MILL CREEK FLOOD RISK MANAGEMENT STUDY, NASHVILLE, TENNESSEE FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT

COMMUNICATION

FROM

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

TRANSMITTING

THE DEPARTMENT'S MILL CREEK FLOOD RISK MANAGEMENT STUDY, NASHVILLE, TENNESSEE FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT FOR MARCH 2016

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

MAR 17 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 the resolutions by the Committee on Transportation and Infrastructure of the United States House of Representatives adopted September 4, 1995 and December 7, 2005, the Secretary of the Army supports the authorization and construction of the Mill Creek Flood Risk Management project in Davidson County and the City of Nashville, Tennessee. The proposal is described in the report of the Chief of Engineers, dated October 16, 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 on Mill Creek. The recommended plan is the National Economic Development (NED) plan and includes constructing a 377-acre-foot capacity storm water detention basin at mile 3.67 on Sevenmile Creek, modifying the Briley Parkway bridge and widening the Mill Creek channel at mile 7.1, raising nine residential structures in-place above the 1-percent chance flood elevation, and purchasing and removing 80 frequently damaged residential structures located in the regulated floodway of Mill Creek and its tributaries.

The purchase and removal of frequently damaged structures will, to the extent practicable, be implemented on a willing seller basis; however, eminent domain by the non-Federal sponsor will be utilized when determined to be warranted. Acquisition of structures for removal will comply with the provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act (P.L. 91-646), as amended, and the uniform regulations contained in 49 Code of Federal Regulations, Part 24, including the provision of payment of relocation assistance benefits to eligible recipients.

Based on October 2015 (FY 2016) price levels, the estimated project first cost of the NED plan, which includes both structural and nonstructural flood risk management features, is $28,785,000 which includes pre-construction engineering and design costs of $1,352,000. The project first costs are allocated to structural flood risk management and nonstructural flood risk management components at a cost of $9,433,000 and $19,352,000 respectively. The total cost of lands, easements, rights-of-way, relocations, and disposal areas (LERRD) is estimated at $20,685,000. This amount includes $3,605,000 allocated to structural project features and $17,080,000 associated with nonstructural project features. Because the non-structural LERRDs are greater than the non-Federal cost share, the sponsor would be reimbursed for an amount currently estimated at $10,307,000. LERRDs for the structural component are 100 percent non-Federal sponsor cost. Additionally, the sponsor is required to pay a minimum 5% cash ($471,000) on the structural component. The Federal share of the total project cost of the structural and nonstructural flood risk management features would be about $17,935,000 (62 percent) and the non-Federal share would be about $10,850,000 (38 percent) overall.

The City of Nashville Metro Water Services, representing the Metropolitan Government of Nashville and Davidson County, is the non-Federal cost-sharing sponsor for all flood risk management features. The non-Federal sponsor would be responsible for operation, maintenance, repair, replacement and rehabilitation (OMRR&R) of the project after construction, at an estimated average annual cost of $52,000.

Based on FY 2016 price levels, a discount rate of 3.125 percent, and a 50-year period of economic analysis, the total equivalent annual costs of the project are estimated to be $1,197,000 including OMRR&R. Implementing the NED plan will reduce expected average annual flood damages by about 50 percent. Equivalent annual residual damages are estimated at $3,070,000. The equivalent annual benefits are estimated to be $2,390,000 with net average annual benefits of $1,193,000. The benefit-to-cost ratio is approximately 2.0 to 1.

An Environmental Assessment and Finding of No Significant Impact were prepared in accordance with the National Environmental Policy Act and the recommended plan has been identified as the environmentally preferred plan. The recommended plan will not result in any significant direct or indirect impacts, causing only minimal and temporary adverse impacts during construction to water quality, aquatic resources, terrestrial resources, socioeconomics, noise, navigation, recreation and scenic resources. Therefore, no compensatory mitigation is required. A final Biological Opinion (BO) was received from the United States Fish and Wildlife Service on March 23, 2015, and states that the preferred alternative would not likely jeopardize the continued existence of the Nashville crayfish with the implementation of the BO.

An Independent External Peer Review (IEPR) was completed by Battelle Memorial Institute. The IEPR panel consisted of four members with expertise in economics and civil works planning, environmental review and environmental policy, hydrologic and hydraulic engineering, and geotechnical and structural engineering. All IEPR review comments have been resolved.

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 March 7, 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

5 Enclosures

1. OMB Clearance letter, dated March 7, 2016
2. Finding of No Significant Impact, dated March 14, 2016
3. Chief's Report, October 16, 2015
4. State and Agency review letters
5. Final Integrated Feasibility Report and Environmental Assessment, July 2015, Mill Creek Flood Risk Management Study, Nashville, Tennessee (CD)

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

March 7, 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 November 2015 Army Corps of Engineers Final Feasibility Report and Environmental Assessment recommending a flood risk management project on the Mill Creek watershed in Nashville and Davidson County, Tennessee. According to the report, the proposed project includes both structural and non-structural measures to reduce the risk of flooding in the Mill Creek watershed. Based on our review of the Corps' report, 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 your submitting this report to Congress. When you do so, please advise the Congress that should the Congress authorize this project for construction, the project would need to compete with other proposed investments for funding in future budgets.

Sincerely,

John Rasquantino
Deputy Associate Director
Energy, Science, and Water

U.S. ARMY CORPS OF ENGINEERS
NASHVILLE DISTRICT

FINDING OF NO SIGNIFICANT IMPACT

Mill Creek Flood Risk Management Study
Integrated Feasibility Report and Environmental Assessment
Nashville, Tennessee

The U. S. Army Corps of Engineers, Nashville District (Corps) has conducted an environmental analysis in accordance with the National Environmental Policy Act of 1969, as amended. The Corps addressed the effects of the recommended plan in the Final Integrated Feasibility Report and Environmental Assessment (IFR/EA), dated July 2015, for the Mill Creek Flood Risk Management Study, Nashville, Davidson County, Tennessee, which is incorporated herein by reference. The purpose of the study is to analyze potential solutions for the flooding problems within the Mill Creek watershed. The recommended plan includes the following actions:

- Construct a 377-acre-foot capacity storm water detention basin at mile 3.67 on Sevenmile Creek;
- Modify the Briley Parkway bridge and widen the Mill Creek channel at mile 7.1;
- Raise nine residential structures in-place above the 1-percent change flood elevation; and,
- Purchase and remove 80 frequently damaged residential structures located in the regulated floodway of Mill Creek and its tributaries.

2. In addition to the "no action" alternative, a wide variety of flood risk management measures were developed that would address one or more of the planning objectives. The recommended plan, Plan BDA, was ultimately determined to be the National Economic Development (NED) Plan and the environmentally-preferred alternative. The NED plan provides the greatest net benefits of any of the considered alternatives. The recommended plan also leaves considerably less residual risk in the floodplain than other plans in the final array.

3. All practicable means to avoid and minimize adverse environmental effects have been incorporated into the recommended plan. The recommended plan will not result in any significant direct or indirect impacts, causing only minimal and temporary adverse impacts during construction to water quality, aquatic resources, terrestrial resources, socioeconomics, noise, navigation, recreation and scenic resources. Therefore, no compensatory mitigation is required.

4. Due to potential impacts to the Nashville crayfish the Corps entered into formal consultation with U.S. Fish and Wildlife Service (USFWS). A Biological Assessment was sent to USFWS on August 28, 2014. A final Biological Opinion (BO) was received from USFWS on March 23, 2015. The USFWS' BO states that the preferred alternative would not likely jeopardize the continued existence of the Nashville crayfish with the implementation of the BO.

5. Section 106 of the National Historic Preservation Act (NHPA) of 1966, as amended, was initiated with the State Historic Preservation Office (SHPO), American Indian Tribes with an ancestral connection to Davidson County, Metropolitan Nashville and Davidson County Historical Commission, and other consulting parties on February 14, 2013. In a letter dated February 11, 2015, SHPO concurred with the Corps determination that "the project will not adversely affect any property that is eligible for listing in the National Register." Section 106 of the NHPA concluded with a "no adverse effect to historic properties" determination.

6. Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations, was signed on February 11, 1994. The order requires Federal agencies to promote "nondiscrimination in Federal programs substantially affecting human health and the environment." The Corps documented no disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority and low-income populations. The proposed action is in compliance with Executive Order 12898 for Environmental Justice.

7. I have reviewed the final IFR/EA and the public and agency comments, in light of the general public interest. Technical and economic criteria used in the formulation of alternative plans were those specified in the Water Resource Council's 1983 <u>Economic and Environmental Principles for Water and Related Land Resources Implementation Studies.</u> 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.

14-MAR-16
DATE

Stephen F. Murphy
Lieutenant Colonel, U.S. Army
District Commander

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

DAEN

OCT 1 6 2015

SUBJECT: Mill Creek Flood Risk Management Study, Nashville, Tennessee

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on managing flood risk along Mill Creek, Nashville, Tennessee. It is accompanied by the report of the district and the division engineers. These reports partially respond to resolutions of the U.S. House of Representatives Committee on Transportation and Infrastructure, adopted September, 4, 1995 and December 7, 2005. These resolutions requested the Secretary of the Army to review pertinent reports on the Cumberland River and its tributaries to determine whether any modifications of the recommendations contained therein are advisable in the interest of environmental restoration and protection, flood damage reduction, enhancement and control of water quality, stream bank protection, regional water systems, recreation, greenways, and other watershed management improvements. Preconstruction engineering and design activities would continue under the authority of the September 4, 1995 and December 7, 2005 resolutions.

2. The reporting officers recommend authorizing a National Economic Development (NED) plan of structural and nonstructural features to manage flood risks along Mill Creek and its tributaries. The NED plan includes constructing a 377-acre-foot capacity storm water detention basin at mile 3.67 on Sevenmile Creek, modifying the Briley Parkway bridge and widening the Mill Creek channel at mile 7.1, raising nine residential structures in-place above the 1-percent chance flood elevation, and purchasing and removing 80 frequently damaged residential structures located in the regulated floodway of Mill Creek and its tributaries. The purchase and removal of frequently damaged structures will, to the extent practicable, be implemented on a willing seller basis; however, eminent domain will be utilized when determined to be warranted. Acquisition of structures for removal will comply with the provisions of the Uniform Relocations Assistance and Real Property Acquisition Policies Act (P.L. 91-646), as amended, and the uniform regulations contained in 49 Code of Federal Regulations, Part 24, including the provision of payment of relocation assistance benefits to eligible recipients. The recommended plan would not have significant adverse effects; consequently, no mitigation measures, beyond best management practices and avoidance, or compensation measures would be required. All features are located in Nashville, Tennessee.

DAEN
SUBJECT: Mill Creek Flood Risk Management Study, Nashville, Tennessee

3. The City of Nashville Metro Water Services, representing the Metropolitan Government of Nashville and Davidson County, is the non-federal cost-sharing sponsor for all flood risk management features. Based on October 2014 price levels, the estimated project first cost of the NED plan, which includes both structural and nonstructural flood risk management features is $28,504,000. This amount includes $9,342,000 allocated to structural flood risk management and $19,162,000 associated with a nonstructural flood risk management program. The total cost of lands, easements, rights-of-way, relocations, and disposal (LERRD) is estimated at $20,482,000. This amount includes $3,571,000 allocated to structural project features and $16,912,000 associated with nonstructural project features. In accordance with the cost sharing provisions of Section 103 of the Water Resources Development Act (WRDA) of 1986, as amended by Section 202 of WRDA 1996, the federal share of the project first cost of the structural and nonstructural flood risk management features would be about $5,304,000 (56.8 percent) and $12,455,000 (65 percent), respectively, and $17,759,000 (62 percent) overall. The non-federal share of the first costs of the structural and nonstructural flood risk management features would be about $4,038,000 (43.2 percent) and $6,707,000 (35 percent), respectively, and $10,745,000 (38 percent) overall. The City of Nashville Metro Water Services will be responsible for the operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the project after construction, a cost currently estimated at about $52,000 per year.

4. Based on a 3.375-percent discount rate and a 50-year period of economic evaluation, the total equivalent annual costs of the project are estimated to be $1,251,000 including OMRR&R. The equivalent annual benefits are estimated to be $2,390,000 with net average annual benefits of $1,139,000. The benefit-cost ratio is approximately 1.9 to 1. Implementing the NED plan will reduce expected average annual flood damages by about 44 percent. Equivalent annual residual damages are estimated at $3,070,000.

5. In accordance with the current Engineer Circular on review of decision documents, all technical, engineering and scientific work underwent an open, dynamic and vigorous review process to ensure technical quality. This included District Quality Control, Agency Technical Review, Policy and Legal Compliance Review, Cost Engineering Mandatory Center of Expertise Review and Certification, Independent External Peer Review (IEPR), and the review and approval of technical models. The IEPR was completed by Battelle Memorial Institute. The IEPR panel consisted of four members with expertise in economics and civil works planning, environmental review and environmental policy, hydrologic and hydraulic engineering, and geotechnical and structural engineering. The review panel identified and documented 14 final comments. Of these, one comment was designated as having high significance, three as having medium-to-high significance, seven as having medium significance, and three as having medium-to-low significance. All IEPR review comments have been resolved. There

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SUBJECT: Mill Creek Flood Risk Management Study, Nashville, Tennessee

have been no significant changes to the plan formulation, engineering assumptions, and environmental analyses that supported the decision-making process and plan selection. All comments from the above referenced reviews will be addressed and incorporated into the final documents as appropriate. A safety assurance review (Type II IEPR) of the structural flood risk management components of the project will be conducted during the design phase of the project.

6. Washington level review indicates that the plan recommended by the reporting officers is technically sound, environmentally and socially acceptable, and on the basis of congressional directives, 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. The recommended plan complies with other Administration and legislative policies and guidelines. The views of interested parties, including federal, state and local agencies have been considered.

7. I concur with the findings, conclusions, and recommendations of the reporting officers. Accordingly, I recommend that the plan to reduce flood damages along Mill Creek and its tributaries at Nashville, Tennessee be authorized in accordance with the reporting officers' recommended plan at an estimated project first cost of $28,504,000 with such modifications as in the discretion of the Chief of Engineers may be advisable. 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, as amended, 33 U.S.C. § 2213. The non-federal sponsors will provide the non-federal cost share and all LERRD. Further, the non-federal sponsors will be responsible for all OMRR&R. This recommendation is subject to the non-federal sponsors agreeing to comply with all applicable federal laws and policies, including but not limited to:

a. Provide 35 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work;

b. Provide a minimum of 35 percent, but not to exceed 50 percent of total structural flood risk management costs as further specified below:

(1) Provide, during the first year of construction, any additional funds necessary to pay the full non-federal share of design costs allocated by the government to the structural flood risk management features;

(2) Provide, during construction, a contribution of funds equal to 5 percent of total structural flood risk management costs;

(3) Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the government to be required or to be necessary for the construction, operation, and maintenance of the structural flood risk management features;

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

c. Provide 35 percent total nonstructural flood risk management costs as further specified below:

(1) Provide, during the first year of construction, any additional funds necessary to pay the full non-federal share of design costs allocated by the government to the nonstructural flood risk management features;

(2) 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 nonstructural flood risk management features;

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

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

e. Agree to participate in and comply with applicable federal floodplain management and flood insurance programs.

f. Comply with Section 402 of the WRDA 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 partnership agreement, and to implement such plan not later than one year after completion of construction of the project.

DAEN
SUBJECT: Mill Creek Flood Risk Management Study, Nashville, Tennessee

g. 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.

h. 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.

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. 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.

k. 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.

l. 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.

m. 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.

8. 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 or 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, interested federal agencies, and other parties will be advised of any significant modifications and will be afforded an opportunity to comment further.

THOMAS P. BOSTICK
Lieutenant General, USA
Chief of Engineers

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

June 30, 2015

Mr. Russ L. Rote, PE, PMP, CFM
Chief, Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
801 Broadway
Nashville, Tennessee 37203

RE: Final Feasibility Report and Environmental Assessment for the Mill Creek Flood Risk Management Study, Nashville, Tennessee

Dear Mr. Rote:

The U.S. Environmental Protection Agency (EPA) has reviewed the above reference document consistent with the National Environmental Policy Act (NEPA) Section 102(2)(C) and the Clean Air Act (CAA) Section 309. The U.S. Army Corps of Engineers (COE) proposes to take both structural and non-structural floodplain control measures to address future potential flooding in the Mill Creek watershed which is located in Nashville, Tennessee. The COE identified and documented past flooding issues in the Final Feasibility Report and Environmental Assessment (FFR/EA) due to historic encroachment into the floodplain.

The FFR/EA included the discussion of the process of developing various flood risk management measures that would address one of more of the planning objectives. The two main objectives of the FFR/EA are to reduce residual risk to life and property and increase flood attenuation opportunities and restore riparian and floodplain connectivity in the Mill Creek watershed. Twelve (12) plans that included one or more of the management measures were developed and then further evaluated for cost efficiency and flood risk reduction effectiveness to a final evaluation of five (5) plans. The COE has identified Plan 'BDA' as the National Economic Development (NED) plan. Plan BDA includes the Ellington Detention (basin), Briley Bridge and Channel Modifications and Non-structural elements.

The three primary elements of the Plan BDA include the construction of a detention basin at Sevenmile Creek that targets a 25-year flood, bridge and channel modifications at Briley Parkway for a 50-year flood event, and a buyout and removal or raise in place of numerous residential buildings located in the 5-year floodplain. Based upon the information contained in the FFR/EA, there are minimal impacts to the jurisdictional wetlands and streams. An estimated 0.05 acres of wetlands impact are associated with the construction of the Ellington Detention Basin. No compensatory mitigation for this impact is required.

The Nashville Crayfish (*Orconectes shoupi*) is an endangered species that is located in the project area and could potentially be effected by channel modifications at Briley Parkway. The COE submitted a Biological Assessment to the U.S. Fish and Wildlife Service (FWS) in August of 2014 and the FWS issued a draft Biological Opinion with the COE's receipt on February 6, 2015. The FWS determined that the proposed project would not likely jeopardize the continued existence of the Nashville Crayfish and provided 'reasonable and prudent measures' as well as other 'terms and conditions' for the proposed project.

For the non-structural element of the Plan BDA, the COE is recommending the 'NS-12' alternative which includes the removal or raise in place of residential structures damaged by the +5-year flood event. This alternative would include 89 residential structures that removes approximately $1.75 million in expected annual damages. The COE evaluated the non-structural residential part of the proposed project in consideration of the Executive Order 12898 on Environmental Justice (Page 142 of the FFR/EA). The COE has concluded that the proposed project will not have a disproportionate, adverse impact on low-income and minority populations. The COE indicates that the overall effect of the project on the community will be a positive one since lower-income residents are more impacted by flooding events due to the average costs of housing within the project study area compared to other areas in Nashville. The COE is proposing full market value for these houses and relocation assistance. No specific neighborhood or community is expected to be effected and the non-structural plan used the 5-year floodplain elevation for determining which residences would be removed or raised in place. EPA requests that specific documentation regarding the percentages of low-income and minority residences from the 89 total (9 raise in place and 80 fee simple acquisition) to be effected compared to county statistics are included in the Finding of No Significant Impact/Chief's Report.

In summary, EPA concurs with the COE that its preferred Plan BDA represents a balanced and environmentally-sound alternative for addressing long-term concerns for flooding in the Mill Creek watershed. EPA requests a copy of the Finding of No Significant Impact/Chief's Report when it becomes available. Thank you for the opportunity to review the FFR/EA and please address any comments to Mr. Christopher Militscher of my staff at 404-562-9512 or Militscher.chris@epa.gov.

Sincerely,

Heinz J. Mueller, Chief
NEPA Program Office
Resource Conservation and Restoration Division

XVIII

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, D.C. 20314-1000

OCT 23 2015

Heinz J. Mueller
Chief NEPA Program Office
United States Environmental Protection Agency
Region IV
61 Forsyth Street
Atlanta, Georgia 30303-8960

Dear Mr. Mueller:

Thank you for providing a detailed review of the Mill Creek, Tennessee Integrated Feasibility Report and Environmental Assessment. Your comments are appreciated and have been considered in the final report.

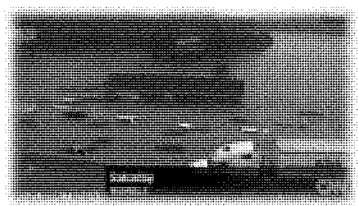
Through the Civil Works Flood Risk Management Program, the Corps manages flood risks while balancing the benefits and costs to the nation. As stated in your letter, the report recommendation represents a balanced and environmentally-sound alternative for addressing long-term concerns for flooding in the Mill Creek watershed.

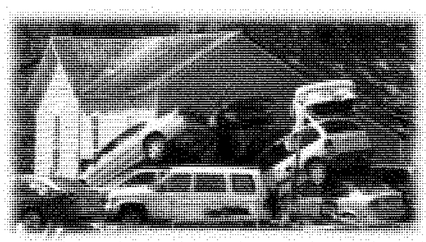
With regard to the implementation of the non-structural plan, your office requested that additional information be added to the Finding of No Significant Impact / Chief's Report describing the background of the residences within the recommended plan. To address this request, additional information has been added to the Finding of No Significant Impact discussion of Executive Order 12898. Further details are provided in the Final Report in section 7.10.

Once this project is authorized by Congress, we look forward to continuing to coordinate with EPA to ensure that project implementation meets Federal flood risk management goals.

THEODORE A. BROWN, P.E.
Chief, Planning and Policy Division
Directorate of Civil Works

Mill Creek Flood Risk Management Study
Nashville, Tennessee





Final Feasibility Report & Environmental Assessment

November 30, 2015

US Army Corps
of Engineers
Nashville District

Executive Summary

Study Information – The purpose of this report is to analyze potential solutions for the flooding problems in the Mill Creek watershed, Nashville, Tennessee. The report documents a Federal interest in implementation of structural and non-structural measures. This report has been prepared in response to the study authorization contained in the US House Committee on Transportation and Infrastructure resolution adopted September 14, 1995. The report presents the flood risk management problems and opportunities within the Mill Creek watershed as well as the measures and alternatives considered to reduce damages within the region. The economic analysis for each management measure and alternative is documented and a tentatively selected plan is recommended. The study was conducted in conjunction with the Metropolitan Government of Nashville and Davidson County (Metro) serving as the non-Federal sponsor, and the U.S. Army Corps of Engineers (Corps).

Problem – The City of Nashville experiences damages from flash floods due to historic encroachment into the floodplain. This encroachment causes a loss of flood storage capacity and insufficient flow capacity or flow restrictions along Mill Creek and its tributaries. The area along Mill Creek is heavily urbanized and includes extensive infrastructure associated with commercial, industrial, and residential developments. As the loss of floodplain storage in the watershed continues to increase, each major flood will incur damages to a larger number of structures resulting in a larger economic impact to the region.

Objectives – The objective of the study is to reduce flood risk and improve the overall quality of life for the residents of Nashville, Tennessee and surrounding communities. The planning objectives are as follows:

- Reduce residual risk to life and property in the Mill Creek watershed
- Increase flood attenuation opportunities and restore riparian and floodplain connectivity in the Mill Creek watershed

Plans Considered – A wide variety of fifty-one flood risk management measures were developed that would address one or more of the planning objectives. These measures were then screened for efficiency and acceptability and combined into alternative plans. Twelve plans that included one or more of the management measures were developed. The twelve plans were evaluated for cost efficiency and flood risk reduction effectiveness. Ultimately, a final array of five plans was developed.

Recommended Plan – The National Economic Development (NED) Plan is the plan that provides the greatest net benefits. Plan BDA, Ellington Detention, Briley Bridge and Channel Modifications and Non-Structural Plan, provides the greatest amount of net benefits. Plan BDA also leaves considerably less residual risk in the floodplain than other plans in the final array.

- Plan BDA maximizes net annual benefits and provides significant residual risk reduction while being cost effective. Plan BDA includes a detention basin at Sevenmile Creek targeting moderate flooding, 1/25 ACE or 25 year flood. Damage reduction is realized up to the 1/500 ACE or 500-year flood. The plan includes bridge and channel modifications at Briley Parkway targeting major flood damages, 1/50 ACE or 50 year event, while realizing significant damage reductions up to the 1/500 ACE or 500 year flood. The plan also combines these structural components with the buyout and removal or raise in place of residential buildings located in the 1/5 ACE or 5-year floodplain. The recommended plan has the potential to remove nearly half of the expected annual damages associated with Mill Creek and tributary flooding.

Project Impacts – Due to the highly developed, urban environment of the project footprint, the resulting environmental impacts for most components of the selected plan are minimal. The Ellington Detention Basin would have minimal impacts to an existing wetland (approximately 0.05 acre permanent impact/0.05 acre temporary impact) and the removal and replacement of the existing bridge at this location. The proposed project, Plan BDA, impacted wetland acreage of 0.05 permanent impacts was minimized and requires no compensatory mitigation per Tennessee Department of Environment and Conservation (TDEC) and Department of the Army (DA) Regulatory requirements. In addition the project meets both Sections 404 (Corps Nationwide Permit 18 – Minor Discharge) and 401 (TDEC General Permit of Minor Alterations to Wetlands) of the Clean Water Act. Therefore no mitigation for impacted wetlands is required. The Nashville Crayfish (*Orconectes shoupi*) is endemic to the Mill Creek watershed and is classified by U. S. Fish and Wildlife Service (USFWS) as endangered. Plan BDA would affect the Nashville Crayfish and as a result USACE has entered into formal consultation with USFWS. USACE submitted a Biological Assessment, dated August 2014, requesting USFWS correspondence that would result in an Endangered Species Act (ESA) determination. USACE received the Draft Biological Opinion from USFWS on 6 February 2015. It is the USFWS' biological opinion that the preferred alternative would not likely jeopardize the continued existence of the Nashville crayfish. The USFWS provided "Reasonable and Prudent Measures" as well as "Terms and Conditions" for the proposed action. These are summarized in Section 6 of this Main Report and Appendix D. The lower reach has Hazardous, Toxic or Radioactive Waste (HTRW) sites; however, the selected plan does not include any of these sites in the footprint of the project.

Benefits and Costs – The recommended plan, Plan BDA, has an investment cost at October 2015 price levels of $28,785,000; an annual cost of $1,197,000 including Operations, Maintenance, Repair, Rehabilitation and Replacement costs (OMRR&R); annual benefits of $2,390,000; net benefits of $1,193,000; and a benefit-to-cost ratio (BCR) of 2.00 at a discount rate of 3.375 percent, a 50-year period of analysis, and a three year construction period. The fully funded total project cost is estimated to be $30,336,000 with a sponsor contribution of $11,437,000 and a Federal contribution of $18,899,000. The sponsor is responsible for 100 percent of the OMRR&R costs.

Timeline – The Chief's Report approval is anticipated by 18 August 2015. Pending Congressional Approval and Appropriations; Preconstruction, Engineering, and Design of the Recommended Plan is scheduled for completion in 2018; and Construction of all measures could be completed by 2021.

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Acronyms and Abbreviations

AAD	Average Annual Damages
AFB	Alternative Formulation Briefing
ASTM	American Society for Testing and Materials
ATR	Agency Technical Review
BCR	Benefit to Cost Ratio
BMP	Best Management Practices
CE	Cost Effective
CELRN	USACE Nashville District
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CPI-U	Consumer Price Index-Urban Consumers
CSO	Combined Sewer Overflow
CWA	Clean Water Act
DNR	Department of Natural Resources
DFAL	Diverse Fish and Aquatic Life
DFIRM	Digital Flood Insurance Rate Maps
EAD	Equivalent Annual Damages
ECO PCX	National Ecosystem Planning Center of Expertise
EGM	Engineering Guidance Memorandum
EOP	Environmental Operating Principle
EPA	Environmental Protection Agency
ER	Ecosystem Restoration
ERDC	Engineer Research and Development Center
FEMA	Federal Emergency Management Agency
FRM	Flood Risk Management
FRM PCX	Flood Risk Management Planning Center of Expertise
FWOP	FWOP Conditions
FWP	Future With Project
GIS	Geographic Information Systems
HAZUS	FEMA Hazard Data
HEC-1	USACE Hydrologic Engineering Center hydrologic model
HEC-2	USACE Hydrologic Engineering Center hydraulic model
HEC-FDA	Hydrologic Engineering Center Flood Damage Analysis Model
HEC-RAS	Hydrologic Engineering Center River Analysis System
HGM	Hydrogeomorphic Assessment
HSI	Habitat Suitability Index
HQUSACE	U.S. Army Corps of Engineers Headquarters
HTRW	Hazardous, Radioactive and Toxic Waste
HUs	Habitat Units
IBI	Index of Biotic Integrity
ICA	Incremental Cost Analysis
IWR	Institute for Water Resources
LER	Lands, Easements, and Rights-of-way
LERRD	Lands, Easements, Right-of-Way, Relocations, and Disposal Areas
LIDAR	Light Detection and Ranging
LRR	Limited Reevaluation Report
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration

NFIP	National Flood Insurance Program
NAVD 1988	North American Vertical Datum 1988
NGVD 1929	National Geographic Vertical Datum 1929
NPDES	National Pollution Discharge Elimination System
NRCS	National Resources Conservation Service
O&M	Operation and Maintenance
OMRR&R	Operation, Maintenance, Repair, Rehabilitation and Replacement
P&G	Principles & Guidelines
PED	Preconstruction Engineering and Design
PDT	Project Delivery Team
P.L.	Public Law
PPA	Project Partnership Agreement
SI	Suitability Index
SWMP	Stormwater Management Plan
TDA	Tennessee Department of Agriculture
TDEC	Tennesse Department of Environment and Conservation
TDOT	Tennessee Department of Transportation
THC	Tennessee Historical Commission
TVA	Tennessee Valley Authority
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WQ	Water Quality

1 Study Information

The purpose of this report is to analyze flood risk management opportunities in Mill Creek, Nashville, TN. The Metropolitan Government of Nashville and Davidson County (abbreviated as Metro Nashville) is the study sponsor. Metro Nashville requested assistance from the U.S. Army Corps of Engineers (USACE) to study and provide recommendations for reducing significant flood damages in the Mill Creek watershed.

1.1 Study Authority

This report is a partial response to the following resolutions, focusing on flood damage reduction in the Mill Creek watershed of Davidson County, Tennessee. Study authority is granted by two resolutions of the US House Committee on Transportation and Infrastructure adopted on 14 September, 1995, and 7 December 2005. The resolutions read as follows, respectively:

> ***U.S. House of Representatives COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE Resolution Docket 2466, Cumberland River, Nashville, Tennessee. Adopted September 14, 1995***
> *"...the Secretary of the Army is requested to review the report of the Chief of Engineers on the* ***Cumberland River and Tributaries...****published as House Document Numbered 761, 79th Congress, and other pertinent reports, with a view to determining whether any modifications of the recommendations contained therein are advisable at the present time, in the interest of environmental restoration, streambank protection, greenways and* ***other purposes*** *for Davidson County, Tennessee."*

> ***COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE OF THE UNITED STATES HOUSE OF REPRESENTATIVES, Resolution Docket 2746, Tennessee River Tributaries, North Carolina, Adopted December 7, 2005***
> *"... the Secretary of the Army is requested to review the report of the Chief of Engineers on the* ***Cumberland River, Kentucky and Tennessee****, published as House Document Numbered 761, 79th Congress, 2nd Session... and other pertinent reports to determine whether any modifications of the recommendations contained therein are advisable at the present time in the interest of environmental restoration and protection,* ***flood damage reduction****, enhancement and control of water quality, streambank protection, regional water systems, recreation, greenways, and other watershed management improvements.*

1.2 Study Partners and Coordination

Metro Nashville is the study sponsor. They are specifically represented by Metro Water Services (MWS). Cost sharing funds are provided by MWS. Metro Nashville includes over 650,000 residents and has an annual operating budget of $1.9 billion. Metro Water Services has an annual operating budget of $119 million. The following table includes the current list of stakeholders for the Mill Creek study.

Table 1. List of Stakeholders

Mill Creek Stakeholders
Metropolitan Government of Nashville and Davidson County
Residents within Mill Creek Watershed – Nashville
Cumberland River Compact
Mill Creek Watershed Assoc
U.S. Fish and Wildlife Service
U.S. Geological Survey
National Weather Service
Natural Resources Conservation Service
Environmental Protection Agency
TN Wildlife Resources Agency
State of Tennessee
TN Department of Transportation
TN Department of Environment and Conservation

1.3 Purpose and Scope

The purpose of this flood risk management study is to document existing and forecasted future conditions, establish defined objectives for future conditions, identify alternatives that would contribute to attaining the objectives, formulate, evaluate and compare alternative plans and recommend a plan with preliminary designs for implementation. This report includes an Environmental Assessment to meet requirements of the National Environmental Policy Act and the Clean Water Act.

The overall objective of the planning study is to improve flood risk management, maintain or improve aquatic ecosystem resources, and improve the overall quality of life for the neighborhoods of Nashville, Tennessee within the Mill Creek watershed. The City experiences routine damages from flash floods because of floodway and floodplain infringement coupled with insufficient flow capacity and urbanization along Mill Creek. Extensive damages during major flooding are incurred by intense weather events, the most recent of which was May 1-2, 2010. The areas along Mill Creek and its tributaries are heavily urbanized and includes expansive infrastructure associated with residential, commercial, and industrial development.

The original intent of this general investigations study was to provide both flood damage reduction solutions and ecosystem restoration solutions for the Mill Creek Watershed area in Nashville, Tennessee. However, it was determined after the May 2010 flood that flood damage reduction alternatives would move forward and the ecosystem restoration alternatives would be pursued and implemented separately by Metro Nashville. The Mill Creek basin was severely impacted by flooding during the record May 2010 flood events. Interstate 24 was flooded and shut down when Mill Creek overtopped it during this event, hundreds of homes and businesses were left damaged in the wake of the flood in addition to two flood related fatalities. As a result, the reinitiated and refocused Mill Creek study will only address flood risk management solutions. Hydraulic and hydrologic conditions were updated, new rainfall-runoff models developed and the economic analysis structure inventory database was updated. This information was then applied to reevaluate alternatives to reduce flood damages such as home buyout and removal, channel modifications, floodplain restoration, bridge modifications, storm water detention structures, and a quarry diversion.

This report analyzes the problems and opportunities and expresses desired outcomes as planning objectives. Alternatives are then developed to address these objectives. These alternatives include a plan of no action and various combinations of flood risk management measures. The economic and environmental impacts of alternatives are then evaluated and a feasible plan is tentatively selected. The report also presents detail on Corps and sponsor participation needed to implement the plan. The report concludes with a recommendation for authorization. The final recommendation will attempt to address the impacts to certain neighborhoods in the Mill Creek watershed that have been experiencing systemic flood risks for decades by providing an economically justified and environmentally acceptable array of implementable solutions.

1.4 Project Location

Located in one of the most rapidly urbanizing areas of Middle Tennessee, the 108-square mile Mill Creek Watershed drains about 13% of Nashville, Davidson County, Tennessee and 6% of Williamson County, Tennessee. The watershed has a teardrop shape, is about 18 miles long and averages 6 miles wide. A study area map is included in Figure 1. About two thirds of the watershed is within Davidson County, one third in Williamson County and a small headwater area extends into Rutherford County.

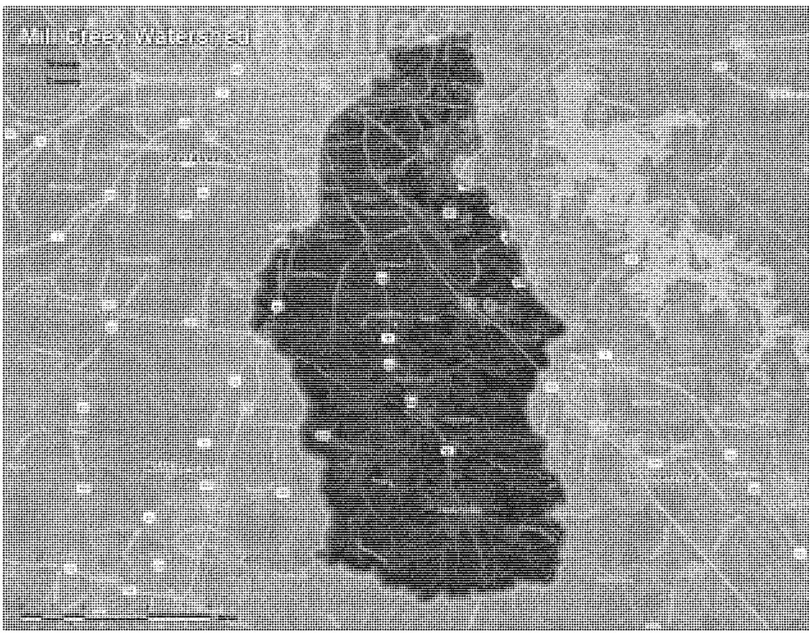

Figure 1. Mill Creek Watershed

Mill Creek flows generally northward from its origin in Nolensville to its confluence with the Cumberland River in Nashville. Along the way it is fed by a number of tributaries, the most significant being Sevenmile Creek which joins Mill Creek at Mile 7.9 and has a drainage area of 17.5 square miles. Other major tributaries in Davidson County include: Collins Creek, Edmonson Branch, Franklin Branch, Holt Creek, Indian Creek, Owl Creek, Sims Branch, Sorghum Branch, Turkey Creek, and Whittemore Branch. A detailed study of flooding and flood damages was not performed for Williamson County, as they elected not to co-sponsor the study.

Topography in the Mill Creek Basin ranges from flat to moderately sloping along the main stem to rolling and hilly uplands which form the watershed divide. Elevations range from about 385 feet above mean sea level at the mouth to around 1200 feet in the upper extremities of the basin. The main stem is 27 miles long and falls about 280 feet from its source to its mouth. Average channel gradient is roughly 10 feet per mile in lower stream reaches and 35 feet per mile in upper stream reaches.

Mill Creek main channel averages approximately 75 to 100 feet wide and the 100-year floodplain about 700 to 800 feet wide. The well-defined streambanks are generally 10 to 15 feet above streambed. The regulated floodway is generally between 400 to 500 feet wide, where prior encroachments have not occurred. The floodway building code regulations and restrictions have varied greatly over the years resulting in areas in the urbanized portions of the stream with floodway encroachments into the riparian zone and in some cases to the stream bank. This can be attributed to both less stringent regulations that predate the FEMA flood insurance study (FIS) maps and increased flows over time due to the increased impervious footprints throughout the watershed as the area transitioned from rural to urban and suburban. Upper portions of Mill Creek and its headwaters flow primarily from farmland. As the stream enters Davidson County, runoff characteristics become primarily suburban, changing to urban approximately halfway through the basin, with residential, commercial, industrial and open area sources. Almost every summer, the flow of Mill Creek approaches zero at Mile 22, near the Williamson county line, and aquatic life is restricted to pools. This lack of continual flow inhibits habitat availability and ecosystem processes and functions of Mill Creek.

Sevenmile Creek originates near the Davidson-Williamson County line and flows north and east before joining Mill Creek. Sevenmile is approximately 7.3 miles long with a drainage area of 17.6 square miles, an average slope of 18.9 feet per mile, an average 100-year floodplain width of 500 feet, and an average floodway width of 200 feet. Streambanks range from 3 to 9 feet high; existing channel averages 20 to 30 feet wide. Approximately half the flow is through a heavily urbanized area, while the upper half is less developed.

As show on Figure 2, as much as 1/4 of the upper watersheds of both Mill and Sevenmile Creeks could be characterized as vacant or farmland as existing land use conditions. This is rapidly changing as vacant land and farms are shifting to suburban development. Williamson County is experiencing Tennessee's fastest rate of growth when ranked by percent change in population. A similar rate of growth is occurring in Davidson County's upstream portion of the watershed.

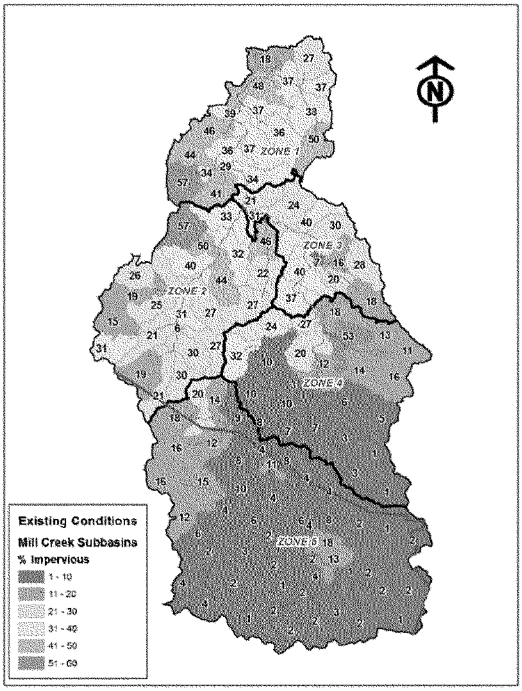

Figure 2. Mill Creek Existing Conditions: % Impervious

Climate conditions in the watershed are relatively uniform. Normal mean monthly temperatures (Nashville Airport 1948 – 2005) vary from 89.8 degrees in July to 46.9 degrees in January and average 59.4 degrees annually. Normal annual precipitation is around 48.1 inches with winter and spring being the wettest and fall being the driest.

The Outer Nashville Basin (Ecoregion 71h) is characterized by open hills, gently rolling to steep; some plains with hills; highly dissected escarpments; moderate gradient bedrock and gravel-bottomed streams. The Inner Nashville Basin (71i) consists of smooth to rolling plains, with some small hills and knobs. Streams are low gradient with clear water on bedrock substrate (EPA, 1997).

The watershed is situated on limestone of Nashville and Stones River groups of Ordovician age. Formations of the Nashville Group exposed (or covered only by soil) include Cathey's, Bigby-Cannon, and Hermitage. Of the Stones River Group, only the Carter's and Lebanon formations are exposed in the study area. Solution cavities and sinkholes have developed along structurally-controlled joints and near-horizontal bedding planes (USACE, 1986). The limestone rock and soils are generally high in phosphorus.

According to US Department of Agriculture Soil Survey of Davidson County, Tennessee (1981), soils of the Mill and Sevenmile Creeks floodplains are in the Arrington-Lindell-Armour association. These soils are undulating to rolling, well to moderately-well drained. Most of these soils qualify as prime farmland soils but are fast becoming sites for residential development. Soils on the uplands adjacent to the floodplain are in the Talbott-Rock Outcrop association. These soils are not prime farmland soils, and are undulating to hilly, well-drained. Soils deeper into the watershed are primarily Stiversville-Hampshire-Urban land. These soils are classified as undulating to hilly and well drained. Outcrops of limestone and a few limestone sinkholes occur. Infiltration rates of much of the soils are low, less than 0.10 inches per hour due to high silt/clay content. Mill Creek soils are predominantly loams or silt loams or mixtures of clays, loams, silt loams, and silty clay loams. Bedrock depths are generally less than five feet and water table depth ranges from four to six feet. A detailed analysis of the soils and infiltration characteristics can be found in Appendix C: Attachment A. Hydrology and Hydraulics Report.

1.5 History of the Investigation

In May 2010, the most damaging flood on record in the watershed occurred. As much as sixteen inches of rainfall fell over the course of thirty-six hours, which resulted in floodwaters 10 to 12 feet deep in some places, damage to at least 700 homes, and displacement of thousands of people, with an estimated $185 million in damages to private property alone. It was a 1/100 to 1/500 annual chance exceedance (ACE) flood depending upon the tributary stream and its recorded flows. More detail is provided in the H+H Appendix. In response to the flood, the City requested to cease the ongoing Investigations study, which Metro Nashville, as the non-Federal sponsor, and USACE initiated by signing a Feasibility Cost Sharing Agreement (FCSA) on 24 April 2003. The Feasibility study was conducting reviews and nearing completion for flood risk management and ecosystem restoration alternatives for main-stem Mill Creek and Sevenmile Creek when the flood occurred in May 2010.

By Letter Agreement Metro Nashville and USACE modified the Feasibility Cost Share Agreement (FCSA) to resume study following the completion of a Metro Nashville funded, county-wide Unified Flood Preparedness Plan (UFPP). The UFPP analyzed the six major streams in Metro Nashville, updated data from the 2010 event and evaluated solutions to flood damages on a reconnaissance level for Cumberland River, Harpeth River, Mill Creek, Richland Creek, Whites Creek, and Browns Creek.

Following completion of the UFPP in January 2013, the Letter Agreement between Metro Nashville and USACE was enacted and the study resumed to build upon the work conducted in the UFPP and update the flood risk management data and alternatives under investigation prior to the flood. The Letter Agreement amending the FCSA was signed on 25 January 2013.

1.6 Previous Studies and Existing Projects

Frequency profiles for Mill Creek and Sevenmile Creek were developed in conjunction with the Davidson and Williamson County Flood Insurance Studies (FIS) beginning in 1977. The hydrologic and hydraulic analyses for these studies are performed by the U.S. Geological Survey (USGS). The work was completed just before the May 1979 flood, the flood of record for Mill Creek prior to May 2010. The statistical frequency analysis for FIS was revised in 1980 by the Corps to reflect this flood. This analysis is discussed later as the adopted procedure.

In 1980 work began on a Stage II report for the Mill Creek Basin. The backwater model developed for the FIS by USGS is converted to a "Water Surface Profiles, HEC-2" computer program format for use in this study. Verification runs are made using this model to determine its accuracy in reproducing the 1979 floods. Several updates were made to the HEC-2 model, but overall it was adequate to investigate and compare flood control alternatives.

Prior to the 1979 floods, a study was conducted by the USGS entitled, "Effects of Urbanization on Flood Characteristics in Nashville-Davidson County Tennessee." The severity of the 1979 floods and the findings in this report (a conclusion of no impact from urbanization) prompted a detailed study by the Corps of Engineers. The Corps study was completed in 1986. The study focused primarily on the Mill Creek and Sevenmile Creek floodplains within Davidson County. Detailed HEC-1 and HEC-2 models were developed for the watershed and study streams. A large array of alternatives was analyzed including both structural and nonstructural solutions. Nonstructural alternatives do not modify floods, but are intended to reduce susceptibility to flood damages. These measures include floodplain zoning ordinances, flood insurance policies, flood forecasting and warning, flood proofing and permanent evacuation of the floodplain. Structural alternatives, on the other hand, actually reduce flood stages in problem areas. These actions may include dams and reservoirs, levees, bridge modifications, channel modifications, or clearing and snagging. A total of 43 plans or combination of plans was evaluated from hydrologic, hydraulic, economic, and environmental viewpoints. The selected plan which provided the greatest return on the investment of tax dollars (the most net benefits) is the NED plan. The 1986 study recommended plan was the construction of a dam at Mile 16.81 on Mill Creek, constructing a dam at Mile 3.70 on Sevenmile Creek, and widening a section of Sevenmile Creek from Mile 0.70 to 1.51. The recommended plan was congressionally authorized for construction but never completed due to public opposition.

The Corps of Engineers completed a Section 22 study (Planning Assistance to States) in 1990 for the Mill Creek Basin within Williamson County. The purpose of the study was to provide Williamson County with hydrologic information concerning the possible use of regional detention to reduce flooding in the Nolensville Community. The study evaluated two regional detention sites which provided flood reductions along Mill Creek in the vicinity of Nolensville, Tennessee. The selection of the sites was based on the hydrology of the basin, available storage, required length of dam, and open area. Based on study results, Williamson County did not proceed with the regional detention approach due to loss of valuable land in the detention areas.

In 1996, the Corps of Engineers conducted a floodway storage analysis for the Cumberland River and Mill Creek in Davidson County, Tennessee to evaluate the requirement to compensate storage for fill in the floodway fringe. An unsteady flow (UNET) model was developed for Mill Creek within Davidson County. Results of the analysis indicated that compensation storage was necessary along most of the Mill Creek main stem to attenuate flood hydrographs and minimize encroachment surcharge.

Metro Nashville has completed several of their own studies for Mill Creek and its tributaries. The Metro/Davidson County and Williamson County governments are both very supportive of the FEMA Flood Insurance Program, solutions to reduce or minimize flooding and improve water quality and ecosystem. The Stormwater Division of Metro Water Services was formed April 1, 2002. The formation of the Stormwater Division nearly doubled the stormwater budget allowing more funding to address immediate problems like local drainage. It has also allowed Metro additional funds for partnering with federal agencies like the Corps and USGS for Watershed Studies like this one to address stormwater drainage and flooding issues.

The Nashville District Corps of Engineers is conducting a General Investigation (GI) Study for the Mill Creek Watershed which began in 2003. The study was scoped for both flood damage reduction and ecosystem restoration components, with FIS updates included under the umbrella of flood damage reduction. A Flood Insurance Study was completed in 2006 as part of the GI Study. The FIS update included a complete restudy of Mill Creek and its tributaries within Davidson County. This study included the development of observed flood and hypothetical (frequency) event based HEC-HMS models and geo-referenced HEC-RAS models. All detailed (Zone AE) and approximate (Zone A) streams shown on FEMA maps were updated to detailed study zones. These models were provided to FEMA for adoption during the next map revision for Davidson County and were put on hold to incorporate new terrain (LiDAR) data and May 2010 Flood impacts to flood frequency.

Other reports following the 2010 flood had regional focuses, but also included much data on Mill Creek. These include the May 2010 Cumberland and Tennessee River Basins Post Flood Technical Report, Metro Nashville Flood Preparedness, and the Metro Nashville Unified Flood Preparedness Plan (UFPP). These are described below:

The 2010 Post Flood Technical Report provides details on the devastating impacts of this flood of record, post completion of the Cumberland River Basin system. Mill Creek data was updated as part of the larger effort to document the event. USACE completed a technical report that provides a thorough and complete understanding of the record flood event of May 1-4, 2010. The report documents the meteorology of the storm, the hydraulic characteristics of the flood event, and the factors that contributed to the severity of the flood. Rainfall totals across the region on May 1 and 2, 2010 far exceeded previous record amounts and resulted in record stages and/or discharges along the Cumberland River, from above Nashville to its confluence with the Ohio River. Some areas received rainfall amounts that exceeded 17 inches during the two-day event, the highest amount in more than 140 years of record. Historical stream flow and flood stage records were exceeded on the Cumberland and many tributaries to both the Cumberland and Duck Rivers as a result of the torrential rains. The report was completed in February 2012.

As a result of the May 2010 flood, Metro Nashville partnered with the Corps to develop flood inundation models and flood preparedness tools for 6 streams in the county (referred to as Metro Flood Preparedness Phase 1). The streams include the Cumberland and Harpeth Rivers and Mill, Browns, Whites and Richland Creeks. The majority of the population impacted by the flood and all of the loss of life was associated with these streams. Three of the streams, the Cumberland River, Mill and Richland Creeks had good existing models which only needed updates. The Harpeth River, Whites and Browns Creeks had models that were 20 to 30 years old using outdated technologies. All stream models have been completely redone. In addition to the modeling, tools that enable the city to better predict what is likely to occur under different flooding scenarios have been completed. With these tools, Metro will know what is flooded at various flood stages on the Cumberland and Harpeth Rivers and be able to predict what could flood on the smaller streams when certain amounts of rain occur. The USGS and NWS are also partnering on this project. The USGS has added new gages and is updating rating curves for the existing gages. NWS is working on additional forecasting for specific creeks and updating flood alerts levels and actions. Phase 2 of the study included Real Time Simulation (RTS) modeling for the 6 streams discussed above.

The modeling will be able to incorporate real time observed data, NEXRAD radar, NWS rainfall predictions to predict inundated areas and depths. The models can be used to simulate the impacts from different rainfall scenarios and have been made available to both Metro and the National Weather Service. Phase 2 also included updating frequency and flow data to turn over to FEMA who will use the date to update the Flood Insurance Study (FIS) maps in Davidson County. The updated products will also be used to evaluate alternatives on three of the streams. About 122 miles of streams have been updated to date. Phase 3 streams include those flowing into the Stones River below J Percy Priest Dam. Phase 4 streams include all the remaining streams in Davidson County. Phase I completed in 2012 and Phase II in 2013. Phases III and IV are underway. Updating the FIS will help better define floodplains and reduce future flood risk as well as provide better tools for decision makers and emergency responders to reduce flood risk.

Following the 2010 flood event, Metro Nashville embarked on a deliberate study, called the Unified Flood Preparedness Plan (UFPP), to identify and evaluate flood damage reduction measures on the Cumberland River and its five major tributaries – Harpeth River, Whites Creek, Browns Creek, Mill Creek and Richland Creek. The goal of the UFPP is to develop a sustainable flood protection program that improves public safety, protects environmental and cultural resources, and supports economic growth by promoting a unified approach to lowering the damages caused by flooding. The UFPP's goal of long-term preparedness is based on a program approach that is collaborative, integrated, comprehensive, and implementable. That report was completed in January 2013. Following this, the Mill Creek Flood Risk Management study was re-initiated in April 2013 upon the arrival of federal funding to complete the study.

1.7 Planning Process and Report Organization

The planning process consists of six major steps: (1) Water and related land resources problems and opportunities; (2) Existing inventory, forecast and analysis of water and related land resources conditions within the study area (problems and opportunities); (3) Future without project conditions; (4) Plan formulation; (5) Evaluation of the effects of the alternative plans; (6) Comparison of the alternative plans; and ultimately selection of the recommended plan based upon the comparison of the alternative plans. The planning process and environmental assessment are closely aligned. The chapter headings and order in this report generally follow the outline of the USACE planning process, per EC 1105-2-100. Chapters of the report relate to the six steps of the planning process as follows:

- The second chapter of this report, Problem Description and Objectives of the Proposed Action, covers the first step in the planning process (Discussion of water and related land resources problems and opportunities).
- The third chapter of the report entails a discussion of the formulation of future without project conditions, and, analysis of build-out scenarios on the attenuation of Mill Creek floodwaters. This section provides the data to link the cost effectiveness of floodplain management practices and long term flood reduction benefits.
- The fourth chapter of this report, Plans, is the focus of the report and is therefore placed before the more detailed discussions of resources and impacts. It covers the third step in the planning process (Plan

formulation), the fifth step in the planning process (Comparison of alternative plans) and the sixth step of the planning process (The selection of the recommended plan based upon the comparison of the alternative plans).

- The fifth chapter of this report, Affected Environment, covers the second step of the planning process (Inventory, forecast and analysis of water and related land resources in the study area).
- The sixth chapter of this report, Effects on Environmental Resources, covers the fourth step of the planning process (Evaluation of the effects of the alternative plans). The fifth and sixth chapters support the integration of the information required by the NEPA process.

This report was written as a part of the USACE Planning modernization. This report is termed a Legacy study per Guiding Principles for Legacy Study Risk Management (dated December 11, 2013), with transition to 3x3x3 planning paradigm. Information contained in the report demonstrates the decision-making process. For more information on the detailed analysis, please refer to the appendices.

2 Problem Description, Study Objectives and Constraints

2.1 National Objectives

A key Federal objective of water resources and related land resource planning is to contribute to the national economic development. The study and its recommendation must be consistent with protecting the nation's environment, pursuant to national environmental statutes, with all Federal planning requirements. Contributions to National Economic Development (NED) are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and in the rest of the nation.

2.2 Public Comments

During the course of the study a number of concerns were identified by the public and community at-large. Input was received through coordination with the sponsor and other agencies through public meetings. Preparation of the Environmental Assessment includes agency and public notification of the proposal and an opportunity for agency and public review and comment prior to agency decision making. Scoping letters have been issued at various stages of this project study. The first letter was issued in November 2003; after reevaluation following the May 2010 flood event, a second letter was issued in January 2013. The letters were sent to the public and to local, state, and federal governmental agencies with jurisdiction by law and special expertise. This Integrated Report/EA was circulated in draft form to the scoping respondents and to local, state, and federal governmental agencies with jurisdiction by law or special expertise for a 30 day review/comment period. A complete discussion of public involvement is included in Chapter 7, Public Involvement.

2.3 Problems and Opportunities

Problems

Located in one of the most rapidly urbanizing areas of Middle Tennessee, the 108-square mile Mill Creek Watershed drains about 13% of Nashville, Davidson County, Tennessee and 6% of Williamson County, Tennessee. Flooding occurs in the Mill Creek basin during all seasons of the year, major floods occur primarily during winter and early spring. In addition to major damages along Mill Creek proper, the tributary streams are also vulnerable to floods resulting from summer and fall thunderstorms. Major flood events, where frequencies are greater than 1/25 ACE, have occurred in 1955, 1960, 1962, 1979 (twice), and 2010. Two of these flood events included frequencies greater than 1/100 ACE. The event in May 1979 included economic damages valued at $85M. The May 2010 flood event resulted in over $185M in damages and also resulted in two fatalities. Rainfall on May 1 and 2, 2010 resulted in record flood stages in the Mill Creek basin. Radar rainfall in the Mill Creek basin ranged from 11 inches to 16 inches during the event. Gage rainfall ranged from 13.5 inches to 16.2 inches over the two-day period. Stream gages at Woodbine and Antioch recorded flooding 3 feet and 4 feet above the previous flood of record, respectively, which occurred in 1979.

All streams in the basin tend to rise rapidly following intense rainfall. Flooding is of relatively short duration, averaging 12 hours. Flooding along the major streams in the watershed also occurs during more frequent (or higher probability of occurrence) flood events. A key contributor to the major damages in Mill Creek is that most development in the watershed was unregulated until after the 1979 floods. Entire sections of lower Mill Creek and Sevenmile Creek were nearly built-out prior to the adoption of floodplain management requirements. Among other factors this contributes, to the nearly 160 residential structures located in the floodway of Mill Creek and its three principal tributaries. A more detailed discussion of historic flooding can be found in the Hydrology and Hydraulics Appendix.

There are over 1200 residential and over 200 non-residential structures in the 500-year (0.2 percent probability or 1/500 ACE) floodplain of Mill Creek in Davidson County with a flood loss potential of nearly $5.3 million annually under existing conditions and $5.5 million under future without project conditions using a 50-year period of analysis. Table 2 shows the number of structures located in the various floodplains. For economic analysis, Mill Creek was divided into seven reaches and Sevenmile Creek into five reaches to facilitate flood damage evaluation. Sorghum Branch and Whittemore Branch have a single reach each. Table 2 also shows these 14 reaches, which define the damage centers in Davidson County for the future without project condition, with total number of structures damages and total future conditions annual damages. Future without project assumptions are discussed in greater detail in Chapter 3. Figure 3 shows a map of the damage reaches described in Table 2.

Table 2. Number of Structures in the Mill Creek Watershed sorted by Damage Reach

Mill Creek						
Reach	Number of Structures in Reach	Residential	Commercial	Industrial	Public	Structure Values $'s=1,000's
MC-1	258	214	32	12	0	51,551.7
MC-2	40	22	18	0	0	17,723.8
MC-3	188	179	9	0	0	20,044.4
MC-4	68	37	25	6	0	67,391.7
MC-5	166	82	80	1	3	41,127.1
MC-6	124	124	0	0	0	11,000.7
MC-7	16	12	4	0	0	6,729.7
Total	860	670	168	19	3	215,569.1
Tributaries						
Sevenmile Creek						
SM-1	119	118	0	0	1	9,165.3
SM-2	129	112	17	0	0	19,564.1
SM-3	135	135	0	0	0	13,004.2
SM-4	10	9	1	0	0	4,027.4
SM-5	7	7	0	0	0	1,354.4
Total	400	381	18	0	1	47,115.4
Sorghum Branch						
SB-1	67	60	5	1	1	17,745.3
Whittemore Branch						
WB-1	138	136	0	0	2	10,456.1

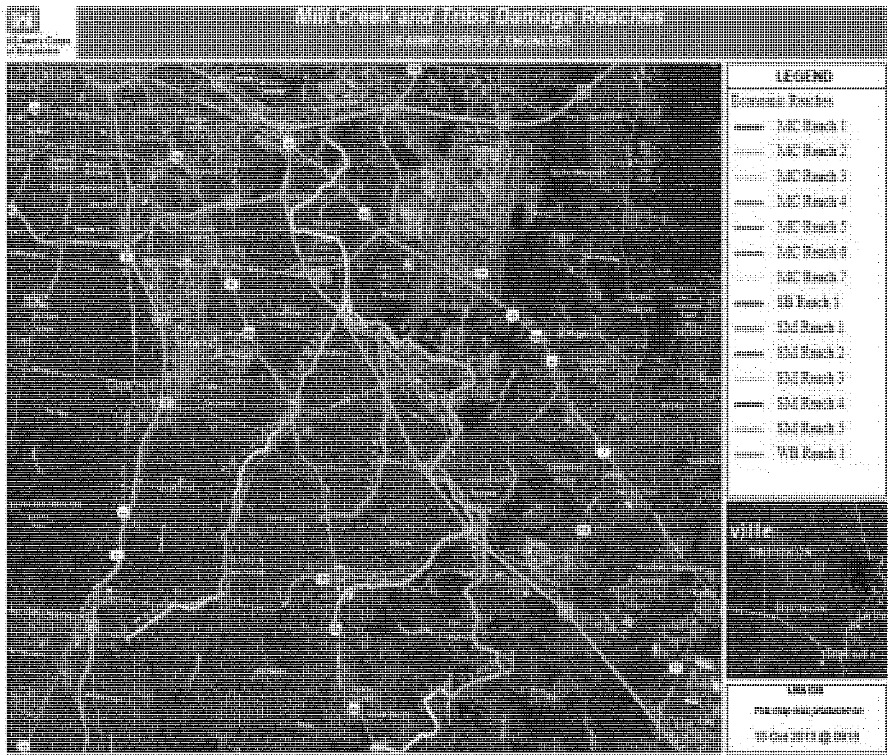

Figure 3. Mill Creek Watershed: Economic Damage Reaches

Table 3 displays flood damages by category for existing and future conditions. Under both existing conditions and future without project conditions the majority of the damages are to residential structures. Under the future without project condition, damages to commercial and industrial property increase at a slightly higher rate than existing conditions. Residential and vehicles account for roughly 64% of the expected annual damages (EADs). More detail can be found in the Economic Analysis Appendix (Appendix A).

Table 3. Mill Creek Damages by Category

	Damages in $1,000			
Expected Annual Damages	**Commercial and Industrial**	**Public**	**Residential and Vehicles**	**Total**
Existing	1,776.7	6.1	3,393.4	**5,176.2**
Future	1,967.7	6.8	3,482.3	**5,456.8**

Ecological Impairment

Assessment of ecological problems and needs was made by researching available studies and reports; conducting interviews with local, state, and federal agencies and with the public; and by conducting onsite visits and data collection. Through these efforts, recurring problems that impact a majority of the watershed and Mill Creek specifically were found to include flooding, impaired water quality, streambank erosion, and loss of aquatic and riparian habitat (See Section 5).

Opportunities

The location of the Mill Creek watershed in one of the fastest growing corridors in the state, combined with the historic flooding along Mill and Sevenmile Creeks were the driving forces behind this study. There was an opportunity to look at a stream, its tributaries and an entire 108 square mile watershed from both quantity and quality aspects and develop tools to help manage growth. The impacts of growth in the entire watershed were considered, but alternatives for improvement or management measures were evaluated for only Davidson County.

The study also looks at the quality and quantity aspects of development together. It serves as a catalyst for bringing many agencies and organizations together to examine these issues. The main opportunities of this study are to reduce flood damages in the Mill Creek Watershed by developing the national economic development (NED) plan. To reduce flood damages long term by analyzing potential projects for non-structural and structural flood damage reduction. And ultimately to buy down future flood risk by removing the most damaged and most susceptible residences from future flood events. Ancillary opportunities include providing additional recreation opportunities in the Mill Creek floodplain, educating citizens and local officials about flood plains, reducing impacts of future developments and increasing open space.
Although the USACE Mill Creek study eventually became only FRM focused, previous evaluations of the environmental and ecosystem restoration opportunities in the study area led to the following cooperative learning opportunities including:

- Formation of interagency working group
- Assistance to Tennessee Department of Agriculture with demonstration of rain gardens in the Sevenmile Creek watershed
- Working with the "Building Outside the Box" effort by Cumberland River Compact to demonstrate innovative "green design" stormwater management structures
- Preparing the Flood Insurance Update for FEMA and Metro
- Working with the Tennessee Stream Mitigation Program
- Field comparison of the TDEC and NRCS stream assessment protocols
- Application of the LRD method for standardizing ecosystem outputs

2.4 Planning Goals and Objectives

Goals

The primary goal for the Mill Creek watershed is achieving long term sustainability for the human and natural environment. The aim is to predict and minimize flood damages in a way that protects, maintains, and restores ecologically sensitive resources of Mill Creek and its tributaries. Additional goals include understanding and detangling the intertwined impacts of urbanization on water from both human and ecological view points. Flood damage reduction encourages economic development in a manner that requires less investment in intervention and recovery at all levels of government and insures a higher quality of life for citizens than under existing conditions.

In its Environmental Operating Principals, the Corps of Engineers has defined environmental sustainability as follows: "a synergistic process whereby environmental and economic considerations are effectively balanced through the life cycle of project planning, design, construction, operation and maintenance to improve the quality of life for present and future generations." Ecosystem sustainability is evidenced by complex and diverse riparian and aquatic communities that are biologically rich with native plant and animal species and are capable of self-regulation well into the future. Sustainability can be encouraged by closely returning a stream's natural hydrology, thereby allowing storm water to rise and recede over longer periods of time than occurs in a highly modified watershed. These goals can be achieved through regional planning for growth and development. A sustainable watershed also provides opportunities for increased community involvement, education, and recreation.

Objectives

Objectives more specifically define study goals. They lead to the development of actions and measures which in turn form the basis of alternatives. Alternatives are specifically defined at discrete locations and are being fully evaluated to determine costs and social, environmental, and economic impacts, both positive and negative. For the Mill Creek study the following objectives have been identified and each is to be measured by its performance during the 50 year life cycle of the recommended project. Note that not all objectives are high priority mission areas for the Corps:

Objective 1 – Reduce residual risk to life and property in the Mill Creek watershed

Objective 2 – Increase flood attenuation opportunities and restore riparian and floodplain connectivity in the Mill Creek watershed

2.5 Planning Constraints

Several major constraints were identified during this study, as listed below.

- Continued rapid development in the upper watershed will impact future conditions.
- The lack of a sponsor for potential improvement measures in Williamson County limits outcomes in both Williamson and Davidson Counties.
- Measures may impact neighborhood cohesion, in the high risk, frequently inundated areas.
- Metro Nashville floodplain ordinance and building codes prohibit new construction or substantial modification in the floodway. It also prescribes residential construction in the floodplain must be built four feet above the base flood elevation (BFE).
- Must avoid impacts to threatened and endangered species.

3 Inventory and Forecast of Resource Conditions

3.1 Historic and Existing Conditions

Basin Description

Mill Creek flows approximately 27 miles in a northerly direction from its headwaters just south of Nolensville, Tennessee in Williamson County, Tennessee to its confluence with the Cumberland River (Cheatham Reservoir) at Mile 194.4 in Nashville, Davidson County, Tennessee. The basin is teardrop shaped with a total drainage area of 108 square miles as shown in Figure 4. It lies principally in Davidson County, although 35 percent of the upper watershed is in Williamson County and a small headwater portion extends into Rutherford County.

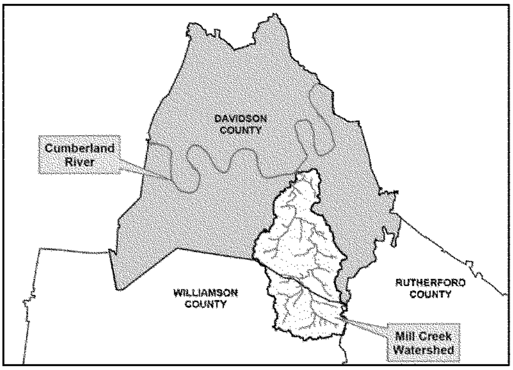

Figure 4. Mill Creek Watershed Vicinity Map

Mill Creek is fed by a number of tributaries; however, its most significant tributaries are Sevenmile Creek in the lower half and Owl Creek in the Upper third of the watershed. Both tributaries flow in a north easterly direction joining Mill Creek at Mile 7.9 and 19.9, respectively. Sevenmile and Owl Creek have drainage areas of 17.5 and 13.2 square miles respectively. The remaining tributaries have drainage areas less than 10 square miles and generally flow to the northeast or northwest.

Topography in the Mill Creek Basin ranges from flat to moderately sloping along the main stem to rolling and hilly uplands which form the watershed divide. Elevations range from about 385 feet above mean sea level at the mouth to around 1200 feet in the upper extremities of the basin.

The land use in the Mill Creek Basin varies greatly and is experiencing very rapid changes. Progressing upstream from the mouth, the lower 9 miles of the watershed are a mixture of residential, commercial, and industrial development. This type of intense development also continues up the Sevenmile Creek Basin for approximately 3 miles. The middle portion of the Mill Creek and the upper half of the Sevenmile Creek Basins are moderately developed, predominately commercial and residential. The upper half of the Mill Creek Basin, encompassing over 40 square miles of drainage area, is mostly in Williamson County and is less developed but experiencing rapid and intense growth.

Historical Flooding

Information is available for several significant floods on Mill and Sevenmile Creeks dating back to 1955. Although this is a relatively short time span, a wide variety of rainfall amounts and storm distributions and durations have occurred which provide excellent insight into the basin's flooding characteristics. A chronological discussion of storms and floods is given in the following paragraphs.

- The flood of 20-21 March 1955 resulted from a period of widespread rainfall during the night of the 20th and a heavy burst of 3 inches for a 6-hour period starting on 21 March. Total rainfall amounts for the storm averaged from 4.8 inches throughout most of the basin to 5.5 inches in the upper most region of the watershed. This resulted in a stage of 19.73 feet at the Mill Creek gage which forced evacuation of families along Mill and Sevenmile Creeks.
- During the night of 16-17 June 1960, a very intense thunderstorm produced a relatively narrow band of heavy rainfall that centered near the Mill Creek headwaters. This flood was higher than the March 1955 flood in the Antioch area just upstream of the gage. However, the maximum stage of 19.15 at the gage was one-half foot lower than the 1955 flood. The lower reaches of Mill Creek and Sevenmile Creek, where most urban development was located at the time, experienced only a moderate rise.
- A wet winter and early spring in 1962 featured several storms which caused moderate flood rises on all streams in the Middle Tennessee area. The most severe of these storms in the Mill Creek watershed occurred in late February 1962 when a 60-hour period of precipitation, beginning on the 25th, produced an average of 6 inches of rainfall. Because the rainfall is widespread and long in duration, the flood crested along the entire lengths of Mill Creek and Sevenmile Creek on 27 February.
- The 4 May 1979 flood was the flood of record on Mill Creek and produced the most severe flood damages ever experienced along the entire stream prior to May 2010. Initial wetting occurred during the early morning of 3 May when an inch of rainfall fell over the entire basin. Starting at 8 p.m. on 3 May an intense thunderstorm, moving from west to east with its center in the upper half of the Mill Creek basin, deposited nearly 5.5 inches of rainfall in a 6-hour period. The lower half of the basin, including Sevenmile Creek, received 3.1 inches during this same 6-hour period. This resulted in a flood with about twice the magnitude of flow of any previously known flood on Mill Creek.
- September in Nashville is usually a very dry month; however, the 11.44 inches of rainfall which fell during September 1979 made this the wettest September since records began in 1871. A part of this record rainfall resulted in severe flooding in the Mill Creek Basin for the second time in 1979. The heaviest rainfall for the month was a direct result of the tropical hurricane Frederick. During the 6-hour period from 1 p.m. to 7 p.m. on 13 September, rainfall amounts of 4.8 to 5.3 inches are recorded throughout the basin. Although the rainfall amounts for this storm closely resemble the May storm, the very dry antecedent moisture conditions resulted in reduced peak discharges which are about two-thirds of the May flood discharges.
- Figure 5, on the following page, depicts Mill Creek flood damages in the Wimpole Drive Thompson Lane area in September 1979.

Figure 5. Wimpole Drive, September 1979

- During the months of April and May of 1984, residents were twice again alarmed by nuisance flooding on Mill Creek and Sevenmile Creek. Although these floods damaged mainly yards and basements, residents and merchants were fearful of a repeat of the 1979 events.
- Flood damages along Mill Creek and its tributaries are documented for several flood events occurring in 1990s and 2000s. On June 4, 1998 flooding was reported along Sevenmile and Mill Creeks. Water threatened the Harding Mall and other structures. The Mill Creek near Nolensville gage reach the year highest marks on June 4^{th} at 16.23 ft and a peak discharge greater than 10,000 cfs. On May 24, 2000 flooding occurred at Sevenmile Creek near the Harding Mall at 0120 CST. Minor flooding was reported on November 29, 2001 when Sevenmile Creek overflowed its banks spilling into many backyards. On May 5, 2003 spotters reported flooding at Edmonson Pike and Blackman Road along Sevenmile Creek. There was six feet of water over roads and some homes were flooded. Highwater marks for this event were as high as the May 1979 flood at some locations along Sevenmile Creek.
- The May 2010 flood is the flood of record along Mill Creek and its tributaries within Davidson County. On Saturday, May 1, 2010, heavy rain began falling in the Cumberland River Valley, Tennessee, and continued through the following day. Within the middle reach of Mill Creek, 16.21 inches of rainfall was measured near the Antioch gage, an unprecedented amount that doubled the previous 2-day record of 6.68 set in September 1979, and exceeded the May monthly total record of 11 inches. The daily rainfall totals were 8.42 inches and 7.79 inches on May 01 and May 02, respectively. The maximum 12-hour rainfall totals were 7.90 inches and 7.72 inches on May 01 and May 02, respectively. This intensity of rainfall quickly overwhelmed tributaries to the Cumberland in the Nashville area, causing wide-spread and serious flooding. There were two fatalities and over $185 million dollars in estimated damages in the Mill Creek watershed, as reported by the May 2010 Post Flood Technical Report. Stream gages at Woodbine and Antioch reported 21.77 feet and 26.00 ft, respectively, 3 and 4 feet above the previous flood of record which occurred in May 1979. The top 10 historic peak discharges for available Mill Creek gages are listed in Table 4.

The picture on the following page, Figure 6 reflects Mill Creek flood damages near the Antioch Pike and Blue Hole Road intersection in May 2010.

Figure 6. May 2010 Mill Creek flood damage Antioch Pike

Table 4. Historic Peak Discharges in the Mill Creek Watershed

Mill Creek At Nolensville
DA 12.0 square miles

Rank	Date	Peak Discharge (cfs)
1	5/1/2010	11,600
2	5/7/1984	11,400
3	5/4/1979	11,400
4	6/26/1994	8,630
5	5/25/2000	8,300
6	9/22/2003	8,160
7	5/14/1995	7,620
8	10/5/1995	7,370
9	1/23/1999	7,020
10	12/1/1991	6,820

Mill Creek Near Nolensville
DA 40.5 square miles

Rank	Date	Peak Discharge (cfs)
1	5/1/2010	30,000
2	5/4/1979	28,600
3	9/13/1979	15,200
4	10/5/1995	13,000
5	5/25/2000	12,600
6	5/14/1995	12,600
7	6/7/2003	12,500
8	5/5/2003	11,100
9	6/26/1994	10,600
10	3/3/1997	10,500

Mill Creek Trib at Glenrose Ave
DA 1.17 square miles

Rank	Date	Peak Discharge (cfs)
1	5/6/1984	833
2	5/4/1979	830
3	6/26/1994	612
4	7/21/1996	550
5	5/3/1993	546
6	5/25/2000	535
7	3/17/2002	523
8	11/27/1994	501
9	7/3/1992	491
10	5/5/2003	460

Mill Creek Near Antioch
DA 64.0 square miles

Rank	Date	Peak Discharge (cfs)
1	5/1/2010	37,910
2	5/4/1979	30,100
3	9/13/1979	19,000
4	3/4/1955	17,000
5	6/17/1960	15,600
6	2/27/1962	13,800
7	5/5/2003	11,500
8	5/25/2000	10,800
9	6/4/1998	10,800
10	5/7/1984	10,700

Mill Creek At Thompson Lane
DA 93.4 square miles

Rank	Date	Peak Discharge (cfs)
1	5/1/2010	33,000
2	5/4/1979	26,200
3	9/13/1979	20,000
4	2/14/1989	16,000
5	5/5/2003	14,200
6	3/12/1975	13,600
7	6/4/1998	13,500
8	5/7/1984	13,400
9	5/25/2000	13,300
10	10/5/1995	13,000

Seven Mile Creek at Blackman Rd
DA 12.2 square miles

Rank	Date	Peak Discharge (cfs)
1	5/1/2010	11,000
2	6/4/1998	10,500
3	5/5/2003	7,320
4	9/13/1979	7,320
5	2/14/1989	4,780
6	4/25/1993	4,040
7	3/29/1975	2,960
8	10/5/1995	2,930
9	5/25/2000	2,500
10	5/19/1983	2,070

Existing Flood Risk Management

In 1986, a USACE Chief's Report recommended construction of a dry dam (peak flow detention structure) located in the vicinity of Old Hickory Boulevard in the Cane Ridge area of South Nashville. The design flood for the project was the 1/100 ACE or 100-year flood. This structure would have had significant flood control benefits in the middle and lower reaches of Mill Creek, by current estimates, nearly $2M in annual damages prevented. The recommended plan was never implemented due to public opposition to the acquisition of land required for the impoundment area. The City of Nashville working with USACE is testing Real Time Simulation Modeling (HEC RTS) for Mill Creek and several other flashy streams in the county. Using real time gage and radar data, the models will enable the city to predict flooding before it occurs and take appropriate actions including road closures, evacuations, and sand bagging.

Natural Resource Conditions

Existing conditions for terrestrial resources are typical of urban/suburban areas. The lower two-thirds of the watershed are urban with some open fields along floodplains and in park lands. Most of the area is residential or commercial land use with minimal habitat value. Vegetation is typical of residential areas with some pockets of floodplain-riparian areas being forested but highly occupied by invasive species. Wildlife species are those typical of urban areas. Aquatic resources through-out Mill Creek are generally acceptable but reflect the consistent bedrock substrate and flashy urban hydrology. Upper-most streams are often flow-limited and go dry on a seasonal basis. The Nashville Crayfish (*Orconectes shoupi*), an endangered species found in numbers in Mill Creek, is listed since it is endemic to Mill Creek. It appears to be tolerable of urban development. No known HTRW issues exist within lands utilized by the alternatives under consideration, however, potential issues do occur in adjacent areas, as would be expected of areas that have been urbanized for a number of years. These are discussed in more detail in Appendix C, Attachment D. Likewise, several historic structures occur within the watershed but are outside of areas required for alternatives under consideration. In summary, existing environmental resources are typical of urban areas and would not affect plan formulation, outside of avoidance of work in streams to avoid potential effects on the Nashville Crayfish.

Federal Interest

A reconnaissance investigation for Mill Creek indicated, "that there is significant potential that cost effective engineering solutions to the problems identified can be formulated. The potential solutions are consistent with Army policy and budgetary policies and the project will meet criteria for Federal participation in project implementation." Current study finds that existing annual damages from flooding in the study area amount to nearly $5.2M. The recent flood in May 2010 resulted in $185M in damages in the Mill Creek watershed. During that flood, two fatalities occurred in the watershed.

3.2 Future Without Project Conditions

Future land use projections were obtained from the Metropolitan Nashville and Davidson County Planning Commission and the Williamson County Planner and Engineer. Metro provided detailed GIS data layers and a parcel by parcel analysis of development potential. The Williamson County data was based on GIS zoning data. Although a large portion of the watershed is under Williamson County jurisdiction today, the urban growth boundaries for the cities of Brentwood and Nolensville will encompass almost all the upper 1/3 of the watershed. The data assumes a continued build out of the ongoing residential development with a smattering of other types of development.

In general, the entire watershed is projected to increase to about 100% build out by 2050. The Mill Creek watershed was divided into 5 major zones as shown in Figure 7. Zones 1, 2, 3 and 4 lie almost entirely within Davidson County and Zone 5 within Williamson County. Zones 1, 2 and 3 are very urbanized while zones 4 and 5 are less developed. The division of zones provides a good separation into smaller subwatershed drainage characteristics and GIS analysis. This build out was then translated to imperviousness based on the relationships developed during the existing conditions analysis of the hyperspectral data. For example, the runoff characteristics for pasture with the potential for conversion to residential development were changed to runoff characteristics for a suitable existing residential development. A comparison of existing and future conditions imperviousness is shown as Table 5. The imperviousness changes from about 40% to 50% in the most downstream areas, from 30% to 40% in the middle, and from about 15% to 30% in the upper part of Davidson County. Williamson County changes would be very similar to the upper part of Davidson County with less density, steeper terrain and more open space where imperviousness would change from about 10% to 20%. The Existing and Future Conditions imperviousness are shown in Figure 7.

Table 5. Comparison of Existing and Future Conditions Imperviousness

Major Basins	Existing Conditions	Future Conditions	Increased Imperviousness
(Zones)	%IMP	%IMP	%IMP
Zone 1	39	45	6
Zone 2	30	39	9
Zone 3	29	36	7
Zone 4	13	31	18
Zone 5	6	20	14

The future without project condition for this study is based on a continuation of existing stormwater detention and floodplain management policies in Davidson and Williamson Counties with these buildout conditions in place. Existing and future conditions discharges are shown in Table 6 and Table 7 at select locations along Mill and Sevenmile Creeks. Discharges along the headwaters of Sevenmile Creek, Whittemore and Sorghum Branches were adopted from previous Metro HEC-1 studies and deemed conservative for Future conditions and are summarized in the hydraulic modeling section of the H+H Appendix.

Risk reduction to people and property are the primary focus of this feasibility study. As documented above, and in Section 3.3 Watershed and Floodplain Management, flooding in the Future Without Project is anticipated to continue and increase in levels of damage and total value of damage. A no action alternative, or no recommended project to address the residual risk associated with the without project condition would result in zero solutions to reduce risks to life and property, and zero reduction to the over $5M in expected annual damages from future flood events. Further detail on development of future without project conditions can be found in the H+H Appendix, Appendix C.

The future without project condition for environmental resources would be a continuation of current land use development, although development within floodplains would be improved over what occurred historically (prior to current floodplain management). Ecological resources would be impacted by urban development, particularly in the upper third of the watershed which would experience higher growth rates.

Current open-areas would be converted to residential-commercial developments as growth continues. Historical development within flood-prone areas would continue to degrade aquatic resources and downstream floodplain areas as debris and sewage would result following periodic flood events.

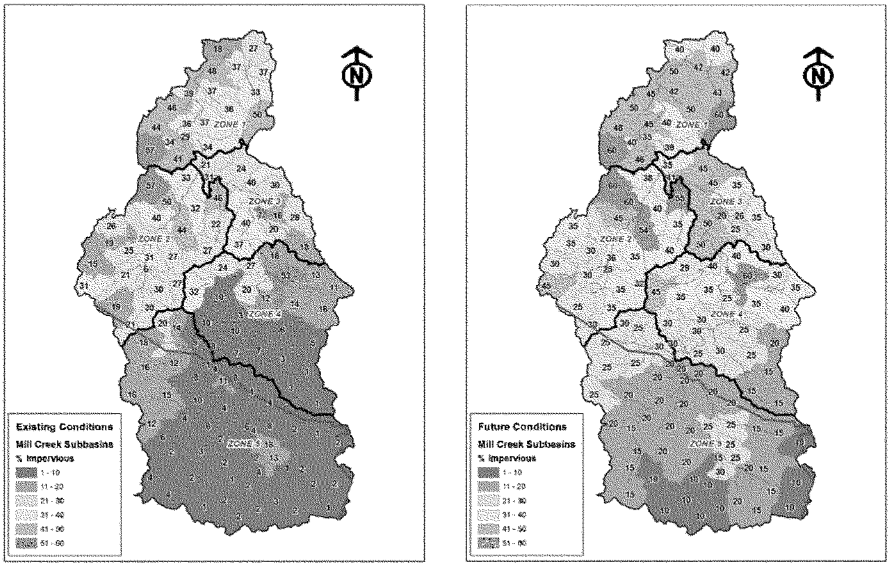

Figure 7. Percent Impervious - Mill Creek Existing and Future Conditions

Table 6. Sevenmile Creek Existing and Future Conditions Discharges

			Frequency Discharges							
Location	Drainage Area		2yr	5yr	10yr	25yr	50yr	100yr	200yr	500yr
	(Sq Miles)		(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
At Oakley Drive	7.28	Existing	2,922	3,784	4,838	5,838	6,594	7,378	8,187	9,382
		Future	3,012	3,842	4,875	5,869	6,626	7,409	8,218	9,419
USGS Gage at Blackman Road	12.05	Existing	3,809	4,891	6,328	7,672	8,692	9,805	10,973	12,947
		Future	3,932	4,979	6,390	7,725	8,745	9,860	11,032	13,016
At Nolensville Pike	14.00	Existing	4,219	5,400	6,795	8,175	9,249	10,186	11,011	13,141
		Future	4,356	5,498	6,858	8,234	9,305	10,238	11,072	13,236
At Paragon Mills Road	16.43	Existing	4,864	6,164	7,597	9,046	10,193	11,025	11,901	13,336
		Future	5,015	6,247	7,663	9,108	10,238	11,075	11,955	13,394
Sevenmile Creek at Mouth	17.53	Existing	4,746	6,006	7,318	8,595	9,618	10,587	11,501	12,815
		Future	4,891	6,113	7,378	8,653	9,677	10,639	11,554	12,871

Table 7. Mill Creek Existing and Future Conditions Discharges

			Frequency Discharges							
Location	Drainage Area		F2YR	F5YR	F10YR	F25YR	F50YR	F100YR	F200YR	F500YR
	(Sq. Miles)		(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
ABOVE OWL CREEK	21.04	Existing	6,403	9,014	12,129	14,872	16,983	19,203	21,668	24,934
		Future	6,731	9,264	12,263	15,008	17,117	19,338	21,803	25,070
USGS GAGE MILL CREEK NEAR NOLENSVILLE	40.46	Existing	8,977	12,734	17,526	21,806	25,142	28,692	32,402	37,720
		Future	9,626	13,151	17,812	22,061	25,410	28,955	32,660	38,014
BELOW COLLINS CREEK	57.31	Existing	8,022	11,240	15,683	19,900	23,267	26,823	30,569	36,139
		Future	8,726	11,851	16,140	20,352	23,696	27,257	31,010	36,623
USACE GAGE MILL CREEK NEAR ANTIOCH	64.20	Existing	7,756	10,461	14,712	18,860	22,059	25,483	29,089	34,311
		Future	8,456	11,102	15,255	19,349	22,538	25,977	29,593	34,850
USGS GAGE MILL CREEK AT THOMPSON LANE	93.20	Existing	10,607	13,257	16,885	20,856	25,111	29,986	35,002	42,103
		Future	11,440	13,986	17,534	21,577	25,813	30,698	35,712	42,857
MILL CREEK AT MOUTH	107.26	Existing	11,581	14,629	18,621	22,399	25,995	30,652	35,557	42,632
		Future	12,587	15,486	19,334	22,871	26,724	31,359	36,318	43,414

3.3 WATERSHED AND FLOODPLAIN MANAGEMENT

This watershed and floodplain management evaluation defines watershed flooding characteristics and demonstrates how changes in land use and floodplain storage characteristics may impact stormwater runoff and flooding in the Mill Creek basin. Increased urbanization can cause radical changes to the topography, ground cover, and stormwater management systems within a watershed. Sometimes, these changes have adverse effects on the environment, primarily through the subsequent increase in runoff quantity and nonpoint source pollution, which has a negative impact on stormwater quality. Both Davidson and Williamson Counties strictly enforce stormwater quantity and floodplain ordinances which provide both technical guidelines requiring on-site detention of stormwater for developments and alternate storage provisions to off-set any filling of the floodplain. To minimize adverse stormwater quantity impacts, all new developments are evaluated for adverse impacts on downstream properties. These requirements are mandatory for all developments that are not served by an adequately sized regional stormwater management facility and subject to review by the regulating jurisdiction. Because detention in downstream areas of a large watershed can cause increased peak flows in downstream channels, the regulating jurisdiction also reserves the right to alter the detention criteria and to prohibit it where it would cause adverse impacts. These decisions are based on sound engineering judgment along with supporting data and studies.

Metro/Davidson County encompasses the lower two-thirds of the watershed and understands their existing flooding problems along Mill Creek and its urbanized tributaries. The majority of the repetitive loss structures were built before the existence of stormwater and floodplain ordinances. These high damage reaches include major transportation infrastructure (Interstate and rail), commercial, industrial and residential components. Flood damages within Williamson County (Brentwood and Nolensville) along headwater streams are very small in comparison to Davidson County.

The upper two-thirds of the Mill Creek watershed is one of the fastest growing areas surrounding Nashville. Communities within the watershed would like to see as much of their rural character preserved as possible. There is consensus among the public that rural character and open spaces are important community amenities and should be preserved as much as is feasible. The method by which rural character preservation and open space could be accomplished varies among different communities; however, the idea of permanently preserving rural open space is a key theme throughout. Both Davidson and Williamson Counties accomplishes this by setting aside a large rural area and open space policies as part of their community plans. Plans also provide for new parks and open space that will provide for future recreational opportunities with the added bonus of providing protection for streams and creeks that make up the watershed. Much of the open space is created with greenways that will connect schools, parks, neighborhoods and centers.

In Metro Nashville, new development and significant redevelopment are required to preserve water quality buffers along intermittent and perennial streams, lakes and ponds with hydrologic connectivity and wetlands that have been identified by the U.S. Army Corps of Engineers, TDEC, or Metro Water Services (MWS) staff. Zone 1 for all buffers is considered a "no disturb zone" where vegetation cannot be disturbed, removed or replanted unless a buffer restoration plan has been approved by MWS. Zone 2 can consist of managed vegetation, meaning the buffer zone can be disturbed and planted with grass or other vegetation. However, no structures or impervious surface can be placed in Zone 2. For FEMA studied streams or streams with a drainage area greater than or equal to one square mile, the stream buffers are defined as Zone 1 = Floodway + 50 feet, and Zone 2 = 25 feet. An illustration of the 75 foot buffer for streams with floodways is shown in Figure 8. The Williamson County portion of the Mill Creek Watershed includes mostly the Cities of Nolensville and Brentwood, Tennessee. Both the City of Nolensville and Brentwood have similar compensation storage regulations requiring at least an equal amount of compensation storage volume as occupied by fill. Nolensville has a 50-foot water quality buffer. Brentwood has no water quality buffers at this time.

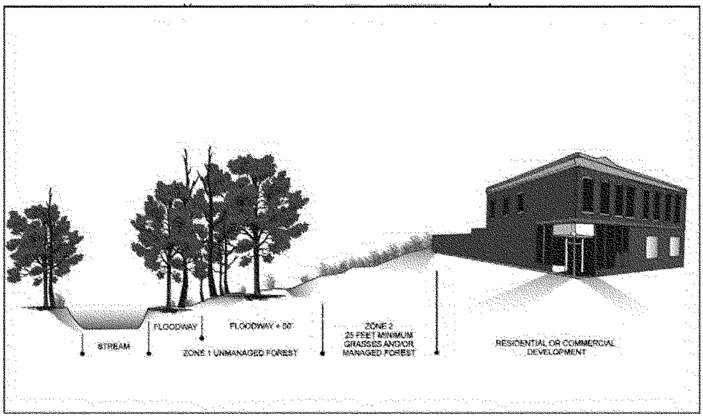

Figure 8. Buffer Example for Streams with Floodways

3.3.1 Watershed Flooding Characteristics

Historical flood events provide much information about the nature of flooding in the Mill Creek basin. Floods occur during all seasons of the year, but are most prevalent during the winter and early spring when antecedent moisture conditions are highest. The floods are flashy, with rates of rise ranging from 2 to 4 feet per hour and durations averaging 12 hours. Floods can be intensified by the orientation of the storm (how the storm tracks across the watershed) and rainfall volumes.

Major storms like the May 2010 event have occurred where initial wetting in combination with large storm event intensified flooding. The May 2010 event was actually two very different flood events occurring on May 01 and May 02, 2010. During the May 01, 2010 and May 1979 flood events of record much heavier rainfall fell in the upper portions of the watershed within Williamson County while the May 02, 2010 event and other significant floods (September 1979) experienced the heaviest rainfall in the lower Davidson County portion of the watershed. The May 01, 2010 maximum precipitation and storm track is shown in Figure 9. The red dots show locations with maximum reported gage precipitation in inches. The black dashed line (and background isohyetal grid) shows the track and direction of the most intense rainfall thru the Nashville area. The May 02, 2010 maximum precipitation and storm track are shown in Figure 10 for comparison. The May 02 event also moved from the west to east in a Northeasterly direction with the most intense portion of the storm moving thru downtown Nashville just northwest of the Mill Creek basin. May 2010 flood event cumulative rainfall curves and streamflow hydrographs are shown in Figure 11.

The May 01, 2010 storm event is possibly the worst-case scenario for flooding along the main stem in the upper two-thirds of the basin. The upper portion (headwaters) of the basin received the heaviest rainfall much earlier during event where Mill Creek was able to rapidly rise to a moderate flood level. As the flood peak traveled downstream it was further intensified by the second wave of heavy rainfall creating the worst flooding ever experienced along Mill Creek. Essentially, the second wave created a near coincidental peak occurrence between the main stem and its lateral inflow tributary streams causing a more severe flood. On May 02, the rainfall was more intense and earlier in the lower portion of the watershed. The lateral tributaries are very flashy and can cause significant flooding along the lower reaches of Mill Creek as identified as peaks number 1 and 2 in Figure 11. Peak number 3 is the runoff contribution from the Mill Creek headwaters after progressing downstream. Although the peak discharges were less on May 02, the flooding in the lower end of the basin along Mill Creek was prolonged by the timing of lateral tributary inflows. Coincidental peaking of the upper Mill and Owl Creeks can also further intensifying downstream flooding as observed from real-time streamflow records at the near Nolensville gage on Mill Creek as shown in Figure 12.

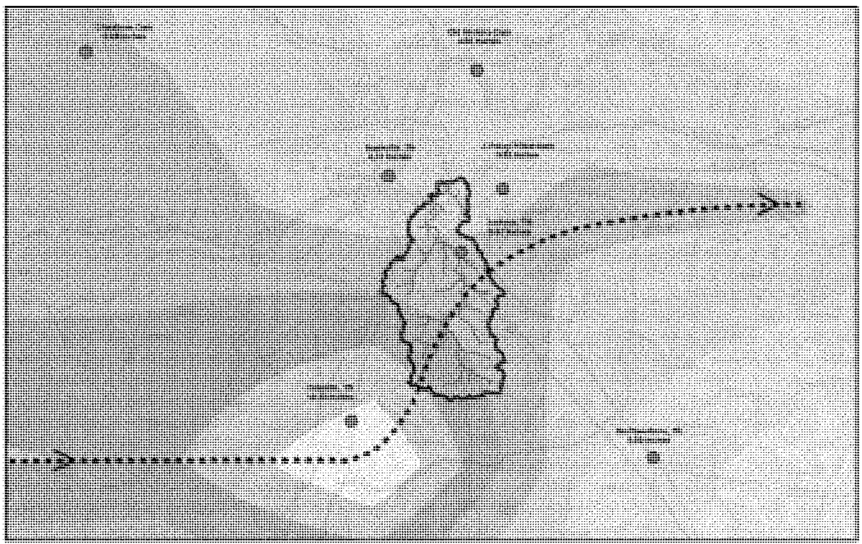

Figure 9. May 01, 2010 Maximum Precipitation and Storm Track

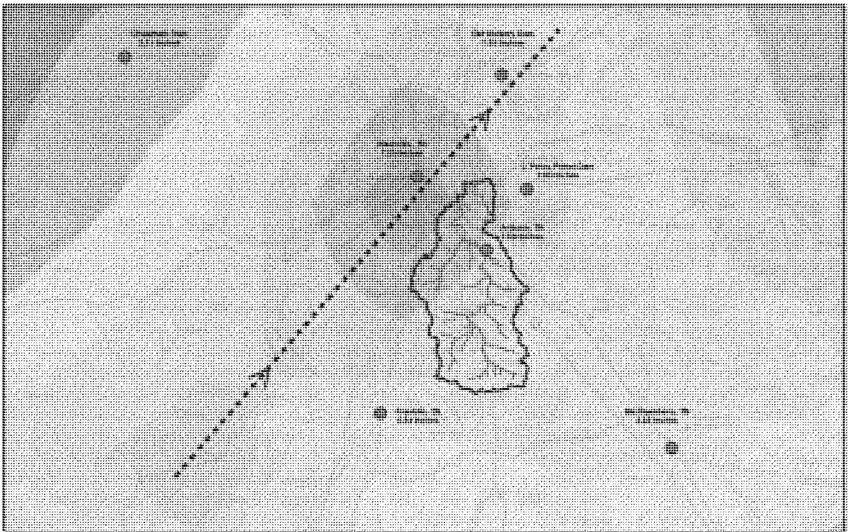

Figure 10. May 02, 2010 Maximum Precipitation and Storm Track

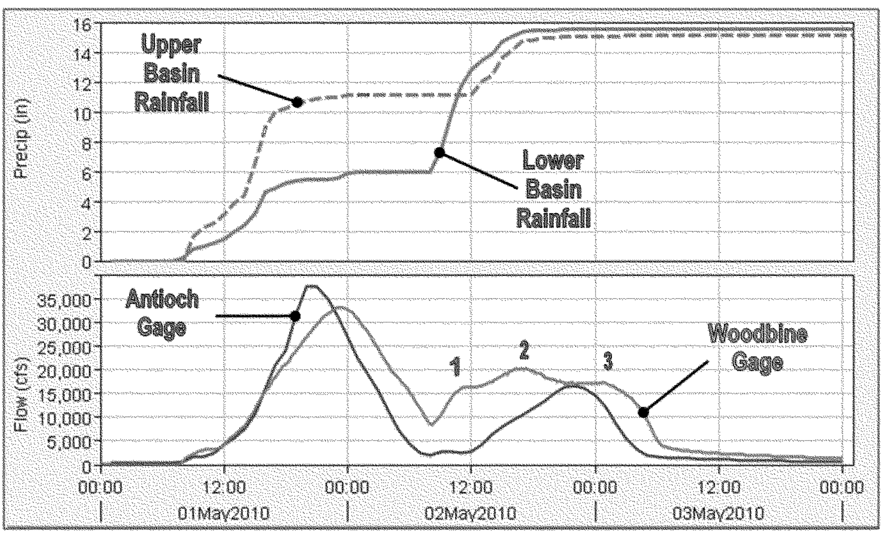

Figure 11. May 2010 Flood Event Cumulative Rainfall and Stream Gage Hydrographs

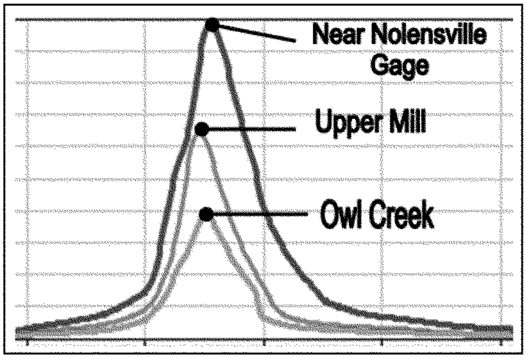

Figure 12. Coincidental Peaking of Headwater Streams

Figure 13 shows the hydrologic response for a 50-year (1/50 ACE) 24-hour uniformly-distributed frequency storm at select locations in the Mill Creek basin. Note that the drainage area for Mill Creek at Davidson/Williamson County line (green hydrograph) is 40 square miles, 75 square miles just above Sevenmile Creek (blue hydrograph) and 93 square miles below Sevenmile Creek (red hydrograph) at Thompson Lane. As observed from real-time gages and modeling studies the peak discharge along Mill Creek can attenuate as it travels downstream from the headwater confluences. When flood flows exceed the channel carrying capacity, water flows into overbank areas where flow is slowed greatly. This is commonly referred to as floodplain storage or valley storage and can be significant in terms of translation and attenuation of the flood wave (hydrograph). As discussed in previous paragraph, the lower reach below Sevenmile Creek can experience multiple flood peaks typically four to six hours apart. This is represented graphically in the upper left corner of Figure 13. The first sharper peak is from the combination of runoff from urbanized Sevenmile Creek and lower Mill Creek tributaries located within Davidson County, while the second peak contribution is from the lesser developed upper Mill Creek basin mostly within Williamson County.

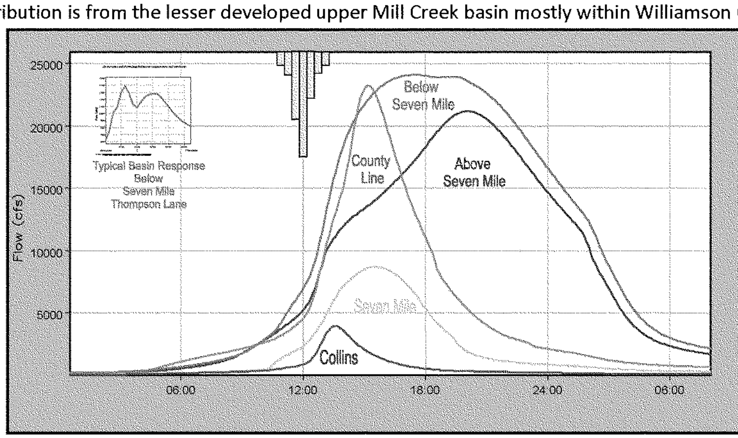

Figure 13. Hydrologic Response for 24-hour Balanced Storm

3.3.2 Watershed Sensitivity to Changes in Imperviousness

Calibration to historic floods show that Mill Creek watershed is not very sensitive to increased imperviousness during winter and early spring months when soils are saturated and the water table is high. Infiltration rates are typically less than 0.1 inches per hour and the moisture deficit (i.e., volume of rainfall the ground can absorb before saturated) is less than 0.5 inches. The two largest floods on record (May 1979 and May 01, 2010) were preceded by a significant rainfall event which kept ground near saturation prior to main event. Modeling results indicate that a uniform increase in imperviousness impacts more frequent floods like the 2-year (1/2 ACE) and 5-year (1/5 ACE) events. The infiltration rates average 0.08 inches per hour for frequency rainfall-runoff simulations. Moisture deficit vary from 0.3 inches for a 500-yr (1/500 ACE) to 1.3 inches for a 2-yr (1/2 ACE). This reflects the likelihood that the more frequent runoff events occur when the moisture deficit in the watershed is high while the less frequent runoff events occur when the moisture deficit in the watershed is low as observed historically. As drainage area increases the effects of imperviousness is slightly greater due to the accumulation of added runoff volume.

3.3.3 Watershed Sensitivity to Changes in Upland Floodwater Controls

Davidson and Williamson County stormwater regulations require new developments to attenuate post-development discharges to a level not to exceed the pre-development discharges for the 2-year thru 100-year frequency flood events. However, detaining the discharge from a site can sometimes exacerbate flooding downstream due to the flow peak timing or the increased volume of runoff coming from a site. If water quantity control (detention) structures are indiscriminately placed in a watershed and changes to the flow timing are not considered, the structural control may increase the peak discharge downstream. Another impact of new development is an increase in the total runoff volume of flow. Thus, even if the peak flow is effectively attenuated, the longer duration of higher flows due to the increased volume may combine with downstream tributaries to increase the downstream peak flows. Metro also implemented the "Ten Percent" rule to further evaluate the increased runoff volume. The rule recognizes that in addition to controlling the peak discharge from the outlet of the detention facility, these facilities change the timing of the entire outflow hydrograph for the stream or river in question. Where required, channel routing calculations must proceed downstream to the confluence point where the drainage area being analyzed represents ten percent or less of the total drainage area. At this point, if the effect of the hydrograph is assessed and shown not to increase flows in the downstream hydrographs, detention can be waived. If increased flows are found, then backwater calculations and determination of flood elevations for the areas impacted by increased flow, if any, must be prepared. Where downstream increases in peak flow or flood elevations are shown, detention will be required on site to attenuate storm flows from post-development to pre-development flows.

It is somewhat challenging to evaluate the sensitivity of upland floodwater controls. There are numerous existing site and regional floodwater controls throughout the Mill Creek basin. Site upland floodwater controls are smaller in size primarily reducing or maintaining flood discharges at a site development outlet and designed for shorter duration storms. Regional floodwater controls or stormwater detention facilities servicing large developments produce more economical and effective results than numerous smaller ones and typically include the evaluation of minimizing downstream peak flow, timing and volume impacts for longer duration storms.

The hydrologic models were developed using a gridded approach where the grid size was generally equivalent to a 10-acre parcel as shown in Figure 14. The 10-acre grid size was well suited for urban areas allowing for a more detailed analysis of infiltration, land use and runoff changes within the watershed. Figure 14 depicts a Mill Creek one square mile subbasin with 10-acre grids superimposed on it. Grid cell parameters were modified to reflect urbanization without upland floodwater controls. This was accomplished by applying a 25% reduction to subbasin time of concentration and Clark unit hydrograph storage parameters. Reduction of these parameters has the effect of peaking the unit hydrograph for each one square mile subbasin. Time of concentration reductions reflect changes in velocity of overland, shallow concentrated and channel flow. For example, travel time from the 10-acre parcel (yellow square) to basin outlet (yellow dot) is reduced from 60 to 45 minutes. Depression areas are filled and upper collection systems are modified (e.g., curb and gutter or concrete pipe) reducing the storage characteristics of the subbasin.

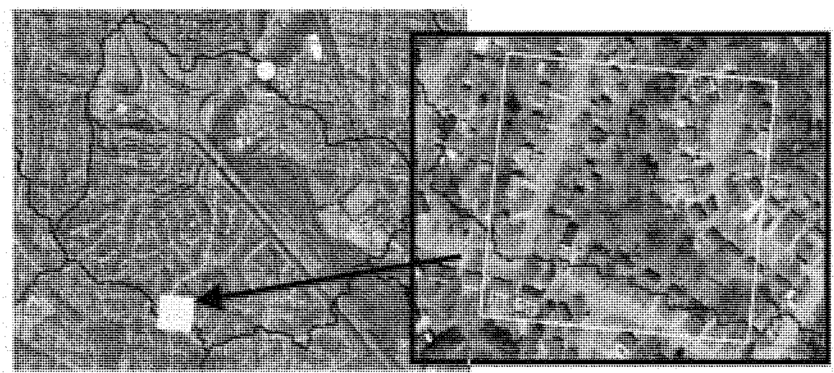

Figure 14. 10-acre grid cells superimposed on one square mile subbasin

Analysis was performed throughout the basin for the 2-yr (1/2 ACE), 10-yr (1/10 ACE), and 100yr (1/100 ACE) frequency flood events. Figure 15 illustrates the sensitivity of analysis results. As the drainage area increased, the impacts from hydrograph peaking were reduced. For example, Turkey Creek has a drainage area of approximately two square miles where the frequency discharge increased by nearly 25 percent. Indian Creek with drainage area of five square miles was slightly less. Along Mill Creek, the frequency flood discharges increased by approximately ten percent at the Nolensville Gage (near Davidson/Williamson County Line) and five percent downstream at the Antioch and Woodbine Gages. A ten percent increase in the 100-year (1/100 ACE) discharge along Mill Creek would increase the flood stage by approximately six inches (0.5 ft). If the upland floodwater controls were fifty percent effective over the range of frequency events, it would equate to a couple (2 – 3) of inches of increase in the 100-yr (1/100 ACE) flood stages along Mill Creek. Smaller tributary creeks would experience greater impact from hydrograph peaking if enforcement of upland floodwater controls is not enforced.

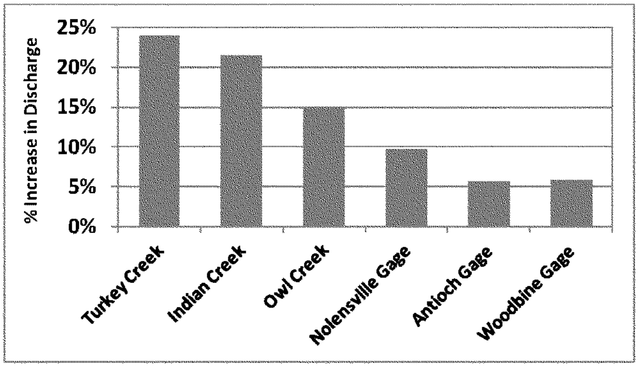

Figure 15. Flood Frequency Discharge Sensitivity to Hydrograph Peaking

3.3.4 Watershed Sensitivity to Changes in Floodplain Storage

Hydrologic and hydraulic models typically do not account for loss of floodplain storage. The standard practice is to compute discharges, water surface profiles, and floodways based on existing conditions with no consideration for increased discharge due to future development or loss of floodplain storage. For this analysis the floodplain storage was divided into 3 major basins named Lower (Nashville), Middle (Antioch) and Upper (Nolensville) as shown in Figure 16. The floodplains in the most downstream basin (Nashville) are urbanized with a combination of natural and man-made storage most of which is along Sevenmile and Mill Creeks. An example of man-made storage is backwater behind the CSX Railroad culvert over Sevenmile Creek. The middle basin (Antioch) has less floodplain development and abundant natural storage along Mill Creek's main stem where storage in backwater areas at the confluences with major tributary streams like Turkey, Indian, Holt and Collins Creeks are also beneficial. Most streams have some natural storage, but as the streams get smaller and steeper, storage becomes less significant in reducing flood elevations and attenuating flood waves. The upper basin (Nolensville) is less urbanized with natural storage along the headwater reaches of Mill and Owl Creeks, but as headwaters streams fan out, storage rapidly diminishes.

Hydrologic model storage parameters were modified to reflect the loss of conveyance and storage in the overbanks. Figure 16 demonstrates the changes in peak flow and flood wave travel time for a major flood event in the Mill Creek basin with and without floodplain storage compensation. The flood wave travel times in the Nolensville basin were reduced by approximately 0.5 hours along the headwater reaches of Owl and Mill Creeks. The travel time along Mill Creek main stem in Antioch basin was reduced by 2.4 hours, the most significant change. Travel times along Sevenmile Creek and Mill Creek in Nashville basin were reduced by 1.8 and 0.9 hours, respectively.

Typical hydrograph responses for major floods (approximately a 50-year) along Mill Creek with and without floodplain storage compensation are shown in Figure 17 for the upper (Nolensville) middle (Antioch) and lower (Nashville) storage basins. Flood peak discharges increased along Mill Creek from 10 percent at the headwater confluences to 30 percent along the lower reaches of Mill Creek. Overbank floodwaters typically become disconnected from the main stem in backwater or slow moving adjacent floodplains. The encroachment without compensation essentially pushes these overbank flood waters back into main channel conveyance area speeding up the Mill Creek main stem hydrograph. The tributaries peaks will also move closer in time to coinciding with the main stem peak further intensifying flood peaks.

A floodway analysis was performed in HEC-RAS for Mill Creek and Sevenmile Creek to demonstrate the impacts from increased development without enforcement of compensation floodplain storage ordinances. The floodway boundaries were first determined using the future conditions discharges for both the 100-yr without and the 100-yr with encroachment. Encroachment surcharges were limited to positive 1.0 ft as required by FEMA. The floodway discharges were then updated using the revised flows from the hydrologic model with modified storage parameters. The revised discharges were based on floodplain condition representing the loss of valley storage equal to the floodway plus 50 ft water quality buffer. The floodway analysis resulted in a 1 – 2 ft increase in 100-yr water surface elevations along Mill Creek in the upper and middle reaches above the Sevenmile Creek confluence and 2 – 5 ft increase along the more developed Mill Creek reach below Sevenmile creek. The larger increases along the lower reach resulted from the combination of flow restrictions thru existing bridges and the increased flow resulting from the accelerated main stem hydrograph. Sevenmile Creek showed less of an impact from loss of floodplain storage with 100-yr water surface increases of 1 ft in the upper reached and as much as 2 feet in the lower end. The Mill Creek hydrologic model was calibrated to both highwater mark and real-time streamflow data where significant flow attenuation was required to reproduce observed data. This analysis only demonstrates the sensitivity of how extreme modifications to floodplains along Mill Creek and its major tributaries could impact flood stages.

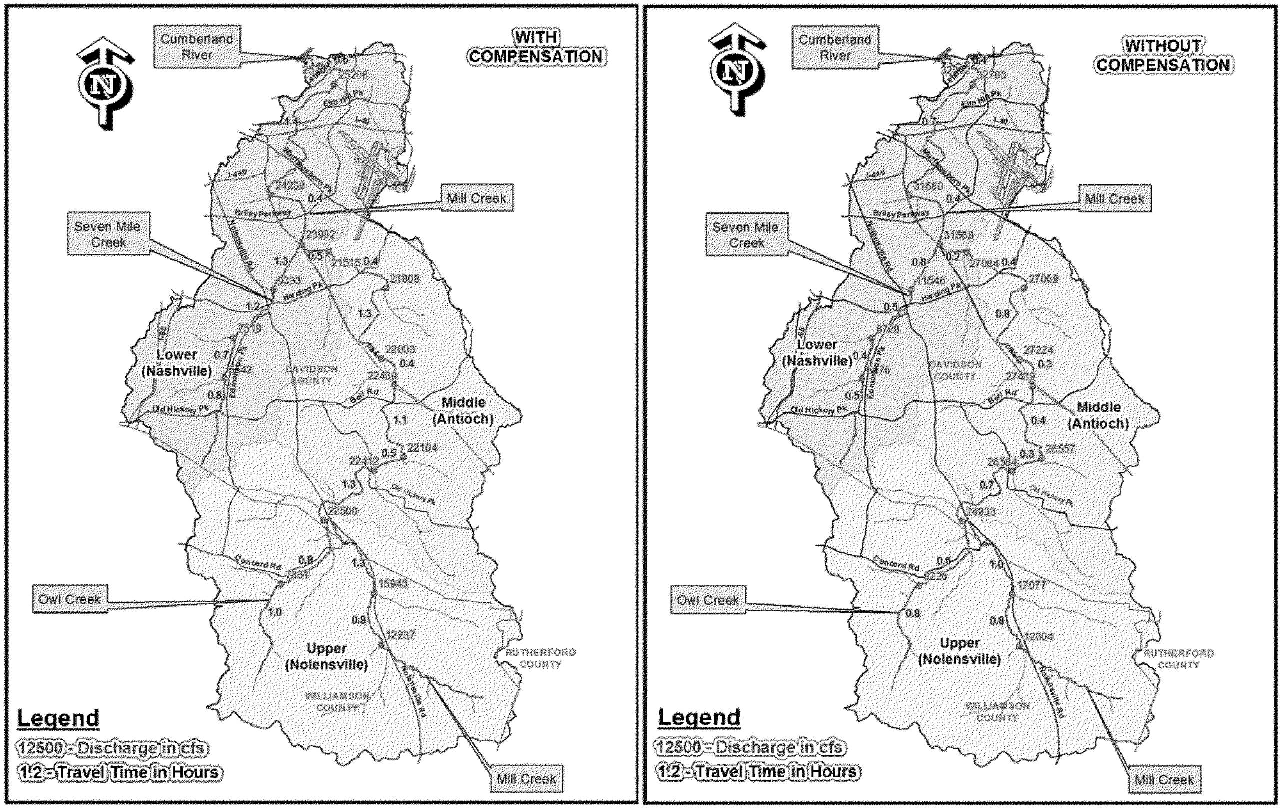

Figure 16. Discharge and Travel Times – With and Without Floodplain Compensation Storage

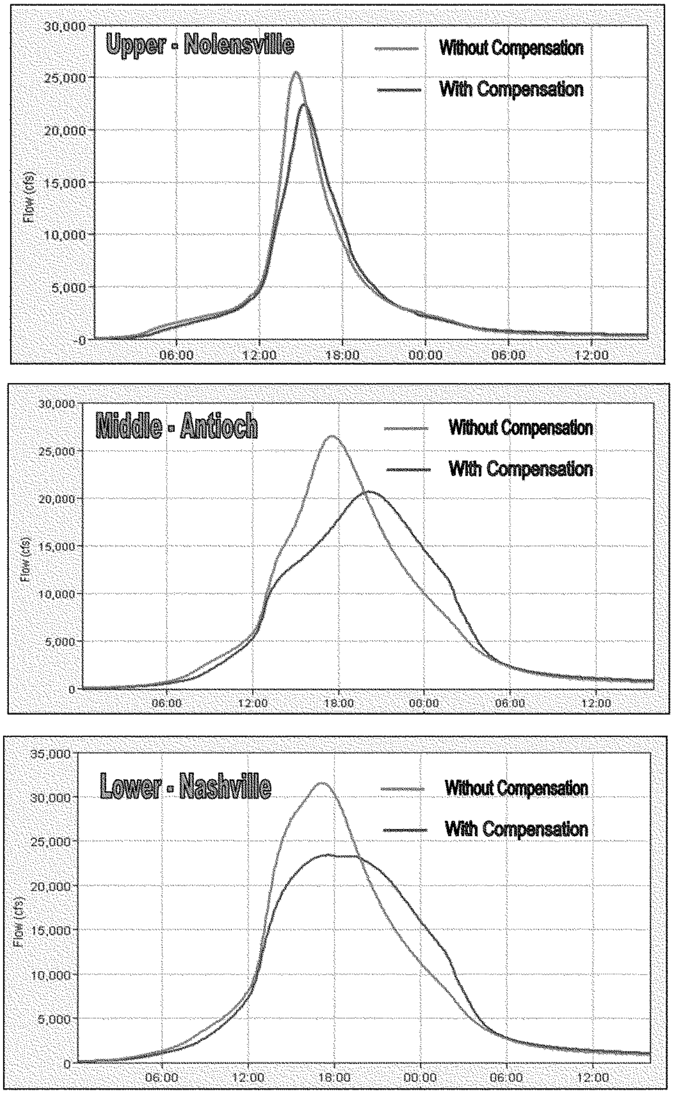

Figure 17. Mill Creek Hydrograph for Major Flood Event

4 Plan Formulation

This chapter describes the process and development of management measures into alternative plans that address the planning objectives and the comparison of those plans. It ultimately describes the recommended Plan and its implementation requirements. Many various flood risk management measures were developed that would address the planning objectives. These measures were then evaluated and screened as described below. Following that preliminary analysis, alternative plans were developed from combinations of the management measures. Throughout the iterative planning process, plans were formulated as a result of analysis.

4.1 Management Measures

Previous USACE and Metro Nashville analysis provided the basis for engineering evaluations in the Mill Creek watershed. All previously engineered measures were reviewed to determine how changes in the watershed would affect their performance. Any measure that was feasible in earlier studies was given particular scrutiny. Forty-three measures were considered in the 1986 study, fifteen of those were carried forward in the 2007 Feasibility Scoping Meeting documentation report. Eight additional measures were considered from development of the Unified Flood Preparedness Plan for a total of fifty-one measures analyzed. These measures were compared against updated H+H data, flood damages reduced and preliminary economic analysis.

Ultimately, based on engineering performance, thirty-one measures, nineteen structural and twelve non-structural, were identified for detailed evaluation to determine whether they would accomplish flood damage reduction in the Mill Creek watershed, based on detailed basin study and the damage centers depicted in Section 3.4 of the Economic Appendix (Appendix A). These preliminary measures were developed by evaluating future without project damage conditions, hydraulic indicators such as head loss through bridges and other constraints, and updating the alternatives evaluated in the numerous earlier studies.

Nonstructural flood damage reduction measures do not modify floods; rather, they reduce flood damage by removing buildings and damageable contents away from the flood waters. Non-structural measures include floodplain zoning ordinances to keep buildings out of the floodplain, flood forecasting and warning, floodplain evacuation (buyout and removal), structure raise-in-place, and flood proofing. Structural measures are designed to keep flood water away from damageable property. Structural measures may include dams and reservoirs, levees, detention basins, bridge modifications, channel modifications, and flow diversions.

The following non-structural measures were considered: flood warning and evacuation planning, raise-in-place, flood-proofing, and evacuation or removal. The following structural measures were considered: levee, floodwalls, detention basin, channel modification, bridge modification. These measures were evaluated against damage center data and environmental impacts. Mill Creek and the tributaries Sevenmile Creek, Sorghum Branch, Whittemore Branch are all urban streams which impacted formulation of management measures. These measures were also coordinated with the sponsor as the PDT participated in the development of the UFPP and the increased level of involvement in multiple projects with the City of Nashville following the May 2010 flood event.

Floodplain zoning management and enforcement is not being considered further because the City has an advanced flood warning system and zoning enforcement office. Metro Nashville has implemented a series of planning, zoning, and codes measures meant to limit future damages and improved this enforcement since May 2010. Briefing and educational materials have been prepared for Metro's Stormwater Variance Committee describing the impacts of varying from Metro's strong stormwater ordinances.

Levees and floodwalls have not been considered in greater detail as a result of preliminary benefit analyses which showed low rankings compared to other measures. While areas in the watershed such as Space Park, sustain significant damages, levees or floodwalls are not viable. The primary limitation there is land due to buildings being constructed right up to the streambank. Ultimately several buyouts of commercial buildings would have to be made to allow for the land required to build this measure. The preliminary benefits did not provide enough cause to consider this measure further.

The remaining measures have been matched to various sites in the study area to accomplish one or more objectives; further detail is provided in Section 4.1.3 for the non-structural measures and 4.1.4 for the structural measures.

4.1.1 Preliminary Flood Damage Reduction Measures

By examining and combining the above series of measures and their ability to accomplish the objectives of the study, the following set of preliminary alternatives for flood damage reduction and ecosystem restoration were formulated and evaluated. As previously stated, this study was modified following the May 2010 flood when the City of Nashville decided to only pursue implementation of flood risk management measures. To be clear, no ecosystem measures will be recommended by this report to be pursued to implementation, but the data developed prior to 2010, has been provided to Metro Nashville and they may choose to continue to pursue these measures independently.

As previously stated, a total of twelve nonstructural and nineteen structural measures were identified for preliminary screening. The nonstructural alternatives address only residential damages and are defined in Section 4.1.3. Preliminary economic analysis found no viable commercial nonstructural measures. Raise-in-place, buyout and removal or evacuation of the floodplain, were the focus of these residential non- structural measures. The preliminary screening of the nonstructural alternatives does not include any ecosystem restoration or recreation features or benefits. Those features could be added by Metro Nashville separate to the results of this study. Nineteen structural measures were identified for preliminary screening and these are described and listed in Table 10. Following early iterations, the number is reduced to fifteen measures and those are listed in Section 4.1.4. They include regional flood control (stormwater detention and diversions), channel and bridge modifications. Combinations of these measures were also evaluated to maximize flood damage reduction benefits. Some measures were screened out early due to preliminary benefit/cost ratios below 1.0, which means costs exceed benefits, or for insignificant economic benefits. Various constraints impacted alternative development including the amount of land area required for an alternative, bridge or channel restrictions, the amount of development in the footprint required for detention sites, etc. In particular, implementation area constraints (Davidson County) prevented large scale detention options in the upper third of the watershed (Williamson County), where it may have greater impacts with sufficient floodplain acreage to yield greater downstream benefits.

4.1.2 Flood Warning and Emergency Evacuation

Mill Creek Flood Warning Plan

People and property in the Mill Creek watershed are impacted by flooding from Mill Creek and its tributaries. The watershed is in one of the most rapidly growing urban areas of Middle Tennessee, thereby putting more people and property at risk. Floods occur during all seasons, but are prevalent during winter and early spring. To better prepare for these eventualities in 2009, USACE partnered with Metro Nashville to develop a flood warning and emergency evacuation plan (FWEEP). The overall objective of a FWEEP is to enable the public and emergency personnel to act to protect lives and property before a flood occurs or reaches damaging or threatening depths. To accomplish this, the FWEEP must be complete, geographically comprehensive, integrated, appropriate, sustainable, collaborative, timely, informative, reliable, redundant, and scalable. To provide this support the following components were created for the FWEEP; a data system, an evaluation system, a notification system, a response and recovery system, and a preparedness education system. The Mill Creek FWEEP is provided as part of this study as Appendix C, Attachment A1. Referencing Chapter 5 of the FWEEP and the implementation table, ten of the thirteen recommendations proposed by the 2009 FWEEP have been implemented by Metro Nashville as part of the City's flood warning program, Metro Nashville Situational Awareness for Flood Events (SAFE). The three remaining items are under development in the SAFE program, which is described in greater detail below.

Metro Nashville Situational Awareness for Flood Events (SAFE)

After the flood of May 2010, Metro Nashville and the Corps initiated a study under the Planning Assistance to States Program to develop Hydrologic and Hydraulic (H&H) models and tools for a comprehensive flood preparedness plan in Davidson County. The tools include geographic information systems (GIS) and automated warning systems (AWS). All of the modeling and mapping products completed for Metro Nashville Flood Preparedness were leveraged for use in development of this report. In Metro, the vast majority of flood damage and potential for loss of life are concentrated on six streams - the Cumberland and Harpeth Rivers and Mill, Richland, Whites, and Browns Creeks. The tools assist Metro in defining flooded areas and depths during storm events and help relate flood forecasts for specific locations to other points within the watershed. The tools and products also allow a better, quicker and more directed response to flood events. The tools have also served as a template for other areas in Tennessee. For example, USACE and the City of Chattanooga are in the second phase of developing a similar program in Hamilton County, Tennessee.

Metro Nashville Flood Preparedness Phase 1 was completed by May 1, 2011, the one-year anniversary of the May 2010 Flood. The Corps developed hydrologic and hydraulic models and inundation mapping for the May 2010 Flood Event and a range of potential floods on the 6 major watersheds. Model development included refinement of existing models for the Cumberland River and Mill Creek and Richland Creek watersheds. New models were developed for the Harpeth River and Whites and Browns Creek watersheds. All hydrologic (HEC-HMS) and hydraulic (HEC-RAS) models were calibrated to May 2010 flood observed discharges and high water marks (HWMs) where available. USACE also assisted in the development of the tools necessary to predict and display potential inundation and depth, and assisted Metro and supporting contractors in training watershed advisors on using tools and interpreting the modeling results. This cooperative effort led to the creation of the Nashville Situational Awareness for Flood Events (SAFE) program.

The Nashville SAFE program is a partnership between Metro Water Services (MWS), Metro Office of Emergency Management (OEM), Metro Planning Department (Planning), the U.S. Army Corps of Engineers (USACE), the U.S. Geological Survey (USGS), the National Weather Service (NWS), and AMEC Environment & Infrastructure, the purpose of which is to provide Metro emergency management personnel with a myriad of internal tools to assist in decision making during a flood event.

The three fundamental components of the program are the Nashville SAFE tool, MWS Watershed Advisors, and Watershed Advisory Guides. Examples of Nashville SAFE Watershed Advisory Guide products are shown as Figure 20 and Figure 21. The Nashville SAFE tool is an internal mapping program developed by Metro Planning which can retrieve real-time NWS, Metro, and USGS precipitation and river stage data and display a resulting flooded area and impacts associated with current and predicted flooding based on modeling provided by the USACE. The MWS Watershed Advisors are a team of trained engineers whose purpose is to analyze current and predicted stream conditions and make recommendations to the Situation Management Team at the Emergency Operations Center during a flood event that will minimize potential human loss or injury and property damage from flooding. Watershed Advisors understand how timing and magnitude of rainfall in a particular area affect the timing and magnitude of flow and stage in streams in the watershed. Additionally, they understand the interrelationships between various types of data available for analysis during a flood event and are able to interpret the data, *in real-time*, while collaborating with NWS, USGS, USACE, and OEM personnel.

Using this collaboration of agency data the Watershed Advisor interprets data shown on the Nashville SAFE Tool and provides scientifically-based impact assessments and decision recommendations to the Situation Management Team during a flooding event. As a supplement to the Nashville SAFE tool, Watershed Advisory Guides have been created by AMEC using modeling and data provided by the USACE, Planning, and the NWS that contains watershed-specific impact assessments performed at 11 flood action levels for six watersheds within Nashville. The impact assessments include tables of bridges, side streets, and critical infrastructure flooded at each action level as well as timing between action levels. The Guides also include watershed maps and stream profiles for rivers and creeks modeled by the USACE.

Other activities within the Nashville SAFE program included installation of several new stage gages throughout Metro by the USGS, installation of 12 precipitation gages throughout Metro by MWS and Metro IT, collection and processing of new LiDAR-based topography for watersheds contributing to Davidson County, replication of Metro Planning's GIS server from the Metro Office Building to the EOC and training of Metro Watershed Advisors and ESC's using a tabletop exercise. In addition to the modeling, tools were developed that enable the city to better predict what is likely to occur under different flooding scenarios. Phase 2 of the study included Real Time Simulation (HEC-RTS) modeling for the 6 streams discussed above. The modeling incorporated real time observed data, NEXRAD radar, NWS rainfall predictions to predict inundated areas and depths. The models are used to simulate the impacts from different rainfall scenarios and are available to both Metro and the National Weather Service. Phase 2 also included updating frequency and flow data to turn over to FEMA who will use the data to update the Flood Insurance Maps in Davidson County.

Flood Frequency Analysis

Flood Frequency Analysis was performed for 4 gage locations in the Mill Creek Watershed using the Hydrologic Engineering Center Statistical Software Package (HEC-SSP). Procedures outlined in Bulletin #17B, "Guidelines for Determining Flood Flow Frequency", U.S. Department of Interior Geological Survey, March 1982, were applied to compute flood frequency curves. The majorities of the streams in Nashville area have on average less than 50 years of systematic record and experienced significant urbanization over the period. Annual peak discharges were obtained from USGS publications where available. May 2010 Event discharges and other historic events were obtained from a combination of USGS publications and calibrated hydrologic and hydraulic models developed by USACE. In some cases the peak discharges computed from models used in frequency analysis were different that USGS published values. Examples of USGS annual peak flow data and HEC-SSP computed frequency curve are shown as Figure 18 and Figure 19, respectively.

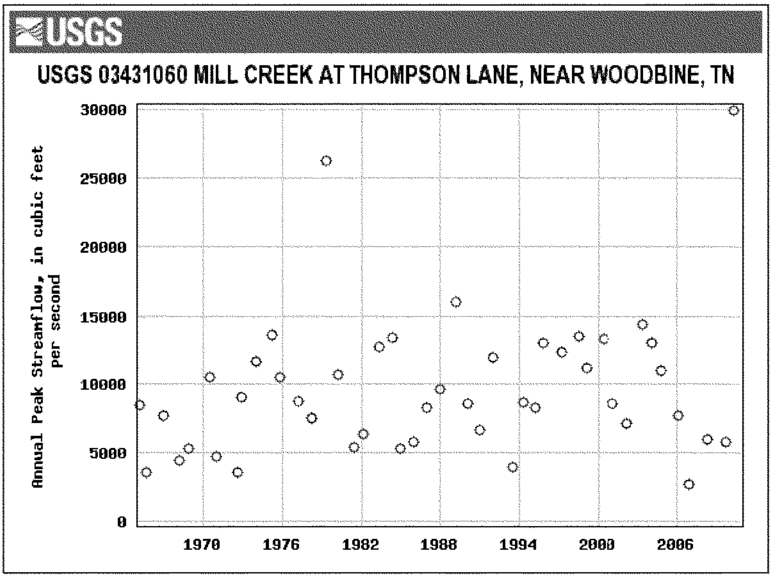

Figure 18. USGS Observed Peak Discharges

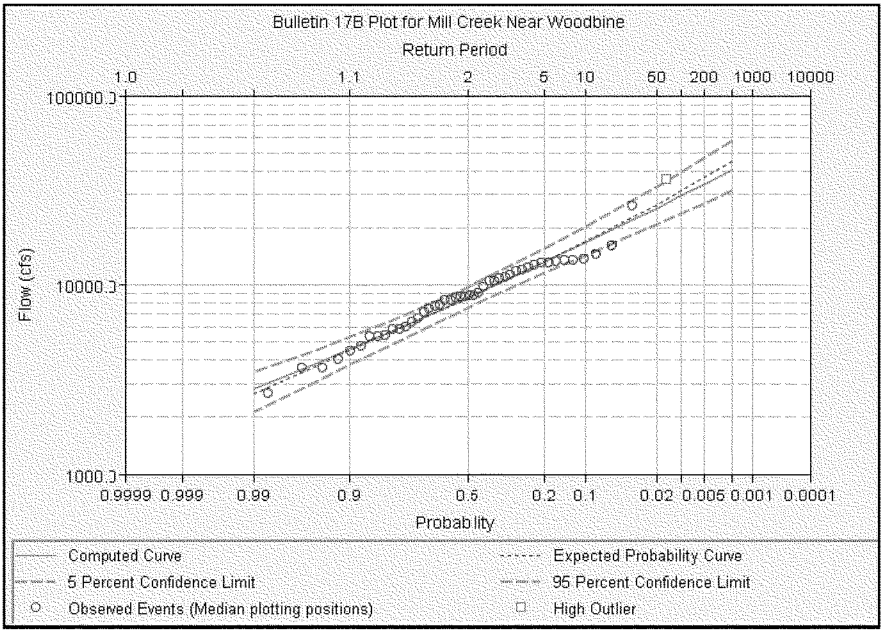

Figure 19. Example HEC-SSP Flood Frequency Curve

The May 2010 flood event was included as a systematic event within the analysis period and sometimes was determined to be a high outlier by HEC-SSP program. Frequency curves were computed using both station skew and regional skew = 0.0 for comparison.

One must be careful in comparing statistical flood frequency results to published and future discharges from FEMA flood insurance studies. Published FEMA values are often computed with rainfall-runoff models using design storms and regression equations that may be significantly different than statistical frequency results. The statistical analysis results are used as a guide to establish flood frequency discharges. Rainfall-runoff models used for this study were calibrated to recent observed storm events and provide reasonable results for establishing frequency discharges based on current watershed conditions. Errors in flow estimates are generally greatest during maximum flood flows. Measurement errors are usually random, and the variance is usually small in comparison to the year-to-year variance in flood flow. The effects of measurement error, therefore, may normally be neglected in flood frequency flow analysis. Peak flow estimates of historic floods can be substantial in error because of the uncertainty in both stage and stage-discharge relationships.

Watershed Action Level Summary
Mill Creek Near Woodbine

River Mile	6.32		Watershed
Datum El.	433.40	NAVD 88	Action
Q	Elev	Stage	Level
45027	457.72	24.32	K
40652	456.73	23.33	J
35601	455.41	22.01	I
31289	454.33	20.93	H
26572	453.18	19.78	G
21890	451.7	18.3	F
17924	450.57	17.17	E
14642	449.22	15.82	D
11364	447.81	14.41	C
7519	445.77	12.37	B
3665	442.48	9.08	A

National Weather Service Flood Categories

Stage	Elevation NAVD88	Flood Categories
21	454.4	Major Flood Stage
17	450.4	Moderate Flood Stage
14	447.4	Flood Stage
12	445.4	Action Stage

Historical Crests

21.4	454.8	5/1/2010
20.6	454.0	5/4/1979
16.9	450.3	2/14/1989
16.2	449.6	5/5/2003
15.6	449.2	3/12/1975

Action Level A
N/A- no flooding

Action Level B
Backyards of houses along Drummond Drive are flooded

Action Level C
Homes in the East Glencliff neighborhood begin to flood
Homes on Curry Rd. begin to flood
Old Dairy King property floods
Homes on Wimpole Drive near Thomson Lane begin to flood
Mobile Home Park off Murfreesboro Road and Philfre drive begins to flood

Action Level D
Commercial buildings on Space Park Drive begin to flood
Flooding becomes more extensive on Wimpole Drive in the Glencliff Estates neighborhood
Flooding becomes extensive at the mobile home park off Murfreesboro Road and Philfre drive

Action Level E
Commercial buildings on Wilhagen Rd begin to flood
Commercial building on the corner of Elm Hill Pike and Massman Drive begins to flood

Action Level F
I-24 just south of sevenmile creek begins to flood
Homes on Hollydale road (near Murfreesboro road) begin to flood
Commercial buildings near Mill Creek at the intersection of Thompson Ln and Murfreesboro Rd begin to flood
Commercial buildings South East of Philfre Ct. near Murfreesboro Road begin to flood
Roads in Millwood Commercial Park off of Murfreesboro Road begin to flood
Commercial buildings at the intersection of Mill Creek and Elm Hill Pike as well as on Massman Drive begin to flood

Action Level G
Extensive flooding in the East Glenncliff neighborhood
Flooding begins at Carlyle Place Neighborhood off of Briley Pkwy
Murfreesboro Road overtops at Mill Creek Crossing
Elm Hill Pike begins to flood
Homes on Bismark drive (North of Elm Hill Pike) begin to flood
East Haven Townhomes and adjacent neighborhood begins to flood

Action Level H
Buildings in Millwood Commercial Park off of Murfreesboro Road begin to flood
Flooding becomes more extensive on Belle Acres neighborhood off of Lebanon Pike

Action Level I
Flooding becomes extensive in the Glencliff Estates neighborhood

Action Level J
I-40 near Frontage Road begins to flood
Extensive flooding on Elissa Drive near Massman Lane

Action Level K
Briley Parkway Just north of I-40 begins to flood
Lebanon Pike begins to flood near Donelson Hills Drive

Watershed Advisory Guide
DRAFT

B.3
Mill Creek Watershed

Figure 20. Mill Creek Watershed Advisory Guide: Action Levels Description

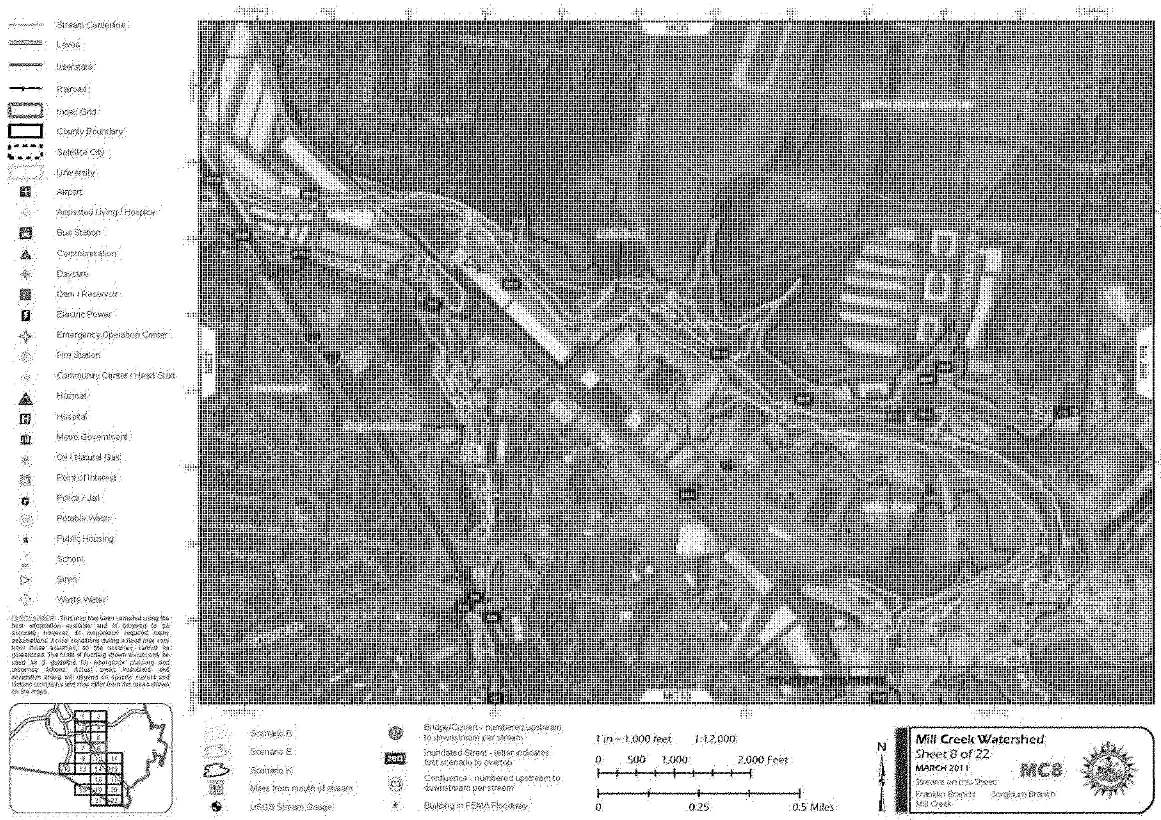

Figure 21. Mill Creek Watershed Advisory Guide: Action Levels with Inundation Mapping

4.1.3 Nonstructural Measures

Non-Structural Measures

The following includes a detailed description of the various non-structural analyses conducted for this study in attempts to meet the planning objectives. Raise-in-place, buyout and removal or evacuation of the floodplain, were the focus of these residential measures. The non-structural measure (raise-in-place) under consideration would include voluntary participation by the property owners. With regard to the evacuation or buyout and removal measures; to the extent practicable, acquisition would be on a voluntary or willing seller basis, but eminent domain could be utilized when determined to be warranted. Flood proofing of commercial structures was eliminated in the preliminary economic analysis due to low net benefits and the sponsor's lack of support. Only one commercial damage center could be reduced. This did not compare favorably to the net reductions provided to residential structures. Per policy guidance, non-structural measures were updated to include only those economically justified following inclusion and benefit reduction of the structural measures.

Metro Nashville Floodplain Management Impacts

It is noteworthy to consider the impact local floodplain ordinances has on the outcomes of these plans. Metro's requirement for new residential structures in the 100-year floodplain to be built 4 feet above the BFE, requires structures being considered for raising in place to elevated 4 feet above the BFE. Thus, the average raising for structures evaluated in the 5-year floodplain was nearly six feet. Metro Nashville has additional restrictions against any new development in the floodway of mapped streams, and included provisions against significant structural modification in the floodway. Thus, city code precludes raising any homes in the floodway. Of the roughly 1,200 residential structures in the floodplain, 156 are in the floodway, meaning none of these structures could be included in raising alternatives which greatly reduced the costs of the raise-in-place measures but also reduced the number of net annual benefits.

NS-1 – Floodway Evacuations

This alternative includes removing all homes in the floodway, regardless of the first floor elevation, and several other structures that would be isolated after removal of the floodway structures. It would remove 156 residential structures from the floodway and eliminate over $1.18 million in expected annual damages (EADs). The total cost for this measure is approximately $37.44 million which when annualized creates $1.66 million in annual costs. This flood reduction measure has a benefit to cost (BCR) of 0.71. This alternative, left considerable residual risk, when compared with the selected plan.

NS-2 – Floodplain Removals with EADs greater than $5,000

Alternative NS-2 evacuates residential structures receiving more than $5,000 in expected annual damages. Eighty-one residential structures and their automobiles are removed from the floodplain at a total cost of over $18.7 million. Annual costs for this measure are nearly $864,000. The alternative creates over $511,875 million in expected annual benefits, has a benefit to cost ratio of 0.59. This alternative has a BCR below 1, not comparing well to the selected plan.

NS-3 - Raises with EAD greater than $5,000

This flood reduction measure raises residential structures that receive greater than $5,000 in EADs. It raises 54 residential structures and creates $679,000 in average annual benefits. Total cost for the alternative is over $11.5 million, which creates annual costs of $591,840. The BCR for this alternative is 1.28. This alternative generally targets the most expensive homes in frequent damage zones. This alternative was eventually removed from later plan development due to low net benefit and lack of plan cohesion. Additionally, sponsor ordinances do not allow significant modification to structures in the floodway removing over half of the buildings from this plan.

NS-4 – Remove all residential structures flooded by the 2-year event

Alternative NS-4 includes removing all homes damaged by the 2-year event, regardless of the first floor elevation, and several other structures that would be isolated after removal of the floodway structures. It would remove 127 residential structures and eliminate nearly $2.48 million in expected annual damages (EADs). The total cost for this measure is approximately $30.2 million which when annualized creates $1.32 million in annual costs. This flood reduction measure has a benefit to cost (BCR) of 1.89. This plan was ultimately not selected due to high residual damages and a lack of connectivity among buyouts as compared with other measures. Other plans ultimately maximized the net benefit in damage reductions. In addition to continuity and residual damage issues, alternative NS-4 does not meet the acceptability screening criteria because of the significant number of residential structures that would remain in the floodway. The floodway is the portion of the floodplain that effectively carries flow and has the greatest flood hazard and associated life safety concerns. Therefore the local, state and federal priority is to keep the floodway free of structures. When compared to NS-5, NS-4 leaves an additional 70 structures in the floodway effecting residual risk.

NS-5 – Remove All residential structures flooded by 5-year event

This alternative includes removing all homes damaged by the 5-year event, regardless of the first floor elevation, and several other structures that would be isolated after removal of the floodway structures. It would remove 202 residential structures and eliminate $2.84 million in expected annual damages (EADs). The total cost for this measure is approximately $39.6 million which when annualized creates $1.72 million in annual costs. This flood reduction alternative has a benefit to cost (BCR) of 1.62. The additional benefits gained by incorporating the 5-year event (NS-5) in addition to the 2-year event (NS-4) has the potential to buy down an additional 60% of the associated risks for the most flood prone residences. This plan was modified during the iterative process to maximize benefits in the plan selection process. Plan NS-5 provides the foundation through which multiple iterations later becomes Plan N-S 11. Plan NS-11 is a variation of NS-5 following inclusion of benefit reductions from all structural measures, and includes an additional 14 homes that are in-between or adjacent to NS-5 homes for the sake of connectivity in implementation. N-S 11 is further modified, at the recommendation of internal policy review. Those recommendations lead to inclusion of only those 5-year structures which still provide benefits that warrant buyout or raise-in-place measures after implementation of the structural measures is considered. N-S 12 which becomes the selected non-structural plan is later referred to as Plan A.

NS-6- Remove all residential structures flooded by 10-year event

This alternative includes removing all homes damaged by the 10-year event, regardless of the first floor elevation, and several other structures that would be isolated after removal of the floodway structures. It would remove 303 residential structures from the floodway and eliminate over $2.64 million in expected annual damages (EADs). The total cost for this measure is approximately $70.6 million which when annualized creates $3.31 million in annual costs. This flood reduction measure has a benefit to cost (BCR) of 0.89. Cost and benefit analysis ruled this out in the development phase, by having lower net benefits compared to the selected plan.

NS-7- Remove all residential structures flooded by 25-year event

Alternative NS-7 includes removing all homes damaged by the 25 year event, regardless of the first floor elevation, and several other structures that would be isolated after removal of the floodway structures. It would remove 392 residential structures and eliminate over $2.98 million in expected annual damages (EADs). The total cost for this measure is approximately $90.7 million which when annualized creates $4.40 million in annual costs. This flood reduction measure has a benefit to cost (BCR) of 0.67. Total project costs as well as low net benefit return for the higher number of structures caused this measure to fall out early in plan development.

NS-8 Floodway Removals of residential structures with EADs > $5,000

This alternative includes removing all homes with EADs greater than $5,000 also in the floodway, regardless of the first floor elevation, and several other structures that would be isolated after removal of the floodway structures. It would remove 33 residential structures from the floodway and eliminate over $201,250 in expected annual damages (EADs). The total cost for this measure is approximately $7.2 million which when annualized creates $331,200 in annual costs. This flood reduction measure has a benefit to cost (BCR) of 0.61. This proposed measure had significant residual risks.

NS-9 Remove all residential structures in the floodway with EADs > $10,000

This alternative includes removing all homes with EADs greater than $10,000 also in the floodway, regardless of the first floor elevation, and several other structures that would be isolated after removal of the floodway structures. It would remove 24 residential structures from the floodway and eliminate over $716,000 in expected annual damages (EADs). The total cost for this measure is approximately $5.8 million which when annualized creates $265,000 in annual costs. This flood reduction measure has a benefit to cost (BCR) of 3.02. This proposed measure had significant residual risks, hand selecting only the most frequently damaged homes, resulting in the targeting of a small segment of the hundreds of at risk structures.

NS-10 Raising all residential structures damaged by the +5- year event

Alternative NS-10 includes raising all homes impacted by the 5-year event, the optimum flood event for non-structural action comparing net benefit and residual risk. It would raise 198 residential structures and eliminate over $2.09 million in expected annual damages (EADs). The total cost for this measure is approximately $31.2 million which when annualized creates $1.29 million in annual costs. This flood reduction measure has a benefit to cost (BCR) of 1.62. When compared to NS-11 this measure is ruled out by lower net benefit totals, attributed principally to the high number of floodway structures as well as to the low frequency damages not prevented and vehicle damages not removed as the structures are still in the flood zone. Of additional note is the Metro floodplain regulations mentioned previously. Structures in the floodway, plus seventy-five foot buffer, cannot be altered or significantly modified. The regulations of the sponsor prevent the majority of the structures in this plan from being raised; regardless of the lower net benefit, and greater residual risk when compared to the selected non-structural plan. Of the 178 structures eligible based upon based upon elevation requirements, approximately 150 of these structures cannot be raised as they are floodway structures.

NS-11 Removal of all residential structures damaged by the +5-year event

This alternative includes removing all homes in the 5 year event, regardless of the first floor elevation, and several other structures that would be isolated after removal of the floodway structures. It would remove 216 residential structures from the floodplain and eliminate over $2.59 million in expected annual damages (EADs). The total cost for this measure is approximately $42 million which when annualized creates $1.91 million in annual costs. This flood reduction measure has a benefit to cost (BCR) of 1.51. This plan is a later version of the optimized Plan NS-5 through the iterative planning process. This measure originally formed the basis of the combined structural alternative plans later analyzed due to maximized net benefits and lowest residual risk. Later, Plan NS-11 was modified to maximize net benefits. The final non-structural plan was optimized to include only those structures within the 1/5 ACE floodplain that still provide benefits, through raise-in-place or buyout measures, after the structural measures are implemented. Raise-in-place or buyout properties that did not meet this metric were removed, resulting in plan NS-12. Additionally, local floodplain ordinance of the Non-Federal Sponsor prevent any rebuilding or new buildings located in the floodway plus a 75' buffer, these restrictions further address reduction of future flood damages and the corresponding reductions of residual risk where these parcels are concentrated. When applying the 75' buffer to the selected non-structural plan all 216 structures/parcels fall under this restriction.

NS-12 Removal or Raise-in-place of residential structures damaged by the +5-year event

This alternative includes the buyout and removal or raise-in-place of structures within the 5-year floodplain that still warrant non-structural measures following implementation of all structural measures. Of the 216 structures identified from Plan NS-11, 89 residential structures still have benefit reductions that warrant either buyout and removal or raise-in-place when evaluated individually after accounting for all structural damage reductions. This plan removes $1.75M in expected annual damages. The total cost for this measure is $17.3M, with an annual cost of $740,000 and a benefit to cost ratio (BCR) of 2.69. See Figure 22 and Figure 23 for sample location maps for the Foxglove and Benzing damage centers, respectively. Appendix B (Real Estate Plan) includes the complete map-book for the recommended Non-Structural Plan A.

Table 8. Final Plan A (Non-Structural Plan)

Final Plan A (NS-12)	Structure Count	EADs Prevented=1000s	Annual Cost=1000s	BCR	Annual Net Benefits=1000s
NS-9	24	716	265	2.70	451
NS-3	54	679	592	1.15	87
NS-12	89	$1,751	$799	2.19	**$952**
NS-11	216	$2,585	$1,911	1.35	674
NS-6	303	$2,636	3,310	.80	-674

Figure 22. Buyout Plan - Plat 7/16 (Sevenmile Creek)

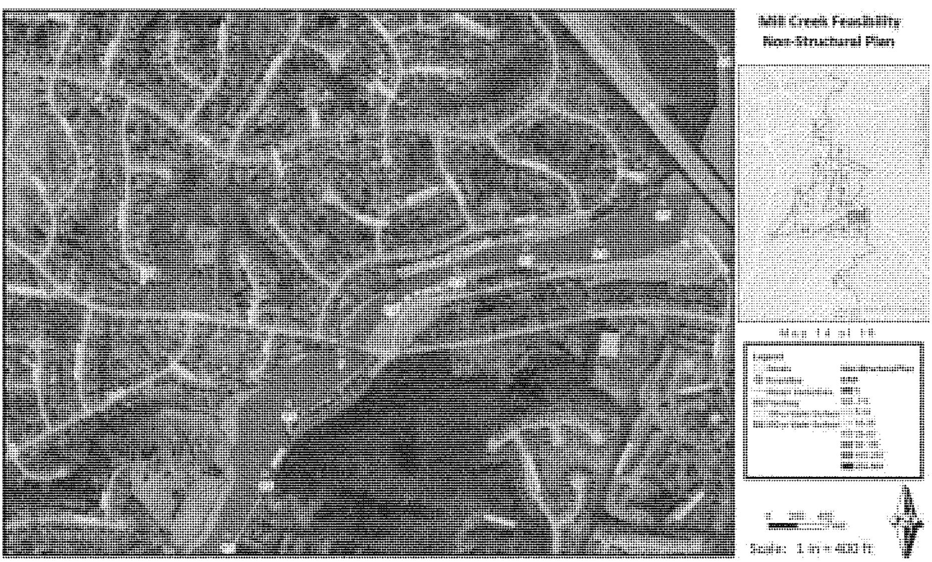

Figure 23. Buyout Plan - Plat 14/16 (Whittemore Branch)

4.1.4 Structural Measures

Preliminary screening was conducted to identify flood reduction measures for further analysis and eliminate costly or impractical ones. The screening described in this section includes structural measures only. To maximize benefits, future conditions models were used to evaluate measures at the screening level. Previous studies evaluated multiple flood reduction measures. The 1986 study recommended a plan to construct regional flood control measures at Mile 16.81 on Mill Creek and Mile 3.70 on Sevenmile Creek, and a widened section of Sevenmile Creek from Mile 0.70 to 1.51. A total of forty-three measures were evaluated from hydrologic, hydraulic, economic, and environmental viewpoints, but the recommended plan was never implemented due to a lack of public support. All previous measures were reviewed to determine how changes in the watershed would affect their performance. Those measures include the forty-three measures considered in the 1986 study, which was later reduced to fifteen by the 2007 Feasibility Scoping Meeting (FSM) documentation report, additional data provided as a result of the Unified Flood Preparedness Plan in 2012 was also considered. Any measure that was feasible in earlier studies was given particular scrutiny.

These measures were evaluated by future without project damage concentrations, hydraulic indicators such as head loss through bridges, floodplain benches, and other constraints evaluated by the numerous earlier studies. As defined in Section 3.4 of the Economic Appendix (Appendix A) the damages along Mill Creek and its principal tributaries are generally spread out among the associated river miles along the stream and its associated floodway and flood fringe areas. The generally divided nature of the damage centers along those reaches made structural measures more difficult to justify on the comparison of project costs to flood damages prevented and the benefits each measure would accrue. Many measures that were evaluated were eliminated when considering reduced benefits when compared to previous study. In today's dollars, damages are much less than in 1986 due to better floodplain management practices, removal of repetitive loss structures, revised flood frequency data, and better modeling techniques. Over the last twenty years, Metro has acquired and demolished over 120 repetitive loss residential structures in the watershed using FEMA Flood Hazard Mitigation Funds. The majority of the homes are in the Paragon Mills, Pebble Creek, Blackman Road, and Wimpole Drive damage areas. Those neighborhoods are located in the tributaries of Sevenmile Creek, Sorghum Branch, Whittemore Branch, and middle reaches of Mill Creek. The locations of the repetitive loss buyouts have effectively reduced the expected annual damages from floods in those neighborhoods. For those reasons, many of the measures evaluated in 1986 were not feasible when re-evaluated in the 2007 FSM. The 2007 FSM carried forward fifteen measures, the re-evaluations in 2013 focused on additional data from the UFPP analysis and added four measures to the fifteen measures carried forward in the 2007 FSM, resulting in detailed analysis conducted on nineteen structural measures in the watershed.

The nineteen structural measures identified for further screening are listed in Table 9. These measures provide benefits in the middle reaches of Mill Creek, characterized by Antioch, Space Park, and Wimpole damage centers. Those locations contain the greatest number of commercial, residential, and industrial structures within the Mill Creek basin. These damage centers are provided in the location map, Figure 24. On the tributaries, Sevenmile damage centers near Paragon Mills and Suter Drive provided the greatest levels of risk reduction. By comparison, the tributaries Whittemore Branch and Sorghum Branch did not contain sufficient density of structures to warrant the benefits for structural measures. The impacts to those neighborhoods were generally spread among non-contiguous frequently damaged structures, which did not support structural solutions.

Table 9. Preliminary Measures

Measure ID	Measure Description	Damage Center
OHC	Mill Creek Old Hickory Detention Basin	Regional – Mill Creek
WE	Mill Creek Wimpole Channel Modifications	Wimpole
MBM	Mill Creek Wimpole Murfreesboro Rd Bridge + Channel Modifications	Wimpole
TBM	Wimpole Murfreesboro Rd + Thompson Lane Bridge + Channel Modifications	Wimpole
ARR	Antioch Railroad Bridge Removal + Channel Modifications	Antioch
APBM	Antioch Franklin Limestone Bridge + Channel Modifications	Antioch
ARC10	Antioch Channel Modifications 10.9	Antioch
ARC11	Antioch Channel Modifications 11.3	Antioch
EB	Ellington Detention Basin	Regional – Seven Mile Creek
SPD	Space Park Briley Bridge Modifications	Space Park
SPRR7	Space Park Briley and Railroad Bridge Modifications	Space Park
SPC	Space Park Briley Railroad + Space South Bridge Modifications	Space Park
SPRR	Space Park Briley Railroad + Space South Bridge and Channel Modifications	Space Park
SPCM	Space Park Channel Modifications	Space Park
OHC60	Old Hickory Detention Basin – 60 ft	Regional Mill Creek
OHCEB	Old Hickory and Ellington Detention Basins	Regional Mill Creek + Seven Mile Creek
OHSPD	Old Hickory Detention + Briley Bridge Modification	Regional – Mill Creek
VQD	Vulcan Quarry Channel Diversion	Regional Mill Creek
WCM200	Wimpole Channel Modifications – 200'	Wimpole

In early formulation, the list is reduced from nineteen to fifteen based on project performance and preliminary economic results. The four measures not carried forward are the largest Old Hickory Detention Basin (OHC60), the largest channel modifications at Wimpole (WCM200), the largest channel modifications at Antioch (ARC11), and the largest channel modifications at Space Park (SPCM). The measures were ineffective and inefficient by comparison to smaller iterations. Therefore, these four measures were removed via incremental analysis which provided that reduced footprints of those management measures were more effective, providing similar stage reductions and benefits while requiring much less real estate and material quantities to effect the key damage centers more efficiently. The remaining fifteen measures and their locations relative to the damage centers are shown in Figure 24.

From that list, measures that did provide protections and benefits to these damage centers which warrant further investigation include regional flood control (stormwater detention and diversions), channel and bridge modifications. Combinations of these measures were also evaluated to maximize flood damage reduction benefits. Some measures were screened out early on during analysis due to preliminary benefit/cost ratios below unity (less than 1.0) or insignificant economic benefits. The locations of these structural measures are shown in Figure 24. On this location map, Mill Creek river miles 4-6 coincide with the

Wimpole damage center, miles 7-9 coincide with the Space Park damage center and miles 10-12 coincide with the Antioch damage center. On Sevenmile Creek, miles 1-3 coincide with the Edmondson and Paragon Mills damage centers.

The best performing measures, depending upon the damage centers are detention basins, bridge modification, and channel modification. Mill Creek is an urban stream and the tributaries are even more heavily impacted by urbanization. For these reasons only two locations provided the land area necessary to locate detention basins. Those locations coincide with numbers 1 and 3 in Table 10. Those sites are at the appropriate locations in Mill Creek and Seven Mile Creek watersheds to affect significant reductions on the major damage centers downstream of those locations. Both sites also happen to be in the mid-point of the watersheds and also have significant unimproved land where a detention site could be proposed. In the case of Mill Creek, the location coincides with a major bend in the creek with a wide undeveloped floodplain. Along Seven Mile Creek, the Ellington detention site is protected in park land / open space by both the State of Tennessee and the City of Nashville. There is no other location along either stream with the requisite acreage and topography to site detention basins.

The locations for bridge modifications, located in Figure 24, coincide with numbers 5, 6, 8, 9, 10, 12, 14, and 15. Those locations include key restrictions at each of the primary damage centers along Mill Creek; Wimpole, Space Park, and Antioch, respectively as provided in Table 10. Those locations are the only ones with significant constriction points that also coincide with significant structure and content damages along Mill Creek. The measures differed in effect on stage and damage reductions and relevant to the costs of the measure to implement, one or two locations proved to be more effective than any combination of the others. The Briley and Railroad bridges at Space Park proved to have the most impact providing benefits to Space Park and Antioch damage center. Bridge modifications investigated along Seven Mile Creek were not carried forward as no restriction point exists which provides benefits substantial enough to warrant investment. Tributaries Sorghum Branch and Whittemore Branch also did not have significant constrictions and benefits to warrant investment and resulted in inefficient measures.

The locations for channel modifications were focused on locations in key damage centers where riparian zone exists to modify the channel and subsequent structure and content damage existed to warrant the investment. These locations existed in Wimpole, Space Park and Antioch damage centers, located in Figure 24, to coincide with numbers 4, 7, 11, and 13 in Table 10. Reductions at Wimpole and Antioch did not warrant further investment, however the Space Park location was further evaluated in multiple iterations. Incremental analysis and engineering results provided that the channel modification combined with the bridge modifications at Briley (number 8) proved most effective by mitigating the key constriction point for the primary damage centers, providing reductions for both Space Park and Antioch. The Franklin Limestone channel modification (number 13) was quite effective at stage reduction in Antioch, but the impacts only benefit a single entity, which eliminates that measure from further consideration in this study due to regulations regarding single-beneficiaries and federal investment. Channel modifications along Seven Mile Creek were not carried forward as the only constriction point that provides needed stage reduction also coincides with no riparian zone or area to implement the measure. To provide the lands needed for such measures, the riparian zone would need to be reclaimed from residential development. Coupled with those significant structure removal costs, the reductions in damages (less than 1%) were not competitive when compared to the detention basin at Ellington, which did not require removal of any structures for implementation. Tributaries Sorghum Branch and Whittemore Branch also did not have significant constrictions and benefits to warrant channel modifications.

For detailed outputs and project description of the best performing measures see the Engineering Appendix (Appendix C). For detailed economic outputs based on the damage centers and river miles of Mill Creek and tributaries see the Economic Appendix (Appendix A). The structural measures are described in more detail in the sections below.

Table 10. Preliminary Structural Alternatives Map Key

No.	Measure Description	Damage Center
1	Old Hickory Detention (Measure C)	Mill Creek
2	Vulcan Quarry Detention (Measure QD)	Mill Creek
3	Ellington Detention (Measure B)	7 Mile Creek
4	Wimpole Channel Mod (Measure E)	Wimpole
5	Murfreesboro Bridge Mod (Measure MBM)	Wimpole
6	Thompson Bridge Mod (Measure TBM)	Wimpole
7	Space Park Channel Mod (Measure SPC)	Space Park
8	Briley Bridge/Channel Mod (Measure D)	Space Park
9	Railroad Bridge Mod 7 (RR7)	Space Park
10	Space Park S. Bridge Mod (SPC)	Space Park
11	Massman Dr. Channel Mod (APC)	Antioch
12	Space Park Railroad Bridge Mod (Measure SPRR)	Antioch
13	Limestone Rd Channel Mod (ARC)	Antioch
14	Railroad Bridge Mod (Measure ARR)	Antioch
15	Antioch Pike Bridge Mod (APBM)	Antioch

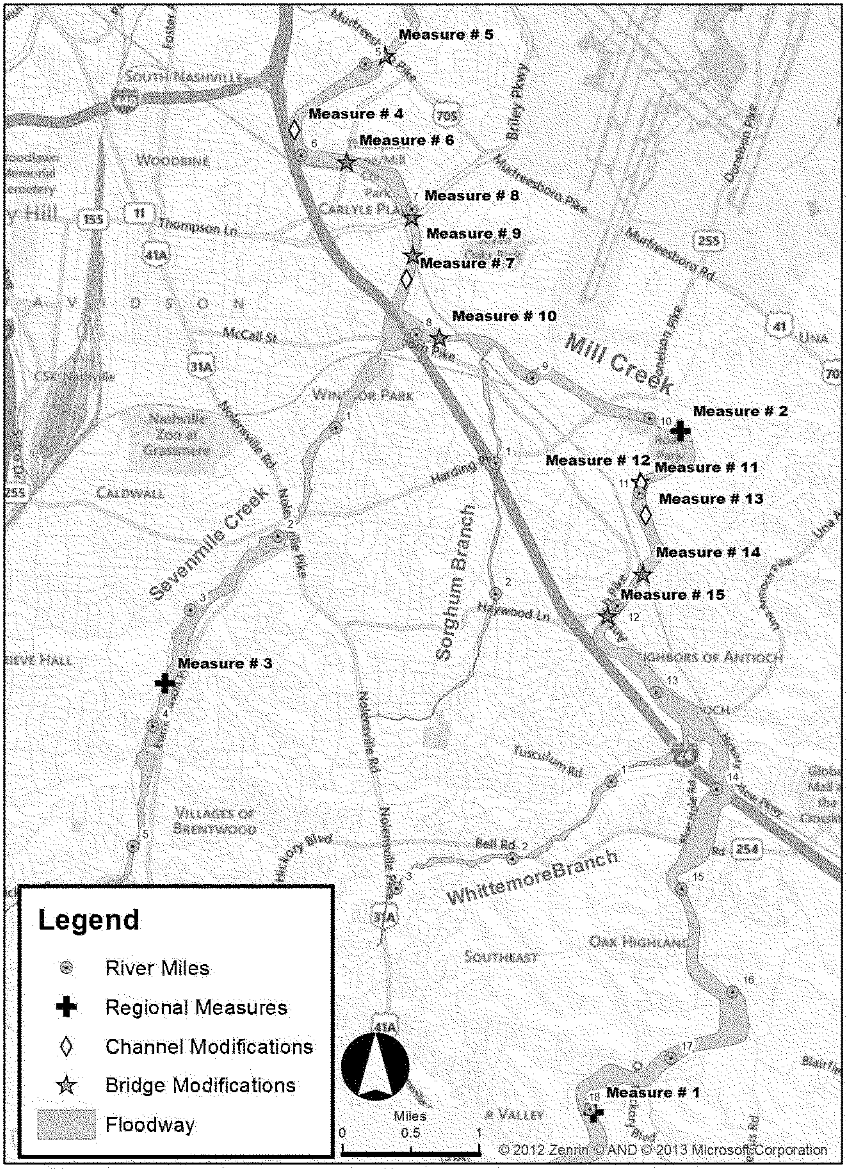

Figure 24. Structural Measures Location Map

Regional Measures

Regional approaches can often produce more economical and effective results than numerous small flood damage reduction projects. The regional detention measures recommended in the 1986 study are impractical today because the storage areas, the natural river valley upstream, have been partially developed. However, modified versions of those measures were developed and evaluated.

RCC Structure above Old Hickory Boulevard (River Mile 18.0)

A new site was selected on Mill Creek at river mile 18.0, approximately 0.6 miles upstream from Old Hickory Boulevard and 1.2 miles upstream from the previous detention site to avoid significant development near the original site. The measure captures 43.0 square miles, 40% of total Mill Creek watershed. The low level outlet will pass normal flow and require no manual or mechanical operation. The embankment acts as a weir or spillway for flows exceeding the 10-year frequency event. The embankment section will be Roller Compacted Concrete and have a vertical upstream face, a 1:1 downstream face with a 15-foot top width. The RCC structure is 23-feet high and 700 feet long. The HEC-HMS model used to calculate frequency discharges for future conditions was modified to represent the storage and outflow characteristics of the proposed measure. The resulting "with project" discharges were then placed in the calibrated HEC-RAS models to calculate frequency-flood profiles. The technical data and H&H results for the Regional Detention measure are included in the Engineering Appendix.

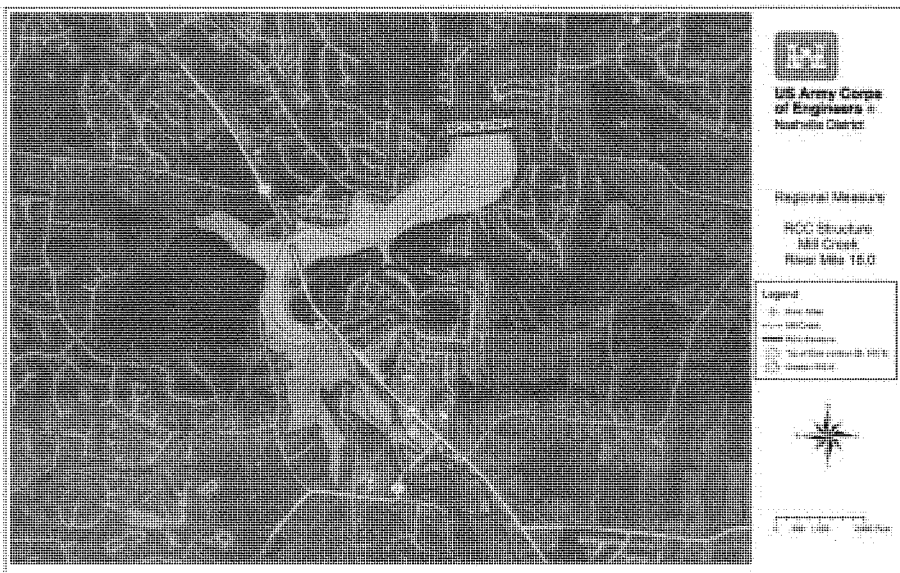

Figure 25. RCC Structure - Mill Creek River Mile 18.0

Vulcan Quarry Diversion

Stormwater diversion into the Vulcan quarry on the right bank of Mill Creek (between river mile 10.2 and 10.6) was evaluated for regional flood reduction as shown in Figure 26. The measure captures 67 square miles, 67% of total Mill Creek watershed. The quarry alternative includes a diversion structure at river mile 10.25 that backs floodwaters into a gate/tunnel structure at river mile 10.36 spilling into the quarry. The measure is designed to start spilling into quarry at the 10-year frequency flood event and is designed to reduce flooding for major flood events. Flood hydrographs generated from the future conditions HEC-HMS model were used as input into an unsteady flow HEC-RAS model developed for the quarry alternative. Output hydrographs from the unsteady flow model were then put back into the HEC-HMS model to calculate the downstream frequency-flood discharges used in HEC-RAS. The technical data for the Vulcan Quarry Diversion is shown below. The Quarry Elevation-Area-Volume relationship and Flood Frequency Data are shown as Tables 11 and 12. The downstream effects for frequency floods and historic floods are also shown as Table 13. Water surface profiles for frequency and historic floods and typical hydrographs for frequency floods and historic floods are shown in the Engineering Appendix, Hydraulic and Hydrologic (H&H) Engineering Attachment. As demonstrated by the tables and figures, the quarry diversion provides significant flood reduction for the less frequent, record floods such as the May 1979 and May 2010 events. If implemented, the quarry diversion could reduce major or record levels by several feet. The Quarry diversion, as designed for this feasibility report, would reduce flow downstream between 30-50 percent and include stage reductions of between three and five feet for record flooding such as May 1979 and May 2010. Reductions by profile are provided in Table 13. As shown in Table 13, the meaure is ineffective in reducing more frequent flood profiles which impacts the cost feasiblility of implementation, especially in regards to the ongoing successful quarry operation. Further detail on performance and cost feasibility is provided in Section 4.2. The complete technical datasets and H&H analysis results for the diversion measure are included in the Engineering Appendix, H&H Attachment.

