossings in the channel that were assumed buried below the stream bottom when initially constructed. Downcutting was also apparent at the bridge abutment foundations for the 75th Street Bridge. This was also the approximate location of upstream monitoring site used in the Use Attainability Study and of a biological sampling site conducted in July of 2003 by the Kansas Department of Parks and Wildlife.

The erosion in the proximity of utility encasements and the exposure of utility encasements are good indicators of stream down cutting. This particular site included one (1) exposed sanitary sewer encasement, one (1) exposed abandoned waterline and other abandoned lines within the banks of the creek. Degrading streams typically exhibit erosive under-cutting of adjacent culvert outlet structures. A 60-inch RCP storm sewer outlet exists on the left bank upstream of the sanitary sewer encasement and downstream of the 75th Street Bridge. The flowline of the storm sewer outlet flared end section is approximately 3 feet above the channel flowline.

SITE CONDITIONS/SITE ANALYSIS

The site is located within a commercial area in the City of Merriam, Kansas in Johnson County. The boundaries of the site include West 75th Street on the south, King Cove to the west, the railroad tracks to the east and extends approximately 100 feet north of the West Frontage Road on the north. The channel dimensions average a channel bottom width of approximately 24 feet with a variations of 1H:1V to 2H:1V side slopes. From the railroad bridge to roughly 270 feet downstream, improvements were constructed to the channel bottom. The improvement includes the entire channel floor covered with large rocks secured under geogrid. The same geogrid and rock are also located on the side slopes for stabilization. At this location, the channel degradation downstream has been halted, resulting in a 3-foot drop in the channel bottom. Proceeding downstream the composition of the channel bottom transitions from rock to soil.

There are several utilities that either cross the channel and/ or outlet into the channel. An existing encased 8-inch sanitary sewer, north of 75th Street, is exposed and evidencing downcutting. Under the 75th Street Bridge, 24-inch and 10-inch abandoned ductile iron pipes are exposed within the creek bottom.

Based on historic data from the KDOT sanitary sewer As Built plans, the site has appeared to downcut approximately 3.5 feet over the last 19 years. An abandoned broken sanitary sewer line was exposed under 75th Street (see photo). Another sewer line crossing the stream was exposed downstream of road (photo). The Turkey Creek drainage area is 4.6 sq. miles at this location. The stream banks are approximately 15 to 20 feet high. The 1-year flow is 2264 cfs and flows 6 to 10 feet deep and 40 to 60 feet wide. The 100-year flow is 15 to over 19 feet deep and is out of bank. The site soils and geotechnical information are being collected and analyzed by the Kansas City District.

The fish diversity at the site was noted in the Use and Attainability Study (4) as 0.678 for the Gleason diversity index and 0.348 for Brillouin diversity index. The total fish richness and mean values for fish diversity and abundance at the site were a richness of 3 and an abundance of 8.0 #/m^3. This compares to diversity indexes of 0.932 to 1.978 for the reference stream at their upstream sites and richness values of 8-13. Water chemistry analysis at this site indicated mercury at levels of 0.104 ug/l and 0.123 ug/l, which is higher than the established USEPA and Kansas chronic criteria of 0.012 ug/l for aquatic life. Chrysene, fluoranthene, PCB's, phenanthrene and pyrene were found at the highest values in Turkey Creek at sediments at this site, above threshold values (REF). When fish tissue was analyzed, PCB1254, PCB1260 and mercury were found in the fish taken from the monitoring location at this site.

RESTORATION DESCRIPTION

To stop stream downcutting using a technique that provides fish and wildlife and water quality benefits, installation of a series of rock riffles is proposed. The riffles are designed to allow for vertical contraction and expansion upstream and downstream based on ratios reported by V. T. Chow in Open Channel Hydraulic (1). The riffles are designed to also allow for fish passage by further flattening the downstream slope per the recommended design by Dr. Robert W. Newbury in Stream Analysis and Fish Habitat Design (3). The riffle rock is sized based on Lane's equation as referenced in the Field Manual of Urban Stream Restoration (2).

This site has particular challenges because of the exposed utilities. The riffle complex is designed to cover the exposed sewer crossings. Riffles were located approximately six bank full widths apart. For the purpose of this analysis, the channel top width for the 1-year flow was considered the bank full width. This site was also tied into a fish passage restoration site upstream and an upstream series of rock riffles.

The elevation of the riffle was chosen to cover existing exposed sewers in the channel bottom and attempt to create no more than a 3' riffle height. The riffle elevation was then checked using critical depth equations to assure the design flow or greater could be passed at critical depth.

The existing condition HEC-RAS model was supplied by the Kansas City District USACOE. The proposed conditions riffle including some of the channel incision elevations were inputted into the model for a range of flows. The HEC-RAS model is included in the Appendix.

HEC-RAS sediment transport functions were used to analyze sediment flow using the proposed conditions model in the reach at 2-year flood elevation and the 25-year flood. Taffaleti and Yang equations were used as the field and flume analysis parameters

match more closely to our conditions. The sediment particle sizes supplied by Geotechnology, Inc. ranged in size from 2.2 mm (D_{16}) to 25 mm (D_{84}). Field observation, however, suggested that much larger rock was present and being transported by the stream. For the supplied data, the models indicated the stream with riffles would be able to pass adequate amounts of sediment. Because of the high velocities in this general area of the steam, the stable channel function of the model was analyzed. The stable channel function indicated to lower the velocities to approximately 3 fps, the channel at its current depth may need to be tripled in size. A more desirable long-term approach at this site would have been to also reconnect the channel and floodplain, creating a 1 to 2-year flow channel and a benched floodplain to carry the 100-year floodplain. Site constraints did not allow this approach at this time. Construction of the riffles will stop the channel evolution process (2) before the channel downcutting can carve out a new wider floodplain and reconstruct a new low flow channel within that new wider floodplain. This process, at the advanced stage of recreating a new channel within the new lower floodplain, was observed near one of the reference sites.

WATER QUALITY BENEFITS

Construction of riffles helps reduce the sediment load to the stream. Actual calculation of the in-channel sediment load due to downcutting was measured to be 0.30 cubic yards per running foot per year. Assuming the same erosion rates exist throughout the project site, an estimated 120 CY streambed material and sediment will erode on an annual basis in a 400-foot stretch of stream. One of the differences noted in the Use Attainability Study between Turkey Creek and the higher quality reference streams was the relative high percentage of clay fines on the substrate of Turkey Creek due to point and nonpoint sources. At this site it appeared the stream downcutting had continued to downcut beyond the rock and gravel substrate to expose a clay bottom at the downstream end of the reach.

Other sources noted water quality benefits due to the construction of rock riffles. Rock riffles help aerate water and increase Dissolved Oxygen (DO) levels per USEPA publication entitled, "Ecological Restoration," (5) and provide habitat for benthic organisms that reduce ammonia to nitrate per conversation with Don Roseboom, co-author of "Field Manual of Stream Restoration." Therefore, riffles can increase DO levels in a stream and reduce NH_3levels.

HABITAT BENEFITS

This portion of the creek is known to have a fisheries population based on the surveys reported in the Use Attainability Study (4) and a recently completed state fish survey. Those fisheries include: Cyprinnel lutrensis (Red Shiner), Lepomis cyanellus (Green Sunfish), Pimephales promelas (Fathead Minnow) and Semotilus atromaculatus (Creek Chub). The July 2003 Kansas Department of Parks and Wildlife survey found the species noted in the Use Attainability Study (4) in addition to Micropterus Salmoides (Largemouth Bass) and Noturus exilis (Slender Madtom). Obstructions created by exposed sewer lines can limit the habitat range of the relatively small-sized fish, such as the Fathead Minnow (Pimephales promelas), that are currently commonly found in Turkey Creek. Creating long reaches of available habitat will improve the survival opportunities of the existing aquatic species in Turkey Creek, so as to help them survive periods of low flow in summer and other potential periods of stress due to natural or man-made water quality changes. This project will increase the connected habitat area

available to the existing fisheries by approximately 500 %, based upon assessment of obstructions inventoried in the Upper Turkey Creek Feasibility Study Environmental Field Assessment provided by the Kansas City District.

MAINTENANCE REQUIREMENTS AND EXPECTED DESIGN LIFE

Generally constructed riffles require no maintenance if properly constructed by burying the end rocks back into the channel banks to stop water from cutting around the riffles.

There is no life expectancy limit noted in the literature. Performance over time can be enhanced as riffle rockattract biological life on the rocks that result in improvement in the food chain and aid in denitrifying ammonia in the water.

This analysis is based on limited survey data and is attempting to model a dynamic incising channel. Before construction plans and specifications are prepared, the site should be surveyed and the analysis checked.

VALUE ENGINEERING ALTERNATIVES

The site is actively downcutting. The model and the survey data is not adequate to try a number of different scenarios at this time. A fish passable structural alternative to the riffles could be considered to determine if it would meet the project goals and still be effective.

REFERENCES

1. Ven Te Chow, Ph.D., "Open-Channel Hydraulics," McGraw-Hill, Inc., 1959.
2. Dr. Robert W. Newbury, et al, "Field Manual of Urban Stream Restoration," Illinois State Water Survey, Champaign, IL, 1998.
3. Dr. Robert W. Newbury and Marc N. Gaboury, "Stream Analysis and Fish Habitat Design," A Field Manual, Newbury Hydraulics Ltd., Gibsons, British Columbia, Canada, 1993.
4. Gary E. Welker and Dr. Donald G. Huggins, "Use Attainability Analysis of Turkey Creek, Johnson and Wyandotte Counties, Kansas", U.S. Environmental Protection Agency, Environmental Services Division, Kansas City, Kansas, Kansas Biological Division, University of Kansas, Lawrence, Kansas, July 1997.
5. United States Environmental Protection Agency, "Ecological Restoration – EPA 841-F-95-007", U.S. Environmental Protection Agency, November 1995.

United States Army Corps of Engineers
Upper Turkey Creek
Task 1-4-1 & 2-4-59 75th Street

HNTB

Engineer's Estimate of Probable Costs

8/12/2004

No.	Item	Quantity	Unit of Measure		Unit Cost		Cost
1	Tree and site protection	30	Each	$	20.00	$	600.00
2	Clearing	0.05	Acre	$	1,200.00	$	60.00
3	Construction limit fence	150	L. F.	$	1.00	$	150.00
4	Erosion control barrier	20	L. F.	$	3.00	$	60.00
5	Construction access road	1	Each	$	1,000.00	$	1,000.00
6	Rock (5ft)	2,227	Tons	$	30.00	$	66,810.00
7	Seeding	0.32	Acre	$	4,000.00	$	1,280.00
8	Erosion control fabric	2460	S. Y.	$	2.00	$	4,920.00
9	Woody trees and shrubs	50	Each	$	200.00	$	10,000.00
10	Asphalt repair	40	S. Y.	$	18.00	$	720.00
11	Mobilization	1	Lump Sum	$	3,000.00	$	3,000.00
					Subtotal:	$	88,600.00
					20% Contingency	$	17,720.00
					Total:	$	106,320.00
					Use:	**$**	**110,000.00**

Notes:

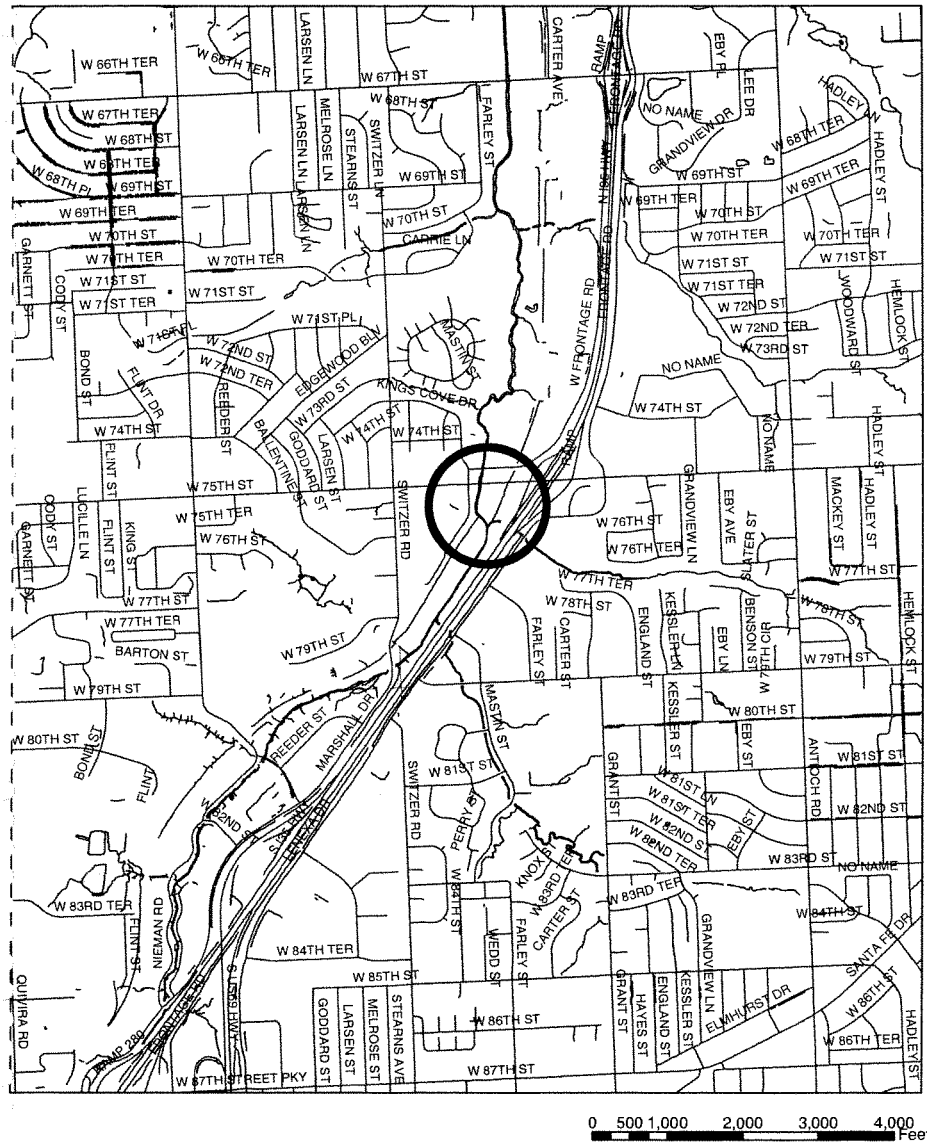
1. The costs shown above represent an estimate of probable cost prepared in good faith and with reasonable care. HNTB has no control over the costs of construction labor, materials or equipment, or over any competitive bidding or negotiating methods.

2. KEI suggested to include permanent signage to display the environmental improvements constructed at each site.

F:\32080\D18_UpperTurkeyCreek\Report\Appendix\[Cost_Estimate.xls]1-1-4 75th Street

Task 1-1-4 & 2-4-59

Location Map

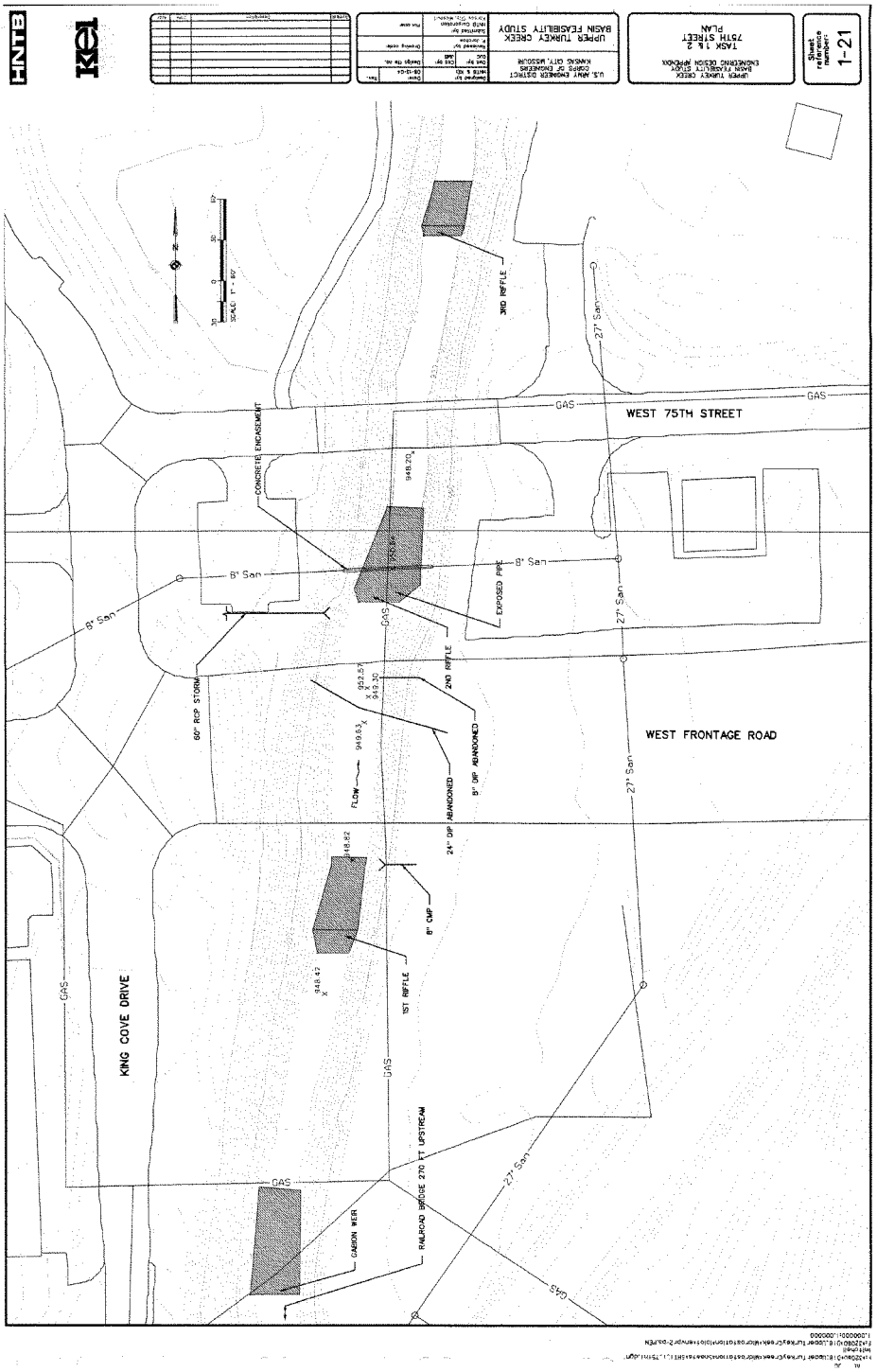


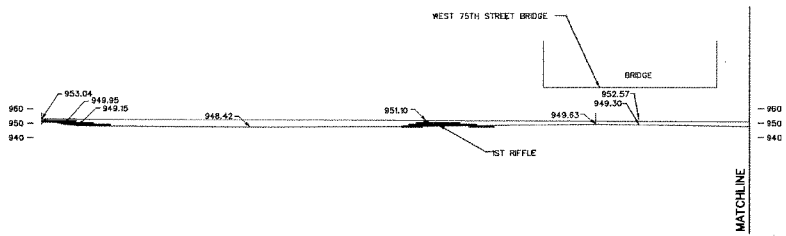
Task 1: 75th Street

Upper Turkey Creek

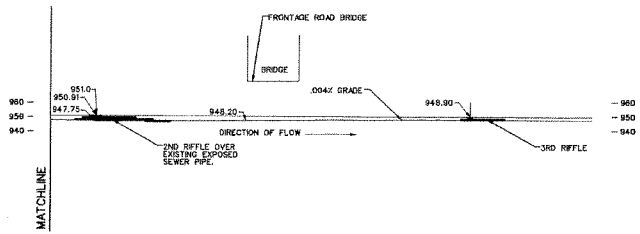
Exposed sanitary encasement, facing downstream (north)

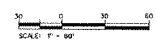
Exposed abandoned waterline, facing upstream (south), under 75th Street Bridge


HNTB
KEL
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI
TASK 1 & 2
75TH STREET
PLAN
Sheet reference number:
1-21
SCALE: 1" = 60'
3RD RIFFLE
27" San
GAS
WEST 75TH STREET
CONCRETE ENCASEMENT
948.20
8" San
EXPOSED PIPE
2ND RIFFLE
60" RCP STORM
952.57
949.30
949.63
FLOW
8" DIP ABANDONED
24" DIP ABANDONED
WEST FRONTAGE ROAD
948.82
8" CMP
1ST RIFFLE
948.42
KING COVE DRIVE
RAILROAD BRIDGE 270 FT UPSTREAM
GABION WEIR



CREEK PROFILE





HNTB

KEL

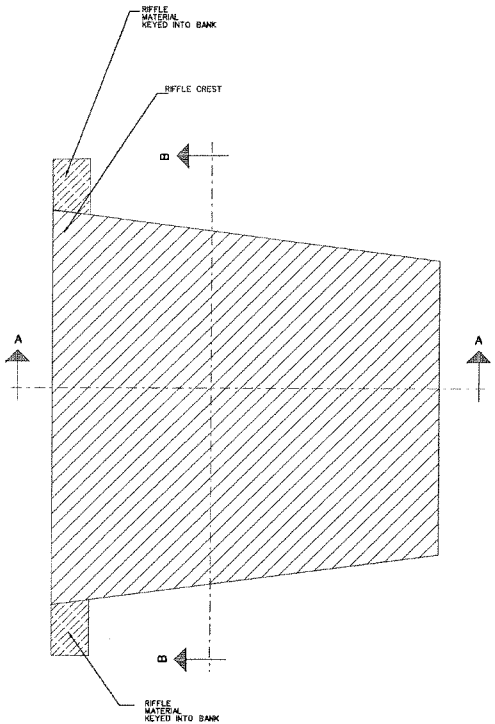
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

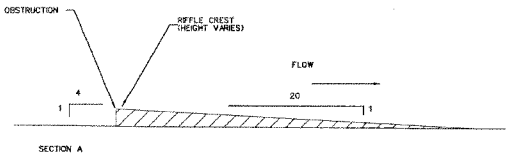
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY

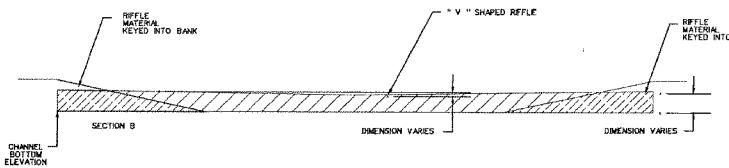
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX

TASK 1&2
75TH ST. PROFILE
UPSTREAM & DOWNSTREAM

Sheet reference number:
1-22







TYPICAL ROCK RIFFLE DETAIL

NOTES:

1. LOCATION OF OBSTRUCTION WHEN RIFFLE IS CONSTRUCTED DOWNSTREAM OF OBSTRUCTION SEE TYPICAL RIFFLE DETAIL.
2. SEE PROFILE AND TEXT FOR RIFFLE MATERIAL SIZES AND RAMP HEIGHT.
3. RIFFLE ROCK KEYED INTO CHANNEL BOTTOM PER ROCK SIZE AND RIFFLE HEIGHT.

HNTB

KEL

Revision	Date	Rev

Assigned by: Jack A. KEL
Date: 08-13-04
Drawing code: Drawing No.
Date: 08-13-04
Drawing code: Drawing No.
Drawn by: Jack A. KEL
Date: 08-13-04
Drawing code: Drawing No.
Supervised by: Michael D. Wenger
Date: 08-13-04
Drawing code: Drawing No.
Rev. date:

U.S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS, KANSAS CITY, MISSOURI

UPPER TURKEY CREEK BASIN FEASIBILITY STUDY

UPPER TURKEY CREEK BASIN FEASIBILITY STUDY
INDEPENDENCE, JACKSON COUNTY, MISSOURI

TASK 1
75TH STREET
TYPICAL ROCK RAMP DETAIL

Sheet reference number:
1-23

TASK 2: REMOVE OBSTRUCTIONS TO FISH AND WILDLIFE PASSAGE

75TH STREET

75TH STREET

TASK OBJECTIVE

The task objective is to design an action to remove obstructions to fish and wildlife passage for habitat restoration.

SITE SELECTION CRITERIA

The criteria in selecting a site for this task was to determine a suitable location that is representative of other similar locations within the Upper Turkey Creek watershed. The demonstration site is ideally the average representation, based on site conditions, accessibility, and utility and development conflicts.

This site is representative of portions of the main stem and tributaries of Turkey Creek that are experiencing obstructions to fish passage. This site was noted as an obstruction to fish passage in the Upper Turkey Creek Feasibility Study Environmental Field Assessment provided by the Kansas City District. It is one of 79 sites noted in the assessment as an obstruction to fish passage. The criterion used in the assessment to determine an obstruction to fish passage was a blockage height 3 feet or greater. This site is immediately upstream of the 75th Street stream downcutting site. Combining the two sites was considered an opportunity to extend the restoration measures for additional environmental benefits.

A man-made gabion geogrid netting weir structure exists on the main stem of Turkey Creek 300 feet upstream of the 75th Street Bridge. Because of the channel downcutting downstream at the Task 1 site and the depth of the channel immediately downstream of the obstruction, it is believed that the gabion is an obstruction too high to allow for reasonable passage of the existing and likely future fish species –using Turkey Creek. This obstruction prevents the channel degradation from continuing to migrate upstream toward the existing railroad bridge.

SITE CONDITIONS/SITE ANALYSIS

The site is located within a commercial area in the City of Merriam, Kansas in Johnson County. The boundaries of the site combined with Task 1 site include the railroad bridge as the upstream limit on the south, King Cove Drive and the Turkey Creek Streamway Park trail on the west, the railroad tracks on the east and extends approximately 100 feet north of the West Frontage Road as the downstream limit on the north. The channel dimensions average a channel bottom width of approximately 24 feet with 1H:1V to 2H:1V side slopes. The stream banks are approximately 15 to 20 feet high and contain the 25- year frequency flood.

From upstream of the railroad bridge to roughly 270 feet downstream, the channel bottom was modified in the last decade. The modifications include covering the entire channel floor with cobble secured under a plastic geogrid, presumably to protect the railroad bridge from being undercut. The same geogrid and cobble is also located on the side slopes for stabilization. At the downstream end of the project a three foot high

cobble-filled plastic geogrid weir was constructed to transition to the downstream channel. The weir is beginning to fail.

The Turkey Creek drainage area is 4.6 sq. miles at this location. The 2-year flow is 3743 cfs and flows approximately 11 feet deep and 50 to 70 feet wide. The 100-year flow is 15 to over 19 feet deep and is out of bank.

Proceeding downstream from the netting to 75th Street Bridge the composition of the channel bottom transitions from gravel to fine-grained sediment. The Kansas City District obtained sediment distribution information for the bottom sediments from Geotechnology, Inc. The results of that sampling are included in the Appendix as specimen 1-71. The results indicate that the d_{84} for the site was 25 mm, which means that 84% of the stream bottom sediments collected at the site were smaller than 25 mm. The d_{75} was 17 mm and the d_{50} was 8.9 mm. The d_{16} was reported as 2.2 mm. The bottom sediments were characterized by the lab as predominantly gravel with some sand and approximately 5 % silt. Site observations suggest that the stream may transport even larger material during periods of high flows. At the downstream end of the reach the stream had been observed to have downcut below the rock and gravel substrate, exposing a clay bottom.

The fish diversity at the site was noted in the Use and Attainability Study (4) as 0.678 for the Gleason diversity index and 0.348 for Brillouin diversity index. The total fish richness and mean values for fish diversity and abundance at the site were a richness of 3. This compares to diversity indexes of 0.932 to 1.978 for the reference stream at their upstream sites and richness values of 8-13. Water chemistry analysis at this site indicated mercury at levels of 0.104 ug/l and 0.123 ug/l, which is higher than the established USEPA and Kansas chronic criteria of 0.012 ug/l for aquatic life. Chrysene, fluoranthene, PCB's, phenanthrene and pyrene were found at the highest values in Turkey Creek at sediments at this site, above threshold values (4). When fish tissue was analyzed, PCB1254, PCB1260 and mercury were found in the fish taken from the monitoring location at this site.

There are several utilities that either cross the channel and/ or outlet into the channel. An existing encased 8-inch sanitary sewer, north of 75th Street downstream of the reach, is exposed, evidencing downcutting. Under the 75th Street Bridge, a 24-inch and 10-inch abandoned ductile iron pipe are exposed within the creek bottom.

RESTORATION DESCRIPTION AND DESIGN

Because of the height of the weir and the concern not to disturb the stabilized stream protecting the upstream railway bridge, downstream improvements leading up to the weir are proposed.

The design consists of a series of riffles to allow fish passage over the weir. Riffles are used extensively in stream restoration projects to deal with fish passage over or around dams that will not be removed. The spacing between the riffles may be much closer than six-bank full widths as would be generally used in a natural stream setting. At this location, the installation of downstream riffles to help arrest stream downcutting, allows the riffles to be placed at a spacing more closely matching natural riffle placement. The

height of the upstream riffle is chosen so as to cover the gabion basket weir. The ramp is designed with a 20H:1V downstream slope (see drawing) to facilitate fish passage. Large boulders are placed on the downstream slope to provide resting spots for the small fisheries such as those that dominate Turkey Creek.

A two feet. high riffle 230 feet downstream of the gabion weir provides the step up to the higher weir elevation. This riffle is designed to be a continuation of and work with the downstream riffle complex designed as part of Task 1. Should the Task 1 riffles not be constructed, this design would need to be revisited and potentially modified. This riffle, too, is designed with a 20H:1V downstream face with occasional boulders for fisheries.

Area topography at one feet. intervals was made available for the site by Johnson County. Limited field surveying to determine current channel inverts in the reach was performed by HNTB. The HEC-RAS model prepared by Johnson County and augmented by 1- and 2- year return frequency flows by the Kansas City District was also used as well as the sediment data on the stream sediment analyzed by Geotechnology, Inc., and provided by the District.

Comparing the survey work performed by HNTB to the Johnson County topography and the HEC-RAS model, the stream had downcut in the area of the gabion structure approximately 6 feet and less further downstream by the exposed utilities. The failing weir may allow for the headcutting to once again move upstream, potentially endangering the upstream railway crossings in the future.

The elevation of the riffles were chosen to cover existing exposed sewers in the channel bottom and attempt to create no more than a 3' riffle height. The riffle elevation was then checked using critical depth equations to assure the design flow or greater could be passed at critical depth. This analysis is included in the Appendix.

The Kansas City District USACOE supplied the existing condition HEC-RAS model. The existing conditions model was updated to include the existing 3-foot high cobble gabion. The proposed conditions riffles and channel incision elevations were inputted into the model and analyzed for a range of flows. The HEC-RAS model indicated that for proposed conditions there would be either no impact or minimal in-bank impacts for the 10-year frequency event. However the existing conditions model was not stable for the 100-year frequency event and became even less stable for the proposed conditions 100-year frequency event._ While the impacts are not expected to be significant, the analysis for the 100-year frequency event will require more study and analysis to develop a stable model. A comparison of existing and proposed conditions is included in the Appendix.

HEC-RAS sediment transport functions were used to analyze sediment flow using the proposed conditions model in the reach at 2-year flood elevation and the 25-year bank full flood. Toffaleti and Yang equations were used as the field and flume analysis parameters used in developing the equations match more closely to our conditions. The sediment particle sizes analyzed by Geotechnology, Inc. ranged from 2.2 mm (d_{16}) to 25 mm (d_{84}). Field observation, however, suggested that much larger rock was present and being transported by the stream. Using the supplied data, the models indicate the stream with riffles would be able to pass a minimum of 1,000 tons per day of sediment for the 1-year frequency event and even more for the higher in-channel flows. Because of the high velocities in this general area of the steam, the stable channel function of the model was used to analyze the stream configuration. The stable channel function

indicated that to lower the channel velocities to approximately 3 fps, the channel at its current depth might need to be tripled in size.

The rock for the riffles was sized using Lane equations to calculate rock size based on tractive force. The existing channels are incised, carrying the 25-year flood flow before spilling out into the floodplain. The rock sizes calculated for the riffles were very large. Crest stone rock sizes were calculated to be 8.3 feet in diameter. Crest stone rock used in riffles will need to be buried in to the channel bottom and channel banks. The rock used to fill in around the crest stones should be of varying smaller gradation. The rock sizing calculations can be found in the Appendix.

A more desirable long-term approach at this site would be to reconnect the channel and floodplain, creating a 1 to2-year flow channel and a benched floodplain to carry the 100-year floodplain. Site constraints did not allow this approach at this time. Construction of the riffles will stop the channel evolution process (2) before the channel downcutting can carve out a new wider floodplain and reconstruct within that new wider floodplain a new low flow channel. This process, at the advanced stage of recreating a new channel within the new lower floodplain, was observed near one of the reference sites.

Because of the active state of stream downcutting, the failing upstream cobble weir and the limited survey data, additional detailed survey data will be required before construction plans and specifications are prepared. At that time, current stream sediment conditions should be checked and evaluated as to the need for updating the sediment information. When the additional information is collected, the design assumptions should be checked and the design modified, if necessary. also stream stability information should be collected on the downstream channel reach and evaluated at that time.

WATER QUALITY BENEFITS

Rock riffles will help stop stream incision and reduce fine-grained sediment input to Turkey Creek, a potential issue noted in the Use Attainability Study. The stream stretch downstream of the weir could be assumed to have similar downcutting characteristics, suggesting that stream downcutting is adding 1.5 CY per year of material including sediment to the stream for a 50-foot stretch.

Other sources noted water quality benefits due to the construction of rock riffles. Rock riffles help aerate water per USEPA publication entitled, "Ecological Restoration," (5) and provide habitat for benthic organisms that reduce ammonia to nitrate per conversation with Don Roseboom, co-author of "Field Manual of Stream Restoration." Therefore, it is assumed that riffles can increase DO levels in a stream and reduce NH_4 levels.

HABITAT BENEFITS

This portion of the creek is known to have a fisheries population based on the surveys reported in the Use Attainability Study (4). Obstructions created by exposed sewer lines will limit the habitat range of relatively small fish, such as the Fathead Minnow (Pimephales promelas), that are currently commonly found in Turkey Creek. Creating long reaches of available habitat will improve the survival opportunities of the existing aquatic species in Turkey Creek, so as to help them survive periods of low flow in

summer and other potential periods of stress due to natural or man-made stream inputs. This project will allow reconnection to an additional 1400 to 1500 feet of stream habitat upstream of the gabion weir.

The Use Attainability Study performed by the United States Environmental Protection Agency (USEPA) in 1997 (4), as well as the Kansas Department of Wildlife and Parks (KDWP) July 2003 sampling events provide a base for assessing current conditions. Along with detailing the present conditions of Upper Turkey Creek, the Use Attainability Study provides two additional streams in Johnson County, Kansas, Mill Creek and Cedar Creek, for comparison (4). A KDWP Urban Resource and Management Project (URAMP) study performed a biological assessment of Tomahawk and Wolf Creeks also located in Johnson County, Kansas (3) that can also be used for reference. These four streams represent less impacted, higher quality streams, and may provide a representation of what habitat types and biota a restored Turkey Creek may support (3,4).

The 1997 study found only four fish species present in Turkey Creek (4). These species included, Cyprinell lutrensis (Red Shiner), Lepomis cyanellus (Green Sunfish), Pimephales promelas (Fathead Minnow), and Semotilus atrmaculatus (Creek Chub). (4) The sampling event performed in July of 2003 found the four species named above as well as one Micropterus Salmoides (Largemouth Bass) and one Noturus exilis (Slender Madtom). Generally, the above species represent tolerant to highly tolerant fishes, meaning that they have the ability to withstand less than ideal conditions such as lower oxygen levels, higher temperatures, lower order food requirements, and other conditions indicative of a lower quality system. In addition to being tolerant species, the above species primarily have tendencies towards pool dwelling. Migration throughout the stream reach is not required for survival (1).

The two studies involving the four reference streams provide some guidance as to what types of fishes could be expected with improvements in habitat connection and water quality. A total of 11 species were present in at least three of the reference watersheds. The following table highlights the species comparison.

Species Common Name	**Reference Watershed Species Currently Present In**	**Currently Present in Turkey Creek**
Black Bullhead	M,W,T	
Yellow Bullhead	M,C,W,T	
Channel Catfish	M,C,W,T	
Slender Madtom	C,W,T	YES
Bluegill	M,C,W,T	
Green Sunfish	M,C,W,T	YES
Longear Sunfish	C,W,T	
Bluntnose Minnow	M,W,T	
Largemouth Bass	M,C,W,T	YES
Central Stoneroller	M,C,W,T	
Fathead Minnow	M,C,W,T	YES
Orangespotted Sunfish	W,T	

Black Crappie	W,T	
White Crappie	W,T	
Golden Shiner	W,T	
Red Shiner	M,C,W,T	YES
Redfin Shiner	M,W,T	
Sand Shiner	W,T	
Creek Chub	M,C,W,T	YES
Suckermouth Minnow	M,W	
Common Carp	W,T	
Johnny Darter	W,T	
Orangethroat Darter	M,W	
Mosquitofish	C,W	
Gizzard Shad	M,W	
Freshwater Drum	C	
Longnose Gar	C	
River Carpsucker	M	

M=Present in Mill Cr., C=Present in Cedar Cr., W=Present in Wolf Cr., T=Present in Tomahawk Cr.

Table 1: Assessment of Plains Fish Species as Related to Study Reach of Turkey Creek (3, 4)

In an effort to assess both present and possible future fisheries conditions along the project reaches of Upper Turkey Creek, Kristen Hase, a biologist with the Kansas Fish and Parks Division responsible for the 2003 sampling of the stream, was contacted for information regarding both the Turkey Creek fishery, and general geographic fisheries information. Ms. Hase indicated that approximately 35 species of fish comprise the plains fishes group common to the project area in Kansas. Accounting for the typically moderate size and low summer flows in Turkey Creek, many of the larger plains species will likely not be present in large numbers or throughout the year. Additionally, the downstream flood diversion channel disrupts the stream connection to the Kansas River. If the ability to reach the stream through bird introduction or stocking should occur, many of the larger river fish such as Channel and Flathead catfish, Freshwater Drum, and River Carpsuckers may utilize the Upper Turkey Creek for various life stages and functions and at key times of the year such as spawning (2).

Generally, Ms. Hase indicated that many of the species listed in Table 1 could reasonably be expected to inhabit Turkey Creek in the event of water quality and habitat improvements. Such species as Longnose Gar, various sucker species, various bullhead species, Channel Catfish, Flathead Catfish, Central Stonerollers, Johnny Darters, and Orange Throat Darters could be expected.

Data from both the Use Attainability Study and the 2003 sampling event indicate that physical stream characteristics suggest that a healthy native fishery is attainable along the reach of Upper Turkey Creek (4) if water quality concerns due to urbanization are addressed. This assessment is based upon the presence of high quality substrate and habitat as well as intermittent quality stream morphology like natural riffle pool structures.

While the potential exists to establish a typical native fishery, several obstacles to this task exist. While pools and riffles could be found throughout the project reach,

connectivity between these features is lacking in many areas. Many of the aforementioned species require both pool and riffle habitats during various life stages, seasons, or even times of the day. A lack of connection during normal flows between these morphologic features prevents access required by certain life functions, and can also lead to fish kills in both summer and winter. In summer, the riffle structure provides highly mixed oxygen rich water. In winter, the deeper pools provide wintering areas for fish species to escape energy sapping higher velocities, and in some cases areas where water temperatures result in nearly complete freezing of the water column.

In addition to prohibitive access, excessively sunny areas of the creek channel were found to have potentially lethal temperatures during the warm summer months as well as low dissolved oxygen levels associated with the elevated temperatures. The unshaded channel reaches may further hinder fish movement between sections due to the uninhabitable conditions that these sections create. Reaches shaded with bankside vegetation were found to have adequate dissolved oxygen levels and temperatures within tolerable ranges for those species both currently found in Turkey Creek, and those with the potential to inhabit the stream under higher water quality conditions.

Given the relatively small nature of the species currently inhabiting Turkey Creek, and the similar size of those species with the potential to reestablish populations, blockages within the stream may cause significant problems. Again, owing to the size of the minnows, shiners, and darters most likely to inhabit the stream, any structure impeding movement, such as sewer line crossings, encased channels, grade control structures similar to the plastic netted gabion, and obstructions caused by channel downcutting at road crossings can be considered blockages to fish movement, specifically during normal flow conditions. While these blockages impede movement throughout the stream reach, the smaller species described above may not require access to extensive stream reaches to survive. Taking this into account, by connecting smaller reaches of stream and giving minnows and darters access to the various habitats present in smaller stream reaches, such as connecting riffles, pools and runs, a healthy complete habitat for fish species within Turkey Creek can be established. Additionally, creating small fisheries access to off channel stormwater detention basins with permanent pools can also provide additional habitat.

While connecting shorter reaches of stream should provide adequate habitat for smaller creek species, larger species with the potential for reintroduction may necessitate access to longer stream reaches to perform life functions like spawning, feeding, wintering, and growing. As noted previously, several larger fish species have the potential for survival given water quality improvements along Turkey Creek. They include Channel Catfish, Flathead Catfish, Longnose Gar, and an increased population of Largemouth Bass. Though these larger species may require access to larger reaches of stream in order to survive, minor blockages will not impede travel as extensively as with the smaller species. Also, many of the movements of these species throughout Turkey Creek will occur during periods of higher flows in spring and fall when access will not be as restrictive due to higher water levels.

Channel Catfish appear to be one of the most likely game species for reintroduction into the Turkey Creek System. The habitat preferences of Channel Catfish indicate that with improved water quality, viable habitat exists along Turkey Creek for a population to exist. The following table outlines the preferred habitat of channel Catfish.

Factor	Preference
Spawning Period	May-June
Spawning Habitat	Build Nests in dark secluded areas like under rocks or manmade cavities
Juvenile Movement	Fry move back down system to lower river sections (assumed slower and wider) in July and August
Temperature	21-30 deg. C
Water Clarity	Turbid
Velocity	Slow water, usually spend daylight hours in water < 0.5fps
Movement	Move from pools during daylight to feed in riffles when dark

Table 2: Preferences of the Channel Catfish (2)

Because of the non-sport nature of the species found in Turkey Creek, little data such as its Froude and Reynolds numbers, velocities and spawning data exists on the physical parameters required by those species.

MAINTENANCE REQUIREMENTS AND EXPECTED DESIGN LIFE

Generally constructed riffles require no maintenance if properly constructed by burying the end rocks back into the channel banks to stop water from cutting around the riffles.

There is no life expectancy limit noted in the literature. Performance over time can be enhanced as riffle rock attract biological life on the rocks that result in improvement in the food chain and aid in denitrifying ammonia in the water.

VALUE ENGINEERING ALTERNATIVES

The site is actively downcutting. The model and the survey data is not adequate to try a number of different scenarios at this time.

REFERENCES

1. Kenneth V. Ruzek, Jr., "Master Index of Freshwater Fishes", http://www.webcityof.com/miffwf.htm, Brooklyn Park, MN, 1996-2000.
2. Robert W. Newbury, Marc N. Gaboury, "Stream Analysis and Fish Habitat Design", Newbury Hydraulics Ltd., Gibsons, British Columbia, 1993.
3. Kansas Wildlife and Parks, "Urban Resources Assessment and Management Project Phase I: Biological Assessment of the Stream and Riparian Resources of Tomahawk and Wolf Creek Watersheds, Johnson County, Kansas," Kansas Department of Wildlife and Parks, 1997.
4. Gary E. Welker and Dr. Donald G. Huggins, "Use Attainability Analysis of Turkey Creek, Johnson and Wyandotte Counties, Kansas", U.S. Environmental Protection Agency, Environmental Services Division, Kansas City, Kansas, Kansas Biological Division, University of Kansas, Lawrence, Kansas, July 1997.
5. U.S. Environmental Protection Agency, "Ecological Restoration – EPA 841-F-95-007," Publication, U.S. Environmental Protection Agency, November 1995.

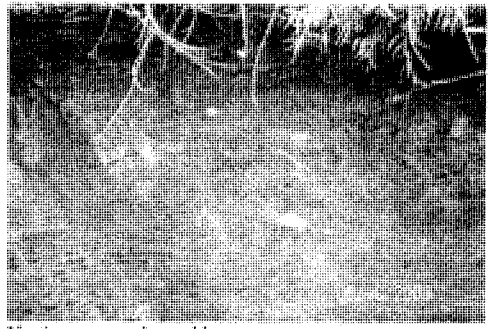
SEE TASK 1: 75TH STREET FOR THE FOLLOWING:

Location Sketch
Plan View
Profile View

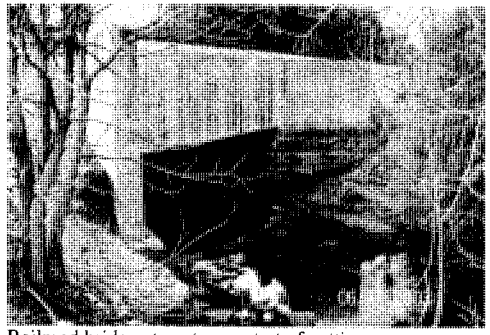
Task 2-4-59: 75th Street

Upper Turkey Creek

Plastic netting on channel bank



Netting across channel bottom



Railroad bridge at upstream start of netting

TASK 3: RETROFIT STORMWATER BASINS FOR WATER QUALITY BENEFITS

Merriam Town Center

MERRIAM TOWN CENTER

TASK OBJECTIVE

The objective of this task is to retrofit a dry detention basin to provide water quality benefits.

SITE SELECTION CRITERIA

The criterion in selecting a site for this task was to determine a suitable location that is representative of other similar locations within the Upper Turkey Creek watershed. The demonstration site is ideally an average representation, based on site conditions, accessibility, and utility and development conflicts.

This site was noted and photographed in the Upper Turkey Creek Feasibility Study Environmental Field Assessment provided by the Kansas City District as one of 22 possible sites. Readily available plans, hydrologic and hydraulic data, and an easy to access location made this site a good demonstration site.

The existing dry detention for the site appeared to be occasionally maintained and was planted with the same grasses as used in the manicured areas. In the existing condition, the storm water runoff is receiving minimal natural treatment. The site collection system directs the flow directly to the detention pond bottom where it takes a direct path to the outlet structure. Dry detention configurations of this type are common throughout the watershed.

SITE CONDITIONS/SITE ANALYSIS

The Merriam Town Center detention basin is located in Johnson County, Kansas, just east of Interstate 35 and north of Johnson Drive. This dry detention basin was designed to contain and release runoff from approximately 44 acres of land in the Merriam Town Center Shopping Area. The detention basin was designed for a 25-year storm for flood control purposes, however it provides little water quality benefit. The principal outlet of the detention basin is a 30-inch reinforced concrete pipe with a 19.2-inch restrictor plate that forces the pipe to be inlet-controlled. As the water exits the basin through the principal outlet, it flows into a culvert under I-35 and then into the main channel of Turkey Creek. The emergency spillway runs parallel with the east side of I-35 and functions as a broad-crested weir.

The basin has approximately 2H:1V side slopes and a 2 percent slope in the bottom of the basin toward the principal outlet. Visible erosion exists near the five site drainage inlet pipes into the detention basin, and also small channels have eroded in the bottom of the basin from the inlets to the outlet pipe. Near the entrance of the basin outlet, there is a small depression where cattails and other wetland plants grow. The remainder of the detention basin and the land outside of the basin is planted with grass, which appears to be regularly mowed.

RESTORATION DESCRIPTION

The design of the existing dry detention basin is proposed to be modified to provide water quality benefits, in addition to the current flood reduction benefits. To improve water quality the outlet structure would be modified by adding a riser structure with staged outlets to increase detention time. Increasing the detention time for frequent events will allow trash, sediments, and the pollutants attached to them to settle out in the basin. The bottom of the detention basin would also be excavated 2 feet deep to provide storage for water quality purposes only. Wetland planting will be implemented.

Additional water quality benefits can be incorporated into the design by adding an optional forebay south of the existing detention basin. Approximately 0.5 acres of parking lot space behind the Merriam Town Center Shopping Area would be removed to make space for the forebay, and two existing inlets re-routed to discharge into the forebay. The parking lot area would be excavated 20 feet deep to create a benched area for the forebay. The bottom elevation of the forebay would be 10 feet higher than the bottom elevation of the deepest portion of the detention area. A 6-inch high weir would be constructed at the edge of the forebay to detain water in it. Additionally, the soil in the forebay would be amended to improve the infiltration capacity, and 6-inch rock would be placed over the soil to stabilize the forebay during large storms. Along with the water quality benefits the forebay will provide, it will also create additional storage in the detention basin to help offset the hydraulic effects of adding a riser structure to the outlet.

The following paragraphs describe the configuration of the riser structure that would be added to the outlet of the detention basin.

Detention Basin Riser Hydraulics:

Water Quality Opening – The lowest opening on the riser, 6 inches in diameter, is designed for the water quality storm event. The opening is sized to detain a 1-inch rainfall for at least 24 hours to provide sufficient time for pollutants to settle out. The invert elevation of the opening is at 933, so the modified detention basin is designed to have a permanent pool of water below elevation 933. The water quality opening is protected from debris and clogging by using a corrugated well around the opening.

Channel Protection Opening – The next opening, 8 inches in diameter, is designed for the channel protection event. The channel protection opening flowline is set at the top of the required storage for the water quality event. This opening was designed to detain a 1-year, 24-hour storm for at least 24 hours to protect the existing downstream channel from erosion caused by large peak flows. The invert elevation of this opening is 936. The channel protection opening is protected from debris and clogging by using a corrugated well around the opening.

Principal Opening – The principal opening flowline is set at the top of the required storage for the channel protection event. The principal opening consists of a 3-foot by 2-foot opening with an invert elevation of 938. The principal opening was designed to drain the detention basin above elevation 938 for a large storm event.

An additional design considered for the Merriam Town Center Detention Basin was to maintain the functionality of the basin as a dry pond. For this design alternative, forebays would be excavated in the bottom of the basin near each of the five inlets. Also, meandering, low flow channels would be excavated from each of the inlets to the outlet to increase the distance stormwater flows to the outlet and to allow more time for sediments to settle out. The pond bottom would be planted in native grasses that would also help to filter pollutants out of storm water. This alternative was not selected because it would not be as effective in improving water quality as the wet bottom alternative.

WATER QUALITY BENEFITS

Literature produced by the USEPA (1,2,3) and Prince George's County, Maryland (4) indicate wet bottom detention basins can remove 30-90 % of the phosphorous, 40-80% of the hydrocarbons, 20-40% of the chemical oxygen demand and 50–90% of the total suspended solids. The addition of the infiltration forebay has the potential to remove additional phosphorous and nitrogen in addition to 90% of the heavy metals and organics, both a significant concern in the watershed at this location.

HABITAT BENEFITS

With the introduction of aquatic plants in the basin, the basin could provide some limited habitat for fish and wildlife, particularly birds. Due to the direct lack of connectivity to green spaces and the stream, the facility will have limited usefulness to fish and other wildlife. However, stormwater basins in other areas have been used for raising native minnows (5) and at a different site such a basin could potentially offer those benefits.

FLOOD REDUCTION IMPACT

The Merriam Town Center Detention Basin was originally designed to store a 25-year storm. The goal of the modified design is to maintain the capacity of the basin to store a 25-year event, although the restoration plan described above does not meet that goal. With the proposed design, a 25-year, 24-hour storm has an elevation of approximately half a foot above the top of the emergency spillway elevation. If this restoration plan reaches the final design stage, the design would be modified to ensure that the basin will hold the 25-year event. This could be achieved through increase the size of the principal opening, increase the size of the existing detention basin, or a combination of the two.

MAINTENANCE REQUIREMENTS AND EXPECTED DESIGN LIFE

The basin should be inspected on a monthly basis or after a storm event to check for erosion, nuisance problems and trash or debris. When any problems are found, repairs should be made as soon as possible. Typical routine maintenance would include vegetation management (removal of unwanted plant species) and trash removal. Periodic maintenance includes repairs to the embankment, inlets and outlet, riprap repair at outfalls and removal of accumulated sediment. (****REF- USEPA Wet Detention Basin Fact Sheet that I'm sure is reference 1,2,or3, but the reference were not included for this section in the draft – so please add the appropriate number when you add the references) If a healthy stand of aquatic plants is established, the potential for algal

growth is reduced or eliminated. The expected life of the wet basin exceeds 20 years if regularly maintained. (6)

VALUE ENGINEERING ALTERNATIVES

One alternative is to remove the parking lot excavation for the forebay and create a forebay in the basin. This alternative will reduce the size of the basin and reduce the efficiency of the design for water quality benefits, significantly reducing the basin's ability to remove heavy metals and organics.

REFERENCES

1. Bland, Jim, "Field Notes: The Fish at Prairie Crossing", Chicago Wilderness Magazine, Volume V, Number 4, Summer 2002, p. 30.
2. Schueler, Thomas R., et al, "A Current Assessment of Urban Best Management Practices: Techniques for Reducing Non-point Source Pollution in the Coastal Zone", Metropolitan Council of Governments, Washington, D.C.1992.

United States Army Corps of Engineers
Upper Turkey Creek
Task 3 Merriam Town Center

HNTB

Engineer's Estimate of Probable Costs

8/12/2004

No.	Item	Quantity	Unit of Measure		Unit Cost		Cost
1	Spillway riser	1	Each	$	6,000.00	$	6,000.00
2	Native grasses	1	Acre	$	4,000.00	$	5,600.00
3	Infiltration soil mix	332	C. Y.	$	7.00	$	2,324.00
4	Erosion control fabric	6776	S. Y.	$	2.00	$	13,552.00
5	Excavation	20,763	C.Y.	$	8.00	$	166,104.00
6	Stacked Stone Weir	30	Ton	$	20.00	$	600.00
7	15" Pipe	45	L. F.	$	37.00	$	1,665.00
8	24" Pipe	38	L. F.	$	45.00	$	1,710.00
9	15" Flared End Section	1	Each	$	400.00	$	400.00
10	24" Flared End Section	1	Each	$	550.00	$	550.00
11	12" Abandon pipe	56	L. F.	$	12.00	$	672.00
12	24" Abandon pipe	200	L. F.	$	20.00	$	4,000.00
13	Curb Inlet	6	L. F.	$	330.00	$	1,980.00
14	4' Manhole	40	L. F.	$	300.00	$	12,000.00
15	Curb	242	L. F.	$	11.50	$	2,783.00
16	Clearing	2	Acre	$	1,200.00	$	2,892.00
17	Construction access road	1	Each	$	150.00	$	150.00
18	Pavement Removal	445	S.Y	$	8.00	$	3,560.00
19	Mobilization	1	Lump Sum	$	9,000.00	$	9,000.00
					Subtotal:	$	235,542.00
					20% Contingency	$	47,108.40
					Total:	$	282,650.40
					Use:	**$**	**290,000.00**

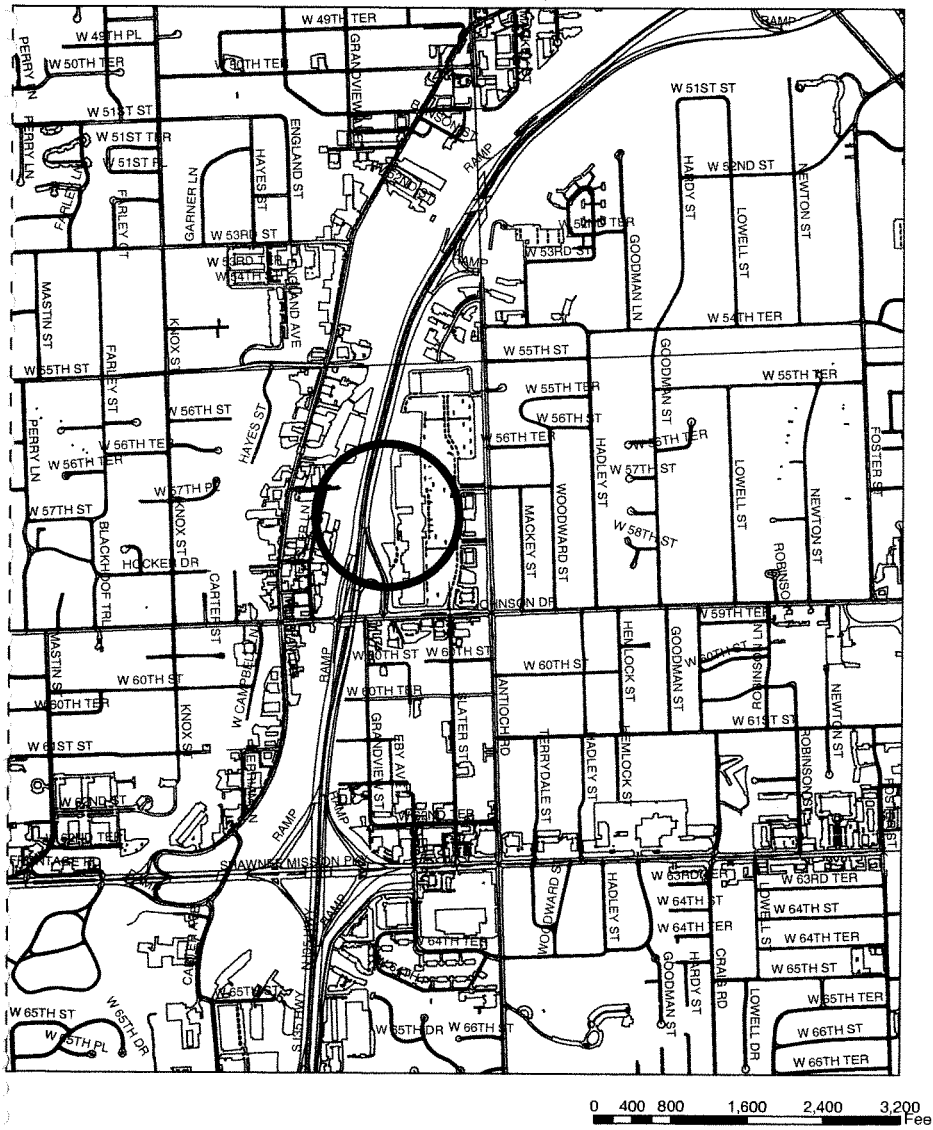
Notes:

1. The costs shown above represent an estimate of probable cost prepared in good faith and with reasonable care. HNTB has no control over the costs of construction labor, materials or equipment, or over any competitive bidding or negotiating methods.

F:\32080\D18_UpperTurkeyCreek\Report\Appendix\[Cost_Estimate.xls]3-2-1 Merriam

Task 3-2-1 Merriam Town Center

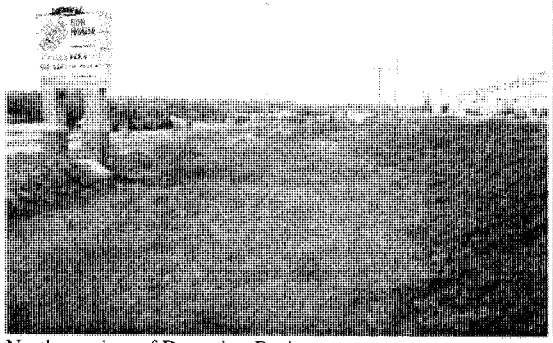
Location Map



0 400 800 1,600 2,400 3,200 Feet

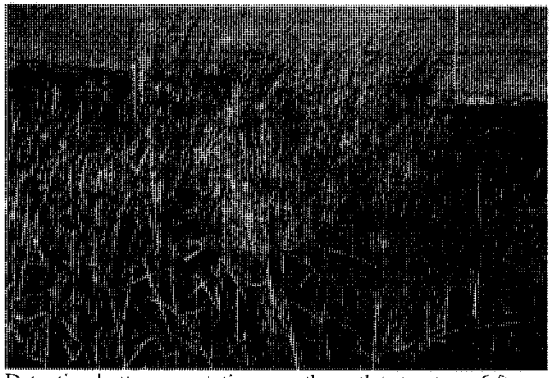
Task 3: Merrian Town Center

Upper Turkey Creek

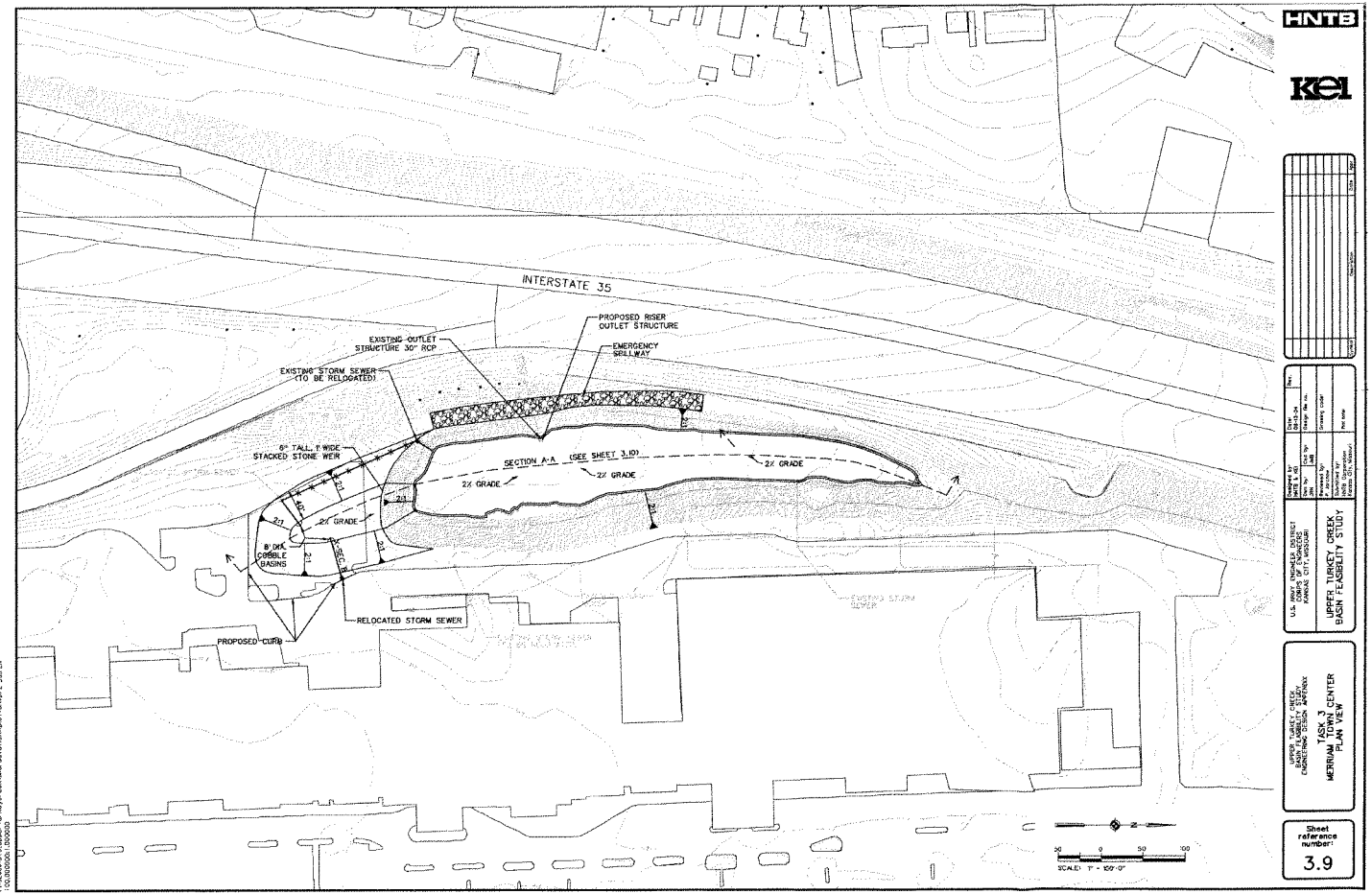


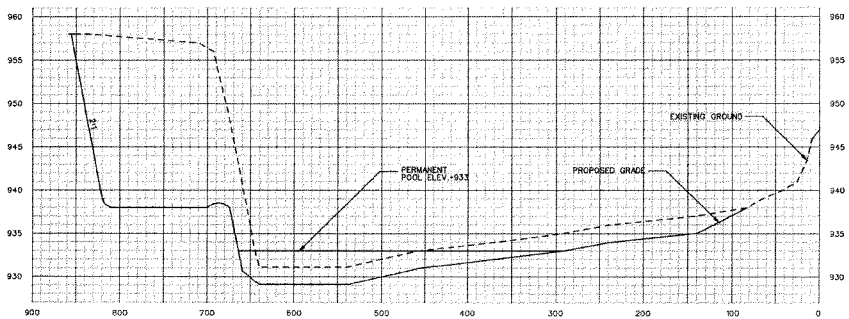
Northern view of Detention Basin

Upstream flared end section of Outlet Structure. 30 in. RCP.



Detention bottom vegetation near the outlet structure, 6 ft. high.


INTERSTATE 35
PROPOSED RISER OUTLET STRUCTURE
EMERGENCY SPILLWAY
EXISTING OUTLET STRUCTURE 30" RCP
EXISTING STORM SEWER (TO BE RELOCATED)
6" TALL 1' WIDE STACKED STONE WEIR
SECTION A-A (SEE SHEET 3.10)
2% GRADE
2% GRADE
2% GRADE
2% GRADE
2:1
8' DIA. COBBLE BASINS
RELOCATED STORM SEWER
PROPOSED CURB
SCALE: 1" = 100'-0"
HNTB
KEL
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS KANSAS CITY, MISSOURI
UPPER TURKEY CREEK BASIN FEASIBILITY STUDY
UPPER TURKEY CREEK CONCEPTUAL DESIGN APPENDIX
TASK 3
MERRIAM TOWN CENTER
PLAN VIEW
Sheet reference number:
3.9



SECTION A-A THROUGH DETENTION BASIN

HORIZ. SCALE: 1" = 100'-0"

VERT. SCALE: 1" = 10'-0"

HNTB

KEI

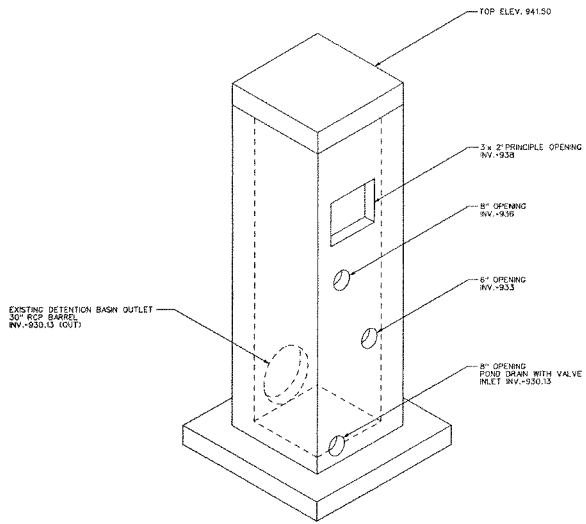
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX

TASK 3
MERRIAM TOWN CENTER
SECTION

Sheet reference number:
3.10



5'x5' INSIDE DIMENSIONS

HNTB

KEI

Date	Rev.
08-01-04	

Design file no.

Drawing code

Plot scale

Designed by: HNTB & KEI

Drawn by: JRN

Checked by: P. Jenkins

Submitted by: HNTB Corporation Kansas City, Missouri

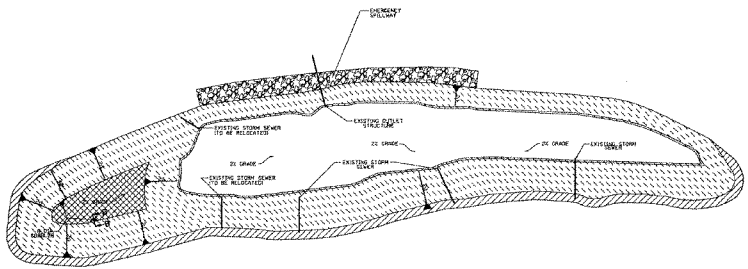
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX

TASK 3
MERRIAM TOWN CENTER
OUTLET STRUCTURE

Sheet reference number:
3.11



LEGEND

- EROSION CONTROL BLANKET AND NATIVE GRASS
- SHRUBS
- RIPRAP
- AMMEND SOIL AND PLANT

50 0 50 100
SCALE: 1" = 100'-0"

HNTB

KEL

Designed by: HNTB & KEL	Date: 08-15-04	Rev.
Dwn by: JBN	Ckd by: JAB	Design file no.
Reviewed by: P. Jarrow	Drawing code:	
Submitted by: HNTB Corporation Kevin Fry, Attorney	Plot date:	

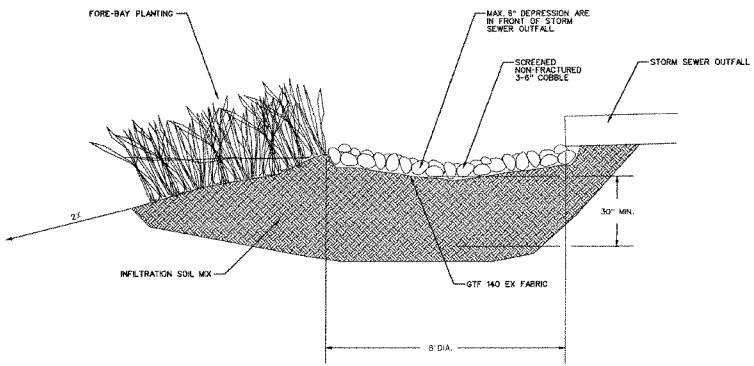
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX

TASK 3
MERRIAM TOWN CENTER
PLANTING PLAN

Sheet reference number:
3.12



SECTION B-B

HNTB

KEL

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX

TASK 3
MERRIAM TOWN CENTER
SECTION A

Sheet reference number:
3.13

TASK 3: RETROFIT STORMWATER BASINS FOR WATER QUALITY BENEFITS

Pine Ridge West Business Park

PINE RIDGE WEST BUSINESS PARK

TASK OBJECTIVE

The objective of this task is to retrofit a stormwater basin for water quality benefits.

SITE SELECTION CRITERIA

The criterion in selecting a site for this task was to determine a suitable location that is representative of other similar locations within the Upper Turkey Creek basin. The demonstration site is ideally an average representation, based on condition, accessibility, and utility and development conflicts.

This site was noted in the Upper Turkey Creek Feasibility Study Environmental Field Assessment provided by the Kansas City District and photographed as one of 22 stormwater basin and swales sites. Currently under construction, the site offered a number of possibilities for demonstrating techniques to improve water quality.

Three existing wet detention ponds were under construction. The basins are interconnected, the top basin flowing into the middle basin that then flows into the lower basin before outletting to a channel that enters Turkey Creek. The large ledge rock walls constructed along the detention pond shoreline and the grouted stone outlets provide little environmental value According to the development plans, the grassy areas are to be maintained as manicured lawn. Wet bottom "reflecting" ponds, such as these basins, are preferred by commercial developers / architects over dry or vegetated wetland ponds, which are considered to offer little aesthetic focus for corporate office occupants and visitors..

SITE CONDITIONS/SITE ANALYSIS

This site is a new commercial development in the City of Lenexa, Kansas in Johnson County. The boundaries of the site include Quiviria Road to the north, 83rd Terrace to the west, 81st Street to the east, and Flint Street to the south. The first phase of the development includes the construction of three retention basins in series to handle the stormwater runoff from the site. The basins are centrally located in order to receive stormwater runoff from future parking lots and buildings.

The proposed plan consists of intercepting and treating stormwater runoff on the site before the stormwater reaches the ponds and including aquatic plants in the pond for habitat and water quality benefits.

The stormwater management features include stormwater infiltration facilities built around the proposed parking lots to help remove stormwater pollutants, reduce runoff volumes and allow for groundwater recharge. Likewise, porous paving is proposed for portions of the parking lot. To further encourage stormwater pollutant removal, reduce time of concentrations, and encourage more stormwater infiltration, grass swales are proposed instead of storm sewers to convey water to the stormwater ponds. Forebays at the pond entrances add additional pollutant removal capability and encourage stormwater cooling before entering the pond system. Aquatic plants added to the ponds provide additional water quality, habitat values and provide an aesthetic visual break to the ledge rock walls.

RESTORATION DESCRIPTION AND DESIGN

The proposed plan consists of intercepting and treating stormwater runoff on the site before the stormwater reaches the ponds and including aquatic plants in the pond for habitat and water quality benefits.

The stormwater management features include stormwater landscape bioretention cells/infiltration facilities built around the proposed parking lot to help remove stormwater pollutants, reduce runoff volumes and allow for groundwater recharge. As the parking lot designs are currently conceptual (i.e. no plans showing parking lot pavement grades, slopes or stormwater collection systems were available) the proposed bioretention cell design in also somewhat conceptual at this time The bioretention cells will require sand amended soils to a depth of approximately 30 inches, a mixture consisting of approximately 50% sand and 50 % in situ soils. The curb around adjacent to the cell will need curb cuts approximately one foot in width at frequent intervals (depending on parking lot grades) to allow stormwater to run off the parking lot and reach the cells. At the entrance to the cells turf or riprap should be placed, to help dissipate the energy in the water entering the cells. Trees and shrubs and herbaceous plants commonly used in landscaping parking lots may be planted. The cells can be under drained with a perforated pipe and connected to the site stormwater drainage system. The bioretention cells would be designed to have no more than a 6-inch depth of water accumulated on its surface during a storm event. A vegetated or riprap overflow outlet should be constructed in the cell for overflow during intense rainfall events. The bioretention cells have been traditionally been mulched with an approximate 3 inch layer of mulch, however some designers are now seeding the basin with grasses with some success.(11)

Porous paving concrete blocks are proposed for portions of the parking lot, to encourage additional stormwater infiltration. They are proposed to be used in areas of the parking lot that will not be subject to high sediment flows and in parking lots that are to be used for office buildings. To further encourage stormwater pollutant removal, increase time of concentrations and encourage more stormwater infiltration, grass swales are proposed as compared to storm sewer to convey water from the parking lot to the stormwater ponds. Forebays with amended sandy soils and covered with rock will be constructed at the location of the future stormwater inlets at the pond entrances. The forebays function much as an infiltration trench and adds additional pollutant removal capability and encourages stormwater cooling before entering the pond system. Aquatic plants added to the ponds provide additional water quality, habitat values and provide an aesthetic visual break to the ledge rock walls.