Diversion Structure – Mill Creek River Mile 10.25
Embankment material = RCC
Culvert opening width = 70 feet
Culvert opening height = 10 feet
Culvert invert elevation = 468 feet
Top of embankment = 494 feet
Top width of embankment = 530 feet
Embankment height at channel = 27 feet
Average embankment height along left overbank = 15 feet

Gate Structure at Tunnel – Mill Creek River Mile 10.36
Sluice gate width = 100 feet
Sluice gate height = 20 feet
Sluice gate invert = 480 feet
Channel invert at gate = 467 feet

Tunnel into Quarry – Mill Creek River Mile 10.36
Tunnel invert = 467 feet
Tunnel length = 200 feet
Depth of rock to tunnel invert = 75 feet
Height of tunnel invert above bottom of quarry = 290 feet

Table 11. Vulcan Quarry Elevation-Area-Volume Relationship

Elevation (Feet)	Area (Acres)	Cumulative Volume (Acre-ft)
175	0.0	0
195	24.1	303
215	36.2	912
235	38.3	1,663
255	41.3	2,453
275	43.2	3,298
295	44.6	4,176
315	46.0	5,083
335	47.0	6,012
355	49.3	6,973
375	52.2	7,983
395	53.8	9,045
415	55.2	10,135
435	59.1	11,274
455	60.6	12,472
475	63.4	13,710
495	74.5	15,099

Table 12. Quarry Frequency-Flood Data

Frequency Event	Quarry Peak Inflow (cfs)	Quarry Peak Stage (ft)	Quarry Peak Volume (acre-ft)
2yr	Not Used		
5yr	Not Used		
10yr	4,900	238	1,770
25yr	6,400	280	3,390
50yr	8,200	300	4,470
100yr	10,200	330	5,650
200yr	13,000	350	6,900
500yr	15,500	390	8,700
May 1979	11,500	325	5,520
May 2010	16,500	473	13,590

Table 13. Vulcan Quarry Diversion Downstream Effects
Space Park - Mill Creek just below Sevenmile Creek confluence

Storm	Future W/O Project		Future with Project		WSEL
Frequency	Discharge	Elevation	Discharge	Elevation	Reduction
or Event	(cfs)	(feet)	(cfs)	(feet)	(feet)
2yr	11,223	458.2	11,223	458.2	0.0
5yr	13,716	459.6	13,716	459.6	0.0
10yr	17,241	461.8	17,241	461.8	0.0
25yr	21,465	463.9	20,800	463.5	-0.3
50yr	25,646	465.9	23,800	465.0	-0.9
100-yr	30,535	468.0	26,500	466.4	-1.5
200-yr	35,494	469.2	29,100	467.6	-1.6
500yr	42,619	471.1	33,500	468.8	-2.3
May 1979	30,000	467.8	20,500	463.3	-4.5
May 2010	36,000	469.3	28,000	466.6	-2.7

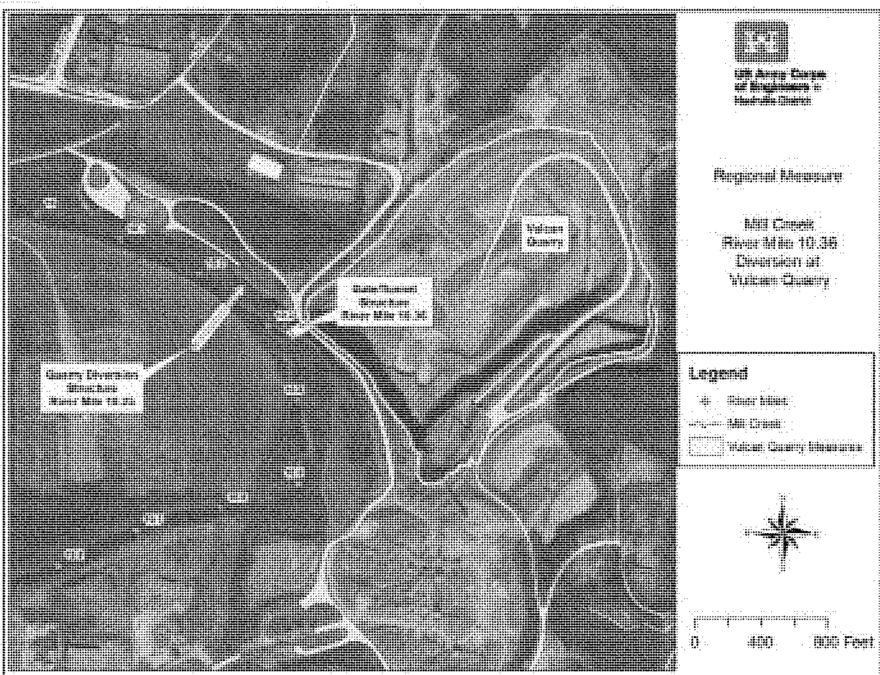

Figure 26. Vulcan Quarry Diversion

Ellington Agricultural Center Regional Detention (River Mile 3.7)

A detention site was selected on Sevenmile Creek at river mile 3.7 located at the Ellington Agriculture Center Entrance Bridge. The measure captures 7.9 square miles, 45% of Sevenmile Creek total watershed. The low level outlet will pass normal flow and require no manual or mechanical operation. The embankment would act as a weir or spillway for flows exceeding the 25-year frequency event. The design of this structure targets reductions in the high frequency (less than 50-year) flood events. The embankment section will be compacted-earth, with armoring and stilling basin on the downstream face. The HEC-HMS model used to calculate frequency discharges for future conditions was modified to represent the storage and outflow characteristics of the proposed measure. The resulting "with project" discharges were then placed in the calibrated HEC-RAS models to calculate frequency-flood profiles. The technical data and H&H results for the Regional Detention measure are included in the Engineering Appendix.

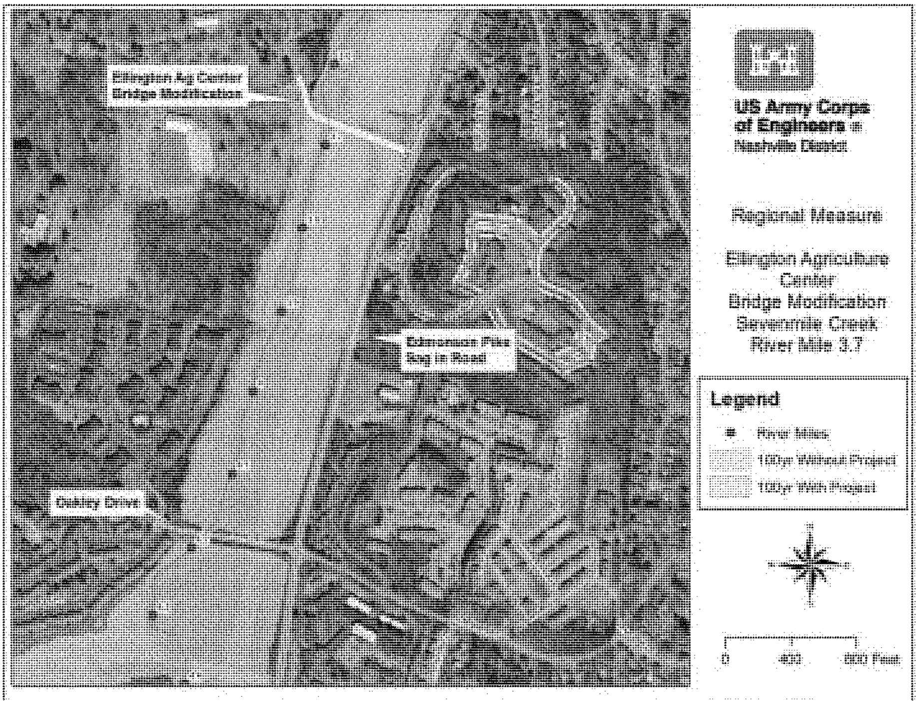

Figure 27. Ellington Bridge Modification

Bridge Modifications

Bridges with significant head loss in target damage centers were removed from the future conditions hydraulic models to evaluate water surface reductions and added benefits. Modifications to hydraulic model (HEC-RAS) cross-section geometry in the vicinity of selected bridges were made to reflect their removal. The intent was to locate bridges that could either be removed or modified to reduce flood damages. Mill Creek bridges included Murfreesboro Road (RM 4.814), Thompson Lane (RM 6.333), Briley Parkway (RM 7.059), CSX Railroad (RM 7.3), Space Park South Drive (RM 8.173), and abandoned railroad (RM 10.915), Franklin Limestone Road (RM 11.083), CSX Railroad RM 11.695 and Antioch Pike (RM 12.096). The HEC-RAS water surface profiles (.wsp files) were then used by the economist to calculate added benefits (reductions in Estimated Annual Damages). Briley Parkway was the only bridge modification to move forward past preliminary analysis. The Briley Parkway bridge modification includes changes to the divided highway, at this location traffic flows east-west. The east and west bound lanes (divided) will be altered on the (downstream) left overbank only. The (downstream) right bank will not be altered as that abutment ties into the cliff (rock). The left overbank modification would include widening the east and west bound bridge openings by approximately 65 feet. The technical data and H&H results for the Briley Parkway bridge modification measure are included in the Engineering Appendix. Project implementation will be performed in conjunction with USACE policy regarding Highway Bridges found in EP 1165-2-1 (page 10-11, paragraph 10-4 a.1) and will be cost-shared according to ER 1105-2-100 (E127-130).

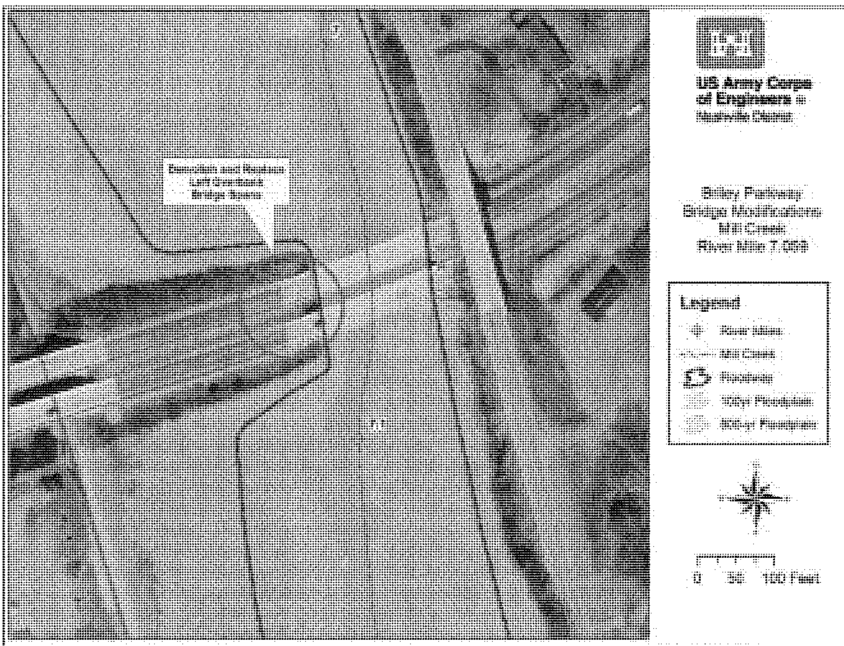

Figure 28. Briley Parkway Bridge Modifications

<u>Channel Modifications</u>

<u>Wimpole Drive Channel Modifications</u>

Channel modifications were analyzed along Mill Creek in the vicinity of the Wimpole Drive residential damage center. The Wimpole Drive channel modifications included a 100-foot high-flow along the left and right overbanks between river mile 4.9 and 6.2. The bench elevation would be approximately 5 to 8 feet above channel bottom. The channel would be cleared and vegetation removed. Slopes would be excavated at a 2H:1V slope. The slopes would be protected with riprap but other flat exposed surfaces could have native grasses planted. The future conditions hydraulic models were modified to include these channel modifications. The technical data and H&H results for the channel modification measures are included in the Engineering Appendix.

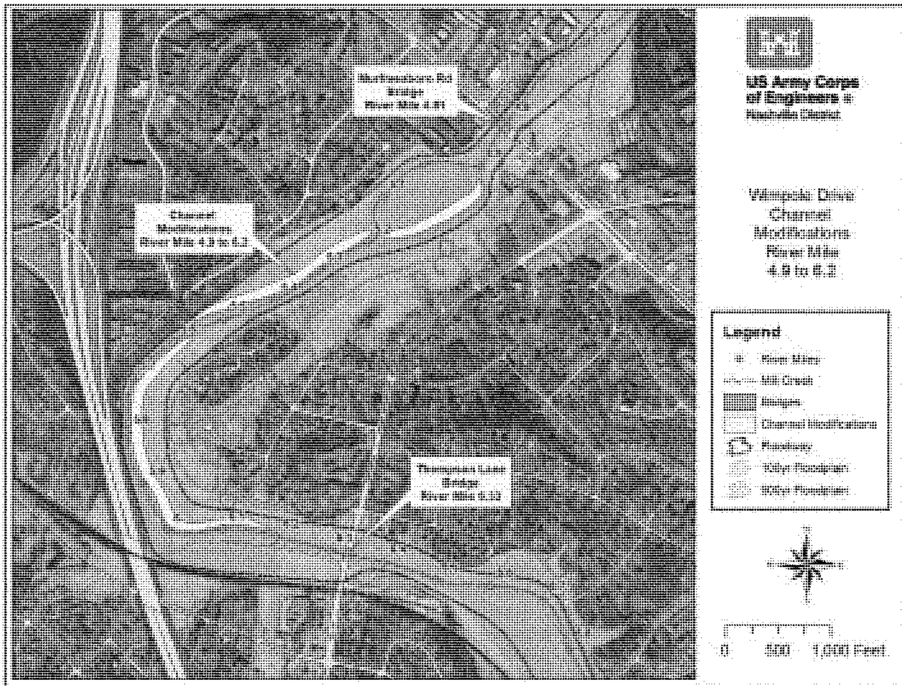

Figure 29. Wimpole Drive Channel Improvements

Space Park Channel Modifications

Channel modifications were analyzed along Mill Creek in the vicinity of the Space Park South commercial and industrial damage center. The Space Park channel modifications include a 50-foot to 100-foot high-flow bench along the left and right overbanks between river mile 7.4 and 7.8. The bench elevation would be approximately 6 to 8 feet above channel bottom. The channel would be cleared and vegetation removed. Slopes would be excavated at a 2H:1V slope. The slopes would be protected with riprap but other flat exposed surfaces could have native grasses planted. The future conditions hydraulic models were modified to include these channel modifications. The technical data and H&H results for the channel modification measures are included in the Engineering Appendix.

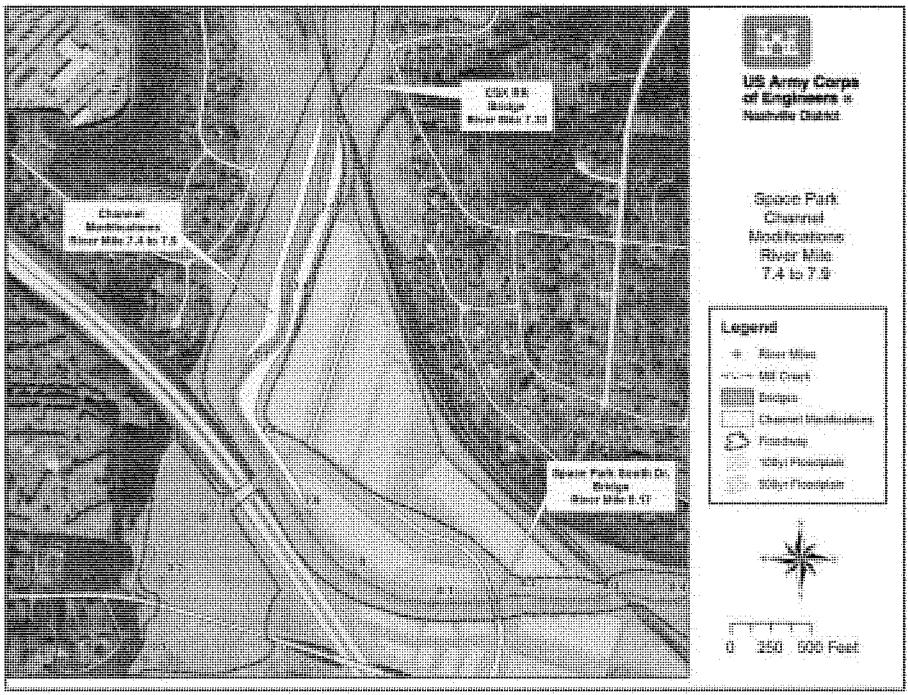

Figure 30. Space Park Channel Modifications

4.1.5 Ecosystem Maintenance and Ancillary Benefits

Ecosystem Restoration - As stated previously, Metro Nashville does not wish to acquire property or implement solutions solely for ecosystem restoration. A National Ecosystem Restoration (NER) plan was considered, but was not supported by the sponsor, Metro Nashville. Following the May 2010 flood, this study was modified as the City of Nashville decided to only pursue implementation of flood risk management measures. The revised scope of work, entered into by letter agreement on 25 January 2013, indicates a sole focus on flood risk management opportunities, by which only incidental environmental benefits can become a part of the recommended plan. No ecosystem measures will be pursued to implementation for this study, but the data has been provided to Metro Nashville and they may choose to pursue these measures independently.

There are significant tracts of public land in the watershed and additional land may be acquired in conjunction with flood damage reduction measures. Over six hundred and fifty acres on thirteen different parcels of public land are available for restoration activities. These parcels are directly adjacent to Mill and Sevenmile Creeks and additional public property in the watershed. Eight of the thirteen original public sites are owned by Metro and three others were acquired following the flood. Restoration measures may be considered for all property in current Metro ownership and could be considered for those being acquired, independent from this study. Two other public sites along the creek are owned by the State of Tennessee and restoration sites continue to be expanded upon there.

Restoration Measures - Maximum ecosystem benefits would be achieved by implementing multiple measures at multiple locations. In-stream habitat structure is present in some areas, but lacks diversity in others. Also sedimentation limits its availability and use to aquatic fauna, specifically the Nashville Crayfish. Lack of flow is also a limiting factor. Thus, the ecosystem restoration measures address lack of flow, sedimentation, in-stream habitat structure, riparian restoration and exotic invasive plant removal.

Bank Stabilization - Bank stabilization measures, such as riprap and/or bioengineering are proposed at Metro's Ezell Park, Wimpole Drive and Antioch Community Center. These sites have active erosion that contributes sediment to Mill Creek. This measure would benefit both water quality and aquatic habitat. Reducing sediment entering the creeks decreases embeddedness of interstitial spaces of gravel and cobble. Also, as sediment load decreases suspended materials are removed and water clarity and temperature improves. Protection of these sites helps reduce a state listed 303(d) contaminant (sedimentation) and protects existing greenway trails and sewer lines that parallel the stream at Antioch and Ezell. Habitat along the top of bank and extending into the riparian zone at each site is also stabilized and a sewer line and greenway trail would be incidentally protected. Alternatives would include placement of riprap, bioengineering, and foreshore dikes. A variation in methods would provide additional habitat diversity both in-stream and along the banks; bioengineering would also add additional filtration for stormwater runoff. The bank stabilization, as well as other measures could serve as demonstration projects to educate residential and commercial entities.

<u>Riparian Vegetation Restoration --Tree Plantings and Exotic Species Removal</u> - There are two components to vegetative restoration. Much of the public lands considered for project work, specifically riparian zones along the creeks, are inhabited with non-native, invasive plant species. Two of the most common species are bush honeysuckle (*Lonicera* spp.) and privet (*Ligustrum* spp.). This measure would remove existing exotic vegetation by mechanical and chemical means. Upon removal of the non-preferred species, native tree and shrub species would be planted.

Removal and plantings would occur to the fullest extent possible along streambanks and within the riparian buffer area. This measure would improve both aquatic and wildlife habitat. Wildlife would be provided additional and diverse food, cover, and travel corridors. Connectivity of riparian corridors is an important component for functional wildlife habitat. Riparian areas represent a small percentage of the landscape (often less than 1%), yet often harbor a disproportionately high number of wildlife species and perform an unequal number of ecological functions compared to most upland habitats (Fischer 2001). In addition with more trees and shrubs, stormwater and non-point source (NPS) pollution runoff is slowed with greater ground infiltration and uptake by the herbaceous layers. Wider zones of native plants would also serve to buffer and capture pollutants, including sediments from surface water. Thereby, water quality within Mill Creek and its tributaries would be improved. Improved water quality means improved clarity, decreased water temperature, decreased suspended solids, and decreased embeddedness. This action translates to improved habitat for aquatic fauna.

<u>Infiltration Basins/Wetlands</u> - Infiltration basins or retention areas, commonly referred to as rain gardens, are depressions constructed to capture stormwater runoff and hold these waters until soil infiltration can occur. They are a stormwater Best Management Practice (BMP) with goals of reducing bank erosion by both decreasing a streams flashiness and velocity. In addition, infiltration basins capture sediment, chemicals, nutrients, and other pollutants before they reach a waterway. With increased development there is great concern over the conversion of natural surfaces to impervious areas, such as highways, parking lots, and rooftops.

As previously mentioned, sections of Mill Creek and its tributaries reach zero flows during summer months or other dry periods. This measure would aid in recharging groundwater which in turn would increase base flow in the creeks. Design features include manipulation of soil material to be a mixture of sand and clay to achieve optimum infiltration and minimize long-term ponding. In addition, hydrophytic vegetation can be planted which encourages uptake of stormwater to prevent runoff to creeks. When infiltration to complement/supplement base flow is a primary goal, as is the situation with Mill Creek, planting shrubs for water uptake would need further evaluation. For preliminary screening of this measure, infiltration basins proposed are sized to capture 10% of the drainage to the specific area.

Wetlands could also be constructed in several areas. A careful evaluation of hydrology and soils will be undertaken at each site to determine whether it is more suitable for a rain garden, infiltration basin or wetland.

In-stream Flow Diversion Structures – To reduce the impacts of low base flow in summer months, in-stream structures to concentrate flow within the creek channel are being evaluated. Because Mill Creek and tributaries have solid bedrock substrates, the channels tend to widen as imperviousness increases in the watershed. While this helps to carry more flow during flood events, there are severe negative impacts during low flow. Wide, shallow streams become heated very quickly. With higher water temperatures, there is decreased dissolved oxygen. Aquatic fauna (animals) become concentrated in pool areas. As this occurs, biological oxygen demand increases, and dissolved oxygen in the water decreases resulting in fish kills. Aquatic floras (plants), such as algae, also respond to increased sunlight and warmer water temperatures. Overabundance, and then die-offs of algae decrease the amount of oxygen available as well as become impediments to fauna.

Structures such as cross vanes and weirs are commonly used to redirect channel flow. By concentrating the stream flow, the water would remain deeper and move through an area faster. With deeper and faster water, dissolved oxygen would be improved and temperatures would remain at more favorable levels. Habitat would be improved for aquatic fauna. Various structures will be evaluated to determine suitable measures within Mill Creek and tributaries. Structures will be evaluated to withstand velocities from high flow events as well as to ensure installed features are not flow impediments.

4.1.6 Screening of Measures

Following the management measure analysis, several items were established to form the basis of alternative development. The non-structural measure (NS-12) provided the greatest net benefit, while also accounting for the lowest residual risk. The NS-12 Plan would remove or raise 89 residential structures that are damaged by the 5 year (1/5 ACE) flood event. The NS-12 measure was determined to form Plan A. All subsequent plans were measured against this. Several non-structural measures were eliminated due to residual risks, costs, and low net benefits in comparison to Plan A. Structural measures eliminated in the initial analysis, due to high costs and low net benefits, included channel modification and bridge modification for the Antioch damage center as well as bridge modifications for the Thompson Lane damage center. The remaining structural measures were combined with one another in various alternatives to compare damages prevented with costs of implementation. More detail on the screening of the structural measures is provided in Section 4.2. below.

4.2 Plan Evaluation and Comparison

Multiple iterations were performed on the previously described measures during the alternative selection process. This process is simplified by Figure 31 below.

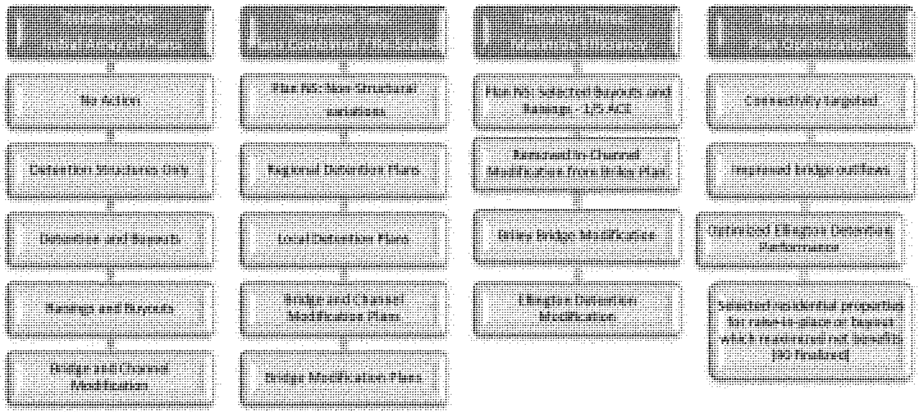

Figure 31. Planning Process - Iterative Comparisons

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

- Acceptability - Acceptability is viability of the plan by the local sponsor and the concerned public. All of the plans in the final array were in accordance with Federal law and policy.
- Completeness - Completeness is the extent to which the plan includes all elements necessary to achieve the objectives of the study. For a project to be successful in this area, it must meet all of the objectives for the project listed in Section 5.
- Effectiveness – An effective plan is responsive to the identified needs and makes significant contributions to the solution of the identified problem. An effective plan contributes to the attainment of the planning objectives. All of the plans in the final array provided some contribution to the planning objectives.
- Efficiency - The cost effectiveness of a plan is expressed in net benefits and is a measure of its efficiency. All of the plans in the final array provided positive net benefits. Plans removed from consideration produced the same level of protection with fewer net benefits than other plans.

As detailed in Section 4.1.4, fifteen of these measures were viable and carried into more detailed screening. Four measures were removed in preliminary screening due to prohibitive costs, low benefits, or ineffective performance at stage reduction. The Vulcan Quarry Diversion (QD) was eliminated due to costs associated with the gate/tunnel and diversion structures coupled with operations costs tied to pump systems needed for an operable quarry. The Quarry is still in operation, meaning opportunity costs must be associated with a massive pump system to prevent the quarry from being inoperable for months at a time following flood events. Lost equipment must also be associated with this measure adding millions of dollars to the overall project total. Different configuration (gated and fuse plug) designs were evaluated for the diversion structure to optimize downstream reductions at different levels of protection. The costs of modified designs were minor in comparison to the quarry pumping and lost operation costs. This measure could reduce flood stages downstream by several feet. Though it is not cost feasible while the quarry is in operation, if another arrangement for compensation could be made or in the event the quarry ceases operations, this measure should get urgent consideration for the reduction in stage, flow and resulting damages of major/record floods. The Massman channel modification, measure APC, was removed due to inefficient performance tied lack of available real estate (lack of riparian zone) and to backwater effects at the damage center to implement the measure. Expensive commercial sites (acreage) must be acquired to provide the required area for the channel modification, rendering the measure cost prohibitive. The Space Park railroad bridge measure and channel modifications were removed via inefficient incremental cost analysis when compared to other measures at the Space Park damage center. The Bridge and channel work in the vicinity of Franklin Limestone Road was removed as incomplete due to the fact that this measure would only benefit a single private entity.

Table 14. Screening Structural Measures

No.	Measure Description	Screening Results
1	Old Hickory Detention (Measure C)	Effective at stage reduction, viable RE costs
2	Vulcan Quarry Detention (Measure QD)	Effective at stage reduction, inefficient economic results due to costs of pump, diversion, gate/tunnel
3	Ellington Detention (Measure B)	Effective at stage reduction, viable on state/metro park lands or open space
4	Wimpole Channel Mod (Measure E)	Effective at stage reduction
5	Murfreesboro Bridge Mod (Measure MBM)	Effective, efficient
6	Thompson Bridge Mod (Measure TBM)	Effective, efficient
7	Space Park Channel Mod (Measure SPC)	Effective, efficient
8	Briley Bridge/Channel Mod (Measure D)	Effective at stage reduction
9	Railroad Bridge Mod 7 (RR7)	Efficient works with downstream measures to reduce stage
10	Space Park S. Bridge Mod (SPC)	Efficient works with downstream measures to reduce stage
11	Massman Dr. Channel Mod (APC)	Inefficient-ineffective, backwater effects impact measure performance in low frequency events
12	Space Park Railroad Bridge Mod (Measure APRR)	Ineffective at stage reduction
13	Limestone Rd Channel Mod (ARC)	Incomplete, ineffective, eliminated as single beneficiary
14	Railroad Bridge Mod (Measure ARR)	Effective, efficient
15	Antioch Pike Bridge Mod (APBM)	Effective at stage reduction

4.2.1 Iteration One: Initial Array of Plans

The purpose of Iteration One was to determine which plans to investigate further. The initial plans were formed following the preliminary cost/benefit analysis of management measures, as these measures were combined into alternative plans. The following alternative plans were considered:

- No Action (Future Without Project Condition)
- Regional Detention Structures
- Detention Structures and Nonstructural – Consisted of raising-in-place or buying out structures that sustained high damage and removing them from the floodplain.
- Non-structural Buy-outs and Raisings – Measures to raise-in-place eligible structures and remove more frequently damaged structures from the floodplain.
- Bridge and Channel Modifications – Measures throughout Mill Creek watershed meant to reduce damages at principal damage centers.

No Action

Major flood events have occurred since the 1950s on the average of nearly every ten years. This continued flooding will result in adverse impacts to the community. Without serious large-scale public involvement in flood damage reductions the area would continue to be at risk from large flooding events. Additionally, the impacted communities will experience repeated economic development concerns as well as potential for the loss of life. The problem would continue to worsen over time with no action taken because growth and redevelopment in the watershed will only increase flows and flood damages for future conditions. The No Action Plan does not alleviate any risks to public health and safety, and when measured against these life and safety risks, does not measure up to the array of plans offered in this document to address residual flood risks in the watershed.

Regional Detention Basins

This plan consisted of three detention basins that met efficiency standards during preliminary analysis. This alternative plan includes the; Old Hickory RCC structure at river mile 18.0, the Vulcan Quarry Diversion, and the Ellington detention site on Sevenmile Creek. This plan reduced the peaks on the lower reaches of Mill Creek by as much 30-40%. Detention becomes cost prohibitive, in particular when comparing the Vulcan Quarry to other plans. The Quarry is still in operation, meaning opportunity costs must be associated with a massive pump system to prevent the quarry from being inoperable for months at a time following flood events. The Old Hickory RCC structure on its own barely passed the unity test when comparing preliminary costs to benefits. In later iterations this plan was modified to examine which individual detention measure would perform best when combined with more cost effective plans. Ellington detention site proved to be a promising measure with good engineering performance and strong preliminary cost to benefit measurements. Preliminary analysis results are below.

Table 15. Detention Basins Preliminary Economic Analysis

Detention Measure	EADs Prevented=1000s	Annual Cost=1000s	BCR	Annual Net Benefits=1000s
Ellington	$420	$209	2.01	211
Old Hickory	$850	$746	1.1	104
Vulcan Quarry	$535	$1,076	0.5	-541

Detention and Non-Structural

This plan compared the relationship between reduced flows from the detention structures to raise-in-place or removed buildings from the floodplain. Since the majority of the non-structural benefits are on the tributary streams to Mill Creek, the Old Hickory detention structure had the greatest likelihood to reduce benefits overall without concerning dual benefits from the buyouts on the tributaries. The Old Hickory RCC structure targeted commercial and industrial damages in the middle and lower reaches of Mill Creek and only intersected with non-structural benefits in the Wimpole Drive damage center. Table 16 below shows the various non-structural plans that were combined with the detention structures from Table 15. More detailed analysis for non-structural results, when combined with the Detention structures, is included in Iteration Two.

Table 16. Non-structural Preliminary Economic Analysis

ACE	Structure Count	EADs Prevented=1000s	Annual Cost=1000s	BCR	Annual Net Benefits=1000s
Floodway	156	$1,180	$1,660	.71	$-480
1/5	202	$2,840	$1,720	1.62	$1,120
1/10	303	$2,950	$3,310	0.89	$-360

Non-Structural (Raisings and Buyouts)

Non-structural analysis included raising in place and buyout/removal options. Flood proofing was screened out in preliminary economic analysis due to low benefits. Eleven various measures were analyzed as described in Section 4.1.3. Only two measures were carried forward into alternative plan development, analysis of the 5 year flood (buyout and raise-in-place). While ultimately neither plan was selected for uniform raise-in-place or buyout and removal, the figures below support the preliminary iterations of the non-structural plan, that the 5-year elevation maximizes net benefits. Later iterations optimize net benefits by individually selecting the appropriate non-structural measure per structure when reviewing the costs and benefits of each measure against construction criteria for floodway, life safety, and raising restrictions based on integrity of the structure at certain heights compared to material or depth and velocity of floodwaters. More detail on the combination of the plans follows in this chapter. Preliminary analysis results are below.

Table 17. Non-structural Preliminary Economic Analysis

ACE	Structure Count	EADs Prevented=1000s	Annual Cost=1000s	BCR	Annual Net Benefits=1000s
1/5 - Raise	178	$2,090	$1,290	1.62	$800
1/5 - Remove	202	$2,800	$1,800	1.55	$1,000
>5k EADs - Raise	54	$759	$592	1.28	$167

Bridge and Channel Modifications

Channel modifications were analyzed along Mill Creek main stem in three damage center locations. The channel modifications included a high-flow bench targeting the 5-year flood elevation and varied in width to as much as 100 feet. The varying alternatives intended to protect industrial, commercial, and residential areas, respectively. Bridge modifications were also analyzed along Mill Creek main stem in three damage centers. Various designs targeted constriction points along the damage center areas. Bridge modifications targeted areas with commercial and residential flood damages. Preliminary analysis results are below. The alternatives are various elements of Plan D (bridge modifications) and Plan E (channel improvements).

Table 18. Bridge and Channel Modifications Preliminary Economic Analysis

Alternative	EADs Prevented=1000s	Annual Cost=1000s	BCR	Annual Net Benefits=1000s
D,E-Wimpole	$278	$393	.70	$-135
D-Space Park	$529	$809	.65	$-280
E-Antioch	$61	$49	1.2	$12
E-Space Park	$217	$328	.66	$-111
D-Briley	$219	$199	1.1	20

(No changes to table 15, as designs/costs for these measures did not vary from Nov to Feb.)

Iteration One Conclusions

Eleven plans were analyzed and the best performing plans move forward in various iterations. The benefits categories used to compare the plans included flood damages reduced or prevented (structure, content and auto). Other benefit categories, such as infrastructure damage and emergency costs were investigated but provided negligible benefits. For those purposes, they were excluded from the calculation and had no bearing on the choice of the selected plan. For further details on benefit figures and economics methodology, see the Economic Analysis Appendix (A). Plans began to be combined by measures that addressed specific damage centers. Plan A became the central non-structural plan due to greatest net benefit results. The Detention Basins plan was eliminated. Therefore the remaining structures were separated, Ellington Detention Structure became Plan B and Old Hickory Detention Structure became Plan C. Plan D includes the bridge modifications with positive net annual benefits and focuses on optimizing their benefit or identifying cost savings to bring those into the next iterative phase. Plan E includes channel improvements that maintain a BCR above unity, the channel work in the vicinity of Wimpole Drive and Space Park were carried forward to evaluate maximization of design. In later iterations these plans were also optimized to improve any channel related benefits. For documentation purposes, the Vulcan Quarry alternative is described as Plan F. The impacts of this alternative, which drastically reduce flows in the lower reaches of Mill Creek, warranted further analysis. Following economic analysis, however, the Vulcan Quarry detention was ruled ineffective and eliminated. The other detention alternatives were carried forward to see if they could be maximized by combination with various plans. If the quarry operation ceases, the associated operation costs and pump station items in this alternative could be re-analyzed and the cost benefit relationship redefined by Metro Nashville.

4.2.2 Iteration Two: Plans Combined, Scaled and Compared

The purpose of Iteration Two was to determine which plans performed best when combined and at what level of protection or scale of the project maximized benefits. The following alternative plans were considered:

Plan A: Non-structural. In this phase of study it became clear that the non-structural component would play a central role in reduction of future damages. Several iterations of buyouts and raisings were compared. Raising structures eliminates the more frequent event damages, but does not remove the residual risk because structures are still in the floodplain or floodway. Likewise, vehicle damages and other associated social effects are not removed from future flood damages. Therefore, uniform raisings were eliminated from further consideration. Raisings (at the optimal scale (1/5 ACE) were equivalent in damages prevented to the Plan C, Old Hickory detention structure. The benefits of both raise-in-place- and buyout and removal provide the optimal scale for Plan A as the 1/5 ACE or 5-year event.

Table 19. Plan A Economic Analysis

ACE	Structure Count	EADs Prevented=1000s	Annual Cost=1000s	BCR	Annual Net Benefits=1000s
Floodway	156	$1,180	$1,660	.71	$-480
1/5	202	$2,800	$1,800	1.62	$1,000
1/10	303	$2,950	$3,310	0.89	$-360

Various iterations of Plan A moved forward to determine the proper structures to remove from the floodway. Once again this table demonstrates the optimal plan is Plan A, the raise in place and removal of residential structures damaged by 1/5 ACE. Later iterations would examine maximizing Plan A to target the most heavily damaged structures associated with 1/5 ACE or in immediate proximity to the 202 structures on the initial list.

Table 20. Plan A Iterations

Plan A Iterations	Structure Count	EADs Prevented =1000s	Annual Cost =1000s	BCR	Annual Net Benefits =1000s
1/5 - Raise	178	$2,090	$1,290	1.62	$800
1/5 - Remove	202	$2,800	$1,800	1.55	$1,000
>5k EADs - Raise	54	$759	$592	1.28	$167

Plan BC: Detention Structures (Ellington and Old Hickory). In this phase of the study it became clear that for the detention structures to work best, the timing, arrival, and magnitude of outflows would have to be maximized. Various iterations of outflows, structure heights, inundated areas, induced damaged, and other factors were examined. Ultimately the optimal scale for Old Hickory is the 1/100 ACE and Ellington site is 1/25 ACE. After many different H+H and Economic analytical approaches, no particular structural alternative came close to the expected annual damages prevented or residual risk components of Plan A. The following table defines that relationship in terms annual damages prevented, annual costs, and net annual benefits.

The combination of Ellington and Old Hickory detention basins is above unity; however, net benefits are maximized by combining structural measures with the scaled Plan A.

Table 21. Plan BC Economic Analysis

Plan BC	EADs Prevented=1000s	Annual Cost=1000s	BCR	Annual Net Benefits=1000s
Ellington & Old Hickory Detention Structures	$1,270	$1,148	1.1	$122

Plan BA: Ellington 1/25 ACE and Non-Structural 1/5 ACE. During Iteration Two it appeared that the smaller and less costly detention site at Ellington on Sevenmile Creek had the opportunity to compare/combine well with Plan A. The majority of flood damages occur on Sevenmile Creek, the largest and most populous tributary to Mill Creek. The area is almost entirely residential, which does create some dual or duplicate benefits when the plans are combined. Even after these are taken into account this measure carries forward favorably. Although, some of the damages prevented by Plan B can be eliminated by Plan A, this alternative compares well with net annual benefits of other plans. The following table defines the results of Plan BA.

Table 22. Plan AB Economic Analysis

Plan BA	EADs Prevented =1000s	Annual Cost =1000s	BCR	Annual Net Benefits =1000s
Ellington Detention Structure & Non-Structural	$2,988	$2,175	1.4	$813

Plan CA: Old Hickory Detention 1/100 ACE and Non-Structural 1/5 ACE. This Plan combines the two greatest annual reductions of flood damages. The damages prevented for this plan are the most significant of any combination. However, the large scale of both measures, create high annual costs such that the net annual benefits of this plan are outweighed by other alternatives. Meaning that for lesser costs, annual benefits are optimized in another plan. The table below shows the results of Plan CA.

Table 23. Plan AC Economic Analysis

Plan CA	EADs Prevented =1000s	Annual Cost =1000s	BCR	Annual Net Benefits =1000s
1/5 ACE Buyouts & Old Hickory Detention Structure	$3,720	$2,655	1.4	$1,065

Plan DA: Non – Structural 1/5 ACE and Space Park Bridge Modifications 1/50 ACE. Iteration Two continued to address potential changes to the bridge modifications that reduce damages at the confluence of Mill Creek and Sevenmile Creek. The table below shows the results of Plan DA. Plan DA can capture many of the same benefits as Plan CA, but at much reduced costs. Going forward the team identified that iterations to Plan DA could provide the maximum benefit at comparatively lower costs. This is borne out by results of Iteration Four.

Table 24. Plan AD Economic Analysis

Plan DA	EADs Prevented =1000s	Annual Cost =1000s	BCR	Annual Net Benefits =1000s
1/5 ACE Buyouts & Mill Creek Bridge Modifications	$3,104	$2,033	1.5	$1,070

Plan EA: Non-Structural 1/5 ACE and Channel Improvements 1/50 ACE. Plan AE, during iteration two evaluated the maximum benefit that various channel improvements at Space Park and Wimpole area damage centers could provide when combined with Plan A. Although iterations from 1/25 to 1/100 ACE were evaluated for both damage centers, the optimized Plan was the 1/50 ACE solely for Wimpole Drive damage center. The results for Plan AE are shown below.

Table 25. Plan AE Economic Analysis

Plan EA	EADs Prevented =1000s	Annual Cost =1000s	BCR	Annual Net Benefits =1000s
1/5 ACE Buyouts & Mill Creek Channel Improvements	$2,975	$2,359	1.3	$615

<u>Iteration Two Conclusions</u>

For Structural analysis, Plans BC and EA were removed from consideration in Iteration Two. Plans BA, CA, and DA produced more net benefits. Further combinations were included in the plans formed in Iterations 3 and 4, for the final array. Table 26 below presents a comparison of the structural plans considered in Iteration Two.

Table 26. Iteration Two Economic Analysis

Mill Creek and Tributaries Alternative Analysis $'s = 1,000's			
Economic Analysis Results	**Plan CA**	**Plan BA**	**Plan DA**
Total Without Project Damages	**5,456.89**	**5,456.89**	**5,456.89**
Annual Non-Structural Benefits	**2,821.8**	**2,520.3**	**2,836.8**
Annual Structural Benefits	**850.3**	**420.0**	**218.6**
Total Annual Benefits	**3,720.2**	**2,988.4**	**3,103.5**
Residual Damages	**1,744.3**	**2,476.1**	**2,361**
Total Non-Structural Cost	**42,503.4**	**42,503.4**	**42,503.4**
Total Structural Cost	**13,834.4**	**4,830.9**	**1,666.4**
Total Project Cost*	**56,337.8**	**47,334.3**	**44,169.8**
Total Annual Cost	**2,655.3**	**2,175.8**	**2,033.9**
Benefit Cost Ratio	**1.4**	**1.4**	**1.5**
Net Annual Benefits	**1,065**	**813**	**1,070**

*TPC at current cost levels (FY15)

4.2.3 Iteration Three: Maximize Plan Efficiency

Plan BA: Attempts to maximize this plan initially met with mixed results. There is a limiting factor to the inundated area immediately upstream of the project area. An access road built immediately upstream for a subdivision / apartment complex reduces any opportunity to increase capacity of the structure, but also prevents any induced damages upstream, varying from Plan CA significantly. Even without increased capacity the structure can separate enough duplicate benefits to warrant further design considerations. The spillway and overflow sections of the weir were maximized to detain water resulting in target reductions increasing from the 1/10 ACE to 1/25 ACE. The raise-in-place and buyouts of plan A intersect with the damages prevented of Plan B. Plan A in the same area also removes significant damages to the structures there within the 5-year floodplain and carries significant net benefits overall. When combined, Plan BA accounts for the duplication of these benefits in the areas downstream of the Ellington project area.

Table 27. Plan AB NED: Net Benefit Analysis

Plan BA	EADs Prevented =1000s	Annual Cost =1000s	BCR	Annual Net Benefits =1000s
1/5 ACE Buyouts & Ellington Detention Structure	$2,988	$2,176	1.4	813

Plan CA: To maximize the protection of structures, the outflows and construction method of the structure were changed. The height and length of the structure were decreased to reduce the footprint of the detention structure and impact in the impoundment area. These actions reduced total benefits distancing this plan from Plan BA and DA as the NED plan. Annual benefits were reduced from $3,720 million to $3,640 million and annual costs decreased from $2,655 to $2,369 million. The decrease in costs to the structure made the net benefits compare more favorably to Plans BA and DA. However, later in 2014, further development within the footprint of the required inundation (detention) area for this structure rendered this re-design and real estate estimates obsolete. An additional 25-30 homes and townhomes were approved for development within the fringe of the 1/100 or 100 year floodplain. Therefore, further iterations of this measure were ceased as the project area required to provide the downstream reductions was no longer available. The addition of 25 to 30 new properties needed for purchase would result in either the structure again being lowered to avoid inundating the subdivision now under construction at this time of the study. The benefits and costs are no longer viable for this measure. For these reasons Plan CA was eliminated in the final array.*

Table 28. Plan AC NED: Net Benefit Analysis

Plan CA*	EADs Prevented =1000s	Annual Cost =1000s	BCR	Annual Net Benefits =1000s
1/5 ACE Buyouts & Old Hickory Detention Structure	$3,640	$2,369	1.5	1,271

Plan DA: This plan provided the most residual risk reduction while still being cost effective. It included 1/5 ACE or 5-year protection by selecting residential structures for raise in place and buyout and removal. This plan was augmented by bridge modification at Briley Parkway targeting the 1/50 or 50-year flood level of protection for key commercial damage centers. The bridge was maximized by removing the channel modifications upstream and downstream of the bridge. This reduced costs while maintaining the damage reductions. An additional 40 feet were added to the left abutment of the bridge. The modification increased excavation and hauling of materials while significant reductions were found in the quantities of the bridge re-build. A pillar was designed eliminating the need to replace the left abutment. These alternatives had cost savings impacts on the project while simultaneously increasing benefits of the alternative.

Table 29. Plan AD2 NED: Net Benefit Analysis

Plan DA	EADs Prevented =1000s	Annual Cost =1000s	BCR	Annual Net Benefits =1000s
1/5 ACE Buyouts & Mill Creek Bridge Modifications	$3,103	$2,034	1.5	1,070

Iteration Three Conclusions

When combined, Plans DA and BA were more efficient than any other plans. The combined elements of Plans DA and BA maximize the residential and commercial protections at the key damage centers along Sevenmile Creek and its confluence with Mill Creek. Figure 32 is a location map for a portion of the recommended non-structural plan along Sevenmile Creek. It becomes clear following these iterations, along with the complications of further construction in the inundation footprint of Plan C that plans B, D, and A must be combined and optimized to reduce risk of future floods.

Table 30. Iteration Three Net Benefits Analysis

Mill Creek and Tributaries			
Alternative Analysis $'s = 1,000's			
	Plan BA	Plan CA*	Plan DA
Total Without Project Damages	5,464.5	5,464.5	5,464.5
Annual Non-Structural Benefits	2,520.3	2,791.5	2,836.8
Annual Structural Benefits	420.0	848.5	218.6
Total Annual Benefits	2,988.4	3,640.0	3,103.5
Residual Damages	2,476.1	1,824.5	2,361
Total Non-Structural Cost	42,503.4	42,503.4	42,503.4
Total Structural Cost (Less PED)	4,830.9	13,834.4	1,710.2
Total Project Cost*	47,334.3	56,337.8	44,169.8
Total Annual Cost	2,175.8	2,369.0	2,033.9
Benefit Cost Ratio	1.4	1.5	1.5
Net Annual Benefits	813	1,250	1,070

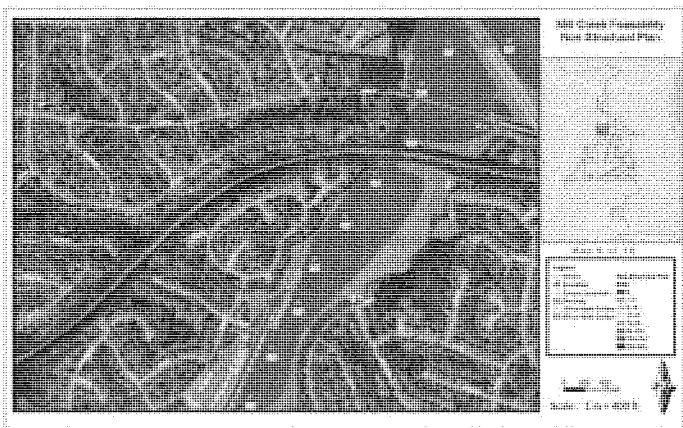

Figure 32. Plan A Location Map: Plat 14/16

4.2.4 Iteration Four: Plan Optimization

The following items were undertaken to optimize Plan BDA;

- Material improvements were made to downstream slope and stilling basin armoring resulting in costs savings for the Ellington Detention measure.
- Improved bridge outflows in conjunction with iteration three, bridge outflows were maximized based on the fill material recommended for removal and design of the pillar/abutment.
- The final non-structural plan was optimized to include only those structures within the 1/5 ACE floodplain that still provide benefits, through raise-in-place or buyout measures, after the structural

measures are implemented. Raise-in-place or buyout properties that did not meet this metric were removed. The final iteration decreased the number of homes in the non-structural plan from 202 to 89, greatly reducing the cost of this measure and maximizing net benefits.

- Cost benefit analysis of the final array are included in Table 33, the Final Array Comparison table.

Table 31. NED Plan: Plan BDA

Plan BDA	EADs Prevented=1000s	Annual Cost=1000s	BCR	Annual Net Benefits=1000s
Ellington Detention, Briley Bridge Modifications and Non-Structural Plan	**$2,390**	**$1,251**	**1.91**	**1,139**

*Figures updated based upon latest economic data, August 2014.

<u>Iteration Four Conclusions</u>

Plan BDA combines the Ellington detention basin and Briley Parkway Bridge modifications with the non-structural buyout and removal and raise in place of selected residential structures impacted by the 1/5 ACE that meet life safety hazard criteria based upon depth and velocity of flows. In Mill Creek and tributaries Sevenmile Creek, Sorghum Branch, and Whittemore Branch, the non-structural plan equates to 89 structures. The recommended plan has the potential to remove nearly half of the expected annual damages associated with Mill Creek and tributary flooding.

4.2.5 Formulation Criteria

The plans were screened by four formulation criteria established in the P&G: acceptability, completeness, effectiveness, and efficiency. Table 32 on the following pages describes how each of the plans meets the criteria.

Table 32. Four Planning Accounts: Formulation Criteria

Plan	Acceptability	Completeness	Effectiveness	Efficiency
No Action	No - Not acceptable. Residual risk factors, systemic flood risk continues without any abatement. Not supported by sponsor.	No – USACE and sponsor would have no impact on future flood risks.	No, continued flooding and damages, no change to existing conditions.	No – The plan results in zero net benefits.
Detention Basins Only	Yes - Significantly reduced flows in the project area and resulted in significant net benefits. Supported by sponsor, implementable by laws and codes.	Yes – Sponsor willing to acquire, USACE maintains capability to design and construct.	No – Removed significant risks from flooding but did not meet all objectives.	No – Most expensive ($60M) plans and still had high residual risks, when combined not a feasible plan to implement. BCR below unity.
Detention and Buyouts	Yes - Reduces flows in the project area and resulted in strong net benefits. Supported by sponsor, implementable by laws and codes.	Yes - Sponsor willing to acquire, USACE maintains capability to design and construct.	Yes, meets planning objectives, positive net benefits. Reduces 60% of risk.	No – High costs. Over $50M for similar residual risk factors to more cost effective options. BCR below unity.
Plan A (Non-structural Plan)	Yes – Non-structural buyouts lower residual risks. Supported by sponsor, implementable by laws and codes.	Yes –Partial solution. Sponsor willing to acquire, USACE maintains capability to design and construct.	Yes, reduces nearly 50% of residual risk, positive net benefits.	Yes – Lower cost option for total removal of nearly 50% residual flood risks. BCR 2.19.
Plan	**Acceptability**	**Completeness**	**Effectiveness**	**Efficiency**
Plan B	Yes - Significantly reduced flows in the project area. Supported by sponsor, implementable by laws and codes.	Yes – Sponsor owns land, USACE maintains capability to design and construct.	Yes, reduces stage for Sevenmile Creek between 1-2 feet.	Yes. Strong net benefits. BCR 1.4
Plan C	Yes - Significantly reduced flows in the project area. Supported by sponsor, implementable by laws and codes.	Yes - Sponsor willing to acquire, USACE maintains capability to design and construct. .	No - Left substantial residual risk in tributary streams.	Only addresses significant reductions for lower / middle reaches Mill Creek. BCR 1.0.
Plan D	Yes, functions to reduce damage at a constriction point. Supported by sponsor, implementable by laws and codes.	Yes- Sponsor willing to acquire, USACE maintains capability to design and construct.	Yes, reduces stage at middle reach up to 1 foot.	Only addresses significant reductions for middle reach of Mill Creek. BCR 1.4
Plan E	Yes, reduces flood flows in the target area. Supported by sponsor, implementable by laws and codes.	Yes- Sponsor willing to acquire, USACE maintains capability to design and construct.	Only impacts nuisance flooding for two damage centers.	Only addresses significant reductions for middle reaches Mill Creek. BCR below unity.
Plan BC	Yes – Reasonably sized structures, functions to reduce flows. Supported by sponsor, implementable by laws and codes.	Yes - Sponsor willing to acquire, USACE maintains capability to design and construct.	Does not address two tributaries. Residual risk is high in the floodway.	High costs. Other plans more efficient. BCR 1.1.
Plan BA	Yes, reduces damages in the target area. Supported by sponsor, implementable by laws and codes.	Yes- Sponsor willing to acquire, USACE maintains capability to design and construct.	Yes, reduces stage and drops residual risk by about 40%.	Yes – Net benefits ranks this plan in the final array. BCR 1.8.

Plan CA	Yes – significant flow reductions on Mill combined with major buyouts on tributary streams. Supported by sponsor, implementable by laws and codes.	Yes- Sponsor willing to acquire, USACE maintains capability to design and construct.	Yes, sound plan for detention of main stem balanced with non-structural measures on the tributaries. Risk reduced by nearly 50%.	Yes- Net benefits ranks this plan in the final array, not carried forward due to new construction in project footprint. BCR 1.6.
Plan DA	Yes – primarily non-structural buyout. Also reduces commercial damages at middle reaches of Mill. Supported by sponsor, implementable by laws and codes.	Yes- Sponsor willing to acquire, USACE maintains capability to design and construct.	Yes - Reduces stage for middle reach Mill Creek. Non-structural benefits significant on tributaries.	Cost effective plan, least cost structural measure. BCR 2.0.
Plan BDA	Yes – Reduces flood stage for middle and lower Sevenmile Creek, middle Mill Creek and includes non-structural measures. Supported by sponsor, implementable by laws and codes.	Yes. Sponsor owns land, willing to acquire LERRDs. USACE maintains capability to design and construct.	Yes. Benefits key damage centers with structural measures. Focuses non-structural plan on repetitive loss homes.	Cost effective, NED Plan. Maximizes net benefits. BCR 2.01.

4.2.6 Plan Formulation and Evaluation Results

Plan formulation results indicated that the following plans composed the final array.

- Plan BA – Ellington Detention Structure & 1/5 ACE Non-Structural Plan
- Plan DA – Briley Bridge Modifications & 1/5 ACE Non-Structural Plan
- Plan BDA – Ellington Detention, Briley Bridge Modifications & 1/5 ACE Non-Structural Plan
- Plan CA – Old Hickory Detention Structure & 1/5 ACE Non-Structural Plan
- Plan EA – Wimpole Bridge and Channel Modifications & 1/5 ACE Non-Structural Plan

4.3 Final Array of Plans

Plan Comparison is the fifth step in the USACE planning process. It is based on the evaluation of the plans, the fourth step in the planning process. The more detailed evaluations of the impacts of the plans are presented in Chapter 6, Effects on Environmental Resources.

Table 33. Final Array Comparison

Mill Creek and Tributaries					
Alternative Analysis $'s = 1,000's					
	Plan DA	Plan BA	Plan BDA	Plan CA	Plan EA
Total Without Project Damages	5,456.9	5,456.9	5,456.9	5,456.9	5,456.9
Total Annual Benefits	1,970.2	2,171.6	2,390.2	2,601.9	2,975.1
Residual Damages	3,486.7	3,285.3	3,066.7	2,855.0	2,489.4
Total Project Cost	22,192	25,474	28,785	35,245	51,554
Total Annual Cost	976.9	1,217.1	1,197.0	1,593.9	2,308.2
Benefit Cost Ratio	2.02	1.78	2.00	1.63	1.27
Net Annual Benefits	933	955	1,193	1,008	634

4.3.1 Planning Objective Matrix

The planning matrix, on the following page, reveals how each of the final array of plans matches up to the planning objectives for the study, identified in Section 2.5. Each plan is to be measured by its performance during the fifty year life cycle of the project.

Table 34. Planning Objective Matrix – Final Array

Objective	Plan DA	Plan BA	Plan BDA	Plan CA	Plan EA
Reduce overall flood damages in the Mill Creek watershed.	Reduces 36 percent of the annual damages.	Reduces 40 percent of the annual damages.	Reduces 44 percent of the annual damages.	Reduces 48 percent of the annual damages.	Reduces 55 percent of the annual damages.
Reduce residual risk to life and property in the Mill Creek Watershed.	Removes 89 residential structures from the 1% floodplain.	Removes 89 residential structures from the 1% floodplain.	Removes 89 residential structures from the 1% floodplain.	Removes 89 residential structures from the 1% floodplain.	Removes 202 residential structures from the 1% floodplain.
Increase flood attenuation opportunities and restore riparian and floodplain connectivity in the Mill Creek Watershed.	Briley modification removes a major constriction point near the confluence of Mill/Sevenmile. Buyout and removal restores some connectivity.	Adds attenuation of approximately 40 acres, through detention basin. Buyout and removal restores some connectivity.	Adds attenuation of approximately 40 acres, through detention basin, removes major constriction point. Buyout and removal restores some connectivity.	Adds nearly 150 acres of property into permanent flood attenuation through flowage easements. Buyout and removal restores some connectivity.	Briley modification removes a major constriction point near the confluence of Mill/Sevenmile. Buyout and removal restores some connectivity.

4.3.2 Action versus No Action

There is systemic risk associated with continual flooding in the Mill Creek watershed. Major flood events have occurred since the 1950s on the average of nearly every ten years. This continued flooding has and will result in adverse impacts to the community. Without serious large-scale public involvement in flood damage reductions the area would continue to be at risk from large flooding events. Additionally, the impacted communities will experience repeated economic development concerns as well as potential for the loss of life. The problem would continue to worsen over time with no action taken because growth and redevelopment in the watershed will only increase flows and flood damages for future conditions. The No Action Plan does not alleviate any risks to public health and safety, and when measured against these life and safety risks, does not measure up to the array of plans offered in this document to address residual flood risks in the watershed.

4.3.3 Risk and Uncertainty

The selected plan BDA provides significant reductions in residual risk to future flood damages. Plan BDA will eliminate approximately 44% of the expected annual damages for the Mill Creek watershed.

Risk reduction to people and property were the primary focus of this project, but must be balanced with scale of the flood damage reduction alternative that reasonably maximizes expected net benefits, per ER 1105-2-101. All project increments comprise different risk management alternatives represented by the tradeoffs among engineering performance, economic performance and project costs. The project objectives focus on maximizing risk and damage reduction, where costs are feasible. Following implementation of the NED Plan, flooding will persist, but fewer people and less property would be affected. For the people in the most danger, those in the floodway and lower elevation areas of the higher frequency floodplain, the NED Plan greatly reduces their risk.

As per U.S. Army Corps of Engineers Guidance documents EM 1110-2-1619 and ER 1105-2-101, a risk and uncertainty analysis is required to be performed for the hydrologic (discharge-probability function), hydraulic (stage-discharge function), and economic (stage-damage function) portions of a feasibility study. The future without project conditions was used for the baseline of all uncertainty analysis contained in this document. Information gathered from this analysis provided the hydrologic and hydraulic uncertainty functions for HEC-FDA, a flood risk analysis model. With the NED Plan (Plan BDA), the detention structure affects timing and flood attenuation. It allows the peak flows in the lower and middle reach tributaries of Sevenmile Creek to vacate before the arrival of peak flows from Sevenmile Creek, itself. This design can mitigate the double peak aspect seen as flood storm systems move from upstream to downstream. Plan BDA can lower the downstream peak flows by between one and two feet, in addition to the non-structural risk reduction of removing people and property from the 5-year floodplain. Flooding along Sevenmile Creek is widespread with multiple residential and commercial areas experiencing significant damage during moderate floods events. The May 1979, September 1979 and May 2003 flood events were identical in magnitude and representative of moderate flooding conditions along Sevenmile Creek with estimated flood frequencies between 1/10 and 1/25 ACE. The May 2010 flood event was the flood of record along Sevenmile Creek with estimated flood frequency of 1/100 ACE or a 100-Year Flood Event. There is insufficient storage above the Ellington detention structure to significantly reduce major floods like the May 2010 event. Moderate floods were targeted to maximize the downstream flood damage reduction (discharge and stage).

Flood performance is summarized below for the 1/10, 1/25, 1/50, 1/100 and 1/500 ACE flood events for key residential and commercial damage centers along Sevenmile Creek. The Bridge and Channel Modifications at Briley Parkway also have significant impacts up to the 1/50 ACE flood events and do reduce stage in the immediate damage center by between 1-3 feet. Briley Parkway is improves the hydraulic capacity of the bridge by removing fill material in the left overbank and restoring the natural floodway along Mill Creek. Flood reductions are experienced across the full range of benchmark floods in the upstream residential subdivision and Space Park commercial area and summarized below. Tables 35-38 , on the following page, provide the stage and flow reductions of measure performance at key damage centers for the various flood events.

Table 35. Ellington Ag Center Regional Detention Downstream Effects
Suter Drive/Blackman Road – Seven Mile Creek – River Mile 2.8

	Future W/O Project		Future W Project		
ACE	Discharge	Elevation	Discharge	Elevation	Reduction
	(cfs)	(feet)	(cfs)	(feet)	(feet)
1/10	5,899	511.8	4,348	510.7	-1.1
1/25	7,129	512.6	5,691	511.7	-1.0
1/50	8,067	513.2	7,041	512.6	-0.7
1/100	9,051	513.8	8,299	513.3	-0.5
1/500	12,003	515.0	11,573	514.7	-0.2

Table 36. Ellington Ag Center Regional Detention Downstream Effects
Nolensville Road / Harding Place – Seven Mile Creek – River Mile 1.9

	Future W/O Project		Future W Project		
ACE	Discharge	Elevation	Discharge	Elevation	Reduction
	(cfs)	(feet)	(cfs)	(feet)	(feet)
1/10	6,858	503.5	5,666	502.2	-1.3
1/25	8,234	504.7	6,564	503.5	-1.2
1/50	9,305	505.8	7,770	503.8	-2.0
1/100	10,238	506.5	9,048	505.4	-1.1
1/500	13,236	508.2	11,707	507.3	-0.9

Table 37. Briley Parkway Bridge and Channel Modification Downstream Effects
Drummond / Upstream from Parkway – Mill Creek – Mile 7.13

	Future W/O Project	Future W Project	
ACE	Elevation (ft)	Elevation (ft)	Reduction (ft)
1/10	458.2	456.7	-1.5
1/50	461.7	459.6	-2.1
1/100	463.6	461.2	-2.4
1/500	467.3	464.4	-2.8

Table 38. Briley Parkway Bridge and Channel Modifications Downstream Effects
Space Park South – Mill Creek – Mile 7.59

	Future W/O Project	Future W Project	
ACE	Elevation (ft)	Elevation (ft)	Reduction (ft)
1/10	461.8	461.3	-0.6
1/50	465.9	465.0	-0.9
1/100	468.0	467.1	-0.9
1/500	471.1	470.0	-1.1

With the implementation of Plan BDA, the opportunity exists to eliminate nearly half of the flood risk associated with future flood events. The locations experiencing the majority of the benefits from flood risk reduction are the tributary communities of Sevenmile and Whittemore Branch as well as the middle reaches of Mill Creek proper. The key component of the non-structural plan has the opportunity to eliminate much of the floodway damages experienced as well as the most frequently damaged properties, those within the 2- and 5-year floodplains. Of course, risks are still associated with those properties on the frequency curve in the 50-, 100-, and 500-year elevations. Major floods will still occur and result in significant damages. Climate variability may affect the level of protection that is estimated from this project. Extreme flood events occurred in May 2010 and others may occur during the life of this project Table 39 below presents the residual risk aspects of Plan BDA. The best way to combat that including prevention of life loss is to continue implementation and improvement of the flood warning and evacuation activities described in Section 4.1.2.

Table 39. Residual Risk (Selected Plan)

Plan BDA	
Residual Annual Damages	**$3.07 million**
Damages Prevented	**$2.39 million**
Reduction in Damages	**44%**
Buildings Removed from the 1/100 ACE	**89**
Depth Reduction Through Middle / Lower Reaches	**Stage reduction of 1 to 3 feet**

The Metro Safe program was developed following the May 2010 flood as Metro Nashville and the Corps initiated a study under the Planning Assistance to States Program to develop Hydrologic and Hydraulic (H&H) models and tools for a comprehensive flood preparedness plan in Davidson County. The tools include geographic information systems (GIS) and automated warning systems (AWS). All of the modeling and mapping products completed for Metro Nashville Flood Preparedness were leveraged for use in development of this report and updating the Flood Insurance Studies. The tools assist Metro in defining flooded areas and depths during storm events and help relate flood forecasts for specific locations to other points within the watershed. The tools and products also allow a better, quicker and more directed response to flood events. To combat the residual risk these tools must continue to be honed and the multi-agency approach continue to effect changes to the comprehensive flood warning approach.

4.3.4 Environmental Considerations

Due to the highly developed, urban environment of the project footprint, the resulting environmental impacts for most components of the selected plan are minimal. The selected plan, Plan BDA (Ellington Detention Basin), would not require mitigation for impacts to existing wetlands (approximately 0.05 acres permanent/0.05 acres temporary impacts) located within the proposed project footprint. The proposed project, Plan BDA, would require no compensatory mitigation per TDEC and DA Regulatory requirements. In addition the project meets both Sections 404 (Corps Nationwide Permit 18 – Minor Discharge) and 401

(TDEC General Permit of Minor Alterations to Wetlands) of the Clean Water Act. Stream impacts would only be associated with Plan B, removal/construction of a bridge. Impacts associated with the removal/construction of a bridge would meet TDEC General Permit for Construction and Removal of Minor Road Crossings. This permit authorizes the construction and/or removal of minor road crossings. TDEC defines "minor road crossings" as a bridged or culverted roadway fill across a stream or river which results in the alteration of 200 linear feet or less of stream bed (on a single stream) or shoreline. The Nashville Crayfish is endemic to Mill Creek and is classified by U. S. Fish and Wildlife Service (USFWS) as endangered. USFWS describes the Nashville Crayfish habitat as creeks with moderate gradients containing benthics, fallen logs and debris; moderate flow and firm, usually rocky, stream bottoms. Plan BDA will affect the Nashville Crayfish. As a result USACE has entered into formal consultation with USFWS. USACE has submitted a Biological Assessment requesting USFWS correspondence. USACE received the Draft Biological Opinion from USFWS on 6 February 2015. It is the USFWS' biological opinion that the preferred alternative would not likely jeopardize the continued existence of the Nashville crayfish. The USFWS provided "Reasonable and Prudent Measures" as well as "Terms and Conditions" for the proposed action. These are summarized in Section 6 of this Main Report and Appendix D.

Regarding the non-structural plan, temporary impacts are anticipated with raise-in-place and structure removal. However, long term benefits would be seen by allowing additional waters to be stored in the floodplain as well as creating open space within the floodplain. It is assumed that any existing vegetation would remain undisturbed by the removal of homes. Depending on local management measures, if the open space was allowed to revegetate with shrub and/or trees, riparian zones could increase in width, thus providing water quality and wildlife benefits. Negligible impacts are anticipated to vegetation by the Briley Bridge modification. The area consists of riprap, with a few trees, some understory, and scrub vegetation. Ground disturbance and removal of scattered bank vegetation would be anticipated. Stormwater permit (NPDES) may be required if more than one acre of vegetation is disturbed. This area would likely be maintained with riprap for slope stability and vegetation would be discouraged as it would impede water flow. The Environmental Impacts of the final array of plans are discussed in further detail in Section 6: Effects on Significant Resources.

4.3.5 System of Accounts – Plan Comparison

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

National Economic Development (NED)

The intent of comparing alternative flood risk reduction plans in terms of national economic development was to identify the beneficial and adverse effects that the plans may have on the national economy. Beneficial effects were considered to be increases in the economic value of the national output of goods and services attributable to a plan. Increases in NED were expressed as the plans' economic benefits, and the adverse NED effects were the investment opportunities lost by committing funds to the implementation of a plan. The NED benefits for the final array were described in Section 4.4.2. Plan BDA has the most net benefits.

Environmental Quality (EQ)

The environmental quality account was another means of evaluating the plans to assist in making recommendations. The EQ account was intended to display the long-term effects that the alternative plans may have on significant environmental resources. The Water Resources Council defined significant environmental resources as those components of the ecological, cultural and aesthetic environments that, if affected by the alternative plans, could have a material bearing on the decision-making process. The EQ account is described in Section 6.

Regional Economic Development (RED)

The regional economic development account was intended to illustrate the effects that the proposed plans would have on regional economic activity, specifically, regional income and regional employment. RED benefits were similar across both plans.

Other Social Effects (OSE)

The other social effects (OSE) account typically includes long-term community impacts in the areas of public facilities and services, recreational opportunities, transportation and traffic and man-made and natural resources. Plan BDA has more opportunity for improvement in these areas than any of the eleven other plans evaluated in the second iterative phase. The table below describes the final array of plans compared by completeness and effectiveness by measurement of the four accounts (national economic development, environmental quality, regional economic development, and other social effects.

Table 40. Plan Comparison (Four Accounts)

Four Accounts	Plan DA Briley Bridge Modification + Non-Structural Plan	Plan BA Ellington Detention + Non-Structural Plan	Plan BDA Ellington Detention, Briley Bridge + Non-Structural Plan	Plan CA Old Hickory Detention + Non-Structural Plan	Plan EA Wimpole Bridge and Channel Modifications + Non-Structural Plan
National Economic Development (NED)	**Avg. Annual Benefits-** $1.97M **Avg. Annual Costs-** $977,000 $993 million in net benefits. 2.02 BCR Ranks 4th.	**Avg. Annual Benefits-** $2.17M **Avg. Annual Costs-**$1.22M $955 million in net benefits. 1.78 BCR Ranks 2nd.	**Avg. Annual Benefits-**$2.39M **Avg. Annual Costs-** $1.25M $1.14 million in net benefits. 2.00 BCR Ranks 1st.	**Avg. Annual Benefits-**$2.60M **Avg. Annual Costs-**$1.59M $1.01 million in net benefits. 1.63 BCR Ranks 3rd.	**Avg. Annual Benefits-**$2.94M **Avg. Annual Costs-** $2.3M $634,000 in net benefits. 1.27 BCR Ranks 5th.
Environmental Quality (EQ) (Non-structural) element is similar for each plan. (Riparian zone returned/ attenuation) EQ comparison for structural aspect.	Construction removes chief constriction point for middle reach Mill Creek. Floodplain attenuation could have limited benefits. Ranks 1st.	Construction footprint (existing roadway) may have limited short term impacts to Sevenmile Creek. Ranks 2nd.	Construction footprint (existing roadway) may have limited short term impacts to Sevenmile Creek. Plan BDA would alter natural high flows by attenuation, base flows unaffected. Ranks 3rd.	Detention site may have impacts to riparian zone in immediate area. New structure. Natural flows unaffected. Ranks 5th.	Construction removes chief constriction point for middle reach Mill Creek. Floodplain attenuation could have limited benefits. Ranks 4th.
Regional Economic Development (RED)	There are no significant changes from NED. Ranks 4th.	There are no significant changes from NED. Ranks 2nd.	There are no significant changes from NED. Ranks 1st.	There are no significant changes from NED. Ranks 3rd.	There are no significant changes from NED. Ranks 5th.
Other Social Effects (OSE)	Each plan carries similar impacts to high risk neighborhoods. Cohesion could be lost in some respects, but health, and risks to future floods and loss of life will be greatly reduced in the highest risk neighborhoods. Plan EA composes a larger buyout/removal program nearly doubling the residual risk reduction of incremental reiterations to the recommended non-structural plan.				

Plan BDA combines the Ellington detention basin and Briley Bridge modification with the non-structural raise-in-place and buyout and removal of residential structures impacted by the 1/5 ACE or 5-year flood event. In Mill Creek and tributaries Sevenmile Creek, Sorghum Branch, and Whittemore Branch, this equates to 89 structures. The recommended plan will remove nearly half of the expected annual damages associated with Mill Creek and tributary flooding. For further detail on the economic analysis of the recommended plan see the Economic Appendix, Appendix A.

4.4 Plan Selection

4.4.1 Designation of NED Plan

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

The NED Plan was determined through the plan formulation iterative process by evaluating the net economic benefits for each particular alternative and targeted damage centers. The NED Plan is Plan BDA.

4.4.2 Recommended Plan

The recommended plan is the NED Plan because it provides the greatest net benefits. Plan BDA also happens to provide significant reductions to residual risk. The recommended plan has the potential to remove nearly half of the expected annual damages associated with Mill Creek and tributary flooding.

4.5 Description of Recommended Plan

4.5.1 Plan BDA Details

The National Economic Development (NED) Plan and recommended plan are both Plan BDA. The recommended plan is the NED Plan because it provides the greatest net benefits. Plan BDA also leaves considerably less residual risk in the floodplain than all other plans in the final array.

- The proposed modifications to the Briley Parkway Bridge will lower the elevation of floodwater between 1 and 3 feet in the Space Park, Drummond Drive, Currey Road, and Antioch Pike damage center.
- The proposed detention structure at Ellington will lower the elevation of floodwater between 1 and 2 feet in the Suter Drive, Nolensville/Harding, and Elysian Fields damage center.
- The buyout and raise in place measures located in every damage center of the watershed will not have a significant reduction in elevation of floodwater, but will permanently remove 89 repetitive loss homes from recurring future damages and potential loss of life in the highest hazard areas.

4.5.2 Design and Construction Considerations

Construction of the bridge modification would occur entirely within the existing footprint of the structure. The Briley Parkway bridge modification would include widening the east and west bound bridge openings by a minimum of 60 feet. Construction of the Ellington Detention Basin would occur primarily within the footprint of the existing access road. The existing box culvert will be replaced with a CONSPAN culvert and the weir, spillway, and stilling basin would be armored on the downstream face of the structure with articulated block. Further detail is found in the Engineering Appendix.

4.5.3 Project Failure

The non-structural project would consist of raise-in-place of homes and the buyout and removal of people and property from the floodplain. There are no associated residual risks with that recommendation. The bridge modification to Briley Parkway would increase the flow capacity of the bridge by roughly 35%; the associated risks with failure at the widened opening are extremely low as any issues would be accounted for during the design phase. The practice is routine among both Nashville and State of Tennessee highway construction departments. Ellington Detention Basin, weir outflows and spillway function to delay peak flows on the lower reaches of Sevenmile Creek. At most, the required armoring must sustain passage of flows for 1-4 hours during major events. Stilling basin and armoring of the toe of structure have been optimized in the design process. The associated risks with failure of the spillway structure are extremely low given depth and duration analysis. Further investigation and optimization would be accounted for in the design phase. Further information is included in the Engineering Appendix (Appendix C).

4.5.4 Real Estate Considerations

The proposed project combines the nonstructural acquisition and demolition and raise-in-place of all residential structures within the 5-year floodplain that meet net benefit requirements following consideration of the bridge modification to Briley Parkway located just downstream of the confluence of Sevenmile Creek and Mill Creek and the Ellington Detention Basin. The nonstructural portion of the project would involve raise-in-place of 9 properties and fee acquisition of 80 properties located along Mill Creek and its tributaries Sevenmile Creek, Sorghum Branch, and Whittemore Branch. The non-structural measure (raise-in-place) under consideration would include voluntary participation by the property owners. With regard to the evacuation or buyout and removal measures; to the extent practicable, acquisition would be on a voluntary or willing seller basis, but eminent domain could be utilized when determined to be warranted. The majority of the residences are single family.

The bridge modification at Briley Parkway would include removal of fill previously used underneath the bridge in order to allow flow capacity closer to the original flood plain area. Metro would need to acquire a Channel Improvement easement within the bridge modification area to perform appropriate operation, maintenance, repair, rehabilitation and replacement (OMRR&R). A temporary work area easement is anticipated for a lay down area for materials. Since Briley Parkway serves as a major connecting freeway that feeds directly into Nashville's interstate system, Metro Nashville owns and the Tennessee Department of Transportation (TDOT) maintains the road and right-of-ways in this location. A compensability determination has been completed for the Briley Bridge measure.

The Ellington Detention Basin will require a temporary work area easement, determination of fee acquisition for structure footprint, and flowage easements for the four properties impacted by the basin. The sponsor Metro Nashville owns one of the properties, a second property is state owned and Metro Nashville will be responsible for acquiring the necessary LERRDs interests for the project. A compensability determination is not yet complete for this measure. Further details are provided in the Real Estate Plan.

4.5.5 Betterments

There are no betterments.

4.5.6 Operations, Maintenance, Repair, Rehabilitation, and Replacement

A summary of the OMRR&R cost estimate appears in the table below.

Table 41. OMRR&R related costs for the NED PLAN.

Plan BDA	Type of action	Annual costs for alternative ($)
1/5 ACE Buyouts	Mowing / waste maintenance	19,115
Briley Bridge Modification	Asphalt / concrete repair	14,357
Ellington Detention	Structure maintenance, asphalt, stilling basin, articulated block, mowing slope	18,256
Total Annual Costs (OMRR&R)		51,728

4.5.7 Economic Summary

For pre Alternative Formulation Briefing (AFB) level analysis the project construction costs were developed using parametric analysis. MII cost estimating system is complete for the recommended plan and has been certified by the USACE Cost Engineering Center of Expertise (Cost DX). These costs, along with annualized costs, annualized benefits, net economic benefits and the benefit-to-cost ratios are shown in the tables below. Plan BDA, is the recommended plan. It is the NED Plan. It has an investment cost at October 2015 price levels of $28,785,000; an annual cost of $1,197,000 including Operations, Maintenance, Repair, Rehabilitation and Replacement costs (OMRR&R); annual benefits of $2,390,000; net benefits of $1,193,000; and a benefit-to-cost ratio (BCR) of 2.00 at an interest rate of 3.375 percent, a 50-year period of analysis, and a three year construction period. The structural components of Plan BDA provide $639,000 annual benefits compared to $453,000 in annual costs for a BCR of 1.41. The non-structural components of Plan BDA provide $1,751,000 annual benefits compared to $798,000 in annual costs for a BCR of 2.19.

Table 42. Plan BDA: NED Plan

Plan BDA	$'s = 1,000s
Total Without Project Damages	**5,457**
Annual Non-Structural Benefits	**1,752**
Annual Structural Benefits	**639**
Total Annual Benefits	**2,390**
Total Non-Structural Cost	**19,162**
Total Structural Cost	**9,342**
Total Project Cost*	**28,785**
Total Annual Cost	**1,197**
Benefit Cost Ratio	**2.00**
Net Annual Benefits	**1,193**

*Project cost at current price levels (FY15)

4.5.8 Sensitivity of Recommended Plan to Future Conditions

As per U.S. Army Corps of Engineers Guidance documents EM 1110-2-1619 and ER 1105-2-101, a risk and uncertainty analysis is required to be performed for the hydrologic (discharge-probability function), hydraulic (stage-discharge function), and economic (stage-damage function) portions of a feasibility study. The future without project conditions was used for the baseline of all uncertainty analysis contained in this document. Information gathered from this analysis provided the hydrologic and hydraulic uncertainty functions for HEC-FDA, a flood risk analysis model. The benefits for the NED Plan are based upon future conditions. It is worth noting, however, that the variation between existing and future conditions is negligible, on the order of 3%. All plan evaluation was conducted in the lower two-thirds of the watershed, which is the area where the build-out of Metro Nashville (along and in floodplains) has already occurred. Additional construction and damages are assumed to fill in the upper third of the watershed where current impervious analysis provides for conversion of a largely rural landscape into suburban over the life of the project. This as stated earlier has little impact to the project, as the upper third of the watershed is in Williamson County, which declined to participate in the study, and thus no projects were evaluated or proposed there. More details are provided in the Economic Analysis Appendix and H+H Appendix (Future Conditions).

4.5.9 Environmental Compliance and Mitigation

All USACE projects must comply with all applicable environmental statutes and policies; detailed discussion is found in Section 7 of this document. No significant environmental impacts have been anticipated to date. Potential impacts to water quality and endangered species have been coordinated. A brief summary of each is found below.

Plan BDA (Ellington Detention Basin) would not require mitigation for impacts to existing wetlands (approximately 0.05 acres permanent/0.05 acres temporary impacts) located within the proposed project footprint. The proposed project, Plan BDA, was minimized and requires no compensatory mitigation per TDEC and DA Regulatory requirements. In addition the project meets Section 404 (Corps Nationwide Permit 18 – Minor Discharge) and would require an Individual Aquatic Resource Alteration Permit (ARAP) (State Section 401 Clean Water Act Water Quality Certification). Stream impacts would only be associated with Plan B, Ellington Detention Structure. An Individual ARAP would be required due to changes in hydraulic capacity at the Ellington Detention Basin, however, TDEC agrees that impacts are minor and of short-term duration.

The Nashville Crayfish is endemic to Mill Creek and is classified by U. S. Fish and Wildlife Service (USFWS) as endangered. Plan BDA would affect the Nashville Crayfish, and as a result, USACE has entered into formal consultation with USFWS. Only short-term and minor effects are anticipated and should be controlled with Best Management Practices (BMPs). Overall benefits would be positive with additional open floodplain areas following completion of the non-structural components of the NED PLAN. USACE received the Final Biological Opinion from USFWS on 23 March 2015. It is the USFWS' biological opinion that the preferred alternative would not likely jeopardize the continued existence of the Nashville crayfish. The USFWS provided "Reasonable and Prudent Measures" as well as "Terms and Conditions" for the proposed action. These are summarized in Section 6 of this Main Report and Appendix D.

4.6 Implementation

4.6.1 Agency Requirements

Project implementation requires approval of the Chief's Report first and foremost. Following report approval the project is eligible for authorization. Following project authorization the project will be eligible for construction funding. It will be considered for inclusion in the President's budget based on national priorities, magnitude of the Federal commitment, economic and environmental feasibility, level of local support, willingness of the non-Federal sponsor to fund its share of the project cost and the budget constraints that may exist at the time of funding. The Planning, Engineering and Design phase of the project can begin after the feasibility report is approved and a design agreement is signed by the non-Federal sponsor.

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

Following the signing of the PPA and the design approval, USACE would officially request the sponsor to acquire the necessary real estate for property buyouts. Separately for Briley Bridge Modification and Ellington Detention Basin, the advertisement of the construction contract would follow the certification of the real estate acquisition and right-of-entry. The final acceptance and transfer of the project to the non-Federal sponsor will follow the delivery of an operation and maintenance manual and as-built drawings. Assuming full funding, the project will be fully constructed by the year 2021.

4.6.2 Cost Share Requirements

Pursuant to Section 103, WRDA 1986, 33 USC 2213, the non-federal cost share for (i) structural flood risk management is at a minimum of 35 percent of total costs for the project, including 5 percent in cash, with LERRD value credited toward the sponsor's cost share, with the sponsor's total share capped at a maximum of 50 percent; and (ii) non-structural flood risk management is a flat 35 percent of total costs for project allocated to non-structural flood risk management, with LERRD value credited toward the sponsor's share. Table 43, on the following page, describes the cost share provisions for the recommended plan.

Table 43. Cost Apportionment (Project First Cost)

Project Description	Federal Contribution $1000s	Non-Federal Contribution $1000s	Total $1000s
Non-Structural FRM*			
Lands / Acquisitions	8,943	4,817	13,760
Raise-in-Place	556	300	856
Metro-RE Admin Costs	641	346	987
USACE-RE Admin Costs	385	205	590
91-646 Relocation Assitance Costs	576	310	886
Demolition / Removal Costs	1,477	796	2,273
Sub-total Non-Structural FRM	**12,578**	**6,774**	**19,352**
Structural FRM*			
Briley / Ellington FRM	5,357		5,357
Briley / Ellington LERRD plus Cash (see below*)		4,076	4,076
Subtotal Structural FRM	**5,357**	**4,076**	**9,433**
Structural LERRD*			
Briley Bridge Modification		1,834	1,834
Ellington Access Road		483	483
Edmondson Pike		735	735
Lands		423	423
Admin Costs		130	130
Sponsor Cash**		471	471
Subtotal Structural LERRD + Cash			**4,076**
Total	17,935	10,850	28,785
Total Cost Share	62.3%	37.7%	100%

*Sponsor will conduct buyouts for the acquisition of the 80 structures. Subject to available appropriations, the sponsor's LERRD expenses will be reimbursed to the extent those expenses are creditable and exceed the sponsor's required cost share, pursuant to Section 103, WRDA 1986, 33 USC 2213. Sponsor's share not to exceed 35% of TPC for Non-Structural project features; sponsor's share not to exceed 50% of TPC for Structural project features. Demolition and Structure removal will be processed via in kind credit. **Sponsor will submit at least 5% Cash for Structural Flood Control measures as part of the required cost share.

4.6.3 Cost Estimate

Table 44 includes cost estimate per October 2015 price levels. Cost estimating assigned the codes with support of the project delivery team. All figures include contingency and inflation.

Table 44. Cost Estimate: Code Designation

Feature Code	Cost Shared ($1000s)	Subtotal ($1000s)
08- Bridges/Pier Construction / Replacement	**2,370**	**2,370**
15- Detention Basin / Fill Placement / Armoring	**5,035**	**5,035**
15-Demolition/Removal	**2,272**	**2,272**
30 – Engineering and Design 31 – Supervision and Administration	**1,352** **676**	**2,028**
01 – Lands (Buyout/Acquisition/RE Administration)	**15,338**	**15,338**
02 – Relocation (Removal Cost + Raise-in-place)	**1,742**	**1,742**
Total		**$28,785**

See Appendix D, for detailed cost estimating materials on the various flood risk management alternatives.

4.6.4 Permits

Briley bridge improvement would be considered an over widening of the left overbank channel to accommodate flood flow. It would meet a Corps nationwide permit and would require an Individual ARAP for bridge modifications since the project would alters the hydraulic capcity.

Ellington Detention Basin would not require mitigation for impacts to existing wetlands (approximately 0.05 acres permanent/0.05 acres temporary impacts) located within the proposed project footprint. Plan BDA wetland impacts, were minimized and requires no compensatory mitigation per TDEC and DA Regulatory requirements. In addition the project meets both Sections 404 (Corps Nationwide Permit 18 – Minor Discharge) and 401 (TDEC General Permit of Minor Alterations to Wetlands) of the Clean Water Act. Therefore no mitigation for impacted wetlands in required.

Stream impacts associated with Plan B, Ellington Detention Structure, would require an Individual ARAP from TDEC.

The Nashville Crayfish is endemic to Mill Creek and is classified by U. S. Fish and Wildlife Service (USFWS) as endangered. Plan BDA would affect the Nashville Crayfish and as a result USACE has entered into formal consultation with USFWS. USACE has submitted a Biological Assessment requesting USFWS correspondence. USACE received the Final Biological Opinion from USFWS on 23 March 2015. It is the USFWS' biological opinion that the preferred alternative would not likely jeopardize the continued existence of the Nashville crayfish. The USFWS provided "Reasonable and Prudent Measures" as well as "Terms and Conditions" for the proposed action. These are summarized in Section 6 of this Main Report and Appendix D.

4.6.5 Non-Federal Sponsor Responsibilities

Sponsor Support and Capability. The non-Federal sponsor fully supports the recommended plan and submits a statement of self-certification of financial capability to accompany the final report package for approvals. They are willing and financially able to support the recommended plan moving forward through Planning, Engineering, and Design (PED) and Implementation. The sponsor has conducted major partnership projects with USACE in the past, most recently Metro Center Levee, and has a dedicated funding stream to implement flood risk reduction projects. The sponsor has clear legal authority to conduct flood risk management projects with federal partners, and has done so, recently with both USACE and NRCS. There is no locally preferred plan (LPP) up for comparison.

Sponsor Responsibilities. As part of the implementation of the selected plan, Metro Nashville will acquire all necessary lands, easements, relocations, rights-of-way, and disposal areas (LERRDs) and seek crediting or reimbursement for those costs in excess of the required cost share. Per ER 1105-2-100, E-127-130, Metro will be responsible for all LERRDs associated with the acquisition of residential structures recommended by the selected plan and acquire all LERRDs associated with the Briley Bridge channel modification and Ellington Detention Basin. Implementation of non-structural measures at individual properties will be dependent on verification of structure characteristics and first floor elevations. The nonstructural portion of the project would involve raise-in-place of 9 properties and fee acquisition of 80 properties located along Mill Creek and its tributaries Sevenmile Creek, Sorghum Branch, and Whittemore Branch. The non-structural measure (raise-in-place) under consideration would include voluntary participation by the property owners. With regard to the evacuation or buyout and removal measures; to the extent practicable, acquisition would be on a voluntary or willing seller basis, but eminent domain could be utilized when determined to be warranted. Metro Nashville will conduct the demolition/removal of the structures for in-kind crediting.

Metro Nashville will coordinate demolition/removal with LRN Construction office, obtain proper permitting and contract approvals. For residences built before 1978, a lead paint and asbestos survey shall be conducted before demolition. If lead paint or asbestos is discovered, it will be abated prior to demolition. Any regulated materials recovered as part of the abatement process will be disposed of in a certified landfill. To meet the CERCLA all appropriate inquiry standards, an updated Phase 1 ESA consistent with ASTM E1527 procedures must be completed within 6 months of construction contract award. The costs to perform the sampling and analyses and update to the Phase 1ESA have been included in the final cost allocation tables. All costs associated with abatement and disposal of asbestos and lead containing material are 100% non-Federal responsibility and are not included as project costs. Cost-share responsibilities are defined in Section 4.6.2.

Per ER 1105-2 100, E-85, the sponsor will be required to eliminate all existing lands uses associated with the residential structures that accept buyouts. This also signifies the elimination of all previous services to those areas previously held in residential property. The sponsor will be required to maintain these properties as open space. Typically in past buyouts for the reduction of flood risks, the sponsor has returned the acquired properties to park lands. Prior to the transfer of maintenance responsibilities from Metro Water Services to Metro Parks and Recreation, the maintenance of the property will be conducted by Metro Water Services. Following transfer of maintenance to Parks and Recreation, the parcels will be utilized as urban gardens, pocket parks, natural trail systems, or multi-use greenway trail systems. The future use of the parcel will depend upon the number of contiguous properties acquired by the sponsor. Where appropriate, in locations outside the floodway, restroom facilities, playground equipment, may also be installed. These land uses will be subject to approval of the Project Partnership Agreement (PPA).

Metro Nashville has extensive experience with home buyout / relocation efforts, via past projects with both USACE and FEMA. The most recent floodway acquisitions occurred following the May 2010 flood. Metro Nashville acquired 240 properties in various watersheds, including Mill Creek, Richland Creek, and Whites Creek, and has returned those lands to natural areas with trails, pocket parks, greenways, and urban gardens. Figure 33 and Figure 34 provide before and after demonstrations for two of those implementation areas along Delray Drive and Wimpole Drive, respectively. Figure 35 provides before and after aerial imageries of the Wimpole Drive implementation program.

<u>Future Land Use – Prior Floodway Buyouts</u>

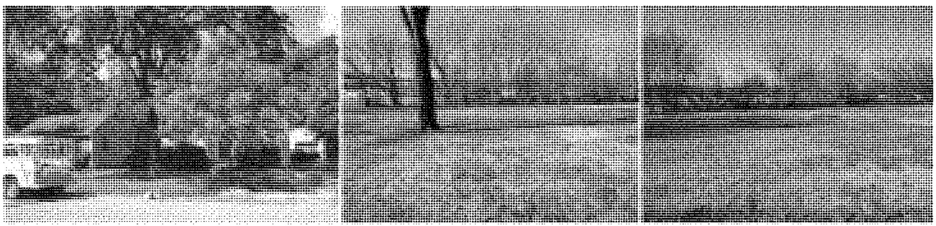

Figure 33. Delray Drive Buyout Program (2010-2012)

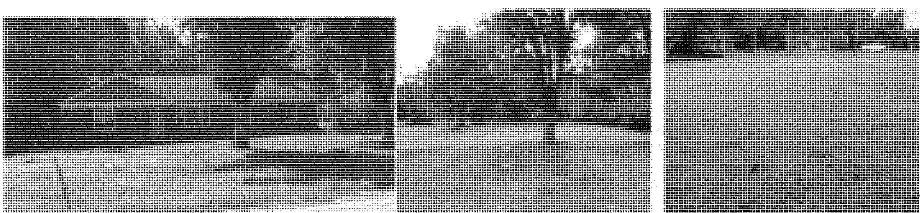

Figure 34. Wimpole Drive Buyout Program (2010-2012)

Figure 35. Wingate Drive Buyout Implementation: Aerial Imagery (2010-2014)

In addition to these specific actions, Metro Nashville will be required by ER 1105-2-100 para. 4-3(b)(2), to uphold the requirements for partnership in the planning, engineering, and design (PED) and implementation phases, signified by the respective legal agreements for each phase. Following Chief's Report approval, this project may be eligible to enter into a PED Agreement to advance the recommended plan from Feasibility phase into final design. Upon completion of the PED phase and authorization by Congress, the project may enter into implementation by entering into a PPA.

Affected Environment*

5.1 Environmental Setting of the Study Area

Mill Creek, a tributary that enters the Cumberland River (Cheatham Reservoir) at Mile 194.4 in Davidson County, drains a watershed of 108 square miles and encompasses portions of Davidson, Rutherford, and Williamson Counties.

5.2 Physical Environment

Land Use

Mill Creek watershed is approximately 69,200 acres and consists of portions of Davidson, Williamson, and Rutherford counties. Davidson County makes up 63.8% of the total basin; 35.2% is Williamson County, and the remaining 1% is Rutherford County. Land use for Mill Creek Watershed is widely varied (Figure 36). In the upstream reaches of the watershed, cropland and hay pastures are common. Ridge areas are covered in deciduous forests. Moving downstream through the watershed and approaching Nashville, land use changes to residential, commercial and industrial. Much of the area is experiencing heavy residential development.

There are thirteen parks (Table 45) providing day use activities within Mill Creek watershed, two major greenways, and a segment of Rails to Trails. Conceptual plans show a contiguous greenway from the headwaters of Sevenmile Creek to the confluence with Mill Creek. Similar plans show a complete greenway from Mill Creek's confluence with the Cumberland River toward its headwaters within Williamson County (Nashville 2008). In addition to the planned greenways, two possible greenway corridors have been suggested through the Mill Creek watershed. The two possible greenways are Ezell Park to J. Percy Priest Reservoir and the southern section of the watershed from Sevenmile to Cane Ridge. (Metro Department of Parks, 2008). The State of Tennessee's Ellington Agricultural Center adjacent to Sevenmile Creek has hiking trails and Metro greenway (at least in sections) paralleling Sevenmile Creek through the campus.

Climate

Summers in Metro Nashville are moderately hot and humid with the temperature averaging in the high 80's °F. Winters can be chilly to cold with average lows of 31°F in December and 28°F during January. The average annual rainfall is 48 inches; May is usually the wettest period (average 5.5 inches) and October averaging the driest period (3.04 inches) (TWC, 2013).

Topography, Physiography, and Soils

Mill Creek watershed study area is located in the northwest part of the Central Basin of Tennessee. Elevations in the drainage basin range from about 385 feet above sea level at the mouth to approximately 1,200 feet in the upper reaches. Slopes are slight to moderate and range up to 20 percent. The watershed is primarily in the Outer Nashville Basin Ecoregion of Tennessee, but a small upstream sector lies in the Inner Nashville Basin Ecoregion (EPA, 1997).

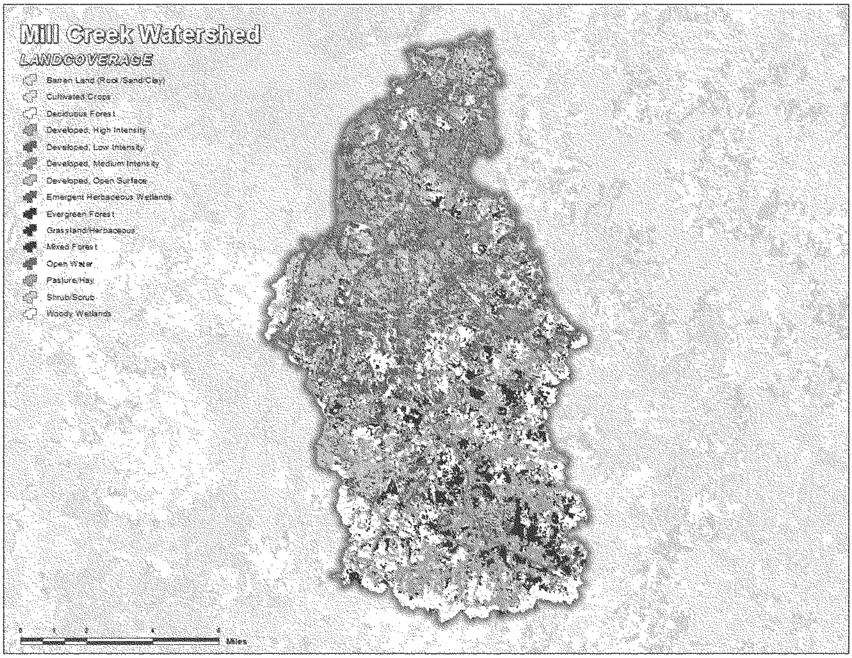

Figure 36. Land coverage Types within Mill Creek Watershed.

The Outer Nashville Basin (Ecoregion 71h) is characterized by open hills, gently rolling to steep; some plains with hills; highly dissected escarpments; moderate gradient bedrock and gravel-bottomed streams. The Inner Nashville Basin (71i) consists of smooth to rolling plains, with some small hills and knobs. Streams are low gradient with clear water on bedrock substrate (EPA, 1997).

The study area is situated on limestone of Nashville and Stones River groups of the Ordovician age. Formations of the Nashville Group exposed (or covered only by soil) include Cathey's, Bigby-Cannon, and Hermitage. Of the Stones River Group, only the Carter's and Lebanon formations are exposed in the study area. Solution cavities and sinkholes have developed along structurally-controlled joints and near-horizontal bedding planes (USACE, 1986). The limestone rock and soils are generally high in phosphorus.

According to US Department of Agriculture Soil Survey of Davidson County, Tennessee (1981), soils of the Mill and Sevenmile Creeks floodplains are in the Arrington-Lindell-Armour association. These soils are undulating to rolling, well to moderately-well drained. Most of these soils qualify as prime farmland soils but are fast becoming sites for residential development. Soils on the uplands adjacent to the floodplain are in the Talbott-Rock Outcrop association. These soils are not prime farmland soils, and are undulating to hilly, well-drained. Soils farther into the watershed away from creeks are primarily Stiversville-Hampshire-Urban land. These soils are classified as undulating to hilly and well drained. Outcrops of limestone and limestone sinkholes occur.

Table 45. Metro Parks within Mill Creek Watershed.

Park	Amenities	Condition
William Coleman	Community center; trails; indoor pool; playground	Poor
Seven Oaks	Playgrounds; picnicking; disc golf, athletic fields; tennis	Good
Paragon Mills	Basketball; athletic fields; playground	Fair
Ezell Road	Trails; soccer fields; boat launch	Poor
William Whitfield	Athletic fields; playgrounds	Fair
William A. Pitts	Basketball; picnicking; athletic fields; playground	Fair
Granberry	Tennis; playgrounds; trails	Good
Antioch	Community center; picnicking; trailhead, playground; canoe launch	Poor
C.R. Crawford	Historic schoolhouse	Poor
Wimpole	Community garden; canoe launch	Unknown
Providence Park	playgrounds	Unknown
Cane Ridge Park	Model airplane field; picnicking; tennis; soccer/athletic fields; trails; basketball; biking; playgrounds;	Good
Edmondson Library	playground	Not listed
Thompson Lane	undeveloped	Not listed
Sevenmile	undeveloped	Not listed
Source: Metro Parks Nashville: Nashville Parks Finder website 2013 and Parks and Greenways Master Plan 2008		

5.3 Water Resources

Watershed Description

Mill Creek, a tributary of the Cumberland River (Cheatham Reservoir) at Mile 194.4 drains 108 square miles south and east of Nashville (Figure 37). Sevenmile Creek is the largest tributary of Mill Creek entering at RM 7.9 miles. Mill Creek begins in the vicinity of Nolensville (Williamson County) and flows northward to its confluence with the Cumberland River. Mill Creek is approximately 27 miles long and falls about 280 feet from its source to its mouth. Average channel gradient is roughly 10 feet per mile in lower stream reaches and 35 feet per mile in upper stream reaches.

Mill Creek's main channel averages approximately 75 to 100 feet wide and the 100-year floodplain is approximately 700 to 800 feet wide. Streambanks, usually well-defined, are generally 10 to 15 feet above streambed. Upper portions of Mill Creek and its headwaters flow primarily from farmland. As the stream enters Davidson County, runoff becomes primarily suburban, changing to urban approximately halfway through the basin, with residential, commercial, industrial, and open area sources. Almost every summer, Mill Creek approaches no flow levels around RM 22 and aquatic life becomes restricted to pools. Although this is common for streams found in Tennessee, this lack of continual flow restricts habitat availability, ecosystem processes, and functions of Mill Creek.

Sevenmile Creek originates near the Davidson-Williamson County line and flows north and east before joining Mill Creek. Sevenmile is approximately 7.3 miles long with a drainage area of 17.6 square miles, an average slope of 18.9 feet per mile, and an average 100-year floodplain width of approximately 500 feet. Streambanks range from 3 to 9 feet high; existing channel averages 20 to 30 feet wide. Approximately half the stream is through a heavily urbanized area, while the upper half is less developed.

Other major tributaries in the Mill Creek watershed include Sims, Sorghum, Franklin, and Whittemore Branches in the lower reaches and Holt, Collins, Indian, Owl, and Turkey Creeks in the upper reaches.

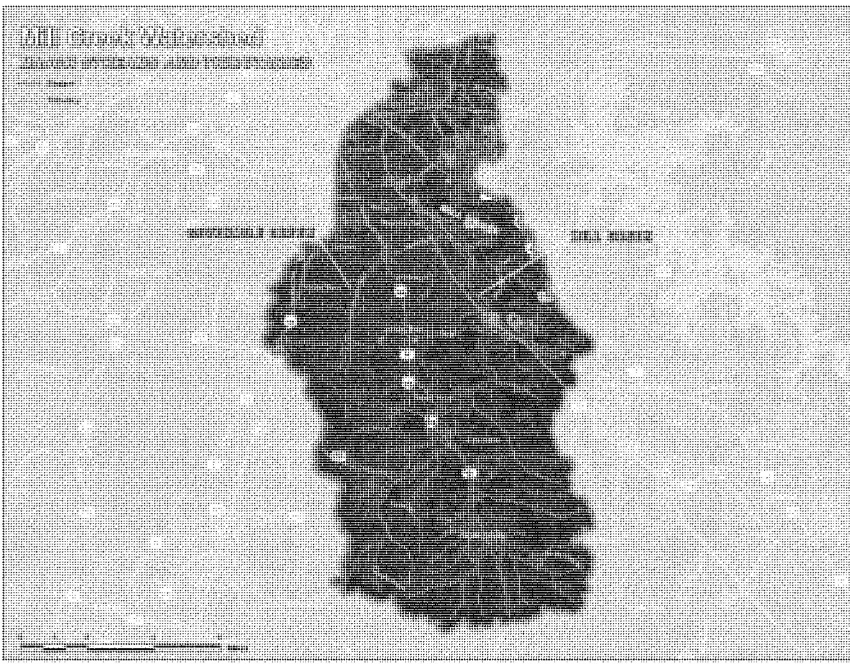

Figure 37. Major Streams and Tributaries within Mill Creek Watershed.

Mill Creek watershed lies within four political jurisdictions: Metropolitan Nashville, City of Nolensville, City of Brentwood, and Williamson County. Each of these entities has developed and incorporated its own stormwater regulations. Therefore, with varying regulations and policies, effective management within the watershed is constrained along political boundaries.

Many agencies and organizations have worked and continue to work in the Mill Creek Watershed to protect the existing resources and rehabilitate/restore those areas that have been impacted. Some of the organizations and agencies taking a strong interest in the watershed and its health include: the Cumberland River Compact, the Nature Conservancy, Tennessee Department of Environment and Conservation (TDEC), USFWS, TWRA, Tennessee Scenic River Association, Metro Nashville, Mill Creek Watershed Organization and the Nashville Zoo.

Groundwater and Public Water Sources

Groundwater recharge of Mill Creek and its tributaries is limited due to an increase of impervious surfaces and poor soil infiltration properties. Direct runoff accounts for a majority of the flow within Mill Creek and tributaries. This creates environmental concerns for water quality and aquatic resources. Runoff over impervious surfaces carries oil and other pollutants directly into streams. With limited groundwater recharge, almost every summer flow approaches no flow in upper sections of Mill Creek as well as its tributaries. With little or no flow aquatic life becomes restricted and concentrated in isolated pools. These pools then become stagnant with increasing water temperatures, high biological oxygen demand, and decreased dissolved oxygen that stress or kill the aquatic life. These microhabitats can also concentrate aquatic fauna, thereby making them easily accessible to predators. As shown in Table 46, July through September are very critical months when stream flow becomes especially limited.

Table 46. Mill Creek Mean Monthly Stream Flows.

	Locations		
Monthly Mean Stream Flow	**Near Nolensville** 40.53 sq mi drainage 1992-2004	**Antioch** 64.00 sq mi drainage 1953-2004	**Woodbine** 93.40 sq mi drainage 1996-2004
Jan	112	162	237
Feb	141	204	353
Mar	164	227	306
Apr	74.4	151	159
May	80.8	101	221
Jun	50.4	59.2	168
Jul	16.4	18.4	34.8
Aug	8.87	16.7	23.8
Sep	14.6	22.9	62.1
Oct	23.2	23.4	35.1
Nov	44.6	58.7	94.8
Dec	79.7	117	180
* Values are in cubic feet per second			
** Source: USGS Monthly Stream flow Statistics for Tennessee; available on webiste			

Water Quality

Several miles of Mill Creek and its tributaries are listed as impaired by TDEC. This information is summarized in Table 47. TDEC defines these streams as Category 5, meaning one or more uses are not being met and a Total Maximum Daily Load (TMDL) is needed for listed pollutants or Category 4a where EPA has approved a pathogen TMDL that addresses some known pollutants. Primary sources for these water quality problems are poor land development practices, lack of dissolved oxygen, sedimentation, collection system failures, MS4 area discharges, and general urban non-point source runoff. Mill Creek and tributaries have experienced fish and crayfish kills as a result of periodic spills from industries, transportation accidents, the Nashville International Airport, and the discharge of inadequately treated sewage.

In the headwaters of Mill Creek some areas still remain in agricultural use. Lands are primarily used for livestock grazing and most of these areas do not exclude livestock from the streams. Not only does this present *Escherichia coli* (*E. coli*) concerns, but the animals trample stream banks, thereby causing unstable banks, erosion and siltation within the streams.

Concerns of E. coli contamination also exist with failing or leaking sewer lines either directly at stream crossings or indirectly when leachate reaches receiving streams. Flooding exacerbates *E. coli* problems by causing sewer systems to overflow or by causing a bypass of the sewer system and direct flow to the streams. New sanitary sewer lines along Mill Creek have been installed to accommodate new development as well as alleviate collection system failures (USACE, 2004).

Table 47. TDEC 303(d) Listed Streams.

Stream	# Miles Impaired	Cause of Impairment	Pollutant Source
Mill Creek	21.5	Nutrients; low DO; siltation; *E. coli*	Collection system failure; Sewer discharges; livestock; minor municipal point source
Sevenmile Creek	4.4	Nutrients; habitat alteration; *E. coli*	MS4 area discharges; hydromodification
Sims Branch	2.9	Nutrients; low DO; habitat alteration; *E. coli*	MS4 area discharges; industrial permitted stormwater; hydromodification
Collins Creek	6.7	Siltation	Land development
Turkey Creek	1.6	Siltation	Land development
Indian Creek	5.7	phosphorus	Land development
UT to Owl Creek	1.6	Siltation; habitat alteration	Land development
Holt Creek	6.2	Siltation	Land development
Whittemore Branch	2.9	Habitat alteration	MS4 area discharges
Sorghum Branch	3.1	Siltation; habitat alteration	MS4 area discharges
Pavilion Branch	1.3	*E. coli*	MS4 area discharges
Source: TDEC 2010 Final 303(d) List			

The Mill Creek Watershed empties into the Cumberland River at Mile 194.4. From the confluence with Cumberland River upstream to approximate Mile 1.4, Mill Creek is an impounded stream and exhibits reservoir characteristics. It rises and falls with Cheatham Lake elevations, which can vary up to several feet. Sediment samples collected in this downstream reach have been found to contain contaminants at or close to threshold effects concentrations, specifically pesticides and polycyclic aromatic hydrocarbon. Sampling indicates the contamination is dropping. The levels seen in 2004 were well below values seen in 1999.

Although there has been a continued presence of contaminants in sediments within the impounded reach of Mill Creek, levels present are not likely to cause harm to health or aquatic environment (USACE, 2004).

The office of the Tennessee Department of Agriculture (TDA), which manages the Non-point Source Pollution Program (Section 319 of Clean Water Act), is located on the Ellington Agricultural Center adjacent to Sevenmile Creek (Approximate RM 3.4). As an initiative in Non-point source pollution, the TDA established various techniques as Best Management Practices (BMP) demonstration sites on campus and along Sevenmile Creek. BMP techniques included collection of building rainwater runoff in rain barrels, site runoff into rain gardens, bank stabilization, permeable concrete for parking areas, in-stream enhancement features along Sevenmile, and establishment of native warm season grasses.

Similarly the Cumberland River Compact, a non-profit organization concerned with the environmental stewardship of the Cumberland River watershed, began a residential housing construction demonstration site. At this subdivision along Franklin Branch, a tributary to Mill Creek, traditional construction methods were employed in one section to compare to innovative techniques aimed at reducing non-point source pollution. These techniques included limited/absent curb and guttering, narrow roadways to limit impervious surfaces, rain gardens, etc. These alternatives are aids to improve water quality and assist in removing tributaries from the state's 303(d) list.

Streams

Mill Creek drains 108 square miles south and east of Nashville. Mill Creek is approximately 27 miles long and falls about 280 feet from its source to its mouth. Average channel gradient is roughly 10 feet per mile in lower stream reaches and 35 feet per mile in upper stream reaches.

Streambanks, usually well-defined, are generally 10 to 15 feet above streambed. Upper portions of Mill Creek and its headwaters flow primarily from farmland. As the stream enters Davidson County, runoff becomes primarily suburban, changing to urban approximately halfway through the basin, with residential, commercial, industrial, and open area sources. Almost every summer, Mill Creek approaches no flow levels around RM 22 and aquatic life becomes restricted to pools. Although this is common for streams found in Tennessee, this lack of continual flow restricts habitat availability, ecosystem processes, and functions of Mill Creek.

Sevenmile Creek is the largest tributary of Mill Creek entering at RM 7.9 miles. Sevenmile is approximately 7.3 miles long with a drainage area of 17.6 square miles, an average slope of 18.9 feet per mile, and an average 100-year floodplain width of approximately 500 feet. Streambanks range from 3 to 9 feet high; existing channel averages 20 to 30 feet wide. Approximately half the stream is through a heavily urbanized area, while the upper half is less developed.

Wetlands

National Wetlands Inventory (NWI) maps indicate wetlands of varying sizes and classes are found within the Mill Creek watershed (Figure 38). As shown in the NWI map a vast majority of potential wetland areas are labeled as freshwater ponds. One wetland area, approximately 0.41 acres in size, is found within and adjacent to Plan B. This wetland is characterized by the Cowardin Classification System and Hydrogeomorphic

Wetland Classification System as a Palustrine, Forested, Broad-leaved Deciduous, Temporary Flooded – Depressional Wetland.

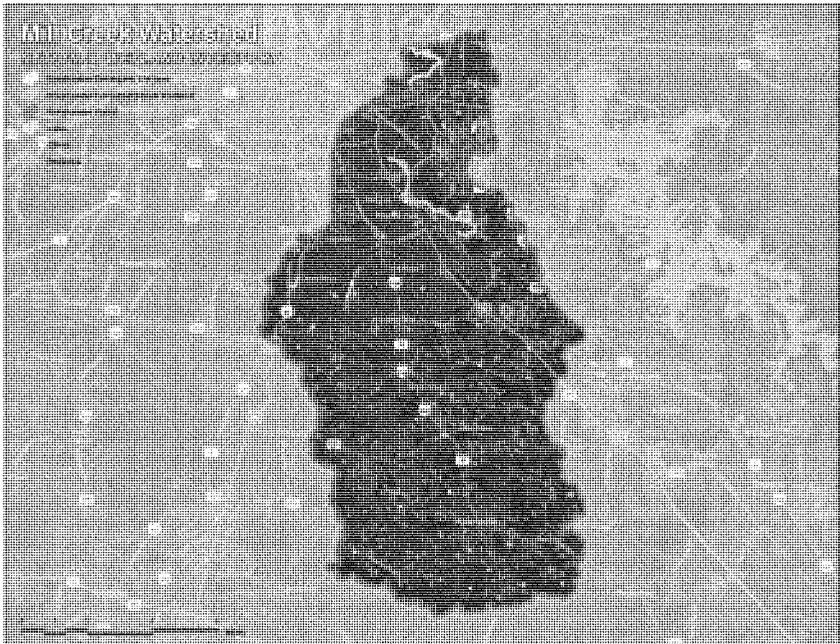

Figure 38. National Wetland Inventory Map for Mill Creek.

5.4 Biological Resources

Vegetation

The predominant forest type found within the Mill Creek Watershed is classified as the Oak hickory forest type. Species which typically make up this forest type include: White oak (*Quercus alba*), southern red oak (*Quercus falcata*), northern red oak (*Quercus rubra*), black oak (*Quercus velutina*), scarlet oak (*Quercus coccinea*), shagbark hickory (*Carya ovata*), pignut hickory (*Carya glabra*), yellow poplar (*Liriodendron tulipifera*), elms (*Ulmus spp.*), red maple (*Acer rubrum*), American beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), black walnut (*Juglans nigra*), white ash (*Fraxinus americana*), and black cherry (*Prunus serotina*). Other species typically found within riparian zones and forested wetland areas include: black willow (*Salix nigra*), sweetgum (*Liquidambar styraciflua*), red maple, blackgum (*Nyssa sylvatica*), green ash (*Fraxinus pennsylvanica*), box elder (*Acer negundo*), cottonwood (*Populus deltoides*), and American sycamore (*Platanus occidentalis*).

Riparian zones along Mill Creek and its tributaries vary greatly. In 1984, the riparian zone was primarily intact along Mill Creek. However, the riparian area, specifically the width of this feature, is being lost, as well as the numerous attributes it provides to the stream and watershed. In other areas of the watershed, particularly in areas zoned for agriculture, riparian zones are either narrow or non-existent. Various data collected by TDEC, TWRA, and the Corps reference limited or absent riparian zone along Mill Creek and/or tributaries. Width of the riparian zone is a limiting factor for the Mill Creek ecosystem.

Aquatic and Wildlife

Aquatic

Mill Creek provides habitat for a vast number of aquatic species. Common species include: stonerollers (*Campstoma*), gizzard shad (*Dorosoma cepediamun*), sculpin (Cottoidea), shiners (Cypriniformes), darters (*Anhingidae*) , and rough fish such as redhorse (*Moxostoma carinatum*), white sucker (*Catostomus commersonii*), northern hog sucker (*Hypentelium nigricans*), carp (*Cuprinidae*), mooneye (*Hiodontidae*), and carpsucker (*Catostomidae*). Sport fishes such as rock bass (*Ambloplites rupestris*), smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropeterus salmoides*), longear sunfish (*Lepomis megalotis*), green sunfish (*Lepomis cyanellus*), catfish (*Ictaluridae*), and freshwater drum (*Aplodinous grunniens*) are common in Mill Creek.

Sevenmile Creek is known to have darters, minnows, smallmouth bass, bluegill (*Lepomis macrochirus*), and bullhead catfish (*Ameiurus melas*). Based on a 1997 TWRA survey, rock bass and smallmouth bass were quite abundant. The report stated that fish were generally healthy with balanced populations representing various age classes.

Benthic species commonly found in the Mill Creek watershed include several species of mayflies, caddisflies, snails, isopods, crayfish, midges, damselflies, hellgrammites, Asian clam (*Corbicula fluminea*), and fingernail clams (*Sphaerium corneum*).

The Nashville Crayfish is probably the most recognized species within the list above. The Nashville Crayfish is endemic to Mill Creek and is classified by USFWS as endangered (See Section 5.4.3). USFWS describes crayfish habitat as creeks with moderate gradients containing benthics, fallen logs and debris; moderate flow and firm, usually rocky, stream bottoms. The crayfish tends to move to open waters when riffles become silt laden. Large slabrock is used primarily by adults for cover; gravel and cobble provide cover for juveniles. Although this may be the preferred habitat, the species has been found in a wide range of environments—cobble runs, pools with 10cm sediment, under slabrocks and other cover, and in areas with 60-90% canopy cover (summarized in USFWS, 2002).

Wildlife

Common wildlife species within the watershed include but are not limited to: red fox (*Vulpes vulpes*), grey fox (*Urocyon cinereoargenteus*), white-tailed deer (*Odocoileus virginianus*), weasels, beaver (*Cators canadensis*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), Virginia opossum (*Didelphis virginiana*), groundhog (*Marmota monax*), mice, bats, and a variety of songbirds, reptiles and amphibians.

A colony of black crowned night herons (*Nycticorax nycticorax*) seasonally inhabits an island within highly urbanized area at Mill Creek RM 5.0.

Threatened and Endangered Species

Table 48 lists the federally threatened and endangered species that potentially occur within Mill Creek watershed. This list includes four mussels, five plants, two bats, one insect, two mammals and one crayfish.

Table 48. USFWS Listings of Threatened and Endangered Species.

Scientific Name	Common Name	Fed. Status
Dalea foliosa	Leafy Prairie-clover	LE
Astragalus bibullatus	Pyne's Ground-plum	LE
Apios priceana	Price's Potato-bean	LT
Physaria globosa	Short's Bladderpod	C
Boechera perstellata	Braun's Rockcress	LE
Plethobasus cooperianus	Orangefoot Pimpleback	LE
Lampsilis abrupta	Pink Mucket	LE
Epioblasma florentina walkeri	Tan Riffleshell	LE
Epioblasma brevidens	Cumberlandian Combshell	LE
Pseudanophthalmus insularis	Baker Station Cave Beetle	C
Orconectes shoupi	Nashville Crayfish	LE
Myotis grisescens	Gray Bat	LE
Myotis sodalis	Indiana Bat	LE
* LE= Listed Endanged, LT=Listed Threatened, C=Canidate Species, DM=Deemed Management		

TDEC, Division of Natural Heritage (DNH) also provided a list of state species occurring inside or within one mile of the Mill Creek watershed. The species are shown in Table 49. DNH listed a heron rookery that occurs within the Mill Creek watershed; the state considers this a rare, but not state listed species/habitat. No heron rookery is found within and surrounding the proposed project locations. Therefore, no impacts to the heron rookery are anticipated.

Table 49. State Listed Species for Mill Creek Watershed.

Scientific Name	Common Name	State Status
Orconectes shoupi	Nashville Crayfish	E
Sphallaplana buchanari	Cave Obligate Planarian	R
Allium stellatum	Glade Onion	E
Anemone carolinana	Carolina anemone	E
Astragulus tennesseensis	Tennessee milk-vetch	S-CE
Echinacea tennesseensis	Tennessee Purple Coneflow er	E
Elymus svensonii	Svenson's w ild-rye	E
Hydrastis canadensis	Goldenseal	S-CE
Hydrocotyle americana	American Water-pennyw ort	E
Juglans cinerea	Butternut	T
Dalea foliosa	Leafy Prairie Clover	E
Leavenworthia exigua var. exigua	Gladecress	S-CE
Panax quinquefolius	American Ginseng	S-CE
Paysonia densipila	Duck River Bladderpod	T
Perideridia americana	Thicket Parsley	E
Talinum calcaricum	Limestone Fame-flow er	S-CE
Phlox bifida spp. stellaria	Glade Cleft Phlox	T
* E=Endangered, T=Threatened, S-CE=Species of Concern		

A brief description for each Federal Listed species can be found below.

- **Orangefoot Pimpleback (*Plethobasus cooperianus*)**
  Historically *P. cooperianus* was found in parts of the Ohio, Cumberland, Tennessee and Wabash Rivers in the states of Alabama, Indiana, Kentucky, Ohio, Pennsylvania, and Tennessee (ESIS, 1996c). The species was once commonly found in the shoals of medium to large rivers with sand and gravel substrate (ESIS, 1996c). *P. cooperianus* was federally listed in 1976 and a recovery plan was written in 1984 (ESIS, 1996c). Since the 1970s, it was found in the lower Ohio, middle reach of the Cumberland River, and flowing reaches of the Tennessee River (TVA, 2003). In recent years, a few individuals have been located in the tailwaters of Kentucky, Pickwick, Wilson, Guntersville, Watts Bar, and Fort Loudoun Dams with the most individuals encountered below Pickwick Dam (TVA, 2003). On the Cumberland River, populations were once commonly found from Clay to Stewart Counties, however, in 1980, only a relic population was identified in Smith County, Tennessee on the Cumberland River (Parmalee and Bogan, 1998; TABS, 2002f). Living individuals are now restricted to a few places on the Tennessee River and limited reproduction appears to be taking place in Hardin County, Tennessee (TABS, 2002f), where Mirarchi et. al.(2004) noted the presence of *P. cooperianus* in the tailwaters of Pickwick Dam. In Alabama, *P. cooperianus* has not been reported since 1979 but it may exist in very few numbers below Wilson or Guntersville Dams (Mirarchi et. al., 2004). In Kentucky, (KCWCS, 2005) *P. cooperianus* is sporadically found in the lower Ohio and Tennessee Rivers in western Kentucky. The National Park Service (2003) plans to reintroduce *P. cooperianus* into the upper Cumberland River system in the Big South Fork National River and Recreational Area in Kentucky and Tennessee.

- **Pink Mucket (*Lampsilis abrupta*)**
  L. abrupta is a wide ranging Interior Basin species historically inhabiting the Mississippi, Ohio, Cumberland, and Tennessee Rivers (Parmalee and Bogan, 1998) in the states of Louisiana Arkansas, Missouri, Illinois, Indiana Ohio, Pennsylvania, West Virginia, Virginia, Kentucky, Tennessee, and Alabama (USFWS, 1997b). *L. abrupta* have been found in medium to large rivers, and riverine sections of impoundments (TVA, 2003). They have been collected in habitats ranging from silt to boulders, but the more typical habitat consists of cobble, gravel and sand with individuals found in water depths ranging from 0.8 to 8 m (2.6 – 26.2 feet) deep (ESIS, 1996e). *L. abrupta* was federally listed in 1976 and a recovery plan was written in 1985 (ESIS, 1996e). According to TVA (2003), *L. abrupta* has been encountered within the last 30 years in nearly all the tailwaters of the mainstem Tennessee River dams and in parts of Bear Creek and the Clinch, French Broad, and Holston rivers, and although always uncommon or rare, old individuals have been found with a few more individuals found more often below Pickwick and Guntersville Dams. On the Cumberland River, populations tend to be localized with one of the larger populations occurring in the Carthage-Rome area in Smith County, Tennessee (Parmalee and Bogan, 1998). The most recently collected individuals in Tennessee are old adults or relicts of former populations and though the species is widely distributed, it is usually not abundant in the Cumberland and Tennessee Rivers (TABS, 2002h). *L. abrupta* only occurs in the riverine reaches below Wilson and Guntersville Dams in Alabama where individuals less than ten years of age are reportedly rare (Mirarchi et. al., 2004). In Kentucky, *L. abrupta* sporadically occur in the upper Green River (KCWCS, 2005). According to the USFWS (1997b), new *L. abrupta* populations have been discovered in the Ohio River after an absence of 75 years. *L. abrupta* is currently known in 16 rivers and tributaries from seven states (USDOE, 2003). The greatest concentrations are in the Tennessee (Tennessee, Alabama), Cumberland (Tennessee, Kentucky), Osage and Meramec Rivers (Missouri); with smaller numbers found in the Clinch (Tennessee); Green (Kentucky); Ohio (Illinois); Kanawha (West Virginia); Big Black, Little Black, and Gasconde (Missouri); and Current and Spring Rivers (Arkansas) (USDOE, 2003).

- **Tan Riffleshell (*Epioblasma florentina walkeri*)**
  E. f. walkeri was added to the federal endangered species list in 1977 (USFWS 1977). This subspecies (or form) is thought to be the eastern headwaters expression of *Epioblasma florentina* (*florentina*, if a subspecies); another subspecies (or form), *Epioblasma florentina curtisi*, occurred in headwater streams in southwestern Missouri and northwestern Arkansas (Parmalee and Bogan 1998). The historic distribution of this complex was limited to the Cumberland and Tennessee River systems in Alabama, Kentucky, Tennessee, and Virginia, and the White and St. Francis River systems in Missouri and Arkansas (USFWS 1984, USFWS 1986). Since the early 1970s, several individuals of the *E. f. walkeri* have been found in the Middle Fork Holston River (USFWS 1984), in the upper Clinch River (Rogers, et al 2001) and, apparently, in the Big South Fork of the Cumberland River (Ahlstedt 2002). Individual animals identified as this species also have been found in the Duck and Hiwassee rivers (Jenkinson 1988, Parmalee and Hughes 1994, respectively) and in a Hiwassee River

tributary (TVA Heritage database record). Critical habitat has not been identified for this species. This species is considered to occur in small rivers and larger creeks.

- **Cumberlandian Combshell (*Epioblasma brevidens*)**
  E. brevidens was historically restricted to, but widespread in the Tennessee and Cumberland Rivers and their major tributaries in the states of Virginia, Kentucky, Mississippi, Alabama, and Tennessee (USFWS, 2004b). According to Parmalee and Bogan (1998) this mussel had been collected in habitats containing sand and gravel, however, in the Cumberland River and its larger tributaries, the substrate consisted of rocky bottoms. This species prefers a water depth of less than 3 feet, however, individuals had been found in deep water areas in the upper riverine portion of Old Hickory Reservoir downstream the Cordell Hull and Center Hill Reservoirs (USFWS, 2004b). *E. brevidens* was federally listed as an Endangered species in 1997 and a recovery plan was written in 2004 (USFWS, 2004b). TVA (2003) notes that current remnant populations only exist in the Tennessee River tributaries of Bear Creek and the Clinch, Powell, and Duck Rivers, and the Cumberland River tributaries of Buck Creek and the Big South Fork. In Kentucky (KCWCS, 2005), *E. brevidens* occurs sporadically in the upper Cumberland River below Cumberland Falls. Mr. Tom Mann, Mississippi Natural Heritage Program, reported finding fresh dead shells in Mississippi in 2000 (KCWCS, 2005). According to Mirarchi et. al. (2004) the only known extant population in Alabama occurs in Bear Creek in Colbert County. Seven units of critical habitat have been identified within the Cumberland and Tennessee River drainages. These units are located on segments of Bear and Buck Creeks; Duck, Nolichucky, and Powell Rivers; the Clinch River and its major tributaries; and the Big South Fork and its tributaries (USFWS, 2004b). According to the USFWS Recovery Plan (2004b), this species is now considered extirpated from the main stems of the Cumberland and Tennessee Rivers. A nonessential experimental population (NEP) for 16 mussels including *E. brevidens* has been established below Wilson Dam in Colbert County, Alabama (USFWS, 2001ba). This area is located between Tennessee River miles (TRM 259.4 246.0) and includes the lower 5 mile reaches of tributaries entering the Wilson Dam tailwaters (USFWS, 2001b) that under Section 10(j) of the Endangered Species Act, cannot be designated as critical habitat for a NEP (USFWS, 2001b).

- **Price's Potato Bean (*Apios priceana*)**
  Apios priceana is a twining herbaceous vine in the Fabaceae family and is currently found in five states; Alabama, Illinois, Kentucky, Mississippi, and Tennessee. *A. priceana* is an open wood, forest edge species often associated with mesic areas such as, stream banks or rivers. *A. priceana* was originally found by Sadlin Price in 1896 in Bowling Green, Kentucky. *A priceana* is a Coastal Plain, Interior Low Plateaus, and Appalachian Plateaus species found in five states; Alabama, Illinois, Kentucky, Mississippi, and Tennessee (USWFS, 1993). *A. priceana* was listed as threatened in 1990 due to the small number of populations and threats to its habitat (USFWS 1990). It is a perennial herbaceous vine that grows in open areas along streams, on dry rocky wooded banks above roads, or near the base of small limestone bluffs often where ravine slopes break into creek or river bottoms (Kral 1983, USFWS 1993, Estes and Chester 2001). Since its description as a new species, 36 populations of Price's potato-bean have been discovered in 22 counties of five states (Alabama,

Illinois, Kentucky, Mississippi, and Tennessee) within the Coastal Plain, Interior Low Plateaus, and Appalachian physiographic provinces (USFWS 1993). Critical habitat has not been designated for this species. Eleven populations in three states have been extirpated: the only two known populations in Illinois, six populations in Kentucky, and three populations in Tennessee. According to the recovery plan for the species there are 25 extant populations known from 15 counties in four states (USFWS 1993). Three additional populations were discovered in southern Middle Tennessee during 2000 and 2001, including a new county record (Estes and Chester 2001, Estes in preparation, Estes and Walck in preparation). Overall, this species appears to be stable (USFWS 2003), at least in part because it occurs in geographically diverse upland habitats, many of which are not subject to habitat degradation.

- **Braun's Rockcress (*Arabis perstellata*)**

  A. perstellata was listed as Endangered in 1995 by the USFWS due to small number of populations (USFWS 1996). *A. perstellata* is a member of the mustard family (Brassicaceae). There are two varieties of *A. perstellata*, small and large rock cress. Both varieties occupy distinct geographic regions. Small *A. perstellata* is found in 27 different populations within Kentucky. Large *A. perstellata* is only found in two populations in Rutherford County, Tennessee (USFWS 1996). *A. perstellata* is typically found on wooded steep slopes with limestone outcrops (USFWS 1996). It can also be found along the base of mature hardwoods or in areas with little to no competition. *A. perstellata* is shade/light tolerant and typically not found in full sunlight areas (USFWS 1996).

- **Pyne's (Guthrie's) Ground-plum (*Astragalus bibullatus*)**
  A.bibullatus was listed endangered in September 1991 (USFWS 1991). There are only 8 known locations of which all are in Rutherford County, Tennessee (USFWS 2009). Based on information from the USFWS in 1991, there were two populations of *A.bibullatus* that were thought to be extirpated; one in Rutherford County and the other north of the Rutherford/Davidson County line (p. 48749). A. *bibullatus* has short stems that are 2 to 6 inches in length supporting 5 to 10 leaves that are 2 to 4 inches long (USFWS 1991). Flowers grow anywhere between 0.6 to 0.8 inches in length, are racemes, and are pale purple in color (Carman 2001). Flowers appear late April to May and seeds disperse around the first of June (USFWS 2009). This species is known to inhabit Cedar Glades within the Stones River Watershed (USFWS 2009).

- **Leafy prairie-clover (*Dalea foliosa*)**
  D. foliosa was listed as endangered in 1991 (USFWS 1991). The species is an inhabitant of cedar glades, limestone barrens, and dolomite prairies in Tennessee, Alabama, and Illinois (Kral 1983, USFWS 1996). These areas typically become quite dry during the growing season. The species' distributional center is the limestone cedar glades of middle Tennessee and northern Alabama. It is considered disjunct in northeastern Illinois where it was feared extinct until 1974 (USFWS 1996). The present range consists of 29 populations, with two populations in two counties in Alabama, three populations in one county in Illinois, and 24 populations in seven counties in Tennessee (USFWS 1996).

- **Short's Bladderpod (*Physaria globosa*)**
  P. globosa is currently proposed as an endangered species under the Endangered Species Act pending final ruling in the Federal Register (USFWS 2013b). TDECs Natural Heritage Program also lists *P. globosa* as Endangered on their 2008 Rare Plant List (p. 28). It occurs in Cheatham, Davidson, Dickson, Jackson, Montgomery, Smith, and Trousdale Counties in Tennessee and can also be found in one Indiana county and two counties in Kentucky (USFWS 2013c). *P. globosa*s grows around rocky cliffs, outcrops, and is commonly found adjacent to rivers or streams and on south to west facing slopes. Tennessee occurrences are located within the Highland Rim and Central Basin sections of the Interior Low Plateaus Province. The most stable and vigorous known populations are found in forested sites where the canopy has remained relatively open (USFWS 2013c).

- **Gray Bat (*Myotis grisescens*)**
  M. grisescens are considered a wide-ranging species, and are known from suitable caves over virtually the entire Cumberland and Tennessee navigation systems. The species was federally listed as Endangered in 1976. *M. grisescens* colonies are residents exclusively of limestone caves or cave-like habitats, and migrate seasonally between maternity and hibernating caves. *M. grisescens* was listed as a federal endangered species in 1976 (USFWS 1976). Although *M. grisescens* occur throughout much of the Midwest and southern United States, their populations are found mainly in Alabama, northern Arkansas, Kentucky, Missouri, and Tennessee (USFWS 1982). *M. grisescens* are known from suitable caves throughout the Tennessee River Valley.

- **Indiana Bat (*Myotis sodalis*)**
  M. sodalis was federally listed as Endangered in 1967, and, although important protections are in place, populations have continued to decline. Although the species ranges throughout most of the eastern portion of the United States, hibernating colonies are known only from Indiana, Missouri, and Kentucky where approximately 87 percent of the population hibernate in only 7 limestone caves. *M. sodalis* has rigid requirements for temperature and relative humidity in hibernating caves, hence the high concentration of individuals hibernating in a few caves. Small numbers of *M. sodalis* have been recorded within 1 mile of six Tennessee and Cumberland River navigation projects; Pickwick, Wheeler, Guntersville, Barkley, and Nickajack (Tennessee Valley Authority, 2005). *M. sodalis*, during winter months, hibernate using caves as discuss above. However, during summer months, *M. sodalis* use trees with specific features. Potential *M. sodalis* summer habitat is described as trees with a diameter at breast height equal to and/or greater than 5 inches to that exfoliating bark, cracks, crevices, and/or hollows.

- **Nashville Crayfish (*Orconectes shoupi*)**
  The Nashville Crayfish was federally listed as Endangered in 1986. Nashville Crayfish can only be found in Davidson and Williamson Counties within Mill Creek and five of its tributaries (Withers). Historic records have shown Nashville Crayfish once were found in Big Creek and the South Harpeth River, Tennessee in Williamson County. No current species' population estimates are available at this time (USFWS 1992). The decline and reason for listing as Endangered is due to water quality

deterioration from development within the associated creeks. By 1992 approximately 40% of Mill Creek and tributaries have been developed with the lower section being more residential while the upper section is comprised more of industrial. Nashville Crayfish is found in a wide range of environments but typically are found in first order or perennial streams that are predominantly gravel comprised of limestone bedrock with scattered flattened limestone slabs and have be located in both pools and riffles areas (Withers). Gravel and cobble substrate tends to provide adequate cover for juveniles while females tend to prefer larger slabrocks when carrying eggs and young (Biggins 1989).

- **Baker Station Cave Beetle (*Pseudanophthalmus insularis*)**
  P. insularis was federally listed as a Candidate species in 2006. *P. insularis* typically occur in twilight zone or deeper in or on moist soil, often near streams or drip areas. They are often found under rocks or debris. *P. insularis* is actually known from only one cave to be found in Davidson County and has not been collected in over 40 years and the known habitat has been polluted. There is far from sufficient evidence to document extirpation from that site, but current existence of this species is uncertain.

Based on habitat description for each species listed above, only the Indiana bat, Price's Potato-bean, and Nashville Crayfish could be found within the proposed project areas. See Table 50 for habitat comparison. Site assessments were conducted at each proposed project location to verify/record habitat types. No suitable habitat for either the Indiana bat or Price's Potato-bean was observed during the site assessments of each proposed project location. Therefore, the Nashville Crayfish is the only T&E Species that could be found within the proposed measure locations. USACE received the Final Biological Opinion from USFWS on 23 March 2015. It is the USFWS' biological opinion that the preferred alternative would not likely jeopardize the continued existence of the Nashville crayfish. The USFWS provided "Reasonable and Prudent Measures" as well as "Terms and Conditions" for the proposed action. These are summarized in Section 6 of this Main Report and Appendix D, Biological Assessment, for a more detail description regarding the Nashville Crayfish.

Table 50. Listed Species Habitat Determination.

Scientific Name	Common Name	Habitat Type	Found within Proposed Project Footprint
Federally Listed Species			
Dalea foliosa	Leafy Prairie-clover	Cedar Glades	Habitat Not Present
Astragalus bibullatus	Pyne's Ground-plum	Cedar Glades	Habitat Not Present
Apios priceana	Price's Potato-bean	Open Woods/Forest Edge	**Habitat Present**
Physaria globosa	Short's Bladderpod	Rock Cliffs/Outcrops	Habitat Not Present
Boechera perstellata	Braun's Rockcress	Wooded Steep Slopes/Limestone Outcrops	Habitat Not Present
Plethobasus cooperianus	Orangefoot Pimpleback	Medium/Large Rivers	Habitat Not Present
Lampsilis abrupta	Pink Mucket	Medium/Large Rivers	Habitat Not Present
Epioblasma florentina walkeri	Tan Riffleshell	Small Rivers/Large Creeks	Habitat Not Present
Epioblasma brevidens	Cumberlandian Combshell	Large Rivers	Habitat Not Present
Pseudanophthalmus insularis	Baker Station Cave Beetle	One Cave in Davidson County	Habitat Not Present
Orconectes shoupi	Nashville Crayfish	Mill Creek Creek and Tributaries	**Habitat Present**
Myotis grisescens	Gray Bat	Caves	Habitat Not Present
Myotis sodalis	Indiana Bat	Caves/Trees	**Habitat Present**
State Listed Species			
Sphallaplana buchanari	Cave Obligate Planarian	Caves	Habitat Not Present
Allium stellatum	Glade Onion	Glade	Habitat Not Present
Anemone carolinana	Carolina Anemone	open Rocky Woods	Habitat Not Present
Astragalus tennesseensis	Tennessee Milk-Vetch	Cedar Glades	Habitat Not Present
Echinacea tennesseensis	Tennessee Purple Coneflower	Cedar Glades	Habitat Not Present
Elymus svensonii	Svenson's wild-Rye	Forest - Hardwoods	Habitat Not Present
Hydrastis canadensis	Goldenseal	Forest - Hardwoods	Habitat Not Present
Hydrocotyle americana	American Water-Pennywort	Wetland	Habitat Not Present
Juglans cinerea	Butternut	Forest - Hardwoods	Habitat Not Present
Leavenwarthia exigua var. exigua	Gladecress	Glade	Habitat Not Present
Panax quinquefolius	American Ginseng	Forest - Hardwoods	Habitat Not Present
Lesquerella densipila	Duck River Bladderpod	Limestone Glades	Habitat Not Present
Perideridia americana	Thicket Parsley	Open Limestone Woods/Bluffs & Cedar Glades	Habitat Not Present
Talinum calcaricum	Limestone Fame-Flower	Limestone Glades	Habitat Not Present
Phlox bifida spp. stellaria	Glade Cleft Phlox	Cedar Glades	Habitat Not Present

5.5 Hazardous, Toxic, and Radioactive Wastes (HTRW)

The purpose of this Hazardous, Toxic, and Radioactive Waste (HTRW) assessment portion of the feasibility study is to identify HTRW concerns in and around the Mill Creek feasibility study measures that may impact the alternatives. According to US Army Corps of Engineers USACE engineering regulation ER 1165-2-132 (June 1992) the feasibility report will document the HTRW impact or potential. The report will either conclude that there is no known HTRW, or that HTRW has been identified. If HTRW is identified, the report will also describe what actions are being taken toward avoidance. It should be noted that during the preconstruction, engineering and design phase, and within six months of any land acquisition and easement agreements of any property, the Nashville District (CELRN) shall perform a Phase Ia Environmental Site Assessment for each land parcel acquisition and easement according to All Appropriate Inquiries (AAI) 40 Code of Federal Regulation (CFR) 312.20.

The Environmental Section of the Engineering and Construction Branch (EC-E) conducted a visual inspection where practicable and conducted an environmental records review for each measure or proposed project site to identify HTRW concerns. CELRN contracted Environmental Data Resources (EDR), Inc to provide environmental records searches for each measure or proposed project site for Mill Creek and tributaries. The environmental records searches fulfill the records search requirements of AAI 40 CFR 312, American Standard Testing Methods (ASTM)-E1527 and ASTM-E1528. All of the selected alternatives were assessed by EC-E for HTRW issues. The alternatives are:

- Briley Bridge Modification
- Ellington Agriculture Center Detention Structure
- Old Hickory Detention Structure
- Non-Structural Plan (Buyout Removal 216 Residential Structures in 5 neighborhoods)
    - Sevenmile Edmondson Pike area – residential non-structural area near Sevenmile Creek Miles 1.9 – 3.1.
    - Sevenmile Elysian Fields area – residential non-structural area near Sevenmile Creek Miles 0.5 – 1.25.
    - Sorghum Branch Willard Drive area – residential non-structural area near Sorghum Branch Creek Miles 1.7 – 2.7.
    - Whittemore Branch Benzing Road area – residential non-structural area near Whittemore Branch Creek Miles 0.5 – 1.8.
    - Wimpole Drive – residential non-structural area near Mill Creek Miles 5.1 - 6.1.

An HTRW summary report of each alternative site visit and EDR, Inc records search are located in Appendix C, Attachment D of this report. The EDR, Inc raw data records search results are voluminous, and are not included in Appendix C, Attachment D. The EDR, Inc raw data records are available electronically at CELRN-EC-E.

HTRW Summary for Structural Projects Sites

There are three structural measures that advanced into the final array of alternatives. The following subsections summarize HTRW findings for the three potential channel or structural improvement areas.

Briley Bridge Modification (Plan DA)

This project is located along Mill Creek Miles 6.9 to 7.0. This area was undeveloped until the 1970s when there was an increase in densely populated residential areas in the vicinity, as well as the development of Space Park, I-24 and Briley Parkway. There are multiple facilities listed in federal, state and other environmental databases. The listed facilities are currently in compliance. Some facilities had environmental violations, but corrected the violations and are currently in compliance. There are no known current environmental conditions that would impact the proposed work at the Briley Bridge.

Ellington Agricultural Center Detention Structure (Plan BA)

Ellington Agricultural Center is in Sevenmile Creek Watershed and is located at Sevenmile Creek Mile 3.7. The area surrounding the channel and culvert is Ellington Agricultural Center on the left bank and a greenway on the right bank. The environmental record search and site visit did not indicate an environmental liability or condition within the Ellington Agricultural Center subject area that would interfere with the proposed projects along Sevenmile Creek near Ellington Agricultural Center.

Old Hickory Detention Structure (Plan CA)

The proposed Old Hickory Detention Structure is near Mill Creek Mile 18. The area is currently an open farm field with residential neighborhoods surrounding the field. There is an underground natural gas pipeline and natural gas pump station running northeast to southwest and located on the west side of the field, and there is an underground sewer line running northeast to southwest and located in the center of the field. The environmental record search and site visit did not indicate an environmental liability or condition within the proposed Old Hickory Detention Structure area adjacent to Mill Creek Mile 18 that would interfere with the proposed project site.

HTRW Summary for Non-Structural Projects Sites

There are five stretches of Mill Creek and tributaries which are potential non-structural flood reduction projects where it is possible that structures in the floodway and up to the 5-year flood event (1/5ACE) may be buyouts. This plan is described in further detail in Chapter 4, and is defined as non-structural plan 5 or NS-5. NS-5 is part of the Tentatively Selected Plan. In that plan, 216 residential structures are recommended for buyout and removal from the floodplain. If the residences were built prior to 1978, a lead paint and asbestos survey shall be conducted prior to demolition. If lead paint or asbestos is discovered, it must be abated prior to demolition. Any regulated materials recovered as part of the abatement process will be disposed of in a certified landfill. To meet the CERCLA all appropriate inquiry standards, an updated Phase 1 ESA consistent with ASTM E1527 procedures must be completed within 6 months of construction contract award. The costs to perform the sampling and analyses and update to the Phase 1ESA have been included in the final cost allocation tables. All costs associated with abatement and disposal of asbestos and lead containing material are 100% non-federal responsibility and are not included as project costs. The following subsections summarize HTRW findings for the five non-structural flood reduction areas.

Sevenmile, Edmondson Pike

Sevenmile Edmondson Pike area is a well established residential area near Sevenmile Creek Miles 1.9 – 3.1. The environmental record search revealed potential Historical Auto Stations, Historical Cleaners, Resources Conservation and Recovery Act (RCRA) Non Generator (NonGen/NLR), and drycleaners. These facilities are either not currently in use, are residential homes at this time, or are downstream of the subject area. Therefore, they are not considered to be an environmental concern towards the subject area because they are not in use or unlikely to impact the subject area. All federal and state listed sited are downstream of the subject area, and therefore not believed to be an environmental concern towards the subject area because they are unlikely to impact the site. The environmental records review and site visit did not indicate a recognizable environmental liability or condition within the Sevenmile Creek – Edmondson Pike area.

Sevenmile, Elysian Fields

This is a well established residential area near Sevenmile Creek Miles 0.5 - 1.25. All Federal and State records were found to be downstream, have no record of violations, and/or have a tank closure status. All historic auto stations and historic drycleaners were determined to have never been an auto station or drycleaner, to be closed, and/or to not be adjacent to the subject area. All RCRA NonGen/NLR sites were found to not have any violations and the Priority Cleaners was found to be in remediation and not adjacent to the subject area. The environmental records review and site visit did not indicate a recognizable environmental liability or condition within the Sevenmile Creek – Elysian Fields subject area that would interfere with the proposed work along Sevenmile Creek Miles 0.5 to 1.25. The HTRW analysis does not extend further upstream than Creek Mile 1.25.

Sorghum Branch – Willard Drive / Margo Lane

This is a well established residential area around Sorghum Branch Creek Miles 1.7 - 2.7. The environmental record search indicated environmental sites which are not adjacent to the subject area, do not exist, are residential structures, not in the same tributary system as Sorghum Branch, or downstream of Sorghum Branch Creek Mile 1.7. The environmental records review and site visit did not indicate a recognizable environmental liability or condition within the Sorghum Branch Creek Miles 1.7 - 2.7.

Whittemore Branch

This is a residential and small rural area near Whittemore Branch Creek Mile 0.5 - 1.8. During the site visit on 27 August 2013, an illegal trash dump site was seen near 229 Benzing Road. The dumped material appears to be household trash and old furniture which are not an HTRW concern. The environmental record search indicated environmental sites which are not adjacent to the subject area, are incompliance, or downstream of Whittemore Branch Creek Mile 0.5. The environmental records review and site visit did not indicate a recognizable environmental liability or condition within the Whittemore Branch Creek Miles 0.5 – 1.8.

Wimpole Drive/ Currey Road

Wimpole Drive is a residential street adjacent to Mill Creek Miles 5.2 - 6.2. Wimpole Drive is a well maintained residential area with an Urban Garden on the western portion of the street adjacent to Mill Creek. An illegal trash pile was seen during the site visit on 26 August 2013 including a rubber mat, a TV and trash bags. The trash does not appear to be an HTRW concern. There are no recognizable environmental conditions seen in the EDR records search or site visit that would interfere with any non-structural projects on Wimpole Drive.

5.6 Air Quality

Air quality in and around the Nashville metropolitan area occasionally exceeds levels established by the EPA. Results for 2005 show the maximum Air Quality Index in Nashville was in the "unhealthy for sensitive groups" range for 10 days, or 3% of total days, in the moderate range for 164 days (45%), and in the good range 191 days (52%). Table 51 presents the last 5 years of ozone monitoring. Davidson County has had the fewest incidences of exceedance when compared with Rutherford, Sumner, Williamson, and Wilson Counties. Numbers of exceedance were significantly lower in 2003 and 2004 when compared to 2002. Other monitored gases, such as carbon dioxide, carbon monoxide, nitrogen dioxide and sulfur dioxide remained in attainment for 2002. According to EPA (2006), there are facilities permitted for air emissions within Mill Creek watershed. Most occur in the vicinity of the Massman Drive or Space Park industrial areas; two facilities are located further into the headwaters.

Vehicle emissions are a primary polluter to air quality. Stricter state regulations help reduce and control air pollution from mobile sources. Currently Davidson, Williamson, Rutherford, Wilson, and Sumner counties require vehicle emissions testing. No alternative would have any significant effect on air quality; there would be no anticipated changes to current attainment status with implementation of Plan A, B, and/or D. BMPs would be utilized during construction to minimize potential temporary, negative impacts to air quality.

Table 51. Ambient Ozone data from State of Tennessee's Ozone monitoring network for Years 2000-2004.

YEAR	2004	2003	2002	2001	2000
County	*# Days with 8 Hour Exceedances*				
Davidson (Trinity Lane)	0	0	0	0	0
Davidson (Percy Priest)	0	1	0	2	3
Williamson (Fairview)	0	1	12	0	8
Rutherford (Eagleville)	1	1	8	0	6
Sumner (Cottontown)	0	0	6	4	5
Sumner (Hendersonville)	0	5	5	6	10
Wilson (Cedars of Lebanon)	0	1	7	0	6

5.7 Noise

Noise levels within the Mill Creek Watershed are indicative of an urban setting. The majority of the noise is due to vehicular traffic and industrial manufacturing. Construction activities typically elevate noise levels to a level commonly produced by heavy equipment such as backhoes, bulldozers and gravel and cement trucks.

5.8 Cultural Resources

Human occupation of the region began approximately 12,000 years ago and has been more or less continuous to the present day. Mobile hunter gatherers occupied the area for the first few thousand years, which are referred to as the Paleoindian and Archaic periods (12,000 – 2700years ago). As people began to rely more on horticulture and agriculture, permanent hamlets and villages were also established during the Woodland period (2700 1100years ago). By Mississippian times (1100 – 350years ago) stratified chiefly societies were present throughout the Cumberland River and its tributaries. The first Euroamericans arrived Davidson County in 1710. Permanent Euroamerican settlements were established in the area in 1779. By the 19th Century, plantations and small settlements were established in the areas surrounding Nashville, including the Mill Creek drainage. By the late 18th century neighborhoods, such as Flat Rock, emerged closer to downtown Nashville. Industrial development in the Mill Creek Watershed expanded in the 20th century, and suburban neighborhoods of tract homes, typically brick ranches, sprung around the industrial corridors.

Archaeological sites provide information on both prehistoric and historic occupation of the area. Site types within the watershed include Pleistocene faunal sites, prehistoric period open habitation, mound, and cemetery sites, and historic period military, religious, medical, rural domestic (house and/or other remains), and cemetery sites. Currently, there are 76 previously recorded archaeological sites within the Mill Creek Watershed, fifty are located in Davidson County, and the remainder are located in Williamson County. Over 600 historic structures are recorded in Davidson and Williamson County in the Tennessee Historical Commission site files. Many of these structures are early-mid 20th century single family residences. Numerous 19th century structures also survive. Historic properties, sites, buildings, structures, objects, and districts that are 50 years old and have significance and retain integrity are listed in or eligible for eligible for listing on the National Register of Historic Places (NRHP). To date fourteen structures in the Mill Creek study area are currently listed on the NRHP. Others within the historic structure inventory may also be National Register eligible; however, it is more likely that most lack either significance or integrity.

Several examples of historic settlement and lifeways survive in the Mill Creek watershed and are open for public visitation. The Croft house, built in 1810 and listed on the NRHP, remained in the same family for five generations. The Croft sisters donated the property to Metro, where the central house and outbuildings are preserved, but the majority of the property houses a zoo. The Tennessee Agricultural Museum on the campus of the Ellington Agricultural Center, near Sevenmile Creek, features log cabins, a heritage garden, and artifacts from pioneering days and agrarian life. The Nolensville Feed Mill is also a notable private historic structure that houses one of the oldest businesses in Williamson County.

5.9 Socioeconomic

5.9.1 Population

Nashville has the largest metropolitan area in the state of Tennessee, spanning thirteen counties. The Nashville Metropolitan Statistical Area (MSA) encompasses Middle Tennessee counties of Cannon, Cheatham, Davidson, Dickson, Hickman, Macon, Robertson, Rutherford, Smith, Sumner, Trousdale, Williamson, and Wilson Counties.

According to the 2012 Census, MSA population was 1,311,789, the largest in the state. Population of Davidson County was 648,295 and the county experienced a 3.4% increase between April 2010 and Jul 2012 (compared to statewide increase of 1.7%). The urban population count was 534,955 or 95% of the county population. The county growth rate for 1990 to 2000 was 11.65%; urban growth rate was 7.5%.

Population within the watershed is concentrated between Sevenmile and Mill Creeks, west of Sevenmile to Interstate (I) 440, southwest of I-24, and a small area between I-24 and I-40. These areas primarily have between 1944 and 4247 residents per square mile with some areas having concentrations reaching 7,343 residents per square mile. The remaining area within the watershed, and specifically the upstream area of Mill Creek, averages less than 1,944 residents per square mile. County wide, population per square mile in 2000 was 1,134.7 residents.

According to Metro statistics, ethnicity is diverse within the Mill Creek watershed and minority ethnicities vary among distribution. Hispanic residents are scattered throughout the watershed; Asian and Pacific Islander residents appear more concentrated in specific areas (Mill Creek/Sevenmile confluence and between Mill Creek and I-24 below Sevenmile Creek); African American residents are fairly scattered through the watershed with one concentrated area between Mill Creek, I-40, and Murfreesboro Road.

5.9.2 Economics

Median household income in 2011 for Davidson County was $46,737 compared to $43,989 for the state. Poverty rate was 17.7% where the state average was 16.9%. Through most of Mill Creek watershed, median household income averages $39,525 to $57,716. At the Mill Creek and Cumberland River confluence and along the Williamson County border, income averages between $57,717 and $90,093. A small portion of the watershed averages less than $39,525 but more than $20,000. Table 52 represents the employment percentages by major industry in Davidson County.

Davidson County unemployment rate in 2012 was 7.1% compared to state average of 8.7%. Davidson County employed 416,378 in top industries in 2012, ranking 2nd in the state (TACIR 2013).

Table 52. Employment Percentages by Major Industry in Davidson County, 2010.

Industry	% Employment
Health Care and Social Assistance	15.4
Construction	3.8
Manufacturing	4.7
Retail Trade	9.8
Administrative, Support, Waste Mngmt & Remediation	6.7
Financial and Insurance	4.5
Professional, Scientific and Technical Services	5.3
Education	3.7
Accommodation and Food Services	9.2
Other Services	2.6
Wholesale Trade	5
Transportation and Warehousing	4.1
Government	
State	9.8
Local	5.7
source: TACIR 2013	

6 Effects on Significant Resources*

Table 53, Summary of the Potential Effects, provides an outline of the potential effects of Plans A, B, D, and No Action. Plan A, B, and D were evaluated as standalone action alternatives. However, as further discussed in Section 4.1, these actions could be combined to maximize potential benefits for flood damage reduction. Following this table is a narrative description of the anticipated impacts to the physical, biological, cultural and socioeconomic environments of the area. This section considers Plan A, B, and D as plans that may be built separately or independent of one another and therefore are evaluated this way from an environmental assessment as schedule or funding levels could impact the order of construction.

6.1 Physical Environment

6.1.1 Land Use

Plan A – Nonstructural (Buyouts/Raising)

Plan A includes a total of 89 residential structures. Under Plan A, 81 residential structures are proposed to be buyouts with the remaining 9 to be raised. See Section 4.1 for more detail on Plan A. The removal/raising of these structures would have temporary impacts during construction but would have positive gains to the existing riparian areas. Riparian areas, when applicable, would be restablished with a mixture of native trees, shrubs, and herbaceous vegetation.

Minor impacts are anticipated to land use practices surrounding the footprint of Plan B. Impacts would involve the placement of fill material to raise the existing roadway and the removal of the existing bridge and pier(s). Land use of the proposed Plan B would remain the same. Materials would be disposed of in an approved commercial landfill. Riparian areas would be replanted with native vegetation to reduce the potential for invasive species generation within any disturbed area.

Plan D – Briley Bridge Modification

Minor impacts are anticipated to land use practices. Impacts would involve the removal of fill material from underneath Briley Parkway Bridge as it crosses Mill Creek at mile 7.059. Land use of the proposed Plan D would remain the same. Material would be disposed of in an approved commercial landfill. Riparian areas would be replanted with native vegetation to reduce the potential for invasive species generation within any disturbed area.

No Action Alternative

Existing conditions would continue to affect the land use within the study area. Sedimentation, water quality, loss of aquatic/terrestrial habitat, riparian zones, recreation, and aesthetics would continue to be affected due to continued flooding with the study area.

Table 53. Summary of the Potential Effect of Plans A, B, D, and No Action.

Resource	Plan A	Plan B	Plan D	No Action Plan
Land Use	Temporary Impact	Minimal Impact	Minimal Impact	No Impact
Climate and Climate Change	No Impact	No Impact	No impact	No Impact
Topography, Physiology, & Soils	No Impact	Minimal Impact	Minimal Impact	No Impact
Water Resources	Positive impact due to water retention in basins and stream, improved water quality from greater nutrient cycling;	Positive impact due to water retention in basins and stream, improved water quality from greater nutrient cycling; temporary increase in turbidity due to basins and channel construction	Positive impact due to water retention in basins and stream, improved water quality from greater nutrient cycling; temporary increase in turbidity due to basins and channel construction	No Impact
Watershed	No Impact	No Impact	No Impact	No Impact
Groundwater and Public Water Sources	No Impact	No Impact	No Impact	No Impact
Water Quality	No Impact	Minimal temporary impact due to construction activity; BMPs implaced	Minimal temporary impact due to construction activity; BMPs implaced	No Impact
Streams	No Impact	Minimal temporary impact due to construction activity; BMPs implaced	Temporary impact due to construction activity; BMPs implaced	No Impact
Wetlands	No Impact	Minor impacts to approximately 0.10 acres (0.05 temporary/0.05 permanent). No mitigation required	No Impact	No Impact
Biological Resources (to include aquatic and terrestrial)	Positive impact from increase riparian zones and flood capacity	Positive impact from increase riparian zones and flood capacity	Positive impact from flow retention and velocity	Negative impact as biological resources continue to be degraded due to channel restrictions and residential housing located within the floodplain, resulting in additional flooding and damages to residential housing
Resource	Plan A	Plan B	Plan D	No Action Plan

Threatened and Endangered Species	No Impact	Likely to Adversely Affect; Formal consultation with Service completed	Likely to Adversely Affect; Formal consultation with Service completed	No Impact
HTRW	Potential impacts from asbestos and lead paint during demolition. Proper surveying and abatement pre-construction and demolition should eliminate impacts.	No Impact	No Impact	No Impact
Air Quality	Project will result in routine construction with temporary impacts to air, noise quality through vehicle emissions and dust.	Project will result in routine construction with temporary impacts to air, noise quality through vehicle emissions and dust.	Project will result in routine construction with temporary impacts to air, noise quality through vehicle emissions and dust.	No Impact
Noise	Minimal impact, temporary increased levels typically associated with construction equipment	Minimal impact, temporary increased levels typically associated with construction equipment	Minimal impact, temporary increased levels typically associated with construction equipment	No Impact
Cultural Resources	No cultural resources impact	No adverse cultural resources impact	No cultural resources impact	No Impact
Socioeconomic	Minimal temporary impact due to construction activity	Minimal temporary impact due to construction activity	Minimal temporary impact due to construction activity	No Impact

6.1.2 Climate and Climate Change

None of the actions would have any significant effect on the local and/or global climate.

Plan A – Nonstructural (Buyouts/Raising)

Plan A would lessen the impacts of flood damage resulting from future flood events which could be part of climate changes patterns as the number of flood prone structures would be decreased.

Plan B – Ellington Agricultural Center Detention Structure

Plan B would allow for normal flows to continue. However during high flow events, Plan B would allow for additional/temporary water storage, reducing impacts downstream of Ellington Agricultural Center bridge.

Plan D – Briley Bridge Modification

There would be beneficial gain with the additional floodplain and flow area beneath Briley Parkway for flood waters to spread out and thereby reduce flow velocity and the erosive force of floodwaters.

No Action Alternative

Existing conditions would continue to affect the land use within the study area. Sedimentation, water quality, loss of aquatic/terrestrial habitat, riparian zones, recreation, and aesthetics would continue to be affected due to continued flooding with the study area.

6.1.3 Topography, Physiography, and Soils

Plan A – Nonstructural (Buyouts/Raising)

With implementation of Plan A the areas would be restored to natural ground elevations and local zoning ordinances would dictate what could be incorporated into the landscape. Plan A would have no significant effect on the topography of the area.

Plan B – Ellington Agricultural Center Detention Structure

The proposed road and bridge modifications would involve the raising of the existing road by placement of fill material. The existing road has previously been raised to approximately 5ft above ground level. Plan B proposes to add an additional 7+ft to aid in water retention. Plan B would have minor effects on the topography of the area. Best management practices (BMPs) would be utilized during construction to minimize potential negative impacts to the aquatic environment.

Plan D – Briley Bridge Modification

Proposed bridge modifications (Plan D) would involve removal of fill material from underneath Briley Parkway Bridge, see Figure 39. Plan D2 would have no significant effect on the topography of the area.

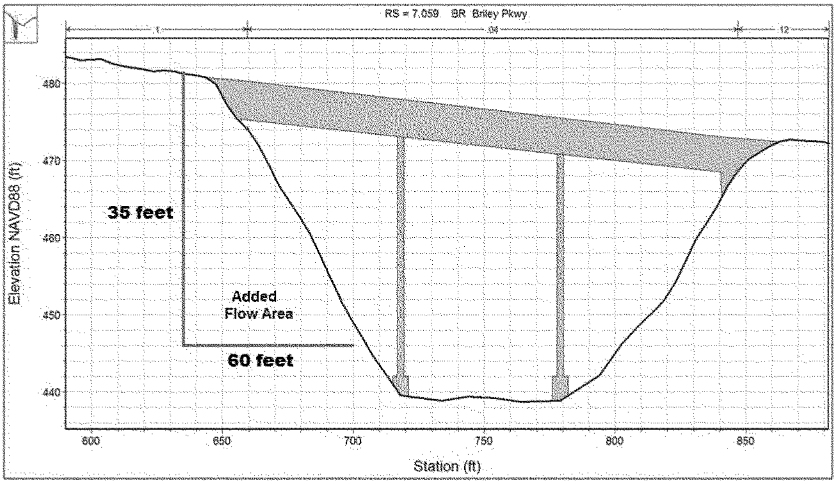

Figure 39. Briley Bridge Modifications. Typical Cross Section Looking Downstream.

6.2 Water Resources

6.2.1 Watershed

Plan A – Nonstructural (Buyouts/Raising)

Temporary impacts are anticipated. However, long term benefits would be seen by allowing additional waters to be stored on the floodplain during major events reducing impacts to commercial and residential structure. There would also be an increase in pervious surfaces that could allow greater infiltration and groundwater recharge.

Plan B – Ellington Agricultural Center Detention Structure

Temporary impacts are anticipated with construction, but the proposed action would also create long term benefits by reducing flows downstream during major events allowing waters to pass under the bridge in a timelier manner, thereby reducing flooding events.

Plan D – Briley Bridge Modification

Temporary impacts are anticipated with construction, but the proposed action would also create long term benefits by reducing backwater and upstream flooding by allowing additional waters to pass under the bridge and remain within the streambanks during major events, thereby reducing flooding events.

No Action Alternative

Existing conditions would continue to affect the watershed. Sedimentation, water quality, aquatic/terrestrial habitats, recreation, and aesthetics would continue to be affected due to continued flooding within the watershed.

6.2.2 Groundwater and Public Water Sources

No plan would have any significant effect on groundwater or any public water sources. Removal of structures would provide additional area for infiltration as long as the sites were maintained in pervious surfaces. No Action would continue with current conditions of direct runoff during flood events and limited infiltration due to impervious surfaces and soil characteristics.

6.2.3 Water Quality

No plan would have any significant effect on water quality. BMPs for erosion and sediment control would be utilized during construction to minimize potential negative impacts to the aquatic environment. Plans A, B, and D provide benefits such as water retention on the floodplain and in Mill Creek and tributary streams and improved water quality from greater nutrient cycling. The No Action Alternative would allow existing conditions to continue with negative impacts occurring during storm events and heavy runoff. Ongoing measures by other agencies, organizations and local governments would likely continue to provide improvements to the watershed's water quality.

6.2.4 Streams

Plan A – Nonstructural (Buyouts/Raising)
Plan A would have no effect on Mill Creek and/Sevenmile Creek. BMPs would be utilized during construction to minimize potential negative impacts to the environment.

Plan B – Ellington Agricultural Center Detention Structure
Temporary impacts are anticipated with construction, but the proposed action would also create long term benefits by reducing flows downstream during major events allowing waters to pass under the bridge in a timelier manner, thereby reducing flooding events. Sevenmile Creek channel is very stable with limestone rock bottom and established vegetated banks. There are no significant sediment aggradation or degradation problems along Sevenmile Creek. Channel incision is also unlikely since the stream bottom is composed of limestone bedrock. It is anticipated that larger materials (gravel and cobbles) may settle during flood events due to decreased velocities upstream from the structure which could create new habitat for the Nashville Crayfish. BMPs would be utilized during construction to minimize potential negative impacts to the environment. Stream impacts would only be associated with Plan B, Ellington Detention Structure. Stream impacts associated with Plan B would require an Individual ARAP from TDEC prior to construction. Following construction the natural hydrogeomorphic channel characteristics would be restored.

Plan D – Briley Bridge Modification
Temporary impacts are anticipated with construction, but the proposed action would also create long term benefits by reducing backwater and upstream flooding and allowing additional waters to pass under the bridge and remain within the streambanks during major events, thereby reducing flooding events. BMPs would be utilized during construction to minimize potential negative impacts to the environment. Following construction the natural Hydrogeomorphic channel characteristics would be restored.

No Action Alternative

Existing conditions would continue to affect the watershed. Sedimentation, water quality, aquatic/terrestrial habitats, recreation, and aesthetics would continue to be affected due to continued flooding within the watershed.

6.2.5 Wetlands

Plan A – Nonstructural (Buyouts/Raising)

No wetland areas present; therefore no impacts anticipated.

Plan B – Ellington Agricultural Center Detention Structure

One wetland area, approximately 0.41 acres in size, is found within and adjacent to Plan B. According to the existing plans approximately 0.10 acres of the above wetland would be unavoidable. Of the 0.10 acres impacted, approximately 0.05 acres would be considered temporary impacts with the remaining 0.05 acres resulting in permanent impacts. These adverse impacts were minimized and require no compensatory mitigation per TDEC General Permit and DA Regulatory requirements. TDEC's general permit authorizes minor alterations of up to 0.10 acres of wetlands that are degraded, of low functional capacity, or in situations where the proposed area lost would result in no significant change in the function and water resource value of the larger wetland system. Cumulative wetland losses for any whole project shall not exceed a 0.25 acre limit (See attached document). Also, the proposed project would meet the requirements of the Corps of Engineers Nationwide Permit 18 – Minor Discharge.