WATER QUALITY BENEFITS

Bioretention cells and the forebays can remove up 60% of the phosphorous, up to 60% of the Kjeldahl nitrogen (), up to 90% of metals, 70-80% of chemical oxygen demand, and 90% of organics (4,5). The forebays can also remove up to 90% of the sediment. Vegetative swales can remove up to 62% of the hydrocarbons (6), 9% of the phosphorous, 38% of nitrate, 69% of chemical oxygen demand, and 81% of total suspended solids. Porous paving can remove 80-85% of Kjeldahl nitrogen and 65% of

phosphorous (7) and up to 99% of metals (11). The wet bottom ponds are expected to reduce phosphorous 30-90%, chemical oxygen demand 20-40% and total suspended solids 50-90% (8, 9).

HABITAT BENEFITS

With the introduction of aquatic plants in the basins, the basin could provide some habitat for fish and wildlife, particularly birds. Due to the direct lack of connectivity to the stream except through a series of weirs, the facility would have limited usefulness to in stream fish.. The basins could be suitable for smaller native fish that could be washed into the creek during a large rainfall event. The fish may be colonize the ponds through being transported by birds or being stocked. Stormwater basins in other areas have been successfully used for raising native minnows (10).

FLOOD REDUCTION IMPACT

Since no modifications are being proposed to the existing wet detention ponds water elevations or outlets, no reduction in peak discharges from the stormwater facility is expected.. However, the contributing sub-basins time of concentrations will be lengthened in addition to diverting some volume of water to groundwater recharge which could result in a reduction in stormwater runoff volumes reaching Turkey Creek. This reduction has not been quantified.

MAINTENANCE REQUIREMENTS AND EXPECTED DESIGN LIFE

Stormwater quality features require maintenance to operate effectively and extend their useful design life. Each feature has different maintenance requirements and a different expected design life.

The bioretention or infiltration cells will need to be maintained much like any other landscape area on the property. The most critical issue in maintaining the bioretention or infiltration cell is not to allow high concentrations of silt to enter the facility. These cells are very effective in highly urbanized areas like paved parking lots, because of the general lack of high concentrations of silts. Other maintenance activities include checking for bare areas and adding mulch as needed (if cell is mulched instead of grassed), checking for and removing any accumulated sediments, looking out for areas of gullies forming through the mulch. It is recommended that every two to three years the mulch be removed, disposed of properly and replaced. (1) No specific life expectancy was given in the literature for bioretention facilities. Facilities have failed in the past due to high concentration of sediments and lack of infiltrating soils. However careful avoidance of sediment loading during construction and afterwards, in addition to the use of sand amended soils and under drains, where necessary, has addressed those concerns. The bioinfiltration cells constructed in the mid 1990's are still functioning in Maryland. Depending on the loadings, bioretention cells may be expected to have life expectancies greater then 10 years, approaching the life expectancy of a well maintained wet basins of 20 years or more. Pollutant removal efficiency may be reduced with age.

The USEPA indicates that vegetated swales can last indefinitely in properly designed and maintained. Maintenance activities generally consist of maintaining the vegetation

to assure there is a thick healthy vegetated cover in the swale. Any bare areas caused by erosion, standing water or sediment accumulation must be repaired as soon as the problem becomes apparent.

The FHWA indicates that block porous paving, as specified in this design, does not have some of the same installation failures as poured porous pavements. To maintain the infiltration capacity the pavement should be kept clean of sediment and vacuumed quarterly. However, FHWA reports a concrete block porous pavement parking lot, unmaintained, had an infiltration capacity of 4 inches per hour when tested nine years after installation. FHWA estimates the useful life of these surfaces to be 15-20 years, at which time the concrete block porous pavers can removed and reused.

At this site the pond forebays will be built and act the same as bioretention cells, except rock riprap instead of mulch will be placed on top on the amended soils. The forebays should be inspected on a regular basis for debris and rock movement. On an annual basis the forebay media should be checked for sediment accumulation. If sediment has accumulated the material should removed and cleaned or replaced. If sediment accumulation is a problem a geotextile should placed under the rock to add in trapping the silt and allowing for easy silt removal in the future.

VALUE ENGINEERING ALTERNATIVES

As an alternative, different features of the water quality treatment measures could be removed or downsized and the remaining measures would still function. To help remove pollutants expected from urban runoff, it is recommended that the infiltration facilities around the parking lot in addition to the pond forebays be kept as minimum measures. These measures are the significant features of the proposed water quality improvement, and can be installed in a cost-effective fashion during normal landscaping.

REFERENCES

1. United States Environmental Protection Agency Office of Water, "Storm Water Technology Fact Sheet Bioretention", Washington, D.C., September 1999.

2. United States Environmental Protection Agency Office of Water, "Storm Water Technology Fact Sheet Wet Detention Ponds", Washington, D.C., September 1999.

3. United States Environmental Protection Agency Office of Water, "Description and Performance of Stormwater Best Management Practices", http://www.epa.gov/ost/stormwater/usw_c.pdf, Washington, D.C.

4. Derek Winogradoff, "Bioretention Monitoring, Preliminary Data Analysis", Department of Environmental Resources, Prince George's County, Maryland, November 1997.

5. United States Environmental Protection Agency Office of Water, "Storm Water Technology Fact Sheet Infiltration Trench", Washington, D.C., September 1999.

6. United States Environmental Protection Agency Office of Water, "Storm Water Technology Fact Sheet Vegetated Swales", Washington, D.C., September 1999.

7. United States Environmental Protection Agency Office of Water, "Storm Water Technology Fact Sheet Porous Pavement", Washington, D.C., September 1999.

8. Ministry of Water, Land and Air Protection, Water, Air and Climate Change Branch, Government of British Columbia, "Water Quality, Best Management Practices to Protect Water Quality", http://wlapwww.gov.bc.ca/wqat/wq/nps/BMP_Compendium/BMP_Introduction /bmphome.htm, Province of British Columbia, 2001.

9. United States Environmental Protection Agency Office of Water, "Storm Water Technology Fact Sheet Wet Detention Ponds", Washington, D.C., September 1999.

10. Bland, Jim, "Field Notes: The Fish at Prairie Crossing", Chicago Wilderness Magazine, Volume V, Number 4, Summer 2002, p. 30.

11. Federal Highway Administration, undated, "Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring Fact Sheet – Porous Pavement", Internet Publication, http://www.fhwa.dot.gov/environment/ultraurb/3fs15.htm.

United States Army Corps of Engineers
Upper Turkey Creek
Task 3 Pine Ridge West Business Park

HNTB

Engineer's Estimate of Probable Costs

8/12/2004

No.	Item	Quantity	Unit of Measure	Unit Cost	Cost
1	Excavation	332	C. Y.	$ 8.00	$ 2,656.00
2	Native grasses	0.18	Acre	$ 4,000.00	$ 720.00
3	Erosion control fabric	1136	S. Y.	$ 5.00	$ 5,680.00
4	Rip Rap	10	Ton	$ 30.00	$ 300.00
5	Woody trees	2	Each	$ 450.00	$ 900.00
6	Woody shrubs	8	Each	$ 40.00	$ 320.00
7	Infiltration soil mix	332	C. Y.	$ 7.00	$ 2,324.00
8	Sub-surface collection pipe	445	L. F.	$ 20.00	$ 8,900.00
9	Culverts under asphalt path	55	L. F.	$ 37.00	$ 2,035.00
10	Asphalt path repair	25	C. Y.	$ 18.00	$ 450.00
11	Limestone removal	44	C. Y.	$ 20.00	$ 880.00
12	New limestone	44	C. Y.	$ 50.00	$ 2,200.00
13	Construction access road	1	Each	$ 150.00	$ 150.00
14	Mobilization	1	Lump Sum	$ 1,000.00	$ 1,000.00
				Subtotal:	$ 28,515.00
				20% Contingency	$ 5,703.00
				Total:	$ 34,218.00
				Use:	**$ 40,000.00**

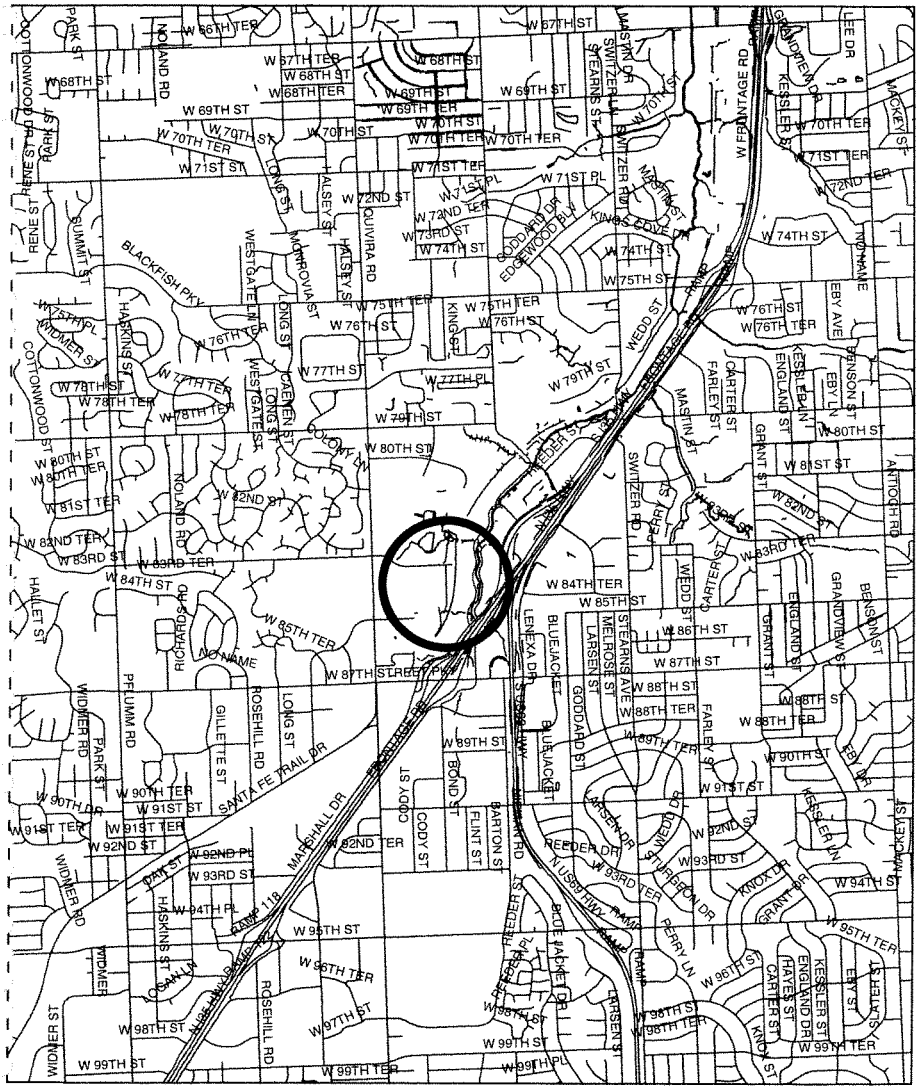
Notes:

1. The costs shown above represent an estimate of probable cost prepared in good faith and with reasonable care. HNTB has no control over the costs of construction labor, materials or equipment, or over any competitive bidding or negotiating methods.

F:\32080\D18_UpperTurkeyCreek\Report\Appendix\[Cost_Estimate.xls]3-4-12 Pine Ridge

Task 3-4-12 Pine Ridge West Business Park

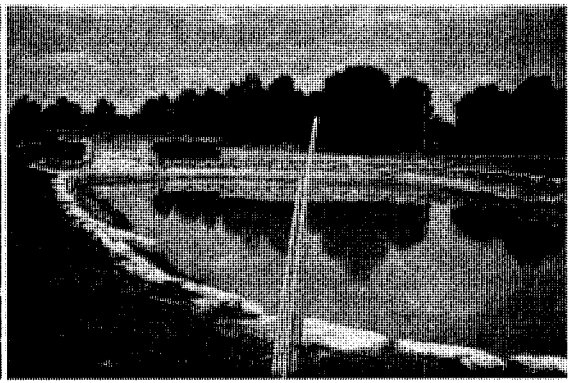
Location Map



Task 3: Pine Ridge Development

Upper Turkey Creek

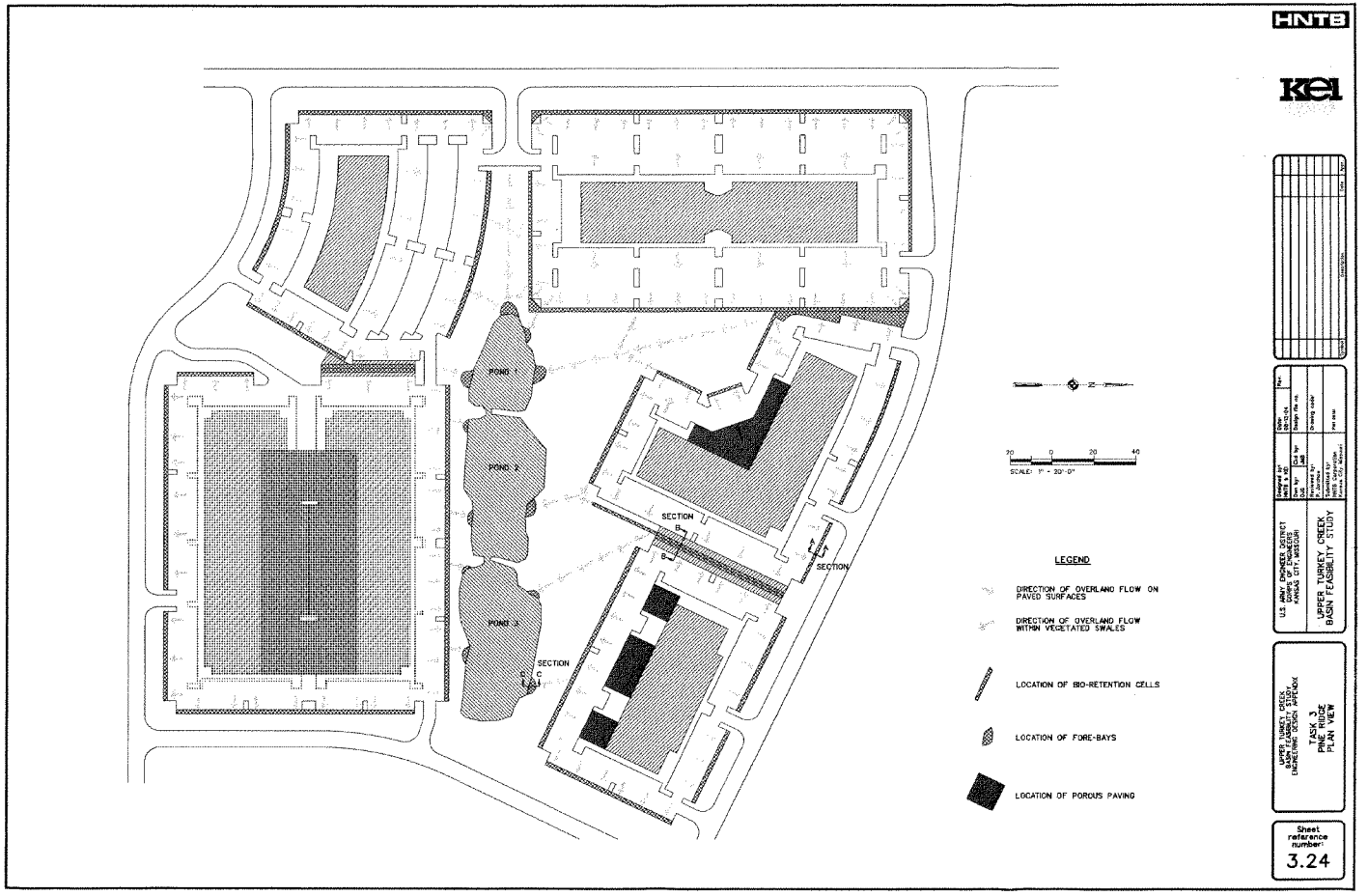
Pine Ridge: Retention Basin Overall View, facing west

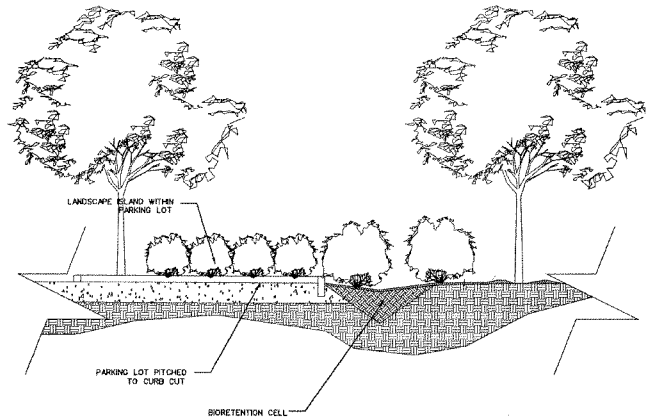


Detention Basin: Facing west Upstream of basin

Upstream Face of downstream pond Outlet Structure, facing

Downstream Channel from outlet, east of Flint Road


HNTB
KEL
POND 1
POND 2
POND 3
SECTION
SECTION
SECTION
SCALE: 1" = 20'-0"
LEGEND
DIRECTION OF OVERLAND FLOW ON PAVED SURFACES
DIRECTION OF OVERLAND FLOW WITHIN VEGETATED SWALES
LOCATION OF BIO-RETENTION CELLS
LOCATION OF FORE-BAYS
LOCATION OF POROUS PAVING
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX
TASK 3
PINE RIDGE
PLAN VIEW
Sheet reference number:
3.24



SECTION A-A

HNTB

KEI

Symbol	Description	Date	Appr.

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

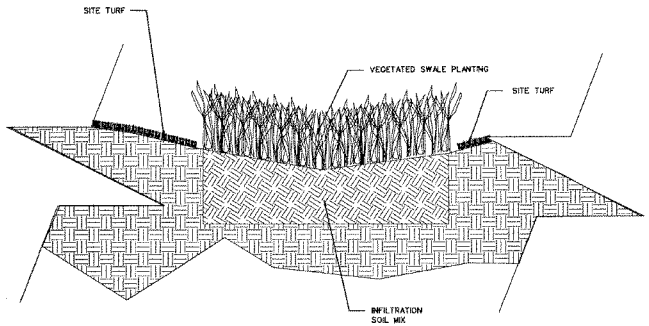
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY

Designed by: HNTB & KEI
Dwn by: DAG
Ckd by: JAB
Reviewed by: P. Jarchow
Submitted by: HNTB Corporation Kansas City, Missouri
Date: 08-30-04
Design file no.
Drawing code:
Plot date:
Rev.

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX

PINE RIDGE TASK 3
BIORETENTION CELL
SECTION A

Sheet reference number:
3.25



SECTION B-B

HNTB

KEI

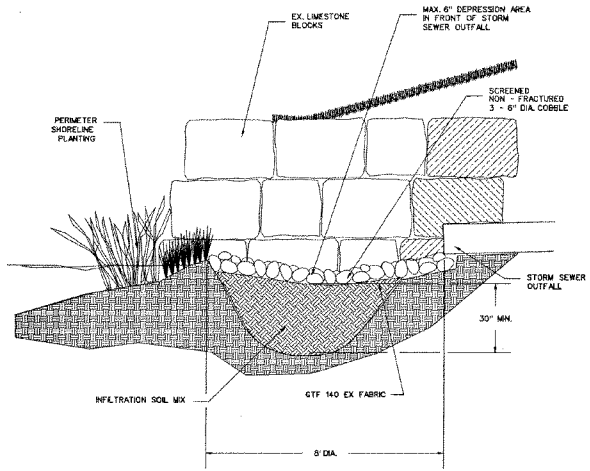
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX

TASK 3 PINE RIDGE
BIO-RETENTION CELL
SECTION B

Sheet reference number:
3.26



SECTION C-C

HNTB

KEI

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX

TASK 3 PINE RIDGE
FORE-BAY
SECTION C

Sheet reference number:
3.27

TASK 5: OPEN UP CHANNEL ENCLOSURES ON TRIBUTARIES

ENCLOSED SYSTEM IN KANSAS CITY, KANSAS

TASK OBJECTIVE

The task objective is to design a more natural open channel to replace a channel enclosure.

SITE SELECTION CRITERIA

The criteria in selecting a site for this task was to determine a suitable location which is representative when compared to other similar locations within the Upper Turkey Creek basin. The demonstration site is ideally an average representation, based on condition, accessibility, and utility and development conflicts.

The site was noted in the Upper Turkey Creek Feasibility Study Environmental Field Assessment provided by the Kansas City District and photographed as a channel enclosure. It is one of 71 channel enclosures documented in the stream assessment.

The Unified Government of Kansas City, Kansas Public Works Department, recommended this site due to the inefficiencies of the closed system drainage. Due to its location within an easement behind residential housing on two parallel streets, other utilities such as sanitary sewer and natural gas are located in the easement as well. This location is representative of the conditions in an urban setting, understanding utility relocations are necessary to provide the increased natural conveyance of an open channel design.

SITE CONDITIONS/SITE ANALYSIS

The site is located in a residential subdivision of the City of Kansas City, Kansas in Wyandotte County. The site boundaries extend from Vista Street on the north, S. 51st on the west, Highland Drive on the east, and Locust Avenue on the south. The storm sewer is located adjacent to the backyard property lines of the residences along Vista and Locust.

The channel is enclosed in a storm sewer system from the upstream end of S. 51st Street to the downstream outlet just east of Highland Drive.

- The enclosed system from S. 51st Street to S. 50th Street consists of 2 – 72-inch RCP, with the exception of the upstream end, which consists of a 90-inch x 58-inch elliptical concrete pipe for a length of approximately 280 feet.
- The enclosed system from 50th Street to Highland Drive consists of 2 – 72-inch RCP that flow into 2 – 54-inch RCP, which eventually outlet into the concrete channel east of Highland Drive.

Therefore, the enclosed system, which starts at S. 51st Street consists of 2 - 48-inch RCP, which then flows into 2- 75-inch x 48-inch elliptical concrete pipe, which then flows into 2 – 54-inch RCP before outletting into the concrete channel downstream of Highland Drive. .

The total area draining to the site is 211 acres. The sanitary, gas, and electrical utilities run parallel, a few feet from the storm sewer system. Downstream of the enclosed system is a concrete lined channel which outlets into a 8x6 RCB under Shawnee Drive.

The site consists of approximately 1800 feet of channel enclosure. No hydrologic model or hydraulic model was provided for this stream reach. HNTB, however, used existing information in their files to estimate flows for various flood frequencies. From this a simple HEC-RAS model was developed. Soils boring data was obtained by the Kansas City District. Near the upstream end of the project reach the soils consisted primarily of clay until about 13.5 feet down where shale was found. The boring log notes the soils as being "wet" at 12.0 feet. Near the downstream end of the project reach the soils consisted primarily of clays until auger refusal occurred at 7.5 feet down. The boring log notes the material was very hard and likely limestone.

REFERENCE STREAM SURVEY

A visual survey was conducted of a reference stream in the Mill Creek Watershed in Johnson County, Kansas to collect information that could be used to design a natural, channel. The reference stream selected was just west of Maurer Road and North of 63rd Street. A 500-foot reach of the stream was surveyed, and the locations of pools and riffles were noted. The stream bottom consisted of sediment with occasional rocks, and the average rock size was 5-inches to 1-foot in diameter. On the day the survey was conducted, the average water depth was 5-inches to 1-foot deep. The bank-full width of the channel ranged from 25 to 27 feet. The right bank was approximately 5-feet high, and the left bank was around 25-feet high.

RESTORATION DESCRIPTION

The proposed restoration improvements to the site include removal of the enclosed system and replacing it with a natural vegetated channel. The channel dimensions include an entire width of 34 feet with two-foot benched areas adjacent to the 1-year frequency flow channel. The total length is approximately 1,800 feet. The bench elevation is set at a one-year storm event. The entire channel is roughly designed to hold a 100-year storm event (see design limitations in the following Flood Reduction Impact section). Due to the existing system being undersized, the culverts under S. 51st Street, S. 50th Street, and Highland Drive are proposed to be upsized to 2-10x4, 2-10x4, and 3-10x4 RCB's respectively to handle a 50-year storm.

The proposed channel will have a 10-foot bottom width, with a 3 to 4-foot deep approximate 1- year channel with 1H:1V to 2H:1V channel side slopes. Riffle structures will be installed every 60 to 100 feet to help reduce the velocities in the channel. The riffles will have a downstream slope of 20H:1V to facilitate fish movement. The channel bank will be vegetated with native grasses and forbs, such as Little Blue Stem, Prairie Cord Grass, Indian Grass, Sedges, Blazing Star, and Asters and shrubs such as Red Osier Dogwood. Native trees, including Red Bud, Green Ash will be periodically planted along the channel for light stream cover. Because of the steep slopes and stream velocities, we expect that several plantings of grasses and forbs, depending on stream flow and weather conditions may need to take place before the plant community starts to thrive.

WATER QUALITY BENEFITS

Water quality information indicates that construction of in-stream structures have a benefit on the in-stream levels of dissolved oxygen (1). Additionally the construction of a

vegetated riparian zone will have further water quality benefits on phosphorus and nitrogen (2).

HABITAT BENEFITS

Currently 1800 feet of stream is not available for fish and wildlife use. Construction of a natural channel in place of a culvert enclosure will provide 1800 feet of additional stream habitat.

FLOOD REDUCTION IMPACT

According to the Unified Government of Kansas City, Kansas, reports indicate frequent flooding occurring within the site area. Detailed hydraulic and hydrologic information were not available in order to complete an accurate analysis of the existing and proposed conditions. Therefore, it is recommended further detailed hydrologic and hydraulic analysis be performed in the next design phase, in order to determine the reduced flooding impact. The present design was developed using Manning's equation to estimate the capacity of the enclosed system. The upstream system from N. 50th Street to N. 51st Street consists of 2 – 72-inch RCP, which hold an estimated 10-year capacity. Further downstream the 2 – 72-inch RCP connect to 2 – 54-inch RCP have an estimated capacity of a 1-year storm. The limitation of a Manning's equation analysis is that downstream backwater impacts, which could control both existing and proposed conditions, are not quantified.

Hydrologic and/or hydraulic models were not available for the site during the period of time of the study. To approximate a design an approximate HEC-RAS model was prepared from plan set data, using regional equation flows. That model was compared to a pipe flow analysis to determine impacts. No riffles were inputted in the model because of the preliminary and approximate nature of the model.

The soil boring data and sediment collected by the Kansas City District was used in HEC-RAS to determine possible stable channel dimensions. A 10 feet bottom width, 3.8 deep channel configuration was chosen for a one-year flow and matched design needs stability curves, comparing channel slope to depth and channel slope to base width were plotted for an assumed sediment concentration of approximately 900 ppm. The two curves provide graphically the channel dimension for a given slope necessary to create a dynamically stable stream that is not aggrading or degrading (incising). The configuration was then checked for a 100-year flow frequency event. The 10 feet channel would need approximately 10 feet depth to be a stable channel. The channel design was thus chosen.

Before construction plans are prepared, detailed surveying, hydrology and hydraulic must be performed to check the design assumptions and proposed design.

To fully design the proposed channel and model the impacts on flooding, a hydrologic and hydraulic model, such as a HEC-1 and HEC-RAS model needs to be prepared. Preliminary analysis indicates the channel may flow at critical depth and therefore the design, if rock grade structures will be an important design feature, to allow for the construction of a vegetated natural channel that allows for instream benthic and small fisheries habitat.

OPERATION AND MAINTENANCE AND LIFE EXPECTANCY

The channel vegetation will require vegetation maintenance, first to establish the vegetation and then mow it on an annual basis preferably in the late fall. After major flood events the channel will need to be checked for signs of erosion. Should erosion occur on the banks, the area should be stabilized immediately. However the low flow channel will be expect to potentially meander within the main channel and not be vegetated for the first foot or two. Unless this low flow meandering seems to be endangering the higher bank stability, the meandering should be allowed to occur in the low flow portion of the channel. The use of fertilizers should be avoided. Trees and shrubs should be maintained so as to provide light shade and not shade out the grasses along the creek. With maintenance, the channel life should be unlimited.

VALUE ENGINEERING

Without a detailed hydraulic analyses, there was no ability to value engineer this site at this site. When the more detailed information becomes available, value engineering of alternatives can be prepared.

REFERENCES

1. U.S. Environmental Protection Agency, "Ecological Restoration – EPA 841-F-95-007," Publication, U.S. Environmental Protections Agency, November 1995.

2. United States Environmental Protection Agency Office of Water, "Description and Performance of Stormwater Best Management Practices", http://www.epa.gov/ost/stormwater/usw_c.pdf, Washington, D.C.,

United States Army Corps of Engineers
Upper Turkey Creek
Task 5 KCK Enclosed System

HNTB

Engineer's Estimate of Probable Costs

8/12/2004

No.	Item	Quantity	Unit of Measure		Unit Cost		Cost
1	Excavation	7,052	C. Y.	$	8.00	$	56,416.00
2	75" x 48" elliptical pipe removal	122	L. F.	$	60.00	$	7,320.00
3	54" pipe removal	895	L. F.	$	60.00	$	53,700.00
4	72" pipe removal	817	L. F.	$	80.00	$	65,360.00
5	Field inlet removal	9	Each	$	2,000.00	$	18,000.00
6	2 - 10' x 4 RCB	90	L. F.	$	750.00	$	67,500.00
7	3 - 10' x 4 RCB	55	L. F.	$	1,050.00	$	57,750.00
8	24" RCP end sections	2	Each	$	550.00	$	1,100.00
9	30" RCP end sections	2	Each	$	730.00	$	1,460.00
10	Rock (2ft)	773	Tons	$	20.00	$	15,460.00
11	Headwall and Apron	28	C. Y.	$	700.00	$	19,600.00
12	Wingwall	7	C. Y.	$	700.00	$	4,900.00
13	Native grasses	2	Acre	$	4,000.00	$	6,120.00
14	Pavement removal	4,800	S .F	$	8.00	$	38,400.00
15	Pavement replacement	4,800	S .F	$	14.00	$	67,200.00
16	Construction access road	2	Each	$	1,000.00	$	2,000.00
17	Mobilization	1	Lump Sum	$	19,000.00	$	19,000.00
					Subtotal:	$	501,286.00
					20% Contingency	$	100,257.20
					Total:	$	601,543.20
					Use:	**$**	**610,000.00**

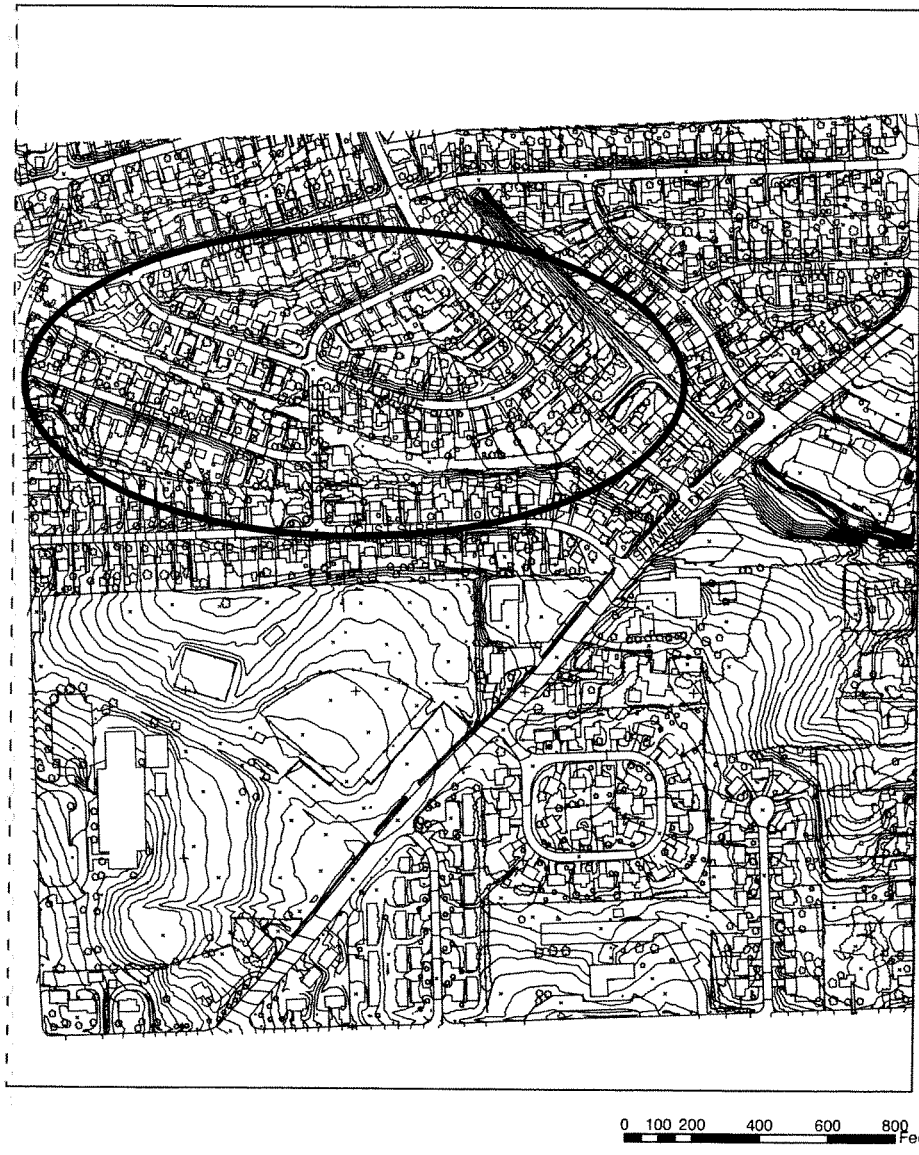
Notes:

1. The costs shown above represent an estimate of probable cost prepared in good faith and with reasonable care. HNTB has no control over the costs of construction labor, materials or equipment, or over any competitive bidding or negotiating methods.

F:\32080\D18_UpperTurkeyCreek\Report\Appendix\[Cost_Estimate.xls]5 kck Enclosed

Task 5 Enclosed System in Kansas City, Ks

Location Map



Task 5: Kansas City, Kansas Enclosed System

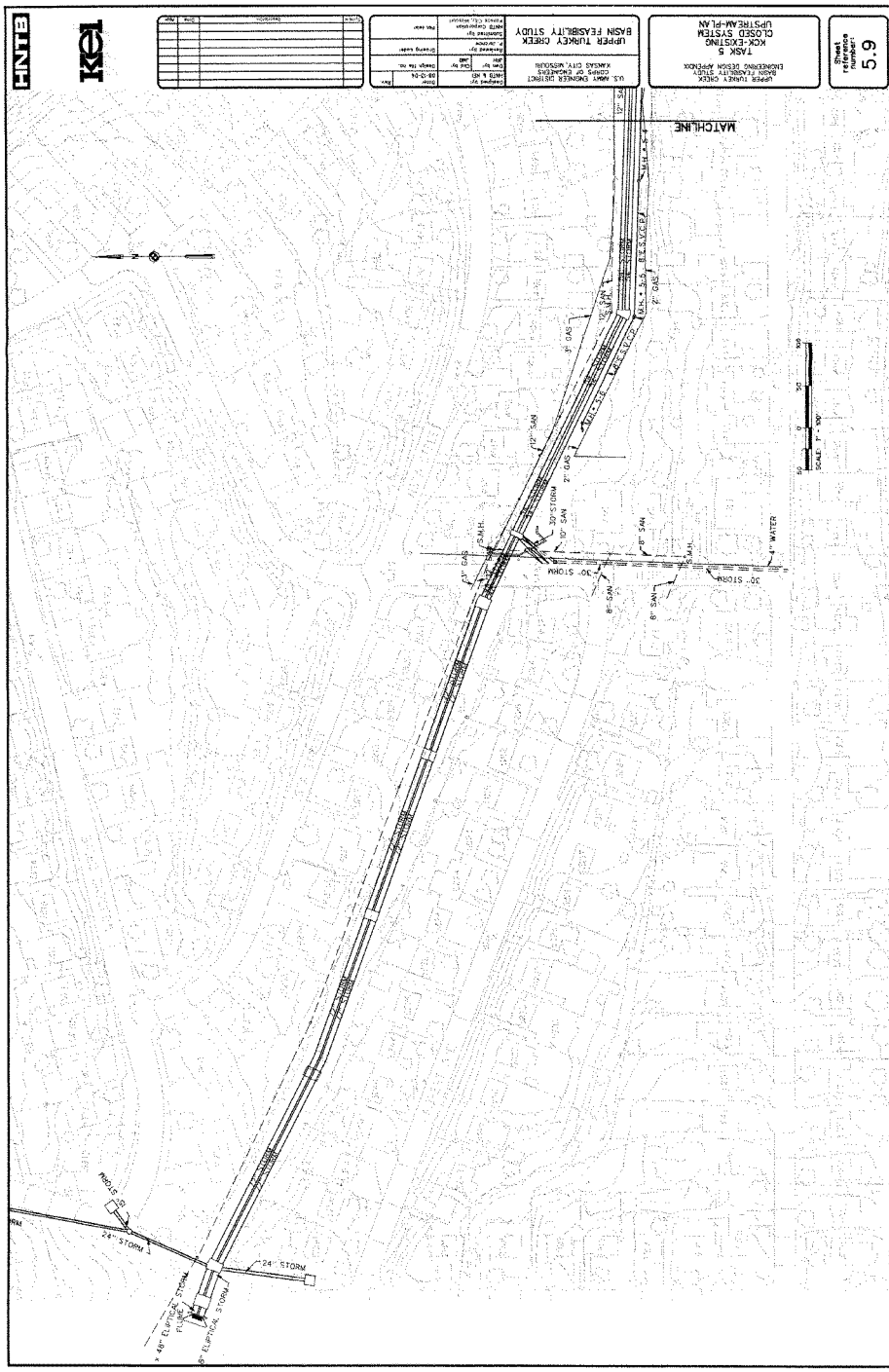
Upper Turkey Creek

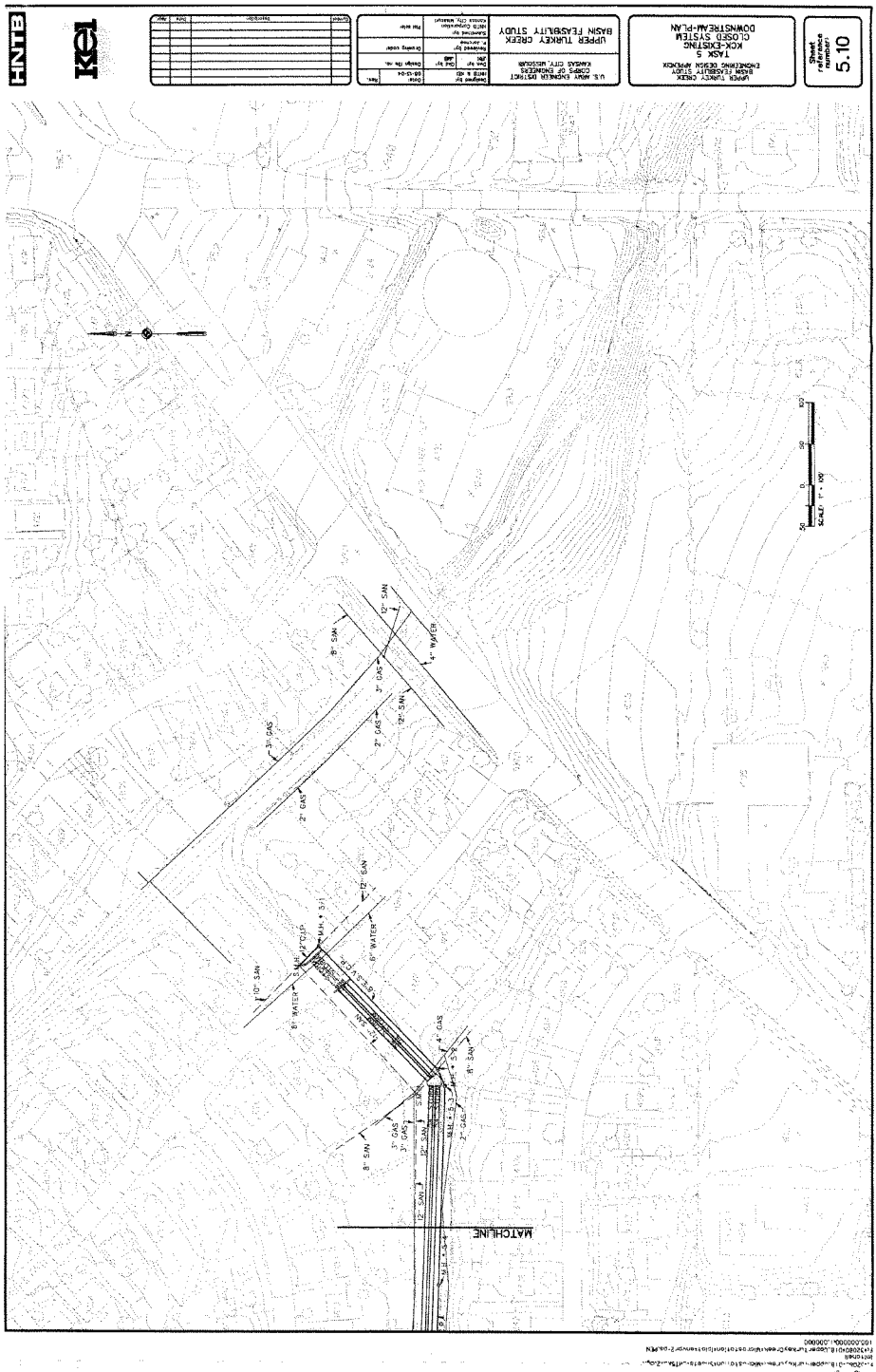
Upstream Face of S. 51st Street Culvert

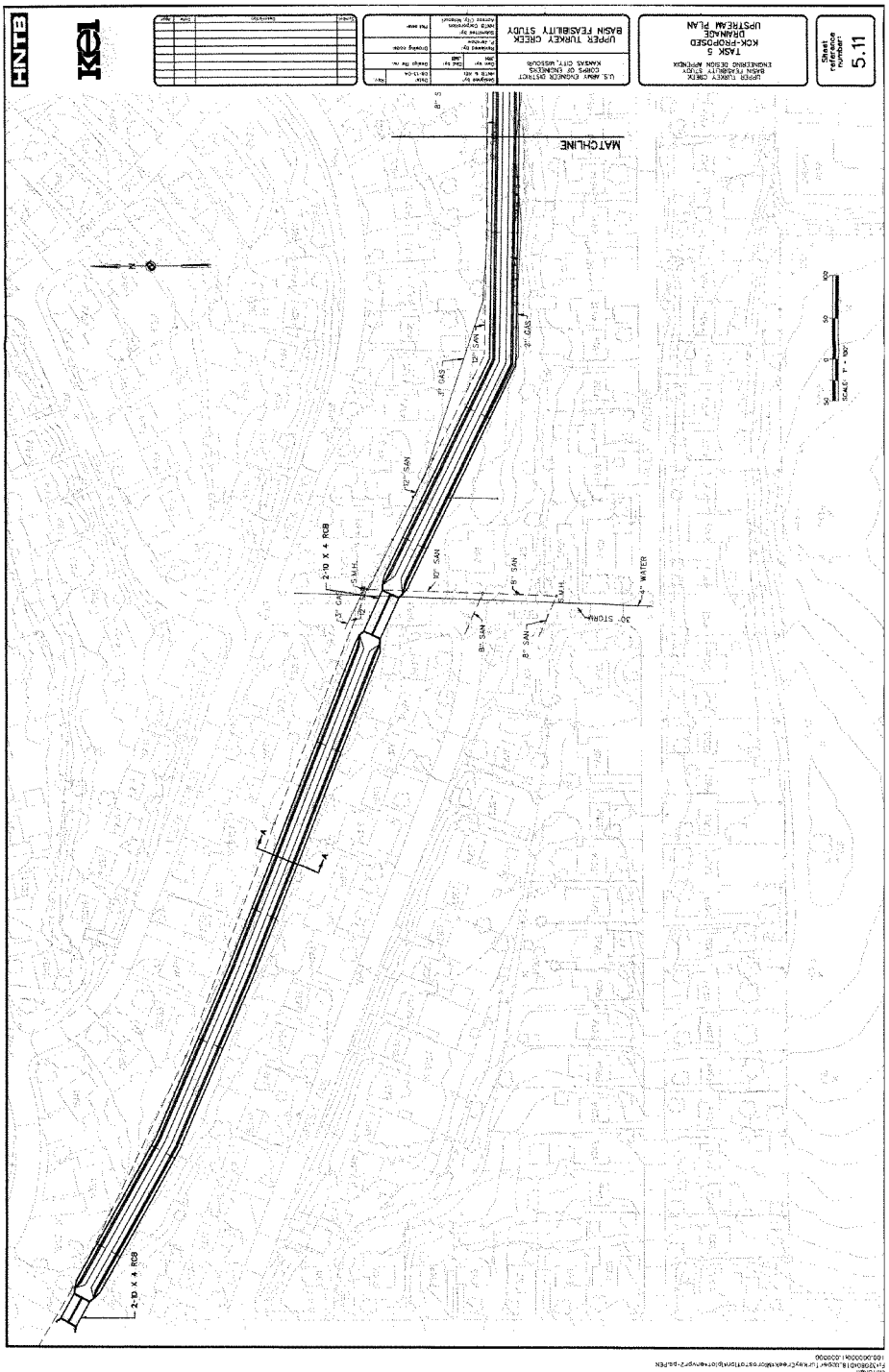
Facing downstream from S. 51st Street

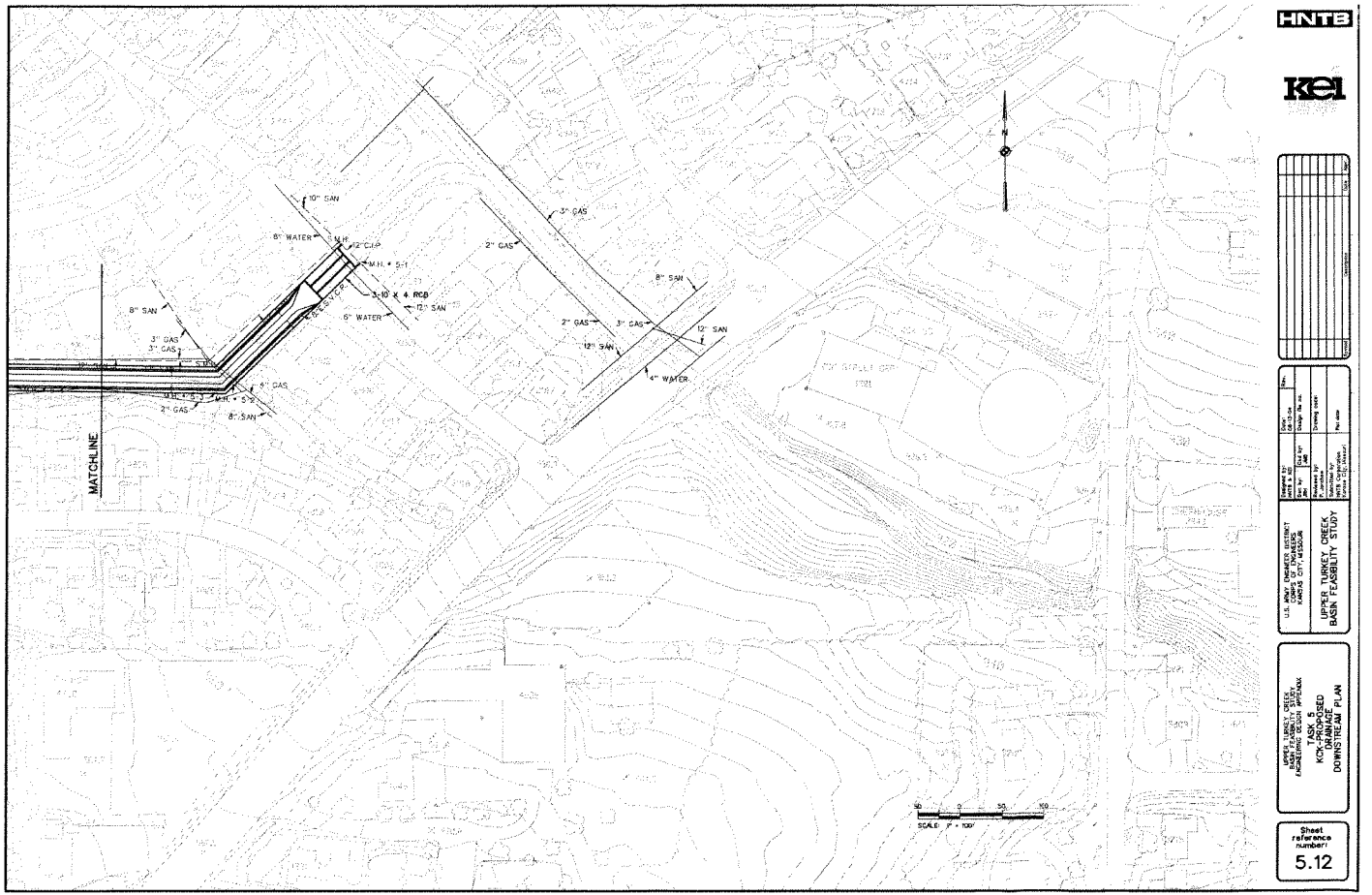
Facing Downstream from S. 50th Street

Concrete Channel downstream of Highland

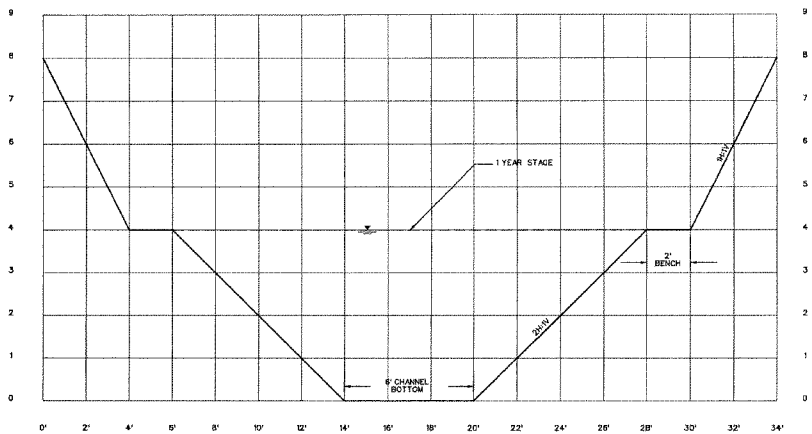

HNTB
kel
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX
TASK 5
KCK-EXISTING
CLOSED SYSTEM
UPSTREAM-PLAN
Sheet reference number:
5.9
MATCHLINE
12" SAN
2" GAS
3" GAS
30" STORM
10" SAN
8" SAN
4" WATER
24" STORM
48" ELIPTICAL STORM
FLUME
SCALE: 1" = 100'


HNTB
KEL
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI
TASK 5
KCK-EXISTING
CLOSED SYSTEM
DOWNSTREAM-PLAN
Sheet reference number:
5.10
MATCHLINE
SCALE: 1" = 100'
12" SAN
8" SAN
4" WATER
3" GAS
2" GAS
10" SAN
6" WATER
4" GAS
8" SAN
2" GAS
12" SAN


HNTB
KEL
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI
TASK 5
KCK-PROPOSED
DRAINAGE
UPSTREAM PLAN
Sheet reference number:
5.11
MATCHLINE
2" GAS
12" SAN
3" GAS
12" SAN
2-10 X 4 RCB
S.M.H.
10" SAN
8" SAN
S.M.H.
4" WATER
30" STORM
8" SAN
8" SAN
2-10 X 4 RCB
SCALE: 1" = 100'



HNTB
KEI
10" SAN
8" WATER
M.H.
12" C.I.P.
M.H. # 5-1
3-10' X 4' RCB
12" SAN
6" WATER
8" SAN
3" GAS
3" GAS
6" GAS
M.H. # 5-3
M.H. # 5-2
2" GAS
8" SAN
MATCHLINE
3" GAS
2" GAS
8" SAN
2" GAS
3" GAS
12" SAN
12" SAN
4" WATER
SCALE: 1" = 100'
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX
TASK 5
KCK-PROPOSED
DRAINAGE
DOWNSTREAM PLAN
Sheet
reference
number:
5.12



CROSS-SECTION FOR CHANNEL

HNTB

KEI

Symbol	Description	Date	Appr.

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY

Designed by: HNTB & KEI
Dwn by: JRK
Ckd by: JAB
Reviewed by: P. Jenkins
Submitted by: HNTB Corporation Kansas City, Missouri
Date: 08/13/04
Design file no.
Drawing code:
Plot date:
Rev.

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX

TASK 5
KCK-PROPOSED
DRAINAGE
CROSS-SECTION A

Sheet reference number:
5.13

LANDSCAPE ON ADJOINING PROPERTY
NATIVE RIPARIAN GRASSES
NATIVE WOODY RIPARIAN SHRUBS PLANTED 4' O.C.
1 YEAR STAGE
NATIVE RIPARIAN GRASSES
CHANNEL BOTTOM
HNTB
KCI
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY MISSOURI
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX
TASK 5
KCK-PROPOSED
PLANTING
CROSS SECTION A
Sheet reference number
5.14

TASK 6: DESIGN A BIOENGINEERING SOLUTION TO STABILIZE STREAMBANKS

KANSAS CITY, KANSAS MAINTENANCE FACILITY

TASK OBJECTIVE

The objective is to design an example of an action to remove retaining walls or other hard surface bank protection where no longer needed, and replace with more vegetated solutions.

SITE SELECTION CRITERIA

The criteria in selecting a site for this task was to determine a suitable location that is representative of other similar locations within the Upper Turkey Creek watershed. The demonstration site is ideally an average representation, based on condition, accessibility, and utility and development conflicts.

This site was inventoried in the Upper Turkey Creek Feasibility Study Environmental Field Assessment provided by the Kansas City District and photographed. It is one of 66 bank erosion sites inventoried in the assessment.

The site was selected based on its unnatural left bank. The tributary is adjacent to the Kansas City, Kansas Street Facilities Maintenance property. Due to the continued asphalt augmentation of the left bank, the corresponding environmental value is negligible. The condition of this stream bank is common in urban areas where the adjacent landowner is attempting to increase usable property.

SITE CONDITIONS/SITE ANALYSIS

This site is located adjacent to a commercial area within a residential neighborhood in Kansas City, Kansas in Wyandotte County. The boundaries of the site include the Unified Government of Kansas City, Kansas Maintenance Facility to the north, Shawnee Mission to the east, 47th Street on the east; and Locust Street on the South. The channel abuts the Kansas City, KS Maintenance Facility to the north and a steep 1H:1V cliff on the south with large brush and trees arching over the channel. Channel measurements indicate a 10-foot bottom and 1H:1V slopes. The north sideslope is covered with debris and asphalt, apparently from what appear to be from the parking lot of maintenance facility. The channel bottom is covered with the same material with some vegetation. The water depth was less than 6-inches. An 8 foot by 6 foot RCB culvert under Shawnee Parkway is at the upstream end of the site. The downstream end directs flow into a 2 – 8 foot by 8 foot RCB Culvert under 47th Street.

No hydraulic analysis was available for this site. Using the HNTB flows provided for the upstream site and the two-foot contour topographic maps we prepared a simple HEC-RAS analysis to analyze sediment flows.

A soil boring taken by the Kansas City District indicated the soils consisted of about 2.5 feet of fill, silty gravelly clay with a gravel zone at about 4 to 5 feet below the surface. The auger refusal occurred at 8.1 feet when a limestone layer was reached.

The site did not appear to be actively downcutting but because of so much work had taken place in the area including a new downstream bridge, and the filling and re-sloping

and asphalting of the stream bank, it was hard to tell. The asphalt cover was eroding at the location of a storm sewer outlet.

RESTORATION DESCRIPTION

The restoration plan consists of removing the recently placed asphalt and fill on the north bank, along the maintenance facility and regrading the slope to a more gradual 2H:1V to 3H:1V slope, similar to what is indicated on the Wyandotte County topography for the site, which is pre-fill. As part of the bank work, the adjacent parking lot at the top of bank would be modified to include a rolled curb to collect the storm water and direct it to a series of stormwater infiltration basins at the top of the bank. The infiltration facilities would help collect the parking lot stormwater and treat it before entering the stream. Rock would be placed at the toe of the bank where needed to help protect the channel toe from erosion. A series of four riffles would be installed in the stream to protect the bioengineering project from downcutting, a common source of failure for bank protection projects. The creek bank will be vegetated with grasses and shrubs. Trees and shrubs will be planted in the infiltration areas along the bank for shade.

Using the sediment transport functions of HEC-RAS and the sediment analysis data, the sediment transport capacity of the channel and riffles were analyzed so as to determine the riffles' ability to pass sediment flows. The sediment sizes for this channel area noted in the report were 0.6 mm to 24 mm. The sediment transport equations chosen to be used were Taffaleti and Yang because of the particle size and channel sizes. The field and work represented. In many cases, they provided similar answers and suggested that the system with riffles would be able to pass significant sediment loads. Because of the lack of a detailed model, no critical depth analysis was done for the riffles. However, Lane's equation was used to size the rock for the riffles.

WATER QUALITY BENEFITS

Asphalt, part of the material dumped along the creek that has also washed in to the creek, is a polluting material in itself. Water quality literature indicates that construction of in-stream structures have a benefit on the in-stream levels of dissolved oxygen. (1) Creation of a vegetated bank will have the similar effect as the construction of a buffer and its water quality benefits (2), though their effect would be reduced to some effect because of the bank slope. The infiltration facilities at the top of bank have a potential to remove up to 60 % of the phosphorous and nitrogen and 90 % of the metals and organics. (3)

HABITAT BENEFITS

Removal of the asphalt from the bank and streams will have a positive effect on aquatic life and habitat. Creation of a vegetated bank will provide additional shading. Water quality improvements due to the buffer- like effect of the vegetated bank in additional to the removal of site runoff pollutants due to the infiltration cells should significantly improve the in-stream habitat. In stream riffles and toe protection rocks should provide additional desirable in-stream aquatic habitat for fish and wildlife.

OPERATION AND MAINTENANCE AND LIFE EXPECTANCY

The vegetation will require maintenance, pruning, trimming, weeding and removal of invasives as will the mulched infiltration planting areas, which will require new mulch yearly or every 2 years. The riffles will require no maintenance, just observation of the rocks that get moved by people. Life expectancy of all the features, except the bioretention infiltration facilities, would exceed 25 years with good maintenance. Because of the nature of the work conducted at the site, the bioretention infiltration basins are only expected to last 10 years. However, the fact that the bioretention cells last only ten years indicate they are receiving significant loadings and important for water quality at the site.

VALUE ENGINEERING

This system was considered a minimum necessary for restoration at this site.

REFERENCES

1. U.S. Environmental Protection Agency, "Ecological Restoration – EPA 841-F-95-007," Publication, U.S. Environmental Protections Agency, November 1995.

2. United States Environmental Protection Agency Office of Water, "Description and Performance of Stormwater Best Management Practices", http://www.epa.gov/ost/stormwater/usw_c.pdf, Washington, D.C.

3. Derek Winogradoff, "Bioretention Monitoring, Preliminary Data Analysis," Department of Environmental Resources, Prince George's County, Maryland, November 1997.

United States Army Corps of Engineers
Upper Turkey Creek
Task 6 KCK Maintenance Facility

HNTB

Engineer's Estimate of Probable Costs

8/12/2004

No.	Item	Quantity	Unit of Measure		Unit Cost		Cost
1	Tree protection	5	Each	$	20.00	$	100.00
2	Clearing	0.27	Acre	$	1,200.00	$	324.00
3	Construction limit fence	500	L. F.	$	1.00	$	500.00
4	Construction access road	1	S. Y.	$	500.00	$	500.00
5	Rock (3ft)	587	Ton	$	30.00	$	17,610.00
6	Seeding	0.84	Acre	$	4,000.00	$	3,360.00
7	Silt Fence	340	L. F.	$	3.00	$	1,020.00
8	Woody trees and shrubs	6002	S. Y.	$	10.00	$	60,020.00
9	Mobilization	1	Lump Sum	$	3,000.00	$	3,000.00
					Subtotal:	$	86,434.00
					20% Contingency	$	17,286.80
					Total:	$	103,720.80
					Use:	**$**	**110,000.00**

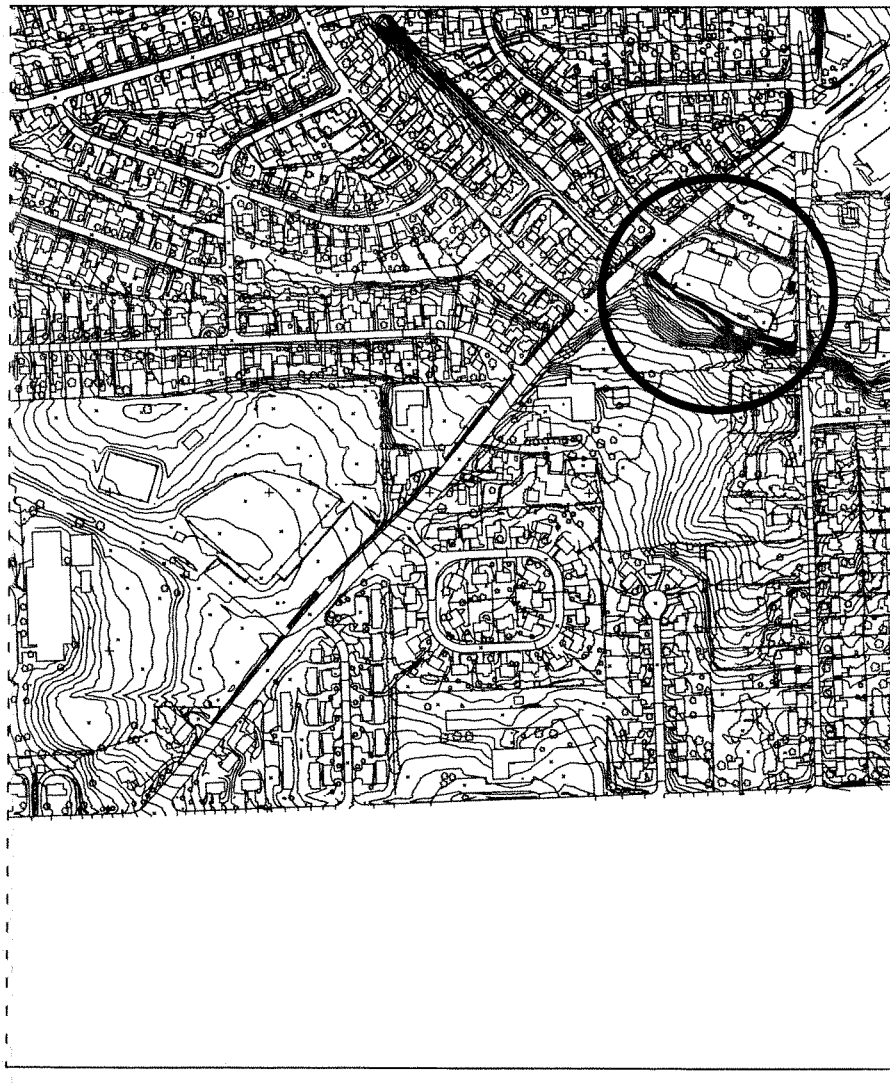
Notes:

1. The costs shown above represent an estimate of probable cost prepared in good faith and with reasonable care. HNTB has no control over the costs of construction labor, materials or equipment, or over any competitive bidding or negotiating methods.

F:\32080\D18_UpperTurkeyCreek\Report\Appendix\[Cost_Estimate.xls]6 kck Maintenance

Task 6 KCK Maintenance Facility

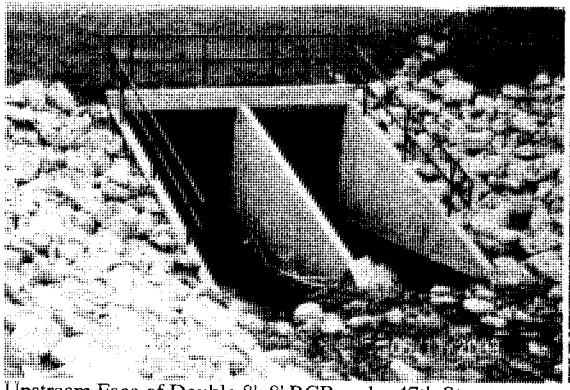
Location Map



0 100 200 400 600 800 Feet

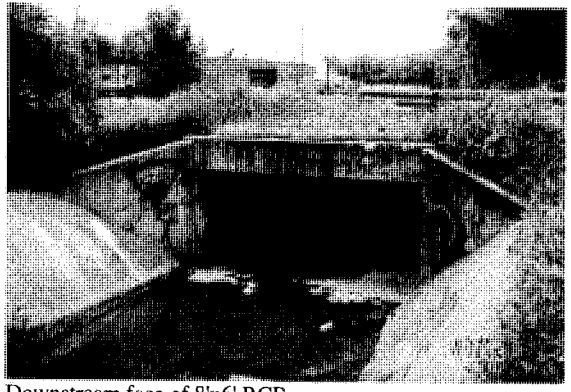
Task 6: KCK Maintenance Facility

Upper Turkey Creek

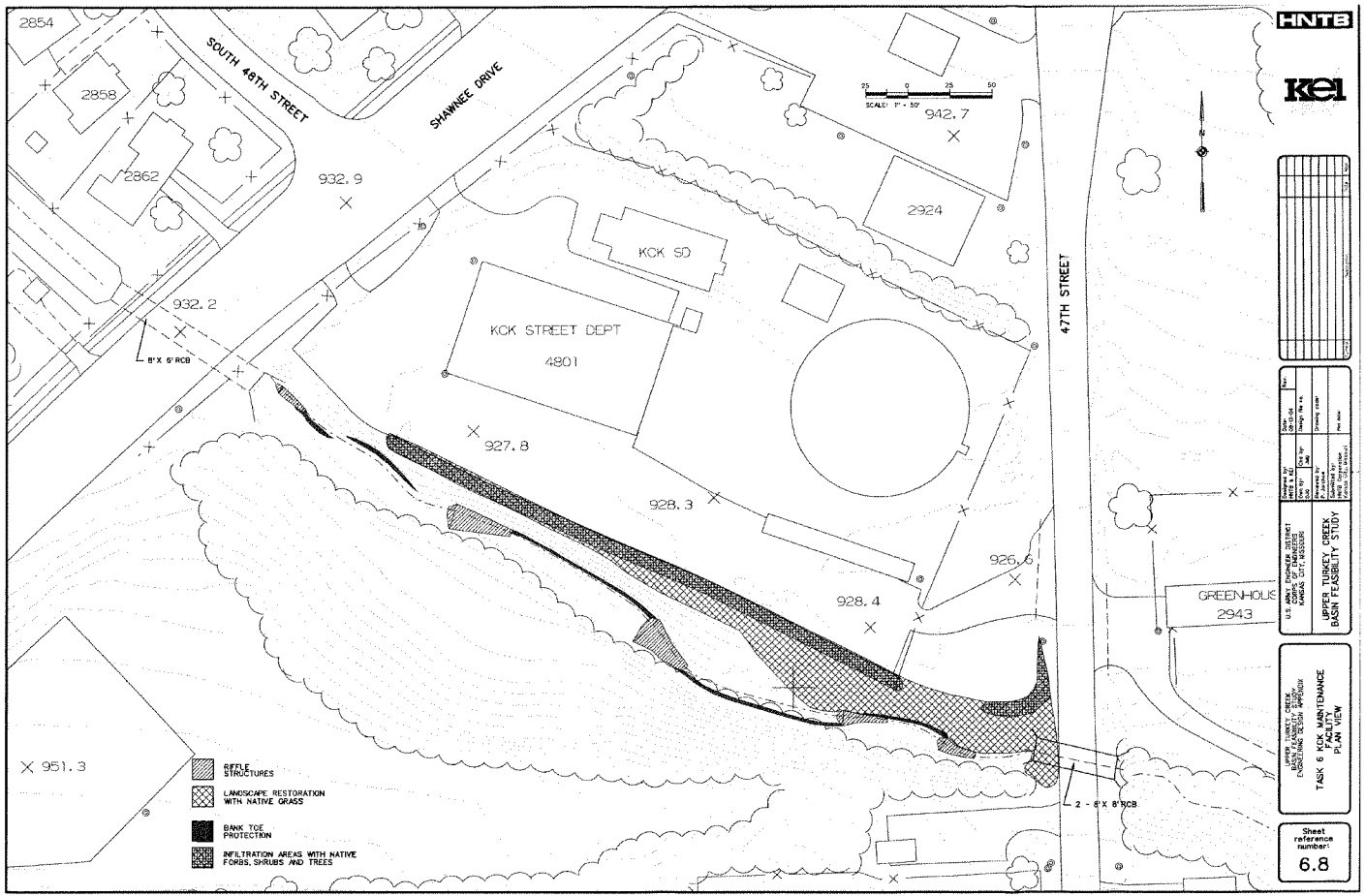


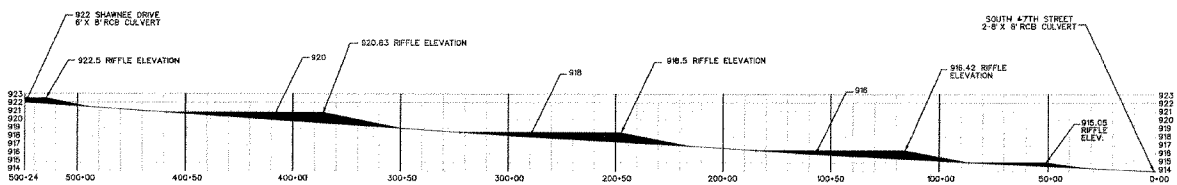
Upstream Face of Double 8'x8' RCB under 47th Street

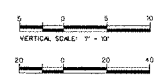
Asphalt-lined channel bank



Downstream face of 8'x6' RCB


2854
2858
2862
SOUTH 48TH STREET
SHAWNEE DRIVE
932.9
932.2
8'X 6'RCB
KCK SD
KCK STREET DEPT
4801
927.8
928.3
928.4
926.6
942.7
2924
47TH STREET
GREENHOUSE
2943
951.3
2 - 8'X 8'RCB
RIFFLE STRUCTURES
LANDSCAPE RESTORATION WITH NATIVE GRASS
BANK TOE PROTECTION
INFILTRATION AREAS WITH NATIVE FORBS, SHRUBS AND TREES
SCALE: 1" = 50'
HNTB
KCI
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS KANSAS CITY, MISSOURI
UPPER TURKEY CREEK BASIN FEASIBILITY STUDY
UPPER TURKEY CREEK BASIN FEASIBILITY STUDY EXISTING CONDITIONS APPENDIX
TASK 6 KCK MAINTENANCE FACILITY PLAN VIEW
Sheet reference number:
6.8





HNTB

KEI

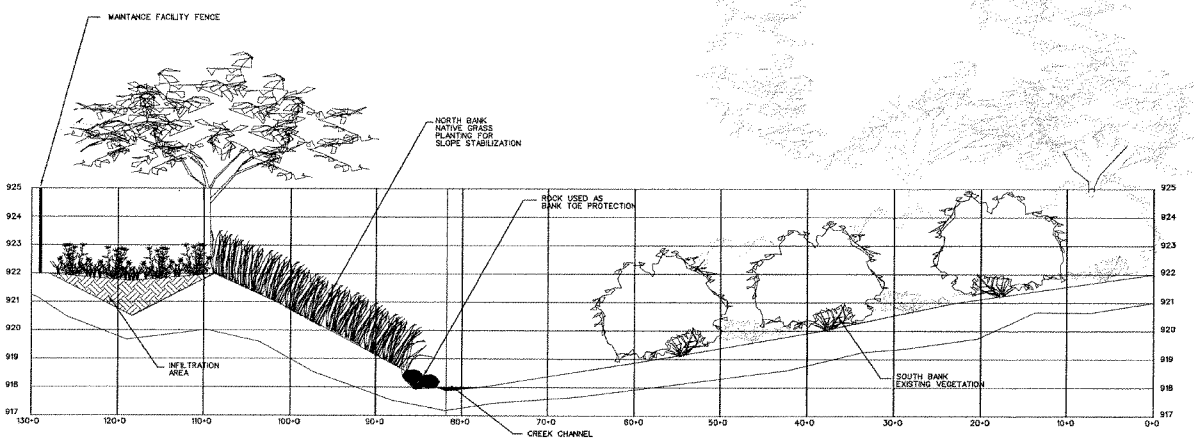
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX

TASK 6 KCK FACILITY PLAN
CREEK PROFILE

Sheet reference number:
6.9



VERTICAL SCALE: 1" = 30'

HORIZONTAL SCALE: 1" = 10'

HNTB

KEI

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX

TASK 6 KCK FACILITY
TYPICAL CREEK SECTION

Sheet reference number:
6.10

TASK 6: 62nd Street and Ballentine

62ND STREET AND BALLENTINE

TASK OBJECTIVE

The objective of this task is to design a bioengineering solution to stabilize eroding streambanks.