Plan D – Briley Bridge Modification

No wetland areas present; therefore no impacts anticipated.

No Action Alternative

Existing conditions would continue to affect the watershed. Sedimentation, water quality, aquatic/terrestrial habitats, recreation, and aesthetics would continue to be affected due to continued flooding within the watershed.

6.3 Biological Resources

6.3.1 Vegetation

Plan A – Nonstructural (Buyouts/Raising)

Temporary impacts are anticipated with residential and isolated structure removal. However, long term benefits would be seen by allowing additional waters to be stored on the floodplain as well as creating open space within the floodplain. It is assumed that any existing vegetation would remain, undisturbed by the removal of homes. Depending on local management measures, if the open space was allowed to revegetate with shrub and/or trees, riparian zones could increase in width, thus providing water quality and wildlife benefits.

Plan B – Ellington Agricultural Center Detention Structure

Negligible impacts are anticipated to vegetation. Ground disturbance and removal of bank vegetation would be anticipated. A stormwater permit, National Pollutant Discharge Eliminating System (NPDES), may be required if more than one acre of vegetation is disturbed. This area would likely be maintained with a mixture of management measures including;riprap for slope stability, manicured (mowed) areas along Ellington Agricutral entrance road, and riparian areas adjacent to Sevenmile Creek. Riparian areas would be replanted with native vegetation to reduce the potential for invasive species generation within any disturbed area and to increase wildlife benefits.

Plan D – Briley Bridge Modification

Negligible impacts are anticipated to vegetation. The area consists of riprap, with a few trees, some understory, and scrub vegetation. Ground disturbance and removal of scattered bank vegetation would be anticipated. Stormwater permit (NPDES) may be required if more than one acre of vegetation is disturbed. This area would likely be maintained with riprap for slope stability and vegetation would be discouraged as it would impede water flow.

No Action Alternative

No impacts to the existing vegetation would be anticipated.

6.3.2 Aquatic and Wildlife

Aquatic

Plan A – Nonstructural (Buyouts/Raising)

No impacts to aquatic life are anticipated during the construction. BMPs would be utilized during construction (structure demolition of residential and isolated structures) to minimize potential negative impacts to the aquatic environment.

Plan B – Ellington Agricultural Center Detention Structure

Temporary impact to aquatic species is anticipated during construction. BMPs would be utilized during construction to minimize potential negative impacts to the aquatic environment. One Federally listed species, the Nashville Crayfish, is found within Seven mile Creek. Given the wide distribution of the Nashville Crayfish within the Mill Creek watershed, it is probable that the proposed Plan B could impact the Nashville Crayfish and/or disturb areas of its habitat. A Biological Assessment (BA) has been provided to USFWS for their review and concurrence with this ESA determination. USACE received the Final Biological Opinion from USFWS on 23 March 2015. It is the USFWS' biological opinion that the preferred alternative would not likely jeopardize the continued existence of the Nashville crayfish. The USFWS provided "Reasonable and Prudent Measures" as well as "Terms and Conditions" for the proposed action. These are summarized in Section 6 of this Main Report and Appendix D. A copy of the BA and BO can be found in the Environmental Appendix D. See Section 6.3.3 for future details regarding Threatened and Endangered Species. During construction the Corps would ensure that suitable habitat for the Nashville Crayfish and other aquatic species was restored. Great consideration would be given to oppurtunities that might arise during construction to further enhance the habitat for aquatic species.

Plan D – Briley Bridge Modification

Temporary impact to aquatic species is anticipated during construction. BMPs would be utilized during construction to minimize potential negative impacts to the aquatic environment. BMPs would be used to maximize control of sediment or potential runoff and stabilization of disturbed areas as soon as possible upon completion of construction. In the long term, the aquatic fauna could benefit with reduced water velocities during storm events as the alternatives would slow floodwaters moving through the watershed. Reduced velocities could reduce how often the habitat areas are flushed or removed (riffle/gravel areas). Greater ground water infiltration could potentially supplement base flow, thereby reducing timeframe of no flows in upper reaches where fauna are limited to pools or forced to migrate downstream. One Federally listed species, the Nashville Crayfish, is found within Seven mile Creek. Given the wide distribution of the Nashville Crayfish within the Mill Creek watershed, it is probable that the proposed Plan B could impact the Nashville Crayfish and/or disturb areas of its habitat. A Biological Assessment (BA) has been provided to USFWS for their review and concurrence with this ESA determination. USACE received the Final Biological Opinion from USFWS on 23 March 2015. It is the USFWS' biological opinion that the preferred alternative would not likely jeopardize the continued existence of the Nashville crayfish. The USFWS provided "Reasonable and Prudent Measures" as well as "Terms and Conditions" for the proposed action. These are summarized in Section 6 of this Main Report and Appendix D. A copy of the BA and BO can be found in the Environmental Appendix D. See Section 6.3.3 for future details regarding Threatened and Endangered Species. During construction the Corps would ensure that suitable habitat for the Nashville Crayfish and other aquatic species was restored. Great consideration would be given to oppurtunities that might arise during construction to further enhance the habitat for aquatic species.

No Action Alternative

The No Action Alternative would result in the continued degradation of the river bank from repeated flooding, and thus, increase the potential for additional negative impacts to aquatic resources.

Terrestrial

Plan A – Nonstructural (Buyouts/Raising)

No impacts to wildlife are anticipated during the construction. However, BMPs would be utilized during construction to minimize potential negative impacts to the environment. Riparian areas, when applicable, would be restablished with a mixture of native trees, shrubs, and herbaceous vegetation. Restablishing riparian zones and increased forested and/or grassed areas would provide benefits to resident and wildlife species.

Plan B – Ellington Agricultural Center Detention Structure

No impacts to wildlife are anticipated during the construction. However, BMPs would be utilized during construction to minimize potential negative impacts to the environment. Riparian areas would be restablished with a mixture of native trees, shrubs, and herbaceous vegetation. Restablishing riparian zones and increased forested and/or grassed areas would provide benefits to resident and wildlife species.

Plan D – Briley Bridge Modification

No impacts to wildlife are anticipated during the construction. However, BMPs would be utilized during construction to minimize potential negative impacts to the environment.

No Action Alternative

The No Action Alternative would create additional concerns for wildlife as existing riparian vegetation is lost. Feeding, foraging and nesting opportunities within the riparian fringe would be compromised by the loss of riparian areas.

6.3.3 Threatened and Endangered Species

Of the listed species presented in Table 50, only the Indiana bat, Price's Potato-bean, and Nashville Crayfish were evaluated for potential presence and for environmental impacts resulting from the Corps' project. Upon review of habitat requirements for these species, it has been determined that Indiana bat and Price's Potato-bean habitats do not occur within the proposed project footprints, therefore no impacts are anticipated. The Corps has made a "no effect" determination regarding the Indiana bat and Price's Potato-bean as a result of Plans B, D, and A.

Given the wide distribution of the Nashville Crayfish within the Mill Creek watershed, it is probable that the proposed Plans B, D, and A could impact the Nashville Crayfish and/or disturb areas of its habitat. Since Plan A would not involve any work within the stream, no impacts to the Nashville Crayfish are anticipated. As a result the Corps made a "No Effect" determination regarding Plan A. However, in regards to Plans B and D, physical impacts to the crayfish are hard to observe and document, but could likely occur. Therefore the Corps determined that both Plans B and D would be "likely to adversely affect" the Nashville Crayfish. At this time the Corps has requested formal consultation with USFWS regarding potential impacts to the Nashville Crayfish. A Biological Assessment (BA) has been provided to USFWS for their review and concurrence with this ESA determination. A copy of the BA and BO can be found in the Environmental Appendix D.

Mitigation/Conservation Measures for impacts to the Nashville Crayfish would be specified in the Biological Opinion (BO) drafted by the USFWS. USFWS Draft BO containing any mitigation/conservation measures was received on February 6, 2015. The Final BO was received March 23, 2015.

It is the USFWS' BO that the preferred alternative would not likely jeopardize the continued existence of the Nashville crayfish because:

1. Nashville crayfish would be relocated short distances upstream of construction activities into suitable habitat and restricted from reentering project sites during construction to minimize mortality,
2. construction activities associated with these projects would include required minimization measures to reduce the potential for Nashville crayfish mortality and permanent destruction or alteration of its habitat,

3. necessary permits would require that no instream work occur from October 1 through May 31 to assure that the Nashville crayfish's reproductive activities would not be affected and that potential effects to hatchlings would be minimized, and
4. Nashville crayfish have persisted in Mill Creek and Sevenmile Creek despite development activities and accidental spills/releases occurring for many years.

Therefore, it is unlikely that the proposed projects would result in significant declines in its population.

The USFWS provided "Reasonable and Prudent Measures (RPM)" as well as "Terms and Conditions (T&Cs)" for the proposed action. T&Cs can be found in Appendix D. The Corps accepts these RPM and T&Cs outlined in the USFWS BO. RPMs and T&Cs would be applied to the NED plan and would be implemented during construction. RPMs include:

1. The must ensure that their approved and permitted contractors implement measures to minimize or eliminate effects from pre-construction and construction activities and to reduce the potential for effects during the operational phase (postconstruction period) of these projects.

2. The USACE, the Tennessee Department of Transportation (TDOT), and Metro Water Services, and their contractors must ensure that the level of Nashville crayfish take associated with individual proposed actions is adequately monitored and reported to the Service.

Table 54 below outlines the incedential take for each stream segment and the estimated amount of suitable habitat affect by each project.

Table 54. USFWS Incidential take by Stream Reach and the Estimated Amount of Suitable Habitat Affected by each Project.

STREAM REACH	INCIDENTAL TAKE BY STREAM REACH (1)	ESTIMATED AMOUNT OF SUITABLE HABITAT AFFECTD BY PROJECT (2)
Mill Creek RM 7.1	All Nashville crayfish within 600 linear feet (ft)	140,000 ft^2
Sevenmile Creek RM 3.67	All Nashville crayfish within 700 linear ft	27,000 ft^2

1) Total incidental take is estimated at 1,300 linear ft of stream channel habitat.
2) Suitable habitiat is estimated to be approximately 100% of incidential take per stream reach.

The complete BO can be found in Appendix D of this document.

Plan A – Nonstructural (Buyouts/Raising)

No impacts to federally listed T&E species are anticipated during the construction.

Plan B – Ellington Agricultural Center Detention Structure

Plan B would affect Nashville Crayfish found within the proposed project footprint. Formal consultation with USFWS is currently underway.

Plan D – Briley Bridge Modification

Plan D would affect Nashville Crayfish found within the proposed project footprint. Formal consultation with USFWS is currently underway.

No Action Alternative

If no projects were initiated for flood damage reduction, there could be increased pressure on the Nashville Crayfish. Nashville Crayfish has been able to survive in more degraded water quality conditions than previously thought, however, water quality remains the primary concern of biologists for this species continued existence. As water quality and habitat degrades, species would become limited to pockets of habitat that would sustain their existence. Existing regulations and their enforcement, in concert with education, would be primary protection for threatened and endangered species. Continued actions by other organizations would also assist in protecting species of concern.

6.4 Hazardous, Toxic, and Radioactive Wastes (HTRW)

No alternative would have any significant effect on HTRW. As mentioned previously in Section 5.5, there are no HTRW issues associated with current soil conditions of the properties composing the recommended plan. However, for residences built prior to 1978, a lead paint and asbestos survey shall be conducted prior to demolition. If lead paint or asbestos is discovered, it must be abated prior to demolition. Any regulated materials recovered as part of the abatement process will be disposed of in a certified landfill. To meet the CERCLA all appropriate inquiry standards, an updated Phase 1 ESA consistent with ASTM E1527 procedures must be completed within 6 months of construction contract award. The costs to perform the sampling and analyses and update to the Phase 1ESA have been included in the final cost allocation tables. All costs associated with abatement and disposal of asbestos and lead containing material are 100% non-Federal responsibility and are not included as project costs.

6.5 Air Quality

No alternative would have any significant effect on air quality; there would be no anticipated changes to current attainment status with implementation of Plan A, B, and/or D. BMPs would be utilized during construction to minimize potential temporary, negative impacts to air quality.

6.6 Noise

Implementation of plans A, B, and D would temporarily increase noise in the immediate project area over the normal existing industrial, residential, and vehicular traffic noise level. These increases would be localized and considered minimal and therefore would have negligible effect.

No Action Alternative

If no projects were initiated for flood damage reduction, no impacts on existing noise levels would be anticipated.

6.7 Cultural Resources

Plan A – Nonstructural (Buyouts/Raising)

One hundred eighty nine structures designated for removal were constructed after 1965 and do not meet the criteria for inclusion in the NRHP. The remaining 27 structures were constructed between 1950 and 1965. The oldest structure, constructed in 1950, is the only wood sided building. The remaining pre-1965 structures are brick veneer structures and may have been the initial structures constructed in the tract developments. The removal of the structures has the potential to cause surficial ground disturbance. There are no confirmed archaeological sites in the buy-out locations. If ground disturbance has the potential to cause effects on archaeological sites, then archaeological surveys will be performed. If a survey reveals the presence of sites, then demolition methods will be developed to minimize ground disturbance. Consultation with the State Historic Preservation Officer is ongoing; however, consultation is expected to conclude with a "no historic properties affected" determination.

Plan B – Ellington Agricultural Center Detention Structure

The plan is located within the Ellington Agricultural Center campus which is eligible for listing on the National Register of Historic Places. The bridge and access road form non-contributing elements within this historic district. The changes would not alter the location, design, setting, materials, workmanship, feeling or association of the historic district. This plan will cause ground disturbance within the Seven Mill Creek floodplain; however, investigations reveal that no archaeological sites would be affected. A no adverse effect determination is under review State Historic Preservation Officer and other consulting parties.

Plan D – Briley Bridge Modification

This plan will cause some ground disturbance on the left descending bank of Mill Creek. The Briley Parkway Bridge was originally constructed in 1965 and rehabilitated in 2009. In part due to the rehabilitation, this bridge is not a significant cultural resource. Archaeological resources along this stretch of Mill Creek are confined to the upper few feet of soil, and would have been disturbed during the original bridge construction and the recent bridge construction. This alternative will have no adverse effect on cultural resources.

No Action Alternative

With the No Action Alternative continued flooding of historic properties, particularly archeological sites, may be adversely affected.

6.8 Socioeconomic

Plan A – Nonstructural (Buyouts/Raising)

Under this plan, only minor socioeconomic impacts are expected to occur for the proposed plan. The primary socioeconomic impact of this alternative would be the demolition of residential structures and the accompanying relocation of affected households. Purchasing the structures to be evacuated, relocation assistance, and costs for moving expenses would be provided to all participants. There is sufficient housing availability within or in proximity to the Mill Creek watershed such that finding alternative housing would not be a concern.

Due to the fact that only 89 homes are included in this plan, there will not be significant impacts to community cohesion. Some neighborhood streets may see as many as eight to twelve homes removed or raised-in-place, but these areas are restricted to floodway or floodplain properties intersected by the 5 year flood elevation. This number equates to five percent of the structures located in the floodplains of Mill Creek. It is notable that the 89 homes are spread out across 20 square miles and are located as much as fifteen river miles apart. Typically the homes selected are in groups of two to five, and the homes will be replaced with pocket park or community garden type amenities. There are numerous housing options available in the watershed available to residents whose homes are selected for buyout and removal.

Plan B – Ellington Agricultural Center Detention Structure

Plan B would not have any significant effect on socioeconomics. Implementation of Plan B could reduce flooding downstream up to two feet. Reduced flooding to homes and structures would also reduce potential property damages claims which would benefit the local government in the long-term.

Plan D – Briley Bridge Modification

Plan D would not have any significant effect on socioeconomics. Reduced flooding to homes and structures provided with the increased flow capacity at Briley Parkway Bridge would also reduce potential property damages claims which would benefit the local government in the long-term.

No Action Alternative

With no federally proposed projects, recurring flood damages would continue to decrease property values, damage properties and infrastructure and discourage growth resulting in an estimated $5.5 million in expected annual damages in the Mill Creek watershed. These limitations would result in reduced capital investments and displacement of people, homes and businesses and additional expenses for maintenance.

6.9 Cumulative Impacts

Cumulative impacts would result from the incremental impact of the proposed actions when added to those of other past, present and reasonably foreseeable future actions in the local area. Geographical boundaries for this discussion of cumulative impacts are the drainage of the Mill Creek watershed. Temporal boundaries established span from the turn of the 20th century to fifty years future projection.

Past and Present Actions

Based on the landscape and land use of the area, development of the floodplain and floodway zones became popular in the watershed many years ago; floodplains continue to receive pressure for structural development. With increasing community growth and decreasing flood storage capacities, increased flood damages to homes and business have occurred. Additional pressures along the creeks led to many of the watershed streams being placed on the 303(d) list for poor water quality. A review of the history for the study area shows several flood events that damaged homes, businesses, and properties. As a result, Metro Nashville has worked with FEMA in the watershed to remove approximately 50 structures to date within the study area. The recommended plan for this report includes the raise in place or buyout and removal of an additional 89 structures located in the 2- and 5-year floodplains. In addition Metro Nashville has implemented ordinances regulating the amount and degree of development that is allowed along creeks and within the floodplains in attempts to reduce damages occurring from flooding and improve aquatic resources and water quality.

Several agencies and interest groups (Metro, TDEC, CRC, TNC, TDA, Nashville Zoo, watershed organizations, etc) are working in the Mill Creek watershed to reverse trends of poor water quality, high impact development and floodplain loss in addition to addressing flooding concerns. These efforts include on-the-ground implementation, ordinance/zoning and public education as measures to improve the natural and social environment in the watershed.

Reasonable Foreseeable Future Actions

Residential as well as commercial development within the Mill Creek watershed is anticipated to continue to grow until the watershed reaches carrying capacity. As areas are developed, additional damages to structures from flooding events could be expected. It is anticipated that buy-out programs through the local government and other agencies and implementation and enforcement of zoning ordinances would continue as means to further reduce damages associated with structural flooding and resource impacts. Other programs and education by watershed stakeholders as mentioned above are also expected to continue as means to improve the quality of the natural resources.

Effects on Resources

Watershed, water quality, land and water resources.

A result of implementation of the proposed plans (A, B, and D) would be that floodplains areas would be cleared of structural impediments. No new development would be allowed within the project footprints through terms of the PPA and the O & M manual. This would reduce the quantity and frequency of property damage and loss due to flooding in the project footprint. This would have positive benefits to aquatic resources and wildlife by improving water quality, increasing riparian zones and improving floodplain quality with open/green space; this in turn would provide beneficial wildlife habitat. There would be removal of flood prone structures and associated debris. This work in coordination with efforts of other agencies such as FEMA buyouts, watershed association/Cumberland River Compact (CRC) low impact developments, etc. would provide positive benefits to the watershed as well as water quality and land/water resources.

Socioeconomics.

With the proposed actions (Plans A, B, and D), reoccurrence of flood damage would be relieved. Structures would be removed reducing damages to properties and potential loss of life. With the proposed actions, those residential structures that would be relocated could choose to accept payment for their property and then move either within or outside of Mill Creek Watershed. With similar relocation/removal programs undertaken by Metro and/or FEMA, the total area and total damages incurred within the watershed, and Davidson County, would continue to decrease. This would provide long term benefits for the local government and taxpayers as the costs associated with reimbursement for property damages would lessen. In addition, as the negative impacts to the natural resources also improved through implementation of measures mentioned above, there could be added investments into parks, greenways, etc that would provide public benefits in areas formerly not available.

7 Public Involvement, Review and Consultation*

7.1 Public Involvement

Historical flooding in the Mill Creek watershed has resulted in a corresponding long public involvement history. Historical involvement is described in Section 1.6 Previous Studies and Existing Projects. Scoping letters have been issued at various stages of this project study. The first letter was issued in November 2003; after reformulation following the May 2010 flood event, a second letter was issued in January 2013. The letters were sent to the public and to local, state, and federal governmental agencies with jurisdiction by law and special expertise (See Section 7.12.1). The draft report was released for 30 day public review on October 30, 2014, as part of the NEPA process. The public and agency review closed on December 4, 2014 with only minor comments received concerning traffic impacts associated with the proposed project. Public involvement for the current project is described in the following sections.

7.2 Institutional Involvement

7.2.1 Agency Coordination and Environmental Compliance

Preparation of the EA includes coordination with local, state and federal government agencies. This included scoping by mail, publishing a Notice of Intent (NOI) in the Federal Register and review of the draft document (See Chapter 8 and Appendix 3).

Compliance with environmental laws and regulations required for the Proposed Action are identified below and summarized in Table 55.

Table 55. Federal Act / Executive Order Compliance

Act/Executive Order	Status	Compliance
Wetlands (EO 11990)	C	No Compensatory Mitigation Required
Prime/Unique Farmlands		N/A
Floodplain Management (EO 11988)	C	No affect
Clean Water Act	C	No Mitigation Required
Section 404	C	No Mitigation Required
Section 401	O	No Mitigation Required, permit required prior to construction
NPDES		As Necessary
Fish and Wildlife Coordination Act	O	Coordination Ongoing Coordination would continue through final design
Endangered Species Act	C	Formal Consultation Required – Final BO received
National Historic Preservation Act	C	No Adverse Affect
Environmental Justice (EO 12898)	C	No affect
Clean Air Act	C	No affect
Climate Change	C	No affect
Comprehensive Environmental Response Compensation and Liability Act (CERCLA)	C	
Resource Conservation and Recovery Act (RCRA)	C	
Wild and Scenic Rivers Act		N/A
Other:		
Local approval for work within floodway		As Necessary
N/A—not applicable C—Complete O - Ongoing		

7.3 Wetland (Executive Order 11990)

The proposed project, Plan BDA, impacted wetland acreage (0.05 permanent impacts) was minimized and requires no compensatory mitigation per TDEC and DA Regulatory requirements. The project meets both Sections 404 (Corps Nationwide Permit 18 – Minor Discharge) and 401 (TDEC General Permit of Minor Alterations to Wetlands) of the Clean Water Act.

Specific to Executive Order 11990 the proposed project, Plan BDA, minimized/avoided impacts to wetland with the footprint design to the greatest extent possible and there is no practicle alternative for the placement of fill into this wetland. Temporary impacts (0.05 acre) would be removed with and restore to existing condition further ensuring wetland impacts are minimal. Functions and benefit of the existing wetland would not be altered with a permanent loss of 0 .05 acre.

7.4 Clean Water Act

Sections 404 and 401

Compliance with Section 404 of the Clean Water Act is required for discharges of dredged or fill material into the waters of the United States, including adjacent wetlands. State Water Quality Certification pursuant to Section 401 is required from TDEC, Division of Water Resources for any activity that may result in a discharge into waters of the State.

The proposed project, Plan BDA, would permanently impact 0.05 acres of wetlands and meets both Sections 404 (Corps Nationwide Permit 18 – Minor Discharge) and 401 (TDEC General Permit of Minor Alterations to Wetlands) of the Clean Water Act. Therefore no mitigation for impacted wetlands is required.

Stream impacts would only be associated with Plan B, Ellington Detention Structure. Plans D and A would not result in any work within streams. Impacts associated with the Ellington Detention Structure (Plan B) along Sevenmile Creek would require an Individual ARAP from TDEC prior to construction.

Best Management Practices would be implemented during construction to address erosion and sediment control as work was performed adjacent or near watercourses. If project plans change and work is required below the ordinary high watermark, then applicable permitting would be requested and received prior to construction.

National Pollutant Discharge Elimination System (NPDES)

A National Pollutant Discharge Elimination System (NPDES) permit for stormwater discharge, administered through TDEC, Water Pollution Control is required when construction or land disturbance exceeds one acre. This permit would be requested by the Contractor prior to construction where necessary.

7.5 Floodplain Management

Executive Order (EO) 11988 (May 24, 1977) outlines the responsibilities of Federal agencies in the role of floodplain management. In accordance with this EO, the Corps is required to evaluate the potential effects of actions on floodplains, and does not undertake actions that directly induce growth in the floodplain, unless no practical alternative exists. Construction of structures and facilities on floodplains must incorporate flood proofing and other accepted flood protection measures. Agencies must attach appropriate use restrictions to property proposed for lease, easement, right-of-way, or disposal to non-Federal public or private parties.

The eight steps associated with the decision making process in EO 11988 were considered in the evaluation of the selected alternative. See Table 56 for more detail on how each step was considered. Based on the findings and determination discussed in this report the selected alternative is in compliance with EO 11988. The Proposed Action would serve to reduce the damaging effects of flooding and improve the overall quality of the floodplain; it would not be directly encouraging growth within the floodplain.

Table 56. Executive Order 11988 Floodplain Management Descriptions

Determine if a proposed action is in the base floodplain.	Yes, the proposed alternatives are within the base floodplain.
Conduct early public review, including public notice.	A public notice / scoping letter was posted in February 2013. Initial comments are received and logged as Appendix D. Additional Draft EA Review to be conducted in September 2014.
Identify and evaluate practicable alternatives to locating in the base floodplain, including alternative sites outside of the floodplain.	See Section 4, Plan Formulation, for description and evaluation of each alternative considered.
Identify impacts of the proposed action.	See Section 4.3 and Section 6 for description of impacts related to the selected alternative.
If impacts cannot be avoided, develop measures to minimize the impacts and restore and preserve the floodplain, as appropriate.	Beneficial impacts to the floodplain are anticipated. The selected alternative will help restore floodplain function and quality by removing structures, fill, and restrictions in the floodway. Potential sources of debris/wastes that follow floods would be reduced.
Reevaluate alternatives.	See Section 4.2
Present the findings and a public explanation.	This document will serve as a tool to present the findings and will provide the public a detailed explanation of how the selected plan was chosen. Upon approval to release the draft report, the NEPA public comment period will occur and include additional public input.
Implement the action.	This action will follow final approvals of the selected alternative. Buyouts will be conducted on a willing seller basis, but eminent domain could be utilized where warranted.

Consideration of ER 1165-2-26 also applies to the implementation of Executive Order 11988. The policy provides that "when no other options exist other than use of floodplains, impacts from floods should be minimized to reduce effects on human health and public safety. Any actions should avoid promotion of development in the floodplain where other alternatives exist. Preservation and restoration of floodplains are primarily environmental values, but they can maintain the beneficial uses of the floodplains through restoring and maintaining wetlands, habitat, and other floodplain ecosystems."

7.6 Environmental Operating Principles

The Actions for Change doctrine has been incorporated into the USACE Campaign Plan and environmental compliance with the Campaign Plan, the Environmental Operating Principles were revised in August 2012 in this process. As described herein, the Mill Creek FRM study has incorporated these principles into the plan formulation and environmental compliance process. The principles are outlined below;

- Foster Sustainability as a way of life throughout the organization.

- Proactively consider environmental consequences of all Corps activities and act accordingly.
- Create mutually supporting economic and environmentally sustainable solutions.
- Continue to meet our corporate responsibility and accountability under the law for activities undertaken by the Corps, which may impact human and natural environments.
- Consider the environment in employing a risk management and systems approach throughout life cycles of projects and programs.
- Leverage scientific, economic and social knowledge to understand the environmental context and effects of Corps actions in a collaborative manner.
- Employ an open, transparent process that respects views of individuals and groups interested in Corps activities.

7.7 Fish and Wildlife Coordination Act

The Corps is required to coordinate water resource project proposals with the USFWS and TWRA under the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.). Coordination with USFWS and TWRA was initiated through a Scoping letter submitted February 2012 and with review of the draft report and unsigned FONSI. For scoping letter responses see Appendix D. Since no written responses were received from the TWRA, follow-up conversations were made to confirm they had no major comments on the draft report. TWRA stated on February 5, 2015 that their only comment was that traffic issues may arise from closure of the Ellington Agricultural Center Entrance Road during construction of the Sevenmile Detention Structure (Plan B). This conversation is documented in Appendix D.

A Fish and Wildlife Coordination Act Report (FCAR) was received from USFWS on July 15, 2015. With this report USFWS has evaluated this project in accordance with the guidelines and directives contained in its Fish and Wildlife Mitigation Policy (Federal Register 46(15):7644-7663; January 23, 1981). The Mitigation Policy is basis by which USFWS makes recommendations, in order of priority, to avoid, minimize, reduce or eliminate the loss over time, or compensate project-related impacts to fish and wildlife resources. USFWS recommendations, followed by Corps responses, are as follows:

- The natural hydrogeomorphic channel characteristics of Mill Creek and Sevenmile Creek would be restored upon completion of in-stream construction activities.
    - *The Corps concurs. The natural hydrogeomorphic channel characteristics would be restored within the project footprint upon completion of the construction activities.*

- Habitat enhancement measures (e.g., slab rock, cobble/boulders, and other in-stream structures) to improve aquatic habitats in Mill Creek and Sevenmile Creek for the federally endangered Nashville crayfish (*Orconectes shoupi*) and other aquatic species will be implemented during project implementation.*The Corps concurs. Term and Condition No. 9 of the BO requires the Corps to ensure conditions within the project footprints have been restored to acceptable conditions, so that Nashville crayfish habitat quality and amount is comparable to conditions present prior to the permitted construction. During construction the Corps would ensure that suitable habitat for the Nashville Crayfish and other aquatic species was restored. Great consideration would be given to oppurtunities that might arise during construction to further enhance the habitat for aquatic species.*

- Streambank stabilization measures would be implemented where necessary.

  - *The Corps concurs. Strreambank stabilization measures would be implemented within the proposed project areas as part of Plan BDA. BMPs would be utilized during construction to minimize potential negative impacts to the environment.*

- Culverts in tributaries within the project area that have structural integrity issues that impede the movement of aquatic organisms shall be identified and replaced with structures that allow passage of aquatic organisms where applicable.

  - *The Corps agrees that culverts within the project area that impede the movement of aquatic organisms should be replaced with structures that do not impede the movement of aquatic organisms. One culvert is located within the project area however it does not impede fish passage. In addition to the extent this recommendation asks for removal of culverts outside the project footprint, the Corps would be s outside of the authority of this project to do so*

- Riparian zones would be re-established within the structural project footprints for the Briley Parkway Bridge over Mill Creek and Sevenmile Creek within the Regional Detention Basin comprising a mix of native tree, shrub, and herbaceous vegetation that benefit resident and migratory wildlife species.

  - *The Corps concurs and will work with the local sponsor as project design progresses. Riparian zones within the project footprint would be re-established with a mixture of native tree, shrub, and herbaceous vegetation that benefit resident and wildlife species when prudent.*

- Floodplain and riparian zone integrity and connectivity, including re-vegetation comprising a mix of native tree, shrub, and herbaceous species that benefit resident and migratory wildlife species, would be re-established on existing properties that will be purchased or elevated within Mill Creek, Sevenmile Creek, Sorghum Branch, and Whittenmore Branch.

  - *The Corps concurs and will work with the local sponsor as project design progresses. Floodplain and riparian zones within the project footprint would be re-established with a mixture of native tree, shrub, and herbaceous vegetation that benefit resident and wildlife species when prudent.*

- Properties to be removed from the floodplain that are purchased should have deed restrictions, covenants, or conservation easements incorporated to keep those areas as restored habitats, open space, and to provide recreational and/or educational opportunities for the general public.

- *The Corps concurs. Appropriate protection measures would be applied to properties removed from the floodplain.Per ER 1105-2-100, E-85, the sponsor would be required to eliminate all existing land uses associated with residential structures that accept buyouts. This also signifies the elimination of all previous services to those areas previously held in residential property. The sponsor would be required to maintain these properties as open space. Typically in past buyouts for the reduction of flood risks, the sponsor has converted the acquired properties to park lands/ green space.*

This FCAR relies on information provided by the Corps as of November 2014. The draft FCAR states "the Service strongly supports implementation of plan BDA". A copy of the FCAR can be found in Appendix D. Coordination with the Service would continue throughout the development and construction of Plan BDA.

7.8 Endangered Species Act

The Endangered Species Act requires the determination of possible affects on or degradation of habitat critical to federally listed endangered or threatened species. This assessment examines these issues through review of occurrence records of plants and animals that are on federal lists, and a review of the project area for the presence of the types of habitats that could support listed species.

The USFWS and the State of Tennessee provided a list of T&E species occurring within the Mill Creek watershed as discussed is Section 5.4. After evaluating the T&E species, and their habitat requirements, the Corps has determined there would be no effect to the Indiana bat and Price's Potato-bean. However, the Corps has determined that Plans B and D would affect the Nashville Crayfish. At this time the Corps has entered into formal consultation with USFWS. A Biological Assessment was sent to USFWS for their concurrence. USACE received the Draft Biological Opinion from USFWS on 6 February 2015. The final BO was received March 23, 2015. It is the USFWS' biological opinion that the preferred alternative would not likely jeopardize the continued existence of the Nashville crayfish because:

1. Nashville crayfish would be relocated short distances upstream of construction activities into suitable habitat and restricted from reentering project sites during construction to minimize mortality,
2. construction activities associated with these projects would include required minimization measures to reduce the potential for Nashville crayfish mortality and permanent destruction or alteration of its habitat,
3. necessary permits would require that no instream work occur from October 1 through May 31 to assure that the Nashville crayfish's reproductive activities would not be affected and that potential effects to hatchlings would be minimized, and
4. Nashville crayfish have persisted in Mill Creek and Sevenmile Creek despite development activities and accidental spills/releases occurring for many years.

Therefore, it is unlikely that the proposed projects would result in significant declines in its population.

The USFWS provided "Reasonable and Prudent Measures (RPM)" as well as "Terms and Conditions (T&Cs)" for the proposed action. RPMs and T&Cs can be found in Appendix D. The Corps accepts these RPM and T&Cs outlined in the USFWS BO. RPMs and T&Cs would be applied to the NED plan and would be implemented during construction. The final USFWS BO is summarized in Section 6 of this Main Report and can be found in Appendix D.

7.9 National Historic Preservation Act

Section 106 of the National Historic Preservation Act of 1966 requires that Federal agencies take into account the effects of its undertakings on historic properties included in or eligible for listing in the National Register of Historic Places and afford the Advisory Council on Historic Preservation (ACHP) an opportunity to comment. The Section 106 process, implemented by regulations of the ACHP at 36 C.F.R. 800, requires agencies to define a project's area of potential effects, identify historic properties that area that may be directly or indirectly affected by the project, assess the potential for adverse effects, resolve those adverse effects, and provide the ACHP a reasonable opportunity to comment on the undertaking.

Section 106 has been initiated with the State Historic Preservation Officer (SHPO), American Indian Tribes with an ancestral connection to Davidson County, Metropolitan Nashville and Davidson County Historical Commission (MHC) and other consulting parties. Consideration of the NED Plan has identified the Ellington Agricultural Center Campus as a National Register eligible District. In a meeting on December 18, 2014, the SHPO and MHC concurred that the existing bridge and access road are non-contributing elements of the historic district; therefore, modification to the bridge and detention center would not adversely affect this historic district. The SHPO provided a No Adverse Affect response on February 11, 2015. See Appendix D for coordination letter and comments.

7.10 Environmental Justice

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations, was signed on February 11, 1994. The order requires Federal agencies to promote "nondiscrimination in Federal programs substantially affecting human health and the environment." In response to this direction, Federal Agencies must identify and address disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority and low-income populations.

The final step in the environmental justice evaluation process is to evaluate the impact of the project on the population and to ascertain whether target populations are affected more adversely than are other residents. The average cost of residential housing within the study area of Alternative Plan A is approximately $85,000 while the average cost within Nashville is approximately $186,000 (Economic Analysis Appendix). This information suggests that lower-income residences would be affected and therefore, would be disproportionately impacted. However, the net result for this population will be positive, as they will receive full market value for their residences and relocation assistance. The residents will no longer be subject to frequent flood events. These frequent flood events (5-year) result in higher life safety risk, damages to personal and real property, and decreased return on investment. It is also worth noting that no specific neighborhood or community is selected, the metric for inclusion in the non-structural plan is simply residences that intersect with the 5-year floodplain elevation. In Mill Creek, this equates to approximately 89 homes, spread out across fifteen river miles, among over twenty square miles. Typically the homes selected are in groups of two to five, and the homes will be replaced with pocket park or community garden type amenities. There are numerous housing options available in the watershed available to residents whose homes are selected for buyout and removal.

7.11 Clean Air Act

The EPA defines ambient air in CFR 40, Part 50, as "that portion of the atmosphere, external to buildings, to which the general public has access." In compliance with the Clean Air Act (CAA) and the 1977 and 1990 Amendments (CAAA), EPA has promulgated ambient air quality standards and regulations. The National Ambient Air Quality Standards (NAAQS) were enacted for the protection of the public health and welfare. To date, EPA has issued NAAQS for six criteria pollutants; carbon monoxide, sulfur dioxide, particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers, ozone, nitrogen dioxide, and lead. Areas that are below the standards are in "attainment," while those that equal or exceed the standards are in "non-attainment."

The CAA and CAAA require the Corps to comply with all applicable parts of these acts and applicable standards. The project area is currently in attainment for air quality. The Corps' Proposed Action would not impact the attainment status of this area and would comply with the CAA Conformity Rule.

7.12 Climate Change

Executive Order 13653, Preparing the United States for the Impacts of Climate Change was signed November 2013. The order requires Federal agencies to review impacts of climate change. The impacts of climate change, including an increase in prolonged periods of excessively high temperatures, more heavy downpours, an increase in wildfires, more severe droughts, permafrost thawing, ocean acidification, and sea-level rise, are already affecting communities, natural resources, ecosystems, economies, and public health across the Nation. These impacts are often most significant for communities that already face economic or health-related challenges, and for species and habitats that are already facing other pressures. Managing these risks requires deliberate preparation, close cooperation, and coordinated planning by the Federal Government, as well as by stakeholders, to facilitate Federal, State, local, tribal, private-sector, and nonprofit-sector efforts to improve climate preparedness and resilience; help safeguard our economy, infrastructure, environment, and natural resources; and provide for the continuity of executive department and agency operations, services, and programs.

The Mill Creek Feasibility Study is also in compliance with the Engineering and Construction Bulletin (ECB 2014-10) "Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects." The subject ECB requires USACE to incorporate climate change and variability in hydrologic analyses. The subject ECB requires that various sensitivity analysis be performed relating to floodplain storage and range of affected flows on a level consummate with HUC-4 subregions. This analysis was performed as part of the Mill Creek study to much greater detail than required, down to one square mile drainage areas in the basin.

Upon implementation of the proposed plan (BDA) the project would be more resilient to respond to climate change. Plan BDA would allow for higher flow at Briley Parkway Bridge; allow for additional retention along Seven mile Creek; and remove/raise structures within the floodplain/floodway. Implementing the recommended alternative to improve flows, retain waters during major events, and remove/raise structures within the floodplain/floodway is an integral part of responding to climate change. Based on the consideration in this report, the report complies with the intent of EO 13653.

7.13 Other State and Local Approvals

Local approval may be required for proposed work within the floodway. One possibility for state and/or local approval would be if asbestos and/or lead materials were to be discovered. Surveys will be conducted for lead and asbestos where necessary, and if found, requirements will be met prior to demolition.

7.14 Additional Required Coordination

7.14.1 Public Review and Responses

Preparation of the EA includes agency and public notification of the proposal and an opportunity for agency and public review and comment prior to agency decision making. Scoping letters have been issued at various stages of this project study. The first letter was issued in November 2003; after reformulation following the May 2010 flood event, a second letter was issued in January 2013. The letters were sent to the public and to local, state, and federal governmental agencies with jurisdiction by law and special expertise. This integrated decision document will be circulated in draft form to the scoping respondents and to local, state, and federal governmental agencies with jurisdiction by law or special expertise for a 30- day review/comment period.

In addition to the NEPA public involvement process for this integrated Feasibility Report and Environmental Assessment, the public and local, state, and federal agencies have had other opportunities to voice their issues and concerns. As this study and evaluation has built upon action alternatives identified in Metro's Unified Flood Preparedness Plan (UFPP), it should be noted that during the preparation of the UFPP, there were three public meetings held and stakeholder and advisory committees identified. The public meetings educated the public on the purpose, scope and goals for reducing flooding impacts in the Metro Nashville/Davidson County area (UFPP 2013).

7.14.2 Scoping Responses

Six responses to the 2003 scoping letter are summarized below. Scoping responses are included in their entirety in the Appendix. There were two responses to the 2013 scoping letter.

- Citizen Comment. Sediment is the primary problem in the Mill Creek watershed. Shoreline erosion is interfering with drinking water plants, smothering aquatic and fish spawning habitat.
- 28 Feb 2013--Via email the project manager was contacted by the Tennessean for additional project information.
- 25 Mar 2013—two citizens requested copy of EA when available for public comment

Federal

- US Fish and Wildlife Service (USFWS).

- USFWS commented on significant impacts to water quality, aquatic habitat and aquatic communities in the streams in the Mill Creek watershed due to residential, commercial, and industrial development. This development has created favorable conditions for more severe flooding and consequent flood damage. Stream modification and removal of riparian vegetation were also noted as contributing to impacts in the watershed.

- USFWS discussed the federally endangered Nashville Crayfish being endemic to the Mill Creek watershed and its dependence upon maintaining good water quality, protection of suitable habitat, and public education. USFWS commented that non-structural alternatives should be given high priority; channel modification, levees, dams, floodwalls, and berms should be measures of last resort. USFWS encouraged that environmental restoration measures be considered as part of this study: restoration of swales and wetlands; riparian, aquatic and terrestrial habitats; and bank stabilization would contribute toward restoring and maintain stream integrity. (By follow-up letter, USFWS agreed to be a cooperating agency for this study.)

- Via email in 2013 the USFWS responded with acknowledgement of the endangered Nashville Crayfish occurring in the project area, and as a result the USFWS will likely have more relevant comments as the project progresses. During scoping review, USFWS pertinent comment was that any alternative that would modify or impact waterways could adversely affect the crayfish; therefore the Service requests that the Corps keep the office informed of its process as plans develop.

- Tennessee Valley Authority (TVA). TVA commented that based on the project description, it appears no TVA approvals or other involvement would be required.
- Congressman Blackburn's office of Franklin, TN requested via email to be kept apprised of any project work that could occur in the Nolensville area.
- Environmental Protection Agency responded with no comments at this time but requested a copy of the Environmental Assessment when available.
- As the proposed projects developed it became clear that work would be required within and adjacent to both Mill Creek and Sevenmile Creek. A meeting was held July 9, 2014 with USFWS to discuss changes with the proposed project plans. After reviewing the proposed project plans with USFWS it was determined that the projects would likely affect the Nashville Crayfish. At this time the Corps entered into formal consultation with USFWS and sent a BA to USFWS. USACE received the Final Biological Opinion from USFWS on 23 March 2015. It is the USFWS' biological opinion that the preferred alternative would not likely jeopardize the continued existence of the Nashville crayfish. The USFWS provided "Reasonable and Prudent Measures" as well as "Terms and Conditions" for the proposed action. These are summarized in Section 6 of this Main Report and Appendix D.

State and Local Agencies

- Tennessee Wildlife Resources Agency (TWRA).
  - TWRA commented that the primary concern of this agency with this and previous Corps flood reduction studies is channel widening alternatives. Existence of the federally endangered Nashville Crayfish should make channel widening alternatives unfeasible. TWRA commented the Corps should

accurately assess ecological impacts if channel widening is seriously considered as an alternative. TWRA is supportive of the continued application of alternatives to remove flood prone structures. Any potential cooperation or partnership between the Corps and FEMA that might address flooding problems in the Mill Creek watershed should be addressed in the draft EA.

- Tennessee Historical Commission (THC). The Ellington Agricultural Center detention structure is present within a National Register Historic District. Final coordination with THC is in process and concurrence with the USACE determination of "no adverse effect to historic properties" is expected.
- Metropolitan Government of Nashville and Davidson County, Planning Department (Metro Planning). Metro Planning is actively engaged with the Mill Creek watershed community in planning for future growth. Metro Planning believes it would be beneficial as part of the Mill Creek Watershed Plan planning process to compare conventional subdivision development and this alternative development model for effects on flooding, water quality, and natural habitat. The department welcomes the opportunity to work with study participants.
- Metropolitan Government of Nashville and Davidson County, Historical Commission (MHC). The Ellington Agricultural Center detention structure is present within a National Register Historic District. Final coordination with MHC is in process and concurrence with the USACE determination of "no adverse effect to historic properties" is expected.
- TDEC Division of Natural Areas, Natural Heritage Program provided an inventory of species found in the state's natural heritage database in support of the planned investigation for the flood risk management proposed project.

Federally Recognized Tribes

- The United Keetoowah Band of Cherokee Indians in Oklahoma acknowledge via email receipt of coordination letter. Further consultation will be required; however a no adverse effect on cultural resources determination is anticipated.

7.14.3 Public Review Comments

One comment from TDEC was received during the public review period for the draft report. The review period began on October 30, 2014, and ended December 4, 2014. TDEC reviewed the document and had no specific comment to add. No comment was received from TWRA regarding the proposed project during the public review period. Follow-up conversations occurred with TWRA to verify their review and they stated on February 5, 2015 that their only comment was that traffic issues may arise from closure of the Ellington Agricultural Center Entrance Road during construction of the Sevenmile Detention Structure (Plan B). This conversation is documented in Appendix D.

8 Recommendations

I recommend that the selected plan (Plan BDA), which maximizes net economic benefits, described in this report for flood risk management in the Mill Creek watershed of Davidson County (Metro Nashville), Tennessee, be authorized for implementation. The plan consists of the construction of the Ellington detention basin, a bridge and channel modification to Briley Parkway and a non-structural plan to raise or buyout and remove 89 residential structures at a presently estimated fully funded total project cost of $28,487,000; provided that, except as otherwise stated in these recommendations, the exact amount of non-Federal contributions shall be determined by the Chief of Engineers following policies satisfactory to the President and the United States Congress prior to project implementation, in accordance with the following requirements to which non-Federal interest must agree prior to implementation:

a. Pursuant to Section 103, WRDA 1986, 33 USC 2213, the non-federal sponsor will provide a minimum of 35 percent, but not to exceed 50 percent of total flood damage reduction costs for structural measures as further specified below:
    1. Provide the required non-Federal share of design costs allocated by the Government to flood damage reduction in accordance with the terms of a design agreement entered into prior to commencement of design work for the flood damage reduction features;
    2. Provide, during the first year of construction, any additional funds necessary to pay the full non-Federal share of design costs allocated by the Government to flood damage reduction;
    3. Provide, during construction, a contribution of funds equal to 5 percent of total flood damage reduction costs;
    4. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the flood damage reduction features;
    5. Provide, during construction, any additional funds necessary to make its total contribution for flood damage reduction equal to at least 35 percent of total flood damage reduction costs;
b. Pursuant to Section 103, WRDA 1986, 33 USC 2213, the non-federal cost share for non-structural flood risk management is a flat 35 percent of total costs for project allocated to non-structural flood risk management, with LERRD value credited toward the sponsor's share.
c. 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;
d. Provide all LERRDs determined by the Government to be necessary for the construction, operation, and maintenance of the project;

e. The Non-Federal Sponsor will also conduct the demolition/removal of the structures and perform this work to be cost shared via in-kind crediting. The Non-Federal Sponsor will coordinate demolition/removal with LRN Construction office, proper permitting, contract approvals will be obtained.
f. Per ER 1105-2-100, E-85, the sponsor will be required to eliminate all existing lands uses associated with the residential structures in the buyout plan. This also signifies the elimination of all previous services to those areas previously held in residential property. The sponsor will be required to maintain these properties as open space.
g. For so long as the project remains authorized operate, maintain, repair, replace, and rehabilitate (OMRR&R) the completed project, or functional portion of the project, 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.
h. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon land which the Non-Federal Sponsor, now or hereafter, owns or controls access to the project for the purpose of inspection, and if necessary after failure to perform by the Non-Federal Sponsor, for the purpose of completing OMRR&R on the project. No completion of OMRR&R by the Federal Government shall operate to relieve the Non-Federal Sponsor of responsibility to meet the Non-Federal Sponsor's obligations, or to preclude the Federal Government from pursuing any other remedy at law or equity to ensure faithful performance.
i. Hold and save the United State free from all damages arising from the construction, OMRR&R of the project and any project related betterments, except for damages due to the fault or negligence of the United State and its contractors.
j. Perform, or cause to be performed, 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), 42 USC 9601-9675, that may exist in, on, or under LERRDs that the Federal Government determines to be required for the construction and OMRR&R of the project.
k. Assume complete financial responsibility, as between the Federal Government and the Non-Federal Sponsor, for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under LERRDs the Federal Government determines to be required for construction and OMRR&R of the project.
l. As between the Federal Government and the Non-Federal Sponsor, the Non-Federal Sponsor shall be considered the operator of the project for the purpose of CERCLA liability. The sponsor will OMRR&R the project in a manner that will not cause liability to arise under CERCLA.
m. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisitions Policies Act of 1970, as amended Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring LERRDs for construction and OMRR&R of the project, and inform all affected persons of applicable benefits, policies, and procedures, in connection with said Act.

n. Participate in and comply with applicable Federal floodplain management and flood insurance programs in accordance with section 402 of Public Law 99-662 and Executive Order 11988.
o. Not less than once each year, inform affected interests of the limitations of the protection afforded by the project;
p. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the floodplain, and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with protection levels provided by the project.
q. In addition to these specific actions, Metro Nashville will be required by ER 1105-2-100 para. 4-3(b)(2), to uphold the requirements for partnership in the planning, engineering, and design (PED) and implementation phases, signified by the respective legal agreements for each phase.
r. 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 WRDA 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.

The recommendations contained herein reflect information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program nor the perspective of higher levels within the Executive Branch. Consequently, the recommendations may be modified before they are approved for implementation.

JOHN L. HUDSON, P.E.
LTC, EN
Commanding

9 List of Preparers

Table 57. Project Delivery Team

Role	PDT Member
Project Manager / Planner	Tom Herbert
Project Engineer / Hydraulic Engineer	Barry Moran
Biologist	Matthew Granstaff
Structural Engineer	Soveriak In
Geotechnical Engineer	Steve Matheny
Real Estate Specialist	Cathy Keith
GIS Coordinator	Bobby Sells
Cultural Resources	Dr. Valerie McCormack
Economist	Phillip Jones
Cost Estimator	Cullum Miller
HTRW	Lannae Long Chris Stoltz
Construction	Jeff Hitchcock

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Mill Creek Economic Analysis

Appendix A

Version November 2015

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1. INTRODUCTION

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

1.1 PURPOSE OF THE STUDY

This appendix describes the economic analysis of the project measures and alternatives for providing flood risk management measures for the City of Nashville, Tennessee. The purpose is to provide comprehensive review of the methodology and results of the economic analysis performed on the FRM alternatives for the study.

1.2 STUDY AREA

Located in one of the most rapidly urbanizing areas of Middle Tennessee, the 108-square mile Mill Creek Watershed drains about 13% of Nashville, Davidson County, Tennessee and 6% of Williamson County, Tennessee. The watershed has a teardrop shape, is about 18 miles long and averages 6 miles wide. About two thirds of the watershed is within Davidson County, one third in Williamson County and a small headwater area extends into Rutherford County.

Mill Creek flows generally northward from its origin in Nolensville to its confluence with the Cumberland River in Nashville. Along the way it is fed by a number of tributaries, the most significant being Sevenmile Creek which joins Mill Creek at Mile 7.9 and has a drainage area of 17.6 square miles. Other major tributaries in Davidson County include: Collins Creek, Edmonson Branch, Franklin Branch, Holt Creek, Indian Creek, Owl Creek, Sims Branch, Sorghum Branch, Turkey Creek, and Whittemore Branch.

Sevenmile Creek originates near the Davidson-Williamson County line and flows north and east before joining Mill Creek. Sevenmile is approximately 7.3 miles long with a drainage area of 17.6 square miles, an average slope of 18.9 feet per mile, and an average 100-year floodplain width of 500 feet. Streambanks range from 3 to 9 feet high; existing channel averages 20 to 30 feet wide. Approximately half the flow is through a heavily urbanized area, while the upper half is less developed.

The aforementioned Sorghum and Whittemore Creeks were also analyzed in the Study. The study area associated with each of these tributaries is primarily residential in nature with a small amount of commercial structures. Figure 1 below displays the study area in comparison with the rest of Davidson County.

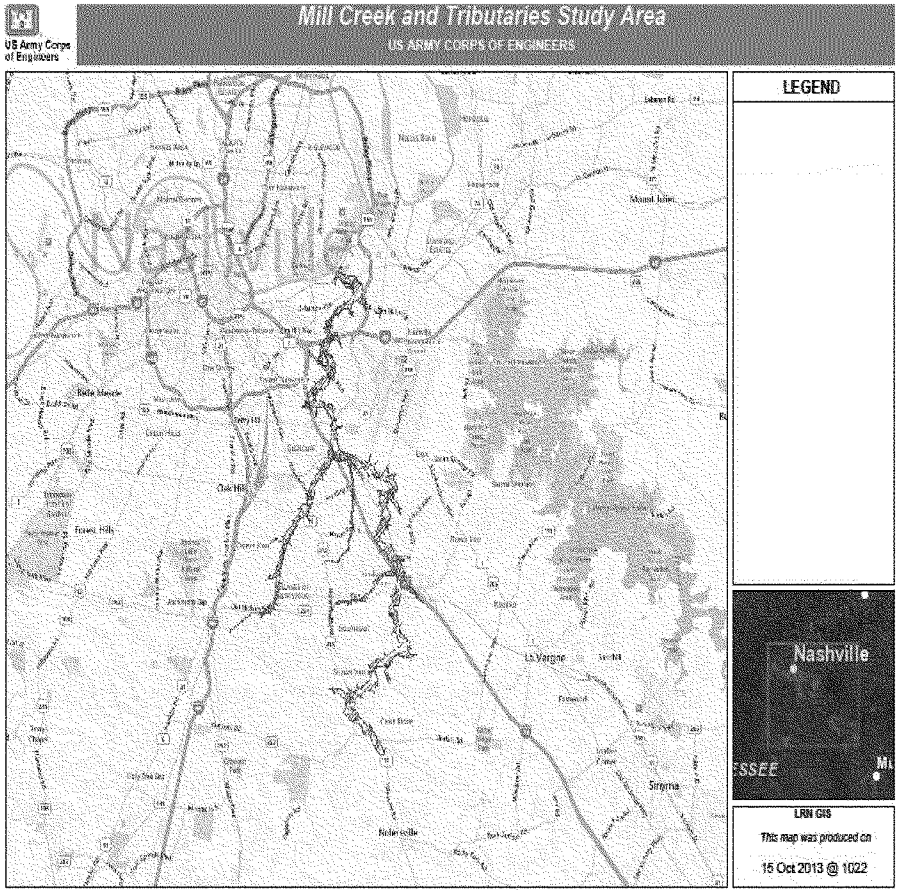


Figure 1: Mill Creek and Tributary Study Area

2. CHARACTERISTICS OF THE STUDY AREA

2.1 DEMOGRAPHIC DATA

Population is one parameter of community change. As the population in an area increases or decreases, so does the demand for infrastructure. Population estimates from the 2010 US Census shows growth in Tennessee and Davidson County is above the nation as a whole. This data is shown in

Table 1 which follows.

Table 1: Population

	Population	Population	% Population Change
Location	2000	2010	2000-2010
Davidson County	569,891	626,681	9.97%
Tennessee	5,689,283	6,346,105	11.54%
United States	281,421,906	308,745,538	9.71%
Data source: 2000 and 2010 US Census			

As shown in Table 1, Davidson County's population grew nearly 10%, while the State of Tennessee grew over 11% over the decade. The national population grew 9.71% along the same period of time. More detailed Nashville/Davidson County population characteristics are listed in Table 2.

Table 2: Population Characteristics of Nashville/Davidson County, TN

	Estimate	Percent	U.S.
Total Population	626,681		
American Indian or Alaska Native	2,091	0.3%	0.9%
Asian	19,027	3.0%	4.8%
Black or African American	173,730	27.7%	12.6%
Native Hawaiian or other Pacific Islander	394	0.1%	0.2%
Some other race	30,757	4.9%	6.2%
Two or more races	15,643	2.5%	2.9%
White	385,039	61.4%	72.4%
Mill Creek Watershed Population	**187,106**		
Age			
Under 18 years	136,391	21.8%	24%
Between 18 and 64 years	424,887	67.8%	63%
65 years and over	65,403	10.4	13%
Income (2010 Dollars)*			
Median per capita income	28,526		27,334
Median housing value (owner occupied)	166,300		188,400
Persons below poverty level		17.7%	13.8%
Unemployment rate		7.3%	7.8%
Data source: 2010 US Census *Data source: US Census 2010 American Community Survey, Selected Social Characteristics, 5-year estimates:2006-2010, Data source: US Bureau of Labor Statistics			

As Table 2 shows the population is primarily white and in general age distribution matches the Nation as a whole. Per capita income is slightly higher than the United States average and the median housing value is roughly 12% lower than the Nation's. Persons living below the poverty level and unemployment rates are higher than the rest of the country on average.

2.2 HOUSING AND FAMILIES

2.2.1 Housing

Davidson County's occupied housing unit mirrors that of the Nation as a whole. Renter occupied units in Davidson County is higher percentage wise than that of the United States. Household size and median vehicles per household is near identical. Housing data is presented in Table 3.

Table 3: Housing

	Davidson County Estimate	%	U.S. Estimate
Total Housing Units	283,978		131,701,730
Occupied housing units	259,499	91.3%	88.6
Owner occupied housing units	145,115	51.1%	57.6
Renter occupied	114,384	40.2%	30.9
Average household size	2.5		2.58
Households median vehicles	2.1		2.2
No vehicles	20431	7.3%	8.9%
1 vehicle	110320	39.2%	33.3%
2 vehicles	104411	37.1%	37.9%
3 or more vehicles	46145	16.4%	20%
Data source: US Census Quick Facts, American Community Survey, October 2012			

2.2.2 Families

Davidson County has a slightly lower average household and family size than the Nation as a whole. The county also has a lower percentage of family households and married couple households than the United States. Family data is displayed in Table 4.

Table 4: Household Data

	Davidson County	%	U.S.
Total Households	259,499	100%	116,716,292
Average Household Size	2.5	-	2.58
1 Person Households	89,503	34.49%	26.74%
2 or More Person Households	169,996	65.51	73.26%
Family Households (Families)	145,166	55.94%	66.43%
Average Family Size	3.02	-	3.14
Married-Couple Family	95,093	36.64%	48.42%
Nonfamily Households	114,333	44.06%	33.57%
Data source: 2000 and 2010 US Census			

2.3 EMPLOYMENT AND LABOR FORCE

2.3.1 Employment

The distribution of employment in Davidson County, TN is representative of the Nation as a whole, except for lower percentages in manufacturing and construction and greater percentages in arts, entertainment and recreation industries, as shown in Table 5.

Table 5: Total and Part-Time Employment by Major Industry Sector by Place of Work, 2010

Employment	Davidson County Estimate	U.S Estimate
Employed population 16 years and over	325,346	141,833,331
Percent Distribution by Employment Sector		
Agriculture, forestry, fishing and hunting, and mining	0.3%	1.9%
Construction	5.3%	7.1%
Manufacturing	7.9%	11.0%
Wholesale trade	1.9%	3.1%
Retail trade	10.8%	11.5%
Transportation and warehousing, and utilities	4.0%	5.1%
Information	3.5%	2.4%
Finance and insurance, and real estate and rental and leasing	7.1%	7.0%
Professional, scientific, and management, and administrative and waste management services	13.0%	10.4%
Educational services, and health care and social assistance	24.4%	22.1%
Arts, entertainment, and recreation, and accommodation and food services	12.3%	8.9%
Other services, except public administration	4.8%	4.9%
Public administration	4.7%	4.8%
*Data source: US Census 2010 American Community Survey, Selected Social Characteristics, 5-year estimates:2006-2010.		

2.3.2 Labor Force
General employment statistics for Davidson County, Tennessee are similar to the Nation as a whole, as seen in Table 6.

Table 6: Employment Status

	Davidson County Estimate	%	U.S. Estimate
Population 16 Years and Over	492,422		238,733,844
In Labor Force	338,685	68.8%	65.0%
Employed	312,839	63.5%	59.4%
Unemployed	25,371	5.2%	5.1%
Not in Labor Force	153,737	31.2%	35.0%
*Data source: US Census 2010 American Community Survey, Selected Social Characteristics, 5-year estimates:2006-2010.			

3. ECONOMIC EVALUATION PROCEDURES, ASSUMPTIONS, AND METHODOLIGIES
The economic analysis evaluated the alternatives in the basis of flood-related costs and damages avoided. Flood damages and costs considered in the economic analysis included flood damages to residential and non-residential structures and contents, damages to vehicles, and public damages (infrastructure and emergency response expenditures).

The economic justification of an alternative was determined by comparing the expected annual benefits to the expected annual costs. If the annual benefits for an alternative exceed the annual costs, then the alternative was considered economically justified. In such cases, the benefit-to-cost ratio (BCR) was greater than 1.0. For this analysis, the expected annual cost of an alternative was determined by considering a number of factors, including construction cost, timing of construction period, and interest during construction, and operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) costs. The costs were based on an October 2015 price level, a period of analysis of 50-years, and were annualized to an annual equivalent cost using FY 2015 Federal Discount Rate of 3.375%. The expected annual cost for an alternative was subtracted from the expected annual benefit to compute the net annual benefit.

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

3.1 HYDROLOGIC AND HYDRAULIC MODELING FOR ECONOMIC EVALUATIONS

Refer to Hydrology and Hydraulics (H&H) Appendix for information on the hydrologic and hydraulic input into the Hydrologic Engineering Center – Flood Damage Analysis software (FDA) version 1.2.4 model.

3.1.1 Base and Most Likely Future Economic Modeling

For the Mill Creek and tributary study, the year the proposed project is expected to be in operation (the base year) was set at 2018. The most likely future year was set at 2058. Local floodplain management ordinances will mitigate most hydrologic impacts from increased development. The H&H Appendix will provide documentation of the development of future without project conditions.

3.2 First Floor Elevations

To identify the structures to include in the study, the 500yr water surface sharefiles were overlaid with the Metro Nashville building footprint layer, identifying 1,455 structures. A unique structure ID was defined by utilizing stream number, bank and object number. All of the first floor elevations of the structures in the study area were obtained by one of three methods. That is to say that first floor elevations were obtained for a 100% sample of the structure inventory. None were inferred by statistical analysis. In the Mill Creek Basin flood risk management study a total of 1,455 structures were assigned first floor elevations. Of these 725 had received fist floor elevation certificates from Metropolitan-Davidson County's property assessor's offices. Ten (10) were surveyed by the Nashville District and 720 structures were assigned a FFE via Lidar. All structures in the SID were accounted for by the aforementioned measures. The analysis was completed by performing zonal statistics based on the LiDAR elevation within the building footprint. The max value was recorded for each structure and analysis on the foundation type and previously surveyed first floors. This analysis was utilized to establish a baseline for different foundation types and the corresponding adjustment to the building max elevation. Those values were: Crawl=ZonalMax+1ft, Slab=ZonalMax, Typical=ZonalMax-.5ft, Partial Basement=ZonalMax, and Full Basement=ZonalMax-5ft.

3.3 Structure and Contents

The purpose of the structure inventory was to collect data on residential and nonresidential structures located in the Study area. Structures were numbered on its respective stream starting downstream and moving upstream. Structures added later were numbered as they were added, irrelevant of their position on a stream. Each residential structure in the structure inventory database (SID) was assigned a vehicle in the SID and given the same identifying number as the structure with a "v" at the end of the number.

3.3.1 Data Collection

The structure database was constructed from the following data sources. Building footprints were obtained from Metro Nashville and geospatial queries were performed to remove outbuildings and small additional structures from that dataset. The remaining footprint layer was spatially joined with the Metro Nashville Assessor's office parcel dataset. Analysis was performed to mitigate multiple structures on single parcel improvements assessment. This data was then exported to excel for the FDA analysis.

3.3.2 Residential Structures

Residential structures were classified first by whether they are a single or multi-family home then structures were delineated by number of stories and presence of basement.

Structures for the four (4) streams were sorted by stream, damage category, and structure occupancy type. Depreciated replacement value estimates were made with the Marshall and Swift Estimator were made for a stratified 20% sample that was selected by the aforementioned criteria that the structures were sorted by. To avoid estimating the same general valued type of structure, it was attempted to estimate lower, middle and higher-end valued structures in each damage category and occupancy type. Samples were taken from each stream; however some streams had more residential than commercial type structures and vice versa. Data from Metro-Davidson County's property tax records provided pertinent information such as the effective age, roof type, exterior type, and general condition which was input into the Marshall and Swift Estimator.

Table 7 displays residential structure occupancy type, structure count and depreciated structure value by stream.

Content values of residential structures were calculated based on US Army Corps of Engineers Economic Guidance Memorandum #04-01. FDA assumes content value to be 100% of structure value which was employed for this analysis. The Institute for Water Resources (IWR) generic residential depth damage functions was used for the analysis.

3.3.3 Commercial and Industrial Structures

Non-residential structure values were retrieved initially from Metro Davidson County's tax assessor's office and are from the 2011 assessment. These values were used as reference points while actual depreciated replacement costs were calculated using Marshall and Swifts Commercial and Agriculture Estimator to October 2014 price levels for all non-residential structures. Structures were categorized by damage categories. The counts of non-residential structures along with total depreciated replacement costs per category are displayed in Table 8. Content values and depth-damage curves for non-residential structures were estimated using generic curves developed by IWR. Each specific curve is assigned a percentage factor to account for contents. Non-residential depth-damage functions used in this analysis are displayed in Table 9 below. A small number of structures with large content values were inventoried during a 2009 Mill Creek analysis. These content values were brought up to FY 2015 level using the Civil Works Construction Cost Index System (CWCCIS) indices.

Table 7: Residential Structures

Mill Creek		
Structure Occupancy Type	**Structure Count**	**Structure DPR Values $=1,000's**
SFR - 1 Story No Basement	289	23,811.5
SFR - 1 Story With Basement	68	5,361.8
SFR - 2 Story No Basement	110	9,836.8
SFR - 2 Story With Basement	1	45.5
SFR - Split Level No Basement	97	6,527.5
SFR - Split Level With Basement	5	612.0
MFR – Apartments	39	33,348.7
Mobile Homes	61	724.0
Mill Creek Total	670	80,267.8
Seven Mile Creek		
SFR - 1 Story No Basement	208	18,277.3
SFR - 1 Story With Basement	30	2,650.4
SFR - 2 Story No Basement	10	1,263.0
SFR - 2 Story With Basement	1	197.0
SFR - Split Level No Basement	38	3,703.8
SFR - Split Level With Basement	1	218.3
MFR – Apartments	95	2,791.2
Seven Mile Creek Total	383	29,101.0
Sorghum Branch		
SFR - 1 Story No Basement	31	2,362.1
SFR - 1 Story With Basement	13	991.9
SFR - Split Level No Basement	5	498.4
MFR – Apartments	11	18,983.9
Sorghum Branch Total	60	22,836.3
Whittemore Branch		
SFR - 1 Story No Basement	84	5,436.9
SFR - 1 Story With Basement	10	860.3
SFR - 2 Story No Basement	10	867.5
SFR - Split Level No Basement	32	2,480.7
Whittemore Branch Total	136	9,645.4

Table 8: Non-Residential Structures

Mill Creek		
Damage Category Type	**Structure Count**	**Structure DPR Values $=1,000's**
Commercial	169	120,961.2
Industrial	19	25,635.2
Public	3	3,795.0
Mill Creek Total	191	150,391.4
Seven Mile Creek		
Commercial	18	18,439.3
Public	1	30.0
Seven Mile Creek Total	19	18,469.3
Sorghum Branch		
Commercial	5	6,124.5
Industrial	1	4,960.0
Public	1	189.5
Sorghum Branch Total	7	11,274.0
Whittemore Branch		
Public	2	450.7
Whittemore Branch Total	2	450.7

After initial runs of the FDA software, damages to several structures within the Mill Creek and Tributaries 500-/year footprint appeared to not represent historic damages. The following list identifies the actions taken to evaluate, confirm, and redefine the data utilized in the structure inventory.

Approximately 20 structures were field surveyed to confirm a valid first floor elevation (FFE) was being employed. FFE's for certain structures were adjusted in the SID.

Structure values for a small number of structures were readdressed and edited accordingly.

River stations were reviewed for a small number of structures to ensure correct data was being used in the analysis.

Describe the shapes of the various distributions used in HEC-FDA. - Distribution shapes used in the Mill Creek Basin study are as follows: Uncertainty distributions of structure values, first floor elevations and content-to-structure value ratios for all structures used a normal distribution, which is bell-shaped in nature. Occupancy type uncertainty distributions of single family residential structures and automobiles are also normal distributions. Occupancy type uncertainty distributions for all non-residential and multi-family residences are triangular distributions. These had an upper limit and lower limit and the best estimate that creates the "triangle", which is usually not symmetrical in nature.

The occupancy types (i.e. depth-damage functions) used in the study were originally developed and constructed with uncertainty described by the distributions. These were based on statistical analysis of empirical data conducted by the Corps' Institute of Water Resources for single family residential and automobile functions, which are normal distributions. These were based on expert elicitation conducted by the New Orleans District for multi-family and non-residential functions, which have triangular distributions. The occupancy types were imported with the distributions already in-place and applied in the study with their original distributions. First floors elevations (FFE) and structure values used normal distributions because it is thought that values above and below the best estimates are equally likely.. Since a majority of the first floor elevations were either provided by Metropolitan-Davidson County or the District using conventional level, a standard deviation of 0.03 feet was used, which is displayed in EM 1110-2-1619 Table 6-5. Due to the uncertainty in non-residential structure values, a 20% standard deviation was used for this type structure. Single family residential structures used a 15% standard deviation in the structure value for the analysis.

Table 9: Non-Residential Depth-Damage Functions

Cloth-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0	0	0	8.3	11.4	13.9	17.2	21.4	26.9	31.5	34.3	37.2	41.2	43.2	45.1
		STL	0	0	0	0	4.8	6	7.8	10.6	13.9	18.1	23.1	26.2	28.8	31.6	33.3	35.1
		STU	0	0.6	0.8	1.4	14.9	18.3	21.3	26.6	30.8	36.7	42.1	44.8	47.8	52.7	55	56.6
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0	12.3	29	38.4	46.3	55.4	70	79	89	95.7	97.9	97.9	99.3
		CTL	0	0	0	0	8.1	19.1	31	40	47	61.4	69.3	81.4	86.4	92.6	95.6	96.4
		CTU	0	0	0	0	17.4	37.4	46.7	54.9	65	80	85.6	95	96.4	97.9	99.3	99.3
		Struct	N		0.03		N		20		T	45	10	10		-901		
Conv-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0	0	0.3	10.2	14.1	18.5	21.9	28.7	35.5	40	44.4	49.5	53.3	54.5	56
		STL	0	0	0	0	6	8.4	11.2	14.4	20	26.3	30.7	35.9	39.1	43.4	45.4	46.9
		STU	0	0.8	0.8	1.3	16.5	20.8	25.4	29.8	35.7	41.9	47.2	53	55.9	59.5	61.1	62.5
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0	11.6	23.1	32.1	39.9	52.9	70.7	79.3	88	94.1	95.7	97.1	98.6
		CTL	0	-0.1	-0.1	0	6.5	15.1	21.6	28.4	37.6	55.6	65.7	71.6	78.1	80.4	81.3	81.4
		CTU	0	0	0	0	18.6	30.4	40.1	50	64	78.6	87.9	94.4	97.7	98.6	100	100
		Struct	N		0.03		N		20		T	34	10	10		-901		
Fast food-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0	0	0	10.4	14.4	19.9	25.6	32.8	41.6	47.1	52	56.9	60.5	63.4	65.1
		STL	0	0	0	0	6	8.6	12.6	18.7	23.5	33.3	40.4	45.8	49.6	53.3	57.4	58.4
		STU	0	0.8	0.8	1.2	17.7	22.7	28.9	38.1	43.4	51.3	56.8	61.4	66.4	70.2	72.2	73.2
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0	10.6	21.3	29.4	38.6	52.7	62.6	73	79.3	88.3	94.9	98.6	98.6
		CTL	0	0	0	0	5	15	21.4	28.7	39.9	49.4	65.4	72.9	82.9	88	94.3	94.3
		CTU	0	0	0	0	16.4	31.3	38.4	51.4	62.3	72.7	79.6	83.6	95.7	98	98.6	98.6
		Struct	N		0.03		N		20		T	27.2	10	10		-901		

Grocery-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0	0	0.1	7.1	10.1	13	16.4	20.8	26.7	30.6	34.4	37.8	41.5	43.3	45.5
		STL	0	0	0	0	4.1	5	6.9	9.7	13.3	17.8	21.9	25.8	28.4	31.4	33.3	35
		STU	0	0.8	0.8	1.5	13.4	16.5	20.1	25.6	30	35.8	41.2	44.7	48.3	52.6	54.6	56.7
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0	24	30.7	36.8	40.9	52.9	64	75.4	87.3	98.9	100	100	100
		CTL	0	0	0	0	17.9	23.9	30.7	36.4	45.3	53.9	67.1	77.1	92.3	94.1	95	95
		CTU	0	0	0	0.2	26.8	35.9	42.1	48.6	63.3	74	87.6	94.7	99.4	100	100	100
		Struct	N		0.03		N		20		T	70	10	10		-901		
Med-Pre-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0.3	0.7	1.3	8.4	12.8	16.3	21	27.9	37.2	40.9	51.9	56.6	61.7	66	67.8
		STL	0	0	0	0	4.7	7.2	9.7	14.5	19.3	27.2	31.5	39.6	45.1	52.6	56.1	59.3
		STU	0	1.1	1.4	2.9	14.4	17.9	22.9	28.8	36.3	44.8	49.9	58.8	63.5	68.7	71.3	73.4
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0	9	14.3	18.4	26.9	40.4	57.1	67.3	75.4	82.3	91.3	96.3	96.9
		CTL	0	0	0	0	5.6	10.3	15	21.9	32.8	46.8	59.1	66.3	73.8	83.8	91.9	92.5
		CTU	0	0	0	0	13.9	21.3	26.9	42.5	52.6	63.3	75	82.3	86.9	94.1	98.1	99.4
		Struct	N		0.03		N		20		T	69.2	10	10		-901		
Office-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0.4	0.4	0.9	9.3	12.3	14.9	17.5	22.2	26.8	30.7	34.7	41.2	46.5	49.4	53.6
		STL	0	0.3	0.3	0.4	5.1	6.9	9.2	11.6	15.4	18.7	22	25.4	30.7	34.5	37.9	39.3
		STU	0	1.1	1.1	2	14	18	21.6	25.4	30.3	35.3	41	44.1	50.3	57.7	60.4	64.6
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0.7	0.7	1	14.3	20	26	34.3	45.4	55	63.9	73.3	76.4	83.4	89.3	91.4
		CTL	0	0.5	0.6	0.7	7.3	13.6	17.9	23.7	34.3	43.6	51.9	59.7	64.4	73.6	79.3	81.9
		CTU	0	1.2	1.3	1.5	22.1	29.3	33.6	41.4	54.6	63.6	71.4	79.6	82.9	85.7	92.1	96.4
		Struct	N		0.03		N		20		T	18.1	10	10		-901		
Office-Pre-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0.8	0.8	1.6	9.9	13.5	16.8	19.4	25.4	30.5	33.5	38.6	45.7	51.1	55	59.1
		STL	0	0.3	0.3	0.4	5.2	7.5	10.3	13.4	18.3	22	24.2	29.1	34.4	39.8	43.7	44.7
		STU	0	1.5	1.5	3.2	14.4	18.4	23.6	27.8	34	39.9	43.8	47.6	55.1	62.4	65.7	70.1
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0.7	0.7	1	14.3	20	26	34.3	45.4	55	63.9	73.3	76.4	83.4	89.3	91.4
		CTL	0	0.5	0.6	0.7	7.3	13.6	17.9	23.7	34.3	43.6	51.9	59.7	64.4	73.6	79.3	81.9
		CTU	0	1.2	1.3	1.5	22.1	29.3	33.6	41.4	54.6	63.6	71.4	79.6	82.9	85.7	92.1	96.4
		Struct	N		0.03		N		20		T	20.8	10	10		-901		
Pub-rec-Eng	PUB	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0	0	0	8.1	11.9	15.4	20.2	26	32.2	36.8	40.7	43.4	47.4	49.4	51.6
		STL	0	0	0	0	4	5.8	8.5	11.8	16.9	23.3	28	32	34.7	38	39.7	41.7
		STU	0	0.6	0.8	1.6	14.4	18.4	22	27.9	34.5	40.4	45.6	49.8	52.2	57.1	58.9	60.6
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0	16.9	25.7	31.4	43.7	62.7	72.9	80	84	91.1	95	95	95
		CTL	0	0	0	0	9.1	17.9	24.4	33.1	50	66	71.3	77.9	85.7	88.6	90.9	91.4
		CTU	0	0	0	0	22.4	32.7	44.1	54.3	71.6	81.6	86.1	89.9	95.3	95.9	97.9	97.9
		Struct	N		0.03		N		20		T	24.6	10	10		-901		
Pub-school-Eng	PUB	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0	0	0.1	7	9.7	12.4	15.3	18.9	24	27.9	31	34.8	39.1	40.8	43
		STL	0	0	0	0	3.8	4.4	6	8.3	10.9	15	18	21.3	24	26	27.4	29.1
		STU	0	0.6	0.8	1.7	12.9	15.8	19.4	23	27.3	33.1	38.4	41.2	45.8	51.3	53.2	55

		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0.4	11.7	16.4	21.9	28.9	40.9	57.7	63.3	70.7	79.3	84.3	87.1	87.1
		CTL	0	0	0	0	7.2	11.6	15.7	23.7	32.9	44.4	50.7	58.4	70.6	74.3	76.4	77.9
		CTU	0	0	0	0.7	16.2	21.6	29.1	35.7	50.9	67	74.3	78.3	84	88	90	90
		Struct	N		0.03		N		20		T	6.5	10	10		-901		
Rec-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0	0	0	8.1	11.9	15.4	20.2	26	32.2	36.8	40.7	43.4	47.4	49.4	51.6
		STL	0	0	0	0	4	5.8	8.5	11.8	16.9	23.3	28	32	34.7	38	39.7	41.7
		STU	0	0.6	0.8	1.6	14.4	18.4	22	27.9	34.5	40.4	45.6	49.8	52.2	57.1	58.9	60.6
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0	16.9	25.7	31.4	43.7	62.7	72.9	80	84	91.1	95	95	95
		CTL	0	0	0	0	9.1	17.9	24.4	33.1	50	66	71.3	77.9	85.7	88.6	90.9	91.4
		CTU	0	0	0	0	22.4	32.7	44.1	54.3	71.6	81.6	86.1	89.9	95.3	95.9	97.9	97.9
		Struct	N		0.03		N		20		T	24.6	10	10		-901		
Rest.-Pre-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0.3	0.3	1.9	14.8	19.4	25.3	32.4	41	49.6	56.3	63.9	67.2	71.3	72.7	73.5
		STL	0	0	0	0.5	8.9	13.1	18.1	24.8	33	40.3	47	55.6	59.6	64.4	66.3	67
		STU	0	1.7	1.7	3.6	21.7	26.4	35.5	42.1	49.9	58.4	64.9	71.4	76	77.4	79.1	79.7
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0	17.1	27.7	35.9	48.9	57.3	71.9	79.7	84.9	92.9	93.4	94.3	94.3
		CTL	0	0	0	0	10.7	20.4	27.9	37.3	45.6	63.3	72.1	78.3	86.3	90	90.9	91.4
		CTU	0	0	0	0	22.9	34.6	42.9	52.1	63.7	78.4	86.6	90	96.3	97.1	97.1	97.1
		Struct	N		0.03		N		20		T	25.8	10	10		-901		
Ser.-related-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0	0	0.1	7	9.7	12.4	15.3	18.9	24	27.9	31	34.8	39.1	40.8	43
		STL	0	0	0	0	3.8	4.4	6	8.3	10.9	15	18	21.3	24	26	27.4	29.1
		STU	0	0.6	0.8	1.7	12.9	15.8	19.4	23	27.3	33.1	38.4	41.2	45.8	51.3	53.2	55
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0.4	11.7	16.4	21.9	28.9	40.9	57.7	63.3	70.7	79.3	84.3	87.1	87.1
		CTL	0	0	0	0	7.2	11.6	15.7	23.7	32.9	44.4	50.7	58.4	70.6	74.3	76.4	77.9
		CTU	0	0	0	0.7	16.2	21.6	29.1	35.7	50.9	67	74.3	78.3	84	88	90	90
		Struct	N		0.03		N		20		T	66	10	10		-901		
Wrehouse-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0	0	0	7.1	10.2	13.3	16.7	20.4	25.5	29.7	32.8	35.5	39.6	42.5	44.5
		STL	0	0	0	0	3.6	4.5	6.2	8.9	11.9	15.9	19	22.4	24.6	26.7	29.2	30.8
		STU	0	0.6	0.8	1.6	13.6	17	20.6	25	28.7	35.1	40.4	43.3	46.2	51.2	53.9	55.9
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0	13.4	20.7	27.6	33.7	47.4	56.9	65.6	73.6	81.3	88.4	91.6	93.6
		CTL	0	0	0	0	7.1	12.3	19.3	25.4	35.7	48.3	57.3	65.9	74.9	81.4	84.1	88.1
		CTU	0	0	0	0	21.1	28	35.6	45.6	57	67.7	76	82.4	89.7	94.1	98.3	99.3
		Struct	N		0.03		N		20		T	83.8	10	10		-901		

3.3.4 Vehicles

Each residential structure was assigned 1 vehicle per structure with a value of $10,000. Values were ascertained using interviews with Metropolitan Davidson County Clerk's office to establish an estimate of per vehicle value. Each vehicle was input into the SID as pseudo structures at the same location as the residence it represented with a FFE of

3 feet below the residential structure itself. PDT elevation surveys and site analysis resulted in the decisions on vehicle FFE and structure FFE. With approximately 160 floodway structures and another approximately 100 structures in the 2 or 5 year flood event elevations, the typical FFE for the study area is going to be 3' above grade, taking into account crawl space, basements, etc. Additionally, structures along Edmondson Pike, Suter Dr, Paragon Mills Rd, Benzing Rd, and Wimpole Dr, located on the creek side of the street, generally maintain structure FFEs below road grade. The slope of the terrain there determines that the residents there park in the rear of the structures, which based upon the slope can be as much as 10' below grade. Based upon the survey data (over 90% of structures have been surveyed) the PDT determined that a 3' below FFE for vehicles is a valid estimate. The key determining factors for that are the terrain and the significant number of structures that are built on downslopes towards the creek. Automobile depth-damage functions with uncertainty were obtained from IWR. Further detail on structure database methodology is provided in the Geospatial Information Systems (GIS) Appendix. The depth-damage function used for vehicles is displayed in Table 10, which follows.

Table 10: Vehicle Depth-Damage Function

Vehicles	Stage	0	0.5	1	2	3	4	5	6	7	8	9	10
	S	0	5.2	24.1	41.9	57.6	71.4	83.1	92.5	97	99.4	100	100
	SN	0	5.2	4.2	3.3	2.8	2.6	3	3.8	4.2	4.4	4.7	4.7
	Struct	N		3		N		30			-901		

3.4 Reach Characteristics Figure 2 represents Mill Creek and tributary damage reaches. Table 11 illustrates the delineation of the reaches and lists the reaches by title, description and river station while Figure 2 gives a visual representation of the streams and assorted reaches within the study area. Table 12 displays number of structures by damage category with total depreciated replacement value per reach per stream.

Table 11: Streams and Reaches Included in the Mill Creek Study Area

Stream	Reach Name	Station Reference	Downstream Station	Upstream Station	Description
Mill_Creek	MC Reach 1	Miles	0.145	3.983	Massman Dr / Wilhagen Rd (Mile 0.145 to 3.983)
Mill_Creek	MC Reach 2	Miles	3.983	4.863	Murfreesboro Pike (Mile 3.983 to 4.863)
Mill_Creek	MC Reach 3	Miles	4.863	7.343	Wimpole Drive / Thompson Lane (Mile 4.86 to 7.34)

Stream	Reach Name	Station Reference	Downstream Station	Upstream Station	Description
Mill_Creek	MC Reach 4	Miles	7.343	10.557	Space Park/Harding Industrial (Mile 7.34 to 10.56)
Mill_Creek	MC Reach 5	Miles	10.557	14.533	Antioch Pike (Mile 10.56 to 14.53)
Mill_Creek	MC Reach 6	Miles	14.533	17.358	Above Bell Road (Mile 14.53 to 17.36)
Mill_Creek	MC Reach 7	Miles	17.358	21.120	Above Old Hickory Blvd (Mile 17.36 to 21.12)
Sevenmile Creek	SM Reach 1	Feet	0	6,606	Paragon Mills (Mile 0.00 to 1.25)
Sevenmile Creek	SM Reach 2	Feet	6,606	11817	Nolensville Rd (Mile 1.25 to 2.24)
Sevenmile Creek	SM Reach 3	Feet	11,817	19,439	Blackman Rd (Mile 2.24 to 3.68)
Sevenmile Creek	SM Reach 4	Feet	19,439	27,802	Above Ellington Ag Center (Mile 3.68 to 5.26)
Sevenmile Creek	SM Reach 5	Feet	27,802	37,112	Above Old Hickory Blvd (Mile 5.26 to 7.03)
Sorghum Branch	SB Reach 1	Feet	0	19,254	Sorghum Branch (Mile 0.00 to 3.65)
Whittemore Branch	WB Reach 1	Feet	0	18,589	Whittemore Branch (Mile 0.00 to 3.52)

Table 12: Structure Inventory by Stream and Reach

Mill Creek						
Reach	Number of Structures in Reach	Residential	Commercial	Industrial	Public	Structure Values $'s=1,000's
MC-1	258	214	32	12	0	51,551.7
MC-2	40	22	18	0	0	17,723.8
MC-3	188	179	9	0	0	20,044.4
MC-4	68	37	25	6	0	67,391.7
MC-5	166	82	80	1	3	41,127.1
MC-6	124	124	0	0	0	11,000.7
MC-7	16	12	4	0	0	6,729.7
	860	670	168	19	3	215,569.1

Reach	Number of Structures in Reach	Residential	Commercial	Industrial	Public	Structure Values $'s=1,000's
Seven Mile Creek						
SM-1	119	118	0	0	1	9,165.3
SM-2	129	112	17	0	0	19,564.1
SM-3	135	135	0	0	0	13,004.2
SM-4	10	9	1	0	0	4,027.4
SM-5	7	7	0	0	0	1,354.4
	400	381	18	0	1	47,115.4
Sorghum Branch						
SB-1	67	60	5	1	1	17745.3
Whittemore Branch						
WB-1	138	136	0	0	2	10,456.1

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

3.6 Without Project Condition

3.6.1 Structures, Content, and Vehicle: EAD and Single Event Damages
Expected Annual Damages (EAD) was calculated for damages to structures, contents and vehicles by the FDA software model. Table 13 displays the existing and future without project estimates of EAD's as calculated in FDA for each stream by reach. Table 14 displays EAD's for existing and future without project conditions by damage category.

Table 13: Equivalent Annual Damages, Existing and Future Without Project

Mill Creek		
Reach	Existing WOP EAD's $ = 1,000's	FWOP EAD's $ = 1,000's
MC-1	282.27	307.36
MC-2	253.19	323.43
MC-3	358.87	408.32

Reach	Existing WOP EAD's $ = 1,000's	FWOP EAD's $ = 1,000's
MC-4	891.77	956.99
MC-5	326.41	353.89
MC-6	20.30	21.72
MC-7	110.99	114.95
Total	2243.80	2,486.66
Seven Mile Creek		
SM-1	730.58	713.74
SM-2	477.72	488.87
SM-3	735.62	759.33
SM-4	210.76	214.02
SM-5	1.09	17.24
Total	2155.76	2,193.20
Sorghum Branch		
SB-1	389.35	389.35
Whittemore Branch		
WB-1	387.68	387.68

Table 14: EAD's by Stream and Damage Category

Sevenmile Creek					
EAD's by Damage Category					
$'s = 1,000's					
	Commercial	Industrial	Public	Residential/Vehicle	Total
Existing Conditions	56.52	0.00	1.83	2,097.41	2,155.76
Future Conditions	57.89	0.00	1.98	2,133.33	2,193.20
Mill Creek					
EAD's by Damage Category					
$'s = 1,000's					
	Commercial	Industrial	Public	Residential/Vehicle	
Existing Conditions	1,576.73	133.70	3.62	529.45	2,243.50
Future Conditions	1,753.98	146.08	4.19	582.41	2,486.66
Sorghum Branch					
EAD's by Damage Category					
$'s = 1,000's					
	Commercial	Industrial	Public	Residential/Vehicle	
Existing Conditions	9.77	0.00	0.00	379.58	389.35
Future Conditions	9.77	0.00	0.00	379.58	389.35
Whittemore Branch					
EAD's by Damage Category					
$'s = 1,000's					
	Commercial	Industrial	Public	Residential/Vehicle	
Existing Conditions	0.00	0.00	0.65	387.03	387.68
Future Conditions	0.00	0.00	0.65	387.03	387.68
Mill Creek and Tributaries					
EAD's by Damage Category					
$'s = 1,000's					
	Commercial	Industrial	Public	Residential/Vehicle	
Existing Conditions	1,643.02	133.70	6.10	3,393.47	5,176.29
Future Conditions	1,821.64	146.08	6.82	3,482.35	5,456.89

Without project estimates of single-event damages in each of the streams reaches in the study area for specified events are displayed in Table 15, which follows.

Table 15: Single Event Damages, Future Without Project Condition

Mill Creek								
	Annual Chance Exceedance (Recurrence Interval) Damages							
	0.5 (2-Year)	0.2 (5-Year)	0.1 (10-Year)	0.04 (25-Year)	0.02 (50-Year)	0.01 (100-Year)	0.005 (200-Year)	0.002 (500-Year)
Reach MC-1								
Damage ($)	0	0	3.57	19.22	1,240.60	7,707.51	16,144.87	28,006.45
Structures (#)	0	0	2	7	22	66	345	438
Reach MC-2								
Damage ($)	123.53	337.91	627.84	857.14	1,143.32	2,082.71	3,223.43	6,155.22
Structures (#)	1	1	1	3	4	29	40	58
Reach MC-3								
Damage ($)	168.73	305.74	691.84	1107.92	1788.94	2903.42	4221.08	6593.78
Structures (#)	23	36	67	95	133	200	260	325
Reach MC-4								
Damage ($)	0	1.36	7.38	26.35	4,989.22	25,415.56	38,557.59	58,770.83
Structures (#)	0	1	3	7	27	60	71	86
Reach MC-5								
Damage ($)	23.56	38.73	402.07	1,589.80	3,110.83	4,892.18	8,199.70	15,731.12
Structures (#)	3	7	35	67	104	148	181	214
Reach MC-6								
Damage ($)	0	0	4.91	22.35	58.88	129.51	288.33	885.16
Structures (#)	0	0	3	6	11	34	82	164
Reach MC-7								
Damage ($)	44.84	76.11	179.53	179.53	295.88	362.22	1810.1	3168.34
Structures (#)	6	10	12	13	16	18	21	22
Total								
Damage ($)	360.66	759.85	1917.14	3802.31	12627.67	43493.11	72445.1	119310.9
Structures (#)	33	55	123	198	317	555	1000	1307

Table 16 Continued: Single Event Damages, Future Without Project Condition

Seven Mile Creek								
	Annual Chance Exceedance (Recurrence Interval) Damages							
	0.5 (2-Year)	0.2 (5-Year)	0.1 (10-Year)	0.04 (25-Year)	0.02 (50-Year)	0.01 (100-Year)	0.005 (200-Year)	0.002 (500-Year)
Reach SM-1								
Damage ($)	439.05	681.39	1,034.98	1,538.04	1,538.04	2,484.59	3,048.74	4,111.94
Structures (#)	86	113	132	153	163	177	191	222
Reach SM-2								
Damage ($)	221.83	335.65	828.27	1,183.96	1,553.54	2,012.62	2,311.83	3,014.65
Structures (#)	34	65	91	122	158	164	179	206
Reach SM-3								
Damage ($)	344.86	616.63	1,195.07	1,966.01	2,741.16	3,558.85	4,357.96	5,670.82
Structures (#)	75	138	196	226	241	247	258	265
Reach SM-4								
Damage ($)	198.66	225.26	240.4	262.15	277.22	290.69	307.55	323.66
Structures (#)	4	4	4	4	5	6	10	10
Reach SM-5								
Damage ($)	0	6.37	32.51	81.25	108.92	144.38	182.63	219.37
Structures (#)	0	5	7	8	8	8	10	13
Total								
Damage ($)	1,204.40	1,865.30	3,331.23	5,031.41	6,218.88	8,491.13	10,208.71	13,340.44
Structures (#)	199	325	430	513	575	602	648	716
Sorghum Branch								
	Annual Chance Exceedance (Recurrence Interval) Damages							
	0.5 (2-Year)	0.2 (5-Year)	0.1 (10-Year)	0.04 (25-Year)	0.02 (50-Year)	0.01 (100-Year)	0.005 (200-Year)	0.002 (500-Year)
Reach SB-1								
Damage ($)	228.30	425.06	662.39	876.95	1,002.06	1,197.16	1,400.40	1,646.55
Structures (#)	33	51	61	66	68	72	77	81
Whittemore Branch								
	Annual Chance Exceedance (Recurrence Interval) Damages							
	0.5 (2-Year)	0.2 (5-Year)	0.1 (10-Year)	0.04 (25-Year)	0.02 (50-Year)	0.01 (100-Year)	0.005 (200-Year)	0.002 (500-Year)
Reach WB-1								
Damage ($)	227.72	366.69	577.73	876.06	1,226.46	1,575.64	1,927.68	2,477.29
Structures (#)	40	58	91	123	154	174	186	204

Mill Creek Basin								
	Annual Chance Exceedance (Recurrence Interval) Damages							
	0.5 (2-Year)	0.2 (5-Year)	0.1 (10-Year)	0.04 (25-Year)	0.02 (50-Year)	0.01 (100-Year)	0.005 (200-Year)	0.002 (500-Year)
Damage ($)	2,021.08	3,416.90	6,488.49	10,586.73	21,075.07	54,757.04	85,981.89	136,775.18
Structures (#)	305	489	705	900	1114	1403	1911	2308

3.6.2 Other Damages

3.6.2.1 Emergency Protection Measures
Emergency costs are incurred by government agencies in the aftermath of flood events and were determined using procedures developed in a study by the U.S. Army Engineer District, Louisville, Kentucky. This study, titled Flood Damage Report for Frankfort, Kentucky, July 1981, provided a basis for estimating these types of costs. Emergency costs were computed using a unit cost for each structure based on the number of structures by frequency in the FDA program which was being considered for non-structural measures. Given that total expected annual damage for emergency costs equaled less than $1,000 for involved structures and the differences among plans was insignificant, calculation of emergency costs for alternative plans was not included in the analysis, but can be added later if resources permit and added value is identified.

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

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

3.3.2.3 National Flood Insurance Program Costs
National Flood Insurance Program (NFIP) administrative costs are applicable under the guidance of Economic Guidance Memorandum (EGM) 06-04 dated 6 April 2006. The aforementioned EGM for 2006 lists an average cost of policy is $192. This cost per policy will be incorporated in the non-structural portion of the analysis on the 80 structures being bought out. None of the structural measures eliminated the need for individual policies.

4. Benefit Analysis

4.1 Non-Structural Analysis

4.1.1 Plan A

As per ER 1105-2-100 analysis of the non-structural (NS) measure was conducted concurrently with structural measures. To analyze the benefits of non-structural residential buyouts plans, the study manager, economist, and GIS specialist used FDA output and GIS to identify and analyze "footprint" potential residential buyouts. Structures used in the non-structural measure provided the best overall BCR which matched maximizing buyouts while keeping social and physical connectivity in the forefront of the selection process. This was in keeping with the local sponsors wishes concerning the non-structural measure. A more in-depth description of the selection process can be found in main body of the report. Specific methodology and assumptions for the non-structural analysis are presented in the following paragraphs.

The NS analysis was developed entirely within the HEC-FDA certified model. To account for NS benefits it was required to make additional HEC-FDA runs with the SID adjusted to account for buyouts and raises. Residential structures which are identified to be bought were removed from the NS HEC-FDA model. Structures which are to be raised had the first floor elevation in the SID adjusted to 1-foot above the 100-year event. This adjusted first floor elevation was ascertained within the HEC-FDA detailed output from the original HEC-FDA analysis. The NS SID was then run within the HEC-FDA model and compared to the with project conditions where applicable and to the without project conditions for those streams where the structural measure did not apply. Damages from this model run were then subtracted from the original HEC-FDA analysis damages to produce NS benefits for the study. A total of 216 residential structures were identified as potential buyouts using the aforementioned criteria.

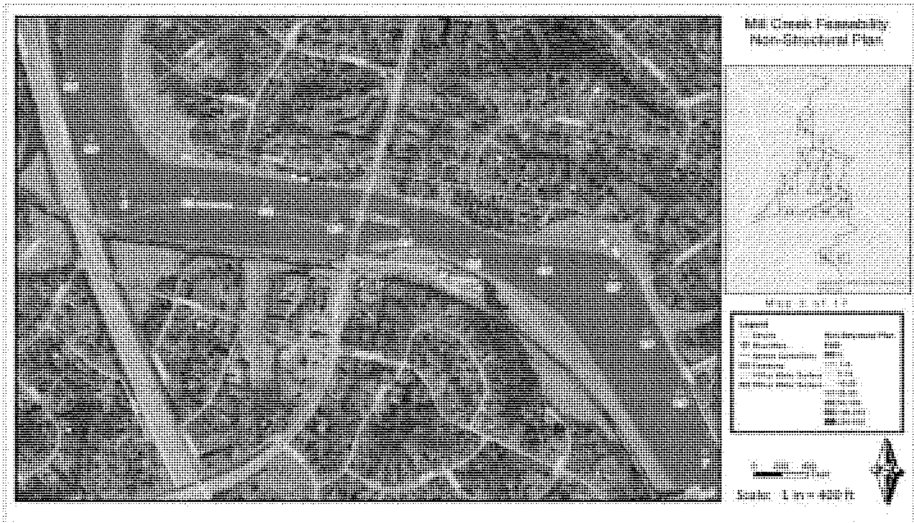


Figure 2: Example of Non-Structural Buyouts

Economic project costs for the non-structural measure was established by taking Metro Davidson County's full appraised value for the residential structure with an additional $28,130 added to account for relocation and administrative costs incurred. Costs were annualized using the appropriate discount rate of 3.3750% and a 50-year project life.

The total project costs for the recommended plan are based upon the gross appraisal values for the improved structure and lands to be purchased. As stated above, removal or demolition costs also factor into the total project cost. The gross appraisals used for the cost estimate take into account not only the structure value, but also the comparisons of all recently sold properties in the general area. Therefore, the gross appraisals are not limited to floodway/floodplain structures. This meets the requirements spelled out in general guidance of WRDA 1999, Section 219, Items 3a-3b. The appraised/improved values take into account the neighborhood as a whole, not the individual structure. Referencing the Section 219 guidance above, the flood-free structures factored into the gross appraisals. In addition to the above description, Real Estate regulations require payment-reimbursement of buyouts to depend upon these gross appraisals. The Real Estate plan describes these requirements and associated costs in further detail.

The aforementioned 216 structures considered for being bought out were also analyzed incorporating raising the residential structure to meet the requirements of FEMA and Metro Davidson County. Of the 216 considered 15 were built on slab and were unable to be raised and 1 structure would have had to have been raised 14 feet which is 2 feet higher than3 the Non-Structural PCX in Omaha suggests. Thus the raising measure considered 198 structures.

EAD's for the 198 structures was calculated in the same manner described in Section 4.1.1 Buyouts of this appendix. While FEMA has requirements to raise to the 100-year event plus 1-foot Metro Davidson County requires raising to the 100-year event plus 4-feet. Using "FDA Detailed Output" the appropriate amount the structure had to be raised was calculated for each of the 198 structures to meet Metro Davidson County's requirements. Amount of raise ranged from 0.76 feet to a high of 14.49 feet. Average amount of raising for the 9 structures was 5.53 feet.

The cost to estimate residential structures was calculated by utilizing equations based upon structure square footage. The equations are displayed in Table 17 which follows.

Table 17: Estimated Cost to Elevate Residential Structures

Estimated Cost to Elevate One-Story Residential Structures		
Square Foot Range	**Cost to Elevate Without Basements**	**Cost to Elevate With Basements**
0 - 1,250	1,000*(2.43*Raising Elevation+62.50)	1,000*(3.10*Raising Elevation+87.50)
1,250 - 1,750	1,000*(2.53*Raising Elevation+65.50)	1,000*(3.23*Raising Elevation+91.00)
1,750 - above	1,000*(2.87*Raising Elevation+72.00)	1,000*(3.53*Raising Elevation+101.00)
Estimated Cost to Elevate Two-Story Residential Structures		
Square Foot Range	**Cost to Elevate Without Basements**	**Cost to Elevate With Basements**
0 - 1,250	1,000*(3.07*Raising Elevation+71.00)	1,000*(3.77*Raising Elevation+96.00)
1,250 - 1,750	1,000*(3.17*Raising Elevation+74.50)	1,000*(3.87*Raising Elevation+100.50)
1,750 - above	1,000*(3.50*Raising Elevation+82.50)	1,000*(4.33*Raising Elevation+110.50)

Table 18 below displays the selected non-structural measure with total number of structures selected. As seen in the table the buyout measure generates over $953,000 in net benefits and eliminates a majority of the residual risk for the structures considered. A further description of the iterations of the non-structural analysis is discussed in detail in the main body of the report.

Table 18: Non-Structural Analysis

Mill Creek and Tributaries Non-Structural Analysis $=1,000's, Interest Rate 3.375%	
	Plan A
Total Structures	**90**
Total Without Project Damages	**5,456.89**
Total Annual Benefits	**1,751.60**
Total Project Costs	19,162.00
Total Annual Cost	798.62
Benefit Cost Ratio	**2.19**
Net Annual Benefits	**952.98**

4.2 Structural Measures Analysis
In the plan formulation process, varieties of structural measures were created and analyzed using the FDA model. Several structural measures were eliminated for either lack of performance or identified as cost prohibitive. All plans analyzed which were eliminated are discussed in more detail in the main body of this report. The following paragraphs provide a brief description of the structural measures carried forward.

Plan B – Ellington Agricultural Center Bridge Modification
A detention site was selected on Sevenmile Creek at river mile 3.7 located at the Ellington Agriculture Center Entrance Bridge. The measure captures 7.9 square miles, 45% of Sevenmile Creek total watershed. The low level outlet will pass normal flow and require no manual or mechanical operation. The embankment would act as a weir or spillway for flows exceeding the 5-year frequency event. The design of this structure targets reductions in the more frequent (less than a 50-year) flood events. The embankment section will be a combination of roller compacted concrete and compacted-earth. The HEC-HMS model used to calculate frequency discharges for future conditions was modified to represent the storage and outflow characteristics of the proposed measure. The resulting "with project" discharges were then placed in the calibrated HEC-RAS models to calculate frequency-flood profiles structural measures.

Figure 3, which follows shows the site of the Ellington Bridge modification site.

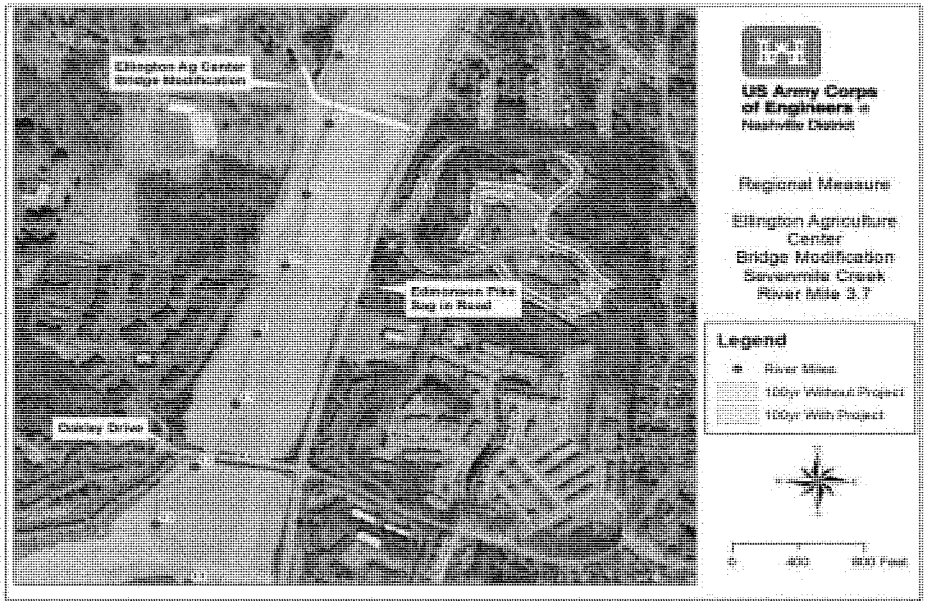


Figure 3: Plan B - Ellington Agricultural Center Bridge Modification Measure

Plan C - RCC Structure Old Hickory Boulevard

Regional approaches can often produce more economical and effective results than numerous small flood damage reduction projects. The regional detention structures recommended in the 1985 study are impractical today because the storage areas, the natural river valley upstream, have been partially developed. A new site was selected on Mill Creek at river mile 18.0, approximately 0.6 miles upstream from Old Hickory Boulevard and 1.2 miles upstream from the previous detention site. The measure captures 43.0 square miles, 40% of total Mill Creek watershed. The low level outlet will pass normal flow and require no manual or mechanical operation. The embankment acts as a weir or spillway for flows exceeding the 10-year frequency event. The embankment section will be Roller Compacted Concrete and have a vertical upstream face, a 1:1 downstream face with a 15-foot top width. The HEC-HMS model used to calculate frequency discharges for future conditions was modified to represent the storage and outflow characteristics of the proposed measure. The resulting "with project" discharges were then placed in the calibrated HEC-RAS models to calculate frequency-flood profiles.

Figure 4 shows the RCC structure on Old Hickory Boulevard. Table 19 displays the performance of the RCC structure.

Figure 4: Plan C - RCC Structure Old Hickory Boulevard

Plan D2 – Briley Parkway Bridge Modification

Bridges with significant head loss in target damage centers were removed from the future conditions hydraulic models to evaluate water surface reductions and added benefits. Modifications to hydraulic model (HEC-RAS) cross-section geometry in the vicinity of selected bridges were made to reflect their removal. The intent was to locate bridges that could either be removed or modified to reduce flood damages. Mill Creek bridges included Murfreesboro Road (RM 4.814), Thompson Lane (RM 6.333), Briley Parkway (RM 7.059), CSX Railroad (RM 7.3), Space Park South Drive (RM 8.173), and abandoned railroad (RM 10.915), Franklin Limestone Road (RM 11.083), CSX Railroad RM 11.695 and Antioch Pike (RM 12.096). The HEC-RAS water surface profiles (.wsp files) were then used by the economist to calculate added benefits (reductions in Estimated Annual Damages). Briley Parkway was the only bridge modification to move forward past preliminary screening. The Briley Parkway bridge modification would include widening the east and west bound bridge openings by a minimum of 60 feet. Figure 5 which follows shows the Briley Parkway Bridge modification measure.

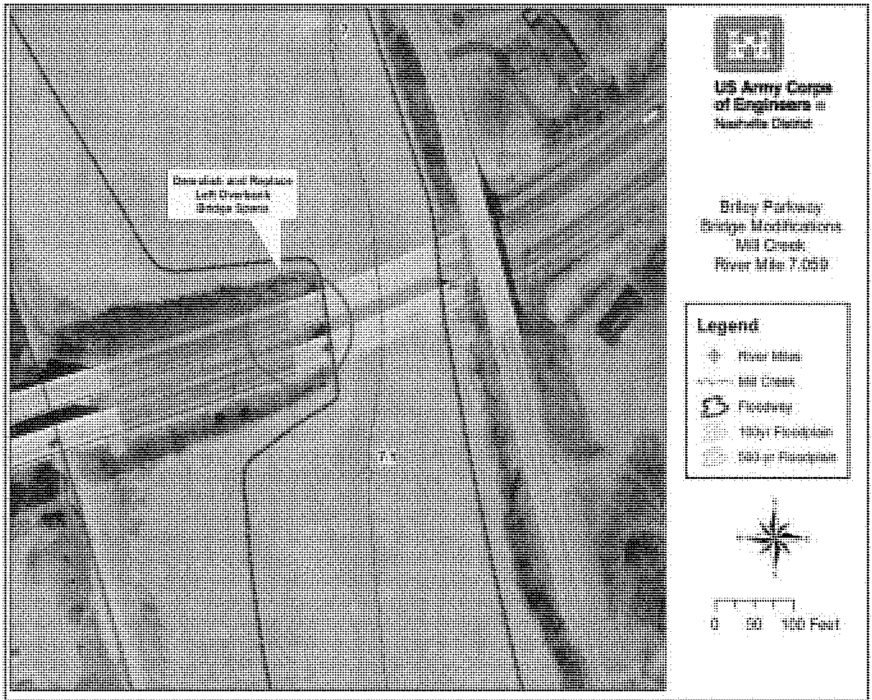


Figure 5: Plan D - Briley Parkway Bridge Modification Near Space Park

Plan E – Wimpole Drive Channel Improvement
Channel modifications were analyzed along Mill Creek in the vicinity of the Wimpole Drive residential damage center. The Wimpole Drive channel modifications included a 100-foot high-flow along the left and right overbanks between river mile 4.9 and 6.2 (Figure 10). The bench elevation would be approximately 5 to 8 feet above channel bottom. The future conditions hydraulic models were modified to include these channel modifications. Table 19 displays the performance of all structural measures.

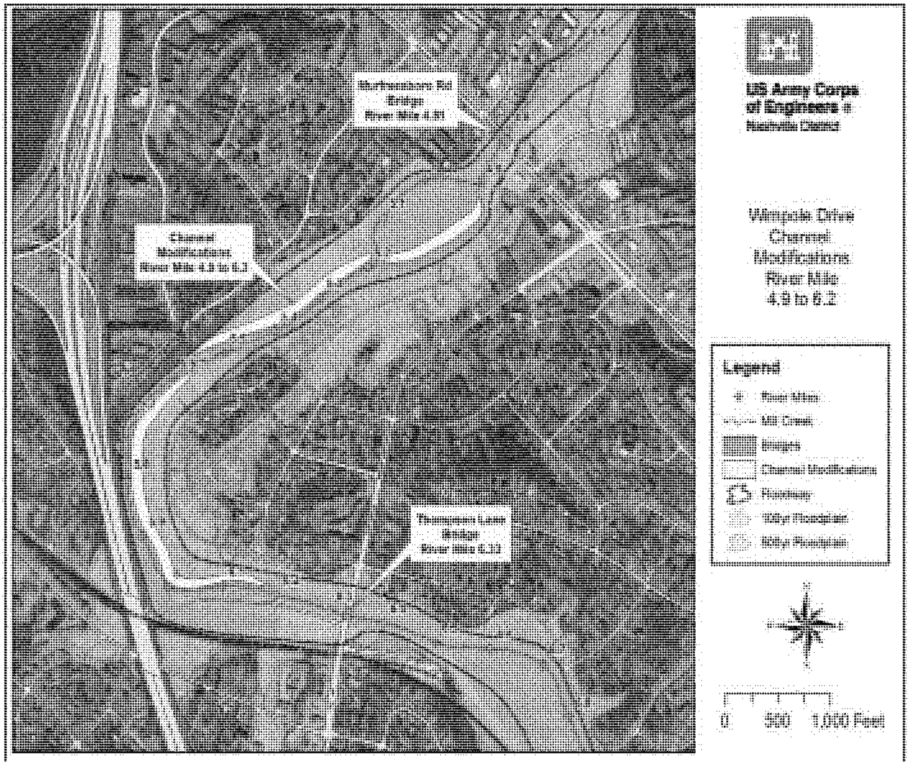


Figure 6: Plan E - Wimpole Drive Channel Modifications

Plan F – Vulcan Quarry

Stormwater diversion into the Vulcan quarry on the right bank of Mill Creek (between river mile 10.2 and 10.6) was evaluated. The measure captures 67 square miles, 62% of total Mill Creek watershed. The quarry alternative includes a diversion structure at river mile 10.25 that backs floodwaters into a gate/tunnel structure at river mile 10.36 spilling into the quarry (Figure 11). The measure is designed to start spilling into quarry at the 10-year frequency flood event. Flood hydrographs generated from the future conditions HEC-HMS model were used as input into an unsteady flow HEC-RAS model developed for the quarry alternative. Output hydrographs from the unsteady flow model were then put back into the HEC-HMS model to calculate the downstream frequency-flood discharges used in HEC-RAS.

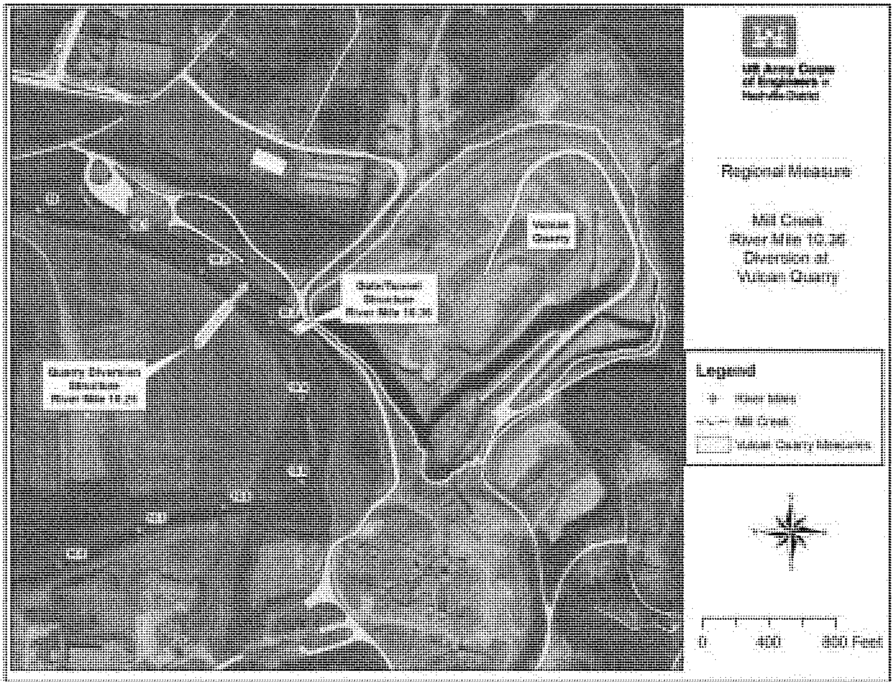


Figure 7: Plan F - Vulcan Quarry Diversion

Table 19 displays the cost, benefits, and economic performance of structural measures considered.

Table 19: Structural Analysis

Mill Creek and Tributaries					
Structural Analysis					
$=1,000's, Interest Rate 3.375%					
	Plan B	Plan C	Plan D	Plan E	Plan F
Total FWOP Damages	**5,456.89**	**5,456.89**	**5,456.89**	**5,456.89**	**5,456.89**
Total Annual Benefits	420.00	850.30	218.60	184.70	535.10
Annual NS Benefits*	0.00	0.00	0.00	0.00	0.00
Annual Structural Benefits	420.00	850.30	218.60	184.70	535.10
Total Project Costs	3,819.00	16,984.74	3,073.70	9,287.80	22,303.90
Non-Structural Costs	0.00	0.00	0.00	0.00	0.00
Structural Costs	6312.00	16,083.00	3,030.00	9,050.20	21,172.90
Interest During Construction	256.00	901.74	43.70	237.60	1,131.00
Total Annual Costs	311.11	832.88	142.45	442.09	1,054.57
Annual Cost	273.74	707.88	128.10	387.09	929.57
Annual O&M Cost	37.37	125.00	14.35	55.00	125.00
Benefit Cost Ratio	1.35	1.02	1.53	0.42	0.51
Net Annual Benefits	108.89	17.42	76.15	-257.39	-519.47

4.3 Alternative Analysis

Non-structural and structural measures were combined to create alternatives to maximize benefits where possible. The aforementioned FDA outputs were incorporated with the non-structural measure in the following manner. Section 4.1 Non-structural Analysis describes how NS benefits were accrued. Table 20 displays the alternative analysis for the Mill Creek Study.

Table 20: Alternative Analysis

Mill Creek and Tributaries							
Alternative Analysis							
$=1,000's, Interest rate 3.375%							
	Plan BA	Plan CA	Plan DA	Plan EA	Plan BC	Plan CD	Plan BDA
Total FWOP Damages	**5,456.89**	**5,456.89**	**5,456.89**	**5,456.89**	**5,456.89**	**5,456.89**	**5,456.89**
Total Annual Benefits	**2,171.60**	**2,601.90**	**1,970.20**	**2,942.30**	**1,262.66**	**1,068.90**	**2,390.20**
Annual NS Benefits*	1,751.60	1,751.60	1,751.60	2,757.60	0.00	0.00	1,751.60
Annual Structural Benefits	420.00	850.30	218.60	184.70	1,262.66	1,068.90	638.60
Total Project Costs	**28,002.60**	**35,245.00**	**22,192.00**	**54,063.80**	**23,552.74**	**20,058.44**	**28,780.32**
Non-Structural Costs	19,162.00	19,162.00	19,162.00	42,503.40	0.00	0.00	19,162.00
Structural Costs	6,312.00	16,083.00	3,030.00	9,050.20	22,395.00	19,113.00	9,342.00
IDC	2,528.60	**	**	2,510.20	1,157.74	945.44	276.32
Total Annual Costs	**1,204.44**	**1,593.91**	**939.25**	**2,308.23**	**1,143.61**	**975.98**	**1,251.20**
Annual Cost	1,167.07	1,468.91	924.90	2,253.23	981.61	835.98	1,199.48
Annual O&M Cost	37.0	125.00	15.0	55.00	162.00	140.00	52.0
Benefit Cost Ratio	**1.80**	**1.63**	**2.10**	**1.27**	**1.10**	**1.09**	**1.91**
Net Annual Benefits	**967.16**	**1,007.99**	**1,030.95**	**634.07**	**119.05**	**92.92**	**1,139.00**

*Includes NFIP Costs – 15.30 and Vehicle Damages 657.30
** IDC included in costs

Plan BDA (non-structural measure, Space Park Briley Bridge Modification, Ellington B1`ridge) is the alternative which optimizes net annual benefits and is the NED or tentatively selected plan. Alternative BDA reduces annual without project damages by over 43% and is a true representative of a regional plan for the Mill Creek basin. Since the flood of 2010 Davidson County developed and installed an exceptional flood warning system. Davidson County's FWEEP is now being used as an example by other municipalities throughout the state of Tennessee. It is estimated that their flood warning system could alleviate up to another 10% of the residual EAD's not addressed by Plan BDA.

Table 22 presents the benefit cost analysis for the NED plan and includes interest during construction (IDC) and annual operations and maintenance (O&M) costs.

Table 21: NED Plan (Plan BDA)

Mill Creek and Tributaries	
Tentatively Selected Plan - BDA	
$'s = 1,000's, Discount Rate = 3.125%	
Total FWOP Damages	**5,456.89**
Total Annual Benefits	**2,390.20**
Annual NS Benefits*	1,751.60
Annual Structural Benefits	638.60
Total Project Cost	**28,780.32**
Non-Structural Cost	19,162.00
Structural Cost	9,342.00
Interest During Construction	276.32
Total Annual Cost	**1,196.97**
Annual Cost	1,145.25
Annual O&M Costs	51.72
Benefit Cost Ratio	**2.00**
Net Annual Benefits	**1,193.23**

*Includes NFIP Costs – 15.30 and Vehicle Damages 657.30

4.4 Risk and Uncertainty

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

4.4.1 First Floor Elevations

Identification of first floor elevations (FFE) was discussed in Section 3.2 of this appendix. Error associated with deriving FFE's was incorporated in FDA after the DQC of this document following guidelines set forth respectively as to how the FFE was derived.

4.4.2 Structure Value

As described earlier in this appendix structure values were initially obtained from Metro Davidson County's Tax Assessor's office. Sampling of each structure type was then input into Marshall and Swift's Residential and Commercial Estimator to establish depreciated replacement costs. Error associated with the structure values were entered as normal distribution with a 2.5 percent standard deviation.

4.4.3 H&H Exceedance Probability Functions

Functions were derived and provided by H&H Branch using the "Graphical from WSP" function using Log Pearson III statistics with a period of 20 to 46 year equivalent record length within the FDA program for each reach, respectively.

4.4.4 H&H Stage-Discharge Function

Functions were derived and provided by the H&H Branch using the "Retrieve from WSP" function using Normal Distribution. Defined uncertainty was calculated for each reach within each stream for without project and all measures considered with the standard deviation of error being entered into the FDA program as defined by the H&H engineer.

5. Cost Analysis

5.1 Project Cost Estimates

Cost estimates were calculated by the Nashville Districts Cost Estimating Branch and provided to the economist. The Cost Estimating Appendix gives an in-depth description of procedures and assumptions in the calculation of the estimates.

5.2 Operations and Maintenance

Operations and maintenance schedules were developed by PDT members from cost estimating, design and planning and are incorporated in the analysis.

5.3 Interest During Construction

Construction schedules were not developed at the time this appendix was being prepared, but will be incorporated to all measures and alternatives at a later date.

The following formula will be used:

IDC = (((1+r)^(n*12)-1)/r))*(p/(n*12))-p; where r=monthly interest rate, n=construction period of months, and p=total project costs.

Interest during construction was calculated for the final array of measures/alternatives using FY 2015 discount rate of 3.375%. Construction periods were developed by the PDT. The NED plan had a period of construction of 36 months for the structural measures and the non-structural portion did not require IDC due to contracts being un 12 months. All other structural measures IDC was calculated with a 24-month construction period.

6. Analysis of Economic Viability

6.1 Economic Analysis Sensitivity

Table 22 below displays the economic viability performed on the NED plan (Plan BDA) using the current discount rate of 3.375% and the OMB rate of 7.0% to test the viability of the economic analysis.

Table 23 displays the sensitivity of the NED plan (BDA) when compared with different NS participation rate and with other structural alternatives. Plan BDA with 100% participation out performs in terms of annual net benefits all other plans including structural alternatives. The most likely NS participation rate of 74%, as displayed combined with BD still out performs structural measures.

Table 22: Economic Analysis Viability

Mill Creek and Tributaries		
NED Plan (Plan BDA) Alternative Viability Analysis		
$=1,000's, Discount Rate 3.125%		
	Plan BDA 3.375% Interest Rate	Plan BDA 7.0% Interest Rate
Total FWOP Damages	**5,456.89**	**5,456.89**
Total Annual Benefits	2,390.20	2,390.20
Annual NS Benefits*	1,751.60	1,751.60
Annual Structural Benefits	638.60	638.60
Total Project Costs	28,780.32	28,780.32
Non-Structural Costs	19,192.00	19,162.00
Structural Costs	9,342.00	9,342.00
Interest During Construction	276.32	276.32
Total Annual Costs	**1,196.97**	**2,137.14**
Annual Cost	1,145.25	2,085.42
Annual O&M Cost	51.72	51.72
Benefit Cost Ratio	**2.00**	**1.12**
Net Annual Benefits	**1,193.23**	**253.06**

*Includes NFIP Costs – 15.30 and
Vehicle Damages 657.30

Table 23: Economic Sensitivity Analysis

Mill Creek and Tributaries			
Tentatively Selected Plan Sensitivity Analysis			
$'s = 1,000's, Discount Rate = 3.125%			
	Plan BDA NED Plan	**Alt. BC**	**Alt. CD**
Total Annual Benefits	2,390.20	**1,262.66**	**1,068.90**
Annual NS Benefits	1,751.60	0.00	0.00
Annual Structural Benefits	638.60	1,262.66	1,068.90
Total Project Cost	28,780.32	**23,552.74**	**20,058.44**
NS Cost	19,162.00	0.00	0.00
Structural Cost	9,342.00	22,395.00	19,113.00
IDC	276.32	1,157.74	945.44
Total Annual Cost	**1,196.97**	**1,087.23**	**975.18**
Annual Cost	1,145.25	937.23	798.18
Annual O&M Costs	51.72	150.00	177.00
Benefit Cost Ratio	**2.00**	**1.16**	**1.10**
Net Annual Benefits	**1,193.23**	**175.43**	**93.72**

6.2 Monte Carlo Analysis of Viability
This viability test will be included prior to ATR using FDA information and guidelines set forth in ER-11058-2-101.

7. Financial Analysis

7.1 Cost apportionment
Cost apportionment and cost share requirements are discussed fully in section 4.6 of the main body of the report.

7.2 Ability to Pay Analysis
Metro-Davidson County is not be eligible for a reduction in their share due to the ability to pay analysis. .

7.3 Financial Capability
Metro Davidson County, Tennessee has stated that it is capable and will to cost share in the project. Davidson County has an exemplary history in cost sharing projects with the Nashville District and no reason exists that it will continue in the future.

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

Appendix B
Real Estate Plan

REAL ESTATE PLAN

Mill Creek Feasibility Study

Nashville, Tennessee

Table of Contents

1 Purpose

The purpose of this Real Estate Plan is to provide real estate acquisition cost estimates for lands required for the completion of the Mill Creek Flood Risk Management Study, Nashville, Tennessee. The study serves to provide recommendations for reducing significant flood damages around the Mill Creek Watershed. The Metropolitan Government of Nashville and Davidson County, Department of Water Services (Metro) will be the non-federal sponsor (NFS) for this proposed project. A letter of intent is provided as attachment 2. Real estate costs will be estimates for the recommended plan which involves mandatory acquisition of approximately 80 residential structures and 9 raises, a bridge modification at Briley Parkway, and Ellington Agricultural Center Regional Detention. The bridge modification at Briley Parkway includes the removal of fill underneath the bridge along with the addition of one bridge span and a new pier to support this span. The alternative at the Ellington Agricultural Center includes the elevation and replacement of the current state owned access road to the Ellington Agricultural Center to create a detention basin which will alleviate flooding downstream.

This study is a partial response to the following resolutions, focusing on flood damage reduction in the Mill Creek watershed of Davidson County, Tennessee. Study authority is granted by two resolutions of the US House Committee on Transportation and Infrastructure adopted on 14 September, 1995, and 7 December 2005.

This report, prepared in accordance with ER 405-1-12, Real Estate Plan (REP), presents the real estate requirements for the Mill Creek Flood Risk Management Study. This REP is Appendix B to the draft Feasibility Study and Environmental Assessment. It is tentative in nature and preliminary for planning purposes only. The plan includes estimated land values and costs associated with the acquisition of lands, easements, and rights-of-way. It also identifies any facility/utility relocations necessary to implement the project. Anticipated requirements for lands, easements, rights-of-way, relocations and disposal areas (LERRD) are based on field inspections by Real Estate Division personnel and information furnished by the project development team. The final real property acquisition lines and estimates of value are subject to change even after approval of the Feasibility Study and Environmental Assessment.

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

The proposed project combines the mandatory nonstructural acquisition and demolition of residential structures impacted by the 5-year flood event with a bridge modification to Briley Parkway located just downstream of the confluence of Seven Mile Creek and Mill Creek and a detention basin located along Seven Mile Creek just upstream of its confluence with Brentwood Branch . The recommended plan has the potential to remove nearly half of the expected annual damages associated with Mill Creek and tributary flooding. The nonstructural portion of the project would involve mandatory fee acquisition of 80 properties located along Mill Creek and its tributaries Seven Mile Creek, Sorghum Branch, and Whittemore Branch. The residences are single family with the exception of five duplexes. There are also 9 residential structures to be raised as part of the nonstructural portion of the project. Only a Right of Entry will be required for the structures approved to be raised. Access to these properties will be provided by public roads. The plan calls to use an "approved landfill" for the disposal of the demolished structures. Although the sponsor indicated a preference to execute a voluntary buy-out plan for the nonstructural portion of the plan, the sponsor has also indicated a willingness to administer a mandatory program using eminent domain if necessary.

The structural portion of the project includes a bridge modification at Briley Parkway that will include removal of fill previously used underneath the bridge in order to allow flow capacity closer to the original flood plain area. Briley Parkway serves as a major connecting freeway that feeds directly into Nashville's interstate system. Preliminary discussions with Metro and Tennessee Department of Transportation (TDOT) indicate the Briley Parkway Bridge Right of Way is owned by Metro and operated and maintained by TDOT. The ROW was initially purchased by Davidson County as part of the Federal Aid Secondary Roads Program using 25% Federal Funds. In the 1980s, Metro added the roadway and bridge to the state system and it is now TDOT responsibility for operation and maintenance. Preliminary indications are that all work associated with the bridge modifications, channel improvement, construction area, and access road will occur within the current Road ROW owned by Metro. It will not be necessary for Metro to acquire additional real estate interests in support of the project unless subsequent plans indicate additional lands are necessary. The plan calls to use an "approved landfill" for the disposal of the fill being removed from underneath the bridge, therefore, a disposal area will not be necessary.

The third aspect of the recommended plan includes the Ellington Agricultural Center Regional Detention. A detention site was selected on Sevenmile Creek at river mile 3.7 located at the Ellington Agriculture Center entrance bridge. The low level outlet will pass normal flow and require no manual or mechanical operation. The embankment will act as a weir or spillway for flows exceeding the 25-year frequency event. The design of this structure targets reductions in the high frequency (less than 50-year) flood events. The embankment section will be compacted earth, with armoring and stilling basin on the downstream face. The detention basin requires the elevation and replacement of the existing access road to the state facility.

The access road is owned by the state of Tennessee and accesses the Ellington Agricultural Center. There are six parcels involved with the lands necessary for the project. 0.83 of an acre of fee will be required from the State of Tennessee for the footprint of the road replacement in order to maintain the road and weir structure. Construction will cause a temporary closure of the access road but there are two other entrances/exits to the west of the property that can be used to access the property. 4.79 acres of temporary work area easement will be required for the staging and construction of the road replacement. 22.07 acres of flowage easement will also be required on State property for the detention basin. A flowage easement of 19.94 acres will be required on Metro owned property for the detention basin. An additional 0.731 of an acre of flowage easement will be required with four private property owners for the detention basin.

Additionally, as a result of the Regional detention, approximately 500 feet of Edmondson

Pike will need to be raised in order to prevent further flooding of properties to the east of Edmonson Pike. A temporary work area easement including 0.56 of an acre will be required from 3 property owners as well as permission from Tennessee Department of Transportation to alter the existing road. During road construction, it is planned for the road to remain open and construction limited to one lane at a time.

The proposed estates necessary for the project are as follows:

STANDARD ESTATE No. 1: FEE

The fee simple title to (the land described in Schedule A) 1/ (Tracts Nos. ___, ___, and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

STANDARD ESTATE No. 6: FLOWAGE EASEMENT (Occasional Flooding)

The perpetual right, power, privilege and easement occasionally to overflow, flood and submerge (the land described in Schedule A) (Tracts Nos. _____, ______, and _____). (and to maintain mosquito control) in connection with the operation and maintenance of the __________ project as authorized by the Act of Congress approved ___________, together with all right, title and interest in and to the structure; and improvements now situate on the land, except fencing (and also excepting ___________ (here identify those structures not designed for human habitation with the District Engineer determines may remain on the land)); provided that no structures for human habitation shall be constructed or maintained on the land, that no other structures shall be constructed or maintained on the land unless as may be approved by in writing by the representative of the United States in charge of the project, and that no excavation can shall be conducted an no landfill placed on the land without such approval as to the location and method of excavation and/or placement of landfill; the above estate is taken subject to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving however to the landowners, their heirs and assigns, all such rights and privileges as may be used and enjoyed without interfering with the use of the project for the purposed authorized by Congress or abridging the rights and easement hereby acquired; provided further that any use of the land shall be subject to Federal and State laws with respect to pollution.

STANDARD ESTATE No. 15: TEMPORARY WORK AREA EASEMENT

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____, and _____), for a period not to exceed _________________, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a work area, including the right to (borrow and/or deposit fill, spoil and waste material thereon) (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 _______________ Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowner, 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.

3 LERRD owned by Non-Federal Sponsor

Metro owns the property required for the Briley Bridge modifications, one of the tracts required for the Ellington Detention area, and the Edmonson Pike road right of way adjacent to the detention basin. The Nonstructural residences are not currently owned by the NFS. Title to properties acquired as part of the project will be held in the name of the NFS.

4 Non-Standard Estates

Non-standard estates will not be used for the proposed project. Only standard estate for Fee Simple, Flowage Easement, and Temporary Work Area Easement will be required for the project. Language pursuant to ER405-1-12 for these estates will be used.

5 Existing Federal Projects

Preliminary indications are that 25% Federal Funds were used for the Briley Parkway Right of Way as part of the Federal Aid Secondary Roads program. This will be given full consideration during LERRDs crediting as appropriate.

6 Federally Owned Land

There are no federally owned lands associated with the project. Although partial federal funds were used for the Briley Parkway Right of Way, these lands are currently owned by Metro.

7 Navigational Servitude

Mill Creek is a navigable stream and subject to navigational servitude. This involves the Briley Parkway Bridge portion of the project and approximately 10 nonstructural acquisitions. The tributaries Seven Mile Creek, Sorghum Branch and Whittemore Branch are not navigable streams and are not subject to navigational servitude. This includes the remaining buyouts and the Ellington Detention Area.

8 Maps depicting project area

A Mill Creek Watershed Vicinity Map (Figure 1) is shown below. All of the residences involved in the mandatory nonstructural fee acquisition are included in Davidson County although some of the Mill Creek watershed extends into Williamson County.

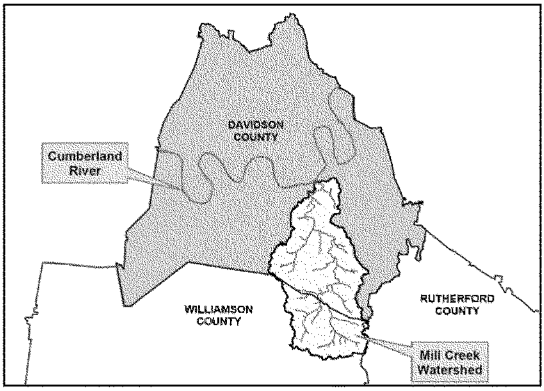


Figure 1. Mill Creek Watershed Vicinity Map

More detailed mapping for the project can be found at the end of this report as Exhibits "A-1" through "A-15".

9 Induced Flooding

No induced flooding will occur as a result of the nonstructural alternative or the Briley Parkway bridge modification. With current hydrology & hydraulics modeling, there are no increases in discharges, flood stages or velocities upstream or downstream from bridge modification or from proposed channel improvement. The removal of construction fill originally placed underneath the Briley Bridge will restore the natural floodway along the left overbank. The Ellington Detention Basin will require acquisition of flowage easement due to the depth and duration increases of the project. Approximately 42.74 acres of flowage easement will be acquired by the NFS to support the detention basin. These properties are shown on Exhibit "A-15".

10 Real Estate Cost Estimate

The real estate cost estimate at Table 1 includes the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate moving expenses for 85 relocations, and federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary. A 15% contingency is applied to the current estimate. Costs and contingency values for the Faciltiy/Utility relocation (item d) were provided by Engineering and Cost Estimating. Contingencies for these items are based on a certified MII cost estimate.

Table 1

Real Estate Costs (LERRDS)

Mill Creek Nonstructural, Briley Parkway Bridge Modification & Ellington Detention Basin Estimate

		Contingency	Total with Contingency
a. Land & Damages			
80 buyouts (nonstructural)	$11,846,050	15%	$13,622,958
Briley Bridge Modification	0		0
Ellington Detention Structure	$364,387	15%	$419,045
9 Raise in Place Structures	$737,390	15%	$848,000
b. P.L. 91-646 Relocation Costs	$762,250	15%	$876,588
c. Administrative Costs			
1. Nonstructural			
Federal (Review of NFS)	$510,000	15%	$586,500
Non-Federal	$850,000	15%	$977,500
2. Ellington Detention			
Federal (Review of NFS)	$42,000	15%	$48,300
Non-Federal	$70,000	15%	$80,500
d. Facility/Utility Relocation			
Briley Parkway Bridge	$1,325,466	37%	$1,815,888
Ellington Access Road	$332,683	44%	$479,064
Edmonson Pike	$505,406	44%	$727,785
Total	**$17,345,632**		**$20,482,128**

11 Relocation Assistance Benefits

No residences and/or businesses will be displaced by the Briley bridge modification or Ellington Detention Structure. There will be 80 properties considered for demolition included in the mandatory nonstructural portion of the project. These 80 properties include 5 Duplex structures and therefore 85 homeowners/tenants will be offered Relocation Assistance Benefits in accordance with the Uniform Act, PL 91-646. Relocation assistance will include moving expenses, supplemental rental assistance for tenants, and approved incidental expenses involved with moving to a new property. Relocation assistance payments were estimated for each property up to $9,450 based on square footage to estimate the number of rooms. Preliminary indications show that adequate housing is available within the local area for these relocations.

12 Mineral Activity

There is no known mineral activity associated with the project.

13 Non-Federal Sponsor Capability

An Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability is included as attachment 1 to this report. It is believed that Metro has sufficient capability to conduct acquisition of private property efficiently due to the fact that they have participated in other acquisition projects that involved federal funding.

14 Zoning

No zoning changes for the subject properties will occur with this proposed project.

15 Land Acquisition Milestones

Nonstructural Acquisitions

The mandatory real estate acquisitions of private properties associated with the nonstructural buyouts is expected to take one to two years after notice to proceed once the Project Partnership Agreement (PPA) is executed. Demolition contracts will be awarded as needed. There will be no construction schedule to consider with this portion of the project.

Briley Bridge Modification

The Briley Parkway Bridge Modification (Relocation) is scheduled to start in 2016 per the Detailed Project Report. It is anticipated to take about one year to complete and will be scheduled to start at the same time as residential acquisition. No real estate acquisition will be required for the bridge modification according to the current design.

Ellington Detention Basin

The Ellington Detention Basin is scheduled to begin in 2018 per the Detailed Project Report. It is anticipated to take about one year to complete and will be scheduled to start when appropriations are received for this project. The amount of time estimated to acquire estates from the five property owners would be approximately six months. Acquisition by the NFS will occur prior to solicitation for contract on the Ellington Agriculture Center road/bridge.

16 Facility or Utility Relocations

No Facility or Utility Relocations will be included in the nonstructural acquisition of private properties. The Briley Parkway Bridge Modification is considered a relocation per ER 1105-2-100: "Alterations to highway bridges necessitated by a flood control project are considered part of LERRD and are a non-Federal responsibility." Additionally, there are light poles, power lines and roadway storm water drainage that will need to be relocated as a result of the Briley Parkway Bridge modification. The bridge structure and roadway storm water drainage are owned by Metro and will be reimbursable expenses subsequent to relocation. The light poles and associated power lines are operated by Nashville Electric Service (NES). Although these utilities serve a public purpose, NES did not acquire specific real estate in this area and consequently, there is not a compensable interest for these utilities. NES will be required to relocate the light poles and power lines as a result of this project at their expense.

The Ellington Detention Basin requires elevation and replacement of the existing access road to Ellington Agricultural Center which is a state owned facility. This road is owned by the State of Tennessee. The state has a compensable interest in the road, and the relocation of this road will be the responsibility of the NFS.

As a result of the detention basin, approximately 500 linear feet of Edmonson Pike will be raised to prevent flooding for the properties to the east of the road. The current ownership of Edmonson Pike in this area belongs to Metro. Metro owns a compensable interest in Edmonson Pike and the relocation of this road will be the responsibility of the NFS.

Any conclusion or categorization contained in this report that an item is a utility or facility relocation to be performed by the NFS 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 the final Attorney's Opinion of Compensability for each of the impacted utilities and facilities.

17 Hazardous, Toxic and Radioactive Waste (HTRW)

According to the Phase 1 Environmental Site Assessment Measure in the Mill Creek project area (September 2013) there are no known current environmental conditions that would impact the proposed work at Damage Center 2 which includes the Briley Parkway bridge modification area. Additionally, Phase I HTRW has been conducted for the buyout structures, and the environmental records review and site visit did not indicate a recognizable environmental liability or condition within the five stretches of Mill Creek and tributaries where the nonstructural buyouts will occur as a result of this project. The environmental record search and site visit did not indicate an environmental liability or condition within the Ellington Agricultural Center subject area that would interfere with the proposed project.

18 Project Opposition

Response has been generally favorable from the State and Local Agencies. Presently there is no known public opposition to this project.

19 Risk Notification

The non-federal sponsor was notified in writing on 12 February 2014 regarding the risks of acquiring land for this project in advance of the Project Partnership Agreement execution.

20 Other Real Estate Issues

There are currently no other Real Estate issues at this time.

ATTACHMENT 1

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

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? (yes/no)

b. Does the sponsor have the power of eminent domain for this project? (yes/no)

c. Does the sponsor have "quick-take" authority for this project? (yes/no)

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary? (yes/no)

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? (yes/no)

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? (yes/no)

b. If the answer to II.a. is "yes," has a reasonable plan been developed to provide such training? (yes/no) n/a

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? (yes/no)

d. Is the sponsor's projected in-house staffing level sufficient considering its other work load, if any, and the project schedule? (yes/no)

e. Can the sponsor obtain contractor support, if required in a timely fashion? (yes/no)

f. Will the sponsor likely request USACE assistance in acquiring real estate? (yes/no) (If "yes," provide description)

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? (yes/no)

b. Has the sponsor approved the project/real estate schedule/milestones? (yes/no)

IV. Overall Assessment:

a. Has the sponsor performed satisfactorily on other USACE projects? (yes/no/not applicable)

b. With regard to this project, the sponsor is anticipated to be: highly capable/fully capable/moderately capable/marginally capable/insufficiently capable. (If sponsor is believed to be "insufficiently capable," provide explanation)

V. Coordination:

a. Has this assessment been coordinated with the sponsor? (yes/no)

b. Does the sponsor concur with this assessment? (yes/no) (If "no," provide explanation)

Prepared by:

Mary C. Keith

Mary C. Keith
Realty Specialist

Reviewed and approved by:

Michael J. Callahan

Michael J. Callahan
Chief, Technical Resources Branch
Real Estate Division

Attachment 2

KARL F. DEAN
MAYOR

METROPOLITAN GOVERNMENT OF NASHVILLE AND DAVIDSON COUNTY

DEPARTMENT OF WATER AND SEWERAGE SERVICES
1600 SECOND AVENUE, NORTH
NASHVILLE, TENNESSEE 37208-2206

July 18, 2014

Dear LTC Hudson,

This letter is to confirm that Metropolitan Government of Nashville and Davidson County (Metro) is a committed participant in the Mill Creek Flood Risk Management Project being proposed in the ongoing feasibility study. At this time the plan includes structural measures in conjunction with the non-structural buyout of homes that have been substantially damaged by previous flooding and are located in the floodway of Mill Creek and several tributaries.

As it has been Metro's practice in all past home buyout projects, to the extent practicable, acquisition would be on a willing seller basis. Subject to approval by its Council and Mayor, Metro has the authority to exercise eminent domain within Metro/Davidson County for valid public purposes. Though never the preferred option, eminent domain could be utilized if determined to be warranted. Conditions that warrant this option could include but are not limited to:

* The homes are subject to cumulative substantial damage or cumulative substantial improvement requirements. The properties are not in compliance with required freeboard requirements which require the lowest finished floor to be four feet above the 1% flood.

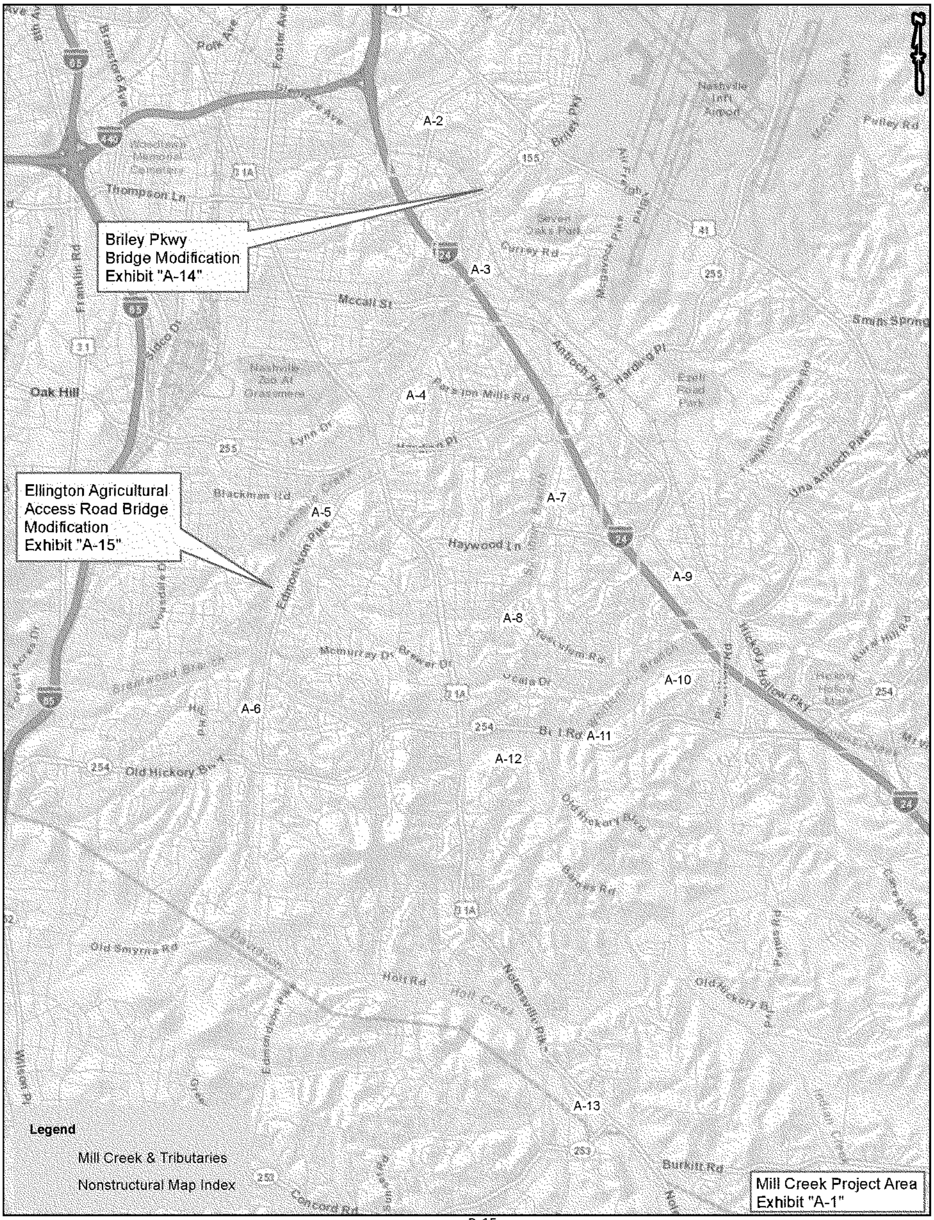
* The homes are located in the regulatory floodway. The floodway is an extremely hazardous area because of the velocity of floodwaters, which can carry debris and potential projectiles. There are threats to life and safety related to structures within the floodway based upon depth of flood waters and velocity of flows. There are also associated risks to our emergency responders when evacuating these areas.

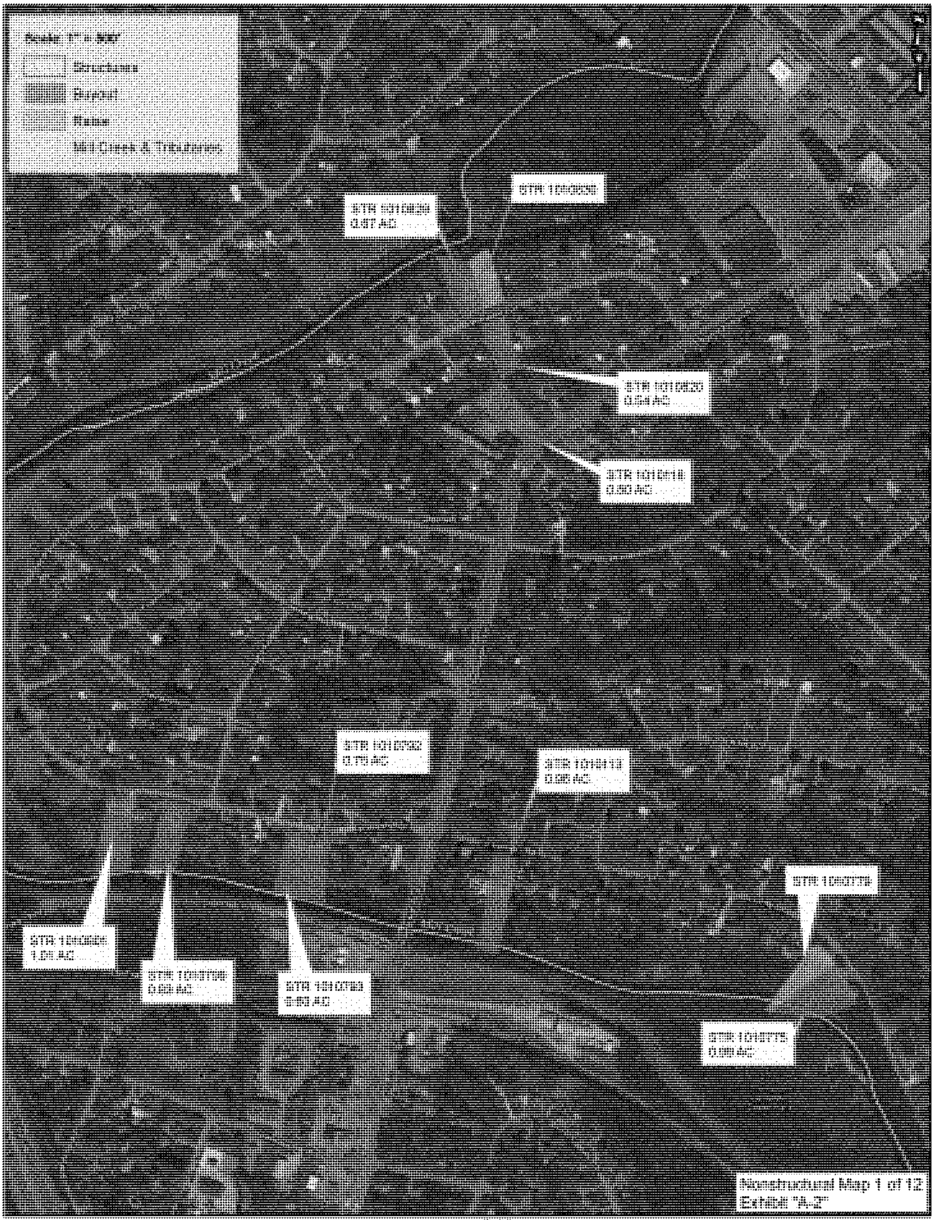
* The removal of these homes and related obstructions in the floodway will provide significant benefits for those floodplain properties that are ineligible for this buyout program. Preserving existing floodway storage and providing additional floodway storage in the Mill Creek watershed is an effective measure to attenuate future floods.

Sincerely,

Scott Potter, PE
Director, Metro Water Services

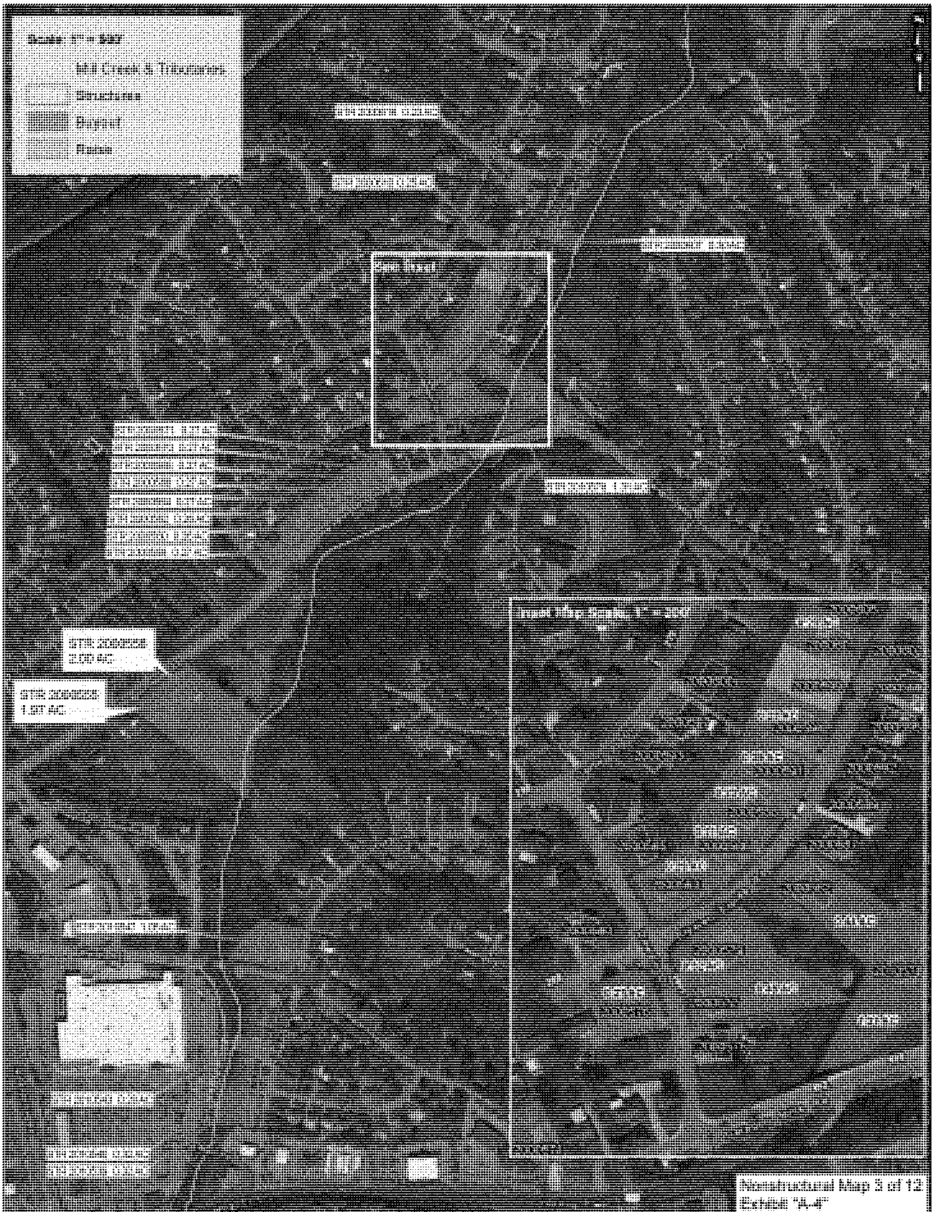
cc: Mr. Mike Wilson, US Army Corps of Engineers
Mr. Russ Rote, US Army Corps of Engineers
Mr. Marty Szeigis, Mayor's Office
Mr. Tom Palko, Metro Water Services
Mr. Roger Lindsey, Metro Water Services
Mr. Jim Snyder, Metro Water Services


Briley Pkwy
Bridge Modification
Exhibit "A-14"
Ellington Agricultural
Access Road Bridge
Modification
Exhibit "A-15"
A-2
A-3
A-4
A-5
A-6
A-7
A-8
A-9
A-10
A-11
A-12
A-13
Legend
Mill Creek & Tributaries
Nonstructural Map Index
Mill Creek Project Area
Exhibit "A-1"


Structures
Buyout
Raise
Mill Creek & Tributaries
Nonstructural Map 1 of 12
Exhibit "A-2"

B-15


Mill Creek & Tributaries
Structures
Buyout
Raise
Nonstructural Map 2 of 12
Exhibit "A-3"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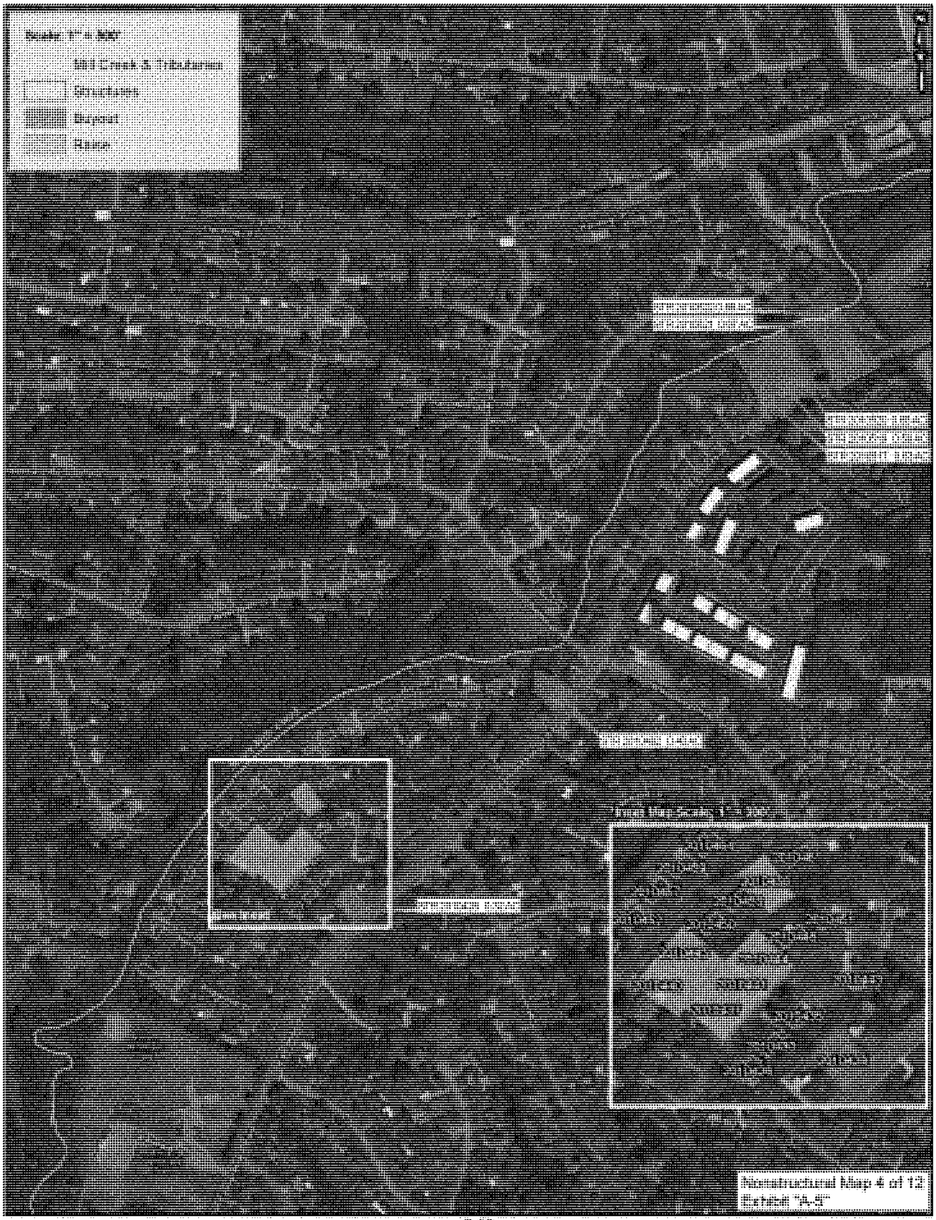
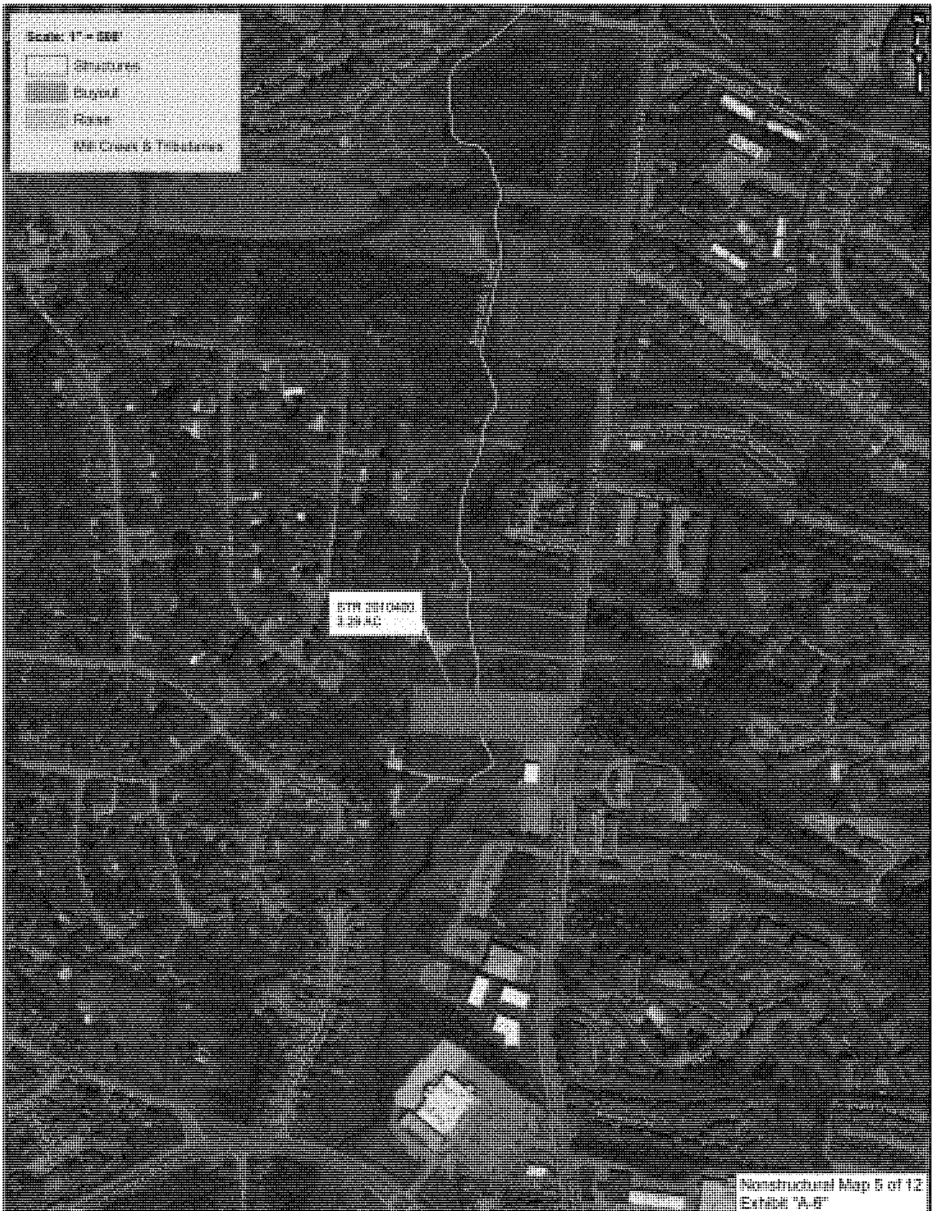
Structures
Buyout
Raise
Nonstructural Map 3 of 12
Exhibit "A-4"


Mill Creek & Tributaries
Structures
Buyout
Raise
Nonstructural Map 4 of 12
Exhibit "A-5"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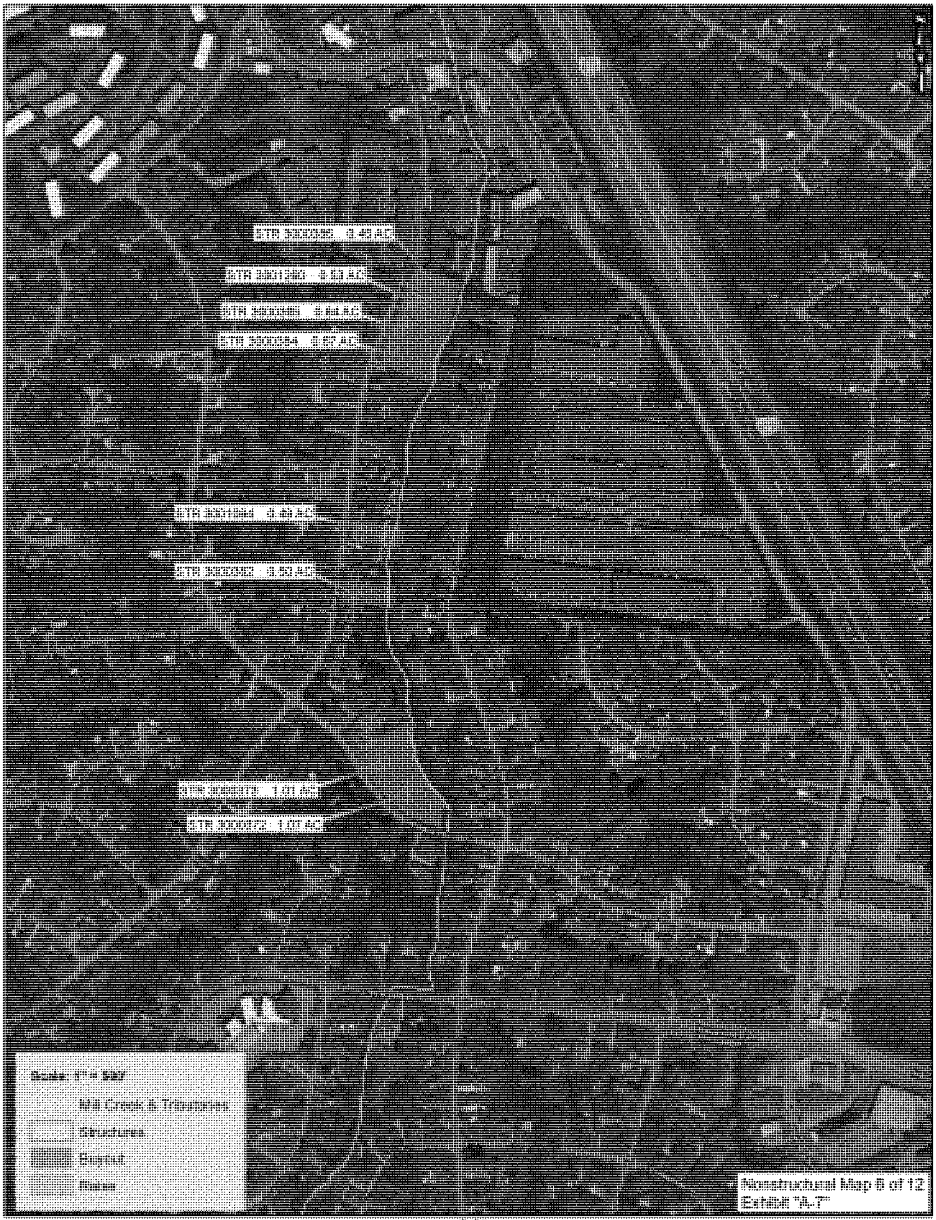
Buyout
Raise
Mill Creek & Tributaries
Nonstructural Map 5 of 12
Exhibit "A-5"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Buyout
Raise
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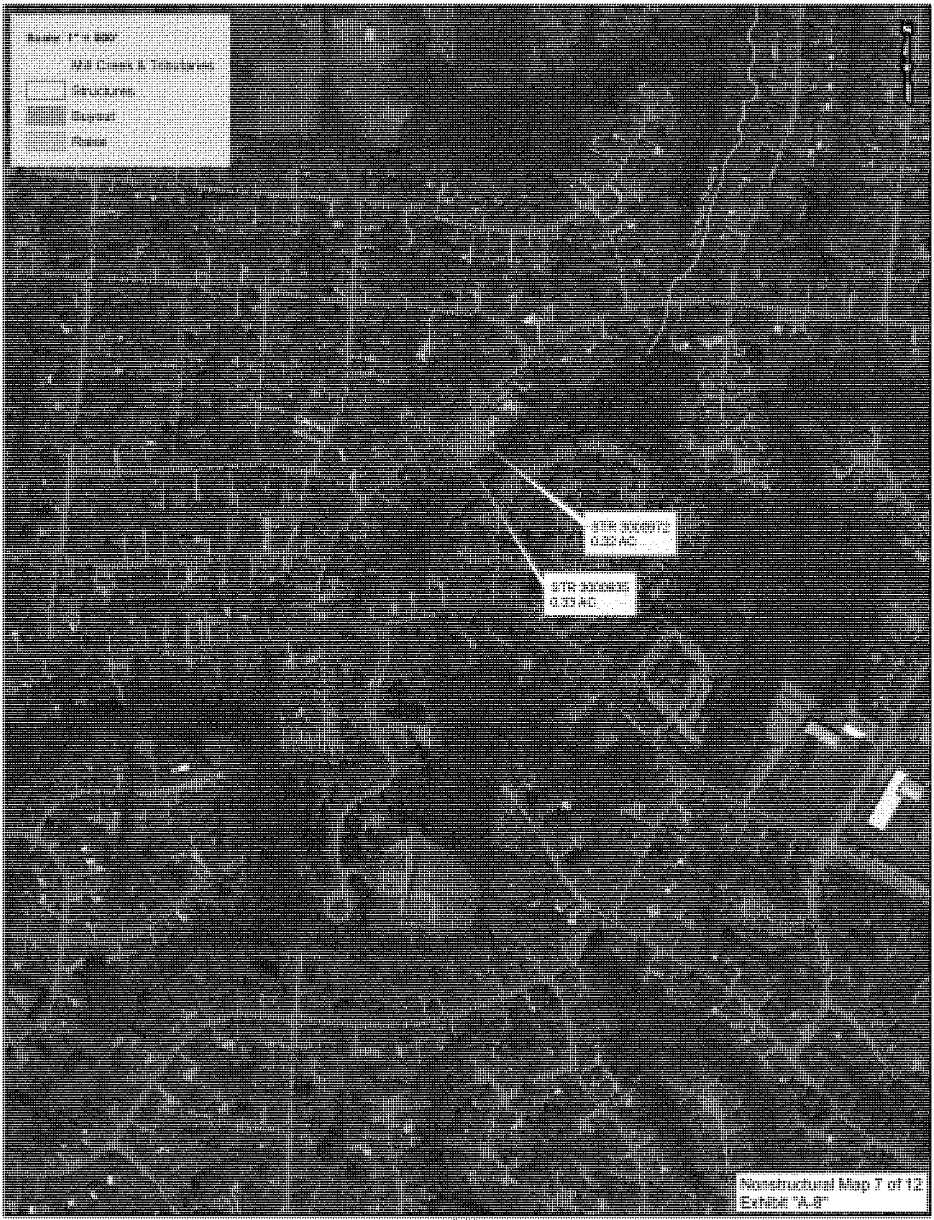
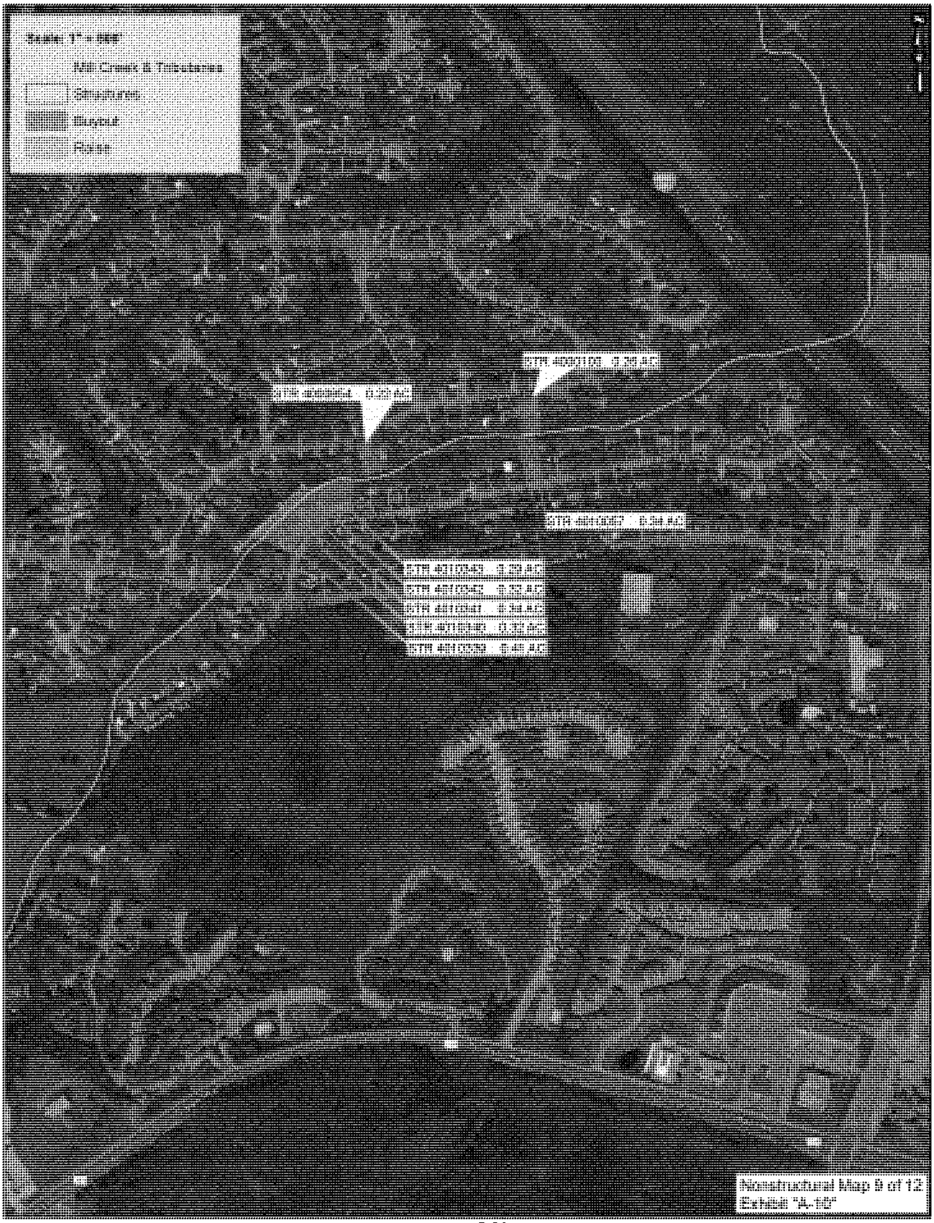
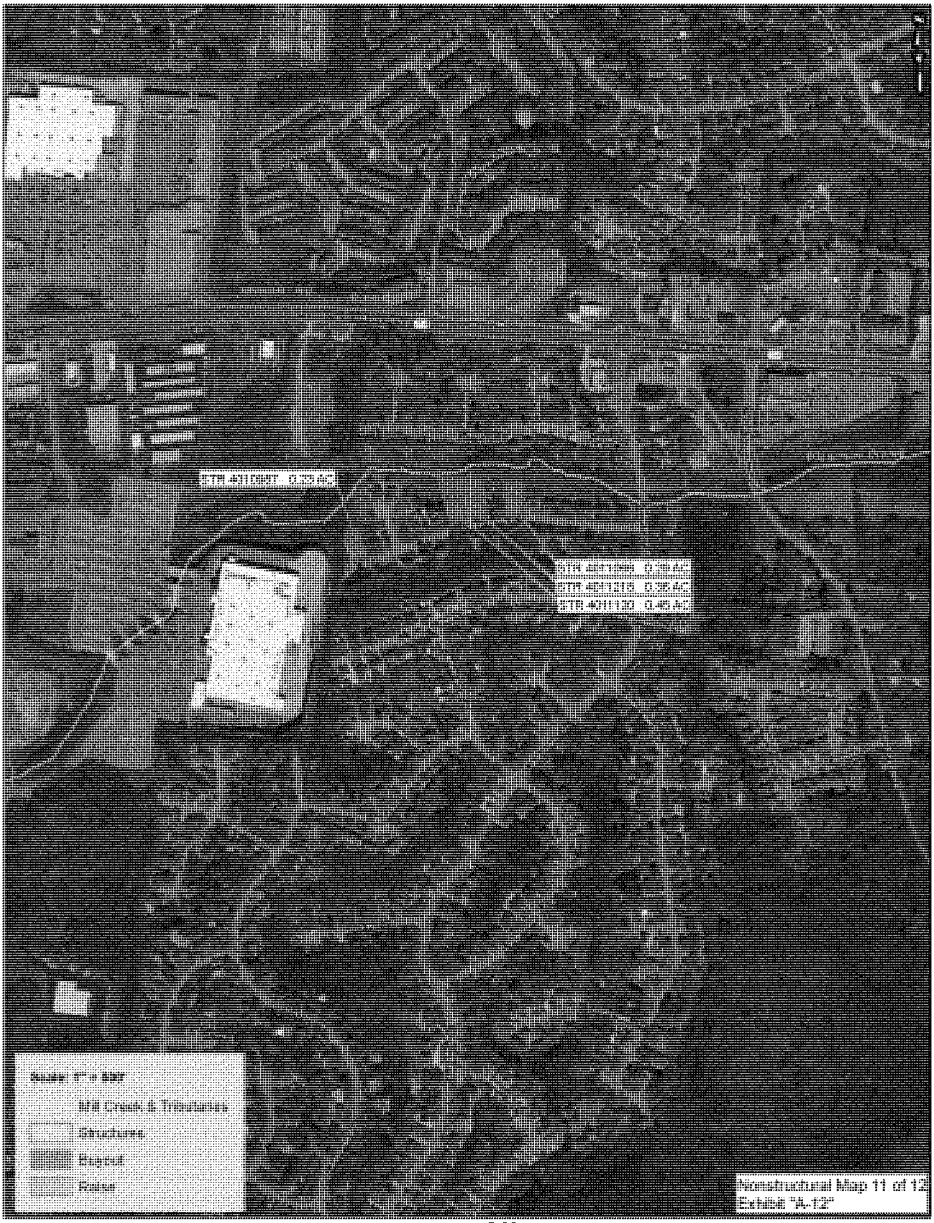
Exhibit "A-7"


Mill Creek & Tributaries
Structures
Buyout
Raise
Nonstructural Map 7 of 12


Mill Creek & Tributaries
Structures
Buyout
Raise
Nonstructural


Mill Creek & Tributaries
Structures
Buyout
Raise
Nonstructural Map 9 of 12
Exhibit "A-10"


Mill Creek & Tributaries
Structures
Buyout
Raise
Nonstructural Map 10 of 12
Exhibit "A-11"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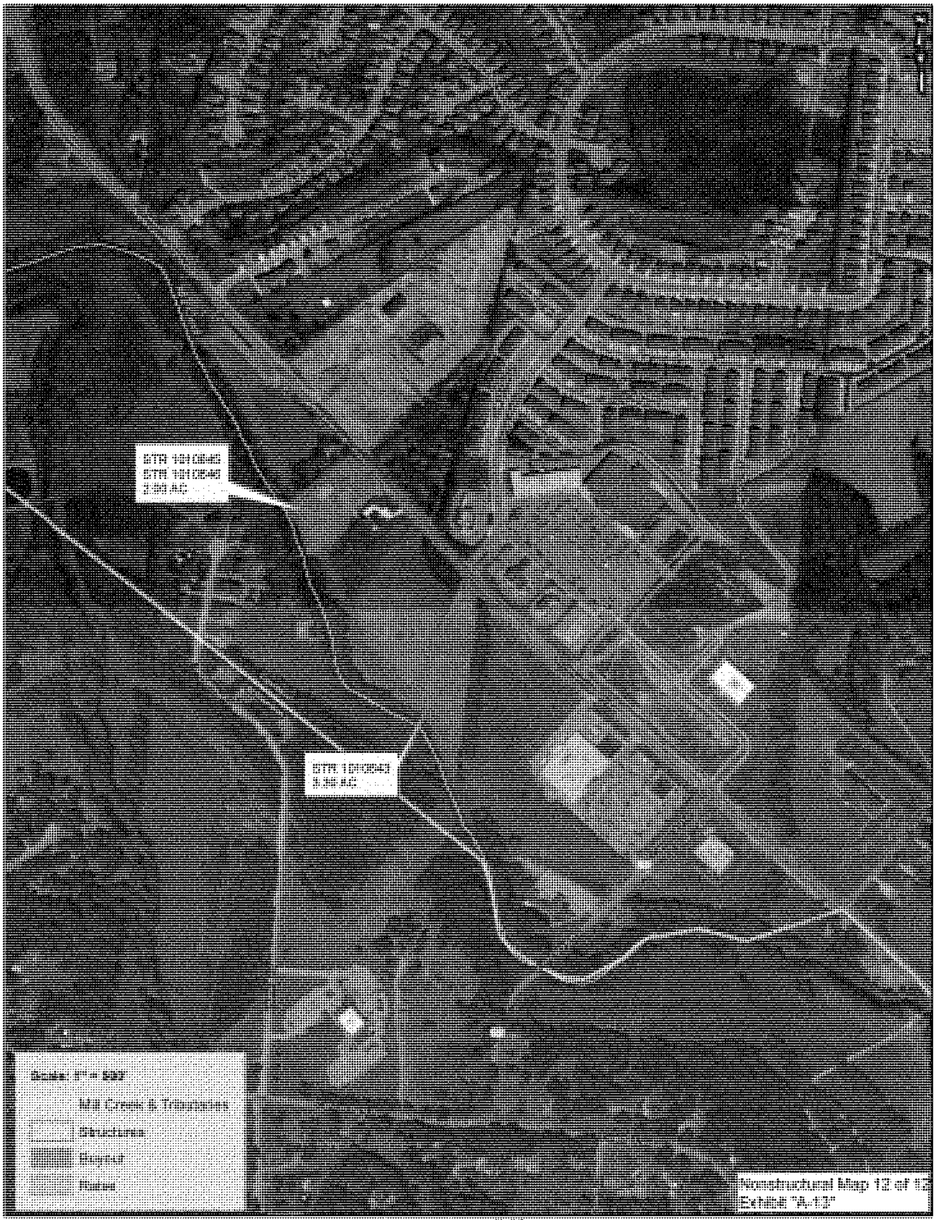
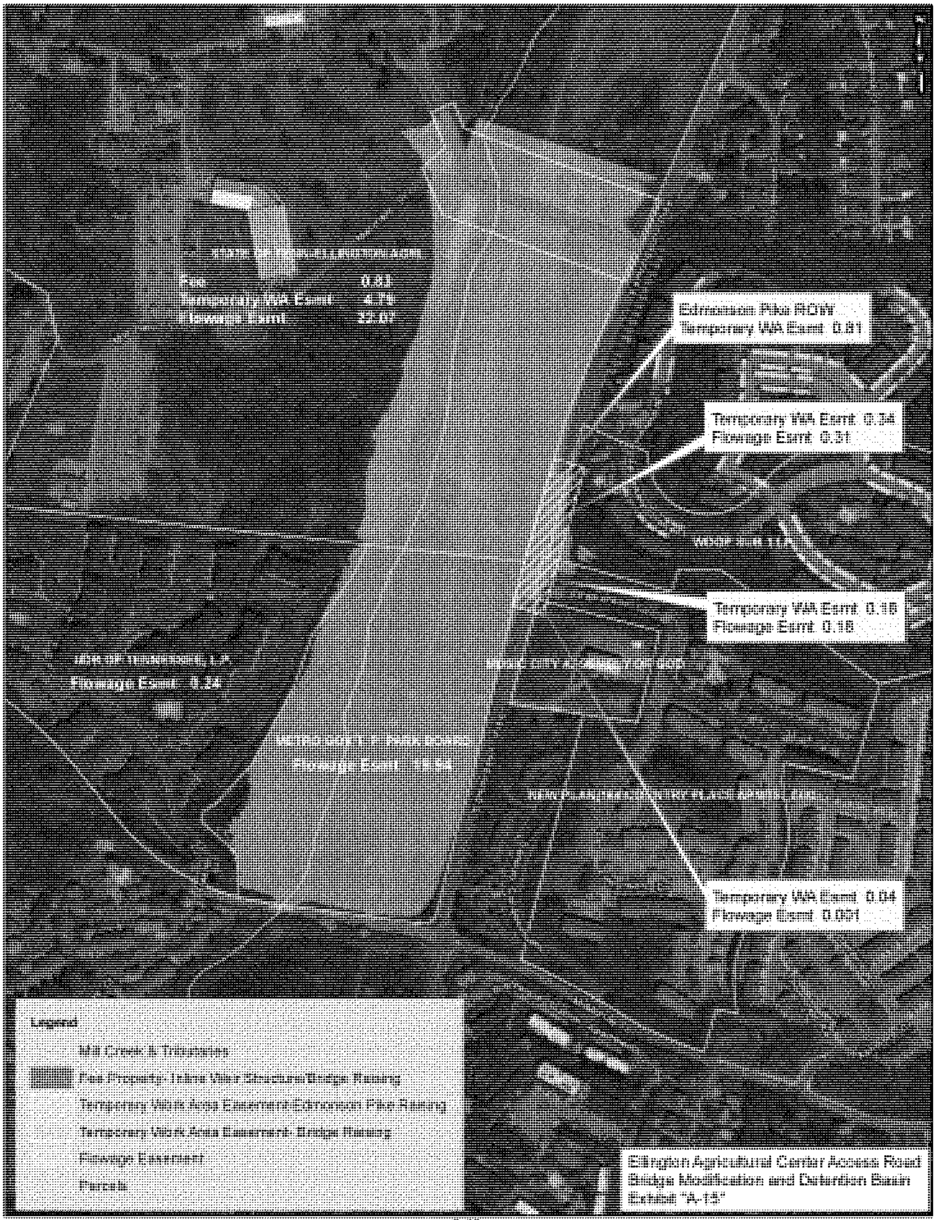
Buyout
Raise
Nonstructural Map 11 of 12
Exhibit "A-12"


Mill Creek & Tributaries
Structures
Nonstructural Map


Scale: 1" = 200'
Construction Area = +/- 1.13 ac
Mill Creek
Briley Parkway Bridge Modification
Exhibit "A-14"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Flowage Esmt 0.31
Temporary WA Esmt 0.18
Flowage Esmt 0.18
Temporary WA Esmt 0.04
Flowage Esmt 0.071
Legend
Mill Creek & Tributaries
Temporary Work Area Easement- Bridge Raising
Flowage Easement
Parcels
Ellington Agricultural Center Access Road
Bridge Modification and Detention Basin
Exhibit "A-15"

US ARMY CORPS OF ENGINEERS
NASHVILLLE DISTRICT

MILL CREEK WATERSHED FEASIBILITY STUDY
Appendix C
Engineering Appendix

Prepared By
US Army Corps of Engineers
Nashville District
June 2015

Appendix C: Engineering Appendix

Appendix C: Engineering Appendix

1.0 Introduction

This appendix documents the engineering analysis and follows the format of Engineering Regulation 1110-2-1150. Included with this appendix are the following reports or attachments; (the Hydrology and Hydraulics Report, the Cost Engineering Report, CSRA, HTRW Report, GIS Report).