SITE SELECTION CRITERIA

The criteria in selecting a site for this task was to determine a suitable location that is representative to other similar locations within the Upper Turkey Creek basin. The demonstration site is ideally an average representation, based on condition, accessibility, and utility and development conflicts.

This site was inventoried in the Upper Turkey Creek Feasibility Study Environmental Field Assessment provided by the Kansas City District and photographed. It is one of the 66 bank erosion sites identified in the assessment.

This site was selected based on its eroding natural reach located between unnatural reaches. The reaches upstream and downstream are concrete and grouted rock channels respectively. The site is located in a residential neighborhood between commercial developments on the right bank / upstream and Shawnee Mission Parkway channelization downstream. Due to the channel improvements, the natural conditions at this site are now subjected to unnatural channel forming discharge peaks and velocities. Locations similar to this are common and it is preferred that these natural conditions are preserved and protected.

SITE CONDITIONS/SITE ANALYSIS

Upon further investigation an uncased sanitary sewer line was also found to be exposed along the creek (see photo), in addition to the exposed line crossing the creek. Plans dating back from the installation indicated the parallel sewer line was to be buried 5 feet in to the bank. A review of historic USGS maps suggest the that the creek bank across the stream from the exposed lateral line has been filled and developed since the time of the sewer installation.

This site is located between a residential neighborhood to the North and a Commercial area to the south in Shawnee, Kansas of Johnson County. The channel dimensions include a bottom width averaging 20 feet with 1H:1V slopes. Heavy erosion is visible on both sides of the channel, especially in the channel bend. The channel bottom primarily consists of silty soil. The average water depth is about 3 feet . A large pond area with water averaging 3 – 5 feet in depth is located where Ballentine Road intersects with the creek and continues through the downstream meander where it connects to the culvert under Shawnee Mission Parkway. Within this same region, an unencased 24"-inch sanitary sewer is exposed at the bottom of the channel.

The two-year flow at the site is 1911 cfs, which is the approximate bank full flow based on the existing HEC-RAS analysis. The sediment data analyzed by Geotechnology, Inc. for the site indicated the grain size distributions to be from 0.6 mm to 24 mm.

RESTORATION DESCRIPTION

The initial approach of simply filling in the creek bank to re-cover the exposed lateral line was discarded because the stream width would have to be significantly narrowed unless the opposite bank, a commercial site, was excavated and regraded. The potential use of vacant adjacent land to redirect the stream was also considered. A new channel was designed to make the channel bend more gradual at the location, in keeping with the recommendation of natural channel design techniques.(2) The new channel was designed to have a 20 foot wide bottom width and a channel with 2V:1H bank slopes up to approximately the 3 foot high channel elevation at which point the channel becomes more gradual with 3V:1H and 5V:1H bank slopes.

The location the two channels join at the upstream end of the reach was relocated to create the more gradual transition. In addition the exposed sewer crossing, the creek bed was covered by a series of rock riffles to help protect the toe of the bank protection project and to keep the channel from downcutting and undermining the vegetated bank solution for the rebuilt stream bend. The creek bank will be vegetated with grasses and shrubs. Trees and shrubs will be planted along the bank for shade. Rock will be added for toe protection downstream of the last riffle.

The sediment carrying capacity of the stream was calculated using the soils data and geotechnical information obtained by the Kansas City District. Because the channel was going to be relocated as part of the project, a stable channel design analysis was also prepared. The sediment analysis indicated that the proposed design could pass an expected sediment load. The stable channel design suggested a channel approximately twice as wide as the channel that currently exists for the same depth of flow.

Riffles were sized using Lane's equation. (3) The riffle crest elevations were initially calculated using critical depth equations and then checked in the HEC-0RAS analysis. The existing HEC-RAS model was modified to reflect surveyed stream bottom elevations and the proposed channel work. The results are included in the Appendix.

WATER QUALITY BENEFITS

Using historic utility plans, the erosion rate at the site was calculated and found to be 0.22 CY per running foot per year. For each 100 foot length of stream in the reach 2.2 CY of sediment is deposited in the stream each year. Water quality literature indicates that construction of in-stream structures have a benefit on the in-stream levels of dissolved oxygen. (1) It is estimated that the sediments deposited in the stream each year from 50 similar sites is 110 cubic yards.

HABITAT BENEFITS

Reconstruction of an eroded bank, particularly with a new channel and the installation of rock riffles for grade protection, will provide an enhanced fish and benthic aquatic habitat over the existing soft sediment bottom stream with visible high level of total suspended solids and exposed sanitary sewer pipes.

OPERATION AND MAINTENANCE AND LIFE EXPECTANCY

Generally, natural riffles and channels require no maintenance. As this is a design scenario the site should be monitored after major flood events to determine the performance of the project. It is expected that the channel and riffle will move with time as the stream reaches a dynamic equilibrium. Ideally, the changes that will occur in the watershed due to development have already taken place. Should the dynamic equilibrium condition appear to potentially cause problems, the stream will need to be reassessed.

There is no life expectancy limit noted in the literature for natural channel and riffles. Performance over time can be enhanced as the channel develops a healthy ecosystem and the riffle attract biological life on the rocks that result in improvement in the food chain and aid in denitrifying ammonia in the water.

The analysis for this design is based on limited survey data and a hydraulic model that should be evaluated because of the response of the downstream structure in the model. Before construction plans and specifications are prepared, the base model should be reviewed, and the design assumptions and analysis rechecked, if necessary.

VALUE ENGINEERING

This design requires extensive relocation of the channel. It appears these actions are in part prompted because of historic filling that took place along the opposite bank for businesses and the fact the utilities were buried throughout the stream reach in the stream or stream corridor. One alternative may be to relocate the sewers, and build a rock diverter structure at the downstream end to protect the downstream home excavate a portion of the overbank to help carry flood flows and allow the stream to continue to erode.

REFERENCES

1. U.S. Environmental Protection Agency, "Ecological Restoration – EPA 841-F-95-007," Publication, U.S. Environmental Protections Agency, November 1995.

2. Dr. Robert W. Newbury and Marc N. Gaboury, "Stream Analysis and Fish Habitat Design," A Field Manual, Newbury Hydraulics Ltd., Gibsons, British Columbia, Canada, 1993.

3. Dr. Robert W. Newbury, et al, "Field Manual of Urban Stream Restoration," Illinois State Water Survey, Champaign, IL, 1998.

United States Army Corps of Engineers
Upper Turkey Creek
Task 6 Ballentine

HNTB

Engineer's Estimate of Probable Costs

8/12/2004

No.	Item	Quantity	Unit of Measure		Unit Cost		Cost
1	Tree protection	15	Each	$	20.00	$	300.00
2	Clearing	2	Acre	$	1,200.00	$	2,400.00
3	Construction limit fence	1000	L. F.	$	1.00	$	1,000.00
4	Sewer line protection	31	C. Y.	$	120.00	$	3,720.00
5	Abandon Sewer	622	L. F.	$	11.00	$	6,842.00
6	24" PVC	400	L. F.	$	30.00	$	12,000.00
7	21" PVC	300	L. F.	$	35.00	$	10,500.00
8	4' Manhole	4	Each	$	3,000.00	$	12,000.00
9	Cut	4974	C. Y.	$	5.00	$	24,870.00
10	Fill	1507	C. Y.	$	5.00	$	7,535.00
10	Erosion control fabric	2243	S. Y.	$	5.00	$	11,215.00
11	Construction access road	2	Each	$	1,000.00	$	2,000.00
12	Rock (?ft)	596	C. Y.	$	30.00	$	17,880.00
13	Native grasses	0.15	Acre	$	4,000.00	$	600.00
14	Native Deciduous trees and shrubs	1514	S. Y.	$	10.00	$	15,140.00
15	Asphalt repair	50	S. Y.	$	18.00	$	900.00
16	Mobilization	1	Lump Sum	$	5,000.00	$	5,000.00
					Subtotal:	$	128,902.00
					20% Contingency	$	25,780.40
					Total:	$	154,682.40
					Use:	**$**	**160,000.00**

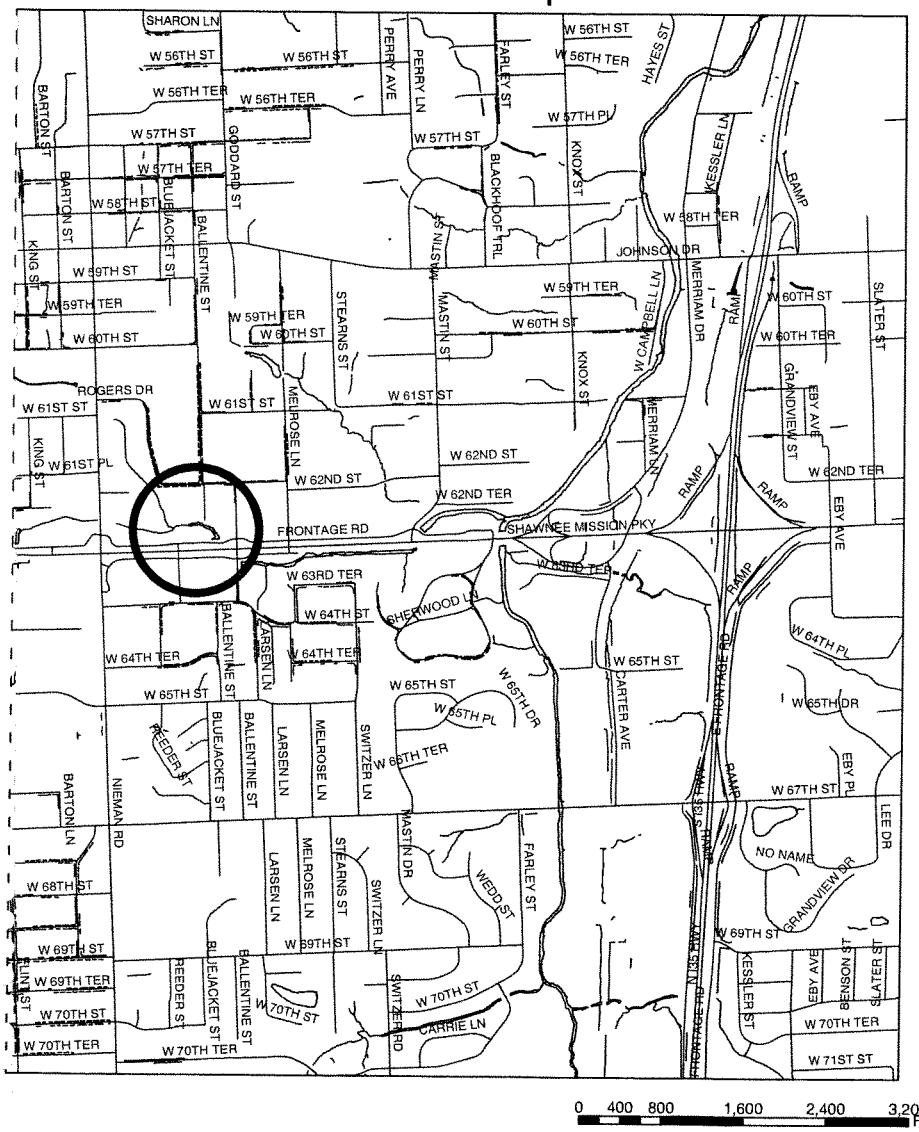
Notes:

1. The costs shown above represent an estimate of probable cost prepared in good faith and with reasonable care. HNTB has no control over the costs of construction labor, materials or equipment, or over any competitive bidding or negotiating methods.

F:\32080\D18_UpperTurkeyCreek\Report\Appendix\[Cost_Estimate.xls]6 Ballentine

Task 62nd and Ballentine

Location Map

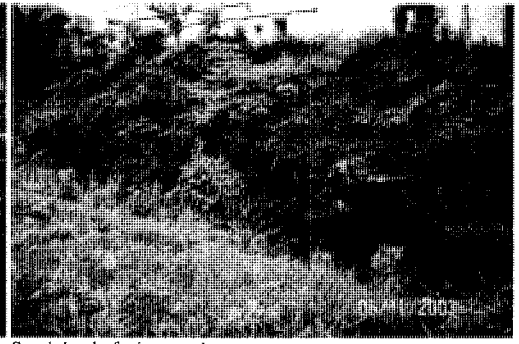


0 400 800 1,600 2,400 3,200 Fe

Task 6: 62nd and Ballentine

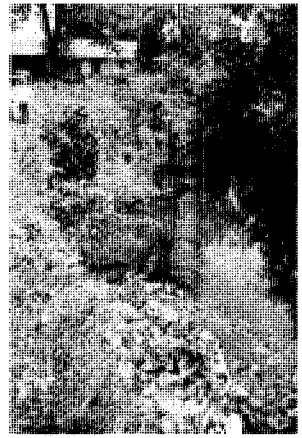
Upper Turkey Creek

Eroding left bank, facing east

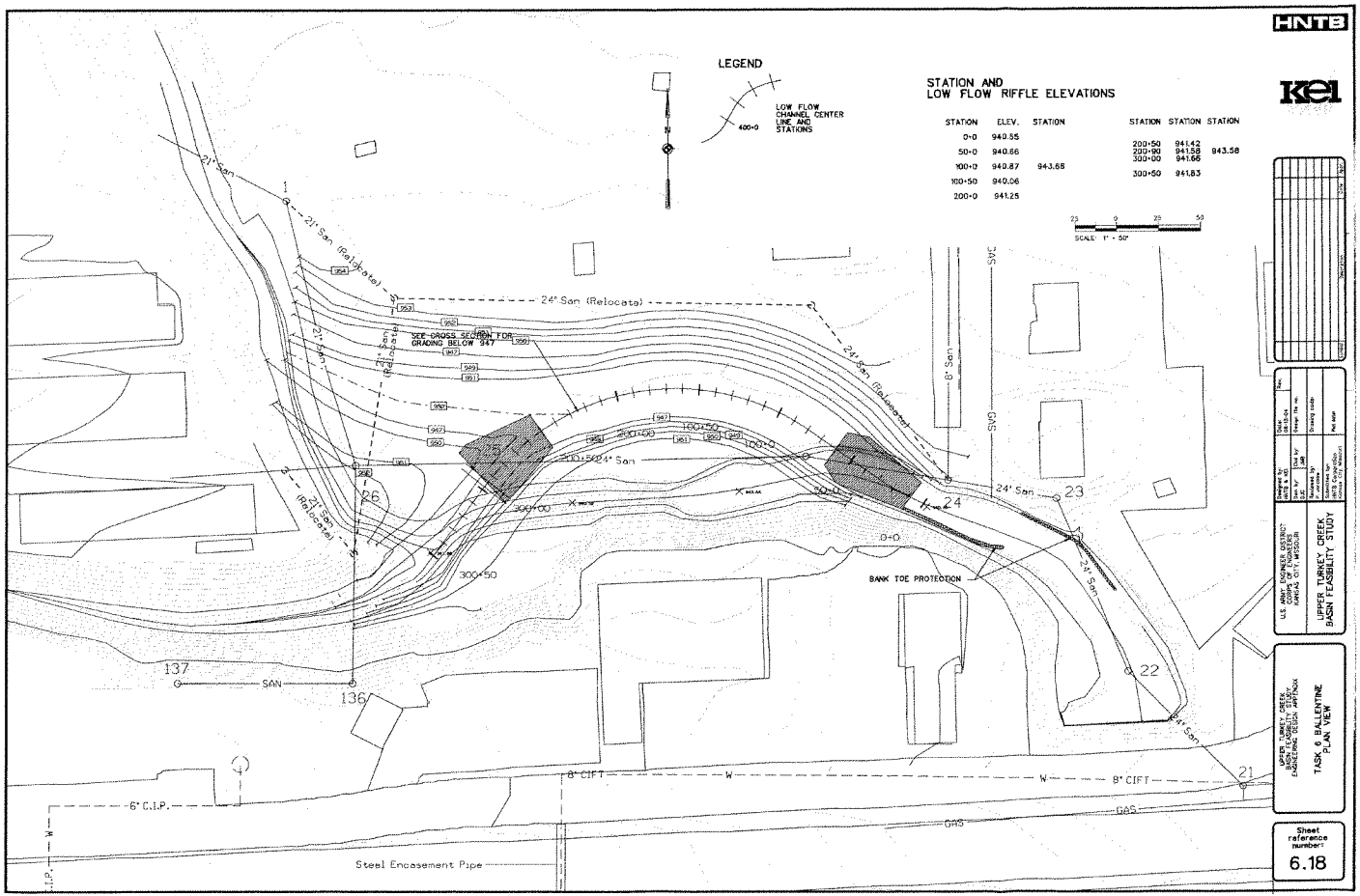


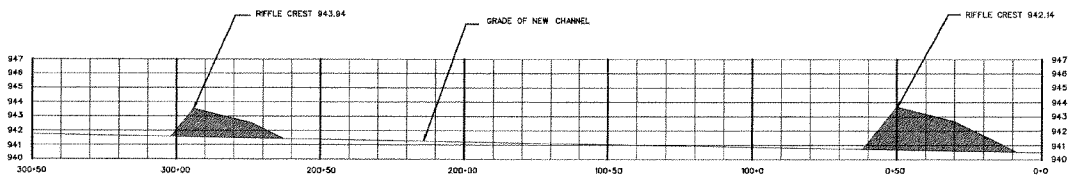
South bank, facing southeast

South bank upstream, facing west



24" sanitary sewer exposed due to north bank erosion, facing


HNTB
KEL
LEGEND
LOW FLOW CHANNEL CENTER LINE AND STATIONS
400+0
STATION AND LOW FLOW RIFFLE ELEVATIONS
STATION ELEV. STATION
0+0 940.55
50+0 940.66
100+0 940.87 943.65
100+50 940.06
200+0 941.25
STATION STATION STATION
200+50 941.42
200+90 941.58 943.58
300+00 941.66
300+50 941.83
SCALE: 1" = 50'
21" San
21" San (Relocate)
24" San (Relocate)
24" San
8" San
SEE CROSS SECTION FOR GRADING BELOW 947
BANK TOE PROTECTION
SAN
8" CIFT
6" C.I.P.
GAS
Steel Encasement Pipe
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS KANSAS CITY, MISSOURI
UPPER TURKEY CREEK BASIN FEASIBILITY STUDY
UPPER TURKEY CREEK BASIN FEASIBILITY STUDY ENGINEERING DESIGN APPENDIX
TASK 6 BALLENTINE PLAN VIEW
Sheet reference number: 6.18



NEW CHANNEL PROFILE

30 0 30 60
VERTICAL SCALE: 1" = 60'

15 0 15 30
HORIZONTAL SCALE: 1" = 30'

HNTB

KEI

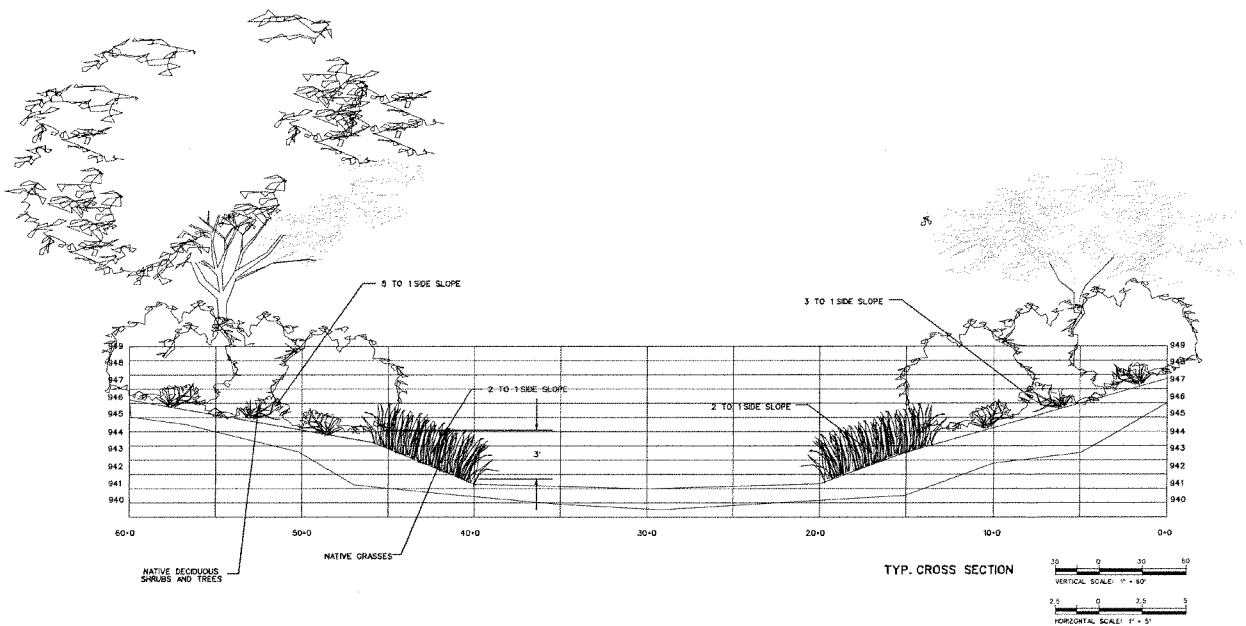
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX

TASK 8 BALLENTINE
CHANNEL PROFILE

Sheet reference number:
6.19



HNTB

KEI

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX

TASK 6 BALLENTINE
TYPICAL CROSS SECTION

Sheet reference number:
6.20

TASK 7: RECONNECT THE CHANNEL AND FLOODPLAIN FOR WATER QUALITY BENEFITS

67TH STREET AND KNOX

TASK OBJECTIVE

The objective of this task is to reconnect the channel and the floodplain for water quality benefits and create open space for greenways and trails.

SITE SELECTION CRITERIA

The criteria in selecting a site for this task was to determine a suitable location that is representative to other similar locations within the Upper Turkey Creek watershed. The demonstration site is ideally an average representation, based on condition, accessibility, and utility and development conflicts.

This site was photographed and inventories in the Upper Turkey Creek Feasibility Study Environmental Field Assessment provided by the Kansas City District. It is one of 53 open areas along the stream noted as part of the assessment.

This site was selected based on its proximity to the unused electrical easement adjacent to the creek main stem. This left bank easement appeared to be regularly mowed. If partially excavated, this particular site could provide some overbank inundation and water quality benefits. Easements with high voltage power lines are common in urban areas, and could be improved environmentally; although, it is important that the vegetation be maintained to prevent conflict with the dangerous lines and that access and geotechnical stability be provided at the power poles.

SITE CONDITIONS/SITE ANALYSIS

This site is located in a commercial area of the City of Merriam, Kansas of Johnson County. The boundaries of the site include 67th Street to the North, Knox Street to the east, Farley Street to the west, and 69th Street to the south. The channel is within a recreational walkway area, which extends further south of the site. The channel bottom is approximately 30-foot wide and the side slopes vary between 1H:1V to 2H:1V. Moderate vegetation is located on both side slopes, with the exception of riprap in the bridge opening under 67th Street. The channel bottom primarily consists of rock. During dry periods, the water depth varies from 1-foot to 3-foot deep.

The utilities located in the area include several power lines on the west of the channel. There are also several culvert outlets on the east and west banks.

The Turkey Creek drainage area is approximately 6.8 square miles at this location. The stream banks are steep with an approximately 1H:1V to 2H:1V side slope and are approximately 12-feet high. The 10-year flood is contained within the banks at this location. The 1-year flow is 2,637 cfs and flows 7 to 8.5 feet deep and 65 to 85 feet wide. The 100-year flow is 13 to over 16 feet deep and is out of bank.

RESTORATION DESCRIPTION

Most natural streams overflow into their floodplains at a flood event between the 1-year and the 2-year frequency events. The proposed design includes reconnecting the channel and floodplain at an elevation just above the 1-year flow frequency elevation. The plan includes excavating a 1200 feet section of overbank approximately 100-150 feet wide and planting the area with native vegetation. Trees would be placed along the

top of the new stream bank to provide shade. The flow channel size will be derived and possible instream structures proposed once soils and geotechnical analyses is available for sediment flow analysis.

WATER QUALITY BENEFITS

Creating a wide vegetated, floodplain subject to near yearly inundation provides a place and a mechanism for silts and any associated pollutants to drop out of the stream and become attached to or used by native vegetation. The floodplain also comes to act as an adjacent overland flow buffer and partial restoration of the riparian corridor. As a stream buffer the reconnected floodplain greenway can remove pollutants and stop pollutants from entering the stream (1). Planted trees can help shade the stream helping to reduce nitrates, pH levels and high stream temperatures and the resulting negative effects on stream dissolved oxygen levels.(2)

HABITAT BENEFITS

Creation of a connected stream floodplain provides a significant area of primarily upland greenway providing habitat and habitat connection for non-aquatic wildlife. Stream shading will improve stream habitat for fisheries.(2)

FLOOD REDUCTION IMPACT

Reconnecting the channel with the floodplain provides additional storage.

MAINTENANCE REQUIREMENT AND EXPECTED DESIGN LIFE

The site require normal vegetation maintenance, include periodic mowing and tree maintenance. The excavated overbank can last indefinitely and has no limited life.

VALUE ENGINEERING ALTERNATIVES

The site could be analyzed using HEC-RAS to determine if less excavation could accomplish similar reductions in channel velocity and bank shear for the bank full event, optimizing the results received from the minimum amount of excavation.

REFERENCES

1. United States Environmental Protection Agency Office of Water, "Description and Performance of Stormwater Best Management Practices", http://www.epa.gov/ost/stormwater/usw_c.pdf, Washington, D.C.

2. U.S. Environmental Protection Agency, "Ecological Restoration – EPA 841-F-95-007," Publication, U.S. Environmental Protections Agency, November 1995.

United States Army Corps of Engineers
Upper Turkey Creek
Task 7 - 67th & Knox

HNTB

Engineer's Estimate of Probable Costs

8/12/2004

No.	Item	Quantity	Unit of Measure		Unit Cost		Cost
1	Utility structure protection	4	Each	$	20.00	$	80.00
2	Tree removal	1	Each	$	2,000.00	$	2,000.00
3	Manhole Adjustments	2	Each	$	500.00	$	1,000.00
4	Utility relocation (Overhead Telephone)	4	Each	$	2,500.00	$	10,000.00
5	Clearing	2.61	Acre	$	1,200.00	$	3,132.00
6	Construction limit fence	1300	L. F.	$	1.00	$	1,300.00
7	Excavation	30664	C. Y.	$	8.00	$	245,312.00
8	Silt Fence	1400	L. F.	$	3.00	$	4,200.00
9	Construction access road	1	Each	$	1,500.00	$	1,500.00
10	Native grasses	2.61	Acre	$	4,000.00	$	10,440.00
11	Woody trees and shrubs	1	Each	$	12.00	$	12.00
12	Mobilization	1	Lump Sum	$	11,000.00	$	11,000.00
					Subtotal:	$	278,976.00
					20% Contingency	$	55,795.20
					Total:	$	334,771.20
					Use:	**$**	**340,000.00**

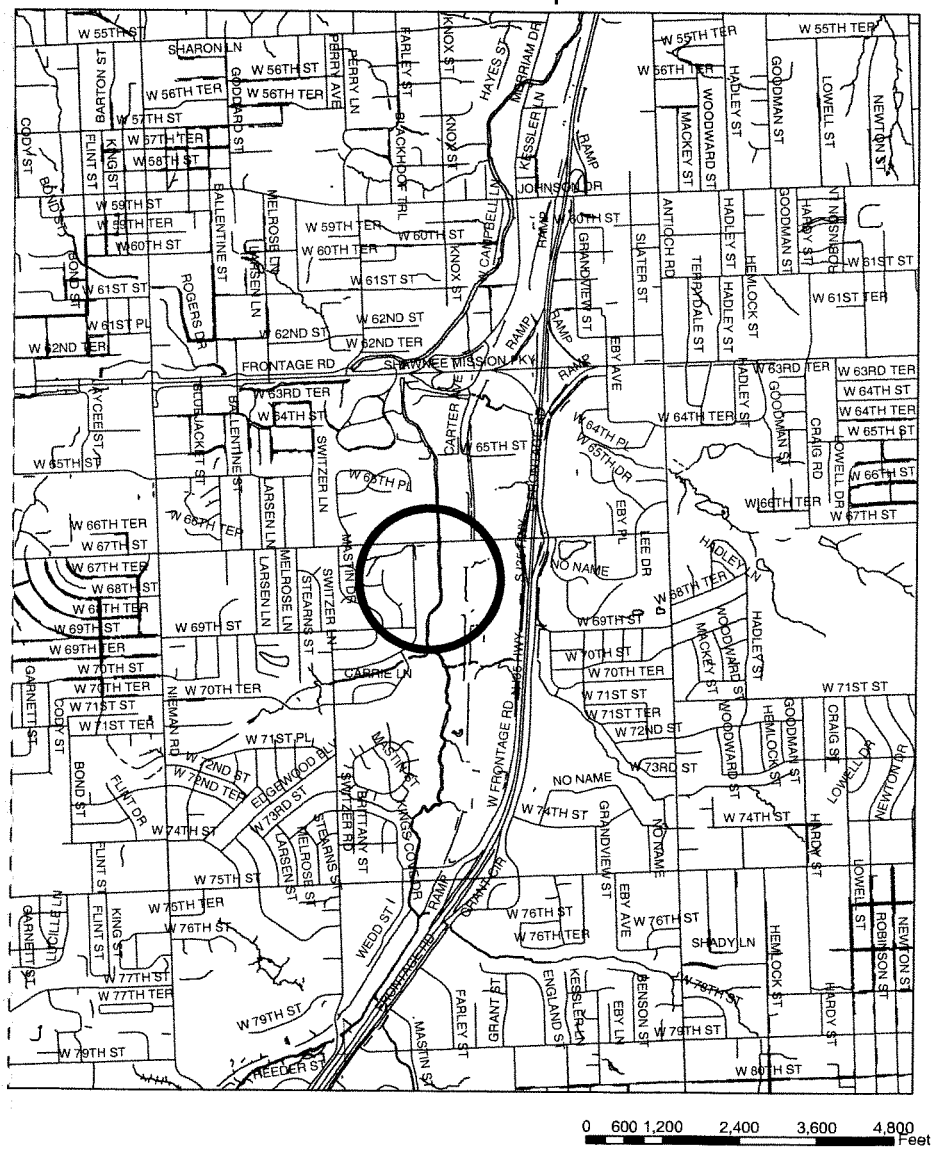
Notes:

1. The costs shown above represent an estimate of probable cost prepared in good faith and with reasonable care. HNTB has no control over the costs of construction labor, materials or equipment, or over any competitive bidding or negotiating methods.

F:\32080\D18_UpperTurkeyCreek\Report\Appendix\[Cost_Estimate.xls]7 67th and Knox

Task 7-2-14 67th and Knox

Location Map



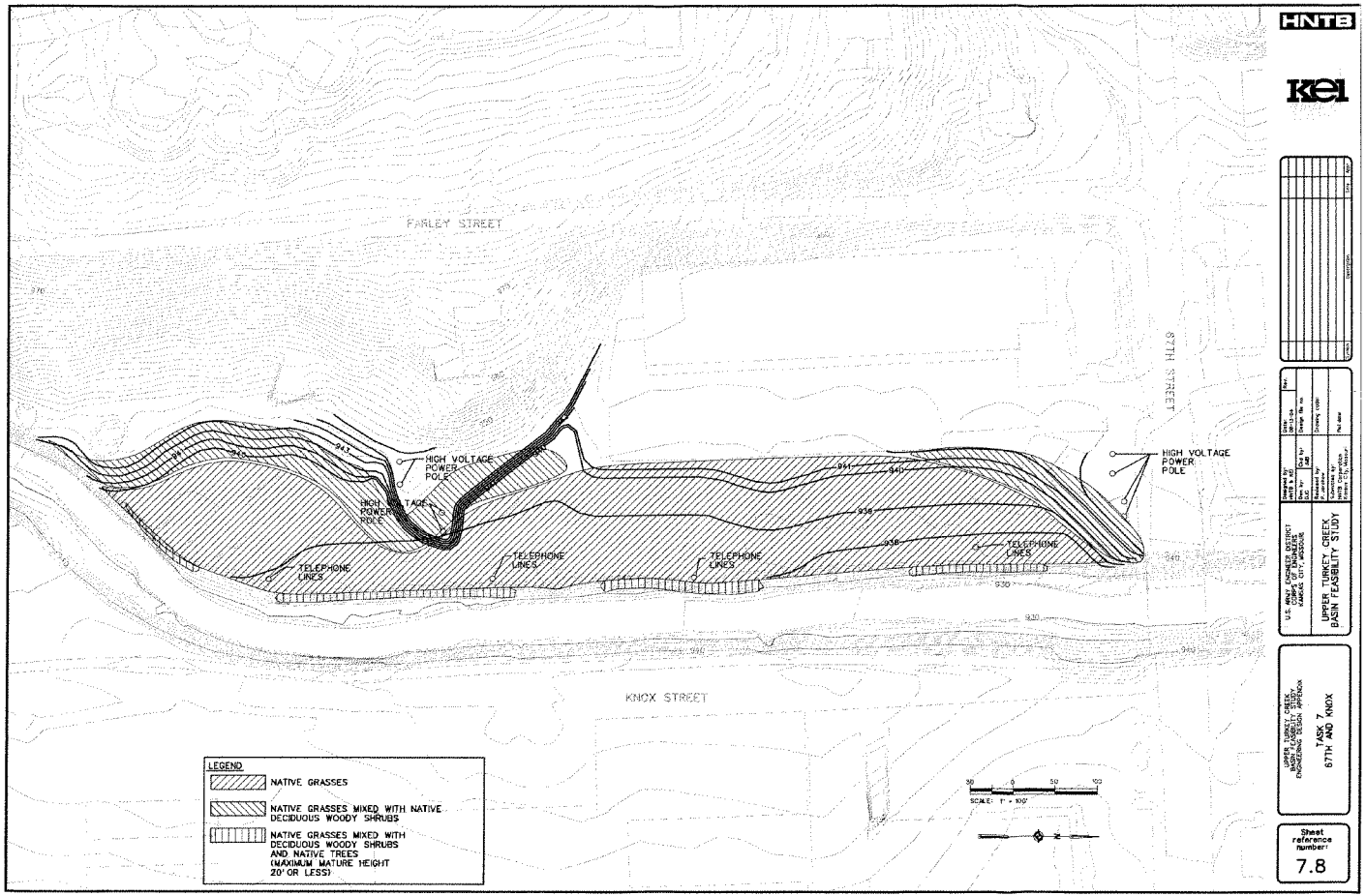
Task 7: 67th and Knox

Upper Turkey Creek

Main channel of UTC South of 67th Street

67th Street Bridge

HNTB
KEL
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
CONCEPTUAL DESIGN APPROACH
TASK 7
67TH & KNOX
GRADING PLAN
Sheet reference number
7.7
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
67TH ST
KNOX ST
HIGH VOLTAGE POWER POLE
TELEPHONE LINES
SCALE: 1" = 100'


FARLEY STREET
67TH STREET
KNOX STREET
HIGH VOLTAGE POWER POLE
HIGH VOLTAGE POWER POLE
HIGH VOLTAGE POWER POLE
TELEPHONE LINES
TELEPHONE LINES
TELEPHONE LINES
TELEPHONE LINES
941
940
939
938
930
LEGEND
NATIVE GRASSES
NATIVE GRASSES MIXED WITH NATIVE DECIDUOUS WOODY SHRUBS
NATIVE GRASSES MIXED WITH DECIDUOUS WOODY SHRUBS AND NATIVE TREES (MAXIMUM MATURE HEIGHT 20' OR LESS)
SCALE: 1" = 100'
N
HNTB
KEI
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS KANSAS CITY, MISSOURI
UPPER TURKEY CREEK BASIN FEASIBILITY STUDY
TASK 7
67TH AND KNOX
Sheet reference number:
7.8

TASK 8: EMPHASIZE STORMWATER AND FLOODWATER INFILTRATION OVER CONVEYANCE SYSTEMS

QUAIL CREEK PARK

TASK OBJECTIVE

The objective of this task is to emphasize natural stormwater and floodwater infiltration systems over concrete lined floodwater and stormwater conveyance systems.

SITE SELECTION CRITERIA

The criteria used in selecting a site for this task was to determine a suitable location which is most representative of other similar locations within the Upper Turkey Creek watershed. The demonstration site is ideally an average representation, based on condition, accessibility, and utility and development conflicts.

This site was inventoried in the Upper Turkey Creek Feasibility Study Environmental Field Assessment provided by the Kansas City District and photographed. It is one of 45 concrete lined channel sections noted in on the assessment.

This site was selected based on its previously problematic past. Homes in this location were prone to inundation and were bought out by the government and the area was turned into a park. The existing concrete channel does not provide adequate conveyance and infiltration. The proposed natural channel can be sized accordingly and its permeable earthen and vegetative components are expected to improve the situation. Locations similar to this are common, making this a suitable demonstration site.

SITE CONDITIONS/SITE ANALYSIS

This site is located in a residential area now used as a recreational park of the City of Merriam, Kansas in Johnson County. The boundaries of the site include 70th Street to the north, I-35 Highway to the west, Grandview Road to the east, and 71st Street to the south. The upstream channel is natural with a rock bottom. The downstream channel is concrete with a bottom approximately 10-foot wide and with side slopes at 1H:1V. The downstream end enters a 20-foot arch culvert that drains under Highway I-35. During dry periods the majority of the channel bottom remains dry.

The utilities located in the area include a power line directly along the top of the east bank. Also, a sanitary sewer line is positioned parallel with the channel approximately 10-feet from the top of bank.

The drainage area is 720 acres. The one-year flood depth is approximately 6 to 9 feet deep and the flow width varies between 30 to 60 feet. The one-year flow is 1,200 cfs.

REFERENCE STREAM SURVEY

Reference stream data was collected at Clear Creek north of 79th Street and east of Mize Road in the Mill Creek Watershed in Johnson County, Kansas. A 200-foot reach of Clear Creek was selected as a reference stream, because it was a stable, natural reach with a meandering form. The reference stream had a shale rock bottom with sediment accumulation in some areas. The bank-full channel width varied from 27 to 32 feet and the channel depth ranged from 4 to 8.5 feet. The water depth ranged from 0.5 to 1.3 inches on the day the survey was conducted.

RESTORATION DESCRIPTION

The proposed restoration plan consists of rebuilding the channel in a natural meandering plan form in combination with leaving the existing concrete channel in place and backfilling it. Part of the reason in leaving the concrete of the existing channel in place was to provide stability for the toe of the bank of the opposite channel bank, which has a very steep high bank with homes very close to the creek. The new channel will have a ten foot bottom width and top width of approximately 50 feet at the one-year flow and a depth of 8 feet. Nine riffles and meander bends are proposed for the new channel and have been designed using the techniques described by Dr. Robert Newberry and Marc Gaboury (1). The channel banks will be vegetated with native grasses and shrubs will be placed along the top of bank for shading.

The data collected from the reference channel was used in preparing the design. Several site constraints also dictated the new channel location. These included avoiding, where possible, buried building foundations and mature trees. Additionally, the plan could not disturb the existing west concrete wall of the existing channel so as to not disturb the base of the bluff with homes west of the existing channel. Therefore it was decided to bury the existing concrete channel undisturbed except at the beginning and end of the new channel.

The Kansas City District collected soil borings and sediment data. Geotechnology, Inc performed sediment distribution analysis on the sediment. The borings show the material to be primarily clay, though one of the borings found wet very fine sand between 4 and 6 feet. The sediment analysis indicated the stream sediment in the area has a d_{50} of 2.1 mm and a d_{84} of 18 mm.

Riffles were sized using Lane's equation ( ). The calculated crest stone rock size was 3.1 feet. The sediment information was used to prepare a stable channel analysis and check sediment flow using HEC-RAS. The results of that analysis is included in the Appendix. The equations chosen to be most appropriate of the site conditions were the Toffaleti and Yang equations. The analysis indicated the proposed design could pass the expected sediment loads in tons per day. The results of that analysis is included in the Appendix.

WATER QUALITY BENEFITS

Concrete channels have little if any water quality benefit as compared to a natural channel. Concrete lined channels stop the natural groundwater and channel connection that allows cooled and cleansed groundwater sources to make up a significant percentage of the stream flow during times of little or no precipitation, particularly in the summer. USGS information suggest this area of the country has on average one of the highest contribution of groundwater to stream flows in the nation with contributions over 90% (2). Concrete channels contain no riffle pool substrate system to allow for oxygenation of stream flows (3) or habitat for ammonia reducing benthic organisms that can live on riffles rocks. Concrete channels speed up in-channel stream velocities causing increased erosion downstream of concrete channel sections and potential for increased total suspended solids, when compared to a healthy stream in dynamic equilibrium. Construction of a natural channel allows for some pollutant removal by streamside vegetation (4). While this site is unique in that the west bank above the

concrete channel is well vegetated and offers some shade to the channel, in general water quality improvements would be expected by the introduction of trees and shrubs along the stream corridor that would result in increased Dissolved Oxygen, decreased temperatures, decreased pH and nitrates. (3)

HABITAT BENEFIT

Removing the concrete channel will allow the creation of 650 feet of new connected aquatic habitat and removal of an existing approximately 600 foot dead zone that would be expected to be impassable, most of the time, by most of the fish and aquatic organisms living in Turkey Creek. Removal of the concrete bottom and construction of riffles will create a substrate for benthic organisms, important for a healthy stream ecosystem. (3) Reduction of in-stream channel velocities due to removal of the concrete will increase the potential for aquatic organisms to live in successfully in the stream system.

FLOOD REDUCTION IMPACT

Concrete channels are generally designed to move water away from an area to a downstream location faster. The resulting cumulative effect can be to actually increase downstream flooding.

The natural, meandering channel will not provide significant flood reduction benefits in Quail Creek Park. The new channel will not reduce the 10-year water surface elevation at all. The main benefits of the natural channel will be water quality and habitat benefits.

MAINTENANCE REQUIREMENT AND EXPECTED DESIGN LIFE

Generally, natural riffles and channels require no maintenance. As this is a design scenario the site should be monitored after major flood events to determine the performance of the project. It is expected that the channel and riffle will move with time as the stream reaches a dynamic equilibrium. Ideally, the changes that will occur in the watershed due to development have already taken place. Should the dynamic equilibrium condition appear to potentially cause problems, the stream will need to be reassessed.

There is no life expectancy limit noted in the literature for natural channel and riffles. Performance over time can be enhanced as the channel develops a healthy ecosystem and the riffle attract biological life on the rocks that result in improvement in the food chain and aid in denitrifying ammonia in the water.

The analysis for this design is based on limited survey data and a hydraulic model that should be evaluated because of the response of the downstream structure in the model. Before construction plans and specifications are prepared, the base model should be reviewed, and the design assumptions and analysis rechecked, if necessary.

VALUE ENGINEERING ALTERNATIVES

This design is believed to be the minimum necessary to achieve the project goals.

United States Army Corps of Engineers
Upper Turkey Creek
Task 8 Quail Creek Park

HNTB

Engineer's Estimate of Probable Costs

8/12/2004

No.	Item	Quantity	Unit of Measure		Unit Cost		Cost
1	Sewer encasement	28	C.Y.	$	120.00	$	3,360.00
2	Tree protection	7	Each	$	20.00	$	140.00
3	Concrete foundation removal	71	C. Y.	$	40.00	$	2,840.00
4	Existing vegetation removal	0.83	Acre	$	1,200.00	$	996.00
5	Existing fence removal	840	L. F.	$	3.00	$	2,520.00
6	Construction limit fence	1700	L. F.	$	2.00	$	3,400.00
7	Excavation	2408	C. Y.	$	8.00	$	19,264.00
8	Fill	1734	C.Y.	$	5.00	$	8,670.00
9	Construction access road	1	Each	$	1,500.00	$	1,500.00
10	Rock (2ft)	72	Ton	$	20.00	$	1,440.00
11	Native grasses	1.2	Acre	$	4,000.00	$	4,800.00
12	Silt Fence	250	L. F.	$	3.00	$	750.00
13	Erosion control fabric	1	S. Y.	$	2.00	$	2.40
14	Woody trees and shrubs	1	Each	$	12.00	$	12.00
15	Mobilization	1	Lump Sum	$	2,000.00	$	2,000.00
					Subtotal:	$	49,694.40
					20% Contingency	$	9,938.88
					Total:	$	59,633.28
					Use:	**$**	**60,000.00**

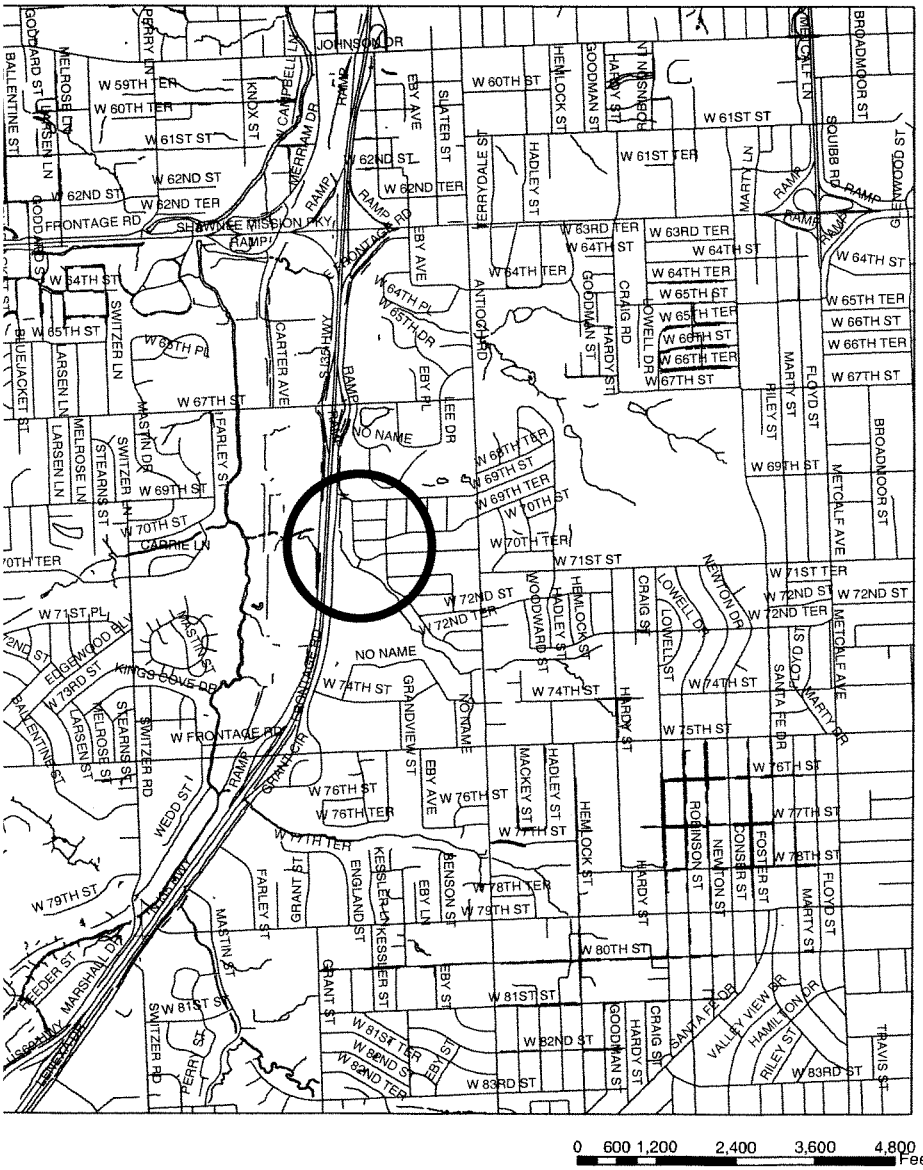
Notes:

1. The costs shown above represent an estimate of probable cost prepared in good faith and with reasonable care. HNTB has no control over the costs of construction labor, materials or equipment, or over any competitive bidding or negotiating methods.

F:\32080\D18_UpperTurkeyCreek\Report\Appendix\[Cost_Estimate.xls]8_1_6 Quail Creek Park

Task 8-1-6 Quail Creek

Location Map

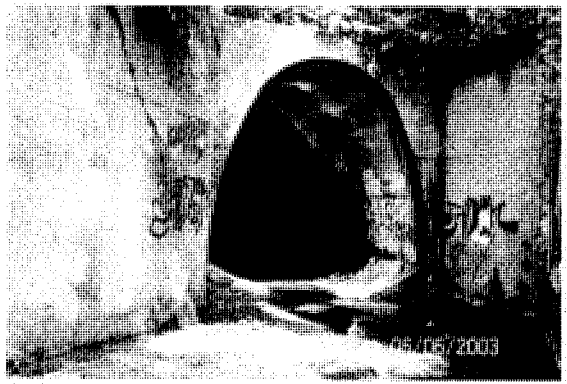


Task 8: Quail Creek

Upper Turkey Creek

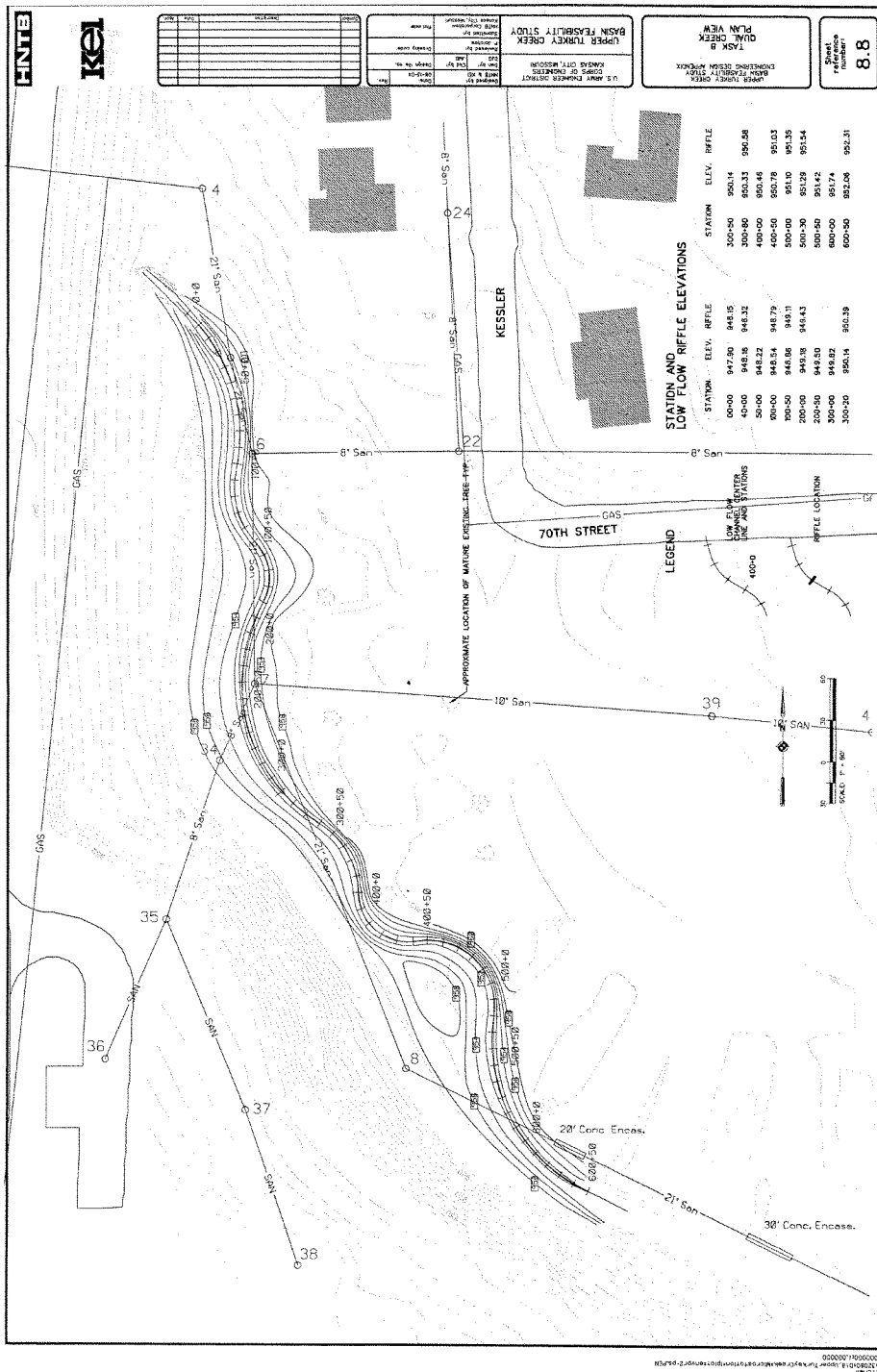
Downstream face of culvert under Grandview Street

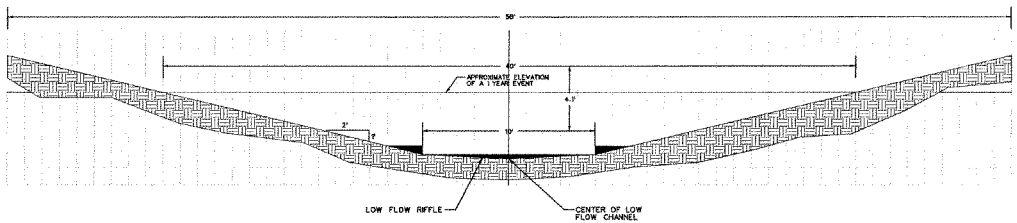
Concrete-lined channel



Arch culvert under I-35 Highway

Quail Creek Park


HNTB
KEL
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI
TASK 8
QUAIL CREEK
PLAN VIEW
Sheet reference number
8.8
STATION AND
LOW FLOW RIFFLE ELEVATIONS
STATION ELEV. RIFFLE
00+00 947.90 948.15
40+00 948.18 948.32
50+00 948.22
100+00 948.54 948.79
100+50 948.86 949.11
200+00 949.18 949.43
200+50 949.50
300+00 949.82
300+20 950.14 950.39
300+50 950.14
300+80 950.33 950.58
400+00 950.46
400+50 950.78 951.03
500+00 951.10 951.35
500+30 951.29 951.54
500+50 951.42
600+00 951.74
600+50 952.06 952.31
LEGEND
LOW FLOW CHANNEL CENTER LINE AND STATIONS
RIFFLE LOCATION
KESSLER
70TH STREET
APPROXIMATE LOCATION OF MATURE EXISTING TREE TYP.
8" San
10" San
21" San
GAS
SAN
20' Conc. Encas.
30' Conc. Encase.
SCALE: 1" = 60'



REMEANDER CHANNEL TYPICAL CROSS-SECTION

EXISTING CHANNEL TO BE FILLED IN AND CONCRETE WALL ON WEST BANK TO REMAIN AND CONCRETE WALL ON EAST BANK TO REMAIN EXCEPT AT BEGINNING AND END OF MEANDER PROJECT

25' 0 25' 50'
HORIZONTAL SCALE: 1" = 50'

HNTB

KEI

Rev.	Date	Description	Drawn	Checked

Designed by: HNTB & KEI
Date: 08-13-04
Drawn by: KEI
Checked by: JAR
Reviewed by: P. Kirchner
Submitted by: HNTB Corporation, Kansas City, Missouri
Drawing code:
Plot scale:

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX
TASK 8
QUAIL CREEK
CROSS-SECTION

Sheet reference number:
8.9

TASK 8: 71st STREET & NIEMAN ROAD

71ST STREET AND NIEMAN ROAD

TASK OBJECTIVE

The purpose of this task is to emphasize stormwater and floodwater storage and infiltration systems over stormwater and floodwater conveyance systems.

SITE SELECTION CRITERIA

The criteria in selecting a site for this task was to determine a suitable location which is most representative to other similar locations within the Upper Turkey Creek watershed. The demonstration site is ideally an average representation, based on condition, accessibility, and utility and development conflicts.

This site was inventoried in the Upper Turkey Creek Feasibility Study Environmental Field Assessment provided by the Kansas City District and noted to be one 53 open areas along the stream. The site has a small drainage area. There was some consideration given to analyzing the site in conjunction with removing an adjacent concrete channel section and a culvert enclosure to determine the cumulative effect stormwater and floodwater storage and infiltration systems over stormwater and floodwater conveyance systems. However this was not done.

This site was selected based on its proximity to the unused electrical easement adjacent to the creek main stem. This left bank easement appeared to be regularly mowed. If inline storage is constructed, this particular site could provide some water quality benefits. Easements with high voltage power lines are common in urban areas, and could be improved environmentally; although, it is important that the vegetation be maintained to prevent conflict with the dangerous lines and that access and geotechnical stability be provided at the power poles.

SITE CONDITIONS/SITE ANALYSIS

In Shawnee a tributary to Upper Turkey Creek crosses under Nieman Road between 71st Street and 72nd Street. The culvert underneath Nieman Road is a six-foot diameter corrugated metal pipe with black PVC liner. East of Nieman Road the tributary is an open channel, lined with concrete for approximately 1,200 feet. The concrete channel is four feet high and four feet wide at the base with 1H:1V side slopes. The slope of the concrete channel is about 1.5 percent. Downstream of the concrete channel, the tributary flows into an enclosed, 8-foot wide by 6-foot tall, corrugated metal arch pipe.

North of the concrete-lined channel and just east of Nieman Road, there is approximately 0.3 acres of open space. Further east, clusters of trees line the north side of the channel. A sanitary sewer line and power poles also run along the north side of the channel. The south side of the concrete channel is adjacent to residential property.

Approximately 99 acres of residential land drains into the culvert underneath Nieman Road. The concrete-lined channel has the capacity to hold a 100-year storm, however the culvert underneath Nieman Road has the capacity for less than a 10-year event, although it is likely that there is some flood reduction storage at the upstream end.

RESTORATION DESCRIPTION

An off-line detention area was designed in the 0.25 acres of open space north of the concrete-lined channel and just east of Nieman Road. The detention area would be approximately 8-foot deep with 2H:1V side slopes. The side slopes and the bottom of the basin would be planted with native grasses, and the soil amended in the bottom of the basin to improve infiltration. The off-line storage will hold 2 acre-feet of water, which corresponds to less than a one-year event. This will be a sufficient volume to store the first flush of frequent storm events, which contain the largest concentrations of trash, sediment, and other pollutants. The water will be detained in the offline storage for 24 hours to allow most of the pollutants to settle out.

To direct water into the offline storage, a 1-foot tall, concrete weir will be constructed and angled within the concrete-lined channel. The in-channel weir will be designed to allow for upstream fish passage. During frequent storm events, water will flow in the culvert under Nieman Road, into the concrete-lined channel, and then 30 feet downstream, the weir will direct the water into a vegetated trapezoidal channel leading to the detention area. The channel will be 4-foot high and 4-foot wide with 2H:1V side slopes. Both the channel bottom and the side slopes will be planted with native grasses. The flow path through the basin will be controlled by berms to allow increase the low-flow distance to the outlet. The outlet of the storage area will be a 12-inch diameter reinforced concrete pipe, draining from the offline storage back into the concrete-lined channel. The outlet pipe will have a 4-inch diameter orifice plate on a clog-maintenance overflow structure the opening, which will discharge and will detain water in the basin for 24 hours. For large storm events, water will remain in the concrete channel, and flow over the one foot tall weir.

WATER QUALITY BENEFITS

The off-line storage facility can be expected to remove 20-40% of the phosphorous, 20-40% of the nitrate, 50-70% of the hydrocarbons, and 50-70% of the total suspended solids for the frequent events that are diverted into the basin (5). Adding additional storage to the watershed can help mitigate the impact of urbanization on flood peaks. Adding additional storage potentially reduces the need for extraordinary measures to protect channel banks and allows for bioengineering projects to have a better chance of success. Therefore an expected benefit is that the there will be more opportunity for environmental restoration to succeed in Upper Turkey Creek and many of the measure discussed in the other tasks have a greater chance of being implemented.

FLOOD REDUCTION IMPACT

The off-line detention area will have only a slight impact on flood reduction, since the detention area holds less than a one-year storm event This basin may have some ability to mitigate the effect of urbanization on this watershed by adjusting the hydrograph so as not to deliver water as quickly to the stream system, potentially effecting the long term need for concrete channels. A primary benefit of the detention area are the water quality benefits. If a larger area of open space was available, a larger detention area could be designed that would have flood reduction benefits in addition to the water quality benefits.

MAINTENANCE REQUIREMENTS AND EXPECTED DESIGN LIFE

Dry detention basins should be checked after every major storm event for erosion on the side slopes; damage from burrowing animals; clogging, debris or other potential failures of the inlets and outlet and structural members of the basin, and; sediment deposition. Vegetation needs to be managed on a regular basis by periodic mowing or burning, removal of undesirable invasive species, and restores or seeded over when necessary.

If maintained, dry detention basins have a life expectancy of 20 years or greater.

VALUE ENGINEERING ALTERNATIVES

This design was the largest size that could be located on this site, but should be enlarged further for more benefits.

United States Army Corps of Engineers
Upper Turkey Creek
Task 8 71st and Neiman

HNTB

Engineer's Estimate of Probable Costs

8/12/2004

No.	Item	Quantity	Unit of Measure		Unit Cost		Cost
1	Excavation	5,151	C. Y.	$	8.00	$	41,208.00
2	Native grasses	0.40	Acre	$	4,000.00	$	1,600.00
3	Infiltration soil mix	691	C. Y.	$	7.00	$	4,837.00
4	Erosion control fabric	1,885	S. Y.	$	2.00	$	3,769.58
5	Concrete weir	1	Each	$	1,000.00	$	1,000.00
6	12-inch diameter RCP	66	L. F.	$	25.00	$	1,650.00
7	4-inch orifice plate	1	Each	$	100.00	$	100.00
8	Existing vegetation removal	0.40	Acre	$	1,200.00	$	480.00
9	Mobilization	1	Lump Sum	$	2,000.00	$	2,000.00
					Subtotal:	$	54,644.58
					20% Contingency	$	10,928.92
					Total:	$	65,573.50
					Use:	**$**	**70,000.00**

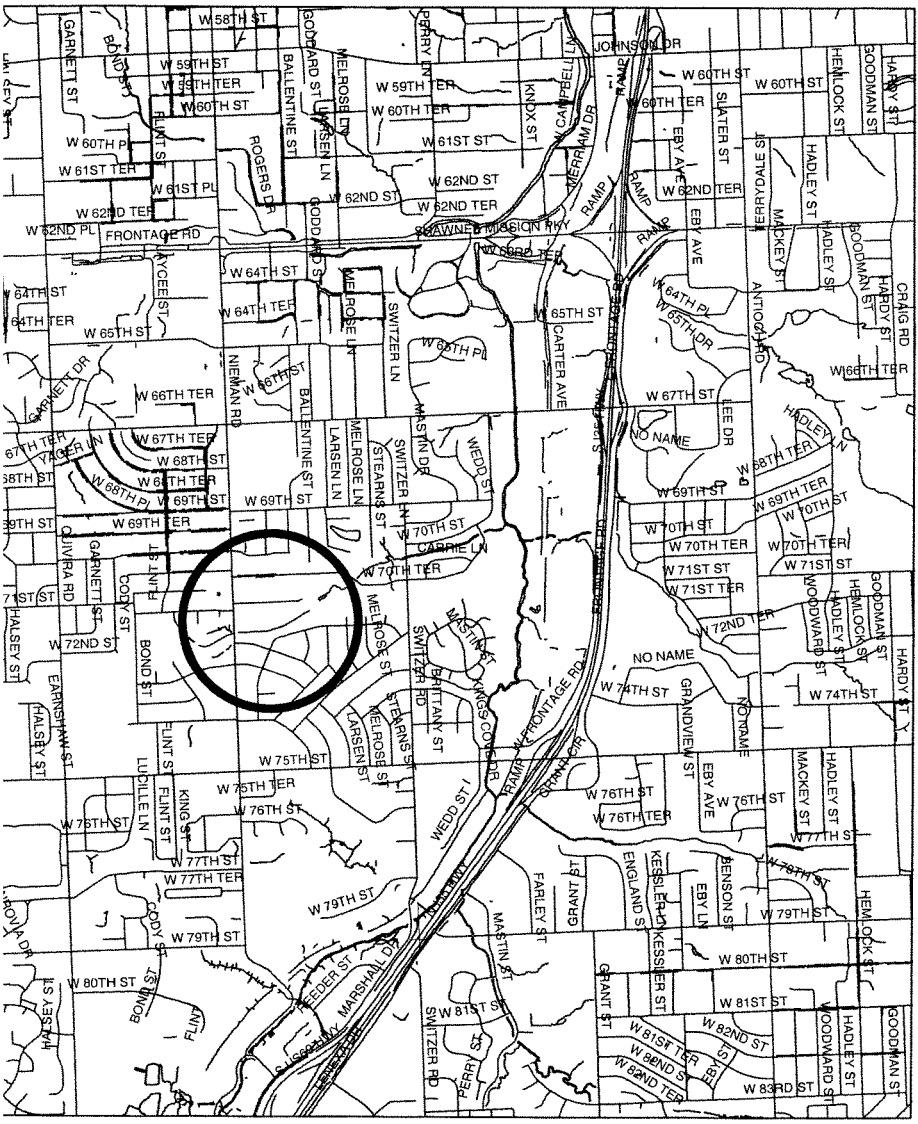
Notes:

1. The costs shown above represent an estimate of probable cost prepared in good faith and with reasonable care. HNTB has no control over the costs of construction labor, materials or equipment, or over any competitive bidding or negotiating methods.

F:\32080\D18_UpperTurkeyCreek\Report\Appendix\[Cost_Estimate.xls]8_3_3471stNeiman

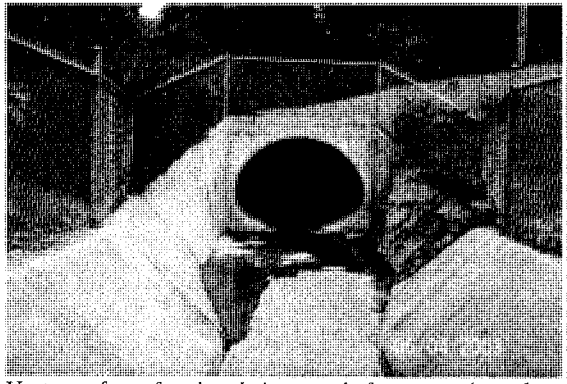
Task 8-3-34 71st & Nieman

Location Map



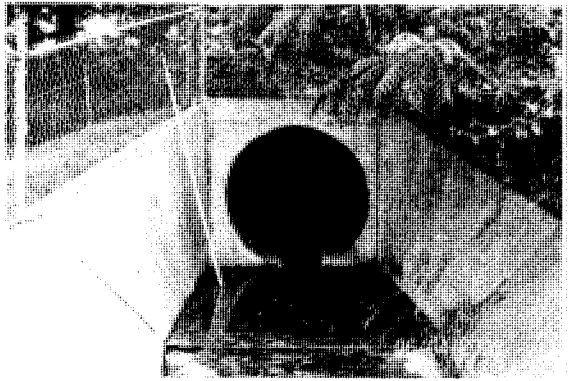
Task 8: 71st and Nieman

Upper Turkey Creek

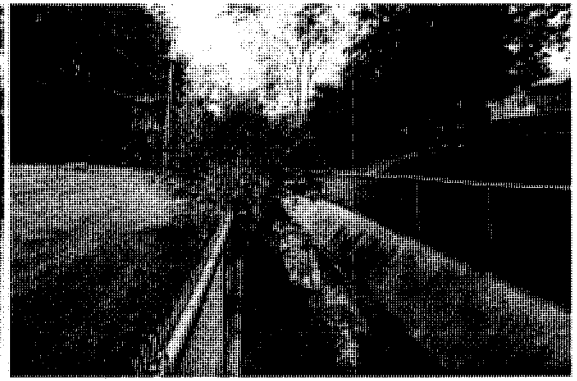


Upstream face of enclosed pipe at end of concrete channel

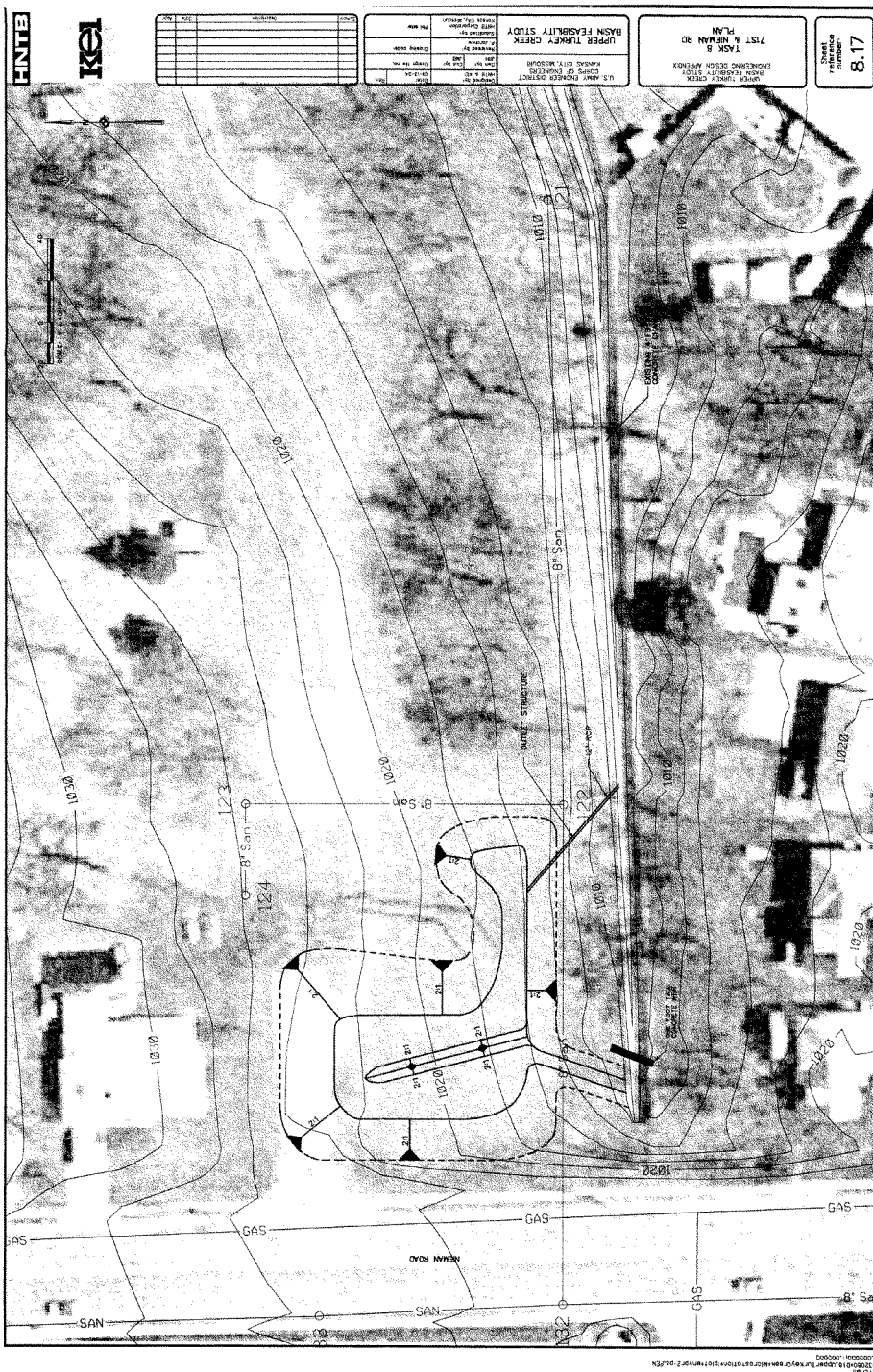
Open space to be excavated for off-line storage



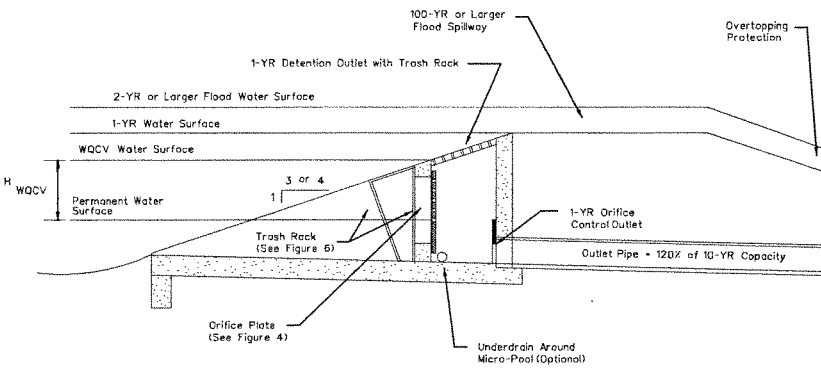
Downstream face culvert under Nieman Road



Concrete-lined channel looking downstream


HNTB
kel
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI
TASK 8
71ST & NIEMAN RD
PLAN
Sheet reference number:
8.17
OUTLET STRUCTURE
NIEMAN ROAD
GAS
SAN
8" San
1010
1020
1030
123
124
122
121

2004
H01B,UpperTurkeyCreek\Microstation\Sheets\Outlet_structure.dgn
H01B,UpperTurkeyCreek\Microstation\plots\envpr2-ps.PEN
0:1.000000



Overtopping Spillway Option

Sheet Reference Number: 17A	UPPER TURKEY CREEK BASIN FEASIBILITY STUDY ENGINEERING DESIGN APPENDIX	U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS KANSAS CITY, MISSOURI UPPER TURKEY CREEK BASIN FEASIBILITY STUDY	Designed by: HNTB & KCI Date: 08-13-04 Rev. Dwn by: JBH Chd by: JMB Design file no. Reviewed by: P. Jarchow Drawing code: Submitted by: HNTB Corporation Kansas City, Missouri Plot date:	Symbol / Description / Date / Appr.