1.1 Hydraulic and Hydrologic Analysis

General

A hydraulic and hydrologic study of Mill Creek and tributaries Sorghum Branch, Whittemore Branch, and Seven Mile Creek was performed for this study. Eight main profiles were evaluated for existing and future conditions. See the H+H appendix (Appendix C Attachment A for in-depth analysis of the existing and future conditions as well as H+H data for the alternative plans.

Background

Mill Creek flows approximately 27 miles in a northerly direction from its headwaters just south of Nolensville, Tennessee in Williamson County, Tennessee to its confluence with the Cumberland River (Cheatham Reservoir) at Mile 194.4 in Nashville, Davidson County, Tennessee. The basin is teardrop shaped with a total drainage area of 108 square miles. It lies principally in Davidson County, although 35 percent of the upper watershed is in Williamson County and a small headwater portion extends into Rutherford County.

1.2 Geospatial Analysis

General

For this feasibility study and HEC-FDA analysis, a structure database was built. Due to time constraints, the level of detail for the structure's first floor elevations (FFE) presented a challenge and required a modification to the new methodology. There were several unique questions that were answered through the development of methodology to build the structure database required for HEC-FDA analysis. The first question centered on getting FFE for the 723 structures that had not previously been surveyed. Evaluation and incorporation of the structure data and first floor elevations obtained from the Nashville Unified Flood Preparedness Plan (UFPP) study was instrumental in developing the first floor elevation methodology. The final piece was utilizing the HEC-FDA data in a GIS format that would allow for alternative development and evaluation by the PDT. All of the GIS analysis was completed utilizing tools contained in ArcGIS Desktop 10.1.

Structure Database

The structure database was constructed from two data sources: Metro Nashville's building footprints and parcel datasets. Geospatial queries were performed on the building footprints to remove outbuildings and small additional structures from that dataset. The resulting footprint layer was spatially joined with the parcel dataset to assign assessors information to each structure. The result yielded some instances of multiple structures on single parcels. The multiple structures were mitigated by creating duplicates, which were evaluated and either removed or assigned appropriate values by percentage of the entire parcel's appraisal. These final structures were then assigned a unique ID that was utilized throughout the entire process of exports to HEC-FDA and rejoins of the resulting data. Structure ID, Damage Category, Address, Occupancy Type, Stream Name, Bank (Left or Right), Station and FFE was exported to excel for HEC-FDA analysis. After the HEC-FDA analysis was completed, the results of the HEC-FDA analysis were joined with the structure database and pertinent results recorded.

1.3 Geotechnical Analysis

General – This section presents general criteria based on the limited assumptions for the geotechnical design of project features. Geotechnical considerations consist of design of the structural foundations, excavation, backfill and scour protection.

Design Criteria – The design documents to be used in geotechnical design will consist of applicable USACE Engineer Manuals, Publications, and TDOT (Tennessee Department of Transportation) Design Standards and Practices.

Regional Geology – Geological analysis will be performed on applicable alternatives in following stages of the project.

Seismological Evaluation – The site is located in Nashville, TN. Nashville, TN is located in the Uniform Building Code seismic risk Zone 1. According to ER 1110-2-1806 *Earthquake Design and Evaluation for Civil Works Projects* "Detailed site explorations, site specific ground motion studies, and structural analyses should be undertaken only for projects in zones 3 and 4, or for zone 2A or 2B when seismic loads control the design." No further seismic considerations will be evaluated.

Subsurface Investigations and In-situ Tests –Pages 26-27 contain figures of exploratory excavation borings taken in the vicinity of the project footprint of the recommended plan for the Ellington detention basin. No further subsurface investigations have been performed yet, as more detailed analysis will be conducted during Preconstruction Engineering and Design.

Excavation, Fill, and Slope Stability – The excavated material is anticipated to consist of sandy and clay soils. Excavation of rock shall be minimal. There is no blasting anticipated at this time. The fill for the bridge abutments will be compacted material in accordance with TDOT Design Standards or Practices. The embankment slopes shall be 3H:1V typically with a maximum slope of 2H:1V.

Design Parameters – Design parameters will be developed when exploratory investigations are performed.

Potential Disposal Sites – No disposal sites have been identified at this level of design. The project sites are in developed or developing areas that have required borrow and/or disposal sites. Approval of potential disposal sites will be required before construction activities are allowed to commence.

1.4 Civil Design

General

Preliminary screening was conducted to identify flood reduction measures for further analysis and eliminate costly or impractical ones. The screening described in this section includes structural measures only. Structural measures are designed to keep flood water away from damageable property. Structural measures may include dams and reservoirs, detention structures levees, bridge modifications, channel modifications, and flow diversions. Nonstructural flood damage reduction measures do not modify floods; rather, they reduce flood damage by removing buildings and damageable contents away from the flood waters. Non-structural measures include floodplain zoning ordinances to keep buildings out of the floodplain, flood forecasting and warning, floodplain evacuation, structure raising, and flood proofing. To maximize benefits, future conditions models were used to evaluate measures at the screening level.

More than 20 measures were identified for preliminary evaluation to determine whether they would accomplish flood damage reduction in the Mill Creek watershed. Two of the measures were eliminated without further consideration: Floodplain zoning management and enforcement was not being considered further because it is already being done. Following the May 2010 flood, Metro Nashville implemented a series of planning, zoning, and codes measures meant to limit future damages. Briefing and educational materials have been prepared for Metro's Stormwater Variance Committee describing the impacts of varying from Metro's strong stormwater ordinances. Levees and floodwalls were also not considered further as a result of earlier studies and preliminary benefit analyses which showed low rankings compared to other measures. The only economically viable location for floodwall or levee measures is in Space Park, the primary limitation there is land due to buildings being constructed right up to the streambank. Ultimately several buyouts of commercial buildings would have to be made to allow for the land to build this measure. The preliminary benefits did not provide enough cause to consider this measure further. The remaining measures have been matched to various sites in the study area to accomplish one or more objectives:

Flood Damage Reduction Measures Considered in Detail

- Detention structures
- Increased channel capacity
- High flow diversion
- Bridge modifications
- Channel modifications
- Removal of structures from the floodway/floodplain

Flood Risk Management Measures

By examining and combining the above series of measures and their ability to accomplish the objectives of the study, the following set of preliminary alternatives for flood damage reduction and ecosystem restoration were formulated and evaluated. This study was modified following the May 2010 flood, and the City of Nashville decided to only pursue implementation of flood risk management measures. To be clear, no ecosystem measures will be pursued to implementation for this study, but the data has been provided to Metro Nashville, and they may choose to pursue these measures independently.

A total of eleven nonstructural and fifteen structural measures were identified for preliminary screening. The nonstructural alternatives address only residential damages and are defined in Section 4.2.4 of the main report. Preliminary economic analysis found no viable commercial nonstructural measures. The preliminary screening of the nonstructural alternatives does not include any ecosystem restoration or recreation features or benefits. Those features could be added by Metro Nashville separate to the results of this study. Fifteen structural measures were identified for preliminary screening and listed in Table 11 of Section 4.2.5 of the main report. They include regional flood control (stormwater detention and diversions), and channel and bridge modifications. Combinations of these measures were also evaluated to maximize flood damage reduction benefits. Some measures were screened out early on during analysis due to preliminary benefit/cost ratios below 1.0, which means costs exceed benefits or insignificant economic benefits.

2.0 Structural Measures

2.1 Roller Compacted Concrete (RCC) Detention Structure above Old Hickory Boulevard (River Mile 18.0)

A new site was selected on Mill Creek at river mile 18.0, approximately 0.6 miles upstream from Old Hickory Boulevard and 1.2 miles upstream from the previous detention site. The RCC embankment will act as a weir or spillway for flows exceeding the 10-year frequency event. The embankment section will be Roller Compacted Concrete (RCC) and has a vertical upstream face, 5 feet horizontal and vertical steps on the downstream face, and a 15-feet wide crest. The RCC structure is 23-feet high and 700 feet long. The RCC conceptual design is based on an existing design for the Center Hill RCC Berm and the 1986 Mill Creek Feasibility Study design. The low level outlet will utilize a box culvert that is 60 feet wide at the base with the total opening area of 760 square feet to pass normal flow and require no manual or mechanical operation. Details for the foundation, splash pad at the toe, and slightly lowered concentrated overflow at crest above channel have not been developed at this time.

Quantity Computations

The RCC detention structure and channel quantities were computed by the Average End Area Method, plus 10% contingency. Cost Engineering added 45% contingency to the overall project costs, through the development of the risk register. There are no soil borings available at this location so an assumed founding level at rock is shown. The rock is visible at the bottom of the creek which is assumed to be top of rock. If this alternative proves a viable alternative for future development, exploratory borings will be procured for the site.

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

Relocations

Utilities located in the vicinity of the project were identified by using GIS files provided by Nashville City Utilities. For the selected plan, sanitary sewer, potable water, gas, electric and telephone lines will have to be removed and relocated in order to construct the RCC structure. In general, quantities reflect an in-kind replacement, meaning that the same size and type of material would be utilized in the relocation of a utility to accommodate the proposed channel work.

Outlet Works

The outlet works would consist of an uncontrolled concrete box culvert located at the base of the structure. The outlet will pass normal flow and require no manual or mechanical operation. The opening would be 60 feet wide (760 square feet of opening) with upstream and downstream invert elevations of 522.0 ft and 521.5 ft, respectively. The culvert barrel would be approximately 35 feet in length and be within the existing channel and flow with inlet control for the full ranges of discharges. The foundation would be on solid, non-erodible limestone. The relatively large conduit design will allow most of the debris to be flushed through the opening where a trash rack will not be required. The maximum outlet velocity would be approximately 20 feet per second.

Embankment

The embankment would have a maximum height above the stream bed of 23.5 feet and acts as a weir or spillway for flows exceeding the 10-year frequency event. The embankment section is approximately 700 feet in length at elevation 545.0 feet and designed to be overtopped and capable of passing all floods. The embankment will be Roller Compacted Concrete and have a vertical upstream face, a 1:1 downstream face with a 15-foot top width.

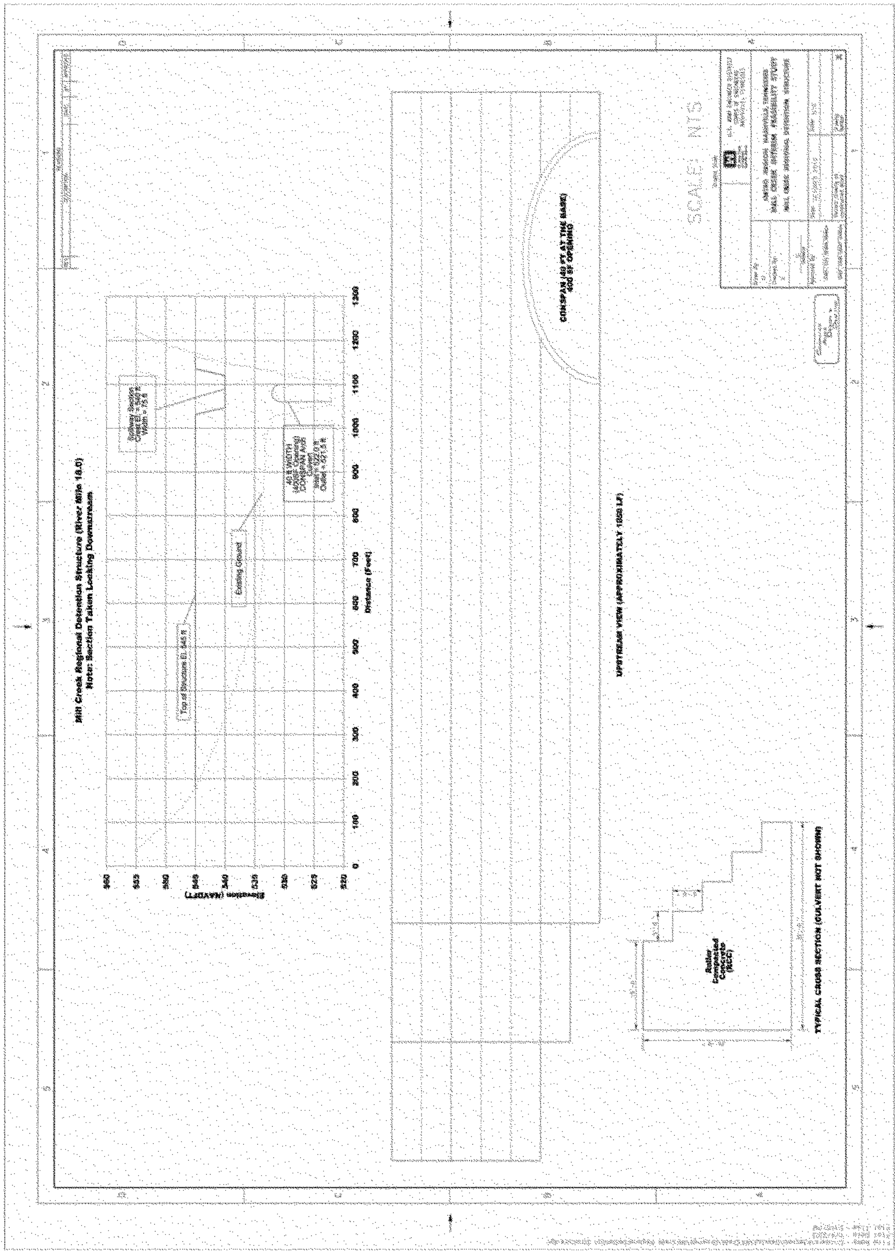
Spillway

The spillway is uncontrolled, broad-crested, 75 feet in length, and has a crest elevation of 540.0 feet. A hydraulic jump energy dissipater with an apron will be used to reduce the energy of flows through the spillway. Quarry run stone will be required for approximately 100 feet downstream of the RCC structure to protect the channel side slopes against turbulence and high velocities caused by the energy dissipation and outlet works.

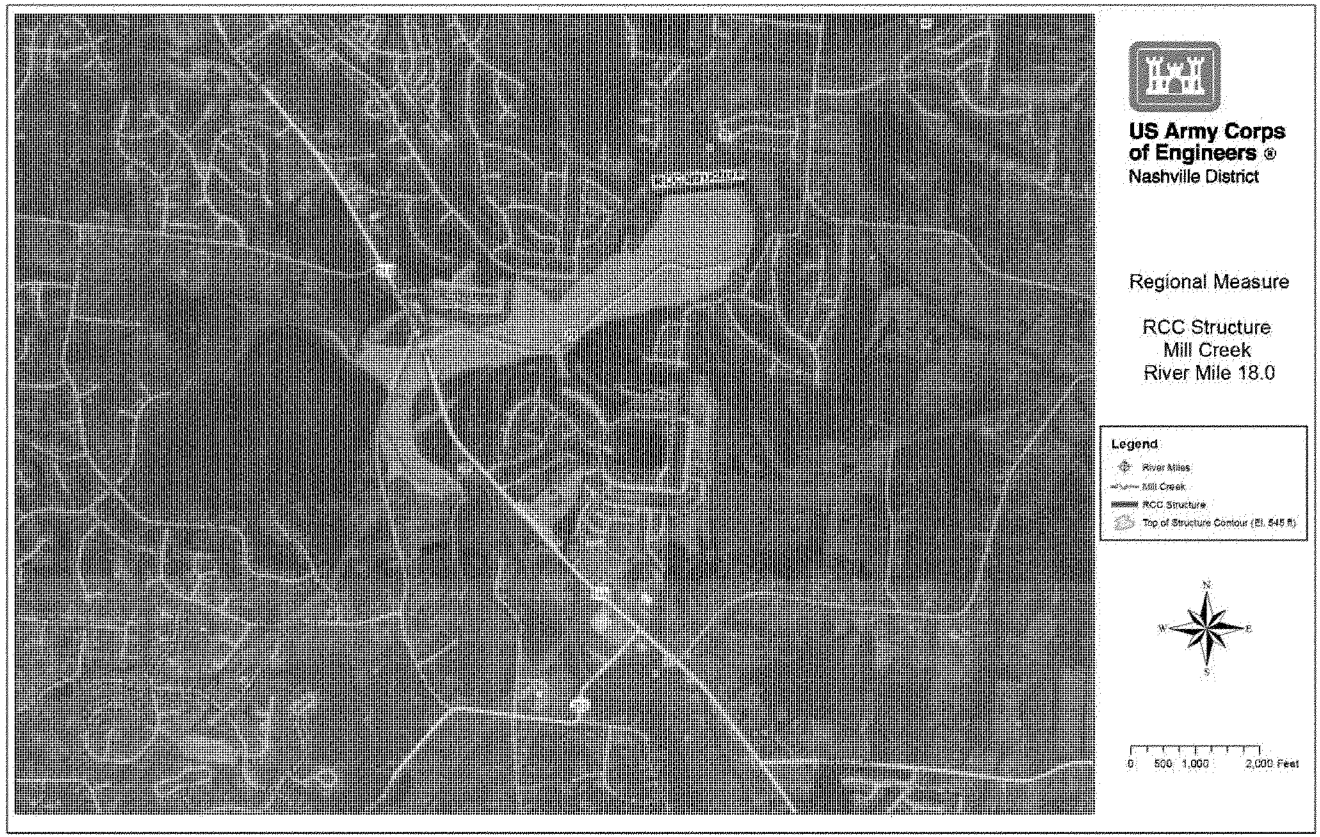
Regional Detention Structure River Mile 18.0 – Reservoir Data

Storm	Discharge		Elevation		Capacity	Area
Frequency	Future	With Project	Future	With Project	With Project	With Project
(Years)	(cfs)	(cfs)	(Feet)	(Feet)	Acre-Feet	Acres
2	8,658	6,648	534.9	540.2	650	130
5	11,920	8,306	536.2	542.6	1,260	180
10	16,604	11,451	537.6	545.2	1,890	240
25	20,016	16,507	538.7	546.7	2,180	260
50	23,052	20,021	539.5	547.4	2,340	280
100	26,375	23,674	540.2	548.1	2,480	290
200	29,800	27,340	540.8	548.6	2,610	300
500	34,772	32,556	541.7	549.4	2,780	320

Historic	Discharge		Elevation		Capacity	Area
Flood	Future	With Project	Future	With Project	With Project	With Project
(Date)	(cfs)	(cfs)	(Feet)	(Feet)	Acre-Feet	Acres
May 1979	28,200	26,600	540.3	548.5	2,590	295
May 2010	35,100	34,400	540.8	549.7	2,840	325



Mill Creek Feas


US Army Corps
of Engineers ®
Nashville District
Regional Measure
RCC Structure
Mill Creek
River Mile 18.0
Legend
River Miles
Mill Creek
RCC Structure
Top of Structure Contour (El. 545 ft)
N
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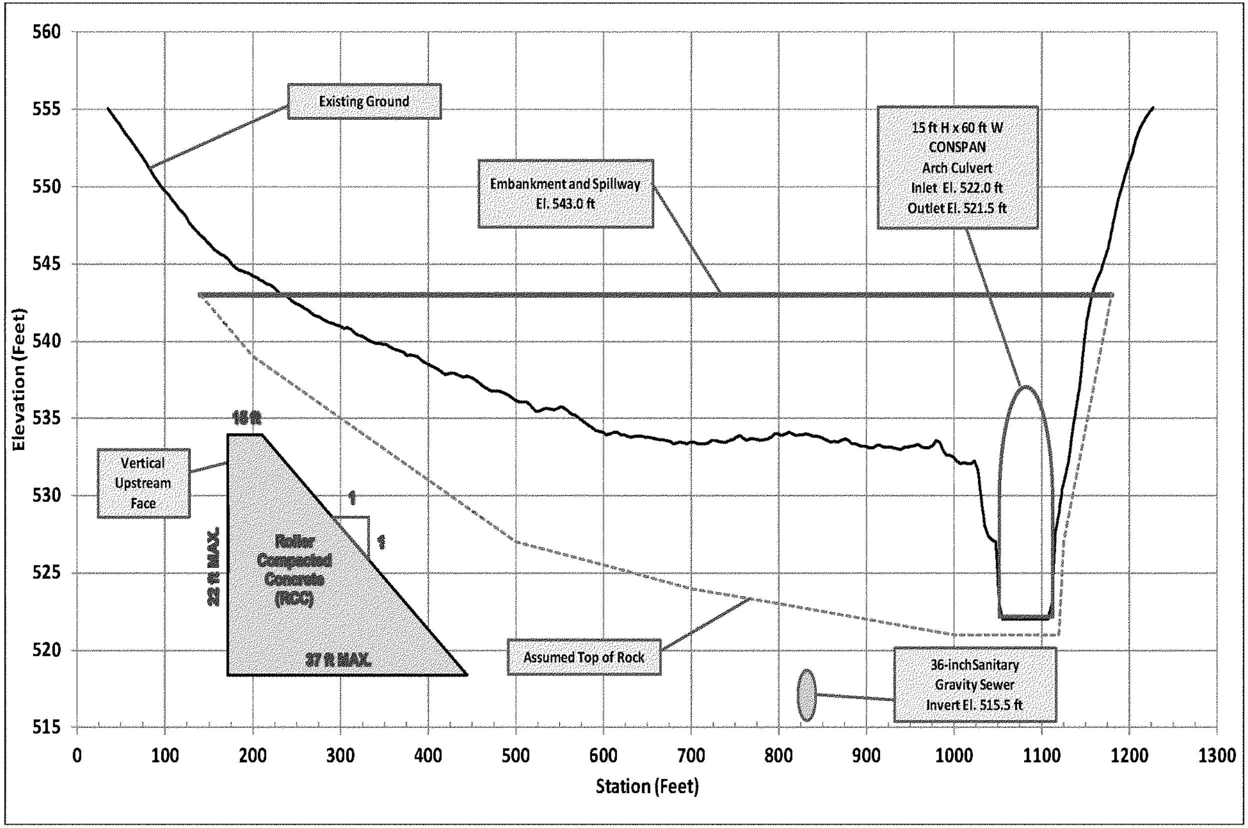
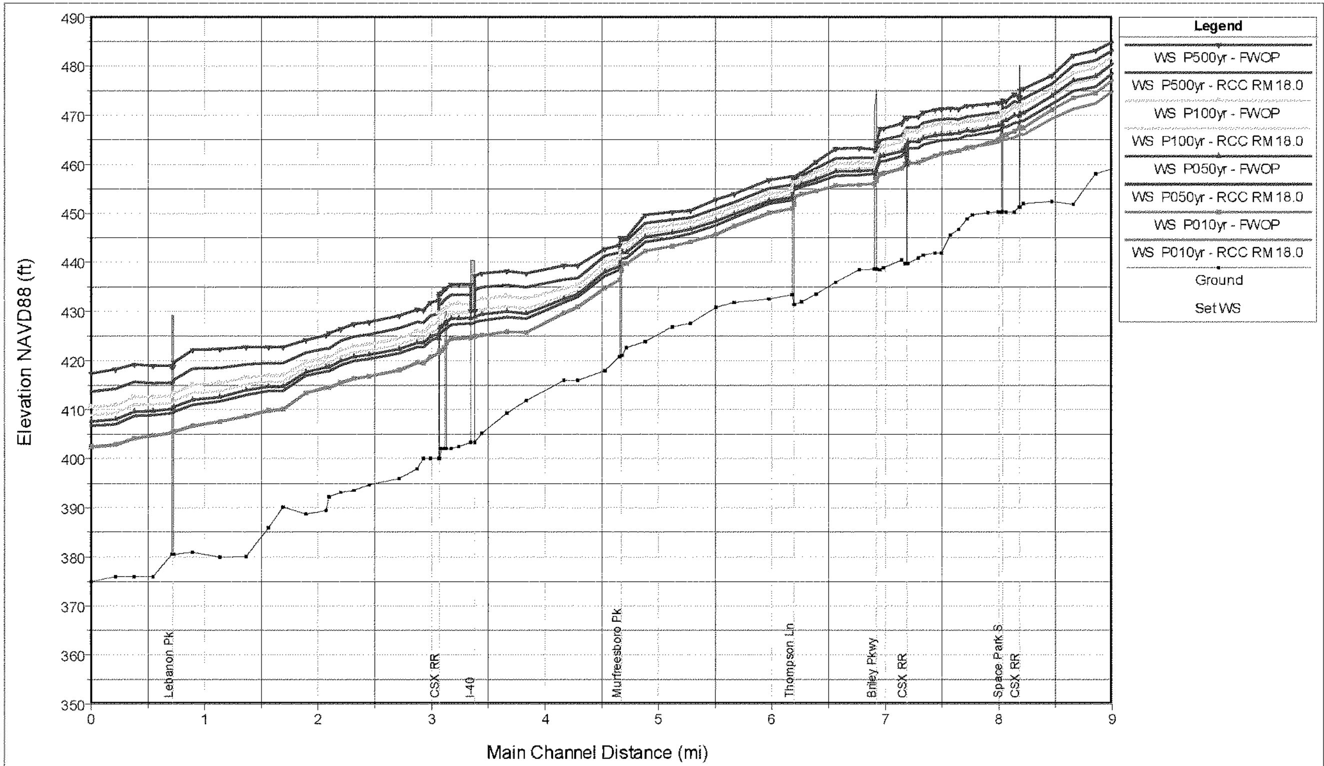
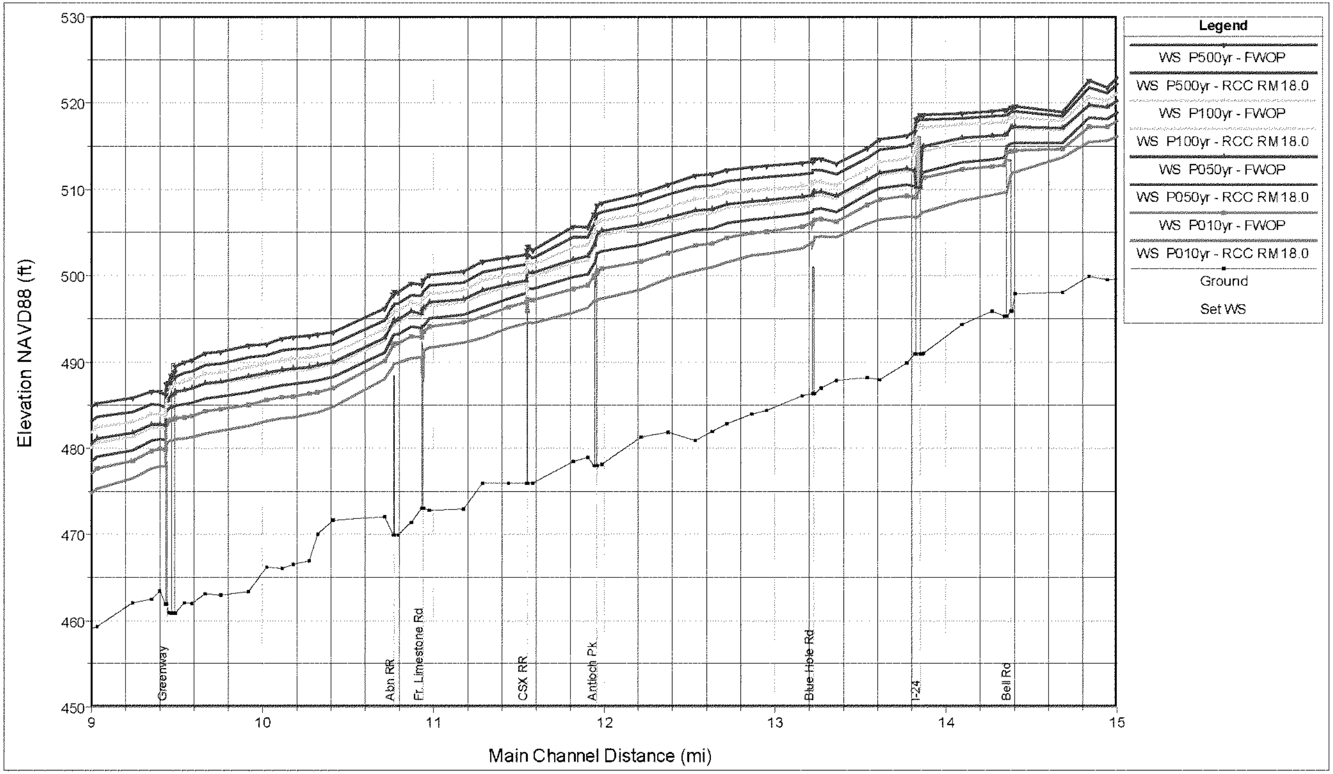
500
1,000
2,000 Feet



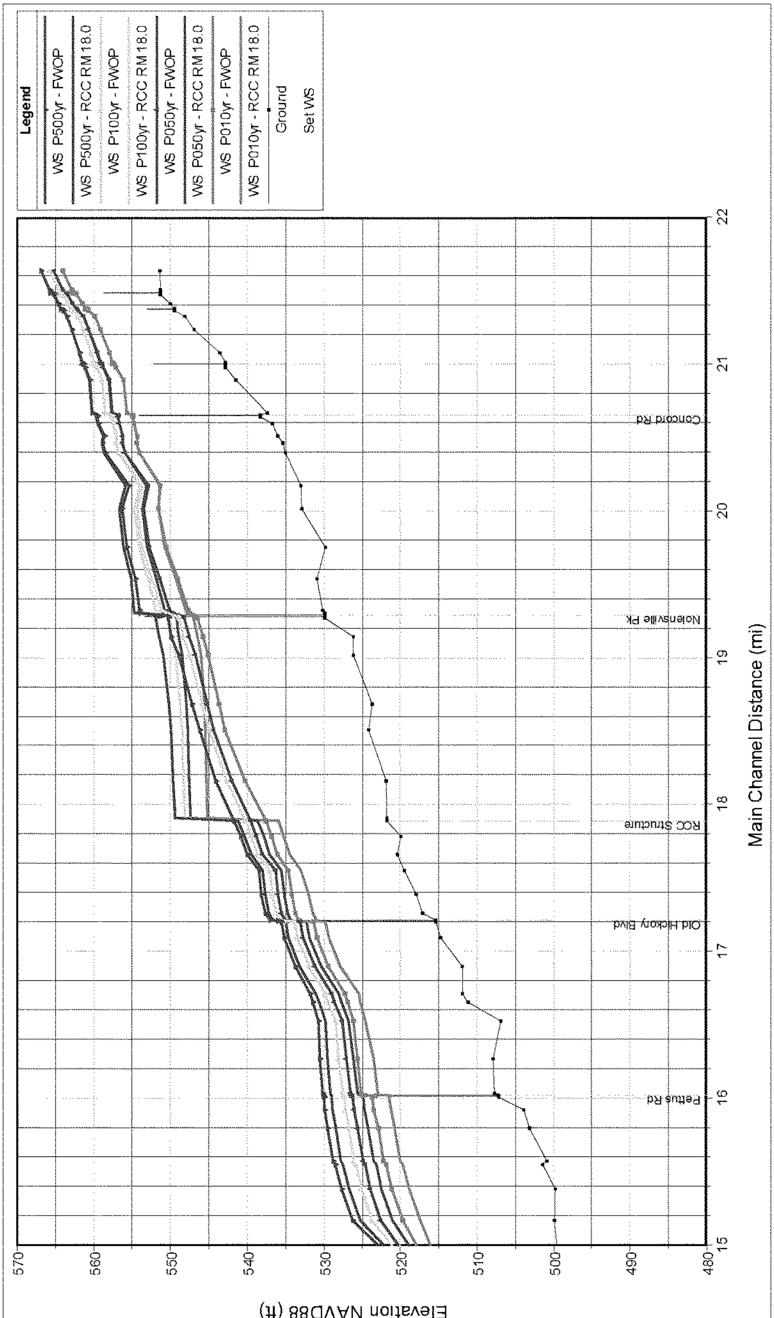
RCC Structure River Mile 18.0 – Typical Cross Section Looking Downstream



RCC Structure - Flood Frequency Water Surface Profiles (River Mile 0 to 9)



RCC Structure - Flood Frequency Water Surface Profiles (River Mile 9 to 15)



RCC Structure - Flood Frequency Water Surface Profiles (River Mile 15 to 22)

2.2 Ellington Agriculture Center Regional Detention (River Mile 3.67)

A detention site was selected on Sevenmile Creek at river mile 3.67 located at the Ellington Agriculture Center Entrance Bridge. The measure captures 7.9 square miles, 45% of Sevenmile Creek's total watershed. The detention structure will replace the existing entrance bridge and therefore must accommodate traffic across its crest. The new structure has two lanes, one in each direction and has an approximately 1 foot high concrete curb on the upstream and downstream side of the 30-foot crest. The structure will have a smaller culvert opening that will restrict the flow during the flood and retain water to minimize flooding downstream. The new low level outlet will be replaced with a box culvert (or Conspan equivalent) that has a 20 feet opening at the base with the total opening area of 160 square feet to pass normal flow and require no manual or mechanical operation. The spillway will be abutted to the compacted-earth embankment on either side.

Quantity Computations

The channel quantities and detention structure were computed by the Average End Area Method. Cross sections depicting the existing geometry channel compared with the proposed geometry were exported into CAD software. The structure cut and fill areas were measured in CAD and transferred into a spreadsheet which totaled the quantities for the alternative. There are no soil borings available at this exact location. The streambed is limestone rock, it is visible at the channel bottom, which is assumed to be top of rock elevation in vicinity of the spillway. Additional borings will be obtained at this location during Preconstruction Engineering and Design (PED) phase.

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

Relocations

Utilities located in the vicinity of the project were identified by using GIS files provided by Nashville City Utilities. For the selected plan, sanitary sewer, potable water, gas, electric and telephone lines will have to be removed and relocated in order to construct the detention structure. In general, quantities reflect an in-kind replacement, meaning that the same size and type of material would be utilized in the relocation of a utility to accommodate the proposed channel work.

Outlet Works

The outlet works would consist of an uncontrolled concrete box culvert (or Conspan equivalent) located at the base of the structure. The outlet will pass normal flow and require no manual or mechanical operation. The opening would be 8 ft high and 20 feet wide (160 square feet of opening) with upstream and downstream invert elevations of 519.0 ft and 518.5 ft, respectively. The culvert barrel would be approximately 30 feet in length and be within the existing channel and flow with inlet control for the full ranges of discharges. The foundation would be on solid, non-erodible limestone. The relatively large conduit design will allow most of the debris to be flushed through the opening where a trash rack will not be required. The maximum outlet velocity would be approximately 15 - 20 feet per second in the Sevenmile Creek Channel.

Embankment

The embankment would have a maximum height above the stream bed of 19.0 feet and acts as a weir or spillway for flows exceeding the 5-year frequency flood event. The embankment section is approximately 800 feet in length at elevation 537.5 feet and designed to be overtopped and capable of passing all floods. The embankment will be compacted clay earthen fill. The earthen embankment would have 3:1 side slopes with a 30-foot top width. The downstream face of the embankment will be covered with articulated concrete blocks to protect against overtopping erosive velocities. The maximum overtopping velocities will be 23.5 fps during the 500-year (1/500 ACE) flood event. Various articulated concrete block products have been designed to withstand velocities of this magnitude. Articulated concrete blocks will be required for approximately 20 feet downstream of the toe of the embankment to protect slope against turbulence and high velocities caused by the energy dissipation.

Spillway

The spillway is uncontrolled, broad-crested, approximately 100 feet in length, conventional concrete construction and has a crest elevation of 535.0 feet. A hydraulic jump energy dissipater with an apron will be used to reduce the energy of flows through the spillway. Articulated concrete blocks will be required for approximately 20 feet downstream of the toe of the structure to protect the channel side slopes against turbulence and high velocities caused by the energy dissipation and outlet works.

Regional Detention Structure River Mile 3.67 – Reservoir Data

Storm	Discharge		Elevation		Capacity	Area
Frequency	Future	With Project	Future	With Project	With Project	With Project
(Years)	(cfs)	(cfs)	(Feet)	(Feet)	Acre-Feet	Acres
2	2,621	2,210	529.9	532.4	101	25
5	3,305	2,631	530.4	535.1	168	36
10	4,244	3,480	530.8	536.7	240	43
25	5,139	4,547	531.2	537.7	288	48
50	5,813	5,515	531.4	538.0	303	50
100	6,542	6,380	531.6	538.3	314	51
200	7,373	7,265	531.8	538.5	323	52
500	8,787	8,698	532.1	538.8	337	53

Level of Risk

An important consideration in the design of any flood control structure is the level of acceptable risk. For structural elements, the risk factor is determined through testing and calculating physical properties. The hydraulic risk associated with a flood control structure can also be determined by calculations based on physical controls. Each of these elements is usually governed by the magnitude of the flood they are to safely pass. The structures considered for this project are designed to overtop and is hydraulically and structurally sound for all magnitudes of floods. Therefore, the event of hydrologic failure of the structure is not considered possible and is not considered a risk.

Spillway Design Flood

The spillway design flood, a large hypothetical flood, is usually selected as the basis for designing the spillway of the structure. The magnitude of this flood is currently based on the maximum incremental damages (determined by comparing pre- and post-project damages) resulting from a hydrologic failure. This criterion does not apply to the structure considered in this study because it is designed to be overtopped. Currently, the structure is sized to obtain the maximum benefits associated with floods through a 500-year event. Because the structure was designed to be overtopped, the height was determined in conjunction with the spillway size and configuration. In effect, the top of the structure acts as a high level spillway capable of passing all floods. Comprehensive HEC-RAS unsteady flow analysis will be performed during the design phase of project where multiple high flow conditions will be further evaluated to address the erosion protection required to safely pass all floods.

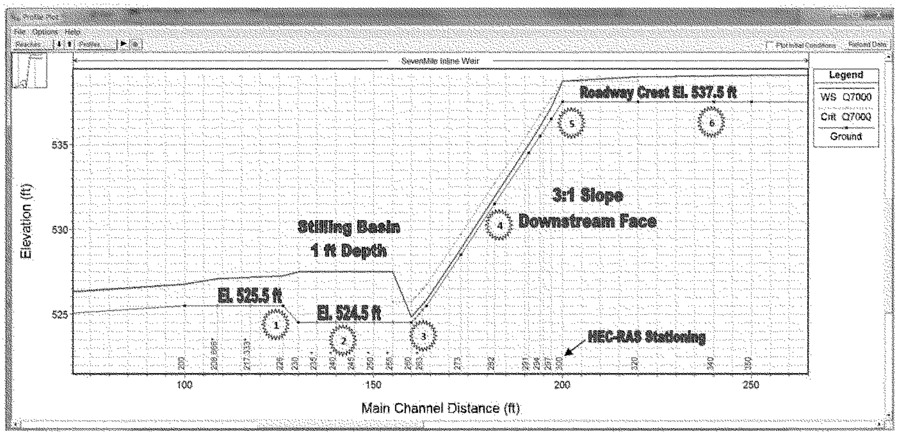
Overtopping Duration and Velocities

Spillway and embankment overtopping durations are shown in table below for the 2-year thru 500-year flood events. A one-dimensional HEC-RAS model was used to estimate the 500-year design velocities for the articulated block armoring the downstream slope and stilling basin. The maximum velocity was estimated to be 23.5 feet per second at the downstream toe of the embankment section during 500-yr event and used for the current design. Comprehensive HEC-RAS unsteady flow analysis will be performed during the design phase of project where multiple high flow conditions will be further evaluated to address the erosion protection required to safely pass all floods.

Ellington Ag Center Spillway (El. 535 ft) and Embankment Crest (El. 537.5 ft)
Overtopping Durations

Freq Years	Inflow cfs	Outflow cfs	Storage ac-ft	Headwater El. ft.	Spillway Duration (Hours)	Crest Duration (Hours)	Crest Depth (ft)
2	2621	2210	100.6	532.4	0		
5	3305	2631	167.6	535.1	1		
10	4244	3480	239.9	536.7	3		
25	5139	4547	288.3	537.7	4	1	0.2
50	5813	5515	302.9	538.0	5	2	0.5
100	6542	6380	313.5	538.3	6	3	0.8
200	7373	7265	323.1	538.5	6.5	3.5	1
500	8787	8698	337	538.8	7	4	1.3

Ellington Ag Center Overtopping Velocities (Embankment Section)



500yr Flood Event - Overtopping WSEL @ 538.8 Ft NAVD88			
Location	**HECRAS Station**	**Location**	**Velocity (fps)**
1	226	End Sill	4.4
2	245	Stilling Basin	2.5
3	260	Toe	23.5
4	282	Mid Slope	19.5
5	300	DS Crest	6.3
6	340	US Crest	5.0

Breach Analysis – Downstream Impacts

Breach analysis was performed for the 500-year flood event using HEC-HMS. Breach discharges were applied to steady flow hydraulic model to determine increases in downstream water surface elevations. Breach size and development times were estimated using the Von Thun & Gillette Equation. The overtopping breach was assumed to occur in the embankment section near the abutments of the structure with bottom width of 42 feet and a 0.3 hour breach development time. Bedrock elevations were obtained from the 1986 Mill Creek Final Interim Feasibility Report Technical appendices. Exploratory excavation was performed at a location approximately 100 feet upstream from the Ellington Agriculture Center entrance roadway. Elevation of bedrock varied near abutment locations and ranged from elevations 525 ft to 540 ft. Elevation 525 ft was applied to be conservative for breach development. Breach analysis resulted in a 50% increase in 500-year discharge over one hour duration immediately downstream from the structure. 500-year water surface elevations increased an average of one foot for two miles downstream from the structure. Comprehensive HEC-RAS unsteady flow analysis will be performed during the design phase of project where multiple high flow conditions and failure modes will be further evaluated to address the downstream hazard potential for loss of life and flooding extent.

Sediment Yield

There has been no data collected in the Mill Creek basin to quantify the movement of deposition of sediment at the proposed Ellington Ag Bridge modification site. The 1986 Mill Creek flood damage reduction study included an estimate of total sediment yield using data collected for J. Percy Priest (JPP) Reservoir Sediment Survey of 1978. The Mill Creek basin parallels the Northwestern boundary of J. Percy Priest's drainage basin sharing common divide for nearly twenty miles. The general land uses, topography, and soil characteristics of the basin are similar. Inspection of the runoff characteristics of each basin show that J. Percy Priest has an average inflow of 1.8 cfs per square mile (cfm) and Mill Creek has 1.5 cfm. The average sediment yield at the 1986 dam site (approximately 200 ft upstream from the Ellington Ag Bridge) was estimated to be 3.2 acre-feet per year based on JPP data.

Based on flow durations, ninety-five percent of the time the flow was assumed to be within the natural channel and passed through the low-level outlet (non-flood) flows. Based on typical sediment rating curves for the region, ninety percent of sediment transport was assumed to occur during flood flows. Trap efficiency was based on the Churchill's (1947) Trap Efficiency Curve using period of retention/mean velocity and was estimated to be 40 percent over the 2-, 50-, and 100-yr frequency flood events. Assuming ninety percent of the total sediment yield was affected by the dam, a conservative estimate of the total sediment trapped was estimated to be 1.2 acre-feet per year. The 1986 dry-dam was more than double the storage capacity at the 500-yr event with a 36 sq ft (6 ft x 6 ft box) low level outlet compared to the 160 sq. ft. (8 ft H x 20 ft W) of the Ellington bridge modification.

The 1986 study estimated sediment deposits to be less than five percent of the reservoir volume over the fifty-year project life and would not threatened the efficiency of the project. Maintenance costs and deposits were assumed to be in the channel where there removal was assumed to be necessary to maintain normal flow. The trap efficiencies for the Ellington Ag bridge modification would be significantly less than the 1986 structure due of the increased velocities and shorter retention times. The proposed low-level outlet is much larger spanning the entire creek bottom allowing for increased flows, velocities and movement of sediments. Impacts to stream channel velocities along Sevenmile Creek are minimal below a 2-year frequency flood event (approximately 2500 cfs). As stated in the environmental characterization, there is lack of habitat for the Nashville Crayfish in the Vicinity of the Ellington project due to the lack of slabrock, cobble runs, pools and/or gravel. Average velocities for the 2-, 10-, 50, and 100-year frequency flood events are listed in tables approximately 1000 feet upstream and downstream from Ellington Ag Bridge Modification.

Channel Velocities 1000 ft Upstream from Ellington Ag Bridge

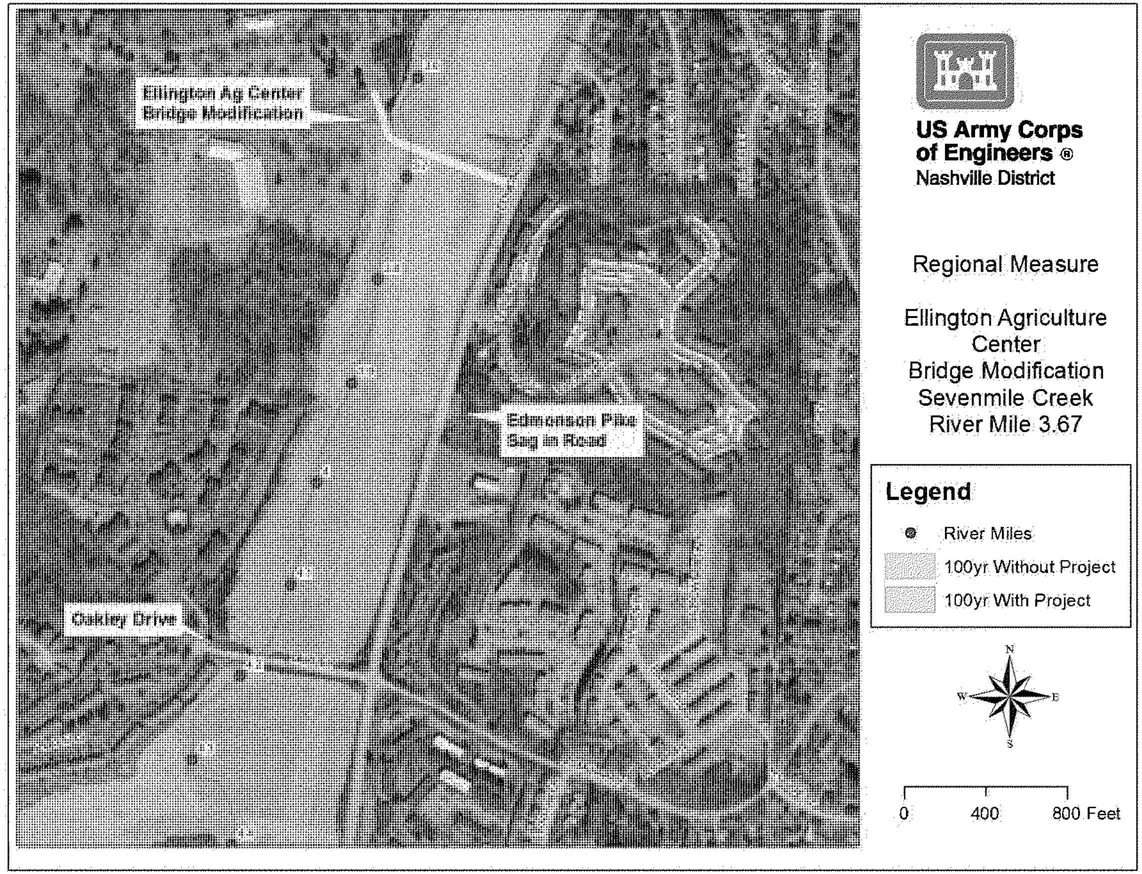
Flood Frequency Event	Without Project Velocity (fps)	With Project Velocity (fps)
2-Year (1/2 ACE)	5.9	4.2
10-Year (1/10 ACE)	6.9	2.4
50-Year (1/50 ACE)	7.7	3.0
100-Year (ACE)	8.0	3.4

Channel Velocities 1000 ft Downstream from Ellington Ag Bridge

Flood Frequency Event	Without Project Velocity (fps)	With Project Velocity (fps)
2-Year (1/2 ACE)	4.2	3.9
10-Year (1/10 ACE)	4.0	4.0
50-Year (1/50 ACE)	4.0	3.8
100-Year (ACE)	4.8	3.8

It is anticipated that larger materials (gravel and cobbles) may settle during flood events due to decreased velocities upstream from the structure which is desirable since these larger sediments would create new habitat for the Nashville Crayfish. It is not anticipated that the change in sediment transport will adversely affect the flood storage attenuation or channel stability of the upstream pool limit or degrade downstream channel. Sevenmile Creek channel is very stable with limestone rock bottom and established vegetated banks. There are few isolated stream bank stability issues along Sevenmile Creek due to burial of sewer lines and utilities near creek stream banks. There are no significant sediment aggradation or degradation problems along Sevenmile Creek. Channel incision is also unlikely since the stream bottom is composed of limestone bedrock.

Further investigation will be performed during design phase to characterize the sediment supply along Sevenmile Creek and to evaluate bedload transport in the vicinity of the Ellington project for the purpose of habitat enhancement for the Nashville Crayfish. Aggradation above and degradation below the structure is not anticipated, but will also be evaluated at that time. This would be performed using the HEC-RAS Steady Transport/Movable Boundary computations. This component of the modeling system is intended for the simulation of one-dimensional sediment transport/movable boundary calculations resulting from scour and deposition over moderate time periods (typically years, although applications to single flood events are possible). The sediment transport potential is computed by grain size fraction, thereby allowing the simulation of hydraulic sorting and armoring. The model is designed to simulate long-term trends of scour and deposition in a stream channel that might result from modifying the frequency and duration of the water discharge and stage, or modifying the channel geometry. This system can be used to evaluate deposition in reservoirs, design channel contractions required to maintain navigation depths, predict the influence of dredging on the rate of deposition, estimate maximum possible scour during large flood events, and evaluate sedimentation in fixed channels. Existing Sevenmile Existing HEC-RAS models will be updated to include sediment transport component.


Ellington Ag Center
Bridge Modification
Edmonson Pike
Sag in Road
Oakley Drive
US Army Corps
of Engineers ®
Nashville District
Regional Measure
Ellington Agriculture
Center
Bridge Modification
Sevenmile Creek
River Mile 3.67
Legend
River Miles
100yr Without Project
100yr With Project
N
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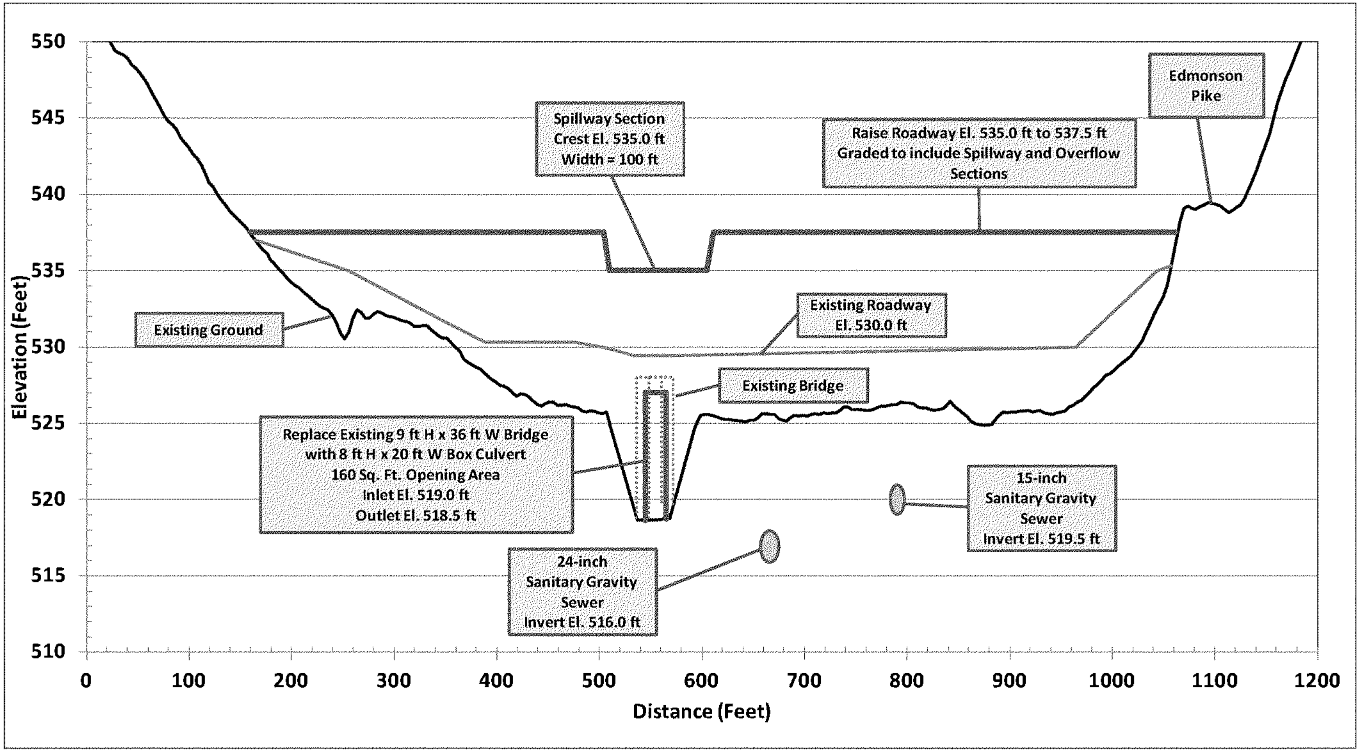
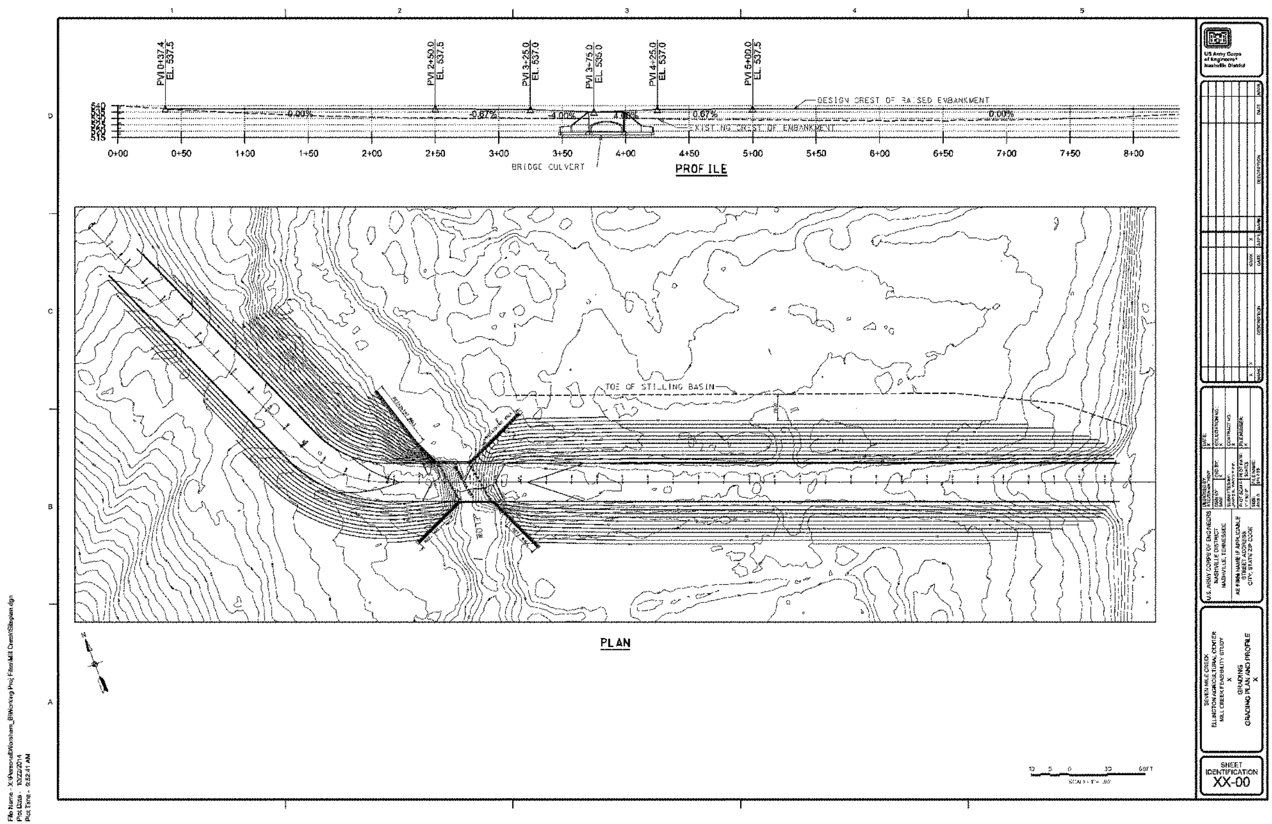
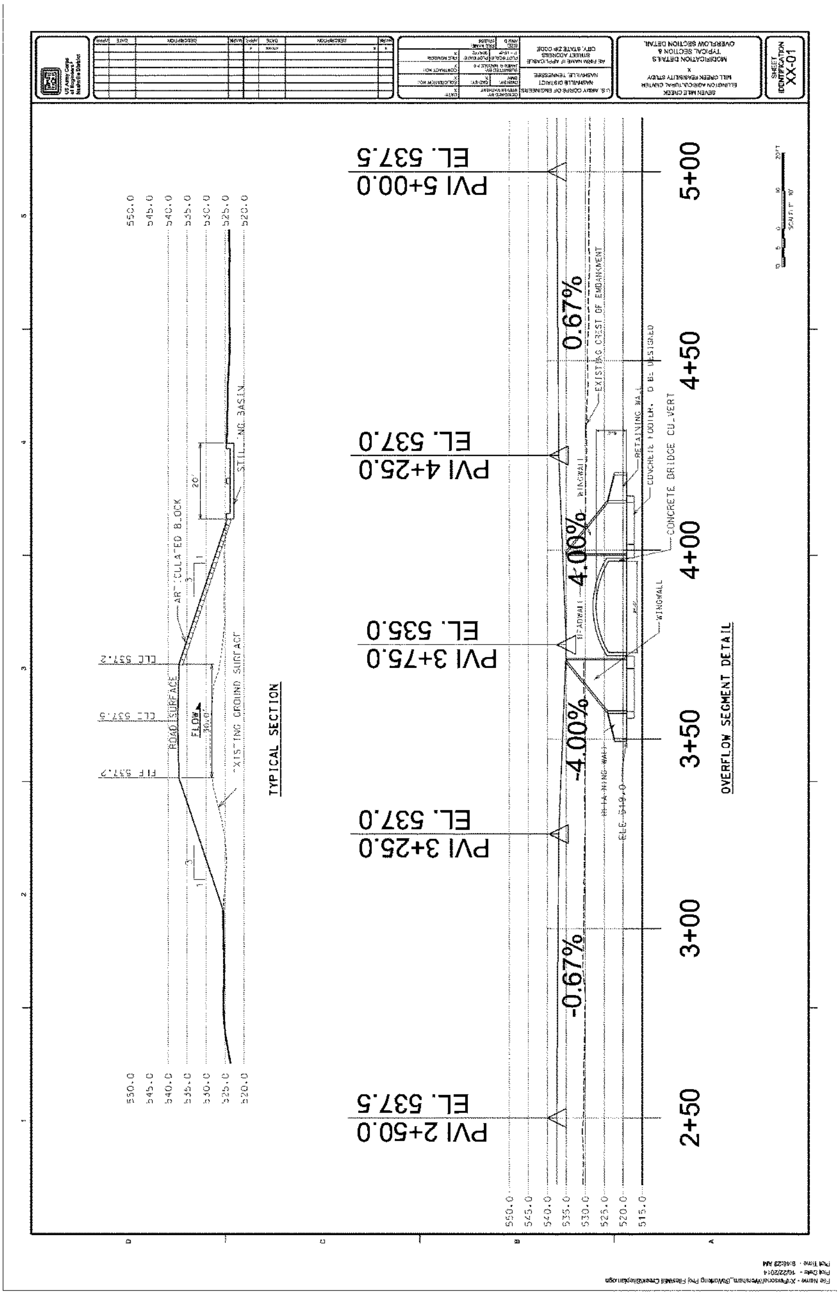
800 Feet



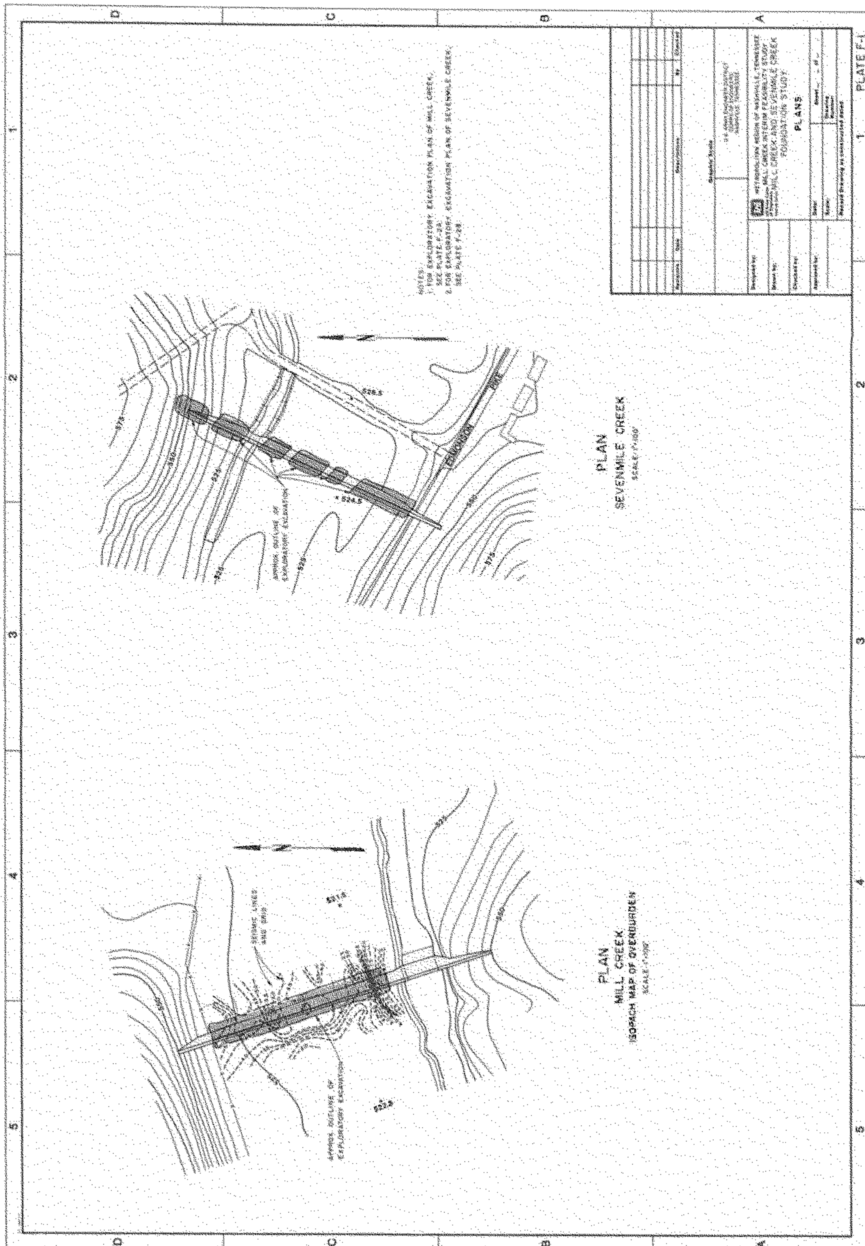
Regional Detention Structure River Mile 3.67 – Typical Cross Section Looking Downstream

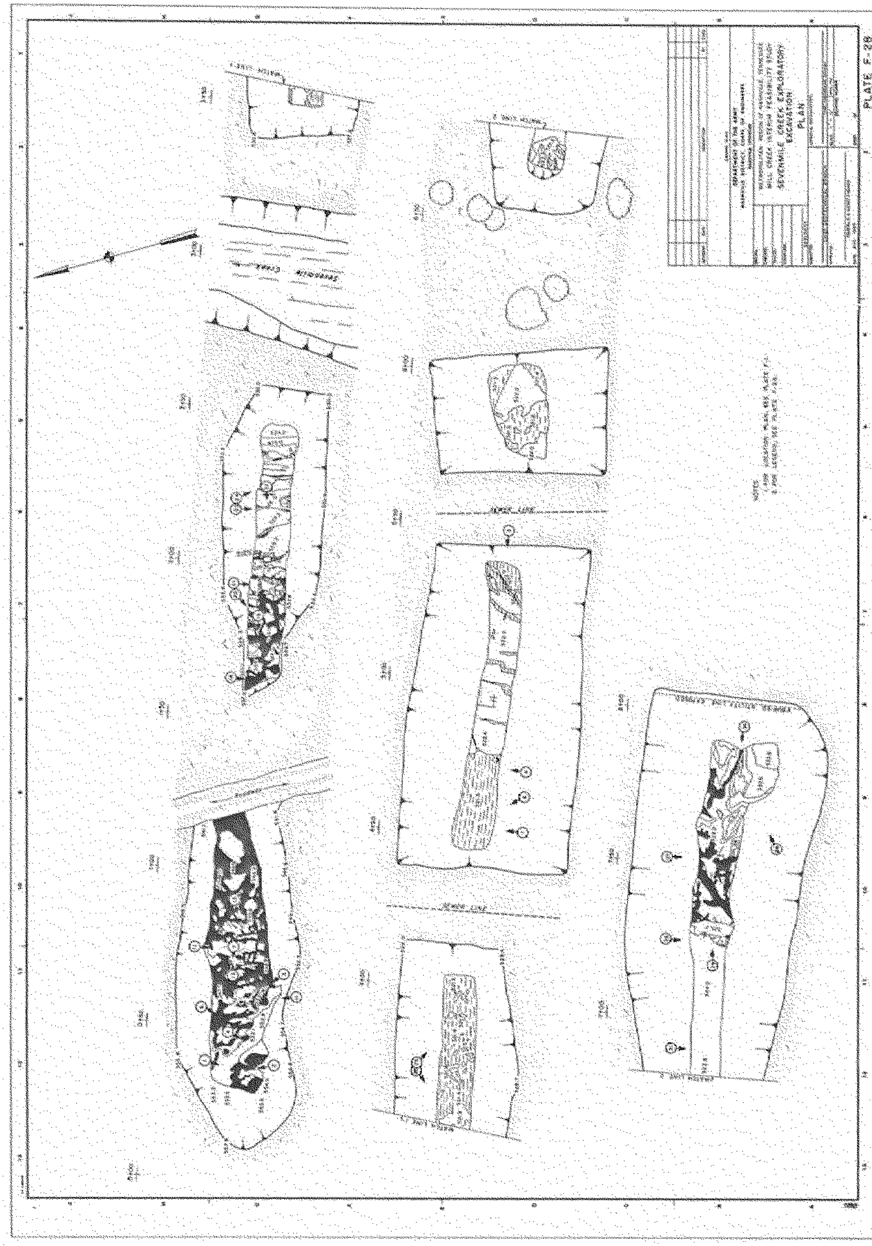


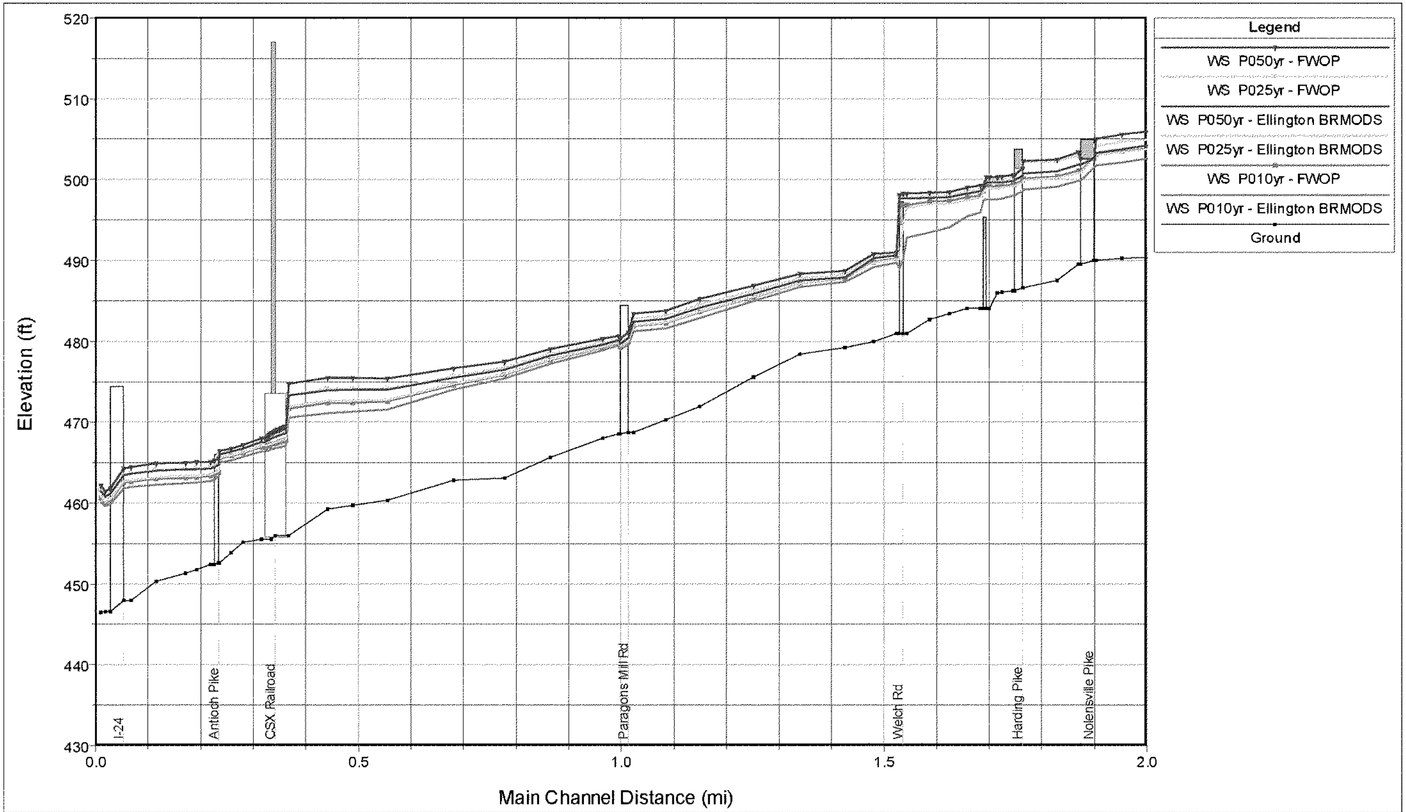
Regional Detention Structure River Mile 3.67 – Plan View



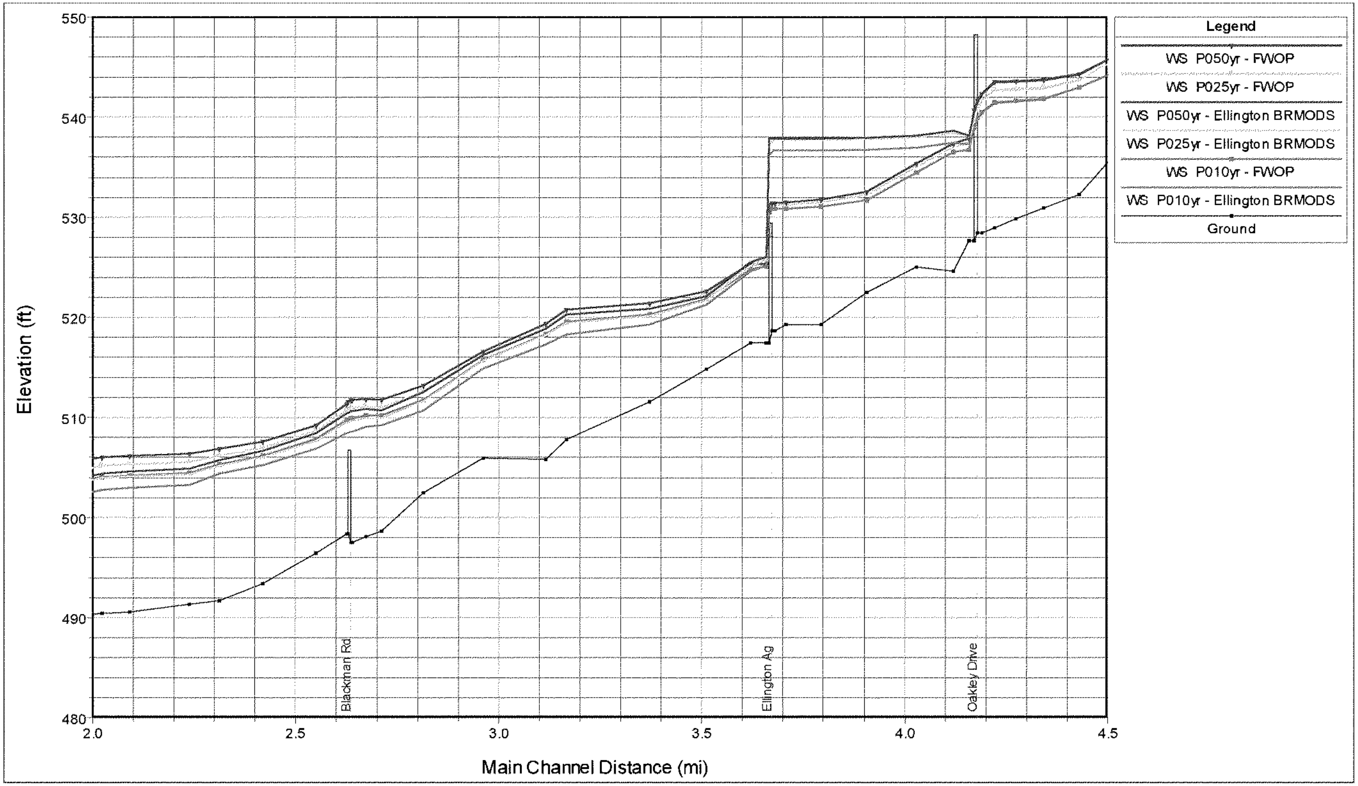
Regional Detention Structure River Mile 3.67 – Typical Section with Outlet Detail


PLAN
SEVENMILE CREEK
PLAN
MILL CREEK
ISOPACH MAP OF OVERBURDEN
PLATE F-1


MILL CREEK INTERIM FEASIBILITY STUDY
SEVENMILE CREEK EXPLORATORY EXCAVATION PLAN
PLATE F-28



Ellington Bridge Modifications 10-, 25, and 50-year Frequency Flood Profiles (River Mile 0 to 2)



Ellington Bridge Modifications 10-, 25, and 50-year Frequency Flood Profiles (River Mile 2.0 to 4.5)

2.3 Briley Parkway Bridge Modifications

Briley Parkway was the only bridge modification to move forward past preliminary screening. The Briley Parkway bridge modification would include widening the east and west bound bridge openings by a minimum of 63 feet.

Structural modifications to existing Briley Parkway bridges

Very little information is known about the condition of the existing bridges. When a plan has been chosen, additional work will be required to find the existing construction information and detailed site inspections will be required to provide a more detailed design for these modifications.

There are two bridges that carry Briley Parkway traffic over Mill Creek near mile marker 7.1. Each bridge has two lanes and carries either eastbound or westbound traffic. To increase the flow through the bridge cross-section, it is proposed to add one additional span at the west end of each bridge and approximately 200 feet of channel widening. The widening will start at the upstream end of the west embankment looking downstream. Each existing bridge has three discontinuous spans, supported by pre-stressed concrete girders. The bridges have out-of-date railings and no shoulder. TDOT may revise the railings and add shoulders to the bridge as part of this project. The bridge design is based on TDOT current standard design details.

Possible Construction Sequence:
Sequence does not include possible rail replacement and shoulder addition by TDOT.

- Step 1: Construct cross-over ramps for closing eastbound bridge.
- Step 2: Close traffic over the eastbound bridge. Convert the westbound bridge to two-way traffic.
- Step 3: Remove west span from eastbound bridge.
- Step 4: Remove west abutment. Abutment is made of piles with a concrete cap beam.
- Step 5: Excavate west bank of Mill Creek.
- Step 6: a. Construct west abutment. b. Construct new pier in location of original west abutment.
- Step 7: Install new pre-stressed concrete girders on both spans.
- Step 8: Construct deck slab.
- Step 9: Construct bridge railings.
- Step 10: Install new traffic controls (lines, signage, etc.).
- Step 11: Revise cross-over ramps for westbound bridge construction.
- Step 12: Close traffic over the westbound bridge. Open eastbound bridge to two-way traffic.
- Repeat steps 3 to 10 for westbound bridge.
- Step 21: Open both bridges to full traffic. Demobilize site.

Quantity Computations

Both east and west bound bridge quantities were computed by the square feet of the deck areas without contingency. Cost Engineering added 44% contingency to the design quantities, based on the results of the risk register development. The abutment excavation quantities were computed by the Average End Area Method. Cut area was measured in CAD and transferred into a spreadsheet which totaled the quantities. Abutment and channel soil excavation assumed to be fill material. There are no soil borings available. Utility quantities were calculated by inserting GIS data received from Nashville City Utilities into ArcMap to identify potential utility conflicts. Aerial imagery was also utilized to identify utility conflicts. Quantities for utility relocation were estimated for areas where conflicts were suspected.

Relocations

Utilities located in the vicinity of the project were identified by using GIS files provided by Nashville City Utilities. For the selected plan, sanitary sewer, potable water, gas, electric and telephone lines will have to be removed and relocated in order to construct the channel. In general, quantities reflect an in-kind replacement, meaning that the same size and type of material would be utilized in the relocation of a utility to accommodate the proposed channel work.

Hydraulics

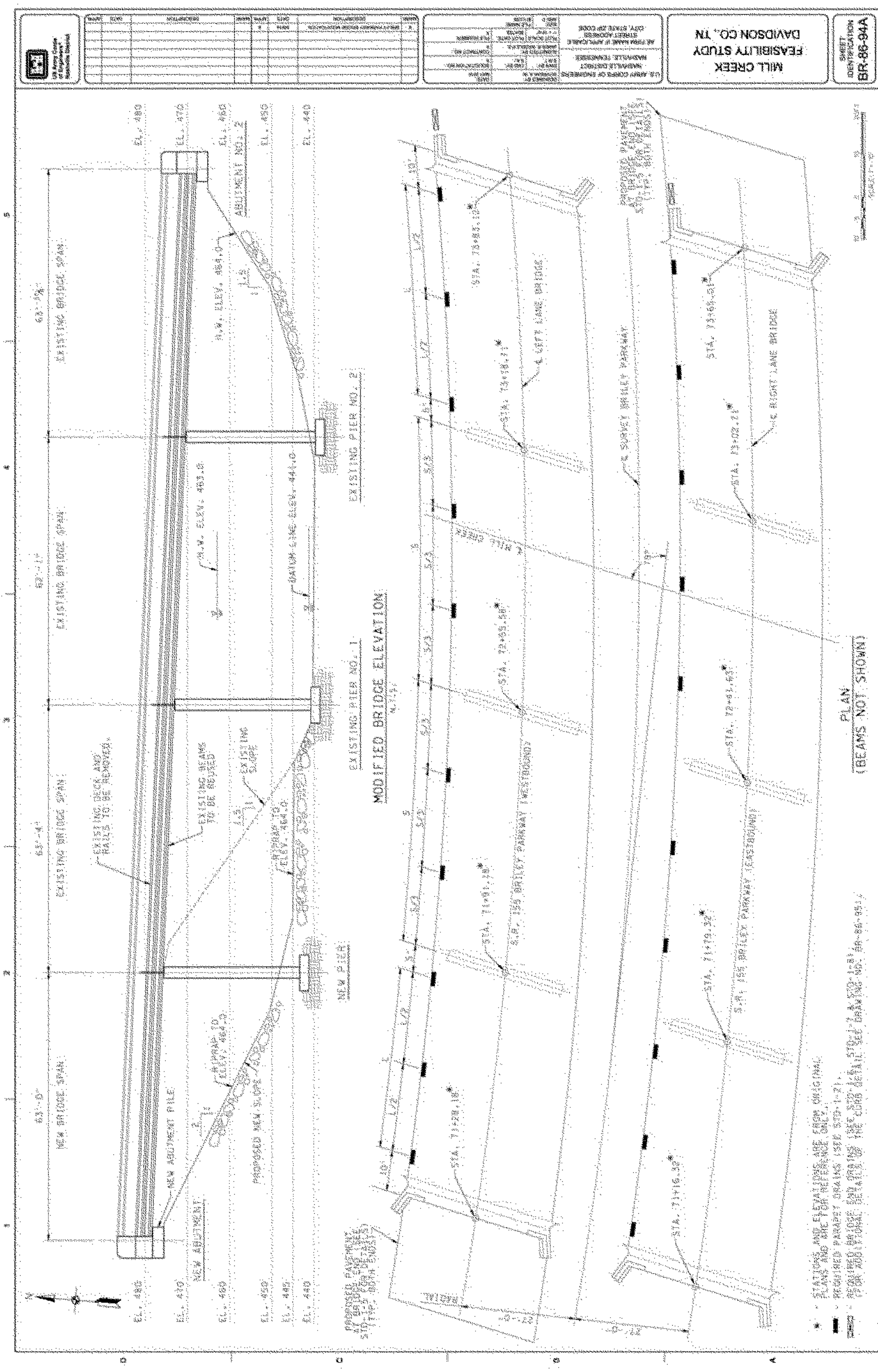
Bridges with significant head loss in target damage centers were removed or modified to evaluate water surface reductions and added benefits. Modifications to hydraulic model (HEC-RAS) cross-section geometry in the vicinity of selected bridges were made to reflect their removal. The intent was to locate bridges that could either be removed or modified to reduce flood damages. Mill Creek bridges included Murfreesboro Road (RM 4.814), Thompson Lane (RM 6.333), Briley Parkway (RM 7.059), CSX Railroad (RM 7.3), Space Park South Drive (RM 8.173), and abandoned railroad (RM 10.915), Franklin Limestone Road (RM 11.083), CSX Railroad RM 11.695 and Antioch Pike (RM 12.096). The HEC-RAS water surface profiles (.wsp files) were then used by the economist to calculate added benefits (reductions in Estimated Annual Damages). Briley Parkway was the only bridge modification to move forward past preliminary screening. The Briley Parkway bridge modification would include widening the east and west bound bridge openings by a minimum of 63 feet as shown to reduce the head loss thru the bridge. Flood reductions for the Briley Parkway measure are shown in the below tables for select damage centers.

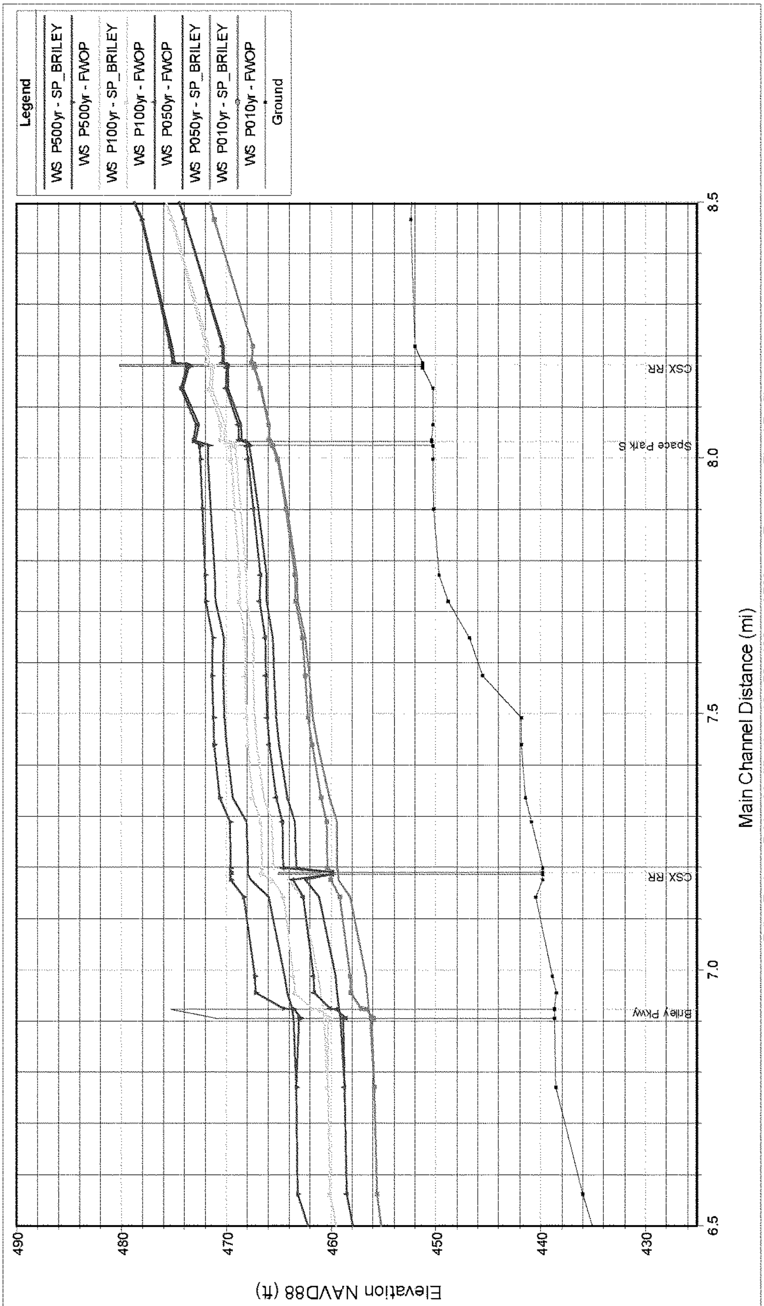
Briley Parkway Bridge Modifications
Just Upstream from Briley Parkway
Mill Creek Mile 7.13

Frequency Event	Future W/O Project Elevation	Future With Project Elevation	WSEL Reduction (feet)
2yr	454.2	453.0	-1.2
5yr	455.7	454.2	-1.4
10yr	458.2	456.7	-1.5
25yr	459.9	458.1	-1.8
50yr	461.7	459.6	-2.1
100yr	463.6	461.2	-2.4
200yr	465.3	462.6	-2.7
500yr	467.3	464.4	-2.8

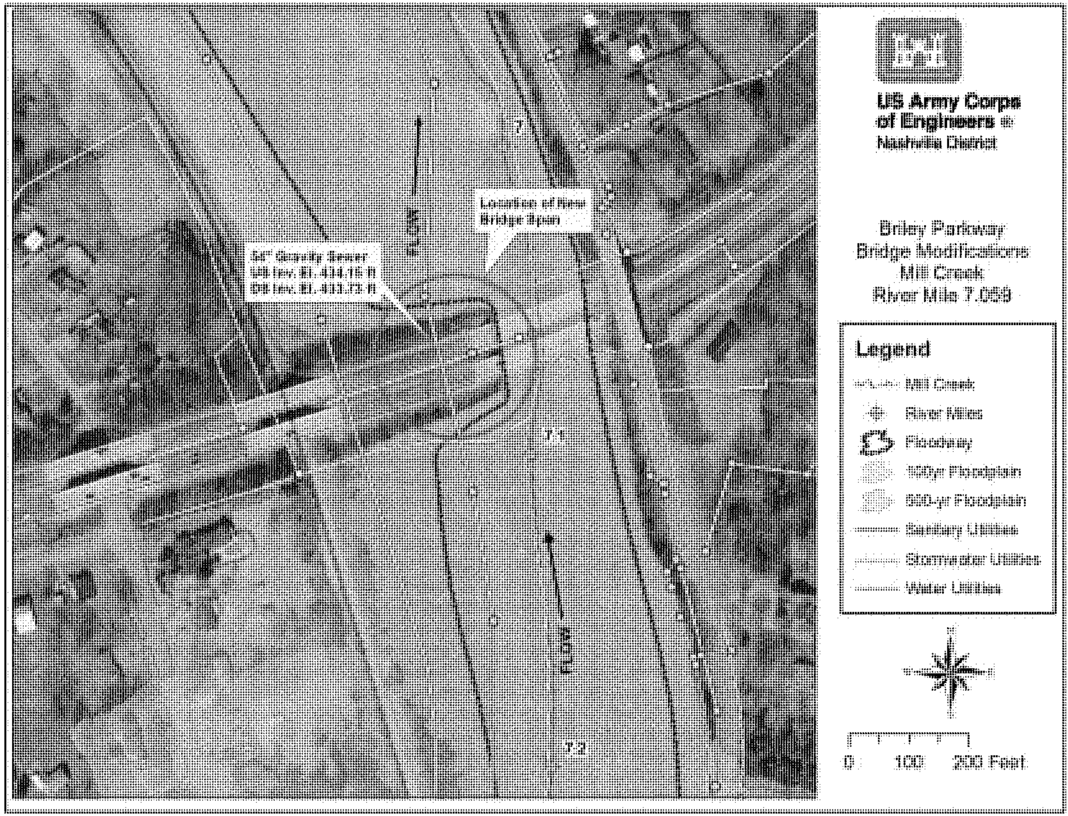
Briley Parkway Bridge Modifications
Space Park South
Mill Creek Mile 7.59

Frequency Event	Future W/O Project Elevation	Future With Project Elevation	WSEL Reduction (feet)
2yr	458.2	458.0	-0.2
5yr	459.6	459.4	-0.3
10yr	461.8	461.3	-0.6
25yr	463.9	463.2	-0.7
50yr	465.9	465.0	-0.9
100yr	468.0	467.1	-0.9
200yr	469.2	468.6	-0.6
500yr	471.1	470.0	-1.1


MILL CREEK
FEASIBILITY STUDY
DAVIDSON CO., TN
BR-86-94A
MODIFIED BRIDGE ELEVATION
PLAN
(BEAMS NOT SHOWN)
EXISTING PIER NO. 1
EXISTING PIER NO. 2
NEW PIER
NEW ABUTMENT
ABUTMENT NO. 2
EXISTING BRIDGE SPAN
NEW BRIDGE SPAN



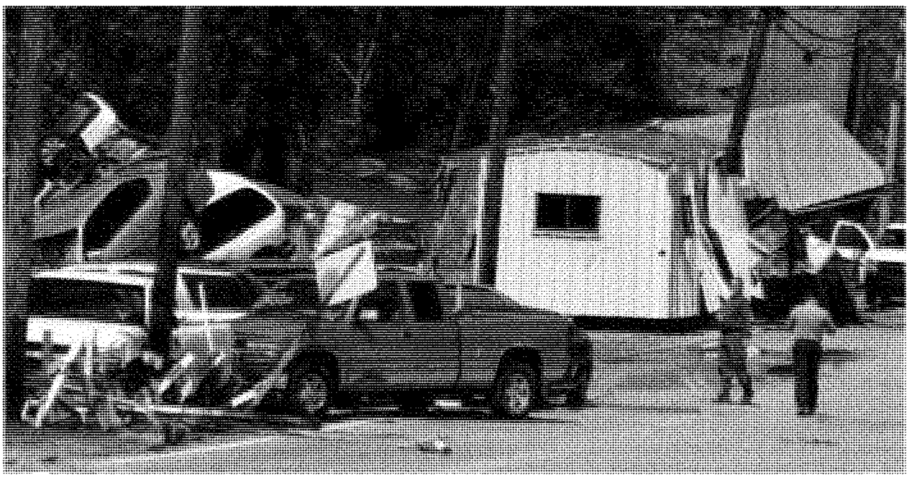
Briley Parkway Bridge Modifications 10-, 50-, 100- and 500-year Frequency Flood Profiles



Briley Parkway Bridge Modifications (East and West Bound Lanes) – Typical Cross Section

US ARMY CORPS OF ENGINEERS
NASHVILLLE DISTRICT

MILL CREEK WATERSHED
FEASIBILITY STUDY
HYDROLOGY AND HYDRAULICS
ENGINEERING - APPENDIX C
ATTACHMENT A



Prepared By

US Army Corps of Engineers

Hydrology and Hydraulics Branch

Nashville District

February 2015

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I. BASIC DATA

a. **Basin Description.** Mill Creek flows approximately 27 miles in a northerly direction from its headwaters just south of Nolensville, Tennessee in Williamson County, Tennessee to its confluence with the Cumberland River (Cheatham Reservoir) at Mile 194.4 in Nashville, Davidson County, Tennessee. The basin is teardrop shaped with a total drainage area of 108 square miles as shown in Figure 1. It lies principally in Davidson County, although 35 percent of the upper watershed is in Williamson County and a small headwater portion extends into Rutherford County.

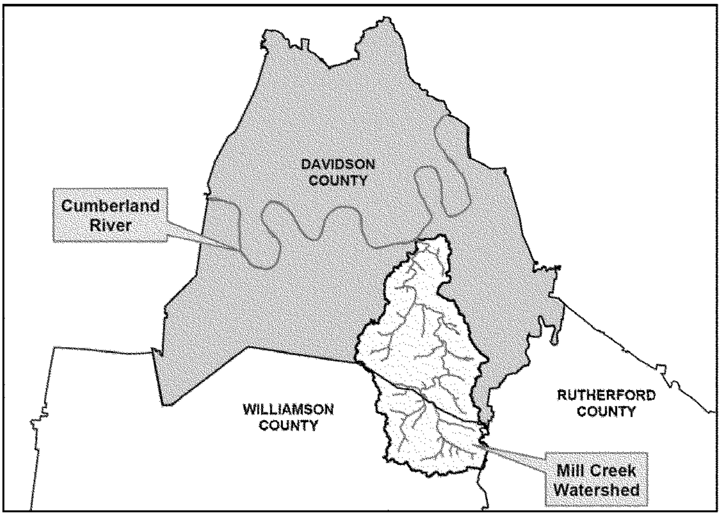

Figure 1: Mill Creek Watershed Vicinity Map

Mill Creek is fed by a number of tributaries; however, its most significant tributaries are Sevenmile Creek in the lower half and Owl Creek in the Upper third of the watershed. Both tributaries flow in a north easterly direction joining Mill Creek at Mile 7.9 and 19.9, respectively. Sevenmile and Owl Creek have drainage areas of 17.5 and 13.2 square miles, respectively. The remaining tributaries have drainage areas less than 10 square miles and generally flow to the northeast or northwest.

Topography in the Mill Creek Basin ranges from flat to moderately sloping along the main stem to rolling and hilly uplands which form the watershed divide. Elevations range from about 385 feet above mean sea level at the mouth to around 1200 feet in the upper extremities of the basin.

The land use in the Mill Creek Basin varies greatly and is experiencing very rapid changes. Progressing upstream from the mouth, the lower 9 miles of the watershed are a mixture of residential, commercial, and industrial development. This type of intense development also continues up the Sevenmile Creek Basin for approximately 3 miles. The middle portion of the Mill Creek and the upper half of the Sevenmile Creek Basins are moderately developed, predominately commercial and residential. The upper half of the Mill Creek Basin, encompassing over 40 square miles of drainage area, is mostly in Williamson County and is less developed but experiencing rapid and intense growth.

b. **Historical Storms and Floods.** Information is available for several significant floods on Mill and Sevenmile Creeks dating back to 1955. Although this is a relatively short time span, a wide variety of rainfall amounts and storm distributions and durations have occurred which provide excellent insight into the basin's flooding characteristics. A chronological discussion of storms and floods is given in the following paragraphs.

The flood of 20-21 March 1955 resulted from a period of widespread rainfall during the night of the 20th and a heavy burst of 3 inches for a 6-hour period starting on 21 March. Total rainfall amounts for the storm averaged from 4.8 inches throughout most of the basin to 5.5 inches in the upper most region of the watershed. This resulted in a stage of 19.73 feet at the Mill Creek gage which forced evacuation of families along Mill and Sevenmile Creeks.

During the night of 16-17 June 1960, a very intense thunderstorm produced a relatively narrow band of heavy rainfall that centered near the Mill Creek headwaters. This flood was higher than the March 1955 flood in the Antioch area just upstream of the gage. However, the maximum stage of 19.15 at the gage was one-half foot lower than the 1955 flood. The lower reaches of Mill Creek and Sevenmile Creek, where most urban development was located at the time, experienced only a moderate rise.

A wet winter and early spring in 1962 featured several storms which caused moderate flood rises on all streams in the Middle Tennessee area. The most severe of these storms in the Mill Creek watershed occurred in late February 1962 when a 60-hour period of precipitation, beginning on the 25th, produced an average of 6 inches of rainfall. Because the rainfall is widespread and long in duration, the flood crested along the entire lengths of Mill Creek and Sevenmile Creek on 27 February.

The 4 May 1979 flood was the flood of record on Mill Creek and produced the most severe flood damages ever experienced along the entire stream prior to May 2010. Initial wetting occurred during the early morning of 3 May when an inch of rainfall fell over the entire basin. Starting at 8 p.m. on 3 May an intense thunderstorm, moving from west to east with its center in the upper half of the Mill Creek basin, deposited nearly 5.5 inches of rainfall in a 6-hour period. The lower half of the basin, including Sevenmile Creek, received 3.1 inches during this same 6-hour period. This resulted in a flood with about twice the magnitude of flow of any previously known flood on Mill Creek.

September in Nashville is usually a very dry month; however, the 11.44 inches of rainfall which fell during September 1979 made this the wettest September since records began in 1871. A part of this record rainfall resulted in severe flooding in the Mill Creek Basin for the second time in 1979. The heaviest rainfall for the month was a direct result of the tropical hurricane Frederick. During the 6-hour period from 1 p.m. to 7 p.m. on 13 September, rainfall amounts of 4.8 to 5.3 inches are recorded throughout the basin. Although the rainfall amounts for this storm closely resemble the May storm, the very dry antecedent moisture conditions resulted in reduced peak discharges which are about two-thirds of the May flood discharges.

During the months of April and May of 1984, residents were twice again alarmed by nuisance flooding on Mill Creek and Sevenmile Creek. Although these floods damaged mainly yards and basements, residents and merchants were fearful of a repeat of the 1979 events.

Flood damages along Mill Creek and its tributaries are documented for several flood events occurring in 1990s and 2000s. On June 4, 1998 flooding was reported along Sevenmile and Mill Creeks. Water threatened the Harding Mall and other structures. The Mill Creek near Nolensville gage reached the year's highest marks on June 4th at 16.23 ft and a peak discharge greater than 10,000 cfs. On May 24, 2000 flooding occurred at Sevenmile Creek near the Harding Mall at 0120 CST. Minor flooding was reported on November 29, 2001 when Sevenmile Creek overflowed its banks spilling into many backyards. On May 5, 2003 spotters reported flooding at Edmonson Pike and Blackman Road along Sevenmile Creek. There was six feet of water over roads and some homes were flooded. Highwater marks for this event were as high as the May 1979 flood at some locations along Sevenmile Creek.

The May 2010 flood is the flood of record along Mill Creek and its tributaries within Davidson County. On Saturday, May 1, 2010, heavy rain began falling in the Cumberland River Valley, Tennessee, and continued through the following day. 16.21 inches of rainfall was measured at the Mill Creek near Antioch Gage, an unprecedented amount that doubled the previous 2-day record of 6.68 set in September 1979, and exceeded the May monthly total record of 11 inches. The daily rainfall totals were 8.42 inches and 7.79 inches on May 01 and May 02, respectively. The maximum 12-hour rainfall totals were 7.90 inches and 7.72 inches on May 01 and May 02, respectively. This intensity of rainfall quickly overwhelmed tributaries to the Cumberland in the Nashville area, causing wide-spread and serious flooding. There were two fatalities and over $185 million dollars in estimated damages in the Mill Creek watershed as reported in the May 2010 Post Flood Technical Report. Stream gages at Woodbine and Antioch reported 21.77 feet and 26.00 ft, respectively, 3 and 4 feet above the previous flood of record which occurred in May 1979.

The top 10 historic peak discharges for available Mill Creek gages are listed in Table 2.

Table 2: Historic Peak Discharges in the Mill Creek Watershed

Mill Creek At Nolensville
DA 12.0 square miles

Rank	Date	Peak Discharge (cfs)
1	5/1/2010	11,600*
2	5/7/1984	11,400
3	5/4/1979	11,400
4	6/26/1994	8,630
5	5/25/2000	8,300
6	9/22/2003	8,160
7	5/14/1995	7,620
8	10/5/1995	7,370
9	1/23/1999	7,020
10	12/1/1991	6,820

Mill Creek Near Nolensville
DA 40.5 square miles

Rank	Date	Peak Discharge (cfs)
1	5/1/2010	30,000*
2	5/4/1979	28,600*
3	9/13/1979	15,200*
4	10/5/1995	13,000
5	5/25/2000	12,600
6	5/14/1995	12,600
7	6/7/2003	12,500
8	5/5/2003	11,100
9	6/26/1994	10,600
10	3/3/1997	10,500

Mill Creek Trib at Glenrose Ave
DA 1.17 square miles

Rank	Date	Peak Discharge (cfs)
1	5/6/1984	833
2	5/4/1979	830
3	6/26/1994	612
4	7/21/1996	550
5	5/3/1993	546
6	5/25/2000	535
7	3/17/2002	523
8	11/27/1994	501
9	7/3/1992	491
10	5/5/2003	460

Mill Creek Near Antioch
DA 64.0 square miles

Rank	Date	Peak Discharge (cfs)
1	5/1/2010	37,910
2	5/4/1979	30,100
3	9/13/1979	19,000
4	3/4/1955	17,000
5	6/17/1960	15,600
6	2/27/1962	13,800
7	5/5/2003	11,500
8	5/25/2000	10,800
9	6/4/1998	10,800
10	5/7/1984	10,700

Mill Creek At Thompson Lane
DA 93.4 square miles

Rank	Date	Peak Discharge (cfs)
1	5/1/2010	33,000*
2	5/4/1979	26,200
3	9/13/1979	20,000
4	2/14/1989	16,000
5	5/5/2003	14,200
6	3/12/1975	13,600
7	6/4/1998	13,500
8	5/7/1984	13,400
9	5/25/2000	13,300
10	10/5/1995	13,000

Seven Mile Creek at Blackman Rd
DA 12.2 square miles

Rank	Date	Peak Discharge (cfs)
1	5/1/2010	11,000*
2	6/4/1998	10,500
3	5/5/2003	7,320
4	9/13/1979	7,320
5	2/14/1989	4,780
6	4/25/1993	4,040
7	3/29/1975	2,960
8	10/5/1995	2,930
9	5/25/2000	2,500
10	5/19/1983	2,070

* Flows estimated from model calibration to high water marks

c. **Previous and Existing Studies.** Frequency profiles for Mill Creek and Sevenmile Creek were developed in conjunction with the Davidson and Williamson County Flood Insurance Studies (FIS) beginning in 1977. The hydrologic and hydraulic analyses for these studies are performed by the U.S. Geological Survey (USGS). The work is completed just before the May 1979 flood of record. The statistical frequency analysis for FIS is revised in 1980 by the Corps to reflect this flood. This analysis is discussed later as the adopted procedure.

In 1980 work began on a Stage II report for the Mill Creek Basin. The backwater model developed for the FIS by USGS is converted to a "Water Surface Profiles, HEC-2" computer program format for use in this study. Verification runs are made using this model to determine its accuracy in reproducing the 1979 floods. Several updates were made to the HEC-2 model, but overall it was adequate to investigate and compare flood control alternatives.

Prior to the 1979 floods, a study was conducted by the USGS entitled, "Effects of Urbanization on Flood Characteristics in Nashville-Davidson County Tennessee." The severity of the 1979 floods and the findings in this report (a conclusion of no impact from urbanization) prompted a detailed study by the Corps of Engineers. The Corps study was completed in 1986. The study focused primarily on the Mill Creek and Seven Mile Creek floodplains within Davidson County. Detailed HEC-1 and HEC-2 models were developed for the watershed and study streams. A large array of alternatives was analyzed including both structural and nonstructural solutions. Nonstructural measures do not modify floods, but are intended to reduce susceptibility to flood damages. These measures include floodplain zoning ordinances, flood insurance policies, flood forecasting and warning, flood proofing and permanent evacuation of the floodplain. Structural measures, on the other hand, actually reduce flood stages in problem areas. These actions may include dams and reservoirs, levees, bridge modifications, channel modifications, or clearing and snagging. A total of 43 plans or combination of plans was evaluated from hydrologic, hydraulic, economic, and environmental viewpoints. The selected plan which provided the greatest return on the investment of tax dollars (the most net benefits) is the NED plan. The 1986 study recommended plan was the construction of a dam at Mile 16.81 on Mill Creek, constructing a dam at Mile 3.70 on Sevenmile Creek, and widening a section of Sevenmile Creek from Mile 0.70 to 1.51. The recommended plan was congressionally authorized for construction but never completed due to lack of public support and public opposition. The majority of the opposition was those directly affected by the plan, their friends, and families outside of flood-prone areas, or citizens upstream who are not being helped by the project. Those who supported the plan while not as vocal were primarily beneficiaries living in historical flood-prone areas.

The Corps of Engineers completed a Section 22 study (Planning Assistance to States) in 1990 for the Mill Creek Basin within Williamson County. The purpose of the study was to provide Williamson County with hydrologic information concerning the possible use of regional detention to reduce flooding in the Nolensville Community. The study evaluated two regional detention sites which provided flood reductions along Mill Creek in the vicinity of Nolensville, Tennessee. The selection of the sites was based on the hydrology of the basin, available storage, required length of dam, and open area. Based on study results, Williamson County did not proceed with the regional detention approach due to loss of valuable land in the detention areas.

In 1996, the Corps of Engineers conducted a floodway storage analysis for the Cumberland River and Mill Creek in Davidson County, Tennessee to evaluate the requirement to compensate storage for fill in the floodway fringe. An unsteady flow (UNET) model was developed for Mill Creek within Davidson County. Results of the analysis indicated that compensation storage was necessary along most to the Mill Creek main stem to attenuate flood hydrographs and minimize encroachment surcharge.

Metro has completed several of their own studies for Mill Creek and its tributaries. The Metro/Davidson County and Williamson County governments are both very supportive of the FEMA Flood Insurance Program, solutions to reduce or minimize flooding and improve water quality and ecosystem. The Stormwater Division of Metro Water Services was formed April 1, 2002. The formation of the Stormwater Division nearly doubled the stormwater budget allowing more funding to address immediate problems like local drainage. It has also allowed Metro additional funds for partnering with federal agencies like the Corps and USGS for Watershed Studies like this one.

The Nashville District Corps of Engineers is conducting a General Investigation (GI) Study for the Mill Creek Watershed which began in 2003. The study was scoped for both flood damage reduction and ecosystem restoration components, with FIS updates included under the umbrella of flood damage reduction. A Flood Insurance Study was completed in 2006 as part of the GI Study. The FIS update included a complete restudy of Mill Creek and its tributaries within Davidson County. This study included the development of observed flood and hypothetical (frequency) event based HEC-HMS models and georeferenced HEC-RAS models. All detailed (Zone AE) and approximate (Zone A) streams shown on FEMA maps were updated to detailed study zones. These models were provided to FEMA for adoption during the next map revision for Davidson County and were put on hold to incorporate new terrain (LiDAR) data and May 2010 flood impacts to flood frequency.

As a result of the May 2010 flood, Metro Nashville partnered with the Corps to develop flood inundation models and flood preparedness tools for 6 streams in the county (referred to as Phase 1). The streams included the Cumberland and Harpeth Rivers and Mill, Browns, Whites and Richland Creeks. The majority of the population impacted by the May 2010 flood and all of the loss of life was associated with these streams. Three of the streams, the Cumberland River, Mill and Richland Creeks had good existing models and were updated. The Harpeth River, Whites and Browns Creeks had models that were 20 to 30 years old using old technology and were completely redone. In addition to the modeling, tools were developed that enable the city to better predict what is likely to occur under different flooding scenarios. Phase 2 of the study included Real Time Simulation (HEC-RTS) modeling for the 6 streams discussed above. The modeling incorporated real time observed data, NEXRAD radar, NWS rainfall predictions to predict inundated areas and depths. The models are used to simulate the impacts from different rainfall scenarios and are available to both Metro and the National Weather Service. Phase 2 also included updating frequency and flow data to turn over to FEMA who will use the data to update the Flood Insurance Maps in Davidson County.

II. HYDROLOGIC MODEL ANALYSIS

The hydrologic models developed previously for the 2006 FIS update were revised to include calibration to the May 2010 flood event and updating hydrologic parameters to current watershed conditions. The hydrologic models were developed using GIS techniques utilizing HEC-GeoHMS. HEC-GeoHMS is a GIS tool that is a software extension to ArcView GIS package for personal computers (Copyright© 1996, Environmental Systems Research Institute, Inc.). It allows the user to visualize spatial information, document watershed conditions, perform spatial analysis, and to help define the structure and parameter inputs to hydrologic models. An analyst, working with GeoHMS, can expediently create hydrologic model inputs that are required for rainfall-runoff simulation using HEC-HMS.

a. **Methodology.** This section describes the development of data necessary to build the HEC-HMS models of the Mill Creek basin. The initial step was to use HEC-GeoHMS to generate the physical parameters of the basin such as drainage area, stream lengths, basin slopes, etc. From these physical parameters, initial estimates of unit hydrograph parameters were developed. Additionally, HEC-GeoHMS develops the Standard Hydrologic Grid file for use in HEC-HMS. Percent impervious relating to land use was developed from hyperspectral imagery and impervious land cover data provided by Metro Nashville GIS. Loss rates relating to soil types were developed using soil information from the State Soil Geographic (STATSGO) database (USDA 1994). Routing data was developed from HEC-RAS models and terrain data. Precipitation data was generated from NEXRAD Stage III, 2-kilometer gridded radar rainfall acquired from the National Weather Service's Ohio River Basin River Forecast Center. Observed streamflow records and highwater marks were used for model calibration. All of these data were used to build the HEC-HMS model and are described in more detail in the following sections.

b. **Basin Development.** A basin file was generated in Geo-HMS that contains the stream alignments and subbasin boundaries that were used by HEC-HMS for a background map of the model schematic. This feature was extremely useful for depicting the layout of the elements in the model schematic. In addition, GeoHMS was used to create tables of subbasin physical characteristics such as drainage area, stream length, length to the center of area, longest flow path, slope, and elevation. These physical parameters were used in other analyses to derive subbasin Clark unit hydrograph parameters required for rainfall-runoff simulation.

   A digital elevation model (DEM) is the basis from which stream slope, flow paths, and drainage boundaries are determined in the GIS model. A 10-ft DEM which was first generated from LiDAR survey data flown in June 2002. The LiDAR data was flown to obtain a vertical accuracy for the creation of 2-ft contours. The LiDAR data included the collection of mass points and hydrologic and land feature breaklines. The average mass point spacing was approximately 8 feet (approximately 2-meters). GIS planimetric layers were also obtained from Metro Nashville GIS to improve the drainage patterns within the terrain dataset. Drainage features were burned into the 10-ft DEM using the terrain reconditioning (stream burning) within the ESRI ArcView 3.2 HEC-GeoHMS extension. Stream burning also was performed where man-made features such as bridges, culverts and buildings cover streams. The goal was the creation of hydrologic model with average subbasin drainage areas of one square mile. The HEC-GeoHMS subbasin delineation is shown in Figure 2. The largest basin is 1.3 square miles. The blue lines show the river system in the basin as generated by HEC-GeoHMS. There are 129 subbasins within the 107.3 square mile area of the Mill Creek basin.

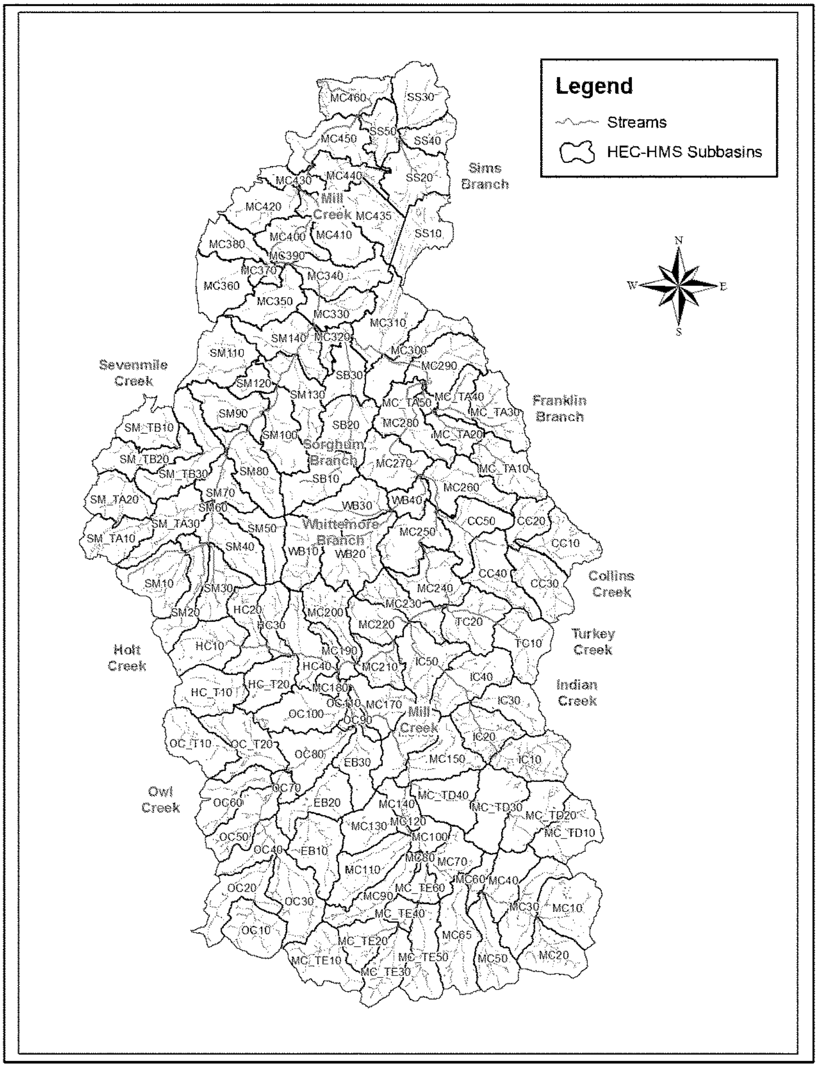

Figure 2: Mill Creek Watershed HEC-GeoHMS Subbasin Delineation

HEC-GeoHMS also generates the grid-cell parameter file. This file represents subbasins as grid cells for the distributed (gridded) modeling approach. The hydrologic models were developed where the grid size was generally equivalent to a 10-acre (200-meter) parcel as shown in Figure 3. The 10-acre grid size was well suited for urban areas allowing for a more detailed analysis of infiltration, landuse and runoff changes within the watershed. Figure 3 depicts a Mill Creek one square mile subbasin with 10-acre grids superimposed on it.

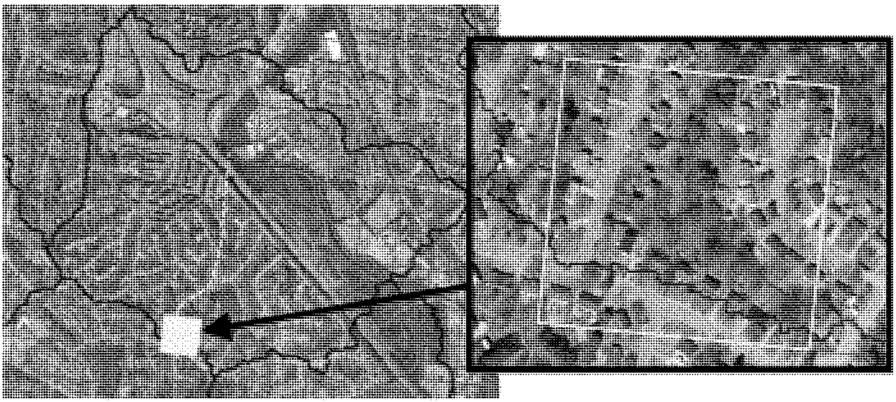

Figure 3: 10-acre grid cells superimposed on one square mile subbasin

c. **Estimation of Basin Runoff Parameters.** The HEC-HMS program allows the analyst to estimate runoff parameters automatically using the optimization manager. Observed discharge must be available for at least one element before optimization can begin. Parameters at any element upstream of the observed flow can be estimated. The program makes an estimate of the required parameters, computes the resulting runoff, and compares the goodness-of-fit between the computed results and observed discharge, based on a peak weighted root-mean-square error. If the fit meets a built-in tolerance, the parameter optimization is complete. If not, new, improved estimates of the parameters are systematically made and the process is repeated until the tolerance is met or changes in the estimates have little or no effect. A graph of the computed and observed runoff hydrographs can be displayed as well as tables of peak flow, volume differences, etc. to compare results. Constraints can be imposed to restrict the parameter space of the search method.

To estimate optimal parameters for the Mill Creek basin, three historical storm events were used. These are the 22-29 May 2000, 22-28 January 2002 and the 21-25 September, 2003 events. Radar rainfall data was available for all 3 events along with recorded hydrographs at the Mill Creek near Nolensville, Mill Creek near Antioch, Mill Creek at Thompson Lane and Mill Creek Trib at Glenrose Ave gaging stations. The initial parameters that were optimized included Clark's Time of Concentration and Storage Coefficient, Initial Baseflow, Recession Constant and Recession Threshold. Even though the baseflow parameters were optimized, they are not applied to the model. It was determined during the calibration process that the Linear Reservoir baseflow method provided a better representation of the baseflow in the Mill Creek basin. Therefore, the baseflow optimization will not be discussed.

In order to optimize the Clark's parameters, it was necessary to develop lumped basin models for the total areas above each of the gages. Figure 4 shows the areas used to develop the lumped basin models. The model for the optimization at the near Nolensville gage included the dotted area in Figure 4. The model for optimization at the near Antioch gage included both the dotted and cross hatched area. The model for optimization at the Thompson Road gage included the dotted, cross-hatched and diagonal lined areas. The model for optimization at the Glenrose included the light green area. It was necessary to develop the lumped basin models, as opposed to the gridded model, since the optimization process is not efficient when dealing with multiple subbasins and multiple grids within each basin. The lumped model optimization provides an expedient method for the estimation of the Clark parameters.

After several trials, the optimal and most reasonable Clark's parameters were adopted for each gaged basin and for each storm event. Once these parameters were determined, a single set of parameters were selected for each of the gaged basins. Table 2 lists the optimization results and estimated Clark's parameters.

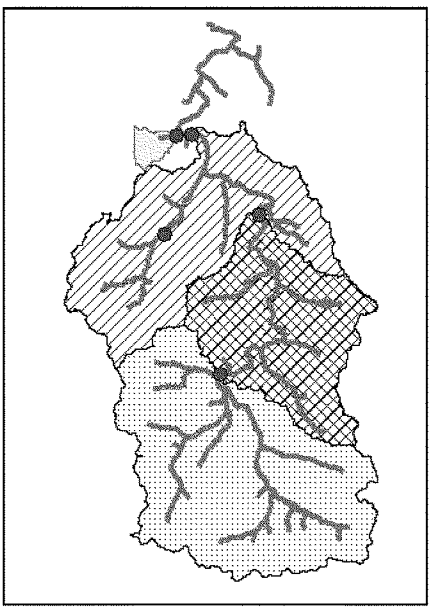

Figure 4: Mill Creek Lumped Basins

Table 2 – Clark Transform Method Optimization Results

Location	Volume (ac-ft)			Peak (cfs)			Time To Peak		Optimized	
	Sim	Obs	% Diff	Sim	Obs	% Diff	Simulated	Observed	Tc	R
September 2003 Event										
Nolensville	7,982	7,344	8.7	9,374	10,496	-10.7	22 Sep, 08:00	22 Sep, 09:00	5.2	2.1
Antioch	13,992	10,296	36	9,155	9,222	-0.7	22 Sep, 11:00	22 Sep, 13:00	7	10
Thompson	17,246	16,427	5	14,146	13,145	8	22 Sep, 11:00	22 Sep, 08:30	8.1	6
Glenrose	291.67	359.7	-18.9	206	205	0.19	22 Sep, 06:00	22 Sep, 02:15	1.5	1.0
January 2002 Event										
Nolensville	4,985	7,428	-32.9	5,685	5,782	-1.7	24 Jan, 08:00	24 Jan, 08:30	3.8	2
Antioch	9,141	8,818	3.7	4,518	4,618	-2.2	24 Jan, 10:00	24 Jan, 11:00	4.1	10.5
Thompson	11,520	15,203	-24	6,978	6,887	1.3	24 Jan, 11:00	24 Jan, 11:30	7	6.5
Glenrose	244.8	303.2	-19.3	273	212	29.1	24 Jan, 05:00	24 Jan, 04:00	1.5	1.0
May 2000 Event										
Nolensville	9,387	8,828	6.3	12,424	12,504	1	25 May, 04:00	25 May, 04:30	3.3	4.2
Antioch	15,623	10,271	52	11,079	11,332	2	25 May, 08:00	25 May, 11:00	7.5	8.3
Thompson	20,566	17,846	15	14,016	13,333	5	25 May, 09:00	25 May, 13:30	10.1	7.7
Glenrose	600	599	0.15	556	535	3.8	25 May, 01:00	25 May, 00:40	1.5	1.0

After optimization trials were complete, single T_c and R values were selected for each of the gaged basins. The initial values are generated by simply averaging the values for each of the flood events. Table 3 shows the average values computed for each lumped subbasin.

Table 3 - Average Clark Transform Parameters

Location	R	R/Tc+R
Mill Creek Near Nolensville	2.77	0.40
Mill Creek Near Antioch	9.60	0.60
Mill Creek Near Woodbine	6.72	0.44
Mill Creek Trib at Glenrose	1.00	0.40

Clark's time-of-concentration, T_c, was based on the physical characteristics of the watershed such as stream length, slope of the watercourse and shape of the basin. Clark's T_C was related to basin characteristics so that T_C could be determined for each subbasin in a sub-divided watershed model. The "Basin Factor," as shown in equation (1) below was used to relate T_C with basin characteristics for the lumped basin models shown in Figure 2.

$$\text{Basin Factor} = \left(\frac{LL_{ca}}{\sqrt{S}}\right) \qquad (1)$$

Where,

L = length (longest flow path) of the main watercourse in miles,

L_{ca} = length (flow path) on the main watercourse from a point closest to the center of area of the basin to the basin outlet in miles, and

S = average slope of the longest flow path between points located at 10 and 85% of the length from the basin outlet (ft./mi.)

A predictive equation for TC is computed following the study of Linsley et al. (1982). The general expression proposed by Linsley has the form,

$$TC = C_t\left(\frac{LL_{ca}}{\sqrt{S}}\right)^n \qquad (2)$$

where C_t and n are the predictive equation parameters. C_t characterizes a type of hydrologic basin, and therefore it remains constant for basins of similar hydrologic characteristics. This assumption was made for the Mill Creek subbasins. Table 4 shows values used in the TC equation and Figure 5 shows the resulting best-fit curve relating Tc and Basin Factor. The slope and lengths are taken directly from the data generated by HEC-GeoHMS.

Table 4 - Values Relating Tc and Basin Factor

HMS Subbasin	Slope 10%-85%	Longest Flow Length	Centroidal Length	Basin Factor	Opt TC
	(Ft/mi)	(Mi)	(Mi)	($LLca/S^{0.5}$)	(Hrs)
Nolensville	21.1	9.75	3.76	7.97	4.09
Antioch	10.6	18.47	10.42	59.22	6.19
Thompson Lane	10.6	23.58	13.78	100.0	8.39
Glenrose Ave	84.5	2.10	0.89	0.20	1.50

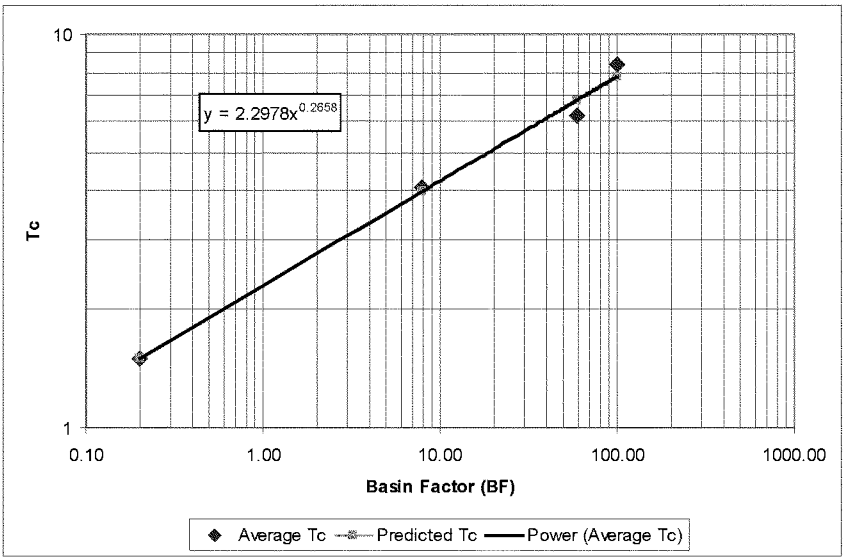

Figure 5 - T_C Regression Relationship

Based on the results, the following relationship was adopted to relate Clark's time-of-concentration, TC to subbasin characteristics:

$$T_C = 2.2978\left(\frac{LL_{ca}}{\sqrt{S}}\right)^{0.2658} \quad (3)$$

Once this relationship was developed for the lumped basins it was applied to the detailed basin delineation shown in Figure 2. One of the main advantages of developing watershed models using the GIS application HEC-GeoHMS was that subbasin and stream characteristics were determined directly from the GIS model. Longest flow path, length to center of area, and slope were used with equation (3) to define Clark's T_C for all the subbasins. Clark's storage coefficient R divided by T_C + R, computed from the average values from Table 3, was used to compute R from T_C for all of the subbasins. Table 5 list the subbasin characteristics generated by HEC-GeoHMS for all 129 basins for existing conditions. Also shown in these tables are the T_C and R values used for each subbasin. It should be noted that the $R/(T_C+R)$ value in Table 3 for the Antioch location is 0.60 but Table 5 reflects a $R/(T_C+R)$ value of 0.40. This change is made during the calibration process when it became apparent that the R value resulting from the 0.60 ratio was too high and that a 0.40 ratio was more appropriate. The Hydrograph attenuation at the Antioch gage is related more to Mill Creek main stem valley storage than by individual subbasin storage, R.

Table 5: HEC-GeoHMS Subbasin Characteristics (Existing Conditions)

HEC-GeoHMS Subbasin Characteristics									
HMS Subbasin Name	HMS Subbasin Area sq mi	Slope 10%-85% ft/mi (S)	Longest Flow Path mi (L)	Centroidal Length mi (L_{ca})	Basin Factor ($LL_{ca}/S^{0.5}$)	Tc $2.298(LLca/s^{0.5})^{0.2658}$	R	R/Tc + R	Percent Impervious (%)
CC10	0.896	73.920	2.086	0.886	0.215	1.53	1.00	0.40	11.21
CC20	0.571	153.120	1.404	0.655	0.074	1.15	0.78	0.40	13.00
CC30	1.044	89.760	2.299	1.271	0.308	1.68	1.10	0.40	15.98
CC40	1.047	84.480	2.438	1.300	0.345	1.73	1.15	0.40	14.26
CC50	0.939	84.480	2.066	0.915	0.206	1.51	1.00	0.40	53.14
EB10	1.063	63.360	1.972	0.841	0.208	1.51	1.01	0.40	3.21
EB20	0.940	58.080	2.114	0.928	0.257	1.60	1.07	0.40	5.78
EB30	0.792	68.640	1.945	0.959	0.225	1.55	1.04	0.40	3.61
HC_T10	1.003	84.480	2.074	0.671	0.151	1.39	0.93	0.40	15.56
HC_T20	0.774	68.640	1.991	1.039	0.250	1.59	1.06	0.40	11.59
HC10	1.035	89.760	2.211	0.762	0.178	1.45	0.97	0.40	18.08
HC20	0.835	100.320	2.003	0.628	0.126	1.32	0.89	0.40	19.75
HC30	0.589	89.760	2.278	1.179	0.283	1.64	1.10	0.40	13.62
HC40	0.993	73.920	2.353	1.151	0.315	1.69	1.13	0.40	9.20
IC10	1.027	79.200	1.739	0.760	0.149	1.38	0.93	0.40	0.98
IC20	0.854	79.200	1.701	0.830	0.159	1.41	0.95	0.40	2.65
IC30	0.814	63.360	1.857	0.835	0.195	1.49	1.00	0.40	1.25
IC40	1.155	95.040	1.659	0.697	0.119	1.30	0.86	0.40	2.65
IC50	1.094	63.360	2.179	1.123	0.307	1.68	1.10	0.40	6.92
MC_TA10	1.000	79.200	1.983	0.837	0.186	1.47	1.00	0.40	18.46
MC_TA20	0.519	36.960	1.331	0.592	0.130	1.33	0.90	0.40	19.50
MC_TA30	1.005	68.640	1.770	0.693	0.148	1.38	0.93	0.40	28.48
MC_TA40	0.480	100.320	1.479	0.642	0.095	1.23	0.83	0.40	16.24
MC_TA50	0.127	47.520	0.839	0.348	0.042	0.99	0.65	0.40	6.60
MC_TD10	1.003	126.720	1.448	0.406	0.052	1.05	0.70	0.40	2.18
MC_TD20	1.000	68.640	1.746	0.592	0.125	1.32	0.89	0.40	0.95
MC_TD30	1.120	63.360	1.533	0.425	0.082	1.18	0.79	0.40	2.29
MC_TD40	0.999	47.520	2.183	0.898	0.284	1.65	1.10	0.40	7.66
MC_TE10	1.077	153.120	1.396	0.430	0.049	1.03	0.69	0.40	1.46
MC_TE20	0.678	110.880	1.510	0.770	0.110	1.28	0.86	0.40	1.73
MC_TE30	0.833	121.440	1.952	0.950	0.168	1.43	0.96	0.40	1.71
MC_TE40	0.282	105.600	1.031	0.387	0.039	0.97	0.65	0.40	2.21
MC_TE50	1.017	105.600	2.259	1.073	0.236	1.57	1.05	0.40	2.25
MC_TE60	0.358	63.360	1.337	0.510	0.086	1.20	0.80	0.40	3.69
MC10	1.207	63.360	1.799	0.750	0.169	1.43	0.96	0.40	2.05
MC100	0.371	110.880	1.145	0.636	0.069	1.13	0.76	0.40	17.72
MC110	1.066	68.640	2.443	1.217	0.359	1.75	1.17	0.40	1.95
MC120	0.053	36.960	0.447	0.187	0.014	0.74	0.49	0.40	4.37
MC130	0.801	84.480	1.768	0.770	0.148	1.38	0.93	0.40	2.48
MC140	0.410	26.400	1.391	0.541	0.147	1.38	0.92	0.40	6.11
MC150	1.011	73.920	2.094	1.072	0.261	1.61	1.08	0.40	3.60
MC160	0.967	52.800	1.680	0.426	0.099	1.24	0.83	0.40	4.05
MC170	0.841	58.080	2.326	1.276	0.389	1.79	1.20	0.40	7.78
MC180	0.178	121.440	0.956	0.502	0.044	1.00	0.67	0.40	0.72
MC190	0.331	105.600	1.385	0.532	0.072	1.14	0.76	0.40	7.52

Table 5: HEC-GeoHMS Subbasin Characteristics (Existing Conditions)

HEC-GeoHMS Subbasin Characteristics									
HMS Subbasin Name	HMS Subbasin Area sq mi	Slope 10%-85% ft/mi (S)	Longest Flow Path mi (L)	Centroidal Length mi (L_{ca})	Basin Factor ($LL_{ca}/S^{0.5}$)	Tc $2.298(LLca/s^{0.5})^{0.2658}$	R	R/Tc + R	Percent Impervious (%)
MC200	0.864	73.920	2.437	1.142	0.324	1.70	1.15	0.40	10.38
MC210	0.657	73.920	1.576	0.591	0.108	1.27	0.85	0.40	6.95
MC220	0.705	68.640	2.459	0.593	0.176	1.45	0.96	0.40	9.90
MC230	0.805	68.640	2.201	1.076	0.286	1.65	1.10	0.40	3.42
MC240	0.970	26.400	2.403	0.695	0.325	1.70	1.15	0.40	11.59
MC250	1.062	73.920	2.151	0.867	0.217	1.53	1.00	0.40	20.34
MC260	1.095	79.200	2.335	1.012	0.266	1.62	1.10	0.41	17.52
MC270	1.011	58.080	2.068	1.004	0.272	1.63	1.10	0.40	36.76
MC280	1.127	52.800	2.566	1.091	0.385	1.78	1.20	0.40	40.19
MC290	1.086	89.760	1.879	0.620	0.123	1.32	1.03	0.44	29.56
MC30	0.978	84.480	1.700	0.252	0.047	1.02	0.68	0.40	1.95
MC300	1.084	73.920	2.579	0.211	0.063	1.10	0.86	0.44	39.67
MC310	1.355	63.360	2.663	1.496	0.501	1.91	1.49	0.44	24.02
MC320	0.305	121.440	1.284	0.679	0.079	1.17	0.91	0.44	31.49
MC330	0.751	100.320	1.506	0.533	0.080	1.17	0.92	0.44	20.71
MC340	1.025	63.360	2.974	1.724	0.644	2.04	1.59	0.44	34.19
MC350	0.885	79.200	1.997	0.977	0.219	1.54	1.20	0.44	40.88
MC360	1.002	105.600	1.651	0.466	0.075	1.15	0.90	0.44	56.90
MC370	0.157	163.680	0.706	0.350	0.019	0.81	0.63	0.44	33.63
MC380	0.810	58.080	1.963	0.739	0.190	1.48	1.15	0.44	44.38
MC390	0.065	58.080	0.616	0.225	0.018	0.79	0.62	0.44	29.06
MC40	0.795	73.920	1.710	0.738	0.147	1.38	0.92	0.40	1.80
MC400	0.770	58.080	1.985	0.737	0.192	1.48	1.16	0.44	36.32
MC410	1.112	73.920	2.895	0.986	0.332	1.71	1.34	0.44	36.89
MC420	0.959	73.920	2.141	1.183	0.295	1.66	1.30	0.44	46.38
MC430	0.394	95.040	1.564	0.672	0.108	1.27	0.99	0.44	39.37
MC435	0.975	79.200	2.146	0.890	0.215	1.53	1.19	0.44	35.69
MC440	0.671	68.640	2.256	1.177	0.321	1.70	1.32	0.44	37.09
MC450	1.122	36.960	2.221	0.670	0.245	1.58	1.23	0.44	48.01
MC460	0.847	15.840	2.142	0.945	0.509	1.92	1.50	0.44	18.19
MC50	0.926	84.480	2.391	1.117	0.291	1.65	1.11	0.40	1.60
MC60	0.317	79.200	1.421	0.569	0.091	1.21	0.81	0.40	0.76
MC65	1.276	73.920	2.749	1.334	0.427	1.83	1.23	0.40	3.49
MC70	0.729	73.920	1.652	0.855	0.164	1.42	0.95	0.40	13.09
MC80	0.037	137.280	0.543	0.284	0.013	0.73	0.49	0.40	2.03
MC90	0.865	68.640	2.755	1.483	0.493	1.90	1.28	0.40	1.40
OC_T10	1.025	63.360	1.915	0.803	0.193	1.48	0.99	0.40	16.30
OC_T20	1.117	58.080	2.322	1.187	0.362	1.75	1.18	0.40	14.57
OC10	0.924	158.400	1.532	0.584	0.071	1.14	0.76	0.40	4.35
OC100	1.045	68.640	2.243	1.122	0.304	1.67	1.12	0.40	8.48
OC110	0.073	31.680	0.639	0.414	0.047	1.02	0.68	0.40	3.60
OC20	1.081	89.760	2.902	1.457	0.446	1.85	1.24	0.40	3.72
OC30	1.177	79.200	2.808	1.180	0.372	1.77	1.18	0.40	2.28
OC40	0.658	132.000	1.919	0.669	0.112	1.28	0.86	0.40	1.99

Table 5: HEC-GeoHMS Subbasin Characteristics (Existing Conditions)

HEC-GeoHMS Subbasin Characteristics									
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OC60	0.881	84.480	2.194	1.126	0.269	1.62	1.09	0.40	11.79
OC70	0.213	100.320	0.968	0.465	0.045	1.01	0.67	0.40	3.85
OC80	1.045	47.520	2.263	1.126	0.369	1.76	1.18	0.40	10.12
OC90	0.217	89.760	1.083	0.486	0.056	1.07	0.71	0.40	11.03
SB10	1.085	68.640	2.102	0.848	0.215	1.53	1.19	0.44	26.53
SB20	0.959	73.920	1.611	0.731	0.137	1.35	1.06	0.44	22.33
SB30	0.689	63.360	1.965	0.718	0.177	1.45	1.13	0.44	45.51
SM_TA10	0.860	116.160	1.773	0.855	0.141	1.36	1.06	0.44	30.83
SM_TA20	0.871	121.440	1.813	0.918	0.151	1.39	1.08	0.44	15.15
SM_TA30	1.001	79.200	2.527	1.116	0.317	1.69	1.32	0.44	21.00
SM_TB10	0.800	73.920	1.834	0.883	0.188	1.47	1.15	0.44	25.80
SM_TB20	0.905	116.160	2.657	1.212	0.299	1.67	1.30	0.44	18.97
SM_TB30	1.302	58.080	2.429	0.260	0.083	1.19	0.92	0.44	25.01
SM10	1.156	132.000	1.775	0.985	0.152	1.39	1.09	0.44	18.68
SM100	0.977	79.200	2.280	1.144	0.293	1.66	1.29	0.44	43.78
SM110	1.109	58.080	1.980	0.707	0.184	1.46	1.14	0.44	57.20
SM120	0.346	110.880	1.195	0.552	0.063	1.10	0.86	0.44	50.28
SM130	0.984	63.360	1.939	0.995	0.242	1.58	1.23	0.44	32.38
SM140	1.101	63.360	2.527	1.149	0.365	1.76	1.37	0.44	32.66
SM20	0.922	68.640	2.815	1.254	0.426	1.83	1.43	0.44	20.91
SM30	0.751	79.200	1.898	0.731	0.156	1.40	1.09	0.44	30.39
SM40	0.921	95.040	2.245	1.141	0.263	1.61	1.26	0.44	30.34
SM50	0.789	100.320	2.446	1.462	0.357	1.75	1.36	0.44	26.58
SM60	0.014	327.360	0.241	0.089	0.001	0.38	0.30	0.44	6.07
SM70	0.641	63.360	2.044	0.687	0.176	1.45	1.13	0.44	31.39
SM80	1.115	79.200	2.473	1.210	0.336	1.72	1.34	0.44	27.04
SM90	0.966	68.640	1.960	0.770	0.182	1.46	1.14	0.44	40.19
SS10	1.014	42.240	2.254	0.844	0.293	1.66	1.29	0.44	50.14
SS20	1.132	84.480	1.852	0.823	0.166	1.43	1.11	0.44	32.81
SS30	1.032	73.920	1.528	0.657	0.117	1.30	1.01	0.44	27.06
SS40	0.505	89.760	1.413	0.689	0.103	1.26	0.98	0.44	37.02
SS50	0.604	89.760	1.504	0.589	0.093	1.22	0.95	0.44	36.73
TC10	1.000	121.440	1.664	0.709	0.107	1.27	0.85	0.40	5.35
TC20	1.030	73.920	1.578	0.742	0.136	1.35	0.90	0.40	6.07
WB10	0.976	100.320	1.872	0.853	0.159	1.41	0.95	0.40	32.01
WB20	1.288	63.360	2.488	1.558	0.487	1.90	1.25	0.40	9.65
WB30	0.991	84.480	2.234	1.032	0.251	1.59	1.05	0.40	24.34
WB40	0.404	31.680	1.389	0.753	0.186	1.47	1.00	0.40	27.04

d. **Baseflow.** The linear reservoir baseflow method was used to route precipitation that infiltrates into the soil as baseflow at the subbasin outlet. This method uses two separate linear reservoirs, groundwater 1 and groundwater 2, to simulate the effects of two subsurface storage components. Six parameters were required for the linear reservoir baseflow method: groundwater 1 and 2 initial baseflow, groundwater 1 and 2 storage coefficient, and groundwater 1 and 2 number of routing steps. Precipitation that infiltrates into the soil was divided equally among the groundwater 1 and 2 linear reservoirs. Groundwater 1 and 2 initial flow parameters were set so that the simulated stream flow matched the observed stream flow at the beginning of a simulation. The storage coefficient parameter determines the rate at which water leaves the linear reservoir. A large storage coefficient results in water being released more slowly from the reservoir as compared to a small storage coefficient. Figure 6 is a sample which shows the hydrographs for linear reservoirs having a storage coefficient of 20 and 100 hours. Notice the GW 2 linear reservoir releases the same volume of water; however, it is spread out over time. For the Mill Creek study, the groundwater 1 storage coefficient was set to a relatively small value of 10 hours to simulate the quicker responding "interflow" portion of a flood hydrograph. The groundwater 2 storage coefficient was set to a large value, 100 hours, to simulate the slower responding baseflow portion of the stream flow hydrograph. The number of routing steps parameter was set to one for both groundwater layers. These values were used for all subbasins. If a value greater than one was specified, then the water from the first linear reservoir is routed to another linear reservoir, in effect creating a cascade of linear reservoirs.

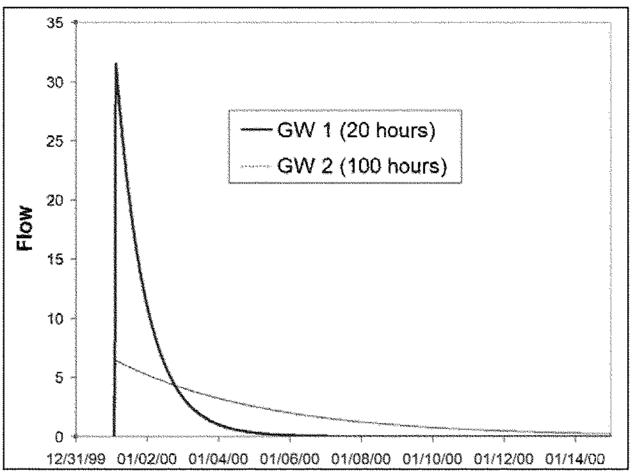


Figure 6 - Simulated Linear Reservoir Baseflow Example

e. **Routing.** The Muskingum-Cunge and Modified Puls hydrologic routing methods were used in the hydrologic model to account for floodplain storage. The Muskingum-Cunge method does an adequate job reproducing observed hydrographs along the main stem of Mill Creek. The main stem was calibrated to three continuous-recording gages having drainage areas of 40.5, 64.0, and 93.2 square miles. The technique has shown to compare well against the full unsteady flow equations over a wide range of flow situations. There are a total of 23 Muskingum-Cunge routing reaches along the Mill Creek main stem within Davidson County. The method was also used to route the inflow hydrographs down the headwater reaches of Mill Creek and Owl Creek within Williamson County. The Muskingum-Cunge routing reach is defined using 8-point cross sections. Hydraulic cross-sections were chosen that best represent the reach channel geometry. Reach length, slope and channel and overbank roughness (Manning's n) are specified at each section. The Muskingum-Cunge cross-sections data was obtained from a combination of survey, hydraulic models and LIDAR mapping. The trapezoidal channel method was used in the upland reaches of basin and estimated from field reconnaissance, aerial imagery and the digital terrain model.

   The modified Puls routing method, also known as storage routing or level-pool routing, was used to route the upstream hydrographs along Sevenmile Creek, Sorghum Branch and Whittemore Branch. The Modified Puls method uses storage-outflow relationships computed from HEC-RAS models. The Modified Puls method was used in lieu of Muskingum Cunge because the HEC-RAS model had an adequate number of cross-sections to define both the conveyance and storage characteristics of the tributaries. These tributaries also have several undersized structures that have significant backwater areas creating additional storage that would not be accounted for in a Muskingum-Cunge cross-section.

f. **Land Cover.** Land cover data was defined using hyperspectral imaging data. The hyperspectral data was collected and processed by BAE Systems. The data was collected between April 27 and June 10, 2002. The processed hyperspectral data contained 57 bands and had a resolution of 4 square meters. Hyperspectral imaging is a collection of electromagnetic radiation reflected from the surface of the earth. In order to determine what the reflectance represents, the spectral data obtained by the hyperspectral sensor is compared, and matched, to spectral data of known absorption features, such as pavement, trees, crops, grass, etc, which are stored in spectral libraries. The hyperspectral data sets were classifiied into 4 categories of land cover: impervious area, grass, trees, and disturbed (bare soil) areas in the Mill Creek watershed and shown as Figure 7.

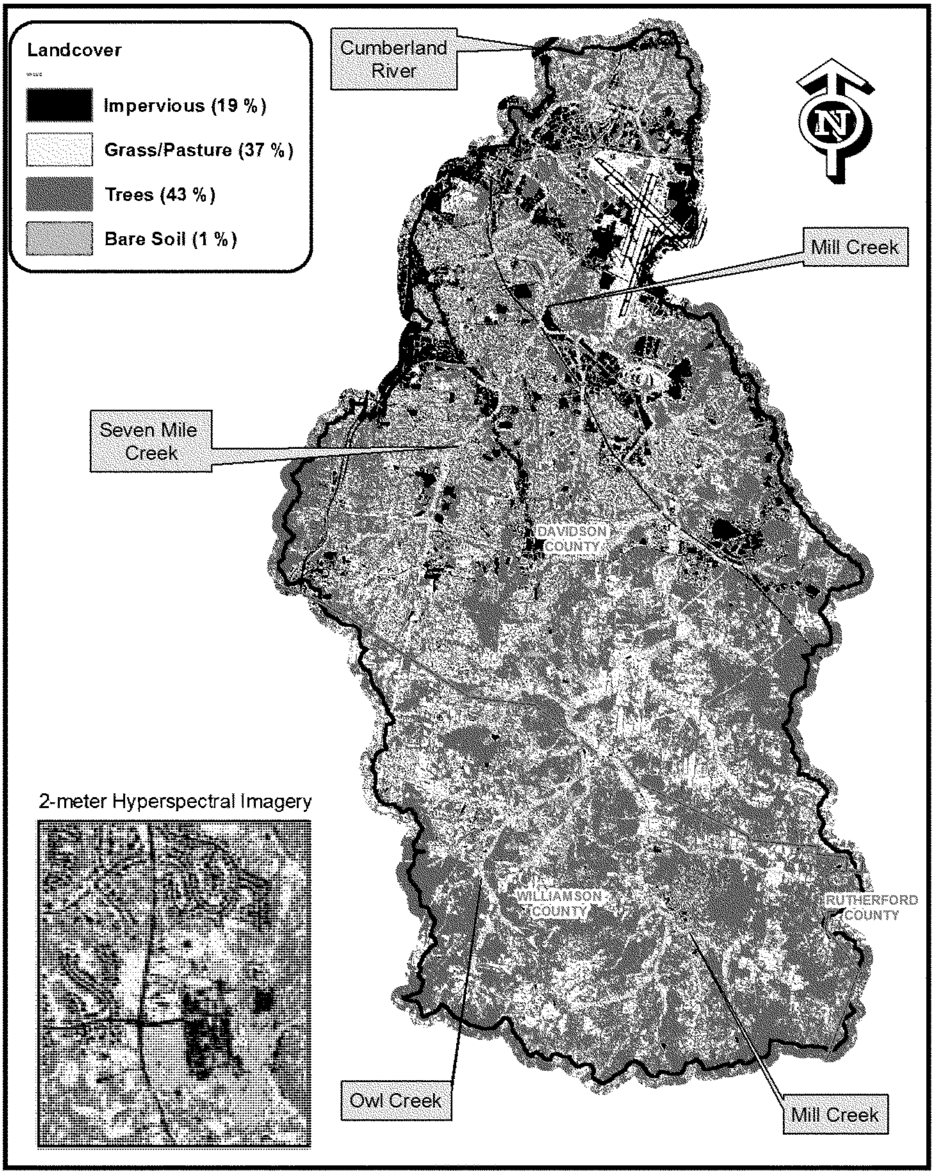


Figure 7: Mill Creek Watershed Land Cover Classification

g. **Loss Method.** The gridded deficit constant loss method used in the HEC-HMS model was developed by HEC for the Mill Creek Watershed Study. This method calculates precipitation lost to storage in the watershed, precipitation infiltrating into the soils, and excess precipitation. Excess precipitation is routed to the subbasin outlet as overland flow using a transform method. Precipitation infiltrating into the soil can be routed to the subbasin outlet using a baseflow method. Average deficit constant loss rates developed from gridded approach were applied to flood frequency lumped HMS models.

The gridded deficit constant loss method tracks the moisture state in each grid cell. It does this using a simple storage layer. Each grid has a pervious and impervious area. An initial moisture deficit is specified at the beginning of a simulation for pervious areas. Precipitation must fill the moisture deficit before infiltration and excess precipitation from pervious areas are calculated. When the moisture deficit is full, the constant loss rate determines the amount of precipitation that infiltrates into the soil and the amount that becomes excess. During periods of no precipitation, water leaves the storage layer until the maximum deficit is reached via evapotranspiration (Priestly-Taylor). The percent impervious area in a grid cell will contribute excess precipitation at every time step when precipitation occurs. No storage occurs on impervious areas.

The gridded deficit constant loss method requires 4 parameter grids:

1. Initial loss,
2. Maximum loss,
3. Constant loss rate (infiltration), and
4. Percent impervious.

The constant loss and percent impervious parameter was estimated using GIS and soil survey data. The constant loss rate was estimated using soil information from the State Soil Geographic (STATSGO) database (USDA 1994). The percent impervious parameter was estimated using hyperspectral data. The initial loss was determined during calibration of the event based models. The maximum loss parameters were determined during the continuous model calibration.

A lumped parameter hydrology model requires subbasin average parameter values. This is not the case for a gridded model, where parameter values must be available for each grid cell. Parameter grids, in DSS format, were developed for each deficit/constant loss parameter. During model calibration, parameters are adjusted to reduce the difference in simulated and observed flow. This is fairly simple in a lumped parameter model; however, in a gridded model a new parameter grid must be developed for each parameter adjustment. To reduce the time and effort involved in creating many parameter grids, an option is available in HEC-HMS that allows the user to specify a ratio, specified for each subbasin, which is multiplied by the parameter value in each grid cell. Figure 8 shows the HEC-HMS option.

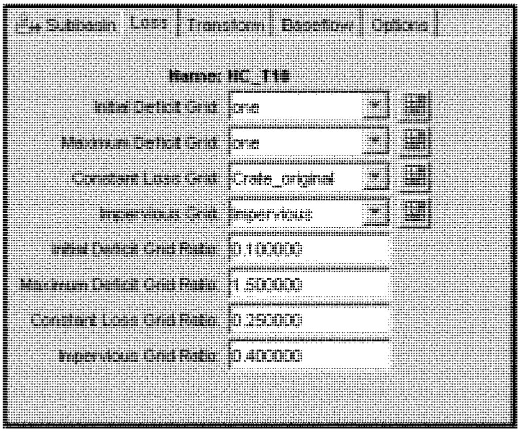


Figure 8 - Deficit/Constant Editor for Subbasin HC_T10

The constant loss rate parameter grid is estimated using the STATSGO database. The database includes a GIS coverage and attribute tables. Figure 9 shows the STATSGO GIS coverage for the Mill Creek watershed. Each STATSGO soil polygon, defined as a map unit id (MUID), represents up to 21 interrelated soil components. The STATSGO database contains attribute information for each soil component, including soil texture type and the percent area of each soil component in a MUID.

As a precipitation event occurs over time, the infiltration capacity of the soil reaches a constant rate. The saturated hydraulic conductivity was used as an initial estimate for the constant loss rate parameter in HEC-HMS. Saturated hydraulic conductivity is related to each soil component based on the soil component's surface soil layer texture type (SURFTEX). Then, an area weighted average saturated hydraulic conductivity (i.e., constant loss rate) is calculated for each MUID. The Surface texture type and corresponding average saturated hydraulic conductivity (SHC) for Mill Creek soils are listed in Table 6. The % Saturation vs. hydraulic conductivity curves used to estimate these values are presented in Figure 9. Hydraulic Conductivity values are converted to inches per hour for this study. Average saturated hydraulic conductivities ranged from 0.0 to 0.40 inches per hour for the Mill Creek soils.

HEC-HMS requires a parameter grid in HEC-DSS format for the gridded constant loss rate parameter. One of the GIS coverages generated by HEC-GeoHMS is vector polygon coverage of the 200 meter standard hydrologic grid. The ArcView GeoProcessing Wizard was used to intersect the STATSGO soil coverage with the vector polygon 200 meter SHG coverage. Using the new coverage, the average saturated hydraulic conductivity was calculated for each grid cell. Grid ratios were applied during model calibration to estimate the actual constant loss rate.