HNTB

TASK 8: PARKING LOT MEDIAN

PARKING LOT MEDIAN

TASK OBJECTIVE

The objective of this task is to emphasize stormwater infiltration over conveyance systems.

SITE SELECTION CRITERIA

This site was inventoried in the Upper Turkey Creek Feasibility Study Environmental Field Assessment provided by the Kansas City District.

The criteria used in selecting a site for this task was to determine a suitable location which is representative of other similar locations within the Upper Turkey Creek watershed. The demonstration site is ideally an average representation, based on condition, accessibility, and utility and development conflicts.

Urbanization changes in watersheds result in many areas designated for paved parking. To lessen the direct pollutant loads into the receiving streams, retrofitting raised parking lot medians with existing-curb protected depressed bioretention infiltration basins, such as those at this site, are ideal. Raised medians provide little environmental benefit and are commonly required as part of the design of a parking lot. This site is one of many which could have been selected.The benefits and costs can easily be applied to other sites.

SITE CONDITIONS/SITE ANALYSIS

This site is located in the Pine Ridge West Business Park of the City of Lenexa, Kansas of Johnson County. The medians are located in the parking lot of building number 18, which is south of the intersection of 80th Street and Flint Road. The elongated median, which separates buildings number 12 and 18, has a private storm sewer system and gas line running parallel.

RESTORATION DESCRIPTION

The restoration work consists of constructing three bioretention infiltration facilities in the existing parking lot islands and medians. The facilities would be designed to have scuppers installed at curb cuts to direct stormwater into the infiltration facility. Boring data obtained by the Kansas City District indicates that the islands have a low permeability rate. Therefore the soil will be amended to a depth of approximately 2.5 feet to include at least 50% sand. An under drain would be built in one of the islands to help drain the facility. The facilities would be landscaped with shrubs, trees and forbs.

WATER QUALITY BENEFITS

Data compiled by the University of Maryland for Prince George's County, Maryland indicates potential pollutant removal rates of up to 95-99% removal of copper, 95% removal of lead and zinc, 57–73 % removal of phosphorous, 45-59% removal of total Kjeldahl nitrogen, 85-99% removal of ammonium, 10-22% removal of nitrate. (6)

HABITAT BENEFITS

There are no expected direct habitat benefits from construction of the infiltration facilities, except by those species that might already use parking lot medians for habitat. However the greatest habitat effect will be the cumulative effect of this and other actions on improving water quality in Turkey Creek and mitigating the potential negative impacts on water quality from non-point stormwater pollution due to urbanization.

FLOOD REDUCTION IMPACT

The flow to the existing storm collection system will be reduced during low flow events and at the beginning of all storm events, reducing the peak by infiltration of early flows. The initial runoff, which contains the highest concentration of pollutants, will be directed toward the designed infiltration areas. During high flow events the capacity of the infiltration facility will be exceeded and the flow would then be directed toward the existing storm sewer collection system.

MAINTENANCE REQUIREMENTS AND EXPECTED DESIGN LIFE

The bioretention or infiltration cells will need to be maintained much like any other landscape area on the property. The most critical issue in maintaining the bioretention or infiltration cell is not to allow high concentrations of silt to enter the facility. These cells are very effective in highly urbanized areas like paved parking lots, because of the general lack of high concentrations of silts. Other maintenance activities include checking for bare areas and adding mulch as needed, checking for and removing any accumulated sediments, looking out for areas of gullies forming through the mulch. It is recommended that every two to three years the mulch be removed, disposed of properly and replaced. (1) No specific life expectancy was given in the literature for bioretention facilities. Facilities have failed in the past due to high concentration of sediments and lack of infiltrating soils. However careful avoidance of sediment loading during construction and afterwards, in addition to the use of sand amended soils and under drains, where necessary, has addressed those concerns. The bioinfiltration cells constructed in the mid 1990's are still functioning in Maryland. Depending on the loadings, bioretention cells may be expected to have life expectancies greater then 10 years, approaching the life expectancy of a well maintained wet basins of 20 years or more. Pollutant removal efficiency may be reduced with age.

VALUE ENGINEERING ALTERNATIVES

One of the islands has an underdrain, the other does not. Both islands could have been designed without an underdrain but it is expected the site advantages of having the underdrain will become obvious and may prompt the other island to be retrofitted with an underdrain.

REFERENCES

1. Robert W. Newbury, Marc N. Gaboury, "Stream Analysis and Fish Habitat Design," Newbury Hydraulics Ltd., Gibsons, British Columbia, 1993.

2. Thomas C. Winter et al, "Groundwater and Surface Water, A Single Source," U.S. Geological Survey Circular 1139, Denver, Colorado, 1998.

3. United States Environmental Protection Agency, "Ecological Restoration – EPA 841-F-95-007", U.S. Environmental Protection Agency, November 1995.

4. United States Environmental Protection Agency Office of Water, "Description and Performance of Stormwater Best Management Practices", http://www.epa.gov/ost/stormwater/usw_c.pdf, Washington, D.C.

5. Ministry of Water, Land and Air Protection, Water, Air and Climate Change Branch, Government of British Columbia, "Water Quality, Best Management Practices to Protect Water Quality", http://wlapwww.gov.bc.ca/wqat/wq/nps/BMP_Compendium/BMP_Introduction /bmphome.htm., Province of British Columbia, 2001.

6. Derek Winogradoff, "Bioretention Monitoring, Preliminary Data Analysis," Department of Environmental Resources, Prince George's County, Maryland, November 1997.

United States Army Corps of Engineers
Upper Turkey Creek
Task 8 Parking Lot Median

HNTB

Engineer's Estimate of Probable Costs

8/12/2004

No.	Item	Quantity	Unit of Measure		Unit Cost		Cost
1	Clearing	0.003	Acre	$	1,200.00	$	3.60
2	Construction limit fence	127.632	L. F.	$	2.00	$	255.26
3	Curb cuts	40	L. F.	$	50.00	$	2,000.00
4	Asphalt removal	2.78	S. Y.	$	10.00	$	27.80
5	12" RCP	69	L.F.	$	30.00	$	2,070.00
6	12" Perforated Pipe	74	L.F.	$	35.00	$	2,590.00
7	Manhole	4	Each	$	3,000.00	$	12,000.00
8	Soil infiltration mix	35	C. Y.	$	7.00	$	245.00
9	Stone mulch	2.8	S. Y.	$	10.00	$	28.00
10	Bark mulch	0.03	Acre	$	500.00	$	15.00
11	Groundcovers	0.01	Acre	$	4,000.00	$	40.00
12	Perennials	91	Each	$	40.00	$	3,640.00
13	Shrubs	64	Each	$	35.00	$	2,240.00
14	Trees	2	Each	$	450.00	$	900.00
15	Seeding	0.003	Acre	$	4,000.00	$	12.00
16	Asphalt repair	2.78	S. Y.	$	18.00	$	50.04
17	Mobilization	1	Lump Sum	$	1,000.00	$	1,000.00
					Subtotal:	$	26,116.70
					20% Contingency	$	5,223.34
					Total:	$	31,340.04
					Use:	**$**	**40,000.00**

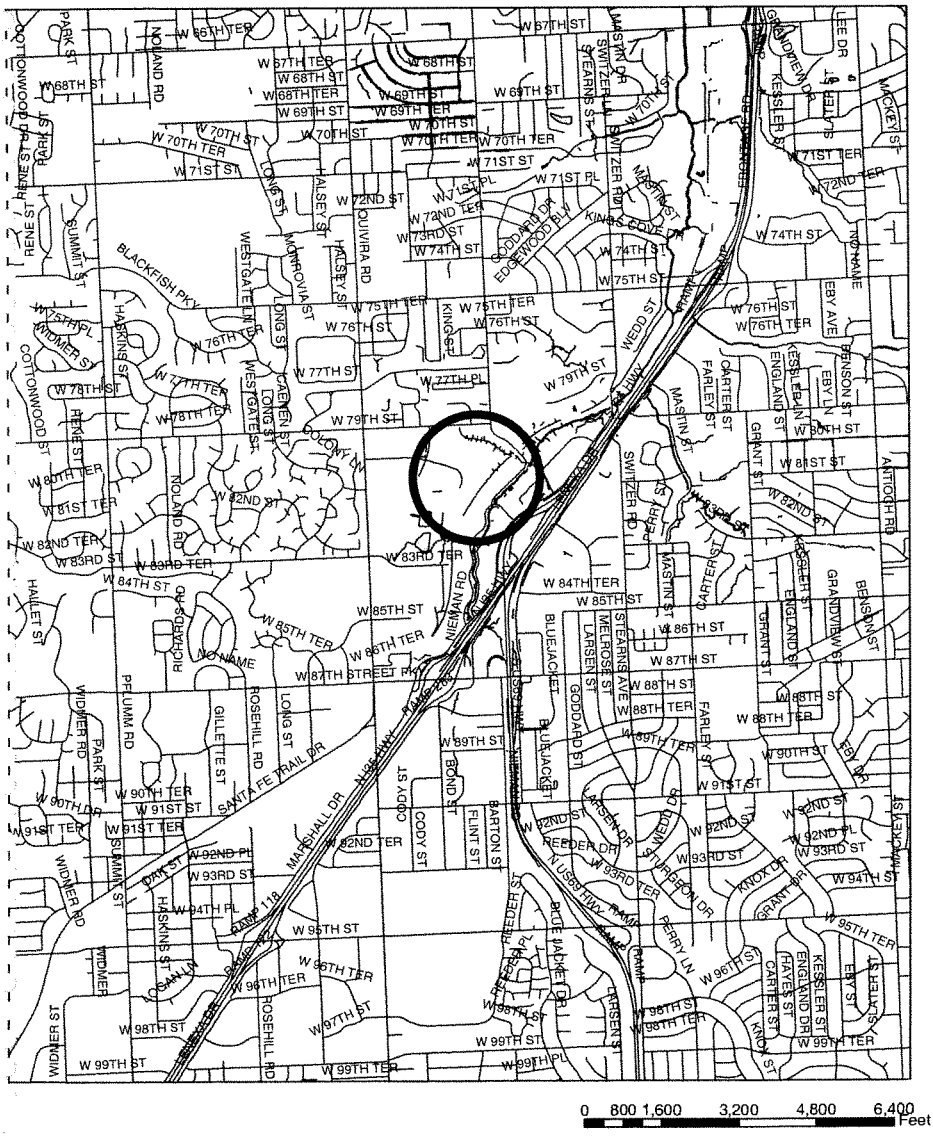
Notes:

1. The costs shown above represent an estimate of probable cost prepared in good faith and with reasonable care. HNTB has no control over the costs of construction labor, materials or equipment, or over any competitive bidding or negotiating methods.

F:\32080\D18_UpperTurkeyCreek\Report\Appendix\[Cost_Estimate.xls]8_4_35 Parking Lot

Task 8-4-35 Parking Lot Median

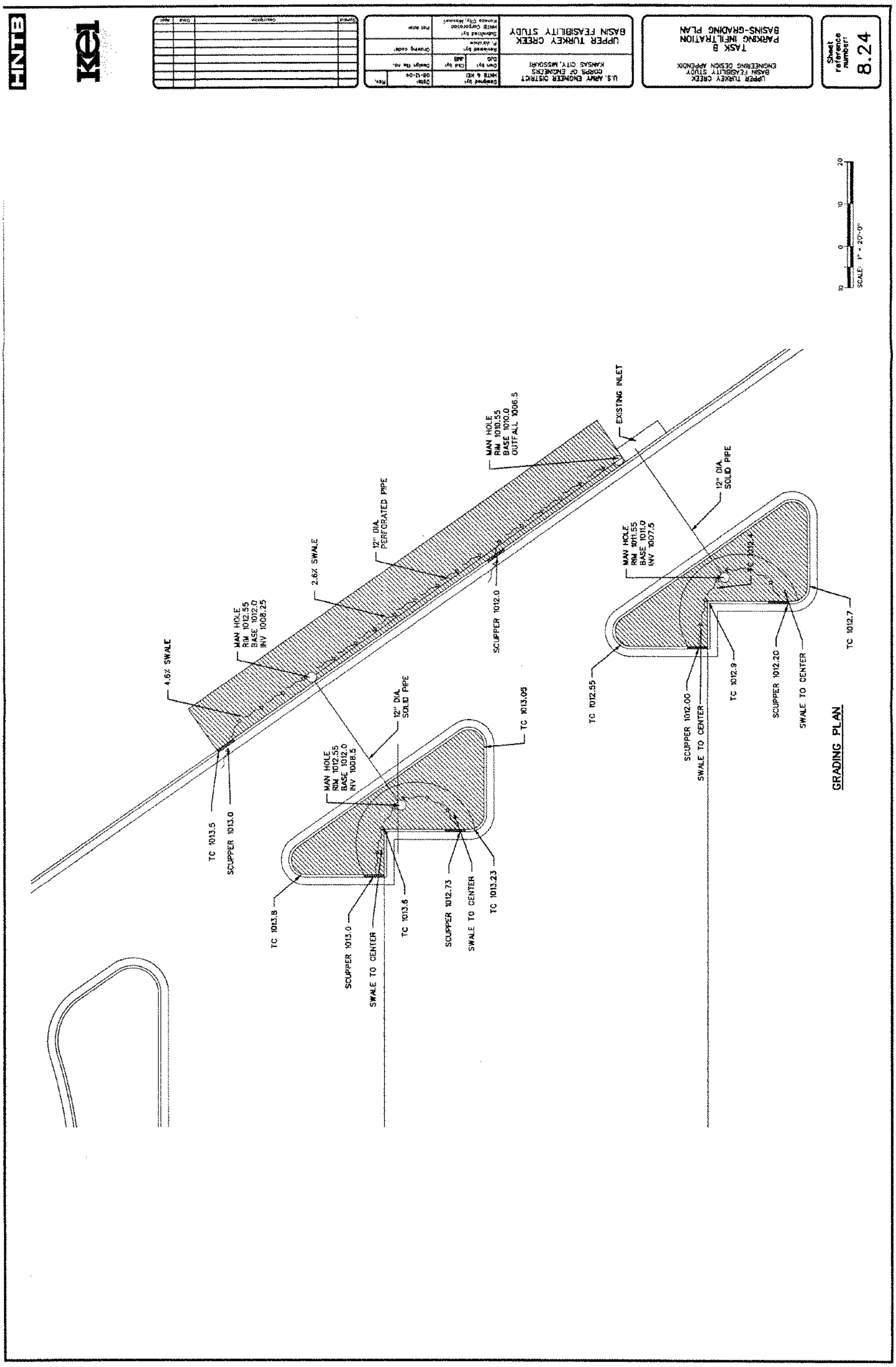
Location Map

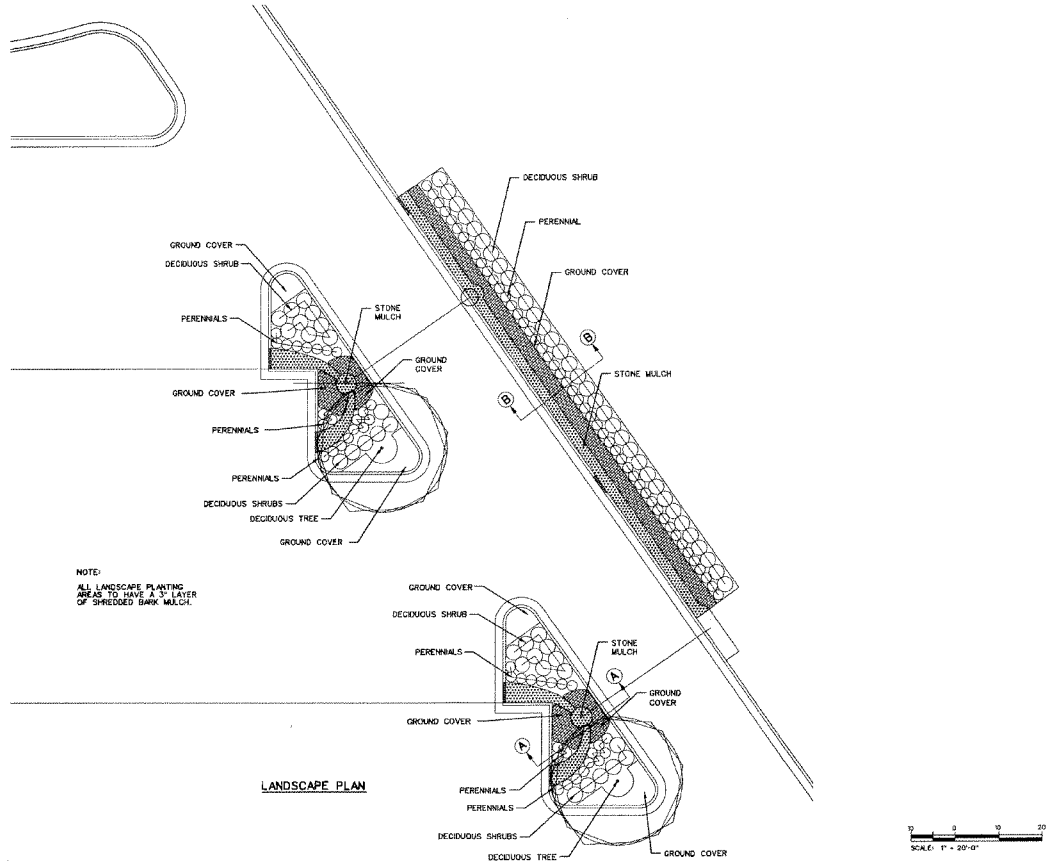


Task 8: Existing Islands

Upper Turkey Creek

Medians


HNTB
KEI
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX
TASK B
PARKING INFILTRATION
BASINS-GRADING PLAN
Sheet reference number:
8.24
SCALE: 1" = 20'-0"
EXISTING INLET
MAN HOLE
RIM 1010.55
BASE 1010.0
OUTFALL 1006.5
12" DIA.
PERFORATED PIPE
2.6% SWALE
MAN HOLE
RIM 1012.55
BASE 1012.0
INV 1008.25
4.6% SWALE
SCUPPER 1012.0
12" DIA.
SOLID PIPE
MAN HOLE
RIM 1011.55
BASE 1011.0
INV 1007.5
TC 1012.4
TC 1012.7
TC 1012.55
SCUPPER 1012.00
SWALE TO CENTER
TC 1012.9
SCUPPER 1012.20
SWALE TO CENTER
GRADING PLAN
TC 1013.05
12" DIA.
SOLID PIPE
MAN HOLE
RIM 1012.55
BASE 1012.0
INV 1008.5
TC 1013.5
SCUPPER 1013.0
TC 1013.8
SCUPPER 1013.0
SWALE TO CENTER
TC 1013.6
SCUPPER 1012.73
SWALE TO CENTER
TC 1013.23



LANDSCAPE PLAN

HNTB

KEL

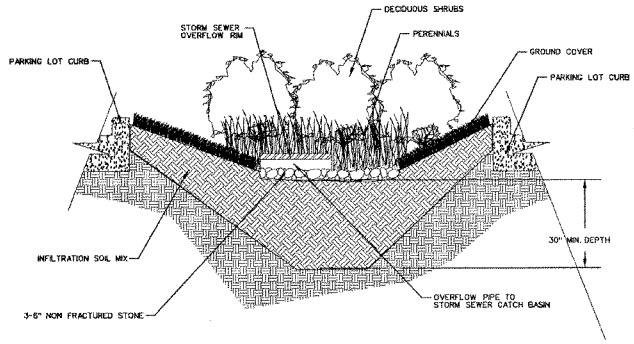
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY

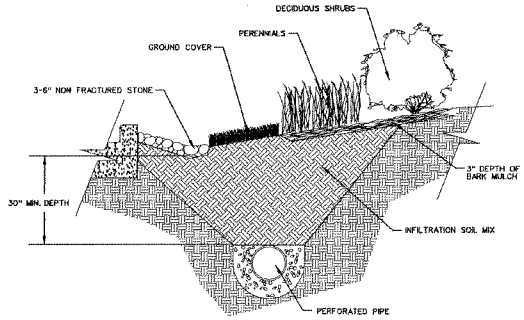
UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX

TASK B
PARKING INFILTRATION
BASINS-PLANTING PLAN

Sheet reference number:
8.25



SECTION A-A



NOTE:
SOIL MIX TO BE COMPRISED OF 75% COARSE SAND AND 25% LOAM.

SECTION B-B

HNTB

KEI

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY

UPPER TURKEY CREEK
BASIN FEASIBILITY STUDY
ENGINEERING DESIGN APPENDIX

TASK B
PARKING INFILTRATION
BASINS-SECTIONS

Sheet reference number:
8.26

Section 3 Stream Assessments

UPPER TURKEY CREEK STREAM HEALTH ASSESSMENT

DRAFT REPORT

Prepared For:

U.S. Army Corps of Engineers
Kansas City District

By

The Louis Berger Group, Inc.

April 2006

TABLE OF CONTENTS

1.0 PURPOSE 1
2.0 INTRODUCTION 1
3.0 EXISTING STUDIES 2
3.1 US ARMY CORPS INITIATIVES AND STUDIES 2
3.2 NORTHEAST JOHNSON COUNTY WATERSHED STUDY 2
3.3 HNTB STUDY 3
4.0 METHODOLOGY 4
4.1 OVERALL STREAM HEALTH ASSESSMENT 4
4.2 PHYSICAL ASSESSMENT AND VISUAL HABITAT SURVEY 4
4.3 BIOLOGICAL SURVEY – MACROINVERTEBRATES 5
4.4 BIOLOGICAL SURVEY – FISH 5
5.0 FINDINGS 6
5.1 WATERSHED WIDE CONDITIONS 8
5.1.1 Physical Condition 8
5.1.2 Vegetative Condition 9
5.1.3 Water Quality 10
5.1.4 Instream Habitat Quality 11
5.1.5 Overall Stream Health Assessment 13
5.2 AREA SPECIFIC HABITAT CONDITIONS 14
5.2.1 Southern Portion of Upper Turkey Creek Watershed 14
5.2.2 Central Portion of Upper Turkey Creek Watershed 15
5.2.3 Northern Portion of Upper Turkey Creek Watershed 17

APPENDIX A STREAM HEALTH ASSESSMENT DATA SHEETS
APPENDIX B BIOLOGICAL DATA FORMS

UPPER TURKEY CREEK
STREAM HEALTH ASSESSMENT

1.0 PURPOSE

The Louis Berger Group, Inc. (Berger) conducted physical, habitat, and biological data collection and evaluation in representative reaches throughout Upper Turkey Creek in May and June 2005, with follow-up in September 2005. Fish surveys and the macroinvertebrate composition of Upper Turkey Creek were also determined via biological surveys conducted along the length of Upper Turkey Creek and its tributaries during the same period. This data was then used to develop an overall stream health assessment ranking for reaches in Upper Turkey Creek, using a ranking methodology that weights the physical, habitat, and biological assessment scores of a given stream reach to generate one metric indicative of the overall conditions at that reach. This report documents the methods and results of these surveys.

2.0 INTRODUCTION

The Upper Turkey Creek watershed is located in eastern Kansas, in Johnson and Wyandotte Counties. The watershed is located in a highly urbanized suburb of Kansas City, Kansas. Turkey Creek and its floodplain have been a part of the Kansas City metropolitan infrastructure since the 1800's. The relatively flat topography associated with the creek and its floodplain has been favorable to the location and development of railroads, highways, and utilities. Commercial and residential development associated with the railroad and highways has also paralleled the creek.

Urbanization and ongoing development in the Upper Turkey Creek watershed has resulted in degradation of environmental resources associated with the creek. The creek has been deepening and widening its channel as a result of high runoff volumes and flow rates associated with urbanization in the watershed. In response, much of the creek channel has been enclosed in culverts, lined with concrete, or otherwise hardened to address channel instability. Stream reaches where the channel has been enclosed or hardened with concrete provide little or no habitat value and represent impassable biological dead zones for most of the fish and other aquatic wildlife in Turkey Creek. Failure of Turkey Creek to attain its designated recreational and aquatic life uses is, in part, a result of these channel modifications.

The modification of natural hydrologic characteristics in the stream and surrounding watershed has also contributed to increased flooding. The Turkey Creek basin experienced major floods in 1961, 1977, 1993, and 1998. The flood events resulted in significant property damage in the downstream reaches of Turkey Creek.

In response to these issues, a resolution on the Committee on Transportation and Infrastructure, U.S. House of Representatives, Docket 2616, was adopted February 16, 2000 which authorized the U.S. Army Corps of Engineers (USACE) Kansas City District to commission a study of the Upper Turkey Creek basin upstream of the existing authorized Turkey Creek Basin, Kansas City, Missouri, and Kansas City, Kansas, Flood Damage Reduction Project. The purpose of the existing project, authorized under the Water Resources Development Act, was to develop a plan for flood damage reduction on Turkey Creek in an area generally from the Interstate 35 tunnel

upstream for about 10,000 feet. The Section 905(b) analysis approved October 5, 2001 indicated a potential federal interest in flood damage reduction and environmental restoration in the Upper Turkey Creek watershed. The Upper Turkey Creek Feasibility Study has been underway since July 2002.

Berger has been contracted to assist the USACE Kansas City District with the identification and evaluation of stormwater runoff conditions and stream degradation, as well as the development of alternative stormwater management measures for the reduction of stormwater runoff, flow and re-establishment of stream and habitat stability, and the development of a comprehensive plan of alternatives that is acceptable to the stakeholders in the Upper Turkey Creek watershed. Elements of the proposed study include, problem area identification via field surveys and stormwater modeling, stormwater flow estimation and mitigation, evaluation of the feasibility of stormwater control implementation, evaluation of potential stream habitat improvements, development of flood control and habitat restoration alternatives, and evaluation of the developed alternatives.

The component discussed in this report is a stream health assessment conducted to determine the existing conditions and identify problem areas to determine restoration alternatives.

3.0 EXISTING STUDIES

The following section briefly describes previous studies, surveys, and other projects that have been conducted within the Turkey Creek Watershed as components of flood management and habitat restoration efforts.

3.1 US Army Corps Initiatives and Studies

A reconnaissance study that evaluated the federal interest in solutions to recurring flood damages, environmental degradation, and related water and land resources needs and opportunities was completed in July 2002. The study recommended several different strategies to restore Turkey Creek and reduce flood damages. The study resulted in a Feasibility Cost Sharing Agreement between the City of Merriam, Kansas, and the federal government. The Feasibility Study of flood damage reduction and ecosystem restoration in the Turkey Creek Basin was initiated in July 2002. Ongoing efforts are being implemented to identify ecosystem restoration opportunities and to identify the value of structures and contents subject to flood damage from Turkey Creek overflows.

3.2 Northeast Johnson County Watershed Study

Johnson County Public Works Department hired the Larkin Group in 2001 to conduct a watershed flood study for five watersheds in Northeast Johnson County. The watersheds included Lake Quivira, Turkey Creek, Brush Creek, Rock Creek, and Dykes Branch. The purpose of the study was to generate updated FEMA maps; identify flood problem areas that were previously unidentified, or had otherwise not previously been addressed; provide a tool and standard for future storm drainage and flood mitigation work in the watershed; and provide a tool for analyzing future projects and their impacts on a watershed-based analysis.

The study provides the Johnson County Stormwater Management Program with tools for managing the watershed into the future, including functioning hydrology and hydraulic models, GIS data of the existing storm drainage system, and mapping products generated in the study.

The study included the development of hydrologic models utilizing HEC-1 and hydraulic models using HEC-RAS. The hydrologic and hydraulic models include the 10-, 50-, 100-, and 500-year storm flow rates for existing and future conditions. The study also identified problem areas utilizing the models and included development of improvements. The improvements component of the study included a discussion of the appropriateness of improvements at identified problem locations, the identification of potential solutions that should be evaluated in more detail, and a discussion of the potential for regional detention/solutions in the watershed.

3.3 HNTB Study

The Upper Turkey Creek Basin Environmental Restoration Report-Feasibility Phase was prepared by HNTB in August 2004 for the USACE Kansas City District. The purpose the report was to identify strategies for environmental restoration within the basin. Nine strategies for environmental restoration were developed and included:

1. stopping and possibly reversing the downcutting of the stream banks;
2. removing fish blockages or finding alternatives to divert fish around the blockages;
3. retrofitting stormwater basins and swales to improve water quality;
4. acquiring open space pertinent to aquatic resources;
5. removing enclosures on tributaries;
6. removing retaining walls, and using bioengineering solutions to improve those locations and other eroded areas;
7. reconnecting the channel and the floodplain;
8. emphasizing stormwater and flood water storage and infiltration systems over stormwater and floodwater conveyance systems; and
9. implementing a public information and awareness campaign addressing regulatory programs, potential regulatory strategies, negative environmental impacts on downstream flooding of stream enclosures and channel modifications, and available alternatives.

The HNTB study provided designs for thirteen projects at twelve sites to address seven of the above-mentioned strategies. The effects on water quality, cost, habitat, and flood control of each alternative were addressed.

4.0 METHODOLOGY

A stream assessment survey was conducted to characterize existing conditions of Upper Turkey Creek and its tributaries. The assessment involved visual inspection and evaluation of physical characteristics of the stream, stream bank, and riparian areas, as well as biological assessment of vegetation, fish, and benthic macroinvertebrate species found.

4.1 Overall Stream Health Assessment

Information collected as part of the field surveys conducted in May, June and September of 2005, was used to characterize the health of each of the surveyed reaches in Upper Turkey Creek watershed. Seventeen different factors were used to characterize physical stream conditions, habitat characteristics and quality, and the biologic community for each surveyed reach. Each factor was scored in the field on a scale of 1-10 based on verbal descriptions corresponding to the level of impairment observed for that stream health factor (See Appendix A). Poor conditions for a given factor would result in a low score, while good conditions for that factor would result in a higher score.

An average score across all stream health factors was then calculated to yield an overall metric indicative of the stream health conditions at each reach. This metric made it possible to separate the reaches of Upper Turkey Creek into minimally impacted reaches, moderately impacted reaches, and highly impacted reaches. Those reaches with an overall score of 0 to 6.0 indicated poor conditions, scores of 6.1 to 7.4 indicated fair conditions, scores of 7.5 to 8.9 indicated good conditions, and scores of 9.0 to 10 indicated excellent conditions for overall stream health. It should be noted, that since Turkey Creek is part of a highly urbanized watershed, an excellent score does not indicate that pristine or natural stream conditions are present. Rather, this ranking would be indicative of a stream that has a relatively low amount of impact for a stream flowing through and receiving drainage from an urban environment.

4.2 Physical Assessment and Visual Habitat Survey

A physical assessment and habitat survey was conducted at representative reaches based on a combination of the EPA Rapid Bioassessment Protocols for Habitat Assessment and Physiochemical Parameters of Streams developed in the Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers (Barbour et. al 1999), and the USDA NRCS Stream Visual Assessment Protocol (USDA, 1998). These protocols provide a standard and repeatable approach to evaluate conditions in streams and aquatic ecosystems. Physical parameters noted included site location, stream channel and bank characteristics, vegetation, substrate composition, available instream habitat for macroinvertebrates and fish, barriers to fish passage, and adjacent watershed features. The visual assessment evaluated both instream habitat characteristics and the characteristics of the riparian and terrestrial habitat adjacent to the stream. Examples of the habitat parameters examined include available cover, substrate embeddedness, channel flow and morphology, and channel habitat types. The complete physical assessment and visual habitat survey data form is included in Appendix A.

4.3 Biological Survey – Macroinvertebrates

Macroinvertebrate sampling is an accurate and reliable method to measure the ecological condition, habitat quality, and water quality of a stream. Certain species of macroinvertebrates are sensitive to habitat and water quality changes and their presence is indicative of good stream health, while other organisms are more tolerant of habitat degradation and represent the majority of species in degraded areas. Macroinvertebrate composition in the Upper Turkey Creek watershed was characterized based on surveys that were conducted both visually and through kick-net samples taken at representative assessment reaches throughout the watershed.

The method used to survey macroinvertebrates was based on a combination of the Save our Streams Methodology (SOS, 2005) and the USEPA Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers (Barbour et. al, 1999). Sampling was conducted by placing a kick net downstream of riffles within a representative reach, followed by agitating cobbles, gravel, leaves, and sand within a meter upstream to dislodge organisms. This procedure was conducted until over 200 macroinvertebrates were collected, or the procedure had been conducted at three locations in the reach. Macroinvertebrate samples collected at each site were identified in the field and individual metrics, including the overall species diversity and the percent of families both tolerant and intolerant to pollution, were calculated in order to determine an overall ecological health score. In reaches where there were no riffles suitable for sampling, boulders, cobbles, and other components of the substrate were examined and observed macroinvertebrates were identified and recorded. The complete macroinvertebrate survey form is included in Appendix B.

4.4 Biological Survey – Fish

Fish species composition within urbanized streams such as Upper Turkey Creek and its tributaries can be limited by habitat degradation, barriers to movement, and poor water quality. Sample reaches were determined based on the presence of available habitat and existing in-stream conditions, and were representative of the diversity of habitats and conditions present within the basin. The draft Upper Turkey Creek Basin Environmental Restoration Report completed by the USACE Kansas City District detailed two fish studies conducted by the USEPA (1997) and the Kansas Department of Wildlife and Parks (2003). A list of 28 species that may be expected to occur in Turkey Creek was compiled based on the results of the three studies. This list includes six species that have been documented in Upper Turkey Creek in previous biological surveys.

The fish species biological survey was developed from the species list presented in the Environmental Restoration Report, and includes species tolerance values specified by the Kansas Department of Wildlife and Parks (2005). Initially, seine hauls were proposed to be used at representative reaches in order to evaluate fish populations and community composition in Upper Turkey Creek and its tributaries. However, the occurrence of deep pools, long shallow broad runs, and variable streambeds over extended reaches in the study area limited the use of seine hauls as a viable method of characterizing fish species composition and abundance. Therefore, fish species composition and qualitative abundance was based on visual observation. The complete fish species biological datasheet and assessment form is included in Appendix B.

5.0 FINDINGS

Stream assessment results were compiled for a total of 100 stream reaches of variable lengths throughout the Upper Turkey Creek watershed. Sections of Turkey Creek and its tributaries enclosed in pipes were not surveyed. The location of the stream assessment reach stations and their overall assessment score are shown in **Figure 1**. Station locations represent the midpoint of the assessed stream reaches.

The lists below present the factors assessed during field surveys organized by general stream health category. The following section describes each of the factors assessed, as well as its general scoring for the Upper Turkey Creek watershed.

Physical Channel Characteristics	Vegetation	Water Quality	Aquatic Communities and Habitat Parameters
• Channel Condition • Hydrologic Alteration • Bank Stability	• Riparian Vegetation • Vegetative Protection • Presence of Invasive Plant Species	• Sediment Deposition • Nutrient Enrichment • Presence of Trash	• Barriers to Fish Movement • Fish Cover • Presence of Pools • Invertebrate Habitat • Canopy Cover • Riffle Embeddedness • Presence of Macroinvertebrates

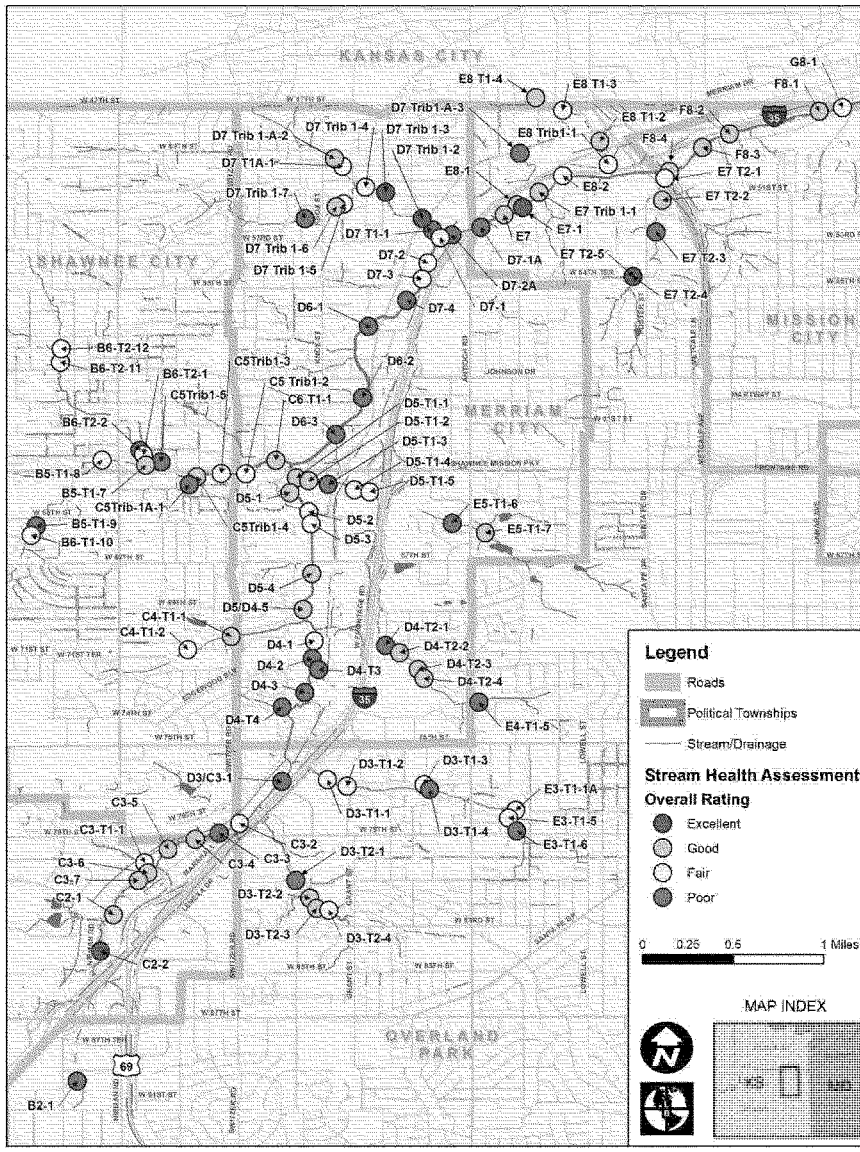


Figure 1: Stream Health Assessment Reaches and Overall Ratings

5.1 Watershed Wide Conditions

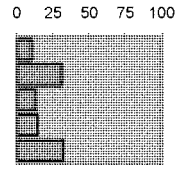
5.1.1 Physical Condition

The following parameters were assessed to determine the overall physical channel condition of the stream.

Channel Condition

The current channel condition was assessed at each reach to determine if the channel is currently altered or has remained in a natural condition. Results showed that approximately one third of the reaches sampled had been altered in the past but the banks had recovered. Another third of the reaches showed either active downcutting or widening, or more than 50% of the channel was covered in riprap. Only a small proportion (10%) of reaches did not have any channel alterations.

Score	*Percent of Sampled Sites*
8-10	10
6-7	31
4-5	13
2-3	14
0-1	32
Total	100

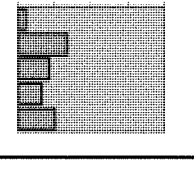


Channel Condition

Hydrologic Alteration

In order to determine the hydrologic alteration within a reach, the following characteristics were examined: the degree of channel incision, access to the flood plain, and the estimated number of annual flooding events that may occur within the reach. Throughout the watershed, the majority of reaches (54%) were considered to have some level of channel incision, and flooding was expected to occur within the reach between every 3 to 7 years. A large proportion (41%) of reaches were considered deeply incised to a point that flooding beyond the banks may not occur at any time. Only 5% of reaches were considered to have very few hydrologic alterations.

Score	*Percent of Sampled Sites*
8-10	5
6-7	33
4-5	21
2-3	16
0-1	25
Total	100

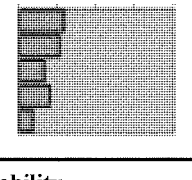


Hydrologic Alteration

Bank Stability

Roughly one-third of the reaches sampled have been stabilized to some degree with riprap, and seven reaches surveyed within the watershed were completely lined with concrete. These stabilization measures account for the stable condition of the many of the sampled reaches. However, nearly half (45%) of the reaches have not been stabilized, showed significant downcutting, and had actively eroding banks.

Score	*Percent of Sampled Sites*
8-10	29
6-7	26
4-5	16
2-3	20
0-1	9
Total	100



Bank Stability

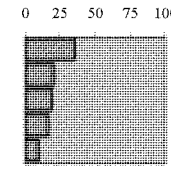
5.1.2 Vegetative Condition

The vegetative condition along a reach is an indicator of stream disturbance and modification, and therefore is both a physical and habitat component of the survey. Vegetative cover provides bank stability, instream protection, and wildlife habitat. The following parameters were used to assess vegetative condition.

Riparian Vegetation

Riparian vegetation provides a measure of bank stabilization, acts as a filter to surface runoff, and serves as habitat for both terrestrial and aquatic biota. The majority of reaches assessed (69%) had a narrow riparian zone impacted by either human disturbance and/or non-native plant species. The remaining (35%) was not considered as impacted and had a wide riparian zone.

Score	*Percent of Sampled Sites*
8-10	35
6-7	20
4-5	19
2-3	16
0-1	9
Total	100

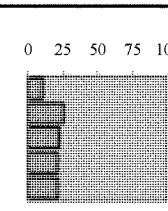


Riparian Vegetation

Vegetative Protection

Vegetative cover protects against bank erosion. Banks that are mostly covered with native vegetation without any human disturbance are favorable. In general, riparian zones in the watershed were equally distributed across categories from poor to good, with 90% of the reaches showing some degrees of disturbance, areas of bare ground, or cut grass. Only 10% of reaches were considered to have a relatively optimal vegetative zone.

Score	*Percent of Sampled Sites*
8-10	10
6-7	25
4-5	22
2-3	21
0-1	21
Total	100

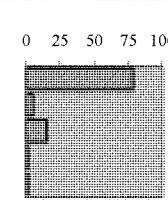


Vegetative Protection

Presence of Invasive Plant Species

Invasive plant species often out-compete native plant species and dominate vegetation composition, especially in urban areas. Surprisingly, the majority (78%) of reaches sampled in Turkey Creek do not contain non-native invasive plants or noxious weeds. Only 22% of sampled reaches had some measure of their vegetative cover comprised of non-native invasives.

Score	*Percent of Sampled Sites*
8-10	78
6-7	5
4-5	15
2-3	1
0-1	1
Total	100



Presence of Invasive Plant Species

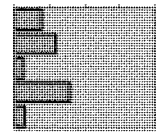
5.1.3 Water Quality

General water quality conditions can be estimated through visual inspection. The following visual water quality factors were assessed in the field.

Sediment Deposition

At each reach, the amount of sediment deposited was visually estimated. Results indicated that almost 40% of reaches have moderate bar and pool sediment deposition, 29% of the reaches had slight sediment deposition, while approximately 20% of the reaches had little to no sediment deposition.

Score	*Percent of Sampled Sites*
8-10	19
6-7	29
4-5	6
2-3	39
0-1	7
Total	100

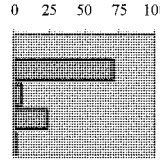


Sediment Deposition

Water appearance

Water appearance can be indicative of instream conditions such as enrichment, sedimentation, and pollution. None of the reaches sampled were considered to have very clear water. However, the majority of samples (70%) were considered to have only occasionally cloudy conditions, with visibility to between 1.5 to 3 feet in depth and no oil sheen on the surface. Considerable cloudiness with visibility of 0.5 to 1.5 feet, a conspicuous odor of ammonia, and/or a heavy green film covering submerged objects, was noted at 23% of sampled sites.

Score	*Percent of Sampled Sites*
8-10	0
6-7	70
4-5	5
2-3	23
0-1	1
Total	100

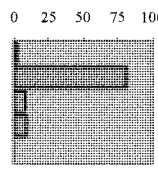


Water Appearance

Nutrient Enrichment

During this field study, the presence of nutrient enrichment was classified by the presence of algae and whether algae cover was dominant within the reach. Overall, the majority of reaches (81%) were considered to have moderate enrichment, with fairly clear or slightly greenish water and some algal growth on stream substrates.

Score	*Percent of Sampled Sites*
8-10	2
6-7	81
4-5	8
2-3	9
0-1	0
Total	100

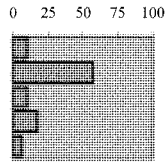


Nutrient Enrichment

Presence of Trash

In urban streams, such as those in the Turkey Creek watershed, trash is expected to be found in stream reaches due runoff from city streets, litter blown in through riparian zones, and illegal dumping.

Score	*Percent of Sampled Sites*
8-10	10
6-7	57
4-5	10
2-3	17
0-1	6
Total	100



Presence of Trash

Results indicate the majority of reaches (57%) contain trash in their floodplains and riparian zones. Trash in these reaches appears to have accumulated over time, with no evidence of any recent dumping or continuous sources. Approximately 34% of sampled sites have a higher presence of trash in streams, floodplains, and riparian zones. Sources for these reaches appear to be continuous, but unknown. Only a small proportion (10%) of the streams sampled showed minimal signs of trash in the stream corridor.

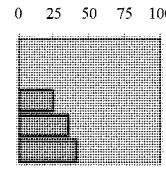
5.1.4 Instream Habitat Quality

Although the assessment parameters described above contribute to habitat quality, several metrics are specifically aimed at characterizing instream habitat. These parameters are described below.

Barriers to Fish Movement

Barriers to fish movement include pipe crossings, waterfalls, dams, and outfalls. Results show that barriers were found within a mile of every sampled reach. The presence of these barriers to fish movement throughout the watershed is an issue that will be addressed in the alternatives section of this report.

Score	*Percent of Sampled Sites*
8-10	0
6-7	0
4-5	24
2-3	35
0-1	41
Total	100

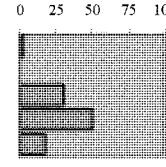


Barriers to Fish Movement

Fish Cover

Quality fish habitats consist of multiple types of instream cover for foraging and shelter. These cover types can include macrophyte beds, riffles, deep pools habitats, undercut banks, overhanging vegetation, and woody debris. Half of the reaches sampled provided between two and three cover types, which is considered a limited number of cover types for quality fish habitat. Roughly, 1/3rd of the sites sampled were considered to have a slightly higher number of cover types available (between 6 and 7). Only two of the reaches sampled provided a multitude of instream cover and high habitat diversity.

Score	*Percent of Sampled Sites*
8-10	2
6-7	0
4-5	30
2-3	50
0-1	17
Total	100

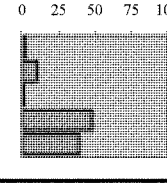


Fish Cover

Presence of Pools

Instream pool areas are important for fish habitat. The majority of reaches either had shallow pools (48%) or pools were absent (39%). Of all the reaches sampled, 12% were considered to have areas abundant with both deep and shallow pools. This is a limiting factor for instream fish habitat.

Score	*Percent of Sampled Sites*
8-10	2
6-7	10
4-5	1
2-3	48
0-1	39
Total	100

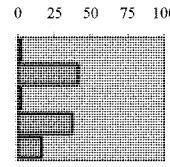


Presence of Pools

Invertebrate Habitat

Invertebrate habitat is considered favorable when there is greater diversity in cover and streambed substrates. Fine woody debris, leaf packs, cobbles, gravel, roots, and boulders all provide opportunity for invertertebrate foraging and shelter. Reaches were primarily composed of either three to four of these cover types (41%) or two to three habitat types (37%).

Score	*Percent of Sampled Sites*
8-10	2
6-7	41
4-5	2
2-3	37
0-1	16
Total	100

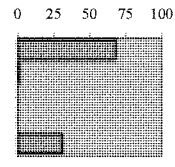


Invertebrate Habitat

Canopy Cover

Tree or shrub canopy cover can provide necessary shade for aquatic organisms within the stream and moderate temperature increases during the summer. The majority of reaches sampled had a favorable amount of canopy over (68%). The remaining reaches (31%) had a small amount of canopy cover that was considered unfavorable.

Score	*Percent of Sampled Sites*
8-10	68
6-7	1
4-5	0
2-3	0
0-1	31
Total	100

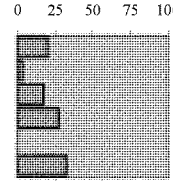


Canopy Cover

Riffle Embeddedness

Riffle embeddedness is both a sign of sedimentation and habitat quality for fish and macroinvertebrates. Embedded cobbles do not allow invertebrates to attach underneath rocks or serve as useful spawning material for many fish species. Roughly on third of the reaches sampled were not embedded, while nearly half showed some level of riffle embeddedness. Riffles were not present in 20% of the reaches

Score	*Percent of Sampled Sites*
No Riffles	20
0-1	3
2-3	17
4-5	27
6-7	0
8-10	32
Total	100

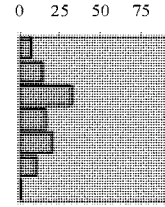


Riffle Embeddedness

Presence of Macroinvertebrates

Overall, invertebrate community composition was based on a three to five minute examination of boulders, cobbles, and various instream habitat. Observations were not able to be made on 7 reaches due to a lack of accessibility to the streambed. At the majority of reaches (59%) pollution tolerant species such as midges, leeches, and aquatic earthworms were present. In addition, 6 samples did not yield any macroinvertebrates. Facultative species that are somewhat tolerant to pollution such as damselflies, dragonflies, and

Score	*Percent of Sampled Sites*
Not assessable	7
<2	14
2-3	32
4-5	16
6-7	20
8-10	10
>10	1
Total	100



Presence of Macroinvertebrates

sowbugs were found at 35% of reaches. Mayflies, stoneflies, and most caddisfiles, which are highly sensitive to pollution, were found at one sampled reach.

5.1.5 Overall Stream Health Assessment

A cumulative assessment score indicative of overall stream health was calculated using the physical, habitat, and biological factor scores described above. A summary of the physical condition assessment scores is presented in **Table 1.**

The results presented in the table are typical for streams flowing in highly urbanized areas where stormwater runoff and riparian modifications create highly variable flow conditions and unstable streambed and banks. Stream health conditions were generally evenly distributed between good, fair, and poor categories. Only five assessed stream reaches were characterized as excellent for an urban stream; four of these stream reaches were located in the northern portion of the Turkey Creek watershed, and all had well developed riparian buffer zones and stable banks. Overall, impaired conditions were noted throughout the watershed, with bank stability, riparian impairments, and obstructions to fish passage commonly noted as major sources of stream health degradation.

Table 1: Overall Stream Health Assessment Scores for Upper Turkey Creek

Assessment Score	% of Reaches
Excellent	5
Good	32
Fair	34
Poor	29
Total	100

5.2 Area Specific Habitat Conditions

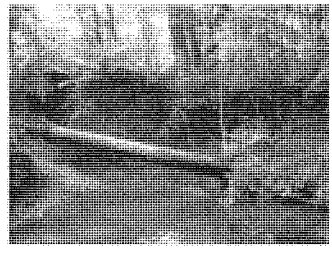
5.2.1 Southern Portion of Upper Turkey Creek Watershed

The southern portion of Turkey Creek begins at roughly W 91st Street and continues north, receiving drainage from three major tributaries, TRIB 95 from the west, and TRIB 85 and TRIB 81 from the east. These tributaries and the southern portion of Turkey Creek below W 75th Street are shown in **Figure 2** (Figures 2, 3, and 4 can be found at the rear of Section 5.0).

TRIB 95 drains an area west of the Turkey Creek mainstem of approximately 260 acres in size centered on the intersection of West 83rd Street and West 75th Street. The majority of the lower portion of this tributary is lined in concrete, the middle section is enclosed in pipe, and the headwaters flow through both enclosed pipes and open channels through residential areas. Reach C3-T1-1 is located at the most downstream section near TRIB 95's confluence with Turkey Creek. This reach has heavy sediment deposition and turbid water quality impacting biotic habitat.

Looking Upstream at Reach C3-T1-1

Further north, TRIB 85 drains an area east of the Turkey Creek mainstem of approximately 790 acres in size centered on the intersection of West 87th Street and West 79th Street. The majority of the headwaters of this stream flow through either enclosed pipes or concrete lined channels. Headwater stream reach D3-T2-4 has very poor bank stability, which is due to high volume flows that pass through a concrete lined stream section immediately upstream. The middle portion of this tributary flows through a park area before entering a concrete channel. Stream reach D3-T2-3 and D3-T2-2 are both located in the park, and have more stable banks, as well as better vegetation and habitat conditions than D3-T2-4. Further downstream, D3-T2-1 is located within a concrete lined channel and therefore had little value for habitat.



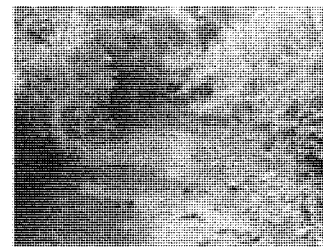
Looking Upstream at D3-T2-4

TRIB 81 is north of TRIB 85 and also drains an area east of the Turkey Creek mainstem. This area is roughly 630 acres in size centered on the intersection of West 83rd Street and West 75th Street. The majority of the headwaters are piped underground. The middle portion of the stream flows through a park and then a concrete channel, and the lower portion is in a natural channel before crossing under the highway in an enclosed pipe, which then enters Turkey Creek. The most upstream reach sampled, E3-T1-6, is located directly below a section of enclosed pipe, has poor instream habitat due to incised stream banks, sediment

Looking Upstream at E3-T1-5

deposition, and managed grasses along both sides of its banks. E3-T1-A, located on a headwater tributary draining from the north, has deeply incised channels, actively eroding banks, and heavy sediment deposition. Further downstream along the tributary in the park area (E3-T1-5) instream habitat, undercut banks, and heavy sediment deposition result in a poor rating. Reach D3-T1-4 was located slightly downstream within a concrete lined channel and therefore had very poor instream habitat. Several hundred feet downstream of the concrete channel, reach D3-T1-3 has poor bank stability and managed grasses along one bank. The most downstream reaches sampled D3-T1-2 and D3-T1-1 have heavy instream sediment deposition, highly eroding banks, and deeply incised channels.

The southern portion of Turkey Creek receives drainage from these three tributaries, draining a total area of approximately 3,700 acres in size. Portions of the headwaters are enclosed in pipes and portions of the mainstem are stabilized with riprap. Reaches sampled along the mainstem overall received scores ranging from poor to excellent. The most upstream reach, B2-1 is located directly below piped headwaters and has deeply incised banks, heavy deposition, and embedded substrates. Conditions further downstream appear to improve at reaches C2-1, C3-7, C3-6, C3-5, and C3-4 where favorable instream habitats, relatively stable banks, and improved vegetative buffer conditions occur. In contrast, reach C3-3 immediately downstream of the higher quality stream reaches to the south, has blown out banks, bank scour, and trees falling into the channel due to erosion from the surrounding outfalls. Directly downstream of West 79th Street, stream reach C3-2 shows sediment deposition as well as restored wetlands on the eastern bank. In general, physical channel conditions degrade north of C3-4, and generally continue as it progresses north and Turkey Creek picks up drainage from TRIB 85 and TRIB 81.



Looking Upstream at C2-2

5.2.2 Central Portion of Upper Turkey Creek Watershed

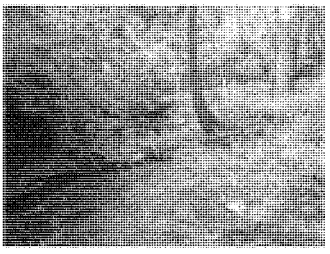
Figure 3 shows the middle section of Turkey Creek between 74th Street and Johnson Drive. Five main tributaries flow into this portion of Turkey Creek. Drainage from TRIB 75, TRIB 70, and TRIB 49 all provide flow input from east of Turkey Creek, while TRIB 71, TRIB 66 (and associated TRIB 60, 63, and 65), and TRIB 40 drain areas to the west.

TRIB 75 drains an area of approximately 690 acres, receiving runoff from neighborhoods surrounding the intersections of Antioch and W. 71st Street, Lowell and W. 75th, and Santee and W. 71st Street. Nearly the entire length of this tributary between Lowell Street and Antioch Road is considered poor aquatic habitat due to either channel enclosures or full concrete channels with a buffer zone consisting mainly of mowed grasses. Below Antioch Road stream health conditions generally improve with multiple

Looking Downstream at D4-T2-4

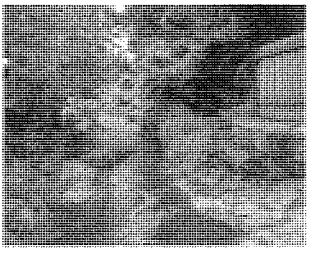
sections of stream stabilized and a well-vegetated riparian zone ranging between 50 and 100 feet wide on either side of the stream. Several improvements in fish habitat such as obstruction removals and bank stabilization at D4-T2-4 would further improve this portion of TRIB 75. Prior to passing under East Frontage Road and entering Turkey Creek, this tributary is again lined with concrete, with poor scores for both vegetation conditions and habitat quality.

TRIB 71 drains approximately 350 acres and enters Turkey Creek from the west just above the confluence of TRIB 75 and Turkey Creek. A significant portion of this tributary consists of concrete lined channels in two sections; a 1,200 foot portion in the headwaters just east of Neiman Road, and a 1,500 foot segment beginning at Switzer Road and continuing to the confluence of TRIB 71 and Turkey Creek. The two stream reaches between these concrete lined sections were assessed (C4-T1-2 and C4-T1-1) and both had well-developed riparian zones and generally good habitat, but could be further improved by bank stabilization measures.



Looking Downstream at C4-T1-2

TRIB 70 drains an area east of Turkey Creek of approximately 500 acres. This tributary is completely enclosed above W. Frontage Road for approximately 1,000 feet. There are several impoundments in the tributary drainage and the Milburn Country Club comprises a large portion of the headwaters of this tributary. Four stream reaches were assessed on this tributary. The stream reach furthest to the east, E5-T1-7, is located just below an impoundment in Antioch Park and receives nearly all of the drainage from the Milburn Country Club. This reach had a well-developed riparian area, and has been restored with riprap, installed meanders, and drop structures (rocks) resulting in an overall good stream health ranking. Continuing west of Antioch Road, stream reach E5-T1-6, was rated poor for stream health. This entire reach was channelized with both banks hardened with stone slab, and rock and concrete slabs placed in the channel. Conditions immediately to the west of Antioch Road, between Interstate 35 and Carter Ave along reaches D5-T1-4 and D5-T1-5 are considered fair. Unstable bank conditions along these reaches are the primary impairment impacting stream health, and during high intensity rain events the lower portion of the stream floods as water backs up behind Carter Avenue. Continuing further downstream to the west of Carter Avenue (D5-T1-3, D5-T1-2, and D5-T1-1) conditions improve with all stream reaches attaining an overall good rating. Review of the 100-year floodplain in this area reveals a zone of flooding that may potentially be formally managed for flood control.



Looking Downstream at E5-T1-6

TRIB 60, 63, 65, and 66 form a complex of tributaries that drain approximately 1,900 acres to the west of Turkey Creek. TRIB 63 drains the southwestern portion of the drainage complex,

and is primarily enclosed or lined with concrete along its 4,800-foot length between just south of West 67th Street and Shawnee Mission Parkway. Two stream reaches on this tributary were assessed B6-T1-10 and B5-T1-9, and were ranked fair and good for stream health, respectively. Conditions at B6-T1-10 are impaired due to poor bank stability and active erosion, while poor banks, riparian areas, and sedimentation are impacting conditions at B5-T1-9. Concrete and enclosed channels are located both upstream and downstream of these reaches, limiting habitat improvement potential. TRIB 65 drains the northern portion of this drainage complex, and generally ranks as either fair or poor for stream health. Stream reaches along this tributary transition between concrete channels and completely enclosed channels, with those stream reaches that are open and unlined in need of bank stability improvements (B6-T2-11 north of Johnson Drive and B5-T1-7 just north of Shawnee Mission Parkway). TRIB 66 largely follows Shawnee Mission Parkway west from Goddard Street to its confluence with Turkey Creek. Stream health conditions along this tributary are generally fair to good with stabilized banks along both sides of the stream as it parallels the parkway.

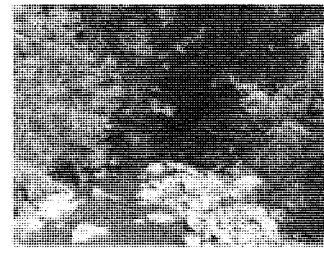
The central segment of Upper Turkey Creek from 75th Street to Johnson Drive flows north through parklands, a mixed commercial/industrial zone, and finally enters a mixed-residential/commercial area north of Shawnee Mission Parkway. The upstream reaches, D4-3, D4-2, and D4-1 have poor instream conditions with actively eroding banks, trees falling into the channel, and areas of exposed soil. Bank stabilization and riparian improvement would benefit the instream habitat within these reaches. Below the confluence with TRIB 71, instream conditions improve (at reaches D5/D4-5, D5-4, D5-3, D5-2 and D5-1) although there are some habitat constraints, such as instream barriers to fish. After the intersection with Shawnee Mission Parkway, instream conditions decline, with hardened banks, a reduction in vegetative cover, and degraded instream habitats.

5.2.3 Northern Portion of Upper Turkey Creek Watershed

The northern portion of Upper Turkey Creek begins just below Johnson Drive and continues north to the intersection of Interstate 35 and Roe Lane. This portion receives drainage from TRIB 40 and TRIB 49, which were not surveyed during this study due to the fact that nearly 6,000 feet of these streams are either enclosed in pipe or lined with concrete, and therefore offer little aquatic habitat benefit. Two major tributaries were surveyed during this study, TRIB 32 draining from the west and TRIB 15 draining from the east. These tributaries and the southern portion of Turkey Creek above Johnson Drive are shown in **Figure 4**.

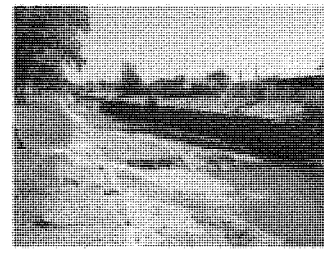
TRIB 32 drains an area west of the Turkey Creek mainstem of roughly 790 acres in size centered on the intersection of West 53rd Street and West 47th Street. Almost all of the stream miles within this tributary are open, unlined stream channels. TRIB 31 drains into TRIB 32 from the southwest. The most upstream reach on TRIB 31, D6-T1-7, has poor bank stability, and stabilization measures in the upstream reaches of this tributary would further enhance the overall condition of this tributary complex. Further downstream on TRIB 31, overall stream health improves with increased bank stability and a functional, yet narrow riparian buffer. The headwaters of TRIB 32 flow primarily through open parkland. The majority of reaches sampled along this stream segment have relatively stable banks, some of which had been restored. Continued riparian improvement along this stream section would further enhance aquatic

habitat. Additionally, habitat scores for several of the reaches sampled along this tributary were low due pipe crossings and other fish blockages.



Looking Upstream at E8-T1-4

TRIB 15 drains an area east of the Turkey Creek mainstem of approximately 490 acres in size centered on the intersection of Johnson Drive and the Interstate 35. The majority of the streams within this watershed are open, unlined channels. The headwaters drain through a forested area, reach E7-T2-5, with excellent bank stability, vegetative cover, and instream habitat limited by fish obstructions. Slightly downstream, habitat quality in stream reach E7-T2-4 is poor due to a concrete lined channel. The reach directly downstream, E7-T2-3, has deeply incised banks, poor water quality, and yard waste dumped into the channel. Continuing downstream along TRIB 15, instream conditions improve, although at reach E7-T2-1, the banks are actively eroding. Bank stabilization at reaches E7-T2-3, E7-T2-2, and E7-T2-1 would improve the rapidly eroding stream channel within this area.



Looking Upstream at D6-2

The mainstem of Turkey Creek above Johnson Drive drains a total of approximately 3,100 acres. Reaches along the mainstem from just below Johnson Drive to slightly above W. 53rd Street are in relatively poor condition with riprap along the banks, a lack of diversity in instream substrates, and in many cases, a lack of a riparian buffer. Directly downstream of the confluence between Turkey Creek and TRIB 40, the banks are stabilized, but instream conditions are poor until the stream enters a section with a forested riparian area. Fish habitat and riparian improvement at several reaches along this portion of the mainstem would allow for improved stream conditions. Below the intersection with Metcalf Ave, instream conditions could be further enhanced by bank stabilization and fish habitat improvement.

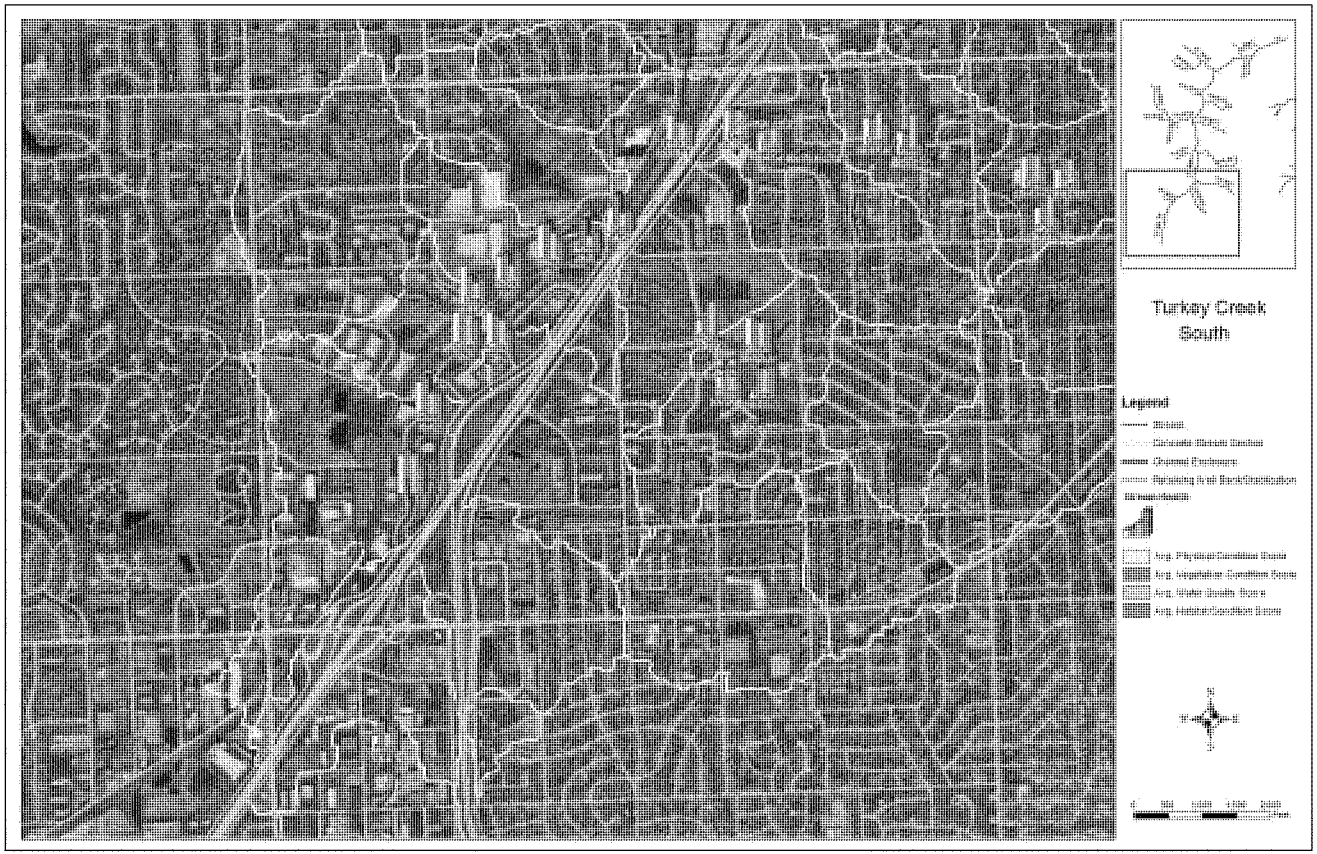


Figure 2. Southern Portion of Upper Turkey Creek Watershed

854

Figure 3. Central Portion of Upper Turkey Creek Watershed

855

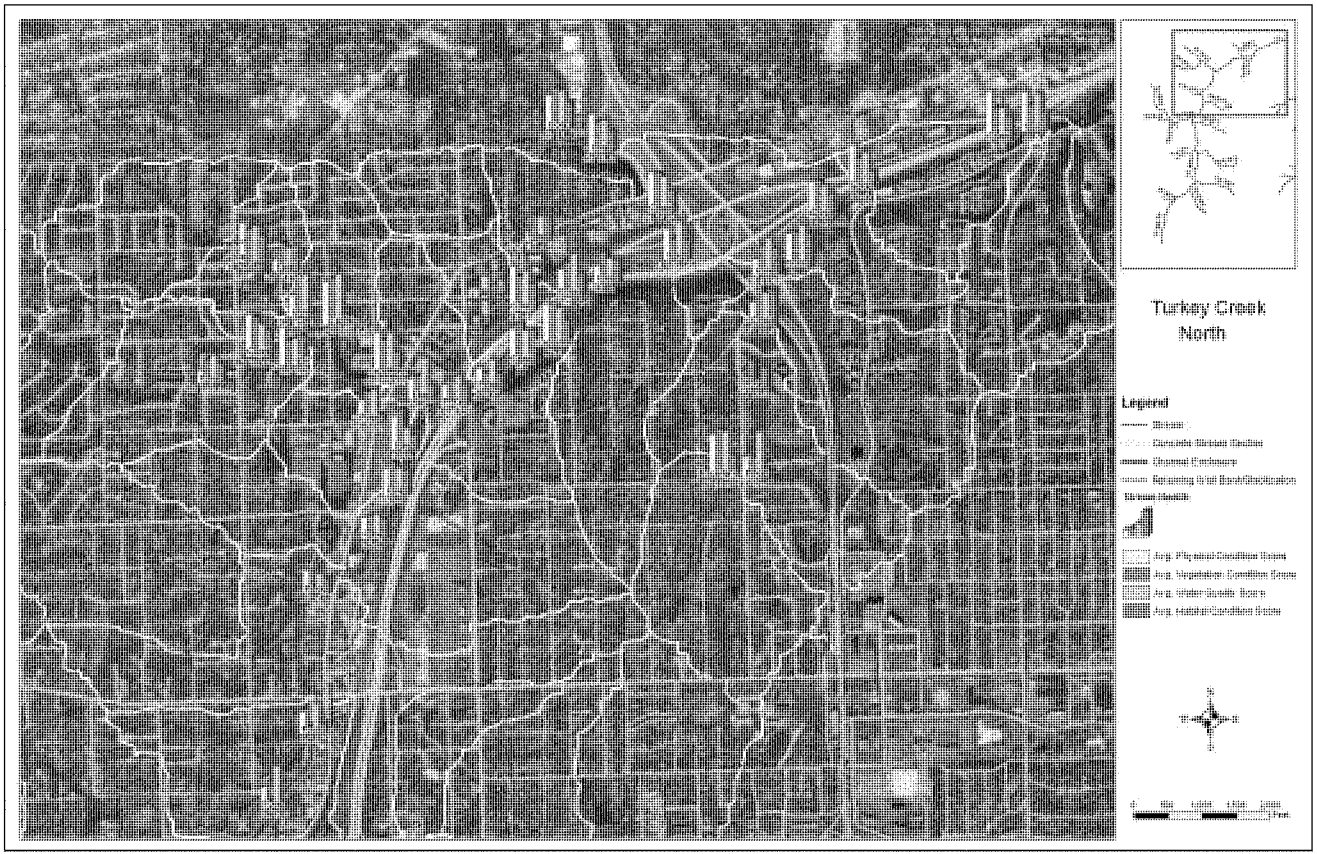


Figure 4. Northern Portion of Upper Turkey Creek Watershed

APPENDIX A STREAM HEALTH ASSESSMENT DATA SHEETS

Overall Assessment Rating	Score
Excellent	9.0-10.0
Good	7.5-8.9
Fair	6.1-7.4
Poor	1.0-6.0

Channel condition				
Description	Natural channel; no structures, dikes. No evidence of downcutting or excessive lateral cutting.	Evidence of past channel alteration, but with significant recovery of channel and banks. Any dikes or levies are set back to provide access to an adequate flood plain.	Altered channel; <50% of the reach with riprap and/or channelization. Excess aggradation; braided channel. Dikes or levees restrict flood plain width.	Channel is actively downcutting or widening. >50% of the reach with riprap or channelization. Dikes or levees prevent access to the flood plain.
Score	10	7	3	1

Hydrologic alteration				
Description	No dams, no water withdrawals, no dikes or other structures limiting the stream's access to the flood plain. Channel is not incised Flooding every 1.5 to 2 years.	Limited channel incision; or withdrawals, although present, do not affect available habitat for biota. Flooding occurs only once every 3 to 5 years	Channel deeply incised; or withdrawals significantly affect available low flow habitat for biota. Flooding occurs only once every 6 to 10 years	No flooding; channel deeply incised; or structures prevent access to flood plain; or dam operations prevent flood flows; or withdrawals have caused severe loss of low flow habitat; or flooding occurs on a 1-year rain event or less.
Score	10	7	3	1

Riparian zone (score each bank separately)					
Description	Natural vegetation extends at least two active channel widths (or >50')on each side; human activities (i.e. parking lots, roadbeds, clear-cuts, lawns) have not impacted zone.	Natural vegetation extends one active channel width (or 25-50')on each side; or if less than one width, covers entire flood plain; human activities have impacted zone minimally.	Natural vegetation extends half of the active channel width (or 15-25') on each side; human activities have had moderate impacts in the zone.	Natural vegetation extends a third of the active channel width (or 10-15')on each side; or filtering function moderately compromised; human activities have impacted zone a great deal.	Natural vegetation less than a third of the active channel width on each side; or lack of regeneration; or filtering function severely compromised; little or no riparian vegetation as a result of human activities.
Score	RB 10	8	5	3	1
	LB 10	8	5	3	1
Note: Determine bank by facing upstream.					

Invasive Species (score each bank separately)					
Description	No nonnative invasive plants or noxious weeds present.	The presence of nonnative invasive plants and/or noxious weeds comprises between 1-25% of vegetation cover.	The presence of nonnative invasive plants and/or noxious weeds comprises between 26 -50% of vegetation cover.	The presence of nonnative invasive plants and/or noxious weeds comprises between 51-75% of vegetation cover.	The presence of nonnative invasive plants and/ or noxious weeds comprises more than 75% of the vegetation cover.
Score	RB 10	8	5	3	1
	LB 10	8	5	3	1

Vegetative protection (score each bank separately)				
Description	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, shrubs, or herbaceous vegetation; vegetative disruption through mowing, etc., not evident; most plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation; disruption evident but not affecting full plant growth potential to a great extent; more than ½ of the plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than ½ of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 2" or less in average stubble height.
Score	RB 10	7	3	1
	LB 10	7	3	1
Note: Determine bank by facing upstream.				

Bank stability				
Description	Banks are stable; banks are low (at elevation of active flood plain); 33% or more of eroding surface area of banks in outside bends is protected by roots that extend to the base-flow elevation.	Moderately stable; banks are low (at elevation of active flood plain); less than 33% of eroding surface area of banks in outside bends is protected by roots that extend to the baseflow elevation.	Moderately unstable; banks may be low, but typically are high (flooding occurs 1 year out of 5 or less frequently); outside bends are actively eroding (overhanging vegetation at top of bank, some mature trees falling into steam annually, some slope failures apparent).	Unstable; banks may be low, but typically are high; some straight reaches and inside edges of bends are actively eroding as well as outside bends (overhanging vegetation at top of bare bank, numerous mature trees falling into stream annually, numerous slope failures apparent).
Score	10	7	3	1

Sediment Deposition				
Description	Little or no enlargement of islands or point bars and less than 20% of the bottom affected by sediment deposition	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment in old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition in pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
Score	10	7	3	1

Water appearance				
Description	Very clear, or clear but tea-colored; objects visible at depth 3 to 6 ft (less if slightly colored); no oil sheen on surface; no noticeable film on submerged objects or rocks.	Occasionally clondy, especially after storm event, bnt clears rapidly; objects visible at depth 1.5 to 3 ft; may have slightly green color; no oil sheen on water surface.	Considerable cloudiness most of the time; objects visible to depth 0.5 to 1.5 ft; slow sections may appear pea-green; bottom rocks or snbmerged objects covered with heavy green or olive-green film; or moderate odor of ammonia or rotten eggs.	Very turbid or mnddy appearance most of the time; objects visible to depth < 0.5 ft; slow moving water may be bright green; other obvious water pollntants; floating algal mats, snrface scnm, sheen or heavy coat of foam on surface; or strong odor of chemicals, oil, sewage, other pollutants.
Score	10	7	3	1

Nutrient enrichment				
Description	Clear water along entire reach; diverse aqnatic plant community inclndes low qnantities of many species of macrophytes; little algal growth present.	Fairly clear or slightly greenish water along entire reach; moderate algal growth on stream snbstrates.	Greenish water along entire reach; overabundance of lush green macrophytes; abnndant algal growth, especially dnring warmer months.	Pea green, gray, or brown water along entire reach; dense stands of macrophytes clog stream; severe algal blooms create thick algal mats in stream.
Score	10	7	3	1

Barriers to Fish Movement					
Description	No barriers	Seasonal water withdrawals inhibit movement within the reach	Drop structures, culverts, dams, or diversions (< 1 foot drop) within the reach	Drop structures, culverts, dams, or diversions (> 1 foot drop) within 3 miles of the reach	Drop structures, culverts, dams, or diversions (> 1 foot drop) within the reach
Score	10	8	5	3	1

Instream fish cover					
Description	>7 cover types available.	6 to 7 cover types available	4 to 5 cover types available	2 to 3 cover types available	None to 1 cover type available
Score	10	8	5	3	1

Example Cover Types:

Dense macrophyte beds—Beds of emergent (e.g., water willow), floating leaf (e.g., water lily), or submerged (e.g., riverweed) aquatic vegetation thick enough to provide invertebrate attachment and fish cover.

Riffles—Area characterized by broken water surface, rocky or firm substrate, moderate or swift current, and relatively shallow depth (usually less than 18 inches).

Isolated/backwater pools—Areas disconnected from the main channel or connected as a "blind" side channel, characterized by a lack of flow except in periods of high water.

Logs/large woody debris—Fallen trees or parts of trees that provide structure and attachment for aquatic macroinvertebrates and hiding places for fish.

Deep pools—Areas characterized by a smooth undisturbed surface, generally slow current, and deep enough to provide protective cover for fish (75 to 100% deeper than the prevailing stream depth).

Overhanging vegetation—Trees, shrubs, vines, or perennial herbaceous vegetation that hangs immediately over the stream surface, providing shade and cover.

Boulders/cobble—Boulders are rounded stones more than 10 inches in diameter or large slabs more than 10 inches in length; cobbles are stones between 2.5 and 10 inches in diameter.

Undercut banks—Eroded areas extending horizontally beneath the surface of the bank forming underwater pockets used by fish for hiding and protection.

Thick root mats—Dense mats of roots and rootlets (generally from trees) at or beneath the water surface forming structure for invertebrate attachment and fish cover.

Pools				
Description	Deep and shallow pools abundant; greater than 30% of the pool bottom is obscure due to depth, or the pools are at least 5 feet deep.	Pools present, but not abundant; from 10 to 30% of the pool bottom is obscure due to depth, or the pools are at least 3 feet deep.	Pools present, but shallow; from 5 to 10% of the pool bottom is obscure due to depth, or the pools are less than 3 feet deep.	Pools absent, or the entire bottom is discernible.
Score	10	7	3	1

Insect/invertebrate habitat				
Description	At least 5 types of habitat available. Habitat is at a stage to allow full insect colonization (woody debris and logs not freshly fallen)	3 to 4 types of habitat. Some potential habitat exists, such as overhanging trees, which will provide habitat, but have not yet entered the stream.	1 to 2 types of habitat. The substrate is often disturbed, covered, or removed by high stream velocities and scour or by sediment deposition.	None to 1 type of habitat.
Score	10	7	3	1
Example cover types include: fine woody debris, submerged logs, leaf packs, undercut banks, submerged roots, cobbles, boulders, coarse gravel.				

Canopy cover (if applicable): Warmwater fishery				
Description	25 to 90% of water surface shaded; mixture of conditions	> 90% shaded; full canopy; same shading condition throughout the reach.	(intentionally blank)	< 25% water surface shaded in reach.
Score	10	7		1

Riffle Embeddedness					
Score	Gravel or cobble particles are < 20% embedded.	Gravel or cobble particles are 20 to 30% embedded	Gravel or cobble particles are 30 to 40% embedded.	Gravel or cobble particles are >40% embedded.	Riffle is completely embedded.
	10	8	5	3	1

Macroinvertebrates Observed				
Description	Community dominated by Group I or intolerant species with good species diversity. Examples include caddisflies, mayflies, stoneflies, hellgrammites.	Community dominated by Group II or facultative species, such as damselflies, dragonflies, aquatic sowbugs, blackflies, crayfish.	Community dominated by Group III or tolerant species, such as midges, craneflies, horseflies, leeches, aquatic earthworms, tubificid worms.	Very reduced number of species or near absence of all macroinvertebrates.
Score	15	6	2	-3

Trash				
Score	Minimal trash (litter) in the stream, floodplain or adjacent riparian habitat; no evidence of dumping of yard wastes or trash.	Trash present in stream or floodplain/riparian zone; trash appears to have accumulated over time; continuous current source not evident; no evidence of dumping of yard waste or trash.	Abundant trash in stream or in floodplain/ riparian zone; source appears to be continuous, but obvious source of trash not evident.	Abundant trash in stream, in wrack and on adjacent foodplain/ riparian zone; evidence of dumping or other obvious sources of trash observed.
Description	10	7	3	1

APPENDIX B BIOLOGICAL DATA SHEETS

Stream Name:_____

Stream Segment: _____

Date:_____ Time:_____

Observers: _____

Location:_____ Lat_____ Long_____

Qualitative listing of aquatic biota:

Estimated abundance: **0**= absent/not observed **1**=Rare, **2**=Common, **3**=Abundant, **4**=Dominant

Periphyton:	0 1 2 3 4	Slimes:	0 1 2 3 4
Filamentous Algae:	0 1 2 3 4	Macroinvertebrates:	0 1 2 3 4
Macrophytes:	0 1 2 3 4	Fish:	0 1 2 3 4

Data Summary of pages 2-7:

- Total Macroinvertebrate Metric Number:_____ Acceptable (Y/N): __
- Percentage of Sensitive Fish Species Present:____ Total # Taxa:___

Macroinvertebrate Tally Sheet

Macroinvertebrates	Tally	Count
Worms		
Flat Worms		
Leeches		
Crayfishes		
Sowbugs		
Scuds		
Stoneflies		
Mayflies		
Dragonflies and Damselflies		
Hellgrammites, Fishflies, and Alderflies		

Macroinvertebrates	Tally	Count
Common Netspinners		
Most Caddisflies		
Beetles		
Midges		
Black Flies		
Most True Flies		
Gilled Snails		
Lunged Snails		
Clams		
Other Subsurface organisms (please specify if possible – if you do not know if the organism is subsurface, please do not include in the total)		
Total number of organisms in the sample		

Illustrations from: Vashell, J. R., Jr. 2001. Guide to the Common Freshwater Invertebrates of North America. MacDonald and Woodward Publishing Co. With permission of the author.

Macroinvertebrate Individual Metrics

Metric Number	Metric Organism Group	Number of metric organism		Total number of organisms in the sample		Percent (This is your value for this metric)
1	Mayflies + Stoneflies + Most Caddisflies		÷		Multiply by 100	%
2	Common Netspinners		÷		Multiply by 100	%
3	Lunged Snails		÷		Multiply by 100	%
4	Beetles		÷		Multiply by 100	%

Metric 5 - % Tolerant

Taxon	Number
Worms	
Flatworms	
Leeches	
Sowbugs	
Scuds	
Dragonflies and Damselflies	
Midges	
Black Flies	
Lunged Snails	
Clams	
Total Tolerant	
Total Tolerant divided by the total number of organisms in the sample	
Multiply by 100 **This is your Value for Metric 5**	

Metric 6 - % Non-Insects

Taxon	Number
Worms	
Flatworms	
Leeches	
Crayfish	
Sowbugs	
Scuds	
Gilled Snails	
Lunged Snails	
Clams	
Total Non-Insects	
Total Non-Insects divided by the total number of organisms in the sample	
Multiply by 100 **This is your Value for this Metric 6**	

Macroinvertebrate Multimetric Index[1]

Write your metric value from the previous page in the 2nd column (Your Metric Value). Determine whether each metric should get a score of 2,1, or 0 - depending upon the range of your metric value. Put a check in the appropriate box for your metric value under 2,1, or 0. Count the total number of 2's, 1's, and 0's. Follow the multiplication at the bottom of the chart to determine your Save Our Streams Multimetric Index score and determine whether the site has acceptable or unacceptable ecological condition.

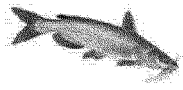
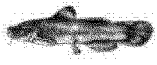
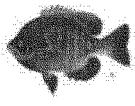
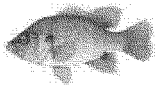
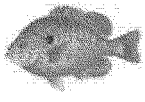
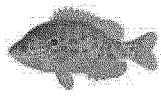
Metric Number	Metric Organism	Your Metric Value	2	1	0
1	% Mayflies + Stoneflies + Most Caddisflies		Greater than 32.2	16.1 - 32.2	Less than 16.1
2	% Common Netspinners		Less than 19.7	19.7 - 34.5	Greater than 34.5
3	% Lunged Snails		Less than 0.3	0.3 - 1.5	Greater than 1.5
4	% Beetles		Greater than 6.4	3.2 - 6.4	Less than 3.2
5	% Tolerant		Less than 46.7	46.7 - 61.5	Greater than 61.5
6	% Non-Insects		Less than 5.4	5.4 - 20.8	Greater than 20.8
			Total # of 2s:	Total # of 1s:	Total # of 0s:
		Subtotals:	Multiply by 2:	Multiply by 1:	Multiply by 0:

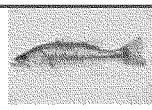
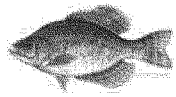
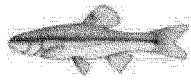
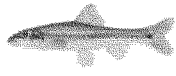
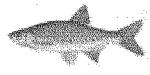
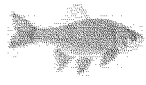
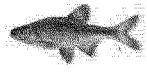
Now add the 3 subtotals to get the Save Our Streams Multimetric Index score:_____

_____**Acceptable ecological condition (7 to 12)** _____**Unacceptable ecological condition (0 to 6)**

[1] Macroinvertebrate data sheets and individual metrics from the Virginia Save our Streams protocol (2005)

Fish Tally Data Sheets

Category	Species (Common Name)	Tolerance Level	Previously Observed in Turkey Creek?	Tally	Count
Sport Fish	Back bullhead	Tolerant	No		
	Yellow Bullhead	Tolerant	No		
	Channel Catfish 	Intermediate	No		
	Slender Madtom 	Sensitive	Yes		
	Bluegill 	Intermediate	No		
	Green Sunfish 	Tolerant	Yes		
	Longear Sunfish 	Sensitive	No		
	Orangespotted Sunfish 	Tolerant	No		
	Largemouth Bass	Intermediate	Yes		

					
	Black Crappie 	**Intermediate**	**No**		
	White Crappie	**Intermediate**	**No**		
Minnows	**Bluntnose Minnow** 	**Tolerant**	**No**		
	Flathead Minnow	**Tolerant**	**Yes**		
	Suckermouth Minnow 	**Tolerant**	**No**		
	Golden Shiner 	**Tolerant**	**No**		
	Red Shiner 	**Tolerant**	**Yes**		
	Redfin Shiner 	**Intermediate**	**No**		
	Sand Shiner	**Tolerant**	**No**		
	Central Stoneroller	**Intermediate**	**No**		

	Common Carp	**Tolerant**	**No**		
	Mosquitofish	**Tolerant**	**No**		
	Creek Chub	**Tolerant**	**Yes**		
Darters	**Johnny Darter**	**Intermediate**	**No**		
	Orangethroat Darter	**Intermediate**	**No**		
Others	**Gizzard Shad**	**Tolerant**	**No**		
	Freshwater Drum	**Intermediate**	**No**		
	Longnose Gar	**Tolerant**	**No**		
	River Carpsucker	**Tolerant**	**No**		
				Total Count:	

Fish Metrics

Tolerance Level:	Number of Individuals:	Total Number of Fish observed:	Percentage Present:	Total Number of Taxa:
Tolerant Species				
Intermediate Species				
Sensitive Species				

Comments: _____

_____

_____

_____

- Fish species list derived from: HNTB Architects Engineers Planners. 2004. Upper Turkey Creek Basin Environmental Restoration Report Feasibility Phase: 2-6.

- Majority of illnstrations from: www.tpwd.state.tx.us, http://fish.dnr.cornell.edu, http://dfw.state.or.us, www.glerl.noaa.gov, www.dnr.state.oh.us, www.sites.state.pa.us.

UPPER TURKEY CREEK BASIN ENVIRONMENTAL ENHANCEMENT
FOR LOCAL IMPLEMENTATION

Johnson and Wyandotte Counties, KS

Project Sponsor Information Document

Prepared For:

U.S. Army Corps of Engineers
Kansas City District

by

The Louis Berger Group, Inc.

August 2009

Table of Contents

1.0 Purpose and Scope **1**

2.0 Problem Definition **1**

2.1 Goals and Objectives of Environmental Enhancement 1

2.2 Environmental Enhancement Measures 2

3.0 Modeling Methodologies Used to Evaluate Environmental Enhancement **3**

3.1 Environmental Enhancement Projects Sites 4

3.1.1 Highland Park 4

3.1.2 Brown Park 4

3.1.3 Downtown Shawnee 5

3.1.4 Nieman Plaza 5

3.1.5 Chatlain Park 5

3.1.6 Turkey Creek Streamway Park 5

3.1.7 Thousand Oaks 6

3.1.8 Quail Creek Park 6

3.1.9 Westbrook 6

3.1.10 JC Penney Outlet 6

3.1.11 Sapling Grove Park 7

Tables

Table 1: Upper Turkey Creek Candidate Restoration Sites 7

Figures

Figure 1: Project Area and Location of Proposed Alternatives, Turkey Creek North.... 10

Figure 1: Project Area and Location of Proposed Alternatives, Turkey Creek Central... 11

Figure 1: Project Area and Location of Proposed Alternatives, Turkey Creek South.... 12

Appendix A

Candidate Restoration Site Fact Sheets

1.0 Purpose and Scope

The U.S. Army Corps of Engineers (USACE), Kansas City District, along with the local sponsor, Merriam, Kansas, initiated the feasibility phase of the Upper Turkey Creek watershed (Figure 1) to examine measures for flood risk management. Congressional authority for Upper Turkey Creek specifically states this project's primary mission is flood risk management. The USACE is considering a watershed approach including collaborative planning, ecosystem restoration, and recreation in the plan formulation process where feasible opportunities are found. The purpose of this document is to describe areas within the basin where opportunities exist to perform environmental enhancement by the project sponsor.

2.0 Problem Definition

The Upper Turkey Creek Basin, Kansas, is a historically connected tributary to the Kansas and Missouri Rivers, which are important ecological resources for the region. Development in the watershed has degraded these natural systems. Direct development impacts have included floodplain filling, channel straightening, concrete lining of channels, channel enclosures, filling on-stream lakes, streambank armoring and fills, the loss of streamside vegetation, and disruptions due to numerous road and utility crossings. Indirect impacts have resulted from development in the watershed, increasing the rate at which water reaches the creek and tributaries.

The Upper Turkey Creek valley is a degraded environmental resource that is still undergoing development. The combination of the direct and indirect impacts has increased the flood peak flows, flood flow volumes, channel flow velocities, and the rapid rate at which stream flows rise and fall after a storm. The result has been instability in the stream as noted by channel incision and streambank erosion. Preventative measures have included enclosing the channels in culverts or lining the channels with concrete in many places. These concrete and enclosed channel sections become generally impassable biological dead zones for most aquatic species in Turkey Creek.

2.1 Goals and Objectives of Environmental Enhancement

The goal under the environmental enhancement is to apply a systems-based approach that provides cost effective, multipurpose, and environmental benefits to address environmental degradation within an urban environmental setting. By focusing on enhancement measures in the upstream tributaries of the watershed, this approach will provide:

<u>A sustainable stream corridor with improved aquatic habitat and improved natural function;</u>

- To improve water quality by reducing factors such as increased sedimentation and turbidity, fecal bacteria, BOD, and temperature.
- To increase habitat connectivity by reducing obstructions, including those limiting fish movements.

- To increase connectivity to the floodplain helping to ensure the benefits of natural function.
- To assess and understand the incidental flooding impacts resulting from environmental enhancement measures.

Enhanced recreational opportunities; and

- To incorporate multi-user recreational opportunities.
- To improve aesthetics through restoration efforts.

A coordinated approach for stream corridor management:

- To unify multi-agency objectives in order to take an integrated comprehensive approach to systems management, when possible.
- To capitalize on coordinated efforts in preserving cultural resources and providing educational opportunities.
- To take advantage of green solutions and Best Management Practices (BMPs) already being implemented by other entities (e.g., MARC, American Public Works KC Ch, local municipalities).

2.2 Environmental Enhancement Measures

A number of measures can be implemented to achieve improved aquatic habitat and natural stream function resulting in a sustainable stream corridor. The different measures are discussed in detail below. They are divided into several categories including bank stabilization, fish habitat improvement, riffle-pool complexes, instream habitat, riparian improvements, and water quality improvements. Recreational opportunities and stream corridor management opportunities are also discussed.

Bank Stabilization Measures: A number of bank stabilization measures have been identified for potential use in achieving a sustainable stream corridor. Implementation of these measures would be based on site-specific information, cost, and perceived benefits. These measures include vegetative/structural measures including: brush layering, brush mattressing, live fascines (wattling), stone riprap with joint plantings, live crib walls, cable concrete revetment with vegetation, and other bank stabilization techniques.

Fish Habitat Improvement: There are a number of reaches where removal of obstructions is recommended to provide continuous lengths of main stem or tributaries where the presence of fish was noted in the surveys.

Riffle-Pool Complexes: The creation of riffle-pool complexes has multiple purposes. It can stop downcutting and headcutting in a manner that provides fish and wildlife habitat and improve water quality. It has been noted that Upper Turkey Creek need additional pool habitat for fish. In addition, the development of riffles improved water quality by aerating water, increasing the level of dissolved oxygen and assist in reducing ammonia levels.

Instream Habitat: There are several measures that could assist in developing instream habitat. Those being considered include the use of root wads, lunker boxes, and anchored logs. Root wads include the root ball of a tree plus part of the trunk. They protect the streambank by deflecting stream flows. They also provide habitat for fish and other aquatic animals, as well as a food source for aquatic insects. Similarly, anchored logs help to establish pools and increase available fish habitat. The creation of lunker boxes provide fish habitat in undercut banks and would be recommended for limited use.

Riparian Habitat: There are several options available to improve riparian habitat, further improving the stream corridor sustainability. These include the development of riparian swales and buffers using native plantings. These would be recommended for use in areas where nonpoint source pollution or run-off was limiting water quality. In addition, as temperature is also considered a pollutant, the planting or removal of trees to assist in the increase in canopy and shading would be used in specific areas. These measures would improve overall water quality in the reaches where they were implemented.

Water Quality Improvement**:** Several measures have also been identified for potential use in areas outside the immediate riparian area. These include the redesign of detention basins to improve water quality. The improvements would result in increased detention time, allowing for more pollutants to settle out of the water column, improving the quality of the water discharged into the stream. Implementation of these measures would be based on site-specific information, cost, and perceived benefits.

Recreational Opportunities: Recreational opportunities in the floodplain of Turkey Creek and tributaries would include trail development, access points, park/greenway amenities and educational outreach.

- Trail development -Multi-use trails (biking, walking, running) with lanes or other use controls, access to parking and distance information. Interconnect trails to create larger system.
- Access Points for Fishing and Wildlife - Parking areas and access to pools and other areas where fish may be prevalent, garbage disposal areas, and kiosks of local fish species.
- Nature viewing areas - Could include viewing platforms and native plantings.
- Park/greenway amenities - Could include composting restroom facilities, parking areas, lighting, and garbage disposal areas (to reduce trash).
- Educational Outreach - Could include kiosks along trails and at trail heads describing the local biota and the stream processes.

3.0 Modeling Methodologies Used to Evaluate Environmental Enhancement

Overall stream health assessments rankings and scores were developed for 106 reaches on the Upper Turkey Creek mainstem and its tributaries. Stream assessments were completed and environmental restoration projects were identified. Various bank stabilization measures were proposed for unstable sections along the mainstem and tributaries. Of the 106 stream assessment

reaches, 33 reaches analyzed in further detail. These 33 stream assessments were performed using a combination of other stream assessment protocols and were converted to scores according to the guidelines and descriptions used in the Subjective Evaluation of Aquatic Habitats developed by the Kansas Department of Wildlife and Parks (KDWP, 2004).

3.1 Environmental Enhancement Projects Sites

Candidate restoration sites in the Upper Turkey Creek watershed have been evaluated for consideration of stream stabilization, fish habitat improvements, riparian corridor improvements, water quality measures and recreational opportunities. Study clusters were evaluated to determine applicable stream stabilization measures, habitat and water quality measures. Clusters in close proximity were grouped to establish a total of 11 project areas including Highland Park, Brown Park, Downtown Shawnee, Nieman Plaza, Chatlain Park, Turkey Creek Streamway Park, Thousand Oaks, Quail Creek Park, Westbrook, JC Penney Outlet, and Sapling Grove Park.

Candidate Restoration Sites are depicted on Figure 1a, 1b, and 1c. Candidate Restoration Site locations and descriptions are described below. Candidate project areas, evaluation clusters and their respective reaches are shown on maps and summarized in Table 1. Fact Sheets detailing each project are in Appendix A.

Candidate restoration sites were identified based on visual observation, an evaluation of the project potential to support USACE flood risk management goals, and potential habitat gains (increases in habitat units). Candidate restoration projects are preliminary environmental enhancement concepts. For alternative formulation, the project will be evaluated for a gain in habit units as well as cost benefit considerations. Environmental enhancement projects will likely be completed by the project sponsors. Hydrologic analyses, hydraulic analyses, geomorphic analyses, and other studies should be completed prior to the final design for each project.

3.1.1 Highland Park

The Highland Park Project Area is located near the intersection of 47th Street and Shawnee Drive. The Highland Park Project Area includes two projects. Portions of the streambank have been covered with asphalt to reduce streambank erosion near the Kansas City, Kansas maintenance facility. The channel is moderate to severe incised and several exposed manholes were noted during the field site visit. The proposed actions would include bank stabilization measure as well as channel morphology work. Environmental enhancement measures that could be applicable include stone riprap with joint plantings, live fascines, riffle/pool complexes, removal of asphalt, brush mattressing, and construction of rock riffles. A total of 3,150 linear feet (l.f.) of tributary would be enhanced. Benefits may include shading, a reduction in bank erosion, enhanced fish passage and increased habitat near the Kansas City, Kansas Maintenance facility.

3.1.2 Brown Park

The Brown Park Project Area is located near Grant Street and West 50th Terrace in Merriam, Kansas. Brown Park includes three projects on two unnamed tributaries. Existing conditions in the reaches consists of active stream downcutting and headcutting, exposed sanitary sewer encasements, exposed abandoned waterline, moderate bank erosion, partial fish blockages in the form of bedrock waterfalls, washed-out erosion mat, narrow floodplain benches, and concrete

lined channel. The proposed actions would include riffle/pool complexes and bank stabilization measures. A total of 2,240 l.f. of tributary would be enhanced. Benefits would include reduced bank erosion, enhanced water quality, and enhanced fish passage.

3.1.3 Downtown Shawnee

The Downtown Shawnee Project Area is located near the intersection of Flint Street and West 57th Street. A project has recently been completed. The project included placement of rock riprap on banks from toe to upper bank on both banks; recently planted trees and shrubs underlain with erosion control blanket; three BMPs/rain gardens on upper banks; and two rock riffle/grade control structures in stream. The adjacent church parking lot west of stream has curb cuts allowing runoff to flow into stream. The banks have been stabilized with large limestone blocks on the downstream end near Johnson Drive. No future projects are recommended

3.1.4 Nieman Plaza

The Nieman Plaza Project Area is located near the intersection of Shawnee Mission Parkway and Nieman Road in Merriam. Neiman Plaza includes two projects on two unnamed tributaries. The tributaries have moderately to severely incised channels, root exposure and undercut banks, narrow floodplain bench, poor quality riparian habitat, and exposed pipe. The proposed actions would include relocation of channel, riffle/pool complexes, and stabilization of the channel and streambanks. Channel erosion is directly behind a commercial development. The project may require channel relocation and possible buyout of the residential property. A total of 1,225 l.f. of tributary would be enhanced.

3.1.5 Chatlain Park

The Chatlain Park project is near the intersection of Carter Avenue and West 63rd Terrace in Merriam. The Chatlain Park Project Area includes two projects. The problem characteristics of the reaches consist of moderately to severely incised channels, narrow-to-absent forested riparian buffer, poor quality riparian habitat, and there has been an unstable drainageway recently constructed that connects to the reach. The candidate restoration project would be a riparian habitat enhancement. Revegetation of upper banks with native riparian tree and shrub species is recommended as well as an expansion of the riparian buffer in the maintained park area. In addition, a bank stabilization project was identified in the project area. A total of 2,060 l.f. of tributary would be enhanced.

3.1.6 Turkey Creek Streamway Park

The Turkey Creek Streamway Park Project area is located in the designated park area west of I-35 between West 67th Street and West 75th Street. The Turkey Creek Streamway Park Project Area includes two projects. The Turkey Creek Streamway Park North project has been stabilized with large riprap for approximately 100 feet on both sides of the bridge on the left and right banks. Stream has been channelized with left and right banks 20 to 25 feet tall. Left bank in most areas contains poor to moderate quality riparian vegetation. The candidate restoration project is removal of existing rip rap, regarding banks and installing appropriate bank stabilization measures and native plantings (brush mattressing; live fascines in the outer bend areas).

Turkey Creek in the Streamway Park South Project Area is eroded with exposed slopes eight to ten feet tall and greater than 1:1 slopes. The stream reach has an established forested riparian

buffer. There is an existing trail in the project area. Further study may be required to determine causative factors for stream bank degradation. Bank stabilization would require removal of some riparian forested areas and restabilization with high shear stress measures (live fascines, stone riprap with joint plantings, concrete revetment). If both projects are completed, a total of 2,900 l.f. of tributary would be enhanced.

3.1.7 Thousand Oaks

The Thousand Oaks Project Area is located near the intersection of Switzer and West 70th Terrace. The Thousand Oaks Project Area includes one project. The stream reach consists of moderate to severe erosion, downcutting, exposed sewer lines, narrow forested riparian buffer, and downcutting from road culvert. The candidate restoration project is a combination of bank stabilization, riparian reforestation and fish blockage removal. A culvert under Switzer road should be lowered if Switzer is widened/improved. Riffle/pool complexes should be installed along with the fish blockage removal. A total of 910 l.f. of tributary would be enhanced.

3.1.8 Quail Creek Park

The Quail Creek Project Area extends eastward from I-35 to Antioch. The Quail Creek Park Streamway Park Project Area includes three projects. The problem characteristics of the reaches consist of concrete lining, moderate to severe erosion, undercutting, limited forested riparian buffer, and exposed utilities. There is an existing trail and transmission line in the park that would need to be relocated as well as a manhole, buried utility line, and large mature trees that may be affected by implementation of the project. In portions of the channel there is moderately eroded on the left and right banks with left bank 20 to 30 feet tall with approximately 1:1 slopes in most areas. Portions of the stream have recently stabilized with erosion control blanket and plantings. The proposed actions would include channel realignment and bank stabilization measures including live crib walls, and stone riprap with joint plantings. A total of 1,880 l.f. of tributary would be enhanced.

3.1.9 Westbrook

The Westbrook Streamway Park is on Turkey Creek and parallels I-35 from 75th street south to Neiman Road. The Westbrook Streamway Park Project Area includes three projects. The problem characteristics of the reaches consist of exposed utilities, downcutting, channelized stream, cleared riparian vegetation, and severe erosion. The proposed actions would include stream stabilization and revegetation of the riparian corridor with native grasses. Measures may include rock riffles, brush mattressing, live fascines, stone riprap with joint plantings, live crib walls, and cable concrete revetment with vegetation. A total of 4,010 l.f. of tributary would be enhanced.

3.1.10 JC Penney Outlet

The JC Penney Outlet Project Area is southwest of the JC Penney Outlet parking lot located at the intersection of Grant Circle and Lenexa Drive. The JC Penny Outlet Project Area includes two projects. The problem characteristics of the reaches consist of moderate erosion, narrow floodplain, and concrete. Bank stabilization and fish blockage removal are recommended. The proposed actions would include riffle/pool complexes to facilitate fish passage, stone riprap with joint plantings, and live crib walls. A total of 2,785 l.f. of tributary would be enhanced.

3.1.11 Sapling Grove Park

The Sapling Grove Park Project Area is directly east of the intersection of West 83rd Street and Connell Street, Merriam, KS. The JC Penny Outlet Project Area includes one project. The problem characteristics of the reaches consist of moderate to severe erosion and limited forested riparian buffer. The proposed actions would include brush mattressing, live fascines, stone riprap with joint plantings, and live crib walls. A total of 750 l.f. of tributary would be enhanced.

Table 1: Upper Turkey Creek Candidate Restoration Sites

Project Area	Project Name	Site Location	Map Book Location	Project Type	Approx Length (feet)	Existing R-Value	Existing Habitat Units	R-Value with Project	Habitat Units with Project
Highland Park	Cluster 1/ Highland Park South	Northwest of the intersection of 47th Street and South 44th Street	E8	1a,1b, 1c	2,600	3.87	3.08	4.54	3.62
Highland Park	Highland Park North	620 feet southwest of the intersection of Shawnee Drive and South 47th Street on the east side of Shawnee Drive	E8	1a,1b 1d	500	2.32	0.32	2.78	0.38
Brown Park	Cluster 2/ Brown Park North	630 east of the intersection of Knox Street and West 50th Terrace	D7	NA	NA	2.58	0.36	2.58	0.36
Brown Park	Brown Park Proper	Located directly south of the intersection of Grant Street and West 50th Terrace in Brown Park, Merriam, KS	D7	1a, 1c	520	1.49	0.27	2.11	0.38
Brown Park	Cluster 3/ Brown Park Central	600 feet south of the intersection of West 51st Street and Knox Street on the east side of Knox	D7	1a,ab, 1c	900	3.76	1.53	4.49	1.82
Brown Park	Cluster 4/ Brown Park South	650 feet north of the intersection of West 53rd Street and Knox Street on the west side of Knox	D7	1a,1b, 1c	820	1.55	0.25	2.16	0.35
Downtown Shawnee	Cluster 5/ Downtown Shawnee	330 feet west of the intersection of Flint Street and West 57th Street directly east of Old Shawnee Town, Shawnee, KS	B6	NA	NA	2.22	0.39	2.22	0.39
Nieman Plaza	Nieman Plaza East	200 feet west of the intersection of Shawnee Parkway and Goddard Street on the north side of Shawnee Parkway, Merriam, KS	C6	1a	700	1.08	0.40	2.01	0.74

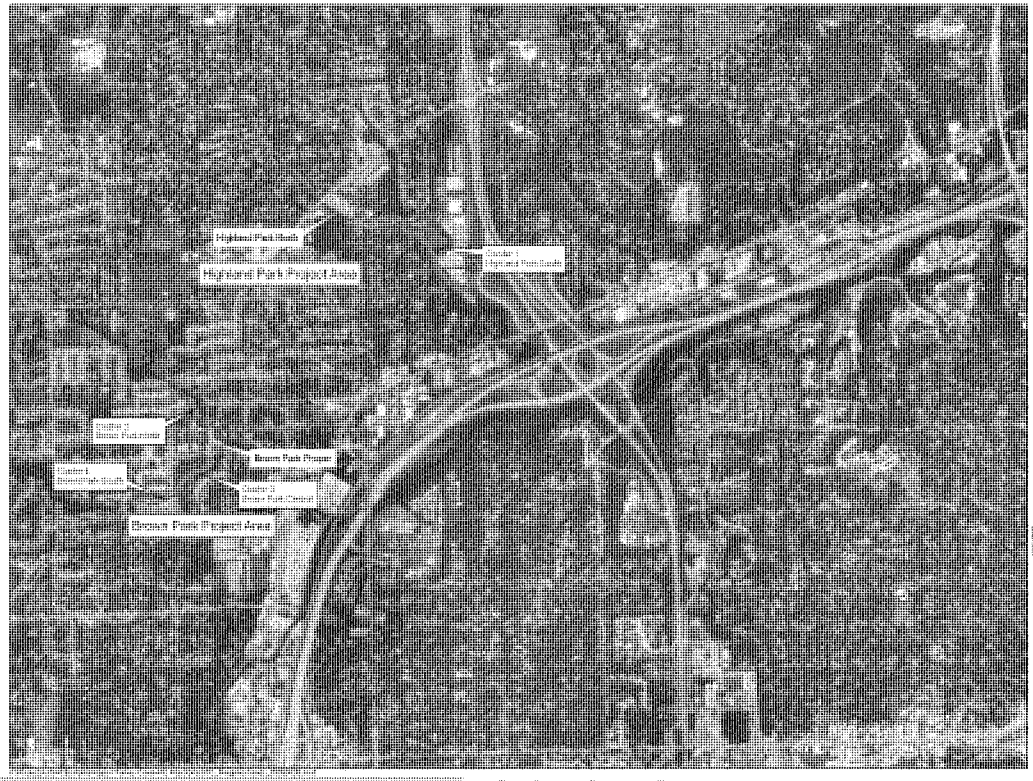
Table 1: Upper Turkey Creek Candidate Restoration Sites

Project Area	Project Name	Site Location	Map Book Location	Project Type	Approx Length (feet)	Existing R-Value	Existing Habitat Units	R-Value with Project	Habitat Units with Project
Nieman Plaza	Cluster 6/ Nieman Plaza West	300 feet north of the intersection of Shawnee Mission Parkway and Nieman Road on the west side of Nieman Road, Merriam, KS	B5	1b, 1c	525	2.22	0.42	2.73	0.52
Chatlain Park	Cluster 7/ Chatlain Park West	80 feet north of the intersection of Carter Avenue and West 63rd Terrace on the west side of Carter Avenue, Merriam, KS	D5	1b	1,060	3.03	0.90	3.53	1.05
Chatlain Park	Cluster 8/ Chatlain Park East	80 feet north of the intersection of Carter Avenue and West 63rd Terrace on the east side of Carter Avenue, Merriam, KS	D5	1b	1,000	2.82	1.03	3.29	1.20
Turkey Creek Streamway Park	Turkey Creek Streamway Park North	720 feet east of the intersection of Wedd Street and West 67th Street on the south side of West 67th Street, Merriam, KS	D4	1b	1,200	2.84	2.11	2.94	2.19
Turkey Creek Streamway Park	Cluster 12/ Turkey Creek Streamway Park South	535 feet southeast of the intersection of West 69th Street, West 70th Street, and Farley Street south of footbridge	D4	1b	1,700	1.83	1.72	2.60	2.44
Thousand Oaks	Cluster 9/ Thousand Oaks	300 feet north of the intersection of Switzer and West 70th Terrace on the west side of Switzer	D4	1a,1b, 1c, 1e	910	3.04	1.12	3.97	1.46
Quail Creek Park	Quail Creek Park Proper	380 feet west of the intersection of Grandview Street and West 73rd Street	D4	1a,1b	820	1.29	0.34	1.70	0.44

Table 1: Upper Turkey Creek Candidate Restoration Sites

Project Area	Project Name	Site Location	Map Book Location	Project Type	Approx Length (feet)	Existing R-Value	Existing Habitat Units	R-Value with Project	Habitat Units with Project
Quail Creek Park	Cluster 10/ Quail Creek Park Central	90 feet southwest of the intersection of Grandview Street and West 71st Street	D4	1b	440	3.87	0.38	4.28	0.42
Quail Creek Park	Cluster 11/ Quail Creek Park South	180 feet west of the intersection of Grandview Street and West 72nd Street on the west side of Grandview Street	D4	1b	620	2.84	0.70	3.30	0.81
Westbrook	Westbrook North	140 feet east of the intersection of West 75th Street and Kings Cove Drive, Merriam, KS	D4	1a, 1c	300	2.01	0.27	2,42	0.32
Westbrook	Cluster 15/ Westbrook Central	Southwest of the intersection of West 75th Street and Highway 69	C3, D3	1b	1,990	2.50	2.71	2.81	3.05
Westbrook	Cluster 17/ Westbrook South	Northeast of the intersection of Nieman Road and West 81st Street	C3	1b	1,720	2.47	1.97	2.91	2.32
JC Penney Outlet	Cluster 13/ JC Penney Outlet West	Southwest of the JC Penney Outlet parking lot located at the intersection of Grant Circle and Lenexa Drive	D3	1b	1,215	1.83	1.62	2.91	1.95
JC Penney Outlet	Cluster 14/ JC Penney Outlet East	1,000 feet west of the intersection of Eby Lane and Antioch Road	D3	1a,1b, 1c	1,570	2.47	0.48	3.35	0.65
Sapling Grove Park	Cluster 16/ Sapling Grove Park	Directly east of the intersection of West 83rd Street and Connell Street, Merriam, KS	D2	1b	750	2.71	1.57	3.23	1.87

1a= Channel Morphology, 1b= In-Stream Habitat/Bank Stabilization, 1c= Fish Blockage, 1d= Water quality, 1e= Riparian Reforestation



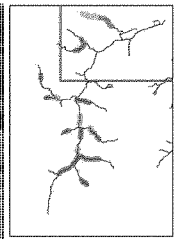


FIGURE 1

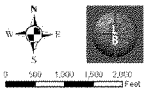
Project Area and Location of Proposed Alternatives

Turkey Creek North

Legend

Proposed Bank Stabilization Areas

Enhancement Sites from Kebbes Report



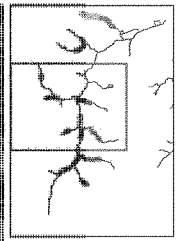


FIGURE 1

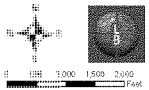
Project Area and Location of Proposed Alternatives

Turkey Creek Central

Legend

Proposed Bank Stabilization Areas

Enhancement Sites from Kabbes Report



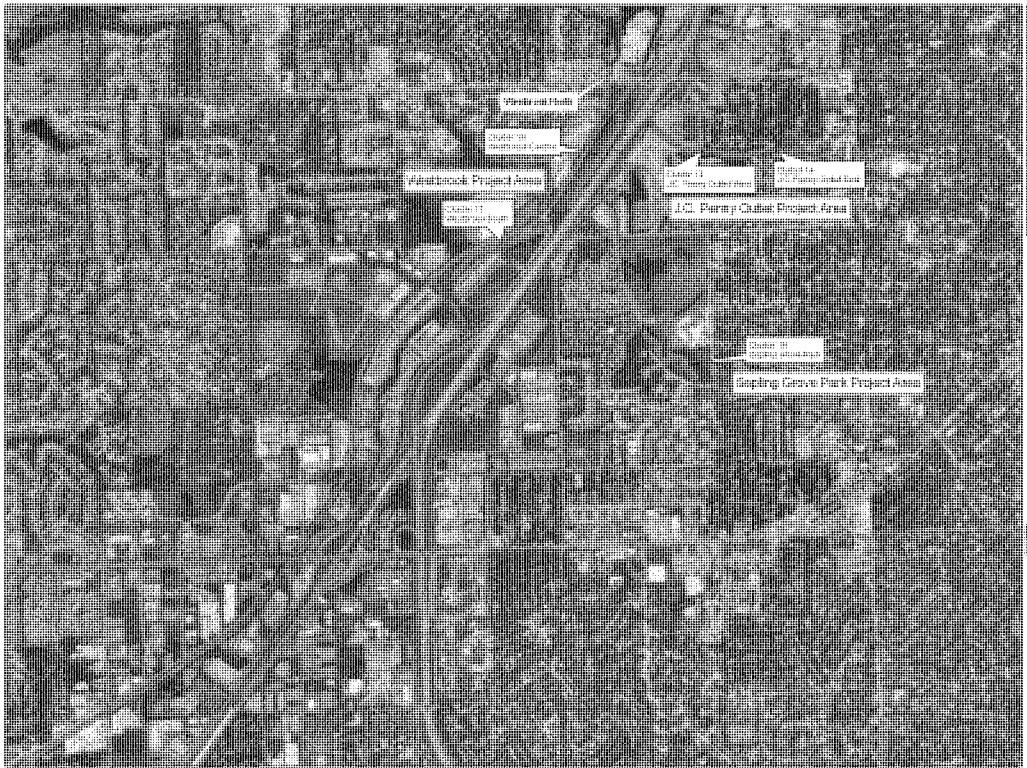


FIGURE 1

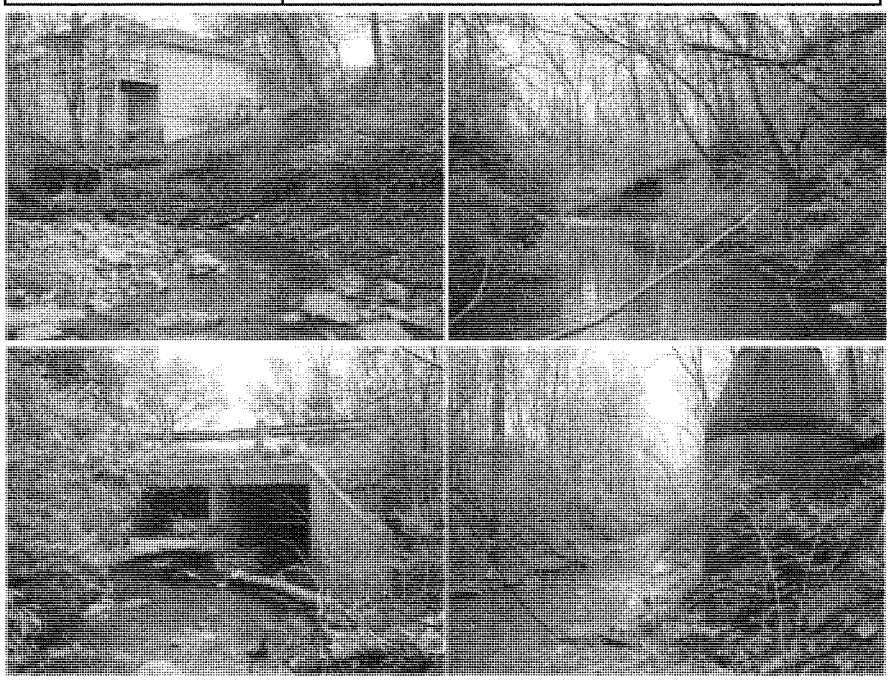
Project Area and Location of Proposed Alternatives

Turkey Creek South

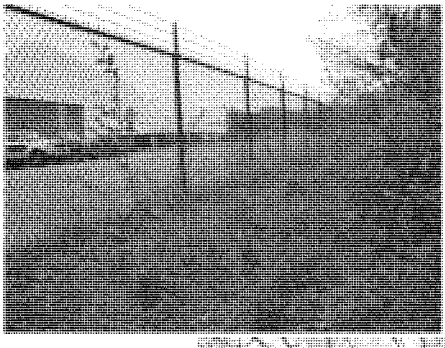
Legend

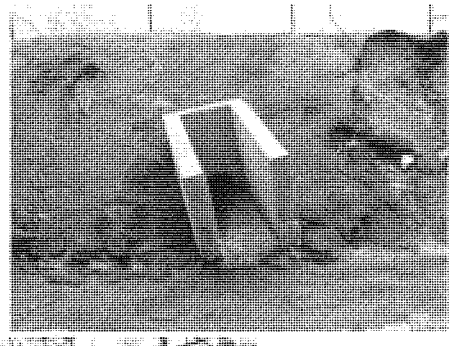
APPENDIX A
Candidate Restoration Site Fact Sheets

Project Area	Highland Park
Candidate Site Location:	Northwest of the intersection of 47th Street and South 44th Street
Project Name:	Cluster 1/Highland Park South
Map Book Location:	E8
Approximate Length (feet):	2,600
Description of Existing Conditions:	Stream is moderately to severely incised on right bank with banks up to seven to eight feet high. Root exposure and undercut banks in some areas. Exposed manholes located along stream as high as eight feet. Left bank has floodplain area on the northern portion of the reach with good forested riparian species. Utility corridor located on adjacent to stream on left bank. Bed composed of bedrock, boulders, cobble, gravel, sand, and silt.
Project Description:	**Bank Stabilization/In Stream Habitat:** Stone Riprap with Joint Plantings, Live Fascines, and Riffle/Pool Complexes are techniques that may be utilized. Selective placement of stone riprap with joint plantings is recommended in steep erosion areas on toe slopes. Live fascines could be planted above the toe slope. Creation of riffles and pools at base flow.

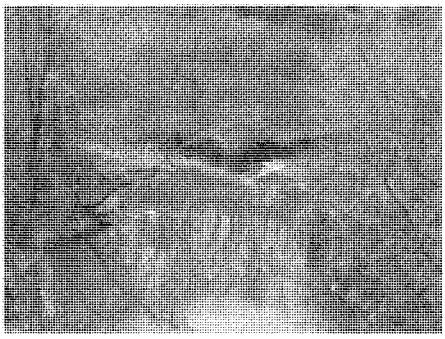


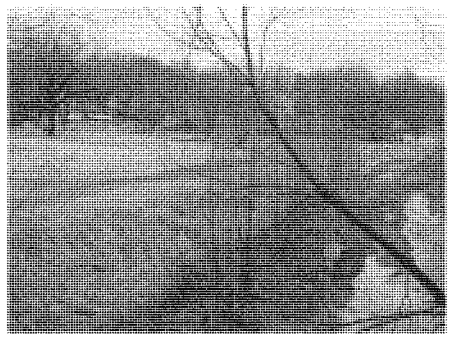
Project Area	Highland Park
Candidate Site Location:	620 feet southwest of the intersection of Shawnee Drive and South 47th Street on the east side of Shawnee Drive
Project Name:	Highland Park North
Map Book Location:	E8
Approximate Length (feet):	550
Description of Existing Conditions:	Left bank heavily covered with asphalt that is eroding and washing into stream channel. Also noted a large concrete culvert setting on toe slope of left bank directly above channel. Maintenance facility parking lot directly to the north of the stream. Right bank consists of heavy forested riparian vegetation on small floodplain bench that slopes up into a broader floodplain.
Project Description:	**Removal of Asphalt, Brush Mattressing and Construction of Rock Riffles** - Removal of asphalt and concrete culvert on left bank followed by regrading and bank stabilization with brush mattressing. Construction of four rock riffles.





Project Area	Brown Park
Candidate Site Location:	Located directly south of the intersection of Grant Street and West 50th Terrace in Brown Park, Merriam, KS
Project Name:	Brown Park Proper
Map Book Location:	D7
Approximate Length (feet):	520
Description of Existing Conditions:	Two unnamed tributaries flow into Brown Park and join to form a tributary to Turkey Creek. Active stream downcutting and headcutting is evident along the north and south tributaries. Two exposed sanitary sewer encasements and one exposed abandoned waterline were noted on the two tributaries. The exposure of utility crossings by stream downcutting is a common problem throughout the Turkey Creek Basin. Future downcutting will significantly lower the stream bottom downstream of existing road crossings. Culverts at these crossings may fail due to erosion of the foundation and may require action to repair the downcutting. Additionally, the culverts could become obstructions to fish passage.
Project Description:	**Riffle/Pool Complex** - Installation of a series of riffles/grade control structures to enhance fish passage. Streambank plantings to increase habitat where possible.

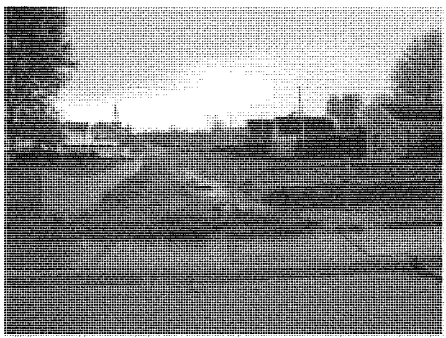


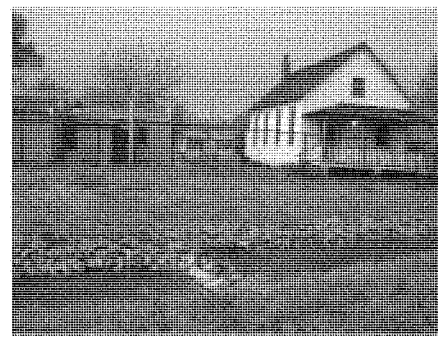


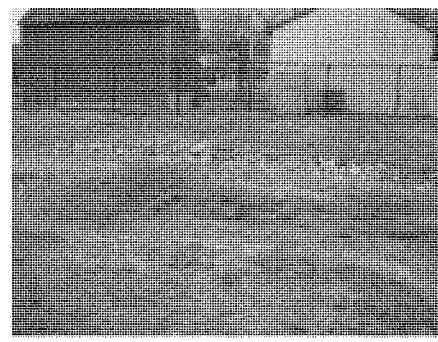
Project Area	Brown Park
Candidate Site Location:	600 feet south of the intersection of West 51st Street and Knox Street on the east side of Knox
Project Name:	Cluster 3/Brown Park Central
Map Book Location:	D7
Approximate Length (feet):	900
Description of Existing Conditions:	Stream appears to be moderately stable with moderate bank erosion in places. The stream has bedrock channel, riffle/pool complexes, and good riparian buffer. Some partial fish blockages in the form of bedrock waterfalls exist. The downstream end of the reach at West 50th Terrace previously had erosion control mat installed, but has since washed out in some places.
Project Description:	**Riffle/Pool Complex and Bank Stabilization:** Construction of riffle/pool complex at fish blockage locations. Bank stabilization with measures that could include live fascines and/or erosion control mat with native vegetation. Causative factors for active erosion should be identified.

Project Area	Brown Park
Candidate Site Location:	650 feet north of the intersection of West 53rd Street and Knox Street on the west side of Knox
Project Name:	Cluster 4/Brown Park South
Map Book Location:	D7
Approximate Length (feet):	820
Description of Existing Conditions:	Stream appears to be moderately stable with no severe bank erosion noted. Narrow floodplain benches and both banks and riffle/pool complexes. The upstream end of the reach at Farley Street and west of Farley Street is concrete lined.
Project Description:	**Removal of Concrete in Channel and Live Fascines -** Removal of concrete lining in channel at upstream end of reach of possible of west side of Farley Street. Revegetation and stabilization of the banks with appropriate native materials. .

Project Area	Downtown Shawnee
Candidate Site Location:	330 feet west of the intersection of Flint Street and West 57th Street directly east of Old Shawnee Town, Shawnee, KS
Project Name:	Cluster 5/Downtown Shawnee
Map Book Location:	B6
Approximate Length (feet):	NA
Description of Existing Conditions:	Noted recent placement of rock riprap on banks from toe to upper bank on both banks. Vegetation is mostly herbaceous with recently planted trees and shrubs underlain with erosion control blanket. Also noted three recently constructed BMPs/rain gardens on upper banks. Two recently constructed rock riffle/grade control structures in stream. Church parking lot west of stream has curb cuts allowing runoff to flow into stream. The banks have been stabilized with large limestone blocks on the downstream end near Johnson Drive.
Project Description:	Project has recently been completed; no project recommended



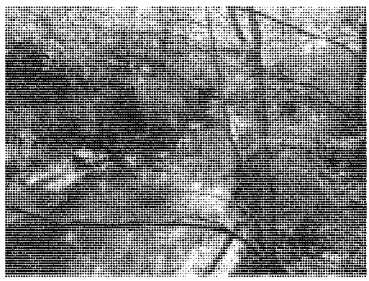


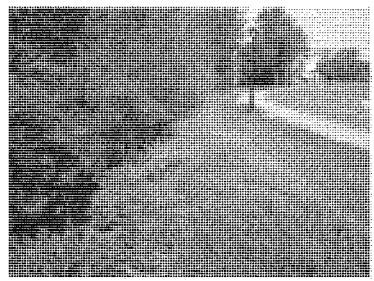


Project Area	Nieman Plaza
Candidate Site Location:	200 feet west of the intersection of Shawnee Parkway and Goddard Street on the north side of Shawnee Parkway, Merriam, KS
Project Name:	Nieman Plaza East
Map Book Location:	C6
Approximate Length (feet):	700
Description of Existing Conditions:	Stream is moderately to severely incised on left bank with banks up to seven feet high. Root exposure and undercut banks in some areas. Severe erosion noted upstream at confluence with northern stream. Right bank has narrow floodplain bench with poor quality habitat. Large exposed pipe in stream near the end of Ballentine Street. Businesses above left bank approximately 40 feet from top of bank. Open lot directly to the north of stream.
Project Description:	**Relocation of Channel and Installation of Riffle/Pool Complexes, Bank Stabilization** - Relocation of channel to the north through open lot and creation of riffles and pools at base flow and directing thalweg flow away from banks during high flow events. Restabilization of the banks with measures such as stone riprap and joint plantings.

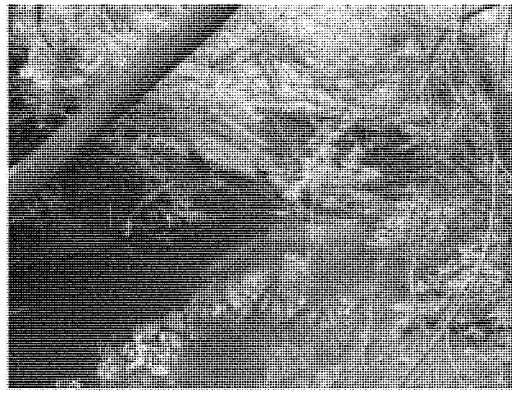
Project Area	Nieman Plaza
Candidate Site Location:	300 feet north of the intersection of Shawnee Mission Parkway and Nieman Road on the west side of Nieman Road, Merriam, KS
Project Name:	Cluster 6/Nieman Plaza West
Map Book Location:	B5
Approximate Length (feet):	525
Description of Existing Conditions:	Stream is moderately to severely incised on right bank with banks up to seven feet high. Right bank is beginning to slump near parking lot with some evident loss of asphalt. Left bank is sparsely vegetated consisting of a single line of trees adjacent to maintained back yards. Right bank has narrow floodplain bench with poor quality habitat. Large exposed pipe in stream near the end of Ballentine Street. Businesses above left bank approximately 20 feet from top of bank. Open lot directly to the north of stream.
Project Description:	**Bank Stabilization-** Recommend leaving existing vegetation on right bank with restabilization of theleft banks with measures such as stone riprap and joint plantings and crib walls. Space is very limited.

Project Area	Chatlain Park
Candidate Site Location:	80 feet north of the intersection of Carter Avenue and West 63rd Terrace on the west side of Carter Avenue, Merriam, KS
Project Name:	Cluster 7/Chatlain Park West
Map Book Location:	D5
Approximate Length (feet):	1,060
Description of Existing Conditions:	Stream is moderately to severely incised on right bank with banks five to seven feet high. Forested riparian buffer from footbridge to confluence with Turkey Creek of varying widths. The buffer on the right bank in this portion of the stream is narrow with a utility road directly to the north. The left bank consist of a 20- to 30-foot forested buffer that transitions to a grassy maintained area in Chatlain Park. The portion of the stream upstream of the footbridge is maintained and consists mostly of herbaceous vegetation with a few scattered trees and shrubs. This portion of the stream channel has heavy cattail (*Typha latifolia*) cover with minimal stream shading.
Project Description:	**Riparian Habitat Enhancement** - Recommend leaving existing vegetation in channel and on right bank. Revegetation of upper banks with riparian tree and shrub species in the upstream portion. Expand riparian buffer in the maintained park area by installing native trees and shrubs.

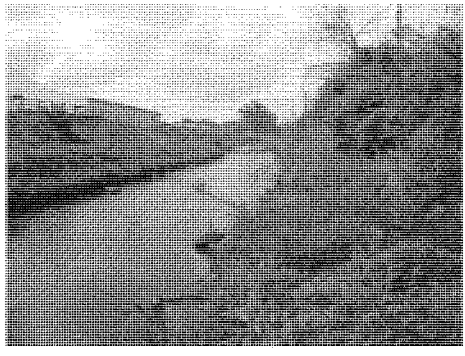


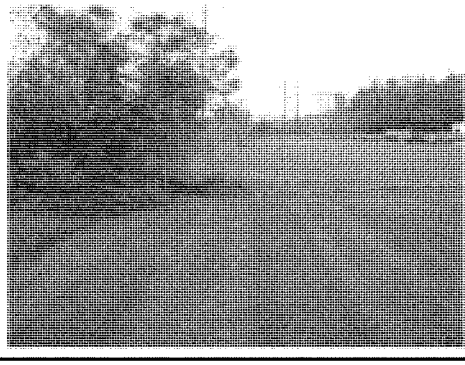


Project Area	Chatlain Park
Candidate Site Location:	80 feet north of the intersection of Carter Avenue and West 63rd Terrace on the east side of Carter Avenue, Merriam, KS
Project Name:	Cluster 8/Chatlain Park East
Map Book Location:	D5
Approximate Length (feet):	1,000
Description of Existing Conditions:	Stream is moderately to severely incised on right bank with heavy bank erosion. Maintained grassy area above right bank with two cellular towers. Left bank consists of good forested riparian buffer in wide floodplain area. Reach of stream from railroad bridge downstream to Carter Avenue recently disturbed and poorly vegetated. Newly constructed drainageway running north and southeast of railroad track that is unstable with woody debris piled along tree line above. Natural gas pipeline running east and west along railroad.
Project Description:	**Bank Stabilization and Live Fascines** - Regrade right bank and restabilize with live fascines or appropriate measure.

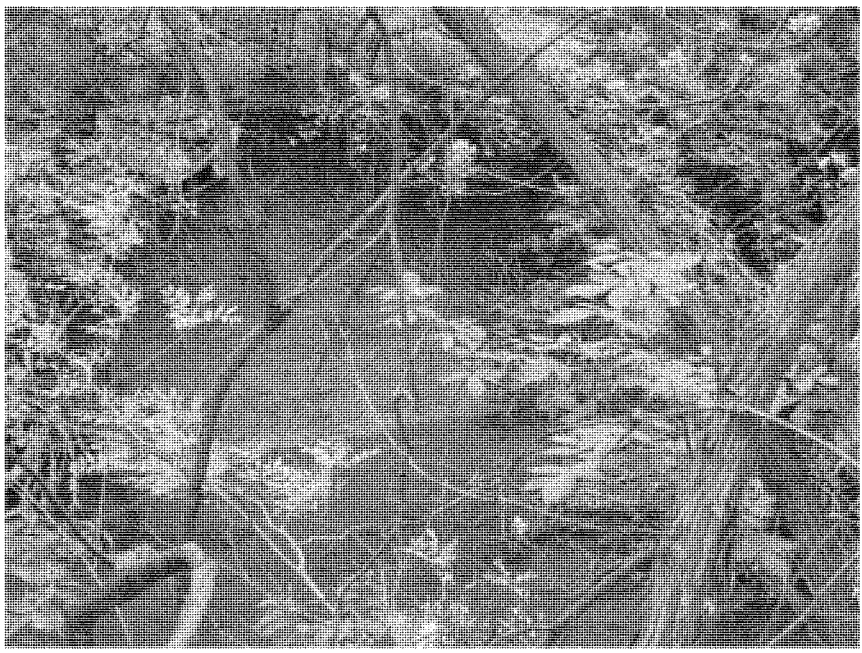


Project Area	Turkey Creek Streamway Park North
Candidate Site Location:	720 feet east of the intersection of Wedd Street and West 67th Street on the south side of West 67th Street, Merriam, KS
Project Name:	Turkey Creek Streamway Park North
Map Book Location:	D4
Approximate Length (feet):	1,200
Description of Existing Conditions:	Evidence of downcutting in channel, large exposed sewer line near West 67th Street bridge. Reach has been stabilized with large riprap for approximately 100 feet on both sides of the bridge on the left and right banks. Stream has been channelized with left and right banks 20 to 25 feet tall. Left bank in most areas contains poor to moderate quality riparian vegetation consisting of small trees and shrubs with some larger willows (*Salix* spp.) on the upstream portion. Right bank consists of mostly herbaceous vegetation. Power line easement above left bank with wide grassy area transitioning in Sante Fe Glass parking lot to the west. Existing trail runs along right bank that appears to have heavy bike and pedestrian usage.
Project Description:	**Bank Stabilization**-Remove existing rip rap and replace with appropriate bank stabilization measures (brush mattressing; live fascines in the outer bend areas).

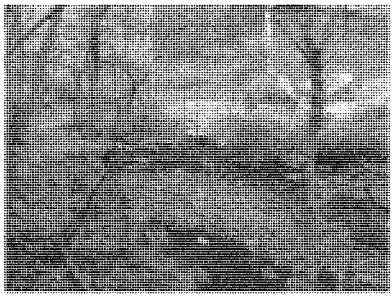


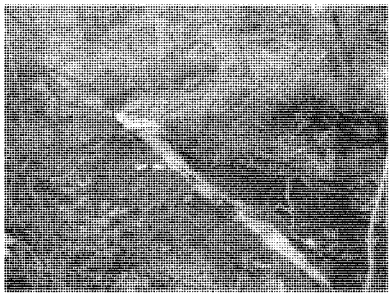


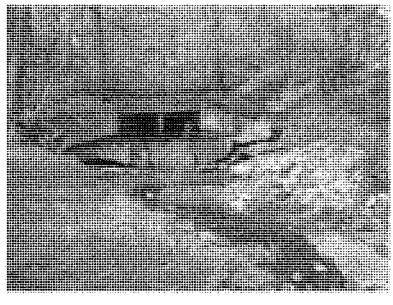
Project Area	Turkey Creek Streamway Park
Candidate Site Location:	535 feet southeast of the intersection of West 69th Street, West 70th Street, and Farley Street south of footbridge
Project Name:	Cluster 12/Turkey Creek Streamway Park South
Map Book Location:	D4
Approximate Length (feet):	1,700
Description of Existing Conditions:	Stream is severely eroded on right bank with banks eight to tenfeet tall with greater than 1:1 slopes. Established forested riparian buffer above left bank greater than 50 feet wide with existing trail. Left banks are moderately to severely eroded with some steep streambank. Railroad approximately 250 feet east of stream.
Project Description:	**Bank Stabilization-** Determine causative factors for stream bank degradation. Bank stabilization would require removal of some riparian forested areas and restabilization with high shear stress measures (i.e. live fascines and stone riprap with joint plantings). Riprap with joint plantings and/or concrete revetment may be required in outer bend areas.



Project Area	Thousand Oaks
Candidate Site Location:	300 feet north of the intersection of Switzer and West 70th Terrace on the west side of Switzer
Project Name:	Cluster 9/Thousand Oaks
Map Book Location:	D4
Approximate Length (feet):	910
Description of Existing Conditions:	Stream is moderately to severely eroded on the left and right banks. Evidence of downcutting in channel, two exposed sewer lines nearby, and culvert on upstream end of reach has an approximately four-foot drop into channel. Forested riparian buffer is limited averaging 10 to 30 feet. Open maintained grassy area on south side of stream. Banks become steeper on upstream end of reach. Channel east of Switzer Road is concrete lined.
Project Description:	**Stream Stabilization/ Riparian Restoration** - Regrade right bank and restabilize with hard structure/native vegetation (live fascines and stone riprap with joint plantings). The road culvert is a fish blockage. If Switzer is widened or improved in the future, recommend lowering the culvert below the stream bottom and construction of riffle/pool complex downstream of culvert. Riparian forested species plantings on south side of stream in open grassy area.





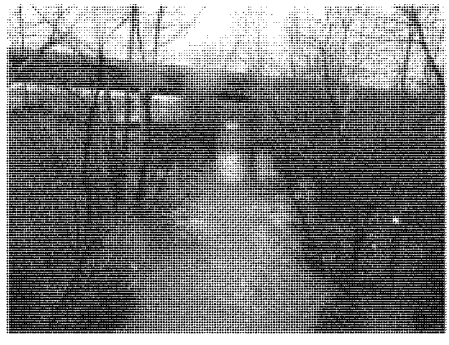


Project Area	Quail Creek Park
Candidate Site Location:	380 feet west of the intersection of Grandview Street and West 73rd Street
Project Name:	Quail Creek Park Proper
Map Book Location:	D4
Approximate Length (feet):	820
Description of Existing Conditions:	Concrete-lined channel located within park area. There is an existing trail and transmission line in the park that would need to be relocated as well as a manhole, buried utility line, and large mature trees that may be affected by implementation of the project. Drainageway flows into the stream from the northeast.
Project Description:	**Bank Stabilization**-Recommend realignment of concrete-lined channel into a natural meandering stream and bank stabilization (Joint planting in stone riprap).

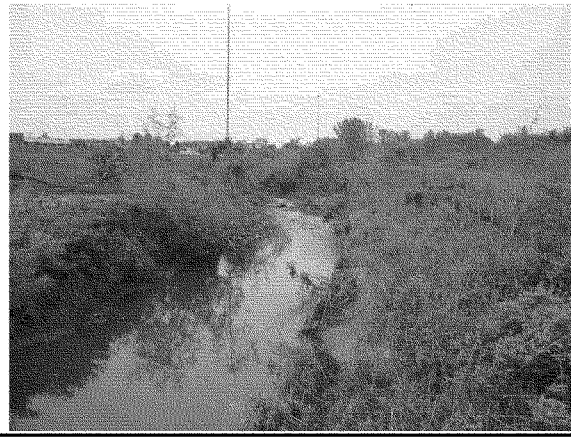
Project Area	Quail Creek Park
Candidate Site Location:	90 feet southwest of the intersection of Grandview Street and West 71st Street
Project Name:	Cluster 10/Quail Creek Park Central
Map Book Location:	D4
Approximate Length (feet):	440
Description of Existing Conditions:	Stream is moderately eroded on the left and right banks with left bank 20 to 30 feet tall with approximately 1:1 slopes in most areas. Top of left bank goes directly into back yard areas. Good forested riparian buffer on both banks but limited on the right bank. Reach of stream has been recently stabilized with netting and plantings. Manhole on right bank and concrete outfall approximately two feet in diameter coming out of left bank.
Project Description:	**Bank Stabilization** - Recommend bank stabilization measures; may include live crib walls on toe slope with stone riprap and joint plantings on lower slopes.

Project Area	Quail Creek Park
Candidate Site Location:	180 feet west of the intersection of Grandview Street and West 72nd Street on the west side of Grandview Street
Project Name:	Cluster 11/Quail Creek Park South
Map Book Location:	D4
Approximate Length (feet):	620
Description of Existing Conditions:	Left bank severely eroded with some undercutting, approximately ten feet tall. Backyards at the top of left bank are eroding due to severe bank erosion. Left bank contains flat floodplain area that appears to have been recently excavated to include a low depressional area that has been planted with willows (*Salix* sp.) and cottonwoods (*Populus deltoides*) underlain with erosion control blanket. Silt fence and large riprap has been placed on edge of excavated area and planting on the west side. This newly constructed area seems to be relieving the some of the left bank erosion.
Project Description:	**Bank Stabilization**-Recommend Live Crib Walls and Stone Riprap with Joint Plantings - Live cribs walls on toe slope and stone riprap with joint plantings on the slopes above for bank stabilization.

Project Area	Westbrook
Candidate Site Location:	140 feet east of the intersection of West 75th Street and Kings Cove Drive, Merriam, KS
Project Name:	Westbrook North
Map Book Location:	D4
Approximate Length (feet):	300
Description of Existing Conditions:	The site contained entirely exposed utility crossings in the channel that are assumed buried below the stream bottom when initially constructed. The exposed utility crossings include sanitary sewer encasements, abandoned waterline, and other abandoned lines within the banks of the creek. Downcutting was also apparent at the bridge abutment foundations of the 75th Street bridge. Previous improvements to the channel include large rocks secured under a geogrid on the channel bottom and side slopes for stabilization from the railroad bridge to approximately 270 feet downstream. At this location, the channel degradation downstream has been halted, resulting in a three-foot drop in the channel bottom.
Project Description:	**Rock Riffles** - The installation of a series of rock riffles that would provide fish and wildlife habitat and water quality benefits. The riffles are currently designed as fish passable grade control structures and are designed to cover the exposed sewer crossings.



Project Area	Westbrook
Candidate Site Location:	Southwest of the intersection of West 75th Street and Highway 69
Project Name:	Cluster 15/Westbrook Central
Map Book Location:	C3, D3
Approximate Length (feet):	1,990
Description of Existing Conditions:	Vegetation appears to have been recently cleared with streambank vegetation consisting mostly of herbaceous species with some scattered willows (*Salix* spp.). Left bank steep with 1:1 slopes, approximately five to six feet tall. Stream is channelized along the railroad tracks and Interstate 35 with limited space for improvements.
Project Description:	**Bank Stabilization**-Methods may include brush mattressing, live fascines, and stone riprap with joint plantings, alternate brush mattressing with live fascines throughout reach and selectively placed stone riprap with joint plantings in excessively eroded areas. Revegetation of the riparian shelf with native grasses.