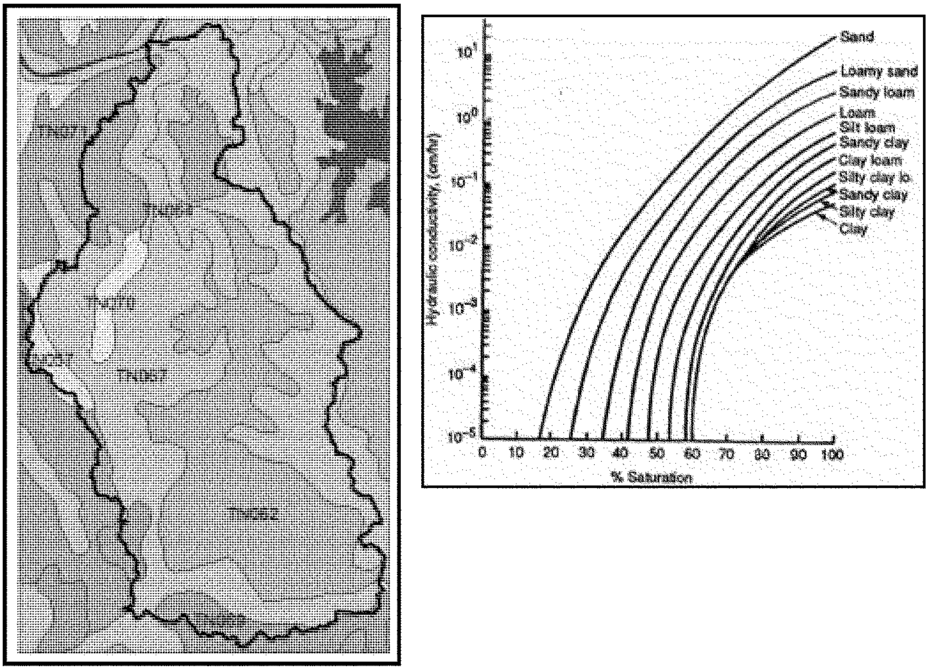


Figure 9 - STATSGO Soil Coverage for the Mill Creek Watershed

Table 6: Initial Estimates of Saturated Hydraulic Conductivity (SHC)

SURFTEX	SHC (inches/hour)
Cherty Silt Loam	0.30
Clay	0.02
Loam	0.40
Silt Loam	0.20
Silty Clay Loam	0.04
Pits	0.00
Water	0.00

h. Event Model Calibration

Event Based Model – The gridded HMS model was used to calibrate to observed flood events. Four recent flood events, May 24-26, 2000, January 22-28, 2002, May 4-22 2003, September 21-25, 2003 and May 01-02, 2010 were used for calibration. Two historic events, May 03-05 and September 13-15, 1979 are also simulated to reproduce the two previous highest floods of record on Mill Creek. The model parameters discussed in the previous sections are used to build the model.

1. **Rainfall** – Hourly radar rainfall was available for all recent events along with recorded hydrographs at the Mill Creek near Nolensville, Mill Creek near Antioch, Mill Creek at Thompson Lane gaging stations. Observed 30-munute basin average rainfall from the 1986 study was converted to radar rainfall using the Gageinterp program for the May and September 1979 flood events.

2. **Transform** – The Clark's parameters, T_C and R, listed in Table 5 were applied in the basin model.

3. **Baseflow** – The Linear Reservoir method was used for the baseflow. As mentioned in section 4, groundwater 1 and groundwater 2 coefficients were set to 10 and 100 hours, respectively. Initial baseflow in discharge per area is set to match observed values.

4. **Loss** – The Gridded-Deficit loss method described above was used as the loss rate method. Each subbasin was assigned a Percent Impervious Grid, a Maximum Deficit Grid, an Initial Deficit Grid and a Constant Loss Grid.

   a. **Percent Impervious Grid** – As described above, the base percent impervious grid was developed from the 2002 hyperspectral imagery. The percent of directly connected impervious area was determined during continuous model calibration. It is determined that a ratio of 0.4 (i.e., 40 percent directly connected) applied to the impervious area grid gave the best results. A global editor was also available in HEC-HMS where you can use linear interpolation, fill commands, and addition and subtraction to change multiple basins. Much of the developed Mill Creek Basin is older residential subdivisions without curb and gutter stormwater collection systems which allow for more infiltration due to overland and open ditch flow. Most of the newer subdivisions have smaller lots with more efficient stormwater collections systems, meaning, the percent of directly connected impervious area will be significantly higher increasing stormwater runoff. The Nashville/Davidson County government has revised their stormwater regulations to encourage best management practices (BMPs) that reduce stormwater runoff and enhance water quality.

b. **Maximum Deficit Grid** – The maximum deficit grid (maximum pore water storage) is necessary for the Deficit-Constant loss method However, it generally does not impact a short duration flood event but is much more applicable to a continuous simulation model. Therefore, the maximum deficit grid data was used in the calibration of the event model without any adjustment. Adjustments are made during continuous simulation.

c. **Initial Deficit Grid** – This grid represents the amount of precipitation that will infiltrate before any runoff from pervious areas begins. It is a reflection of the soil moisture at the start of an event. This is an event dependent value. To facilitate the use of HEC-HMS options, a grid of 1.0 inches for each grid cell was developed. This value was adjusted for each event by applying a ratio. The ratios are determined during the calibration. Table 7 shows the initial deficit ratios used for each event and the watershed average constant loss rates.

d. **Constant Loss Grid** – As with the initial deficit grid, the constant loss grid was adjusted for each flood event. Table 7 shows the ratios adopted along with the actual range of the constant loss rate over the entire Mill Creek basin.

Table 7 - Event Model Initial Deficit and Average Constant Loss

Observed Flood Event	Initial Deficit Ratio (inches)	Average Constant Loss (inches/hour)
May 1979	0.10	0.27
September 1979	1.00	0.08
May 2000	0.50	0.27
January 2002	0.35	0.11
May 2003	0.50	0.10
September 2003	1.00	0.07
May 2010	0.50	0.08

5. **Routing** – The routing methods described previously are applied to the basin models for calibration. Channel and overbank Manning's roughness coefficients were calibrated to 0.045 - 0.05 and 0.10 - 0.12, respectively.

6. **Results** – Figures 11 through 15 and Table 8 shows the results of the model calibration. Some results are better than others but it is judged that, overall, the chosen model parameters did an adequate job of reproducing these events. The precipitation for the May 2010 varied significantly across the basin. The Stage III Doppler hourly data was compared to observed hourly USACE and Metro SCADA 15-minute rainfall gages. Precipitation multipliers between 103% and 115% were applied to HEC-HMS model for better calibration to measured rainfall (See Figure 10), hydrographs and high water marks for the May 2010 Event. Rating curves for Mill Creek main stem

gages are currently being updated by USACE and USGS where published discharges may slightly change in the future.

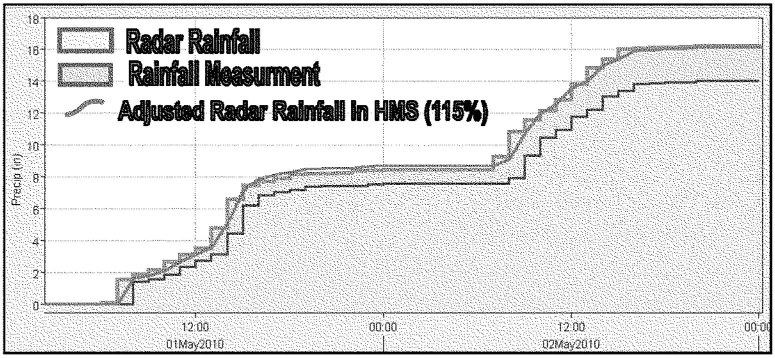


Figure 10: Mill Creek near Antioch Gage – Cumulative Rainfall Curves

Mill Creek Watershed: HEC-HMS Event Calibration				
	May 2000			
	Observed	Computed	Observed	Computed
Gage Location	Peak Flow	Peak Flow	Runoff Volume	Runoff Volume
	(cfs)	(cfs)	(inches)	(inches)
Mill Creek near Nolenville, TN	12,504	12,586	3.13	2.96
Mill Creek near Antioch, TN	11,332	11,345	2.26	2.64
Mill Creek near Woodbine, TN	13,333	11,313	2.47	2.54

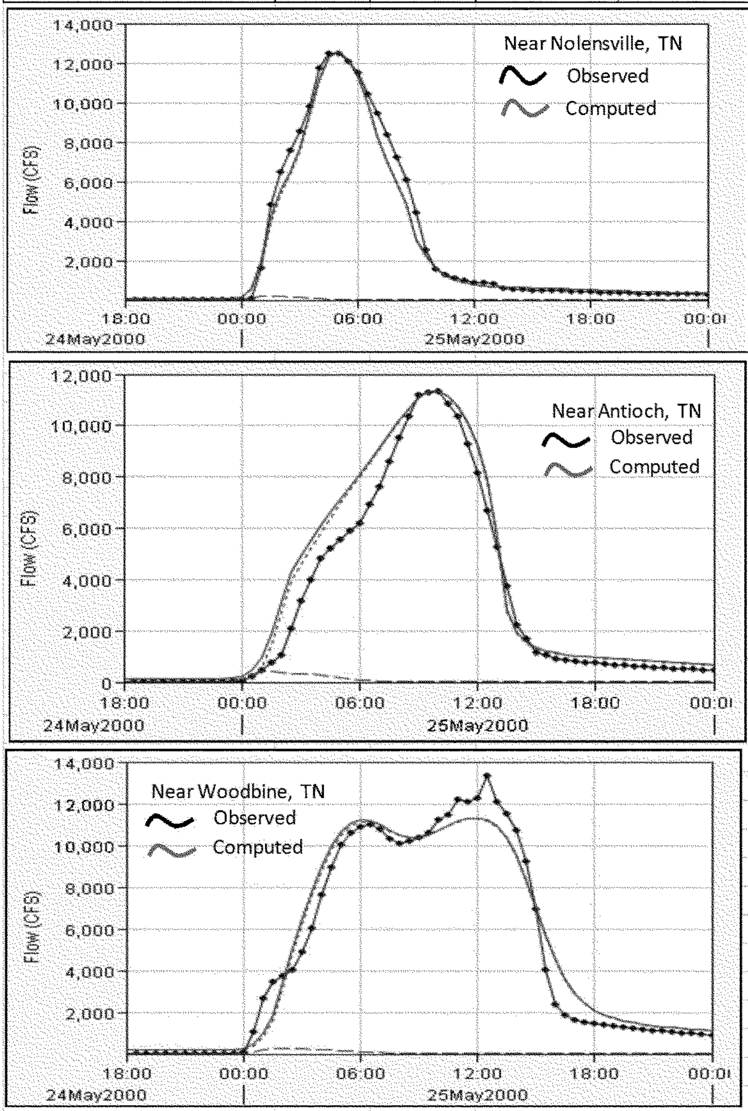


Figure 11: May 2000 Flood Event Calibration

Mill Creek Watershed: HEC-HMS Event Calibration				
	January 2002			
	Observed	Computed	Observed	Computed
Gage Location	Peak Flow	Peak Flow	Runoff Volume	Runoff Volume
	(cfs)	(cfs)	(inches)	(inches)
Mill Creek near Nolenville, TN	5,782	5,294	3.43	2.98
Mill Creek near Antioch, TN	4,618	5,681	2.59	2.97
Mill Creek near Woodbine, TN	6,877	7,377	3.08	3.03

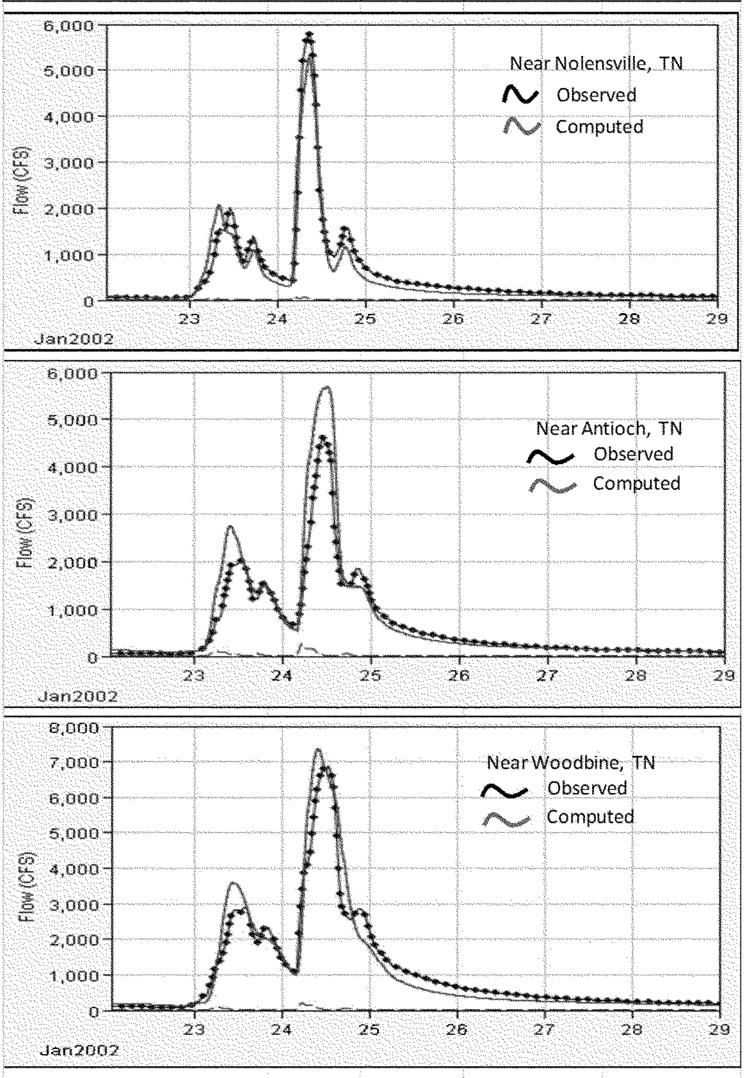


Figure 12: January 2002 Flood Event Calibration

Mill Creek Watershed: HEC-HMS Event Calibration				
	May 2003			
	Observed	Computed	Observed	Computed
Gage Location	Peak Flow	Peak Flow	Runoff Volume	Runoff Volume
	(cfs)	(cfs)	(inches)	(inches)
Mill Creek near Nolenville, TN	11,080	10,700	6.43	6.50
Mill Creek near Antioch, TN	11,497	11,944	5.45	6.80
Mill Creek near Woodbine, TN	14,207	14,730	7.35	6.97

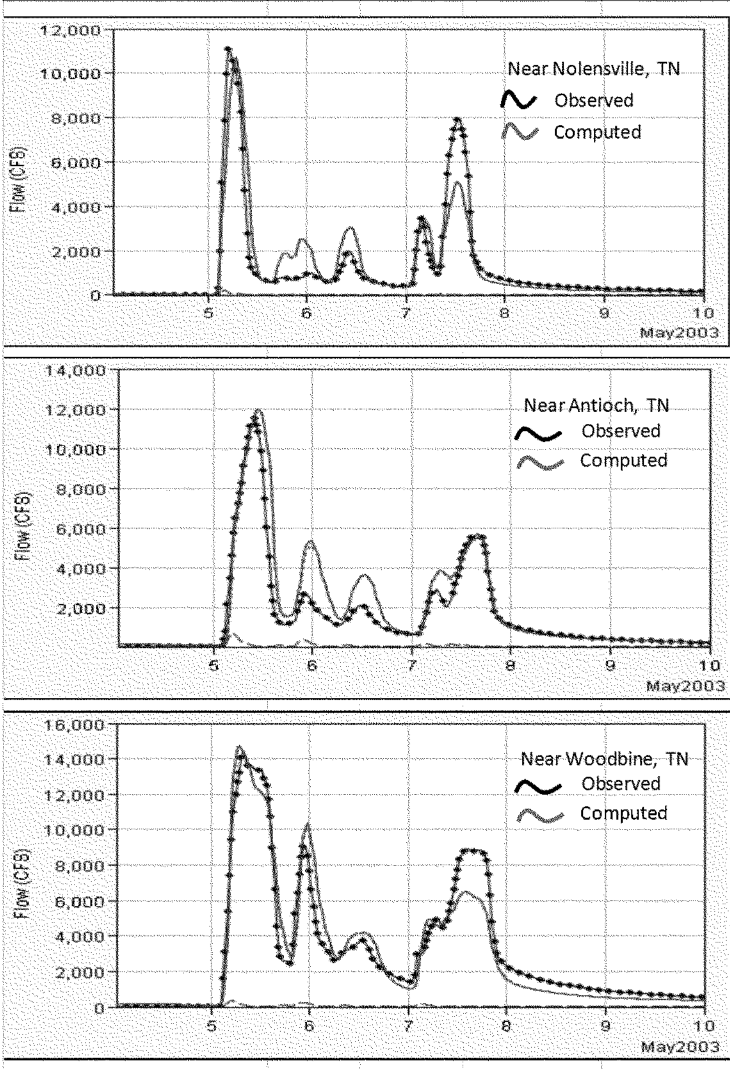


Figure 13: May 2003 Flood Event Calibration

Mill Creek Watershed: HEC-HMS Event Calibration				
	September 2003			
Gage Location	Observed Peak Flow (cfs)	Computed Peak Flow (cfs)	Observed Runoff Volume (inches)	Computed Runoff Volume (inches)
Mill Creek near Nolenville, TN	10,496	9,844	3.29	3.69
Mill Creek near Antioch, TN	9,223	11,353	2.82	3.54
Mill Creek near Woodbine, TN	13,145	13,112	3.19	3.42

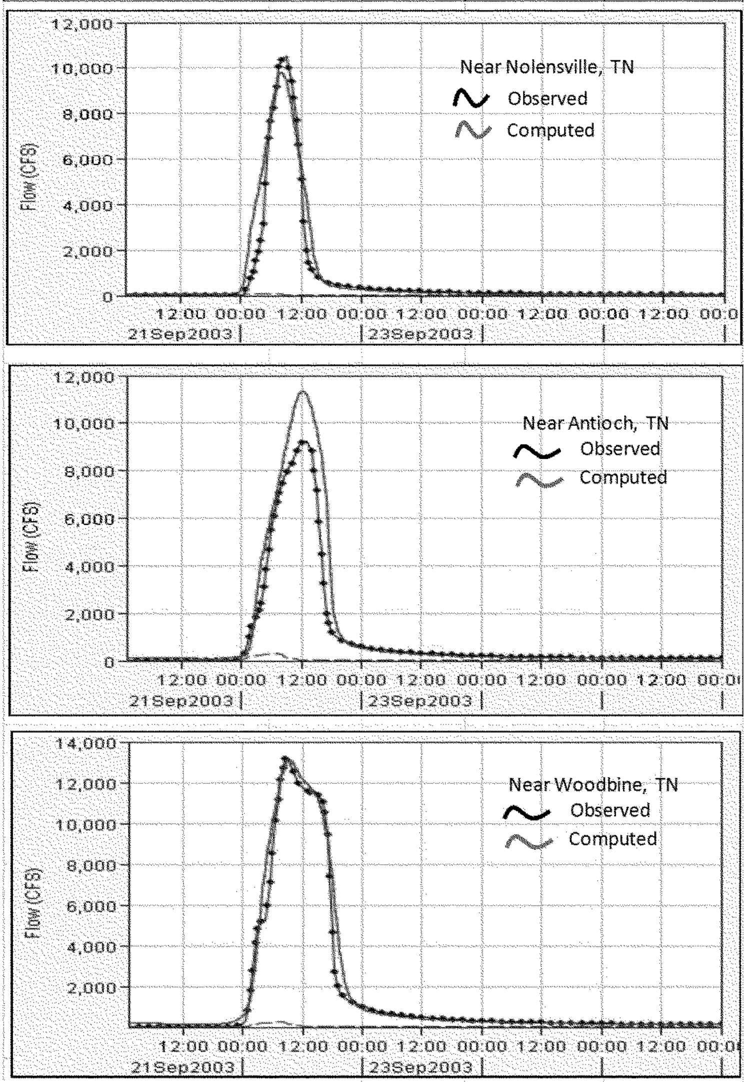
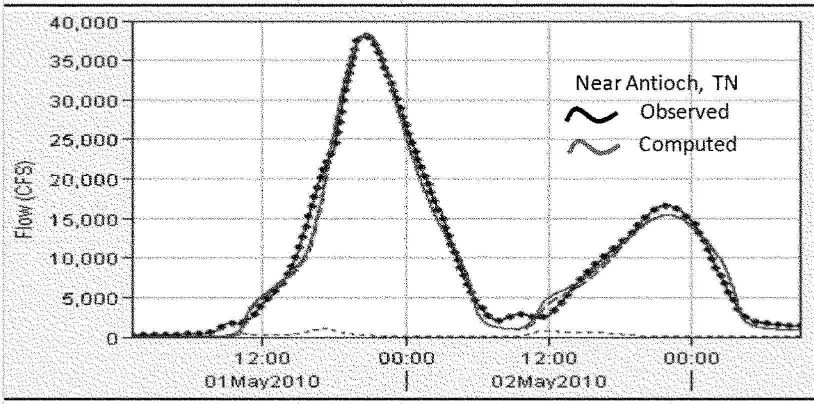


Figure 14: September 2003 Flood Event Calibration

Mill Creek Watershed: HEC-HMS Event Calibration				
	May 2010			
	Observed	Computed	Observed	Computed
Gage Location	Peak Flow	Peak Flow	Runoff Volume	Runoff Volume
	(cfs)	(cfs)	(inches)	(inches)
Mill Creek near Nolensville, TN	33,000*	35,400	N/A	13.60
Mill Creek near Antioch, TN	37,907	38,390	13.8	13.38
Mill Creek near Woodbine, TN	29,900	33,178	12.77	12.19

* Observed Peak Flow from HEC-RAS Calibration to High Water Marks



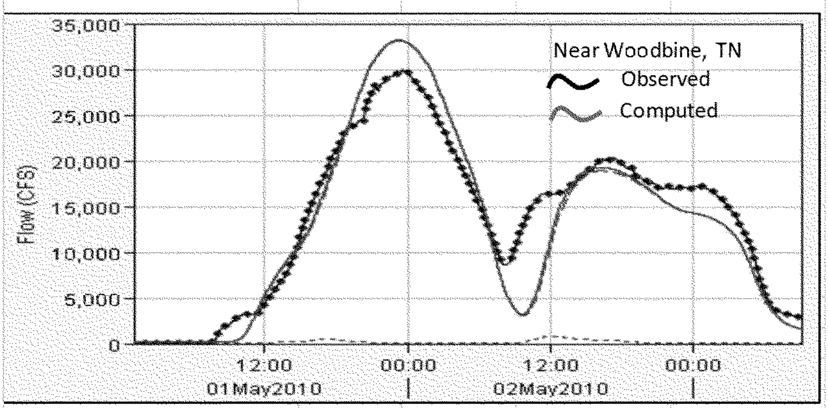


Figure 15: May 2010 Flood Event Calibration

Table 8: May and September 1979 Flood Event Calibration

Mill Creek Watershed: HEC-HMS Event Calibration				
	May 1979			
	Observed	Computed	Observed	Computed
Gage Location	Peak Flow	Peak Flow	Runoff Volume	Runoff Volume
	(cfs)	(cfs)	(inches)	(inches)
Mill Creek near Nolenville, TN	28,600*	28,610	N/A	N/A
Mill Creek near Antioch, TN	30,100	27,500	N/A	N/A
Mill Creek near Woodbine, TN	26,200	27,100	N/A	N/A
* Observed Peak Flow from HEC-RAS Calibration to High Water Marks				
	September 1979			
	Observed	Computed	Observed	Computed
Gage Location	Peak Flow	Peak Flow	Runoff Volume	Runoff Volume
	(cfs)	(cfs)	(inches)	(inches)
Mill Creek near Nolenville, TN	15,300*	17,670	N/A	N/A
Mill Creek near Antioch, TN	19,000	18,860	N/A	N/A
Mill Creek near Woodbine, TN	20,000	23,370	N/A	N/A
* Observed Peak Flow from HEC-RAS Calibration to High Water Marks				

III. STATISTICAL ANALYSIS OF PEAK STREAMFLOWS

Flood Frequency Analysis was performed for 4 gage locations in the Mill Creek Watershed using the Hydrologic Engineering Center Statistical Software Package (HEC-SSP). Procedures outlined in Bulletin #17B, "Guidelines for Determining Flood Flow Frequency", U.S. Department of Interior Geological Survey, March 1982, were applied to compute flood frequency curves. The majorities of the streams in Nashville area have on average less than 50 years of systematic record and experienced significant urbanization over the period. Annual peak discharges were obtained from USGS publications where available. May 2010 Event discharges and other historic events were obtained from a combination of USGS publications and calibrated hydrologic and hydraulic models developed by USACE. In some cases the peak discharges computed from models used in frequency analysis were different that USGS published values. Examples of USGS annual peak flow data and HEC-SSP computed frequency curve are shown as Figure 16 and 17, respectively. The May 2010 flood event was included as a systematic event within the analysis period and sometimes was determined to be a high outlier by HEC-SSP program. Frequency curves were computed using both station skew and regional "Generalized" skew = 0.0 for comparison. Regional skew coefficients were obtained from Bulletin 17B. The "Cumberland and Duck River Basins: May 2010 Post Flood Technical Report" (USACE 2012) includes an evaluation of the impacts the May 2010 flood had on frequency curves. A large majority of the data collection has been performed over the last 30 years where there have been few large flood events. A total of 13 gages were evaluated where the average computed skew increased from -0.322 to -0.075 with the addition of the May 2010 Flood Event. The peak flow-frequency curves were used for comparison to the existing conditions hypothetical HEC-HMS models. Since a single flow-frequency curve is not adopted at each gage location, the curves are used as a guide to determine if hypothetical model is producing results that fell in a range when compared to computed frequency flows.

One must be careful in comparing statistical flood frequency results to published and future discharges from FEMA flood insurance studies. Published FEMA values are often computed with rainfall-runoff models using design storms and regression equations that may be significantly different than statistical frequency results. The statistical analysis results are used as a guide to establish flood frequency discharges. Rainfall-runoff models used for this study were calibrated to recent observed storm events and provide reasonable results for establishing frequency discharges based on current watershed conditions. Errors in flow estimates are generally greatest during maximum flood flows. Measurement errors are usually random, and the variance is usually small in comparison to the year-to-year variance in flood flow. The effects of measurement error, therefore, may normally be neglected in flood frequency flow analysis. Peak flow estimates of historic floods can be substantial in error because of the uncertainty in both stage and stage-discharge relationships.

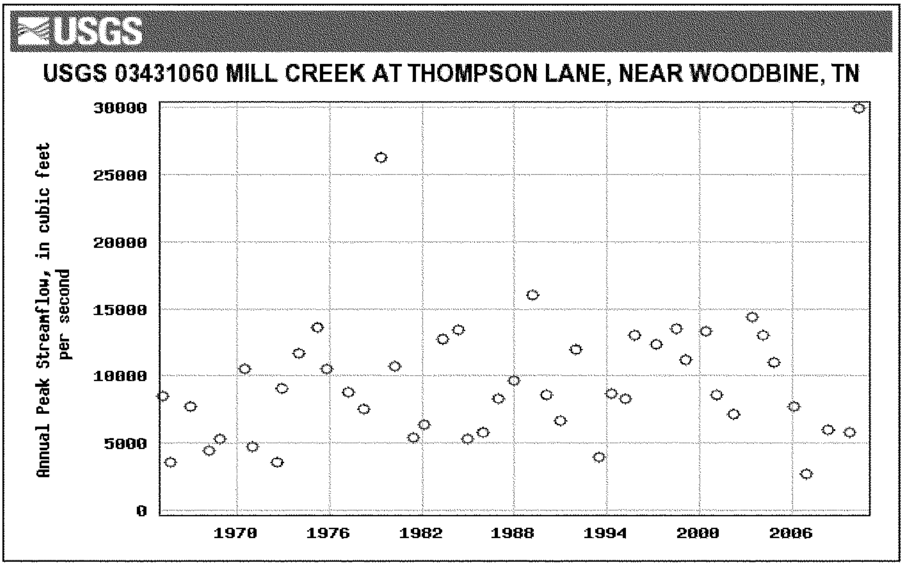


Figure 16: Example of USGS Observed Peak Discharges

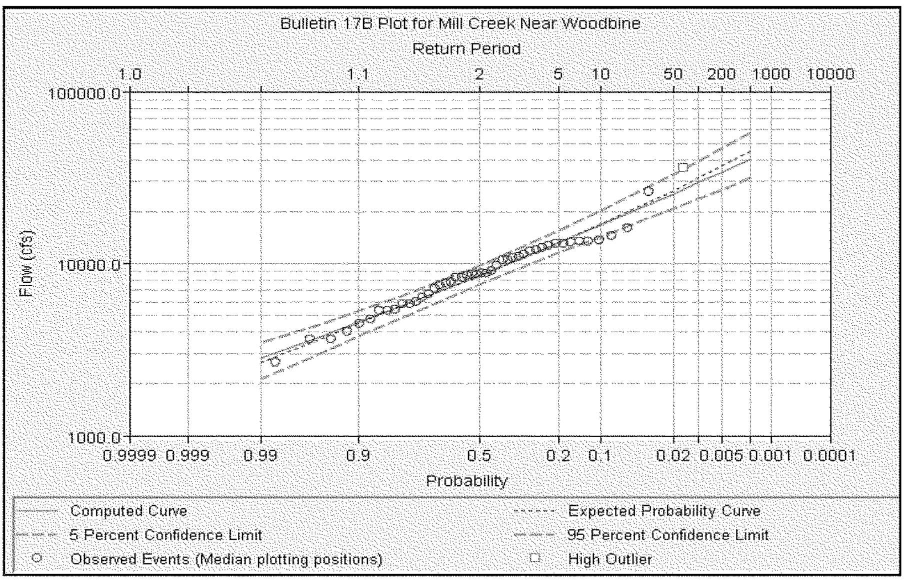


Figure 17: Example HEC-SSP Flood Frequency Curve

a. **Mill Creek at Nolensville (03430400).** The SSP period of record is water years 1965 through 2004, and the May 2010 Event. The crest stage recorder was located within Williamson County at the Sunset Road Bridge over Mill Creek in the basin headwaters and was taken out of service in 2004. It has a drainage area of 12.0 square miles and datum of 586.18 feet above sea level NGVD29. The gage is located approximately 23.9 miles above the mouth of Mill Creek and was operated by the United States Geological Survey (USGS) and was taken out of service in 2004. As recommended by the Hydrologic Engineering Center, the May 2010 flood event was added as a systematic event to extend the period of record. May 2010 event discharge was estimated using the calibrated May 2010 Event HEC-HMS and HEC-RAS models. HEC-SSP results are shown in Table 9. HEC-SSP Reports are included as Appendix C7.

Table 9: Mill Creek at Nolensville HEC-SSP Results

		Station Skew = -0.806	Regional Skew = 0.0
		HEC-SSP	HEC-SSP
Percent Chance	Return	Computed	Computed
Exceedance	Period	Flow	Flow
	(years)	(cfs)	(cfs)
0.2	500	14,183	23,937
0.5	200	13,336	20,217
1	100	12,590	17,587
2	50	11,737	15,102
4	25	10,752	12,750
10	10	9,190	9,811
20	5	7,735	7,673
50	2	5,165	4,795

b. **Mill Creek near Antioch (03431000).** The SSP period of record is water years 1954 through 2010. The continuous recording gage is located in Davidson County just below Franklin Limestone Road (HEC-RAS river mile 11.076) and has a drainage area of 64.0 square miles. The gage datum is 472.57 feet above sea level NGVD29 and is owned by the U.S. Army Corps of Engineers and operated by the USGS. The May 2010 Flood discharge was obtained from the Nashville District U.S. Army Corps of Engineers Water Management Section. HEC-SSP results are shown in Table 10. HEC-SSP Reports are included as Appendix C7.

Table 10: Mill Creek near Antioch HEC-SSP Results

		Station Skew = 0.704	Regional Skew = 0.0
		HEC-SSP	HEC-SSP
Percent Chance	Return	Computed	Computed
Exceedance	Period	Flow	Flow
	(years)	(cfs)	(cfs)
0.2	500	42,959	27,714
0.5	200	33,119	23,738
1	100	26,983	20,891
2	50	21,786	18,168
4	25	17,383	15,556
10	10	12,560	12,233
20	5	9,508	9,765
50	2	5,978	6,345

c. **Mill Creek near Woodbine (03431060).** The SSP period of record is water years 1965 through 2010. The continuous-recording gage is located in Davidson County just below the Thompson Lane Bridge (HEC-RAS river mile 6.320) and has a drainage area of 93.4 square miles. The gage datum is 432.55 feet above sea level NGVD29 and is owned and operated by the USGS. HEC-SSP results are shown in Table 11. HEC-SSP Reports are included as Appendix C7.

Table 11: Mill Creek near Woodbine HEC-SSP Results

		Station Skew = 0.138	Regional Skew = 0.0
		HEC-SSP	HEC-SSP
Percent Chance	Return	Computed	Computed
Exceedance	Period	Flow	Flow
	(years)	(cfs)	(cfs)
0.2	500	40,331	37,051
0.5	200	33,951	31,803
1	100	29,503	28,037
2	50	25,350	24,431
4	25	21,460	20,963
10	10	16,655	16,540
20	5	13,194	13,244
50	2	8,557	8,657

d. **Sevenmile Creek at Blackman Road (03431040).** The SSP period of record is water years 1965 through 2004 and the May 2010 Event. The crest stage recorder is located within Davidson County just below the Blackman Road Bridge over Sevenmile Creek and was taken out of service in 2004. It has a drainage area of 12.2 square miles and datum of 499.08 feet above sea level NGVD29. Some of the higher discharge values published for the gage were questionable. There are known issues with the rating curve due to bridge replacement and gage relocation over the period of record. Calibration to high water marks for May 1979, May 2003 and May 2010 event indicate some error in discharges for larger events. Blackman Road discharges were revised based on a rating curve developed by the Corps of Engineers from the HEC-RAS model calibration to high water marks. HEC-SSP results are shown in Table 12. Differences in rating curves and computed Frequency Curves between the USGS published and HEC-RAS Rating are shown as Figures 18 and 19. HEC-SSP Reports are included as Appendix C7.

Table 12: Seven Mile at Blackman Road HEC-SSP Results

		Station Skew = 0.133	Regional Skew = 0.0
		HEC-SSP	HEC-SSP
Percent Chance	Return	Computed	Computed
Exceedance	Period	Flow	Flow
	(years)	(cfs)	(cfs)
0.2	500	12,432	11,301
0.5	200	10,179	9,458
1	100	8,648	8,166
2	50	7,250	6,955
4	25	5,974	5,819
10	10	4,449	4,415
20	5	3,393	3,407
50	2	2,049	2,076

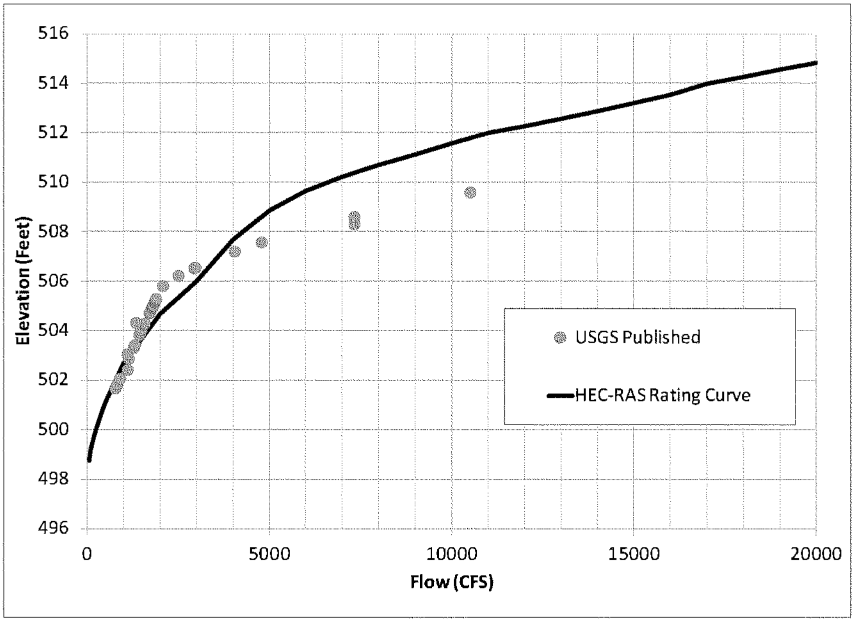


Figure 18: Sevenmile Creek at Blackman Road Rating Curves

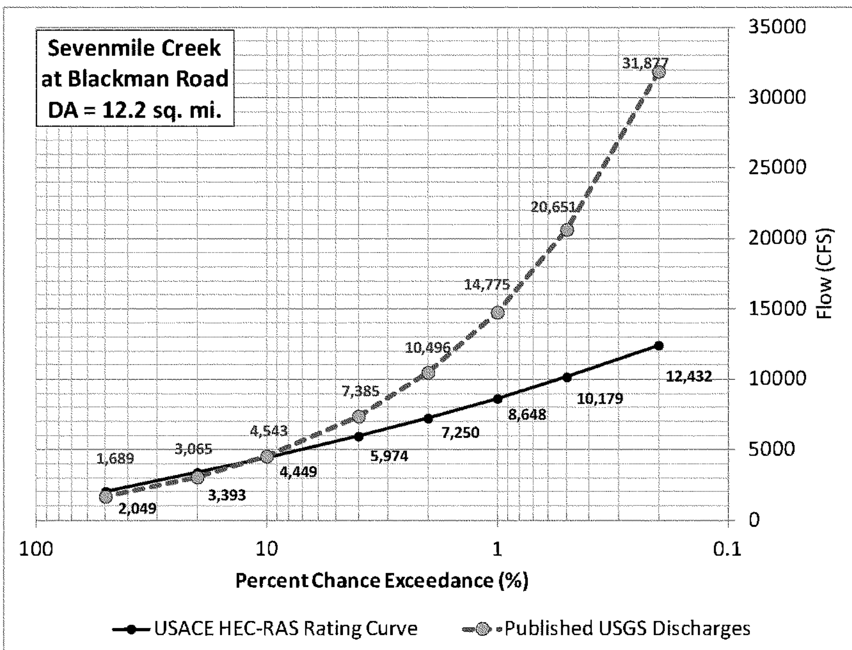


Figure 19: Comparison of Computed Flood Frequency Curves (Blackman Road)

IV. EXISTING CONDITIONS HYPOTHETICAL FLOODS

Existing condition hypothetical flood hydrographs were developed for the 0.5 (2-year), 0.2 (5-year), 0.1 (10-year), 0.04 (25-year), 0.02 (50-year), 0.01 (100-year), 0.005 (200-year) and 0.002 (500-year) annual exceedance probabilities. The event-based gridded model was converted to a lumped HMS basin model to compute hypothetical floods. The methods (transform, baseflow, routing, land use, loss method) discussed previously in the development and calibration of the event based model, were used as a guide in the development of the hypothetical flood basin model. Average parameter values developed in the gridded model were applied to the lumped flood frequency model.

a. **Precipitation.** Table 13 contains the frequency precipitation estimates obtained from the NOAA Precipitation Frequency Data Server, for the Mill Creek Watershed. The precipitation frequency values are part of NOAA Atlas 14, released June, 2004. Atlas 14 precipitation varied across the Mill Creek Watershed. Adopted values were obtained from the upper basin near Nolensville and produced more conservative precipitation values.

Table 13

Mill Creek Watershed - NOAA Atlas 14 Precipitation, 2012 FIS Update								
Latitude (decimal degrees): 35.9415				**Longitude (decimal degrees): -86.6654**				
Frequency	5-min	15-min	1-hour	2-hours	3-hours	6-hours	12-hours	1-day
2-yr	0.46	0.93	1.62	1.89	2.05	2.49	2.97	3.60
5-yr	0.54	1.09	1.98	2.31	2.50	3.02	3.60	4.38
10-yr	0.60	1.21	2.28	2.65	2.87	3.47	4.13	5.01
25-yr	0.67	1.36	2.68	3.13	3.39	4.10	4.87	5.89
50-yr	0.73	1.48	3.01	3.52	3.81	4.62	5.47	6.58
100-yr	0.79	1.59	3.35	3.92	4.25	5.16	6.11	7.31
200-yr	0.85	1.70	3.71	4.34	4.71	5.74	6.78	8.05
500-yr	0.93	1.84	4.21	4.94	5.36	6.55	7.71	9.07

Storm depth-area reduction was applied in HEC-HMS to produce flow along Mill Creek. The values in Table13 were reduced in accordance with TP-40 when developing storms with an area larger than 10 square miles. Seven different storm sizes were selected for the Mill Creek hydrologic model: 10, 21.04, 42.3, 57.31, 73.59, 93.2, and 107.26 square miles.

The frequency precipitation values are computed to correctly distribute the precipitation over 24 hours at a 5 minute time step. The storms are centered so that the peak intensity occurred during the 12th hour of each 24 hour storm event.

b. **Losses**. As with the event-based model, the constant loss method was employed in the existing condition hypothetical model. The constant loss rate parameter averaged 0.08

inches per hour for the frequency rainfall-runoff simulations. The initial loss parameter was varied from 0.3 inches to 1.3 inches among the different annual exceedance probability events as shown in Table 14. This reflects the likelihood that the more frequent runoff events occur when the moisture deficit in the watershed is high while the less frequent runoff events occur when the moisture deficit in the watershed is low.

Table 14

Hypothetical Event Initial Deficit and Constant Loss Rate		
Hypothetical Flood Event	**Average Initial Deficit (inches)**	**Average Constant Loss (inches/hour)**
2yr	1.30	0.08
5yr	1.20	0.08
10yr	1.00	0.08
25yr	0.80	0.08
50yr	0.70	0.08
100yr	0.50	0.08
200yr	0.40	0.08
500yr	0.30	0.08

c. **Calibration.** The peak flow-frequency curves described previously in section are used for comparison to the existing conditions hypothetical HEC-HMS model. Since a single flow-frequency curve is not adopted at each gaged location, the curves are used as a guide to determine if the hypothetical model is producing results that fell in a reasonable range when compared to observed frequency flows.

d. **Results.** The resultant hypothetical HEC-HMS flows compared to flow-frequency curves and published Flood Insurance Studies for the gaged locations are shown on Figures 23 thru 26.

e. **Discussion**. Figure 20 shows the typical hydrologic response at select locations in the Mill Creek basin for a 24-hour frequency storm uniformly-distributed over the watershed. Note that the drainage area for Mill Creek at Davidson/Williamson County line (green hydrograph) is 40 square miles, 75 square miles just above Sevenmile Creek (blue hydrograph) and 93 square miles below Sevenmile Creek (red hydrograph) at Thompson Lane. As observed from real-time gages and model calibration the peak discharge along Mill Creek attenuates as it moves downstream from the headwater confluences. Attenuation is dependent on the combination of basin configuration, storm event orientation and available floodplain storage. When flood flows exceed the channel carrying capacity, water flows into overbank areas where flow can be slowed greatly. This is commonly referred to as floodplain storage or valley storage and can be significant in terms of translation and attenuation of the flood wave (hydrograph). Major storms like the May 2010 event have occurred where initial wetting in combination with large storm event moving from west to east in a northeasterly direction intensify Mill Creek basin response. The May 01, 2010 maximum precipitation and storm track are shown in Figure 21. The red dots show locations with maximum reported gage precipitation in inches. The black dashed line (and background isohyetal grid) shows the track and direction of the most intense rainfall thru the Nashville area. The May 02, 2010 maximum precipitation and storm track are shown in Figure 22 for comparison. The May 02 event also moved from the west to east in a Northeasterly direction with the most intense portion of the storm moving thru downtown Nashville just northwest of the Mill Creek basin. The May 01, 2010 storm event is possibly the worst-case scenario for flooding along the main stem. The upper portion (headwaters) of the basin received the heaviest rainfall much earlier during event where Mill Creek was able to steadily rise to a moderate flood level. As the flood peak traveled down the main stem it was intensified by the second wave of heavy rainfall creating the worst flooding ever experienced along Mill Creek. Essentially, the second wave created a near coincidental peak occurrence between the main stem and its lateral inflow tributary streams causing a more severe flood. It is recommended that future studies incorporate the routing of the main stem hydrograph in combination with storm distribution, orientation and timing.

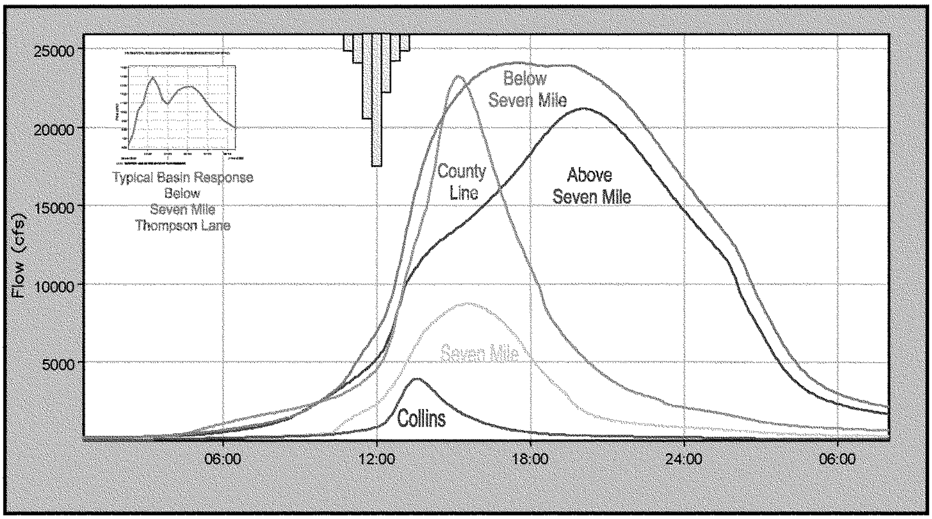


Figure 20 - Hydrologic Response for 24-hour Balanced Storm

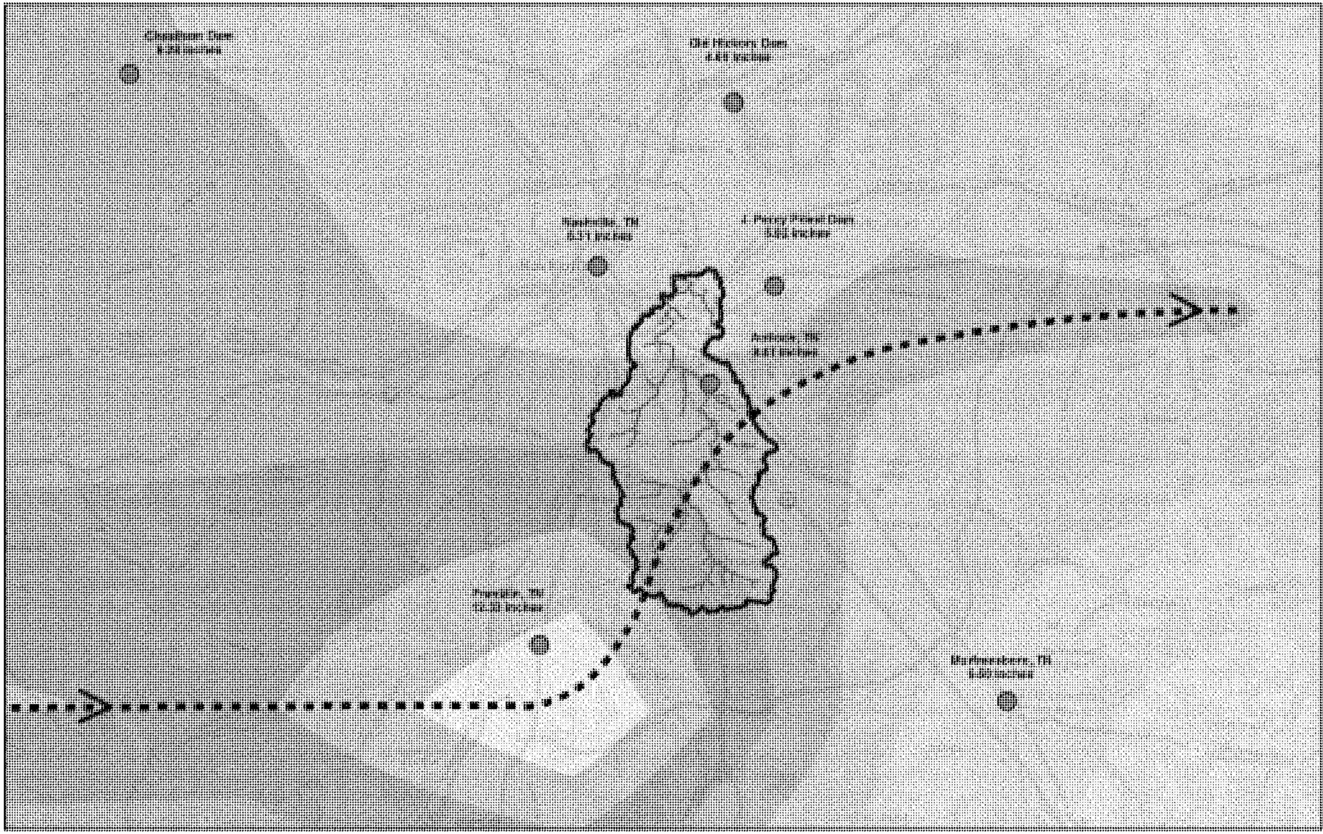


Figure 21 – May 01, 2010 Maximum Precipitation and Storm Track (Nashville and Surrounding Area)

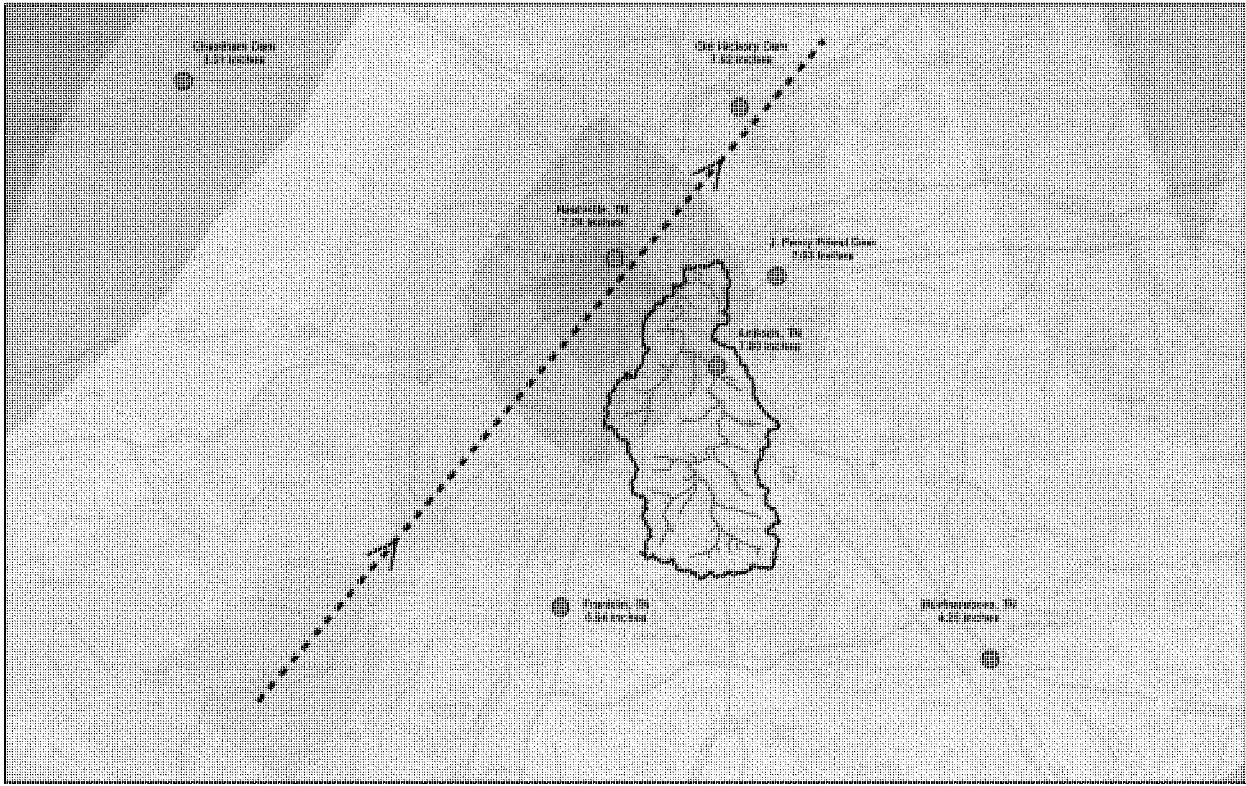


Figure 22 – May 02, 2010 Maximum Precipitation and Storm Track (Nashville and Surrounding Area)

HEC-SSP results with May 2010 Flood Event (1965 - 2003, May 2010 Historic Event)
Mill Creek at Nolensville, TN
Drainage Area = 12 Square Miles

		Station Skew = -0.806	Regional Skew = 0.0	Depth Area Adj = None
		HEC-SSP	HEC-SSP	HEC-HMS
Percent Chance	Return	Computed	Computed	Computed
Exceedance	Period	Flow	Flow	Flow
	(years)	(cfs)	(cfs)	(cfs)
0.2	500	**14,183**	23,937	18,883
0.5	200	**13,336**	20,217	16,597
1	100	**12,590**	17,587	14,957
2	50	**11,737**	15,102	13,387
4	25	**10,752**	12,750	11,856
10	10	**9,190**	9,811	9,904
20	5	**7,735**	7,673	7,658
50	**2**	**5,165**	4,795	5,655

April 20, 2001 FIS	
0.2	15850
1	10750
2	9200
10	5850

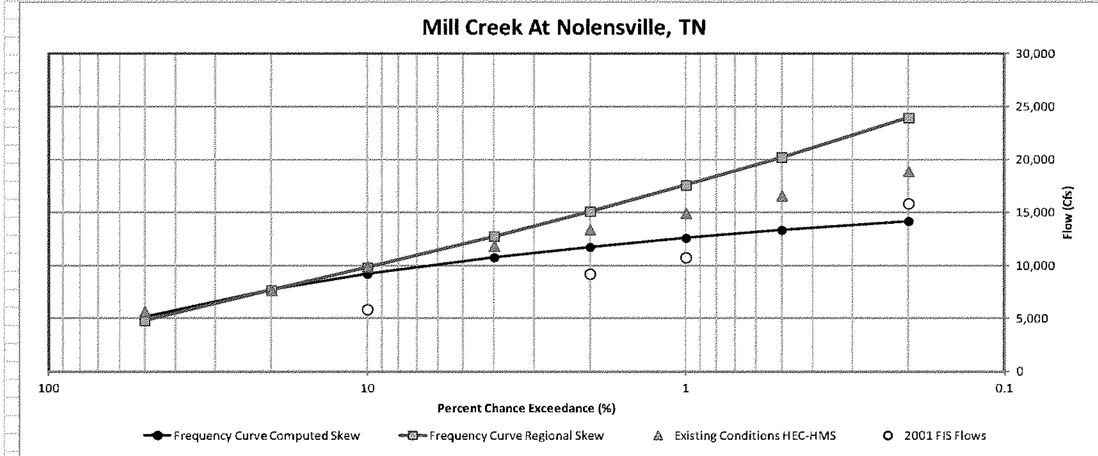


Figure 23 - Mill Creek at Nolensville HEC-SSP Comparison to Published Discharges

HEC-SSP results with May 2010 Flood Event (1954 - 2010)
Mill Creek Near Antioch, TN
Drainage Area = 64 Square Miles

		Station Skew = 0.704	Regional Skew = 0.0	Depth Area Adj = 65 Sq. Mi.
		HEC-SSP	HEC-SSP	HEC-HMS
Percent Chance Exceedance	Return Period (years)	Computed Flow (cfs)	Computed Flow (cfs)	Computed Flow (cfs)
0.2	500	**42,959**	27,714	34,311
0.5	200	**33,119**	23,738	29,089
1	100	**26,983**	20,891	25,483
2	50	**21,786**	18,168	22,059
4	25	**17,383**	15,556	18,860
10	10	**12,560**	12,233	14,712
20	5	**9,608**	9,765	10,461
50	2	**5,978**	6,345	7,756

April 20, 2001 FIS	
0.2	40,500
1	27,000
2	22,600
10	13,900

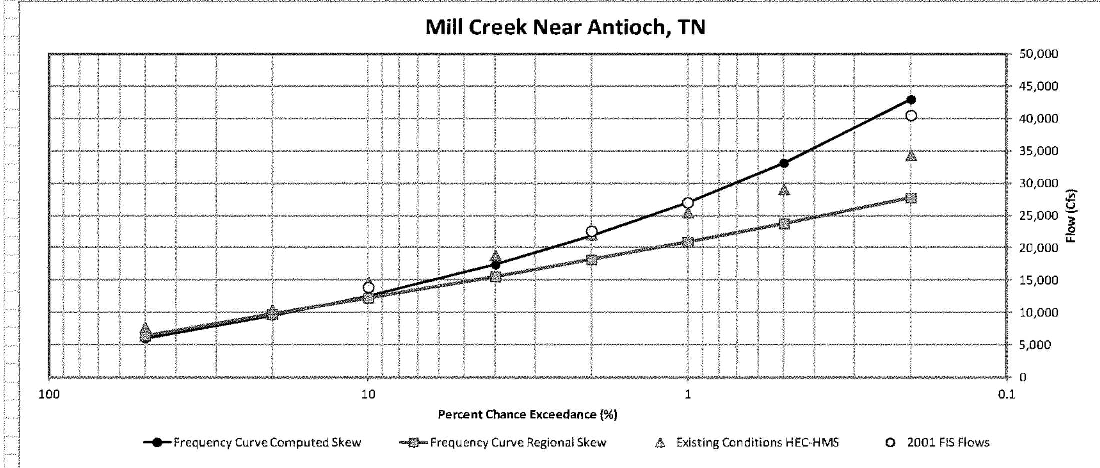


Figure 24 - Mill Creek near Antioch HEC-SSP Comparison to Published Discharges

HEC-SSP results with May 2010 Flood Event (1965 - 2010)
Mill Creek Near Woodbine, TN
Drainage Area = 93.4 Square Miles

		Station Skew = 0.138	Regional Skew = 0.0	Depth Area Adj = 93 Sq. Mi.
		HEC-SSP	HEC-SSP	HEC-HMS
Percent Chance	Return	Computed	Computed	Computed
Exceedance	Period	Flow	Flow	Flow
	(years)	(cfs)	(cfs)	(cfs)
0.2	500	**40,331**	37,051	42,103
0.5	200	**33,951**	31,803	35,002
1	100	**29,503**	28,037	29,986
2	50	**25,350**	24,431	25,111
4	25	**21,460**	20,963	20,856
10	10	**16,655**	16,540	16,885
20	5	**13,194**	13,244	13,257
50	2	**8,557**	8,657	10,607

April 20, 2001 FIS	
0.2	45,550
1	29,700
2	24,950
10	15,000

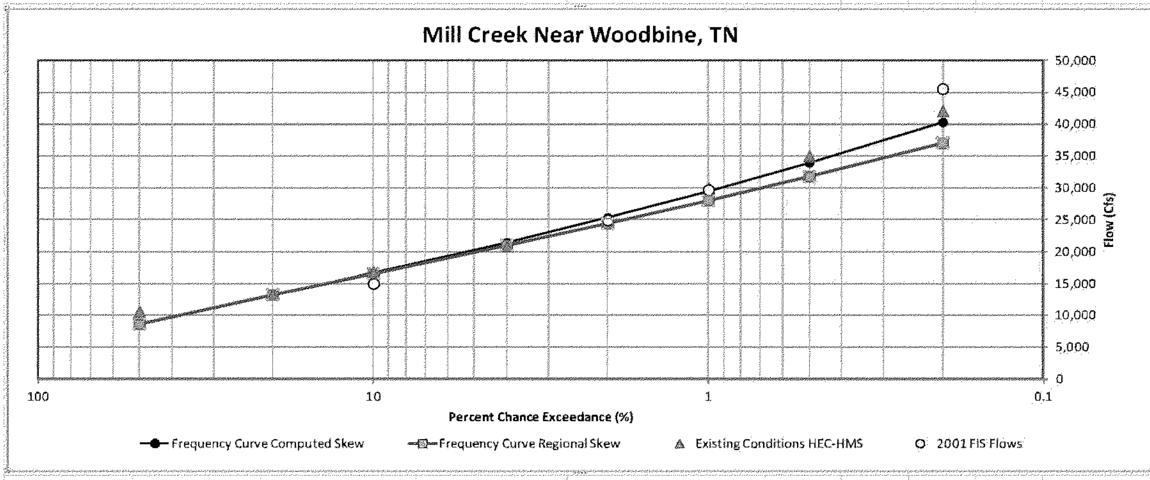


Figure 25 - Mill Creek near Woodbine HEC-SSP Comparison to Published Discharges

HEC-SSP results with May 2010 Flood Event (1965 - 2004, May 2010)
Sevenmile Creek at Blackman Rd
Drainage Area = 12.2 Square Miles

		Station Skew = 0.133	Regional Skew = 0.0	Depth Area Adj = None
		HEC-SSP	HEC-SSP	HEC-HMS
Percent Chance	Return	Computed	Computed	Computed
Exceedance	Period	Flow	Flow	Flow
	(years)	(cfs)	(cfs)	(cfs)
0.2	500	**12,432**	11,301	12,955
0.5	200	**10,179**	9,458	10,979
1	100	**8,648**	8,166	9,810
2	50	**7,250**	6,955	8,697
4	25	**5,974**	5,819	7,676
10	10	**4,449**	4,415	6,334
20	5	**3,393**	3,407	4,900
50	2	**2,049**	2,076	3,820

April 20, 2001 FIS	
0.2	15,500
1	9,500
2	7,600
10	4,420

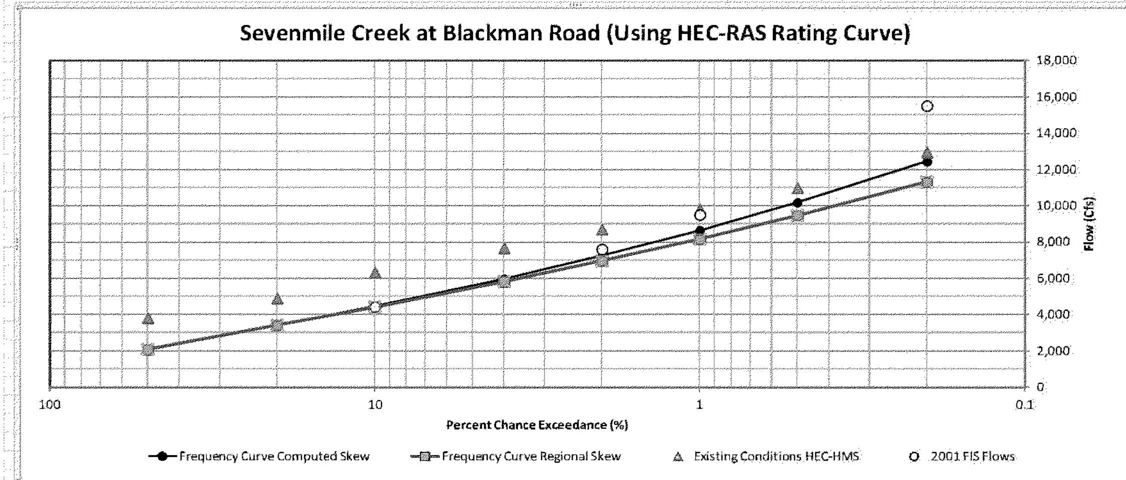


Figure 26 - Sevenmile Creek at Blackman Road HEC-SSP Comparison to Published Discharges

V. WATERSHED AND FLOODPLAIN MANAGEMENT

This watershed and floodplain management evaluation attempts to capture how changes in land use, basin imperviousness, and floodplain storage characteristics may impacts stormwater runoff and flood stages. It does not account for damages to future buildings in the floodplain.

Increased urbanization within Davidson and Williamson Counties has caused radical changes to the topography, ground cover, and stormwater management systems within the Mill Creek watershed. These changes have adverse effects on the environment, primarily through the subsequent increase in stormwater runoff quantity and nonpoint source pollution, which has a negative impact on stormwater quality.

Both Davidson and Williamson Counties enforce ordinances restricting development in the floodplains. These ordinances provide both technical guidelines requiring on-site detention of stormwater for developments and alternate storage provisions to off-set any filling of the floodplain.

To minimize adverse stormwater quantity impacts, all new developments are evaluated for adverse impacts on downstream properties. These requirements are mandatory for all developments that are not served by an adequately sized regional stormwater management facility and subject to review by the regulating jurisdiction. Because detention in downstream areas of a large watershed can cause increased peak flows in downstream channels, the regulating jurisdiction also reserves the right to alter the detention criteria and to prohibit it where it would cause adverse impacts. These decisions are based on sound engineering judgment along with supporting data and studies.

Floodplain or valley storage can also be significant in determining flood magnitude and how flood peaks translate downstream. Larger streams like Mill Creek often provide enough valley storage to attenuate or reduce flood heights. Previous studies show that Mill Creek is very sensitive to valley storage. The amount of valley storage under future conditions depends on which floodplain management policies and ordinances are in effect in each jurisdiction.

Metro/Davidson County requires that all new development encumbered by natural floodplain or floodway, shall leave a minimum of fifty percent of the natural floodplain area, including all of the floodway area, or all of the floodway area plus 50 feet on each side of the waterway, whichever is greater, in its original, natural state. All floodplain alterations that result in filling or elimination of floodplain storage must provide compensating storage capacity by removing at least an equal amount of volume as occupied by the fill. The compensating storage capacity calculation must not include dredging or cut volumes below the 2-year flood elevation. Metro's base flood and designated height are the 100-year event and one foot, respectively. Residential construction is required to have their lowest floor 4 feet above the base flood elevation. Commercial, industrial, or non-residential construction is required to build their lowest floor one foot above the base flood elevation.

In Metro, new development and significant redevelopment are also required to preserve water quality buffers along intermittent and perennial streams, lakes and ponds with hydrologic connectivity and wetlands that have been identified by the U.S. Army Corps of Engineers, TDEC, or Metro Water Services (MWS) staff. Zone 1 for all buffers is considered a "no disturb zone" where vegetation cannot be disturbed, removed or replanted unless a buffer restoration plan has been approved by MWS. Zone 2 can consist of managed vegetation, meaning the buffer zone can be disturbed and planted with grass or other vegetation. However, no structures or impervious surface can be placed in Zone 2. For FEMA studied streams or streams with a drainage area greater than or equal to one square mile, the stream buffers are defined as Zone 1 = Floodway + 50 feet, and Zone 2 = 25 feet. An illustration of the 75 foot buffer for streams with floodways is shown in Figure 27.

The Williamson County portion of the Mill Creek Watershed includes mostly the Cities of Nolensville and Brentwood, Tennessee. Both the City of Nolensville and Brentwood have similar compensation storage regulations requiring at least an equal amount of compensation storage volume as occupied by fill. Nolensville has a 50-foot water quality buffer. Brentwood has no water quality buffers at this time.

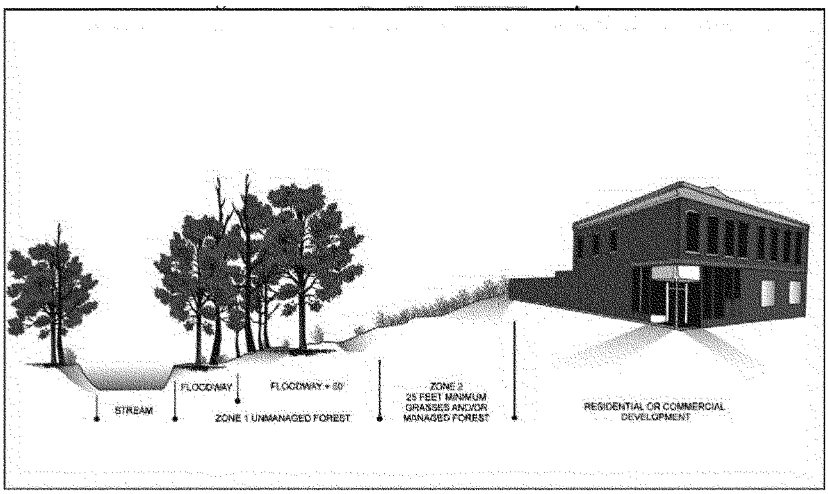


Figure 27: Buffer Example for Streams with Floodways

a. Watershed Sensitivity to Changes in Imperviousness

The gridded HMS model was used to evaluate the watershed sensitivity to changes in imperviousness. Not all impervious surfaces are directly connected to the drainage system. Direct connections from storm sewers and such quickly reach the stream, while unconnected impervious areas may infiltrate the water table and only reach the stream days later. A downspout draining to a lawn is an example of disconnected imperviousness. Continuous simulation modeling results showed that approximately half of the existing impervious surface in the watershed is disconnected from the drainage system. 25, 50, 75, and 100 percent impervious grid cells were analyzed to evaluate watershed sensitivity to increased imperviousness. A 25 percent grid would represent a watershed condition that is 50 percent impervious with half of the hard surfaces disconnected from the drainage system or a subbasin that is 25 percent parking lot where all is directly connected to the drainage system. The 50, 75, and 100 would represent watershed conditions as the imperviousness increases. Initial losses and infiltration rates used in the frequency rainfall-runoff simulation were applied for this analysis (See Table 14). The analysis assumed that the time of concentration for each sub-basin did not change significantly with development. The results were compared to existing conditions frequency-flood discharges for gaged and ungaged locations in the watershed, and are presented in Table 15.

Modeling results and calibration to historic floods show that the Mill Creek watershed is not as sensitive to imperviousness during winter and early spring months when soils are saturated and the water table is high. Infiltration rates are typically less than 0.1 inches per hour and the moisture deficit (i.e., volume of rainfall the ground can absorb before saturated) is less than 0.5 inches. The two largest floods on record (May 1979 and May 2010) were also preceded by a significant rainfall event which kept ground near saturation prior to event. Modeling results indicate that a uniform increase in imperviousness impacts more frequent rainfall events like the 2-year and 5-year events. As drainage area increases the effects of imperviousness is slightly greater due to the accumulation of added runoff volume as predicted. Note that Table 15 shows flow as a percentage. A ten percent flow increase on a small tributary like Turkey Creek equates to several hundred cubic feet per second (cfs) as compared to several thousand cfs on Mill Creek. For example, the existing conditions 2-year flood frequency discharge for Mill Creek near Antioch Gage is approximately 8,000 cfs. If the watershed was developed to 50 percent connected impervious, the 2-year discharge would increase by 26 percent resulting in a discharge of approximately 2,000 cfs higher or 10,000 cfs.

Table 15: Mill Creek Watershed – Sensitivity to Imperviousness

		2 -Year				5 -Year			
		Mill Creek Watershed				Mill Creek Watershed			
	Drainage	Peak Flow Increase above Existing Conditions				Peak Flow Increase above Existing Conditions			
Location	Area (Sq. Mi.)	25% Imp	50% Imp	75% Imp	100% Imp	25% Imp	50% Imp	75% Imp	100% Imp
Mill Creek at Thompson Lane	93.2	12%	24%	36%	48%	5%	12%	18%	25%
Mill Creek Nr Antioch Gage	64.2	12%	26%	40%	54%	6%	13%	20%	27%
Mill Creek at Nolensville Rd	40.5	11%	23%	35%	46%	4%	8%	12%	17%
Mill Creek at Sunset Rd	12.2	6%	13%	20%	27%	2%	4%	5%	7%
Sevenmile Creek at Mouth	17.6	4%	12%	21%	29%	2%	5%	8%	11%
Seven Mile at Blackman Rd	12.1	5%	13%	21%	30%	2%	5%	7%	10%
Collins Creek at Mouth	4.5	5%	12%	19%	26%	1%	3%	5%	7%
Indian Creek at Mouth	4.9	7%	14%	20%	28%	2%	4%	6%	8%
Sorghum Branch at Mouth	2.7	4%	12%	20%	28%	2%	4%	7%	9%
Whittemore Branch at Mouth	3.7	4%	12%	19%	26%	2%	3%	4%	6%

		10 -Year				50 -Year			
		Mill Creek Watershed				Mill Creek Watershed			
	Drainage	Peak Flow Increase above Existing Conditions				Peak Flow Increase above Existing Conditions			
Location	Area (Sq. Mi.)	25% Imp	50% Imp	75% Imp	100% Imp	25% Imp	50% Imp	75% Imp	100% Imp
Mill Creek at Thompson Lane	93.2	4%	8%	11%	15%	2%	5%	9%	13%
Mill Creek Nr Antioch Gage	64.2	4%	8%	13%	17%	3%	5%	8%	11%
Mill Creek at Nolensville Rd	40.5	3%	5%	8%	11%	2%	3%	5%	7%
Mill Creek at Sunset Rd	12.2	1%	3%	4%	5%	1%	2%	2%	3%
Sevenmile Creek at Mouth	17.6	1%	3%	4%	6%	1%	2%	4%	5%
Seven Mile at Blackman Rd	12.1	1%	3%	6%	8%	1%	2%	4%	5%
Collins Creek at Mouth	4.5	1%	2%	4%	5%	1%	2%	3%	3%
Indian Creek at Mouth	4.9	1%	3%	4%	6%	1%	2%	2%	3%
Sorghum Branch at Mouth	2.7	1%	3%	4%	6%	0%	2%	3%	4%
Whittemore Branch at Mouth	3.7	1%	2%	3%	4%	1%	1%	2%	3%

		100 -Year				500 -Year			
		Mill Creek Watershed				Mill Creek Watershed			
	Drainage	Peak Flow Increase above Existing Conditions				Peak Flow Increase above Existing Conditions			
Location	Area (Sq. Mi.)	25% Imp	50% Imp	75% Imp	100% Imp	25% Imp	50% Imp	75% Imp	100% Imp
Mill Creek at Thompson Lane	93.2	1%	5%	8%	12%	1%	4%	7%	9%
Mill Creek Nr Antioch Gage	64.2	2%	5%	7%	10%	2%	4%	6%	8%
Mill Creek at Nolensville Rd	40.5	1%	3%	4%	6%	1%	2%	3%	5%
Mill Creek at Sunset Rd	12.2	0%	1%	2%	2%	1%	1%	2%	2%
Sevenmile Creek at Mouth	17.6	1%	2%	3%	4%	0%	1%	2%	3%
Seven Mile at Blackman Rd	12.1	1%	2%	3%	4%	1%	1%	2%	3%
Collins Creek at Mouth	4.5	1%	1%	2%	3%	0%	1%	2%	2%
Indian Creek at Mouth	4.9	1%	1%	2%	3%	1%	1%	2%	3%
Sorghum Branch at Mouth	2.7	0%	1%	2%	3%	0%	1%	2%	2%
Whittemore Branch at Mouth	3.7	1%	1%	2%	3%	0%	1%	2%	2%

b. **Watershed Sensitivity to Changes in Floodplain Storage**

Hydrologic and hydraulic models typically do not account for loss of floodplain storage. The standard practice is to compute discharges, water surface profiles, and floodways based on existing conditions with no consideration for increased discharge due to future development or loss of floodplain storage. For this analysis the floodplain storage was divided into 3 major basins named Lower (Nashville), Middle (Antioch) and Upper (Nolensville) as shown in Figure 31. The floodplains in the most downstream basin (Nashville) are urbanized with a combination of natural and man-made storage most of which is along Sevenmile and Mill Creeks. An example of man-made storage is backwater behind the CSX Railroad culvert over Sevenmile Creek. The middle basin (Antioch) has less floodplain development and abundant natural storage along Mill Creek's main stem where some of the storage is in backwater areas at the confluences with major tributary streams like Turkey, Indian, Holt and Collins Creeks. Most streams have some natural storage, but as the streams get smaller and steeper, storage becomes less significant in reducing flood elevations and attenuating flood waves. The upper basin (Nolensville) is less urbanized with natural storage along the headwater reaches of Mill and Owl Creeks, but as headwaters streams fan out, storage rapidly diminishes.

The Muskingum-Cunge cross-section geometry and Modified Puls storage curves in the hydrologic model were modified to reflect the loss of conveyance and storage in the overbanks as shown in Figures 28 and 29. The red line represents conditions where fill is placed to the floodway limits without compensation and the blue line represents existing cross-section conditions with no encroachment. Metro requires stream buffers beyond floodway for FEMA studied streams. The green and grey lines represent the 50-ft ("no disburb" zone) and 75-ft "managed growth" vegetation buffers.

The 25 and 50 percent impervious watershed results with and without compensation (fill to floodway) storage are compared to existing conditions in Table 16. The significant increases in discharge result from the reduction of slow moving floodwaters in the overbanks. These overbank floodwaters typically become disconnected from the main stem in backwater or slow moving adjacent floodplains. The encroachment essentially pushes these overbank flood waters back into main channel conveyance area speeding up the Mill Creek main stem hydrograph. The tributaries peaks will also move closer in time to coinciding with the main stem peak further intensifying flood peaks. Typical hydrograph responses for major floods (approximately a 50-year) along Mill Creek are shown in Figure 30 for the upper (Nolensville) middle (Antioch) and lower (Nashville) storage basins. Figure 31 demonstrates the changes in peak flow and flood wave travel time for a major flood event in the Mill Creek basin with and without compensation. The flood wave travel times in Nolensville basin were reduced by approximately 0.5 hours along the headwater reaches of Owl and Mill Creeks. The travel time along Mill Creek main stem in Antioch basin was reduced by 2.4 hours. The travel times along Sevenmile

Creek and Mill Creek in Nashville basin were reduced by 1.8 and 0.9 hours, respectively. A floodway analysis was performed in HEC-RAS for Mill Creek and Sevenmile Creek to evaluate the impacts from reduction in floodplain storage. The floodway boundaries were first determined using the future conditions discharges for both the 100-year and 100-yr with encroachment. Encroachment surcharges were limited to positive 1.0 ft and - 0.09 ft as required by FEMA. The floodway discharges were then updated using the revised flows from the hydrologic model with modified storage parameters. The revised discharges were based on floodplain condition representing the loss of valley storage equal to the floodway with 50 ft water quality buffer, also referred to as the "no disturb" zone. The floodway analysis results are shown in Table 17 for gaged and ungaged locations in the Mill Creek watershed.

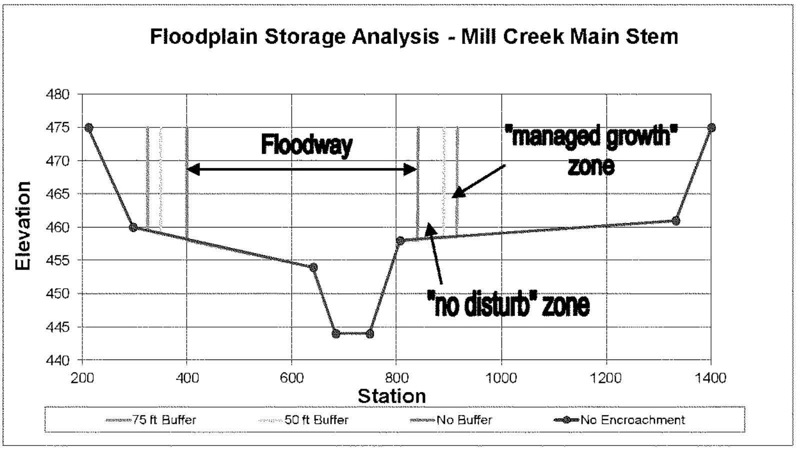


Figure 28: Typical Muskingum Cunge Cross-Section

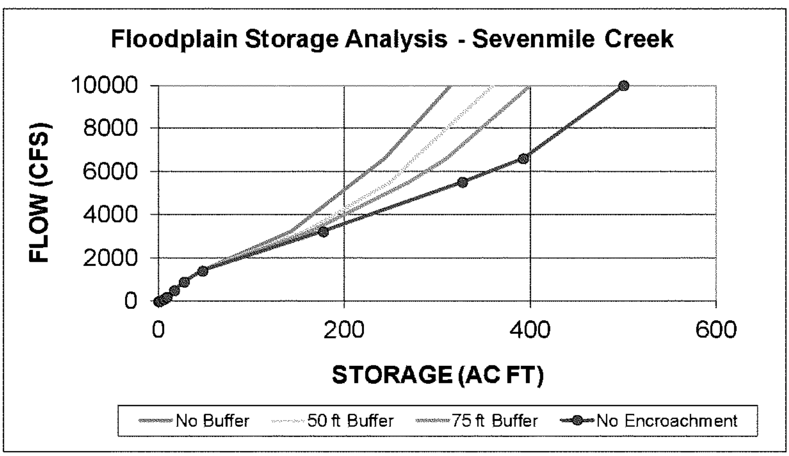


Figure 29: Typical Modified Puls Storage Outflow Curve

Table 16: Floodplain Storage Analysis – Placement of fill to Floodway without Storage Compensation

		2 -Year				5 -Year				10 -Year			
		Mill Creek Watershed				Mill Creek Watershed				Mill Creek Watershed			
		Peak Flow Increase above Existing Conditions				Peak Flow Increase above Existing Conditions				Peak Flow Increase above Existing Conditions			
		25% Impervious Grid		50% Impervious Grid		25% Impervious Grid		50% Impervious Grid		25% Impervious Grid		50% Impervious Grid	
Location	Drainage Area (Sq. Mi.)	With Compensation	Without Compensation	With Compensation	Without Compensation	With Compensation	Without Compensation	With Compensation	Without Compensation	With Compensation	Without Compensation	With Compensation	Without Compensation
Mill Creek at Thompson Lane	93.2	12%	13%	24%	28%	5%	12%	12%	20%	4%	14%	8%	21%
Mill Creek Nr Antioch Gage	64.2	12%	24%	26%	41%	6%	26%	13%	34%	4%	25%	8%	30%
Mill Creek at Nolensville Rd	40.5	11%	21%	23%	34%	4%	16%	8%	20%	3%	14%	5%	17%
Mill Creek at County Line	21.0	8%	15%	17%	24%	3%	10%	6%	13%	2%	10%	4%	12%
Owl Creek at Mouth	13.2	7%	20%	16%	30%	1%	14%	3%	16%	1%	15%	3%	17%
Seven Mile at Mouth	17.5	4%	18%	12%	28%	2%	18%	5%	21%	1%	20%	3%	22%
Seven Mile at Blackman Rd	12.1	5%	15%	13%	24%	2%	13%	5%	16%	1%	16%	3%	19%
Sorghum Branch at Mouth	2.7	4%	20%	12%	29%	2%	18%	4%	20%	1%	17%	3%	18%
Whittemore Branch at Mouth	3.7	4%	5%	12%	13%	2%	3%	3%	5%	1%	5%	2%	7%

		50 -Year				100 -Year				500 -Year			
		Mill Creek Watershed				Mill Creek Watershed				Mill Creek Watershed			
		Peak Flow Increase above Existing Conditions				Peak Flow Increase above Existing Conditions				Peak Flow Increase above Existing Conditions			
		25% Impervious Grid		50% Impervious Grid		25% Impervious Grid		50% Impervious Grid		25% Impervious Grid		50% Impervious Grid	
Location	Drainage Area (Sq. Mi.)	With Compensation	Without Compensation	With Compensation	Without Compensation	With Compensation	Without Compensation	With Compensation	Without Compensation	With Compensation	Without Compensation	With Compensation	Without Compensation
Mill Creek at Thompson Lane	93.2	2%	31%	5%	36%	1%	33%	5%	37%	1%	32%	4%	35%
Mill Creek Nr Antioch Gage	64.2	3%	26%	5%	29%	2%	26%	5%	29%	2%	28%	4%	30%
Mill Creek at Nolensville Rd	40.5	2%	15%	3%	17%	1%	15%	3%	17%	1%	15%	2%	16%
Mill Creek at County Line	21.0	1%	10%	2%	11%	1%	9%	2%	10%	1%	8%	2%	9%
Owl Creek at Mouth	13.2	1%	14%	2%	15%	1%	13%	1%	14%	0%	12%	1%	12%
Seven Mile at Mouth	17.5	1%	27%	2%	29%	1%	28%	2%	30%	0%	33%	1%	34%
Seven Mile at Blackman Rd	12.1	1%	20%	2%	22%	1%	20%	2%	21%	1%	24%	1%	25%
Sorghum Branch at Mouth	2.7	0%	17%	2%	19%	0%	17%	1%	18%	0%	17%	1%	18%
Whittemore Branch at Mouth	3.7	1%	8%	1%	9%	1%	8%	1%	9%	0%	10%	1%	11%

Table 17: Floodway Storage Analysis: Placement of fill to Floodway + 50 ft "Water Quality" Buffer

	River	Drainage	Future	With Compensation		Without Compensation	
	Mile	Area	W/O Project	Floodway	Surcharge	Floodway	Surcharge
Location	(Miles)	(Sq. Miles)	WSEL (feet)	WSEL (feet)	(feet)	WSEL (feet)	(feet)
Mill Creek at Lebanon Pike	0.86	106.4	413.25	413.45	0.2	417.33	4.1
Mill Creek at Massman Drive	2.35	101.0	422.1	422.2	0.1	425.0	2.9
Mill Creek at I-40	3.51	99.0	432.2	433.2	1.0	437.2	5.0
Mill Creek at Murfeesboro Pike	4.83	94.0	443.73	444.69	1.0	447.2	3.5
Mill Creek at Thompson Lane	6.34	93.2	456.4	457.4	1.0	459.0	2.6
Mill Creek at Space Park	7.59	91.4	468.0	468.1	0.1	470.7	2.7
Mill Creek Nr Antioch Gage	11.08	64.2	497.3	497.4	0.2	498.8	1.5
Mill Creek at I-24	13.98	57.3	517.3	517.9	0.6	519.1	1.9
Mill Creek at Pettus Road	16.16	50.8	527.4	527.9	0.5	529.1	1.7
Mill Creek at Nolensville Rd	19.43	40.5	550.5	550.8	0.2	551.5	1.0
Mill Creek at Concord Road	20.79	21.0	557.8	558.1	0.3	558.6	0.8
Seven Mile at I-24	354.99	17.5	465.2	465.2	0.1	466.7	1.5
Seven Mile at CSX Railroad	1938.71	16.4	476.0	476.0	0.0	478.5	2.5
Seven Mile at Paragons Mill Road	5729.72	15.5	484.3	485.2	0.9	486.5	2.3
Seven Mile at Nolensville Road	10053.00	14.0	505.9	505.9	0.0	507.9	2.0
Seven Mile at Blackman Road	14112.00	12.2	512.3	512.4	0.1	513.2	0.8
Seven Mile at Ellington Ag Center	19582.00	7.9	531.7	532.2	0.5	532.2	0.5
Seven Mile at Oakley Drive	22286.00	7.3	544.3	544.6	0.2	544.7	0.4

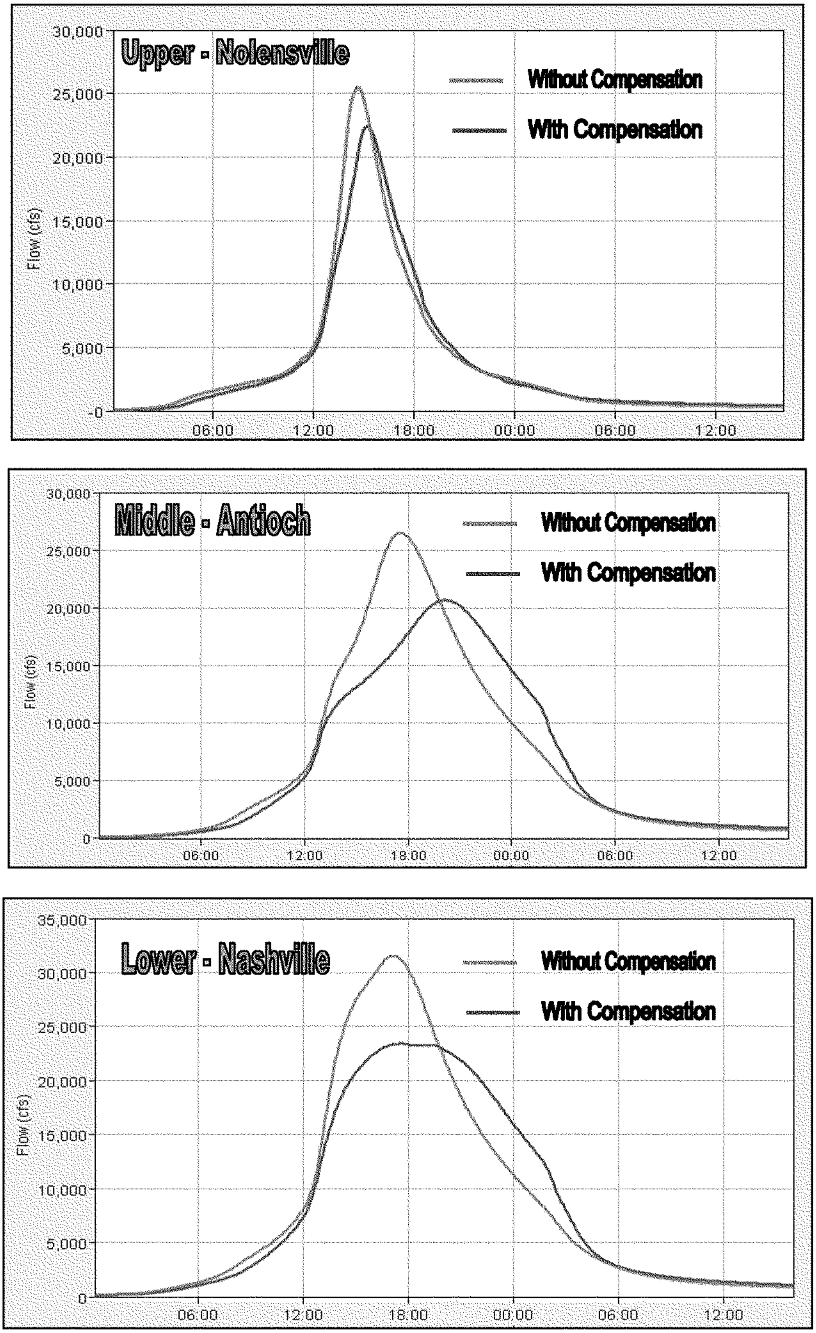


Figure 30: Mill Creek Typical Hydrographs for Major Flood Event

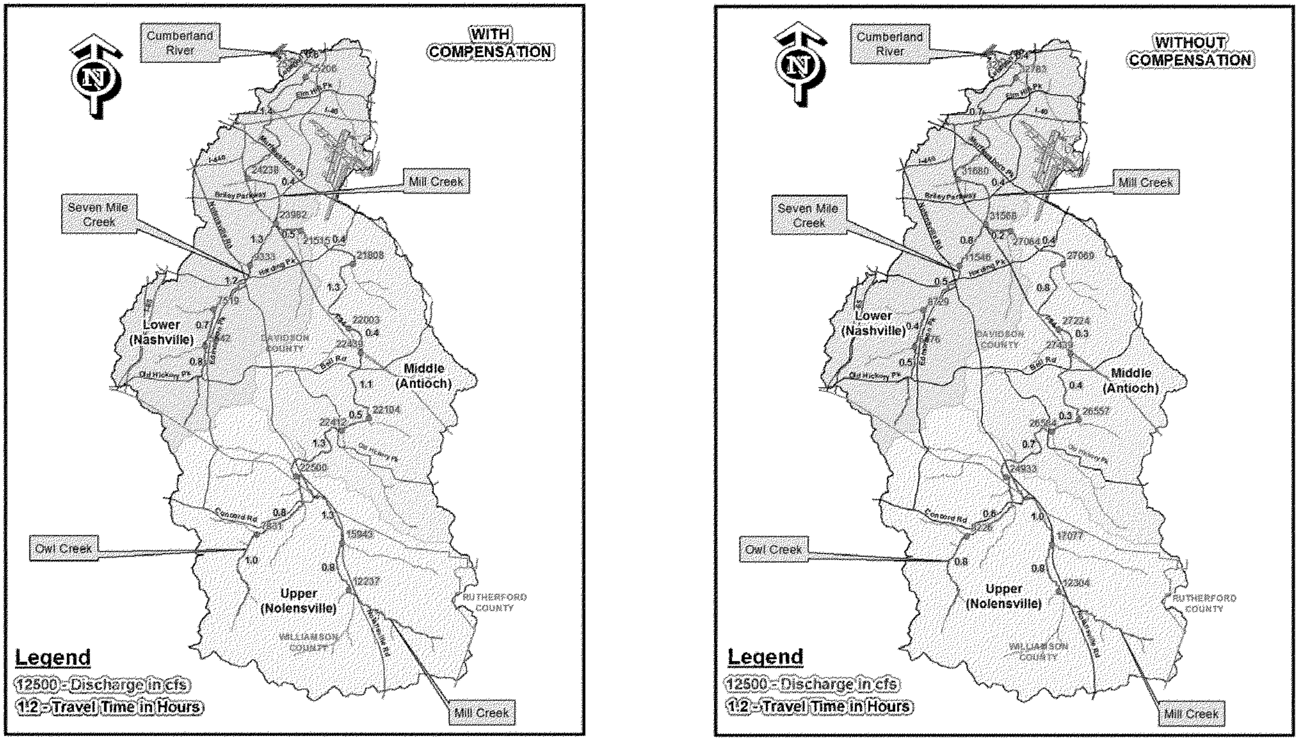


Figure 31: Discharge and Travel Times for Major Flood Event – With and Without Compensation Storage

c. **Future Without Project Conditions**

Future land use projections were obtained from the Metropolitan Nashville and Davidson County Planning Commission and the Williamson County Planner and Engineer. Metro provided detailed GIS data layers and a parcel by parcel analysis of development potential. The Williamson County data was based on GIS zoning data. Although a large portion of the watershed is under Williamson County jurisdiction today, the urban growth boundaries for the cities of Brentwood and Nolensville will encompass almost all the upper 1/3 of the watershed. The data assumes a continued build out of the ongoing residential development with a smattering of other types of development.

In general, the entire watershed is projected to increase to about 100% build out by 2050. The Mill Creek watershed was divided into 5 major zones as shown in Figure 32. Zones 1, 2, 3 and 4 lie almost entirely within Davidson County and Zone 5 within Williamson County. Zones 1, 2 and 3 are very urbanized while zones 4 and 5 are less developed. The division of zones does not necessarily follow any particular trend, but provides a good separation of the watershed drainage characteristics and GIS analysis. This build out was then translated to imperviousness based on the relationships developed during the existing conditions analysis of the hyperspectral data. For example, the runoff characteristics for pasture with the potential for conversion to residential development were changed to runoff characteristics for a suitable existing residential development. A comparison of existing and future conditions imperviousness is shown as Table 18. The imperviousness changes from about 40% to 50% in the most downstream areas, from 30% to 40% in the middle, and from about 15% to 30% in the upper part of Davidson County. Williamson County changes would be very similar to the upper part of Davidson County with less density, steeper terrain and more open space where Imperviousness would change from about 10% to 20%. The Existing and Future Conditions imperviousness are shown in Figure 32.

Table 18: Comparison of Existing and Future Conditions Imperviousness

Major Basin (Zone)	Existing Conditions (%) IMP	Future Conditions (%) IMP	Increased Imperviousness (%)
Zone 1	39%	45%	6%
Zone 2	30%	39%	9%
Zone 3	29%	36%	7%
Zone 4	13%	31%	18%
Zone 5	6%	20%	14%

The future without project conditions for this study is based on a continuation of existing stormwater detention and floodplain management policies in Davidson and Williamson Counties with these buildout conditions in place. Future conditions assume that enforcement of existing floodplain ordinances will prevent measurable increase in water surface profiles due to floodplain encroachment and loss of valley storage. Both Metro Nashville and the City of Nolensville have recently revised their stormwater and floodplain regulations. As a result of the May 2010 flood, Metro passed an ordinance in 2011 to prohibit variances for filling the floodplain. In 2006, Metro implemented a no adverse impact policy to help mitigate any potential flooding impacts from new development and significant redevelopment. Metro updated their stormwater regulations where developments are required to attenuate post-development discharges to a level not to exceed the pre-development discharges for the 2-year thru 100-year frequency flood events. However, detaining the discharge from a site can sometimes exacerbate flooding downstream due to the flow peak timing or the increased volume of runoff coming from a site. If water quantity control (detention) structures are indiscriminately placed in a watershed and changes to the flow timing are not considered, the structural control may increase the peak discharge downstream. Another impact of new development is an increase in the total runoff volume of flow. Thus, even if the peak flow is effectively attenuated, the longer duration of higher flows due to the increased volume may combine with downstream tributaries to increase the downstream peak flows. Metro also implemented the "Ten Percent" rule to further evaluate the increased runoff volume. The rule recognizes that in addition to controlling the peak discharge from the outlet of the detention facility, these facilities change the timing of the entire outflow hydrograph for the stream or river in question. Where required, channel routing calculations must proceed downstream to the confluence point where the drainage area being analyzed represents ten percent or less of the total drainage area. At this point, if the effect of the hydrograph is assessed and shown no to increase flows in the downstream hydrographs, detention can be waived. If increased flows are found, then backwater calculations and determination of flood elevations for the areas impacted by increased flow, if any, must be prepared. Where downstream increases in peak flow or flood elevations are shown, detention will be required on site to attenuate storm flows from post-development to pre-development flows. This study also includes the expansion of modeling studies to all streams in Metro with drainage areas greater than one square mile where Metro floodplain and floodway regulations will be enforced in the future. Existing and future conditions discharges are shown in Tables 19 and 20 at select locations along Mill and Sevenmile Creeks.

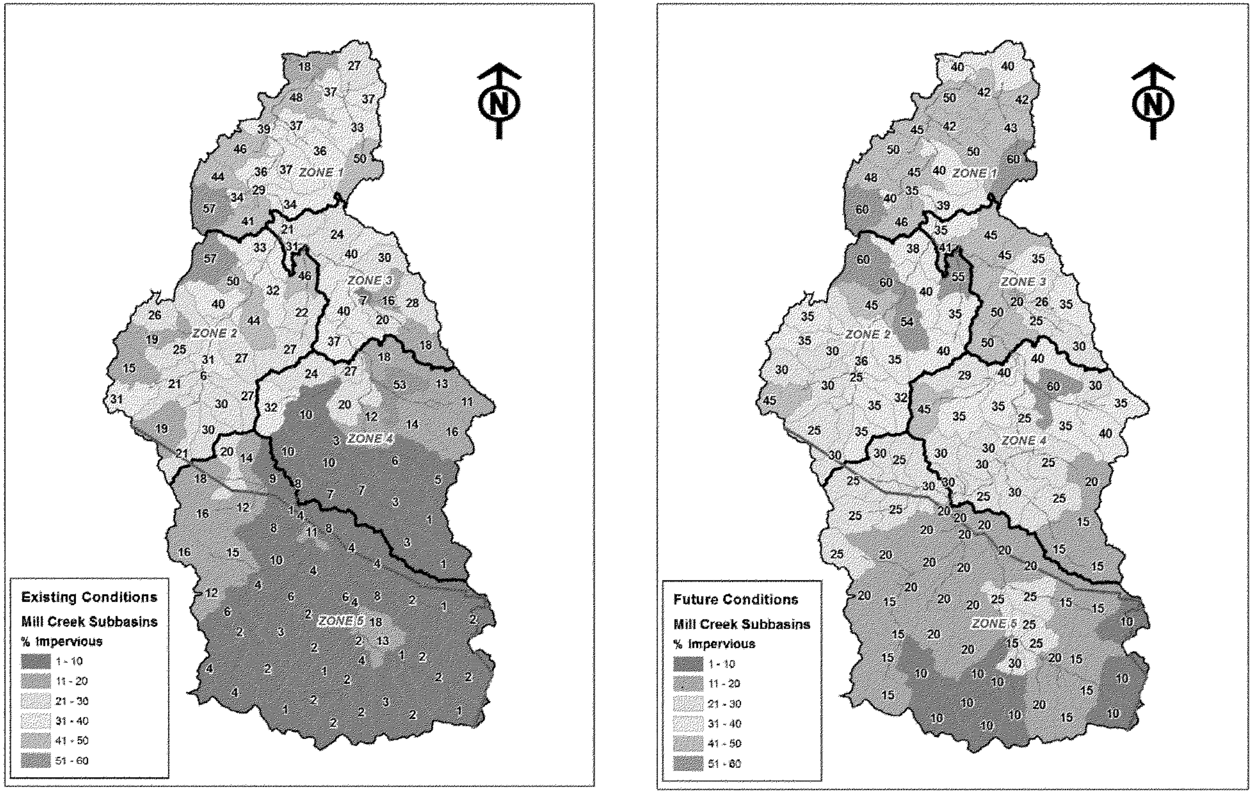


Figure 32: Percent Impervious for Mill Creek Watershed

Table 19: Mill Creek Existing and Future Conditions Discharges

Location	Drainage Area (Sq. Miles)		F2YR (cfs)	F5YR (cfs)	F10YR (cfs)	F25YR (cfs)	F50YR (cfs)	F100YR (cfs)	F200YR (cfs)	F500YR (cfs)
ABOVE OWL CREEK	21.04	Existing	6,403	9,014	12,129	14,872	16,983	19,203	21,668	24,934
		Future	6,731	9,264	12,263	15,008	17,117	19,338	21,803	25,070
USGS GAGE MILL CREEK NEAR NOLENSVILLE	40.46	Existing	8,977	12,734	17,526	21,806	25,142	28,692	32,402	37,720
		Future	9,626	13,151	17,812	22,061	25,410	28,955	32,660	38,014
BELOW COLLINS CREEK	57.31	Existing	8,022	11,240	15,683	19,900	23,267	26,823	30,569	36,139
		Future	8,726	11,851	16,140	20,352	23,696	27,257	31,010	36,623
USACE GAGE MILL CREEK NEAR ANTIOCH	64.20	Existing	7,756	10,461	14,712	18,860	22,059	25,483	29,089	34,311
		Future	8,456	11,102	15,255	19,349	22,538	25,977	29,593	34,850
USGS GAGE MILL CREEK AT THOMPSON LANE	93.20	Existing	10,607	13,257	16,885	20,856	25,111	29,986	35,002	42,103
		Future	11,440	13,986	17,534	21,577	25,813	30,698	35,712	42,857
MILL CREEK AT MOUTH	107.26	Existing	11,581	14,629	18,621	22,399	25,995	30,652	35,557	42,632
		Future	12,587	15,486	19,334	22,871	26,724	31,359	36,318	43,414

Frequency Discharges columns: F2YR through F500YR.

Table 20: Sevenmile Creek Existing and Future Conditions Discharges

Location	Drainage Area (Sq Miles)		2yr (cfs)	5yr (cfs)	10yr (cfs)	25yr (cfs)	50yr (cfs)	100yr (cfs)	200yr (cfs)	500yr (cfs)
At Oakley Drive	7.28	Existing	2,922	3,784	4,838	5,838	6,594	7,378	8,187	9,382
		Future	3,012	3,842	4,875	5,869	6,626	7,409	8,218	9,419
USGS Gage at Blackman Road	12.05	Existing	3,809	4,891	6,328	7,672	8,692	9,805	10,973	12,947
		Future	3,932	4,979	6,390	7,725	8,745	9,860	11,032	13,016
At Nolensville Pike	14.00	Existing	4,219	5,400	6,795	8,175	9,249	10,186	11,011	13,141
		Future	4,356	5,498	6,858	8,234	9,305	10,238	11,072	13,236
At Paragon Mills Road	16.43	Existing	4,864	6,164	7,597	9,046	10,193	11,025	11,901	13,336
		Future	5,015	6,247	7,663	9,108	10,238	11,075	11,955	13,394
Sevenmile Creek at Mouth	17.53	Existing	4,746	6,006	7,318	8,595	9,618	10,587	11,501	12,815
		Future	4,891	6,113	7,378	8,653	9,677	10,639	11,554	12,871

VI. HYDRAULIC MODELING ANALYSIS

Hydraulic modeling was performed using the Hydrologic Engineering Center's River Analysis System model (HEC-RAS) version 4.1.0, utilizing their ArcMap geographic interface GeoRAS.

The HEC-RAS models were first calibrated to observed flood events where high water marks were available. Discharges for historic floods were obtained from calibrated HEC-HMS models, past studies and stream gage records. There have been significant changes to floodplain and bridge geometries over the last 30 years where model calibration primarily focuses on the recent May 2010 flood event. There were also significant debris problems (houses, tractor trailers, large trees, etc.) during the May 2010 Event where model calibration was difficult in some locations. The debris option in HEC-RAS was utilized to achieve better calibration along Mill Creek and its tributaries. Historic flood Inundation maps and high water mark profiles are included as Appendix C5 and C6, respectively. Historic floods include the August 1976, May 1979, September 1979, May 2003, and May 2010 flood events for selected streams.

The HEC-RAS program was used to compute frequency based flood elevations based on 2-, 5-, 10-, 25-, 50-, 100-, 200- and 500-year frequency precipitation events and appropriate loss rate parameters. The resulting frequency based elevations are transposed to flooded areas using HEC-GeoRAS and a detailed Digital Elevation Model (DEM). The DEM is based on LIDAR data flown in 2011. All data used for HEC-RAS modeling are referenced to the Tennessee State Plane Coordinate System and North American Vertical Datum (NAVD 88).

Mill Creek and its tributaries were modeled using gradually varied steady flow simulation. Peak flows were computed with the HEC-HMS event model and in some cases previously published discharges were adopted if more conservative.

The original 2006 Study limits were all streams in Mill Creek watershed with drainage areas greater than one square mile or existing FIS limits, whichever is smaller. This criterion is followed as close as possible. There were a couple of small tributaries with drainage areas greater than one square mile that were not included because much of the modeled area is in backwater from a receiving stream or the modeled reach would be very short. This update also includes local detailed Metro Nashville studies not currently included in the 2001 Effective FIS. The 56.91 miles of modeled stream are listed in Table 21 and shown as Figure 33.

Table 21: Mill Creek Watershed HEC-RAS Models

Stream Name	River Miles
Collins Creek	1.41
Franklin Branch	2.74
Franklin Branch Tributary 1	1.65
Franklin Branch Tributary 2	0.75
Franklin Branch Tributary 3	0.48
Holt Creek	2.46
Indian Creek	3.25
Mill Creek	21.78
Sevenmile Creek	7.03
Sevenmile Creek Tributary 1	1.75
Sevenmile Creek Tributary 2	1.25
Sims Branch	2.08
Sorghum Branch	3.65
Turkey Creek	1.8
Whittemore Branch	3.52
Whittemore Branch Tributrary	1.31
Total River Miles	56.91

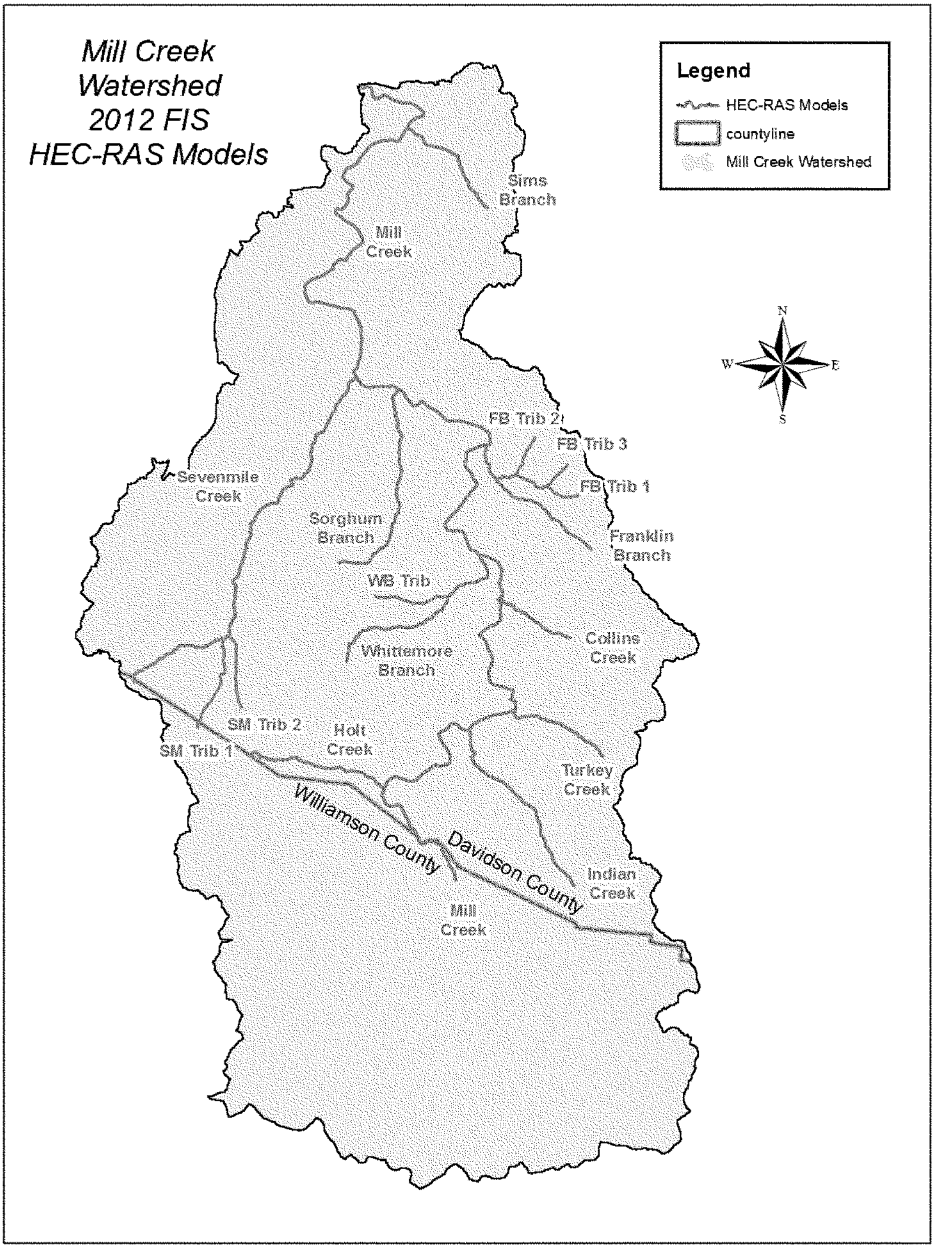


Figure 33: Mill Creek Watershed HEC-RAS Models

a. **Model Development.** The hydraulic models for this study were based on the most advanced technology available within the Corps of Engineers at the time of the study. The latest emerging technologies from the Hydrologic Engineering Center (HEC) in the use of GIS to produce advanced hydrology and hydraulic models were utilized. HEC's GeoRAS geospatial processing tools were used in conjunction with the software package River Analysis System (HEC-RAS) to perform the hydraulic analysis. A separate HEC-RAS model was created for each stream segment within the Mill Creek watershed. Cross-section and Bridge data was developed from field survey and existing modeling studies combined with overbank data take from the Digital Elevation Model (DEM) developed from the 2011 LiDAR dataset. Cross-section locations for the channel survey were laid out to match existing FIS cross-sections and local studies where available. Additional sections were added for model stability, definition, and HEC-GeoRAS floodplain delineation. HEC-GeoRAS was used to import the stream alignment, cross-section locations, cross-section station-elevation data, and reach lengths into HEC-RAS. The overbank station-elevation data is extracted and combined with the channel survey, existing HEC-2/HEC-RAS, and bridge survey data using the HEC-RAS graphical cross-section editor. A detailed description of model geometry development was provided in HEC-RAS at each cross-section. At new cross-sections where no surveys are performed, sections are extracted from the DEM geometry with channel geometry interpolated from bounding sections.

b. **Mapping and Survey Data.** 1-ft vertical accuracy LIDAR data was collected for Davidson County in 2011. Detailed DEMs were used in combination with existing HEC-2/HEC-RAS models and new surveys to develop the hydraulic models. All hydraulic models are referenced to the Tennessee State Plane Coordinate System with NAVD 88 vertical datum.

   Existing HEC-2/HEC-RAS hydraulic models were available for the majority of streams. Bridges and cross-sections in existing models were inspected for accuracy. Among the items looked at were span width, pier width and height, distance between piers, and distance between streambed/bank and the bottom of the spans, and overtopping geometry. Pictures and measurements were taken at all bridges. Measurements were taken using laser distance meters, level and rod, and survey tape. Pictures include upstream and downstream face and approach and exit sections. A detailed survey was performed on structures that were significantly different or not included in the existing model.

   AMEC, an engineering contractor, completed detailed surveys for Collins Creek, Franklin Branch, Holt Creek, Indian Creek, Sims Branch, Tributaries to Franklin Branch, and Turkey Creek. Detailed surveys of the structures as well as transect cross-sections were performed for these streams.

c. **Roughness Coefficients.** Roughness coefficients (Manning's n values) were estimated based on photos, site observation, and high resolution aerial photography. The channels are typically bedrock with earthen banks. Natural areas that are not maintained typically have a good vegetative buffer with large trees with medium undergrowth. Maintained areas are typically grassy with a small amount of larger growth near the bank. Overbanks are level to steeply-graded with uses ranging from wooded and open land in the undeveloped areas to residential and commercial in the urban areas. The Manning's n values are listed in Table 22.

Table 22: Roughness Coefficients (Manning's n)

	Manning's n		
Stream	Left Overbank	Channel	Right Overbank
Collins Creek	0.07 - 0.10	0.045 - 0.050	0.07 - 0.10
Franklin Branch	0.07 - 0.10	0.045 - 0.050	0.07 - 0.10
Franklin Branch Tributary 1	0.08 - 0.12	0.035 - 0.055	0.08 - 0.12
Franklin Branch Tributary 2	0.12	0.055	0.12
Franklin Branch Tributary 3	0.12	0.055	0.12
Holt Creek	0.07 - 0.12	0.043 - 0.047	0.07 - 0.12
Indian Creek	0.08 - 0.10	0.045 - 0.055	0.08 - 0.10
Mill Creek	0.055 - 0.14	0.030 - 0.050	0.055 - 0.12
Sevenmile Creek	0.07 - 0.12	0.035 - 0.055	0.07 - 0.12
Sevenmile Creek Tributary 1	0.065 - 0.15	0.035 - 0.050	0.065 - 0.15
Sevenmile Creek Tributary 2	0.08 - 0.10	0.045 - 0.055	0.08 - 0.10
Sims Branch	0.06 - 0.10	0.035 - 0.045	0.06 - 0.10
Sorghum Branch	0.08 - 0.12	0.040 - 0.045	0.08 - 0.12
Turkey Creek	0.06 - 0.12	0.045 - 0.050	0.065 - 0.12
Whittemore Branch	0.08 - 0.12	0.045 - 0.075	0.08 - 0.12
Whittemore Branch Tributrary	0.08 - 0.09	0.045	0.08 - 0.09

d. **Contraction and Expansion Coefficients.** Contraction and expansion (C & E) coefficients at bridges and culverts were conservatively set at 0.3 and 0.5, respectively. Elsewhere, they were set at 0.1 and 0.3, respectively.

e. **Ineffective Flow Areas and Blocked Obstructions.** The mapping and geometry at each cross-section was examined for placement ineffective flow areas and large structures (blocked obstructions). Ineffective flow areas were also set at bridges and culverts using a contraction ratio of 1.0 and an expansion ratio of 2.0. Large buildings were represented in the model using either blocked obstructions or ineffective flow at the appropriate cross-sections.

f. **Adopted Flood Frequency Discharges.** Adopted Discharges for the future conditions hypothetical events were obtained from the HEC-HMS model for Mill Creek and lower reaches of Sevenmile Creek (below Old Hickory Boulevard). Discharges along the headwaters of Sevenmile Creek, Whittemore and Sorghum Branches were adopted from previous Metro watershed studies and deemed appropriate for Future conditions. Previous Metro studies were completed in the mid to late 1990s using hydrologic (HEC-1) models with significantly more detail than the HMS model, where subbasin delineations averaged less than 100 acres (0.16 square miles). Previous models applied SCS Type II Storm Distribution, SCS Curve Number loss method, and SCS Unit Hydrograph methodologies which are very appropriate for urban, steep, and flashy streams like those found in headwaters of the Mill Creek Basin. Flow change locations in HEC-RAS are determined by comparing the HEC-HMS junction and reach locations with the cross-section locations in GIS. Depending on the location, the unrouted (HMS junctions) or routed (HMS reaches) peak discharge was used. Along some of the tributaries where a large increase in flow occurs due to local subbasins, the flow change locations were adjusted to better distribute flow along the subbasin reach. Flow change locations along streams where previous studies were adopted flow change locations were not changed. Adopted future conditions discharges are summarized Tables 23 thru 26 for Mill and Sevenmile Creeks and Sorghum and Whittemore Branches. Discharges and Flood frequency profiles for the remaining streams can be found in the 2012 FIS Update Report. Non-structural and Structural alternatives did not encompass the remaining streams and were not included in this feasibility report.

g. **Downstream Boundary Conditions.** The normal depth method was used as the downstream boundary condition for all streams. The downstream slopes for normal depth computations were obtained from stream invert (thalweg) profiles for Mill Creek tributaries. For Mill Creek, the normal depth slope was set where the 100-year Mill Creek water surface elevation matched the Cumberland River 10-year water surface elevation accounting for a moderate flood along the Cumberland River. This procedure was adopted from previous Nashville District studies and deemed appropriate.

h. **Water Surface Profiles.** Water surface profiles were computed in HEC-RAS for the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year flood events. Future Conditions flood frequency profiles for Mill and Sevenmile Creeks and Sorghum and Whittemore Branches are included as Appendix C1.

i. **Floodway Analysis.** Floodway analysis was performed for all streams within Davidson County. Existing floodway boundaries were followed where reasonable along streams where detailed studies were available. At new sections where the effective floodway widths were inadequate, the basis of equal conveyance reduction from each side of the floodplain was applied. Floodways were delineated at the encroachment stations at cross sections and interpolated between cross sections. The interpolated boundaries between cross sections consists of smooth lines following the general flow direction and flow depth of floodwaters, gradually widening or narrowing to reflect the changes in floodway width between cross sections. In cases where cross-section orientation was significantly skewed, further adjustments were made to align floodway perpendicular to flood flows. Encroachment surcharges were limited to positive 1.0 ft and - 0.09 ft as required by FEMA. Floodway tables are included as Appendix C2.

j. **Inundation Boundaries.** Inundation boundaries were computed using HEC-GeoRAS for all flood frequency profiles included in HEC-RAS models. The GeoRAS output includes inundation depth and water surface grids and an Arcmap GIS geodatabase with vector and polygon data (cross-sections, inundation boundaries, stream centerline, etc.). Future conditions 100-year and 500-year floodplain and floodway maps are included as Appendix C3. Maps also display residential and non-residential structures damaged by eight flood frequency events.

Table 23: Mill Creek Summary of Future Conditions Discharges

				Frequency Discharges							
LOCATION	Drainage Area	STORM_DA	HEC-RAS	F2YR	F5YR	F10YR	F25YR	F50YR	F100YR	F200YR	F500YR
	(Sq. Miles)	(Sq. Miles)	Station	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
ABOVE OWL CREEK	20.07	21.04	21.777	6,589	9,064	11,962	14,620	16,650	18,809	21,174	24,342
ABOVE OWL CREEK	21.04	21.04	21.378	6,731	9,264	12,263	15,008	17,117	19,338	21,803	25,070
BELOW OWL CREEK	35.04	42.30	19.896	9,654	13,234	17,855	21,868	25,053	28,389	31,868	36,919
BELOW HOLT CREEK	40.45	42.30	19.447	9,626	13,151	17,812	22,061	25,410	28,955	32,660	38,014
USGS GAGE MILL CREEK NEAR NOLENSVILLE	40.46	42.30	19.416	9,626	13,151	17,812	22,061	25,410	28,955	32,660	38,014
BELOW NOLENSVILLE RD	41.64	42.30	18.828	9,088	12,427	16,843	20,966	24,196	27,625	31,193	36,408
ABOVE OLD HICKORY BLVD	42.30	42.30	18.034	8,840	12,116	16,390	20,428	23,547	26,983	30,501	35,613
BELOW INDIAN CREEK	47.95	57.31	17.238	8,803	12,091	16,416	20,535	23,741	27,224	30,858	36,060
BELOW TURKEY CREEK	50.78	57.31	16.412	8,726	11,982	16,326	20,489	23,728	27,215	30,898	36,333
ABOVE BELL ROAD	51.75	57.31	14.825	8,559	11,621	15,779	19,852	23,045	26,446	30,020	35,388
BELOW COLLINS CREEK	57.31	57.31	14.015	8,726	11,851	16,140	20,352	23,696	27,257	31,010	36,623
BELOW WHITTEMORE BRANCE	62.06	73.59	13.095	8,669	11,693	15,971	20,172	23,523	27,111	30,894	36,459
BELOW ANTIOCH PIKE	63.08	73.59	11.965	8,590	11,436	15,646	19,795	23,054	26,570	30,266	35,665
USACE GAGE MILL CREEK NEAR ANTIOCH	64.20	73.59	11.014	8,456	11,102	15,255	19,349	22,538	25,977	29,593	34,850
BELOW TRIBUTARY FRANKLIN BRANCH	67.33	73.59	10.467	8,552	11,215	15,409	19,561	22,799	26,301	29,984	35,332
AT SPACE PARK	69.50	73.59	9.385	8,528	11,110	15,154	19,234	22,399	25,819	29,391	34,627
BELOW SORGHUM BRANCH	73.59	73.59	8.363	8,691	11,299	15,410	19,597	22,848	26,380	30,070	35,481
BELOW SEVEN MILE CREEK	91.43	93.20	7.793	11,223	13,716	17,241	21,465	25,646	30,535	35,494	42,619
ABOVE BRILEY PARKWAY	92.18	93.20	7.132	11,291	13,800	17,318	21,491	25,692	30,557	35,548	42,673
USGS GAGE MILL CREEK AT THOMPSON LANE	93.20	93.20	6.347	11,440	13,986	17,534	21,577	25,813	30,698	35,712	42,857
GLENROSE TRIB	96.12	107.26	5.813	11,631	14,251	17,832	21,565	25,785	30,651	35,651	42,732
BELOW MURFREESBORO RD	96.89	107.26	4.433	11,671	14,301	17,900	21,577	25,825	30,645	35,604	42,636
ABOVE I-40	98.96	107.26	3.806	11,890	14,581	18,232	21,823	26,024	30,883	35,863	42,947
ABOVE ELM HILL PIKE	101.00	107.26	3.275	12,062	14,805	18,521	22,069	26,204	31,076	36,064	43,165
BELOW SIMS BRANCH	106.41	107.26	1.513	12,552	15,427	19,240	22,733	26,659	31,538	36,518	43,706
MILL CREEK AT MOUTH	107.26	107.26	0.145	12,587	15,486	19,334	22,871	26,724	31,359	36,318	43,414

Table 24: Sevenmile Creek Summary of Future Conditions Discharges

Flooding Source and Location	HEC-RAS	Area	Frequency Discharges (CFS)							
Sevenmile Creek	Station	(Sq Mi)	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	200-Yr	500-Yr
At a point 185 feet upstream of Church St	37112.40	0.08	72	116	150	191	222	298	298	329
At a point 315 feet upstream of Cloverland Drive	35689.40	0.16	148	233	298	365	416	558	558	612
At a point 145 feet upstream of Cloverland Drive	35526.70	0.16	144	184	215	247	271	420	509	577
At a point 370 feet upstream of Fredericksburg Way	34368.40	0.16	115	147	171	210	239	261	403	510
At a point 910 feet downstream of Fredericksburg Way	33087.40	0.33	222	307	372	444	499	563	739	873
At a point 165 feet upstream of Barrington Place	30163.80	0.95	476	777	1,004	1,286	1,499	1,788	2,099	2,335
At a point 310 feet downstream of Barrington Place	29689.20	1.11	547	902	1,171	1,525	1,793	2,126	2,515	2,809
At a point 135 feet downstream of Chadwick Ln	29104.00	1.18	570	948	1,234	1,592	1,862	2,233	2,636	2,941
At a point 375 feet downstream of Chadwick Ln	28949.50	1.35	608	1,041	1,369	1,766	2,067	2,473	2,940	3,293
Just downstream of the confluence of Sevenmile Creek Tributary 1	27970.90	2.08	653	1,109	1,454	1,953	2,331	2,789	3,333	3,745
At a point 185 feet upstream of Old Hickory Boulevard	27885.30	2.08	649	1,066	1,381	1,919	2,326	2,766	3,314	3,729
Just downstream of the confluence of Sevenmile Creek Tributary 2	27294.80	2.82	896	1,484	1,929	2,668	3,227	3,779	4,413	4,893
At a point 915 feet downstream of Old Hickory Blvd	26787.30	3.42	1,123	1,820	2,348	3,304	4,028	4,706	5,516	6,129
At a point 1695 feet downstream of Old Hickory Blvd	25999.30	3.42	1,119	1,810	2,333	3,288	4,010	4,696	5,501	6,110
At a point 0.42 mile downstream of Old Hickory Blvd	25481.10	3.72	1,215	1,946	2,499	3,557	4,358	5,126	6,030	6,714
At a point 0.46 mile downstream of Old Hickory Blvd	25290.90	3.72	1,210	1,943	2,497	3,555	4,356	5,122	6,027	6,711
At a point 0.51 mile downstream of Old Hickory Blvd	25010.20	3.72	1,207	1,938	2,491	3,548	4,348	5,116	6,021	6,706
At a point 0.44 mile upstream of Oakley Drive	24331.30	3.72	1,187	1,925	2,483	3,467	4,211	4,969	5,870	6,552
At a point 1685 feet upstream of Oakley Drive	23386.70	4.54	1,774	2,241	2,890	3,499	3,953	4,422	4,908	5,744
At a point 915 feet upstream of Oakley Drive	22927.80	7.28	3,012	3,842	4,875	5,869	6,626	7,409	8,218	9,419
At a point 0.46 mile downstream of Ellington Agricultural Center Entrance	16717.70	10.93	3,660	4,633	5,899	7,129	8,067	9,051	10,102	12,003
USGS gage at Blackman Road	14113.00	12.05	3,932	4,979	6,390	7,725	8,745	9,860	11,032	13,016
At a point 760 feet upstream of Nolensville Pike	10683.60	13.01	4,094	5,177	6,600	7,976	9,024	9,861	11,011	13,257
At a point 375 feet upstream of Nolensville Pike	10307.10	14.00	4,356	5,498	6,858	8,234	9,305	10,238	11,072	13,236
At a point 720 feet downstream of Welch Road	7075.58	15.45	4,806	6,048	7,483	8,947	10,098	11,106	11,978	14,266
At a point 635 feet downstream of Paragon Mills	4566.99	16.43	5,015	6,247	7,663	9,108	10,238	11,075	11,955	13,394
At a point 560 feet upstream of Railroad	2330.62	16.43	4,657	5,830	7,073	8,308	9,295	10,252	11,155	12,439
At a point 430 feet upstream of Interstate 24	604.50	17.53	4,891	6,113	7,378	8,653	9,677	10,639	11,554	12,871

Table 25: Sorghum Branch Summary of Future Conditions Discharges

Flooding Source and Location	HEC-RAS	Area	Frequency Discharges (CFS)							
Sorghum Branch	Station	(Sq Mi)	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	200-Yr	500-Yr
Just downstream of Nolensville Pike	19254.50	0.40	230	390	570	601	625	685	754	850
At a point 115 feet upstream of Park Court	16624.30	0.51	265	462	685	735	775	860	950	1,075
At a point 105 feet upstream of Tusculum Road	16385.10	0.84	380	676	1,010	1,119	1,205	1,340	1,474	1,660
At a point 1375 feet downstream of Packard Dr	12814.70	1.09	445	800	1,200	1,351	1,470	1,650	1,837	2,095
At a point 260 feet downstream of Haywood Ln	11196.70	1.34	525	861	1,240	1,458	1,630	1,845	2,097	2,445
At a point 1285 feet downstream of Willard Dr	9221.27	1.55	595	985	1,425	1,655	1,835	2,085	2,390	2,810
At a point 1460 feet upstream of Linbar Drive	8309.19	1.69	620	998	1,425	1,688	1,895	2,145	2,437	2,840
At a point 340 feet downstream of Linbar Drive	6549.71	2.02	725	1,157	1,645	1,959	2,205	2,485	2,817	3,275
At a point 290 feet upstream of Harding Place	5350.79	2.37	835	1,256	1,730	2,083	2,360	2,550	2,773	3,080
At a point 200 feet upstream of CSX Railroad	889.96	2.72	845	965	1,100	1,162	1,210	1,225	1,252	1,290

Table 26: Whittemore Branch Summary of Future Conditions Discharges

Flooding Source and Location	HEC-RAS	Area	Frequency Discharges (CFS)							
Whittemore Branch	Station	(Sq Mi)	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	200-Yr	500-Yr
At a point 450 feet upstream of Brentwood Highlands Drive	18589.10	0.24	251	352	466	566	645	737	818	930
At a point 90 feet downstream of Church Access	17625.80	0.39	432	601	791	953	1,080	1,230	1,352	1,520
At a point 185 feet upstream of Nolensville Pike	16561.70	0.50	591	811	1,060	1,267	1,430	1,620	1,784	2,010
At a point 700 feet downstream of Nolensville Pike	15682.60	0.90	757	1,010	1,296	1,559	1,765	1,978	2,167	2,429
At a point 110 feet upstream of Old Hickory	12290.90	1.35	1,011	1,362	1,758	2,133	2,428	2,735	2,983	3,325
At a point 870 feet downstream of Old Hickory	11318.60	1.83	1,179	1,608	2,092	2,519	2,854	3,169	3,434	3,801
At a point 100 feet upstream of Benzing Road	9229.09	2.24	1,294	1,751	2,266	2,748	3,126	3,464	3,737	4,114
Just downstream of confluence of Whittemore Branch Tributary	5796.57	3.33	1,800	2,509	3,309	4,045	4,624	5,145	5,550	6,110
At a point 485 feet upstream of Interstate 24	2799.65	3.62	1,864	2,465	3,142	3,696	4,132	4,414	4,651	4,979

VII. SCREENING OF FLOOD DAMAGE REDUCTION MEASURES

Preliminary screening was conducted to identify flood reduction measures for further analysis and eliminate costly or impractical ones. The screening described in this section includes structural measures only. To maximize benefits, future conditions models were used to evaluate measures at the screening level.

Previous studies evaluated multiple flood reduction measures. The 1986 study recommended a plan to construct regional flood control measures at Mile 16.81 on Mill Creek and Mile 3.70 on Sevenmile Creek, and a widened section of Sevenmile Creek from Mile 0.70 to 1.51. The plan was congressionally authorized for construction but never completed due to a lack of public support. A total of 43 plans were evaluated from hydrologic, hydraulic, economic, and environmental viewpoints.

15 Structural measures were identified for preliminary screening and listed in Table 27. They include regional flood control (stormwater detention and diversions) and channel and bridge modifications. Combinations of these measures were also evaluated to maximize flood damage reduction benefits. Some measures were screened out early on during analysis due to preliminary benefit/cost ratios below unity (less than 1.0) or insignificant economic benefits. The locations of these Structural measures are shown in Figure 34.

Table 27: Preliminary Screening - Structural Measures

No.	Structural Measure Description	Target Damage Area(s)
1	Detention Structure (RCC) above Old Hickory Blvd (RM 18.0)	Mill Creek
2	Diversion at Vulcan Quarry	Mill Creek
3	Ellington Agriculture Center Regional Detention	Sevenmile Creek
4	Wimpole Drive Channel Modifications	Wimpole Drive
5	Murfreesboro Rd Bridge Modifications	Wimpole Drive
6	Thompson Lane Bridge Modifications	Wimpole Drive
7	Space Park Channel Improvements	Space Park
8	Briley Parkway Bridge Modifications	Space Park
9	Railroad Bridge River Mile 7.3 Bridge Modifications	Space Park
10	Space Park South Bridge Modifications	Space Park
11	Antioch Channel Improvements	Antioch
12	Removal of Abandoned Railroad Bridge RM 10.9	Antioch
13	Franklin Limestone Road Channel Modifications	Antioch
14	Railroad Bridge River Mile 11.7 Bridge Modifications	Antioch
15	Antioch Pike Bridge Modifications	Antioch

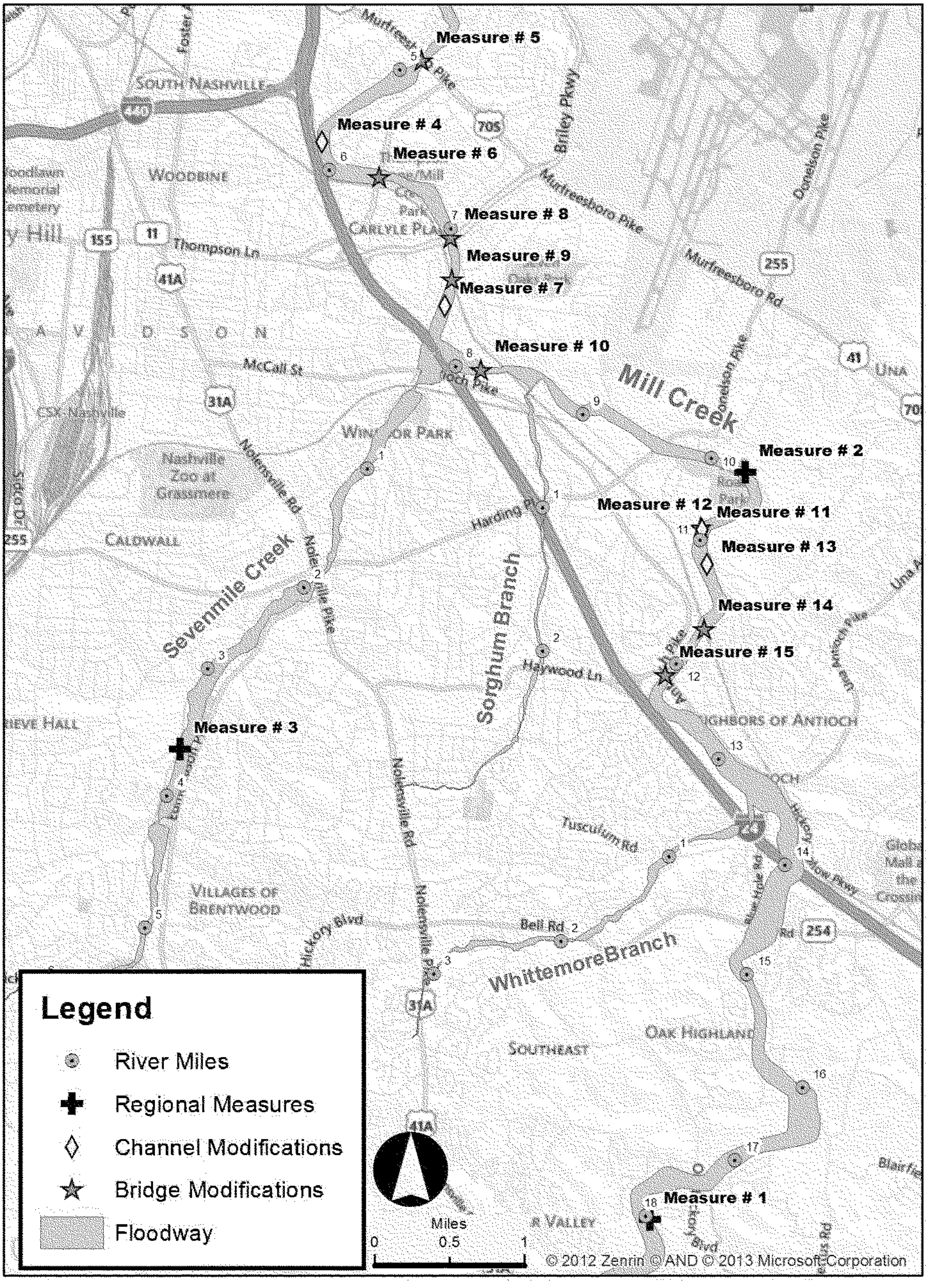


Figure 34 – Structural Measures Location Map

a. Regional Measures

1. RCC Structure above Old Hickory Boulevard (River Mile 18.0)

A new regional detention site was selected on Mill Creek at river mile 18.0, approximately 0.6 miles upstream from Old Hickory Boulevard as shown in Figure 35. The measure captures 43.0 square miles, 40% of total Mill Creek watershed. The measure includes the construction of a 21.5 ft tall Roller Compacted Concrete (RCC) structure as shown in Figure 36.

a. Outlet Works

The outlet works would consist of an uncontrolled concrete Conspan arch culvert located at the base of the structure. The outlet will pass normal flow and require no manual or mechanical operation. The arch opening would be 15 ft high and 60 feet wide with upstream and downstream invert elevations of 522.0 ft and 521.5 ft, respectively. The culvert barrel would be approximately 35 feet in length and be within the existing channel and flow with inlet control for the full ranges of discharges. The foundation would be on solid, non-erodible limestone. The relatively large conduit design will allow most of the debris to be flushed through the opening where a trash rack will not be required. The maximum outlet velocity would be approximately 20 feet per second.

b. Embankment and Spillway

The embankment would have a maximum height above the stream bed of 21.5 feet and acts as a weir or spillway for flows exceeding the 10-year frequency event. The embankment and spillway section is approximately 750 feet in length at elevation 543.0 feet and designed to be overtopped and capable of passing all floods. The embankment will be Roller Compacted Concrete and have a vertical upstream face, a 1:1 downstream face with a 15-foot top width.

A hydraulic jump energy dissipater with a 30 ft apron will be used to reduce the energy of flows through the spillway. Quarry run stone will be required for approximately 50 feet downstream of the RCC structure to protect the channel side slopes against turbulence and high velocities caused by the energy dissipation and outlet works.

Further evaluation and design of outlet works and spillway will be performed during advanced engineering studies to optimize the net benefits of this measure.

The HEC-HMS model used to calculate frequency discharges for future conditions was modified to represent the storage and outflow characteristics of the proposed measure. The reservoir data for the proposed measure are shown in Table 28. The resulting "with project" discharges were then placed in the calibrated HEC-RAS models to calculate frequency-flood profiles. Water surface elevations were set in the model just upstream from the RCC Structure to match HEC-HMS pool elevations. Flows were reduced in RAS just upstream from the RCC structure to reflect the flow reduction due to attenuation. The downstream effects at select damage centers are shown in Tables 29 thru 32. There are several adverse impacts caused by the temporary ponding of water upstream from the structure. They include flooding of farm land, open space, and roads upstream from the RCC structure at levels greater than previously experienced. Flowage easements in this area would be acquired to implement this measure. The increased backwater effects for the 500-year frequency flood event dissipate in the vicinity of Nolensville Road Bridge at river mile 19.5. The upstream impacts just downstream from Nolensville Road Bridge in the vicinity of Sunnywood Drive are shown in Table 33. Water surface profiles for the 10-, 50-, 100-, and 500-year frequency floods are shown in Figures 37 thru 39. Water surface profiles do not include the backwater effects from the Cumberland River. Typical hydrographs for the 10-yr and 100-year frequency floods are shown in Figure 40. Sevenmile Creek, the largest tributary flows into Mill Creek at mile 7.5 in the vicinity of the Space Park commercial development. Sevenmile Creek controls the flooding up to the 10-year frequency flood event along Mill Creek below river mile 7.5. Mill Creek begins to control flooding below Sevenmile Creek for larger floods like the 25, 50-, 100-, and 500-year Events. Frequency flood events assume a uniform rainfall distribution over the entire watershed. Both the May 1979 and May 2010 events resulted in larger storms in the upper half of the watershed above Sevenmile Creek. Further evaluation of rainfall distribution and storm orientation will be considered during advanced engineering studies to optimize the net benefits of this measure.

Table 28: Regional Detention Structure River Mile 18.0 – Reservoir Data

Storm	Discharge		Elevation		Capacity	Area
Frequency	Future	With Project	Future	With Project	With Project	With Project
(Years)	(cfs)	(cfs)	(Feet)	(Feet)	Acre-Feet	Acres
2	8,658	7,785	534.9	536.5	364	79
5	11,920	10,254	536.2	539.9	665	131
10	16,604	12,152	537.6	542.5	1,226	181
25	20,016	16,491	538.7	544.3	1,634	216
50	23,052	20,077	539.5	545.0	1,803	231
100	26,375	23,453	540.2	545.7	1,951	244
200	29,800	27,429	540.8	546.3	2,085	256
500	34,772	32,651	541.7	547.1	2,259	271

Historic	Discharge		Elevation		Capacity	Area
Flood	Future	With Project	Future	With Project	With Project	With Project
(Date)	(cfs)	(cfs)	(Feet)	(Feet)	Acre-Feet	Acres
May 1979	28,200	26,600	540.3	546.2	2,059	254
May 2010	35,100	34,400	540.8	547.3	2,312	276

Table 29: RCC Structure Downstream Effects – Antioch Pike
Mill Creek
River Mile 12.86

Storm	Future W/O Project		Future with Project		WSEL
Frequency	Discharge	Elevation	Discharge	Elevation	Reduction
or Event	(cfs)	(feet)	(cfs)	(feet)	(feet)
2yr	8,669	499.8	8,037	499.3	-0.5
5yr	11,693	501.8	10,270	501.0	-0.9
10yr	15,971	504.4	12,763	502.5	-1.9
25yr	20,172	506.8	15,875	504.4	-2.4
50yr	23,523	508.2	19,180	506.3	-2.0
100-yr	27,111	509.5	22,895	508.0	-1.6
200-yr	30,894	510.8	26,622	509.4	-1.4
500yr	36,459	512.3	31,930	511.1	-1.2
May 1979	30,000	510.6	25,000	508.9	-1.7
May 2010	38,000	512.6	35,823	512.1	-0.6

Table 30: RCC Structure Downstream Effects – Harding Industrial Rd
Mill Creek just above Sevenmile Creek
River Mile 8.80

Storm	Future W/O Project		Future with Project		WSEL
Frequency	Discharge	Elevation	Discharge	Elevation	Reduction
or Event	(cfs)	(feet)	(cfs)	(feet)	(feet)
2yr	8,528	469.5	8,013	469.1	-0.4
5yr	11,110	471.3	10,066	470.6	-0.7
10yr	15,154	473.6	12,673	472.2	-1.4
25yr	19,234	475.6	15,605	473.9	-1.8
50yr	22,399	477.1	18,524	475.3	-1.8
100-yr	25,819	478.6	21,869	476.9	-1.7
200-yr	29,391	480.1	25,280	478.4	-1.8
500yr	34,627	482.2	30,167	480.4	-1.8
May 1979	30,000	480.2	24,000	477.7	-2.5
May 2010	36,000	482.5	32,635	481.2	-1.3

Table 31: RCC Structure Downstream Effects – Space Park
Mill Creek just below Sevenmile Creek
River Mile 7.59

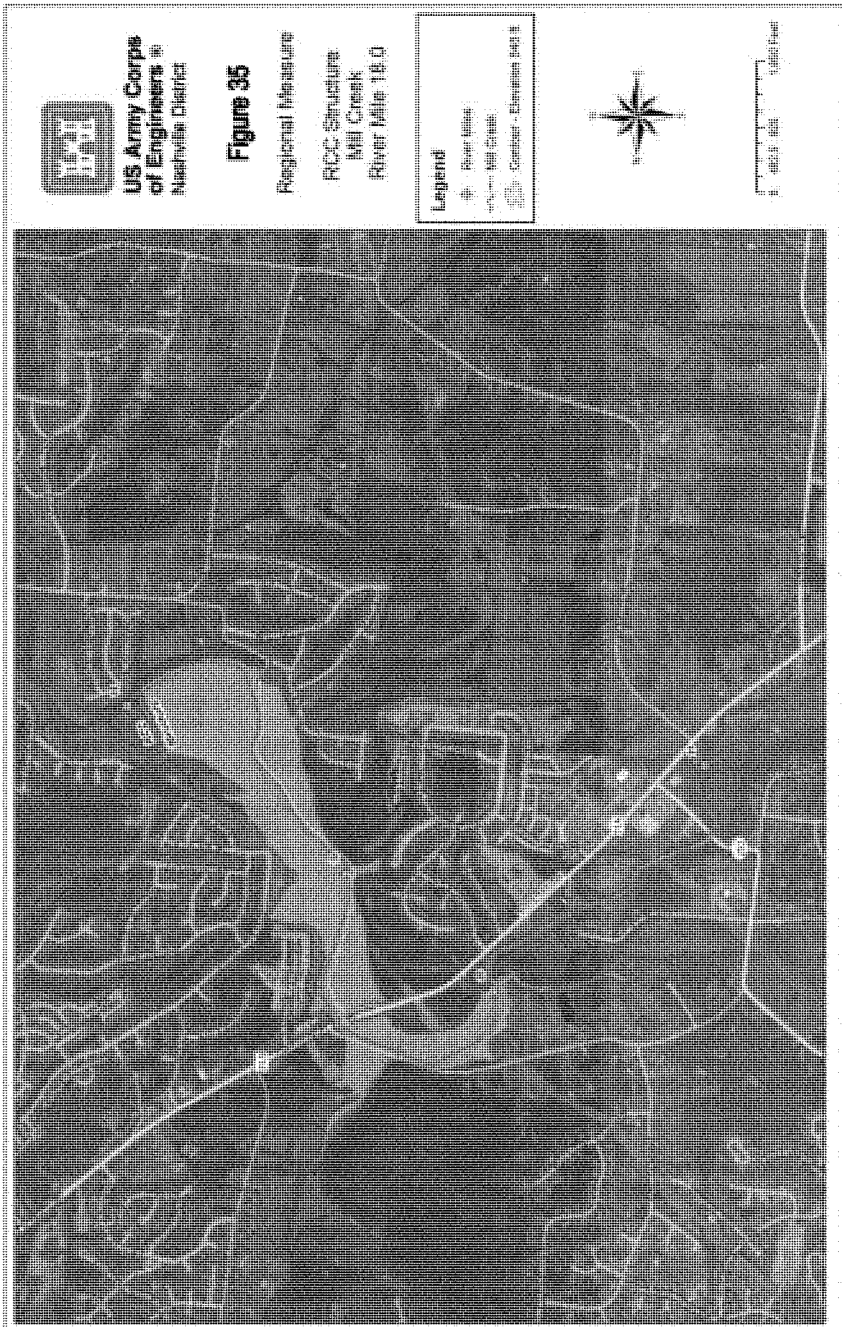
Storm	Future W/O Project		Future with Project		WSEL
Frequency	Discharge	Elevation	Discharge	Elevation	Reduction
or Event	(cfs)	(feet)	(cfs)	(feet)	(feet)
2yr	11,223	458.2	11,133	458.2	0.0
5yr	13,716	459.6	13,614	459.6	-0.1
10yr	17,241	461.8	17,027	461.7	-0.1
25yr	21,465	463.9	20,339	463.3	-0.6
50yr	25,646	465.9	23,504	464.9	-1.0
100-yr	30,535	468.0	26,964	466.6	-1.4
200-yr	35,494	469.2	30,390	467.9	-1.3
500yr	42,619	471.1	35,664	469.2	-1.9
May 1979	30,000	467.8	24,000	465.1	-2.7
May 2010	36,000	469.3	32,400	468.4	-0.9

Table 32: RCC Structure Downstream Effects – Massman Drive
Mill Creek
River Mile 2.35

Storm	Future W/O Project		Future with Project		WSEL
Frequency	Discharge	Elevation	Discharge	Elevation	Reduction
or Event	(cfs)	(feet)	(cfs)	(feet)	(feet)
2yr	12,062	411.0	11,995	410.9	-0.1
5yr	14,805	413.0	14,730	413.0	-0.1
10yr	18,521	415.6	18,391	415.5	-0.1
25yr	22,069	417.8	21,727	417.6	-0.2
50yr	26,204	419.9	24,731	419.3	-0.7
100-yr	31,076	422.1	28,338	421.0	-1.1
200-yr	36,064	424.0	31,905	422.5	-1.6
500yr	43,165	426.5	36,869	424.4	-2.0
May 1979	30,000	421.2	24,000	418.4	-2.8
May 2010	34,000	422.8	30,700	421.5	-1.3

Table 33: RCC Structure Upstream Impacts – Sunnywood Drive
Mill Creek
River Mile 18.828

Storm	Future W/O Project		Future with Project		WSEL
Frequency	Discharge	Elevation	Discharge	Elevation	Reduction
or Event	(cfs)	(feet)	(cfs)	(feet)	(feet)
2yr	9,088	541.0	7,785	541.0	0.0
5yr	12,427	542.3	10,254	542.3	0.0
10yr	16,843	543.7	12,152	543.7	0.0
25yr	20,966	544.6	16,491	545.3	0.7
50yr	24,196	545.2	20,077	546.1	0.9
100-yr	27,625	545.8	23,453	546.9	1.1
200-yr	31,193	546.4	27,429	547.6	1.2
500yr	36,408	547.2	32,651	548.5	1.3
May 1979	27,800	545.9	26,600	547.5	1.6
May 2010	30,000	546.2	28,470	548.4	2.1



US Army Corps
of Engineers
Figure 35
Legend

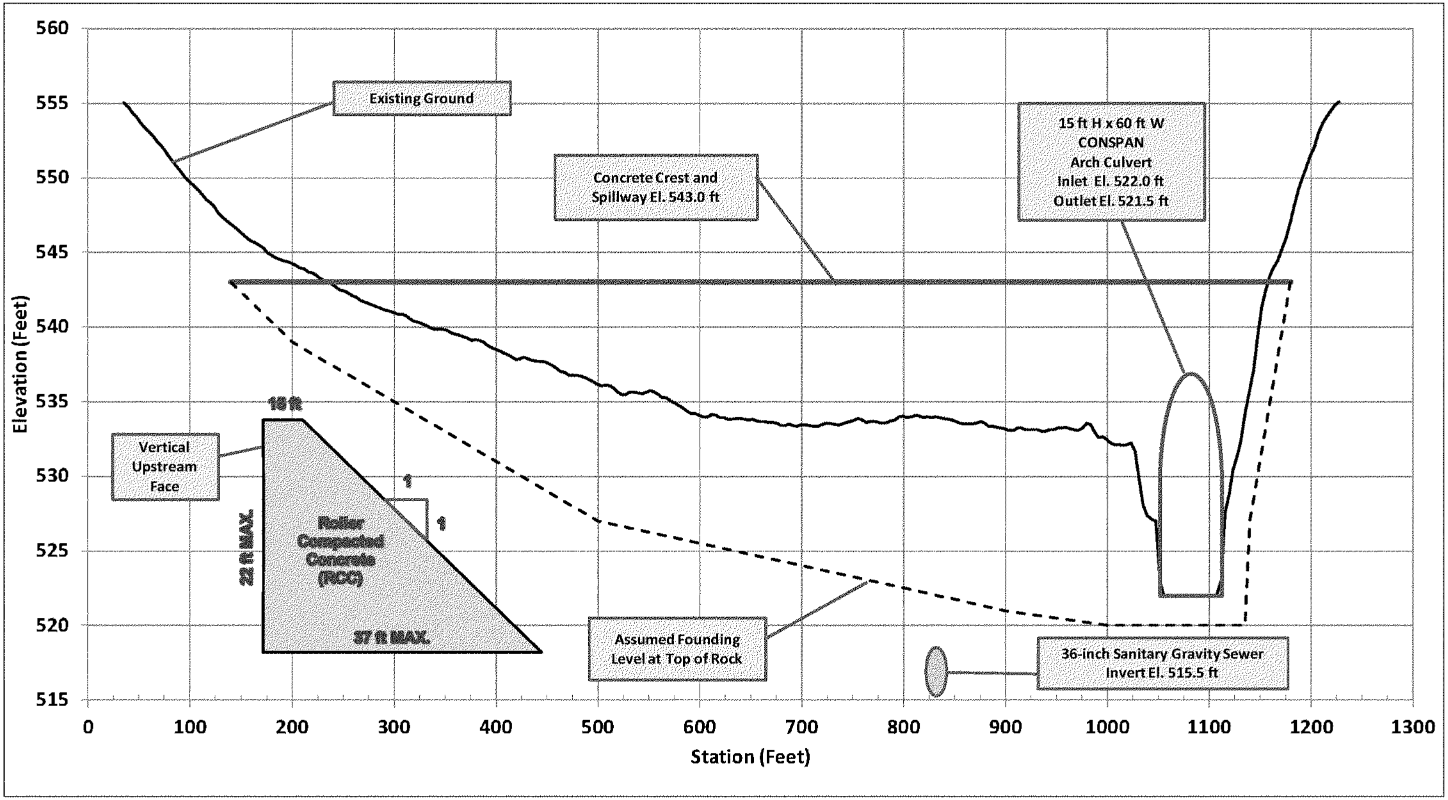


Figure 36: RCC Structure River Mile 18.0 – Typical Cross Section Looking Downstream

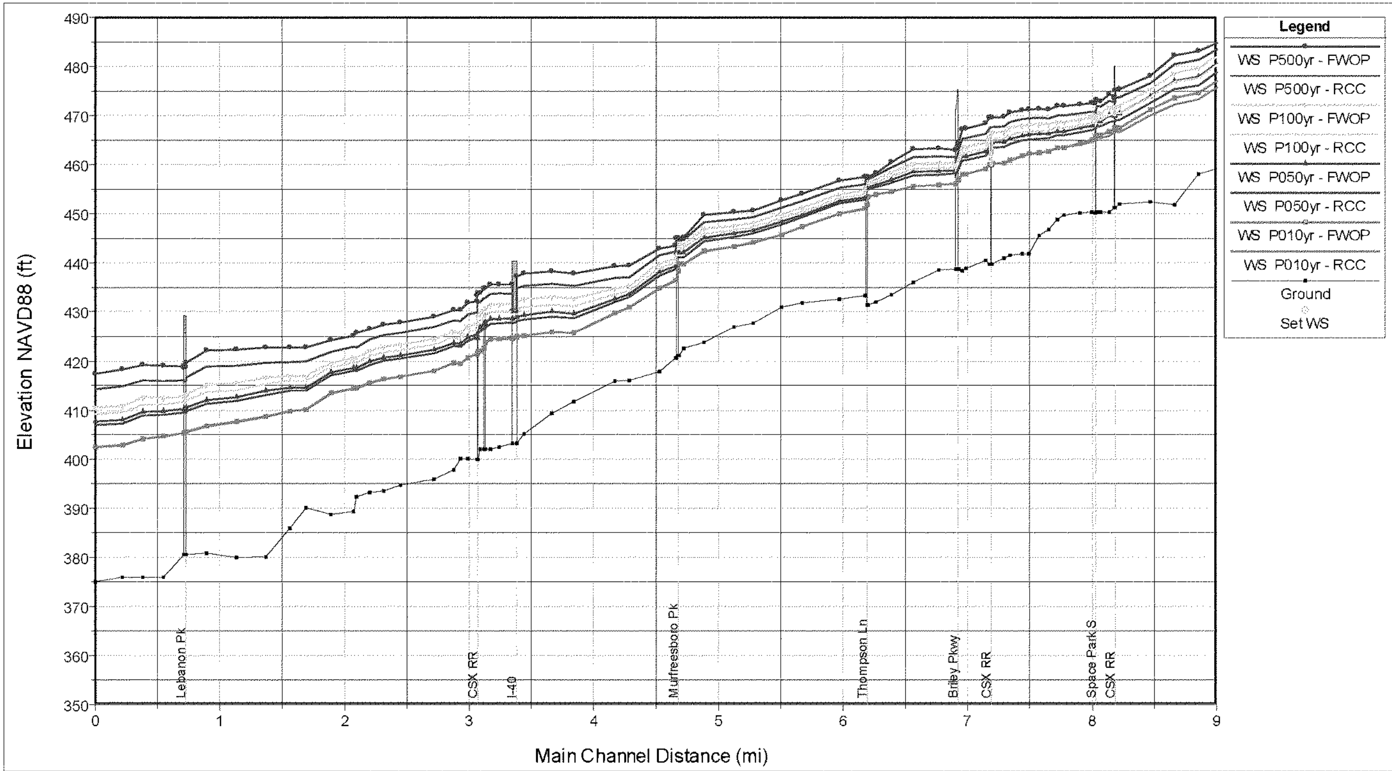


Figure 37: RCC Structure - Flood Frequency Water Surface Profiles (River Mile 0 to 9)

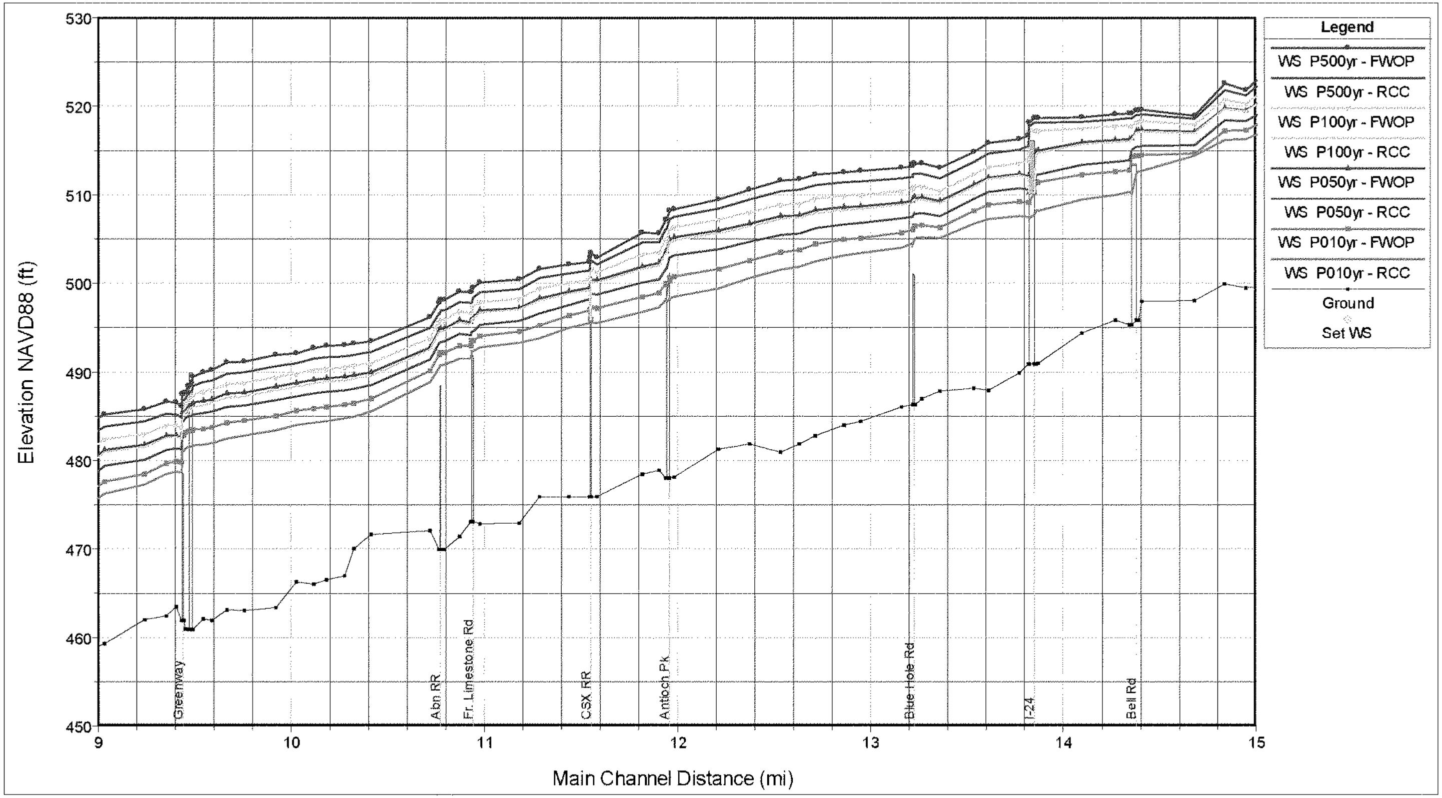


Figure 38: RCC Structure - Flood Frequency Water Surface Profiles (River Mile 9 to 15)

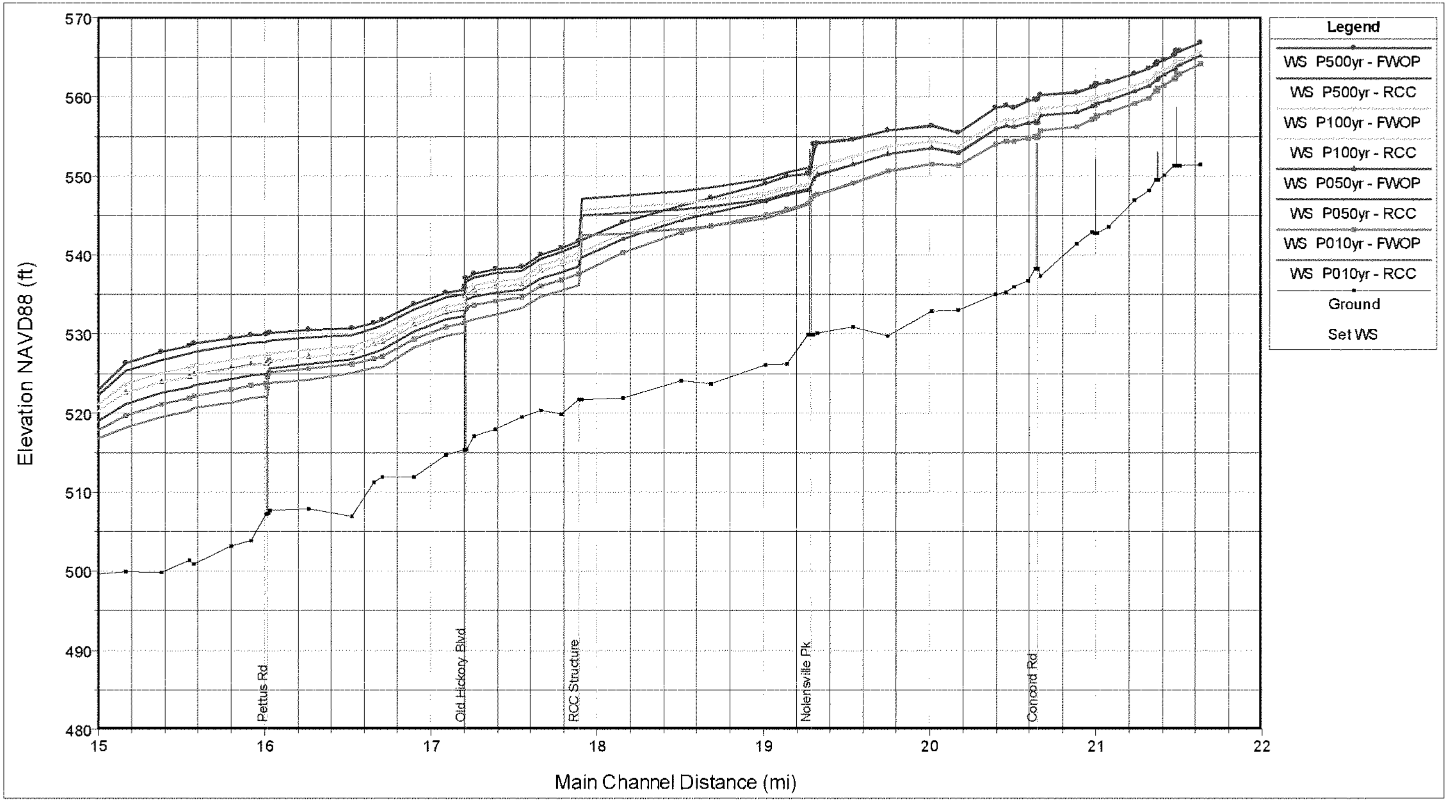


Figure 39: RCC Structure - Flood Frequency Water Surface Profiles (River Mile 15 to 22)

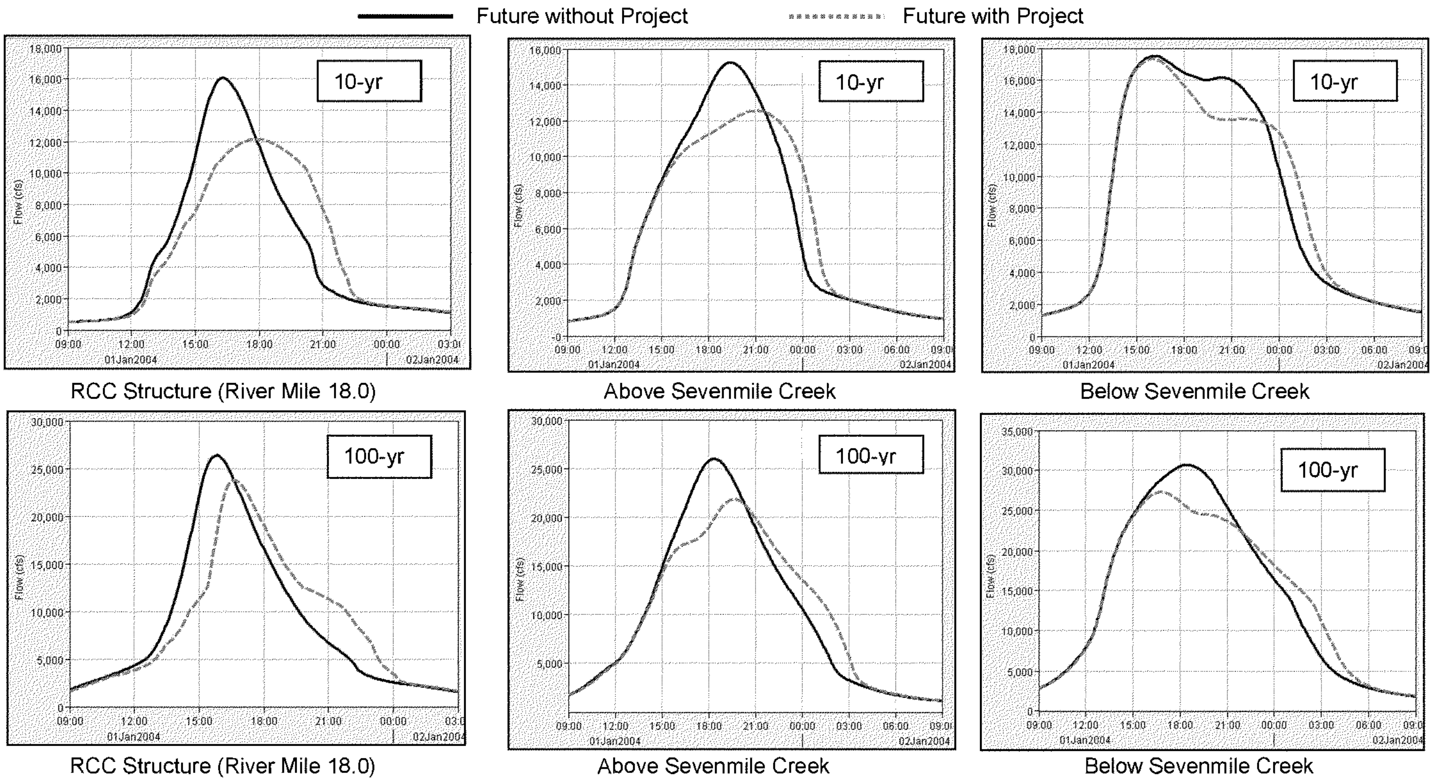


Figure 40: RCC Structure – Typical 10yr and 100yr Frequency-Flood Hydrographs

2. Vulcan Quarry Diversion

Stormwater diversion into the Vulcan quarry along the right bank of Mill Creek between river miles 10.3 and 10.6 was evaluated for regional flood reduction as shown in Figure 41. The measure captures 67 square miles, 62% of total Mill Creek watershed. The quarry alternative includes a diversion structure at river mile 10.25 that backs floodwaters into a gate/tunnel structure at river mile 10.36 spilling into the quarry. The measure is designed to start spilling into quarry at the 10-year frequency flood event and is designed to reduce flooding for moderate to major flood events. Flood hydrographs generated from the future conditions HEC-HMS model were used as input into an unsteady flow HEC-RAS model developed for the quarry alternative. Output hydrographs from the unsteady flow model were then put back into the HEC-HMS model to calculate the downstream frequency-flood discharges used in HEC-RAS. The technical data for the Vulcan Quarry Diversion are shown in Tables 34 thru 36. The Quarry Elevation-Area-Volume relationship and Flood Frequency Data are shown as Tables 37 and 38, respectively. The downstream effects for frequency floods and historic floods are shown in Tables 39 thru 41. Water surface profiles for frequency and historic floods are shown as Figures 42 thru 44. Typical hydrographs for frequency floods and historic floods are shown as Figures 45 and 46, respectively. As shown in tables and figures, the quarry diversion has a significant flood reduction for the less frequent floods like the May 1979 and May 2010 events where the flood volumes.