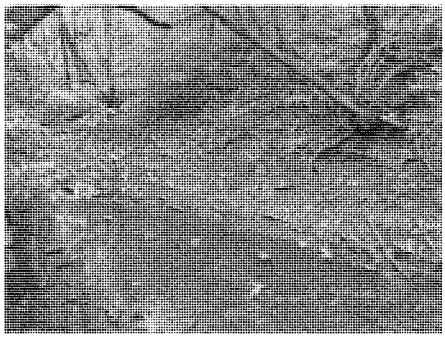


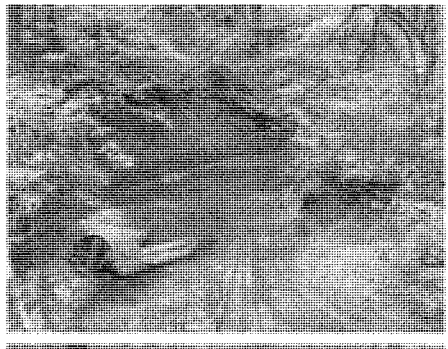
Project Area	Westbrook
Candidate Site Location:	Northeast of the intersection of Nieman Road and West 81st Street
Project Name:	Cluster 17/Westbrook South
Map Book Location:	C3
Approximate Length (feet):	1,720
Description of Existing Conditions:	Some areas of heavy bank erosion on both banks with banks as high as 15 feet. Most of the reach is located within 20 feet from the edge of an existing railroad bed. Vegetation eonsists of low- to moderate-quality forested riparian buffer on the right bank with a grassy floodplain area above adjacent to a parking lot for a commercial area. The left bank has very limited riparian vegetation due to proximity to railroad tracks, but some large trees are on top of bank. The west end of the reach has severe undercutting and bank erosion with several large trees lodged in the right bank. There is a concrete drainageway coming off parking lot on west end of reach with evidence of recent disturbance. Severe erosion noted upstream at confluence with north tributary.
Project Description:	**Bank Stabilization-** Regrading of right bank to create a more gradual transition into the floodplain area above, allowing for a reduction in velocity and thereby reducing undercutting and bank erosion. Placement of live crib walls and cable concrete revetment along lct banks to stabilize banks.

Project Area	JC Penney Outlet
Candidate Site Location:	Southwest of the JC Penney Outlet parking lot located at the intersection of Grant Circle and Lenexa Drive
Project Name:	Cluster 13/JC Penney Outlet West
Map Book Location:	D3
Approximate Length (feet):	1,215
Description of Existing Conditions:	Moderate bank erosion with steep side slopes above. Left bank has narrow floodplain area and right bank is directly adjacent to the JC Penney Outlet parking lot. Mature forested riparian buffer on both banks but limited on the right bank.
Project Description:	**Bank Stabilization-**Placement of live crib walls and stone riprap on toe slopes to provide bank stabilization.

Project Area	JC Penney Outlet
Candidate Site Location:	1,000 feet west of the intersection of Eby Lane and Antioch Road
Project Name:	Cluster 14/JC Penney Outlet East
Map Book Location:	D3
Approximate Length (feet):	1,570
Description of Existing Conditions:	Moderate bank erosion with banks four feet tall in some areas. Left bank has a mature forested riparian buffer on steep slopes with houses above. The right bank vegetation consists of a narrow line of trees with maintained grass above and is directly adjacent to residential backyards with houses within 100 feet in some areas. Evidence of backyards eroding into stream. Upstream end of reach transitions from a natural channel to concrete-lined channel with a two-foot dropoff of concrete into natural channel.
Project Description:	**Bank Stabilization/Fish Blockage Removal:** Live crib walls and stone riprap with joint plantings on the toe slopes for bank stabilization and installation of riffle/pool complex downstream of concrete channel to reduce downcutting of stream and facilitate fish passage.

Project Area	Sapling Grove Park
Candidate Site Location:	Directly east of the intersection of West 83rd Street and Connell Street, Merriam, KS
Project Name:	Cluster 16/Sapling Grove Park
Map Book Location:	D2
Approximate Length (feet):	750
Description of Existing Conditions:	Moderate to severe bank erosion with banks as high as 35 feet tall in some areas. One extremely eroded bank area at outer bend of stream on western portion of reach near Knox Street. Mature forested riparian buffer on both banks but limited on right bank. Reach appears to be creating a floodplain on the right bank. Stream appears stable on northwest end of reach with a good forested riparian buffer and wide floodplain established.
Project Description:	**Banks Stabilization** - Selective placement of live crib walls with stone riprap with joint plantings on the toe slope with live fascines on the banks above on the left bank. Regrading of right bank followed by brush mattressing and selective placement of live crib walls with stone riprap with joint plantings.





Section 4 Water Quality

ADMINISTRATIVELY EXTENDED BEYOND EXPIRATION DATE

12/19/03
cc JPD
Tony H.
LHM
EMH

K A N S A S

RODERICK L. BREMBY, SECRETARY

KATHLEEN SEBELIUS, GOVERNOR

DEPARTMENT OF HEALTH AND ENVIRONMENT

December 17, 2003

Johnson County Unified
Wastewater District
7311 West 130th Street, Suite 100
Overland Park, KS 66213

Re: Kansas Water Pollution Control
Permit No. M-KS45-OO01
Nelson Complex

Dear Permittee:

You have fulfilled all the filing requirements for a Kansas Water Pollution Control Permit and Authorization to Discharge under the National Pollutant Discharge Elimination System (NPDES). We are pleased to forward your new permit. While it is permissible to make as many copies as needed for monitoring and reporting purposes, you need to retain the original permit for your files.

We suggest you carefully read the terms and conditions of your permit and understand these terms and conditions are enforceable under both State and Federal law.

Please notice the reporting paragraph on page 2 of your permit, where all reports are due by the 28th day of the schedule noted. Please submit reports to the, Technical Services Section, Bureau of Water, 1000 SW Jackson St., Suite 420, Topeka, Kansas 66612-1367.

If you have any questions concerning this permit, please contact the Permit Clerk at (785) 296-5513.

Sincerely,

Karl Mueldener, P.E.
Director, Bureau of Water

pc: NE - District Office
RG - Permit File

DEC 19 2003
JOHNSON COUNTY

DIVISION OF ENVIRONMENT
Bureau of Water
CURTIS STATE OFFICE BUILDING, 1000 SW JACKSON ST., STE 420, TOPEKA, KS 66612-1367
Voice 785-296-5500 Fax 785-296-0086 http://www.kdhe.state.ks.us

Kansas Permit No.: M-KS45-0001

Federal Permit No.: KS0055492

KANSAS WATER POLLUTION CONTROL PERMIT AND
AUTHORIZATION TO DISCHARGE UNDER
THE NATIONAL POLLUTANT DISCHARGE
ELIMINATION SYSTEM

Pursuant to the Provisions of Kansas Statutes Annotated 65-164 and 65-165, the Federal Water Pollution Control Act as amended, (33 U.S.C. 1251 et seq; the "Act"),

Owner:	Johnson County Unified Wastewater Districts
Owner's Address:	7311 W. 130th St. Suite 100 Overland Park, KS 66213
Facility Name:	Nelson Complex Wastewater Treatment Plant
Facility Location:	NE¼, Section 5, Township 12S, Range 25E Johnson County, Kansas
Receiving Stream:	Kansas River via Turkey Creek
River Basin:	Kansas River Basin

is authorized to discharge from the wastewater treatment facility described herein, in accordance with permit limitations and monitoring requirements as set forth herein.

This permit shall become effective January 1, 2004, will supercede all previous permits and/or agreements in effect between the Kansas Department of Health and Environment and the permittee, and will expire September 30, 2006.

FACILITY DESCRIPTION:

Mission Township M.S.D. #1

1. Bar Screen & Grit Chamber
2. Primary Clarifiers (2)
3. Primary Trickling Filters (2)
4. Intermediate Clarifiers (4)
5. Secondary Trickling Filters (3)
6. Final Clarifiers (3)
7. Sludge Thickening & Holding Tanks
8. Sludge Dewatering
9. Design Flow = 7.0 MGD

Turkey Creek M.S.D. #1

1. Bar Screen & Grit Chambers
2. Primary Clarifiers (4)
3. Trickling Filters (4)
4. Final Clarifiers (4)
5. Sludge Thicking & Holding Tanks
6. Sludge Dewatering
7. Design Flow = 8.0 MGD

Disinfection through common Outfall 001:

Primary: UV Disinfection
Backup: Chlorination with hypochlorite and dechlorination with bisulfite

Secretary, Kansas Department of Health and Environment

December 17, 2003
Date

A. PERMIT LIMITATIONS AND MONITORING REQUIREMENTS

The permittee is authorized to discharge from outfall(s) with serial number(s) as specified in this permit. The permit limitations shall become effective on the dates specified herein. Such discharges shall be controlled, limited, and monitored by the permittee as specified. There shall be no discharge of floating solids or visible foam in other than trace amounts.

Monitoring reports shall be submitted on or before the 28th day of the following month. In the event no discharge occurs, written notification is still required.

Effective Date	Upon Issuance		
Outfall Number and Parameter(s)	Final Limits	Measurement Frequency	Sample Type
Outfall 001 - Nelson Complex Combined Outfall			
Carbonaceous Biochemical Oxygen Demand (5-Day)**		*3/Week	24-Hour Composite
Weekly Average-mg/l	40		
Monthly Average-mg/l	25		
Total Suspended Solids		*3/Week	24-Hour Composite
Weekly Average-mg/l	45		
Monthly Average-mg/l	30		
Ammonia (as N) - mg/l (Monthly Average)		3/Week	Grab
January	10.4		
February	10.0		
March	6.4		
April	6.6		
May	4.9		
June	3.9		
July	3.1		
August	3.3		
September	4.0		
October	6.7		
November	9.1		
December	11.3		
Fecal Coliform - (colonies/100ml)		3/Week	Grab
Monthly Geometric Mean	200		
pH - Standard Units	6.0 - 9.0	3/Week	Grab
Total Phosphorus (as P) - mg/l	Monitor	Monthly	Grab
Nitrates (as N) - mg/l	Monitor	Monthly	Grab
Nitrites (as N) - mg/l	Monitor	Monthly	Grab
Total Kjeldahl Nitrogen (as N) - mg/l	Monitor	Monthly	Grab
Temperature - °C	Monitor	Weekly	Grab
Dissolved Oxygen - mg/l		Daily	Grab
Weekly Average, Minimum	6.0		
Flow - MGD	Monitor	Daily	Meter

Effective Date Upon Issuance

Outfall Number or Monitoring Location and Parameter(s)	Final Limits	Measurement Frequency	Sample Type
Outfall 001 - Nelson Complex Combined Outfall			
Total Residual Chlorine - ug/l****		Daily	Grab
Daily Maximum	11		
Whole Effluent Toxicity	See Supplemental Condition F.1		
Priority Pollutant Scan	See Supplemental Condition F.2		

EXTRANEOUS FLOW BASINS AND HOLDING STATIONS

Monitoring Location 002 - Turkey Creek Extraneous Flow Facility
Monitoring Location 003 - Belinder Pumping Station
Monitoring Location 004 - 75th & Nall Holding Station
Monitoring Location 005 - Martway Holding Station

Monitoring of the following parameters daily when a discharge occurs from Monitoring Locations 002 - 005 is required. A sample shall be taken within the first 12 hours after initiation of discharge and once every 24 hours thereafter.

Biochemical Oxygen Demand (5-day) - mg/l	Monitor	Daily	Grab
Total Suspended Solids - mg/l	Monitor	Daily	Grab
Ammonia (as N)- mg/l	Monitor	Daily	Grab
pH - S.U.	Monitor	Daily	Grab
Temperature - °C	Monitor	Daily	Grab
Fecal Coliform - Colonies/100ml	Monitor	Daily	Grab
Total Residual Chlorine - ug/l***	Monitor	Daily	Grab
Flow - (Average & Peak) MGD	Monitor	Daily	Meter
Duration of Discharge - hours	Monitor	Daily	

Monitoring Location 006A - Brush Creek - Downstream of the Belinder Pumping Station and Prior to the KS-MO State Line

A sample of the water in Brush Creek shall be monitored for the following parameters any time there is flow from Monitoring Locations 003, 004, or 005. Sampling shall be in conjunction with the sampling schedule for these Monitoring Locations.

Dissolved Oxygen - mg/l	Monitor	Daily	Grab
Temperature - °C	Monitor	Daily	Grab
pH - Standard Units	Monitor	Daily	Grab
Fecal Coliform - colonies\100ml	Monitor	Daily	Grab
Stream Flow - cfs (while Monitoring Location 003, 004, or 005 is discharging)	Monitor	Daily	Estimate

Effective Date	Upon Issuance		
Monitoring Location and Parameter(s)	Final Limits	Measurement Frequency	Sample Type

Monitoring Location 007A - Turkey Creek - At least 600 meters downstream of the discharge point of the Nelson Complex to Turkey Creek and upstream of Greystone Tunnel

A sample of the water in Turkey Creek shall be monitored for the following parameters any time there is flow from Monitoring Location 002. Sampling shall be in conjunction with the sampling schedule for Monitoring Location 002.

Dissolved Oxygen - mg/l	Monitor	Daily	Grab
Temperature - °C	Monitor	Daily	Grab
pH - Standard Units	Monitor	Daily	Grab
Fecal Coliform - colonies\100ml	Monitor	Daily	Grab
Stream Flow - cfs (while Monitoring Location 002 is discharging)	Monitor	Daily	Estimate

*Influent sample required also.
**Minimum removal of 85% required for Biochemical Oxygen Demand (5-Day) and TSS.
***Test required only if chlorine is used for disinfection.
****This test is required only if disinfection is by chlorination. Permittee shall conduct testing for total residual chlorine according to the methods prescribed in 40 CFR Part 136. The current acceptable quantification level for total residual chlorine in wastewater is 100 micrograms/L. Test results in excess of the quantification level are violations of the permit limits.

B. STANDARD CONDITIONS

In addition to the specified conditions stated herein, the permittee shall comply with the attached Standard Conditions dated August 1, 1996.

C. PRETREATMENT PROGRAM

The permittee shall continue to implement and administer their Pretreatment Program in accordance with the General Pretreatment Regulations 40 CFR Part 403, as approved by the Kansas Department of Health and Environment or the Environmental Protection Agency.

D. SCHEDULE OF COMPLIANCE Reissuance of this permit does not supercede the terms and conditions of Consent Order 02-E-0055 until the Consent Order is closed.

E. SUPPLEMENTAL CONDITIONS

1. Reopener Clause: This permit shall be reopened and provisions added to implement new state or federal regulations addressing Sanitary Sewer Overflows.

2. The Permittee shall continue its program of collection system improvements to reduce infiltration and inflow and implement other upgrades to the Extraneous Flow Basins and Holding Stations cited herein in an effort to improve effluent quality, and reduce the frequency and duration of such intermittent discharges. The permittee shall submit its program of activities for KDHE review and approval by March 28, 2002, and provide an annual report by March 28th of each year thereafter describing the program activities completed, the results of such activities, and a projection of the activities to be accomplished during the remaining calendar year.

F. BIOMONITORING AND PRIORITY POLLUTANTS

1. Whole Effluent Toxicity:

a. Chronic Whole Effluent Toxicity (WET) testing shall be conducted in February, May, August and November of each year. The No Observed Effect Concentration, NOEC, for the months of November through March (winter time period) shall be equal to or greater than 50% effluent. Test results below 50% during this winter time period are violations of this permit. The No Observed Effect Concentration, NOEC, for the months of April through October (summer time period) shall be equal to or greater than 96% effluent. Test results below 96% during this summer time period are violations of this permit. The test procedures shall be in accordance with the EPA document, Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms, third edition, July 1994, (EPA/600/4-91/002) using test organisms *Pimephales promelas* (fathead minnow) and *Ceriodaphnia dubia* (water flea) within a dilution series of (winter time - 0, 25, 35, 50, 75, 100% effluent / summer time - 0, 50, 80, 90, 96, 100% effluent). KDHE reserves the right to increase or decrease testing frequency based upon compliance history and toxicity testing results.

b. If the WET test results indicate the NOEC is equal to or greater than NOEC limits provided above for the appropriate time period, the effluent has passed the toxicity test and the test report shall be due with the next scheduled Discharge Monitoring Report.

c. If the WET test results indicate the NOEC is less than the NOEC limits provided above for the appropriate time period, the effluent has failed the toxicity test and the permittee shall immediately notify KDHE by telephone at (785) 296-5517 and submit to KDHE a copy of the test report within five days of receipt of the information. KDHE reserves the right to require the permittee to take such actions as are reasonable to identify and remedy any identified or predicted toxic conditions in the receiving stream outside of the mixing zone which is caused by the permittee's effluent.

d. The Permittee shall also test a portion of the effluent sample used for the biomonitoring (WET) for the following substances (required minimum reportable detection levels are in parenthesis):

Total Recoverable Antimony (10 µg/L)	Total Recoverable Nickel (50 µg/L)
Total Recoverable Arsenic (10 µg/L)	Total Recoverable Selenium (5 µg/L)
Total Recoverable Beryllium (5 µg/L)	Total Recoverable Silver (2 µg/L)
Total Recoverable Cadmium (2 µg/L)	Total Recoverable Thallium (10 µg/L)
Total Recoverable Chromium (10 µg/L)	Total Recoverable Zinc (20 µg/L)
Total Recoverable Copper (10 µg/L)	Ammonia (0.2 mg/L)
Total Recoverable Lead (5 µg/L)	Total Hardness (as $CaCO_3$ mg/L)
Total Mercury (0.2 µg/L-Cold Vapor Method)	pH
	Effluent Temperature (during sampling

The Permittee may coordinate this testing with any other testing required by this permit and use the test results to satisfy this, as well as the other corresponding testing requirements.

2. Priority Pollutant Scan

a. A Priority Pollutant Scan on the effluent shall be conducted between June 1, 2005 and December 1, 2005 for the parameters listed in the attached Table I, Priority Pollutant Scan. Sample results shall be reported with the next Discharge Monitoring Report following receipt of the results but not later than January 28, 2006.

Sample type shall be 24-hour composite except for Volatiles which shall be a grab sample.

b. See Supplemental Condition F.1.d. for minimum detection limits for certain metals in the Priority Pollutant Scan.

G. Domestic Sewage Sludge Disposal / Re-use

Permittee currently disposes of domestic wastewater treatment sludge in a landfill. This method is subject to the 40 CFR Part 503 sludge regulations. Permittee shall notify the appropriate regulatory agency prior to changing the method of sludge disposal/re-use.

Table I

Priority Pollutant Scan

Metals
- Total Recoverable Arsenic (ug/l)
- Total Recoverable Beryllium (ug/l)
- Total Recoverable Cadmium (ug/l)
- Total Recoverable Chromium (ug/l)
- Total Recoverable Copper (ug/l)
- Total Recoverable Lead (ug/l)
- Total Mercury (ug/l)
- Total Recoverable Molybdenum (ug/l)
- Total Recoverable Potassium (ug/l)
- Total Recoverable Nickel (ug/l)
- Total Recoverable Selenium (ug/l)
- Total Recoverable Silver (ug/l)
- Total Recoverable Thallium (ug/l)
- Total Recoverable Zinc (ug/l)

Pesticides
- Aldrin (mg/l)
- Alpha-BHC (mg/l)
- Beta-BHC (mg/l)
- Gamma-BHC (mg/l)
- Delta-BHC (mg/l)
- Chlordane (mg/l)
- 4,4-DDT (mg/l)
- 4,4-DDD (mg/l)
- 4,4-DDE (mg/l)
- Dieldrin (mg/l)
- Alpha-endosulfan (mg/l)
- Beta-endosulfan (mg/l)
- Endosulfan sulfate (mg/l)
- Endrin (mg/l)
- Endrin aldehyde (mg/l)
- Heptachlor (mg/l)
- Heptachlor epoxide (mg/l)
- Toxaphene (mg/l)
- Malathion (mg/l)
- Diazinon (mg/l)

Polychlorinated Biphenyls (mg/l)
- PCB-1242
- PCB-1254
- PCB-1221
- PCB-1232
- PCB-1248
- PCB-1260
- PCB-1016

Priority Pollutant Scan (continued)

Base/Neutral
- Acenaphthene (mg/l)
- Acenaphtylene (mg/l)
- Anthracene (mg/l)
- Benzidine (mg/l)
- Benzo(a) anthracene (mg/l)
- Benzo(a)pyrene (mg/l)
- 3,4-benzofluoranthene (mg/l)
- Benzo (ghi) perylene (mg/l)
- Benzo (b) fluoranthene (mg/l)
- Bis(2-chloroethoxy)methane (mg/l)
- Bis(2-chloroethyl)ether (mg/l)
- Bis(2-ethylhexyl)phthalate (mg/l)
- Bis(2-chloroisopropyl) ether (mg/l)
- 1,2-diphenylhydrazine (mg/l)
- Fluoranthene (mg/l)
- Fluorene (mg/l)
- Nitrobenzene (mg/l)
- N-nitrosodimethylamine (mg/l)
- N-nitrosodi-n-propylamine (mg/l)
- N-nitrosodiphenylamine (mg/l)
- Phenanthrene (mg/l)
- Pyrene (mg/l)
- 1,2,4-trichlorobenzene (mg/l)
- 4-bromophenyl phenyl ether (mg/l)
- Butyl benzyl phthalate (mg/l)
- 2-chloronaphthalene (mg/l)
- 4-chlorophenyl phenyl ether (mg/l)
- Chrysene (mg/l)
- Dibenzo(a,h) anthracene (mg/l)
- 1,2-dichlorobenzene (mg/l)
- 1,3-dichlorobenzene (mg/l)
- 1,4-dichlorobenzene (mg/l)
- 3,3-dichlorobenzidine (mg/l)
- Dimethyl phthalate (mg/l)
- Diethyl phthalate (mg/l)
- Di-n-butyl phthalate (mg/l)
- 2,4-dinitrotoluene (mg/l)
- 2,6-dinitrotoluene (mg/l)
- Di-n-octyl phthalate (mg/l)
- Hexachlorobenzene (mg/l)
- Hexachlorobutadiene (mg/l)
- Hexachlorocyclopentadiene (mg/l)
- Hexachloroethane (mg/l)
- Indeno (1,2,3-cd) pyrene (mg/l)
- Naphthalene (mg/l)
- Isophorone (mg/l)

Priority Pollutant Scan (continued)

Acid Compounds
- 2-chlorophenol (mg/l)
- 2,4-dichlorophenol (mg/l)
- 2,4-dimethylphenol (mg/l)
- 2,4-dinitrophenol (mg/l)
- 2-nitrophenol (mg/l)
- 4-nitrophenol (mg/l)
- Parachlorometa cresol (mg/l)
- Pentachlorophenol (mg/l)
- Phenol (mg/l)
- 4,6-dinitro-o-cresol (mg/l)
- 2,4,6-trichlorophenol (mg/l)

Volatiles
- Acrolein (mg/l)
- Acrylonitrile (mg/l)
- Benzene (mg/l)
- Bromoform (mg/l)
- Carbon Tetrachloride (mg/l)
- Chlorobenzene (mg/l)
- Chlorodibromomethane (mg/l)
- Chloroethane (mg/l)
- 2-chloroethylvinyl ether (mg/l)
- Chloroform (mg/l) (mg/l)
- Dichlorobromomethane (mg/l)
- 1,1-dichloroethane (mg/l)
- 1,2-dichloroethane (mg/l)
- 1,1-dichloroethylene (mg/l)
- 1,2-dichloropropane (mg/l)
- 1,3-dichloropropylene (mg/l)
- Ethylbenzene (mg/l)
- Methyl bromide (mg/l)
- Methyl chloride (mg/l)
- Methylene chloride (mg/l)
- 1,1,2,2-tetrachloroethane (mg/l)
- Tetrachloroethylene (mg/l)
- Toluene (mg/l)
- 1,2 trans-dichloroethylene (mg/l)
- 1,1,1-trichloroethane (mg/l)
- 1,1,2-trichloroethane (mg/l)
- Trichloroethylene (mg/l)
- Vinyl chloride (mg/l)

Miscellaneous
- Total Cyanide (mg/l)*
- Total Phenols (mg/l)

* The total cyanide analysis must include preliminary treatment of the sample to avoid NO_2^- interference. Addition of sulfamic acid to the sample before distillation can prevent such interference, see Standard Methods for the Examination of Water and Wastewater, 18th Edition, 4500-CN B. Preliminary Treatment of Samples.

STANDARD CONDITIONS FOR KANSAS WATER POLLUTION CONTROL AND NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT

1. Representative Sampling:

   A. Samples and measurements taken as required herein shall be representative of the nature and volume of the monitored discharge. All samples shall be taken at the location designated in this permit, and unless specified, at the outfall(s) before the effluent joins or is diluted by any other water or substance.

   B. Monitoring results shall be recorded and reported on forms acceptable to the Division and postmarked no later than the 28th day of the month following the completed reporting period. Signed and certified copies of these, prepared in accordance with KAR 28-16-59 and all other reports required herein, shall be submitted to

      Kansas Department of Health & Environment
      Bureau of Water-Technical Services Section
      1000 SW Jackson Street, Suite 420
      Topeka, KS 66612-1367

2. Schedule of Compliance: No later than 14 calendar days following each date identified in the "Schedule of Compliance," the permittee shall submit to the above address, either a report of progress or, in the case of specific action being required by identified dates, a written notice of compliance or noncompliance. In the latter case, the notice shall include the cause of noncompliance, any remedial actions taken, and the probability of meeting the next scheduled requirements, or, if there are no more scheduled requirements, when such noncompliance will be corrected.

3. Definitions:

   A. The "daily average" discharge means either the total discharge by weight during a calendar month divided by the number of days in the month that the facility was operating or the average concentration for the month. The daily average discharge shall be determined by the summation of all measured daily discharges by weight divided by the number of days during the calendar month when the measurements were made, or by the summation of all concentrations determined during the calendar month divided by the number of samples collected and analyzed.

   B. The "daily maximum" discharge means the total discharge by weight or average concentration during a 24 hour period.

   C. The "monthly average", other than for fecal coliform bacteria, is the arithmetic mean of the value of effluent samples collected in a period of 30 consecutive days. The monthly average for fecal coliform bacteria is the geometric mean of the value of the effluent samples collected in a period of 30 consecutive days.

   D. The "weekly average", other than for fecal coliform bacteria, is the arithmetic mean of the value of effluent samples collected in a period of 7 consecutive days. The weekly average for fecal coliform bacteria is the geometric mean of the value of effluent samples collected in a period of 7 consecutive days.

   E. A "grab sample" is an individual sample collected in less than 15 minutes.

F. A "composite sample" is a combination of individual samples in which the volume of each individual sample is proportional to the discharge flow, the sample frequency is proportioned to the flow rate over the sample period, or the sample frequency is proportional to time.

G. The "act" means the Clean Water Act, 30 USC Section 1251 et seq.

H. The terms "Director", "Division", and "Department" refer to the Director, Division of Environment, Kansas Department of Health and Environment, respectively.

I. "Severe property damage" means substantial physical damage to property, damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

J. "Bypass" means any diversion of waste streams from any portion of a treatment facility or collection syste

4. Test Procedures: All analysis required by this permit shall conform to the requirements of 33 USC Section 1314(h), and shall be conducted in a laboratory certified by this Department. For each measurement or sample, the permittee shall record the exact place, date, and time of sampling; the date of the analyses, the analytical techniques or methods used, and the individual(s) who performed the sampling and analysis and, the results. If the permittee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved procedures, the results shall be included in the Discharge Monitoring Report form required in 1.B. above. Such increased frequencies shall also be indicated.

5. Records Retention: All records and information resulting from the monitoring activities required by this permit, including all records of analyses and calibration and maintenance of instrumentation and recordings from continuous monitoring instrumentation, shall be retained for a minimum of 3 years, or longer if requested by the Division.

6. Change in Discharge: All discharges authorized herein shall be consistent with the terms and conditions of this permit. The discharge of any pollutant not authorized by this permit or of any pollutant identified in this permit more frequently than or at a level in excess of that authorized shall constitute a violation of this permit. Any anticipated facility expansions, productions or flow increases, or process modifications which result in a new, different, or increased discharge of pollutants shall be reported to the Division at least one hundred eighty (180) days before such chang

7. Noncompliance Notifications: If for any reason, the permittee does not comply with, or will be unable to comply with any daily maximum or weekly average effluent limitations specified in this permit, the permittee shall provide the Department with the following information in writing within five days of becoming aware of such condition:

   A. A description of the discharge and cause of noncompliance, and

   B. the period of noncompliance including exact dates and times or if not corrected, the anticipated time the noncompliance is expected to continue and steps taken to reduce, eliminate and prevent recurrence of the noncomplying discharge.

   The above information shall be provided with the submittal of the regular Discharge Monitoring Report form for violations of daily average or monthly average effluent limitations.

8. Facilities Operation: The permittee shall at all times maintain in good working order and efficiently and effectively operate all treatment, collection, control systems or facilities, to achieve compliance with the terms of this permit. Such proper operation and maintenance procedures shall also include adequate laboratory controls and appropriate quality assurance procedures. Maintenance of treatment facilities which results in degradation of effluent quality, even though not causing violations of effluent limitations shall be scheduled during noncritical water quality periods and shall be carried out in a manner approved in advance by the Division. The permittee shall take all necessary steps to minimize or prevent any adverse impact to waters of the State resulting from noncompliance with any effluent limitations specified in this permit, including such accelerated or additional monitoring as necessary to determine the nature and impact of the noncomplying discharge. When necessary to maintain compliance with the permit conditions, the permittee shall halt or reduce those activities under its control which generate wastewater routed to this facility.

9. Immediate Reporting Required: Any diversion from, or bypass of facilities necessary to maintain compliance with the permit is prohibited, except: where no feasible alternatives to the bypass exist and 1) where necessary to prevent loss of human life, personal injury or severe property damage; or 2) where excessive stormwater inflow or infiltration would damage any facilities necessary to comply with this permit or 3) where the permittee notifies the Director seven days in advance of an anticipated bypass. The Director or Director's designee may approve a bypass, after considering its adverse effects, if any of the three conditions listed above are met. The permittee shall immediately notify the Division by telephone [(913) 296-5517 or the appropriate KDHE District Office] of each bypass and shall confirm the telephone notification with a letter explaining what caused this spill or bypass and what actions have been taken to prevent recurrence. Written notification shall be provided to the Director within five days of the permittee becoming aware of the bypass. The Director or Director's designee may waive the written report on a case-by-case basis.

10. Removed Substances: Solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters shall be disposed of in a manner acceptable to the Division.

11. Power Failures: The permittee shall provide an alternative power source sufficient to operate the wastewater control facilities or otherwise control pollution and all discharges upon the loss of the primary source of power to the wastewater control facilities.

12. Right of Entry: The permittee shall allow authorized representatives of the Division of Environment or the Environmental Protection Agency upon the presentation of credentials, to enter upon the permittee's premises where an effluent source is located, or in which are located any records required by this permit, and at reasonable times, to have access to and copy any records required by this permit, to inspect any monitoring equipment or monitoring method required in this permit, and to sample any influents to, discharges from or materials in the wastewater facilities.

13. Transfer of Ownership: The permittee shall notify the succeeding owner or controlling person of the existence of this permit by certified letter, a copy of which shall be forwarded to the Division. The succeeding owner shall secure a new permit. The permit is not transferable to any person except after notice and approval by the Director. The Director may require modification or revocation and reissuance of the permit to change the name of the permittee and incorporate such other requirements as may be necessary.

14. Availability of Records: Except for data determined to be confidential under 33 USC Section 1318, all reports prepared in accordance with the terms of this permit shall be available for public inspection at the offices of the Department. Effluent data shall not be considered confidential. Knowingly making any false statement on any such report or tampering with equipment to falsify data may result in the imposition of criminal penalties as provided for in 33 USC Section 1319 and KSA 65-170c.

15. Permit Modifications and Terminations: As provided by KAR 28-16-62, after notice and opportunity for a hearing, this permit may be modified, suspended or revoked or terminated in whole or in part during its term for cause as provided, but not limited to those set forth in KAR 28-16-62 and KAR 28-16-28b through f. The permittee shall furnish to the Director, within a reasonable amount of time, any information which the Director may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or to determine compliance with this permit. The permittee shall also furnish upon request, copies of all records required to be kept by this permit.

16. Toxic Pollutants: Notwithstanding paragraph 15 above, if a toxic effluent standard or prohibition (including any schedule of compliance specified at such effluent standards) is established under 33 USC Section 1317(a) for a toxic pollutant which is present in the discharge and such standard or prohibition is more stringent than any limitation for such pollutant in this permit, this permit shall be revised or modified in accordance with the toxic effluent standard or prohibition. Nothing in this permit relieves the permittee from complying with federal toxic effluent standards as promulgated pursuant to 33 USC Section 1317.

17. Civil and Criminal Liability: Except as authorized in paragraph 9 above, nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance as provided for in KSA 65-170d, KSA 65-167, and 33 USC Section 1319.

18. Oil and Hazardous Substance Liability: Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities or penalties to which the permittee is or may be subject to under 33 USC Section 1321 or KSA 65-164 et seq. The municipal permittee shall promptly notify the Division by telephone upon discovering crude oil or any petroleum derivative in its sewer system or wastewater treatment facilities.

19. Industrial Users: The municipal permittee shall require any industrial user of the treatment works to comply with 33 USC Section 1317, 1318 and any industrial user of storm sewers to comply with 33 USC Section 1308.

20. Property Rights: The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights nor any infringements of or violation of federal, state or local laws or regulations.

21. Operator Certification: The permittee shall ensure the wastewater facilities are under the supervision of an operator certified by the Department. If the permittee does not have a certified operator or loses its certified operator, appropriate steps shall be taken to obtain a certified operator as required by KAR 28-16-30 et seq.

22. Severability: The provisions of this permit are severable. If any provision of this permit or any circumstance is held invalid, the application of such provision to other circumstances and the remainder of the permit shall not be affected thereby.

23. Removal from Service: The permittee shall inform the Division at least three months before a pumping station, treatment unit, or any other part of the treatment facility permitted by this permit is to be removed from service and shall make arrangements acceptable to the Division to decommission the facility or part of the facility being removed from service such that the public health and waters of the state are protected.

24. Duty to Reapply: A permit holder wishing to continue any activity regulated by this permit after the expiration date, must apply for a new permit at least 180 days prior to expiration of the permit.

Appendix K
Cultural Resources

DEPARTMENT OF THE ARMY
KANSAS CITY DISTRICT, CORPS OF ENGINEERS
635 FEDERAL BUILDING
KANSAS CITY, MISSOURI 64106-2896

May 9, 2012

REPLY TO
ATTENTION OF

Environmental Resources Section
Planning Branch

Ms. Jennie A. Chinn
Executive Director, State Historic Preservation Officer
Kansas State Historical Society
6425 S. W. 6th Avenue
Topeka, Kansas 66615-1099

Dear Ms. Chinn:

The attached report Archeological Survey of Upper Turkey Creek Basin Flood Risk Management Project Johnson County, Kansas details the results of an archeological survey conducted by the Kansas City District, Corps of Engineers (Corps). This correspondence initiates Section 106 consultation for the proposed project.

The archeological survey was conducted by David Cain, an archeological intern. Mr. Cain meets the Secretary of Interiors standards for conducting archeological investigations. In sum, the survey found no archeological sites or artifacts during the survey. The former Ft. Leavenworth-Ft. Scott military road is mapped bisecting the project area. The former road is marked by a sign in the project area, but no trace of the road remains due to the severe urban development in the area. I have reviewed the report and concur with his recommendations that no historic properties will be effected by the proposed undertaking. At this time, I request your review and concurrence as well.

Thank you for your consideration in this matter. If you have any questions or have need of further information please contact me at timothy.m.meade@usace.army.mil or at (816) 389-3138.

Sincerely,

Timothy Meade
District Archeologist

Enclosure

KSR&C No. 12-05-134

6425 SW 6th Avenue
Topeka, KS 66615

Kansas

phone: 785-272-8681
fax: 785-272-8682
cultural_resources@kshs.org

Kansas Historical Society

Sam Brownback, Governor
Jennie Chinn, Executive Director

May 15, 2012

Timothy Meade
Cultural Resource Manager
Kansas City District, Corps of Engineers
700 Federal Building
Kansas City, Missouri 64106-2896

RE: Flood Risk Management Project
Upper Turkey Creek Basin
Johnson County

Dear Mr. Meade:

In accordance with 36 CFR 800, the Kansas State Historic Preservation Office has reviewed a report entitled *Archeological Survey of Upper Turkey Creek Basin, Flood Risk Management Project Johnson County, Kansas*, by David I. Cain. We find the report to be acceptable and concur with the recommendation that the project as proposed should have no effect on properties listed in the National Register of Historic Places or otherwise identified in our files. This office has no objection to implementation of the flood risk management project.

This information is provided at your request to assist you in identifying historic properties, as specified in 36 CFR 800 for Section 106 consultation procedures. If you have questions or need additional information regarding these comments, please contact Tim Weston at 785-272-8681 (ext. 214) or Kim Gant at 785-272-8681 (ext.225).

Sincerely,

Jennie Chinn, Executive Director and
State Historic Preservation Officer

Timothy Weston for

Patrick Zollner
Deputy SHPO

928

Archeological Survey of
Upper Turkey Creek Basin, Flood Risk Management Project
Johnson County, Kansas

David I. Cain

United States Army Corps of Engineers

Kansas City District

Management Summary

On December 2, 2011, The Kansas City District of the United States Army Corps of Engineers (Corps) conducted a cultural resources survey of a portion of the Upper Turkey Creek drainage basin in Johnson County, Kansas. No previously recorded archeological sites are located on or boarding this proposed project area in the Kansas State Historic Preservation Office (SHPO) database. No historic properties listed eligible for the National Register of Historic Places were found within one mile of the survey area. This survey recorded no new sites or NRHP eligible historic properties. Based on the results of this survey, no additional investigations are recommended to proceed with this project.

Table of Contents

Management Summary 1

Project Description 3

Project Area 3

Project Area Geology 3

Cultural Context 3

Prehistoric Contexts 3

Historic Contexts 4

Archeological Investigations 4

Background Review Results 4

Field Methodology 4

Methodology 4

Survey Results and Management Recommendations ..... Error! Bookmark not defined.

Background Review Results 4

Fieldwork Results 5

Discussion 5

Recommendations 5

References Cited 6

List of Figures

Figure 1: Project Area on 1:24K USGS Topo 7

Figure 2: Project Area on Kansas SHPO Viewer Output 8

List of Photos

Photo 1: Current Condition of Stream Banks 9

Photo 2: Historic Military Marker 9

Project Description

The project area begins 468 meters northwest of the intersection of Shawnee Mission Parkway and I-35 and extends along Upper Turkey Creek from Shawnee Mission Parkway north 1,944 meters to Merriam Drive (Figure 1). The proposed project will consist of levees and flood walls and is designed to update and improve a system of preexisting flood control structures that currently exist between Merriam Drive and Shawnee Mission Parkway. The proposed construction activities are expected to intermittently disturb both banks of this portion of the creek to replace existing flood control measures and bank stabilization with larger ones designed to handle periods of heavier flooding. The legal description of the proposed project area is Township 12 south, Range 24 east, Section 12.

Project Area

Upper Turkey Creek reaches through an urban environment surrounded by commercial and residential properties. The banks of this creek have been heavily modified and are currently lines with large limestone blocks (Photograph 1). Evidence of previous disturbance is present throughout the proposed project area. A series of trails and recreation areas border the west bank of this stretch of the creek.

Project Area Geology

Within the project area Upper Turkey Creek is a perennial stream that flows from the southwest to northeast. The areas surrounding this creek are the primary flood plain of the Upper Turkey Creek. Soils mapped within the project area include Kinnebec Silt loam, Oska-Martin complex and Vinland-Rock outcrop (USDA 2010). The Kennebec soils consist of very deep, moderately well drained soils formed in alluvium. These soils are on flood plains in river valleys and on drainage ways on uplands. Oska-Martin complex soils form residuum and colluviums derived from limestone and shale. Vinland-Rock outcrop are found on hill slopes in the uplands. It should be noted here that soils observed during the current fieldwork appeared to be fill, intermittently mixed with limestone gravel.

Cultural Context

Prehistoric Contexts

North American archeologists generally assign one of four major periods to prehistoric sites. These four periods are further divided into three subdivisions differentiating between early, middle and late occupations in that period. Paleoindian, the oldest of these periods, refers to occupations between 11,500-9,800 years before present. This period is often characterized by fluted projectile point types and other lithic technologies specific to the cultures of this time.

Following the Paleoindian period, the Archaic period defines cultures living between 9,800-2,700 years before present. This period is associated with the first domesticated plants and the first known use of North American pottery. After the Archaic period, the woodland period is associated with occupations between 2,700-1,000 years before present. Ceramics, lithic heat treatment, mound building and agriculture are wide-spread practices, common during this time period. The Mississippian period, 1,000-650 years before present, is associated with groups of much higher social complexity. It was during this period that the bow and arrow completely replaced the atlatl and shell became the predominant temper in pottery (Ray et. al. 2011).

Historic Contexts

Historic context in North America occupies a relatively short scope of time. The Historic period in North America includes all time where a written account of events was kept. This includes the terminal prehistoric (650-350 years before present), The Protohistoric (350-280 years before present), the pre-antebellum (before 1861) and post antebellum (after 1865-50 years before present) periods.

Archeological Investigations

Background Review Results

The background review of the project area consisted of search of the Kansas State Historical Society's Archeological Inventory Map Viewer on-line, the National Register of Historic Places on-line and Corps records for cultural resource sites and potential historical properties in the project area. The review found no archeological sites mapped in or near the project area. However, a former military road is depicted on the map viewer crossing the proposed project area. The road connected Ft. Leavenworth and Ft. Scott and is depicted crossing Turkey Creek just north of Shawnee Mission Parkway (Figure 2). The trail is also noted in the project area with a marker sign (Photograph 2).

Field Methodology

USACE intern archeologist David I. Cain served as the project archeologist for the field investigations. Pedestrian survey was conducted along the entire length of the west bank of the creek. Exposed ground surfaces including cut banks were observed for artifacts.The east bank was not surveyed because of severe disturbance from commercial structures and parking lots.

Fieldwork Results

Fieldwork was conducted by archeological intern David I. Cain on December 2, 2011. No archeological sites or artifacts were observed during the survey. Survey conditions found patchy ground vegetation along the upper bank of the creek and areas of bank visibility provided many areas of 90-100% ground surface visibility. Average ground surface visibility along the

immediate terrace is between 60-85% on the west side. Areas of higher visibility are present nearer the stream bank. As mentioned, the east side of the stream is largely obstructed by commercial development and parking lots. A disturbed and highly mixed layer of fill was observed throughout the proposed project area. No natural soil layers were observed in the banks of the creek within the project area.

No trace of the military trail remains within the project area. As noted a sign marks its former loeation. A modern pedestrian bridge appears to be at or very near the crossing point. The area around the trail crossing is currently a small public recreation area that has been landscaped for public use. It is likely that the surrounding urban development has destroyed any trace of the former trail.

Discussion

As can be seen in Photograph 2, the banks of this waterway have been heavily modified in the past. The proposed project would cut back these previously modified stream banks to facilitate the construction of the proposed flood control measures. Based on the apparent disturbances observed in the project area, Recommendations

Recommendations

Because of the disturbed nature of the project area, the lack of sites found during the survey, and because no trace of the former military trail remain; the proposed construction impacts have little likelihood of impacting historic properties. However, if project plans change to include areas not considered in this survey, those changes would need to be reviewed by the District Archeologist to determine if additional investigations are required. In the unlikely event that unanticipated archeological deposits are encountered during construction, work in the area of the discovery would cease and the District Archeologist notified.

References Cited

Ray, Jack H. et. al.

2011 American Recovery and Reinvestment Act 2009 Section 110 Compliance Report for the U.S. Army Corps of Engineers, Kansas City District: NHPA, Cultural Resource Investigations Technical Report. No. 21, Vol2. Center for Archaeological Research, Missouri State University, Springfield, Missouri.

United States Department of Agriculture

2010 National Cooperative Soil Survey, Web Soil Survey, Web based GIS, http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm, Accessed March3, 2012.

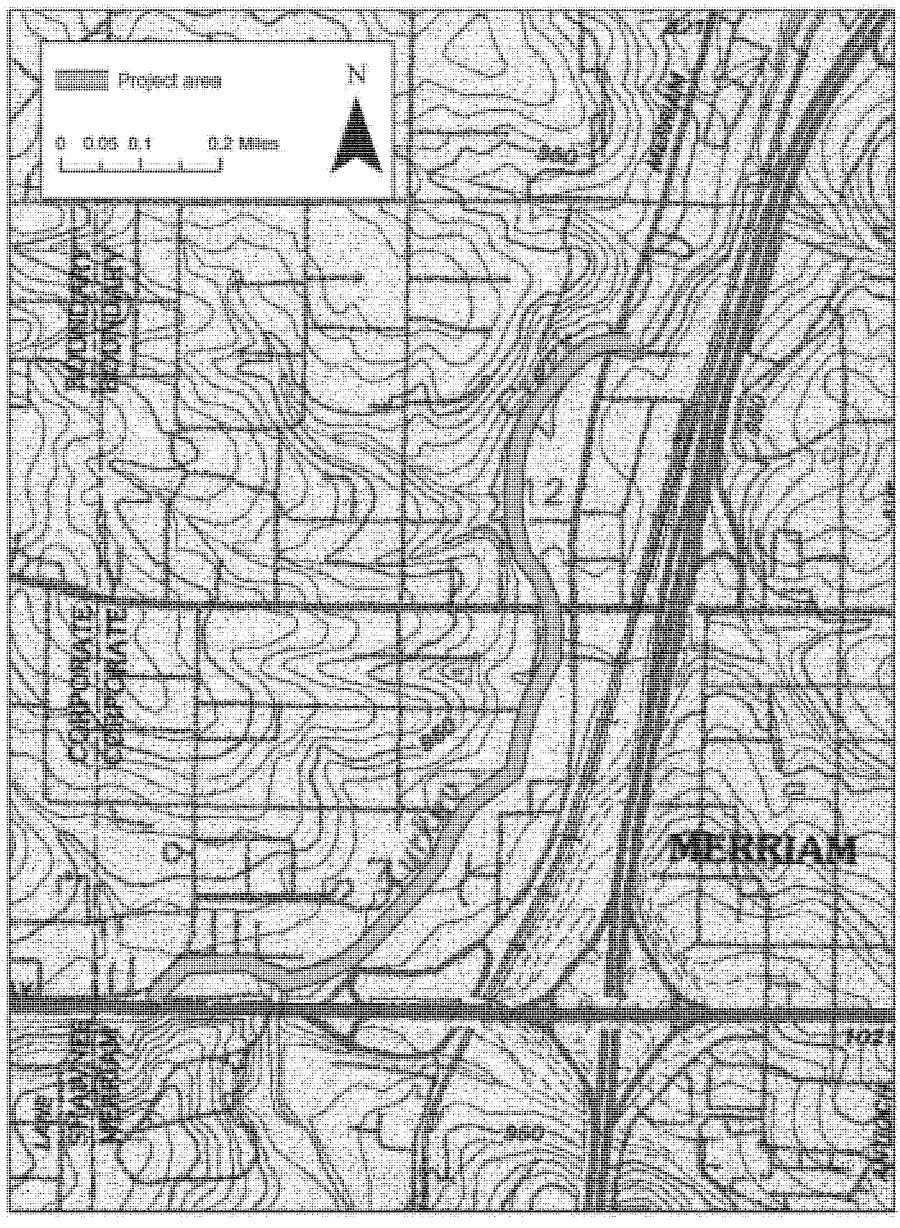
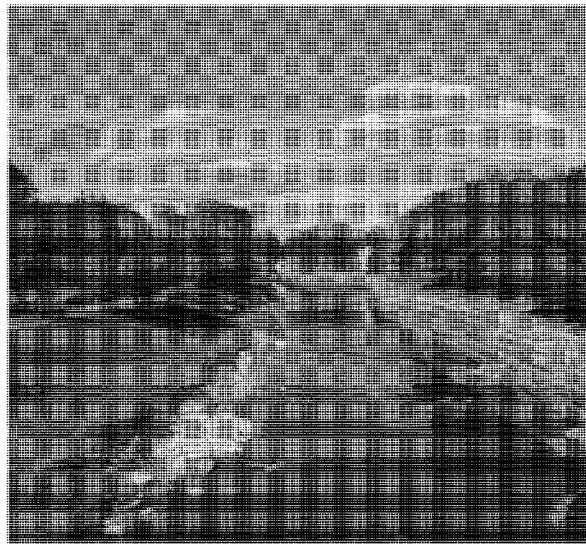
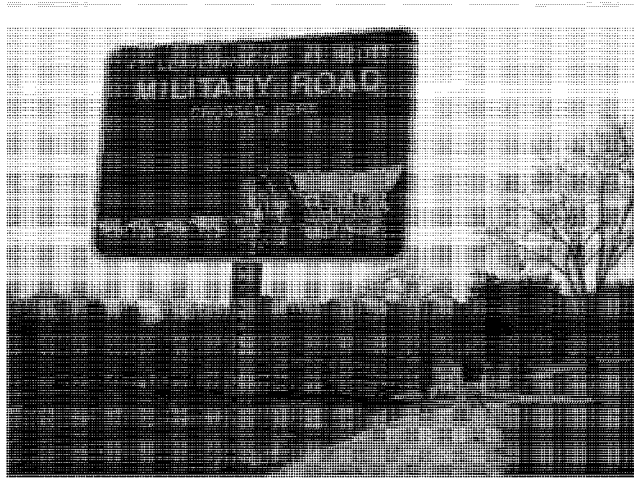


Figure 1: Project Area on 1:24K USGS Topo

Figure 2: Project Area on Kansas SHPO Viewer Output



Photograph 1: Current Condition of Stream Banks



Photograph 2: Historic Military Road Marker

Appendix L
Total Project Cost Summary, Project Cost and Schedule Risk Analysis, Cost Report, Contract Schedule

Section 1
Total Project Cost Summary

****** TOTAL PROJECT COST SUMMARY ******

PROJECT: Upper Turkey Creek - P2 Number 105941
LOCATION: Merriam, KS

DISTRICT: Kansas City
POC: CHIEF, COST ENGINEERING, Dillon
PREPARED: 10/28/2014

This Estimate reflects the scope and schedule in report; Feasibility Study

Civil Works Work Breakdown 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-14 ($K)		COST ($K)	CNTG ($K)	FULL ($K)
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
02	RELOCATIONS	$4,214	$1,054	25%	$5,268	0.0%	$4,214	$1,054	$5,268	$0		$4,860	$1,215	$6,075
06	FISH & WILDLIFE FACILITIES	$12	$3	25%	$15	0.0%	$12	$3	$15	$0		$13	$3	$17
09	CHANNELS & CANALS	$0	$0 -		$0	-	$0	$0	$0	$0		$0	$0	$0
11	LEVEES & FLOODWALLS	$18,052	$4,513	25%	$22,565	0.0%	$18,052	$4,513	$22,565	$0		$20,810	$5,203	$26,013
		$0	$0 -		$0	-	$0	$0	$0	$0		$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:	$22,278	$5,570		$27,848	0.0%	$22,278	$5,570	$27,848	$0		$25,684	$6,421	$32,105
01	LANDS AND DAMAGES	$4,096	$758	19%	$4,854	0.0%	$4,096	$758	$4,854	$0		$4,557	$843	$5,400
30	PLANNING, ENGINEERING & DESIGN	$2,453	$613	25%	$3,066	0.0%	$2,453	$613	$3,066	$0		$3,042	$761	$3,803
31	CONSTRUCTION MANAGEMENT	$1,449	$362	25%	$1,811	0.0%	$1,449	$362	$1,811	$0		$1,911	$478	$2,389
	PROJECT COST TOTALS:	$30,276	$7,303	24%	$37,579		$30,276	$7,303	**$37,579**	$0		$35,195	$8,502	$43,697

_____ CHIEF, COST ENGINEERING, Dillon

_____ PROJECT MANAGER, Rast

_____ CHIEF, REAL ESTATE, Wilson

ESTIMATED FEDERAL COST:	**65%**	**$28,403**
ESTIMATED NON-FEDERAL COST:	**35%**	**$15,294**
ESTIMATED TOTAL PROJECT COST:		**$43,697**

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: Upper Turkey Creek - P2 Number 105941
LOCATION: Merriam, KS
This Estimate reflects the scope and schedule in report; Feasibility Study

DISTRICT: Kansas City
POC: CHIEF, COST ENGINEERING, Dillon
PREPARED: 10/28/2014

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 10/28/2014 Effective Price Level: 10/1/2014				Program Year (Budget EC): 2015 Effective Price Level Date: 1 OCT 14								
				RISK BASED										
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 1 or CONTRACT 1													
02	RELOCATIONS	$1,516	$379	25%	$1,895	0.0%	$1,516	$379	$1,895	2020Q4	11.9%	$1,696	$424	$2,120
06	FISH & WILDLIFE FACILITIES	$12	$3	25%	$15	0.0%	$12	$3	$15	2020Q4	11.9%	$13	$3	$17
09	CHANNELS & CANALS	$0	$0	25%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	$6,269	$1,567	25%	$7,836	0.0%	$6,269	$1,567	$7,836	2020Q4	11.9%	$7,014	$1,754	$8,768
	#N/A	$0	$0	0%	$0	0.0%	$0 $0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:	$7,797	$1,949	25%	**$9,746**		$7,797	$1,949	$9,746			$8,724	$2,181	$10,905
01	LANDS AND DAMAGES	$2,414	$447	19%	$2,861	0.0%	$2,414	$447	$2,861	2019Q3	9.2%	$2,635	$488	$3,123
30	PLANNING, ENGINEERING & DESIGN													
2.0%	Project Management	$156	$39	25%	$195	0.0%	$156	$39	$195	2018Q1	11.6%	$174	$44	$218
1.0%	Planning & Environmental Compliance	$78	$20	25%	$98	0.0%	$78	$20	$98	2018Q1	11.6%	$87	$22	$109
4.5%	Engineering & Design	$351	$88	25%	$439	0.0%	$351	$88	$439	2018Q1	11.6%	$392	$98	$490
1.0%	Reviews, ATRs, IEPRs, VE	$78	$20	25%	$98	0.0%	$78	$20	$98	2018Q1	11.6%	$87	$22	$109
0.5%	Life Cycle Updates (cost, schedule, risks)	$39	$10	25%	$49	0.0%	$39	$10	$49	2018Q1	11.6%	$44	$11	$54
1.0%	Contracting & Reprographics	$78	$20	25%	$98	0.0%	$78	$20	$98	2018Q1	11.6%	$87	$22	$109
1.0%	Engineering During Construction	$78	$20	25%	$98	0.0%	$78	$20	$98	2020Q4	24.2%	$97	$24	$121
0.0%	Planning During Construction	$0	$0	25%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	25%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
6.5%	Construction Management	$507	$127	25%	$634	0.0%	$507	$127	$634	2020Q4	24.2%	$630	$157	$787
0.0%	Project Operation:	$0	$0	25%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Management	$0	$0	25%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:	$11,576	$2,737		**$14,313**		$11,576	$2,737	$14,313			$12,957	$3,068	**$16,024**

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: Upper Turkey Creek - P2 Number 105941
LOCATION: Merriam, KS
This Estimate reflects the scope and schedule in report; Feasibility Study

DISTRICT: Kansas City
POC: CHIEF, COST ENGINEERING, Dillon
PREPARED: 10/28/2014

Estimate Prepared: 41940
Effective Price Level: 41913

Program Year (Budget EC): 2015
Effective Price Level Date: 1 OCT 14

Civil Works Work Breakdown 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)	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													
02	RELOCATIONS	$1,153	$288	25%	$1,441	0.0%	$1,153	$288	$1,441	2022Q2	15.3%	$1,329	$332	$1,661
06	FISH & WILDLIFE FACILITIES	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	$5,597	$1,399	25%	$6,997	0.0%	$5,597	$1,399	$6,997	2022Q2	15.3%	$6,451	$1,613	$8,064
	#N/A	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
							$0							
	CONSTRUCTION ESTIMATE TOTALS:	$6,750	$1,688	25%	**$8,438**		$6,750	$1,688	$8,438			$7,780	$1,945	$9,725
01	LANDS AND DAMAGES	$654	$121	19%	$775	0.0%	$654	$121	$775	2020Q4	11.9%	$732	$135	$867
30	PLANNING, ENGINEERING & DESIGN													
2.0%	Project Management	$135	$34	25%	$169	0.0%	$135	$34	$169	2021Q1	25.4%	$169	$42	$212
1.0%	Planning & Environmental Compliance	$68	$17	25%	$85	0.0%	$68	$17	$85	2021Q1	25.4%	$85	$21	$107
4.5%	Engineering & Design	$304	$76	25%	$380	0.0%	$304	$76	$380	2021Q1	25.4%	$381	$95	$477
1.0%	Reviews, ATRs, IEPRs, VE	$68	$17	25%	$85	0.0%	$68	$17	$85	2021Q1	25.4%	$85	$21	$107
0.5%	Life Cycle Updates (cost, schedule, risks)	$34	$9	25%	$43	0.0%	$34	$9	$43	2021Q1	25.4%	$43	$11	$53
1.0%	Contracting & Reprographics	$68	$17	25%	$85	0.0%	$68	$17	$85	2021Q1	25.4%	$85	$21	$107
1.0%	Engineering During Construction	$68	$17	25%	$85	0.0%	$68	$17	$85	2022Q2	31.7%	$90	$22	$112
0.0%	Planning During Construction	$0	$0	25%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	25%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
6.5%	Construction Management	$439	$110	25%	$549	0.0%	$439	$110	$549	2022Q2	31.7%	$578	$145	$723
0.0%	Project Operation:	$0	$0	25%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Management	$0	$0	25%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:	$8,588	$2,105		**$10,693**		$8,588	$2,105	$10,693			$10,029	$2,460	**$12,488**

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: Upper Turkey Creek - P2 Number 105941
LOCATION: Merriam, KS
This Estimate reflects the scope and schedule in report; Feasibility Study

DISTRICT: Kansas City
POC: CHIEF, COST ENGINEERING, Dillon
PREPARED: 10/28/2014

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 41940 Effective Price Level: 41913				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)	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 3 or CONTRACT 3													
02	RELOCATIONS	$1,545	$386	25%	$1,931	0.0%	$1,545	$386	$1,931	2023Q4	18.7%	$1,835	$459	$2,293
06	FISH & WILDLIFE FACILITIES	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	$6,186	$1,547	25%	$7,733	0.0%	$6,186	$1,547	$7,733	2023Q4	18.7%	$7,345	$1,836	$9,181
	#N/A	$0	$0	0%	$0	0.0%	$0 $0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:	$7,731	$1,933	25%	**$9,664**		$7,731	$1,933	$9,664			$9,180	$2,295	$11,475
01	LANDS AND DAMAGES	$1,028	$190	19%	$1,218	0.0%	$1,028	$190	$1,218	2022Q3	15.8%	$1,190	$220	$1,410
30	PLANNING, ENGINEERING & DESIGN													
2.0%	Project Management	$155	$39	25%	$194	0.0%	$155	$39	$194	2022Q3	33.0%	$206	$52	$258
1.0%	Planning & Environmental Compliance	$77	$19	25%	$96	0.0%	$77	$19	$96	2022Q3	33.0%	$102	$26	$128
4.5%	Engineering & Design	$348	$87	25%	$435	0.0%	$348	$87	$435	2022Q3	33.0%	$463	$116	$579
1.0%	Reviews, ATRs, IEPRs, VE	$77	$19	25%	$96	0.0%	$77	$19	$96	2022Q3	33.0%	$102	$26	$128
0.5%	Life Cycle Updates (cost, schedule, risks)	$39	$10	25%	$49	0.0%	$39	$10	$49	2022Q3	33.0%	$52	$13	$65
1.0%	Contracting & Reprographics	$77	$19	25%	$96	0.0%	$77	$19	$96	2022Q3	33.0%	$102	$26	$128
1.0%	Engineering During Construction	$77	$19	25%	$96	0.0%	$77	$19	$96	2023Q4	39.8%	$108	$27	$135
0.0%	Planning During Construction	$0	$0	25%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	25%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
6.5%	Construction Management	$503	$126	25%	$629	0.0%	$503	$126	$629	2023Q4	39.8%	$703	$176	$879
0.0%	Project Operation:	$0	$0	25%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Management	$0	$0	25%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:	$10,112	$2,461		**$12,573**		$10,112	$2,461	$12,573			$12,210	$2,975	**$15,185**

Section 2
Project Cost and Schedule Risk Analysis

US Army Corps
of Engineers®

Upper Turkey Creek
Project Cost and Schedule Risk Analysis Report

Prepared for:

U.S. Army Corps of Engineers,
Walla Walla District

Prepared by:

U.S. Army Corps of Engineers

Kansas City District

December 10, 2014

TABLE OF CONTENTS

EXECUTIVE SUMMARY ..... ES 1

MAIN REPORT 5

1.0 PURPOSE 5

2.0 BACKGROUND 5

3.0 REPORT SCOPE 5

3.1 Project Scope 6

3.2 USACE Risk Analysis Process 6

4.0 METHODOLOGY / PROCESS 7

4.1 Identify and Assess Risk Factors 8

4.2 Quantify Risk Factor Impacts 9

4.3 Analyze Cost Estimate and Schedule Contingency 9

5.0 PROJECT ASSUMPTIONS 10

6.0 RESULTS 11

6.1 Risk Register 11

6.2 Cost Contingency and Sensitivity Analysis 12

6.2.1 Sensitivity Analysis 13

6.2.2 Sensitivity Analysis Results 13

6.3 Schedule and Contingency Risk Analysis 14

7.0 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS 16

7.1 Major Findings/Observations 17

7.2 Recommendations 21

LIST OF TABLES

Table ES-1. Construction Contingency Results ES-1

Table 1. Construction Cost Contingency Summary 9

Table 2. Schedule Duration Contingency Summary 11

Table 3. Project Cost Comparison Summary (Uncertainty Analysis) 15

Table 4. Construction Schedule Comparison Summary 16

LIST OF FIGURES

Figure 1. Cost Sensitivity Analysis 10

Figure 2. Schedule Sensitivity Analysis 12

LIST OF APPENDICES

Risk Register ..... APPENDIX A

EXECUTIVE SUMMARY

The US Army Corps of Engineers (USACE), Kansas City District, presents this cost and schedule risk analysis (CSRA) report regarding the risk findings and recommended contingencies for the Upper Turkey Creek. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a *Monte-Carlo* based risk analysis was conducted by the Project Development Team (PDT) on remaining costs. The purpose of this risk analysis study is to present the cost and schedule risks considered, those determined and respective project contingencies at a recommended 80% confidence level of successful execution to project completion.

The Recommended Plan is a levee and floodwall plan in the City of Merriam, KS. These features would extend approximately from Shawnee Mission Parkway to Merriam Drive, which is a 1.5-mile stretch that includes Merriam's main downtown reach. Most of the protected area is on the right bank of Turkey Creek while much of the left bank remains as an unoccupied floodplain. The features are designed for a small urban watershed with levees no more than 6 feet high. The Recommended Plan includes 6,810 feet of floodwall up to 6 feet high, 3,384 feet of levees up to 6 feet high, storm drainage work, approximately 12,427 augercast piles, and a detention area.

An overview of major construction features is included below:

- Levees and floodwalls
- Drainage system modifications
- Bridge modifications/headwalls
- Storm sewer modifications
- Environmental mitigation

Of these major construction features, a majority of the costs are in the construction of the levees, floodwalls, augercast piles, and drainage structures.

Specific to the Upper Turkey Creek Project, the current fully funded estimate approximates $42.9M. The current year estimate with contingency approximates $37.6M. Based on the results of the analysis, the Cost Engineering Mandatory Center of Expertise for Civil Works (MCX located in Walla Walla District) recommends a contingency value of approximately $7.3M or approximately 24% of base project cost ($30.3M) at an 80% confidence level of successful execution. This contingency includes a separate $0.8M for Real Estate, another $5.5M for the construction costs, and $1.0M for design and construction management. It should be noted that the contingency from the cost risk model is 25% but when the costs are inputted into the TPCS, the overall contingency drops to 24% due to using the 19% contingency on Real Estate costs in the TPCS. This contingency percentage was provided by the Real

Estate Section. This brings the overall contingency down from 25% in the risk model to 24% when the costs are inputted in the TPCS.

Cost estimates fluctuate over time. During this period of study, minor cost fluctuations can and have occurred. For this reason, contingency reporting is based in cost and per cent values. Should cost vary to a slight degree with similar scope and risks, contingency per cent values will be reported, cost values rounded.

Table ES-1. Construction Contingency Results

Base Case Construction Cost Estimate	$30,276,000	
Confidence Level	**Construction Value ($$)**	**Contingency (%)**
5%	$32,086,200	6%
50%	$35,718,600	18%
80%	**$37,837,500**	**25%**
90%	$38,745,600	28%

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

The PDT worked through the risk register on one occasion: 3 November 2014. That period of time allowed improved project scope definition, investigations, design and cost information, and resulted in reduced risks in certain project areas. The key risk drivers identified through sensitivity analysis suggest a cost contingency of $7.3M and schedule risks adding a potential of 64 months to the project schedule, which corresponds to $0.6 M in cost impacts, both at an 80% confidence level.

Cost Risks: From the CSRA, the key or greater Cost Risk items of include:

- PR-5: Market Conditions – While competitive at this time, out-year contracts face greater uncertainty relative to market and inflation conditions.
- CO-5: Site Access Restrictions – Tight corridor to work within. Could reduce production rates by 20%.

Moderate risks, when combined, can also become a cost impact.

- PPM-1: Project Purpose – Pump Plants. The USACE Value Engineering review determined that internal drainage could be accommodated with a detention basin and gravity drain. During design, it could be determined that a pump station would be needed to remove internal drainage.
- CO-4: Modifications– All major projects will have modifications. Assuming these will add 10% to the construction costs.

- ET-3: Prime/Sub Structure– Additional layers of markups may be removed if less of the work is subcontracted. Assume relief wells & earthwork to be performed by sub.
- TR-1: Ground Improvement – AGP (Augercast Grouted Piles) Lengths - Length may increase by 20% and may decrease by 10% due to variations in the depth of bedrock since the piles will be driven down to bedrock.
- TR-5: Floodwall Lengths– River mileage versus lengths of wall not consistent. Assume increase/decrease 5% floodwall/levee length based on natural progression into PED.

Schedule Risks: The high value of schedule risk indicates a significant uncertainty of key risk items, time duration growth that can translate into added costs. Over time, risks increase on those out-year contracts where there is greater potential for change in new scope requirements, uncertain market conditions, and unexpected high inflation. The greatest risk is:

- PPM-1: Project Purpose – Prot Height – Design based on Atlas 14 flows with the removal of free board; Results in a lower reliability. May have to re-design if new design guidance is issued.
- PPM-2: Project Purpose – Pump Plants – The USACE Value Engineering review determined that internal drainage could be accommodated with a detention basin and gravity drain. During design, it could be determined that a pump station would be needed to remove internal drainage.
- CO-5: Site Access Restrictions – Tight corridor to work within. Could reduce production rates by 20%.
- CA-2: Numerous Separate Contracts - Estimate assumes three contracts. One contract per Reach. There is a possibility 1 additional contract would be added.

Moderate risks, when combined, can also become a time and resulting cost impact.

- PR-1: Adequacy of Project Funding – Most likely will receive incremental funding and extend the number of contracts beyond the 3 currently assumed.
- LD-4: Objections to right of way taking- May need to go into condemnation process
- LD-3: Real Estate Plan Defined – Parcels - Baseline estimate currently does not include approx 5 parcels. These parcels are assumed to be added to the baseline estimate. Assume 1 additional parcel will be required.

Recommendations: Timely coordination and risk resolution between the Sponsor and USACE is needed in areas of ROW, site access and staging, and funding needs and updates as applicable. The PDT must include the recommended cost and schedule contingencies and incorporate risk monitoring and mitigation on those identified risks. Further iterative study and update of the risk analysis throughout the project life-cycle is

important in support of the remaining project work within an approved budget and appropriation.

MAIN REPORT

1.0 PURPOSE

Within the authority of the US Army Corps of Engineers (USACE), Kansas City District, this report presents the efforts and results of the cost and schedule risk analysis for Upper Turkey Creek. The report includes risk methodology, discussions, findings and recommendations regarding the identified risks and the necessary contingencies to confidently administer the project, presenting a cost and schedule contingency value with an 80% confidence level of successful execution.

2.0 BACKGROUND

The Recommended Plan is a levee and floodwall plan in the City of Merriam, KS. These features would extend approximately from Shawnee Mission Parkway to Merriam Drive, which is a 1.5-mile stretch that includes Merriam's main downtown reach. Most of the protected area is on the right bank of Turkey Creek while much of the left bank remains as an unoccupied floodplain. The features are designed for a small urban watershed with levees no more than 6 feet high. The Recommended Plan includes 6,810 feet of floodwall up to 6 feet high, 3,384 feet of levees up to 6 feet high, storm drainage work, approximately 12,427 augercast piles, and a detention area.

An overview of major construction features is included below:

- Levees and floodwalls
- Drainage system modifications
- Bridge modifications/headwalls
- Storm sewer modifications
- Environmental mitigation

Of these major construction features, a majority of the costs are in the construction of the levees, floodwalls, augercast piles, and drainage structures.

3.0 REPORT SCOPE

The scope of the risk analysis report is to identify cost and schedule risks with a resulting recommendation for contingencies at the 80 percent confidence level using the risk analysis processes, as mandated by U.S. Army Corps of Engineers (USACE)

Engineer Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works, ER 1110-2-1302, 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 construction features. The CSRA excludes Real Estate costs and does not include consideration for life cycle costs.

3.1 Project Scope

The formal process included extensive involvement of the PDT for risk identification and the development of the risk register. The analysis process evaluated the Micro Computer Aided Cost Estimating System (MCACES) cost estimate, project schedule, and funding profiles using Crystal Ball software to conduct a *Monte Carlo* simulation and statistical sensitivity analysis, per the guidance in Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

The project technical scope, estimates and schedules were developed and presented by the Kansas City District. Consequently, these documents serve as the basis for the risk analysis.

The scope of this study addresses the identification of concerns, needs, opportunities and potential solutions that are viable from an economic, environmental, and engineering viewpoint.

3.2 USACE Risk Analysis Process

The risk analysis process for this study follows the USACE Headquarters requirements as well as the guidance provided by the Cost Engineering MCX. The risk analysis process reflected within this report uses probabilistic cost and schedule risk analysis methods within the framework of the Crystal Ball software. Furthermore, the scope of the report includes the identification and communication of important steps, logic, key assumptions, limitations, and decisions to help ensure that risk analysis results can be appropriately interpreted.

Risk analysis results are also intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as the project progresses through planning and implementation. To fully recognize its benefits, cost and schedule risk analysis should be considered as an ongoing process conducted concurrent to, and iteratively with, other important project processes such as scope and execution plan development, resource planning, procurement planning, cost estimating, budgeting and scheduling.

In addition to broadly defined risk analysis standards and recommended practices, this risk analysis was performed to meet the requirements and recommendations of the following documents and sources:

- Cost and Schedule Risk Analysis Process guidance prepared by the USACE Cost Engineering MCX.
- Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008.
- Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

4.0 METHODOLOGY / PROCESS

The Cost Engineering Section of the Kansas City District performed the Cost and Schedule Risk Analysis, relying on the Project Delivery Team (PDT) to provide expertise and information gathering. The Upper Turkey Creek PDT conducted initial risk identification on November 3, 2014. The initial risk identification meeting also included qualitative analysis to produce a risk register that served as the draft framework for the risk analysis.

Name	Office	Representing
[illegible]	NWK	Plan Formulation
[illegible]	NWK	Plan Formulation
[illegible]	NWK	Plan Formulation
[illegible]	NWK	Real Estate
[illegible]	NWK	Geotechnical Engineering
[illegible]	NWK	Environmental Resources
[illegible]	NWK	Civil Engineering
[illegible]	NWK	Cost Engineering
[illegible]	NWK	Contracting
[illegible]	NWK	Construction
[illegible]	NWK	Hydraulic Engineering
[illegible]	NWK	Structural Engineering

The draft CSRA model was completed November 6, 2014.

The risk analysis process for this study is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve the desired level of cost confidence. Per regulation and guidance, the P80 confidence level (80% confidence level) is the normal and accepted cost

confidence level. District Management has the prerogative to select different confidence levels, pending approval from Headquarters, USACE.

In simple terms, contingency is an amount added to an estimate to allow for items, conditions or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required. The amount of contingency included in project control plans depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that project leadership is willing to accept the more contingency should be applied in the project control plans. The risk of overrun is expressed, in a probabilistic context, using confidence levels.

The Cost MCX guidance for cost and schedule risk analysis generally focuses on the 80-percent level of confidence (P80) for cost contingency calculation. It should be noted that use of P80 as a decision criteria is a risk averse approach (whereas the use of P50 would be a risk neutral approach, and use of levels less than 50 percent would be risk seeking). Thus, a P80 confidence level results in greater contingency as compared to a P50 confidence level. The selection of contingency at a particular confidence level is ultimately the decision and responsibility of the project's District and/or Division management.

The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a commercially available risk analysis software package (Crystal Ball) that is an add-in to Microsoft Excel. Cost estimates are packaged into an Excel format and used directly for cost risk analysis purposes. The level of detail recreated in the Excel-format schedule is sufficient for risk analysis purposes that reflect the established risk register, but generally less than that of the native format.

The primary steps, in functional terms, of the risk analysis process are described in the following subsections. Risk analysis results are provided in Section 6.

4.1 Identify and Assess Risk Factors

Identifying the risk factors via the PDT is considered a qualitative process that results in establishing a risk register that serves as the document for the quantitative study using the Crystal Ball risk software. Risk factors are events and conditions that may influence or drive uncertainty in project performance. They may be inherent characteristics or conditions of the project or external influences, events, or conditions such as weather or economic conditions. Risk factors may have either favorable or unfavorable impacts on project cost and schedule.

A formal PDT meeting was held with the Upper Turkey Creek PDT for the purposes of identifying and assessing risk factors. The meeting (conducted November 3, 2014)

included capable and qualified representatives from multiple project team disciplines and functions, including project management, cost engineering, design, environmental compliance, and real estate.

The meeting focused primarily on risk factor identification using brainstorming techniques, but also included some facilitated discussions based on risk factors common to projects of similar scope and geographic location.

4.2 Quantify Risk Factor Impacts

The quantitative impacts (putting it to numbers of cost and time) of risk factors on project plans were analyzed using a combination of professional judgment, empirical data and analytical techniques. Risk factor impacts were quantified using probability distributions (density functions) because risk factors are entered into the Crystal Ball software in the form of probability density functions.

Similar to the identification and assessment process, risk factor quantification involved multiple project team disciplines and functions. However, the quantification process relied more extensively on collaboration between cost engineering and risk analysis team members with lesser inputs from other functions and disciplines. This process used an iterative approach to estimate the following elements of each risk factor:

- Maximum possible value for the risk factor
- Minimum possible value for the risk factor
- Most likely value (the statistical mode), if applicable
- Nature of the probability density function used to approximate risk factor uncertainty
- Mathematical correlations between risk factors
- Affected cost estimate and schedule elements

The resulting product from the PDT discussions is captured within a risk register as presented in section 6 for both cost and schedule risk concerns. Note that the risk register records the PDT's risk concerns, discussions related to those concerns, and potential impacts to the current cost and schedule estimates. The concerns and discussions support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

4.3 Analyze Cost Estimate and Schedule Contingency

Contingency is analyzed using the Crystal Ball software, an add-in to the Microsoft Excel format of the cost estimate and schedule. *Monte Carlo* simulations are performed by applying the risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT.

Contingencies are calculated by applying only the moderate and high level risks identified for each option (i.e., low-level risks are typically not considered, but remain within the risk register to serve historical purposes as well as support follow-on risk studies as the project and risks evolve).

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the baseline cost estimate. Each option-specific contingency is then allocated on a civil works feature level based on the dollar-weighted relative risk of each feature as quantified by *Monte Carlo* simulation. Standard deviation is used as the feature-specific measure of risk for contingency allocation purposes. This approach results in a relatively larger portion of all the project feature cost contingency being allocated to features with relatively higher estimated cost uncertainty.

5.0 PROJECT ASSUMPTIONS

The following data sources and assumptions were used in quantifying the costs associated with the Upper Turkey Creek project.

a. The Kansas City District provided MII MCACES (Micro-Computer Aided Cost Estimating Software) files electronically to the Cost MCX in Walla Walla. The MII and CWE files transmitted and downloaded on November 10, 2014 was the basis for the initial cost and schedule risk analyses. The MII and CWE files dated December 1, 2014 (post ATR) served as the basis for the final CSRA.

b. The cost comparisons and risk analyses performed and reflected within this report are based on design scope and estimates that are at the preconstruction engineering and design (PED) level, most approximating a 15% design stage.

c. Schedules are analyzed for impact to the project cost in terms of delayed funding, uncaptured escalation (variance from OMB factors and the local market) and unavoidable fixed contract costs and/or languishing federal administration costs incurred throughout delay.

d. Per the CWCCIS Historical State Adjustment Factors in EM 1110-2-1304, State Adjustment Factor for the State of Kansas is 0.94, meaning that the average inflation for the project area is assumed to be 6% lower than the national average for inflation. Therefore, it is assumed that the project inflations experienced are similar (or better) to OMB inflation factors for future construction. Thus, the risk analyses accounted for no escalation over and above the national average; however, recent experience in the past five years does indicate construction inflation above the standard OMB rates published. This risk was considered with the delay impacts.

e. Per the data in the estimate, the Job Office Overhead (JOOH) percentage for the Prime Contractor is 15% and 10% for home office overhead (HOOH).

f. The Cost Engineering MCX guidance generally focuses on the eighty-percent level of confidence (P80) for cost contingency calculation. For this risk analysis, the eighty-percent level of confidence (P80) was used. It should be noted that the use of P80 as a decision criteria is a moderately risk averse approach, generally resulting in higher cost contingencies. However, the P80 level of confidence also assumes a small degree of risk that the recommended contingencies may be inadequate to capture actual project costs.

h. All risk level impacts (high, moderate, and low), as identified in the risk register, were considered for the purposes of calculating cost contingency. Probabilities were used to account for the likelihood of occurrence.

i. Three separate smaller contracts are assumed to mitigate the risk of not receiving funding for the whole project at once.

j. Subcontractors are assumed for a majority of the earthwork, augercast pile work, paving work, bridge work, and utility relocation work.

k. Site access restrictions could be difficult for the contractor. The cost risk analysis includes a risk assuming that production rates could be reduced by 20%.

6.0 RESULTS

The cost and schedule risk analysis results are provided in the following sections. In addition to contingency calculation results, sensitivity analyses are presented to provide decision makers with an understanding of variability and the key contributors to the cause of this variability.

6.1 Risk Register

A risk register is a tool commonly used in project planning and risk analysis. The actual risk register is provided in Appendix A. The complete risk register includes low level risks, as well as additional information regarding the nature and impacts of each risk.

It is important to note that a risk register can be an effective tool for managing identified risks throughout the project life cycle. As such, it is generally recommended that risk registers be updated as the designs, cost estimates, and schedule are further refined, especially on large projects with extended schedules. Recommended uses of the risk register going forward include:

- Documenting risk mitigation strategies being pursued in response to the

identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders, and leadership/management with a documented framework from which risk status can be reported in the context of project controls.
- Communicating risk management issues.
- Providing a mechanism for eliciting feedback and project control input.
- Identifying risk transfer, elimination, or mitigation actions required for implementation of risk management plans.

6.2 Cost Contingency and Sensitivity Analysis

The result of risk or uncertainty analysis is quantification of the cumulative impact of all analyzed risks or uncertainties as compared to probability of occurrence. These results, as applied to the analysis herein, depict the overall project cost at intervals of confidence (probability).

Table 1 provides the construction cost contingencies calculated for the P80 confidence level and rounded to the nearest thousand. The construction cost contingencies for the P5, P50 and P90 confidence levels are also provided for illustrative purposes only.

Cost contingency for the Construction risks (including schedule impacts converted to dollars) was quantified as approximately $7.3 Million at the P80 confidence level (24% of the baseline construction cost estimate. A 19% contingency was provided by the Real Estate Section and this contingency has been used for the Real Estate costs in the TPCS. This brings the overall contingency down from 25% in the risk model to 24% when the costs are inputted in the TPCS.).

Table 1. Construction Cost Contingency Summary

Base Case Construction Cost Estimate	**$30,276,000**	
Confidence Level	**Construction Value ($$)**	**Contingency (%)**
5%	$32,086,200	6%
50%	$35,718,600	18%
80%	**$37,837,500**	**25%**
90%	$38,745,600	28%

6.2.1 Sensitivity Analysis

Sensitivity analysis generally ranks the relative impact of each risk/opportunity as a percentage of total cost uncertainty. The Crystal Ball software uses a statistical measure (contribution to variance) that approximates the impact of each risk/opportunity contributing to variability of cost outcomes during *Monte Carlo* simulation.

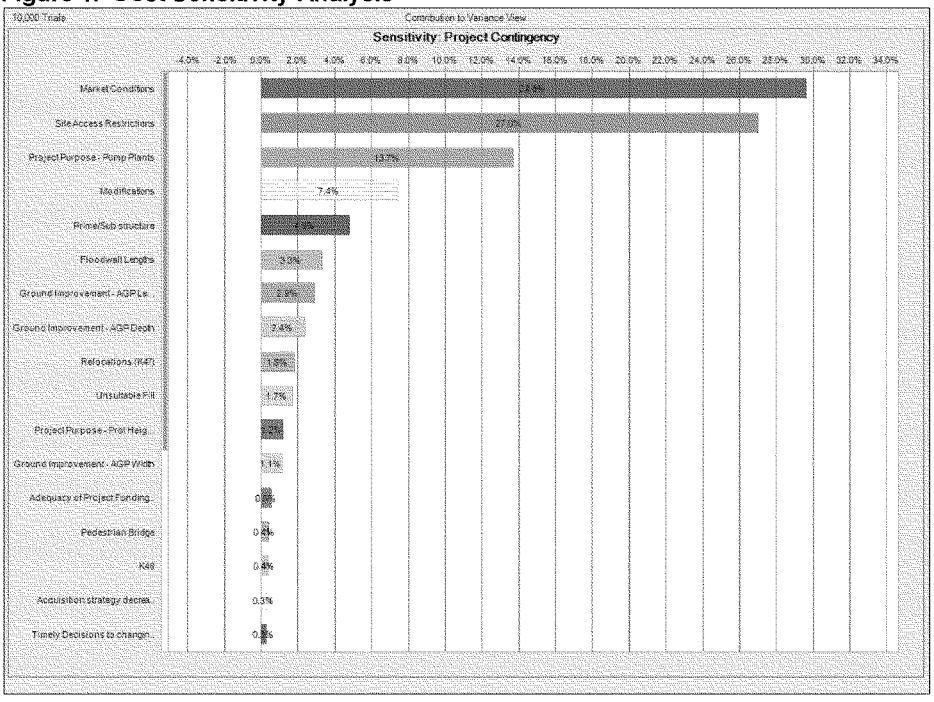
Key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and their potential impacts throughout the project lifecycle. Together with the risk register, sensitivity analysis results can also be used to support development of strategies to eliminate, mitigate, accept or transfer key risks.

6.2.2 Sensitivity Analysis Results

The risks/opportunities considered as key or primary cost drivers and the respective value variance are ranked in order of importance in contribution to variance bar charts. Opportunities that have a potential to reduce project cost and are shown with a negative sign; risks are shown with a positive sign to reflect the potential to increase project cost. A longer bar in the sensitivity analysis chart represents a greater potential impact to project cost.

Figure 1 presents a sensitivity analysis for cost growth risk from the high level cost risks identified in the risk register. Likewise, Figure 2 presents a sensitivity analysis for schedule growth risk from the high level schedule risks identified in the risk register.

Figure 1. Cost Sensitivity Analysis



6.3 Schedule and Contingency Risk Analysis

The result of risk or uncertainty analysis is quantification of the cumulative impact of all analyzed risks or uncertainties as compared to probability of occurrence. These results, as applied to the analysis herein, depict the overall project duration at intervals of confidence (probability).

Table 2 provides the schedule duration contingencies calculated for the P80 confidence level. The schedule duration contingencies for the P50 and P90 confidence levels are also provided for illustrative purposes.

Schedule duration contingency was quantified as 64 months based on the P80 level of confidence. These contingencies were used to calculate the projected residual fixed cost impact of project delays that are included in the Table 1 presentation of total cost

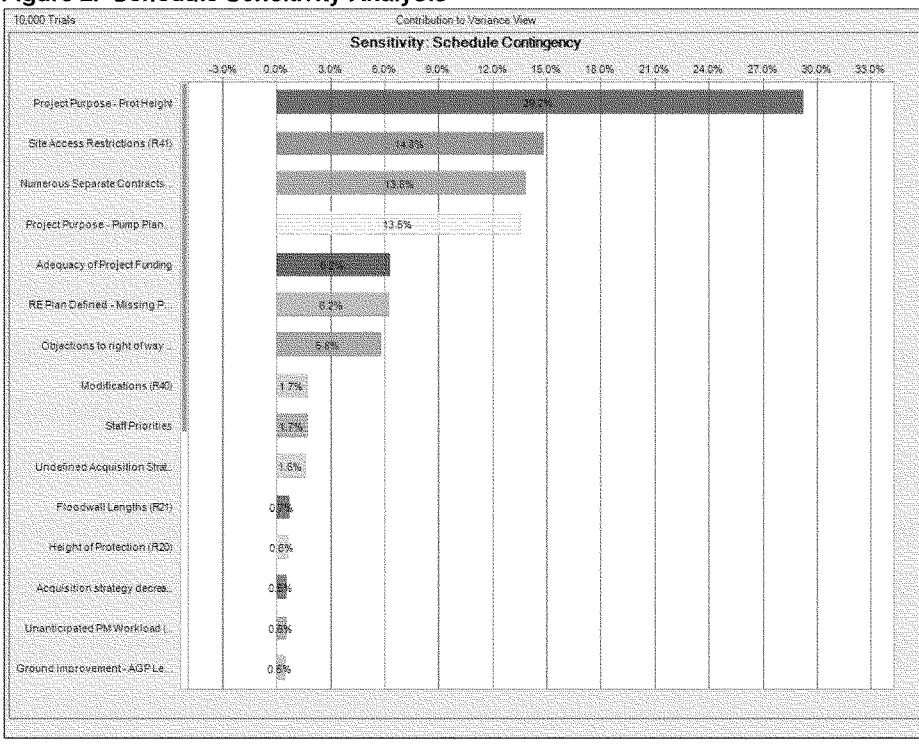
contingency. The schedule contingencies were calculated by applying the high level schedule risks identified in the risk register for each option to the durations of critical path and near critical path tasks.

The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented. Schedule contingency impacts presented in this analysis are based solely on projected residual fixed costs.

Table 2. Schedule Duration Contingency Summary

Risk Analysis Forecast (Base Schedule = 60 months)	Schedule Duration (months)	Contingency[1] (months)
50% Confidence Level		
Project Duration	111	51
80% Confidence Level		
Project Duration	124	64
90% Confidence Level		
Project Duration	130	70

Figure 2. Schedule Sensitivity Analysis



7.0 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS

This section provides a summary of significant risk analysis results that are identified in the preceding sections of the report. Risk analysis results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as projects progress through planning and implementation. Because of the potential for use of risk analysis results for such diverse purposes, this section also reiterates and highlights important steps, logic, key assumptions, limitations, and decisions to help ensure that the risk analysis results are appropriately interpreted.

7.1 Major Findings/Observations

Project cost and schedule comparison summaries are provided in Table 3 and Table 4 respectively. Additional major findings and observations of the risk analysis are listed below.

The PDT worked through the risk register on one occasion: 3 November 2014. That period of time allowed improved project scope definition, investigations, design and cost information, and resulted in reduced risks in certain project areas. The key risk drivers identified through sensitivity analysis suggest a cost contingency of $7.3M and schedule risks adding a potential of 64 months to the project schedule, which corresponds to $0.6 M in cost impacts, both at an 80% confidence level.

Cost Risks: From the CSRA, the key or greater Cost Risk items of include:

- PR-5: Market Conditions – While competitive at this time, out-year contracts face greater uncertainty relative to market and inflation conditions.
- CO-5: Site Access Restrictions – Tight corridor to work within. Could reduce production rates by 20%.

Moderate risks, when combined, can also become a cost impact.

- PPM-1: Project Purpose – Pump Plants. The USACE Value Engineering review determined that internal drainage could be accommodated with a detention basin and gravity drain. During design, it could be determined that a pump station would be needed to remove internal drainage.
- CO-4: Modifications– All major projects will have modifications. Assuming these will add 10% to the construction costs.
- ET-3: Prime/Sub Structure– Additional layers of markups may be removed if less of the work is subcontracted. Assume relief wells & earthwork to be performed by sub.
- TR-1: Ground Improvement – AGP (Augercast Grouted Piles) Lengths - Length may increase by 20% and may decrease by 10% due to variations in the depth of bedrock since the piles will be driven down to bedrock.
- TR-5: Floodwall Lengths– River mileage versus lengths of wall not consistent. Assume increase/decrease 5% floodwall/levee length based on natural progression into PED.

Schedule Risks: The high value of schedule risk indicates a significant uncertainty of key risk items, time duration growth that can translate into added costs. Over time, risks increase on those out-year contracts where there is greater potential for change in new

scope requirements, uncertain market conditions, and unexpected high inflation. The greatest risk is:

- PPM-1: Project Purpose – Prot Height – Design based on Atlas 14 flows with the removal of free board; Results in a lower reliability. May have to re-design if new design guidance is issued.
- PPM-2: Project Purpose – Pump Plants – The USACE Value Engineering review determined that internal drainage could be accommodated with a detention basin and gravity drain. During design, it could be determined that a pump station would be needed to remove internal drainage.
- CO-5: Site Access Restrictions – Tight corridor to work within. Could reduce production rates by 20%.
- CA-2: Numerous Separate Contracts - Estimate assumes three contracts. One contract per Reach. There is a possibility 1 additional contract would be added.

Moderate risks, when combined, can also become a time and resulting cost impact.

- PR-1: Adequacy of Project Funding – Most likely will receive incremental funding and extend the number of contracts beyond the 3 currently assumed.
- LD-4: Objections to right of way taking- May need to go into condemnation process
- LD-3: Real Estate Plan Defined – Parcels - Baseline estimate currently does not include approx 5 parcels. These parcels are assumed to be added to the baseline estimate. Assume 1 additional parcel will be required.

Table 3. Construction Cost Comparison Summary (Uncertainty Analysis)

Most Likely Cost Estimate	$30,276,000		
Confidence Level	Project Cost	Contingency	Contingency %
5%	$32,086,200	$1,816,200	6.00%
10%	$32,691,600	$2,421,600	8.00%
15%	$33,297,000	$3,027,000	10.00%
20%	$33,599,700	$3,329,700	11.00%
25%	$34,205,100	$3,935,100	13.00%
30%	$34,507,800	$4,237,800	14.00%
35%	$34,810,500	$4,540,500	15.00%
40%	$35,113,200	$4,843,200	16.00%
45%	$35,415,900	$5,145,900	17.00%
50%	$35,718,600	$5,448,600	18.00%
55%	$36,021,300	$5,751,300	19.00%
60%	$36,324,000	$6,054,000	20.00%
65%	$36,626,700	$6,356,700	21.00%
70%	$36,929,400	$6,659,400	22.00%
75%	$37,232,100	$6,962,100	23.00%
80%	$37,837,500	$7,567,500	25.00%
85%	$38,140,200	$7,870,200	26.00%
90%	$38,745,600	$8,475,600	28.00%
95%	$39,956,400	$9,686,400	32.00%

Table 4. Construction Schedule Comparison Summary (Uncertainty Analysis)

Most Likely Schedule Duration	60 Months		
Confidence Level	Project Duration	Contingency	Contingency %
5%	90.0 Months	30.0 Months	50.00%
10%	94.2 Months	34.2 Months	57.00%
15%	97.2 Months	37.2 Months	62.00%
20%	99.6 Months	39.6 Months	66.00%
25%	102.0 Months	42.0 Months	70.00%
30%	103.8 Months	43.8 Months	73.00%
35%	105.6 Months	45.6 Months	76.00%
40%	107.4 Months	47.4 Months	79.00%
45%	109.2 Months	49.2 Months	82.00%
50%	111.0 Months	51.0 Months	85.00%
55%	112.8 Months	52.8 Months	88.00%
60%	114.6 Months	54.6 Months	91.00%
65%	116.4 Months	56.4 Months	94.00%
70%	118.8 Months	58.8 Months	98.00%
75%	121.2 Months	61.2 Months	102.00%
80%	123.6 Months	63.6 Months	106.00%
85%	126.6 Months	66.6 Months	111.00%
90%	130.2 Months	70.2 Months	117.00%
95%	136.2 Months	76.2 Months	127.00%

7.2 Recommendations

Risk Management is an all-encompassing, iterative, and life-cycle process of project management. The Project Management Institute's (PMI) *A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 4th edition*, states that "project risk management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project." Risk identification and analysis are processes within the knowledge area of risk management. Its outputs pertinent to this effort include the risk register, risk quantification (risk analysis model), contingency report, and the sensitivity analysis.

The intended use of these outputs is implementation by the project leadership with respect to risk responses (such as mitigation) and risk monitoring and control. In short, the effectiveness of the project risk management effort requires that the proactive management of risks not conclude with the study completed in this report.

The Cost and Schedule Risk Analysis (CSRA) produced by the PDT identifies issues that require the development of subsequent risk response and mitigation plans. This section provides a list of recommendations for continued management of the risks identified and analyzed in this study. Note that this list is not all inclusive and should not substitute a formal risk management and response plan.

The CSRA study serves as a "road map" towards project improvements and reduced risks over time. Timely coordination and risk resolution between the Sponsor, Railroad, and USACE is needed in areas of ROW, mobile home relocations, site access and staging, and funding needs and updates as applicable. The PDT must include the recommended cost and schedule contingencies and incorporate risk monitoring and mitigation on those identified risks. Further iterative study and update of the risk analysis throughout the project life-cycle is important in support of remaining within an approved budget and appropriation.

Risk Management: Project leadership should use of the outputs created during the risk analysis effort as tools in future risk management processes. The risk register should be updated at each major project milestone. The results of the sensitivity analysis may also be used for response planning strategy and development. These tools should be used in conjunction with regular risk review meetings.

Risk Analysis Updates: Project leadership should review risk items identified in the original risk register and add others, as required, throughout the project life-cycle. Risks should be reviewed for status and reevaluation (using qualitative measure, at a minimum) and placed on risk management watch lists if any risk's likelihood or impact significantly increases. Project leadership should also be mindful of the potential for secondary (new risks created specifically by the response to an original risk) and residual risks (risks that remain and have unintended impact following response).

Site Access Restrictions: Communication with the sponsor will be important in order to ensure as much access for the contractor is provided as possible. This communication should also include discussing securing optimal locations for the staging areas to help reduce any loss in production rates due to the tight access conditions present at the site.

Levees and Floodwalls: Adequate borings should be completed ahead of time so that project designers can have sufficiently and confidently size the floodwalls and augercast grouted piles. This will help to lower the uncertainty in the sizing of those structures that is currently accounted for in the cost risk analysis.

APPENDIX A

	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost			Project Schedule			Rough Order Impact (mo)
				Likelihood*	Impact*	Risk Level*	Likelihood*	Impact*	Risk Level*	
	PROJECT & PROGRAM MGMT									
PPM-1	Project Purpose - Prot Height	Design based on Atlas 14 flows with the removal of free board; Results in a lower reliability.	It is unlikely that changes in the design guidance will occur which will change the levee design parameters. Impact would be significant if height had to be increased as the total length of protection is approx 10,000 lf. The result would be Atlas 14 dollar increase. This would result in an additional 1.7 lf of FW height x 7205 lf x 1.5 f/27 = 680 cy x $1000/cy = $680,000.	Unlikely	Significant	MODERATE	Unlikely	Crisis	HIGH	
PPM-2	Project Purpose - Pump Plants	Pump Plants	The USACE Value Engineering review determined that internal drainage could be accommodated with a detention basin and gravity drain. If during design, pump stations are needed to remove internal drainage, this would be a crisis (>$2M) impact to the cost of the project. Additionally, should the design parameters for the internal drainage change, such as a requirement for detention of a larger storm event or quantity, it could require a second detention basin, more land acquisition, and additional infrastructure. Overall a crisis impact (>$2M).	Unlikely	Critical	MODERATE	Unlikely	Crisis	HIGH	
PPM-3	Staff Priorities	No control over staff priorities; Competing with other projects, funding, resources. The Project Manager currently does not have control over staff priorities.	There is a possibility that other priority projects will require staff to be pulled from this project and put on the priority project.	Likely	Negligible	LOW	Likely	Marginal	MODERATE	
PPM-4	Losing Critical Staff at Crucial Point	Critical Staff members leave at crucial points in the project.	Turnover could happen during PED Phase.	Likely	Negligible	LOW	Likely	Marginal	MODERATE	
PPM-5	Timely Decisions to changing policies	Policy implementation to clarify the decision that has been made on current ongoing projects	Waiting for decisions on how to implement decisions.	Likely	Marginal	MODERATE	Likely	Negligible	LOW	
PPM-6	Pressure to Deliver Project on accelerated Schedule	Increased resources will result in more cost. Schedule will be reduced.	An allowance of $100k was used to account for learning curve to bring personnel onboard, additional overtime, and possible duplication of work.	Likely	Negligible	LOW	Likely	Marginal	MODERATE	
PPM-7	Unanticipated PM Workload	PMs current workload would require more delegation of Work.	Additional time effort will be required resulting in higher durations to accomplish work	Very Unlikely	Negligible	LOW	Very Unlikely	Marginal	LOW	
	CONTRACT ACQUISITION RISKS									
CA-1	Undefined Acquisition Strategy	Concern that construction contracts will go to 8a setaside. Contracts for levees and floodwall most likely will go to small business competitive. Due to complexity of the contracts required.	Production rate decrease (90%), higher HOOH (add'l 5%), more subcontracting (assuming all earthwork is subcontracted). Total increase = $3.5M. Schedule increase = 60 months / 0.9 = 66 months = 6 months	Very Unlikely	Crisis	HIGH	Very Unlikely	Critical	LOW	

			addl time.						
CA-2	Numerous Separate Contracts	Estimate assumes three contracts. One contract per Reach	There is a possibility 1 additional contract would be added. Assumes an additional contract @ $125k each	Unlikely	Negligible	LOW	Unlikely	Critical	MODERATE
CA-3	Acquisition strategy decreasing competition	IFB solicitation is assumed	If source Selection for Best Value is required assume $200k in level of Effort for COE plus assume $250k in construction cost increase for best value	Very Likely	Marginal	MODERATE	Very Likely	Marginal	MODERATE
	TECHNICAL RISKS								
TR-1	Ground Improvement - AGP Length	Length of FW treated with AGP	Length may increase by 20% and may decrease by 10%. Range from -$680k to +$1.4M. Total duration of AGPwork is 311 days / 21 days/mo = 15 months. Increase = 15 x 0.2 = 3 months. Decrease = 15 x 0.1 = 1.5 months.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE
TR-2	Ground Improvement - AGP Width	Width of AGP	Width of 15 lf may decrease 10%. Decrease of $680k. Total duration of AGPwork is 311 days / 21 days/mo = 15 months. Decrease = 15 x 0.1 = 1.5 months.	Likely	Significant	HIGH	Likely	Negligible	LOW
TR-3	Ground Improvement - AGP Depth	Depth of AGP	Depth includes 15 lf deep with only two borings. Assume 2 lf plus/minus. Range from -$840k to +$840k. Total duration of AGP work is 311 days / 21 days/mo = 15 months. Increase = 15 x (2/15) = 2 months. Decrease = 15 x (2/15) = 2 months.	Likely	Significant	HIGH	Unlikely	Negligible	LOW
TR-4	Height of Protection	Changes in existing grade to determine the new levee/FW height. Existing surveys are based on 2' Contours.	May need to add/decrease 1 lf of levee and floodwall. Assume 30% of existing length will require 1 lf raise/decrease. Assume this will be split out as 15% levee height change of 1' and 15% will be floodwall height change of 1'. Levee: 1' raise = add'l 1000 cy of levee fill x $34.07/ecy = +$34,000 so assume -$34,000 for 1 ft decrease over 15% of levee. Floodwall: -$106k to +$106k. Total for levee plus floodwall = -$140k to +$140k.	Unlikely	Negligible	LOW	Unlikely	Negligible	LOW
TR-5	Floodwall Lengths	River mileage versus lengths of wall not consistent	Assume increase/decrease 5% floodwall/levee length based on natural progression into PED. Total cost for levees & floodwalls = $18.1M x 0.05 = -$905,000 to +$905,000.	Very Likely	Marginal	MODERATE	Very Likely	Marginal	MODERATE
TR-6	Transitions From FW to Lev	lw all transition instead of FW transition.	No concerns noted in this risk area for the risk element.	Unlikely	Negligible	LOW	Unlikely	Negligible	LOW
TR-7	Transitions From FW to Lev	Transition length may increase; add additional 5lf	No concerns noted in this risk area for the risk element.	Likely	Negligible	LOW	Unlikely	Negligible	LOW
TR-8	Storm Sewer Pipe Crossing Conduit Size	24"/36"/42" dia pipe size used. Criteria requires 48" pipe size. 24" dia pipe size used based on Geotech input	Impact will be pipe size increase to 48" dia. Assume 20% chance of occurring. Pipe size and Flap gate size increase = say $320k	Unlikely	Negligible	LOW	Unlikely	Negligible	LOW
TR-9	Storm Sewer Ponding Area	Size of Detention Ponding area may change	Size of the Ponding area may be reduced. Assume 15% reduction in quantity. Assume 60% chance of decreasing in size. Say 700 cy x $40/cy + 700 x 40% unsuitable x 1.5 tons/cy x $50/ton = $49k	Likely	Marginal	MODERATE	Likely	Negligible	LOW

TR-10	Gasline on Merriam	May Need to remove Gasline from bridge and place underground	Relocate gas line during parapet wall. Place in creek as a crossing. 60% likely to occur. Assume $500/lf x 100 lf	Likely	Negligible	LOW	Likely	Negligible	LOW
TR-11	Pedestrian Bridge	May Need to relocate downstream pedestrian bridge	Assume the full relocation of existing bridge	Unlikely	Marginal	LOW	Unlikely	Negligible	LOW
	LANDS AND DAMAGES RISKS								
LD-1	Real Estate Plan Defined - Staging Area	Staging area is still not defined.	This area has not been included. Assume 2 acres required per contract. Assume 6 acres total. These acres are included in the base estimate. Assume 1 additional acre required.	Unlikely	Negligible	LOW	Unlikely	Negligible	LOW
LD-2	Real Estate Plan Defined - Utilities	Utility Temporary easement changing footprint.	Incomplete data for Utilities	Very Likely	Negligible	LOW	Very Likely	Negligible	LOW
LD-3	Real Estate Plan Defined - Parcels	Baseline estimate currently does not include approx 5 parcels	These parcels are assumed to be added to the baseline estimate. Assume 1 additional parcel will be required.	Likely	Negligible	LOW	Likely	Marginal	MODERATE
LD-4	Objections to right of way taking	May need to go into condemnation process	Additional legal fees, increase of valuation of land, ;	Likely	Negligible	LOW	Likely	Marginal	MODERATE
	REGULATORY AND ENVIRONMENTAL RISKS								
RE-1	Mitigation Plantings	The mitigation area and number of plantings is not adequate for the project impacts	Should the mitigation area or number of plantings increase, this would result in a negligible impact to the project (<$100k).	Unlikely	Negligible	LOW	Unlikely	Negligible	LOW
RE-2	New Bat Regulations	Limited construction	Bat Survey;$10k ;	Unlikely	Negligible	LOW	Unlikely	Negligible	LOW
	CONSTRUCTION RISKS								
CO1	Levee	Availability of offsite fill. Current estimate assume fill from project site is not reusable.	No concerns noted in this risk area for the risk element. Material quote may increase by $5/bcy x 33,711 bcy = $168,555 say $170k.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
CO2	Unsuitable Fill	Detailed site investigation or geotechnical investigations have not been performed along the entire alignments.	Assumes unsuitable fill quantity could double for both levee/Floodw all. Delay w ill be based on additional cy time. Assume 10% to 50%...9,089 bcy currently estimated to be unsuitable = 9089cy x 1.5 tons/cy x $50/ton = High Range 680k; 3636 cy x 1.5 tons/cy x $50/ton = $275k	Unlikely	Negligible	LOW	Unlikely	Negligible	LOW
CO3	Construction during flood events	May need to clean up the site in response.	Assume 2 site cleanups per contract at 40 hrs per site cleanup. Total increase = $100k.	Likely	Negligible	LOW	Likely	Negligible	LOW

CO4	Modifications	Assume 10%	Assume 10% x $22.2M construction costs = $2.2M	Very Likely	Marginal	Moderate	Very Unlikely	Significant	LOW
CO5	Site Access Restrictions	Tight corridor to work within.	Assume production rates to be reduced by 20%. increase of $2.8M & delay of up 12 months based on 60 months x 0.2 = 12 months.	Likely	Crisis	HIGH	Likely	Critical	HIGH
CO6	Adequate Staging Area	No area available for Staging	May require $50k per contract in add'l mobs x 3 contracts = $150k.	Likely	Negligible	LOW	Likely	Negligible	LOW
	ESTIMATE AND SCHEDULE RISKS								
ET1	Cost of Fuel	Fuel costs appear to be rising more than inflation. Current pricing used in the estimate. Fuel may increase up to 25% more per gallon and may decrease 10% per gallon. ($437k) to $1.2M	Fuel costs appear to be rising more than inflation. Current pricing used in the estimate. Fuel may increase up to 25% more per gallon and may decrease 10% per gallon. ($105k) to $300k	Unlikely	Marginal	LOW	Unlikely	Negligible	LOW
ET2	Cost of Steel	Steel pricing is fluctuating. Current steel pricing used. Steel may increase by 10% more per pound.	Steel pricing is fluctuating. Current steel pricing used. Steel may increase by 10% more per pound. increase = $85k.	Likely	Negligible	LOW	Unlikely	Negligible	LOW
ET3	Prime/Sub structure	Additional layers of markups may be if more of the work is subcontracted. Assume relief wells to be performed by sub. say $500k.	Additional layers of markups may be added if more of the work is subcontracted. Assume earthwork to be performed by sub = $1.1M add'l costs.	Unlikely	Significant	MODERATE	Unlikely	Negligible	LOW
ET4	Relocations	Utility relocations may have to be relocated in a different configuration. Historically this item could double in cost. Pavement/Retaining wall, trail alignments have not been completely located.	Utility relocations may have to be relocated in a different configuration. Historically this item requires a higher contingency. Pavement/Retaining wall, trail alignments have not been completely located. Assume $4M x 25% contingency = $1M	Likely	Critical	HIGH	Likely	Negligible	LOW
ET5	Mob/Demob	Mobilization costs appear too low.	Mob/Demob may need to include site staging setup, multiple mob/demobs within the project.	Very Likely	Marginal	MODERATE	Very Unlikely	Negligible	LOW
	Programmatic Risks	(External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)							
PR1	Adequacy of Project Funding	Most likely will receive incremental funding	Currently assume 3 contracts. Assume 1.5% for 5 years for schedule contingency = 5 years x 1.5%compounded = 7.7% x $7.7M (third contract) = say $0.6M	Very Likely	Significant	HIGH	Likely	Marginal	MODERATE
PR2	Stake holders request late changes.	Adjust alignment of trail	Design delay	Likely	Negligible	LOW	Likely	Negligible	LOW
PR3	Market Conditions	Assume number of bidders affect overall construction prices.	Assume -10% plus 15% depending on the number of bidders. $25M x 15% = $3.75M; $25M x -10% = _$2.5M	Likely	Crisis	HIGH	Unlikely	Negligible	LOW

Section 3
Cost Report

UTC Alternative 2d_12-5-14 incl Pre-Atlas 14 with Soil Mix

This estimate is for the feasibility study's recommended alternative to construct a flood risk management project in the City of Merriam in Johnson County, Kansas along Turkey Creek. The recommended plan is a levee and floodwall plan in the City of Merriam. These features extend approximately from Shawnee Mission Parkway to Merriam Drive, which is a stretch that includes Merriam's main downtown reach, as well as a commercial and industrial area just south of Johnson Drive. Most of the protected area is on the right bank of Turkey Creek. The features are designed for a small urban watershed with levees not exceeding six feet in height. The current National Economic Development (NED) Plan is Alternative 2d with Soil Mix.

975

Estimated by	.
Designed by	
Prepared by	
Preparation Date	10/16/2014
Effective Date of Pricing	10/1/2014
Estimated Construction Time	730 Days

This report is not copyrighted, but the information contained herein is For Official Use Only.

Description	Quantity	UOM	ContractCost	Escalation	Contingency	MiscOwner	SIOH	OwnerMarkup	ProjectCost
Project Cost Summary Report			**30,276,073**	**0**	**0**	**0**	**0**	**0**	**30,276,073**
			11,576,157.32						*11,576,157.32*
Contract 1 - Reach 1	**1.00**	**EA**	**11,576,157**	**0**	**0**	**0**	**0**	**0**	**11,576,157**
01 Lands and Damages	**1.00**	**LS**	**2,414,395**	**0**	**0**	**0**	**0**	**0**	**2,414,395**
			2,414,395.00						*2,414,395.00*
0123 Construction Contract(s) Documnts	**1.00**	**EA**	**2,414,395**	**0**	**0**	**0**	**0**	**0**	**2,414,395**
02 Relocations	**1.00**	**LS**	**1,515,909**	**0**	**0**	**0**	**0**	**0**	**1,515,909**
			77,315.15						*77,315.15*
0201 Roads, Construction Activities	**1.00**	**EA**	**77,315**	**0**	**0**	**0**	**0**	**0**	**77,315**
0203 Cemetery, Utilities, & Structure	**1.00**	**LS**	**1,438,593**	**0**	**0**	**0**	**0**	**0**	**1,438,593**
06 Fish and Wildlife Facilities	**1.00**	**LS**	**12,061**	**0**	**0**	**0**	**0**	**0**	**12,061**
0603 Wildlife Facilities & Sanctuary	**1.00**	**LS**	**12,061**	**0**	**0**	**0**	**0**	**0**	**12,061**
11 Levees and Floodwalls	**1.00**	**LS**	**6,268,793**	**0**	**0**	**0**	**0**	**0**	**6,268,793**
1101 Levees	**1.00**	**LS**	**1,410,780**	**0**	**0**	**0**	**0**	**0**	**1,410,780**
1102 Floodwalls	**1.00**	**LS**	**4,858,013**	**0**	**0**	**0**	**0**	**0**	**4,858,013**
30 Planning, Engineering and Design	**1.00**	**LS**	**858,000**	**0**	**0**	**0**	**0**	**0**	**858,000**
31 Construction Management	**1.00**	**LS**	**507,000**	**0**	**0**	**0**	**0**	**0**	**507,000**
3123 Construction Contracts	**1.00**	**LS**	**507,000**	**0**	**0**	**0**	**0**	**0**	**507,000**
			8,588,276.01						*8,588,276.01*
Contract 2 - Reach 2	**1.00**	**EA**	**8,588,276**	**0**	**0**	**0**	**0**	**0**	**8,588,276**
01 Lands and Damages	**1.00**	**LS**	**653,961**	**0**	**0**	**0**	**0**	**0**	**653,961**
			653,961.00						*653,961.00*
0123 Construction Contract(s) Documnts	**1.00**	**EA**	**653,961**	**0**	**0**	**0**	**0**	**0**	**653,961**
02 Relocations	**1.00**	**LS**	**1,153,113**	**0**	**0**	**0**	**0**	**0**	**1,153,113**
			330,907.13						*330,907.13*
0201 Roads, Coustruction Activities	**1.00**	**EA**	**330,907**	**0**	**0**	**0**	**0**	**0**	**330,907**
0203 Cemetery, Utilities, & Structure	**1.00**	**LS**	**822,205**	**0**	**0**	**0**	**0**	**0**	**822,205**
11 Levees and Floodwalls	**1.00**	**LS**	**5,597,202**	**0**	**0**	**0**	**0**	**0**	**5,597,202**
1101 Levees	**1.00**	**LS**	**674,864**	**0**	**0**	**0**	**0**	**0**	**674,864**

Description	Quantity	UOM	ContractCost	Escalation	Contingency	MiscOwner	SIOH	OwnerMarkup	ProjectCost
1102 Floodwalls	1.00	LS	4,922,339	0	0	0	0	0	4,922,339
30 Planning, Engineering and Design	1.00	LS	745,000	0	0	0	0	0	745,000
31 Construction Management	1.00	LS	439,000	0	0	0	0	0	439,000
3123 Construction Contracts	1.00	LS	439,000	0	0	0	0	0	439,000
			10,111,639.32						*10,111,639.32*
Contract 3 - Reach 3	1.00	EA	10,111,639	0	0	0	0	0	10,111,639
01 Lands and Damages	1.00	LS	1,027,574	0	0	0	0	0	1,027,574
			1,027,574.00						*1,027,574.00*
0123 Construction Contract(s) Documnts	1.00	EA	1,027,574	0	0	0	0	0	1,027,574
02 Relocations	1.00	LS	1,545,040	0	0	0	0	0	1,545,040
			551,487.92						*551,487.92*
0201 Roads, Construction Activities	1.00	EA	551,488	0	0	0	0	0	551,488
0203 Cemetery, Utilities, & Structure	1.00	LS	993,553	0	0	0	0	0	993,553
11 Levees and Floodwalls	1.00	LS	6,186,025	0	0	0	0	0	6,186,025
1101 Levees	1.00	LS	1,195,513	0	0	0	0	0	1,195,513
1102 Floodwalls	1.00	LS	4,990,511	0	0	0	0	0	4,990,511
30 Planning, Engineering and Design	1.00	LS	850,000	0	0	0	0	0	850,000
31 Construction Management	1.00	LS	503,000	0	0	0	0	0	503,000
3123 Construction Contracts	1.00	LS	503,000	0	0	0	0	0	503,000

Description	Quantity	UOM	DirectCost	SubCMU	CostToPrime	JOOH_PRM	HOOH_PRM	Profit_PRM	Bond_PRM	PrimeCMU	ContractCost
Contract Cost Summary Report			**22,544,916**	**1,645,430**	**16,192,416**	**2,428,862**	**1,862,128**	**1,638,672**	**156,064**	**6,085,727**	**30,276,073**
			8,863,937.03		*5,666,918.49*						*11,576,157.32*
Contract 1 - Reach 1	**1.00**	**EA**	**8,863,937**	**582,376**	**5,666,918**	**850,038**	**651,696**	**573,492**	**54,618**	**2,129,844**	**11,576,157**
01 Lands and Damages	**1.00**	**LS**	**2,414,395**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2,414,395**
			2,414,395.00		*0.00*						*2,414,395.00*
0123 Construction Contract(s) Documnts	**1.00**	**EA**	**2,414,395**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2,414,395**
02 Relocations	**1.00**	**LS**	**920,078**	**181,730**	**1,101,807**	**165,271**	**126,708**	**111,503**	**10,619**	**414,101**	**1,515,909**
			44,422.88		*56,194.95*						*77,315.15*
0201 Roads, Construction Activities	**1.00**	**EA**	**44,423**	**11,772**	**56,195**	**8,429**	**6,462**	**5,687**	**542**	**21,120**	**77,315**
0203 Cemetery, Utilities, & Structure	**1.00**	**LS**	**875,655**	**169,958**	**1,045,612**	**156,842**	**120,245**	**105,816**	**10,078**	**392,981**	**1,438,593**
06 Fish and Wildlife Facilities	**1.00**	**LS**	**6,930**	**1,836**	**8,766**	**1,315**	**1,008**	**887**	**84**	**3,295**	**12,061**
0603 Wildlife Facilities & Sanctuary	**1.00**	**LS**	**6,930**	**1,836**	**8,766**	**1,315**	**1,008**	**887**	**84**	**3,295**	**12,061**
11 Levees and Floodwalls	**1.00**	**LS**	**4,157,534**	**398,810**	**4,556,345**	**683,452**	**523,980**	**461,102**	**43,914**	**1,712,448**	**6,268,793**
1101 Levees	**1.00**	**LS**	**1,021,315**	**4,082**	**1,025,397**	**153,810**	**117,921**	**103,770**	**9,883**	**385,383**	**1,410,780**
1102 Floodwalls	**1.00**	**LS**	**3,136,220**	**394,728**	**3,530,948**	**529,642**	**406,059**	**357,332**	**34,032**	**1,327,065**	**4,858,013**

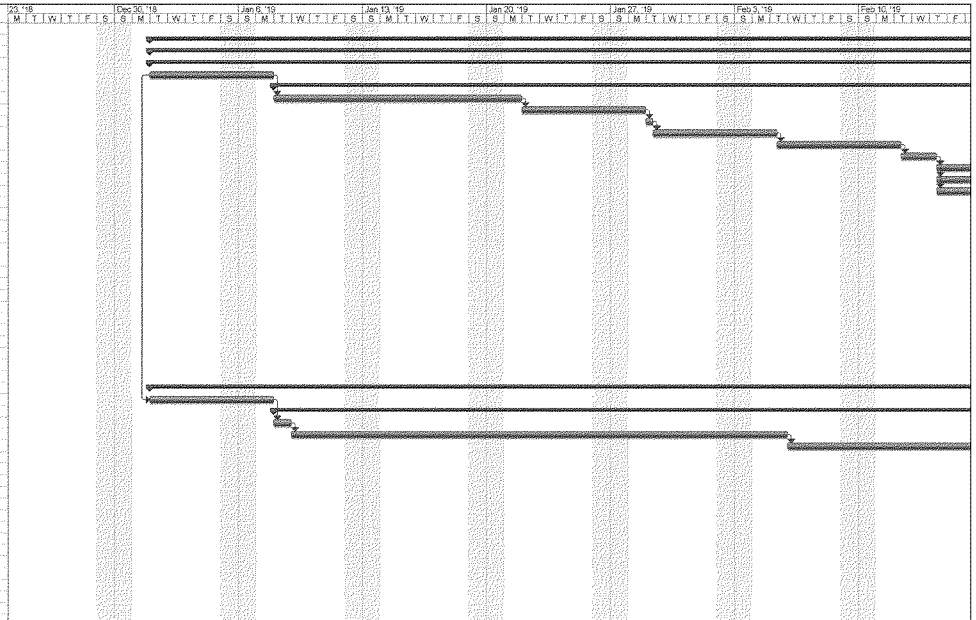
Description	Quantity	UOM	DirectCost	SubCMU	CostToPrime	JOOH_PRM	HOOH_PRM	Profit_PRM	Bond_PRM	PrimeCMU	ContractCost
30 Planning, Engineering and Design	**1.00**	**LS**	**858,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**858,000**
31 Construction Management	**1.00**	**LS**	**507,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**507,000**
3123 Construction Contracts	**1.00**	**LS**	**507,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**507,000**
Contract 2 - Reach 2	**1.00**	**EA**	*6,252,158.16* **6,252,158**	**492,132**	*4,906,329.50* **4,906,330**	**735,949**	**564,228**	**496,521**	**47,288**	**1,843,986**	*8,588,276.01* **8,588,276**
01 Lands and Damages	**1.00**	**LS**	**653,961**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**653,961**
0123 Construction Contract(s) Documnts	**1.00**	**EA**	*653,961.00* **653,961**	**0**	*0.00* **0**	**0**	**0**	**0**	**0**	**0**	*653,961.00* **653,961**
02 Relocations	**1.00**	**LS**	**676,345**	**161,772**	**838,117**	**125,717**	**96,383**	**84,817**	**8,078**	**314,996**	**1,153,113**
0201 Roads, Construction Activities	**1.00**	**EA**	*190,128.96* **190,129**	**50,384**	*240,513.13* **240,513**	**36,077**	**27,659**	**24,340**	**2,318**	**90,394**	*330,907.13* **330,907**
0203 Cemetery, Utilities, & Structure	**1.00**	**LS**	**486,216**	**111,387**	**597,603**	**89,641**	**68,724**	**60,477**	**5,760**	**224,602**	**822,205**
11 Levees and Floodwalls	**1.00**	**LS**	**3,737,852**	**330,361**	**4,068,213**	**610,232**	**467,844**	**411,703**	**39,210**	**1,528,989**	**5,597,202**
1101 Levees	**1.00**	**LS**	**489,057**	**1,454**	**490,511**	**73,577**	**56,409**	**49,640**	**4,728**	**184,353**	**674,864**
1102 Floodwalls	**1.00**	**LS**	**3,248,796**	**328,907**	**3,577,702**	**536,655**	**411,436**	**362,063**	**34,482**	**1,344,637**	**4,922,339**

Description	Quantity	UOM	DirectCost	SubCMU	CostToPrime	JOOH_PRM	HOOH_PRM	Profit_PRM	Bond_PRM	PrimeCMU	ContractCost
30 Planning, Engineering and Design	1.00	LS	745,000	0	0	0	0	0	0	0	745,000
31 Construction Management	1.00	LS	439,000	0	0	0	0	0	0	0	439,000
3123 Construction Contracts	1.00	LS	439,000	0	0	0	0	0	0	0	439,000
Contract 3 - Reach 3	1.00	EA	*7,428,820.83* 7,428,821	570,921	*5,619,167.96* 5,619,168	842,875	646,204	568,660	54,158	2,111,897	*10,111,639.32* 10,111,639
01 Lands and Damages	1.00	LS	1,027,574	0	0	0	0	0	0	0	1,027,574
0123 Construction Contract(s) Documnts	1.00	EA	*1,027,574.00* 1,027,574	0	*0.00* 0	0	0	0	0	0	*1,027,574.00* 1,027,574
02 Relocations	1.00	LS	901,342	221,639	1,122,981	168,447	129,143	113,646	10,823	422,059	1,545,040
0201 Roads, Construction Activities	1.00	EA	*316,867.83* 316,868	83,970	*400,837.80* 400,838	60,126	46,096	40,565	3,863	150,650	*551,487.92* 551,488
0203 Cemetery, Utilities, & Structure	1.00	LS	584,474	137,669	722,143	108,322	83,046	73,081	6,960	271,409	993,553
11 Levees and Floodwalls	1.00	LS	4,146,905	349,282	4,496,187	674,428	517,061	455,014	43,335	1,689,838	6,186,025
1101 Levees	1.00	LS	868,935	0	868,935	130,340	99,927	87,936	8,375	326,579	1,195,513
1102 Floodwalls	1.00	LS	3,277,970	349,282	3,627,252	544,088	417,134	367,078	34,960	1,363,259	4,990,511

Description	Quantity	UOM	DirectCost	SubCMU	CostToPrime	JOOH_PRM	HOOH_PRM	Profit_PRM	Bond_PRM	PrimeCMU	ContractCost
30 Planning, Engineering and Design	**1.00**	**LS**	**850,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**850,000**
31 Construction Management	**1.00**	**LS**	**503,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**503,000**
3123 Construction Contracts	**1.00**	**LS**	**503,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**503,000**

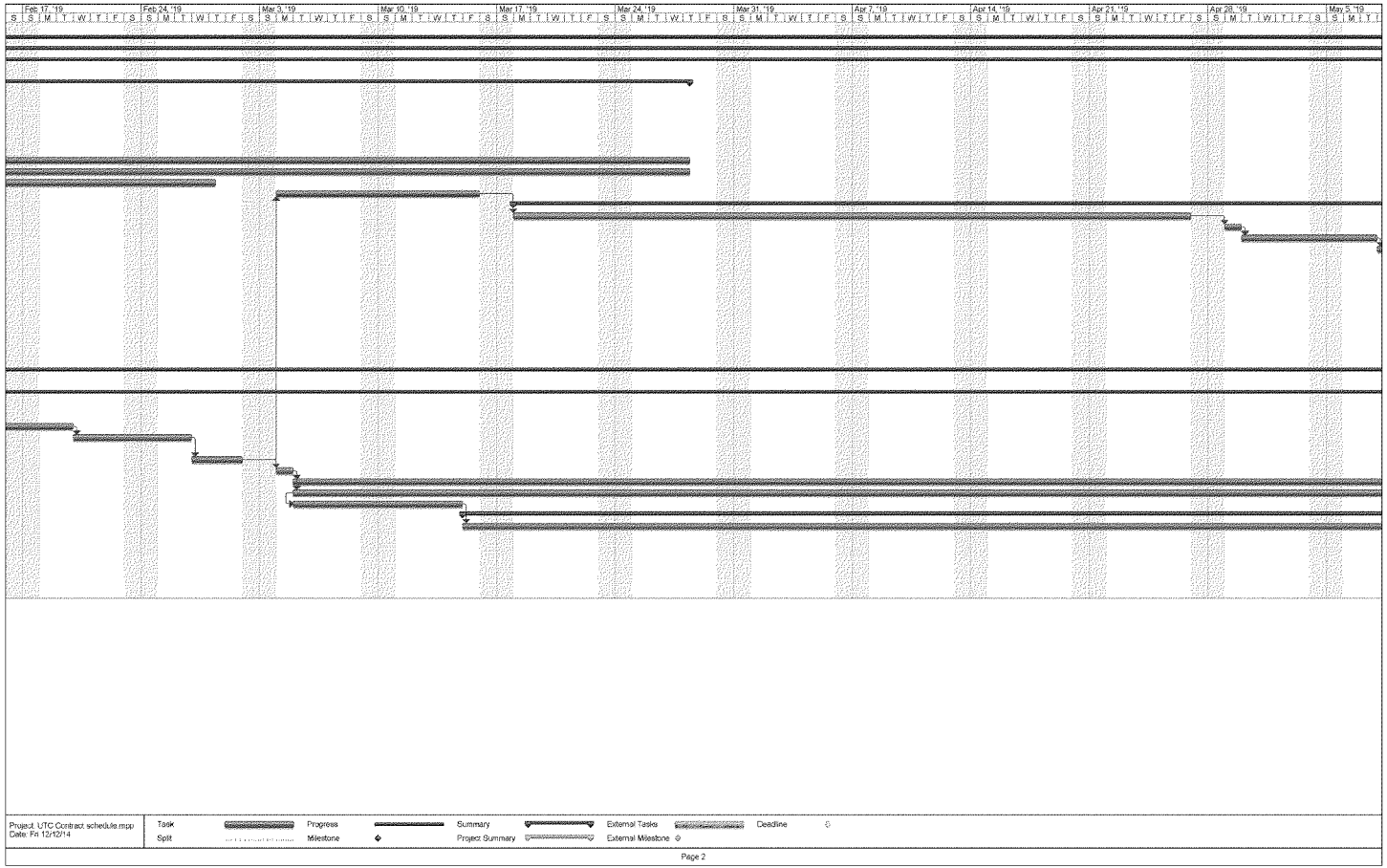
Section 4
Contract Schedule

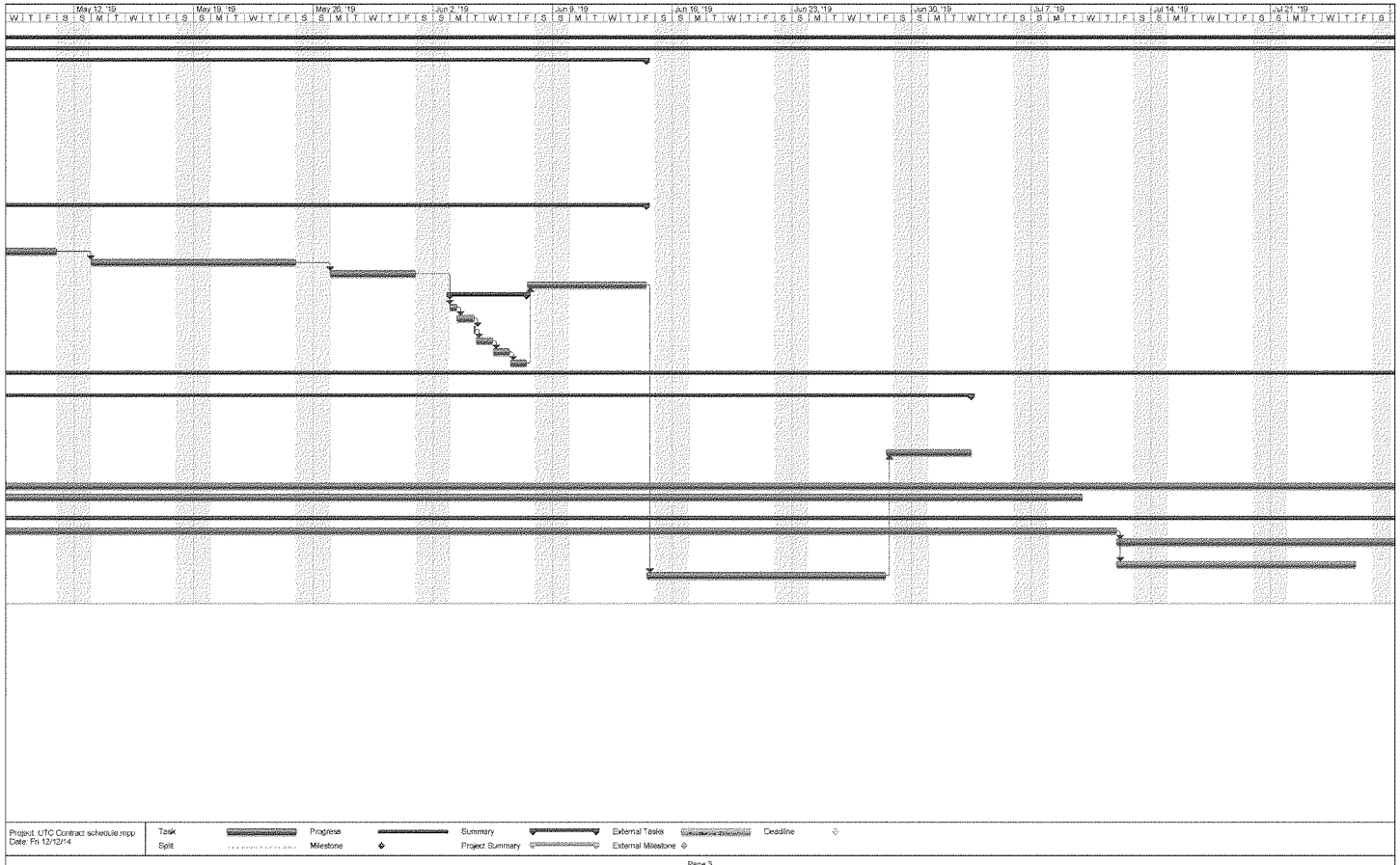
ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
1						
2	**UTC**	**952 days**	**Tue 1/1/19**	**Wed 8/24/22**		
3	**Contract 1**	**254 days**	**Tue 1/1/19**	**Fri 12/20/19**		
4	**Levees**	**118.5 days**	**Tue 1/1/19**	**Fri 6/14/19**		
5	Mob	5 days	Tue 1/1/19	Mon 1/7/19		
6	**Drainage Detent**	**57.25 days**	**Tue 1/8/19**	**Thu 3/28/19**		
7	Site Prep	10 days	Tue 1/8/19	Mon 1/21/19	5	
8	Excavation	5 days	Tue 1/22/19	Mon 1/28/19	7	
9	Grading	0.25 days	Tue 1/29/19	Tue 1/29/19	8	
10	Bldg Demo	5 days	Tue 1/29/19	Tue 2/5/19	9	
11	Storm Sewe	5 days	Tue 2/5/19	Tue 2/12/19	10	
12	Cleanup	2 days	Tue 2/12/19	Thu 2/14/19	11	
13	Outlet Struct	30 days	Thu 2/14/19	Thu 3/28/19	12	
14	Inlet Structu	30 days	Thu 2/14/19	Thu 3/28/19	12	
15	Street Grate	10 days	Thu 2/14/19	Thu 2/28/19	12	
16	Inspection Trench	10 days	Mon 3/4/19	Fri 3/15/19	40	
17	**Lev Right Bank**	**64.5 days**	**Mon 3/18/19**	**Fri 6/14/19**		
18	Site Prep	30 days	Mon 3/18/19	Fri 4/26/19	16	
19	Stripping	1 day	Mon 4/29/19	Mon 4/29/19	18	
20	Foundation	6 days	Tue 4/30/19	Tue 5/7/19	19	
21	Fill Stripped	3 days	Wed 5/8/19	Fri 5/10/19	20	
22	Fill for Lever	10 days	Mon 5/13/19	Fri 5/24/19	21	
23	Topsoil	5 days	Mon 5/27/19	Fri 5/31/19	22	
24	Seeding	5 days	Fri 6/7/19	Fri 6/14/19	31	
25	**Lev Left Bank**	**4.5 days**	**Mon 6/3/19**	**Fri 6/7/19**		
26	Stripping	0.25 days	Mon 6/3/19	Mon 6/3/19	23	
27	Foundation	1 day	Mon 6/3/19	Tue 6/4/19	26	
28	Fill Stripped	0.25 days	Tue 6/4/19	Tue 6/4/19	27	
29	Fill for Levee	1 day	Tue 6/4/19	Wed 6/5/19	28	
30	Topsoil	1 day	Wed 6/5/19	Thu 6/6/19	29	
31	Seeding	1 day	Thu 6/6/19	Fri 6/7/19	30	
32	**Floodwall**	**254 days**	**Tue 1/1/19**	**Fri 12/20/19**		
33	Mob	5 days	Tue 1/1/19	Mon 1/7/19	5SS	
34	**Site Work**	**126.5 days**	**Tue 1/8/19**	**Wed 7/3/19**		
35	Clearing	1 day	Tue 1/8/19	Tue 1/8/19	33	
36	Bldg Demo	20 days	Wed 1/9/19	Tue 2/5/19	35	
37	Site Prep - F	10 days	Wed 2/6/19	Tue 2/19/19	36	
38	Site Prep - L	5 days	Wed 2/20/19	Tue 2/26/19	37	
39	Site Restora	3 days	Fri 6/28/19	Wed 7/3/19	50	
40	Inspection Trench	3 days	Wed 2/27/19	Fri 3/1/19	38	
41	Foundation Earth	1 day	Mon 3/4/19	Mon 3/4/19	40	
42	Drainage Structu	105 days	Tue 3/5/19	Mon 7/29/19	41	
43	Augercast Piles	91 days	Tue 3/5/19	Tue 7/9/19	41	
44	Earthwork	8 days	Tue 3/5/19	Thu 3/14/19	43SS	
45	**Floodwall**	**201 days**	**Fri 3/15/19**	**Fri 12/20/19**		
46	FW	85 days	Fri 3/15/19	Thu 7/11/19	44	
47	4 ft high pari	58 days	Fri 7/12/19	Tue 10/1/19	46	
48	4 ft high pari	58 days	Wed 10/2/19	Fri 12/20/19	47	
49	Floodgate	10 days	Fri 7/12/19	Thu 7/25/19	46	
50	Seeding	10 days	Fri 6/14/19	Fri 6/28/19	24	
51	**Contract 2**	**220 days**	**Wed 1/1/20**	**Tue 11/3/20**		
80	**Contract 3**	**168 days**	**Mon 1/3/22**	**Wed 8/24/22**		

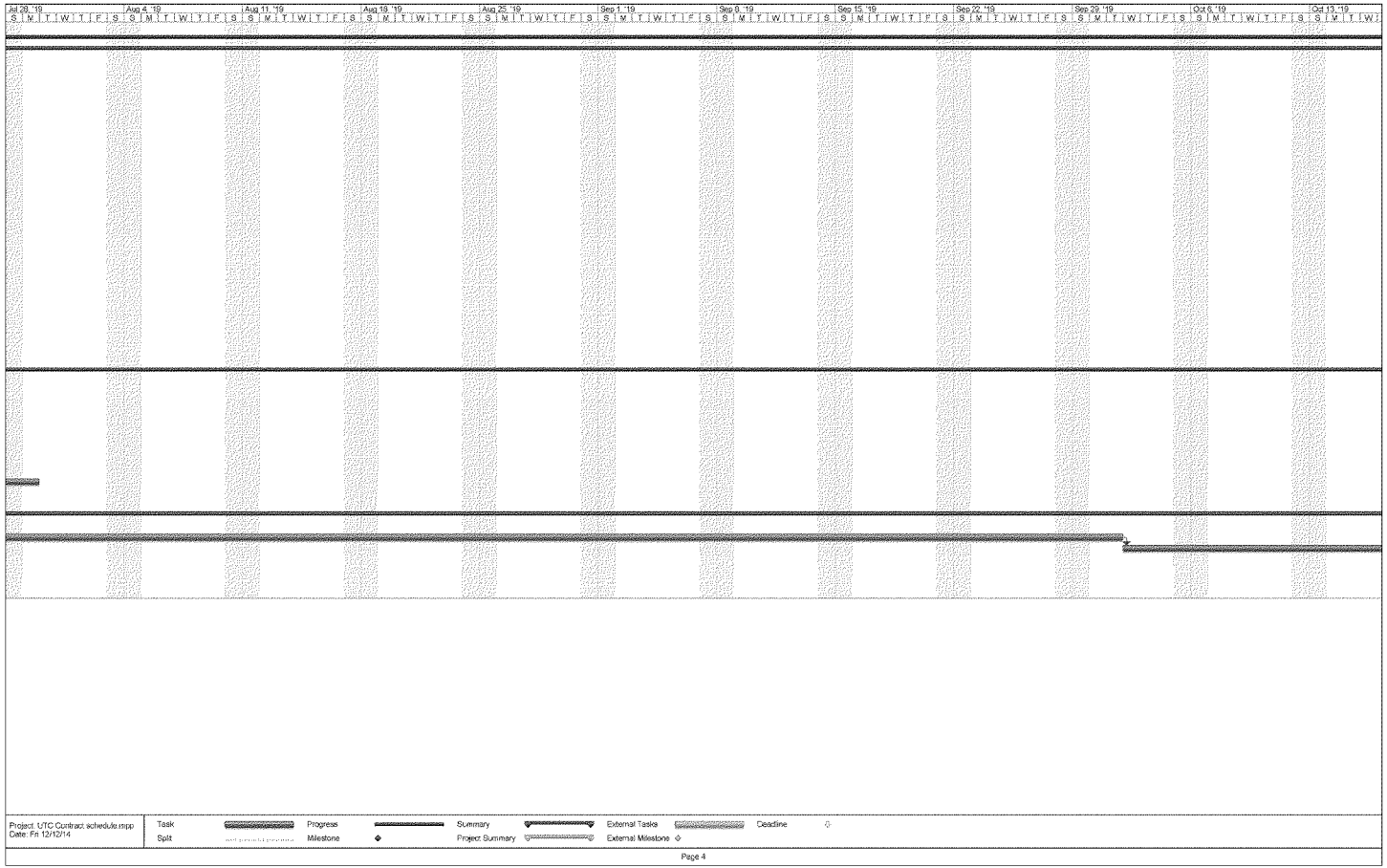


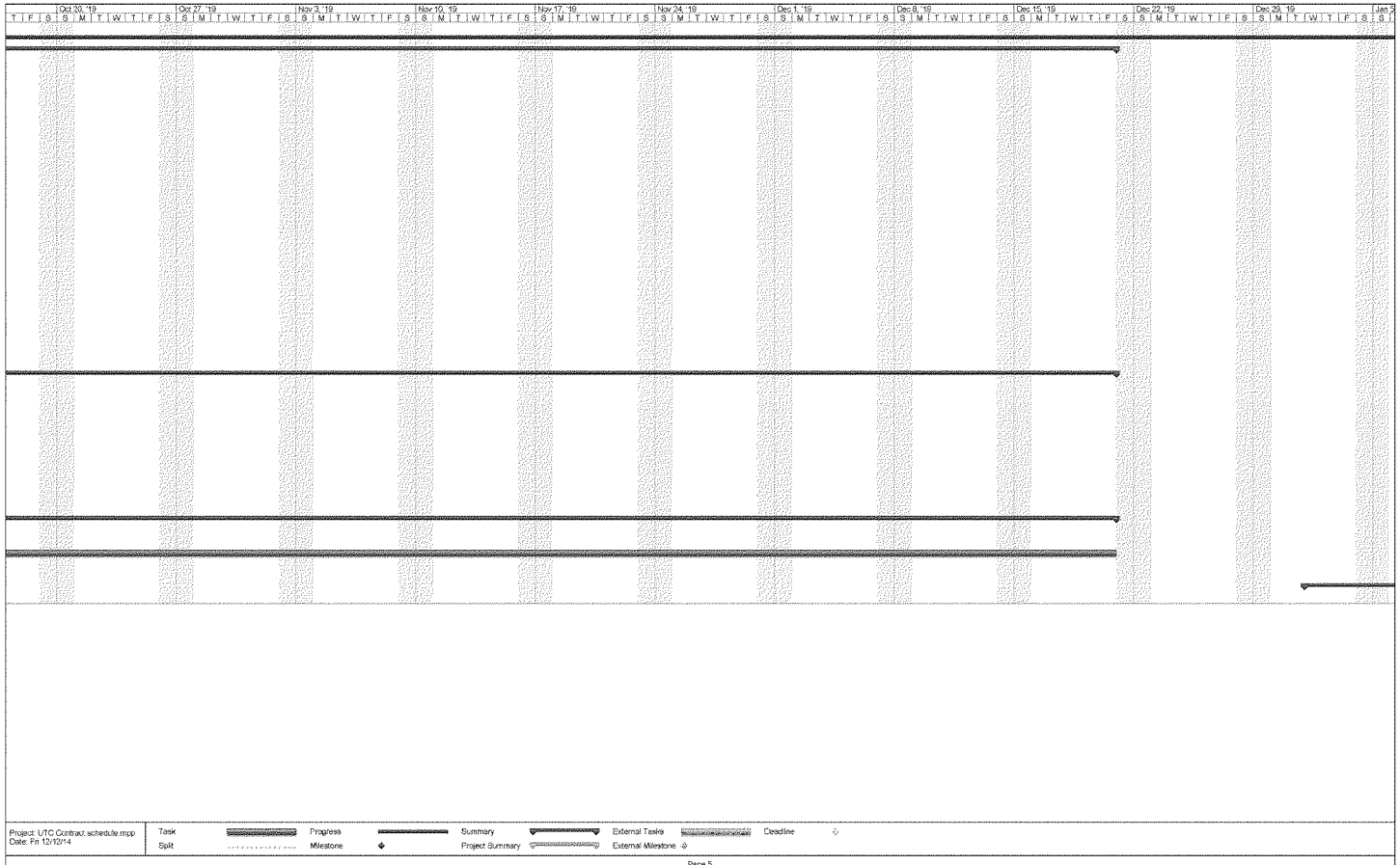
Project: UTC Contract schedule.mpp
Date: Fri 12/12/14

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone


Feb 17, '19
Feb 24, '19
Mar 3, '19
Mar 10, '19
Mar 17, '19
Mar 24, '19
Mar 31, '19
Apr 7, '19
Apr 14, '19
Apr 21, '19
Apr 28, '19
May 5, '19
Project: UTC Contract schedule.mpp
Date: Fri 12/12/14
Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline
Page 2


May 12, '19
May 19, '19
May 26, '19
Jun 2, '19
Jun 9, '19
Jun 16, '19
Jun 23, '19
Jun 30, '19
Jul 7, '19
Jul 14, '19
Jul 21, '19
Project: UTC Contract schedule.mpp
Date: Fri 12/12/14
Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline
Page 3


Jul 28, '19
Aug 4, '19
Aug 11, '19
Aug 18, '19
Aug 25, '19
Sep 1, '19
Sep 8, '19
Sep 15, '19
Sep 22, '19
Sep 29, '19
Oct 6, '19
Oct 13, '19
Project: UTC Contract schedule.mpp
Date: Fri 12/12/14
Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline
Page 4


Oct 20, '19
Oct 27, '19
Nov 3, '19
Nov 10, '19
Nov 17, '19
Nov 24, '19
Dec 1, '19
Dec 8, '19
Dec 15, '19
Dec 22, '19
Dec 29, '19
Jan 5
Project: UTC Contract schedule.mpp
Date: Fri 12/12/14
Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline
Page 5

Appendix M
Cost Effective Incremental Cost Analysis (CE-ICA)

Compensatory Mitigation Determination

I. OVERVIEW

During the development of feasibility reports, the environmental impacts of each alternative evaluated in detail by the U.S. Army Corps of Engineers must be captured and quantified to better compare the alternatives, and if necessary, determine any compensatory mitigation that may be required for Clean Water Act Section 404 authorization. One method to evaluate the environmental impacts of alternatives is the Habitat Evaluation Procedure (HEP). HEP was developed by the U.S. Fish and Wildlife Service (USFWS) (1980) and evaluates the quality and quantity of available habitat for selected wildlife species or groups of species. HEP provides information for two general types of wildlife habitat comparisons. One, the relative value of different areas at the same point in time, and two, the relative value of the same area at future points in time. By combining these two types of comparisons, the impact of proposed land and water use changes on wildlife habitat can be quantified. HEP describes relative habitat value for selected wildlife species as a Habitat Suitability Index (HSI) with a value ranging from 0.0 (unsuitable) to 1.0 (optimal). This value is multiplied by the area of available habitat to obtain Habitat Units (HUs). To calculate habitat value over a period of time, such as 50-year period of analysis, Habitat Units are averaged on a yearly basis to provide Average Annual Habitat Units (AAHU).

II. BACKGROUND

The purpose of the Upper Turkey Creek feasibility study is to identify, evaluate and recommend to decision makers a solution for flood risk management within the Upper Turkey Creek watershed. A flood risk management project is needed to reduce the risk from flooding that could result in loss of life and/or property damage in the Upper Turkey Creek basin. Flooding along Turkey Creek led to presidential disaster declarations in 1993 and 1998. Sadly, the 1998 flood event resulted in the loss of two lives.

Turkey Creek is a right bank tributary of the lower Kansas River located in Johnson and Wyandotte Counties, Kansas. The Turkey Creek watershed is approximately 23 square miles in size. Turkey Creek is approximately 15 miles long and runs parallel to Interstate 35 (I-35) nearly its entire length. The watershed contains the some of the most intensely developed urban locations in Johnson and Wyandotte Counties, Kansas. Approximately 75% of Turkey Creek consists of residential, commercial, and industrial land use (Lee *et al*, 2005). Additionally, nearly 30% of the watershed consists of impervious surfaces. Construction of the I-35 embankment reduced the width of the Turkey Creek floodplain from approximately 1,000 feet to about 50 to 400 feet,

depending on the location. Other development has highly altered much of the floodplain and creek channel.