<u>Table 34: Diversion Structure – Mill Creek River Mile 10.25</u>
Embankment material = RCC
Culvert opening width = 70 feet
Culvert opening height = 10 feet
Culvert invert elevation = 468 feet
Top of embankment = 494 feet
Top width of embankment = 530 feet
Embankment height at channel = 27 feet
Average embankment height along left overbank = 15 feet

<u>Table 35: Gate Structure at Tunnel – Mill Creek River Mile 10.36</u>
Sluice gate width = 100 feet
Sluice gate height = 20 feet
Sluice gate invert = 480 feet
Channel invert at gate = 467 feet

<u>Table 36: Tunnel into Quarry – Mill Creek River Mile 10.36</u>
Tunnel invert = 467 feet
Tunnel length = 200 feet
Depth of rock to tunnel invert = 75 feet
Height of tunnel invert above bottom of quarry = 290 feet

Table 37: Vulcan Quarry – Elevation-Area-Volume Relationship

Elevation (Feet)	Area (Acres)	Cumulative Volume (Acre-ft)
175	0.0	0
195	24.1	303
215	36.2	912
235	38.3	1,663
255	41.3	2,453
275	43.2	3,298
295	44.6	4,176
315	46.0	5,083
335	47.0	6,012
355	49.3	6,973
375	52.2	7,983
395	53.8	9,045
415	55.2	10,135
435	59.1	11,274
455	60.6	12,472
475	63.4	13,710
495	74.5	15,099

Table 38: Quarry Frequency-Flood Data

Frequency Event	Quarry Peak Inflow (cfs)	Quarry Peak Stage (ft)	Quarry Peak Volume (acre-ft)
2yr	Not Used		
5yr	Not Used		
10yr	4,900	238	1,770
25yr	6,400	280	3,390
50yr	8,200	300	4,470
100yr	10,200	330	5,650
200yr	13,000	350	6,900
500yr	15,500	390	8,700
May 1979	11,500	325	5,520
May 2010	16,500	473	13,590

Table 39: Vulcan Quarry Diversion Downstream Effects - Harding Industrial
Mill Creek just above Sevenmile Creek
River Mile 8.80

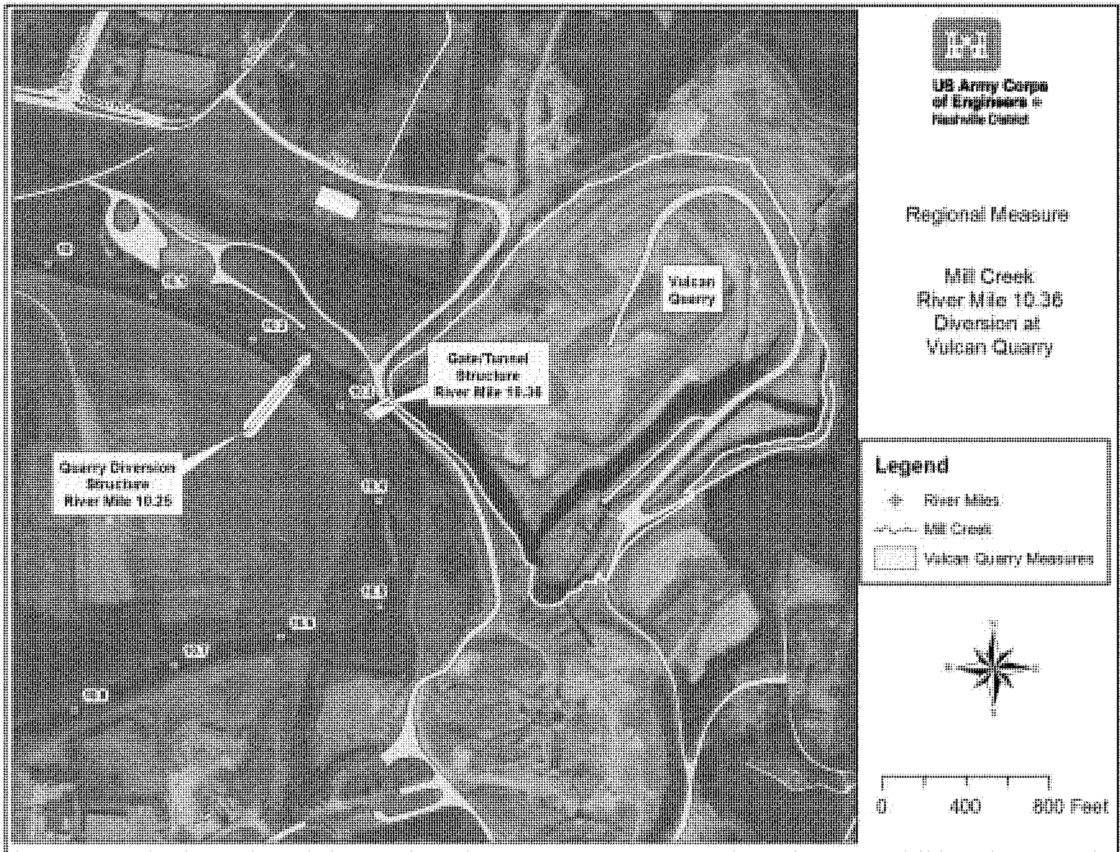
Storm	Future W/O Project		Future with Project		WSEL
Frequency	Discharge	Elevation	Discharge	Elevation	Reduction
or Event	(cfs)	(feet)	(cfs)	(feet)	(feet)
2yr	8,528	469.5	8,528	469.5	0.0
5yr	11,110	471.3	11,110	471.3	0.0
10yr	15,154	473.6	13,000	472.5	-1.1
25yr	19,234	475.6	13,500	472.8	-2.8
50yr	22,399	477.1	15,000	473.7	-3.4
100-yr	25,819	478.6	16,000	474.3	-4.3
200-yr	29,391	480.1	17,000	474.9	-5.3
500yr	34,627	482.2	20,000	476.4	-5.8
May 1979	30,000	480.2	17,500	474.8	-5.4
May 2010	36,000	482.5	21,000	476.5	-6.0

Table 40: Vulcan Quarry Diversion Downstream Effects - Space Park
Mill Creek just below Sevenmile Creek
River Mile 7.59

Storm	Future W/O Project		Future with Project		WSEL
Frequency	Discharge	Elevation	Discharge	Elevation	Reduction
or Event	(cfs)	(feet)	(cfs)	(feet)	(feet)
2yr	11,223	458.2	11,223	458.2	0.0
5yr	13,716	459.6	13,716	459.6	0.0
10yr	17,241	461.8	17,241	461.8	0.0
25yr	21,465	463.9	20,800	463.5	-0.3
50yr	25,646	465.9	23,800	465.0	-0.9
100-yr	30,535	468.0	26,500	466.4	-1.5
200-yr	35,494	469.2	29,100	467.6	-1.6
500yr	42,619	471.1	33,500	468.8	-2.3
May 1979	30,000	467.8	20,500	463.3	-4.5
May 2010	36,000	469.3	28,000	466.6	-2.7

Table 41: Vulcan Quarry Diversion Downstream Effects - Massman Drive
Mill Creek
River Mile 2.35

Storm	Future W/O Project		Future with Project		WSEL
Frequency	Discharge	Elevation	Discharge	Elevation	Reduction
or Event	(cfs)	(feet)	(cfs)	(feet)	(feet)
2yr	12,062	411.0	12,062	411.0	0.0
5yr	14,805	413.0	14,805	413.0	0.0
10yr	18,521	415.6	18,521	415.6	0.0
25yr	22,069	417.8	22,000	417.7	0.0
50yr	26,204	419.9	25,100	419.5	-0.5
100-yr	31,076	422.1	28,300	421.0	-1.1
200-yr	36,064	424.0	31,300	422.3	-1.8
500yr	43,165	426.5	36,000	424.1	-2.3
May 1979	30,000	421.2	21,000	416.7	-4.5
May 2010	34,000	422.8	27,000	419.9	-2.9


US Army Corps
of Engineers
Regional Measure
Mill Creek
River Mile 10.36
Diversion at
Vulcan Quarry
Legend
River Miles
Mill Creek
Vulcan Quarry Measures
0
400
800 Feet
Vulcan
Quarry
Gate/Tunnel
Structure
River Mile 10.36
Quarry Diversion
Structure
River Mile 10.25

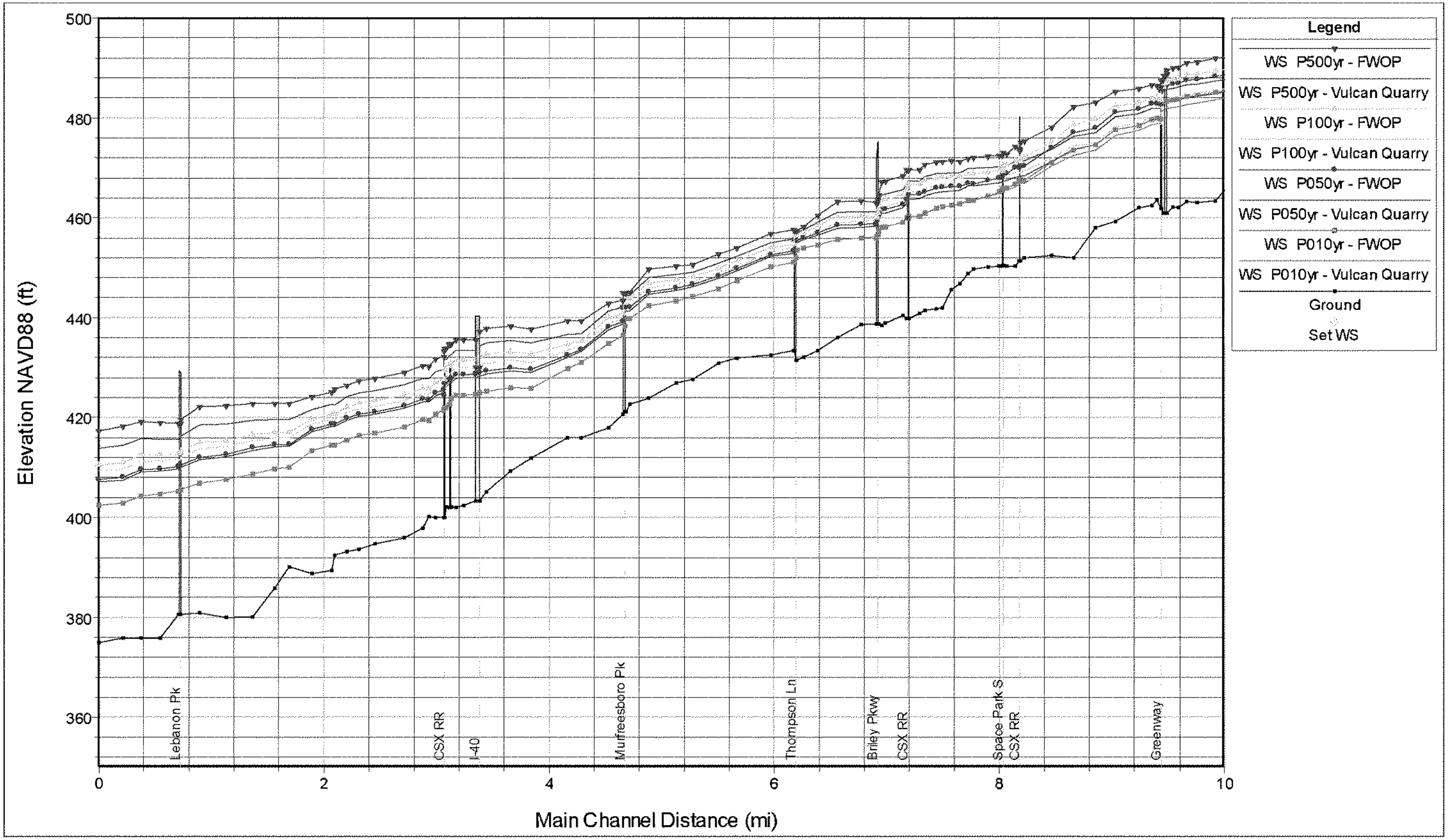


Figure 42: Vulcan Quarry Diversion - Flood Frequency Water Surface Profiles (River Mile 0 to 10)

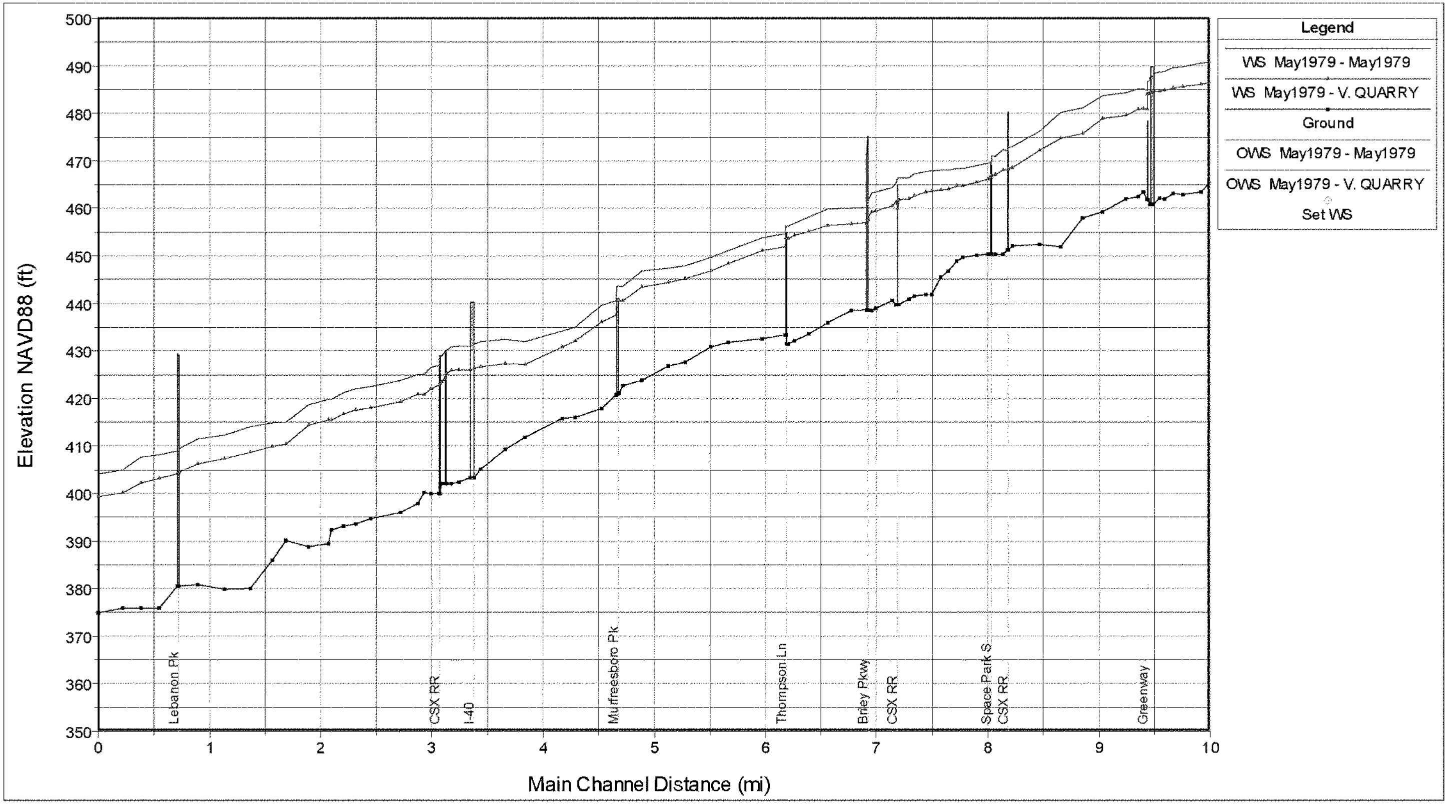


Figure 43: Vulcan Quarry Diversion – May 1979 Flood Event Water Surface Profiles (River Mile 0 to 10)

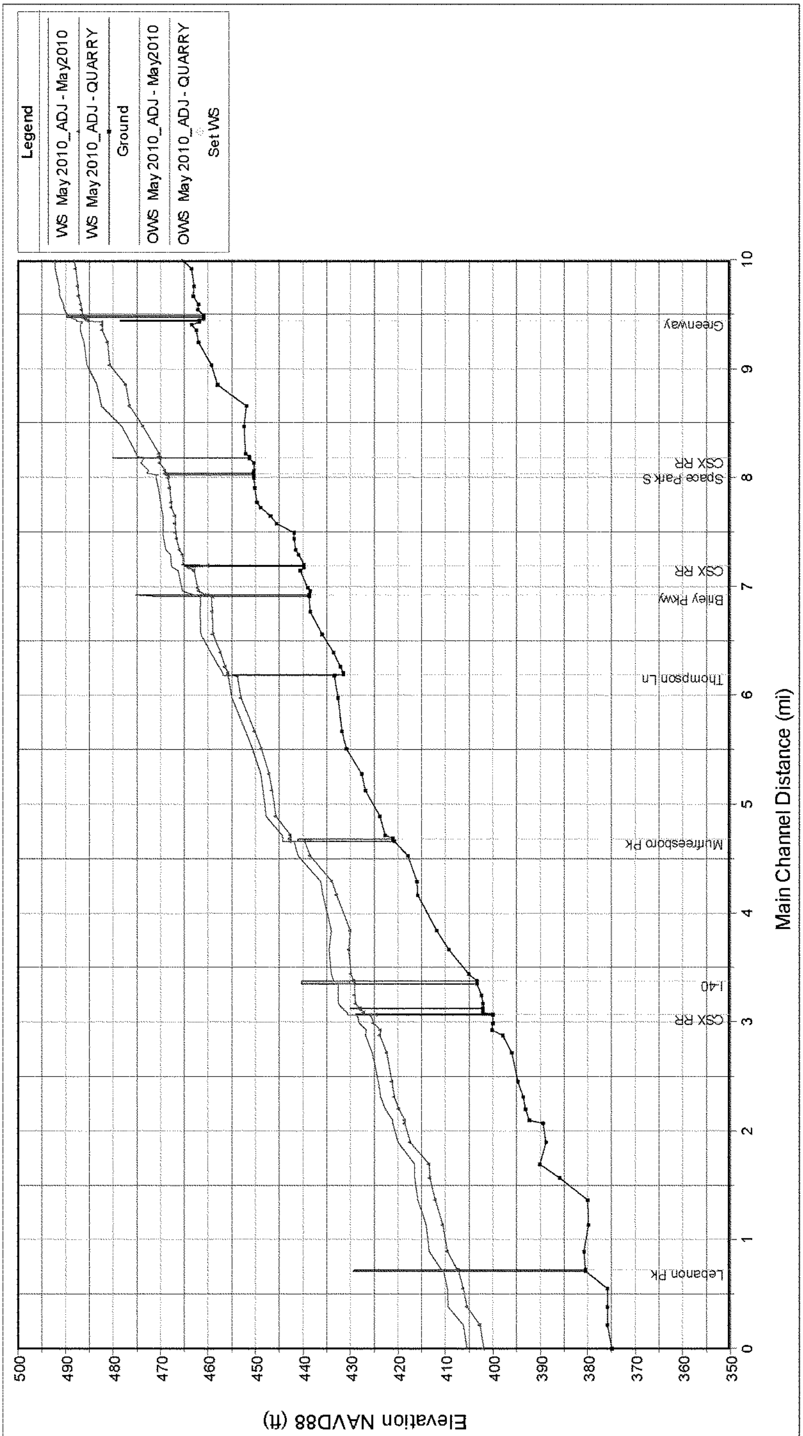


Figure 44: Vulcan Quarry Diversion – May 2010 Flood Event Water Surface Profiles (River Mile 0 to 10)

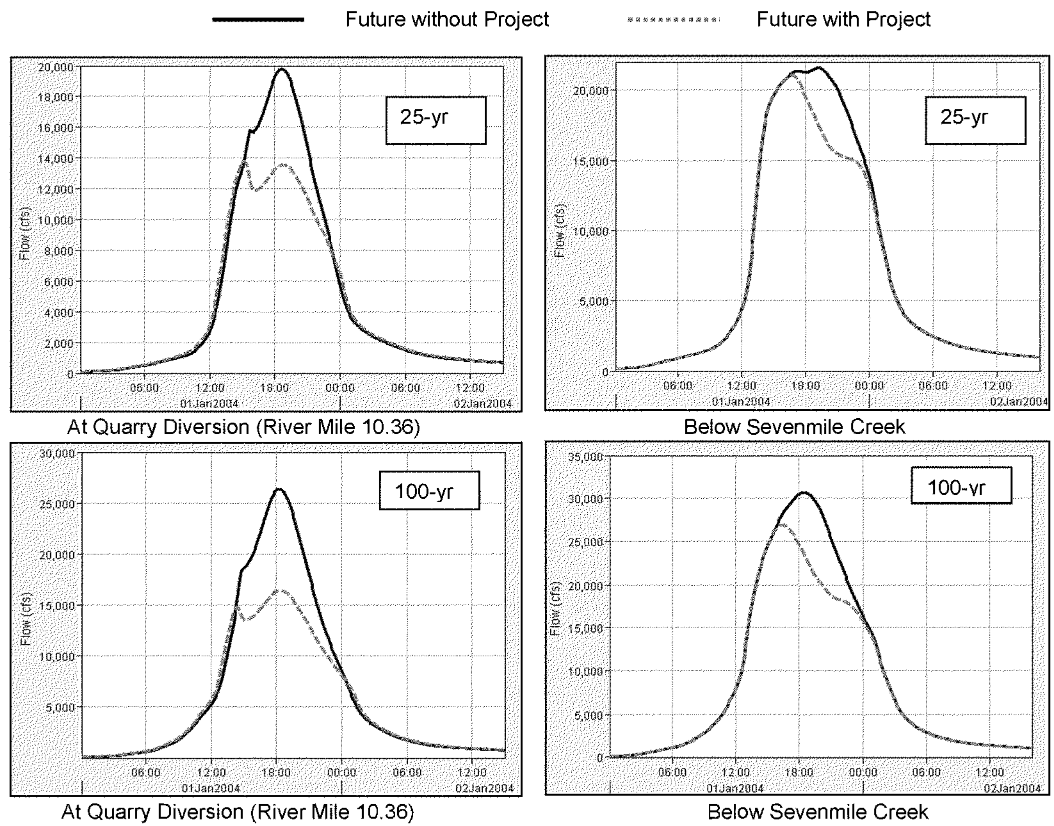


Figure 45: Vulcan Quarry Diversion – Typical 25yr and 50yr Frequency-Flood Hydrographs

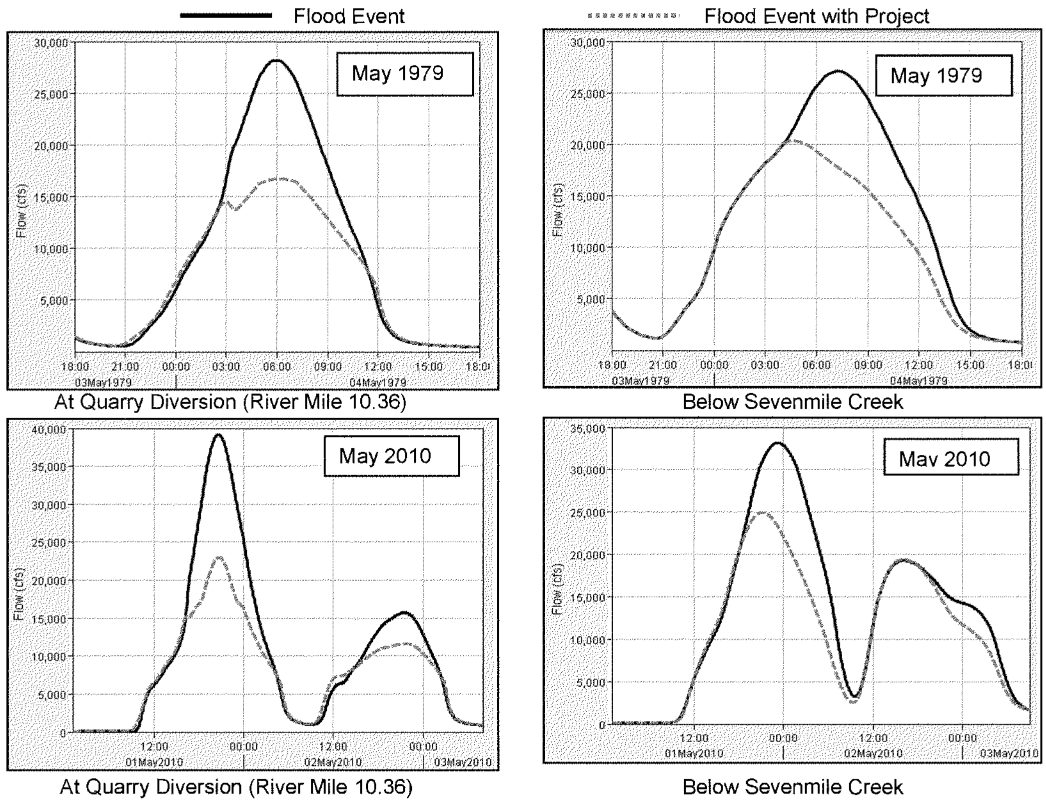


Figure 46: Vulcan Quarry Diversion – May 1979 and May 2010 Flood Hydrographs

3. Ellington Agriculture Center Regional Detention (River Mile 3.67)

Regional detention site was selected on Sevenmile Creek at river mile 3.67 at the Ellington Agriculture Center Entrance as shown in Figure 47. The measure captures 7.9 square miles, 45% of Sevenmile Creek total watershed. The measure includes the construction of a 19 ft tall conventional concrete and earthen structure as shown in Figure 48.

a. Outlet Works

The outlet works would consist of an uncontrolled concrete box culvert (or Conspan equivalent) located at the base of the structure. The outlet will pass normal flow and require no manual or mechanical operation. The opening would be 8 ft high and 20 feet wide (or Conspan equivalent, 160 square feet of opening) with upstream and downstream invert elevations of 519.0 ft and 518.5 ft, respectively. The culvert barrel would be approximately 30 feet in length and be within the existing channel and flow with inlet control for the full ranges of discharges. The foundation would be on solid, non-erodible limestone. The relatively large conduit design will allow most of the debris to be flushed through the opening where a trash rack will not be required. The maximum outlet velocity would be approximately 15 - 20 feet per second in the Sevenmile Creek Channel.

b. Embankment

The embankment would have a maximum height above the stream bed of 19.0 feet and acts as a weir or spillway for flows exceeding the 5-year frequency flood event. The embankment section is approximately 800 feet in length at elevation 537.5 feet and designed to be overtopped and capable of passing all floods. The embankment will be a combination of conventional concrete and clay earthen fill. The earthen embankment on either side of the concrete section would have a 3:1 side slopes with a 30-foot top width. The downstream face of the embankment will be covered with articulated concrete blocks to protect against overtopping erosive velocities. The maximum overtopping velocities will be 23.5 fps during the 500-year flood event. Various articulated concrete block products have been designed to withstand velocities of this magnitude. Articulated concrete block stilling basin (1-ft deep) will be required for approximately 20 feet downstream of the toe of the embankment to protect slope against turbulence and high velocities caused by the energy dissipation.

c. Spillway

The spillway section is an uncontrolled, broad-crested, 100 feet in length, conventional concrete construction and has a crest elevation of 535.0 feet. A hydraulic jump energy dissipater with an apron will be used to reduce the energy of flows through the spillway. Articulated concrete block stilling basin (1-ft deep) will be required for approximately 20 feet downstream of the toe of the structure to protect the channel side slopes against turbulence and high velocities caused by the energy dissipation and outlet works.

The HEC-HMS model used to calculate frequency discharges for future conditions was modified to represent the storage and outflow characteristics of the proposed measure. The reservoir data for the proposed measure are shown in Table 42. The resulting "with project" discharges were then placed in the calibrated HEC-RAS models to calculate frequency-flood profiles. The hydraulic structure was modeled in HEC-RAS as an inline structure. Flows were reduced in RAS just upstream from the structure to reflect the flow reduction due to attenuation. The downstream effects at select damage centers are shown in Tables 43 thru 45. There are minor adverse impacts caused by the temporary ponding of water upstream from the structure including flooding of Edmonson Pike greater than previously experienced. The proposed measure includes the raising of a 500-ft section of Edmonson Pike. There are no adverse impacts to homes in the ponding area. All of the impacted lands are publically owned properties currently used for greenway and ecosystem restoration. The increased backwater effects for the 500-year frequency flood event dissipate in the vicinity of Oakley Drive at river mile 4.2. Water surface profiles for this measure for the 10-, 25-, and 50-year frequency floods are shown in Figures 49 and 50. Water surface profiles do not include the backwater effects from Mill Creek. Typical hydrographs for the 10-yr and 25-year frequency floods are shown in Figure 51. Sevenmile Creek, the largest tributary flows into Mill Creek at mile 7.5 in the vicinity of the Space Park commercial development. There were small adverse impacts along Mill Creek below the Sevenmile Creek Confluence as shown in Tables 46 and 47.

Table 42: Regional Detention Structure River Mile 3.67 – Reservoir Data

Storm	Discharge		Elevation		Capacity	Area
Frequency	Future	With Project	Future	With Project	With Project	With Project
(Years)	(cfs)	(cfs)	(Feet)	(Feet)	Acre-Feet	Acres
2	2,621	2,210	529.9	532.4	101	25
5	3,305	2,631	530.4	535.1	168	36
10	4,244	3,480	530.8	536.7	240	43
25	5,139	4,547	531.2	537.7	288	48
50	5,813	5,515	531.4	538.0	303	50
100	6,542	6,380	531.6	538.3	314	51
200	7,373	7,265	531.8	538.5	323	52
500	8,787	8,698	532.1	538.8	337	53

Table 43: Ellington Ag Center Bridge Modifications Downstream Effects
Suter Drive/Blackman Road
Sevenmile Creek
River Mile 2.8

Storm	Future W/O Project		Future with Project		WSEL
Frequency	Discharge	Elevation	Discharge	Elevation	Reduction
or Event	(cfs)	(feet)	(cfs)	(feet)	(feet)
2yr	3,660	510.2	3,090	509.7	-0.5
5yr	4,633	510.9	3,596	510.1	-0.8
10yr	5,899	511.8	4,348	510.7	-1.1
25yr	7,129	512.6	5,691	511.7	-1.0
50yr	8,067	513.2	7,041	512.6	-0.7
100-yr	9,051	513.8	8,299	513.3	-0.5
200-yr	10,102	514.2	9,557	513.9	-0.3
500yr	12,003	515.0	11,573	514.7	-0.2

Table 44: Ellington Ag Center Bridge Modifications Downstream Effects
Nolensville Road/Harding Place
Sevenmile Creek
River Mile 1.8

Storm	Future W/O Project		Future with Project		WSEL
Frequency	Discharge	Elevation	Discharge	Elevation	Reduction
or Event	(cfs)	(feet)	(cfs)	(feet)	(feet)
2yr	4,356	497.7	3,814	496.9	-0.7
5yr	5,498	498.9	4,636	498.0	-0.9
10yr	6,858	500.4	5,666	499.1	-1.3
25yr	8,234	502.3	6,564	500.2	-2.1
50yr	9,305	502.5	7,770	501.0	-1.5
100-yr	10,238	502.7	9,048	502.4	-0.3
200-yr	11,072	502.9	10,144	502.7	-0.3
500yr	13,236	504.0	11,707	503.1	-0.9

Table 45: Ellington Ag Center Bridge Modifications Downstream Effects
Paragons Mill Road
Sevenmile Creek
River Mile 1.1

Storm	Future W/O Project		Future with Project		WSEL
Frequency	Discharge	Elevation	Discharge	Elevation	Reduction
or Event	(cfs)	(feet)	(cfs)	(feet)	(feet)
2yr	4,806	480.2	4,302	479.7	-0.5
5yr	6,048	481.3	5,267	480.6	-0.7
10yr	7,483	482.3	6,483	481.6	-0.6
25yr	8,947	483.2	7,617	482.3	-0.8
50yr	10,098	483.8	8,332	482.8	-1.0
100-yr	11,106	484.3	9,700	483.6	-0.6
200-yr	11,978	484.7	10,880	484.2	-0.5
500yr	14,266	485.8	12,550	485.0	-0.8

Table 46: Ellington Ag Center Bridge Modifications Downstream Effects
Space Park South
Mill Creek
River Mile 7.59

Storm	Future W/O Project		Future with Project		WSEL
Frequency	Discharge	Elevation	Discharge	Elevation	Reduction
or Event	(cfs)	(feet)	(cfs)	(feet)	(feet)
2yr	11,223	458.2	10,993	458.1	-0.1
5yr	13,716	459.6	13,245	459.4	-0.3
10yr	17,241	461.8	17,024	461.7	-0.1
25yr	21,465	463.9	22,330	464.3	0.4
50yr	25,646	465.9	26,257	466.2	0.3
100-yr	30,535	468.0	30,812	468.0	0.1
200-yr	35,494	469.2	35,694	469.2	0.0
500yr	42,619	471.1	42,485	471.1	0.0

Table 47: Ellington Ag Center Bridge Modifications Downstream Effects
Massman Drive
Mill Creek
River Mile 2.35

Storm	Future W/O Project		Future with Project		WSEL
Frequency	Discharge	Elevation	Discharge	Elevation	Reduction
or Event	(cfs)	(feet)	(cfs)	(feet)	(feet)
2yr	12,062	411.0	11,833	410.8	-0.2
5yr	14,805	413.0	14,384	412.7	-0.3
10yr	18,521	415.6	17,892	415.2	-0.4
25yr	22,069	417.8	22,619	418.0	0.2
50yr	26,204	419.9	26,652	420.1	0.2
100-yr	31,076	422.1	31,296	422.2	0.1
200-yr	36,064	424.0	36,161	424.1	0.0
500yr	43,165	426.5	42,992	426.4	-0.1

d. Level of Risk

An important consideration in the design of any flood control structure is the level of acceptable risk. For structural elements, the risk factor is determined through testing and calculating physical properties. The hydraulic risk associated with a flood control structure can also be determined by calculations based on physical controls. Each of these elements is usually governed by the magnitude of the flood they are to safely pass. The structures considered for this project are designed to overtop and is hydraulically and structurally sound for all magnitudes of floods. Therefore, the event of hydrologic failure of the structure is not considered possible and is not considered a risk.

e. Spillway Design Flood

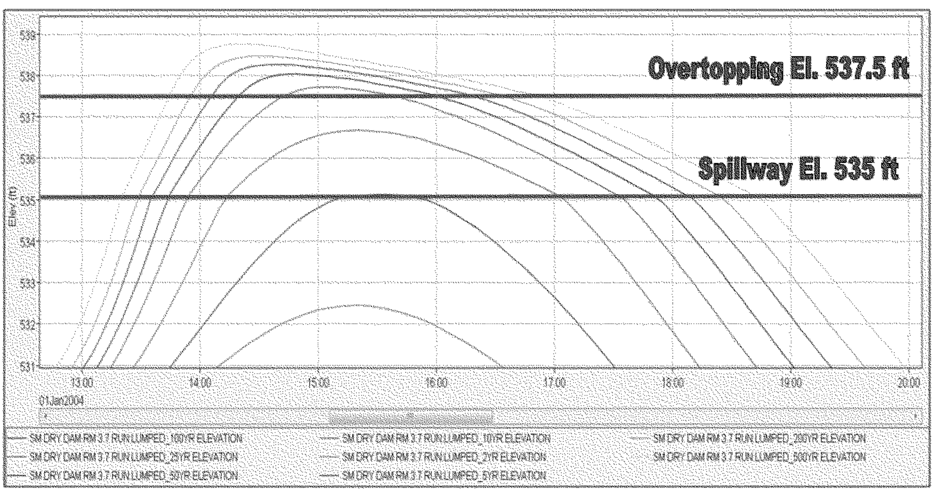
The spillway design flood, a large hypothetical flood, is usually selected as the basis for designing the spillway of the structure. The magnitude of this flood is currently based on the maximum incremental damages (determined by comparing pre- and post-project damages) resulting from a hydrologic failure. This criterion does not apply to the structure considered in this study because it is designed to be overtopped. The structure is sized to obtain the maximum benefits associated with floods through a 500-year event. Because the structure was designed to be overtopped, the height was determined in conjunction with the spillway size and configuration. In effect, the top of the structure acts as a high level spillway capable of passing all floods.

f. Overtopping Duration and Velocities

Spillway and embankment overtopping durations are shown in table below for the 2-year thru 500-year flood events. A one-dimensional HEC-RAS model was used to estimate the 500-year design velocities for the articulated block armoring the downstream slope and stilling basin. The maximum velocity was estimated to be 23.5 feet per second at the downstream toe of the embankment section during 500-yr event and used for the design. Comprehensive HEC-RAS unsteady flow analysis will be performed during the design phase of project where multiple high flow conditions will be further evaluated to address the erosion protection required to safely pass all floods.

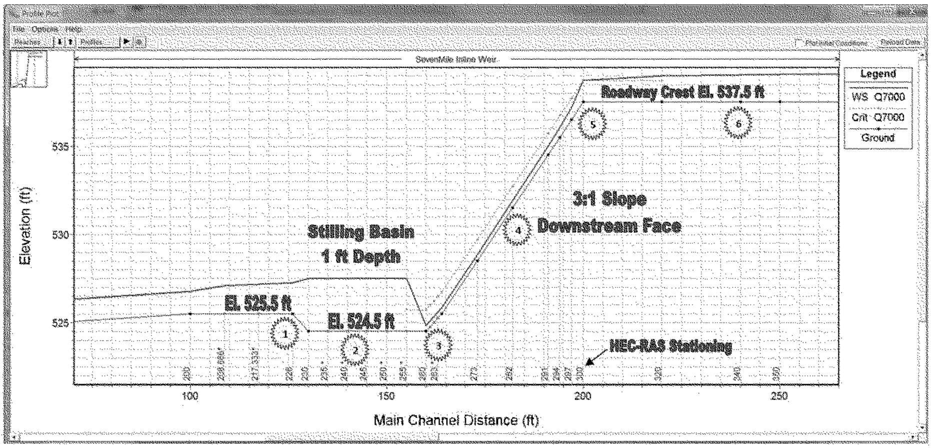
Ellington Ag Center Spillway (El. 535 ft) and Embankment (El. 537.5 ft) Overtopping Durations

					Spillway	Crest	Crest
Freq	Inflow	Outflow	Storage	Headwater	Duration	Duration	Depth
Years	cfs	cfs	ac-ft	El. ft.	(Hours)	(Hours)	(ft)
2	2621	2210	100.6	532.4	0		
5	3305	2631	167.6	535.1	1		
10	4244	3480	239.9	536.7	3		
25	5139	4547	288.3	537.7	4	1	0.2
50	5813	5515	302.9	538.0	5	2	0.5
100	6542	6380	313.5	538.3	6	3	0.8
200	7373	7265	323.1	538.5	6.5	3.5	1
500	8787	8698	337	538.8	7	4	1.3



Ellington Ag Center - Duration of Overtopping

Ellington Ag Center Overtopping Velocities (Embankment Section)



500yr Flood Event - Overtopping WSEL @ 538.8 Ft NAVD88			
Location	HECRAS Station	Location	Velocity (fps)
1	226	End Sill	4.4
2	245	Stilling Basin	2.5
3	260	Toe	23.5
4	282	Mid Slope	19.5
5	300	DS Crest	6.3
6	340	US Crest	5.0

g. Breach Analysis – Downstream Impacts

Breach analysis was performed for the 500-year flood event using HEC-HMS. Breach discharges were applied to steady flow hydraulic model to determine increases in downstream water surface elevations. Breach size and development times were estimated using the Von Thun & Gillette Equation. The overtopping breach was assumed to occur in the embankment section near the abutments of the structure. Bedrock elevations were obtained from the 1986 Mill Creek Final Interim Feasibility Report Technical appendices. Exploratory excavation was performed at a location approximately 100 feet upstream from the Ellingtion Agriculture Center entrance roadway. Elevation of bedrock varied near abutment locations and ranged from elevations 525 ft to 540 ft. Elevation 525 ft was applied to be conservative for breach development. Breach analysis resulted in a 50% increase in 500-year discharge over one hour duration immediately downstream from the structure. 500-year water surface elevations increased an average of one foot for two miles downstream from the structure. Comprehensive HEC-RAS unsteady flow analysis will be performed during the design phase of project where multiple high flow conditions and failure modes will be further evaluated to address the downstream hazard potential for loss of life and flooding extent.

Breach Equation Applied (500yr Event)

Von Thun and Gillette (1990):

Von Thun and Gillette used 57 dams from both the Froehlich (1987) paper and the MacDonald and Langridge-Monopolis (1984) paper to develop their methodology. The method proposes to use breach side slopes of 1.0H:1.0V, except for dams with cohesive soils, where side slopes should be on the order of 0.5H:1V to 0.33H:1V. The data that Von Thun and Gillette used for their regression analysis had the following ranges:

- **Height of the dams:** 3.66 – 92.96 m (12 – 305 ft)
  - with 89% < 30 m, and 75% < 15 m

- **Volume of water at breach time:** 0.027 – 660.0 $m^3 \times 10^6$ (22 - 535,000 acre-ft)
  - with 89% < 25.0 $m^3 \times 10^6$, and 84% < 15.0 $m^3 \times 10^6$

Note that Von Thun and Gillette's breach formation time equations are presented for both "erosion resistant" and "easily erodible" dams. The paper states: "It is suggested that these limits be viewed as upper and lower bounds corresponding respectively to well-constructed dams of erosion resistant materials and poorly-constructed dams of easily eroded materials".

$$B_{ave} = 2.5\, h_w + C_b$$

Where: B_{ave} = Average breach width (m)
h_w = Depth of water above the bottom of the breach (m)
C_b = Coefficient, which is a function of reservoir size, see below.

Reservoir Size, m^3	C_b, meters	Reservoir Size, acre-feet	C_b, feet
< $1.23*10^6$	6.1	< 1,000	20
$1.23*10^6$ - $6.17*10^6$	18.3	1,000-5,000	60
$6.17*10^6$ - $1.23*10^7$	42.7	5,000-10,000	140
> $1.23*10^7$	54.9	>10,000	180

$$t_f = 0.02\, h_w + 0.25 \qquad \text{(erosion resistant)}$$

$$t_f = 0.015\, h_w \qquad \text{(easily erodible)}$$

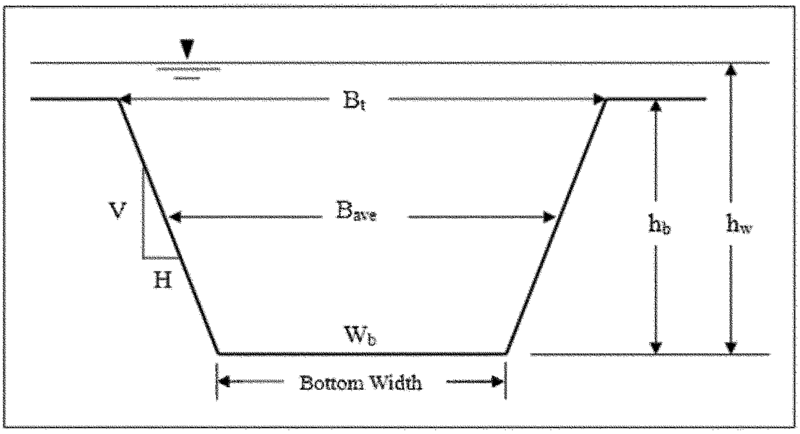
Where: t_f = Breach formation time (hrs).
h_w = Depth of water above the bottom of the breach (m).

Breach Results (500yr Event)

Von Thun & Gillette

C_B =	20	ft	6.1	m	(Width based on reservoir size (See table below))		
Side Slope =	1.0		1.0	H:1V	Slopes: 1.0 ; 0.5-0.33 for cohesive soils		
B_{ave} =	54	ft	17	m		67	B_t = Top Width (ft)
$W_{b\ ft}$ =	42	ft	13	m		TRUE	Fits within embankment?
t_{f1} =	0.3	hrs	0.3	hrs	(erosion resistant)		Choose either t_{f1} or t_{f2} (do not add)
t_{f2} =	0.1	hrs	0.1	hrs	(easily erodible)		

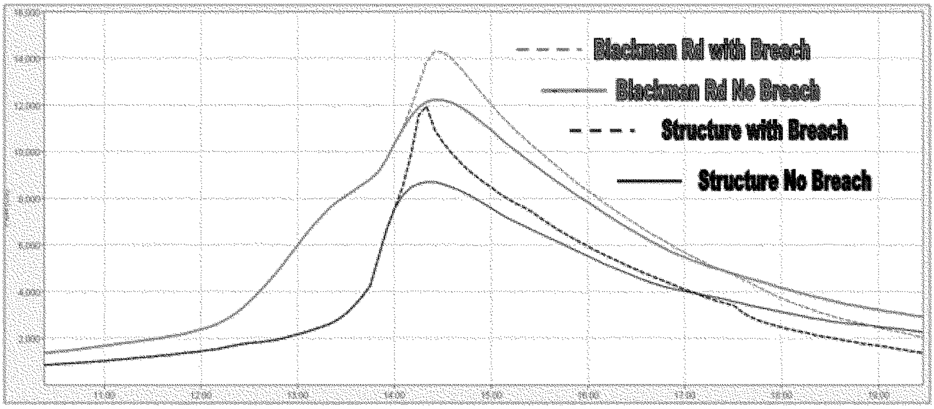
Reservoir Size	C_B (ft)	C_B (m)
< 1,000 ac-ft	20	6.1
1,000 - 5,000 ac- ft	60	18.3
5,000 - 10,000 ac- ft	140	42.7
> 10,000 ac-ft	180	54.9



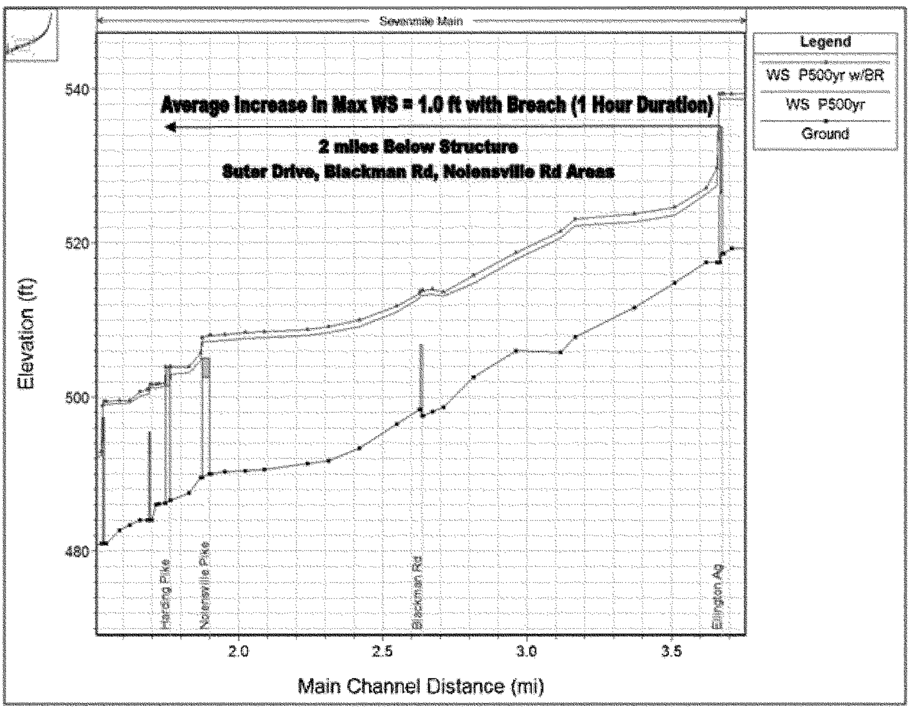
Hydrologic Model Inputs

Basin Name: Dry Dams FWOP
Element Name: SM Dry Dam RM 3.7

Method:	Overtop Breach
Direction:	Main
*Top Elevation (FT)	537.5
*Bottom Elevation (FT)	525.0
*Bottom Width (FT)	42
*Left Slope (xH:1V)	1
*Right Slope (xH:1V)	1
*Development Time (HR)	0.3
Trigger Method:	Elevation
*Trigger Elevation (FT)	538.5
Progression Method:	Linear



500-yr Hydrographs With and Without Breach



Increase in Water Surface Elevations

h. Sediment Yield

There has been no data collected in the Mill Creek basin to quantify the movement of deposition of sediment at the proposed Ellington Ag Bridge modification site. The 1986 Mill Creek flood damage reduction study included an estimate of total sediment yield using data collected for J. Percy Priest (JPP) Reservoir Sediment Survey of 1978. The Mill Creek basin parallels the Northwestern boundary of J. Percy Priest's drainage basin sharing common divide for nearly twenty miles. The general land uses, topography, and soil characteristics of the basin are similar. Inspection of the runoff characteristics of each basin show that J. Percy Priest has an average inflow of 1.8 cfs per square mile (cfm) and Mill Creek has 1.5 cfm. The average sediment yield at the 1986 dam site (approximately 200 ft upstream from the Ellington Ag Bridge) was estimated to be 3.2 acre-feet per year based on JPP data. Based on flow durations, ninety-five percent of the time the flow was assumed to be within the natural channel and passed through the low-level outlet (non-flood) flows. Based on typical sediment rating curves for the region, ninety percent of sediment transport was assumed to occur during flood flows. Trap efficiency was based on the Churchill's (1947) Trap Efficiency Curve using period of retention/mean velocity and was estimated to be 40 percent over the 2-, 50-, and 100-yr frequency flood events. Assuming ninety percent of the total sediment yield was affected by the dam, a conservative estimate of the total sediment trapped was estimated to be 1.2 acre-feet per year. The 1986 dry-dam was more than double the storage capacity at the 500-yr event with a 36 sq ft (6 ft x 6 ft box) low level outlet compared to the 160 sq. ft. (8 ft H x 20 ft W) of the Ellington bridge modification. The 1986 study estimated sediment deposits to be less than five percent of the reservoir volume over the fifty-year project life and would not threatened the efficiency of the project. Maintenance costs and deposits were assumed to be in the channel where there removal was assumed to be necessary to maintain normal flow. The trap efficiencies for the Ellington Ag bridge modification would be significantly less than the 1986 structure due of the increased velocities and shorter retention times. The proposed low-level outlet is much larger spanning the entire creek bottom allowing for increased flows, velocities and movement of sediments. Impacts to stream channel velocities along Sevenmile Creek are minimal below a 2-year frequency flood event (approximately 2500 cfs). As stated in the environmental characterization, there is lack of habitat for the Nashville Crayfish in the Vicinity of the Ellington project due to the lack of slabrock, cobble runs, pools and/or gravel. Average velocities for the 2-, 10-, 50, and 100-year frequency flood events are listed in tables approximately 1000 feet upstream and downstream from Ellington Ag Bridge Modification.

Channel Velocities 1000 ft Upstream from Ellington Ag Bridge

Flood Frequency Event	Without Project Velocity (fps)	With Project Velocity (fps)
2-Year (1/2 ACE)	5.9	4.2
10-Year (1/10 ACE)	6.9	2.4
50-Year (1/50 ACE)	7.7	3.0
100-Year (ACE)	8.0	3.4

Channel Velocities 1000 ft Downstream from Ellington Ag Bridge

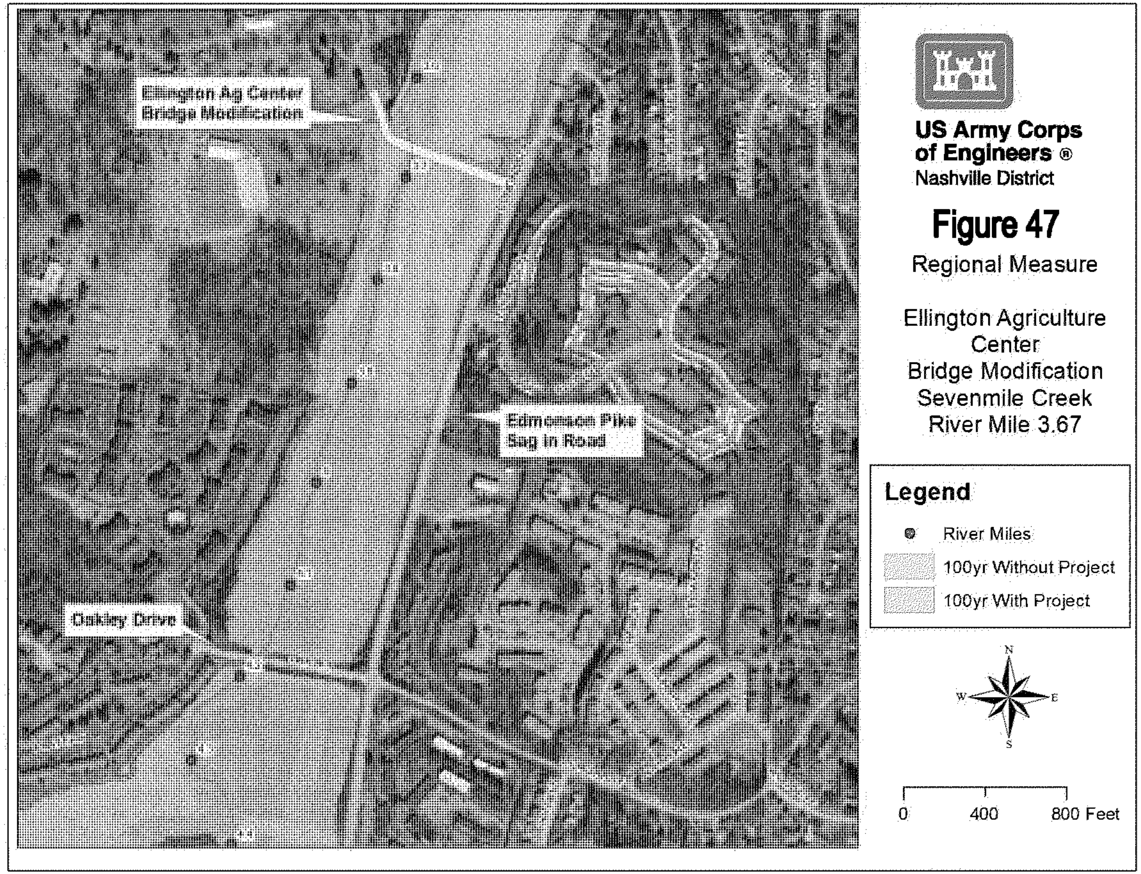
Flood Frequency Event	Without Project Velocity (fps)	With Project Velocity (fps)
2-Year (1/2 ACE)	4.2	3.9
10-Year (1/10 ACE)	4.0	4.0
50-Year (1/50 ACE)	4.0	3.8
100-Year (ACE)	4.8	3.8

It is anticipated that larger materials (gravel and cobbles) may settle during flood events due to decreased velocities upstream from the structure which is desirable since these larger sediments would create new habitat for the Nashville Crayfish. It is not anticipated that the change in sediment transport will adversely affect the flood storage attenuation or channel stability of the upstream pool limit or degrade downstream channel. A typical stream reach in the vicinity of project is shown below for leaf off (winter) and leaf on (summer) conditions. Sevenmile Creek channel is very stable with limestone rock bottom and established vegetated banks. There are few isolated stream bank stability issues along Sevenmile Creek due to burial of sewer lines and utilities near creek stream banks. There are no significant sediment aggadation or degradation problems along Sevenmile Creek. Channel incision is also unlikely since the stream bottom is composed of limestone bedrock.

If warranted, further investigation can be performed during design phase to characterize the sediment supply along Sevenmile Creek and to evaluate bedload transport in the vicinity of the Ellington project for the purpose of habitat enhancement for the Nashville Crayfish. Aggradation above and degradation below the structure is not anticipated, but can also be evaluated at that time. This would be performed using the HEC-RAS Steady Transport/Movable Boundary computations. This component of the modeling system is intended for the simulation of one-dimensional sediment transport/movable boundary calculations resulting from scour and deposition over moderate time periods (typically years, although applications to single flood events are possible). The sediment transport potential is computed by grain size fraction, thereby allowing the simulation of hydraulic sorting and armoring. The model is designed to simulate long-term trends of scour and deposition in a stream channel that might result from modifying the frequency and duration of the water discharge and stage, or modifying the channel geometry. This system can be used to evaluate deposition in reservoirs, design channel contractions required to maintain navigation depths, predict the influence of dredging on the rate of deposition, estimate maximum possible scour during large flood events, and evaluate sedimentation in fixed channels. Existing Sevenmile Existing HEC-RAS models will be updated to include sediment transport component.

Sevenmile Creek – Typical Channel in Winter (Leaf Off)

Sevenmile Creek – Typical Channel in Summer (Leaf On)


Ellington Ag Center
Bridge Modification
Edmonson Pike
Sag in Road
Oakley Drive
US Army Corps
of Engineers ®
Nashville District
Figure 47
Regional Measure
Ellington Agriculture
Center
Bridge Modification
Sevenmile Creek
River Mile 3.67
Legend
River Miles
100yr Without Project
100yr With Project
N
W
E
S
0
400
800 Feet

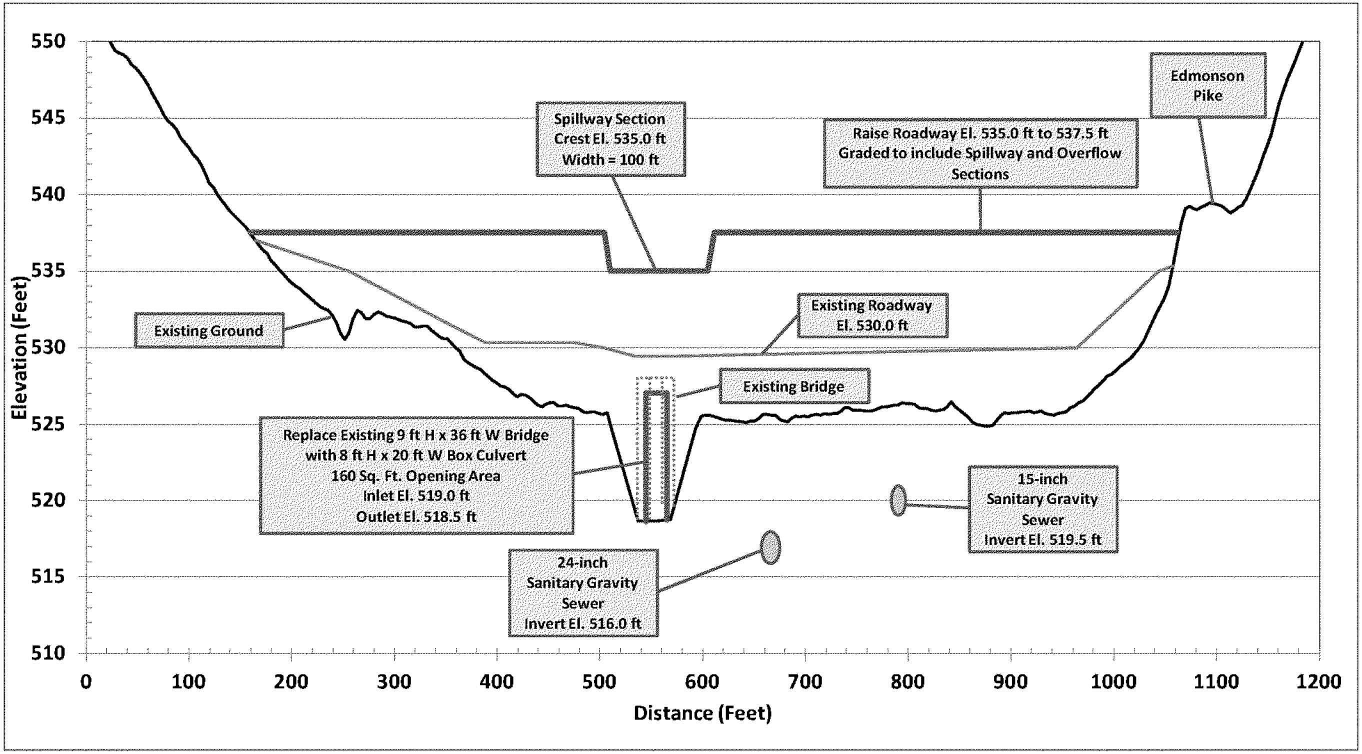


Figure 48: Regional Detention Structure River Mile 3.67 – Typical Cross Section Looking Downstream

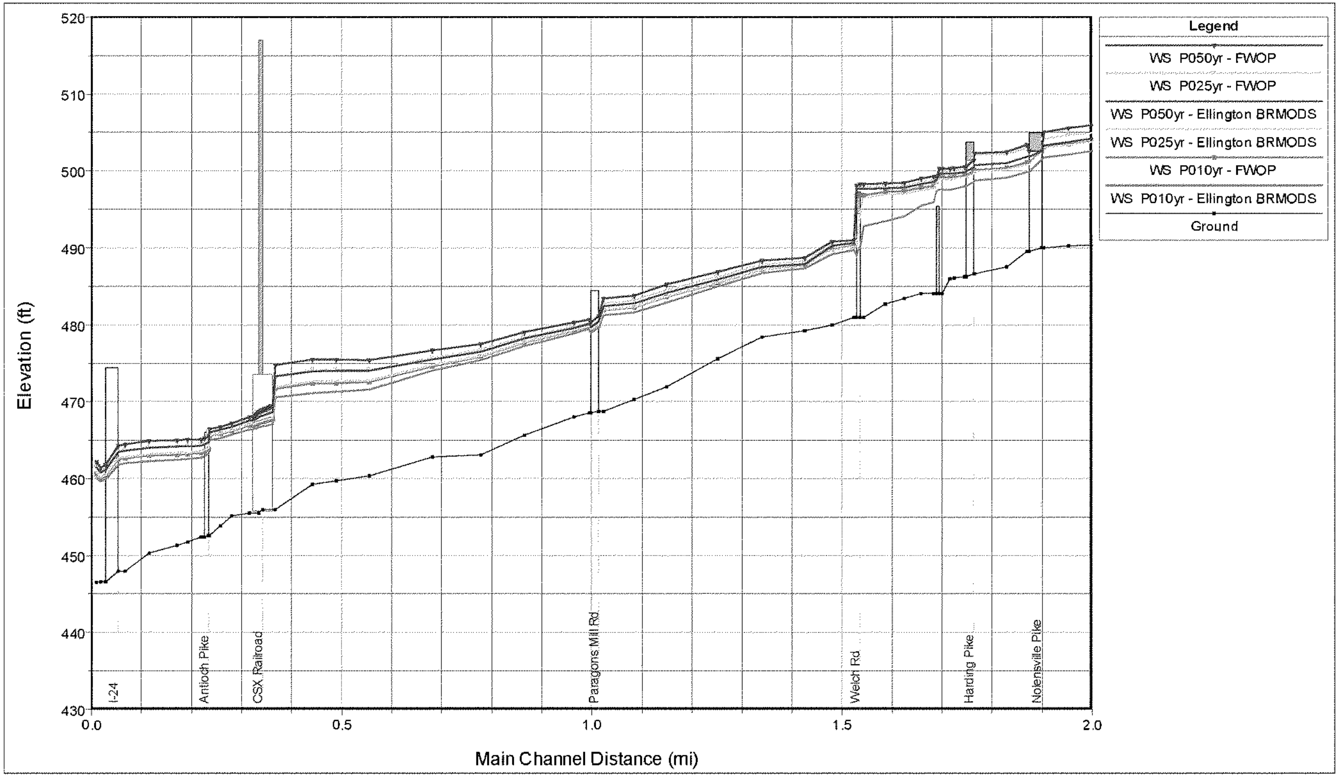


Figure 49: Ellington Bridge Modifications 10-, 25, and 50-year Frequency Flood Profiles (River Mile 0 to 2)

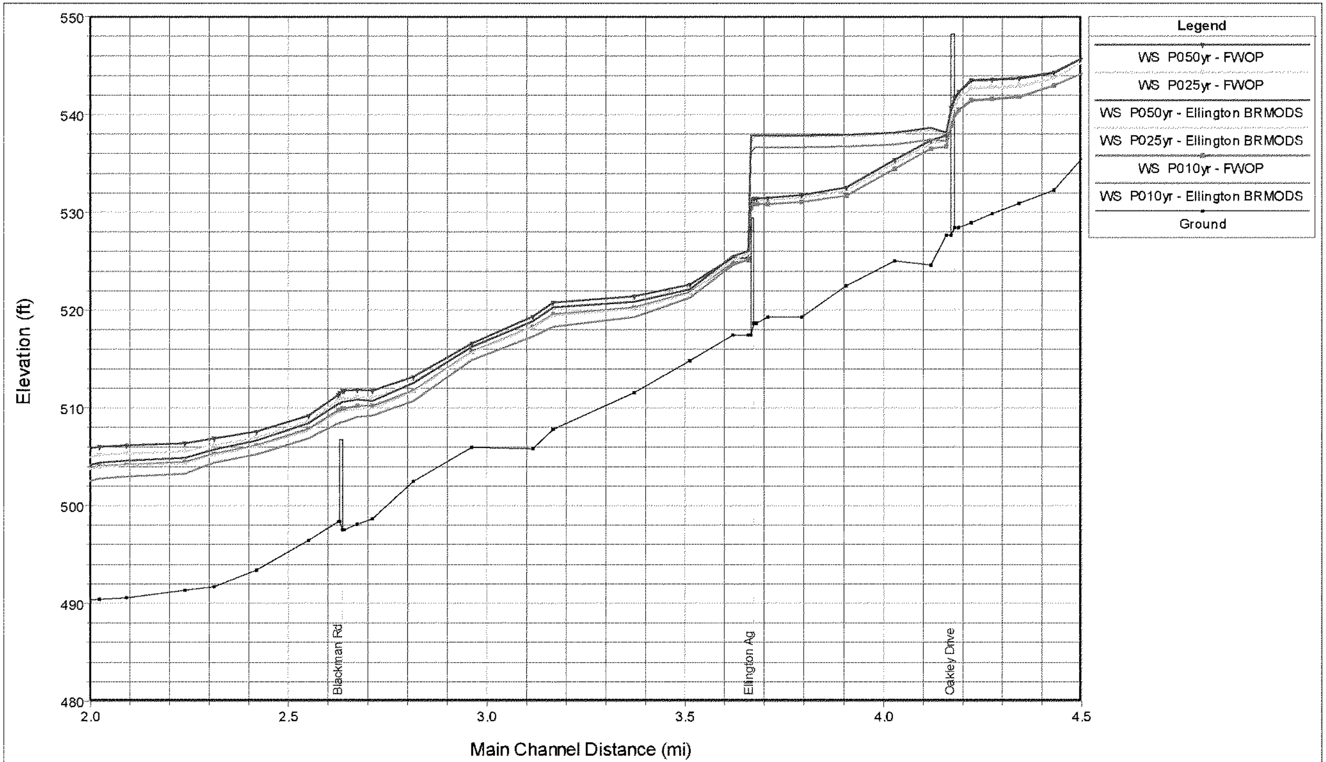


Figure 50: Ellington Bridge Modifications 10-, 25, and 50-year Frequency Flood Profiles (River Mile 2.0 to 4.5)

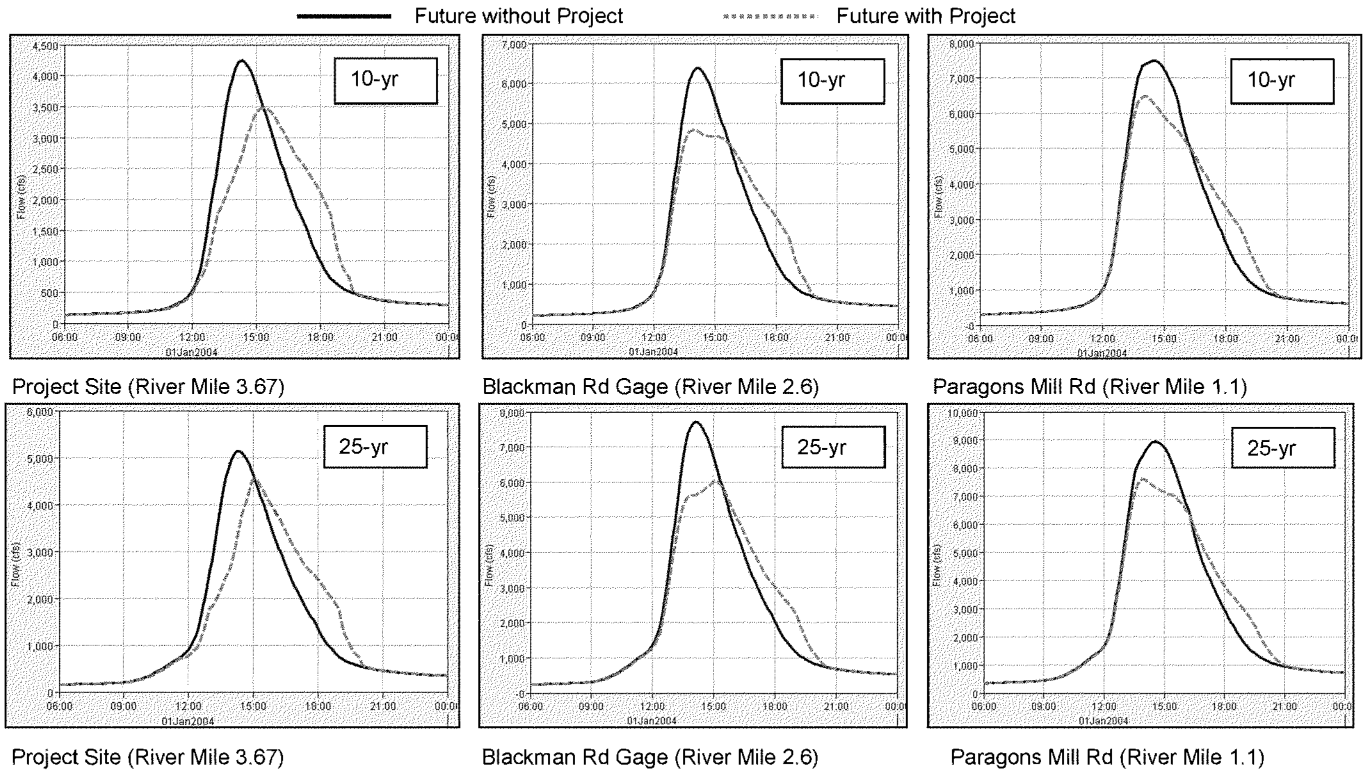


Figure 51: Ellington Agriculture Center Bridge Modifications - 10yr and 25yr Frequency-Flood Hydrographs

b. Bridge Modifications

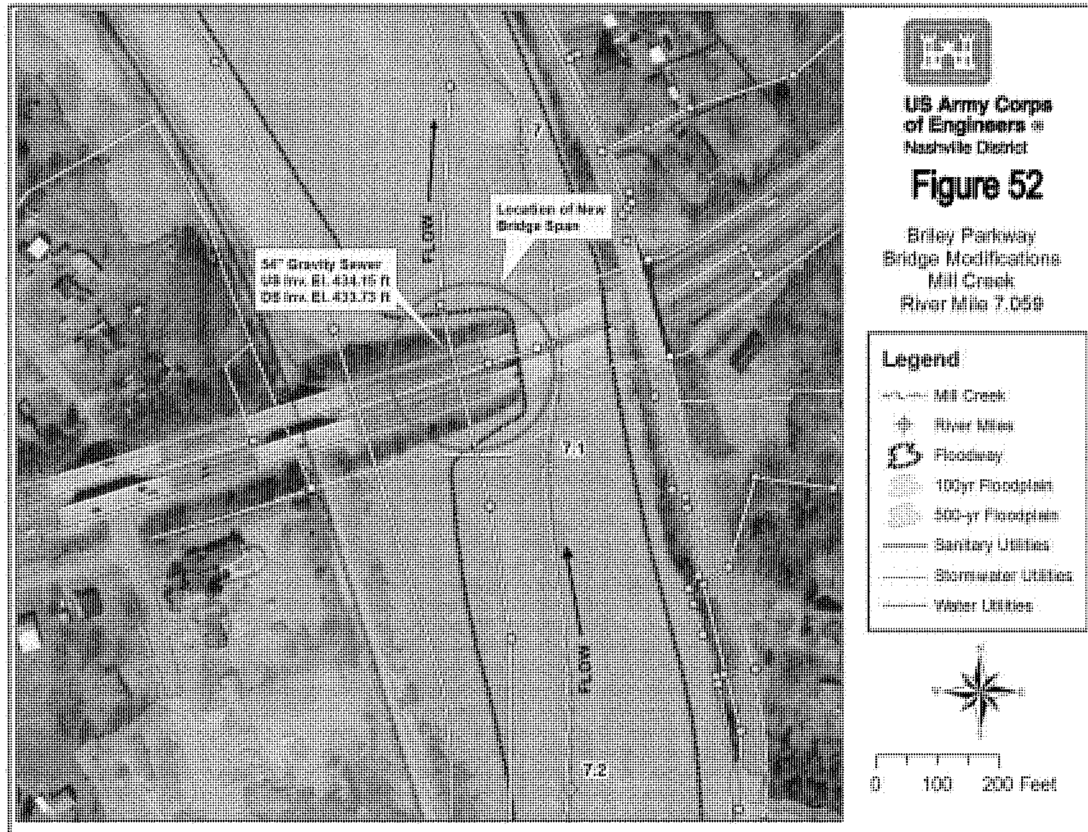
Bridges with significant head loss in target damage centers were removed or modified to evaluate water surface reductions and added benefits. Modifications to hydraulic model (HEC-RAS) cross-section geometry in the vicinity of selected bridges were made to reflect their removal. The intent was to locate bridges that could either be removed or modified to reduce flood damages. Mill Creek bridges included Murfreesboro Road (RM 4.814), Thompson Lane (RM 6.333), Briley Parkway (RM 7.059), CSX Railroad (RM 7.3), Space Park South Drive (RM 8.173), and abandoned railroad (RM 10.915), Franklin Limestone Road (RM 11.083), CSX Railroad RM 11.695 and Antioch Pike (RM 12.096). The HEC-RAS water surface profiles (.wsp files) were then used by the economist to calculate added benefits (reductions in Estimated Annual Damages). Briley Parkway was the only bridge modification to move forward past preliminary screening. The Briley Parkway bridge modification would include widening the east and west bound bridge openings by a minimum of 63 feet as shown in Figures 52 and 53 to reduce the head loss thru the bridge. Flood reductions for the Briley Parkway measure are shown in Tables 48 and 49 for select damage centers. The 10-, 50-, 100- and 500-year water surface profiles are included as Figure 54.

Table 48: Briley Parkway Bridge Modifications
Just Upstream from Briley Parkway
Mill Creek Mile 7.13

Frequency Event	Future W/O Project Elevation	Future With Project Elevation	WSEL Reduction (feet)
2yr	454.2	453.0	-1.2
5yr	455.7	454.2	-1.4
10yr	458.2	456.7	-1.5
25yr	459.9	458.1	-1.8
50yr	461.7	459.6	-2.1
100yr	463.6	461.2	-2.4
200yr	465.3	462.6	-2.7
500yr	467.3	464.4	-2.8

Table 49: Briley Parkway Bridge Modifications
Space Park South
Mill Creek Mile 7.59

Frequency Event	Future W/O Project Elevation	Future With Project Elevation	WSEL Reduction (feet)
2yr	458.2	458.0	-0.2
5yr	459.6	459.4	-0.3
10yr	461.8	461.3	-0.6
25yr	463.9	463.2	-0.7
50yr	465.9	465.0	-0.9
100yr	468.0	467.1	-0.9
200yr	469.2	468.6	-0.6
500yr	471.1	470.0	-1.1


US Army Corps of Engineers
Nashville District
Figure 52
Briley Parkway
Bridge Modifications
Mill Creek
River Mile 7.059
Legend
Mill Creek
River Miles
Floodway
100yr Floodplain
500-yr Floodplain
Sanitary Utilities
Stormwater Utilities
Water Utilities
0 100 200 Feet
54" Gravity Sewer
US Inv. EL 434.15 ft
DS Inv. EL 433.73 ft
Location of New
Bridge Span
FLOW
FLOW
7.1
7.2

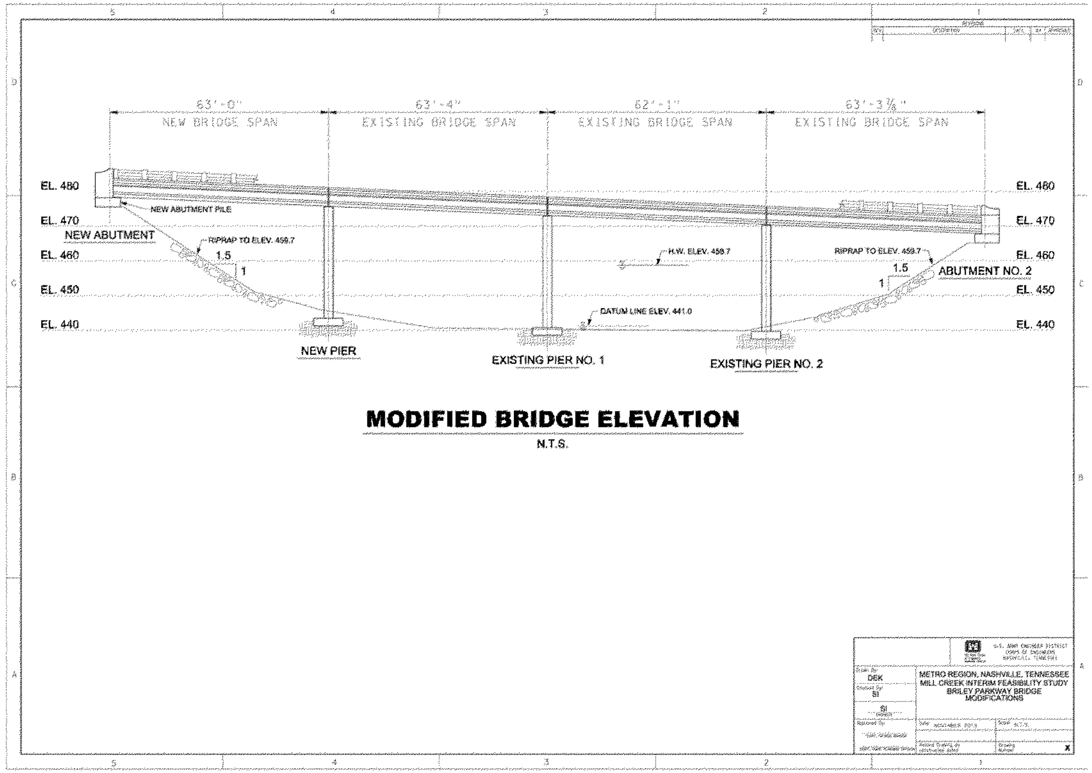


Figure 53: Briley Parkway Bridge Modifications (East and West bound Lanes) – Typical Cross Section Looking Downstream

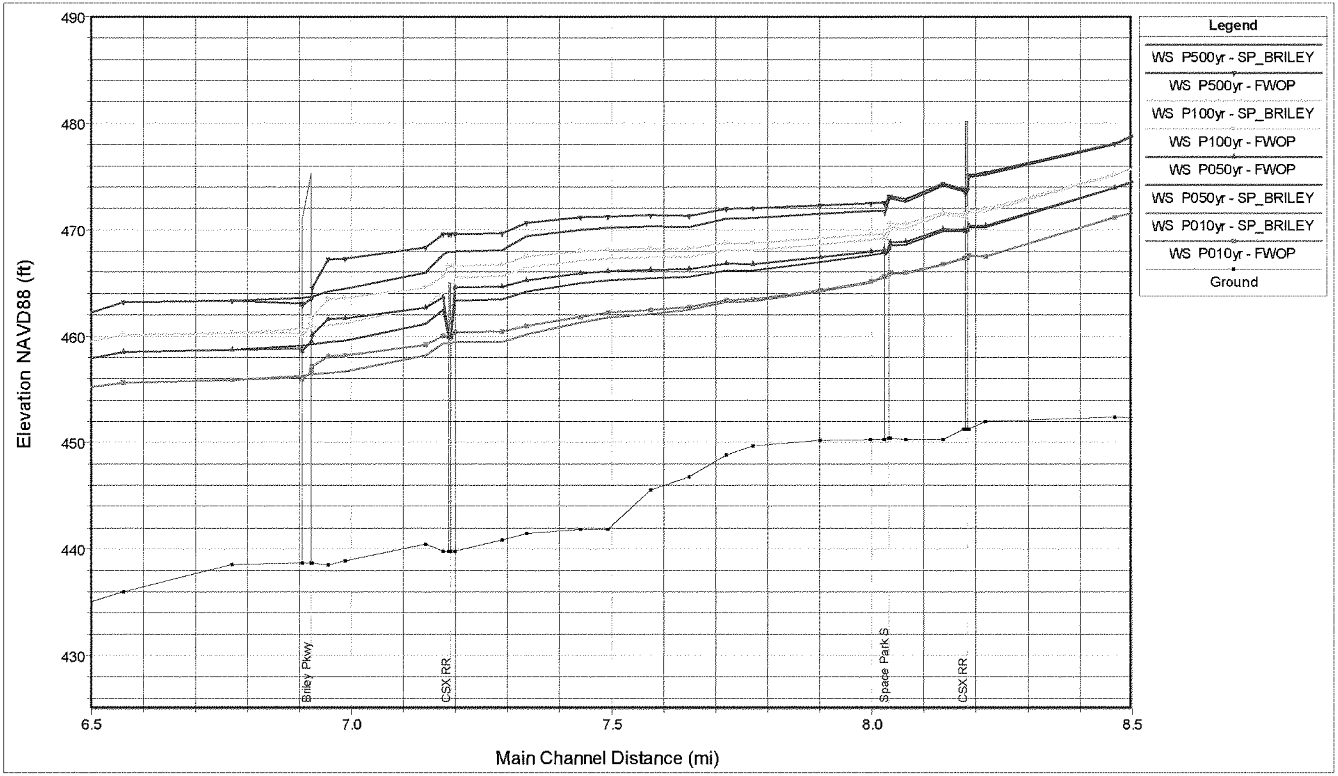


Figure 54: Briley Parkway Bridge Modifications 10-, 50-, 100- and 500-year Frequency Flood Profiles

c. Channel Modifications

1. Wimpole Drive Channel Modifications

Channel modifications were analyzed along Mill Creek in the vicinity of the Wimpole Drive residential damage center as shown in Figure 55. The Wimpole Drive channel modifications included a 100-foot high-flow along the left and right overbanks between river mile 4.9 and 6.2 (See Figure 56). The bench elevation would be approximately 5 to 8 feet above channel bottom. The future conditions hydraulic models were modified to include these channel modifications. Flood reductions for the Wimpole Drive Channel Modifications measure are shown in Tables 50 thru 52 for select damage centers. The 10-, 50-, 100- and 500-year water surface profiles are included as Figure 57.

Table 50: Wimpole Channel Modifications
Adjacent to Wimpole Drive
Mill Creek Mile 5.3

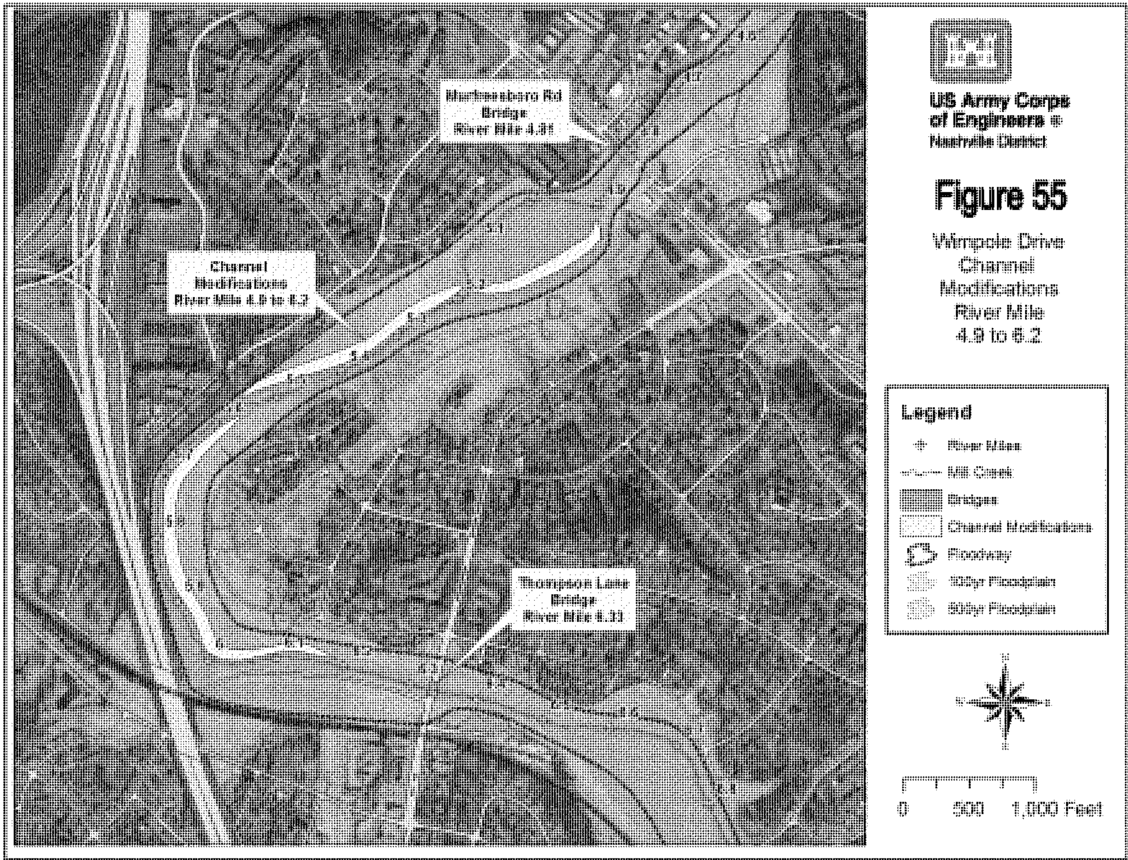
Frequency Event	Future W/O Project Elevation	Future With Project Elevation	WSEL Reduction (feet)
2yr	440.6	439.3	-1.3
5yr	441.6	440.4	-1.2
10yr	443.4	442.6	-0.7
25yr	444.6	443.9	-0.7
50yr	446.0	445.3	-0.6
100yr	447.6	447.0	-0.5
200yr	448.8	448.3	-0.5
500yr	450.3	449.8	-0.6

Table 51: Wimpole Channel Modifications
Adjacent to Wimpole Drive
Mill Creek Mile 5.8

Frequency Event	Future W/O Project Elevation	Future With Project Elevation	WSEL Reduction (feet)
2yr	445.1	443.0	-2.1
5yr	446.1	443.9	-2.2
10yr	447.4	445.4	-2.0
25yr	448.5	446.5	-2.0
50yr	449.8	447.8	-2.0
100yr	451.3	449.3	-2.0
200yr	452.5	450.5	-2.0
500yr	454.0	452.0	-2.0

Table 52: Wimpole Channel Modifications
Just Upstream from Thompson Lane Bridge
Mill Creek Mile 6.4

Frequency Event	Future W/O Project Elevation	Future With Project Elevation	WSEL Reduction (feet)
2yr	449.4	447.9	-1.4
5yr	450.6	449.1	-1.4
10yr	453.9	450.6	-3.3
25yr	454.7	454.9	0.2
50yr	455.9	455.6	-0.3
100yr	457.1	456.3	-0.8
200yr	457.7	456.4	-1.3
500yr	458.2	457.5	-0.7


US Army Corps
of Engineers ®
Nashville District
Figure 55
Wimpole Drive
Channel
Modifications
River Mile
4.9 to 6.2
Legend
River Miles
Mill Creek
Bridges
Channel Modifications
Floodway
100yr Floodplain
500yr Floodplain
0 500 1,000 Feet
Channel
Modifications
River Mile 4.9 to 6.2
Thompson Lane
Bridge
Bridge

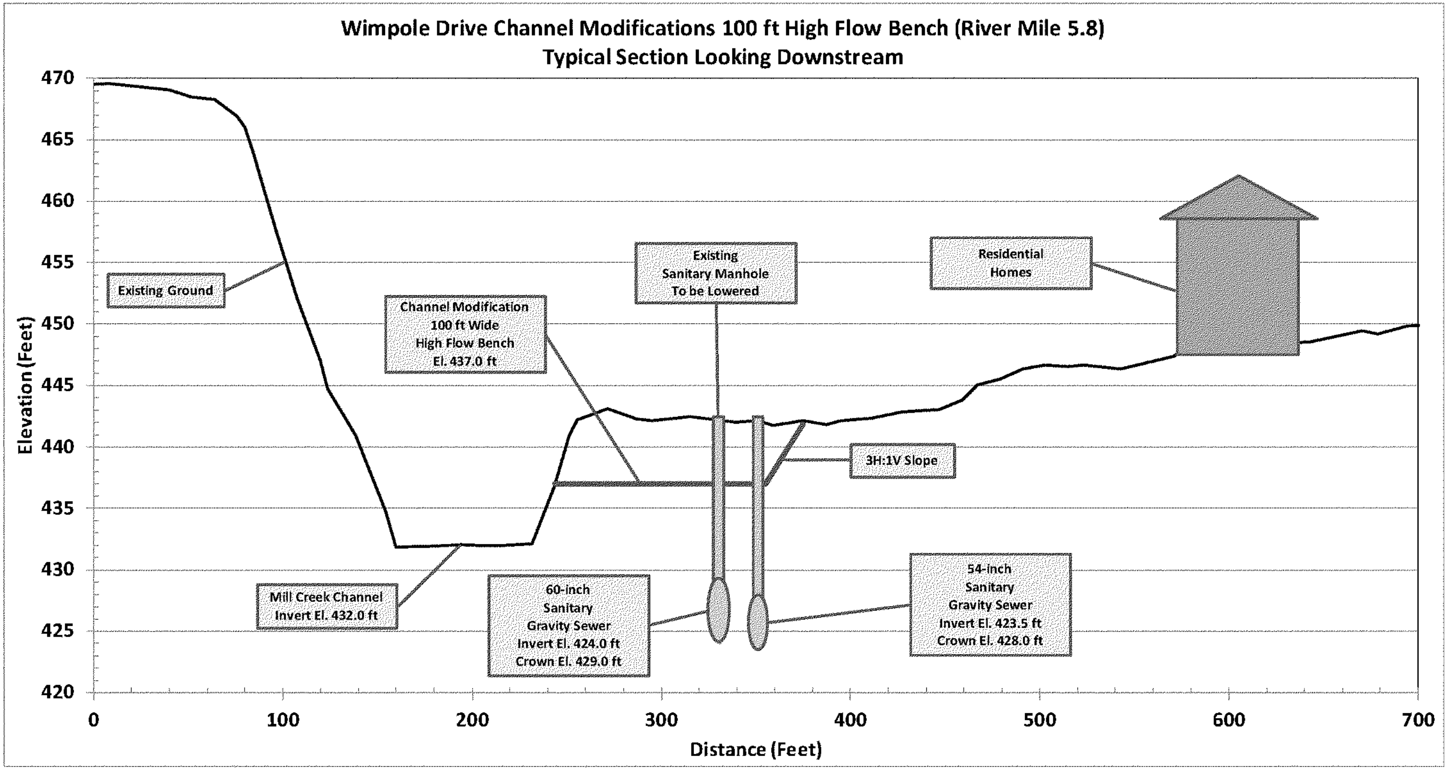


Figure 56: Wimpole Drive Channel Modifications – Typical Cross Section

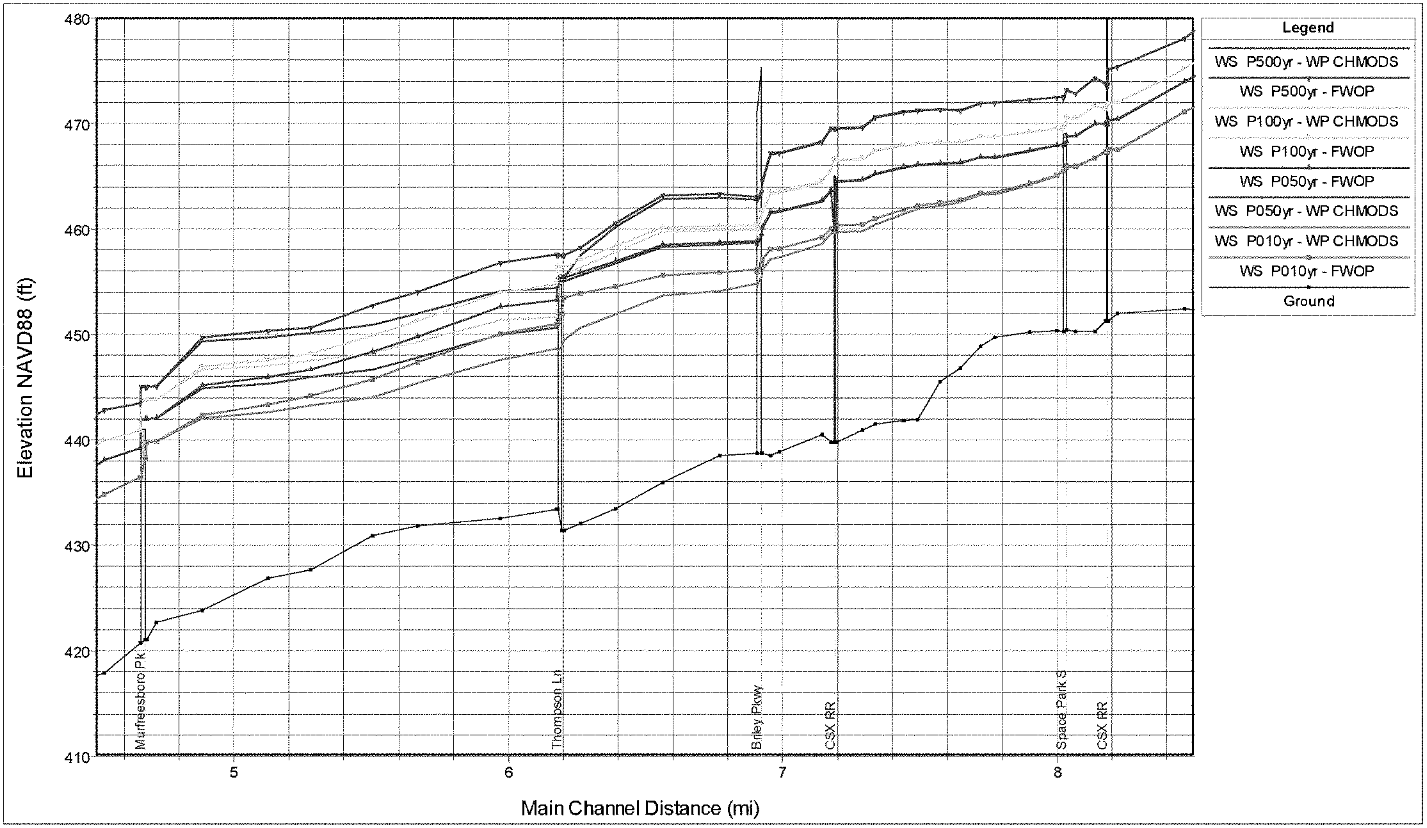


Figure 57: Wimpole Drive Channel Modifications 10-, 50-, 100-, and 500-year Frequency Flood Profiles

2. Space Park Channel Modifications

Channel modifications were analyzed along Mill Creek in the vicinity of the Space Park South commercial and industrial damage center as shown in Figure 58. The Space Park channel modifications include a 50-foot to 100-foot high-flow bench along the left and right overbanks between river mile 7.4 and 7.8 (See Figure 59). The bench elevation would be approximately 6 to 8 feet above channel bottom. The future conditions hydraulic models were modified to include these channel modifications. Flood reductions for the Space Park Channel Modifications measure are shown in Tables 53 thru 55 for select damage centers. The 10-, 50-, 100- and 500-year water surface profiles are included as Figure 60.

Table 53: Space Park Channel Modifications
Mill Creek Mile 7.6

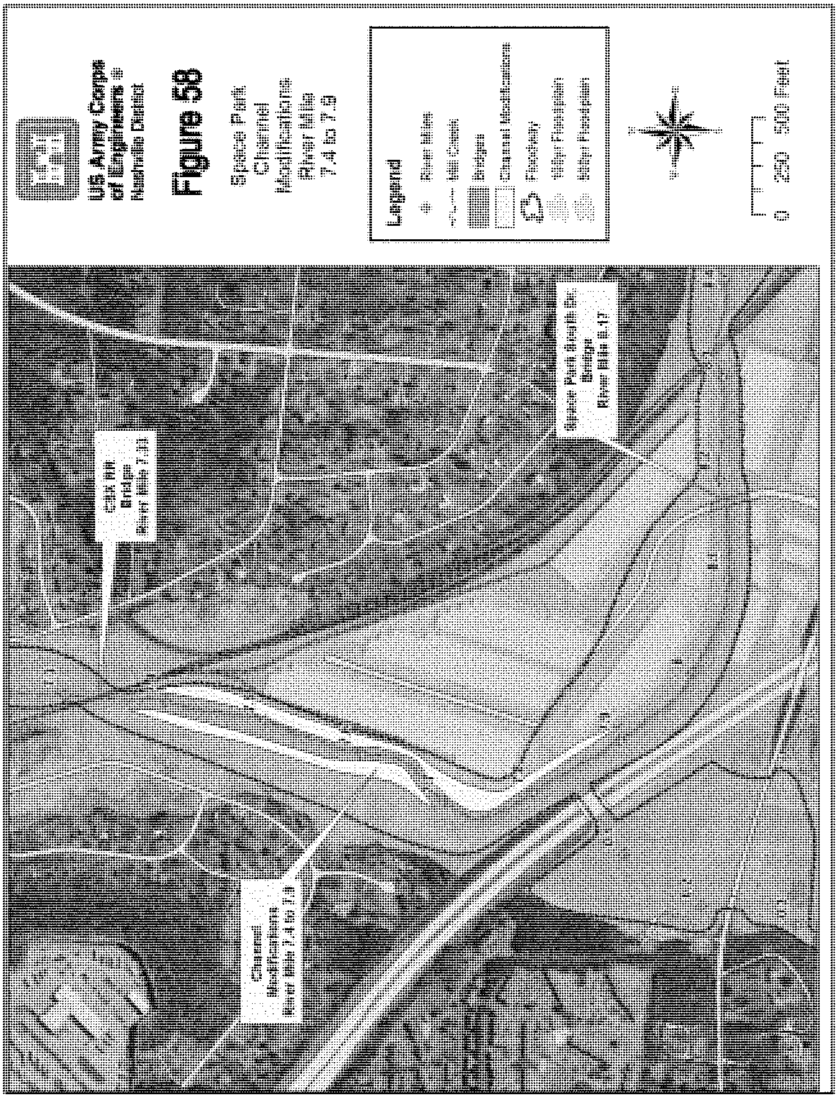
Frequency Event	Future W/O Project Elevation	Future With Project Elevation	WSEL Reduction (feet)
2yr	458.2	457.3	-0.9
5yr	459.6	458.8	-0.9
10yr	461.8	461.1	-0.8
25yr	463.9	463.2	-0.7
50yr	465.9	465.4	-0.5
100yr	468.0	467.4	-0.5
200yr	469.2	468.6	-0.6
500yr	471.1	470.5	-0.6

Table 54: Space Park Channel Modifications
Mill Creek Mile 7.8

Frequency Event	Future W/O Project Elevation	Future With Project Elevation	WSEL Reduction (feet)
2yr	460.1	458.1	-1.9
5yr	461.2	459.3	-1.9
10yr	462.8	461.2	-1.5
25yr	464.5	463.2	-1.3
50yr	466.3	465.3	-1.0
100yr	468.2	467.4	-0.8
200yr	469.4	468.6	-0.9
500yr	471.3	470.4	-0.8

Table 55: Space Park Channel Modifications
Mill Creek Mile 8.0

	Future	Future	WSEL
Frequency	W/O Project	With Project	Reduction
Event	Elevation	Elevation	(feet)
2yr	461.5	460.5	-1.0
5yr	462.8	461.8	-1.0
10yr	464.3	463.5	-0.8
25yr	465.8	465.1	-0.7
50yr	467.4	466.6	-0.8
100yr	469.2	468.5	-0.7
200yr	470.4	469.7	-0.8
500yr	472.3	471.5	-0.8


US Army Corps of Engineers
Nashville District
Figure 58
Legend
0 250 500 Feet

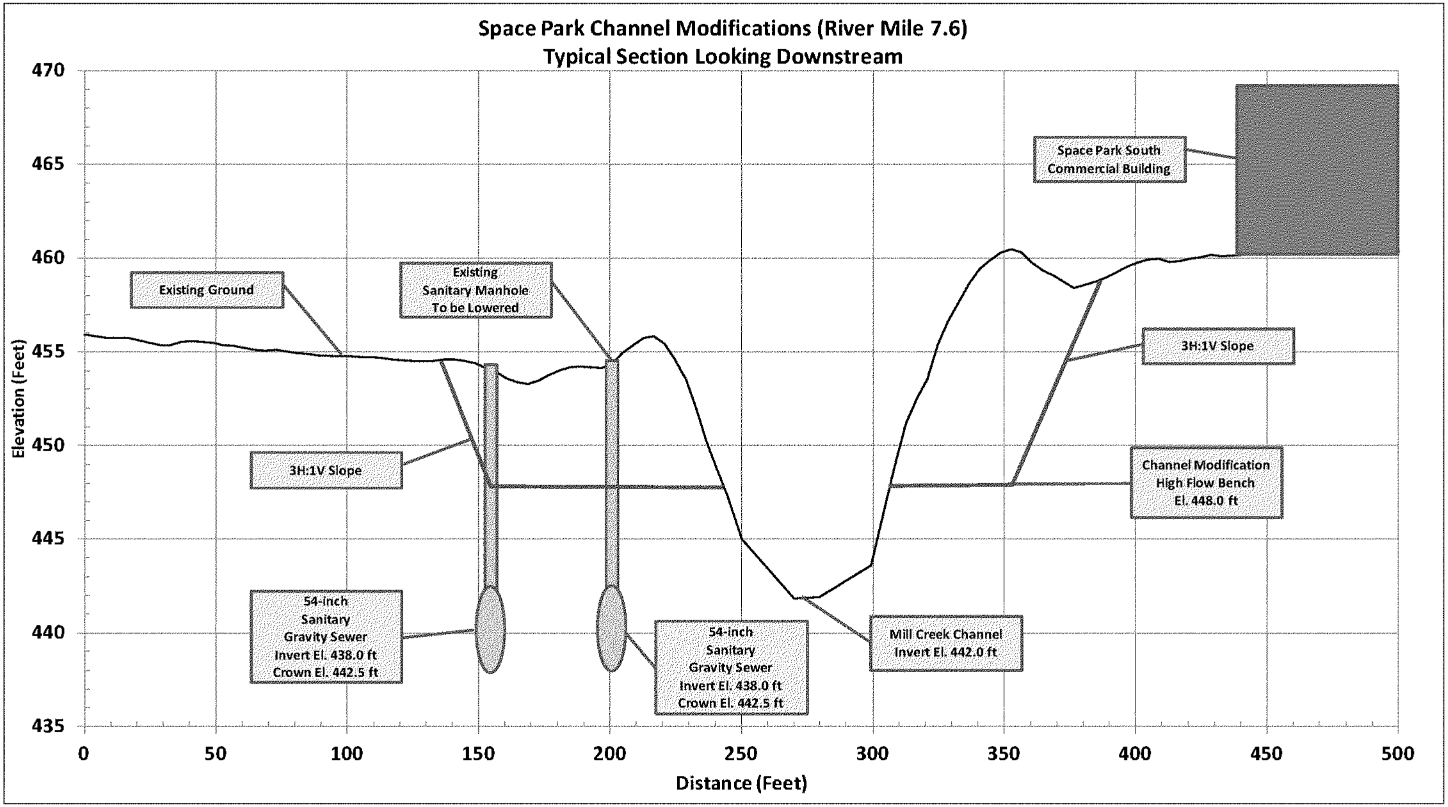


Figure 59: Space Park Channel Modification Typical Cross Section

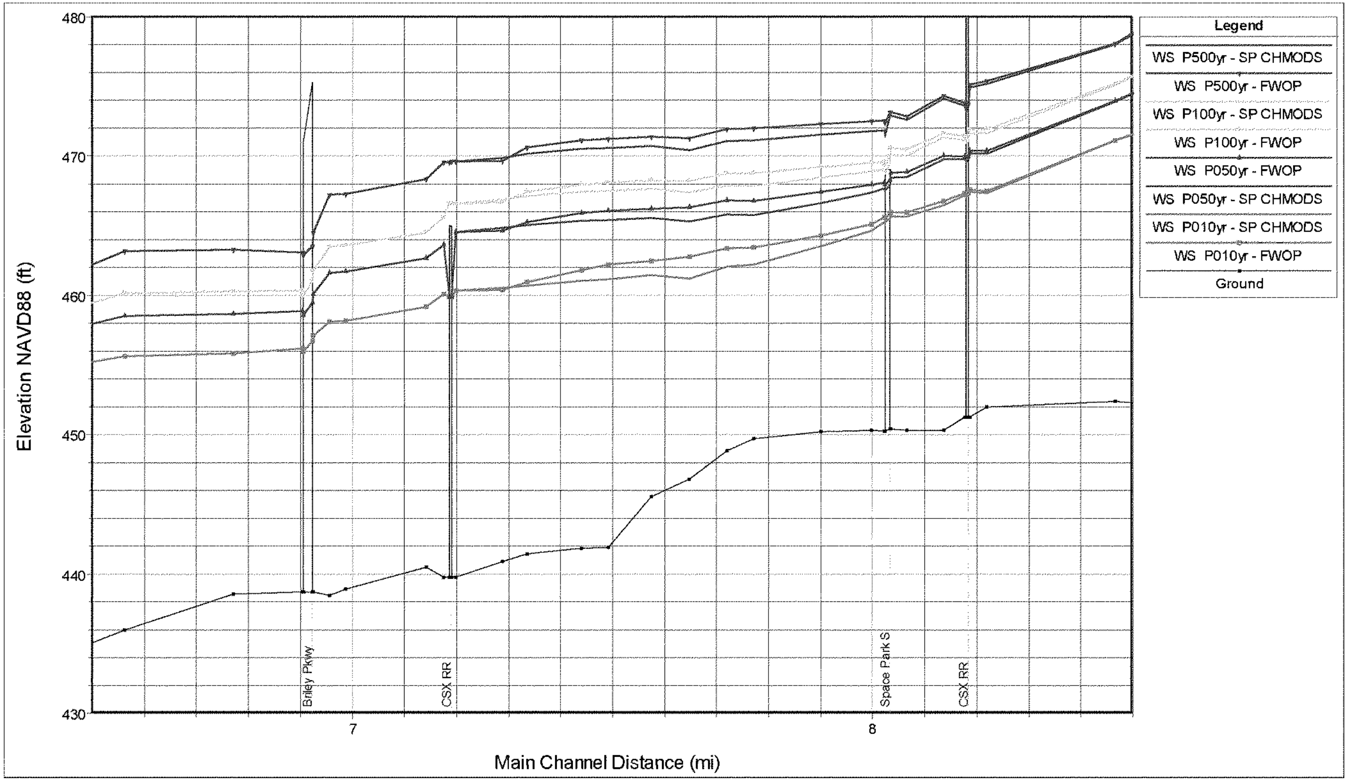


Figure 60: Space Park Channel Modification 10-, 50-, 100-, and 500-year Frequency Flood Profiles

VIII. RISK-BASED UNCERTAINTY ANALYSIS

a. Introduction

As per U.S. Army Corps of Engineers Guidance documents EM 1110-2-1619 and ER 1105-2-101, a risk and uncertainty analysis is required to be performed for the hydrologic (discharge-probability function), hydraulic (stage-discharge function), and economic (stage-damage function) portions of a feasibility study. This document details the methods and results of the hydrologic and hydraulic components of the risk-based uncertainty analysis.

The future without project conditions was used for the baseline of all uncertainty analysis contained in this document. Information gathered from this analysis is meant to provide the hydrologic and hydraulic uncertainty functions for HEC-FDA, a flood risk analysis model.

b. Hydrologic Uncertainty

An analytical approach was adopted to develop the discharge-probability functions for each economic reach. Mill Creek has two stream gages that have over thirty years of peak flow data and Sevenmile Creek has one. The location of these gages and which economic reach they are on is shown in Figure 61. These stream gages were used for the HEC-HMS hydrologic model calibration and to derive the mean discharge-probability function for the economic reaches. The gage on Mill Creek at Thompson Lane (MC Reach 3) has 46 years of peak flow data, the gage on Mill Creek near Antioch (MC Reach 5) has 57 years of peak flow data, and the gage on Sevenmile Creek at Blackman Rd (SM Reach 3) has 40 years of peak flow data. Table 4-5 shown below was taken from EM 1110-2-1619, provides estimation guidelines to get equivalent record length depending on the method of hydrologic calibration.

Table 4-5
Equivalent Record Length Guidelines

Method of Frequency Function Estimation	Equivalent Record Length[1]
Analytical distribution fitted with long-period gauged record available at site	Systematic record length
Estimated from analytical distribution fitted for long-period gauge on the same stream, with upstream drainage area within 20% of that of point of interest	90% to 100% of record length of gauged location
Estimated from analytical distribution fitted for long-period gauge within same watershed	50% to 90% of record length
Estimated with regional discharge-probability function parameters	Average length of record used in regional study
Estimated with rainfall-runoff-routing model calibrated to several events recorded at short-interval event gauge in watershed	20 to 30 years
Estimated with rainfall-runoff-routing model with regional model parameters (no rainfall-runoff-routing model calibration)	10 to 30 years
Estimated with rainfall-runoff-routing model with handbook or textbook model parameters	10 to 15 years

[1] Based on judgment to account for the quality of any data used in the analysis, for the degree of confidence in models, and for previous experience with similar studies.

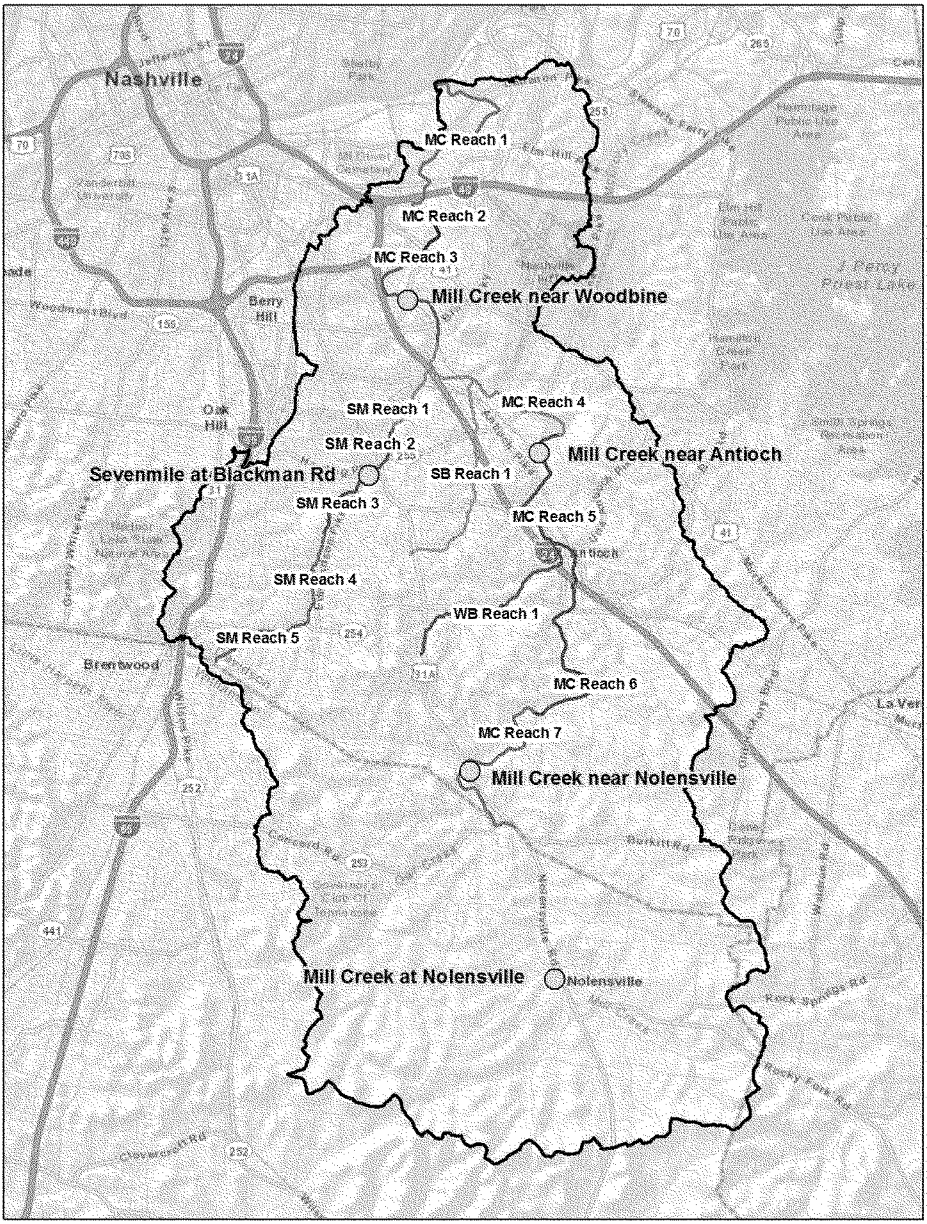


Figure 61: Mill Creek Watershed Stream Gage Locations and Economic Reaches

Equivalent record length is a measure of the statistical reliability of the probability discharge-function at a particular point in a basin. Intuitively, the further upstream from the gaged basin one goes, the less impact that drainage area has on the hydrologic calibration. As such, the equivalent record length decreases and the overall confidence bands of the discharge-probability function increase to account for the added deviation from the mean.

Table 56 shows the equivalent record of length for every economic reach in the Mill Creek watershed. For Mill Creek economic reaches MC-01 to MC-03, the equivalent period of record was the record length of the gage at Thompson Lane. For economic reach MC-04, the equivalent periods of record was scaled depending on the percentage of the representative drainage area to the overall total gaged area. For economic reach MC-05, the equivalent period of record was the record length of the gage near Antioch. For economic reaches MC-06 and MC-07, the equivalent periods of record was scaled depending on the percentage of the representative drainage area to the overall total gaged area. For Economic reaches SM-01, SM-02, SM-04, SM-05, SB-01, and WB-01 the criteria given in Table 4-5 for calibrated watersheds was used to determine the equivalent record of length of 30 years. For economic reach SM-03, the equivalent period of record was the record length of the gage at Blackman Rd.

Table 56: Mill Creek Economic Reaches Equivalent Period of Record

Stream	Economic Reach	Basin Area (AC)	% of Gaged Area.	Equivalent Period of Record
Mill Creek	MC-01	107.3	113.0	46
	MC-02	98	104.7	46
	MC-03	93.4	100	46
	MC-04	92.38	98.9	45
	MC-05	64	100	57
	MC-06	51.8	80.9	46
	MC-07	43	67.2	38
Sevenmile Creek	SM-01	-	-	30
	SM-02	-	-	30
	SM-03	12.2	100	40
	SM-04	-	-	30
	SM-05	-	-	30
Sorghum Branch	SB-01	-	-	30
Whittemore Branch	WB-01	-	-	30

c. Hydraulic Uncertainty

To account for stage-discharge uncertainty, a high-risk and low-risk scenario was developed for each hydraulic model used in the study. Differences in risk were represented by changes to the hydraulic parameters in the HEC-RAS models. A sensitivity analysis was conducted on hydraulic parameters where professional engineering judgment was applied to determine "reasonable" range of values. High water mark calibration and observed debris conditions during multiple flood events helped in this determination of reasonable range for manning's and bridge debris adjustments. The hydraulic parameter changes for both low and high risk scenarios for Mill Creek and its major tributaries are shown in Tables 57 and 58.

Table 57: Stage-Discharge Uncertainty Analysis: HEC-RAS Parameter Adjustments - Mill Creek

Parameter	Low	FWOP	High
Contraction Coefficients			
Channel	0.1	0.1	0.3
Bridge XS	0.2	0.3	0.5
Expansion Coefficients			
Channel	0.3	0.3	0.5
Bridge XS	0.4	0.5	0.7
Debris at Bridges (with piers)			
Floating Debris at Piers in Channel	None	None	20 ft wide and 10 ft Tall
Debris at Bridges (without piers)			
Lowering of Bridge Deck	None	None	2 ft
Bridge Weir Coefficient	3.1	2.6	2.5
Manning's n in Channel and Overbanks	10% decrease	None	20% increase

Table 58: Stage-Discharge Uncertainty Analysis: HEC-RAS Parameter Adjustments - Mill Creek Tributaries

Parameter	Low	FWOP	High
Contraction Coefficients			
Channel	0.1	0.1	0.3
Bridge XS	0.2	0.3	0.5
Expansion Coefficients			
Channel	0.3	0.3	0.5
Bridge XS	0.4	0.5	0.7
Debris at Bridges (with piers)			
Floating Debris at Piers in Channel	None	None	10 ft wide and 5 ft Tall
Debris at Bridges (without piers)			
Lowering of Bridge Deck	None	None	1 ft
Debris at Culverts *			
Depth blocked (% rise, measured from invert)	None	None	50%*
Bridge Weir Coefficient	3.1	2.6	2.5
Manning's n in Channel and Overbanks	10% decrease	None	20% increase

*** Larger Culverts (at RR's and Interstates) use a depth blocked of 25%**

The mean stage difference between the high-risk and low-risk water surface profiles in the HEC-RAS hydraulic model was used estimate the stage-discharge function deviation for each economic reach. As per guidance in EM 1110-2-1619, the stage-discharge standard deviation represents the *mean* stage difference for the entire reach divided by a factor of 4. Stage-discharge deviations for future without project conditions and structural measures are shown in Tables 59 thru 65.

Table 59: Standard Deviation (ft) Future without Project Conditions (and Existing Conditions)

Stream	Economic Reach	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	200-Year	500-Year
Mill Creek	MC-01	0.79	0.89	0.98	1.03	1.09	1.12	1.20	1.46
	MC-02	0.57	0.72	0.56	0.65	0.81	0.81	0.81	0.93
	MC-03	0.54	0.68	0.49	0.58	0.67	0.65	0.67	0.70
	MC-04	0.58	0.57	0.67	0.68	0.70	0.72	0.74	0.85
	MC-05	0.60	0.62	0.53	0.59	0.55	0.50	0.50	0.50
	MC-06	0.46	0.42	0.34	0.46	0.48	0.49	0.54	0.55
	MC-07	0.28	0.33	0.34	0.38	0.41	0.43	0.47	0.52
Sevenmile Creek	SM-01	0.46	0.51	0.57	0.63	0.77	0.95	1.14	1.03
	SM-02	0.29	0.40	0.16	0.30	0.25	0.25	0.27	0.31
	SM-03	0.21	0.23	0.24	0.28	0.27	0.20	0.26	0.28
	SM-04	0.19	0.21	0.20	0.19	0.20	0.22	0.24	0.27
	SM-05	0.36	0.32	0.22	0.19	0.22	0.26	0.25	0.24
Sorghum Branch	SB-01	0.23	0.24	0.27	0.29	0.30	0.29	0.31	0.36
Whittemore Branch	WB-01	0.25	0.29	0.30	0.33	0.37	0.36	0.39	0.39

Table 60: Standard Deviation (ft) - RCC Structure above Old Hickory Boulevard

Stream	Economic Reach	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	200-Year	500-Year
Mill Creek	MC-01	0.79	0.89	0.95	1.02	1.04	1.12	1.11	1.21
	MC-02	0.56	0.72	0.74	0.62	0.70	0.82	0.81	0.81
	MC-03	0.54	0.68	0.53	0.56	0.65	0.67	0.65	0.65
	MC-04	0.54	0.61	0.58	0.70	0.70	0.69	0.71	0.74
	MC-05	0.56	0.61	0.58	0.57	0.57	0.58	0.52	0.50
	MC-06	0.45	0.45	0.40	0.34	0.43	0.49	0.50	0.55
	MC-07	0.26	0.25	0.31	0.34	0.38	0.39	0.46	0.57

Table 61: Standard Deviation (ft) - Vulcan Quarry Diversion

Stream	Economic Reach	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	200-Year	500-Year
Mill Creek	MC-01	0.79	0.89	0.98	1.03	1.07	1.11	1.07	1.19
	MC-02	0.57	0.72	0.56	0.64	0.72	0.79	0.74	0.72
	MC-03	0.54	0.68	0.49	0.56	0.62	0.63	0.59	0.57
	MC-04	0.59	0.58	0.63	0.68	0.73	0.70	0.63	0.64
	MC-05	0.59	0.58	0.49	0.56	0.51	0.47	0.41	0.43
	MC-06	0.46	0.42	0.34	0.44	0.46	0.46	0.48	0.52
	MC-07	0.28	0.33	0.34	0.37	0.39	0.41	0.45	0.50

Table 62: Standard Deviation (ft) - Ellington Ag Bridge Modifications									
Stream	Economic Reach	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	200-Year	500-Year
Mill Creek	MC-01	0.79	0.89	0.98	1.03	1.09	1.12	1.20	1.46
	MC-02	0.57	0.72	0.56	0.65	0.81	0.81	0.81	0.93
	MC-03	0.54	0.68	0.49	0.58	0.67	0.65	0.67	0.70
	MC-04	0.58	0.57	0.67	0.68	0.70	0.72	0.74	0.85
	MC-05	0.60	0.62	0.53	0.59	0.55	0.50	0.50	0.50
	MC-06	0.46	0.42	0.34	0.46	0.48	0.49	0.54	0.55
	MC-07	0.28	0.33	0.34	0.38	0.41	0.43	0.47	0.52
Sevenmile Creek	SM-01	0.44	0.48	0.54	0.58	0.63	0.77	0.97	0.94
	SM-02	0.29	0.30	0.39	0.15	0.28	0.24	0.25	0.29
	SM-03	0.20	0.21	0.23	0.29	0.27	0.27	0.27	0.28
	SM-04	0.45	0.34	0.25	0.18	0.20	0.22	0.23	0.25
	SM-05	0.36	0.32	0.22	0.19	0.22	0.26	0.25	0.24

Table 63: Standard Deviation (ft) - Briley Parkway Bridge Modifications									
Stream	Economic Reach	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	200-Year	500-Year
Mill Creek	MC-01	0.79	0.89	0.98	1.03	1.09	1.12	1.20	1.46
	MC-02	0.57	0.72	0.56	0.65	0.81	0.81	0.81	0.93
	MC-03	0.49	0.64	0.44	0.53	0.64	0.62	0.64	0.65
	MC-04	0.55	0.53	0.63	0.63	0.68	0.72	0.69	0.75
	MC-05	0.57	0.61	0.53	0.59	0.55	0.50	0.50	0.50
	MC-06	0.46	0.42	0.34	0.46	0.48	0.49	0.54	0.55
	MC-07	0.28	0.33	0.34	0.38	0.41	0.43	0.47	0.52

Table 64: Standard Deviation (ft) Wimpole Drive Channel Modifications									
Stream	Economic Reach	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	200-Year	500-Year
Mill Creek	MC-01	0.79	0.89	0.98	1.03	1.09	1.12	1.20	1.46
	MC-02	0.56	0.76	0.80	0.65	0.81	0.81	0.81	0.93
	MC-03	0.54	0.79	0.81	0.53	0.61	0.60	0.62	0.41
	MC-04	0.58	0.57	0.69	0.68	0.69	0.71	0.74	0.81
	MC-05	0.60	0.62	0.53	0.59	0.55	0.50	0.50	0.50
	MC-06	0.46	0.42	0.34	0.46	0.48	0.49	0.54	0.55
	MC-07	0.28	0.33	0.34	0.38	0.41	0.43	0.47	0.52

Table 65: Standard Deviation (ft) - Space Park Channel Improvements									
Stream	Economic Reach	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	200-Year	500-Year
Mill Creek	MC-01	0.79	0.89	0.98	1.03	1.09	1.12	1.20	1.46
	MC-02	0.57	0.72	0.56	0.65	0.81	0.81	0.81	0.93
	MC-03	0.54	0.68	0.49	0.58	0.67	0.65	0.67	0.70
	MC-04	0.59	0.59	0.68	0.69	0.71	0.71	0.74	0.84
	MC-05	0.60	0.62	0.53	0.59	0.55	0.50	0.50	0.50
	MC-06	0.46	0.42	0.34	0.46	0.48	0.49	0.54	0.55
	MC-07	0.28	0.33	0.34	0.38	0.41	0.43	0.47	0.52

APPENDIX C1
MILL CREEK WATERSHED
FEASIBILITY STUDY
FLOOD FREQUENCY PROFILES

Table C1-1: Mill Creek Flood Frequency Profiles - Future Conditions

Cumberland River Backwater from Draft 2012 FIS Update (Station 1006699) shown in Bold Blue Italic

1006699		*406.47*	*409.33*	*410.60*	*413.18*	*415.26*	*417.60*	*421.73*	*423.19*

Mill Creek Tributary Backwater elevations in Bold Red Italic

River Mile	Stream Invert NAVD 88	2 -Year W.S. Elev NAVD 88	5 -Year W.S. Elev NAVD 88	10 -Year W.S. Elev NAVD 88	25 -Year W.S. Elev NAVD 88	50 -Year W.S. Elev NAVD 88	100 -Year W.S. Elev NAVD 88	200 -Year W.S. Elev NAVD 88	500 -Year W.S. Elev NAVD 88	
0.145	374.98	*406.47*	*409.33*	*410.60*	*413.18*	*415.26*	*417.60*	*421.73*	*423.19*	
0.362	375.90	*406.47*	*409.33*	*410.60*	*413.18*	*415.26*	*417.60*	*421.73*	*423.19*	
0.526	375.90	*406.47*	*409.33*	*410.60*	*413.18*	*415.26*	*417.60*	*421.73*	*423.19*	
0.692	375.90	*406.47*	*409.33*	*410.60*	*413.18*	*415.26*	*417.60*	*421.73*	*423.19*	
0.855	380.50	*406.47*	*409.33*	*410.60*	*413.18*	*415.26*	*417.60*	*421.73*	*423.19*	
0.872	380.50	*406.47*	*409.33*	*410.60*	*413.18*	*415.26*	*417.60*	*421.73*	*423.19*	
1.038	380.90	*406.47*	*409.33*	*410.60*	*413.18*	*415.26*	*417.60*	*421.73*	*423.19*	
1.277	379.90	*406.47*	*409.33*	*410.60*	*413.18*	*415.26*	*417.60*	*421.73*	*423.19*	
1.513	380.06	*406.47*	*409.33*	*410.60*	*413.18*	*415.26*	*417.60*	*421.73*	*423.19*	
1.709	385.90	*406.47*	*409.33*	*410.60*	*413.18*	*415.26*	*417.60*	*421.73*	*423.19*	Mouth of Sims Branch
1.834	390.13	*406.47*	*409.33*	*410.60*	*413.18*	*415.26*	*417.60*	*421.73*	*423.19*	
2.036	388.74	408.94	*410.91*	*413.44*	*415.59*	*417.68*	*419.67*	*421.73*	*424.24*	
2.216	389.40	410.00	411.98	414.48	416.58	418.65	*420.65*	*422.46*	*425.12*	
2.240	392.34	410.04	412.01	414.49	416.58	418.65	420.61	422.37	425.67	
2.346	393.18	410.99	413.01	415.57	417.75	419.94	422.08	424.04	426.47	
2.459	393.56	411.74	413.78	416.34	418.52	420.73	422.90	424.89	427.39	
2.596	394.69	412.29	414.33	416.86	419.01	421.18	423.34	425.32	427.83	
2.861	395.94	413.65	415.59	418.03	420.14	422.32	424.53	426.55	429.08	
3.021	397.88	415.34	417.31	419.64	421.63	423.67	425.82	427.84	430.40	
3.073	400.13	415.30	417.22	419.52	421.50	423.57	425.72	427.75	430.31	
3.134	400.04	416.50	418.42	420.72	422.75	424.86	427.08	429.15	431.81	
3.210	400.00	417.15	419.13	421.51	423.51	425.50	427.59	429.57	432.20	
3.217	400.00	417.58	419.59	422.00	425.50	426.80	429.51	431.55	433.73	
3.231	402.09	417.58	419.59	422.02	425.55	426.86	429.56	431.64	433.84	
3.260	402.01	418.16	420.20	422.64	426.05	427.48	430.29	432.36	434.65	
3.275	402.06	419.31	421.36	423.80	426.24	427.81	430.78	432.66	434.79	
3.316	402.01	419.87	421.95	424.44	426.88	428.54	431.46	433.38	435.54	
3.388	402.45	420.03	422.08	424.54	426.97	428.63	431.53	433.45	435.53	
3.495	403.30	420.29	422.28	424.69	427.06	428.70	431.55	433.43	435.57	

Table C1-1: Mill Creek Flood Frequency Profiles - Future Conditions

Cumberland River Backwater from Draft 2012 FIS Update (Station 1006699) shown in Bold Blue Italic

1006699		*406.47*	*409.33*	*410.60*	*413.18*	*415.26*	*417.60*	*421.73*	*423.19*

Mill Creek Tributary Backwater elevations in Bold Red Italic

River Mile	Stream Invert NAVD 88	2 -Year W.S. Elev NAVD 88	5 -Year W.S. Elev NAVD 88	10 -Year W.S. Elev NAVD 88	25 -Year W.S. Elev NAVD 88	50 -Year W.S. Elev NAVD 88	100 -Year W.S. Elev NAVD 88	200 -Year W.S. Elev NAVD 88	500 -Year W.S. Elev NAVD 88
3.522	403.30	420.56	422.56	424.98	427.35	429.03	432.18	434.43	437.18
3.586	405.11	420.72	422.72	425.16	427.61	429.39	432.62	434.96	437.83
3.806	409.34	421.95	423.71	425.94	428.24	430.00	433.10	435.41	438.28
3.983	411.79	422.42	423.81	425.79	427.96	429.62	432.69	434.94	437.76
4.313	415.89	427.01	428.15	429.76	431.17	432.57	434.67	436.64	439.30
4.433	416.02	428.37	429.50	430.99	432.32	433.61	435.26	436.87	439.39
4.672	417.90	431.81	433.15	434.82	436.37	438.07	439.93	441.48	442.83
4.802	420.73	433.53	434.89	436.43	437.81	439.25	440.84	442.19	443.44
4.828	421.06	434.74	436.11	439.79	440.77	442.02	443.73	444.53	445.01
4.863	422.67	434.89	436.22	439.83	440.81	442.07	443.78	444.59	445.08
5.030	423.85	438.76	439.99	442.37	443.71	445.19	446.93	448.20	449.69
5.270	426.90	440.62	441.60	443.35	444.58	445.96	447.58	448.83	450.32
5.424	427.64	441.63	442.62	444.19	445.38	446.67	448.13	449.29	450.62
5.651	430.89	443.06	444.20	445.74	447.02	448.37	449.85	451.12	452.77
5.813	431.85	445.13	446.14	447.39	448.54	449.80	451.30	452.47	454.01
6.118	432.58	447.55	448.67	450.08	451.37	452.62	453.96	455.27	456.80
6.320	433.40	448.71	449.76	451.02	452.19	453.28	454.74	456.00	457.57
6.347	431.40	448.91	450.00	453.45	454.00	455.42	456.38	457.06	457.50
6.407	432.04	449.37	450.57	453.93	454.71	455.92	457.06	457.70	458.21
6.535	433.50	450.06	451.35	454.56	455.57	456.96	458.38	459.42	460.54
6.707	435.97	451.26	452.66	455.63	456.94	458.50	460.12	461.45	463.17
6.916	438.54	451.71	453.07	455.86	457.16	458.69	460.29	461.60	463.30
7.050	438.70	452.49	453.73	456.17	457.43	458.86	460.33	461.53	463.06
7.070	438.70	453.37	454.71	457.12	458.56	460.11	461.72	463.10	464.52
7.101	438.48	454.08	455.59	458.09	459.84	461.60	463.49	465.19	467.24
7.132	438.90	454.19	455.68	458.17	459.90	461.71	463.61	465.32	467.27
7.287	440.50	455.57	456.97	459.19	460.95	462.68	464.52	466.22	468.33
7.321	439.80	456.45	457.89	460.07	461.90	463.66	465.56	467.27	469.56
7.343	439.80	456.55	458.00	460.35	462.44	464.55	466.56	467.67	469.61

Table C1-1: Mill Creek Flood Frequency Profiles - Future Conditions

Cumberland River Backwater from Draft 2012 FIS Update (Station 1006699) shown in Bold Blue Italic

1006699		*406.47*	*409.33*	*410.60*	*413.18*	*415.26*	*417.60*	*421.73*	*423.19*

Mill Creek Tributary Backwater elevations in Bold Red Italic

	Stream	2 -Year	5 -Year	10 -Year	25 -Year	50 -Year	100 -Year	200 -Year	500 -Year	
River	Invert	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	
Mile	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	
7.434	440.89	456.52	458.01	460.40	462.53	464.67	466.66	467.78	469.68	
7.481	441.47	457.16	458.64	460.96	463.12	465.25	467.45	468.70	470.61	
7.585	441.85	458.21	459.64	461.82	463.85	465.90	467.96	469.20	471.13	
7.637	441.88	458.98	460.28	462.20	464.12	466.08	468.10	469.34	471.25	
7.719	445.56	459.46	460.65	462.45	464.31	466.24	468.23	469.47	471.38	
7.793	446.80	460.07	461.17	462.76	464.47	466.30	468.21	469.41	471.27	
7.865	448.86	*460.83*	*461.96*	*463.40*	*465.02*	*466.81*	*468.74*	*470.02*	*471.94*	*Mouth of Seven Mile Creek*
7.916	449.71	460.90	462.03	463.45	465.04	466.78	468.74	470.05	472.00	
8.046	450.20	461.54	462.76	464.31	465.84	467.41	469.19	470.43	472.30	
8.143	450.32	462.11	463.45	465.13	466.56	467.93	469.51	470.69	472.51	
8.168	450.26	462.51	463.91	465.60	466.94	468.09	469.56	470.72	472.55	
8.180	450.41	462.72	464.16	465.96	467.49	468.82	470.57	471.85	473.17	
8.210	450.30	462.76	464.18	465.97	467.52	468.83	470.49	471.66	472.86	
8.282	450.30	463.13	464.62	466.77	468.64	470.03	471.66	472.91	474.31	
8.322	451.30	463.81	465.43	467.34	468.76	469.99	471.45	472.57	473.80	
8.332	451.30	463.95	465.60	467.58	469.08	470.37	471.87	473.37	475.15	
8.363	452.00	463.79	465.47	467.50	469.05	470.40	471.96	473.52	475.37	
8.611	452.40	*467.76*	*469.23*	*471.14*	*472.77*	*473.95*	*475.20*	*476.46*	*478.09*	*Mouth of Sorghum Branch*
8.802	451.90	*469.53*	*471.27*	*473.59*	*475.62*	*477.07*	*478.57*	*480.14*	*482.19*	
8.999	458.03	470.75	472.42	474.58	476.46	477.98	479.68	481.14	483.13	
9.178	459.30	473.58	475.29	477.63	479.69	481.15	482.38	483.58	485.22	
9.385	462.05	475.04	476.46	478.49	480.36	481.74	482.97	484.16	485.80	
9.498	462.46	476.18	477.61	479.64	481.49	482.77	483.91	485.04	486.59	
9.546	463.46	476.50	477.92	479.88	481.54	482.77	483.89	484.99	486.52	
9.576	461.90	476.50	477.89	479.81	481.51	482.65	483.65	484.63	486.12	
9.588	461.90	476.99	480.57	482.86	484.69	485.46	486.14	486.71	487.48	
9.596	460.98	477.28	480.80	483.13	485.00	485.56	486.25	486.84	487.64	
9.609	460.90	477.57	480.98	483.33	485.23	486.22	486.95	487.59	488.45	
9.634	460.90	477.73	481.10	483.47	485.43	486.53	487.41	488.24	489.47	

Table C1-1: Mill Creek Flood Frequency Profiles - Future Conditions

Cumberland River Backwater from Draft 2012 FIS Update (Station 1006699) shown in Bold Blue Italic

1006699		*406.47*	*409.33*	*410.60*	*413.18*	*415.26*	*417.60*	*421.73*	*423.19*

Mill Creek Tributary Backwater elevations in Bold Red Italic

River	Stream	2 -Year	5 -Year	10 -Year	25 -Year	50 -Year	100 -Year	200 -Year	500 -Year	
River	Invert	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	
Mile	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	
9.688	462.10	477.88	481.19	483.60	485.59	486.74	487.73	488.68	490.00	
9.733	461.96	478.06	481.35	483.75	485.76	486.93	487.92	488.85	490.18	
9.809	463.16	478.66	481.79	484.28	486.31	487.53	488.59	489.62	491.04	
9.902	463.00	479.27	482.11	484.53	486.51	487.68	488.74	489.75	491.18	
10.064	463.40	480.09	482.66	485.04	487.08	488.33	489.40	490.49	491.91	
10.172	466.24	480.76	483.22	485.59	487.55	488.73	489.76	490.77	492.09	
10.260	466.05	481.14	483.51	485.89	487.89	489.11	490.19	491.28	492.71	
10.325	466.55	481.27	483.63	486.03	488.03	489.26	490.36	491.45	492.91	
10.421	466.94	*481.97*	*484.05*	*486.32*	*488.22*	*489.41*	*490.50*	*491.58*	*493.02*	
10.467	470.06	482.18	484.22	486.48	488.41	489.60	490.68	491.75	493.20	
10.557	471.62	*483.05*	*484.86*	*486.95*	*488.78*	*489.92*	*490.99*	*492.06*	*493.48*	*Mouth of Franklin Branch*
10.862	472.07	486.57	488.10	490.10	491.69	492.76	493.79	494.81	496.17	
10.910	469.90	487.73	489.52	491.91	493.58	494.69	495.63	496.47	497.82	
10.919	469.90	487.84	489.85	492.15	493.73	494.86	495.83	496.75	498.11	
10.936	469.90	487.94	489.92	492.18	493.77	494.89	495.84	496.76	498.10	
11.014	471.36	488.47	490.54	492.96	494.70	495.84	496.82	497.73	499.11	
11.076	473.05	488.59	490.59	492.90	494.45	495.56	496.61	497.60	498.98	
11.088	473.05	488.94	491.49	493.51	494.92	496.24	497.26	498.21	499.53	
11.120	472.80	489.07	491.81	494.07	495.70	496.93	497.91	498.83	500.10	
11.323	472.90	489.97	492.41	494.56	496.09	497.24	498.23	499.16	500.48	
11.432	475.90	490.48	492.93	495.22	496.99	498.31	499.41	500.37	501.63	
11.584	475.90	491.66	494.10	496.34	497.90	499.05	500.02	500.92	502.12	
11.691	475.90	492.34	494.66	496.92	498.52	499.46	500.39	501.25	502.41	
11.698	475.90	492.40	494.73	497.26	499.20	500.44	501.58	502.40	503.39	
11.727	475.90	492.32	494.64	497.17	499.10	500.32	501.24	502.01	502.92	
11.965	478.43	493.72	495.93	498.48	500.54	501.91	503.29	504.35	505.69	
12.050	478.90	494.31	496.43	498.92	500.87	502.30	503.50	504.42	505.60	
12.086	478.00	495.08	497.35	500.00	502.11	503.60	504.85	505.90	507.15	
12.105	478.00	495.20	497.49	500.58	503.41	504.91	506.09	507.05	508.20	

Table C1-1: Mill Creek Flood Frequency Profiles - Future Conditions

Cumberland River Backwater from Draft 2012 FIS Update (Station 1006699) shown in Bold Blue Italic

1006699		*406.47*	*409.33*	*410.60*	*413.18*	*415.26*	*417.60*	*421.73*	*423.19*

Mill Creek Tributary Backwater elevations in Bold Red Italic

River Mile	Stream Invert NAVD 88	2 -Year W.S. Elev NAVD 88	5 -Year W.S. Elev NAVD 88	10 -Year W.S. Elev NAVD 88	25 -Year W.S. Elev NAVD 88	50 -Year W.S. Elev NAVD 88	100 -Year W.S. Elev NAVD 88	200 -Year W.S. Elev NAVD 88	500 -Year W.S. Elev NAVD 88	
12.129	478.15	495.26	497.60	500.78	503.65	505.17	506.32	507.28	508.40	
12.360	481.30	496.49	498.66	501.64	504.40	505.94	507.18	508.21	509.48	
12.520	481.87	497.95	499.92	502.61	505.18	506.71	507.98	509.22	510.58	
12.677	480.90	498.85	500.87	503.53	506.01	507.55	508.87	510.14	511.59	
12.776	481.90	499.18	501.21	503.76	506.16	507.69	508.99	510.27	511.73	
12.860	482.81	499.78	501.83	504.42	506.75	508.24	509.54	510.81	512.28	
13.009	484.00	500.62	502.59	504.95	507.13	508.58	509.86	511.10	512.57	
13.095	484.40	*500.81*	*502.77*	*505.13*	*507.30*	*508.74*	*510.02*	*511.26*	*512.74*	
13.305	486.08	*501.45*	*503.44*	*505.72*	*507.76*	*509.14*	*510.38*	*511.61*	*513.08*	*Mouth of Whittemore Branch*
13.363	486.30	502.48	504.08	506.07	507.96	509.31	510.54	511.76	513.22	
13.375	486.30	502.95	504.73	506.48	508.29	509.65	510.84	512.03	513.49	
13.412	486.96	503.03	504.82	506.58	508.38	509.72	510.90	512.08	513.53	
13.503	487.85	503.02	504.70	506.28	507.98	509.29	510.45	511.59	513.01	
13.682	488.20	504.34	506.25	508.20	509.92	511.14	512.27	513.40	514.80	
13.757	487.95	504.77	506.77	508.86	510.69	511.96	513.16	514.34	515.85	
13.915	489.88	*505.17*	*507.14*	*509.25*	*511.10*	*512.39*	*513.59*	*514.75*	*516.26*	
13.961	490.90	505.17	507.08	509.12	510.90	512.15	513.92	515.14	516.74	
14.004	490.90	505.68	507.69	511.33	512.73	514.83	517.27	517.96	518.64	
14.015	491.00	*505.64*	*507.70*	*511.39*	*512.85*	*515.02*	*517.23*	*517.91*	*518.63*	*Mouth of Collins Creek*
14.239	494.36	507.14	509.01	512.30	513.90	515.96	517.48	518.20	518.78	
14.415	495.86	507.95	509.59	512.64	514.23	516.21	517.71	518.45	519.08	
14.488	495.30	508.43	509.95	512.81	514.36	516.30	517.80	518.54	519.19	
14.533	495.85	510.59	512.17	514.42	515.87	517.22	518.26	518.88	519.51	
14.550	497.94	510.66	512.28	514.50	515.94	517.30	518.35	518.97	519.61	
14.825	498.09	512.46	513.99	514.69	515.86	517.14	517.94	518.49	518.96	
14.981	499.90	514.09	515.81	517.26	518.76	519.80	520.70	521.51	522.59	
15.089	499.51	514.38	515.96	517.28	518.61	519.54	520.31	520.98	521.83	
15.311	499.90	515.90	517.79	519.68	521.37	522.56	523.68	524.76	526.26	
15.525	499.82	517.38	519.24	521.14	522.77	523.93	525.07	526.16	527.73	

Table C1-1: Mill Creek Flood Frequency Profiles - Future Conditions

Cumberland River Backwater from Draft 2012 FIS Update (Station 1006699) shown in Bold Blue Italic

1006699		*406.47*	*409.33*	*410.60*	*413.18*	*415.26*	*417.60*	*421.73*	*423.19*

Mill Creek Tributary Backwater elevations in Bold Red Italic

River Mile	Stream Invert NAVD 88	2 -Year W.S. Elev NAVD 88	5 -Year W.S. Elev NAVD 88	10 -Year W.S. Elev NAVD 88	25 -Year W.S. Elev NAVD 88	50 -Year W.S. Elev NAVD 88	100 -Year W.S. Elev NAVD 88	200 -Year W.S. Elev NAVD 88	500 -Year W.S. Elev NAVD 88	
15.691	501.40	518.25	520.01	521.86	523.47	524.61	525.76	526.93	528.53	
15.718	500.90	518.68	520.39	522.20	523.77	524.90	526.04	527.20	528.77	
15.943	503.19	519.40	521.09	522.90	524.46	525.59	526.72	527.88	529.49	
16.063	503.89	519.88	521.60	523.50	524.98	526.07	527.17	528.30	529.86	
16.153	507.19	520.23	521.83	523.67	525.15	526.22	527.30	528.42	529.97	
16.167	507.30	*520.80*	*523.29*	*524.99*	*525.60*	*526.40*	*527.42*	*528.51*	*530.04*	
16.177	507.68	521.23	523.46	525.14	525.77	526.55	527.54	528.62	530.12	
16.412	507.88	*521.81*	*523.94*	*525.58*	*526.29*	*527.07*	*528.02*	*529.05*	*530.50*	*Mouth of Turkey Creek*
16.671	506.90	523.77	524.85	526.16	526.89	527.56	528.40	529.34	530.70	
16.800	511.21	524.33	525.52	526.91	527.77	528.65	529.38	530.21	531.40	
16.855	511.90	*524.42*	*525.68*	*527.19*	*528.13*	*529.00*	*529.75*	*530.58*	*531.76*	
17.044	511.90	526.93	528.19	529.41	530.40	531.17	531.91	532.67	533.72	
17.238	514.74	*528.36*	*529.62*	*530.91*	*531.94*	*532.70*	*533.44*	*534.18*	*535.19*	*Mouth of Indian Creek*
17.347	515.36	528.84	530.05	531.34	532.35	533.10	533.82	534.55	535.56	
17.358	515.37	529.89	531.52	533.34	534.42	535.08	535.70	536.27	537.03	
17.406	517.10	530.18	531.81	533.70	534.82	535.52	536.18	536.79	537.60	
17.533	517.94	530.74	532.39	534.18	535.30	536.01	536.69	537.31	538.14	
17.693	519.45	531.86	533.22	534.67	535.66	536.25	536.95	537.60	538.45	
17.806	520.37	533.43	534.67	536.05	537.14	538.03	538.62	539.17	539.96	
17.929	519.90	534.22	535.46	536.84	537.92	538.78	539.41	540.02	540.83	
18.034	521.73	534.90	536.16	537.56	538.69	539.50	540.18	540.82	541.69	
18.302	521.84	537.74	539.00	540.27	541.23	541.97	542.64	543.31	544.14	
18.651	524.10	540.07	541.48	542.90	543.73	544.37	544.93	545.46	546.20	
18.828	523.69	541.02	542.33	543.69	544.58	545.23	545.82	546.39	547.18	
19.161	526.15	542.41	543.72	545.08	546.06	546.78	547.45	548.10	548.97	
19.285	526.17	543.04	544.38	545.79	546.83	547.59	548.32	549.01	549.94	
19.416	529.91	*543.91*	*545.20*	*546.50*	*547.48*	*548.17*	*548.83*	*549.46*	*550.28*	
19.447	529.91	544.34	545.86	547.46	548.71	549.62	550.52	551.51	553.96	
19.468	530.14	544.42	545.98	547.68	549.08	550.10	551.12	552.20	554.08	

Table C1-1: Mill Creek Flood Frequency Profiles - Future Conditions

Cumberland River Backwater from Draft 2012 FIS Update (Station 1006699) shown in Bold Blue Italic

1006699		*406.47*	*409.33*	*410.60*	*413.18*	*415.26*	*417.60*	*421.73*	*423.19*

Mill Creek Tributary Backwater elevations in Bold Red Italic

River Mile	Stream Invert NAVD 88	2 -Year W.S. Elev NAVD 88	5 -Year W.S. Elev NAVD 88	10 -Year W.S. Elev NAVD 88	25 -Year W.S. Elev NAVD 88	50 -Year W.S. Elev NAVD 88	100 -Year W.S. Elev NAVD 88	200 -Year W.S. Elev NAVD 88	500 -Year W.S. Elev NAVD 88	
19.682	530.85	*545.83*	*547.38*	*549.07*	*550.40*	*551.39*	*552.38*	*553.42*	*554.55*	*Mouth of Holt Creek*
19.896	529.79	547.69	549.07	550.61	551.85	552.75	553.66	554.59	555.69	
20.159	532.89	549.03	550.21	551.55	552.66	553.48	554.36	555.23	556.29	
20.317	533.00	549.36	550.30	551.34	552.19	552.88	553.67	554.47	555.40	
20.541	534.97	551.24	552.62	554.00	555.11	555.92	556.71	557.52	558.55	
20.608	535.33	551.73	553.06	554.39	555.48	556.27	557.05	557.85	558.85	
20.652	536.01	551.76	553.06	554.36	555.42	556.20	556.94	557.67	558.63	
20.740	536.73	552.13	553.46	554.79	555.88	556.68	557.45	558.34	559.41	
20.782	538.30	552.32	553.65	554.98	556.07	556.87	557.69	558.61	559.64	
20.797	538.30	552.38	553.69	555.07	556.15	556.91	557.79	558.68	559.67	
20.811	537.34	552.65	554.17	555.68	556.82	557.62	558.52	559.28	560.20	
21.033	541.47	553.53	554.85	556.17	557.24	558.00	558.87	559.61	560.55	
21.120	542.83	555.03	556.02	557.15	558.08	558.76	559.53	560.24	561.14	
21.142	542.80	555.17	556.17	557.29	558.22	558.90	559.68	560.39	561.30	
21.148	542.80	555.50	556.46	557.55	558.45	559.12	559.88	560.59	561.49	
21.156	542.80	555.57	556.53	557.61	558.52	559.19	559.94	560.65	561.55	
21.223	543.52	555.95	556.92	558.00	558.89	559.55	560.29	560.99	561.88	
21.378	546.90	557.13	558.12	559.16	560.03	560.66	561.35	562.03	562.89	
21.467	548.11	557.81	558.84	559.89	560.73	561.36	562.02	562.68	563.53	
21.507	549.50	558.95	559.78	560.67	561.50	562.04	562.62	563.21	564.01	
21.514	549.50	559.14	559.96	560.82	561.61	562.14	562.71	563.32	564.10	
21.522	549.50	559.34	560.18	561.04	561.83	562.37	562.94	563.54	564.31	
21.554	550.06	559.73	560.60	561.50	562.28	562.80	563.34	563.92	564.66	
21.615	551.30	560.54	561.38	562.24	562.95	563.44	563.95	564.50	565.21	
21.624	551.30	560.64	561.50	562.35	563.05	563.53	564.04	564.59	565.29	
21.633	551.30	561.21	562.02	562.84	563.51	563.99	564.48	565.01	565.70	
21.651	551.34	561.27	562.09	562.91	563.58	564.06	564.56	565.09	565.77	
21.777	551.40	562.39	563.27	564.11	564.79	565.23	565.71	566.22	566.88	

Table C1-2: Sevenmile Creek Flood Frequency Profiles - Future Conditions

Mill Creek Backwater elevations in Bold Red Italic

Mill Creek Backwater at Mouth of Sevenmile Creek

7.865		*460.83*	*461.96*	*463.40*	*465.02*	*466.81*	*468.74*	*470.02*	*471.94*	*Mouth of Sevenmile Creek*

	Stream	2 -Year	5 -Year	10 -Year	25 -Year	50 -Year	100 -Year	200 -Year	500 -Year
River	Invert	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev
Station	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88
50.55858	446.50	*460.83*	*461.96*	*463.40*	*465.02*	*466.81*	*468.74*	*470.02*	*471.94*
98.74029	446.62	*460.83*	*461.96*	*463.40*	*465.02*	*466.81*	*468.74*	*470.02*	*471.94*
354.9965	447.97	*460.83*	*461.96*	*463.40*	*465.02*	*466.81*	*468.74*	*470.02*	*471.94*
604.5016	450.37	*460.83*	*461.96*	*463.40*	*465.02*	*466.81*	*468.74*	*470.02*	*471.94*
906.094	451.38	*460.83*	461.99	*463.40*	*465.02*	*466.81*	*468.74*	*470.02*	*471.94*
1012.432	451.83	461.13	462.07	*463.40*	*465.02*	*466.81*	*468.74*	*470.02*	*471.94*
1156.009	452.44	462.28	462.37	*463.40*	*465.02*	*466.81*	*468.74*	*470.02*	*471.94*
1246.114	452.62	463.74	464.68	465.56	466.08	*466.81*	*468.74*	*470.02*	*471.94*
1362.794	453.86	463.99	464.93	465.82	466.39	*466.81*	*468.74*	*470.02*	*471.94*
1483.269	455.15	464.45	465.35	466.21	466.79	467.20	*468.74*	*470.02*	*471.94*
1666.545	455.50	465.14	466.07	466.95	467.60	468.07	*468.74*	*470.02*	*471.94*
1938.712	455.99	468.09	469.90	471.71	473.43	474.76	476.03	477.20	478.81
2330.623	459.26	468.62	470.51	472.36	474.10	475.46	476.75	477.94	479.58
2581.737	459.74	469.00	470.67	472.45	474.16	475.51	476.79	477.98	479.61
2930.636	460.40	470.08	471.03	472.55	474.16	475.43	476.84	478.01	479.64
3599.25	462.86	473.05	473.74	474.60	475.69	476.72	477.42	478.44	479.94
4105.81	463.08	474.50	475.17	475.90	476.74	477.55	478.15	479.05	480.38
4566.992	465.68	476.15	476.91	477.71	478.46	479.05	479.51	480.15	481.23
5091.726	468.02	477.97	478.71	479.25	479.82	480.31	480.66	481.12	481.98
5250.48	468.57	478.73	479.37	479.80	480.32	480.74	481.04	481.39	482.10
5400.715	468.75	479.83	480.93	481.88	482.78	483.40	483.80	484.18	485.24
5729.717	470.30	480.16	481.26	482.25	483.17	483.77	484.25	484.67	485.76
6070.034	471.90	481.45	482.58	483.60	484.52	485.30	485.74	486.16	487.00
6606.196	475.60	483.73	484.66	485.48	486.26	486.86	487.27	487.64	488.43
7075.583	478.38	485.73	486.48	487.17	487.82	488.34	488.74	489.08	489.88
7528.769	479.20	486.47	487.15	487.86	488.23	488.74	489.16	489.51	490.36
7816.581	480.00	488.48	489.16	489.86	490.45	490.85	491.16	491.44	492.10
8046.877	481.01	489.00	489.63	490.32	490.75	491.00	491.92	492.20	492.87
8145.723	480.96	490.99	492.57	496.80	497.88	498.29	498.62	498.88	499.44
8377.836	482.72	491.79	493.23	497.30	497.97	498.38	498.70	498.97	499.54
8578.194	483.41	492.82	493.91	497.37	498.03	498.46	498.80	499.06	499.54
8757.146	484.03	494.16	495.29	497.81	498.56	499.06	499.46	499.84	500.68

Table C1-2: Sevenmile Creek Flood Frequency Profiles - Future Conditions

Mill Creek Backwater elevations in Bold Red Italic

Mill Creek Backwater at Mouth of Sevenmile Creek

7.865		*460.83*	*461.96*	*463.40*	*465.02*	*466.81*	*468.74*	*470.02*	*471.94*	*Mouth of Sevenmile Creek*

	Stream	2 -Year	5 -Year	10 -Year	25 -Year	50 -Year	100 -Year	200 -Year	500 -Year
River	Invert	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev
Station	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88
8887.646	484.03	494.76	495.82	498.04	498.80	499.30	499.72	500.10	501.01
8973.962	484.03	496.01	497.42	499.17	499.87	500.34	500.68	500.98	501.68
9058.74	486.00	496.04	497.42	499.15	499.85	500.30	500.64	500.94	501.62
9105.075	486.08	496.16	497.51	499.21	499.90	500.36	500.70	501.00	501.72
9210.738	486.25	496.52	497.83	499.41	500.11	500.57	500.91	501.20	501.88
9319.791	486.60	497.21	498.57	500.16	502.11	502.31	502.51	502.73	503.98
9658.83	487.52	497.67	498.94	500.42	502.25	502.47	502.69	502.91	503.99
9871.357	489.52	498.40	499.64	501.12	502.96	503.42	503.88	504.34	505.85
10053.05	490.00	500.16	501.55	503.13	504.14	505.02	505.85	506.81	508.05
10307.08	490.26	500.60	501.92	503.52	504.66	505.61	506.49	506.96	508.19
10683.6	490.43	501.40	502.59	504.06	505.15	506.06	506.90	507.37	508.46
11038.22	490.59	501.68	502.80	504.22	505.29	506.17	507.00	507.47	508.56
11817.06	491.33	502.29	503.15	504.46	505.51	506.38	507.19	507.68	508.76
12207.49	491.70	503.68	504.43	505.33	506.14	506.86	507.59	508.08	509.11
12775.03	493.38	504.57	505.32	506.20	506.97	507.62	508.30	508.79	509.80
13460.48	496.47	506.16	506.98	507.88	508.63	509.22	509.81	510.46	511.38
13866.71	498.40	507.46	508.55	509.76	510.72	511.34	511.96	512.37	513.04
13936.34	497.53	507.61	508.74	509.96	510.89	511.75	512.34	512.76	513.42
14112.97	498.05	508.38	509.18	510.20	511.07	511.88	512.46	512.88	513.54
14315.7	498.64	508.56	509.26	510.18	510.96	511.76	512.34	512.74	513.39
14862.27	502.51	510.19	510.93	511.81	512.64	513.23	513.75	514.21	514.96
15638.59	505.95	514.34	515.07	515.78	516.30	516.62	516.94	517.31	517.94
16452.37	505.82	516.78	517.55	518.33	518.93	519.34	519.73	520.11	520.72
16717.7	507.79	517.64	518.57	519.54	520.32	520.81	521.24	521.65	522.30
17801.9	511.58	518.89	519.50	520.27	520.95	521.40	521.82	522.23	522.89
18540.11	514.79	521.09	521.45	521.86	522.27	522.59	522.93	523.26	523.78
19118.76	517.44	523.96	524.39	524.83	525.18	525.41	525.63	525.84	526.16
19316.05	517.44	524.40	524.77	525.08	525.27	525.33	525.39	525.86	526.54
19429.43	518.64	529.92	530.42	530.83	531.18	531.40	531.61	531.84	532.14
19582.59	519.27	529.96	530.46	530.87	531.23	531.47	531.68	531.91	532.23
20033	519.27	530.10	530.63	531.09	531.49	531.75	532.00	532.27	532.62
20624.26	522.46	530.55	531.14	531.70	532.19	532.53	532.85	533.17	533.61

Table C1-2: Sevenmile Creek Flood Frequency Profiles - Future Conditions
Mill Creek Backwater elevations in Bold Red Italic

Mill Creek Backwater at Mouth of Sevenmile Creek

7.865		*460.83*	*461.96*	*463.40*	*465.02*	*466.81*	*468.74*	*470.02*	*471.94*	*Mouth of Sevenmile Creek*

	Stream	2 -Year	5 -Year	10 -Year	25 -Year	50 -Year	100 -Year	200 -Year	500 -Year	
River	Invert	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	
Station	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	
21275.06	525.01	533.25	533.86	534.48	535.02	535.37	535.71	536.06	536.51	
21755.4	524.63	535.40	535.97	536.56	537.03	537.40	537.74	538.07	538.52	
21956.65	527.63	535.77	536.28	536.72	537.33	537.85	538.40	538.91	539.61	
22127.21	528.47	538.17	539.26	540.52	541.61	542.35	543.07	543.78	544.80	
22286.04	528.96	538.90	540.11	541.50	542.70	543.53	544.34	545.14	546.28	
22565.92	529.83	539.20	540.31	541.64	542.81	543.63	544.42	545.22	546.36	
22927.78	530.90	539.90	540.71	541.83	542.95	543.74	544.53	545.31	546.43	
23386.72	532.26	541.75	542.35	542.96	543.70	544.33	544.99	545.69	546.72	
24000.4	537.48	543.54	544.16	545.01	546.34	546.67	546.89	547.36	547.83	
24206.86	537.48	544.94	546.70	547.50	547.90	548.31	548.76	549.03	549.11	
24238.43	538.10	546.14	547.12	547.90	548.41	548.90	549.38	549.83	550.06	
24331.35	539.27	546.16	547.16	547.94	548.47	548.96	549.45	549.91	550.14	
24579.36	539.27	546.24	547.27	548.07	548.67	549.21	549.74	550.27	550.56	
24830.55	540.71	546.62	547.91	548.31	548.92	549.33	549.67	550.29	550.66	
24932.28	540.71	548.44	548.49	549.82	550.70	551.30	551.81	552.29	552.67	
24957.09	541.00	549.39	550.33	550.87	551.67	552.20	552.63	553.08	553.39	
25010.21	541.44	549.53	550.35	550.90	551.74	552.27	552.73	553.22	553.56	
25074.12	541.97	549.51	550.37	550.93	551.77	552.31	552.77	553.26	553.60	
25148.82	541.97	549.57	550.41	550.96	551.82	552.38	552.85	553.34	553.69	
25170.45	542.03	549.86	550.77	551.12	551.66	552.19	552.73	553.27	553.64	
25290.87	543.87	550.46	551.10	551.76	552.47	552.97	553.40	553.86	554.19	
25481.06	544.67	550.93	551.75	551.97	552.68	553.17	553.60	554.06	554.39	
25694.72	545.56	551.81	552.64	553.11	553.77	554.20	554.59	555.02	555.32	
25832.54	545.56	552.15	552.84	553.18	554.06	554.48	554.87	555.29	555.59	
25860.2	545.56	552.48	554.27	555.67	556.35	556.65	556.91	557.19	557.38	
25999.26	546.17	552.82	554.34	555.72	556.41	556.73	557.01	557.30	557.51	
26429.81	549.12	555.08	555.84	556.46	557.26	557.71	558.10	558.52	558.81	
26787.3	550.33	557.10	557.94	558.24	559.01	559.36	559.64	560.03	560.35	
27294.85	556.18	560.19	561.33	561.98	562.58	563.02	563.42	563.79	564.02	
27475.97	556.83	562.03	562.41	562.77	563.36	563.77	564.15	564.54	564.80	
27633.62	557.39	562.45	563.04	563.49	564.03	564.38	564.75	565.15	565.43	*Mouth of Sevenmile Creek Trib 2*
27802.73	558.27	563.97	565.90	567.84	568.57	568.64	568.98	569.32	569.52	

Table C1-2: Sevenmile Creek Flood Frequency Profiles - Future Conditions

Mill Creek Backwater elevations in Bold Red Italic

Mill Creek Backwater at Mouth of Sevenmile Creek

7.865		*460.83*	*461.96*	*463.40*	*465.02*	*466.81*	*468.74*	*470.02*	*471.94*	*Mouth of Sevenmile Creek*

	Stream	2 -Year	5 -Year	10 -Year	25 -Year	50 -Year	100 -Year	200 -Year	500 -Year	
River	Invert	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	
Station	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	
27885.28	558.97	564.33	566.11	567.85	568.58	568.66	569.00	569.34	569.55	
27970.91	559.70	564.86	566.31	567.93	568.69	568.83	569.19	569.56	569.80	
28027.65	559.82	565.26	566.52	567.93	568.68	568.83	569.20	569.60	569.87	
28092.67	559.95	566.05	567.20	568.10	568.91	569.15	569.59	570.01	570.30	*Mouth of Sevenmile Creek Trib 1*
28157.7	560.27	566.45	568.23	569.33	569.93	570.14	570.42	570.68	570.86	
28405.57	562.50	567.08	568.72	569.69	570.28	570.53	570.85	571.15	571.36	
28633.69	565.30	569.21	570.45	570.95	571.44	571.81	572.35	572.72	572.97	
28779.71	565.96	570.93	571.96	572.55	573.17	573.57	574.02	574.50	574.84	
28841.3	566.06	571.12	572.19	572.86	573.53	573.97	574.44	574.93	575.27	
28874.6	565.99	573.02	573.59	574.01	574.41	574.69	574.99	575.32	575.54	
28949.5	566.39	573.22	573.93	574.40	574.85	575.16	575.52	575.90	576.16	
29104	567.34	573.43	574.18	574.66	575.13	575.46	575.84	576.24	576.52	
29254.71	569.19	573.62	574.22	574.48	574.90	575.49	576.05	576.61	576.98	
29313.98	569.52	574.24	575.34	576.11	577.07	577.57	578.11	578.67	579.05	
29365.19	569.52	574.50	575.65	576.44	577.52	578.30	579.29	580.45	581.27	
29436.84	569.87	574.60	575.72	576.56	577.71	578.59	579.64	580.84	581.68	
29590.91	572.50	576.29	577.16	577.59	578.29	578.98	579.90	581.02	581.83	
29689.19	572.63	577.59	578.08	578.48	579.02	579.55	580.34	581.34	582.09	
29806.34	575.00	578.73	579.35	579.64	579.95	580.26	580.79	581.65	582.31	
29907.91	575.40	579.32	579.77	580.05	580.35	580.63	581.04	581.78	582.40	
29985.28	575.80	579.63	580.35	580.77	581.19	581.53	581.97	582.24	582.41	
30046.42	575.80	580.81	581.34	582.71	583.36	583.69	584.14	584.51	584.75	
30163.82	576.92	581.36	582.18	583.13	583.49	583.74	584.06	584.29	584.64	
30361.92	578.87	583.12	584.41	585.15	585.93	586.47	587.15	587.89	588.32	
30487.81	580.36	583.81	584.84	585.49	586.20	586.70	587.32	588.05	588.47	
30637.51	581.84	585.14	585.90	586.42	587.00	587.43	587.96	588.79	589.30	
30810.68	582.24	586.04	586.75	587.21	587.72	588.10	588.57	589.44	589.99	
30874.46	581.84	586.30	587.04	587.54	588.07	588.46	588.93	589.84	590.44	
30930.17	581.84	586.34	587.11	587.62	588.16	588.58	589.10	590.20	590.96	
31018.51	583.60	586.23	587.02	587.53	588.08	588.50	589.02	590.09	590.84	
31203.94	585.70	588.98	589.51	589.89	590.30	590.59	590.87	591.64	592.22	
31394.58	586.96	590.93	591.65	592.06	592.49	592.79	593.10	593.85	594.33	

Table C1-2: Sevenmile Creek Flood Frequency Profiles - Future Conditions

Mill Creek Backwater elevations in Bold Red Italic

Mill Creek Backwater at Mouth of Sevenmile Creek

7.865		*460.83*	*461.96*	*463.40*	*465.02*	*466.81*	*468.74*	*470.02*	*471.94*	*Mouth of Sevenmile Creek*

	Stream	2 -Year	5 -Year	10 -Year	25 -Year	50 -Year	100 -Year	200 -Year	500 -Year
River	Invert	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev
Station	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88
31602.46	588.96	592.95	593.64	594.03	594.44	594.73	595.05	595.84	596.39
31749.15	593.60	596.14	596.60	596.94	597.25	597.50	597.78	598.44	598.93
31850.33	593.60	597.92	598.59	599.00	599.44	599.74	600.07	600.93	601.50
31903.63	595.30	597.73	598.12	598.59	599.28	599.70	600.13	601.33	602.27
31988.26	597.00	599.97	600.40	600.51	600.65	600.82	600.98	601.71	602.47
32287.75	598.22	602.45	603.08	603.52	603.94	604.20	604.49	605.03	605.30
32590.98	598.22	603.46	604.21	604.68	605.13	605.44	605.78	606.54	606.96
32851.41	603.25	605.84	606.39	606.72	607.10	607.36	607.67	608.42	609.00
33087.43	607.19	610.52	611.15	611.60	611.96	612.21	612.48	613.17	613.62
33393.28	610.69	613.35	613.90	614.30	614.70	614.94	615.18	615.71	615.99
33680.74	617.02	618.85	619.04	619.19	619.44	619.58	619.66	620.19	620.51
33843.91	619.52	621.83	622.06	622.21	622.39	622.52	622.63	623.21	623.59
33940.83	622.00	623.71	623.99	624.26	624.61	624.77	624.88	625.44	626.20
34076.92	626.50	632.94	635.18	638.20	638.55	638.63	638.69	638.91	639.10
34368.4	630.73	632.97	635.21	638.20	638.55	638.63	638.69	638.91	639.10
34627.42	637.00	638.78	639.05	639.24	639.43	639.55	640.30	640.67	640.93
34829.09	639.60	641.89	642.20	642.41	642.62	642.76	643.47	643.82	644.06
35000.3	644.60	646.36	646.62	646.81	646.99	647.13	647.83	648.22	648.50
35282.04	653.87	655.84	656.18	656.45	656.70	656.86	657.58	658.17	658.37
35364.19	657.11	658.61	658.82	658.98	659.14	659.24	659.79	660.11	660.34
35414.63	658.65	662.65	663.35	663.90	664.50	665.21	667.48	667.73	667.84
35526.69	661.67	664.18	664.67	665.01	665.30	665.49	667.39	667.62	667.72
35607.82	662.17	665.61	665.79	666.10	666.62	666.94	668.16	668.16	668.39
35689.38	663.67	666.21	667.11	667.62	668.06	668.36	669.11	669.11	669.40
35852.27	665.17	667.87	668.80	669.39	669.93	670.32	671.29	671.29	671.62
35941.25	667.58	668.67	669.03	669.27	669.53	670.03	671.10	671.10	671.44
35965.94	680.50	681.67	682.03	682.29	682.56	682.72	683.08	683.08	683.21
36000.93	682.500	683.65	684.02	684.27	684.53	684.67	685.17	685.17	685.33
36159.45	688.900	690.11	690.38	690.55	690.79	690.95	691.33	691.33	691.48
36322.45	695.500	696.63	696.98	697.20	697.41	697.57	697.92	697.92	698.05
36440.97	699.800	701.06	701.35	701.53	701.76	701.90	702.24	702.24	702.38
36617.2	706.500	707.62	707.95	708.17	708.40	708.56	708.92	708.92	709.06

Table C1-2: Sevenmile Creek Flood Frequency Profiles - Future Conditions

Mill Creek Backwater elevations in Bold Red Italic

Mill Creek Backwater at Mouth of Sevenmile Creek

7.865		*460.83*	*461.96*	*463.40*	*465.02*	*466.81*	*468.74*	*470.02*	*471.94*	*Mouth of Sevenmile Creek*

	Stream	2 -Year	5 -Year	10 -Year	25 -Year	50 -Year	100 -Year	200 -Year	500 -Year
River	Invert	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev
Station	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88
36717.9	709.290	711.44	711.83	712.03	712.24	712.40	712.77	712.77	712.93
36830.3	711.790	714.15	714.70	715.01	715.36	715.53	715.88	715.88	715.99
36898.88	714.590	716.55	716.97	717.18	717.41	717.56	717.87	717.87	717.98
36991.73	717.680	720.49	721.81	722.89	723.82	724.07	724.42	724.42	724.58
37046.43	722.980	724.43	724.80	725.03	725.18	725.29	725.50	725.50	725.57
37112.44	725.800	727.07	727.23	727.42	727.60	727.72	727.99	727.99	728.09

Table C1-3: Sorghum Branch Flood Frequency Profiles - Future Conditions

Mill Creek Backwater elevations in Bold Red Italic

Mill Creek Backwater at Mouth Sorghum Branch

8.611		467.76	469.23	471.14	472.77	473.95	475.20	476.46	478.09	Mouth of Sorghum Branch

River Station	Stream Invert NAVD 88	2 -Year W.S. Elev NAVD 88	5 -Year W.S. Elev NAVD 88	10 -Year W.S. Elev NAVD 88	25 -Year W.S. Elev NAVD 88	50 -Year W.S. Elev NAVD 88	100 -Year W.S. Elev NAVD 88	200 -Year W.S. Elev NAVD 88	500 -Year W.S. Elev NAVD 88
99.43906	457.37	467.76	469.23	471.14	472.77	473.95	475.20	476.46	478.09
229.3311	458.60	467.76	469.23	471.14	472.77	473.95	475.20	476.46	478.09
333.1076	459.00	467.76	469.23	471.14	472.77	473.95	475.20	476.46	478.09
449.9857	459.43	467.76	469.23	471.14	472.77	473.95	475.20	476.46	478.09
543.0981	459.69	468.12	469.23	471.14	472.77	473.95	475.20	476.46	478.09
634.6407	459.93	468.28	469.23	471.14	472.77	473.95	475.20	476.46	478.09
703.2004	461.00	468.32	469.23	471.14	472.77	473.95	475.20	476.46	478.09
794.1959	462.00	471.26	472.16	473.12	473.55	473.95	475.20	476.46	478.09
842.413	461.93	471.61	472.48	473.42	473.84	474.16	475.20	476.46	478.09
889.9554	462.46	471.66	472.53	473.48	473.90	474.22	475.20	476.46	478.09
1352.194	466.93	472.07	472.91	473.81	474.22	474.52	475.20	476.46	478.09
1488.255	466.70	472.36	473.25	474.06	474.46	474.75	475.97	476.46	478.09
1613.987	466.80	474.14	475.82	476.38	476.62	476.77	477.13	477.29	478.09
1750.717	467.03	474.39	476.10	476.87	477.34	477.69	478.06	478.34	478.77
1830.868	467.42	474.57	476.24	477.04	477.50	477.86	478.20	478.49	478.90
1875.579	467.53	474.87	476.55	477.38	477.84	478.17	478.47	478.73	479.12
1930.666	467.58	475.16	476.83	477.43	477.85	478.18	478.50	478.77	479.18
2092.968	468.03	475.33	477.01	477.70	478.16	478.51	478.81	479.06	479.45
2503.566	470.03	476.30	477.68	478.41	478.88	479.22	479.48	479.73	480.08
2887.314	474.63	477.94	478.68	479.53	480.00	480.24	480.37	480.48	480.88
3021.489	474.70	479.87	480.79	481.36	481.72	482.02	482.24	482.51	482.69
3072.763	475.00	480.96	481.62	482.18	482.48	482.70	482.85	483.03	483.20
3257.271	475.43	481.42	482.13	482.73	483.09	483.34	483.51	483.71	483.98
3489.778	476.03	482.46	483.51	484.46	485.03	485.42	485.65	485.88	486.19
3607.842	477.93	482.91	484.09	485.01	485.55	485.94	486.17	486.41	486.74
3745.908	477.80	483.54	484.45	485.27	485.75	486.09	486.29	486.50	486.76
3844.353	478.10	483.83	484.98	486.37	487.54	488.53	489.23	490.08	491.33
4104.79	478.03	484.39	485.65	487.18	488.38	489.37	490.09	490.96	492.22
4352.364	480.42	486.15	487.29	488.80	489.51	489.77	490.11	491.01	492.30
4642.547	482.93	489.19	490.59	491.40	491.81	492.14	492.26	492.48	493.06
4887.879	484.80	489.85	491.10	491.96	492.37	492.72	492.85	492.98	493.19
5265.231	486.60	492.38	494.30	496.24	497.57	499.45	500.35	501.10	503.32

Table C1-3: Sorghum Branch Flood Frequency Profiles - Future Conditions

Mill Creek Backwater elevations in Bold Red Italic

Mill Creek Backwater at Mouth Sorghum Branch

8.611		*467.76*	*469.23*	*471.14*	*472.77*	*473.95*	*475.20*	*476.46*	*478.09*	*Mouth of Sorghum Branch*

River Station	Stream Invert NAVD 88	2 -Year W.S. Elev NAVD 88	5 -Year W.S. Elev NAVD 88	10 -Year W.S. Elev NAVD 88	25 -Year W.S. Elev NAVD 88	50 -Year W.S. Elev NAVD 88	100 -Year W.S. Elev NAVD 88	200 -Year W.S. Elev NAVD 88	500 -Year W.S. Elev NAVD 88
5350.791	486.63	492.98	*494.87*	496.80	*498.16*	499.99	500.89	*501.67*	503.85
5520.771	491.43	493.95	*495.40*	497.16	*498.46*	500.19	501.05	*501.81*	503.93
5629.878	491.04	495.72	*496.40*	497.63	*498.70*	500.22	501.03	*501.74*	503.79
5918.411	492.02	497.73	*499.81*	502.13	*504.35*	505.74	507.54	*507.83*	507.93
6256.521	494.53	499.58	*501.02*	502.88	*504.79*	506.10	507.82	*508.19*	508.42
6549.714	496.33	502.63	*504.06*	505.25	*505.87*	506.54	507.88	*508.21*	508.42
6760.614	498.03	504.09	*505.83*	507.32	*508.10*	508.66	509.36	*509.85*	510.43
6849.149	499.90	504.25	*506.02*	507.56	*508.41*	509.03	509.78	*510.36*	511.07
6983.726	500.20	505.39	*507.41*	509.88	*511.54*	512.17	512.69	*513.06*	513.44
7066.032	500.43	505.44	*507.44*	509.92	*511.59*	512.24	512.77	*513.16*	513.59
7281.266	502.43	507.45	*508.84*	510.53	*511.83*	512.40	512.88	*513.24*	513.63
7531.359	503.63	509.43	*510.64*	511.59	*512.40*	512.90	513.37	*513.80*	514.29
7656.953	505.93	510.59	*511.84*	512.86	*513.60*	514.13	514.70	*515.28*	515.98
7965.322	507.33	512.58	*513.71*	514.65	*515.14*	515.45	515.86	*516.32*	516.93
8309.187	509.03	514.28	*515.68*	516.73	*517.06*	517.30	517.55	*517.85*	518.26
8832.558	512.93	516.58	*517.43*	518.35	*518.61*	518.86	519.09	*519.38*	519.76
9221.274	517.23	520.59	*521.63*	522.22	*522.51*	522.66	522.94	*523.19*	523.49
9683.394	520.03	524.27	*524.95*	525.65	*525.95*	526.18	526.43	*526.71*	527.06
10080.84	522.34	526.70	*527.49*	528.09	*528.41*	528.59	528.80	*529.05*	529.31
10379.91	524.33	528.60	*529.39*	529.94	*530.13*	530.31	530.50	*530.76*	531.03
10531.72	525.30	529.78	*530.62*	531.10	*531.33*	531.55	531.80	*532.06*	532.39
10589.88	525.50	530.28	*532.73*	533.38	*533.71*	533.91	534.10	*534.21*	534.51
10743.38	525.13	530.73	*532.95*	533.58	*533.86*	534.05	534.25	*534.38*	534.68
10930.71	527.43	531.06	*533.08*	533.68	*533.94*	534.34	535.20	*535.55*	535.96
11196.66	529.43	534.05	*535.32*	536.57	*537.20*	537.57	537.71	*538.05*	538.48
11332.84	530.93	534.95	*536.45*	537.94	*538.17*	538.41	538.66	*538.89*	539.20
11447.35	530.80	537.01	*538.81*	539.11	*539.34*	539.50	539.69	*539.85*	540.01
11503.88	531.30	538.00	*541.16*	542.61	*543.02*	543.27	543.59	*543.57*	543.92
11650.38	531.43	538.42	*541.59*	543.28	*543.76*	544.07	544.52	*544.73*	545.24
11850.8	533.05	538.74	*541.72*	543.37	*543.84*	544.15	544.59	*544.81*	545.32
12202.48	535.03	540.04	*542.15*	543.57	*544.02*	544.33	544.76	*545.00*	545.51
12526.06	536.83	541.62	*543.28*	544.42	*544.77*	545.03	545.42	*545.70*	546.18

Table C1-3: Sorghum Branch Flood Frequency Profiles - Future Conditions

Mill Creek Backwater elevations in Bold Red Italic

Mill Creek Backwater at Mouth Sorghum Branch

8.611		467.76	469.23	471.14	472.77	473.95	475.20	476.46	478.09

Mouth of Sorghum Branch

River Station	Stream Invert NAVD 88	2 -Year W.S. Elev NAVD 88	5 -Year W.S. Elev NAVD 88	10 -Year W.S. Elev NAVD 88	25 -Year W.S. Elev NAVD 88	50 -Year W.S. Elev NAVD 88	100 -Year W.S. Elev NAVD 88	200 -Year W.S. Elev NAVD 88	500 -Year W.S. Elev NAVD 88
12814.73	538.43	543.12	544.75	545.95	546.26	546.47	546.76	547.03	547.37
13031.49	539.86	544.34	546.01	547.35	547.70	547.94	548.27	548.60	549.03
13361	542.03	546.34	547.85	549.15	549.50	549.75	550.12	550.44	550.81
13564.62	543.74	547.84	549.30	550.47	550.80	551.04	551.40	551.74	552.08
13810.29	545.83	549.92	551.33	552.45	552.78	553.04	553.41	553.77	554.23
13996.18	549.56	552.71	553.88	554.88	555.17	555.38	555.72	556.24	557.36
14177.88	553.20	556.68	557.85	559.31	559.52	559.66	559.89	560.18	560.19
14231.46	553.130	559.20	561.25	561.53	561.60	561.64	561.71	561.79	561.86
14375.15	553.730	559.50	561.33	561.65	561.73	561.79	561.87	561.95	562.03
14624.73	557.13	560.75	562.30	563.31	563.65	563.94	564.32	564.67	565.13
15008.61	560.93	565.77	566.85	567.42	567.75	568.18	568.48	568.72	569.06
15299.34	563.93	568.98	570.42	571.63	571.86	571.92	572.14	572.37	572.68
15587.3	568.63	571.95	573.22	573.91	574.08	574.28	574.48	574.66	575.27
15698.76	569.78	573.19	574.46	575.51	575.83	576.04	576.39	576.73	576.81
15877.57	571.63	575.03	576.33	577.36	577.66	577.89	578.22	578.51	579.00
16096.59	574.28	577.70	578.91	579.83	580.31	580.49	581.01	581.32	581.66
16212.03	575.13	579.48	580.86	582.06	582.23	582.45	582.54	582.75	583.04
16253.14	576.43	580.04	581.50	582.61	582.78	582.89	583.05	583.25	583.48
16319.42	576.43	580.72	583.02	583.97	584.27	584.46	584.71	584.96	585.26
16385.08	577.79	580.93	583.21	584.35	584.74	585.01	585.37	585.71	586.17
16444.06	579.43	581.85	583.55	584.81	585.24	585.55	585.95	586.34	586.84
16504.12	581.45	583.87	584.50	585.09	585.22	585.32	585.57	585.98	586.49
16555.86	581.55	585.07	585.79	586.58	586.73	586.85	587.10	587.34	589.16
16624.32	581.35	585.46	586.38	587.30	587.49	587.63	587.94	588.25	589.69
16830.05	582.67	585.89	586.82	587.70	587.88	588.02	588.32	588.62	589.88
16978.29	584.35	586.90	587.69	588.33	588.45	588.54	588.74	588.95	589.86
17145.97	586.23	589.36	590.18	590.85	590.94	591.01	591.19	591.38	591.86
17262.46	587.53	590.77	591.75	592.65	592.81	592.92	593.21	593.52	593.78
17340.81	588.39	591.63	592.60	593.38	593.49	593.58	593.79	594.04	594.30
17424.81	589.23	592.54	593.52	594.30	594.40	594.47	594.63	594.79	594.97
17493.31	590.22	593.28	594.38	595.45	595.62	595.75	596.06	596.41	596.85
17527.76	590.72	594.48	595.34	596.69	596.94	597.09	597.50	598.03	598.66

Table C1-3: Sorghum Branch Flood Frequency Profiles - Future Conditions

Mill Creek Backwater elevations in Bold Red Italic

Mill Creek Backwater at Mouth Sorghum Branch

8.611		*467.76*	*469.23*	*471.14*	*472.77*	*473.95*	*475.20*	*476.46*	*478.09*	*Mouth of Sorghum Branch*

River Station	Stream Invert NAVD 88	2 -Year W.S. Elev NAVD 88	5 -Year W.S. Elev NAVD 88	10 -Year W.S. Elev NAVD 88	25 -Year W.S. Elev NAVD 88	50 -Year W.S. Elev NAVD 88	100 -Year W.S. Elev NAVD 88	200 -Year W.S. Elev NAVD 88	500 -Year W.S. Elev NAVD 88
17558.1	590.72	596.26	*600.02*	601.01	*601.13*	601.24	601.46	*601.65*	601.91
17581.91	591.27	596.77	*600.18*	601.23	*601.36*	601.48	601.72	*601.95*	602.25
17637.99	593.50	596.81	*600.23*	601.31	*601.45*	601.57	601.82	*602.07*	602.39
17674.56	593.50	596.88	*600.23*	601.31	*601.45*	601.58	601.82	*602.07*	602.39
17698.86	593.50	597.20	*600.37*	601.34	*601.48*	601.61	601.85	*602.10*	602.41
17724.15	593.50	597.27	*600.43*	601.42	*601.56*	601.68	601.93	*602.18*	602.50
17759.71	593.70	597.32	*600.43*	601.42	*601.56*	601.68	601.93	*602.17*	602.50
17820.62	594.70	597.39	*600.44*	601.42	*601.56*	601.68	601.93	*602.17*	602.50
17840.7	595.03	597.49	*600.44*	601.42	*601.56*	601.68	601.93	*602.17*	602.49
17861.77	595.38	600.13	*601.40*	602.09	*602.19*	602.27	602.45	*602.62*	602.87
17898.51	595.74	600.16	*601.44*	602.13	*602.23*	602.31	602.48	*602.66*	602.90
18053.14	597.27	600.32	*601.57*	602.29	*602.39*	602.47	602.66	*602.84*	603.09
18178.73	598.51	601.38	*602.29*	603.02	*603.13*	603.21	603.39	*603.60*	603.86
18332.43	600.03	603.44	*604.34*	605.10	*605.21*	605.29	605.49	*605.71*	606.00
18479.11	601.99	605.29	*606.28*	607.14	*607.28*	607.39	607.66	*607.97*	608.40
18589.15	604.53	606.93	*607.82*	608.66	*608.80*	608.89	609.14	*609.63*	610.50
18659.13	604.93	608.47	*609.68*	610.79	*611.01*	611.18	611.61	*611.93*	612.02
18756.4	604.93	608.67	*610.26*	611.56	*611.70*	611.82	612.08	*612.26*	612.28
18808.11	605.23	608.85	*610.44*	611.74	*611.87*	611.98	612.22	*612.41*	612.48
18931.78	606.74	609.92	*611.29*	612.54	*612.69*	612.81	613.07	*613.30*	613.56
19029.73	608.68	611.17	*612.07*	613.04	*613.18*	613.29	613.53	*613.77*	614.05
19181.85	611.70	614.11	*614.71*	615.27	*615.36*	615.43	615.61	*615.82*	616.11
19254.46	613.43	615.56	*616.22*	616.87	*616.96*	617.04	617.22	*617.44*	617.70

Table C1-4: Whittemore Branch Flood Frequency Profiles - Future Conditions
Mill Creek Backwater elevations in Bold Red Italic

Mill Creek Backwater at Mouth Whittemore Branch

13.305		*501.45*	*503.44*	*505.72*	*507.76*	*509.14*	*510.38*	*511.61*	*513.08*	*Mouth of Whittemore Branch*

	Stream	2 -Year	5 -Year	10 -Year	25 -Year	50 -Year	100 -Year	200 -Year	500 -Year	
River	Invert	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	
Station	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	
91.34178	482.83	*501.45*	*503.44*	*505.72*	*507.76*	*509.14*	*510.38*	*511.61*	*513.08*	
348.5757	485.43	*501.45*	*503.44*	*505.72*	*507.76*	*509.14*	*510.38*	*511.61*	*513.08*	
672.6573	486.63	*501.45*	*503.44*	*505.72*	*507.76*	*509.14*	*510.38*	*511.61*	*513.08*	
1138.872	489.63	*501.45*	*503.44*	*505.72*	*507.76*	*509.14*	*510.38*	*511.61*	*513.08*	
1544.734	492.58	*501.45*	*503.44*	*505.72*	*507.76*	*509.14*	*510.38*	*511.61*	*513.08*	
1868.71	494.93	502.74	503.69	*505.72*	*507.76*	*509.14*	*510.38*	*511.61*	*513.08*	
2208.971	496.09	504.89	505.85	506.30	*507.76*	*509.14*	*510.38*	*511.61*	*513.08*	
2500.824	496.40	506.63	508.34	509.99	511.37	512.72	513.74	514.60	515.84	
2799.648	498.93	507.12	508.82	510.71	512.20	513.58	514.59	515.44	516.67	
3254.177	502.03	508.81	509.99	511.23	512.45	513.73	514.71	515.54	516.75	
3706.334	505.13	510.89	511.93	512.97	513.84	514.61	515.33	516.01	517.07	
4261.212	508.63	514.34	515.34	516.27	517.03	517.47	517.74	518.23	518.55	
4805.898	512.03	519.07	520.07	521.03	521.81	523.22	523.58	523.80	524.08	
5088.175	513.13	521.40	522.79	524.20	525.28	525.39	525.72	525.98	526.30	
5265.63	513.45	522.26	523.62	524.69	525.62	525.81	526.14	526.40	526.73	
5340.409	515.01	522.76	524.37	525.93	526.54	526.64	526.74	526.80	526.85	
5465.904	515.43	523.02	524.74	526.39	527.11	527.38	527.65	527.84	528.11	
5796.573	517.23	524.10	525.42	526.89	527.67	528.03	528.37	528.62	528.95	
5961.832	518.13	524.92	525.81	527.04	527.84	528.26	528.65	528.95	529.35	*Mouth of Whittemore Branch Trib*
6414.732	521.99	528.09	529.67	530.19	530.47	530.69	530.92	531.07	531.28	
6531.309	522.76	530.55	530.50	531.51	533.36	533.61	533.88	534.03	534.26	
6557.823	522.76	532.30	533.03	534.10	534.21	534.42	534.59	534.69	534.80	
6685.265	523.13	532.82	533.62	534.56	534.87	535.18	535.43	535.62	535.87	
6889.102	525.81	532.90	533.74	534.77	535.18	535.53	535.83	536.05	536.36	
7201.942	529.93	535.60	536.25	536.65	537.12	537.47	537.74	537.94	538.21	
7537.021	533.16	538.45	538.88	539.44	539.80	540.04	540.26	540.43	540.66	
7917.563	536.83	541.23	541.97	542.59	543.15	543.55	543.88	544.14	544.47	
8175.323	537.87	543.27	544.05	544.81	545.44	545.89	546.27	546.55	546.92	
8534.703	539.33	544.86	545.38	546.10	546.88	547.12	547.25	547.62	547.83	
8778.572	540.23	547.12	548.04	548.71	549.00	549.40	549.79	549.81	550.10	
8987.559	541.33	548.73	549.56	550.18	550.81	551.11	551.37	551.64	551.90	
9106.154	542.80	549.17	549.94	550.53	551.09	551.41	551.71	551.99	552.27	

Table C1-4: Whittemore Branch Flood Frequency Profiles - Future Conditions

Mill Creek Backwater elevations in Bold Red Italic

Mill Creek Backwater at Mouth Whittemore Branch

13.305		*501.45*	*503.44*	*505.72*	*507.76*	*509.14*	*510.38*	*511.61*	*513.08*	*Mouth of Whittemore Branch*

River Station	Stream Invert NAVD 88	2 -Year W.S. Elev NAVD 88	5 -Year W.S. Elev NAVD 88	10 -Year W.S. Elev NAVD 88	25 -Year W.S. Elev NAVD 88	50 -Year W.S. Elev NAVD 88	100 -Year W.S. Elev NAVD 88	200 -Year W.S. Elev NAVD 88	500 -Year W.S. Elev NAVD 88
9147.164	542.60	550.16	*550.93*	551.55	*552.11*	552.57	552.93	*553.18*	553.55
9229.091	542.43	550.46	*551.31*	552.01	*552.54*	552.96	553.31	*553.55*	553.90
9293.79	542.50	550.65	*551.58*	552.31	*552.90*	553.32	553.67	*553.91*	554.26
9356.652	542.87	551.04	*551.54*	552.12	*552.74*	553.22	553.59	*553.82*	554.18
9432.692	542.73	551.23	*551.73*	552.30	*552.89*	553.35	553.71	*553.94*	554.30
9668.316	545.33	551.60	*552.32*	553.02	*553.60*	554.00	554.33	*554.57*	554.92
9813.415	545.40	552.68	*553.19*	553.86	*554.36*	554.70	555.00	*555.22*	555.52
9931.14	546.22	557.07	*558.22*	558.44	*558.72*	558.92	559.09	*559.10*	559.25
9986.33	546.23	557.09	*558.24*	558.47	*558.75*	558.96	559.13	*559.15*	559.30
10131.03	547.03	557.20	*558.30*	558.54	*558.80*	558.98	559.12	*559.13*	559.24
10178.89	547.30	557.26	*558.35*	558.61	*558.89*	559.09	559.25	*559.28*	559.42
10222.73	547.62	557.38	*558.81*	559.34	*559.85*	560.20	560.52	*560.71*	561.04
10280.72	548.15	557.35	*558.80*	559.33	*559.85*	560.22	560.55	*560.75*	561.10
10538.19	550.48	558.00	*559.41*	560.19	*560.87*	561.36	561.80	*562.13*	562.59
10764.63	552.53	558.90	*560.15*	561.06	*561.81*	562.37	562.86	*563.24*	563.76
10886.6	554.60	559.48	*560.52*	561.45	*562.20*	562.74	563.22	*563.59*	564.11
10918.84	554.50	561.77	*562.03*	562.55	*563.07*	563.50	563.87	*564.18*	564.61
10990.34	555.13	561.90	*562.24*	562.78	*563.31*	563.72	564.09	*564.38*	564.80
11318.59	557.63	563.20	*563.93*	564.56	*565.03*	565.36	565.65	*565.88*	566.21
11539.1	560.27	565.32	*565.87*	566.46	*566.95*	567.35	567.67	*567.92*	568.26
11722.58	562.46	567.20	*567.70*	568.18	*568.60*	568.92	569.25	*569.48*	569.80
12079.57	565.69	570.79	*571.50*	572.01	*572.42*	572.75	573.01	*573.26*	573.53
12166.32	566.11	572.16	*572.50*	572.94	*573.25*	574.01	574.32	*574.60*	574.87
12228.52	566.19	575.82	*576.13*	576.67	*577.02*	577.16	577.34	*577.49*	577.66
12290.93	567.91	575.78	*576.07*	576.64	*577.01*	577.14	577.33	*577.49*	577.67
12409.23	570.81	575.99	*576.48*	577.06	*577.46*	577.69	577.95	*578.14*	578.38
12548.89	573.33	577.66	*577.95*	578.22	*578.42*	578.51	578.72	*578.90*	579.14
12667.26	574.31	578.76	*579.11*	579.38	*580.48*	580.79	581.15	*581.35*	581.60
12738.07	574.52	581.32	*581.91*	582.69	*582.77*	582.91	583.07	*583.23*	583.45
12790.71	574.83	581.40	*582.01*	582.78	*582.91*	583.08	583.27	*583.45*	583.69
13039.69	578.23	583.15	*584.06*	584.64	*585.00*	585.18	585.33	*585.56*	585.78
13347.89	582.43	587.30	*587.58*	587.91	*588.20*	588.45	588.69	*588.85*	589.08

Table C1-4: Whittemore Branch Flood Frequency Profiles - Future Conditions

Mill Creek Backwater elevations in Bold Red Italic

Mill Creek Backwater at Mouth Whittemore Branch

13.305		*501.45*	*503.44*	*505.72*	*507.76*	*509.14*	*510.38*	*511.61*	*513.08*	*Mouth of Whittemore Branch*

	Stream	2 -Year	5 -Year	10 -Year	25 -Year	50 -Year	100 -Year	200 -Year	500 -Year
River	Invert	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev
Station	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88
13590.49	583.74	588.64	*589.05*	589.44	*589.74*	589.96	590.17	*590.34*	590.57
13884.41	585.33	590.76	*591.21*	591.73	*592.07*	592.35	592.52	*592.57*	593.01
14129.62	586.81	592.99	*593.56*	593.94	*594.25*	594.43	594.65	*594.89*	594.94
14495.51	589.03	595.52	*595.96*	596.42	*596.76*	597.04	597.27	*597.43*	597.81
14820.69	589.34	597.32	*598.09*	598.75	*599.27*	599.61	599.95	*600.25*	600.55
15001.79	589.52	598.21	*599.17*	600.03	*600.71*	601.19	601.72	*602.07*	602.51
15063.95	589.58	598.75	*599.92*	600.96	*601.73*	602.27	602.81	*603.20*	603.71
15113.94	589.58	598.79	*599.97*	601.02	*601.80*	602.35	602.90	*603.30*	603.82
15125.15	591.39	598.80	*599.98*	601.04	*601.83*	602.38	602.93	*603.34*	603.87
15139.18	593.64	598.77	*599.95*	601.00	*601.79*	602.33	602.88	*603.29*	603.81
15245.1	593.64	599.18	*600.31*	601.36	*602.16*	602.72	603.28	*603.71*	604.26
15284.9	593.68	599.29	*600.42*	601.48	*602.29*	602.85	603.43	*603.86*	604.43
15317.37	593.70	599.31	*600.44*	601.49	*602.30*	602.87	603.44	*603.87*	604.43
15354.96	593.70	599.44	*600.56*	601.62	*602.44*	603.01	603.59	*604.04*	604.61
15386.32	593.89	599.53	*600.66*	601.74	*602.57*	603.16	603.75	*604.21*	604.80
15411.6	594.050	599.52	*600.64*	601.71	*602.54*	603.12	603.71	*604.16*	604.75
15444.71	594.050	599.66	*600.78*	601.85	*602.69*	603.28	603.87	*604.34*	604.94
15466.86	594.870	599.72	*600.84*	601.92	*602.76*	603.36	603.96	*604.43*	605.04
15484.57	595.540	599.73	*600.84*	601.91	*602.75*	603.34	603.94	*604.41*	605.01
15524.61	595.540	600.05	*601.10*	602.15	*602.99*	603.59	604.19	*604.67*	605.28
15549.35	596.01	600.17	*601.22*	602.28	*603.12*	603.73	604.34	*604.82*	605.45
15569.45	596.40	600.21	*601.23*	602.27	*603.10*	603.70	604.31	*604.78*	605.40
15622.93	596.40	600.88	*601.77*	602.74	*603.55*	604.14	604.73	*605.21*	605.84
15637.98	596.80	600.91	*601.79*	602.75	*603.55*	604.13	604.72	*605.19*	605.81
15682.64	597.97	603.04	*603.86*	604.73	*605.46*	606.04	606.60	*606.72*	608.43
15830.08	601.83	607.21	*607.99*	608.85	*609.64*	610.23	610.85	*611.47*	611.68
15903.21	602.56	607.93	*608.57*	609.26	*609.89*	610.38	610.92	*611.49*	611.70
16008.78	603.62	608.83	*609.38*	610.67	*611.27*	611.82	612.13	*612.36*	612.68
16259.62	606.13	611.91	*613.04*	613.77	*614.25*	614.49	614.84	*615.13*	615.50
16346.29	608.55	612.42	*613.55*	614.32	*614.80*	615.08	615.37	*615.62*	615.97
16448.69	609.40	614.88	*616.24*	618.24	*618.71*	619.01	619.31	*619.51*	619.77
16561.72	611.23	615.08	*616.14*	618.21	*618.67*	618.96	619.25	*619.44*	619.68

Table C1-4: Whittemore Branch Flood Frequency Profiles - Future Conditions

Mill Creek Backwater elevations in Bold Red Italic

Mill Creek Backwater at Mouth Whittemore Branch

13.305		*501.45*	*503.44*	*505.72*	*507.76*	*509.14*	*510.38*	*511.61*	*513.08*	*Mouth of Whittemore Branch*

	Stream	2 -Year	5 -Year	10 -Year	25 -Year	50 -Year	100 -Year	200 -Year	500 -Year
River	Invert	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev
Station	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88	NAVD 88
16681.13	613.16	617.86	*618.41*	619.00	*619.50*	619.86	620.26	*620.65*	621.18
16730.17	613.96	618.29	*618.88*	619.46	*619.92*	620.23	620.59	*620.89*	621.16
16782.23	614.80	619.21	*620.06*	621.89	*622.09*	622.23	622.39	*622.50*	622.58
16831.92	614.99	619.58	*620.39*	622.08	*622.37*	622.65	622.99	*623.26*	623.69
16943.07	615.43	620.63	*621.38*	622.52	*622.88*	623.15	623.45	*623.69*	624.01
17010.54	614.83	621.04	*621.84*	622.85	*623.25*	623.55	623.88	*624.12*	624.44
17065.79	614.83	621.23	*622.95*	623.61	*624.48*	625.25	626.22	*626.82*	627.73
17117.69	617.23	621.58	*622.86*	623.55	*624.48*	625.30	626.40	*627.26*	627.85
17196.45	617.23	623.97	*624.62*	625.41	*625.95*	626.39	626.95	*627.50*	628.03
17285.17	619.13	625.05	*625.77*	626.43	*626.94*	627.30	627.69	*628.07*	628.47
17371.64	622.73	625.65	*626.42*	627.11	*627.64*	627.97	628.30	*628.57*	628.86
17444.44	622.73	626.95	*627.91*	629.40	*630.81*	631.29	631.69	*631.98*	632.32
17493.55	623.31	627.18	*628.01*	629.17	*630.66*	631.11	631.48	*631.75*	632.05
17539.02	623.85	628.79	*629.59*	630.17	*631.02*	631.49	631.87	*632.13*	632.42
17580.24	624.33	629.45	*630.37*	631.18	*631.84*	632.27	632.70	*632.99*	633.41
17605.89	624.33	634.54	*635.02*	635.31	*635.62*	635.81	636.03	*636.14*	636.38
17625.81	624.86	634.53	*635.01*	635.30	*635.61*	635.79	636.01	*636.12*	636.36
17655.32	625.64	634.65	*635.18*	635.55	*635.93*	636.16	636.44	*636.61*	636.90
17682.61	626.37	634.65	*635.18*	635.55	*635.92*	636.15	636.42	*636.59*	636.87
17769.17	627.25	635.07	*636.06*	637.14	*637.99*	638.39	638.72	*638.92*	639.23
17850.65	627.46	635.13	*636.13*	637.22	*638.11*	638.53	638.89	*639.18*	639.52
18012.86	627.89	635.20	*636.20*	637.27	*638.13*	638.53	638.88	*639.16*	639.48
18087.12	627.60	635.28	*636.30*	637.38	*638.24*	638.65	639.01	*639.29*	639.63
18181.13	627.60	635.52	*636.84*	638.40	*639.82*	640.74	641.79	*642.76*	644.17
18249.81	629.37	635.60	*636.93*	638.50	*639.90*	640.83	641.88	*642.87*	644.29
18365.18	632.00	635.78	*637.13*	638.66	*640.01*	640.90	641.91	*642.86*	644.25
18589.1	635.35	639.21	*639.83*	640.67	*641.57*	642.21	642.94	*643.67*	644.81

APPENDIX C2
MILL CREEK WATERSHED
FEASIBILITY STUDY
FLOODWAY DATA

Table C2-1: Mill Creek Floodway Data

Bold/Blue/Italic indicates Backwater from Cumberland River Station 1006699 (2012 FIS Update)

Flooding Source	Floodway			Base Flood			
		Section	Mean	Water Surface Elevation			
Mill Creek	Width	Area	Velocity	(Feet NAVD 88)			
River Mile	(Feet)	(Sq. Ft.)	(fps)	Regulatory	Without Floodway	With Floodway	Increase
0.145	150	4363	7.2	***417.6***	410.5	410.6	0.1
0.362	550	4473	7.1	***417.6***	410.9	411.0	0.1
0.526	720	9117	3.5	***417.6***	412.6	412.6	0.0
0.692	270	4078	7.7	***417.6***	412.5	412.6	0.1
0.855	112	3464	9.7	***417.6***	412.8	413.1	0.2
0.872	112	3441	9.6	***417.6***	413.3	413.5	0.2
1.038	640	6790	4.6	***417.6***	415.1	415.2	0.1
1.277	1420	7241	4.4	***417.6***	415.4	415.6	0.2
1.513	1000	7975	4.0	***417.6***	416.6	416.6	0.0
1.709	505	5594	5.6	***417.6***	417.0	417.2	0.3
1.834	482	3708	8.4	***417.6***	417.0	417.2	0.2
2.036	333	4760	6.7	419.7	419.7	419.8	0.1
2.216	160	3547	8.8	420.7	420.7	420.7	0.1
2.240	150	3248	9.6	420.6	420.6	420.7	0.1
2.346	205	4108	7.6	422.1	422.1	422.2	0.1
2.459	233	4938	6.3	422.9	422.9	423.0	0.1
2.596	240	5584	5.6	423.3	423.3	423.5	0.1
2.861	210	3635	8.6	424.5	424.5	424.6	0.1
3.021	203	3834	8.1	425.8	425.8	426.1	0.3
3.073	215	2906	10.7	425.7	425.7	425.9	0.2
3.134	250	3893	8.0	427.1	427.1	427.1	0.0
3.210	270	4048	7.7	427.6	427.6	427.8	0.2
3.217	270	4884	6.4	429.5	429.5	430.1	0.6
3.231	270	5130	6.1	429.6	429.6	430.2	0.7
3.260	310	5189	6.0	430.3	430.3	430.8	0.5
3.275	295	5102	6.2	430.8	430.8	431.7	0.9
3.316	410	8913	3.5	431.5	431.5	432.3	0.8
3.388	337	6834	4.5	431.5	431.5	432.3	0.7
3.495	232	5167	6.0	431.6	431.6	432.5	0.9
3.522	232	5330	5.8	432.2	432.2	433.2	1.0
3.586	350	6588	4.7	432.6	432.6	433.3	0.6
3.806	935	15294	2.0	433.1	433.1	434.0	0.9
3.983	275	4444	6.9	432.7	432.7	433.7	1.0
4.313	325	3196	9.6	434.7	434.7	435.3	0.6
4.433	304	2510	12.2	435.3	435.3	435.8	0.6
4.672	375	4331	7.1	439.9	439.9	440.0	0.1
4.802	230	2954	10.4	440.8	440.8	441.2	0.3
4.828	280	3682	8.3	443.7	443.7	444.7	1.0
4.863	296	3422	9.0	443.8	443.8	444.7	0.9
5.030	782	10419	2.9	446.9	446.9	447.6	0.6
5.270	450	5530	5.5	447.6	447.6	448.1	0.6
5.424	400	5010	6.1	448.1	448.1	448.8	0.7
5.651	370	4241	7.2	449.9	449.9	450.4	0.5
5.813	424	4577	6.7	451.3	451.3	451.7	0.4
6.118	600	6476	4.7	454.0	454.0	454.1	0.2
6.320	543	4278	7.2	454.7	454.7	454.9	0.2
6.347	470	4458	6.9	456.4	456.4	457.4	1.0
6.407	295	3839	8.0	457.1	457.1	457.7	0.7
6.535	300	4565	6.7	458.4	458.4	458.8	0.4

Table C2-1: Mill Creek Floodway Data

Bold/Blue/Italic indicates Backwater from Cumberland River Station 1006699 (2012 FIS Update)

Flooding Source	Floodway			Base Flood			
		Section	Mean	Water Surface Elevation			
Mill Creek	Width	Area	Velocity	(Feet NAVD 88)			
River Mile	(Feet)	(Sq. Ft.)	(fps)	Regulatory	Without	With	Increase
					Floodway	Floodway	
6.707	610	10257	3.0	460.1	460.1	460.4	0.3
6.916	470	7277	4.2	460.3	460.3	460.8	0.5
7.050	158	2548	12.0	460.3	460.3	460.8	0.5
7.070	152	2581	11.8	461.7	461.7	461.8	0.0
7.101	296	5040	6.1	463.5	463.5	463.5	0.0
7.132	313	4929	6.2	463.6	463.6	463.6	0.0
7.287	285	4388	7.0	464.5	464.5	464.6	0.0
7.321	229	5013	6.1	465.6	465.6	465.5	0.0
7.343	242	5328	5.7	466.6	466.6	466.8	0.3
7.434	375	5853	5.2	466.7	466.7	467.0	0.3
7.481	422	6135	5.0	467.5	467.5	467.6	0.1
7.585	460	6524	4.7	468.0	468.0	468.1	0.1
7.637	470	7066	4.3	468.1	468.1	468.3	0.2
7.719	455	5395	5.7	468.2	468.2	468.5	0.2
7.793	252	3570	8.6	468.2	468.2	468.4	0.2
7.865	455	4902	5.4	468.7	468.7	469.5	0.8
7.916	427	4409	6.0	468.7	468.7	469.5	0.8
8.046	455	4486	5.9	469.2	469.2	470.0	0.8
8.143	439	3740	7.1	469.5	469.5	470.3	0.8
8.168	460	3204	8.2	469.6	469.6	470.3	0.8
8.180	440	3664	7.2	470.6	470.6	471.4	0.9
8.210	240	2956	8.9	470.5	470.5	471.4	0.9
8.282	240	2965	8.9	471.7	471.7	471.8	0.1
8.322	162	3188	8.3	471.5	471.5	472.4	0.9
8.332	162	3270	8.1	471.9	471.9	472.9	1.0
8.363	248	3315	8.0	472.0	472.0	472.9	0.9
8.611	160	2471	10.5	475.2	475.2	475.7	0.5
8.802	430	5103	5.1	478.6	478.6	478.9	0.3
8.999	455	3630	7.1	479.7	479.7	479.7	0.1
9.178	446	6237	4.1	482.4	482.4	482.6	0.3
9.385	395	4704	6.3	483.0	483.0	483.5	0.6
9.498	403	4630	6.4	483.9	483.9	484.4	0.5
9.546	430	4798	6.6	483.9	483.9	484.5	0.6
9.576	471	4014	9.6	483.7	483.7	484.4	0.7
9.588	482	5227	6.3	486.1	486.1	486.9	0.8
9.596	501	5892	5.6	486.3	486.3	487.1	0.9
9.609	430	3844	6.8	487.0	487.0	487.6	0.6
9.634	496	4092	6.4	487.4	487.4	488.0	0.6
9.688	480	6225	4.2	487.7	487.7	488.3	0.5
9.733	435	5666	4.6	487.9	487.9	488.5	0.5
9.809	400	5700	4.6	488.6	488.6	488.9	0.3
9.902	365	5622	4.7	488.7	488.7	489.2	0.5
10.064	295	4676	5.6	489.4	489.4	489.8	0.4
10.172	310	5270	5.0	489.8	489.8	490.4	0.7
10.260	365	5937	4.4	490.2	490.2	490.8	0.6
10.325	440	6611	4.0	490.4	490.4	491.1	0.7
10.421	415	5707	4.6	490.5	490.5	491.4	0.9
10.467	450	5613	4.7	490.7	490.7	491.5	0.8
10.557	435	4378	5.9	491.0	491.0	491.8	0.8

Table C2-1: Mill Creek Floodway Data

Bold/Blue/Italic indicates Backwater from Cumberland River Station 1006699 (2012 FIS Update)

Flooding Source	Floodway			Base Flood			
		Section	Mean	Water Surface Elevation			
Mill Creek	Width	Area	Velocity	(Feet NAVD 88)			
River Mile	(Feet)	(Sq. Ft.)	(fps)	Regulatory	Without Floodway	With Floodway	Increase
10.862	366	3073	8.5	493.8	493.8	494.0	0.3
10.910	412	4006	6.5	495.6	495.6	495.8	0.2
10.919	460	4834	5.4	495.8	495.8	496.2	0.3
10.936	425	4315	6.0	495.8	495.8	496.2	0.3
11.014	472	6835	3.8	496.8	496.8	497.2	0.4
11.076	565	4335	6.1	496.6	496.6	496.9	0.3
11.088	570	4977	5.3	497.3	497.3	497.4	0.2
11.120	575	7004	3.8	497.9	497.9	498.5	0.5
11.323	430	4246	6.3	498.2	498.2	498.9	0.6
11.432	505	4643	5.7	499.4	499.4	499.8	0.4
11.584	455	5090	5.2	500.0	500.0	500.5	0.5
11.691	200	4312	6.5	500.4	500.4	501.0	0.6
11.698	492	5439	4.9	501.6	501.6	502.3	0.7
11.727	300	3768	7.1	501.2	501.2	502.1	0.8
11.965	320	4462	6.0	503.3	503.3	503.9	0.6
12.050	355	3633	7.5	503.5	503.5	504.2	0.7
12.086	393	4933	5.5	504.9	504.9	505.3	0.5
12.105	393	5092	5.3	506.1	506.1	506.8	0.7
12.129	343	5893	4.6	506.3	506.3	507.0	0.7
12.360	439	6078	4.5	507.2	507.2	507.8	0.6
12.520	445	6452	4.2	508.0	508.0	508.5	0.5
12.677	695	8871	3.1	508.9	508.9	509.3	0.5
12.776	640	7773	3.5	509.0	509.0	509.5	0.5
12.860	560	8264	3.3	509.5	509.5	509.9	0.4
13.009	670	9760	2.8	509.9	509.9	510.4	0.6
13.095	750	10847	2.5	510.0	510.0	510.6	0.6
13.305	905	10422	2.6	510.4	510.4	511.0	0.6
13.363	1246	11876	2.3	510.5	510.5	511.2	0.7
13.375	1207	11908	2.3	510.8	510.8	511.5	0.7
13.412	1084	11508	2.4	510.9	510.9	511.5	0.6
13.503	755	6760	4.0	510.5	510.5	511.2	0.7
13.682	523	6677	4.1	512.3	512.3	512.7	0.4
13.757	692	9863	2.8	513.2	513.2	513.5	0.4
13.915	628	9683	2.8	513.6	513.6	513.9	0.3
13.961	845	9328	2.9	513.9	513.9	514.0	0.0
14.004	835	13368	2.0	517.3	517.3	517.9	0.6
14.015	888	15458	1.8	517.2	517.2	518.0	0.8
14.239	875	13488	2.0	517.5	517.5	518.3	0.8
14.415	1033	12746	2.1	517.7	517.7	518.5	0.7
14.488	1020	12038	2.2	517.8	517.8	518.5	0.7
14.533	1020	12205	2.2	518.3	518.3	519.1	0.8
14.550	1100	13306	2.0	518.4	518.4	519.1	0.8
14.825	395	3804	7.0	517.9	517.9	518.8	0.9
14.981	475	6009	4.5	520.7	520.7	521.2	0.5
15.089	280	3169	8.6	520.3	520.3	521.2	0.8
15.311	410	4984	5.5	523.7	523.7	524.0	0.3
15.525	425	5583	4.9	525.1	525.1	525.4	0.3
15.691	582	6689	4.1	525.8	525.8	526.2	0.4
15.718	630	7765	3.5	526.0	526.0	526.5	0.4

Table C2-1: Mill Creek Floodway Data

Bold/Blue/Italic indicates Backwater from Cumberland River Station 1006699 (2012 FIS Update)

Flooding Source	Floodway			Base Flood			
		Section	Mean	Water Surface Elevation			
Mill Creek	Width	Area	Velocity	(Feet NAVD 88)			
River Mile	(Feet)	(Sq. Ft.)	(fps)	Regulatory	Without	With	Increase
					Floodway	Floodway	
15.943	620	7271	3.7	526.7	526.7	527.1	0.4
16.063	935	10146	2.7	527.2	527.2	527.6	0.4
16.153	990	9582	2.8	527.3	527.3	527.7	0.4
16.167	1000	9279	2.9	527.4	527.4	527.9	0.5
16.177	1000	10440	2.6	527.5	527.5	528.1	0.5
16.412	1128	9532	2.9	528.0	528.0	528.6	0.6
16.671	515	5237	5.2	528.4	528.4	529.0	0.6
16.800	486	4904	5.6	529.4	529.4	530.0	0.6
16.855	476	4407	6.2	529.8	529.8	530.4	0.6
17.044	630	5880	4.6	531.9	531.9	532.6	0.7
17.238	610	6090	4.5	533.4	533.4	534.0	0.6
17.347	505	4000	6.8	533.8	533.8	534.6	0.8
17.358	505	5006	5.4	535.7	535.7	536.5	0.8
17.406	575	5930	4.6	536.2	536.2	536.9	0.8
17.533	845	7796	3.5	536.7	536.7	537.6	0.9
17.693	610	4637	6.5	537.0	537.0	537.8	0.8
17.806	510	5063	5.3	538.6	538.6	539.3	0.6
17.929	485	4753	5.7	539.4	539.4	540.0	0.6
18.034	473	4147	6.5	540.2	540.2	540.8	0.6
18.302	665	5470	5.1	542.6	542.6	543.3	0.6
18.651	555	5502	5.0	544.9	544.9	545.6	0.7
18.828	520	5714	4.8	545.8	545.8	546.6	0.8
19.161	530	5536	5.2	547.5	547.5	548.3	0.8
19.285	524	5213	5.6	548.3	548.3	549.0	0.6
19.416	251	3058	9.5	548.8	548.8	549.6	0.8
19.447	258	3665	7.9	550.5	550.5	550.8	0.2
19.468	409	4960	5.7	551.1	551.1	551.6	0.5
19.682	505	5461	5.2	552.4	552.4	552.8	0.5
19.896	660	6788	4.2	553.7	553.7	554.0	0.3
20.159	1050	9524	2.0	554.4	554.4	554.9	0.5
20.317	319	2630	7.4	553.7	553.7	554.5	0.9
20.541	685	5825	3.3	556.7	556.7	557.0	0.3
20.608	470	4347	4.5	557.1	557.1	557.1	0.1
20.652	432	4383	4.4	556.9	556.9	557.4	0.5
20.740	605	5537	3.5	557.5	557.5	557.8	0.4
20.782	574	5982	3.7	557.7	557.7	557.9	0.3
20.797	566	4361	4.7	557.8	557.8	558.1	0.3
20.811	790	6979	2.8	558.5	558.5	558.7	0.2
21.033	520	4509	4.3	558.9	558.9	559.2	0.3
21.120	515	4412	4.4	559.5	559.5	560.0	0.4
21.142	543	4531	4.3	559.7	559.7	560.1	0.5
21.148	543	4770	4.1	559.9	559.9	560.5	0.6
21.156	543	5026	3.9	559.9	559.9	560.6	0.6
21.223	550	4851	4.0	560.3	560.3	561.0	0.7
21.378	600	5515	3.5	561.4	561.4	562.3	0.9
21.467	627	4788	3.9	562.0	562.0	562.9	0.9
21.507	630	4784	3.9	562.6	562.6	563.3	0.7
21.514	630	4895	3.8	562.7	562.7	563.4	0.7
21.522	630	4837	3.9	562.9	562.9	563.6	0.7

Table C2-1: Mill Creek Floodway Data

Bold/Blue/Italic indicates Backwater from Cumberland River Station 1006699 (2012 FIS Update)

Flooding Source	Floodway			Base Flood			
		Section	Mean	Water Surface Elevation			
Mill Creek	Width	Area	Velocity	(Feet NAVD 88)			
River Mile	(Feet)	(Sq. Ft.)	(fps)	Regulatory	Without	With	Increase
					Floodway	Floodway	
21.554	614	4568	4.1	563.3	563.3	564.0	0.6
21.615	515	3846	4.9	564.0	564.0	564.5	0.5
21.624	510	3631	5.2	564.0	564.0	564.6	0.6
21.633	513	4133	4.6	564.5	564.5	565.2	0.7
21.651	520	3973	4.7	564.6	564.6	565.3	0.7
21.777	445	3283	5.7	565.7	565.7	566.5	0.8

Table C2-2: Sevenmile Creek Floodway Data

Bold/Red/Italic indicates Backwater from Mill Creek River Mile 7.865

Flooding Source	Floodway			Base Flood			
		Section	Mean	Water Surface Elevation			
Sevenmile Creek	Width	Area	Velocity	(Feet NAVD 88)			
River Station	(Feet)	(Sq. Ft.)	(fps)	Regulatory	Without	With	Increase
					Floodway	Floodway	
50.55858	298	2859	3.7	***468.74***	462.8	462.9	0.1
98.74029	135	1018	10.5	***468.74***	462.0	462.1	0.1
354.9965	135	2037	5.2	***468.74***	465.2	465.2	0.1
604.5016	1095	8150	1.3	***468.74***	465.7	465.7	0.0
906.094	865	5973	1.7	***468.74***	465.8	465.8	0.0
1012.432	865	5374	1.9	***468.74***	465.8	465.8	0.0
1156.009	572	2943	4.0	***468.74***	465.9	465.9	0.0
1246.114	645	2735	4.1	***468.74***	467.1	467.1	0.0
1362.794	636	2050	5.0	***468.74***	467.4	467.4	0.0
1483.269	427	1251	8.2	***468.74***	467.8	467.8	0.0
1666.545	93	982	10.4	***468.74***	468.6	468.6	0.0
1938.712	115	2055	5.0	475.97	476.0	476.0	0.0
2330.623	616	6670	1.5	476.69	476.8	476.8	0.0
2581.737	595	6031	1.8	476.73	476.8	476.8	0.0
2930.636	555	4111	2.7	476.77	476.8	476.8	0.0
3599.25	392	3070	3.6	477.37	477.4	477.5	0.1
4105.81	495	2704	4.1	478.11	478.2	478.3	0.1
4566.992	482	2808	3.9	479.48	479.5	479.6	0.0
5091.726	265	1845	6.0	480.64	480.7	481.0	0.3
5250.48	230	1573	7.7	481.02	481.0	481.6	0.5
5400.715	320	3018	5.6	483.78	483.8	484.8	1.0
5729.717	346	2004	5.5	484.23	484.3	485.2	0.9
6070.034	233	2032	5.5	485.72	485.7	486.4	0.6
6606.196	346	2368	4.7	487.25	487.3	487.9	0.7
7075.583	418	3209	3.5	488.72	488.7	489.3	0.6
7528.769	296	1799	5.7	489.14	489.2	490.1	0.9
7816.581	197	1623	6.3	491.14	491.2	491.4	0.2
8046.877	237	1701	6.0	491.90	491.9	492.6	0.7
8145.723	300	3277	3.1	498.60	498.6	499.3	0.7
8377.836	234	2222	4.6	498.69	498.7	499.4	0.7
8578.194	158	1581	6.5	498.78	498.8	499.4	0.6
8757.146	180	1711	6.0	499.44	499.5	500.2	0.7
8887.646	267	2035	5.0	499.70	499.7	500.6	0.9
8973.962	263	2136	4.8	500.66	500.7	501.2	0.5
9058.74	230	1715	6.0	500.62	500.6	501.1	0.5
9105.075	139	1291	7.9	500.68	500.7	501.0	0.3
9210.738	149	1330	7.7	500.89	500.9	501.4	0.5
9319.791	147	1701	6.0	502.51	502.5	502.5	0.0
9658.83	108	1084	9.4	502.68	502.7	502.7	0.0
9871.357	160	1289	7.9	503.86	503.9	503.9	0.0
10053.05	160	1863	5.5	505.81	505.9	505.9	0.0
10307.08	339	3057	3.4	506.45	506.5	506.5	0.0
10683.6	712	6795	1.5	506.86	506.9	507.0	0.1
11038.22	547	4723	2.1	506.96	507.0	507.1	0.1
11817.06	467	3305	3.0	507.15	507.2	507.4	0.2
12207.49	474	3376	2.9	507.56	507.6	507.9	0.3
12775.03	277	2151	4.6	508.27	508.3	508.5	0.2
13460.48	392	1613	6.1	509.79	509.8	510.1	0.3
13866.71	586	3668	2.7	511.95	512.0	512.1	0.2

Table C2-2: Sevenmile Creek Floodway Data

Bold/Red/Italic indicates Backwater from Mill Creek River Mile 7.865

Flooding Source	Floodway			Base Flood			
		Section	Mean	Water Surface Elevation			
Sevenmile Creek	Width	Area	Velocity	(Feet NAVD 88)			
River Station	(Feet)	(Sq. Ft.)	(fps)	Regulatory	Without	With	Increase
					Floodway	Floodway	
13936.34	586	3759	2.6	512.32	512.3	512.4	0.1
14112.97	538	3778	2.6	512.44	512.5	512.6	0.1
14315.7	382	2295	3.9	512.32	512.3	512.5	0.2
14862.27	326	1542	5.9	513.73	513.8	513.8	0.0
15638.59	420	1947	4.7	516.92	516.9	517.5	0.6
16452.37	411	1667	5.4	519.72	519.7	520.3	0.5
16717.7	606	4155	2.2	521.23	521.2	521.7	0.5
17801.9	508	3011	2.5	521.80	521.8	522.6	0.7
18540.11	439	1738	4.3	522.92	522.9	523.5	0.6
19118.76	449	1886	3.9	525.62	525.6	525.7	0.1
19316.05	75	522	14.2	525.37	525.4	525.6	0.2
19429.43	377	2820	2.6	531.61	531.6	532.0	0.4
19582.59	379	2799	2.7	531.68	531.7	532.2	0.5
20033	452	2827	2.6	532.00	532.0	532.5	0.5
20624.26	427	1885	3.9	532.85	532.9	533.2	0.3
21275.06	498	1963	3.8	535.69	535.7	535.7	0.0
21755.4	404	1877	4.0	537.72	537.7	537.8	0.1
21956.65	92	583	12.7	538.38	538.4	538.4	0.0
22127.21	92	987	7.5	543.05	543.1	543.1	0.0
22286.04	621	5265	1.4	544.31	544.3	544.6	0.2
22565.92	717	5365	1.4	544.40	544.4	544.6	0.2
22927.78	579	3462	2.1	544.50	544.5	544.8	0.2
23386.72	360	1757	2.5	544.97	545.0	545.3	0.3
24000.4	269	845	5.9	546.89	546.9	547.0	0.1
24206.86	205	989	5.0	548.76	548.8	549.0	0.2
24238.43	203	2002	2.5	549.42	549.4	549.8	0.4
24331.35	224	1977	2.5	549.49	549.5	549.9	0.4
24579.36	230	1895	2.7	549.78	549.7	550.1	0.4
24830.55	194	795	6.4	549.67	549.7	550.0	0.4
24932.28	238	1344	3.8	551.81	551.8	551.8	0.0
24957.09	245	1818	2.8	552.63	552.6	553.3	0.6
25010.21	266	1745	2.9	552.73	552.7	553.3	0.5
25074.12	251	1597	3.2	552.77	552.8	553.3	0.6
25148.82	232	1292	4.0	552.85	552.9	553.4	0.5
25170.45	236	1133	4.5	552.73	552.7	553.4	0.6
25290.87	237	1212	4.2	553.40	553.4	553.9	0.5
25481.06	241	1117	4.6	553.60	553.6	554.4	0.8
25694.72	190	985	4.8	554.59	554.6	555.2	0.6
25832.54	182	960	4.9	554.87	554.9	555.7	0.8
25860.2	178	1362	3.5	556.91	556.9	557.5	0.6
25999.26	197	1184	4.0	557.01	557.0	557.7	0.7
26429.81	204	963	4.9	558.10	558.1	558.8	0.7
26787.3	157	619	7.6	559.64	559.6	560.1	0.5
27294.85	225	996	3.8	563.42	563.4	564.3	0.9
27475.97	204	812	3.4	564.15	564.2	564.8	0.7
27633.62	137	513	5.4	564.75	564.8	565.3	0.5
27802.73	140	967	2.9	568.98	569.0	569.8	0.8
27885.28	166	949	2.9	569.00	569.0	569.9	0.9

Table C2-2: Sevenmile Creek Floodway Data

Bold/Red/Italic indicates Backwater from Mill Creek River Mile 7.865

Flooding Source	Floodway			Base Flood			
		Section	Mean	Water Surface Elevation			
Sevenmile Creek	Width	Area	Velocity	(Feet NAVD 88)			
River Station	(Feet)	(Sq. Ft.)	(fps)	Regulatory	Without Floodway	With Floodway	Increase
27970.91	114	647	4.3	569.19	569.2	569.9	0.7
28027.65	112	614	4.0	569.20	569.2	570.2	1.0
28092.67	194	803	3.1	569.59	569.6	570.6	1.0
28157.7	191	903	2.7	570.42	570.4	571.3	0.9
28405.57	155	696	3.6	570.85	570.9	571.6	0.8
28633.69	127	419	5.9	572.35	572.4	572.7	0.3
28779.71	174	765	3.2	574.02	574.0	574.5	0.5
28841.3	193	838	3.0	574.44	574.4	574.9	0.4
28874.6	190	628	3.9	574.99	575.0	575.1	0.1
28949.5	177	732	3.4	575.52	575.5	575.6	0.0
29104	122	504	4.4	575.84	575.8	575.8	0.0
29254.71	68	217	9.8	576.05	576.1	576.1	0.0
29313.98	50	339	6.3	578.11	578.1	578.1	0.0
29365.19	50	396	5.4	579.29	579.3	579.2	0.0
29436.84	124	652	3.3	579.64	579.6	579.6	0.0
29590.91	106	443	4.8	579.90	579.9	579.9	0.0
29689.19	135	463	4.6	580.34	580.3	580.4	0.0
29806.34	107	385	4.7	580.79	580.8	581.3	0.5
29907.91	75	282	6.4	581.04	581.0	581.9	0.9
29985.28	51	219	8.2	581.97	582.0	582.7	0.7
30046.42	72	378	4.7	584.14	584.1	584.8	0.6
30163.82	38	201	8.9	584.06	584.1	584.9	0.9
30361.92	41	189	3.0	587.15	587.2	587.2	0.1
30487.81	23	118	4.8	587.32	587.3	587.4	0.0
30637.51	24	120	4.7	587.96	588.0	588.0	0.0
30810.68	29	132	4.3	588.57	588.6	588.6	0.0
30874.46	31	203	2.8	588.93	588.9	589.0	0.0
30930.17	31	209	2.7	589.10	589.1	589.1	0.0
31018.51	19	87	6.5	589.02	589.0	589.1	0.0
31203.94	19	76	7.4	590.87	590.9	590.9	0.1
31394.58	20	82	6.9	593.10	593.1	593.1	0.0
31602.46	20	81	7.0	595.05	595.1	595.1	0.0
31749.15	25	64	8.8	597.78	597.8	597.8	0.0
31850.33	35	132	4.3	600.07	600.1	600.1	0.0
31903.63	35	100	5.6	600.13	600.1	600.1	0.0
31988.26	29	70	8.1	600.98	601.0	601.0	0.0
32287.75	34	108	5.2	604.49	604.5	604.5	0.0
32590.98	29	134	4.2	605.78	605.8	605.8	0.0
32851.41	17	54	10.4	607.67	607.7	607.7	0.0
33087.43	33	93	6.1	612.48	612.5	612.5	0.0
33393.28	18	60	4.4	615.18	615.2	615.2	0.0
33680.74	32	42	6.3	619.66	619.7	619.7	0.0
33843.91	35	67	3.9	622.63	622.6	622.6	0.0
33940.83	35	47	5.6	624.88	624.9	624.9	0.0
34076.92	33	377	0.7	638.69	638.7	639.1	0.4
34368.4	80	497	0.5	638.69	638.7	639.2	0.5
34627.42	21	47	9.0	640.30	640.3	640.3	0.0
34829.09	24	58	7.2	643.47	643.5	643.5	0.0

Table C2-2: Sevenmile Creek Floodway Data

Bold/Red/Italic indicates Backwater from Mill Creek River Mile 7.865

Flooding Source	Floodway			Base Flood			
		Section	Mean	Water Surface Elevation			
Sevenmile Creek	Width	Area	Velocity	(Feet NAVD 88)			
River Station	(Feet)	(Sq. Ft.)	(fps)	Regulatory	Without	With	Increase
					Floodway	Floodway	
35000.3	20	47	8.9	647.83	647.8	647.9	0.0
35282.04	64	93	4.5	657.58	657.6	657.8	0.2
35364.19	27	53	7.9	659.79	659.8	659.8	0.0
35414.63	28	188	2.2	667.48	667.5	667.9	0.5
35526.69	23	88	4.8	667.39	667.4	667.8	0.4
35607.82	22	68	7.1	667.31	667.3	667.8	0.5
35689.38	22	64	7.6	668.74	668.7	668.8	0.0
35852.27	49	201	1.3	670.81	670.8	670.8	0.0
35941.25	21	49	5.3	670.60	670.6	670.6	0.0
35965.94	27	41	6.4	682.90	682.9	682.9	0.0
36000.93	27	41	6.3	684.93	684.9	685.0	0.0
36159.45	22	36	7.2	691.14	691.1	691.2	0.0
36322.45	21	35	7.4	697.74	697.7	697.7	0.0
36440.97	24	37	6.9	702.05	702.1	702.1	0.0
36617.2	20	34	7.6	708.74	708.7	708.7	0.0
36717.9	20	36	7.2	712.59	712.6	712.6	0.0
36830.3	19	40	6.4	715.70	715.7	715.8	0.1
36898.88	25	38	6.8	717.71	717.7	717.7	0.0
36991.73	25	150	1.7	724.29	724.3	725.0	0.7
37046.43	40	48	5.4	725.40	725.4	725.4	0.0
37112.44	43	48	5.4	727.87	727.9	727.9	0.0

Table C2-3: Sorghum Branch Floodway Data

Bold/Red/Italic indicates Backwater from Mill Creek River Mile 8.611

Flooding Source	Floodway			Base Flood			
		Section	Mean	Water Surface Elevation			
Sorghum Branch	Width	Area	Velocity	(Feet NAVD 88)			
River Station	(Feet)	(Sq. Ft.)	(fps)	Regulatory	Without Floodway	With Floodway	Increase
99.43906	34	165	7.4	***475.20***	463.1	463.1	0.0
229.3311	34	119	10.3	***475.20***	464.4	464.4	0.1
333.1076	19	123	10.0	***475.20***	466.5	466.7	0.2
449.9857	16	107	11.4	***475.20***	467.0	467.6	0.6
543.0981	26	239	5.1	***475.20***	470.1	470.3	0.2
634.6407	26	237	5.2	***475.20***	470.3	470.4	0.1
703.2004	20	161	7.6	***475.20***	470.3	470.4	0.2
794.1959	50	385	3.2	***475.20***	474.0	474.0	0.0
842.413	50	474	2.6	***475.20***	474.3	474.3	0.0
889.9554	75	532	2.3	***475.20***	474.3	474.3	0.0
1352.194	110	553	4.6	***475.20***	474.6	474.7	0.0
1488.255	148	464	7.3	475.97	476.0	476.0	0.0
1613.987	125	613	5.0	477.13	477.1	477.6	0.4
1750.717	159	551	4.6	478.06	478.1	478.1	0.1
1830.868	180	639	4.0	478.20	478.2	478.5	0.3
1875.579	191	847	3.1	478.47	478.5	478.8	0.3
1930.666	188	787	3.3	478.50	478.5	478.8	0.3
2092.968	194	779	3.3	478.81	478.8	479.1	0.3
2503.566	197	747	3.4	479.48	479.5	479.9	0.4
2887.314	130	401	6.4	480.37	480.4	480.9	0.5
3021.489	161	564	4.5	482.24	482.2	482.4	0.2
3072.763	144	585	4.4	482.85	482.9	483.5	0.6
3257.271	105	364	7.0	483.51	483.5	484.0	0.5
3489.778	130	503	5.1	485.65	485.7	485.7	0.1
3607.842	135	540	4.7	486.17	486.2	486.3	0.2
3745.908	45	375	6.8	486.29	486.3	486.7	0.4
3844.353	37	419	6.1	489.23	489.2	489.7	0.5
4104.79	94	709	3.6	490.09	490.1	490.5	0.4
4352.364	113	415	6.1	490.11	490.1	490.6	0.5
4642.547	111	566	4.5	492.26	492.3	492.5	0.3
4887.879	31	222	11.5	492.85	492.9	493.2	0.3
5265.231	33	395	6.5	500.35	500.4	500.4	0.0
5350.791	90	730	3.5	500.89	500.9	500.9	0.0
5520.771	75	520	4.8	501.05	501.1	501.1	0.0
5629.878	38	330	7.5	501.03	501.0	501.1	0.0
5918.411	43	576	4.3	507.54	507.5	507.5	0.0
6256.521	115	677	3.7	507.82	507.8	507.9	0.1
6549.714	48	293	8.5	507.88	507.9	508.0	0.1
6760.614	39	346	6.2	509.36	509.4	509.5	0.1
6849.149	54	385	5.6	509.78	509.8	509.9	0.1
6983.726	55	516	4.4	512.69	512.7	513.3	0.6
7066.032	51	420	5.1	512.77	512.8	513.3	0.5
7281.266	42	334	6.4	512.88	512.9	513.5	0.6
7531.359	65	297	7.2	513.37	513.4	513.9	0.6
7656.953	85	349	6.1	514.70	514.7	514.7	0.0
7965.322	128	378	5.7	515.86	515.9	516.0	0.1
8309.187	165	733	2.9	517.55	517.6	518.1	0.6
8832.558	112	371	5.6	519.09	519.1	519.5	0.4
9221.274	102	328	6.4	522.94	522.9	523.0	0.0

Table C2-3: Sorghum Branch Floodway Data

Bold/Red/Italic indicates Backwater from Mill Creek River Mile 8.611

Flooding Source	Floodway			Base Flood			
		Section	Mean	Water Surface Elevation			
Sorghum Branch	Width	Area	Velocity	(Feet NAVD 88)			
River Station	(Feet)	(Sq. Ft.)	(fps)	Regulatory	Without Floodway	With Floodway	Increase
9683.394	85	363	5.1	526.43	526.4	527.1	0.7
10080.84	95	389	4.7	528.80	528.8	529.3	0.5
10379.91	86	288	6.4	530.50	530.5	531.1	0.6
10531.72	72	302	6.5	531.80	531.8	532.7	0.9
10589.88	74	422	5.7	533.50	533.5	534.5	1.0
10743.38	125	489	3.8	534.51	534.5	535.2	0.7
10930.71	123	257	7.2	535.20	535.2	535.2	0.0
11196.66	105	339	5.4	537.71	537.7	537.9	0.2
11332.84	129	310	5.3	538.66	538.7	538.7	0.0
11447.35	18	141	11.7	539.69	539.7	539.8	0.1
11503.88	79	487	5.2	543.59	543.6	544.5	0.9
11650.38	168	1025	1.6	544.52	544.5	545.3	0.8
11850.8	187	1094	1.5	544.59	544.6	545.4	0.8
12202.48	115	558	3.0	544.76	544.8	545.6	0.8
12526.06	156	476	3.5	545.42	545.4	546.1	0.7
12814.73	113	285	5.8	546.76	546.8	546.9	0.1
13031.49	46	186	7.2	548.27	548.3	548.3	0.0
13361	42	175	7.7	550.12	550.1	550.1	0.0
13564.62	27	151	8.9	551.40	551.4	551.4	0.0
13810.29	27	147	9.1	553.41	553.4	553.4	0.0
13996.18	23	108	12.5	555.72	555.7	555.7	0.0
14177.88	179	302	4.4	559.89	559.9	559.9	0.0
14231.46	246	523	2.6	561.71	561.7	561.7	0.0
14375.15	51	179	7.5	561.87	561.9	561.9	0.0
14624.73	150	354	3.8	564.32	564.3	564.3	0.0
15008.61	76	168	8.0	568.48	568.5	568.5	0.0
15299.34	86	230	5.8	572.14	572.1	572.1	0.0
15587.3	38	133	10.1	574.48	574.5	574.6	0.2
15698.76	39	161	8.3	576.39	576.4	576.4	0.0
15877.57	55	190	7.1	578.22	578.2	578.4	0.1
16096.59	77	173	7.8	581.01	581.0	581.1	0.0
16212.03	62	159	8.4	582.54	582.5	582.6	0.0
16253.14	22	135	10.0	583.05	583.1	583.1	0.0
16319.42	49	201	7.3	584.71	584.7	584.8	0.0
16385.08	52	216	6.2	585.37	585.4	585.4	0.0
16444.06	49	215	4.0	585.95	586.0	586.0	0.0
16504.12	29	90	9.6	585.57	585.6	585.6	0.0
16555.86	29	128	6.7	587.10	587.1	587.3	0.2
16624.32	46	209	4.1	587.94	587.9	588.1	0.1
16830.05	40	141	4.9	588.32	588.3	588.4	0.1
16978.29	23	82	8.4	588.74	588.7	588.9	0.1
17145.97	17	73	9.4	591.19	591.2	591.4	0.2
17262.46	32	101	6.8	593.21	593.2	593.3	0.1
17340.81	27	89	7.7	593.79	593.8	594.0	0.2
17424.81	19	84	8.2	594.63	594.6	594.9	0.3
17493.31	19	67	10.2	596.06	596.1	596.1	0.1
17527.76	14	59	11.6	597.50	597.5	597.6	0.1
17558.1	27	163	4.2	601.46	601.5	601.8	0.3

Table C2-3: Sorghum Branch Floodway Data

Bold/Red/Italic indicates Backwater from Mill Creek River Mile 8.611

Flooding Source	Floodway			Base Flood			
		Section	Mean	Water Surface Elevation			
Sorghum Branch	Width	Area	Velocity	(Feet NAVD 88)			
River Station	(Feet)	(Sq. Ft.)	(fps)	Regulatory	Without Floodway	With Floodway	Increase
17581.91	37	249	2.8	601.72	601.7	602.0	0.3
17637.99	38	253	2.7	601.82	601.8	602.1	0.2
17674.56	42	258	2.9	601.82	601.8	602.1	0.3
17698.86	42	259	3.0	601.85	601.9	602.2	0.3
17724.15	41	269	2.5	601.93	601.9	602.3	0.3
17759.71	36	245	2.8	601.93	601.9	602.3	0.3
17820.62	36	201	3.4	601.93	601.9	602.3	0.3
17840.7	34	198	3.9	601.93	601.9	602.3	0.4
17861.77	37	235	3.3	602.45	602.5	603.2	0.8
17898.51	32	198	3.5	602.48	602.5	603.3	0.8
18053.14	27	128	5.4	602.66	602.7	603.4	0.7
18178.73	22	86	8.0	603.39	603.4	603.7	0.3
18332.43	16	70	9.8	605.49	605.5	605.6	0.1
18479.11	20	89	7.7	607.66	607.7	608.0	0.3
18589.15	18	64	10.7	609.15	609.2	609.2	0.0
18659.13	90	170	4.0	611.60	611.6	611.6	0.0
18756.4	71	147	4.6	612.07	612.1	612.1	0.0
18808.11	30	102	6.7	612.22	612.2	612.2	0.0
18931.78	24	109	6.3	613.07	613.1	613.1	0.0
19029.73	21	82	8.4	613.53	613.5	613.6	0.0
19181.85	22	73	9.3	615.61	615.6	615.7	0.1
19254.46	22	68	10.0	617.22	617.2	617.2	0.0

Table C2-3: Whittemore Branch Floodway Data

Bold/Red/Italic indicates Backwater from Mill Creek River Mile 13.305

Flooding Source	Floodway			Base Flood			
		Section	Mean	Water Surface Elevation			
Whittemore Branch	Width	Area	Velocity	(Feet NAVD 88)			
River Station	(Feet)	(Sq. Ft.)	(fps)	Regulatory	Without Floodway	With Floodway	Increase
91.34178	53	440	10.0	***510.38***	495.1	495.1	0.0
348.5757	49	423	10.4	***510.38***	496.7	496.7	0.0
672.6573	56	480	9.2	***510.38***	499.1	499.1	0.1
1138.872	44	402	11.0	***510.38***	501.5	501.7	0.1
1544.734	185	864	5.1	***510.38***	504.8	504.8	0.0
1868.71	203	813	5.4	***510.38***	505.8	506.1	0.3
2208.971	36	404	10.9	***510.38***	507.1	507.9	0.8
2500.824	44	713	6.2	513.74	513.7	514.1	0.3
2799.648	367	2894	1.5	514.59	514.6	514.9	0.3
3254.177	267	1601	3.2	514.71	514.7	515.0	0.3
3706.334	141	802	6.4	515.33	515.3	515.5	0.2
4261.212	65	457	11.3	517.74	517.7	517.9	0.1
4805.898	127	684	7.5	523.58	523.6	523.6	0.0
5088.175	150	1015	5.1	525.72	525.7	526.2	0.5
5265.63	129	808	6.4	526.14	526.1	526.7	0.6
5340.409	283	1059	4.9	526.74	526.7	527.7	1.0
5465.904	287	1841	2.8	527.65	527.7	528.5	0.8
5796.573	308	1815	2.8	528.37	528.4	528.9	0.6
5961.832	400	1242	2.8	528.65	528.7	529.2	0.5
6414.732	292	699	5.0	530.92	530.9	531.0	0.1
6531.309	181	687	6.3	533.88	533.9	533.9	0.0
6557.823	171	811	4.7	534.59	534.6	535.1	0.5
6685.265	165	835	4.2	535.43	535.4	535.6	0.2
6889.102	161	688	5.0	535.83	535.8	536.0	0.1
7201.942	188	682	5.1	537.74	537.7	537.9	0.1
7537.021	130	534	6.5	540.26	540.3	540.3	0.0
7917.563	105	483	7.2	543.88	543.9	544.1	0.2
8175.323	210	1033	3.4	546.27	546.3	546.3	0.1
8534.703	239	601	5.8	547.25	547.3	547.4	0.2
8778.572	206	684	5.1	549.79	549.8	549.8	0.0
8987.559	165	731	4.7	551.37	551.4	551.5	0.1
9106.154	178	498	7.0	551.71	551.7	551.9	0.1
9147.164	248	933	3.7	552.93	552.9	553.0	0.1
9229.091	247	1094	3.2	553.31	553.3	553.4	0.1
9293.79	279	1225	2.6	553.67	553.7	553.7	0.0
9356.652	247	970	3.3	553.59	553.6	553.6	0.0
9432.692	226	855	3.7	553.71	553.7	553.7	0.0
9668.316	239	809	3.9	554.33	554.3	554.5	0.1
9813.415	188	454	8.4	554.92	554.9	555.0	0.1
9931.14	288	1416	2.2	559.10	559.1	559.4	0.3
9986.33	175	892	3.6	559.14	559.1	559.5	0.3
10131.03	76	521	6.1	559.12	559.1	559.5	0.4
10178.89	50	443	7.2	559.25	559.3	559.7	0.4
10222.73	54	500	6.3	560.52	560.5	560.8	0.3
10280.72	80	555	5.7	560.55	560.6	560.9	0.3
10538.19	108	678	4.7	561.80	561.8	562.0	0.2
10764.63	140	829	3.8	562.86	562.9	562.9	0.0
10886.6	165	756	4.2	563.22	563.2	563.4	0.1
10918.84	158	856	3.7	563.87	563.9	564.1	0.2

Table C2-3: Whittemore Branch Floodway Data
Bold/Red/Italic indicates Backwater from Mill Creek River Mile 13.305

Flooding Source	Floodway			Base Flood			
		Section	Mean	Water Surface Elevation			
Whittemore Branch	Width	Area	Velocity	(Feet NAVD 88)			
River Station	(Feet)	(Sq. Ft.)	(fps)	Regulatory	Without	With	Increase
					Floodway	Floodway	
10990.34	144	762	4.2	564.09	564.1	564.3	0.2
11318.59	134	615	5.2	565.65	565.7	565.9	0.3
11539.1	160	683	4.0	567.67	567.7	568.0	0.3
11722.58	211	685	4.0	569.25	569.3	569.3	0.0
12079.57	175	466	5.9	573.01	573.0	573.1	0.1
12166.32	176	425	6.4	574.32	574.3	574.4	0.0
12228.52	220	1204	2.3	577.34	577.3	577.7	0.4
12290.93	276	881	3.1	577.33	577.3	577.7	0.4
12409.23	251	710	2.8	577.95	578.0	578.3	0.3
12548.89	133	340	5.8	578.72	578.7	578.9	0.2
12667.26	159	351	5.9	581.15	581.2	581.2	0.0
12738.07	180	587	3.4	583.07	583.1	583.1	0.0
12790.71	160	568	3.5	583.27	583.3	583.3	0.0
13039.69	135	327	6.0	585.33	585.3	585.6	0.3
13347.89	196	593	3.3	588.69	588.7	588.9	0.2
13590.49	180	521	3.8	590.17	590.2	590.2	0.1
13884.41	260	492	4.0	592.52	592.5	592.7	0.2
14129.62	205	513	3.9	594.65	594.7	594.7	0.0
14495.51	133	400	5.0	597.27	597.3	597.5	0.2
14820.69	66	285	6.9	599.95	600.0	600.0	0.0
15001.79	58	318	6.2	601.72	601.7	601.8	0.1
15063.95	68	833	2.4	602.81	602.8	603.1	0.3
15113.94	67	836	2.4	602.90	602.9	603.2	0.3
15125.15	87	970	2.0	602.93	602.9	603.2	0.3
15139.18	66	581	3.4	602.88	602.9	603.2	0.3
15245.1	66	608	3.3	603.28	603.3	603.5	0.3
15284.9	84	800	2.5	603.43	603.4	603.7	0.3
15317.37	69	645	3.1	603.44	603.4	603.7	0.3
15354.96	68	642	3.1	603.59	603.6	603.9	0.3
15386.32	118	1116	1.8	603.75	603.8	604.0	0.3
15411.6	64	583	3.4	603.71	603.7	604.0	0.3
15444.71	67	624	3.2	603.87	603.9	604.1	0.3
15466.86	86	736	2.7	603.96	604.0	604.2	0.3
15484.57	65	535	3.7	603.94	603.9	604.2	0.3
15524.61	67	565	3.5	604.19	604.2	604.4	0.2
15549.35	92	716	2.8	604.34	604.3	604.6	0.2
15569.45	65	484	4.1	604.31	604.3	604.5	0.2
15622.93	66	517	3.8	604.73	604.7	604.9	0.2
15637.98	43	347	5.7	604.72	604.7	604.9	0.2
15682.64	27	148	13.4	606.60	606.6	606.6	0.0
15830.08	140	397	4.1	610.85	610.9	610.8	0.0
15903.21	124	327	5.0	610.92	610.9	611.0	0.1
16008.78	108	284	5.7	612.13	612.1	612.2	0.0
16259.62	115	314	5.2	614.84	614.8	614.8	0.0
16346.29	39	231	7.0	615.37	615.4	615.4	0.0
16448.69	55	426	4.2	619.31	619.3	619.8	0.5
16561.72	33	210	7.7	619.25	619.3	619.8	0.5
16681.13	39	174	7.1	620.26	620.3	620.6	0.3

Table C2-3: Whittemore Branch Floodway Data
Bold/Red/Italic indicates Backwater from Mill Creek River Mile 13.305

Flooding Source	Floodway			Base Flood			
		Section	Mean	Water Surface Elevation			
Whittemore Branch	Width	Area	Velocity	(Feet NAVD 88)			
River Station	(Feet)	(Sq. Ft.)	(fps)	Regulatory	Without Floodway	With Floodway	Increase
16730.17	30	148	8.3	620.59	620.6	620.9	0.3
16782.23	40	224	5.5	622.39	622.4	623.2	0.8
16831.92	44	219	5.6	622.99	623.0	623.4	0.5
16943.07	37	192	6.4	623.45	623.5	623.9	0.5
17010.54	18	160	7.7	623.88	623.9	624.3	0.4
17065.79	24	201	6.1	626.22	626.2	626.6	0.4
17117.69	38	185	6.7	626.40	626.4	626.8	0.4
17196.45	38	189	6.5	626.95	627.0	627.3	0.3
17285.17	38	176	7.0	627.69	627.7	628.0	0.3
17371.64	24	129	9.6	628.30	628.3	628.6	0.3
17444.44	25	227	5.4	631.69	631.7	632.5	0.8
17493.55	34	189	6.5	631.48	631.5	632.5	1.0
17539.02	34	165	7.5	631.87	631.9	632.6	0.8
17580.24	22	144	8.6	632.70	632.7	633.0	0.3
17605.89	45	344	4.0	636.03	636.0	637.0	1.0
17625.81	44	298	4.1	636.01	636.0	637.0	1.0
17655.32	44	309	2.4	636.44	636.4	637.4	0.9
17682.61	34	261	2.8	636.42	636.4	637.4	0.9
17769.17	62	339	2.3	638.72	638.7	639.0	0.3
17850.65	36	291	2.5	638.89	638.9	639.2	0.3
18012.86	33	196	3.8	638.88	638.9	639.2	0.3
18087.12	21	166	4.4	639.01	639.0	639.3	0.3
18181.13	25	234	3.2	641.79	641.8	642.1	0.3
18249.81	44	272	2.7	641.88	641.9	642.2	0.3
18365.18	23	140	5.3	641.91	641.9	642.2	0.3
18589.1	16	96	7.7	642.94	642.9	643.1	0.2

HYDROLOGY AND HYDRAULICS

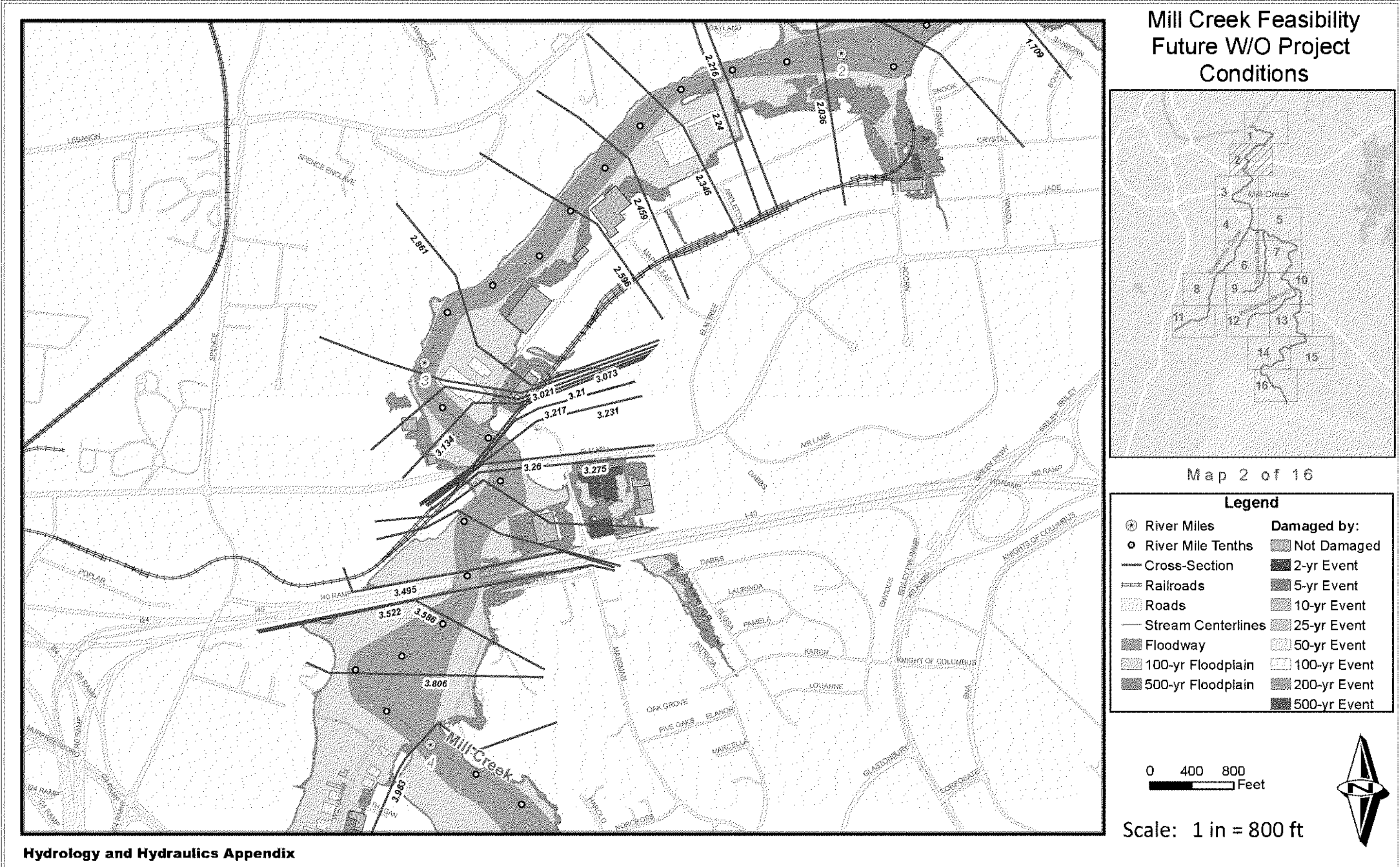
APPENDIX C3

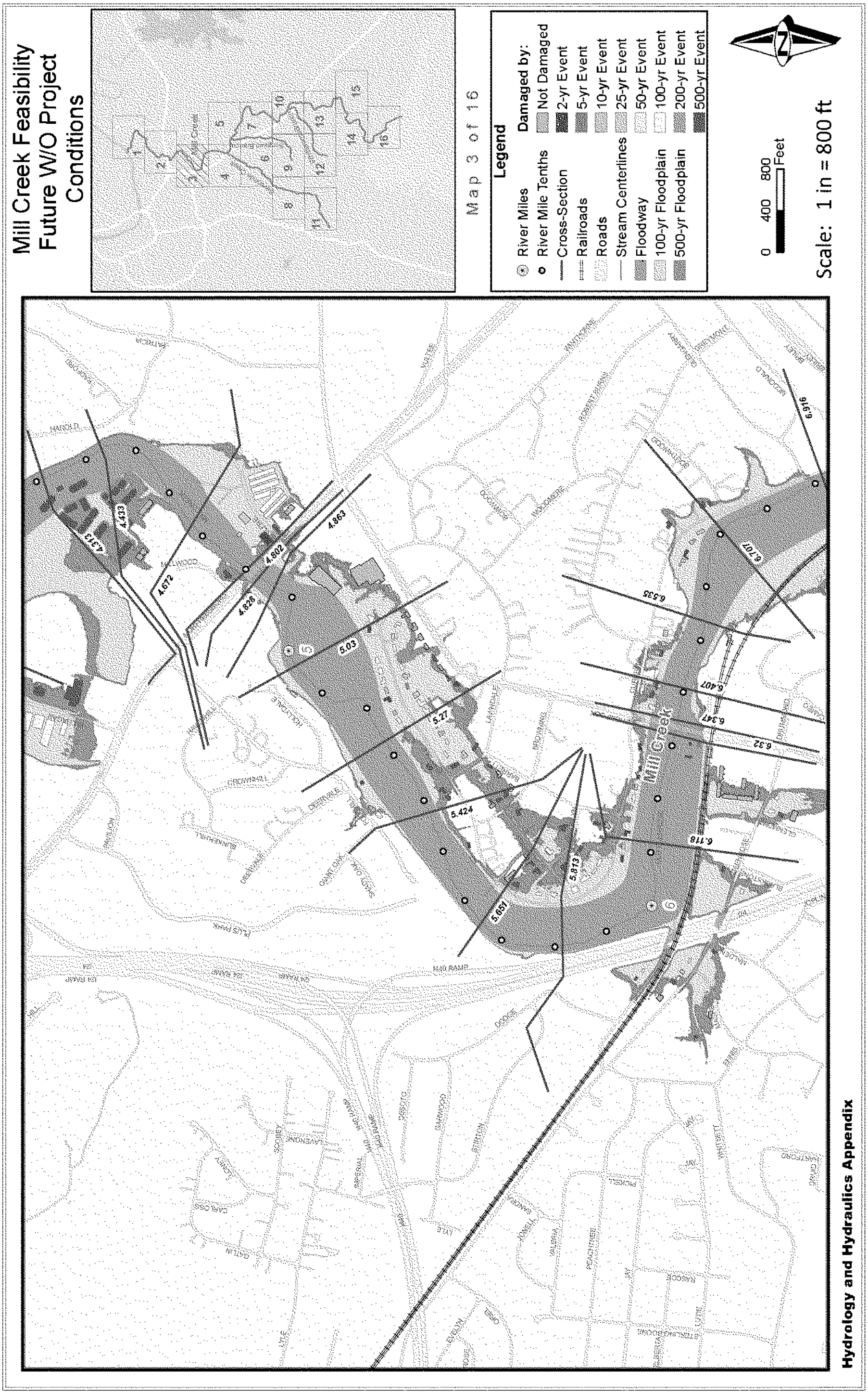
FUTURE WITHOUT PROJECT CONDITIONS

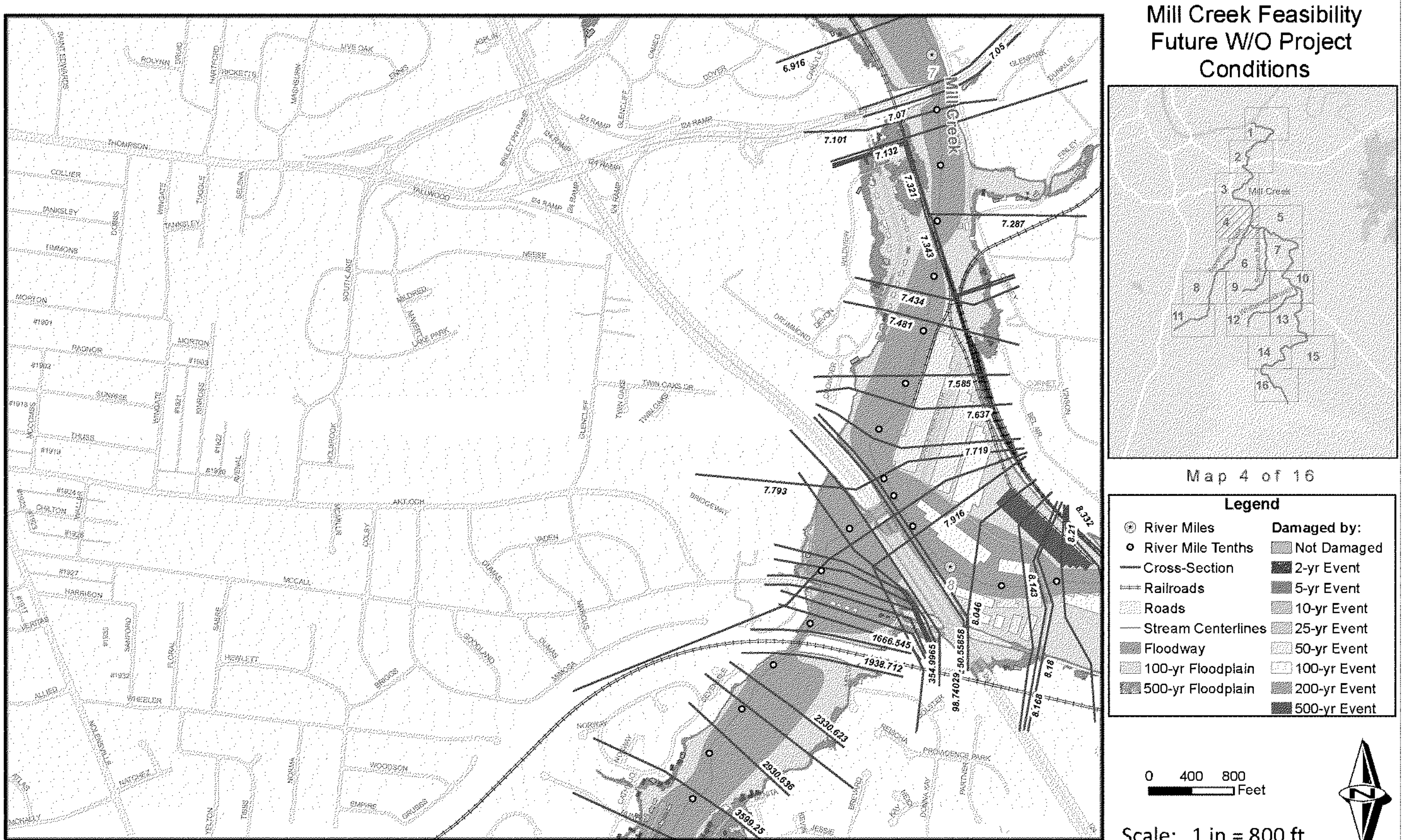
INUNDATION MAPS

US Army Corps
of Engineers ®
Nashville District


Mill Creek Feasibility
Future W/O Project
Conditions
Map 1 of 16
Legend
River Miles
River Mile Tenths
Cross-Section
Railroads
Roads
Stream Centerlines
Floodway
100-yr Floodplain
500-yr Floodplain
Damaged by:
Not Damaged
2-yr Event
5-yr Event
10-yr Event
25-yr Event
50-yr Event
100-yr Event
200-yr Event
500-yr Event
0 400 800
Feet
Scale: 1 in = 800 ft
Mill Creek
0.145
0.362
0.526
0.692
0.855
0.872
1.038
1.277
1.513
1.709
1.834
2.036
2.24
Hydrology and Hydraulics Appendix


Mill Creek Feasibility
Future W/O Project
Conditions
Map 2 of 16
Legend
River Miles
River Mile Tenths
Cross-Section
Railroads
Roads
Stream Centerlines
Floodway
100-yr Floodplain
500-yr Floodplain
Damaged by:
Not Damaged
2-yr Event
5-yr Event
10-yr Event
25-yr Event
50-yr Event
100-yr Event
200-yr Event
500-yr Event
0 400 800
Feet
Scale: 1 in = 800 ft
N
Mill Creek
1.709
2.036
2.216
2.24
2.346
2.459
2.596
2.861
3.021
3.073
3.21
3.217
3.231
3.134
3.26
3.275
3.495
3.522
3.586
3.806
3.983
Hydrology and Hydraulics Appendix


Mill Creek Feasibility
Future W/O Project
Conditions
Map 3 of 16
Legend
River Miles
River Mile Tenths
Cross-Section
Railroads
Roads
Stream Centerlines
Floodway
100-yr Floodplain
500-yr Floodplain
Damaged by:
Not Damaged
2-yr Event
5-yr Event
10-yr Event
25-yr Event
50-yr Event
100-yr Event
200-yr Event
500-yr Event
0 400 800 Feet
Scale: 1 in = 800 ft
N
Mill Creek
4.313
4.433
4.672
4.802
4.828
4.863
5.03
5.27
5.424
5.651
5.813
6.118
6.32
6.347
6.407
6.535
6.707
6.916
Hydrology and Hydraulics Appendix


Mill Creek Feasibility
Future W/O Project
Conditions
Map 4 of 16
Legend
River Miles
River Mile Tenths
Cross-Section
Railroads
Roads
Stream Centerlines
Floodway
100-yr Floodplain
500-yr Floodplain
Damaged by:
Not Damaged
2-yr Event
5-yr Event
10-yr Event
25-yr Event
50-yr Event
100-yr Event
200-yr Event
500-yr Event
0 400 800
Feet
Scale: 1 in = 800 ft
Mill Creek
6.916
7.05
7.07
7.101
7.132
7.321
7.287
7.343
7.434
7.481
7.585
7.637
7.719
7.793
7.916
8.046
8.143
8.21
8.332
8.18
8.168
1666.545
1938.712
354.9965
98.74029
50.55858
2330.623
2930.636
3599.25

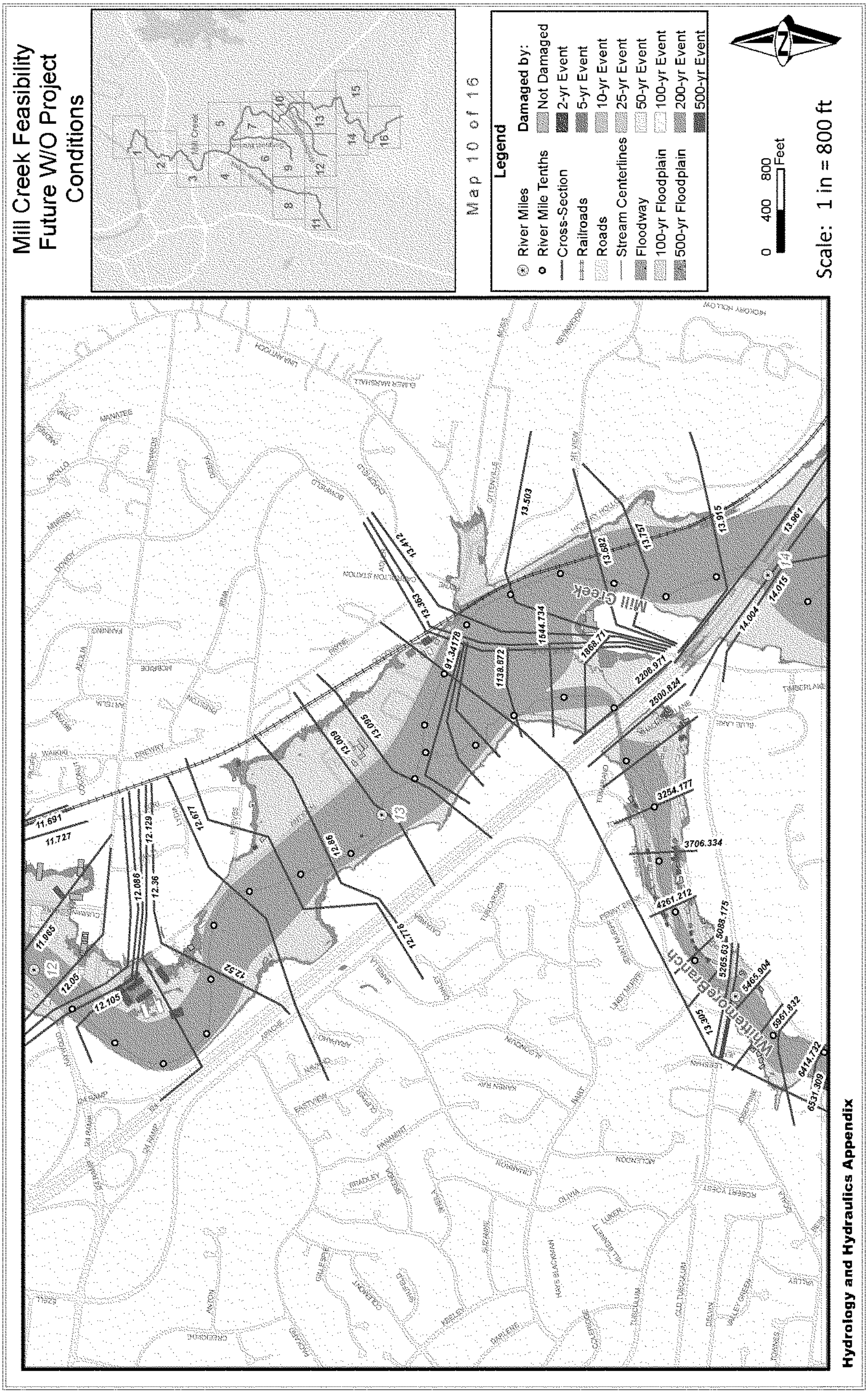

Mill Creek Feasibility
Future W/O Project
Conditions
Map 5 of 16
Legend
River Miles
River Mile Tenths
Cross-Section
Railroads
Roads
Stream Centerlines
Floodway
100-yr Floodplain
500-yr Floodplain
Damaged by:
Not Damaged
2-yr Event
5-yr Event
10-yr Event
25-yr Event
50-yr Event
100-yr Event
200-yr Event
500-yr Event
0 400 800 Feet
Scale: 1 in = 800 ft
Mill Creek
Sorghum Branch
Hydrology and Hydraulics Appendix

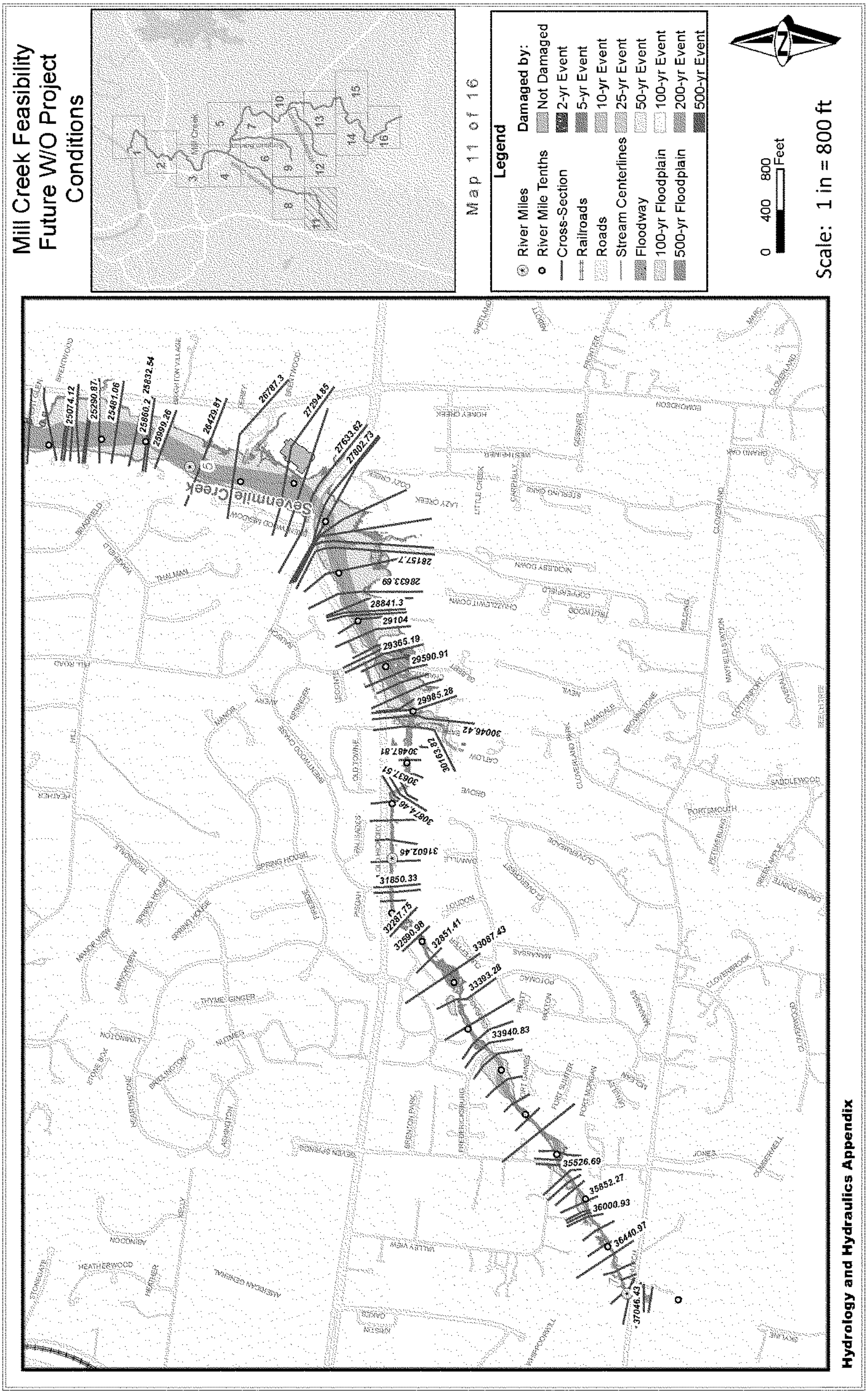

Mill Creek Feasibility
Future W/O Project
Conditions
Map 6 of 16
Legend
River Miles
River Mile Tenths
Cross-Section
Railroads
Roads
Stream Centerlines
Floodway
100-yr Floodplain
500-yr Floodplain
Damaged by:
Not Damaged
2-yr Event
5-yr Event
10-yr Event
25-yr Event
50-yr Event
100-yr Event
200-yr Event
500-yr Event
0 400 800 Feet
Scale: 1 in = 800 ft
Hydrology and Hydraulics Appendix

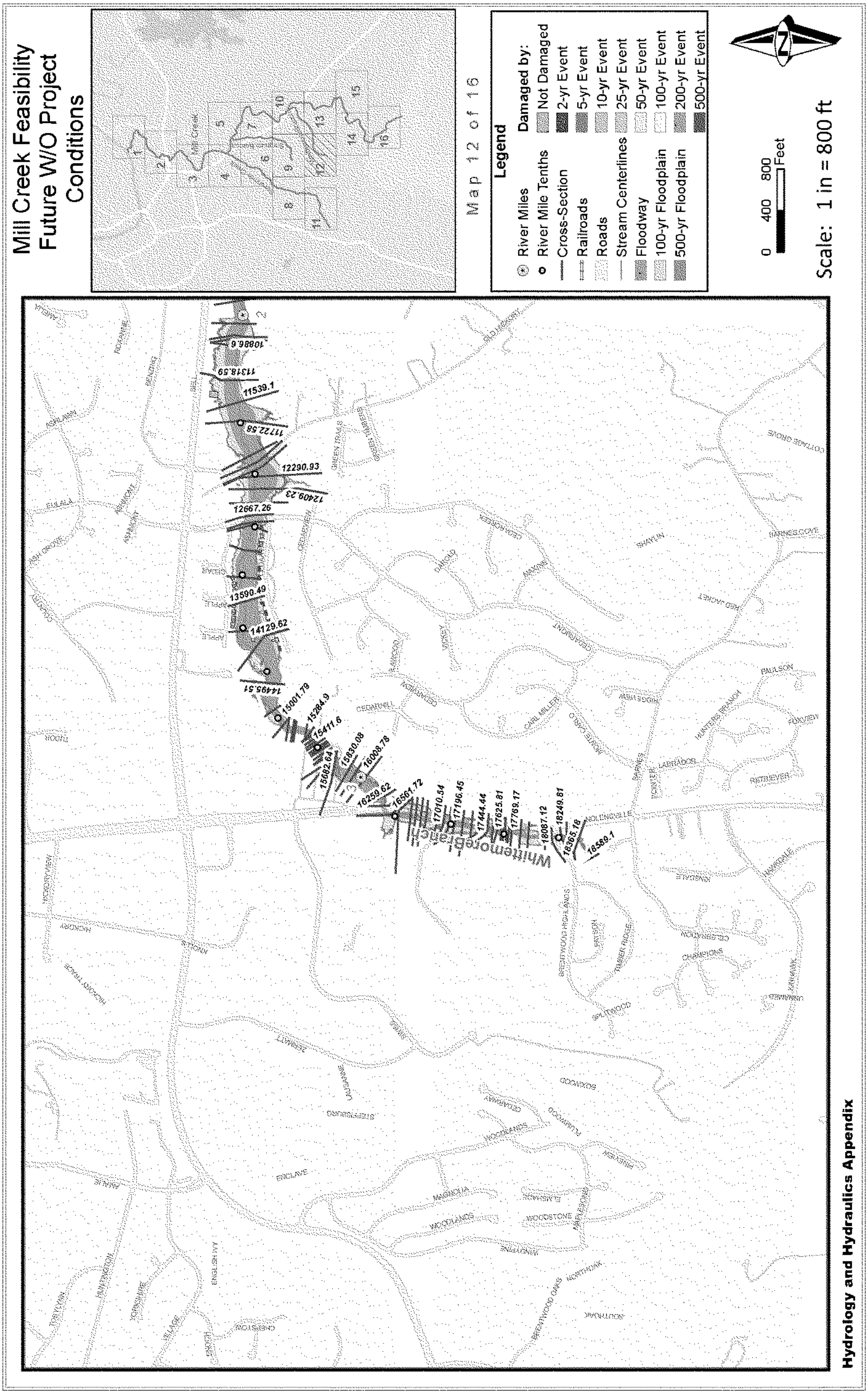

Mill Creek Feasibility
Future W/O Project
Conditions
Map 7 of 16
Legend
River Miles
River Mile Tenths
Cross-Section
Railroads
Roads
Stream Centerlines
Floodway
100-yr Floodplain
500-yr Floodplain
Damaged by:
Not Damaged
2-yr Event
5-yr Event
10-yr Event
25-yr Event
50-yr Event
100-yr Event
200-yr Event
500-yr Event
0 400 800 Feet
Scale: 1 in = 800 ft
Mill Creek
Sorghum Branch
Hydrology and Hydraulics Appendix

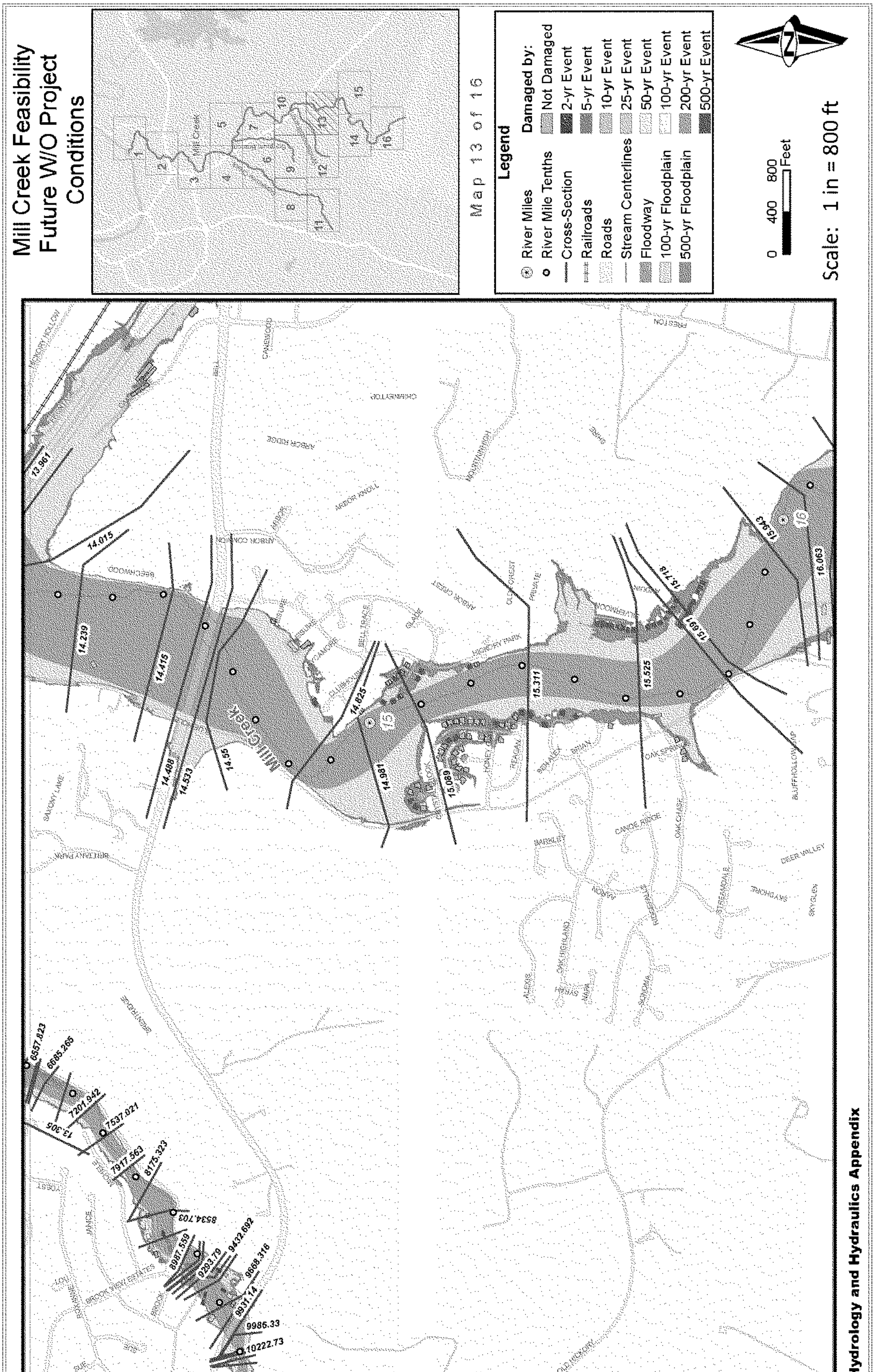
Mill Creek Feasibility Future W/O Project Conditions

Mill Creek Feasibility
Future W/O Project
Conditions
Map 9 of 16
Legend
River Miles
River Mile Tenths
Cross-Section
Railroads
Roads
Stream Centerlines
Floodway
100-yr Floodplain
500-yr Floodplain
Damaged by:
Not Damaged
2-yr Event
5-yr Event
10-yr Event
25-yr Event
50-yr Event
100-yr Event
200-yr Event
500-yr Event
0 400 800 Feet
Scale: 1 in = 800 ft
11503.88
11650.38
11850.8
12202.48
12526.06
12814.73
13031.49
13361
13564.62
13810.29
13996.18
14375.15
14624.73
15008.61
15299.34
15587.3
16253.14
16385.08
16444.06
16624.32
16830.05
17145.97
17698.86
17898.51
18053.14
18332.43
18589.15
18756.4
19254.46


Mill Creek Feasibility
Future W/O Project
Conditions
Map 10 of 16
Legend
River Miles
River Mile Tenths
Cross-Section
Railroads
Roads
Stream Centerlines
Floodway
100-yr Floodplain
500-yr Floodplain
Damaged by:
Not Damaged
2-yr Event
5-yr Event
10-yr Event
25-yr Event
50-yr Event
100-yr Event
200-yr Event
500-yr Event
0 400 800 Feet
Scale: 1 in = 800 ft
Mill Creek
Whittemore Branch
Hydrology and Hydraulics Appendix


Mill Creek Feasibility
Future W/O Project
Conditions
Map 11 of 16
Legend
River Miles
River Mile Tenths
Cross-Section
Railroads
Roads
Stream Centerlines
Floodway
100-yr Floodplain
500-yr Floodplain
Damaged by:
Not Damaged
2-yr Event
5-yr Event
10-yr Event
25-yr Event
50-yr Event
100-yr Event
200-yr Event
500-yr Event
0 400 800 Feet
Scale: 1 in = 800 ft
N
Sevenmile Creek
Hydrology and Hydraulics Appendix

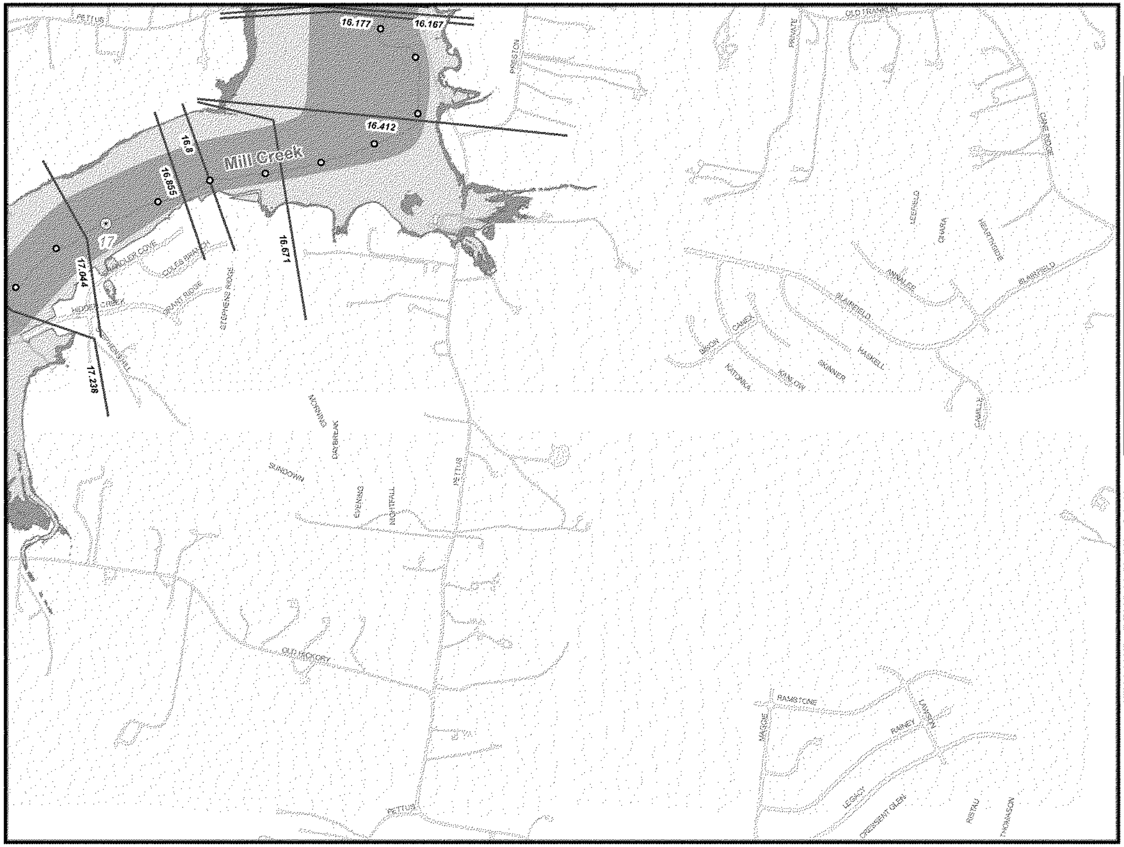

Mill Creek Feasibility
Future W/O Project
Conditions
Map 12 of 16
Legend
River Miles
River Mile Tenths
Cross-Section
Railroads
Roads
Stream Centerlines
Floodway
100-yr Floodplain
500-yr Floodplain
Damaged by:
Not Damaged
2-yr Event
5-yr Event
10-yr Event
25-yr Event
50-yr Event
100-yr Event
200-yr Event
500-yr Event
0 400 800 Feet
Scale: 1 in = 800 ft
Whittemore Branch
Hydrology and Hydraulics Appendix

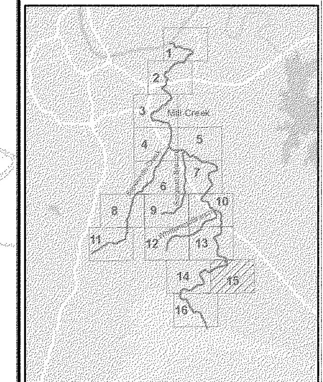


Hydrology and Hydraulics Appendix

Mill Creek Feasibility
Future W/O Project Conditions
Map 14 of 16
Legend
River Miles
River Mile Tenths
Cross-Section
Railroads
Roads
Stream Centerlines
Floodway
100-yr Floodplain
500-yr Floodplain
Damaged by:
Not Damaged
2-yr Event
5-yr Event
10-yr Event
25-yr Event
50-yr Event
100-yr Event
200-yr Event
500-yr Event
0 400 800 Feet
Scale: 1 in = 800 ft
Mill Creek
Hydrology and Hydraulics Appendix

Mill Creek Feasibility
Future W/O Project Conditions





Map 15 of 16

Legend

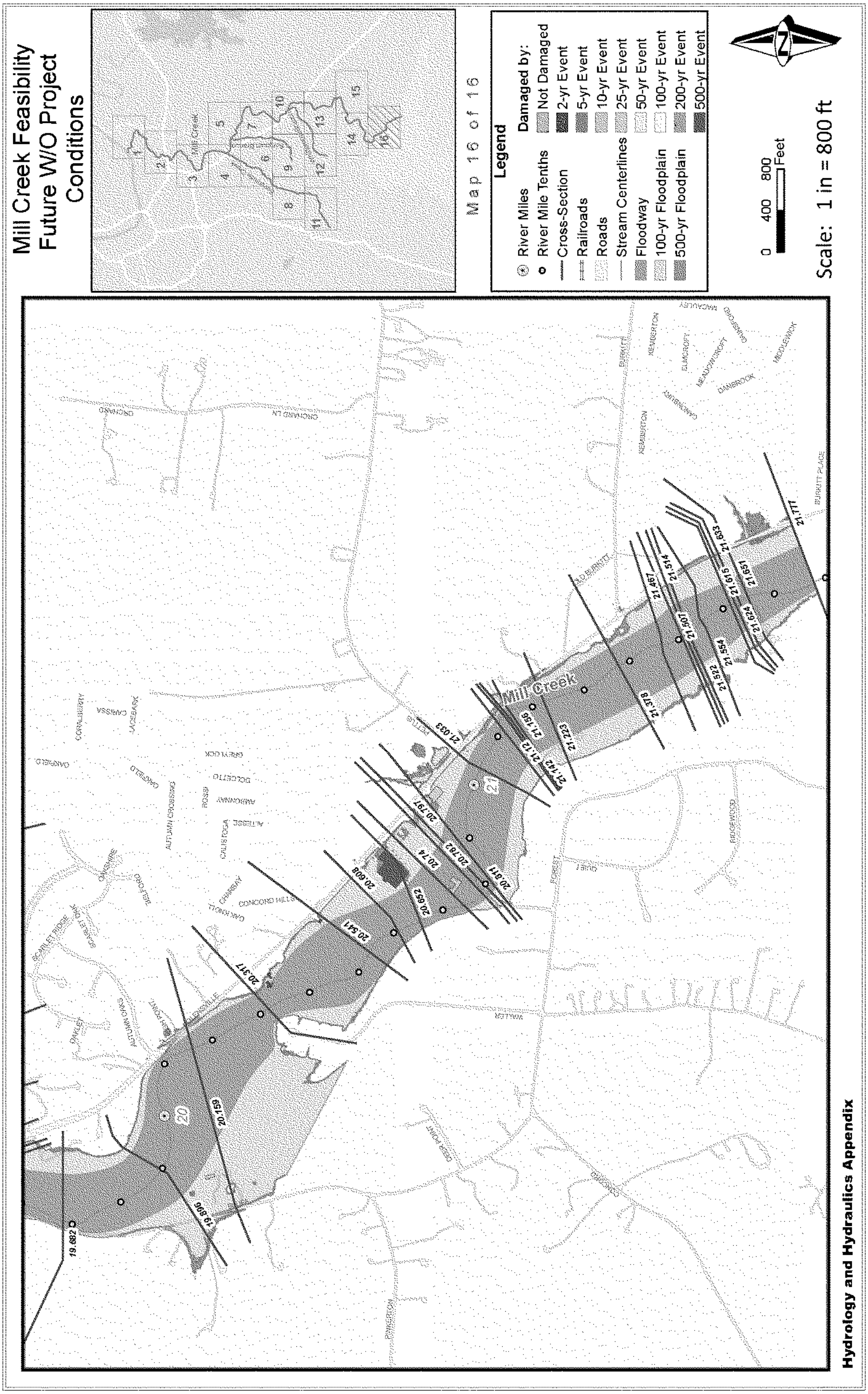
River Miles	**Damaged by:**
River Mile Tenths	Not Damaged
Cross-Section	2-yr Event
Railroads	5-yr Event
Roads	10-yr Event
Stream Centerlines	25-yr Event
Floodway	50-yr Event
100-yr Floodplain	100-yr Event
500-yr Floodplain	200-yr Event
	500-yr Event

0 400 800 Feet

Scale: 1 in = 800 ft

N

Hydrology and Hydraulics Appendix


Mill Creek Feasibility
Future W/O Project
Conditions
Map 16 of 16
Legend
River Miles
River Mile Tenths
Cross-Section
Railroads
Roads
Stream Centerlines
Floodway
100-yr Floodplain
500-yr Floodplain
Damaged by:
Not Damaged
2-yr Event
5-yr Event
10-yr Event
25-yr Event
50-yr Event
100-yr Event
200-yr Event
500-yr Event
0 400 800 Feet
Scale: 1 in = 800 ft
Mill Creek
20
21
19.682
19.896
20.159
20.317
20.541
20.608
20.652
20.74
20.782
20.797
20.811
21.033
21.12
21.142
21.196
21.223
21.378
21.467
21.507
21.514
21.522
21.554
21.615
21.624
21.633
21.651
21.777

HYDROLOGY AND HYDRAULICS

APPENDIX C4

FUTURE WITHOUT PROJECT CONDITIONS

WATER SURFACE PROFILES

US Army Corps
of Engineers ®
Nashville District

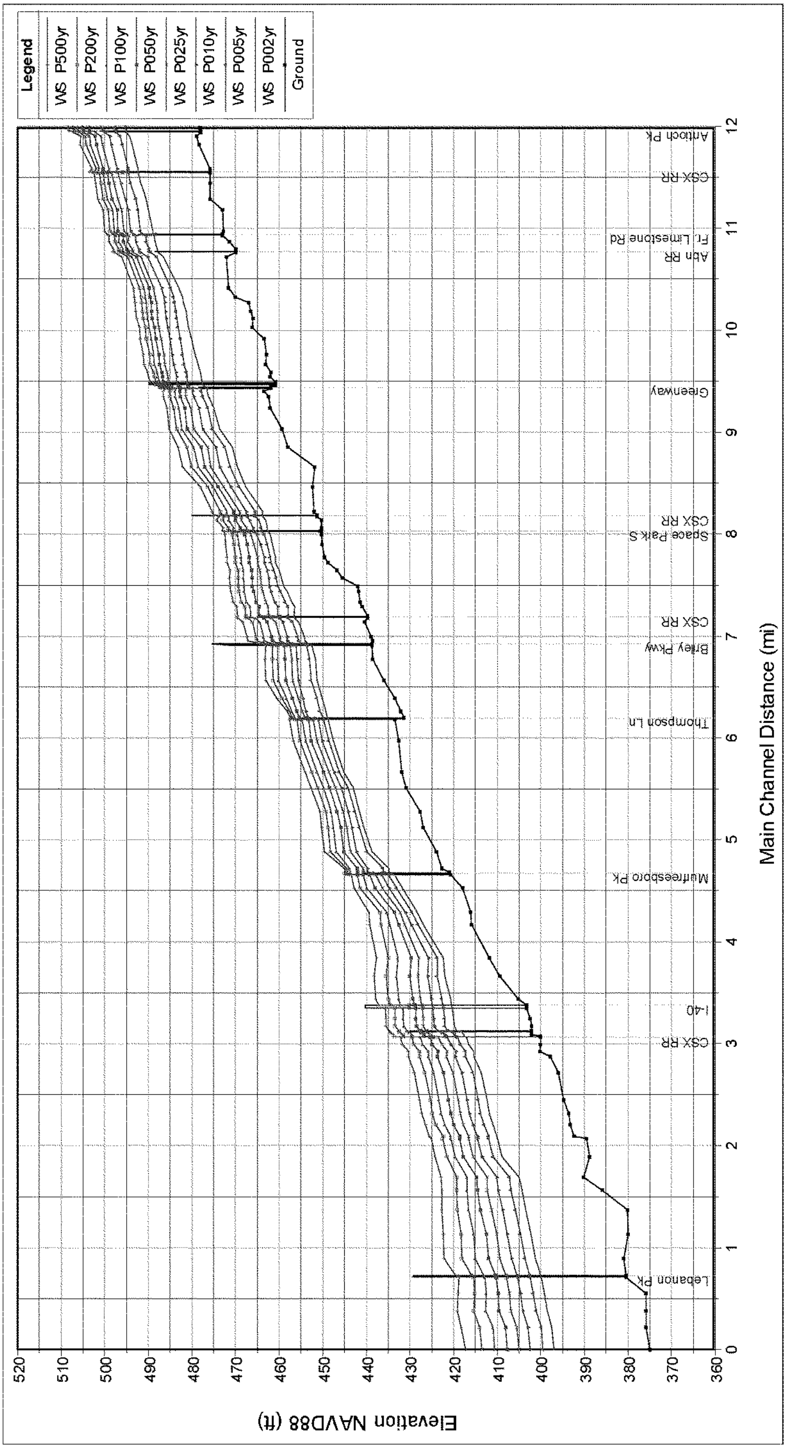


Figure C4 - 1: Mill Creek Frequency Flood Water Surface Profiles – River Mile 0 to 12 (Cumberland River Backwater not Shown)

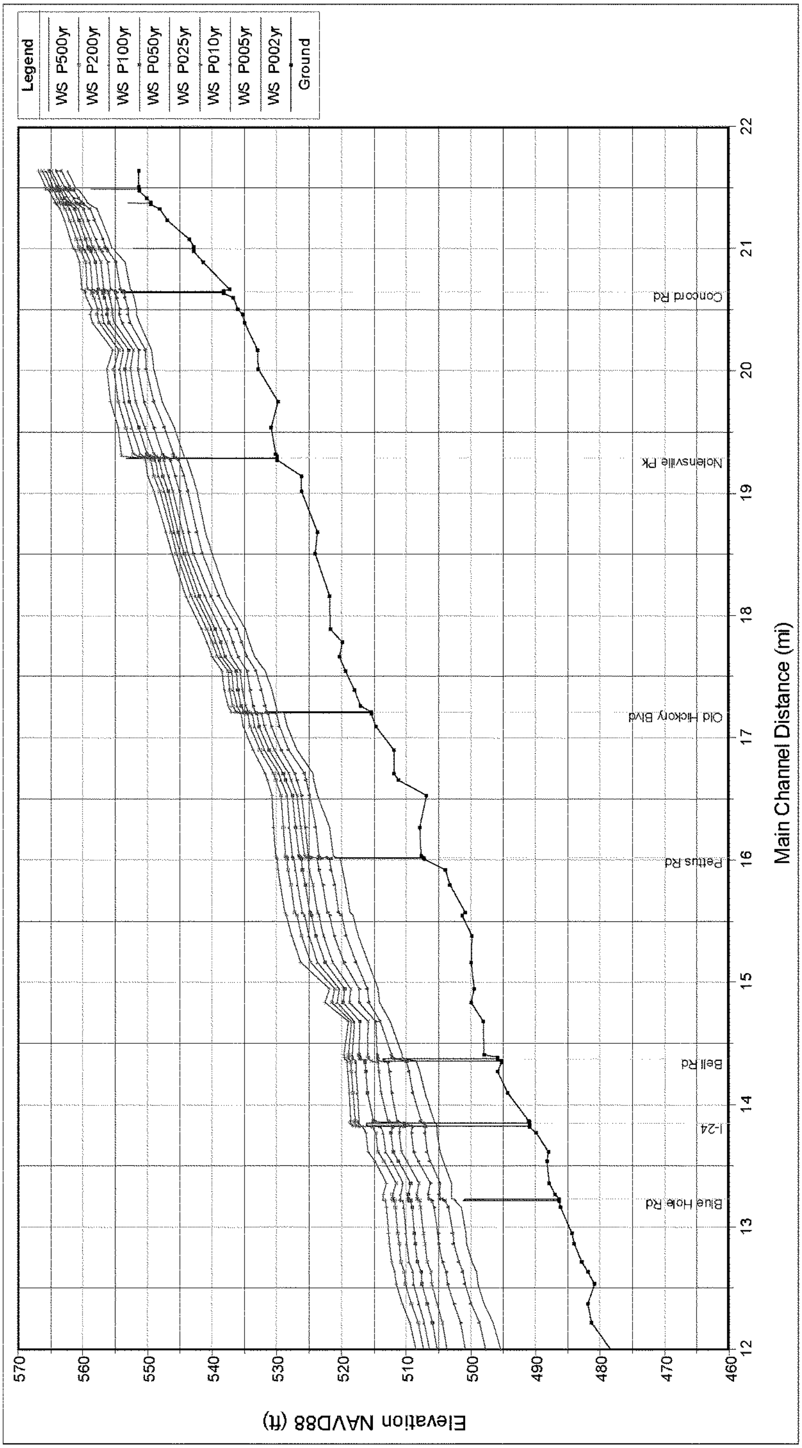


Figure C4 -2: Mill Creek Frequency Flood Water Surface Profiles – River Mile 12 to 22

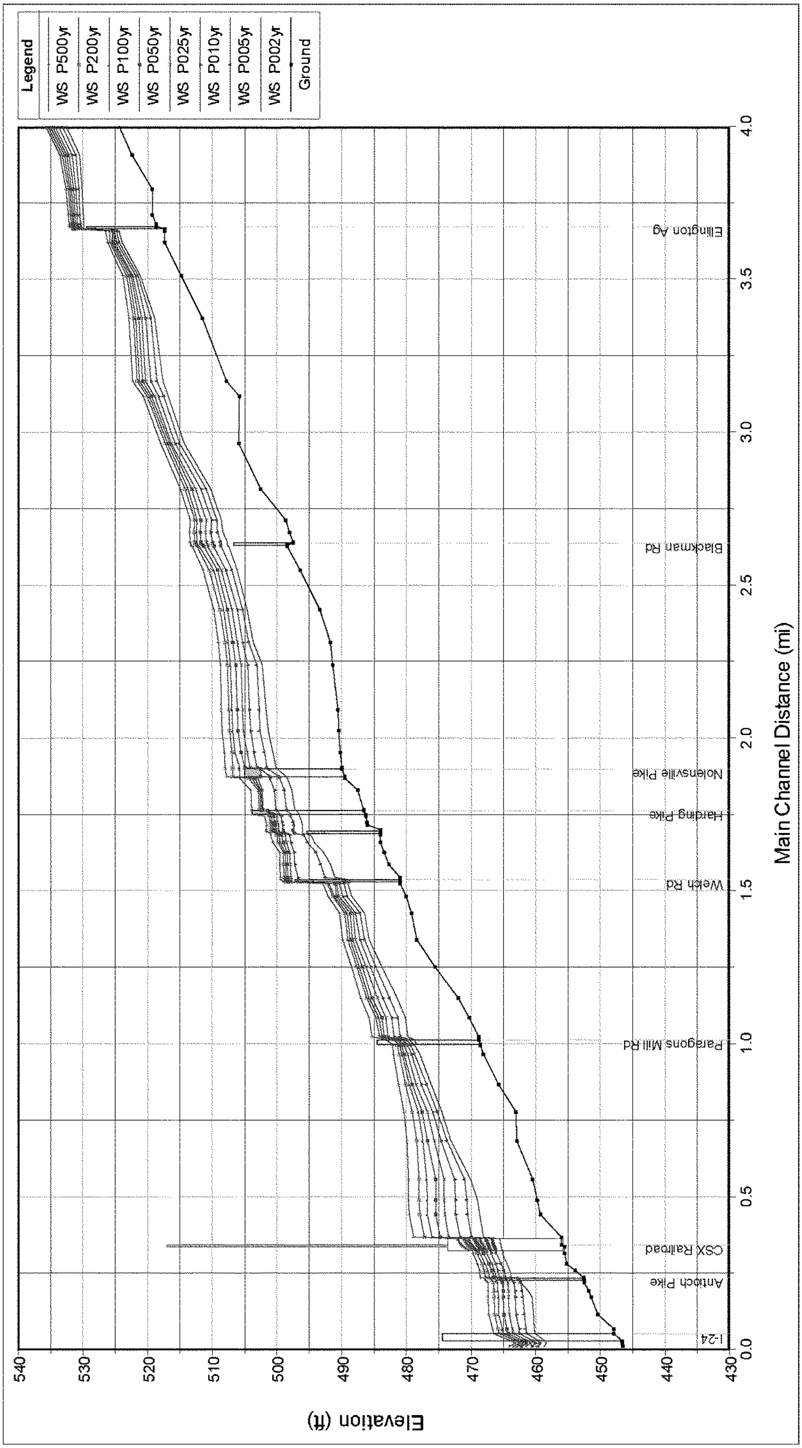


Figure C4 - 3: Sevenmile Creek Frequency Flood Water Surface Profiles – River Mile 0 to 4 (Mill Creek Backwater not Shown)

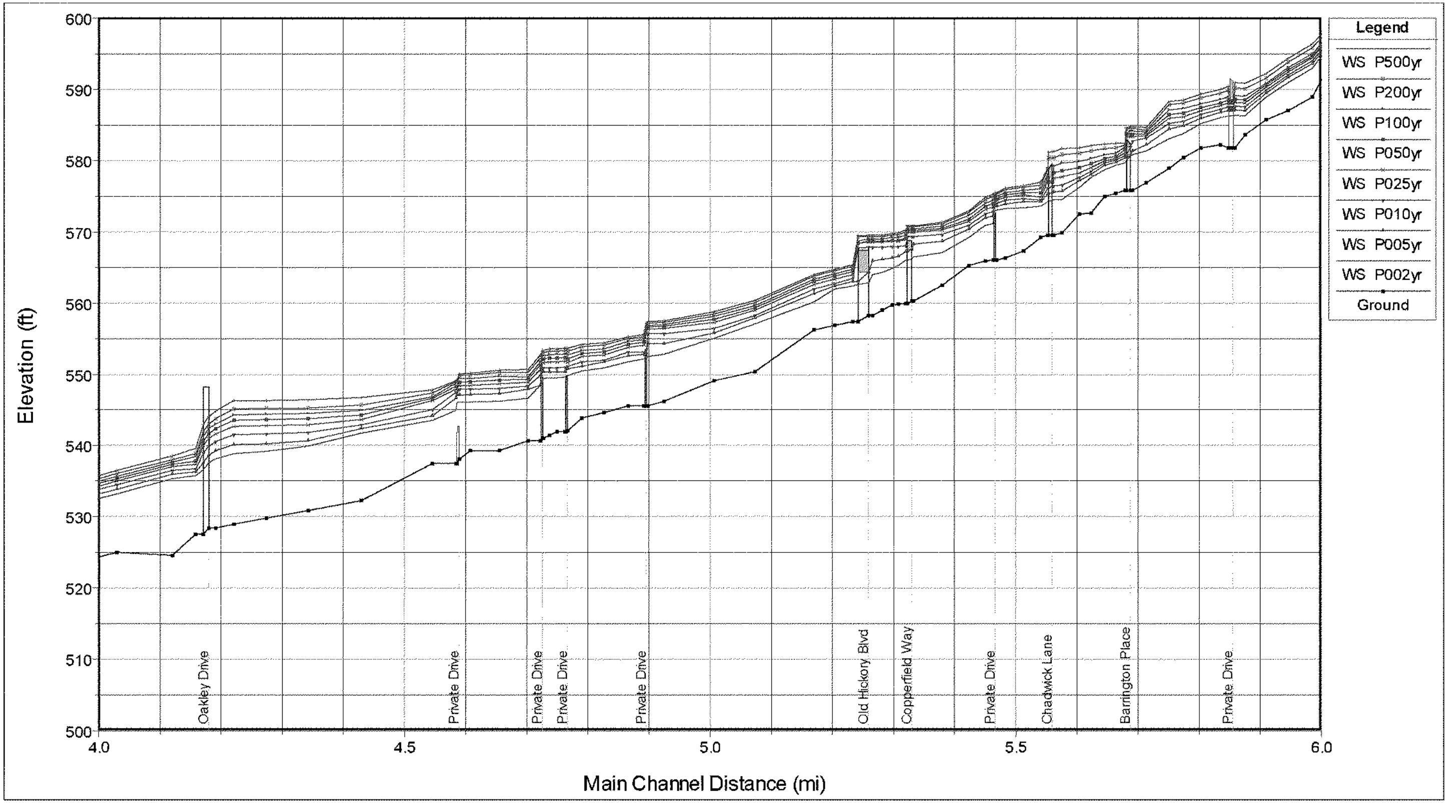


Figure C4 - 4: Sevenmile Creek Frequency Flood Water Surface Profiles – River Mile 4 to 6

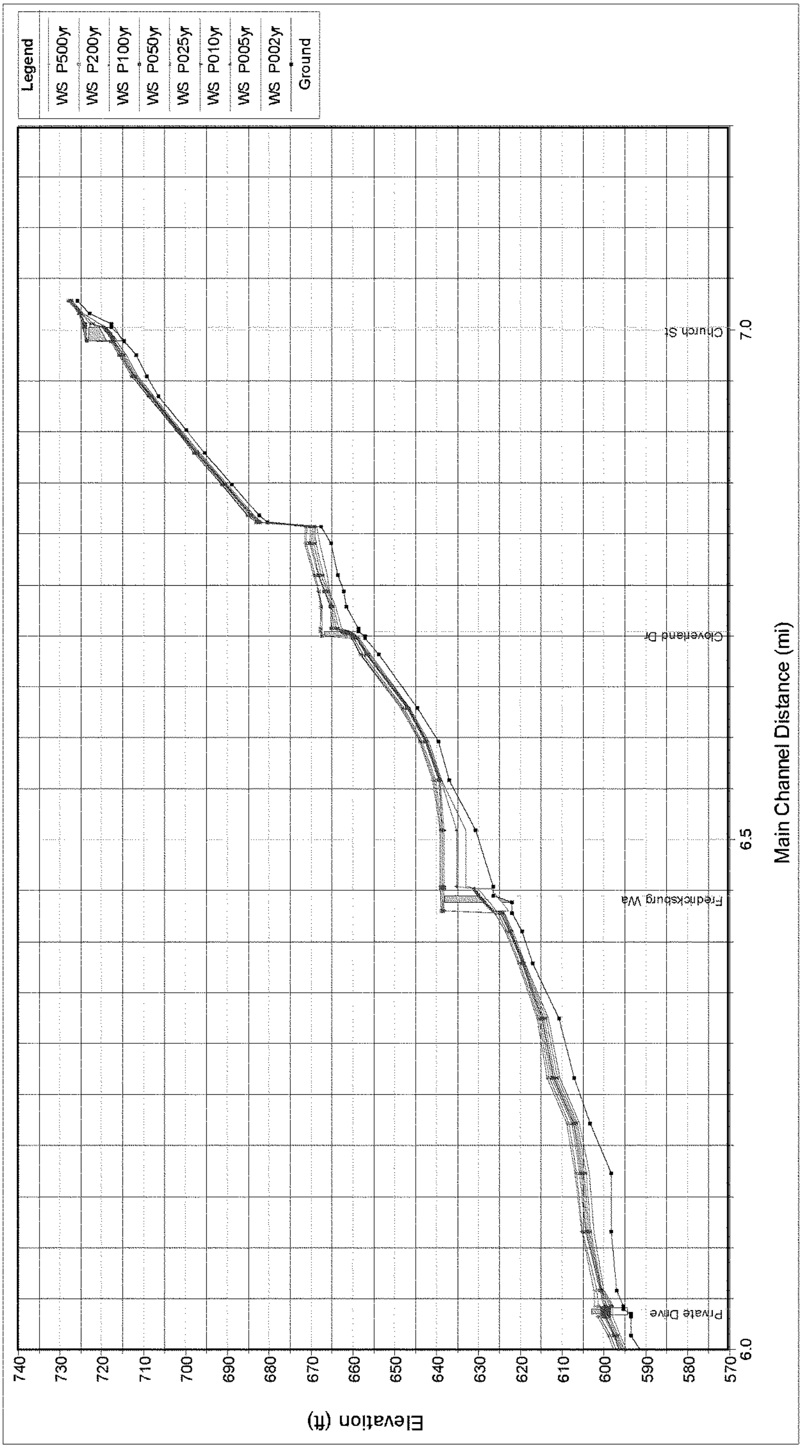


Figure C4 - 5: Sevenmile Creek Frequency Flood Water Surface Profiles – River Mile 6 to 7.2

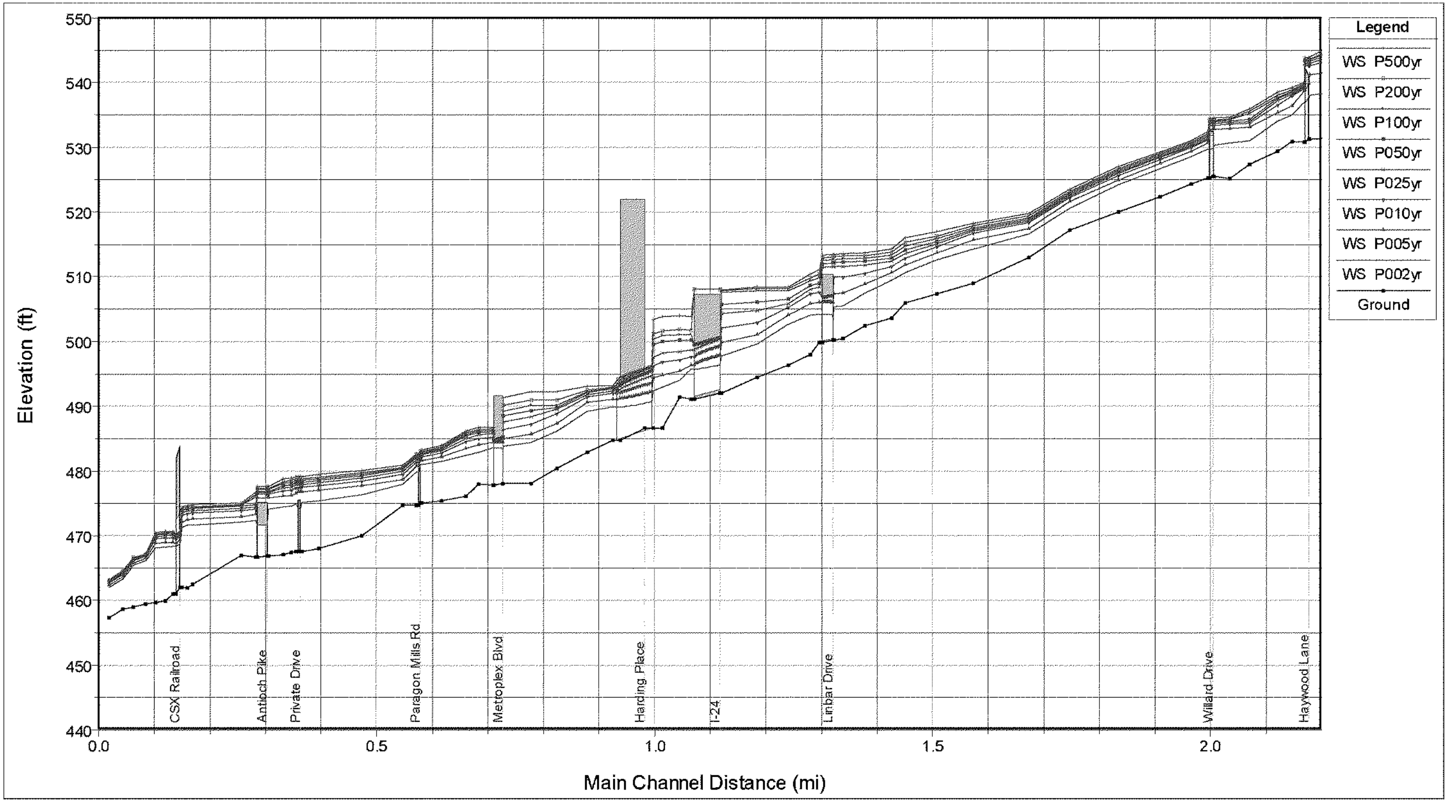


Figure C4 - 6: Sorghum Branch Frequency Flood Water Surface Profiles – River Mile 0 to 2.2 (Mill Creek Backwater not Shown)

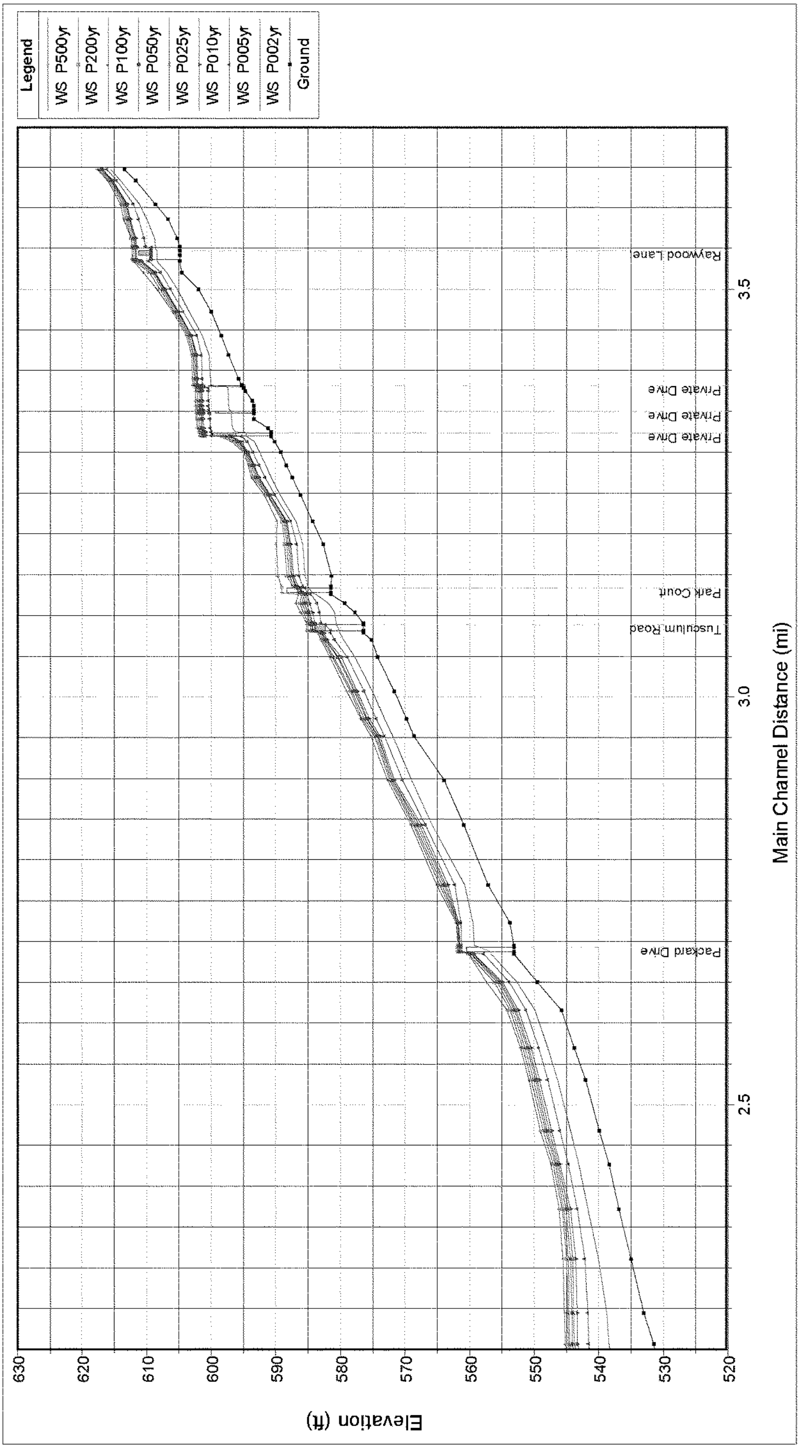


Figure C4 - 7: Sorghum Branch Frequency Flood Water Surface Profiles – River Mile 2.2 to 3.7

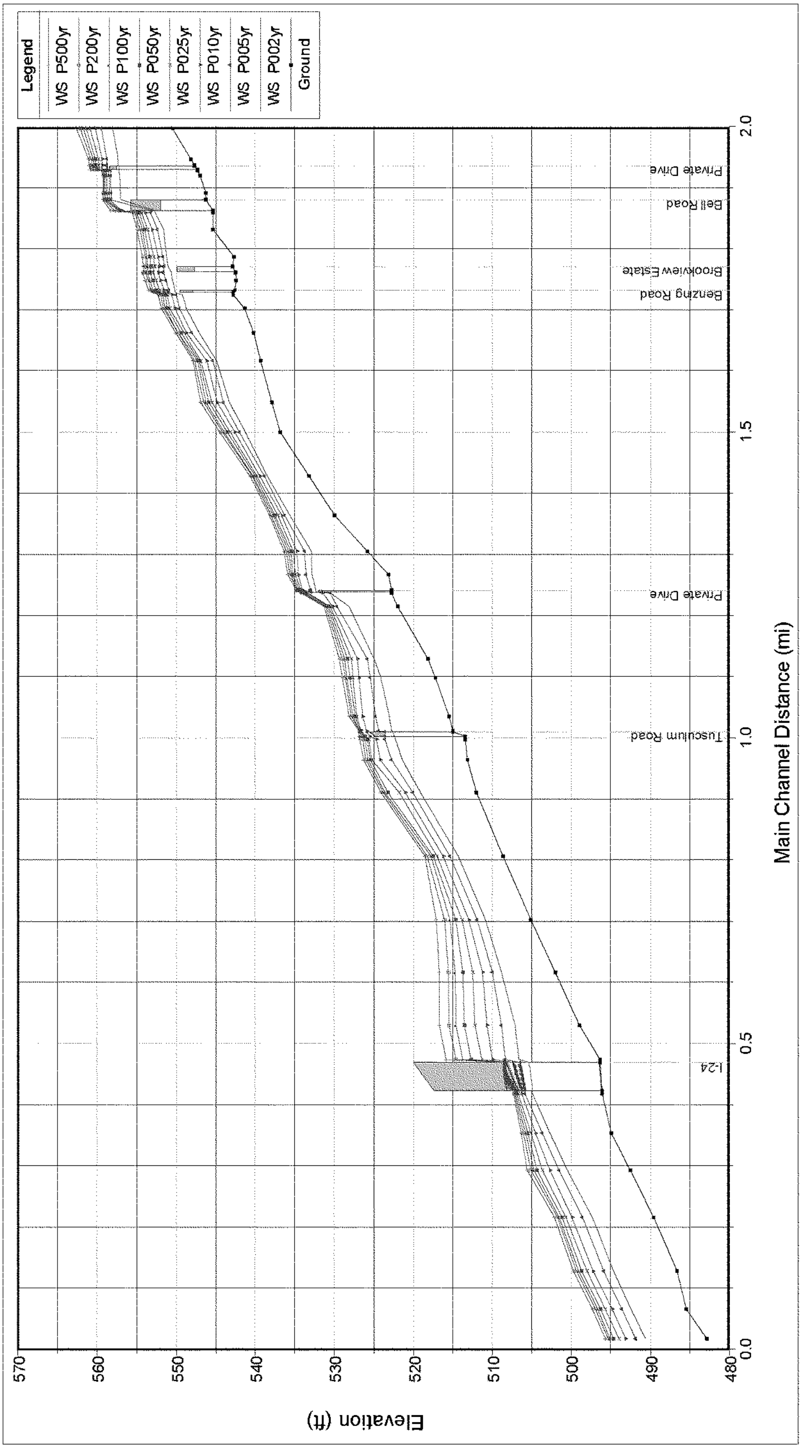


Figure C4 - 8: Whittemore Branch Frequency Flood Water Surface Profiles – River Mile 0 to 2 (Mill Creek Backwater not Shown)

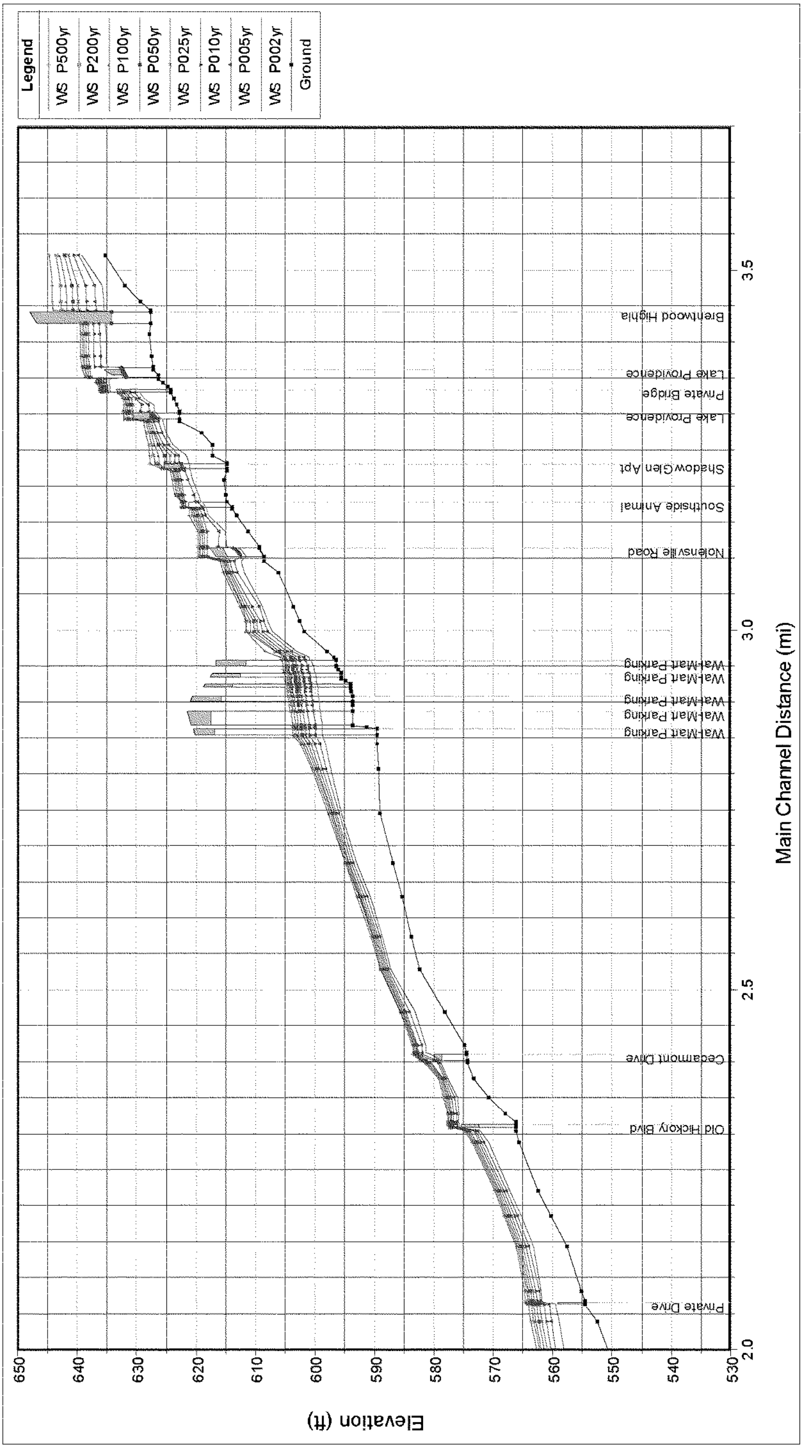


Figure C4 - 9: Whittemore Branch Frequency Flood Water Surface Profiles -- River Mile 2.0 to 3.7

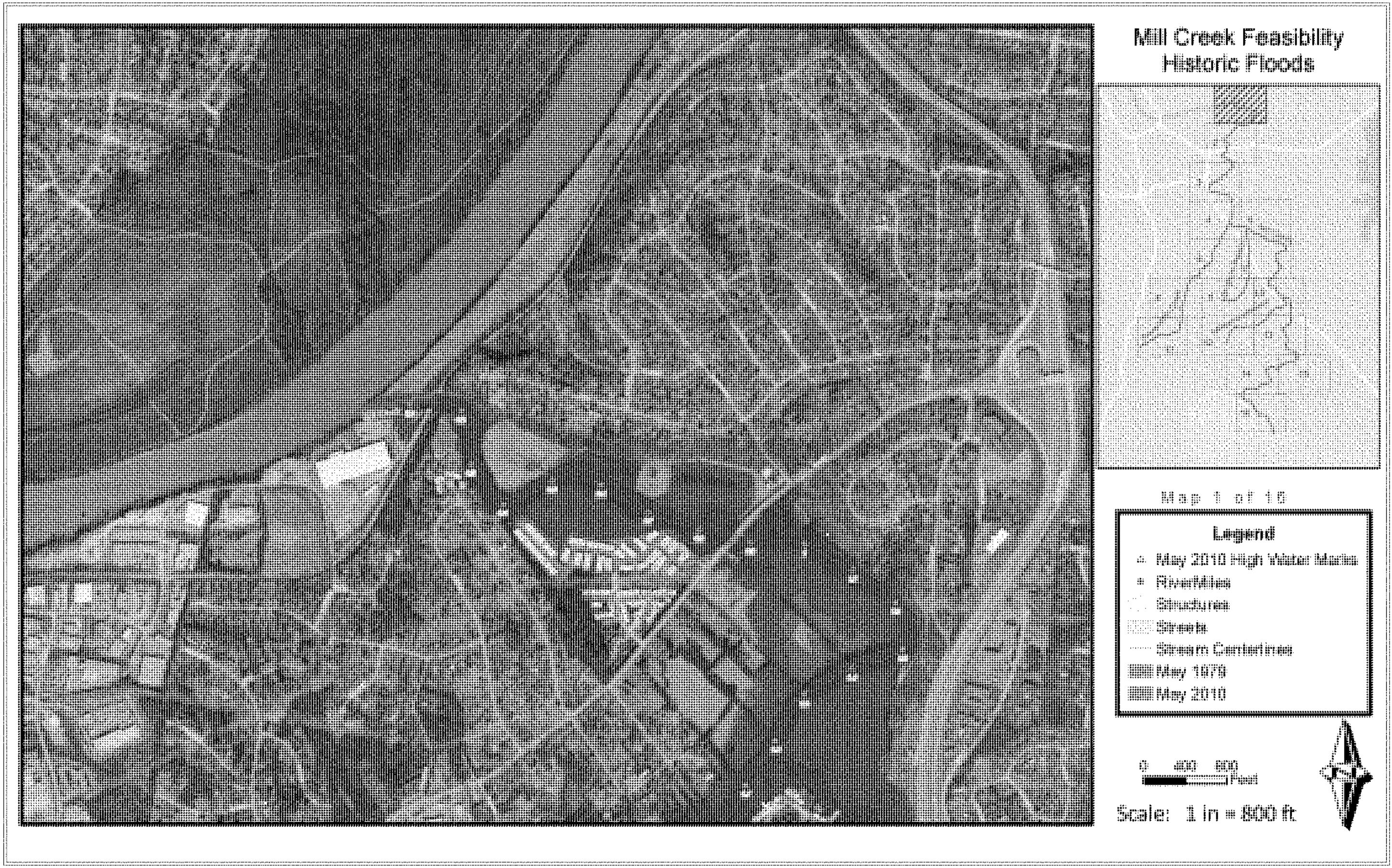
HYDROLOGY AND HYDRAULICS

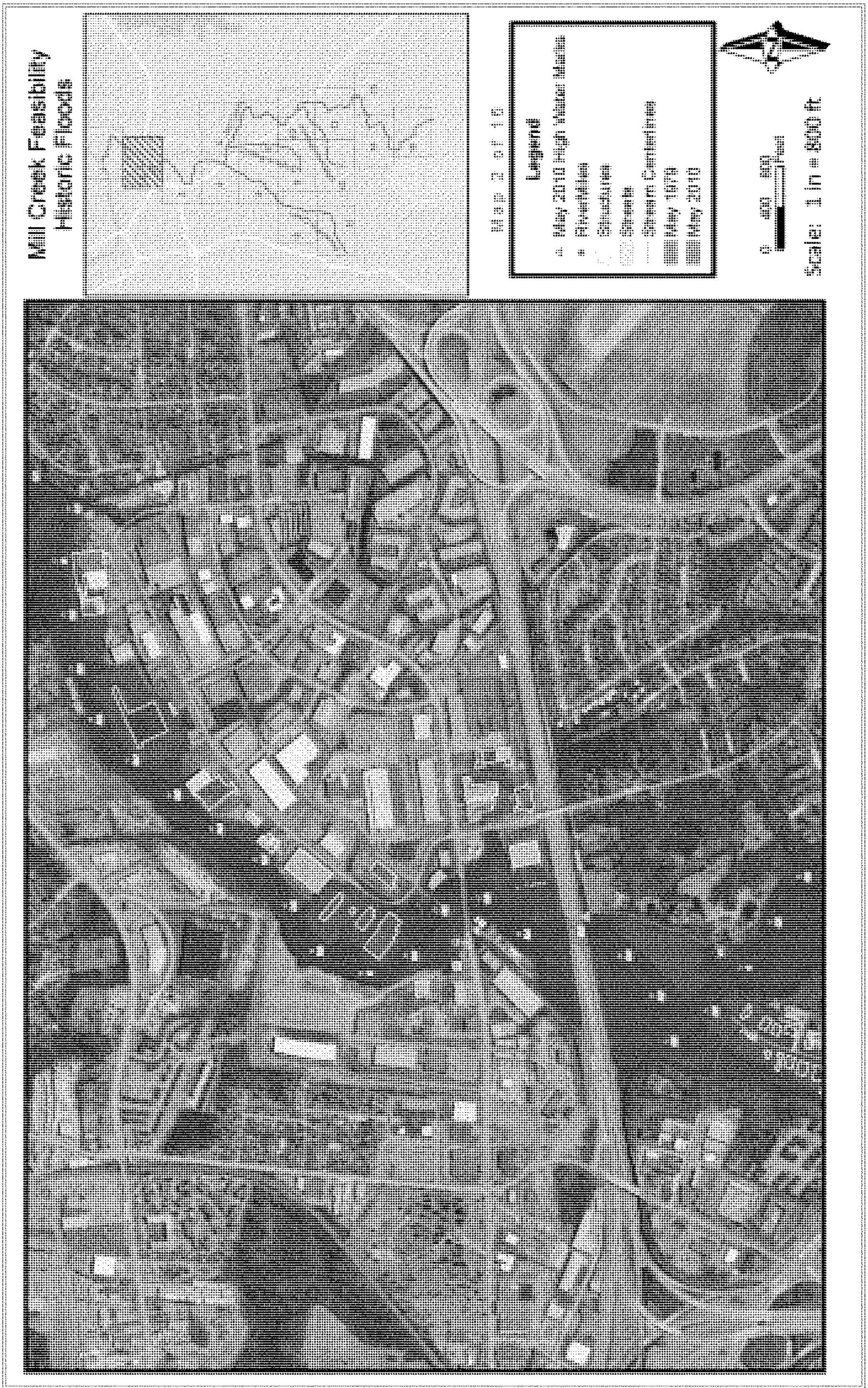
APPENDIX C5

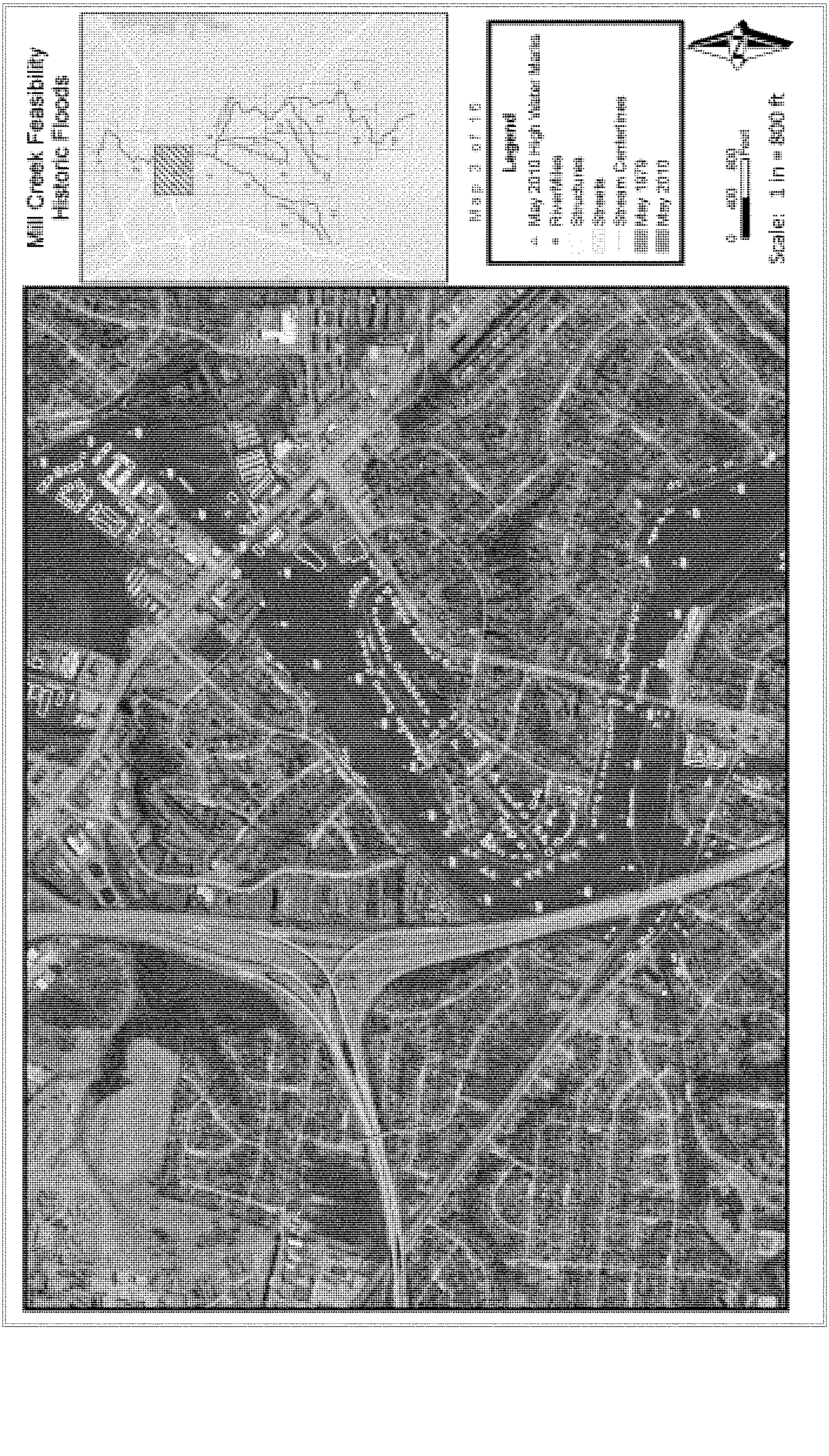
HISTORIC FLOODS

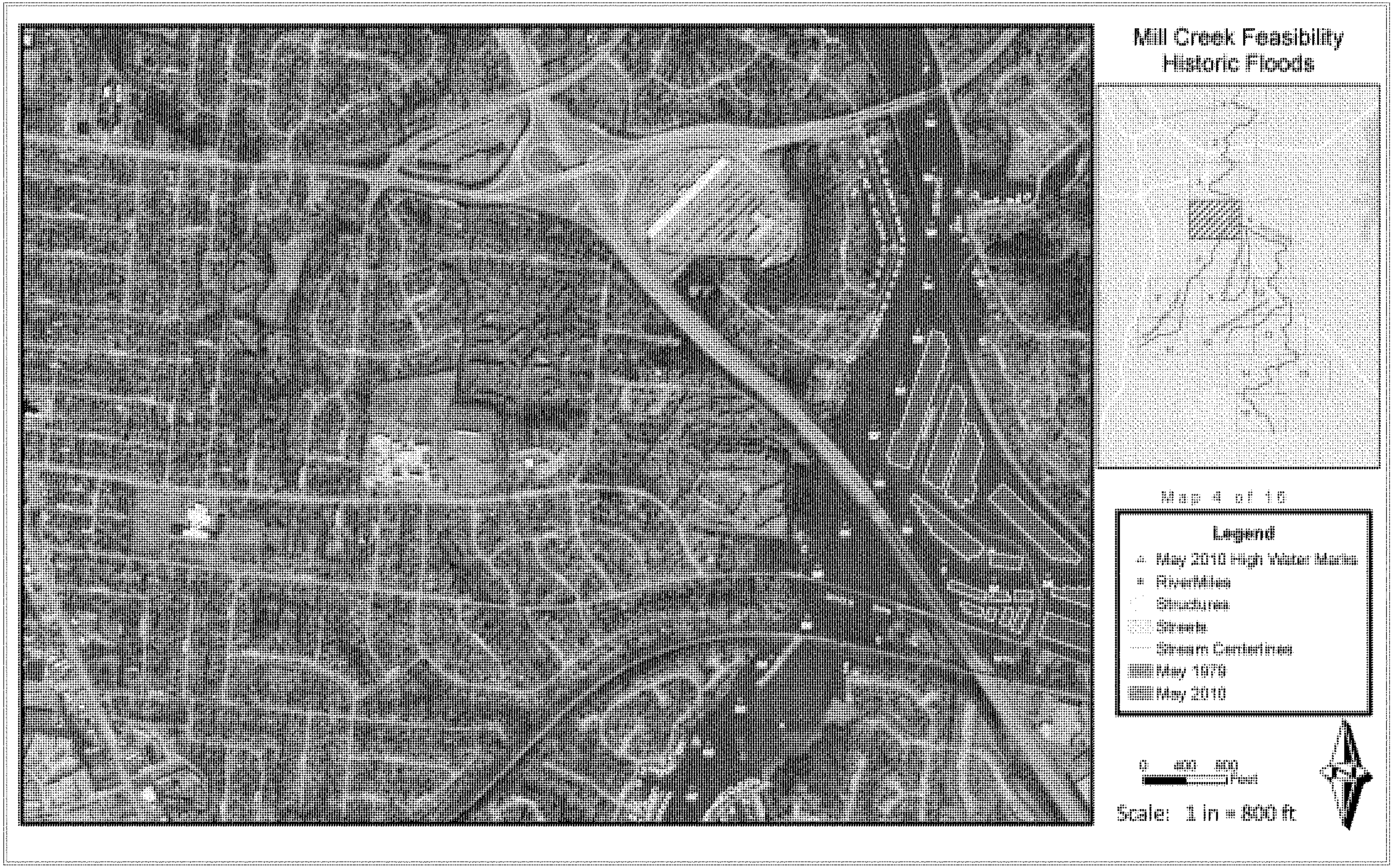
INUNDATION MAPS

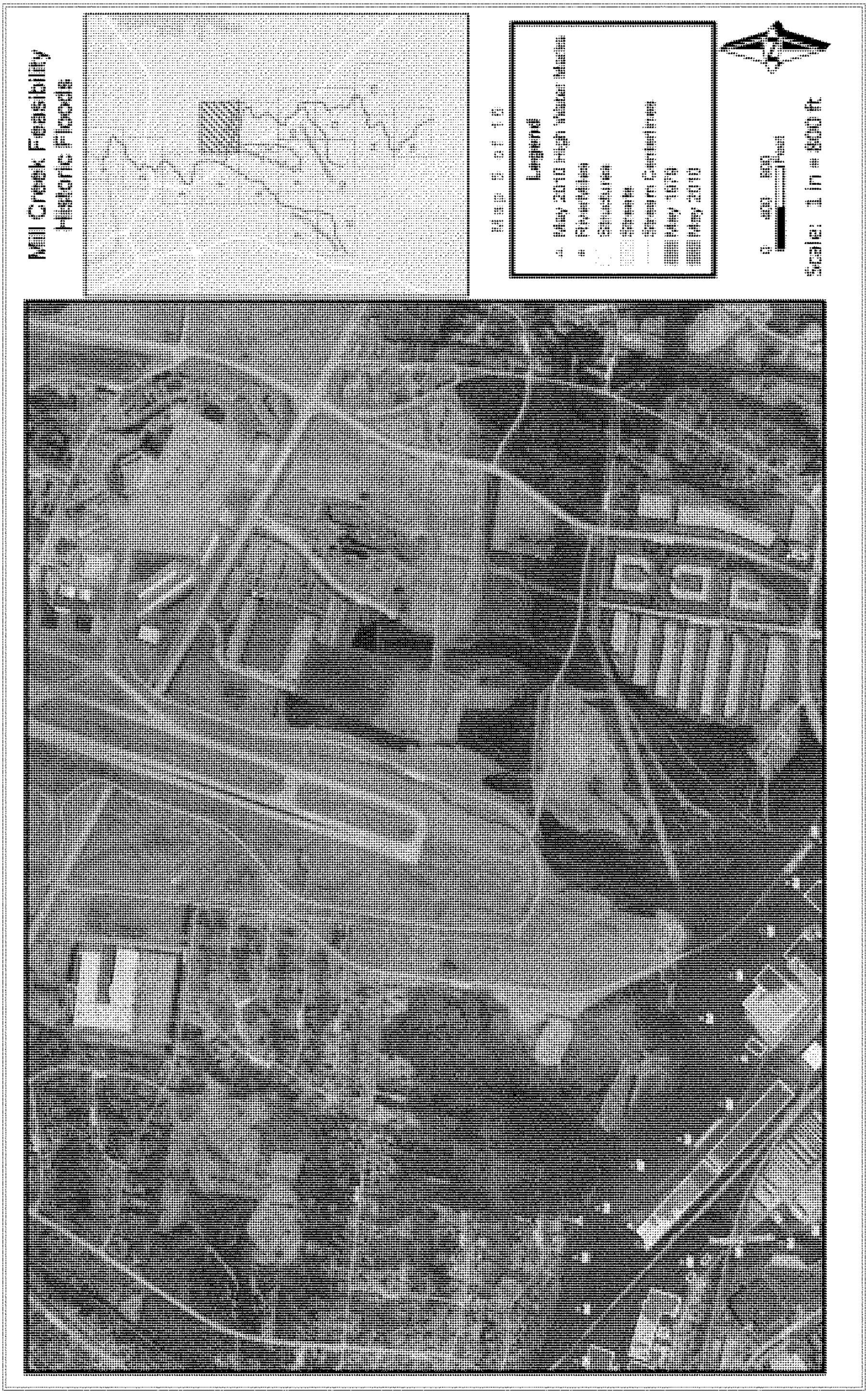
US Army Corps
of Engineers ®
Nashville District