Most of Turkey Creek and its tributaries have been channelized, with numerous reaches in which the banks, or in some locations the entire channel, have been lined with rock or concrete. At least four lakes exist on tributaries to Turkey Creek, and the upper reach in Lenexa has several small (1- to 2-foot high) dams. Several waterfalls, approximately 5 feet or less in height also exist on the creek and tributaries. Some of the smaller (3-foot or less) waterfalls, for example those between Lamar and Metcalf Avenues and 63rd and 67th Streets, are due to concrete-covered utility crossings.

Within the City of Merriam in Johnson County, the Merriam Drainage District has modified the Turkey Creek Channel from 63rd Street downstream to 51st Street. Most of this work occurred between 1967 and 1972, but the District has since accomplished an extensive streambank protection effort relying primarily on large cut limestone blocks to armor the channel slope. The last segments of armoring were placed in the early 1980s, but large floods occasionally displace the stone blocks, requiring continual maintenance of the project. The Drainage District's efforts have produced a channel of nearly uniform width deepened to bedrock through the project area with very little riparian corridor.

III. SELECTED INDICATOR SPECIES AND HABITAT SUITABILITY INDICES

Three factors were considered when selecting Habitat Suitability Index models for the Upper Turkey Creek Flood Risk Management Project. First, it was important to select species that would utilize the existing habitat types that would be impacted by the proposed project. This included riverine and riparian habitat types in the Midwestern United States. Second, species were selected in which their preferred habitat conditions would seem likely to also benefit other species that may also utilize that habitat type. Last, only available species for which there was a certified or approved HSI model, in accordance with EC 1105-2-412 Assuring Quality of Planning Models, were considered. Using these criteria, specific Habitat Suitability Index (HSI) models used for the Upper Turkey Creek Flood Risk Management Project were the green sunfish (*Lepomis cyanellus*) and the fox squirrel (*Sciurus niger*). These models are available online at
http://el.erdc.usace.army.mil/emrrp/emris/EMRIS_PDF/GreenSunfish.pdf and
http://el.erdc.usace.army.mil/emrrp/emris/EMRIS_PDF/FoxSquirrel.pdf.

Green sunfish (*Lepomis cyanellus*): The riverine cover type for the green sunfish HSI model was selected to evaluate in-stream aquatic habitat (Stuber et al, 1982). Green sunfish are known to inhabit a wide range of riverine conditions and are one of only four

fish species that are known to occur in Turkey Creek. This HSI model is applicable throughout North America. The green sunfish model is composed of food and cover, water quality, and other reproduction life requisites. Specific variables for the riverine sunfish model, including assumptions, are shown in Table 1.

The formula for calculating the HSI of the green sunfish is as follows:

Food & Cover	$C_{F/C} = (V_1 * V_2)^{(1/2)}$
Water Quality	$C_{WQ} = (2V_4 + V_5 + V_6 + (2(V_7 + V_8)/2))/6$ If V_4, V_7, or V_8 ≤ 0.4, C_{WQ} equals the lowest of the following: V_4, V_7, or above equation
Reproduction	$C_R = (V_9 * V_{10} * V_{12})^{(1/3)}$
Other	$C_{OT} = (V_3 + ((V_{11} + V_{13})/2) + 0.5V_{14})/2.5$
HSI	$(C_{F/C} * C_{WQ} * C_R * C_{OT})^{(1/4)}$

Table 1: Variables included in the green sunfish HSI model for the riverine cover type. Assumptions for each of the variables are also included. Table modified from Stuber et al, 1982.

Variable	Description	Assumptions of Model
V_1	Percent of the bottom of pools covered with vegetation, rocks, of debris during summer	Vegetation, rocks, and debris have similar value as cover objects. The average percent (35%) bottom covered by vegetation in areas where green sunfish were collected in stream is optimal.
V_2	Percent pool area during average summer flow	Green sunfish typically inhabit pool areas of stream, and optimal habitat consists of at least 50% pool area.
V_3	Stream gradient within representative reach	Species abundance is greatest in lower (≤ 2 m/km) gradient streams.
V_4	Minimum dissolved oxygen levels during summer	Dissolved oxygen requirements are presumably similar to those of the bluegill. Dissolved oxygen levels that are near lethal are unsuitable, and levels that result in avoidance are suboptimal.
V_5	Maximum monthly average turbidity within pools during summer	Moderate (25 – 100 JTU) turbidities correlated with high species abundance are optimum.
V_6	pH range during summer growing season	Optimal pH range is presumably the same as that for all freshwater fish. Levels that impair growth or reproduction are suboptimal, and levels that lead to death are unsuitable.
V_7	Maximum midsummer temperature with pools (Adult, Juvenile)	Optimal temperature for adults and juveniles are those where growth and food conversion efficiency are maximal.
V_8	Maximum midsummer temperature with pools (Fry)	The same assumption as for V_7 applies to green sunfish fry.
V_9	Maximum temperature within pools during spawning (June – July) (Embryo)	Optimal temperature for embryonic development is those at which survival is highest. Temperatures that result in little or no survival are unsuitable.
V_{10}	Substrate composition within pools for spawning (Embryo)	The substrate within which the greatest survival of eggs takes place is considered optimum.
V_{11}	Average current velocity within pools during average summer flow (Adult, Juvenile)	Velocities that are commonly inhabited by green sunfish are optimal.
V_{12}	Average current velocity within pools during spawning (June – July) (Embryo)	Low velocities during spawning increase the survival of eggs. Higher velocities (> 15 cm/sec) are unsuitable because survival is very low.
V_{13}	Average current velocity within pools during average summer flow (Fry)	The same assumption as for V_{11} applies to fry and juvenile green sunfish
V_{14}	Average stream width within representative reach	The size of the stream commonly inhabited by green sunfish is the optimum.

Fox squirrel (*Sciurus niger*): The fox squirrel HSI model was selected to evaluate riparian habitat (Allen, 1982). Fox squirrels are most abundant in open deciduous forest stands with very little understory vegetation. This habitat type is prevalent along the banks of Turkey Creek. This HSI model is applicable throughout the range of fox squirrel, except for subspecies inhabiting the Outer Coastal Plain Forest and Southeastern Mixed Forests. The green sunfish model is composed of winter food and cover/reproduction life requisites. A HSI value is based on the limiting factor concept and equals the lowest life requisite value. Several of the field techniques were modified to utilize GIS capabilities including the ability to measure the area of individual tree stands remotely. For each alternative, measurements were taken for 38 to 44 individual stands of trees, depending on the size of the project area, and the results were combined into single outputs. Specific variables, and modified techniques, for the fox squirrel model are shown in Table 2.

The formula for calculating the HSI of the fox squirrel is as follows:

Winter Food	$= (3V_1 + V_2)/3$
Cover/Reproduction	$= (V_3 * V_4 * V_5)$^(1/3)
HSI	= lowest value of either Winter Food or Cover/Reproduction

Table 2: Variables included in the fox squirrel HSI model. Several of the suggested techniques were modified to make better use of GIS capabilities including the ability to measure the area of individual tree stands remotely.

Variable	Description	Suggested Technique	Utilized Technique
V_1	Percent canopy closure of trees that produce hard mast (e.g. oak, hickory, walnut, pecan, beech) ≥ 10 inches diameter at breast height (dbh).	Calculated area of plant using crown diameter on strip quadrat.	Estimated percent canopy cover of each stand in field, and then calculated total percentage for all stands combined.
V_2	Distance to available grain	On site inspection, remote sensing	On site inspection, remote sensing
V_3	Average dbh of overstory trees of those trees which are ≥ 80 percent of the height of the tallest trees in the stand	Cruise for tallest tree in stand. Sample with optical range finder and Biltmore stick on strip quadrat.	Cruise for tallest 20 percent of trees in stand and measured dbh using calibrated diameter tape (D-tape).
V_4	Percent tree canopy closure of all woody vegetation greater than 16.5 feet in height.	Line intercept, remote sensing	Estimated percent canopy cover of each stand in field, then calculated total percentage for all stands combined.
V_5	Percent shrub crown cover of woody vegetation less than 16.5 feet in height.	Line intercept	Estimated percent canopy cover of each stand in field, then calculated total percentage for all stands combined.

IV. ALTERNATIVES

A No-Action alternative, three structural alternatives, and one non-structural alternative (property buy-out) are being evaluated in detail in the Turkey Creek feasibility report. However, the No-Action alternative and the Property Buy-Out alternative were not evaluated using HEP. It is assumed that the existing habitat conditions for each of these alternatives would not change over a 50 year period of analysis.

Alternative 1 – Channel Widening: Within the project area, the Upper Turkey Creek channel bottom would be widened to a width of 90 – 110 feet and the channel top

widths would be widened to 160 – 175 feet depending on location. Side slopes would vary from 2H:1V to 3H:1V. At the Shawnee Mission Parkway and Merriam Drive Bridges, the channel bottom would be widened to approximately 200 feet to accommodate new bridges with wider openings at each of these locations. Also, two sewer lines and two waterlines that cross under Turkey Creek would be replaced.

Alternative 2 – Levees and Floodwalls (NED Plan): In total, 6,822 linear feet of floodwalls, 3 – 6 feet in height, and 3,383 linear feet of levees, 3 – 5 feet in height, would be constructed within the project area. Additionally, two sewer lines and two waterlines that cross under Turkey Creek would be replaced. A grass detention basin approximately 2 acres in size would be constructed on property that is immediately downstream of the Merriam Marketplace. About 4,000 linear feet of replacement and new stormwater drainage lines would be associated with the detention basin.

Alternative 3 – Channel Widening with Levees and Floodwalls: With this alternative, the channel bottom would be widened to a width of 90 – 110 feet and the channel top widths would be widened to 160 – 175 feet depending on location. Side slopes would vary from 2H:1V to 3H:1V. Two sewer lines and two water lines that cross under Turkey Creek would be replaced. In total, 3,810 linear feet of floodwalls, 1 – 4 feet in height, and 1,350 linear feet of levees, 2 – 5 feet in height, would be constructed. A grass detention basin approximately 2 acres in size would be constructed on property that is part of the Merriam Marketplace. About 4,000 linear feet of replacement and new stormwater drainage lines would be associated with the detention basin.

V. DATA INPUTS & ASSUMPTIONS

To the extent possible, existing data was utilized for determining HSI scores for the existing conditions. Other data was obtained from GIS and from field measurements. The future without project conditions was assumed to be the same as the existing conditions because there were not any known reasons to speculate otherwise. Variable input for the future with project conditions was determined by evaluating how each alternative would impact the existing condition. In some cases, background information could be obtained or calculations could be conducted to determine the future with project conditions, but in most cases it was dependant on professional judgment. Details on data input and assumptions are further explained for each of the models as follows.

Green sunfish: The green sunfish HSI model was used to determine the existing condition, the future with project, and the future without project conditions for each of the proposed flood risk management alternatives. Because changes from the existing conditions would be the result of geomorphic changes to the creek channel, it was assumed that there would not be any incremental changes in habitat quality over the 50 year period of analysis for any of the structural alternatives. For this reason, the

average annual habitat units (AAHUs) determined for 50 year period of analysis would be the same as the habitat units (HUs) determined for the future with project condition.

For the existing condition, and future without project condition, it was estimated that approximately 10% of the bottom of pools were covered with vegetation, rocks, and debris during the summer (V_1). This is an estimated value based on visual observations of the creek within the project area. Turkey Creek contains very little emergent vegetation. During certain periods of the summer, filamentous algae blooms can occur and cover most of the substrate within the channel. Otherwise substrate within the pools typically consists of bedrock and cobble sized rocks. For Alternatives 1 and 3, which consist of channel widening, it was estimated the amount of cover in the bottom of pools would be half of what currently exists. It was assumed that the existing cover would remain in place after the channel was widened to be about two times its existing width. It was also assumed that no new cover would exist in locations that would consist of new aquatic habitat as a result of the channel widening. Because there would not be any changes to the geomorphology of the creek channel with Alternative 2, it was assumed that the amount of cover in the bottom of pools would be the same as the existing condition.

For the percentage of pool area (V_2), it was estimated based on visual observations that approximately 15% of Turkey Creek within the project area currently contains shallow pools. Most of these pools are generally less than two feet in depth. For Alternatives 1 and 3, which consist of channel widening, it was estimated that at least 11% of the channel would contain pools. This value was selected as the most conservative value, meaning the worst case scenario, which could be input into the model without causing this portion of the suitability index to be zero. In reality, any number of shallow pools could be excavated into the bedrock during the channel widening process increasing the score for this component of the model. Because there would not be any changes to the geomorphology of the creek channel with Alternative 2, it was assumed that the amount of cover in the bottom of pools would be the same as the existing condition.

The stream gradient (V_3) was calculated by determining the elevation of the creek at the upstream and downstream most portions of the project area. It is assumed that none of the alternatives would result in any changes to the gradient of the creek.

Minimum dissolved oxygen levels in summer (V_4) were assumed to generally be greater than 5 mg/L for the existing conditions and all of the future with project conditions. Monthly data has been collected by the USEPA at two locations upstream of the project area on Turkey Creek. Data indicated that dissolved oxygen concentrations range from 5 mg/L to 11 mg/L during the summer months for years 2007 through 2010. This data

is available online at www.kcwaters.org. It was assumed that none of the alternatives would result in any long-term changes to dissolved oxygen concentrations in Turkey Creek.

The maximum monthly average turbidity in pools during the summer (V_5) for the existing conditions and all of the future with project conditions was also estimated using data collected by the USEPA at two locations upstream of the project area. This data is available online at www.kcwaters.org. The monthly average turbidity value between the years 2007 through 2010 was 4.1 NTU, which is equivalent to 4.1 JTU. It was assumed that none of the alternatives would result in any long-term changes to turbidity concentrations in Turkey Creek. Although, it is recognized that there may be minor reductions in turbidity for Alternatives 2 and 3 due to the grass detention basin. However, it is not possible to quantify the extent of these benefits. Any reductions in minor long-term reductions in turbidity would not result in the need for compensatory mitigation. A conservative assumption is being made with regard to any potential minor changes in turbidity.

The pH range during the summer (V_6) for the existing conditions and all of the future with project conditions was estimated from data collected by the USEPA at two locations sampled monthly upstream of the project area. This data is available online at www.kcwaters.org. The pH generally was is the 7.0 to 8.0 range which is typical for most water bodies in the region due to high concentrations of calcium carbonate derived from limestone that is common in the area. However, there was one record of a pH 3.5. It was assumed that this data point was an anomaly. It was assumed that none of the alternatives would result in any long-term changes to the pH of Turkey Creek.

The maximum temperature within pools for all life stages of green sunfish (V_7, V_8, and V_9) was assumed to be equal to the highest temperature, 28.0 degrees Celsius, recorded by the USEPA from two locations sampled monthly upstream of the project area during the summer months.

The substrate composition within pools (V_{10}) for the existing and all of the future with project conditions was determined to be predominantly composed of bedrock. This is a result of the extensive modifications that have already occurred to the Turkey Creek channel within the project area.

No existing data was available to determine the average water velocity within pools for the various life stages of green sunfish (V_{11}, V_{12}, and V_{13}). The value for these variables was estimated by dividing the baseflow volume of 1 cfs for Turkey Creek (Lee *et al*,

2005) by an assumed cross sectional area of 50 ft^2. This resulted in a velocity of 0.02 ft/sec, which is equal to 0.6 cm/sec.

Average steam width (V_{14}) was determined for the existing conditions using Google Earth Pro. This distance, 15 meters, was also used for Alternative 2 because this alternative would not result in any changes to the average stream width when compared to the existing conditions. A stream width of 28 meters was input for Alternatives 1 and 3, as this would be the new designed width of the channel for each of these alternatives. Values input into the green sunfish model are shown in Table 3.

Table 3: Values input into the green sunfish HSI model for the existing condition & future without project condition, and future with project condition for Alternatives 1 through 3.

Variables Input	Existing Condition & Future Without Project	Alternative 1	Alternative 2	Alternative 3
V_1 (%)	10	5	10	5
V_2 (%)	15	11	15	11
V_3 (m/km, 0-10)	5.26	5.26	5.26	5.26
V_4 (A, B, C, or D)	A	A	A	A
V_5 (JTU, 0-200)	4.1	4.1	4.1	4.1
V_6 (A, B, C, or D)	A	A	A	A
V_7 (10-40)	28.0	28.0	28.0	28.0
V_8 (10-40)	28.0	28.0	28.0	28.0
V_9 (10-40)	28.0	28.0	28.0	28.0
V_{10} (A, B, C, or D)	A	A	A	A
V_{11} (cm/sec, 0-40)	0.6	0.6	0.6	0.6
V_{12} (cm/sec, 0-20)	0.6	0.6	0.6	0.6
V_{13} (cm/sec, 0-10)	0.6	0.6	0.6	0.6
V_{14} (m, 0-40)	15	28	15	28

Fox Squirrel: The fox squirrel HSI model was used to determine the existing conditions within the project footprint for each of the alternatives. It is assumed that any habitat would be entirely lost with each of the alternatives and not replaced over the 50 year project life. This is a reasonable assumption because woody vegetation is typically not permitted to grow on or near levees because they may compromise the integrity of the structures. The difference in size of the project areas resulted in different variable inputs for each of the alternatives. Alternative1 has an estimated project area of 32.4

acres, Alternative 2 has an estimated project area of 26.5 acres, and Alternative 3 has an estimated project footprint of 36.7 acres. The size of the project area was estimated by expanding out 50 feet from any project features from each of the alternatives to allow space for construction.

The percentage of the canopy closure from trees that produce hard mast (V_1) was determined by estimating the percent canopy cover of hard mast producing trees in the field for each stand, then calculating the total percentage for all stands combined. The exact distance to available grain (V_2) was not determined. However, it was assumed to be at least 1000 meters from the project area due to the urban nature of the project area. The model assigns an output value of 0.1 for this specific variable for all distances greater than 600 meters. The average diameter at breast height (DBH) of the overstory (V_3) was determined with field measurements of the tallest 20% of trees in each stand, as described in the model. The percentage of total tree canopy cover (V_4) was determined by estimating the percent of canopy cover in the field for each stand, then calculation of the total percentage for all stands combined. The percentage of shrub crown cover (V_5) was calculated in a manner analogous to the percentage of total tree canopy cover. Values input into the fox squirrel model are shown in Table 4.

Table 4: Values input into the fox squirrel HSI model for the existing conditions and future without project for Alternatives 1 through 3.

Variables Input	Alternative 1	Alternative 2	Alternative 3
V_1 (% Canopy of Mast)	3.5	2.8	3.3
V_2 (Distance to Available Grain)	1000	1000	1000
V_3 (Average DBH of Overstory)	13.3	12.0	12.8
V_4 (% Tree Canopy Closure)	15.4	10.5	13.8
V_5 (% Shrub Crown Cover)	2.1	2.9	4.9

VI. RESULTS

Green Sunfish: The results for the calculations of the life requisites, the HSI score, and the Habitat Units for the existing condition, the future without project, and the future with project for each of the alternatives are shown in Table 5. It was assumed that the future without project condition of the in-stream habitat would remain constant over the 50 year period of analysis. This assumption was made because the creek is already highly disturbed and has been channelized. Therefore, the average annual habitat units (AAHUs) determined for 50 year period of analysis would be the same as the existing

habitat units (HUs) for the future without project condition. As stated previously, any changes from the existing conditions would be the result of geomorphic changes to the creek channel and it was assumed that there would not be any incremental changes in habitat quality over the 50 year period of analysis for any of the structural alternatives. For this reason, the average annual habitat units (AAHUs) determined for the 50 year period of analysis would be the same as the habitat units (HUs) determined for the future with project condition. None of the alternatives evaluated for the Upper Turkey Creek Flood Risk Management Project would result in any long-term negative impacts to the in-stream aquatic habitat as determined by the green sunfish HSI model.

Table 5: Green sunfish life requisite values, HSI scores, Habitat Units, and Average Annual Habitat Units for the existing condition (EC), future without project (FWOP), and future with project (FW) for each of the alternatives.

	Alternative 1			Alternative 2			Alternative 3		
Life Requisite	EC	FWOP	FW	EC	FWOP	FW	EC	FWOP	FW
Food & Cover	0.23	0.23	0.09	0.23	0.23	0.23	0.23	0.23	0.09
Water Quality	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Reproduction	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58
Other	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
HSI	0.54	0.54	0.42	0.54	0.54	0.54	0.54	0.54	0.42
Project Area (acres)	7	7	20	7	7	7	7	7	20
Habitat Units	3.67	3.67	8.26	3.67	3.67	3.67	3.67	3.67	8.26
AAHU	3.67	3.67	8.26	3.67	3.67	3.67	3.67	3.67	8.26

Fox Squirrel: The results for the calculations the life requisites, the HSI score, Habitat Units, and the Average Annual Habitat Units (AAHUs) for the future with and future without project condition for each of the alternatives are shown in Table 6. It was assumed that the existing condition of the riparian corridor would remain constant over the 50 year period of analysis for the without project condition. This assumption was made because the lands within riparian corridor are essentially developed with manicured lawns or parklands with mostly mature trees. Therefore, the average annual habitat units (AAHUs) determined for the 50 year period of analysis would be the same as the habitat units (HUs) for the future without project condition. For the with project condition, it is assumed that any riparian habitat within the project footprint would be entirely lost for each of the alternatives and would not be replaced over the life of the project, 50 years. This is a reasonable assumption because woody vegetation is typically not permitted to grow on or near levees or floodwalls because they compromise the integrity of the structures. Therefore, the average annual habitat units for the with project condition would be 0 for each of the alternatives. As shown in Table

6, the with project condition would result in a loss ranging between 2.74 and 4.23 AAHUs depending on the alternative.

Table 6: Fox squirrel life requisite values, HSI scores, Habitat Units, and Average Annual Habitat Units (AAHU) for the existing condition (EC), future without project (FWOP) and future with project (FWP) for each of the alternatives.

	Alternative 1			Alternative 2			Alternative 3		
Life Requisite	EC	FWOP	FWP	EC	FWOP	FWP	EC	FWOP	FWP
Winter Food	0.12	0.12	0	0.10	0.10	0	0.12	0.12	0
Cover/Reproduction	0.84	0.84	0	0.68	0.68	0	0.79	0.79	0
HSI	0.12	0.12	0	0.10	0.10	0	0.12	0.12	0
Project Area (acres)	32.40	32.40	32.4	26.47	26.47	26.47	36.69	36.69	36.69
Habitat Units	3.94	3.94	0	2.74	2.74	0	4.23	4.23	0
AAHU	3.94	3.94	0	2.74	2.74	0	4.23	4.23	0

VII. COMPENSATORY MITIGATION

Compensatory mitigation was determined for Alternative 2 – Levees and Floodwalls (NED plan). Utilizing the green sunfish HSI model, no compensatory mitigation would be required for any of the alternatives for in-stream impacts. Utilizing the fox squirrel HSI model, compensatory mitigation for impacts to the riparian habitat would be needed to offset 2.74 Average Annual Habitat Units (AAHU).

Twenty four mitigation options were developed to compensate for riparian habitat that would be lost as a result of implementing Alternative 2 (Table 7). Each of these mitigation options would require planting hard mast producing trees, such as oak, walnut, and/or pecan. Variables that were manipulated to develop various mitigation options included the initial size of the tree that would be planted, the density of the tree plantings, and the size of the planting area. The initial size of the trees at time of planting consisted of either 5/8 inch diameter or 1 inch diameter trees. Tree densities evaluated included planting trees with 35, 40, or 45 feet on center. The size of the areas evaluated consisted of 5, 7, 9, and 11 acres. It is assumed that all of the mitigation options would be implemented in open locations that currently consist of manicured lawns and would have a HSI value of 0.0. The City of Merriam has identified several locations within parks that they own that could be utilized for tree plantings.

The future with project condition for variables in the fox squirrel HSI mode was predicted for each of the mitigation options at years 0, 5, 15, 25, and 50. A 50 year period of analysis was used to evaluate the mitigation options. Because the HSI scores would be identical for mitigation options having the same size tree at planting and the same density, these were grouped together (Tables 8 – 13). The percent of canopy closure from mast producing trees for input into the HSI model was estimated by assuming the crown dimensions shown in Tables 14 – 19. In order to calculate the net Average Annual Habitat Units (AAHU) for each of the mitigation options, the cumulative habitat units were calculated for each of the mitigation options following procedures from the U.S. Fish and Wildlife Service Ecological Service Manual 102 (USFWS, 1980) at year 0 (Table 20), year 0 – 5 (Table 21), year 5 – 15 (Table 22), year 15 – 25 (Table 23), and year 25 – 50 (Table 24). Using these cumulative habitat units, net Average Annual Habitat Units were determined for each of the mitigation options (Table 25). Any selected mitigation option must have at least a net AAHU of 0 to be considered.

Table 7: Mitigation Options Formulated to Compensate for Impacts to the Riparian Habitat as a Result of Implementing a Structural Alternative.

Mitigation Option	Caliper of Tree When Planted	Density of Trees	Number of Acres Planted
Mitigation Option 1	5/8 inch	35 foot x 35 foot	5
Mitigation Option 2	5/8 inch	40 foot x 40 foot	5
Mitigation Option 3	5/8 inch	45 foot x 45 foot	5
Mitigation Option 4	1 inch	35 foot x 35 foot	5
Mitigation Option 5	1 inch	40 foot x 40 foot	5
Mitigation Option 6	1 inch	45 foot x 45 foot	5
Mitigation Option 7	5/8 inch	35 foot x 35 foot	7
Mitigation Option 8	5/8 inch	40 foot x 40 foot	7
Mitigation Option 9	5/8 inch	45 foot x 45 foot	7
Mitigation Option 10	1 inch	35 foot x 35 foot	7
Mitigation Option 11	1 inch	40 foot x40 foot	7
Mitigation Option 12	1 inch	45 foot x45 foot	7
Mitigation Option 13	5/8 inch	35 foot x 35 foot	9
Mitigation Option 14	5/8 inch	40 foot x 40 foot	9
Mitigation Option 15	5/8 inch	45 foot x 45 foot	9
Mitigation Option 16	1 inch	35 foot x 35 foot	9
Mitigation Option 17	1 inch	40 foot x 40 foot	9
Mitigation Option 18	1 inch	45 foot x 45 foot	9
Mitigation Option 19	5/8 inch	35 foot x 35 foot	11
Mitigation Option 20	5/8 inch	40 foot x 40 foot	11
Mitigation Option 21	5/8 inch	45 foot x 45 foot	11

Mitigation Option 22	1 inch	35 foot x 35 foot	11
Mitigation Option 23	1 inch	40 foot x 40 foot	11
Mitigation Option 24	1 inch	45 foot x 45 foot	11

Table 8: Fox squirrel HSI calculations if 5/8 inch diameter trees were planted with 35 x 35 foot spacing.

Mitigation Options 1, 7, 13, 19: 5/8 Inch Diameter, 35x35 Spacing					
Variables Input	**Year 0**	**Year 5**	**Year 15**	**Year 25**	**Year 50**
V_1 (% Canopy Closure of Mast)	0.08	0.74	8.26	33.06	100
V_2 (Distance to Available Grain, m, 0-800)	1000	1000	1000	1000	1000
V_3 (Average DBH of Overstory, inches, 0-20)	0	0	6	12	25
V_4 (% Tree Canopy Closure)	0	0	8.26	33.06	100
V_5 (% Shrub Crown Cover)	0.08	0.74	0	0	0
Winter Food	0.03	0.03	0.24	0.86	0.63
Cover/Reproduction	0.00	0.00	0.00	0.84	0.79
HSI	**0.00**	**0.00**	**0.00**	**0.84**	**0.63**

Table 9: Fox squirrel HSI calculations if 5/8 inch diameter trees were planted with 40 x 40 foot spacing.

Mitigation Options 2,8,14,20: 5/8 Inch Diameter, 40x40 Spacing					
Variables Input	**Year 0**	**Year 5**	**Year 15**	**Year 25**	**Year 50**
V_1 (% Canopy Closure of Mast)	0.06	0.56	6.2	24.79	75.93
V_2 (Distance to Available Grain, m, 0-800)	1000	1000	1000	1000	1000
V_3 (Average DBH of Overstory, inches, 0-20)	0	0	6	12	25
V_4 (% Tree Canopy Closure)	0	0	6.2	24.79	75.93
V_5 (% Shrub Crown Cover)	0.06	0.56	0	0	0
Winter Food	0.03	0.03	0.19	0.65	0.87
Cover/Reproduction	0.00	0.00	0.00	0.84	0.93
HSI	**0.00**	**0.00**	**0.00**	**0.65**	**0.87**

Table 10: Fox squirrel HSI calculations if 5/8 inch diameter trees were planted with 45 x 45 foot spacing.

Mitigation Options 3,9,15,21: 5/8 Inch Diameter, 45x45 Spacing					
Variables Input	**Year 0**	**Year 5**	**Year 15**	**Year 25**	**Year 50**
V_1 (% Canopy Closure of Mast)	0.05	0.45	5.05	20.2	61.87
V_2 (Distance to Available Grain, m, 0-800)	1000	1000	1000	1000	1000
V_3 (Average DBH of Overstory, inches, 0-20)	0	0	6	12	25
V_4 (% Tree Canopy Closure)	0	0	6.2	20.2	61.87
V_5 (% Shrub Crown Cover)	0.05	0.56	0	0	0
Winter Food	0.03	0.03	0.19	0.54	1.01
Cover/Reproduction	0.00	0.00	0.00	0.84	0.99
HSI	**0.00**	**0.00**	**0.00**	**0.54**	**0.99**

Table 11: Fox squirrel HSI calculations if 1 inch diameter trees were planted with 35 x 35 foot spacing.

Mitigation Options 4, 10, 16, 22: 1 Inch Diameter, 35x35 Spacing					
Variables Input	**Year 0**	**Year 5**	**Year 15**	**Year 25**	**Year 50**
V_1 (% Canopy Closure of Mast)	0.17	2.07	11.9	40	100
V_2 (Distance to Available Grain, m, 0-800)	1000	1000	1000	1000	1000
V_3 (Average DBH of Overstory, inches, 0-20)	0	0	8	14	25
V_4 (% Tree Canopy Closure)	0	0	11.9	40	100
V_5 (% Shrub Crown Cover)	0.17	2.07	0	0	0
Winter Food	0.03	0.03	0.33	1.03	0.63
Cover/Reproduction	0.00	0.00	0.34	0.95	0.79
HSI	**0.00**	**0.00**	**0.33**	**0.95**	**0.63**

Table 12: Fox squirrel HSI calculations if 1 inch diameter trees were planted with 40 x 40 foot spacing.

Mitigation Options 5, 11, 17, 23: 1 Inch Diameter, 40x40 Spacing					
Variables Input	**Year 0**	**Year 5**	**Year 15**	**Year 25**	**Year 50**
V_1 (% Canopy Closure of Mast)	0.25	1.55	8.93	30	75.93

V_2 (Distance to Available Grain, m, 0-800)	1000	1000	1000	1000	1000
V_3 (Average DBH of Overstory, inches, 0-20)	0	0	8	14	25
V_4 (% Tree Canopy Closure)		0	8.93	30	75.93
V_5 (% Shrub Crown Cover)	0.25	1.55	0	0	0
Winter Food	0.03	0.03	0.26	0.78	0.87
Cover/Reproduction	0.00	0.00	0.31	0.95	0.93
HSI	**0.00**	**0.00**	**0.26**	**0.78**	**0.87**

Table 13: Fox squirrel HSI calculations if 1 inch diameter trees were planted with 45 x 45 foot spacing.

Mitigation Options 6, 12, 18, 24: 1 Inch Diameter, 45x45 Spacing					
Variables Input	**Year 0**	**Year 5**	**Year 15**	**Year 25**	**Year 50**
V_1 (% Canopy Closure of Mast)	0.20	1.26	7.27	24.44	61.87
V_2 (Distance to Available Grain, m, 0-800)	1000	1000	1000	1000	1000
V_3 (Average DBH of Overstory, inches, 0-20)	0	0	8	14	25
V_4 (% Tree Canopy Closure)	0	0	7.27	24.44	61.87
V_5 (% Shrub Crown Cover)	0.2	1.26	0	0	0
Winter Food	0.03	0.03	0.22	0.64	1.01
Cover/Reproduction	0.00	0.00	0.29	0.95	0.99
HSI	**0.00**	**0.00**	**0.22**	**0.64**	**0.99**

Table 14: Values used to estimate the percent of cover from mast producing trees for 5/8 inch diameter trees planted with 35 x 35 foot spacing. Estimates were used for input into the fox squirrel HSI model.

	Spacing	Trees/Acre	Crown Dimensions	Cover/Tree (sf)	Total Cover (sf)/Acre	% Cover Mast/Acre
YR-0	35x35	36	1x1	1	36	0.08
YR-5	35x35	36	3x3	9	324	0.74
YR-15	35x35	36	10x10	100	3600	8.26
YR-25	35x35	36	20x20	400	14400	33.06
YR-50	35x35	36	35x35	1225	44100	101.24

Table 15: Values used to estimate the percent of cover from mast producing trees for 5/8 inch diameter trees planted with 40 x 40 foot spacing. Estimates were used for input into the fox squirrel HSI model.

	Spacing	Trees/Acre	Crown Dimensions	Cover/Tree (sf)	Total Cover (sf)/Acre	% Cover Mast/Acre
YR-0	40x40	27	1x1	1	27	0.06
YR-5	40x40	27	3x3	9	243	0.56
YR-15	40x40	27	10x10	100	2700	6.20
YR-25	40x40	27	20x20	400	10800	24.79
YR-50	40x40	27	35x35	1225	33075	75.93

Table 16: Values used to estimate the percent of cover from mast producing trees for 5/8 inch diameter trees planted with 45 x 45 foot spacing. Estimates were used for input into the fox squirrel HSI model.

	Spacing	Trees/Acre	Crown Dimensions	Cover/Tree (sf)	Total Cover (sf)/Acre	% Cover Mast/Acre
YR-0	45x45	22	1x1	1	22	0.05
YR-5	45x45	22	3x3	9	198	0.45
YR-15	45x45	22	10x10	100	2200	5.05
YR-25	45x45	22	20x20	400	8800	20.20
YR-50	45x45	22	35x35	1225	26950	61.87

Table 17: Values used to estimate the percent of cover from mast producing trees for 1 inch diameter trees planted with 35 x 35 foot spacing. Estimates were used for input into the fox squirrel HSI model.

	Spacing	Trees/Acre	Crown Dimensions	Cover/Tree (sf)	Total Cover (sf)/Acre	% Cover Mast/Acre
YR-0	35x35	36	2x2	4	144	0.17
YR-5	35x35	36	5x5	25	900	2.07
YR-15	35x35	36	12x12	144	5184	11.90
YR-25	35x35	36	22x22	484	17424	40
YR-50	35x35	36	35x35	1225	44100	101.24

Table 18: Values used to estimate the percent of cover from mast producing trees for 1 inch diameter trees planted with 40 x 40 foot spacing. Estimates were used for input into the fox squirrel HSI model.

	Spacing	Trees/Acre	Crown Dimensions	Cover/Tree (sf)	Total Cover (sf)/Acre	% Cover Mast/Acre

YR-0	40x40	27	2x2	4	108	0.25
YR-5	40x40	27	5x5	25	675	1.55
YR-15	40x40	27	12x12	144	3888	8.93
YR-25	40x40	27	22x22	484	13068	30
YR-50	40x40	27	35x35	1225	33075	75.93

Table 19: Values used to estimate the percent of cover from mast producing trees for 1 inch diameter trees planted with 45 x 45 foot spacing. Estimates were used for input into the fox squirrel HSI model.

	Spacing	Trees/Acre	Crown Dimensions	Cover/Tree (sf)	Total Cover (sf)/Acre	% Cover Mast/Acre
YR-0	45x45	22	2x2	4	88	0.20
YR-5	45x45	22	5x5	25	550	1.26
YR-15	45x45	22	12x12	144	3168	7.27
YR-25	45x45	22	22x22	484	10648	24.44
YR-50	45x45	22	35x35	1225	26950	75.93

Table 20: Baseline conditions calculated for the No Action & Future Without Project and each of the mitigation options following procedures in the U.S. Fish and Wildlife Service Ecological Service Manual 102 (USFWS, 1980).

Mitigation Option	Year	Project Area (Acres)	HSI	Cumulative HU	Gross AAHU
No Action & Future Without Project	0	26.47	0.12	NA	NA
Mitigation Option 1	0	5	0.00	NA	NA
Mitigation Option 2	0	5	0.00	NA	NA
Mitigation Option 3	0	5	0.00	NA	NA
Mitigation Option 4	0	5	0.00	NA	NA
Mitigation Option 5	0	5	0.00	NA	NA
Mitigation Option 6	0	5	0.00	NA	NA
Mitigation Option 7	0	7	0.00	NA	NA
Mitigation Option 8	0	7	0.00	NA	NA
Mitigation Option 9	0	7	0.00	NA	NA
Mitigation Option 10	0	7	0.00	NA	NA
Mitigation Option 11	0	7	0.00	NA	NA
Mitigation Option 12	0	7	0.00	NA	NA
Mitigation Option 13	0	9	0.00	NA	NA
Mitigation Option 14	0	9	0.00	NA	NA
Mitigation Option 15	0	9	0.00	NA	NA
Mitigation Option 16	0	9	0.00	NA	NA

Mitigation Option 17	0	9	0.00	NA	NA
Mitigation Option 18	0	9	0.00	NA	NA
Mitigation Option 19	0	11	0.00	NA	NA
Mitigation Option 20	0	11	0.00	NA	NA
Mitigation Option 21	0	11	0.00	NA	NA
Mitigation Option 22	0	11	0.00	NA	NA
Mitigation Option 23	0	11	0.00	NA	NA
Mitigation Option 24	0	11	0.00	NA	NA

Table 21: Cumulative Habitat Units (HU) and Gross Average Annual Habitat Units (AAHU) for target years 0 – 5 calculated for the No Action/Future Without Project and each of the mitigation options following procedures in the U.S. Fish and Wildlife Service Ecological Service Manual 102 (USFWS, 1980).

Mitigation Option	Year	Project Area (Acres)	HSI	Cumulative HU	Gross AAHU
No Action & Future Without Project	5	26.47	0.12	16	0.3
Mitigation Option 1	5	5	0.00	0	0.0
Mitigation Option 2	5	5	0.00	0	0.0
Mitigation Option 3	5	5	0.00	0	0.0
Mitigation Option 4	5	5	0.00	0	0.0
Mitigation Option 5	5	5	0.00	0	0.0
Mitigation Option 6	5	5	0.00	0	0.0
Mitigation Option 7	5	7	0.00	0	0.0
Mitigation Option 8	5	7	0.00	0	0.0
Mitigation Option 9	5	7	0.00	0	0.0
Mitigation Option 10	5	7	0.00	0	0.0
Mitigation Option 11	5	7	0.00	0	0.0
Mitigation Option 12	5	7	0.00	0	0.0
Mitigation Option 13	5	9	0.00	0	0.0
Mitigation Option 14	5	9	0.00	0	0.0
Mitigation Option 15	5	9	0.00	0	0.0
Mitigation Option 16	5	9	0.00	0	0.0
Mitigation Option 17	5	9	0.00	0	0.0
Mitigation Option 18	5	9	0.00	0	0.0
Mitigation Option 19	5	11	0.00	0	0.0
Mitigation Option 20	5	11	0.00	0	0.0
Mitigation Option 21	5	11	0.00	0	0.0
Mitigation Option 22	5	11	0.00	0	0.0
Mitigation Option 23	5	11	0.00	0	0.0
Mitigation Option 24	5	11	0.00	0	0.0

Table 22: Cumulative Habitat Units (HU) and Gross Average Annual Habitat Units (AAHU) for target years 5 – 15 calculated for the No Action/Future Without Project and each of the mitigation options following procedures in the U.S. Fish and Wildlife Service Ecological Service Manual 102 (USFWS, 1980).

Mitigation Option	Year	Project Area (Acres)	HSI	Cumulative HU	Gross AAHU
No Action & Future Without Project	15	26.47	0.12	32	0.6
Mitigation Option 1	15	5	0.00	0	0.0
Mitigation Option 2	15	5	0.00	0	0.0
Mitigation Option 3	15	5	0.00	0	0.0
Mitigation Option 4	15	5	0.33	8	0.2
Mitigation Option 5	15	5	0.26	7	0.1
Mitigation Option 6	15	5	0.22	6	0.1
Mitigation Option 7	15	7	0.00	0	0.0
Mitigation Option 8	15	7	0.00	0	0.0
Mitigation Option 9	15	7	0.00	0	0.0
Mitigation Option 10	15	7	0.33	12	0.2
Mitigation Option 11	15	7	0.26	9	0.2
Mitigation Option 12	15	7	0.22	8	0.2
Mitigation Option 13	15	9	0.00	0	0.0
Mitigation Option 14	15	9	0.00	0	0.0
Mitigation Option 15	15	9	0.00	0	0.0
Mitigation Option 16	15	9	0.33	15	0.3
Mitigation Option 17	15	9	0.26	12	0.2
Mitigation Option 18	15	9	0.22	10	0.2
Mitigation Option 19	15	11	0.00	0	0.0
Mitigation Option 20	15	11	0.00	0	0.0
Mitigation Option 21	15	11	0.00	0	0.0
Mitigation Option 22	15	11	0.33	18	0.4
Mitigation Option 23	15	11	0.26	14	0.3
Mitigation Option 24	15	11	0.22	12	0.2

Table 23: Cumulative Habitat Units (HU) and Gross Average Annual Habitat Units (AAHU) for target years 15 – 25 calculated for the No Action & Future Without Project and each of the mitigation options following procedures in the U.S. Fish and Wildlife Service Ecological Service Manual 102 (USFWS, 1980).

Mitigation Option	Year	Project Area (Acres)	HSI	Cumulative HU	Gross AAHU
No Action & Future Without Project	25	26.47	0.12	32	0.6
Mitigation Option 1	25	5	0.84	21	0.4
Mitigation Option 2	25	5	0.65	16	0.3
Mitigation Option 3	25	5	0.54	14	0.3
Mitigation Option 4	25	5	0.95	32	0.6
Mitigation Option 5	25	5	0.78	26	0.5
Mitigation Option 6	25	5	0.64	22	0.4
Mitigation Option 7	25	7	0.84	29	0.6
Mitigation Option 8	25	7	0.65	23	0.5
Mitigation Option 9	25	7	0.54	19	0.4
Mitigation Option 10	25	7	0.95	45	0.9
Mitigation Option 11	25	7	0.78	36	0.7
Mitigation Option 12	25	7	0.64	30	0.6
Mitigation Option 13	25	9	0.84	38	0.8
Mitigation Option 14	25	9	0.65	29	0.6
Mitigation Option 15	25	9	0.54	24	0.5
Mitigation Option 16	25	9	0.95	58	1.2
Mitigation Option 17	25	9	0.78	47	0.9
Mitigation Option 18	25	9	0.64	39	0.8
Mitigation Option 19	25	11	0.84	46	0.9
Mitigation Option 20	25	11	0.65	36	0.7
Mitigation Option 21	25	11	0.54	30	0.6
Mitigation Option 22	25	11	0.95	70	1.4
Mitigation Option 23	25	11	0.78	57	1.1
Mitigation Option 24	25	11	0.64	47	0.9

Table 24: Cumulative Habitat Units (HU) and Gross Average Annual Habitat Units (AAHU) for target years 25 – 50 calculated for the No Action & Future Without Project and each of the mitigation options following procedures in the U.S. Fish and Wildlife Service Ecological Service Manual 102 (USFWS, 1980).

Mitigation Option	Year	Project Area (Acres)	HSI	Cumulative HU	Gross AAHU
No Action & Future Without Project	50	26.47	0.12	79	1.6
Mitigation Option 1	50	5	0.63	92	1.8
Mitigation Option 2	50	5	0.87	95	1.9

Mitigation Option 3	50	5	0.99	96	1.9
Mitigation Option 4	50	5	0.63	99	2.0
Mitigation Option 5	50	5	0.87	103	2.1
Mitigation Option 6	50	5	0.99	102	2.0
Mitigation Option 7	50	7	0.63	129	2.6
Mitigation Option 8	50	7	0.87	133	2.7
Mitigation Option 9	50	7	0.99	134	2.7
Mitigation Option 10	50	7	0.63	138	2.8
Mitigation Option 11	50	7	0.87	144	2.9
Mitigation Option 12	50	7	0.99	143	2.9
Mitigation Option 13	50	9	0.63	165	3.3
Mitigation Option 14	50	9	0.87	171	3.4
Mitigation Option 15	50	9	0.99	172	3.4
Mitigation Option 16	50	9	0.63	178	3.6
Mitigation Option 17	50	9	0.87	186	3.7
Mitigation Option 18	50	9	0.99	183	3.7
Mitigation Option 19	50	11	0.63	202	4.0
Mitigation Option 20	50	11	0.87	209	4.2
Mitigation Option 21	50	11	0.99	210	4.2
Mitigation Option 22	50	11	0.63	217	4.3
Mitigation Option 23	50	11	0.87	227	4.5
Mitigation Option 24	50	11	0.99	224	4.5

Table 25: Net Average Annual Habitat Units (AAHUs) were calculated for the Future Without Project and each of the mitigation options following procedures in the U.S. Fish and Wildlife Service Ecological Service Manual 102 (USFWS, 1980).

Mitigation Option	Gross Year 0 to Year 50 HU	Gross AAHU	Net AAHU
No Action/Future Without	159	2.65	
Mitigation Option 1	113	2.26	(0.39)
Mitigation Option 2	111	2.23	(0.43)
Mitigation Option 3	109	2.18	(0.47)
Mitigation Option 4	139	2.78	0.13
Mitigation Option 5	136	2.71	0.06
Mitigation Option 6	129	2.58	(0.07)
Mitigation Option 7	158	3.16	0.51
Mitigation Option 8	156	3.12	0.47
Mitigation Option 9	153	3.06	0.41

Mitigation Option 10	195	3.89	1.24
Mitigation Option 11	190	3.80	1.15
Mitigation Option 12	180	3.61	0.96
Mitigation Option 13	203	4.06	1.41
Mitigation Option 14	200	4.01	1.36
Mitigation Option 15	196	3.93	1.28
Mitigation Option 16	250	5.00	2.35
Mitigation Option 17	244	4.88	2.23
Mitigation Option 18	232	4.64	1.99
Mitigation Option 19	248	4.97	2.32
Mitigation Option 20	245	4.90	2.25
Mitigation Option 21	240	4.80	2.15
Mitigation Option 22	306	6.12	3.47
Mitigation Option 23	298	5.97	3.32
Mitigation Option 24	284	5.67	3.02

Selection of the most appropriate mitigation option was then determined through the CE/ICA process using IWR-Planning Suite. An additional criterion for selecting a mitigation option is that it must provide enough AAHUs to meet or exceed the number of AAHUs that would be lost as a result of implementing a particular alternative.

Each of the mitigation options was mutually exclusive from the others. Therefore, no additional permutations or combinations of options were evaluated under CE/ICA. IWR Planning Suite was used to determine which of the options were "cost effective" and which options were "best buys." Cost effective options are those options for which there is no other option that achieves greater output at a lesser cost (identified in Table 26). Best buy options are the array of cost effective options for which the average cost for the *incremental* output is strictly increasing (identified in Table 27). The output used for CE/ICA was the Fox Squirrel AAHU. The cost used for CE/ICA was average annual cost, including the cost of purchasing trees, installation, Preconstruction Engineering and Design (PED), and real estate. In addition to Tables 26 and 27, the results of CE/ICA are also displayed graphically in Figures 1 and 2.

Table 26: Results of IWR Planning Suite cost effective analysis.

Mitigation Option	Total Cost	Average Annual Cost[a]	Fox Squirrel AAHU Gain	Cost Effective?
No Mitigation	$0	$0	0.00	Yes
Mitigation Option 1	$14,802	$689	2.26	Yes

Mitigation Option 2	$13,851	$645	2.23	Yes
Mitigation Option 3	$13,323	$620	2.18	Yes
Mitigation Option 4	$30,483	$1,419	2.78	No
Mitigation Option 5	$25,612	$1,192	2.71	No
Mitigation Option 6	$22,906	$1,066	2.58	No
Mitigation Option 7	$20,722	$965	3.16	Yes
Mitigation Option 8	$19,392	$903	3.12	Yes
Mitigation Option 9	$18,652	$868	3.06	Yes
Mitigation Option 10	$42,676	$1,987	3.89	No
Mitigation Option 11	$35,857	$1,669	3.80	No
Mitigation Option 12	$32,069	$1,493	3.61	No
Mitigation Option 13	$26,643	$1,240	4.06	Yes
Mitigation Option 14	$24,932	$1,161	4.01	Yes
Mitigation Option 15	$23,982	$1,116	3.93	Yes
Mitigation Option 16	$54,870	$2,554	5.00	No
Mitigation Option 17	$46,102	$2,146	4.88	No
Mitigation Option 18	$41,232	$1,919	4.64	No
Mitigation Option 19	$32,564	$1,516	4.97	Yes
Mitigation Option 20	$30,473	$1,419	4.90	Yes
Mitigation Option 21	$29,311	$1,364	4.80	Yes
Mitigation Option 22	$67,063	$3,122	6.12	Yes
Mitigation Option 23	$56,347	$2,623	5.97	Yes
Mitigation Option 24	$50,394	$2,346	5.67	No

Note: IWR – Institute of Water Resources

[a] The average annual cost was determined using an October 2011 price level and the FY 2012 federal interest rate of 4.000% over a 50-year period of analysis.

Table 27: Results of IWR Planning Suite incremental cost analysis.

Mitigation Option	Average Annual Cost	Fox Squirrel AAHU Gain	Best Buy?
No Mitigation	$0	0.00	Yes
Mitigation Option 1	$689	2.26	No
Mitigation Option 2	$645	2.23	No
Mitigation Option 3	$620	2.18	No
Mitigation Option 7	$965	3.16	Yes
Mitigation Option 8	$903	3.12	No
Mitigation Option 9	$868	3.06	Yes
Mitigation Option 13	$1,240	4.06	No

Mitigation Option 14	$1,161	4.01	No
Mitigation Option 15	$1,116	3.93	Yes
Mitigation Option 19	$1,516	4.97	No
Mitigation Option 20	$1,419	4.90	Yes
Mitigation Option 21	$1,364	4.80	Yes
Mitigation Option 22	$3,122	6.12	Yes
Mitigation Option 23	$2,623	5.97	Yes
Mitigation Option 24	$2,346	5.67	No

Note: IWR – Institute of Water Resources

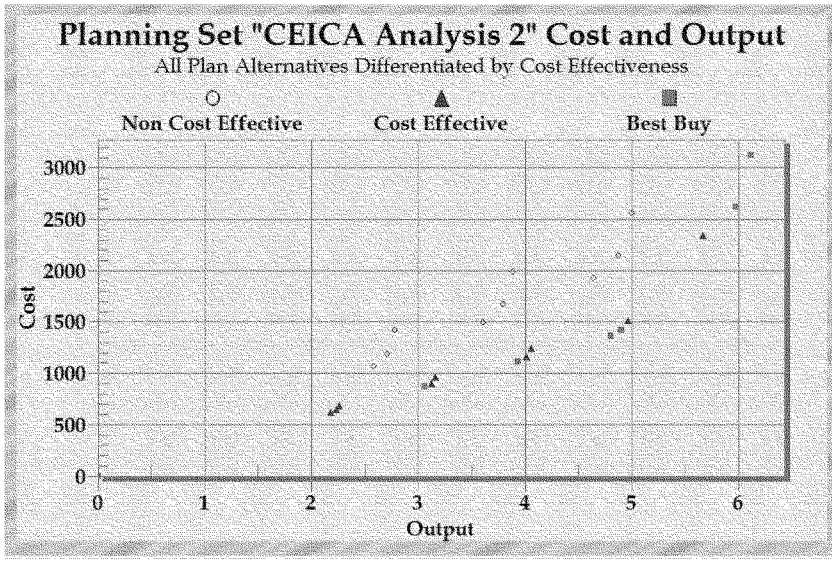


Figure 1: Planning Set "CE/ICA Analysis 2" Cost and Output

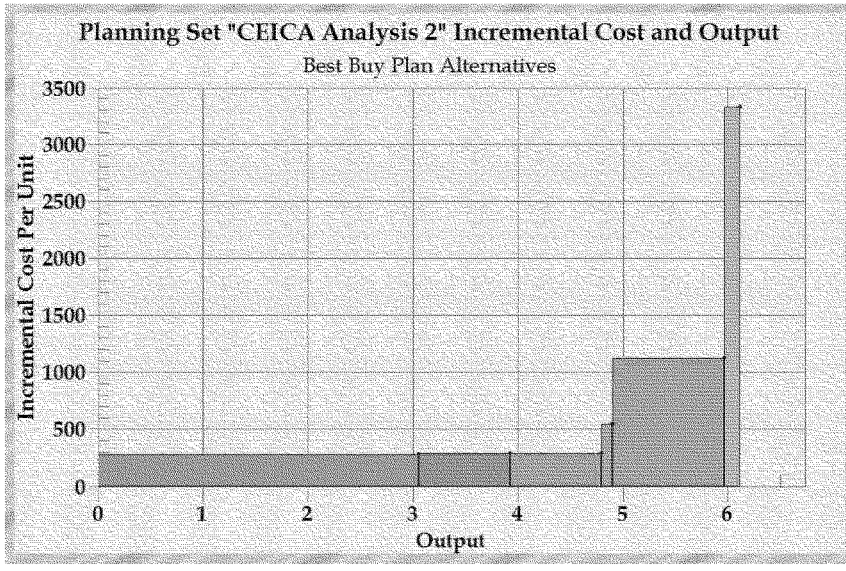


Figure 2: Planning Set "CE/ICA Analysis 2" Incremental Cost and Output

***output is in Average Annual Habitat Units (AAHUs), **each color bar represents a mitigation option alternative**

The criteria for determining which mitigation option(s) would be used in the economic screening were that the option:

1. Is a best buy option as determined by CE/ICA
2. Meets the minimum mitigation requirement for a given alternative
3. Is the lowest-cost option of the options that meet criteria 1 and 2

The best buy options are evaluated for criteria 2 in Table 28. The final results of all criteria are shown in Table 29.

Table 28: Evaluation of Best Buy Options against Minimum Mitigation Requirement

Mitigation Option (Re-ordered by ascending cost and output)	Fox Squirrel AAHU Gain	Meets Minimum Mitigation Requirement for Alt 1 (3.94)	Meets Minimum Mitigation Requirement for Alt 2 (2.74)	Meets Minimum Mitigation Requirement for Alt 3 (4.23)
No Mitigation	0.00	No	No	No
Mitigation Option 9	3.06	No	No	No
Mitigation Option 15	3.93	No	Yes	No
Mitigation Option 21	4.80	Yes	Yes	Yes

Mitigation Option 20	4.90	Yes	Yes	Yes
Mitigation Option 23	5.97	Yes	Yes	Yes
Mitigation Option 22	6.12	Yes	Yes	Yes

Table 29: Mitigation Options and Mitigation Costs Used in Economic Screening

Alternative	Mitigation Option Used in Economic Screening	Total Cost
Alternative 1d: Channel Widening	Mitigation Option 21	$29,311
Alternative 2d: Levees and Floodwalls	Mitigation Option 9	$18,652
Alternative 3d: Combination Widening and Levees and Floodwalls	Mitigation Option 21	$29,311

Based on this analysis, mitigation option 9 would be the selected as an appropriate method to mitigate for impact to the riparian corridor if Alternative 2 is selected. This option would result in planting 5/8 inch diameter trees with 45 x 45 foot spacing over a seven acre area. If Alternative 1 or Alternative 3 is selected, mitigation option 21 would be appropriate. Areas identified for mitigation by the project sponsor are depicted in Figures 3 and 4.

Figure 3: Map Depicting Potential Mitigation Planting Sites.

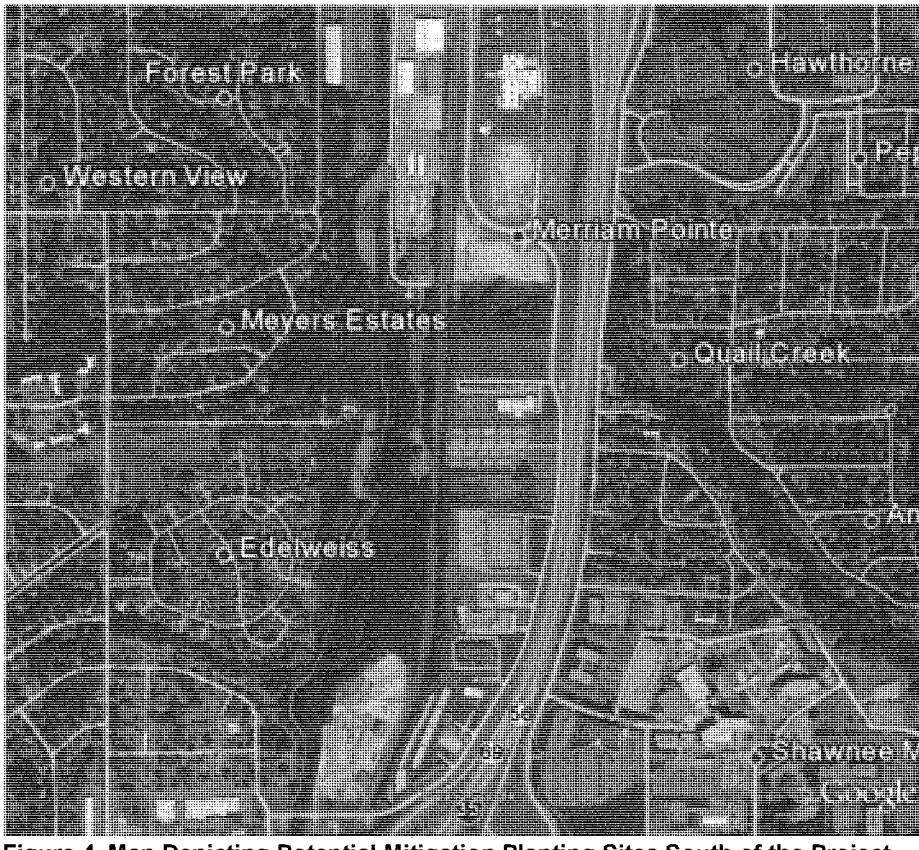


Figure 4. Map Depicting Potential Mitigation Planting Sites South of the Project Area.

VIII. MITIGATION MONITORING AND SUCCESS CRITERIA

The first year following planting the mitigation areas will be monitored under the warranty of the contractor. Following the first year, the project sponsor will be responsible for monitoring the mitigation plantings annually to determine survival and overall health of the plantings. Specific measures will be placed in the O&M plan and given to the sponsor. To be considered successful the survival rate of the planting shall be at least 80% after the end of three years. If the survival rate falls below 80% then either the contractor, if still in the warranty period, or the project sponsor will be required to re-plant the needed number of trees. After 3 years the trees would be considered established. At that point they shouldn't require as much care except in extreme

situations such as drought or disease. If that should occur then the sponsor shall notify the Corps and consult a certified arborist to determine needed treatment. An annual report shall be submitted to the Corps identifying the overall health of the plantings, any issues that need addressed, and actions that have been taken during the year.

Literature Cited

Lee, C.J., Mau, D.P., and Rasmussen, T.J.. 2005. Effects of nonpoint and selected point contaminant sources on stream-water quality and relation to land use in Johnson County, northeastern Kansas, October 2002 through June 2004: U.S. Geological Survey Scientific Investigations Report 2005–5144, 104 p

U.S. Fish and Wildlife Service (USFWS). 1980. Habitat Evaluation Procedures (HEP) ESM 102, 130 p.

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, KANSAS CITY DISTRICT
635 FEDERAL BUILDING
601 E. 12TH STREET
KANSAS CITY, MISSOURI 64106-2824

Finding of No Significant Impact

UPPER TURKEY CREEK
JOHNSON COUNTY AND WYANDOTTE COUNTY, KANSAS
INTEGRATED FEASIBILITY STUDY AND ENVIRONMENTAL ASSESSMENT

The U.S. Army Corps of Engineers, Kansas City District (Corps), has conducted an environmental analysis in accordance with the National Environmental Policy Act of 1969, as amended. The Corps assessed the effects of the following actions in the Final Feasibility Study and Environmental Assessment, dated March 2015 for the Upper Turkey Creek Flood Risk Management Project. The final recommendation is contained in the report of the Chief of Engineers, dated 17 June 2015. These reports are incorporated herein by reference.

PROJECT DESCRIPTION

In addition to the no-action alternative, four alternatives with varying levels of flood risk reduction were evaluated, including the recommended plan. The recommended plan was identified as National Economic Development (NED) plan and is the environmentally preferred alternative. All practicable means to avoid and minimize adverse environmental effects have been incorporated into the recommended plan. The recommended plan would not result in any impacts to federally listed threatened or endangered species or their designated critical habitat; would have no impact to sites listed on or eligible for inclusion on the National Register of Historic Places; and would not significantly affect any wetlands or waters of the U.S., nor any important wildlife habitat.

The recommended plan will result in unavoidable impacts to 3.6 acres of riparian floodplain tree habitat. To mitigate for these unavoidable impacts, the Corps will compensate for the loss by planting 185 hard mast-producing trees over a seven-acre area within the Upper Turkey Creek watershed. Habitat Evaluation Procedures with the fox squirrel habitat suitability index model was utilized to determine needed mitigation for the riparian floodplain trees.

Technical and economic criteria used in the formulation of alternative plans were those specified in the Water Resource Council's 1983 Economic and Environmental Principles for Water and Related Land Resources Implementation Studies. All applicable laws, executive orders, regulations, and local government plans were considered in the evaluation of the alternatives. It is my determination that the

recommended plan does not constitute a major federal action that would significantly affect the human environment; therefore, preparation of an Environmental Impact Statement is not required.

Date: 29 JUN 16

Andrew D. Sexton
Colonel, Corps of Engineers
District Commander

US Army Corps
of Engineers
Kansas City District

U.S. Army Corps of Engineers - Kansas City District

Finding of No Significant Impact

UPPER TURKEY CREEK
JOHNSON COUNTY AND
WYANDOTTE COUNTY KANSAS
FLOOD RISK MANAGEMENT PROJECT

DRAFT

March 2015

DEPARTMENT OF THE ARMY
KANSAS CITY DISTRICT, CORPS OF ENGINEERS
600 FEDERAL BUILDING
KANSAS CITY, MISSOURI 64106-2896

Finding of No Significant Impact

UPPER TURKEY CREEK JOHNSON COUNTY AND WYANDOTTE COUNTY KANSAS FLOOD RISK MANAGEMENT PROJECT

March 2015

DRAFT

Summary

The U.S. Army Corps of Engineers, Kansas City District (USACE), in cooperation with the City of Merriam (local sponsor), conducted a feasibility study to determine the Federal interest in constructing a flood risk management project in the City of Merriam in Johnson County Kansas along Turkey Creek. This feasibility study was conducted under the authority of the Resolution of the Committee on Transportation and Infrastructure, U.S. House of Representatives, Docket 2616, adopted February 16, 2000. The Recommended Plan is a system of levees and floodwalls in the City of Merriam. These features extend approximately from Shawnee Mission Parkway to Merriam Drive, which is a stretch of the creek that flows through downtown Merriam, as well as a commercial and industrial area just south of Johnson Drive. The Recommended Plan includes approximately 6,800 feet of floodwall up to 6.5 feet in height, 3,400 feet of levees up to 6 feet in height, a total of 4,000 feet of storm drainage work, and a 2.14-acre-foot volume detention area.

Alternatives

A total of five alternatives, including the "No-Action" alternative, were evaluated in terms of individual and cumulative effects for the proposed project, which are addressed below.

"No-Action" Alternative: Under the "No-Action" Alternative, no additional flood protection along Turkey Creek in the City of Merriam would be constructed. The areas along Turkey Creek would continue to be susceptible to flooding during large rainfall events.

Alternative 1d – Channel Widening: Channel widening was considered as a flood abatement measure in areas where overbank expansion was available. This alternative would consist of widening the channel to meet the 1-percent annual chance flood event (100-year return interval). Channels would be lined with biostabilization, rip-rap or concrete block measures. Areas that require steeper slopes in excess of 1H:1V would be treated with hardened revetments, such as pre-cast block retaining wall or the local limestone blocking currently used by Merriam Drainage District in the Merriam downtown stream reaches. Bridge modifications were also considered in channel widening alternatives.

Alternative 2d – Levees and Floodwalls (NED/Recommended Plan): This alternative would construct a system of levees and floodwalls along Turkey Creek in the City of Merriam approximately from Shawnee Mission Parkway to Merriam Drive. This alternative would also include modification of storm sewer line, installation of flap gates on drainage structures discharging to the creek, expansion of a pedestrian bridge across the creek, replacement of sewer and water lines crossing Turkey Creek, and a 2.14-acre-foot volume grass detention basin.

Alternative 3d – Combination of Channel Widening and Levees/Floodwalls: This alternative would construct a system of levees and floodwalls along with channel widening and flap gates, modification of storm sewer, and expansion of a pedestrian bridge as discussed under Alternative 2d. Levee and floodwall heights would be considerably lower than those proposed under Alternative 2d as a result of reductions in water surface elevations that would occur due to the channel widening. Rip-rap would be used for stabilization under this alternative.

Alternative 4 – Non-structural Buyout: This alternative would consist of buying at-risk structures and removing them from the floodplain and relocating occupants to another location outside of the floodplain. Once the structures are removed the area would be considered for restoration.

Summary of Environmental Impacts

The Recommended Plan would help reduce flood risk to structures along Turkey Creek in the City of Merriam, Kansas. The Recommended Plan would not adversely impact any Federally-listed threatened or endangered species or their habitats. Approximately 1,000 cubic yards of clean rip-rap would be placed below the ordinary high water mark along several reaches of Turkey Creek. The limestone revetment blocks currently in these locations would be removed and replaced by the rip-rap for a net balance of fill below the ordinary high water mark following construction. No wetlands would be impacted by the proposed project. Approximately 3.6 acres of trees would be removed for construction of the levees/floodwalls. These trees, located along the riparian corridor, are mostly in manicured turf grass, park-like settings that are immediately adjacent to the creek. This would create a minor long-term impact to wildlife. Mitigation for these impacts is described below. There would be a positive impact to safety and economics from decreasing the flood risk adjacent to the channel. There would be

temporary construction-related impacts including noise, soils, and water quality, which would subside after construction is complete. There would likely be no impact to cultural or historic resources.

Mitigation Measures

The Recommended Plan would result in 3.6 acres of riparian floodplain trees being removed during construction. To compensate for the loss, 185 hard mast producing trees would be planted over a 7-acre area within the Upper Turkey Creek watershed. Habitat Evaluation Procedures (HEP) with the Fox Squirrel habitat suitability index (HSI) model was utilized to determine needed mitigation for the riparian floodplain trees. The Green Sunfish HSI was utilized to determine the effect on aquatic habitat. No long-term adverse impacts to aquatic habitat were projected for the Recommended Plan; therefore, no mitigation is warranted or suggested for aquatic habitat.

Public Involvement

A public workshop was held on July 25, 2001, at the Merriam City Hall to explain to the public the scope of the Reconnaissance Study. On July 17, 2003, a Turkey Creek Awareness Workshop was held at the Antioch Public Library in Shawnee Mission, Kansas, to explain the ongoing activities of local, state and Federal organizations and discuss future management of Turkey Creek. A Concepts Workshop was held on September 16, 2004, to present and discuss preliminary concepts for flood risk management. The final project alternatives were presented to the public at an October 19, 2011 meeting at the Community Center in the City of Merriam. USACE circulated a Notice of Availability (Notice) on June 27, 2013 for the Feasibility Report with Integrated Environmental Assessment (EA) and Draft Finding of No Significant Impact (FONSI). The thirty-day comment period was extended for the public and resource agencies to have a closing date of August 21, 2013. The Notice was e-mailed to individuals, agencies, and businesses listed on the USACE Regulatory mailing list. The Feasibility Report/EA and Draft FONSI were also made available on the USACE webpage and hard copies were provided on request. A public meeting was held in conjunction with the open comment period on August 14, 2013, at the Merriam City Hall to detail the Recommended Plan and take comments on the draft Feasibility Report with Integrated Environmental Assessment. All comments received during the public review period were addressed. Comments were received during the public review period from the following entities: Kansas State Historic Preservation Officer, Kansas Department of Wildlife, Parks, and Tourism, U.S. Environmental Protection Agency, U.S. Fish & Wildlife Service, and a letter signed by two private citizens. There were no comments that required reevaluation of the alternatives, identification of a new Recommended Plan, or a critical change to the impact analysis. Copies of the substantial comments from the letters and USACE responses can be found in Chapter 8 of the Main Feasibility Report. The actual letters can be found in Appendix H.

Conclusion

After evaluating the anticipated environmental, economic, and social effects of the proposed activity, it is my determination that construction of the proposed project does not constitute a major Federal action that would significantly affect the quality of the human environment; therefore, preparation of an Environmental Impact Statement is not required.

Date: _____ _____

Andrew D. Sexton
Colonel, Corps of Engineers
District Commander

DRAFT

Appendix O
Mitigation Plan

Mitigation Plan

Upper Turkey Creek

Johnson and Wyandotte Counties, Kansas

Flood Risk Management Project

Description of the Mitigation

The proposed project would result in a loss of 3.6 acres of tree canopy cover. These trees are mostly mast producing trees with a manicured grass understory. The model that best met this habitat type was the Habitat Evaluation Procedures (HEP) Fox Squirrel Habitat Suitability Index (HSI) model. Applying the Fox Squirrel model to the preferred alternative resulted in a loss of 2.7 Average Annual Habitat Units (AAHU) over the life of the project. The mitigation that most closely matched the habitat loss is the planting of hard mast trees such as oaks, walnut, and pecans in open areas within the watershed.

Twenty-four mitigation options were developed for evaluation utilizing the IWR-Planning Suite, Cost Effectiveness (CE)/Incremental Cost Analysis (ICA) process. Variables in the options included the size of tree to be planted, the density of the planting, and the number of acres to be planted. The CE/ICA indicated that the option that best met the number of AAHU's needed for the most cost effective value was the planting of 185 hard mast producing 5/8th inch caliper seedlings over a 7 acre area.

Type, Amount, and Characteristics of the Habitat being Restored

The project is in a highly urbanized area containing mostly commercial/industrial buildings very near the creek, along with several park areas. Due to the highly developed nature of the area, most of the remaining trees are located in areas with little underbrush and a manicured grass understory. The canopy is relatively open. The proposed project would remove approximately 3.6 acres of tree canopy cover from mostly mast producing trees, resulting in a net loss of 2.7 AAHUs.

To mitigate for this lost habitat, 185 hard mast producing trees (oaks, walnut, pecan, etc,) with an initial size of 5/8-inch caliper diameter will be planted within the watershed. Trees will be planted over a 7 acre area that is currently open and devoid of trees. The seedlings will be on approximately 45 foot centers creating a semi-open canopy when matured. The city owns several park areas located near Upper Turkey Creek that could be used for this mitigation.

Ecological Success Criteria

To be considered successful the survival rate of the plantings should be at least 80% after 3 years following planting. If, at any time within the first 3 years the survival rate falls below 80%, then the trees must be replaced with like trees. After 3 years the trees will be considered significantly established enough to ensure long-term survival. The habitat being created is designed to provide habitat for fox squirrel, however, all animals within the area should benefit by the plantings.

Monitoring

The first year following planting the mitigation areas will be monitored under the warranty of the contractor. Following the first year, the project sponsor and USACE will be responsible for monitoring and documenting success of the trees until the success criteria have been met. If the survival rate falls below 80%, then the trees must be replaced with like trees using project funds. After 3 years the trees will be considered established to ensure long-term survival. Specific measures detailing the monitoring procedures and timing will be placed in the O&M plan and given to the sponsor. A report should be prepared annually until ecological success has been determined that that details when the survey was done, and who did the survey (including their expertise), overall survival rate of the plantings, overall health of the trees, and recommendations, if any, to improve the health and survivability of the plants. If the survival rate has fallen below 80%, then a brief outline of the number and species of trees to be replanted, and the schedule for when the replanting will occur.

Contingency Plan (Adaptive Management)

The trees will be overplanted by approximately 20% with the expectation that not all of the trees will survive. This percentage is based on experience from other similar projects within the District. If during the first year following planting the survival rate falls below the 80% survival rate, the contractor shall replant like trees.. The contractor will not be released from the warranty until such action is accomplished. Until the ecological success criteria have been met, the project sponsor and USACE will be responsible for replacing trees that have not survived. During periods of prolonged drought, the trees may be watered to improve survival rates. Any problems with insects or disease will be dealt with on a case by case basis with input from appropriate experts/agencies as needed.

Lands

A total of 7 acres of land within the Upper Turkey Creek watershed that are currently lacking trees are required to establish the mitigation planting area. The city currently owns several park areas on or near the project area that contains potential planting

sites. A map depicting the potential sites can be found in Figures 3 and 4 of the Compensatory Mitigation Determination, Appendix M. A total of 18 park areas consisting of approximately 10 acres of suitable area is currently available for mitigation plantings.