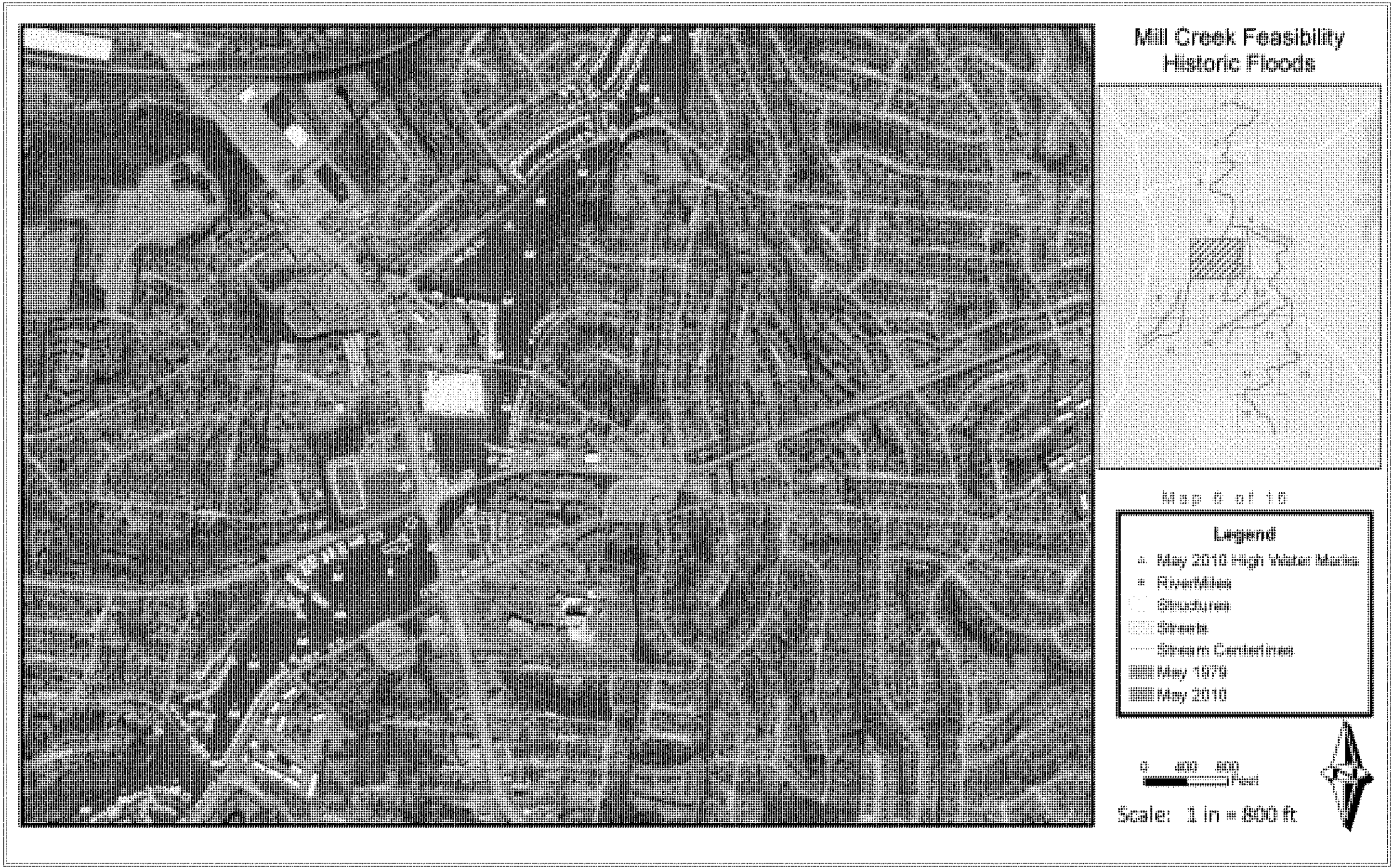

Mill Creek Feasibility
Historic Floods
Map 1 of 10
Legend
May 2010 High Water Marks
RiverMiles
Structures
Streets
Stream Centerlines
May 2010
0
400
800
Feet
Scale: 1 in = 800 ft

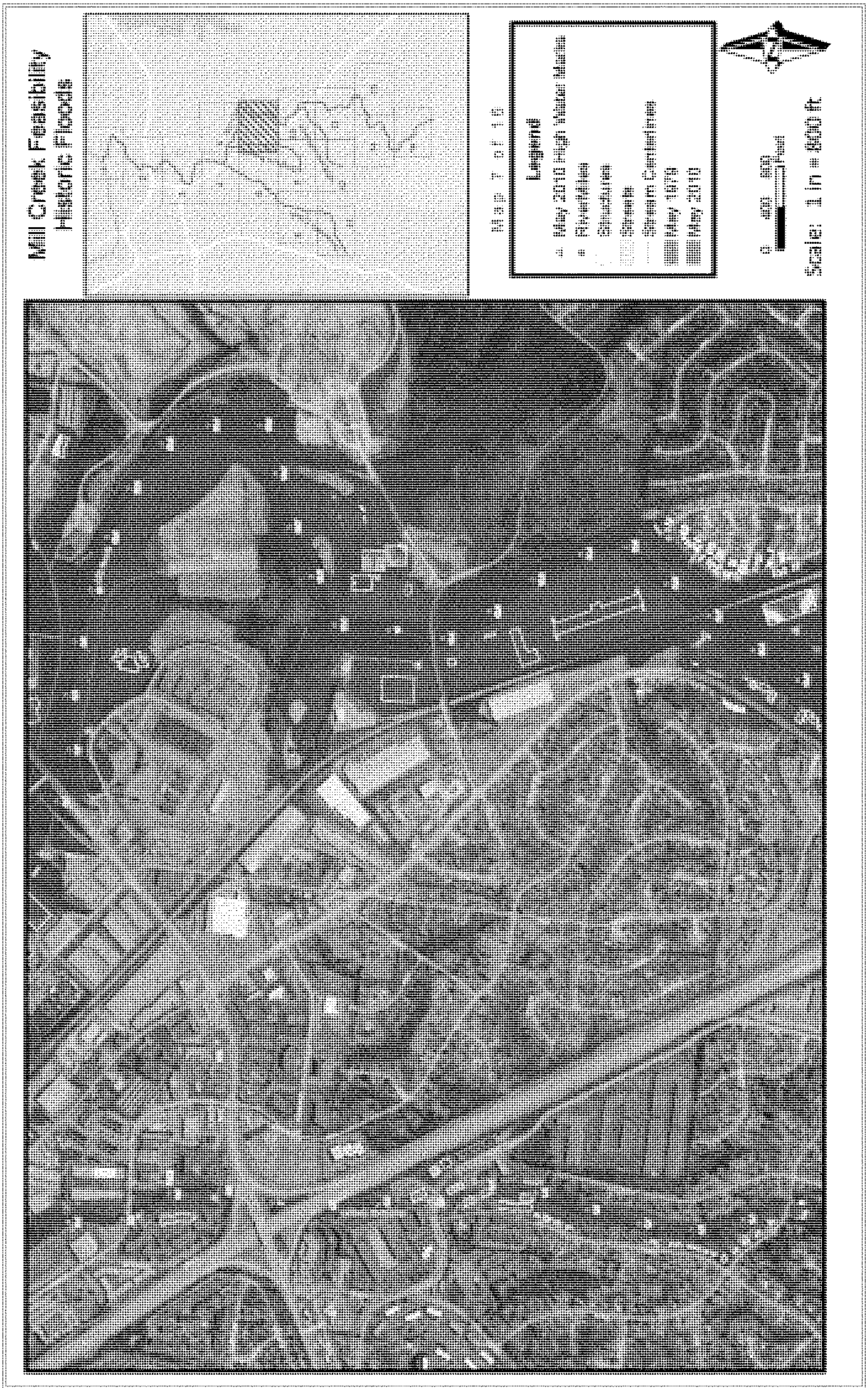

Mill Creek Feasibility
Historic Floods
Map 2 of 10
Legend
May 2010 High Water Marks
Structures
Streets
Stream Centerlines
May 1979
May 2010
0 400 800 Feet
Scale: 1 in = 800 ft

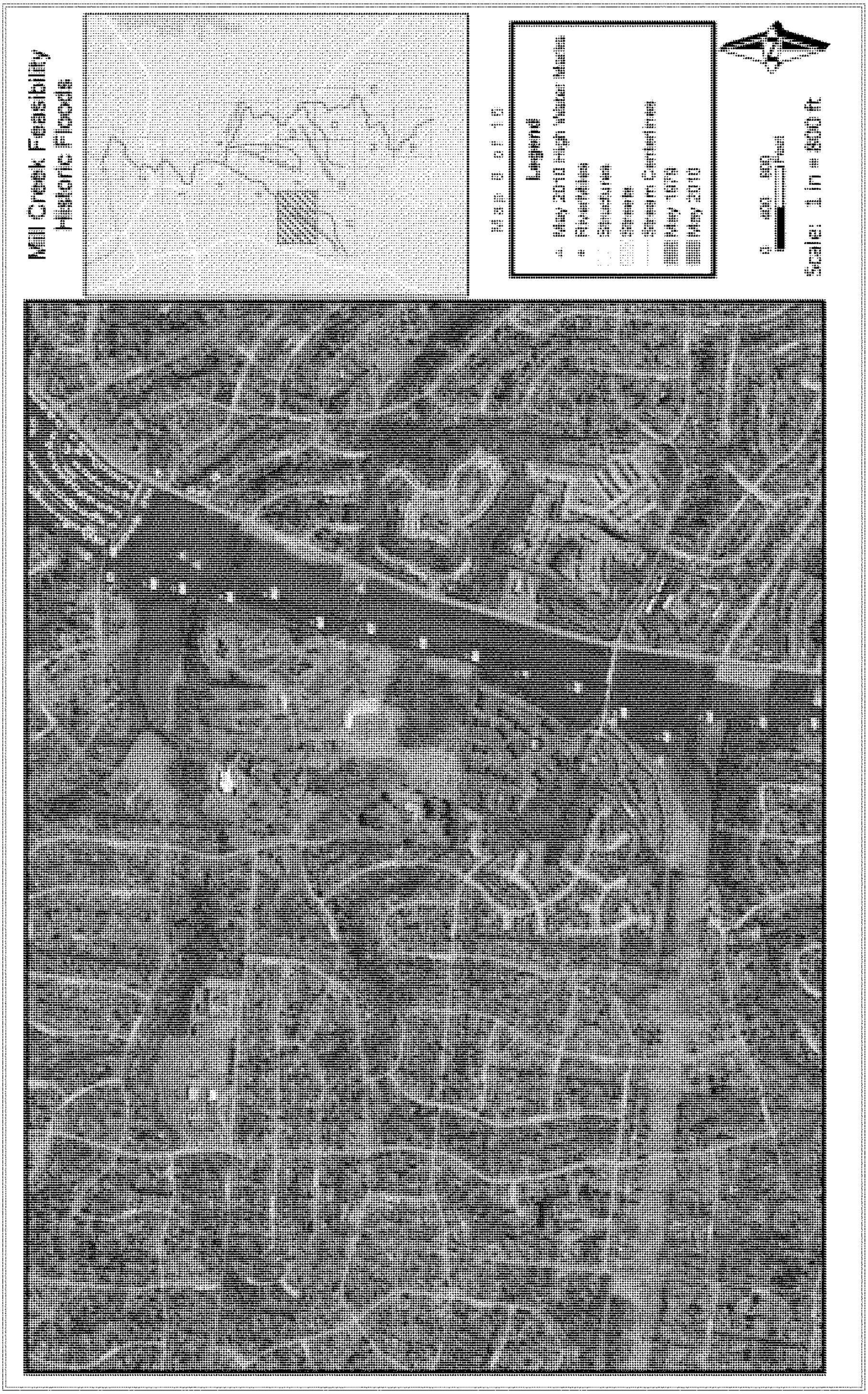

Mill Creek Feasibility
Historic Floods
Legend
May 2010 High Water Marks
Stream Centerlines
May 2010

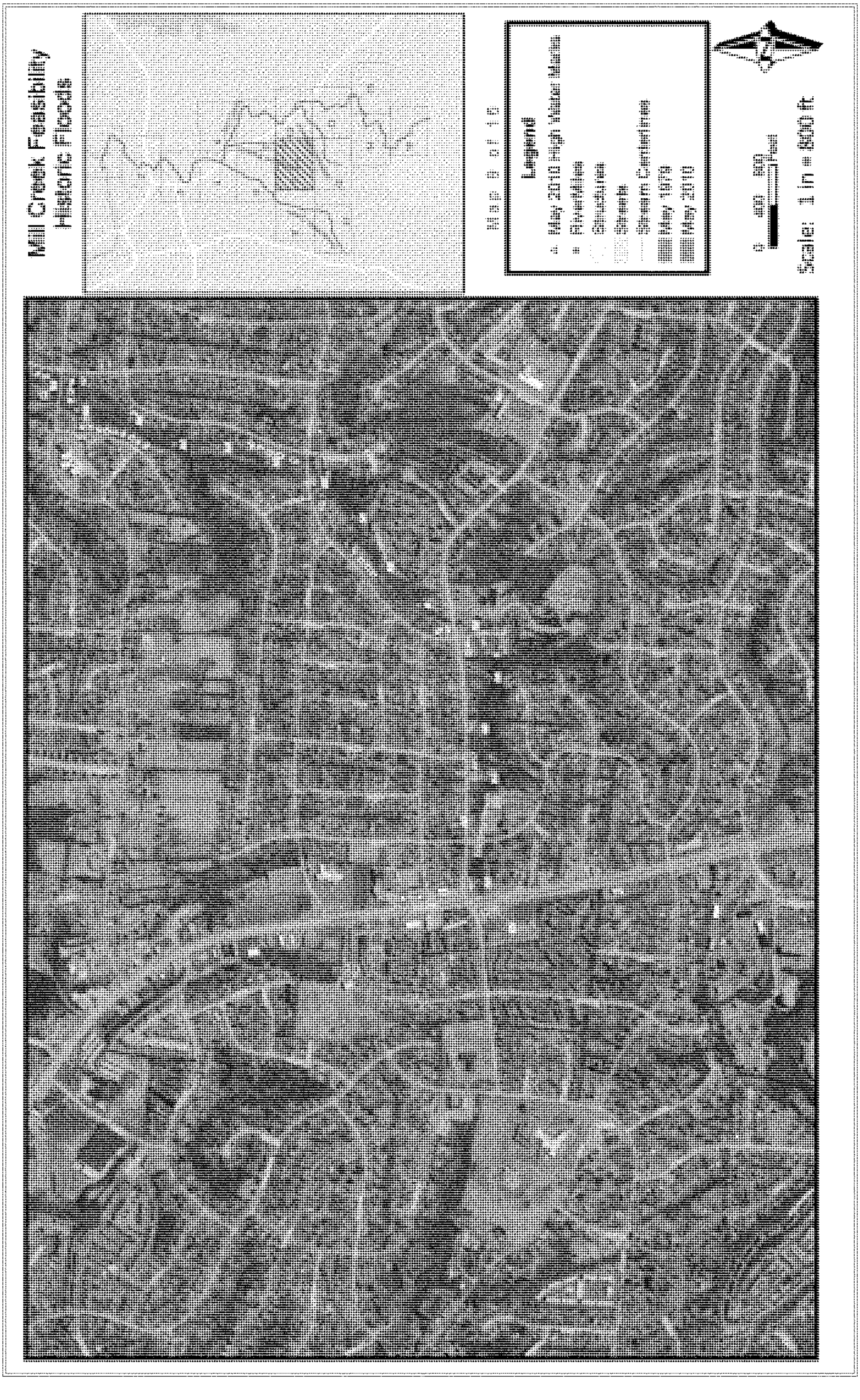

Mill Creek Feasibility
Historic Floods
Map 4 of 10
Legend
May 2010 High Water Marks
RiverMiles
Structures
Streets
Stream Centerlines
May 1979
May 2010
0 400 800
Feet
Scale: 1 in = 800 ft

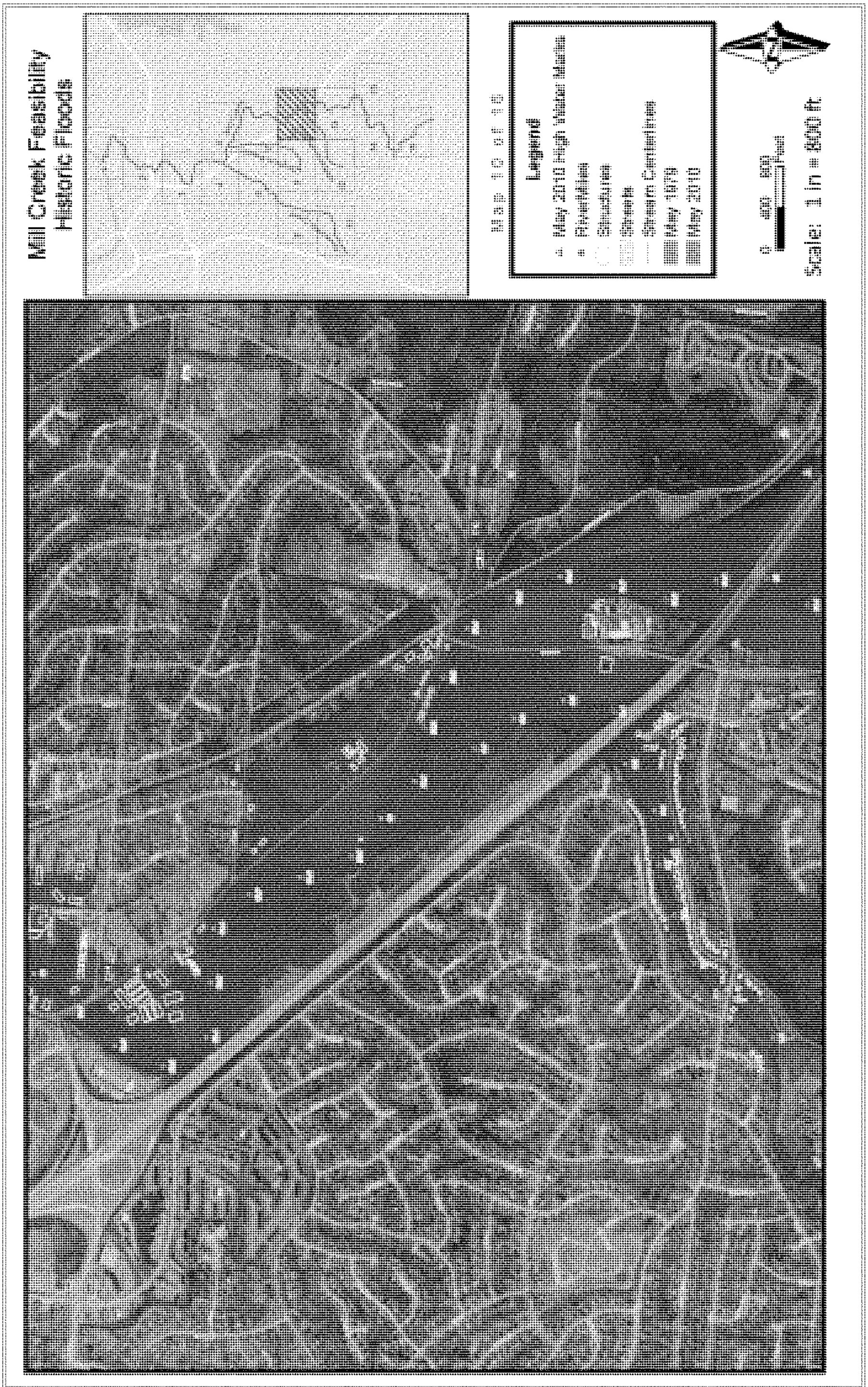

Mill Creek Feasibility
Historic Floods
Legend
May 2010 High Water Marks
Structures
Streets
Stream Centerlines
May 2010
Feet

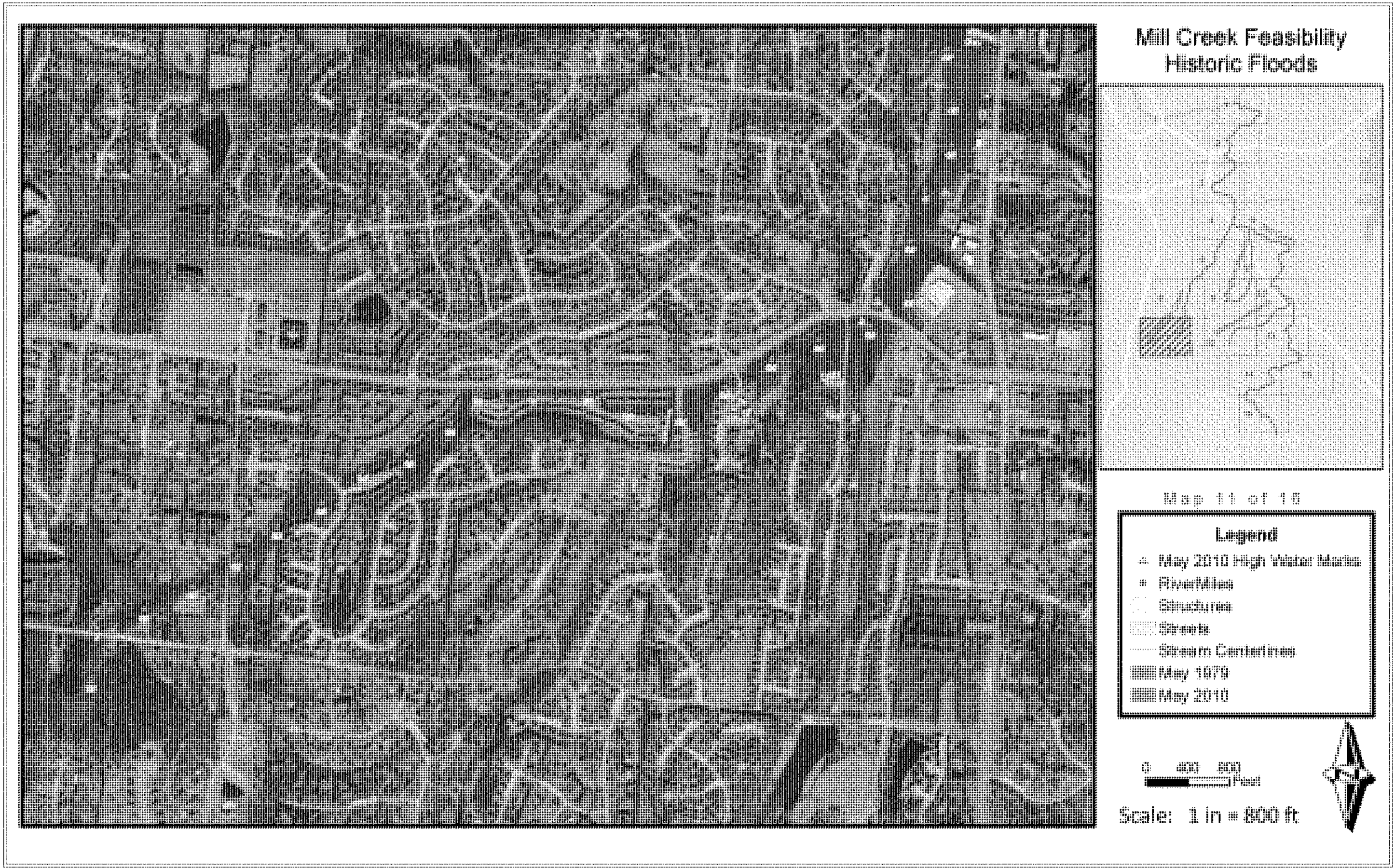

Mill Creek Feasibility
Historic Floods
Map 6 of 10
Legend
May 2010 High Water Marks
RiverMiles
Structures
Streets
Stream Centerlines
May 1979
May 2010
0 400 800
Feet
Scale: 1 in = 800 ft

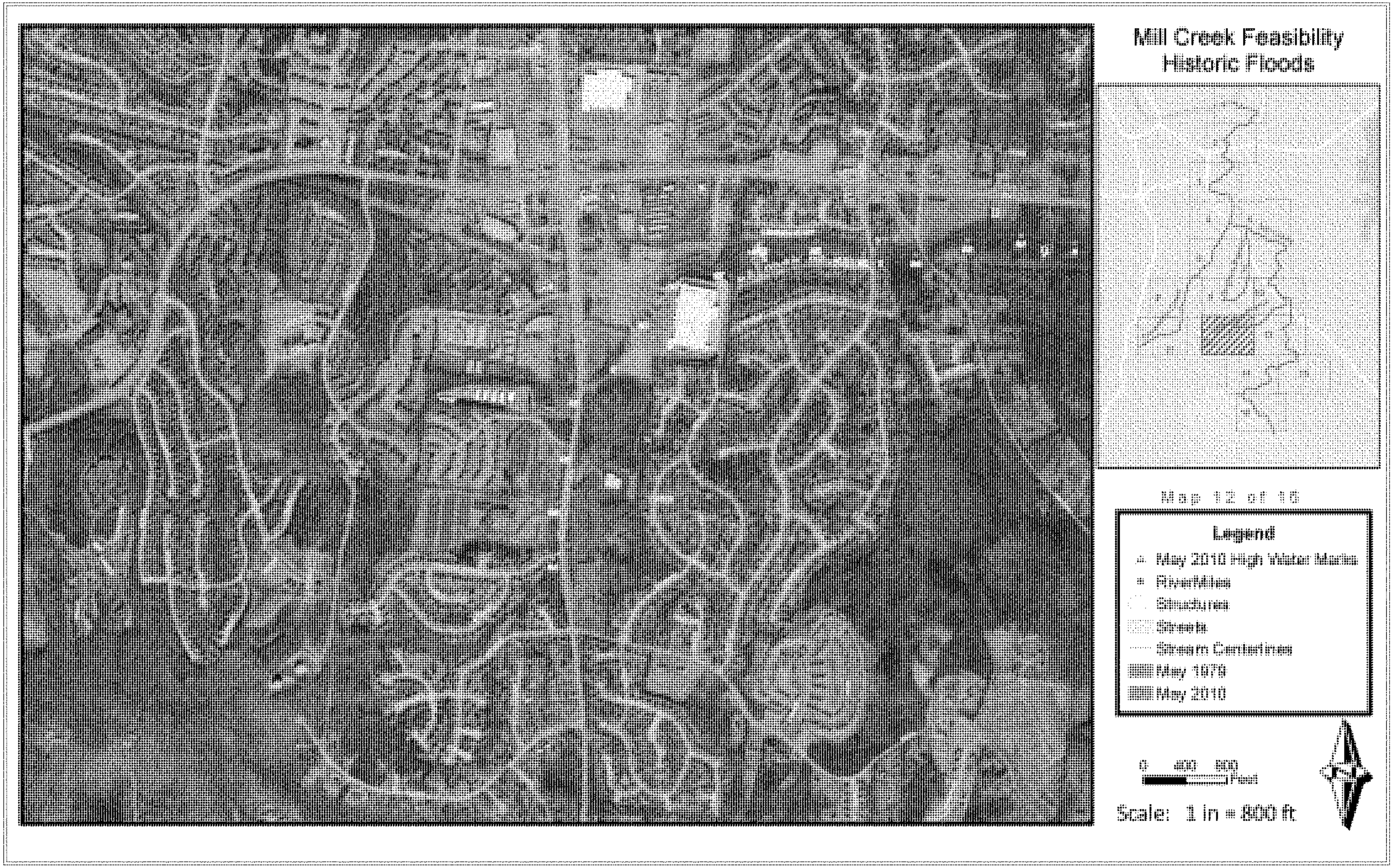

Mill Creek Feasibility
Historic Floods
Map 7 of 10
Legend
May 2010 High Water Marks
Rivermiles
Structures
Stream Centerlines
May 2010
Feet

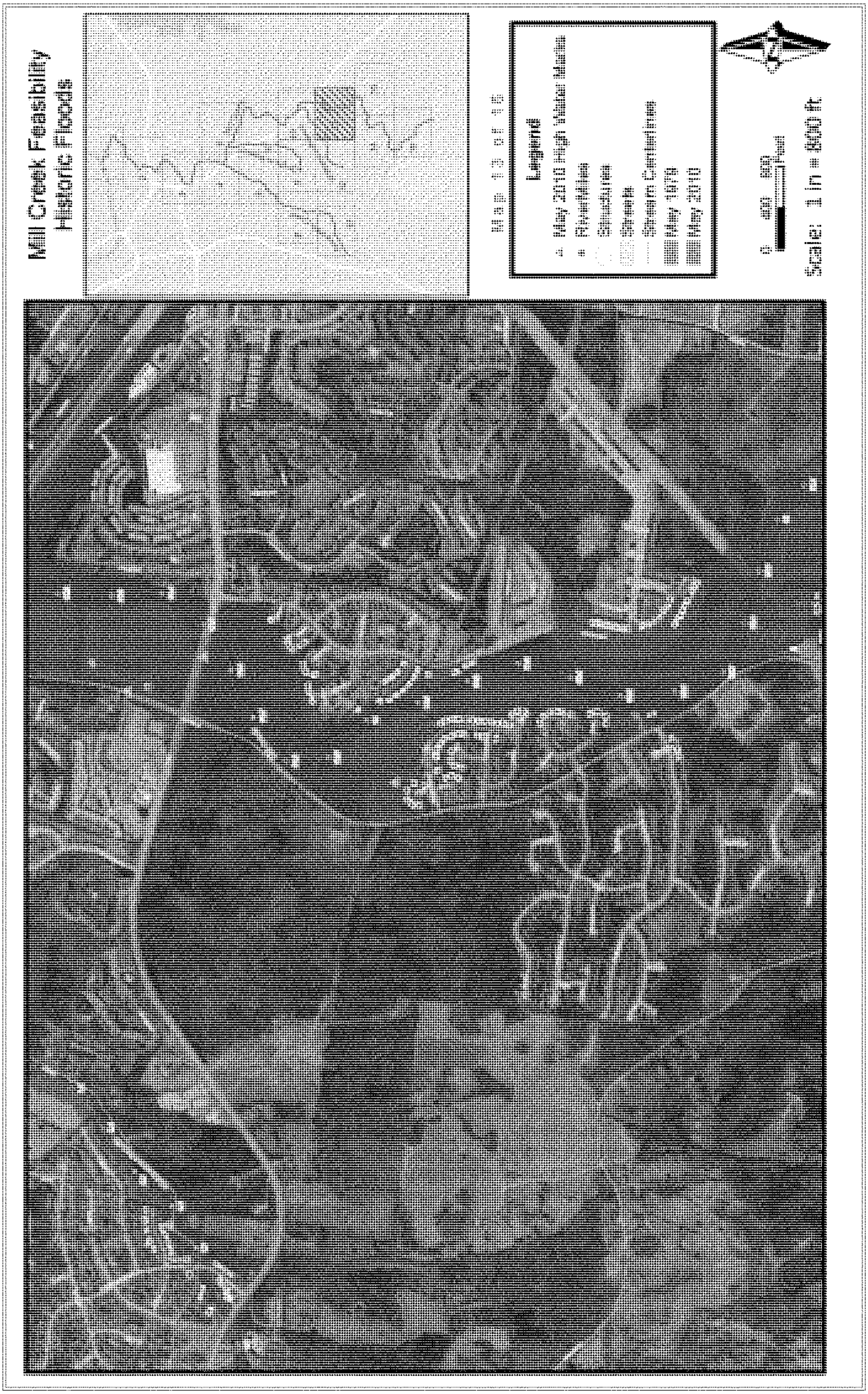

Mill Creek Feasibility
Historic Floods
Legend
May 2010 High Water Marks
Structures
Streets
Stream Centerlines
May 1979
May 2010
Scale: 1 in = 800 ft

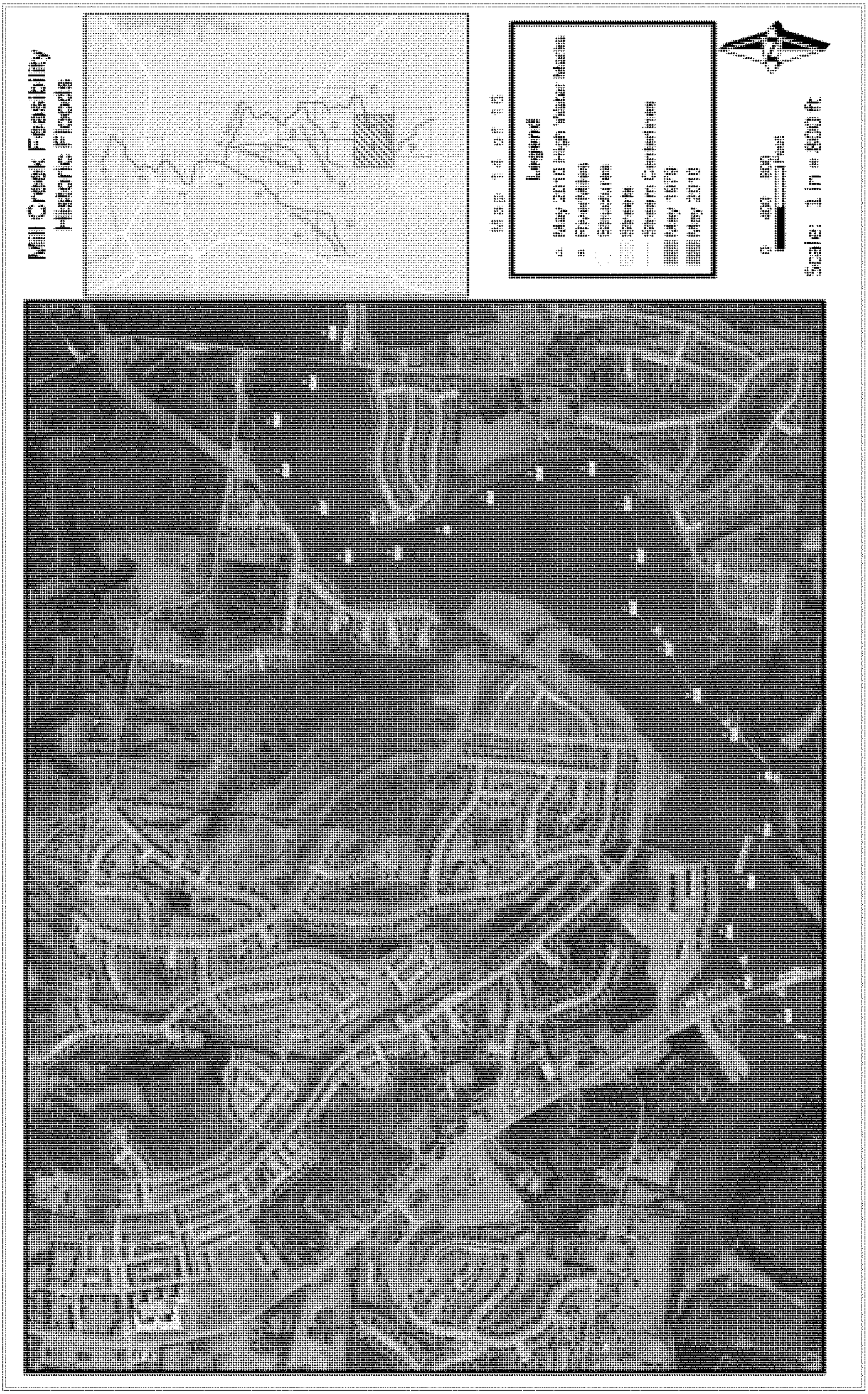

Mill Creek Feasibility
Historic Floods
Legend
Structures
Streets
Stream Centerlines
May 2010
Feet
Scale: 1 in = 500 ft

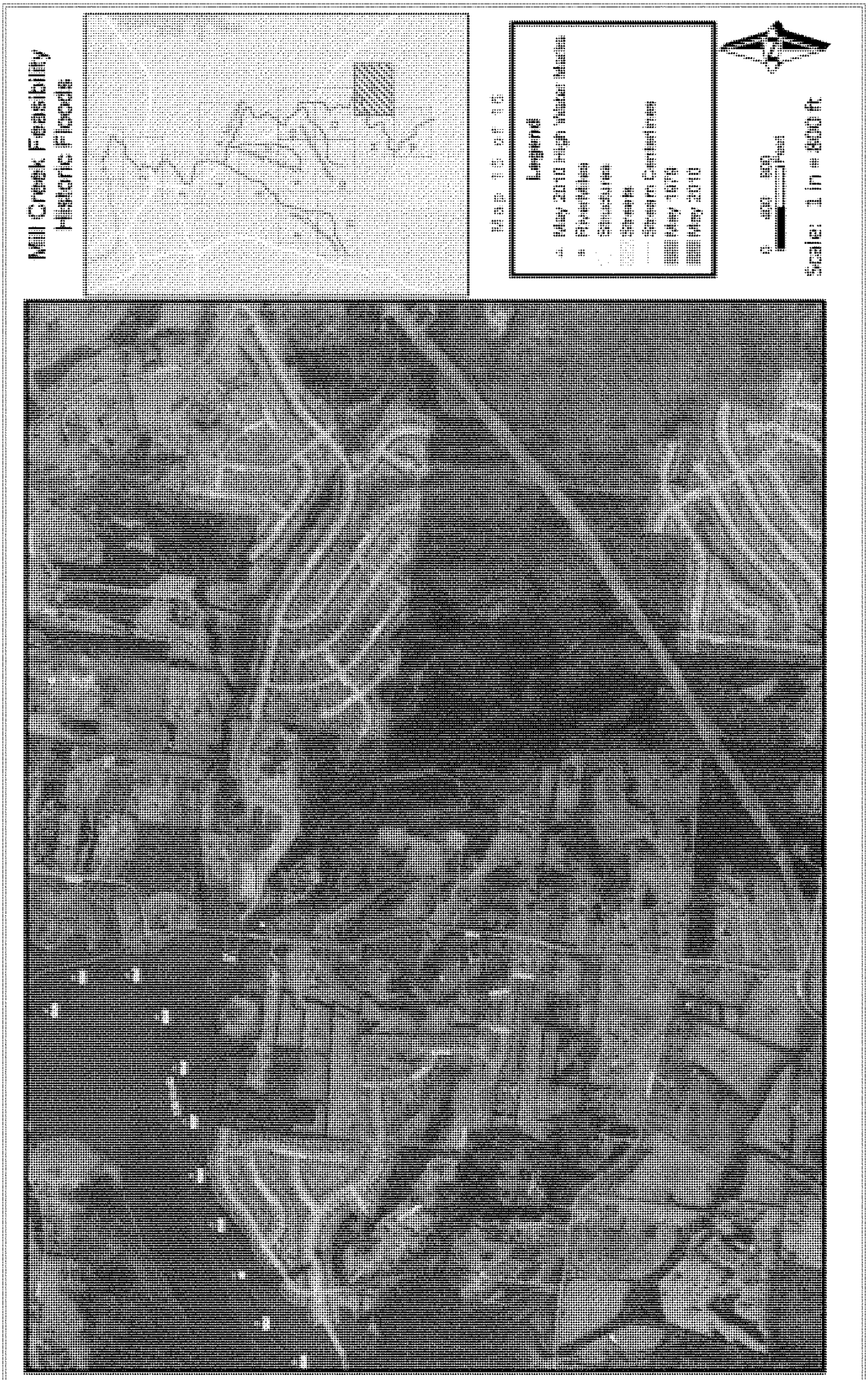

Mill Creek Feasibility
Historic Floods
Map 10 of 18
Legend
May 2010 High Water Marks
RiverMiles
Structures
Streets
Stream Centerlines
May 1979
May 2010
0 400 800
Feet
Scale: 1 in = 800 ft

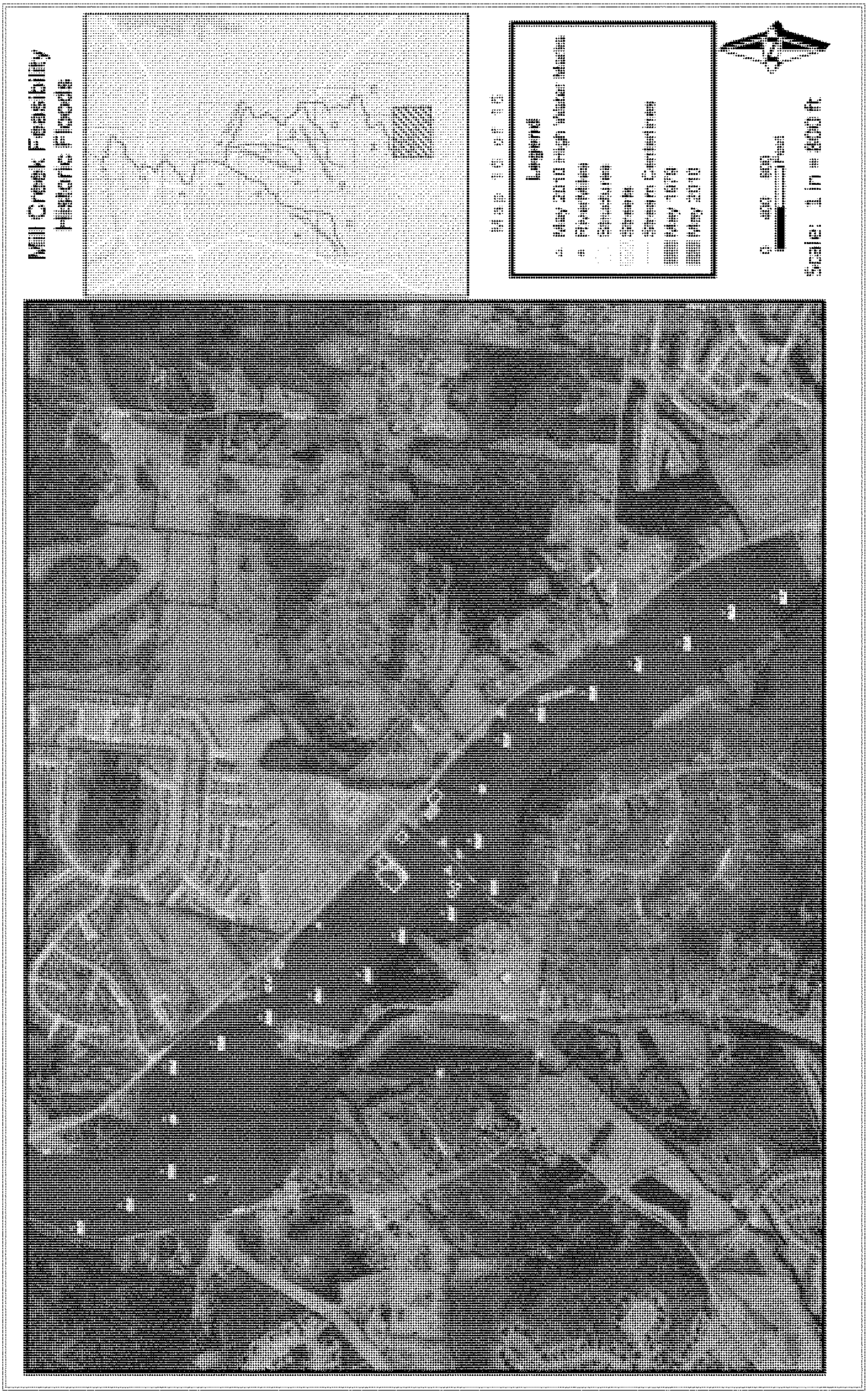

Mill Creek Feasibility
Historic Floods
Legend
May 2010 High Water Marks
RiverMiles
Structures
Streets
Stream Centerlines
May 1979
May 2010
Scale: 1 in = 800 ft


Mill Creek Feasibility
Historic Floods
Map 12 of 16
Legend
May 2010 High Water Marks
RiverMiles
Structures
Streets
Stream Centerlines
May 1979
May 2010
0 400 800
Feet
Scale: 1 in = 800 ft


Mill Creek Feasibility
Historic Floods
Map 13 of 15
Legend
May 2010 High Water Marks
RiverMiles
Structures
Streets
Stream Centerlines
May 2010
0 400 800
Feet
Scale: 1 in = 800 ft


Mill Creek Feasibility
Historic Floods
Legend
May 2010 High Water Marks
Rivermiles
Structures
Streams
Stream Centerlines
May 1979
May 2010
Scale: 1 in = 800 ft


Mill Creek Feasibility
Historic Floods
Legend
May 2010 High Water Marks
Rivermiles
Structures
Streets
Stream Centerlines
May 1979
May 2010
Scale: 1 in = 800 ft


Mill Creek Feasibility
Historic Floods
Legend
May 2010 High Water Marks
Stream Centerlines
May 1979
May 2010
Scale: 1 in = 800 ft

HYDROLOGY AND HYDRAULICS

APPENDIX C6

HISTORIC FLOODS

WATER SURFACE PROFILES

US Army Corps
of Engineers ®
Nashville District

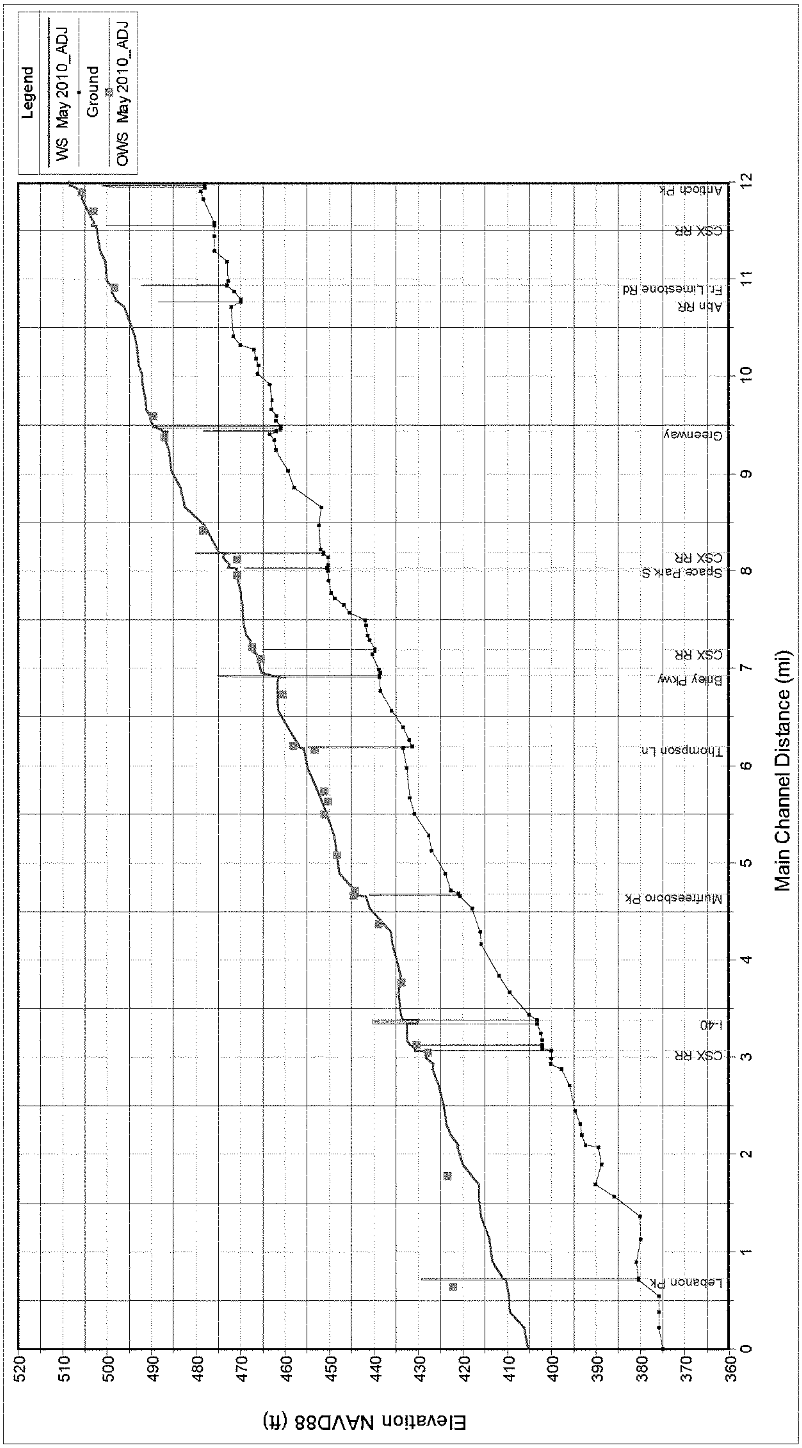


Figure C6 - 1: Mill Creek May 2010 Flood Event – River Mile 0 to 12 (Cumberland River Backwater Not Shown)

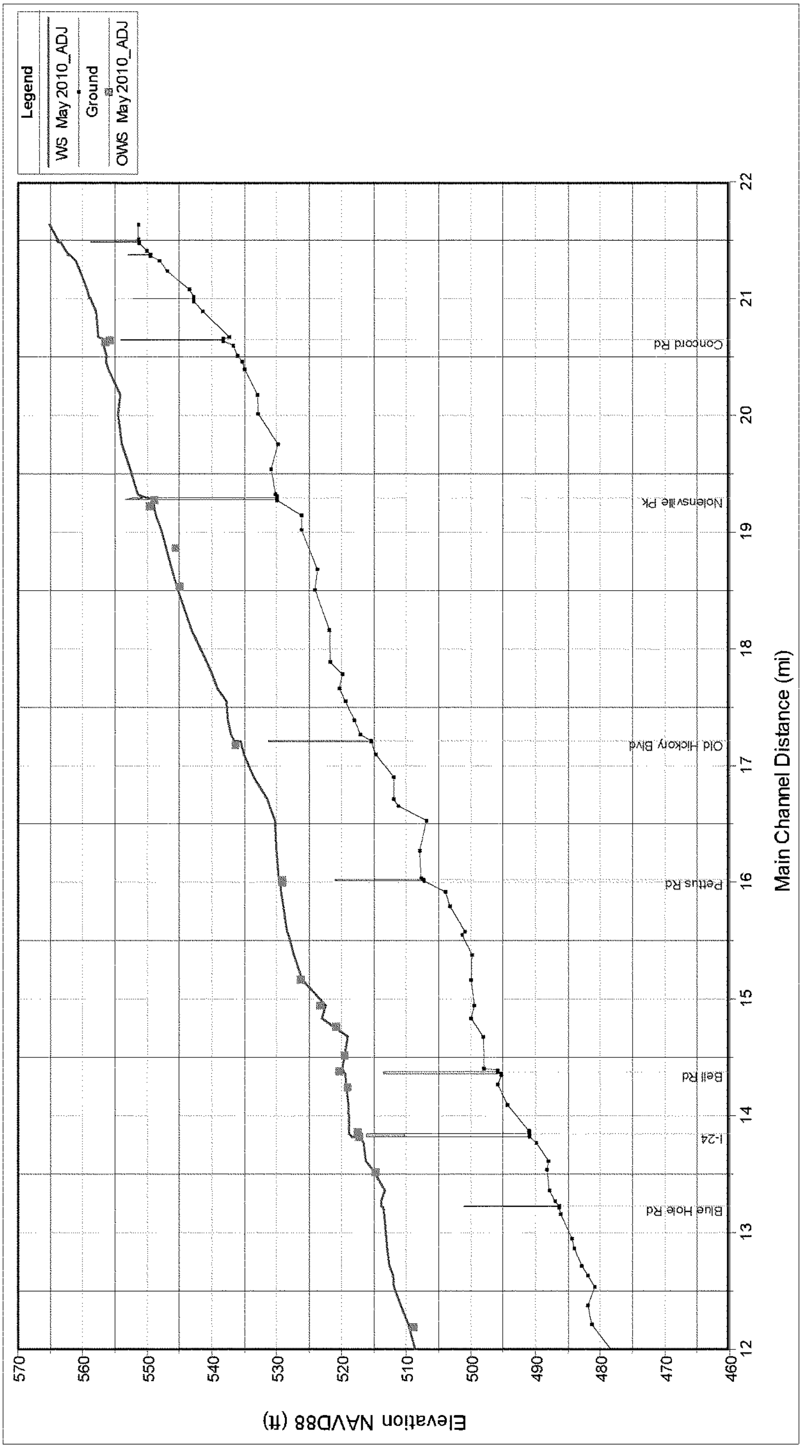


Figure C6 - 2: Mill Creek May 2010 Flood Event – River Mile 12 to 22

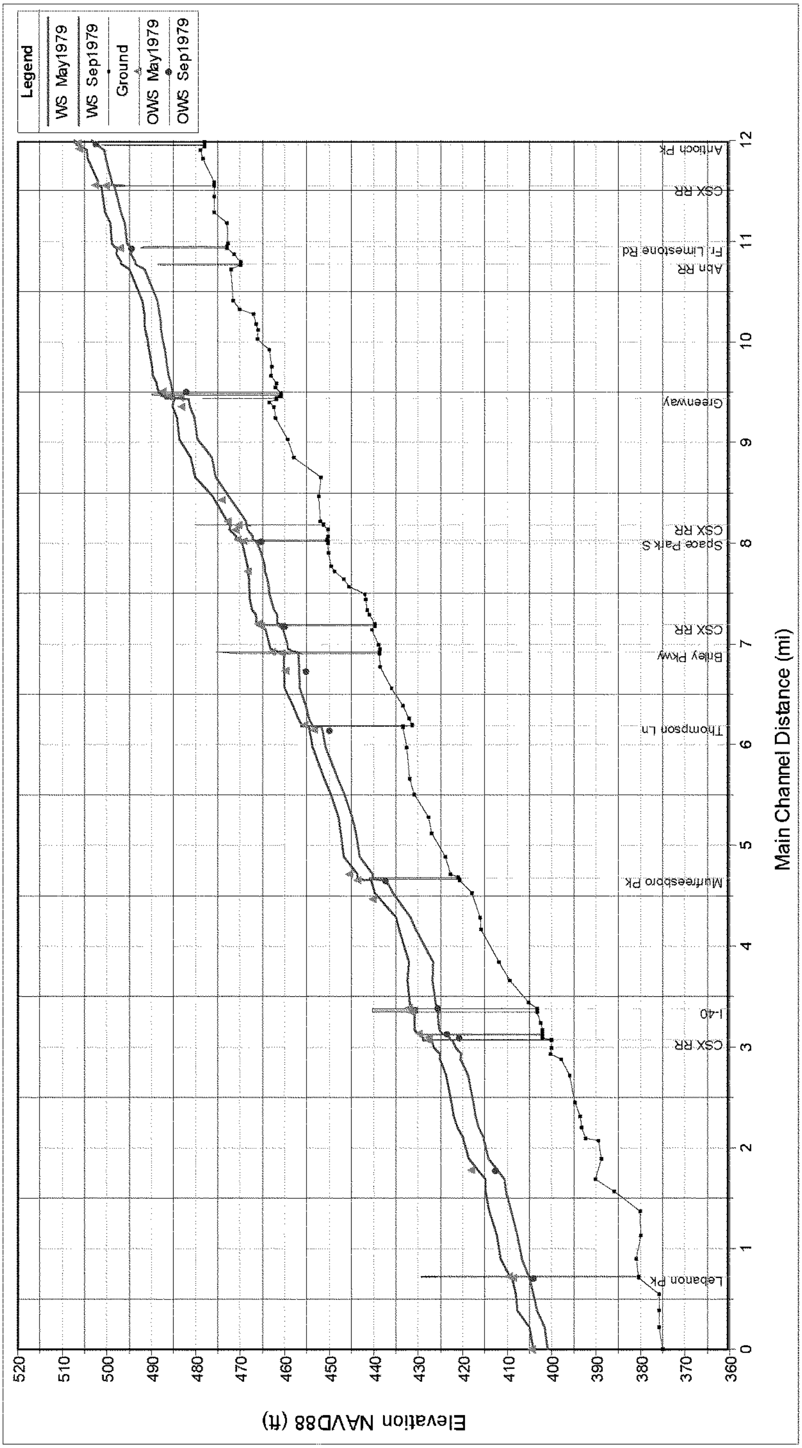


Figure C6 - 3: Mill Creek May 1979 and September 1979 Flood Events – River Mile 0 to 12

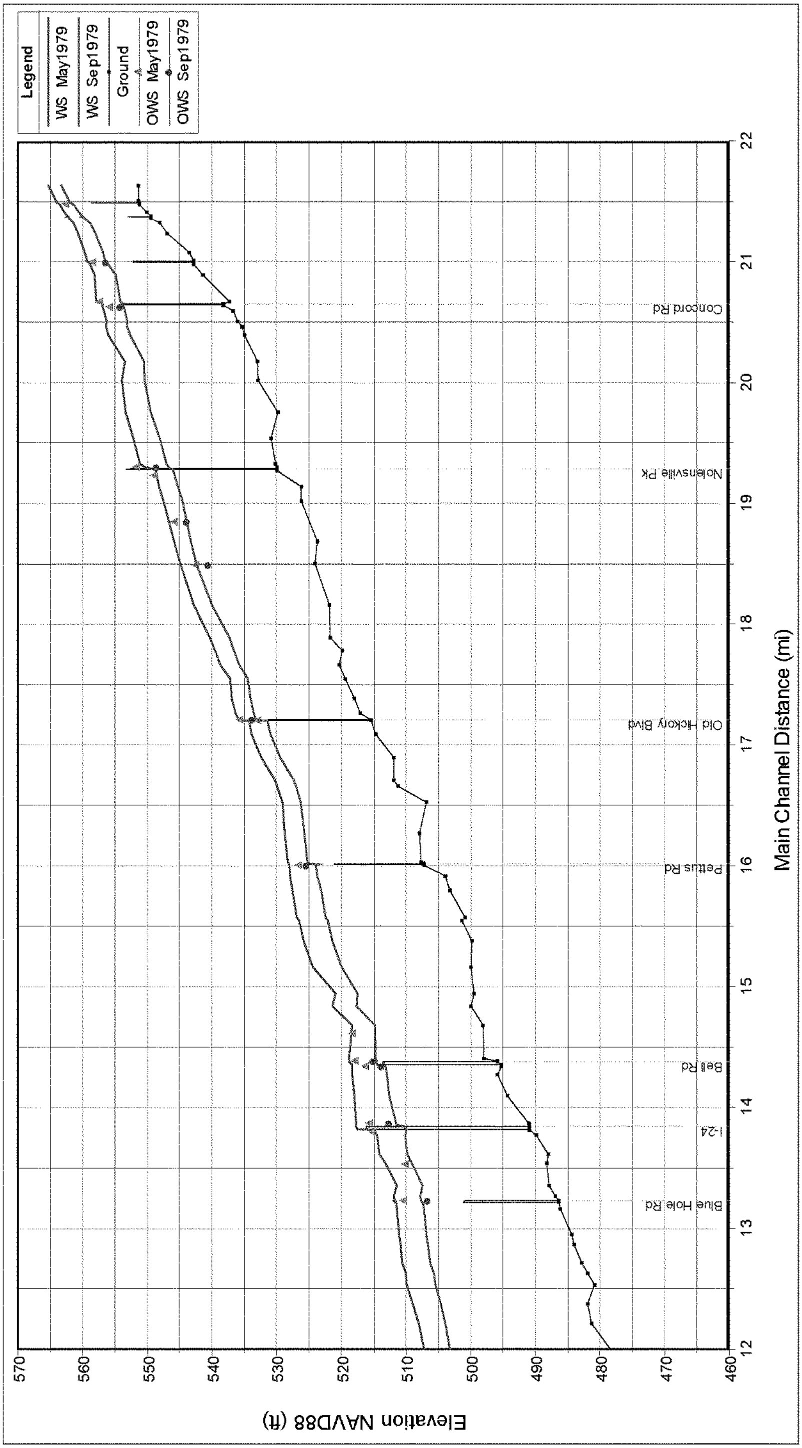


Figure C6 - 4: Mill Creek May 1979 and September 1979 Flood Events – River Mile 12 to 22

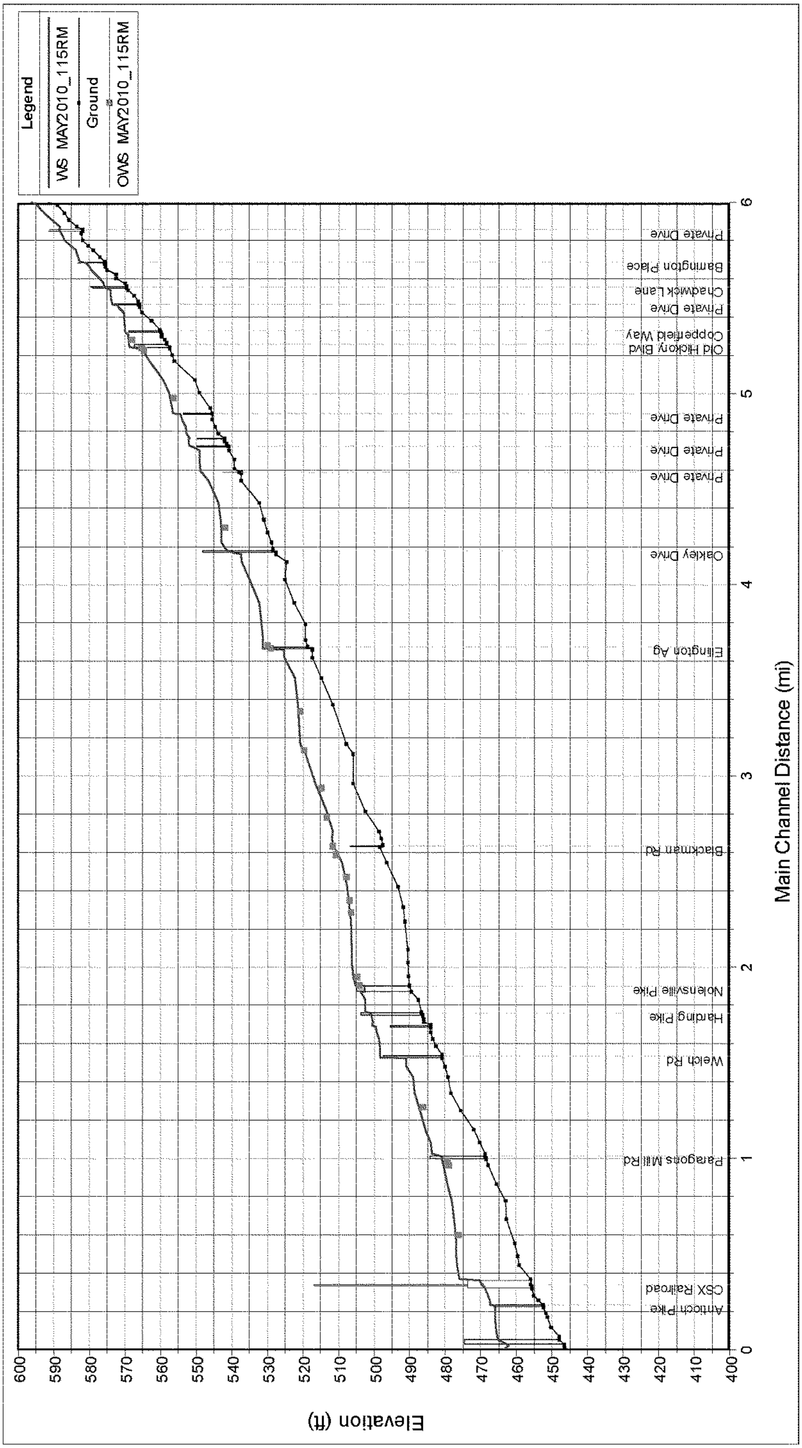


Figure C6 - 5: Sevenmile Creek May 2010 Flood Event – River Mile 0 to 6 (Mill Creek Backwater not Shown)

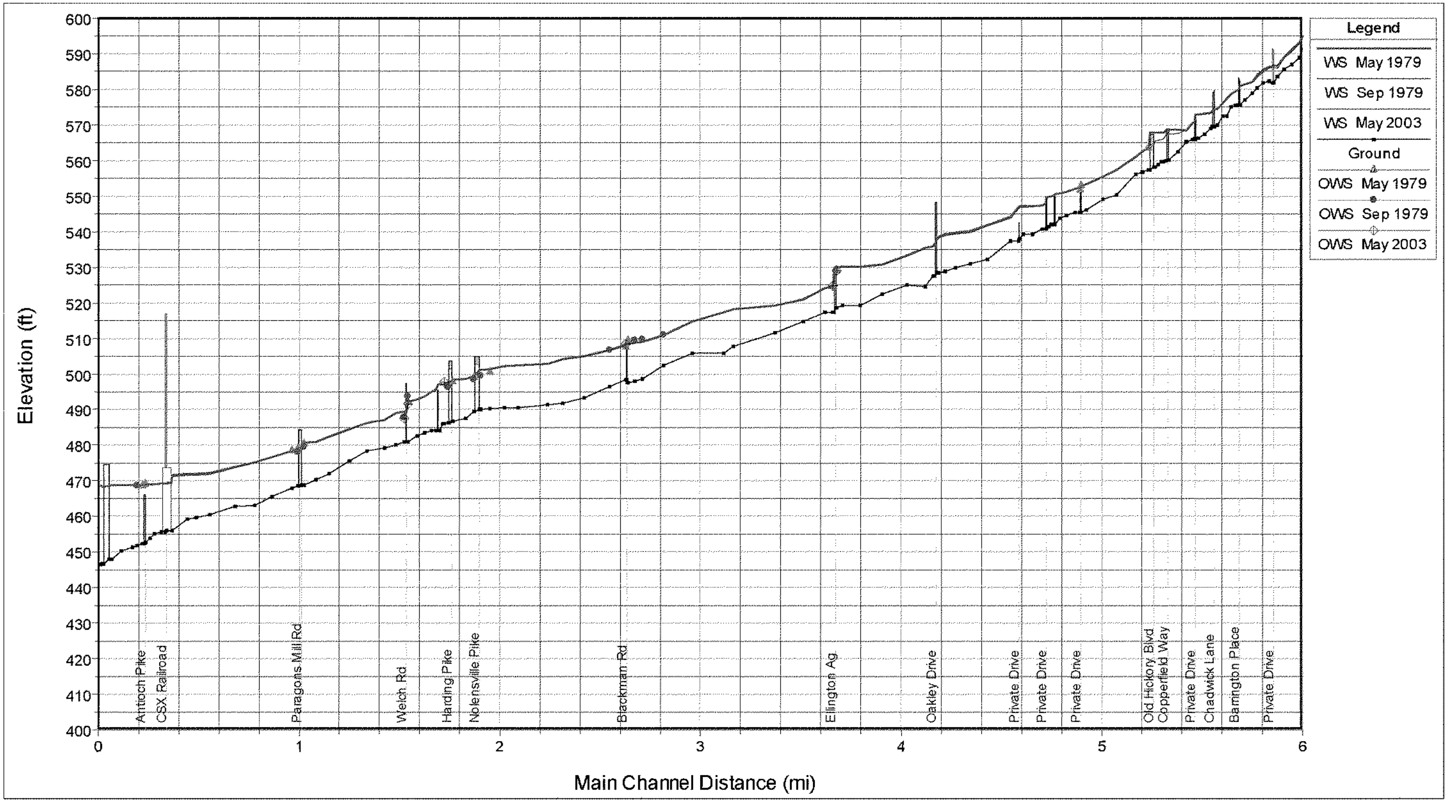


Figure C6 – 6: Sevenmile Creek May 1979, September 1979, and May 2003 Flood Events – River Mile 0 to 6

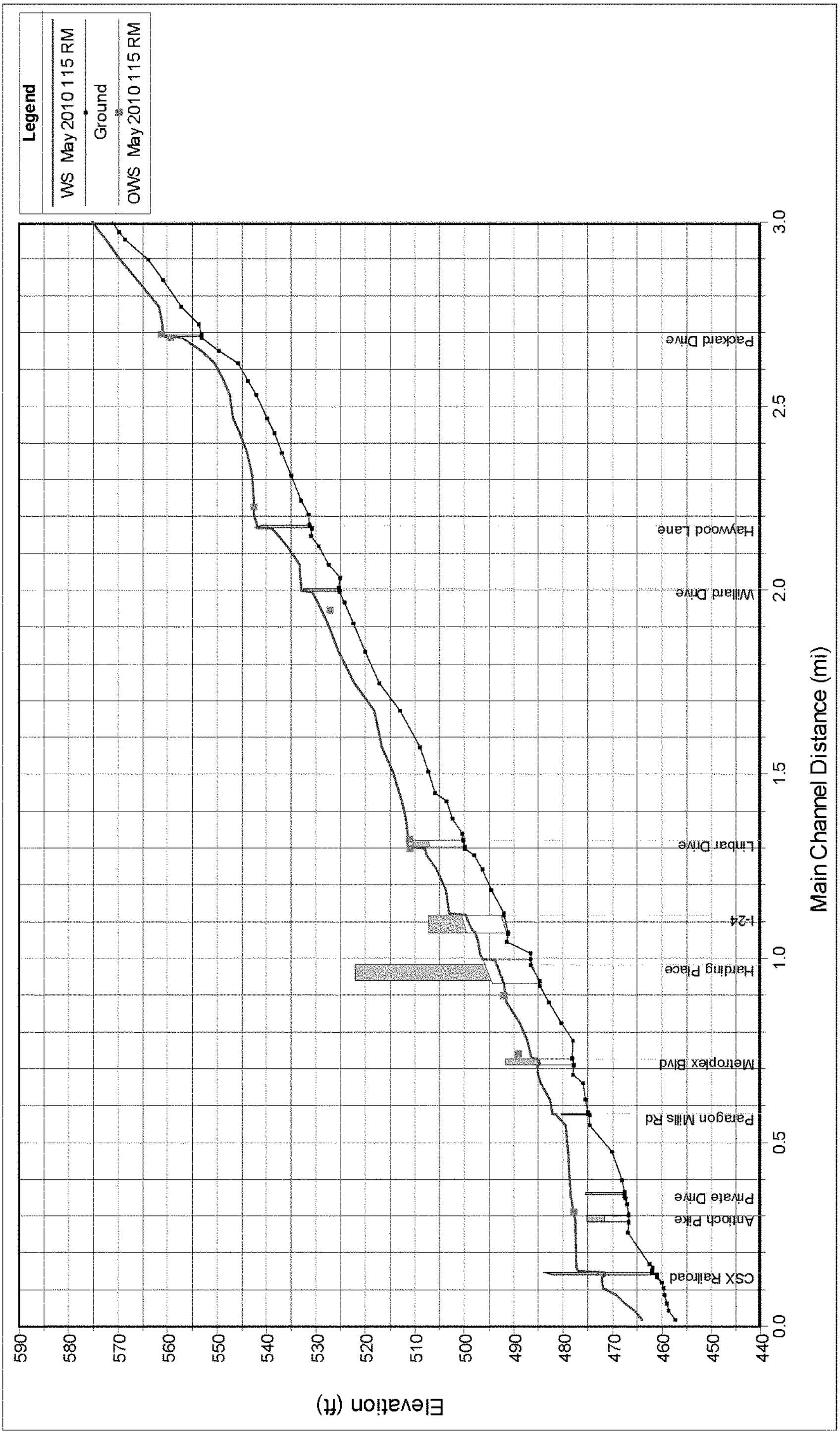


Figure C6 – 7: Sorghum Branch May 2010 Flood Event – River Mil 0 to 3 (Mill Creek Backwater Not Shown)

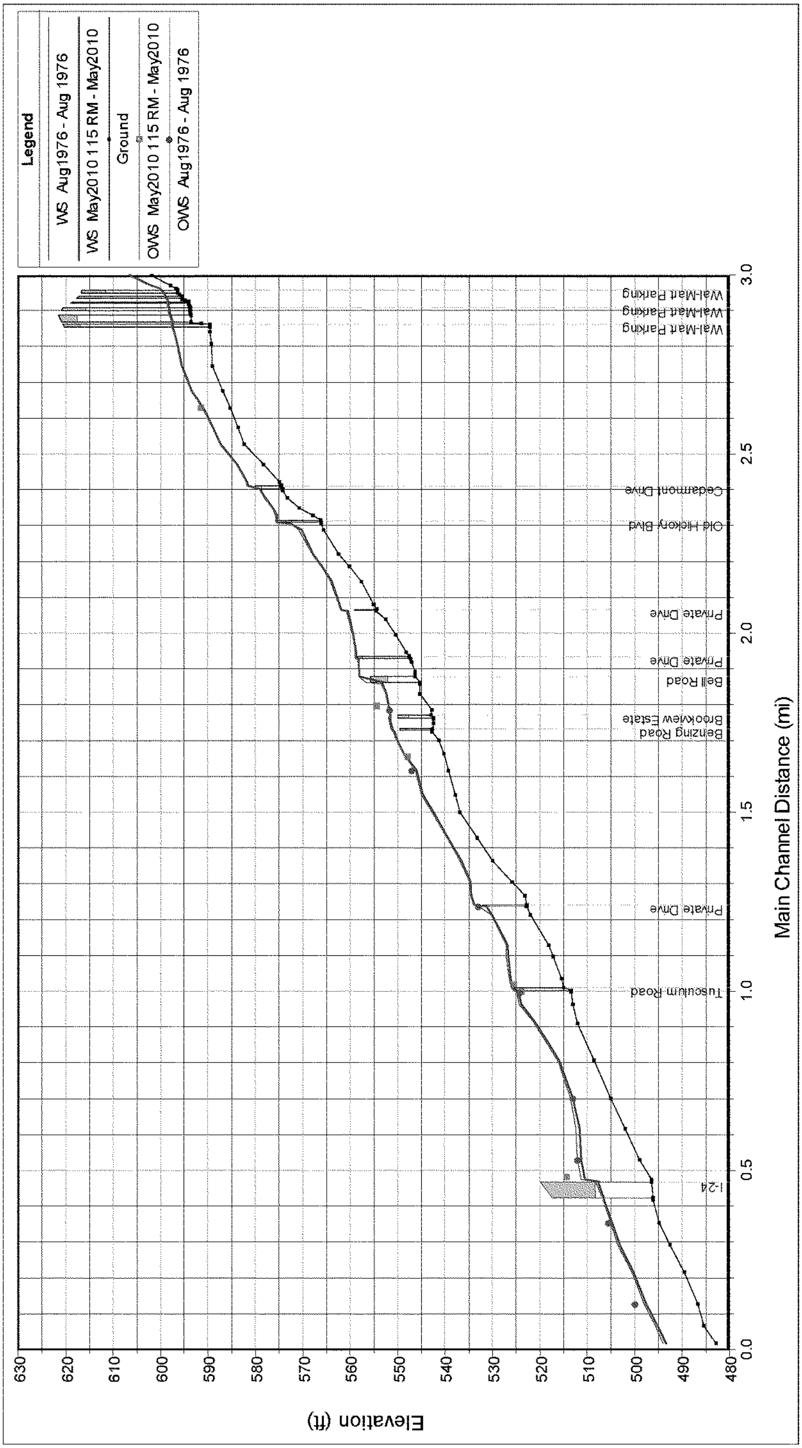


Figure C6 - 8: Whittemore Branch May 2010 and August 1976 Flood Events – River Mil 0 to 3

APPENDIX C7

MILL CREEK WATERSHED

FEASIBILITY

HEC-SSP

BULLETIN 17B

FREQUENCY ANALYSIS

REPORTS

Bulletin 17B Frequency Analysis - Mill Creek at Nolensville

17 Oct 2012   12:21 PM

--- Input Data ---

Analysis Name: Mill Creek at Nolensville

Description: Nashville Flood Preparedness Phase 2

Data Set Name: MILL CREEK-NOLENSVILLE, TN-FLOW-ANNUAL PEAK

DSS File Name:
C:\sspproj\Mill_Creek_Watershed\Mill_Creek_at_Nolensville\Mill_Creek_at_Nolensville\Mill_Creek_at_Nolensville.dss

DSS Pathname: /MILL CREEK/NOLENSVILLE, TN/FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name:
C:\sspproj\Mill_Creek_Watershed\Mill_Creek_at_Nolensville\Mill_Creek_at_Nolensville\Bulletin17bResults\Mill_Creek_at_Nolensville\Mill_Creek_at_Nolensville.rpt

XML File Name:
C:\sspproj\Mill_Creek_Watershed\Mill_Creek_at_Nolensville\Mill_Creek_at_Nolensville\Bulletin17bResults\Mill_Creek_at_Nolensville\Mill_Creek_at_Nolensville.xml

Start Date:

End Date:

Skew Option: Use Station Skew

Regional Skew: 0.0

Regional Skew MSE: 0.01

PLotting Position Type: Median

Upper Confidence Level: 0.05

Lower Confidence Level: 0.95

Use non-standard frequencies

Frequency: 0.2

Frequency: 0.5

Frequency: 1.0

Frequency: 2.0

Frequency: 4.0

Frequency: 10.0

Frequency: 20.0

Frequency: 50.0

Frequency: 80.0

Frequency: 90.0

Frequency: 95.0

Frequency: 99.0

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

<< Low Outlier Test >>

Based on 41 events, 10 percent outlier test deviate K(N) = 2.692

Computed low outlier test value = 1,065.71

0 low outlier(s) identified below test value of 1,065.71

<< High Outlier Test >>

Based on 41 events, 10 percent outlier test deviate K(N) = 2.692

Computed high outlier test value = 21,572.42

0 high outlier(s) identified above test value of 21,572.42

--- Final Results ---

<< Plotting Positions >>

MILL CREEK-NOLENSVILLE, TN-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events			
	FLOW		Water	FLOW	Median
Day Mon Year	CFS	Rank	Year	CFS	Plot Pos
25 Mar 1965	4,040.0	1	2010	11,600.0	1.69
30 Aug 1966	2,040.0	2	1984	11,400.0	4.11
15 May 1967	3,520.0	3	1979	11,400.0	6.52

11 Mar 1968	3,970.0	4	1994	8,630.0	8.94	
28 Dec 1968	1,500.0	5	2000	8,300.0	11.35	
21 Jun 1970	5,420.0	6	2003	8,160.0	13.77	
21 Dec 1970	2,200.0	7	1995	7,620.0	16.18	
09 Aug 1972	3,780.0	8	1996	7,370.0	18.60	
04 Dec 1972	4,800.0	9	1999	7,020.0	21.01	
27 Nov 1973	5,190.0	10	1992	6,820.0	23.43	
29 Mar 1975	5,710.0	11	1997	6,720.0	25.85	
29 Mar 1976	2,100.0	12	1983	6,720.0	28.26	
12 Mar 1977	4,800.0	13	2001	6,600.0	30.68	
13 Mar 1978	4,530.0	14	1987	6,500.0	33.09	
04 May 1979	11,400.0	15	1990	6,480.0	35.51	
28 Mar 1980	5,360.0	16	1982	6,100.0	37.92	
30 Mar 1981	1,560.0	17	1988	5,760.0	40.34	
17 Aug 1982	6,100.0	18	1975	5,710.0	42.75	
26 Dec 1982	6,720.0	19	1989	5,690.0	45.17	
07 May 1984	11,400.0	20	1970	5,420.0	47.58	
27 Nov 1984	1,710.0	21	1980	5,360.0	50.00	
04 Sep 1986	4,670.0	22	1974	5,190.0	52.42	
26 Nov 1986	6,500.0	23	1977	4,800.0	54.83	
25 Dec 1987	5,760.0	24	1973	4,800.0	57.25	
14 Feb 1989	5,690.0	25	2004	4,710.0	59.66	
03 Feb 1990	6,480.0	26	1998	4,700.0	62.08	
22 Dec 1990	4,610.0	27	1986	4,670.0	64.49	
02 Dec 1991	6,820.0	28	1991	4,610.0	66.91	
23 Mar 1993	1,240.0	29	1978	4,530.0	69.32	
26 Jun 1994	8,630.0	30	1965	4,040.0	71.74	
14 May 1995	7,620.0	31	1968	3,970.0	74.15	
05 Oct 1995	7,370.0	32	1972	3,780.0	76.57	
03 Mar 1997	6,720.0	33	1967	3,520.0	78.99	
04 Jun 1998	4,700.0	34	2002	3,210.0	81.40	
23 Jan 1999	7,020.0	35	1971	2,200.0	83.82	

25 May 2000	8,300.0	36	1976	2,100.0	86.23
16 Dec 2000	6,600.0	37	1966	2,040.0	88.65
24 Jan 2002	3,210.0	38	1985	1,710.0	91.06
22 Sep 2003	8,160.0	39	1981	1,560.0	93.48
05 Feb 2004	4,710.0	40	1969	1,500.0	95.89
01 May 2010	11,600.0	41	1993	1,240.0	98.31

<< Skew Weighting >>

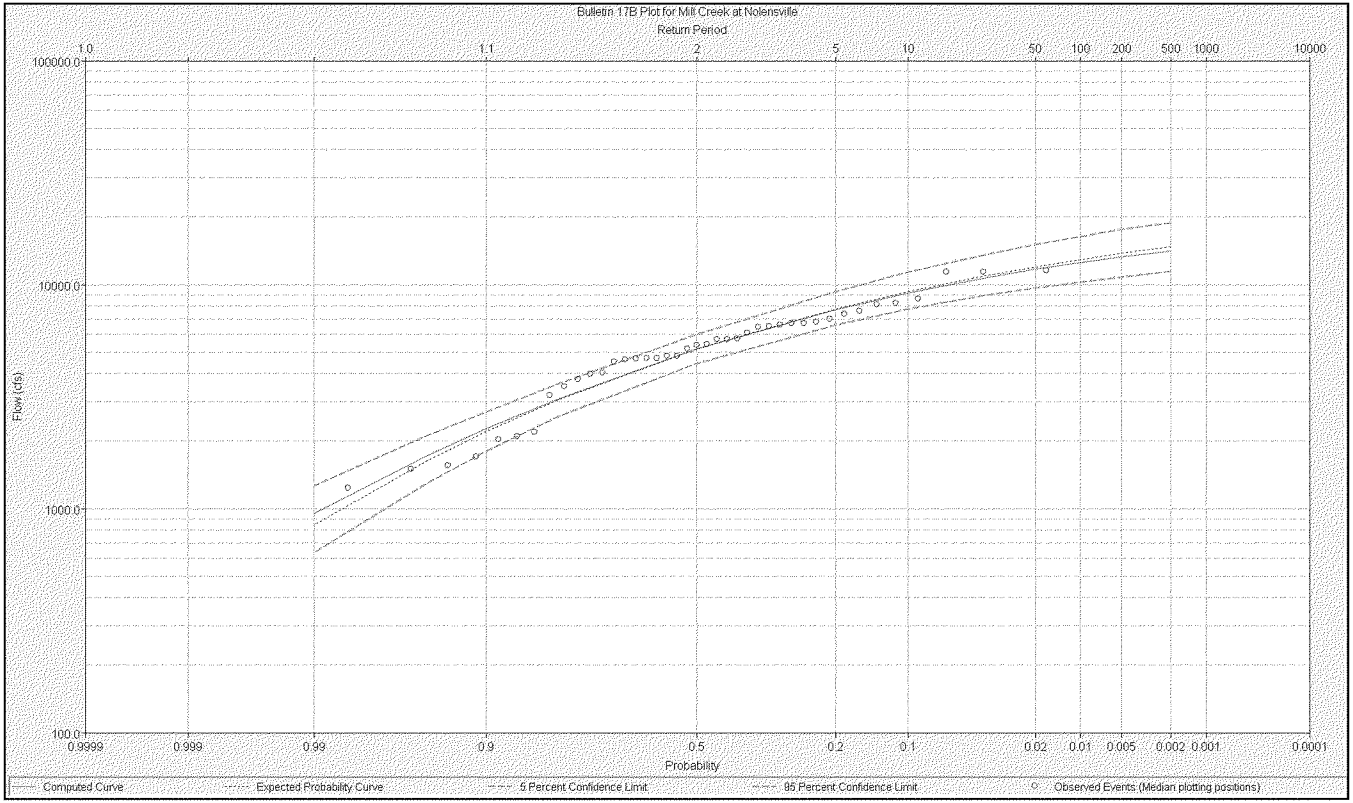
Based on 41 events, mean-square error of station skew =	0.194
Mean-square error of regional skew =	0.01

<< Frequency Curve >>

MILL CREEK-NOLENSVILLE, TN-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
14,183.3	14,739.9	0.2	18,970.2	11,440.9
13,335.7	13,781.8	0.5	17,630.1	10,836.2
12,590.3	12,962.3	1.0	16,467.9	10,298.8
11,736.6	12,027.0	2.0	15,156.5	9,676.2
10,751.8	10,967.3	4.0	13,671.8	8,947.3
9,189.9	9,307.6	10.0	11,385.3	7,763.6
7,734.6	7,793.6	20.0	9,341.7	6,622.0
5,164.6	5,164.6	50.0	5,996.1	4,471.6
3,102.6	3,060.3	80.0	3,614.2	2,583.5
2,272.4	2,207.7	90.0	2,714.1	1,805.7
1,715.0	1,633.9	95.0	2,111.8	1,296.0

```
|       951.3        844.1 |      99.0     |      1,263.9        639.4 |
|-------------------------|-------------|------------------------|


<< Systematic Statistics >>

MILL CREEK-NOLENSVILLE, TN-FLOW-ANNUAL PEAK

----------------------------------------------------------------

|        Log Transform:        |                              |
|          FLOW, CFS            |       Number of Events       |
|------------------------------|------------------------------|
|  Mean                  3.681  |  Historic Events          0  |
|  Standard Dev          0.243  |  High Outliers         0     |
|  Station Skew         -0.806  |  Low Outliers          0     |
|  Regional Skew         0.000  |  Zero Events           0     |
|  Weighted Skew        -0.040  |  Missing Events        0     |
|  Adopted Skew         -0.806  |  Systematic Events       41  |
|------------------------------|------------------------------|


--- End of Analytical Frequency Curve ---
```



Bulletin 17B Plot for Mill Creek at Nolensville
Return Period
1.0
1.1
2
5
10
50
100
200
500
1000
10000
Flow (cfs)
100000.0
10000.0
1000.0
100.0
0.9999
0.999
0.99
0.9
0.5
0.2
0.1
0.02
0.01
0.005
0.002
0.001
0.0001
Probability
Computed Curve
Expected Probability Curve
5 Percent Confidence Limit
95 Percent Confidence Limit
Observed Events (Median plotting positions)

Bulletin 17B Frequency Analysis - Mill Creek Near Antioch

17 Oct 2012 12:32 PM

--- Input Data ---

Analysis Name: Mill Creek Near Antioch

Description: Nashville Flood Preparedness Phase 2

Data Set Name: MILL CREEK-ANTIOCH, TN-FLOW-ANNUAL PEAK

DSS File Name:
C:\sspproj\Mill_Creek_Watershed\Mill_Creek_near_Antioch\Mill_Creek_Near_Antioch\Mill_Creek_Near_Antioch.dss

DSS Pathname: /MILL CREEK/ANTIOCH, TN/FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name:
C:\sspproj\Mill_Creek_Watershed\Mill_Creek_near_Antioch\Mill_Creek_Near_Antioch\Bulletin17bResults\Mill_Creek_Near_Antioch\Mill_Creek_Near_Antioch.rpt

XML File Name:
C:\sspproj\Mill_Creek_Watershed\Mill_Creek_near_Antioch\Mill_Creek_Near_Antioch\Bulletin17bResults\Mill_Creek_Near_Antioch\Mill_Creek_Near_Antioch.xml

Start Date:

End Date:

Skew Option: Use Station Skew

Regional Skew: 0.0

Regional Skew MSE: 0.01

Plotting Position Type: Median

Upper Confidence Level: 0.05

Lower Confidence Level: 0.95

Use Historic Data

Historic Period Start Year: 1850

Historic Period End Year: ---

Use non-standard frequencies

Frequency: 0.2

Frequency: 0.5

Frequency: 1.0

Frequency: 2.0

Frequency: 4.0

Frequency: 10.0

Frequency: 20.0

Frequency: 50.0

Frequency: 80.0

Frequency: 90.0

Frequency: 95.0

Frequency: 99.0

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

--- Preliminary Results ---

<< Plotting Positions >>

MILL CREEK-ANTIOCH, TN-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events			
	FLOW		Water	FLOW	Median
Day Mon Year	CFS	Rank	Year	CFS	Plot Pos
24 Mar 1954	6,850.0	1	2010	37,910.0*	1.22
21 Mar 1955	17,000.0	2	1979	30,100.0	2.96
17 Feb 1956	7,320.0	3	1955	17,000.0	4.70
29 Jan 1957	5,570.0	4	1960	15,600.0	6.45
20 Dec 1957	5,120.0	5	1962	13,800.0	8.19
01 Jul 1959	2,880.0	6	2003	12,000.0	9.93
17 Jun 1960	15,600.0	7	2000	10,800.0	11.67
12 Apr 1961	4,020.0	8	1998	10,800.0	13.41
27 Feb 1962	13,800.0	9	1984	10,700.0	15.16
11 Mar 1963	7,220.0	10	1974	10,500.0	16.90
04 Mar 1964	5,660.0	11	1999	10,400.0	18.64
26 Mar 1965	6,810.0	12	1975	9,980.0	20.38
01 Oct 1965	3,070.0	13	2004	9,890.0	22.13
06 Mar 1967	6,430.0	14	1970	9,270.0	23.87

12 Mar 1968	3,410.0	15	1992	8,540.0	25.61
18 Apr 1969	3,440.0	16	1997	8,410.0	27.35
21 Jun 1970	9,270.0	17	1996	7,720.0	29.09
04 Jan 1971	3,860.0	18	1956	7,320.0	30.84
09 Aug 1972	3,300.0	19	1973	7,220.0	32.58
10 Dec 1972	7,220.0	20	1963	7,220.0	34.32
27 Nov 1973	10,500.0	21	1980	6,980.0	36.06
12 Mar 1975	9,980.0	22	2005	6,970.0	37.80
20 Mar 1976	4,000.0	23	1983	6,870.0	39.55
12 Mar 1977	5,640.0	24	1954	6,850.0	41.29
13 Mar 1978	5,600.0	25	1965	6,810.0	43.03
04 May 1979	30,100.0	26	1989	6,630.0	44.77
28 Mar 1980	6,980.0	27	1995	6,590.0	46.52
01 Jan 1981	2,810.0	28	1988	6,590.0	48.26
09 Feb 1982	4,340.0	29	1967	6,430.0	50.00
19 May 1983	6,870.0	30	1987	6,360.0	51.74
07 May 1984	10,700.0	31	1990	6,220.0	53.48
27 Nov 1984	3,670.0	32	1994	5,750.0	55.23
04 Sep 1986	4,440.0	33	1964	5,660.0	56.97
26 Nov 1986	6,360.0	34	1977	5,640.0	58.71
25 Dec 1987	6,590.0	35	1978	5,600.0	60.45
14 Feb 1989	6,630.0	36	1957	5,570.0	62.20
03 Feb 1990	6,220.0	37	2006	5,430.0	63.94
22 Dec 1990	4,520.0	38	2001	5,350.0	65.68
03 Dec 1991	8,540.0	39	1958	5,120.0	67.42
23 Mar 1993	2,610.0	40	2002	5,070.0	69.16
09 Mar 1994	5,750.0	41	1991	4,520.0	70.91
14 May 1995	6,590.0	42	1986	4,440.0	72.65
05 Oct 1995	7,720.0	43	1982	4,340.0	74.39
03 Mar 1997	8,410.0	44	1961	4,020.0	76.13
04 Jun 1998	10,800.0	45	1976	4,000.0	77.87
23 Jan 1999	10,400.0	46	2008	3,910.0	79.62

25 May 2000	10,800.0	47	2009	3,880.0	81.36
16 Feb 2001	5,350.0	48	1971	3,860.0	83.10
24 Jan 2002	5,070.0	49	1985	3,670.0	84.84
05 May 2003	12,000.0	50	2007	3,550.0	86.59
05 Feb 2004	9,890.0	51	1969	3,440.0	88.33
19 Oct 2004	6,970.0	52	1968	3,410.0	90.07
23 Jan 2006	5,430.0	53	1972	3,300.0	91.81
01 Jan 2007	3,550.0	54	1966	3,070.0	93.55
04 Apr 2008	3,910.0	55	1959	2,880.0	95.30
26 Sep 2009	3,880.0	56	1981	2,810.0	97.04
01 May 2010	37,910.0	57	1993	2,610.0	98.78

* Outlier

<< Skew Weighting >>

Based on 57 events, mean-square error of station skew = 0.161

Mean-square error of regional skew = 0.01

<< Frequency Curve >>

MILL CREEK-ANTIOCH, TN-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
56,602.9	66,546.1	0.2	86,098.5	41,428.4
41,512.5	46,659.8	0.5	59,832.2	31,577.1
32,584.0	35,537.0	1.0	45,061.6	25,523.8
25,359.4	26,978.7	2.0	33,635.4	20,456.6
19,517.1	20,333.6	4.0	24,822.0	16,207.5

```
|    13,465.9    13,748.9 |     10.0     |    16,216.8    11,594.4 |
|     9,863.2     9,960.6 |     20.0     |    11,441.1     8,682.0 |
|     5,974.0     5,974.0 |     50.0     |     6,730.9     5,281.0 |
|     4,058.6     4,038.1 |     80.0     |     4,622.7     3,481.8 |
|     3,456.7     3,428.2 |     90.0     |     3,980.6     2,909.9 |
|     3,087.5     3,051.0 |     95.0     |     3,588.5     2,560.7 |
|     2,608.1     2,562.7 |     99.0     |     3,079.0     2,112.0 |
|-------------------------|--------------|-------------------------|


<< Systematic Statistics >>
MILL CREEK-ANTIOCH, TN-FLOW-ANNUAL PEAK
----------------------------------------------------------------
|        Log Transform:        |                               |
|          FLOW, CFS           |       Number of Events        |
|------------------------------|-------------------------------|
| Mean                   3.811 | Historic Events            0  |
| Standard Dev           0.237 | High Outliers           0     |
| Station Skew           0.896 | Low Outliers            0     |
| Regional Skew          0.000 | Zero Events             0     |
| Weighted Skew          0.052 | Missing Events          0     |
| Adopted Skew           0.896 | Systematic Events        57   |
|------------------------------|-------------------------------|
--- End of Preliminary Results ---
-----------------------
<< High Outlier Test >>
-----------------------
 Based on 57 events, 10 percent outlier test deviate K(N) = 2.818
                     Computed high outlier test value = 30,237.46
       1 high outlier(s) identified above test value of 30,237.46
```

```
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* Note - Collection of historical information and            *
*        comparison with similar data should be explored,    *
*        if not incorporated in this analysis.               *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


Statistics and frequency curve adjusted for 1 high outlier(s)
<< Systematic Statistics >>
MILL CREEK-ANTIOCH, TN-FLOW-ANNUAL PEAK
----------------------------------------------------------------
|       Log Transform:         |                               |
|         FLOW, CFS            |       Number of Events        |
|------------------------------|-------------------------------|
| Mean                 3.802   | Historic Events          0    |
| Standard Dev         0.222   | High Outliers         1       |
| Station Skew         0.704   | Low Outliers          0       |
| Regional Skew        0.000   | Zero Events           0       |
| Weighted Skew        0.052   | Missing Events        0       |
| Adopted Skew         0.896   | Systematic Events       57    |
|                              | Historic Period        161    |
|------------------------------|-------------------------------|
Warning: Sample size is greater than 147 events. Outlier test is based on an approximate formula.
----------------------
<< Low Outlier Test >>
----------------------
Based on 161 events, 10 percent outlier test deviate K(N) = 3.174
                       Computed low outlier test value = 1,248.56


         0 low outlier(s) identified below test value of 1,248.56
```

--- Final Results ---

<< Plotting Positions >>

MILL CREEK-ANTIOCH, TN-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events			
	FLOW		Water	FLOW	Median
Day Mon Year	CFS	Rank	Year	CFS	Plot Pos
24 Mar 1954	6,850.0	1	2010	37,910.0*	0.43
21 Mar 1955	17,000.0	2	1979	30,100.0	1.63
17 Feb 1956	7,320.0	3	1955	17,000.0	3.40
29 Jan 1957	5,570.0	4	1960	15,600.0	5.17
20 Dec 1957	5,120.0	5	1962	13,800.0	6.94
01 Jul 1959	2,880.0	6	2003	12,000.0	8.71
17 Jun 1960	15,600.0	7	2000	10,800.0	10.48
12 Apr 1961	4,020.0	8	1998	10,800.0	12.25
27 Feb 1962	13,800.0	9	1984	10,700.0	14.02
11 Mar 1963	7,220.0	10	1974	10,500.0	15.79
04 Mar 1964	5,660.0	11	1999	10,400.0	17.56
26 Mar 1965	6,810.0	12	1975	9,980.0	19.33
01 Oct 1965	3,070.0	13	2004	9,890.0	21.10
06 Mar 1967	6,430.0	14	1970	9,270.0	22.87
12 Mar 1968	3,410.0	15	1992	8,540.0	24.64
18 Apr 1969	3,440.0	16	1997	8,410.0	26.41
21 Jun 1970	9,270.0	17	1996	7,720.0	28.18
04 Jan 1971	3,860.0	18	1956	7,320.0	29.95
09 Aug 1972	3,300.0	19	1973	7,220.0	31.72
10 Dec 1972	7,220.0	20	1963	7,220.0	33.49
27 Nov 1973	10,500.0	21	1980	6,980.0	35.26
12 Mar 1975	9,980.0	22	2005	6,970.0	37.03
20 Mar 1976	4,000.0	23	1983	6,870.0	38.80
12 Mar 1977	5,640.0	24	1954	6,850.0	40.57

13 Mar 1978	5,600.0	25	1965	6,810.0	42.34
04 May 1979	30,100.0	26	1989	6,630.0	44.11
28 Mar 1980	6,980.0	27	1995	6,590.0	45.88
01 Jan 1981	2,810.0	28	1988	6,590.0	47.65
09 Feb 1982	4,340.0	29	1967	6,430.0	49.42
19 May 1983	6,870.0	30	1987	6,360.0	51.19
07 May 1984	10,700.0	31	1990	6,220.0	52.97
27 Nov 1984	3,670.0	32	1994	5,750.0	54.74
04 Sep 1986	4,440.0	33	1964	5,660.0	56.51
26 Nov 1986	6,360.0	34	1977	5,640.0	58.28
25 Dec 1987	6,590.0	35	1978	5,600.0	60.05
14 Feb 1989	6,630.0	36	1957	5,570.0	61.82
03 Feb 1990	6,220.0	37	2006	5,430.0	63.59
22 Dec 1990	4,520.0	38	2001	5,350.0	65.36
03 Dec 1991	8,540.0	39	1958	5,120.0	67.13
23 Mar 1993	2,610.0	40	2002	5,070.0	68.90
09 Mar 1994	5,750.0	41	1991	4,520.0	70.67
14 May 1995	6,590.0	42	1986	4,440.0	72.44
05 Oct 1995	7,720.0	43	1982	4,340.0	74.21
03 Mar 1997	8,410.0	44	1961	4,020.0	75.98
04 Jun 1998	10,800.0	45	1976	4,000.0	77.75
23 Jan 1999	10,400.0	46	2008	3,910.0	79.52
25 May 2000	10,800.0	47	2009	3,880.0	81.29
16 Feb 2001	5,350.0	48	1971	3,860.0	83.06
24 Jan 2002	5,070.0	49	1985	3,670.0	84.83
05 May 2003	12,000.0	50	2007	3,550.0	86.60
05 Feb 2004	9,890.0	51	1969	3,440.0	88.37
19 Oct 2004	6,970.0	52	1968	3,410.0	90.14
23 Jan 2006	5,430.0	53	1972	3,300.0	91.91
01 Jan 2007	3,550.0	54	1966	3,070.0	93.68
04 Apr 2008	3,910.0	55	1959	2,880.0	95.45
26 Sep 2009	3,880.0	56	1981	2,810.0	97.22

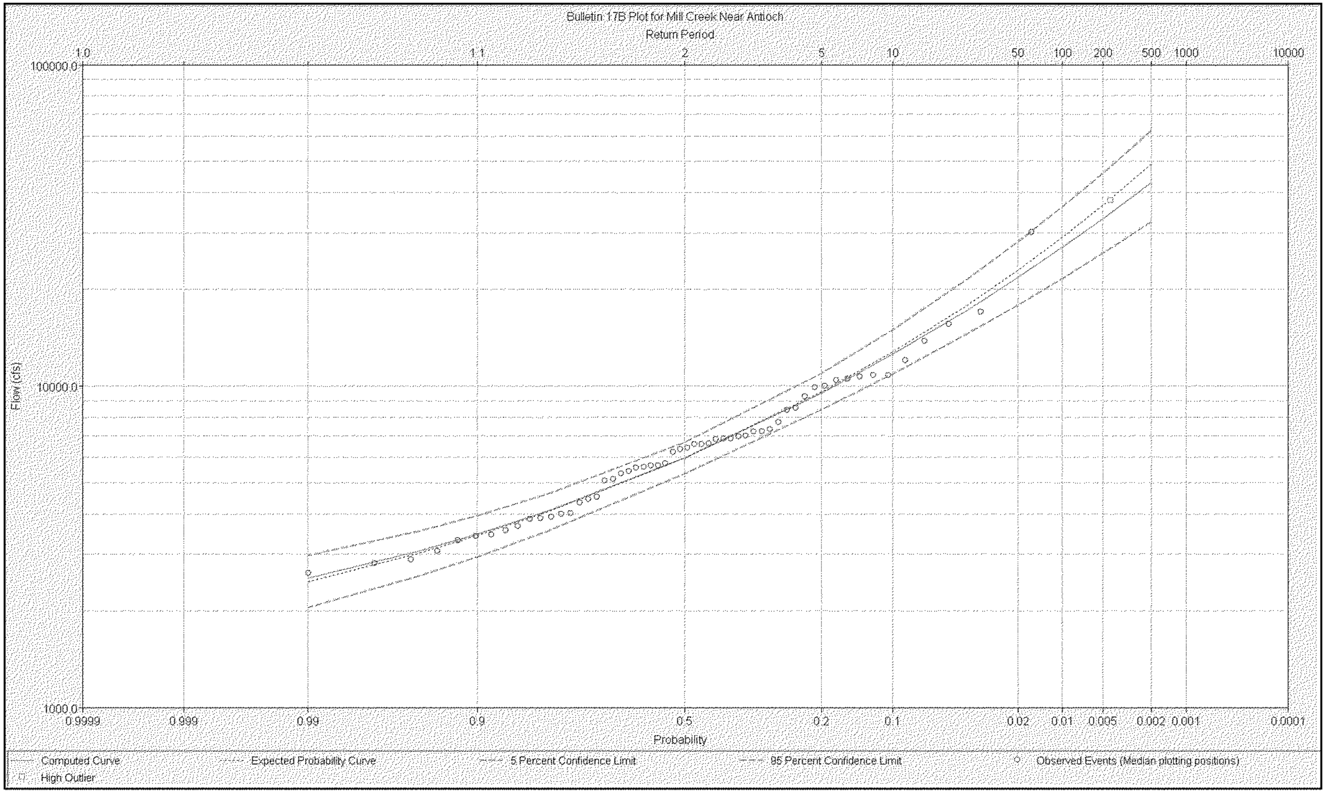
```
| 01 May 2010    37,910.0  |  57      1993     2,610.0   98.99    |
|---------------------------|--------------------------------------|
|      Note: Plotting positions based on historic period (H) = 161 |
|             Number of historic events plus high outliers (Z) = 1 |
|              Weighting factor for systematic events (W) = 2.8571 |
--------------------------------------------------------------------
                                                        * Outlier
<< Skew Weighting >>
-----------------------------------------------------------------
Based on 161 events, mean-square error of station skew =    0.065
Mean-square error of regional skew =                         0.01
-----------------------------------------------------------------
<< Frequency Curve >>
MILL CREEK-ANTIOCH, TN-FLOW-ANNUAL PEAK
-------------------------------------------------------------------
| Computed    Expected   |  Percent    |    Confidence Limits     |
|    Curve    Probability |  Chance     |       0.05        0.95 |
|        FLOW, CFS        | Exceedance  |        FLOW, CFS         |
|-------------------------|-------------|-------------------------|
|    42,959.3    49,158.5 |      0.2    |    62,333.4    32,547.5 |
|    33,119.3    36,531.7 |      0.5    |    45,944.5    25,909.5 |
|    26,983.3    29,038.3 |      1.0    |    36,154.4    21,634.8 |
|    21,786.4    22,968.2 |      2.0    |    28,176.1    17,906.8 |
|    17,383.0    18,009.4 |      4.0    |    21,687.4    14,645.7 |
|    12,559.7    12,791.1 |     10.0    |    14,942.5    10,919.8 |
|     9,508.1     9,591.9 |     20.0    |    10,937.6     8,432.6 |
|     5,977.7     5,977.7 |     50.0    |     6,685.5     5,329.2 |
|     4,090.4     4,069.0 |     80.0    |     4,621.2     3,542.8 |
|     3,461.6     3,430.7 |     90.0    |     3,956.3     2,939.3 |
|     3,062.2     3,021.8 |     95.0    |     3,536.1     2,557.8 |
|     2,518.7     2,464.3 |     99.0    |     2,963.6     2,045.0 |
|-------------------------|-------------|-------------------------|
```

<< Adjusted Statistics >>

MILL CREEK-ANTIOCH, TN-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	3.802	Historic Events	0
Standard Dev	0.222	High Outliers	1
Station Skew	0.704	Low Outliers	0
Regional Skew	0.000	Zero Events	0
Weighted Skew	0.094	Missing Events	0
Adopted Skew	0.704	Systematic Events	57
		Historic Period	161

--- End of Analytical Frequency Curve ---



Bulletin 17B Plot for Mill Creek Near Antioch
Return Period
1.0
1.1
2
5
10
50
100
200
500
1000
10000
100000.0
10000.0
1000.0
Flow (cfs)
0.9999
0.999
0.99
0.9
0.5
0.2
0.1
0.02
0.01
0.005
0.002
0.001
0.0001
Probability
Computed Curve
Expected Probability Curve
5 Percent Confidence Limit
95 Percent Confidence Limit
Observed Events (Median plotting positions)
High Outlier

Bulletin 17B Frequency Analysis - Mill Creek Near Woodbine

17 Oct 2012   12:40 PM

--- Input Data ---

Analysis Name: Mill Creek Near Woodbine

Description: Nashville Flood Preparedness Phase 2

Data Set Name: Mill Creek Near Woodbine-THOMPSON LANE, NEAR WOODBINE, TN-FLOW-ANNUAL PEAK

DSS File Name:
C:\sspproj\Mill_Creek_Watershed\Mill_Creek_near_Woodbine\Mill_Creek_Near_Woodbine\Mill_Creek_Near_Woodbine.dss

DSS Pathname: /MILL CREEK/THOMPSON LANE, NEAR WOODBINE, TN/FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name:
C:\sspproj\Mill_Creek_Watershed\Mill_Creek_near_Woodbine\Mill_Creek_Near_Woodbine\Bulletin17bResults\Mill_Creek_Near_Woodbine\Mill_Creek_Near_Woodbine.rpt

XML File Name:
C:\sspproj\Mill_Creek_Watershed\Mill_Creek_near_Woodbine\Mill_Creek_Near_Woodbine\Bulletin17bResults\Mill_Creek_Near_Woodbine\Mill_Creek_Near_Woodbine.xml

Start Date:

End Date:

Skew Option: Use Station Skew

Regional Skew: 0.0

Regional Skew MSE: 0.01

Plotting Position Type: Median

Upper Confidence Level: 0.05

Lower Confidence Level: 0.95

Use non-standard frequencies

Frequency: 0.2

Frequency: 0.5

Frequency: 1.0

Frequency: 2.0

Frequency: 4.0

Frequency: 10.0

Frequency: 20.0

Frequency: 50.0

Frequency: 80.0

Frequency: 90.0

Frequency: 95.0

Frequency: 99.0

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

--- Preliminary Results ---

<< Plotting Positions >>

Mill Creek Near Woodbine-THOMPSON LANE, NEAR WOODBINE, TN-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events			
	FLOW		Water	FLOW	Median
Day Mon Year	CFS	Rank	Year	CFS	Plot Pos
26 Mar 1965	8,500.0	1	2010	36,000.0*	1.51
01 Oct 1965	3,600.0	2	1979	26,200.0	3.66
28 Dec 1966	7,700.0	3	1989	16,000.0	5.82
12 Mar 1968	4,450.0	4	2003	14,400.0	7.97
28 Nov 1968	5,350.0	5	1975	13,600.0	10.13
21 Jun 1970	10,500.0	6	1998	13,500.0	12.28
21 Dec 1970	4,700.0	7	1984	13,400.0	14.44
28 Jul 1972	3,600.0	8	2000	13,300.0	16.59
10 Dec 1972	9,080.0	9	2004	13,000.0	18.75
10 Jan 1974	11,700.0	10	1996	13,000.0	20.91
12 Mar 1975	13,600.0	11	1983	12,700.0	23.06
17 Oct 1975	10,500.0	12	1997	12,300.0	25.22
12 Mar 1977	8,800.0	13	1992	12,000.0	27.37
14 Mar 1978	7,490.0	14	1974	11,700.0	29.53
04 May 1979	26,200.0	15	1999	11,200.0	31.68
28 Mar 1980	10,700.0	16	2005	11,000.0	33.84

06 Jun 1981	5,370.0	17	1980	10,700.0	35.99
09 Feb 1982	6,360.0	18	1976	10,500.0	38.15
19 May 1983	12,700.0	19	1970	10,500.0	40.30
07 May 1984	13,400.0	20	1988	9,690.0	42.46
28 Nov 1984	5,320.0	21	1973	9,080.0	44.61
27 Nov 1985	5,780.0	22	1977	8,800.0	46.77
26 Nov 1986	8,290.0	23	1994	8,710.0	48.92
25 Dec 1987	9,690.0	24	2001	8,620.0	51.08
14 Feb 1989	16,000.0	25	1990	8,600.0	53.23
03 Feb 1990	8,600.0	26	1965	8,500.0	55.39
22 Dec 1990	6,640.0	27	1987	8,290.0	57.54
03 Dec 1991	12,000.0	28	1995	8,250.0	59.70
01 Jan 1993	4,000.0	29	2006	7,730.0	61.85
27 Mar 1994	8,710.0	30	1967	7,700.0	64.01
08 Mar 1995	8,250.0	31	1978	7,490.0	66.16
05 Oct 1995	13,000.0	32	2002	7,170.0	68.32
03 Mar 1997	12,300.0	33	1991	6,640.0	70.47
04 Jun 1998	13,500.0	34	1982	6,360.0	72.63
23 Jan 1999	11,200.0	35	2008	5,940.0	74.78
25 May 2000	13,300.0	36	1986	5,780.0	76.94
16 Feb 2001	8,620.0	37	2009	5,760.0	79.09
17 Mar 2002	7,170.0	38	1981	5,370.0	81.25
05 May 2003	14,400.0	39	1969	5,350.0	83.41
05 Feb 2004	13,000.0	40	1985	5,320.0	85.56
19 Oct 2004	11,000.0	41	1971	4,700.0	87.72
23 Jan 2006	7,730.0	42	1968	4,450.0	89.87
15 Nov 2006	2,670.0	43	1993	4,000.0	92.03
04 Apr 2008	5,940.0	44	1972	3,600.0	94.18
26 Sep 2009	5,760.0	45	1966	3,600.0	96.34
01 May 2010	36,000.0	46	2007	2,670.0	98.49

* Outlier

<< Skew Weighting >>

Based on 46 events, mean-square error of station skew = 0.121

Mean-square error of regional skew = 0.01

<< Frequency Curve >>

Mill Creek Near Woodbine-THOMPSON LANE, NEAR WOODBINE, TN-FLOW-ANNUAL PEAK

Computed Curve	Expected Probability	Percent Chance	Confidence Limits 0.05	Confidence Limits 0.95
FLOW, CFS		Exceedance	FLOW, CFS	
40,331.4	44,958.5	0.2	57,208.7	31,278.7
33,951.0	36,828.7	0.5	46,590.7	26,927.4
29,503.0	31,420.1	1.0	39,429.3	23,818.8
25,349.8	26,564.9	2.0	32,946.8	20,847.8
21,460.2	22,175.9	4.0	27,080.4	17,990.9
16,654.8	16,955.2	10.0	20,160.5	14,328.2
13,193.6	13,314.7	20.0	15,459.4	11,557.9
8,557.3	8,557.3	50.0	9,687.5	7,553.5
5,642.0	5,595.4	80.0	6,443.1	4,811.0
4,567.5	4,496.7	90.0	5,302.0	3,781.8
3,848.9	3,755.6	95.0	4,543.3	3,101.0
2,814.3	2,676.4	99.0	3,442.3	2,146.0

```
<< Systematic Statistics >>

Mill Creek Near Woodbine-THOMPSON LANE, NEAR WOODBINE, TN-FLOW-ANNUAL PEAK

----------------------------------------------------------------

|        Log Transform:       |                               |

|          FLOW, CFS          |       Number of Events        |

|-----------------------------|-------------------------------|

|  Mean                3.937  |  Historic Events          0   |

|  Standard Dev        0.219  |  High Outliers         0      |

|  Station Skew        0.138  |  Low Outliers          0      |

|  Regional Skew       0.000  |  Zero Events           0      |

|  Weighted Skew       0.011  |  Missing Events        0      |

|  Adopted Skew        0.138  |  Systematic Events       46   |

|-----------------------------|-------------------------------|


--- End of Preliminary Results ---


----------------------

<< Low Outlier Test >>

----------------------

 Based on 46 events, 10 percent outlier test deviate K(N) = 2.736

                      Computed low outlier test value = 2,173.33


         0 low outlier(s) identified below test value of 2,173.33


-----------------------

<< High Outlier Test >>

-----------------------

 Based on 46 events, 10 percent outlier test deviate K(N) = 2.736

                    Computed high outlier test value = 34,483.26

       1 high outlier(s) identified above test value of 34,483.26
```

```
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* Note - Collection of historical information and          *
*        comparison with similar data should be explored, *
*        if not incorporated in this analysis.            *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

Statistics and frequency curve adjusted for 1 high outlier(s)

--- Final Results ---

<< Plotting Positions >>

Mill Creek Near Woodbine-THOMPSON LANE, NEAR WOODBINE, TN-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events			
	FLOW		Water	FLOW	Median
Day Mon Year	CFS	Rank	Year	CFS	Plot Pos
26 Mar 1965	8,500.0	1	2010	36,000.0*	1.51
01 Oct 1965	3,600.0	2	1979	26,200.0	3.66
28 Dec 1966	7,700.0	3	1989	16,000.0	5.82
12 Mar 1968	4,450.0	4	2003	14,400.0	7.97
28 Nov 1968	5,350.0	5	1975	13,600.0	10.13
21 Jun 1970	10,500.0	6	1998	13,500.0	12.28
21 Dec 1970	4,700.0	7	1984	13,400.0	14.44
28 Jul 1972	3,600.0	8	2000	13,300.0	16.59
10 Dec 1972	9,080.0	9	2004	13,000.0	18.75
10 Jan 1974	11,700.0	10	1996	13,000.0	20.91
12 Mar 1975	13,600.0	11	1983	12,700.0	23.06
17 Oct 1975	10,500.0	12	1997	12,300.0	25.22
12 Mar 1977	8,800.0	13	1992	12,000.0	27.37
14 Mar 1978	7,490.0	14	1974	11,700.0	29.53
04 May 1979	26,200.0	15	1999	11,200.0	31.68
28 Mar 1980	10,700.0	16	2005	11,000.0	33.84
06 Jun 1981	5,370.0	17	1980	10,700.0	35.99

09 Feb 1982	6,360.0	18	1976	10,500.0	38.15
19 May 1983	12,700.0	19	1970	10,500.0	40.30
07 May 1984	13,400.0	20	1988	9,690.0	42.46
28 Nov 1984	5,320.0	21	1973	9,080.0	44.61
27 Nov 1985	5,780.0	22	1977	8,800.0	46.77
26 Nov 1986	8,290.0	23	1994	8,710.0	48.92
25 Dec 1987	9,690.0	24	2001	8,620.0	51.08
14 Feb 1989	16,000.0	25	1990	8,600.0	53.23
03 Feb 1990	8,600.0	26	1965	8,500.0	55.39
22 Dec 1990	6,640.0	27	1987	8,290.0	57.54
03 Dec 1991	12,000.0	28	1995	8,250.0	59.70
01 Jan 1993	4,000.0	29	2006	7,730.0	61.85
27 Mar 1994	8,710.0	30	1967	7,700.0	64.01
08 Mar 1995	8,250.0	31	1978	7,490.0	66.16
05 Oct 1995	13,000.0	32	2002	7,170.0	68.32
03 Mar 1997	12,300.0	33	1991	6,640.0	70.47
04 Jun 1998	13,500.0	34	1982	6,360.0	72.63
23 Jan 1999	11,200.0	35	2008	5,940.0	74.78
25 May 2000	13,300.0	36	1986	5,780.0	76.94
16 Feb 2001	8,620.0	37	2009	5,760.0	79.09
17 Mar 2002	7,170.0	38	1981	5,370.0	81.25
05 May 2003	14,400.0	39	1969	5,350.0	83.41
05 Feb 2004	13,000.0	40	1985	5,320.0	85.56
19 Oct 2004	11,000.0	41	1971	4,700.0	87.72
23 Jan 2006	7,730.0	42	1968	4,450.0	89.87
15 Nov 2006	2,670.0	43	1993	4,000.0	92.03
04 Apr 2008	5,940.0	44	1972	3,600.0	94.18
26 Sep 2009	5,760.0	45	1966	3,600.0	96.34
01 May 2010	36,000.0	46	2007	2,670.0	98.49

* Outlier

<< Skew Weighting >>

Based on 46 events, mean-square error of station skew = 0.121

Mean-square error of regional skew = 0.01

<< Frequency Curve >>

Mill Creek Near Woodbine-THOMPSON LANE, NEAR WOODBINE, TN-FLOW-ANNUAL PEAK

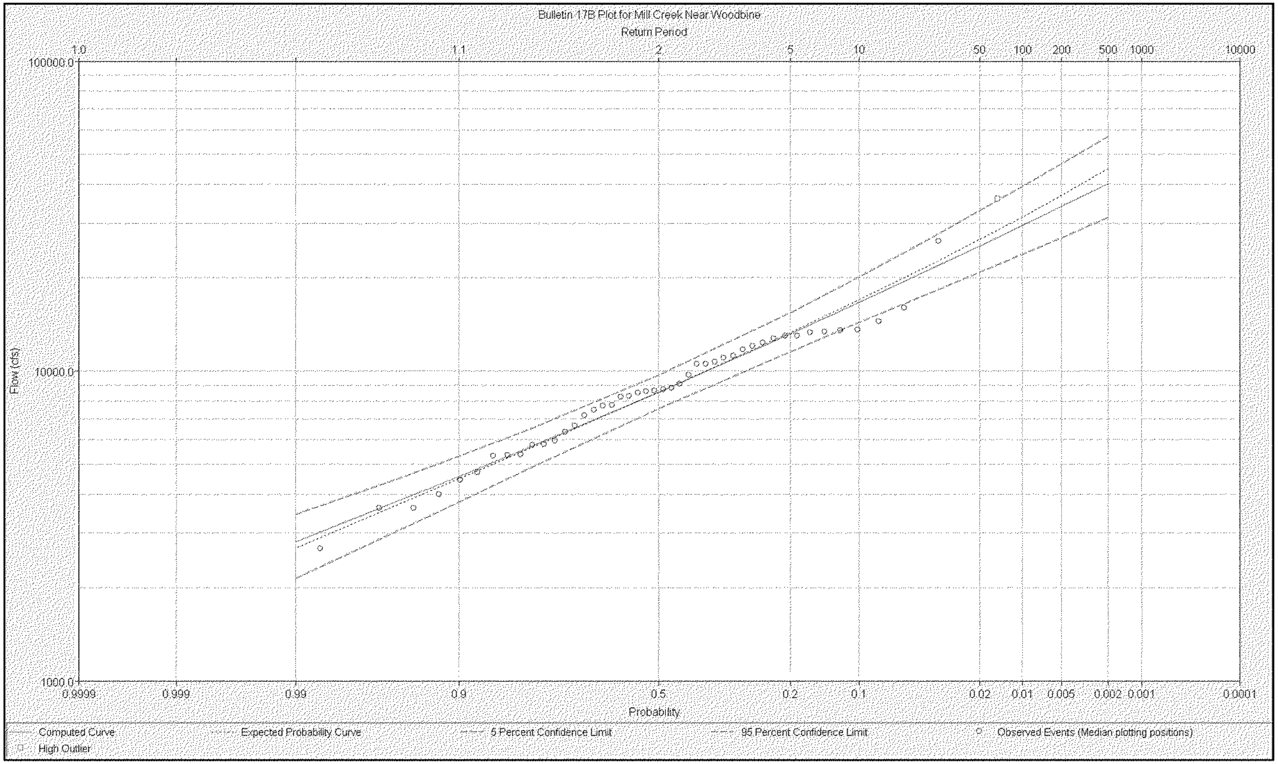
Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
40,331.4	44,958.5	0.2	57,208.7	31,278.7
33,951.0	36,828.7	0.5	46,590.7	26,927.4
29,503.0	31,420.1	1.0	39,429.3	23,818.8
25,349.8	26,564.9	2.0	32,946.8	20,847.8
21,460.2	22,175.9	4.0	27,080.4	17,990.9
16,654.8	16,955.2	10.0	20,160.5	14,328.2
13,193.6	13,314.7	20.0	15,459.4	11,557.9
8,557.3	8,557.3	50.0	9,687.5	7,553.5
5,642.0	5,595.4	80.0	6,443.1	4,811.0
4,567.5	4,496.7	90.0	5,302.0	3,781.8
3,848.9	3,755.6	95.0	4,543.3	3,101.0
2,814.3	2,676.4	99.0	3,442.3	2,146.0

<< Systematic Statistics >>

Mill Creek Near Woodbine-THOMPSON LANE, NEAR WOODBINE, TN-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	3.937	Historic Events	0
Standard Dev	0.219	High Outliers	1
Station Skew	0.138	Low Outliers	0
Regional Skew	0.000	Zero Events	0
Weighted Skew	0.011	Missing Events	0
Adopted Skew	0.138	Systematic Events	46

--- End of Analytical Frequency Curve ---


Bulletin 17B Plot for Mill Creek Near Woodbine
Return Period
1.0
1.1
2
5
10
50
100
200
500
1000
10000
Flow (cfs)
100000.0
10000.0
1000.0
0.9999
0.999
0.99
0.9
0.5
0.2
0.1
0.02
0.01
0.005
0.002
0.001
0.0001
Probability
Computed Curve
Expected Probability Curve
5 Percent Confidence Limit
95 Percent Confidence Limit
Observed Events (Median plotting positions)
High Outlier

Bulletin 17B Frequency Analysis - Sevenmile Creek at Blackman (using HEC-RAS Rating Curve)

17 Oct 2012 12:45 PM

--- Input Data ---

Analysis Name: RAS Rating Sevenmile Blackman

Description: Flow adjusted with RAS Rating Curve

Data Set Name: RAS Rating-BLACKMAN RD,NR NASHVILLE TN-FLOW-ANNUAL PEAK

DSS File Name:
C:\sspproj\Mill_Creek_Watershed\Sevenmile_Cr_at_Blackman_Rd\Sevenmile_Cr_at_Blackman_Rd.dss

DSS Pathname: /SEVENMILE CREEK/BLACKMAN RD,NR NASHVILLE TN/FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/RAS RATING 2.628/

Report File Name:
C:\sspproj\Mill_Creek_Watershed\Sevenmile_Cr_at_Blackman_Rd\Bulletin17bResults\RAS_Rating_Sevenmile_Blackman\RAS_Rating_Sevenmile_Blackman.rpt

XML File Name:
C:\sspproj\Mill_Creek_Watershed\Sevenmile_Cr_at_Blackman_Rd\Bulletin17bResults\RAS_Rating_Sevenmile_Blackman\RAS_Rating_Sevenmile_Blackman.xml

Start Date:

End Date:

Skew Option: Use Station Skew

Regional Skew: 0.0

Regional Skew MSE: 0.01

Plotting Position Type: Median

Upper Confidence Level: 0.05

Lower Confidence Level: 0.95

Use non-standard frequencies

Frequency: 0.2

Frequency: 0.5

Frequency: 1.0

Frequency: 2.0

Frequency: 4.0

Frequency: 10.0

Frequency: 20.0

Frequency: 50.0

Frequency: 80.0

Frequency: 90.0

Frequency: 95.0

Frequency: 99.0

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

--- Preliminary Results ---

<< Plotting Positions >>

RAS Rating-BLACKMAN RD,NR NASHVILLE TN-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events			
	FLOW		Water	FLOW	Median
Day Mon Year	CFS	Rank	Year	CFS	Plot Pos
11 Feb 1965	916.1	1	2010	11,000.0*	1.69
14 Aug 1966	674.2	2	1998	5,948.0	4.11
06 Mar 1967	1,323.2	3	1979	4,779.7	6.52
11 Mar 1968	803.2	4	2003	4,525.4	8.94
18 Apr 1969	1,373.7	5	1989	3,935.3	11.35
21 Jun 1970	1,828.3	6	1993	3,717.7	13.77
22 Feb 1971	722.6	7	1975	3,335.3	16.18
09 Aug 1972	1,096.0	8	1996	3,323.5	18.60
10 Dec 1972	1,373.7	9	2000	3,141.2	21.01
27 Jun 1974	2,462.1	10	1983	2,871.2	23.43
29 Mar 1975	3,335.3	11	1984	2,477.3	25.85
20 Mar 1976	2,219.7	12	1974	2,462.1	28.26
11 Apr 1977	1,792.9	13	1987	2,447.0	30.68
13 Mar 1978	2,265.2	14	1986	2,424.2	33.09
13 Sep 1979	4,779.7	15	1980	2,416.7	35.51
17 May 1980	2,416.7	16	1995	2,401.5	37.92
06 Jun 1981	2,363.6	17	1997	2,371.2	40.34

09 Feb 1982	1,575.8	18	1981	2,363.6	42.75
19 May 1983	2,871.2	19	1978	2,265.2	45.17
06 May 1984	2,477.3	20	1994	2,257.6	47.58
01 Jan 1985	600.0	21	1976	2,219.7	50.00
04 Sep 1986	2,424.2	22	1990	2,212.1	52.42
26 Nov 1986	2,447.0	23	1988	2,189.4	54.83
25 Dec 1987	2,189.4	24	2004	2,060.6	57.25
14 Feb 1989	3,935.3	25	1992	2,037.9	59.66
17 Oct 1989	2,212.1	26	1970	1,828.3	62.08
22 Dec 1990	1,813.1	27	1991	1,813.1	64.49
02 Dec 1991	2,037.9	28	1977	1,792.9	66.91
25 Apr 1993	3,717.7	29	2001	1,681.8	69.32
15 Apr 1994	2,257.6	30	2002	1,631.3	71.74
27 Nov 1994	2,401.5	31	1982	1,575.8	74.15
05 Oct 1995	3,323.5	32	1973	1,373.7	76.57
03 Mar 1997	2,371.2	33	1969	1,373.7	78.99
04 Jun 1998	5,948.0	34	1967	1,323.2	81.40
23 Jan 1999	1,191.9	35	1999	1,191.9	83.82
25 May 2000	3,141.2	36	1972	1,096.0	86.23
15 Apr 2001	1,681.8	37	1965	916.1	88.65
12 Jul 2002	1,631.3	38	1968	803.2	91.06
05 May 2003	4,525.4	39	1971	722.6	93.48
05 Feb 2004	2,060.6	40	1966	674.2	95.89
01 May 2010	11,000.0	41	1985	600.0	98.31

* Outlier

<< Skew Weighting >>

Based on 41 events, mean-square error of station skew = 0.134

Mean-square error of regional skew = 0.01

<< Frequency Curve >>

RAS Rating-BLACKMAN RD,NR NASHVILLE TN-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
12,431.6	14,336.7	0.2	19,234.2	9,107.4
10,179.3	11,325.7	0.5	15,112.1	7,663.9
8,647.7	9,391.7	1.0	12,420.9	6,653.2
7,250.4	7,709.1	2.0	10,057.0	5,705.3
5,974.4	6,236.7	4.0	7,986.7	4,812.4
4,449.2	4,554.5	10.0	5,645.7	3,698.5
3,392.8	3,433.6	20.0	4,132.6	2,883.0
2,049.1	2,049.1	50.0	2,388.9	1,756.0
1,260.6	1,246.9	80.0	1,484.2	1,033.9
985.0	965.0	90.0	1,183.1	778.4
806.5	780.8	95.0	988.7	615.7
559.2	523.3	99.0	716.1	398.4

<< Systematic Statistics >>

RAS Rating-BLACKMAN RD,NR NASHVILLE TN-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	3.317	Historic Events	0
Standard Dev	0.256	High Outliers	0
Station Skew	0.133	Low Outliers	0
Regional Skew	0.000	Zero Events	0

```
| Weighted Skew         0.009  | Missing Events          0     |
| Adopted Skew          0.133  | Systematic Events        41   |
|------------------------------|-------------------------------|

--- End of Preliminary Results ---

----------------------
<< Low Outlier Test >>
----------------------
 Based on 41 events, 10 percent outlier test deviate K(N) = 2.692
                         Computed low outlier test value = 425.54

          0 low outlier(s) identified below test value of 425.54

-----------------------
<< High Outlier Test >>
-----------------------
 Based on 41 events, 10 percent outlier test deviate K(N) = 2.692
                      Computed high outlier test value = 10,127.5
       1 high outlier(s) identified above test value of 10,127.5

   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
   * Note - Collection of historical information and          *
   *        comparison with similar data should be explored, *
   *        if not incorporated in this analysis.             *
   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
    Statistics and frequency curve adjusted for 1 high outlier(s)
```

--- Final Results ---

<< Plotting Positions >>

RAS Rating-BLACKMAN RD,NR NASHVILLE TN-FLOW-ANNUAL PEAK

Events Analyzed			Ordered Events			
		FLOW		Water	FLOW	Median
Day Mon Year		CFS	Rank	Year	CFS	Plot Pos
11 Feb 1965		916.1	1	2010	11,000.0*	1.51
14 Aug 1966		674.2	2	1998	5,948.0	3.80
06 Mar 1967		1,323.2	3	1979	4,779.7	6.22
11 Mar 1968		803.2	4	2003	4,525.4	8.65
18 Apr 1969		1,373.7	5	1989	3,935.3	11.07
21 Jun 1970		1,828.3	6	1993	3,717.7	13.50
22 Feb 1971		722.6	7	1975	3,335.3	15.92
09 Aug 1972		1,096.0	8	1996	3,323.5	18.35
10 Dec 1972		1,373.7	9	2000	3,141.2	20.77
27 Jun 1974		2,462.1	10	1983	2,871.2	23.20
29 Mar 1975		3,335.3	11	1984	2,477.3	25.62
20 Mar 1976		2,219.7	12	1974	2,462.1	28.04
11 Apr 1977		1,792.9	13	1987	2,447.0	30.47
13 Mar 1978		2,265.2	14	1986	2,424.2	32.89
13 Sep 1979		4,779.7	15	1980	2,416.7	35.32
17 May 1980		2,416.7	16	1995	2,401.5	37.74
06 Jun 1981		2,363.6	17	1997	2,371.2	40.17
09 Feb 1982		1,575.8	18	1981	2,363.6	42.59
19 May 1983		2,871.2	19	1978	2,265.2	45.02
06 May 1984		2,477.3	20	1994	2,257.6	47.44
01 Jan 1985		600.0	21	1976	2,219.7	49.87
04 Sep 1986		2,424.2	22	1990	2,212.1	52.29
26 Nov 1986		2,447.0	23	1988	2,189.4	54.71
25 Dec 1987		2,189.4	24	2004	2,060.6	57.14

```
| 14 Feb 1989     3,935.3  |   25      1992      2,037.9   59.56    |
| 17 Oct 1989     2,212.1  |   26      1970      1,828.3   61.99    |
| 22 Dec 1990     1,813.1  |   27      1991      1,813.1   64.41    |
| 02 Dec 1991     2,037.9  |   28      1977      1,792.9   66.84    |
| 25 Apr 1993     3,717.7  |   29      2001      1,681.8   69.26    |
| 15 Apr 1994     2,257.6  |   30      2002      1,631.3   71.69    |
| 27 Nov 1994     2,401.5  |   31      1982      1,575.8   74.11    |
| 05 Oct 1995     3,323.5  |   32      1973      1,373.7   76.54    |
| 03 Mar 1997     2,371.2  |   33      1969      1,373.7   78.96    |
| 04 Jun 1998     5,948.0  |   34      1967      1,323.2   81.38    |
| 23 Jan 1999     1,191.9  |   35      1999      1,191.9   83.81    |
| 25 May 2000     3,141.2  |   36      1972      1,096.0   86.23    |
| 15 Apr 2001     1,681.8  |   37      1965        916.1   88.66    |
| 12 Jul 2002     1,631.3  |   38      1968        803.2   91.08    |
| 05 May 2003     4,525.4  |   39      1971        722.6   93.51    |
| 05 Feb 2004     2,060.6  |   40      1966        674.2   95.93    |
| 01 May 2010    11,000.0  |   41      1985        600.0   98.36    |
|--------------------------|--------------------------------------|
|       Note: Plotting positions based on historic period (H) = 46 |
|             Number of historic events plus high outliers (Z) = 1 |
|               Weighting factor for systematic events (W) = 1.125 |
--------------------------------------------------------------------
                                                         * Outlier
<< Skew Weighting >>
-----------------------------------------------------------------
Based on 41 events, mean-square error of station skew =     0.134
Mean-square error of regional skew =                         0.01
-----------------------------------------------------------------
```

<< Frequency Curve >>

RAS Rating-BLACKMAN RD,NR NASHVILLE TN-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
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8,647.7	9,391.7	1.0	12,420.9	6,653.2
7,250.4	7,709.1	2.0	10,057.0	5,705.3
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2,049.1	2,049.1	50.0	2,388.9	1,756.0
1,260.6	1,246.9	80.0	1,484.2	1,033.9
985.0	965.0	90.0	1,183.1	778.4
806.5	780.8	95.0	988.7	615.7
559.2	523.3	99.0	716.1	398.4

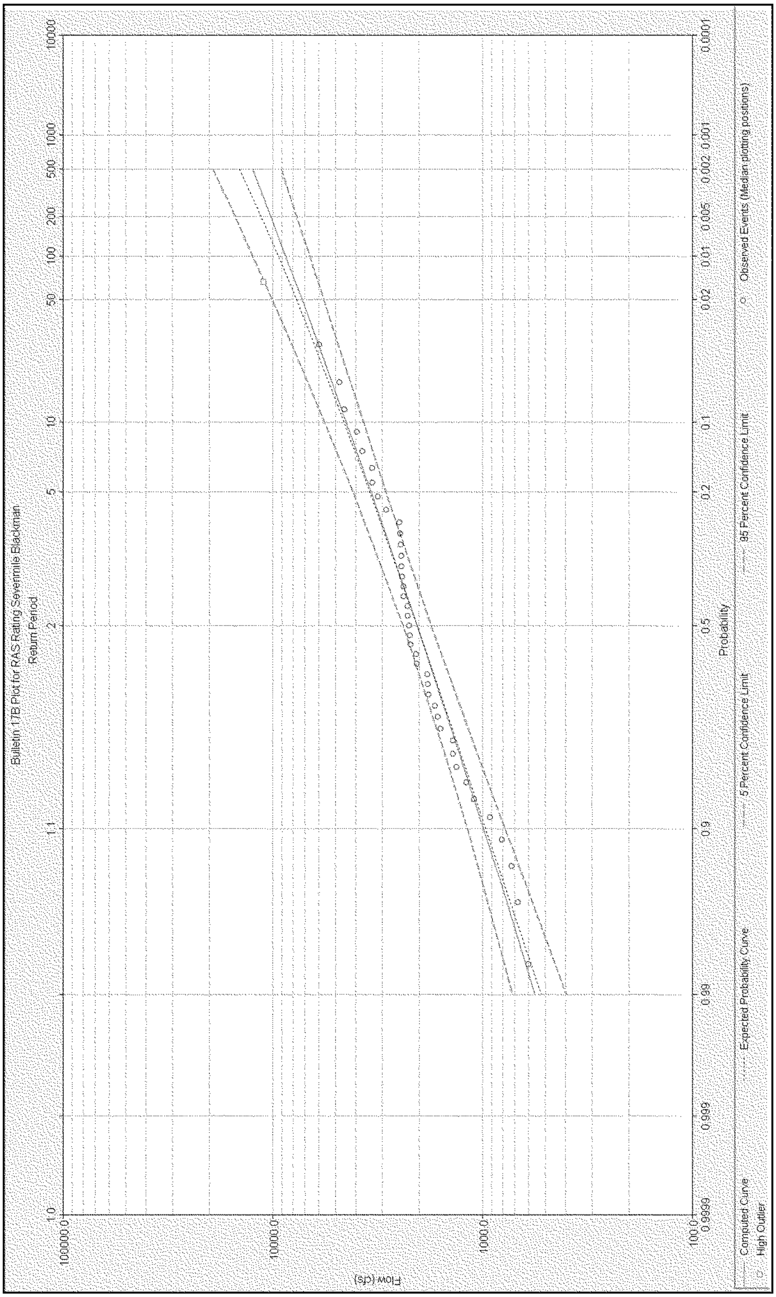
<< Systematic Statistics >>

RAS Rating-BLACKMAN RD,NR NASHVILLE TN-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	3.317	Historic Events	0
Standard Dev	0.256	High Outliers	1
Station Skew	0.133	Low Outliers	0
Regional Skew	0.000	Zero Events	0
Weighted Skew	0.009	Missing Events	0

```
|  Adopted Skew          0.133  |  Systematic Events        41  |
|                               |  Historic Period          46  |
|-------------------------------|-------------------------------|
```

--- End of Analytical Frequency Curve ---


Bulletin 17B Plot for RAS Rating Sevenmile Blackman
Return Period
1.0
1.1
2
5
10
50
100
200
500
1000
10000
100000.0
10000.0
1000.0
100.0
Flow (cfs)
0.9999
0.999
0.99
0.9
0.5
0.2
0.1
0.02
0.01
0.005
0.002
0.001
0.0001
Probability
Computed Curve
Expected Probability Curve
5 Percent Confidence Limit
95 Percent Confidence Limit
High Outlier
Observed Events (Median plotting positions)

APPENDIX C8

RCC Structure Above Old Hickory Boulevard

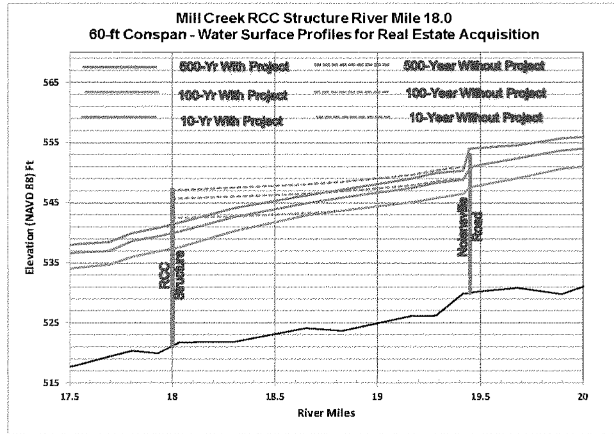
Process to Evaluate

Real Estate Acquisition

RCC Structure above Old Hickory Boulevard - Process to Evaluate Real Estate Acquisition

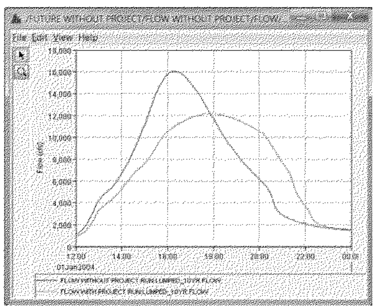
Step 1: Compute Increase in Depth at Cross-Section Locations Impacted By Project for 10yr, 100yr, and 500yr Events

1A. Identified Cross Section locations and parcels impacted by with project conditions

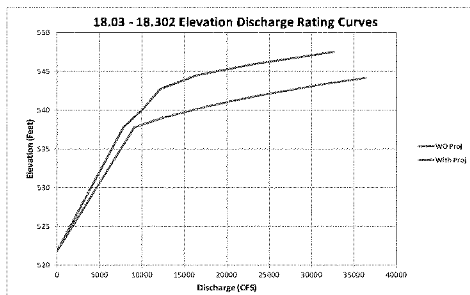


1B. Depth Increace Computed as Difference Between Future With and Future Without Project Water Surface Elevations from HEC-RAS Model

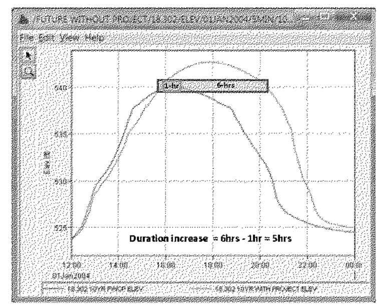
Step 2: Develop Increased Duration Data (Shown Below) for 10yr, 100yr and 500yr Events



2A. Discharge-Time Hydrographs (With and Without Project)



2B. Apply Elevation-Discharge Relationship (With and Without Project)



2C. Compute Elevation-Time Hydrographs (With and Without Project)

Step 3: Develop Increased Duration and Depth Data for 10yr, 100yr and 500yr Events

Table

Duration_XS

FID	Shape *	Id	RM	10_HR_INC	100_HR_INC	500_HR_INC	10_DP_INC	100_DP_INC	500_DP_INC
0	Polyline	0	18.03	5	5	5	2.5	3.5	3.5
1	Polyline	0	18.302	5	5	5	2.5	3.5	3.5
2	Polyline	0	18.651	4	4	4	0.5	1.6	1.9
3	Polyline	0	18.828	3	3	4	0.1	1.1	1.4
4	Polyline	0	19.161	2	2	2	0	0.5	0.6
5	Polyline	0	19.285	1	1	1	0	0.3	0.5
6	Polyline	0	19.416	1	1	1	0	0.2	0.5

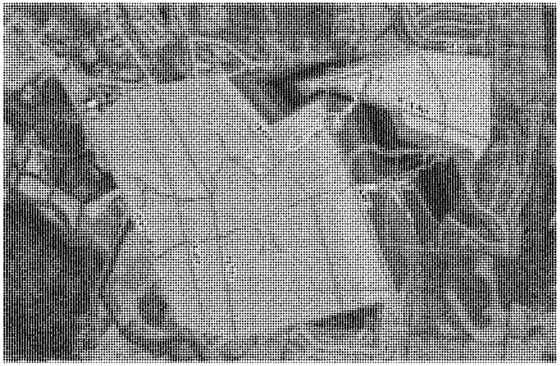
1 (0 out of 7 Selected)

Duration_XS

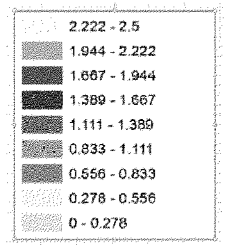
ID	Description
RM	River Mile
10_HR_INC	Increase in duration (hours) of 10yr flood event
100_HR_INC	Increase in duration (hours) of 100yr flood event
500_HR_INC	Increase in duration (hours) of 500yr flood event
10_DP_INC	Increase in depth (feet) of 10yr flood event
100_DP_INC	Increase in depth (feet) of 100yr flood event
500_DP_INC	Increase in depth (feet) of 500yr flood event

GIS Attribute Data Created from Increased Depth (Feet) and Duration (Hours) Data

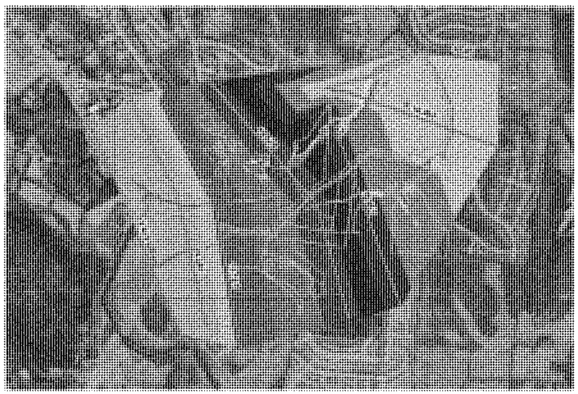
Step 4: Develop Increased Duration and Depth Grids for 10yr, 100yr and 500yr Events using GIS procedures



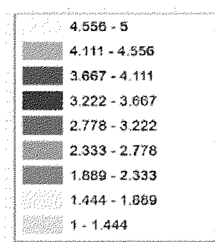
10yr Depth Increase Grid (Feet) Example



4A. GIS Zonal Statistics was used to extract the max increased depth intersection a parcel



10yr Duration Increase Grid (Hours) Example



4B. GIS Zonal Statistics was used to extract the max increased duration intersection a parcel

MII Independent Government Estimate

This represents the Current Working Estimate (CWE) for the Mill Creek Watershed Feasibility Study.

The Tentatively Selected Plan (TSP) was initially identified to be the Briley Parkway Bridge Modification alternative but after the Alternative Formulation Briefing (AFB) the direction was given to include an MII Level Feasibility estimate for another structural measure (Ellington Detention). Also included is the cost for the Non-Structural Alternative consisting of 3 different measures, 1) Buy-Out option, 2) Raise-in-Place Option, and 3) Buy-Out and Remove option for the eligible residents and business owners.

Mark-ups: FOOH, HOOH, Profit, and Bond are added where applicable for a Prime Contractor self performing the work. It is unknown at this point how the contract will be solicitated. For unit price items where the bid item was abstracted from another project that already includes all the indirect costs, the Contractor will be reflected as "No Mark-Up".

Estimated by USACE-LRN-EC-E

Designed by USACE-LRN

Prepared by Cullum Miller

Preparation Date 9/25/2014

Effective Date of Pricing 9/25/2014

Estimated Construction Time Days

Direct Cost Markups		**Category**		**Method**		
Productivity		Productivity		Productivity		
Overtime		Overtime		Overtime		
	Days/Week	*Hours/Shift*	*Shifts/Day*	*1st Shift*	*2nd Shift*	*3rd Shift*
Standard	5.00	8.00	1.00	8.00	0.00	0.00
Actual	5.00	8.00	1.00	8.00	0.00	0.00

Day	*OT Factor*	*Working*	*OT Percent*	*FCCM Percent*
Monday	1.50	Yes	0.00	0.00
Tuesday	1.50	Yes		
Wednesday	1.50	Yes		
Thursday	1.50	Yes		
Friday	1.50	Yes		
Saturday	1.50	No		
Sunday	2.00	No		

Sales Tax	TaxAdj	Running % on Selected Costs
MatlCost		

Contractor Markups	**Category**	**Method**
JOOH	JOOH	Direct %
HOOH	HOOH	Running %
Profit	Profit	Running %
Bond	Bond	Running %
Excise Tax	Excise	Running %

Owner Markups		**Category**		**Method**		
Escalation		Escalation		Escalation		
	StartDate	*StartIndex*	*EndDate*		*EndIndex*	*Escalation*
	11/14/2014	0.00	11/14/2014		0.00	0.00
Contingency		Contingency		Running %		
SIOH		SIOH		Running %		

Currency in US dollars

Description	Quantity	UOM	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectCost
Direct Costs			**870,660**	**370,125**	**844,409**	**20,381,713**	**22,466,907**
01 Lands and Damages	**1.00**	**EA**	**0**	**0**	**0**	**16,981,807**	**16,981,807**
01 Ellington Agricultural Detention - Real Estate Costs	**1.00**	**EA**	**0**	**0**	**0**	**476,387**	**476,387**
(Note: This value was provided by Real Estate Division. Additionally, as a result of the abbreviated CSRA along with coordination with LRN Real Estate Division Chief, a contingency of 15% will be applied in the TPCS.)							
USR 01 Ellington Agriculture Center Detention - Lands & Damages	1.00	LS	0	0	0	476,387	476,387
(Note: This value was provided by Real Estate Division. $364,387 is for the Lands/Damages and $112,000 is for the admin costs which Total - $476,387.)							
03 Non-Structural Alternative	**1.00**	**EA**	**0**	**0**	**0**	**16,505,420**	**16,505,420**
(Note: Non-Structural Costs were provided by the PDT, specifically Real Estate, Economics, and the PM. As a result of the abbreviated CSRA along with coordination with LRN Real Estate Division Chief, an additional contingency of 15% will be applied in the TPCS.)							
01 Buy-Out	**1.00**	**EA**	**0**	**0**	**0**	**13,968,320**	**13,968,320**
(Note: (80 Structures))							
USR 01 Buy-Out Option - 80 Structures	80.00	EA	0	0	0	13,968,320	13,968,320
(Note: These Non-Structural Costs have been provided by the PDT (specifically Real Estate, Economics, PM, and LRD). This cost includes land ($11,846,050), relocation ($762,250), and admin costs ($510,000+$850,000) for a Total of $13,968,320 for a per Structure cost of $174,604.)							
02 Demolition and Removal	**1.00**	**EA**	**0**	**0**	**0**	**1,800,000**	**1,800,000**
(Note: (80 Structures))							
USR 03 Buy-Out Option - 80 Structures	80.00	EA	0	0	0	1,800,000	1,800,000
(Note: These Non-Structural Costs have been provided by the PDT (specifically Real Estate, Economics, PM, and LRD). These were based off recent "Demolition and Removal" costs from the local sponsor along with LRN specific relocation and admin costs. Therefore, this per structure cost includes land, relocation, and admin costs. Per Structure = $22,500 = Total = $1,800,000.)							
03 Raise	**1.00**	**EA**	**0**	**0**	**0**	**737,100**	**737,100**
(Note: (9 Structures))							
USR 01 Raise - 9 Structures	9.00	EA	0	0	0	737,100	737,100
(Note: These Non-Structural Costs have been provided by the PDT (specifically Real Estate, Economics, and the PM). Per Structure = $81,900 = Total = $737,100)							
02 Relocations	**1.00**	**EA**	**0**	**0**	**0**	**68,700**	**68,700**
01 Ellington Agricultural Detention - Relocation Cost	**1.00**	**EA**	**0**	**0**	**0**	**31,000**	**31,000**
(Note: Utilities located in the vicinity of the project were identified by using GIS files provided by Nashville City Utilities. For the selected plan, sanitary sewer, potable water, gas, electric and telephone lines will have to be removed and relocated in order to construct the detention structure. In general, quantities reflect an in-kind replacement, meaning that the same size and type of material would be utilized in the relocation of a utility to accommodate the proposed channel work. This value was provided by Real Estate Division and confirmed by RS Means (Relocation of Existing Utility Poles).)							
USR Relocation Cost - Ellington Agriculture Center Detention	1.00	LS	0	0	0	31,000	31,000
(Note: This value was provided by Real Estate Division (Relocation of Existing Utility Poles))							
02 Briley Parkway Bridge Modification - Relocation Cost	**1.00**	**EA**	**0**	**0**	**0**	**37,700**	**37,700**
(Note: Utilities located in the vicinity of the project were identified by using GIS files provided by Nashville City Utilities. For the selected plan, sanitary sewer, potable water, gas, electric and telephone lines will have to be removed and relocated in order to construct the channel. In general, quantities reflect an in-kind replacement, meaning that the same size and type of material would be utilized in the relocation of a utility to accommodate the proposed channel work. This value was provided by Real Estate Division.)							
USR Relocation Cost - Briley Parkway Bridge	1.00	LS	0	0	0	37,700	37,700
(Note: This value was provided by Real Estate Division & Project Manager)							
08 Bridges	**1.00**	**EA**	**74,485**	**60,545**	**0**	**1,547,448**	**1,682,478**
Briley Parkway Bridge Modification	**1.00**	**EA**	**74,485**	**60,545**	**0**	**1,547,448**	**1,682,478**
(Note: The Briley Parkway Bridge Modification construction will be procured/constructed by TDOT due to this being a state highway bridge and considered to be a part of the local sponsor's LERRDs. (See in Project Notes the TDOT Briley Pkwy Bridge Bid Schedule and Prices) Therefore, TDOT unit prices were applied to the design quantities with construction contingency applied according to the results of the CSRA. The Corps' Federal ($'s) portion will be provided to Metro/TDOT and there will be some coordination and S&A by USACE. The Briley Parkway bridge modification alternative will consist of widening the east and west bound bridge openings by a minimum of 63 feet to increase the flow through the bridge cross-section. It is proposed to add one additional span at the west end of each bridge and approximately 200 feet of channel widening. The widening will start at the upstream end of the west embankment looking downstream. Each existing bridge has three discontinuous spans, supported by pre-stressed concrete girders. As a result of the CSRA & Cost ATR Certification, a contigency of 44.69% has been applied. Note, the estimate layout reflects the TDOT Bid Schedule and Quantities, as it appears some items are duplicated but reflected this way to be consistent with the bid schedule (for both east and west bound bridge lanes).)							
08.05 Mob/DeMob	**1.00**	**EA**	**0**	**0**	**0**	**140,000**	**140,000**
(Note: The Briley Parkway Bridge Modification construction will be procured/constructed by TDOT due to this being a state highway bridge and considered to be a part of the local sponsor's LERRDs. Therefore, TDOT unit prices were applied to the design quantities with construction contingency applied according to the results of the CSRA. The Corps' Federal ($'s) portion will be provided to Metro/TDOT and there will be some coordination and S&A by USACE.)							
USR 08.05.1 Mob/DeMob	1.00	LS	0	0	0	140,000	140,000
(Note: The Briley Parkway bridge modification alternative will consist of widening the east and west bound bridge openings by a minimum of 63 feet to increase the flow through the bridge cross-section. It is proposed to add one additional span at the west end of each bridge and approximately 200 feet of channel widening. The widening will start at the upstream end of the west embankment looking downstream. Each existing bridge has three discontinuous spans, supported by pre-stressed concrete girders. The Mobilization/DeMob payment specific to the construction of this work by TDOT may or may not be paid as a separate CLIN Item. However 5% of the construction contract (~1.4 Mil) = $70,000 should be a fair and reasonable allotment but could be distributed or accounted for in the existing TDOT CLIN Items.)							
08.1 Demolition/Disposal	**1.00**	**EA**	**0**	**0**	**0**	**79,380**	**79,380**
(Note: The Briley Parkway Bridge Modification construction will be procured/constructed by TDOT due to this being a state highway bridge and considered to be a part of the local sponsor's LERRDs. Therefore, TDOT unit prices were applied to the design quantities with construction contingency applied according to the results of the CSRA. The Corps' Federal ($'s) portion will be provided to Metro/TDOT and there will be some coordination and S&A by USACE.)							
USR 08.1.1 Demolition/Disposal	1,764.00	SF	0	0	0	79,380	79,380
(Note: The Briley Parkway bridge modification alternative will consist of widening the east and west bound bridge openings by a minimum of 63 feet to increase the flow through the bridge cross-section. It is proposed to add one additional span at the west end of each bridge and approximately 200 feet of channel widening. The widening will start at the upstream end of the west embankment looking downstream. Each existing bridge has three discontinuous spans, supported by pre-stressed concrete girders. The Mobilization/DeMob payment specific to the construction of this work by TDOT may or may not be paid as a separate CLIN Item. However 5% of the construction contract (~1.4 Mil) = $70,000 should be a fair and reasonable allotment but could be distributed or accounted for in the existing TDOT CLIN Items.)							
08.15 Excavation	**14,400.00**	**CY**	**74,485**	**60,545**	**0**	**53,914**	**188,944**
(Note: The Briley Parkway Bridge Modification construction will be procured/constructed by TDOT due to this being a state highway bridge and considered to be a part of the local sponsor's LERRDs. Therefore, TDOT unit prices were applied to the design quantities with construction contingency applied according to the results of the CSRA. The Corps' Federal ($'s) portion will be provided to Metro/TDOT and there will be some coordination and S&A by USACE.)							
HNC 312316440205 Excavate and load, bank measure, medium material, 3/4 C.Y. bucket, wheeled loader	14,400.00	BCY	27,350	9,798	0	0	37,148
USR 01 Disposal/Dump Fee	18,720.00	LCY	0	0	0	53,914	53,914
(Note: Quote from American Farms in Nashville (John Stevenson) 14,400 CY plus 30% swell = 18,720 LCY)							
RSM 312323201066 Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 12 C.Y. truck, cycle 10 miles, 35 MPH, excludes loading equipment	18,720.00	LCY	47,136	50,747	0	0	97,883
(Note: Quote from American Farms in Nashville (John Stevenson) 14,400 CY plus 30% swell = 18,720 LCY)							
08.2 Concrete Class A (Abutment)	**1.00**	**EA**	**0**	**0**	**0**	**33,300**	**33,300**
(Note: There are two lanes, east and west bound bridge openings and therefore 2 abutments - 1 for each direction.)							

Labor ID: NLS2012 EQ ID: EP14R03 Currency in US dollars TRACES MII Version 4.2

Description	Quantity	UOM	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectCost
USR 08.2.1 Concrete Class A (Abutment)	37.00	CY	0	0	0	16,650	16,650
(Note: east and west bound bridge openings by a minimum of 63 feet to increase the flow through the bridge cross-section.)							
USR 08.2.2 Concrete Class A (Abutment)	37.00	CY	0	0	0	16,650	16,650
08.3 Concrete Class A (Pier)	**1.00**	**EA**	**0**	**0**	**0**	**79,200**	**79,200**
(Note: There are two lanes, east and west bound bridge openings and therefore 2 piers - 1 for each direction.)							
USR 08.3.1 Concrete Class A (Pier)	88.00	CY	0	0	0	39,600	39,600
USR 08.3.2 Concrete Class A (Pier)	88.00	CY	0	0	0	39,600	39,600
08.4 Concrete Class D (New Deck) 63' x 34.5'	**1.00**	**EA**	**0**	**0**	**0**	**137,550**	**137,550**
(Note: There are two lanes, east and west bound bridge openings and therefore 2 new decks - 1 for each direction.)							
USR 08.4.1 Concrete Class D (New Deck) 63' x 34.5'	131.00	CY	0	0	0	68,775	68,775
USR 08.4.2 Concrete Class D (New Deck) 63' x 34.5'	131.00	CY	0	0	0	68,775	68,775
08.5 Concrete Class D (Existing Deck) 63.33' x 34.5'	**1.00**	**EA**	**0**	**0**	**0**	**137,550**	**137,550**
(Note: There are two lanes, east and west bound bridge openings and therefore 2 existing deck replacements - 1 for each direction.)							
USR 08.5.1 Concrete Class D (Existing Deck) 63.33' x 34.5'	131.00	CY	0	0	0	68,775	68,775
USR 08.5.2 Concrete Class D (Existing Deck) 63.33' x 34.5'	131.00	CY	0	0	0	68,775	68,775
08.6 Concrete Parapet Single Slope (New)	**1.00**	**EA**	**0**	**0**	**0**	**55,440**	**55,440**
(Note: There are two lanes, east and west bound bridge openings and therefore 4 new single slope parapets - 2 for each direction.)							
USR 08.6.1 Concrete Parapet Single Slope (New)	252.00	LAN	0	0	0	13,860	13,860
(Note: There are 4 of these)							
USR 08.6.2 Concrete Parapet Single Slope (New)	252.00	LAN	0	0	0	13,860	13,860
(Note: There are 4 of these)							
USR 08.6.3 Concrete Parapet Single Slope (New)	252.00	LAN	0	0	0	13,860	13,860
(Note: There are 4 of these)							
USR 08.6.4 Concrete Parapet Single Slope (New)	252.00	LAN	0	0	0	13,860	13,860
(Note: There are 4 of these)							
08.7 Concrete Parapet Single Slope (Existing)	**1.00**	**EA**	**0**	**0**	**0**	**55,880**	**55,880**
(Note: There are two lanes, east and west bound bridge openings and therefore 4 existing single slope parapets replacemnts - 2 for each direction.)							
USR 08.7.1 Concrete Parapet Single Slope (Existing)	254.00	LF	0	0	0	13,970	13,970
(Note: There are 4 of these)							
USR 08.7.2 Concrete Parapet Single Slope (Existing)	254.00	LF	0	0	0	13,970	13,970
(Note: There are 4 of these)							
USR 08.7.3 Concrete Parapet Single Slope (Existing)	254.00	LF	0	0	0	13,970	13,970
(Note: There are 4 of these)							
USR 08.7.4 Concrete Parapet Single Slope (Existing)	254.00	LF	0	0	0	13,970	13,970
(Note: There are 4 of these)							
08.8 Bridge Beam	**1.00**	**EA**	**0**	**0**	**0**	**564,480**	**564,480**
(Note: There are two lanes, east and west bound bridge openings and therefore 8 bridge beams - 4 for each direction.)							
USR 08.8.1 Bridge Beam	504.00	LF	0	0	0	70,560	70,560
(Note: There are 8 of these)							
USR 08.8.2 Bridge Beam	504.00	LF	0	0	0	70,560	70,560
(Note: There are 8 of these)							
USR 08.8.3 Bridge Beam	504.00	LF	0	0	0	70,560	70,560
(Note: There are 8 of these)							
USR 08.8.4 Bridge Beam	504.00	LF	0	0	0	70,560	70,560
(Note: There are 8 of these)							
USR 08.8.5 Bridge Beam	504.00	LF	0	0	0	70,560	70,560
(Note: There are 8 of these)							
USR 08.8.6 Bridge Beam	504.00	LF	0	0	0	70,560	70,560
(Note: There are 8 of these)							
USR 08.8.7 Bridge Beam	504.00	LF	0	0	0	70,560	70,560
(Note: There are 8 of these)							
USR 08.8.8 Bridge Beam	504.00	LF	0	0	0	70,560	70,560
(Note: There are 8 of these)							
08.9 H Pile 10X42(Abutment)	**1.00**	**EA**	**0**	**0**	**0**	**18,648**	**18,648**
(Note: There are two lanes, east and west bound bridge openings and therefore 2 H Pile Abutments - 1 for each direction.)							
USR 08.9.1 H Pile 10X42(Abutment)	222.00	LF	0	0	0	9,324	9,324
(Note: There are 2 of these)							
USR 08.9.2 H Pile 10X42(Abutment)	222.00	LF	0	0	0	9,324	9,324
(Note: There are 2 of these)							
08.10 Steel Bar Reinforcement (Abutment)	**1.00**	**EA**	**0**	**0**	**0**	**6,901**	**6,901**
(Note: There are two lanes, east and west bound bridge openings and therefore the Steel Reinforcement for each abutment for each direction was reflected separately.)							
USR 08.10.1 Steel Bar Reinforcement (Abutment)	3,834.00	LB	0	0	0	3,451	3,451
(Note: 2 Abutments)							
USR 08.10.2 Steel Bar Reinforcement (Abutment)	3,834.00	LB	0	0	0	3,451	3,451
(Note: 2 Abutments)							
08.11 Steel Bar Reinforcement (Pier)	**1.00**	**EA**	**0**	**0**	**0**	**38,761**	**38,761**
(Note: There are two lanes, east and west bound bridge openings and therefore the Steel Reinforcement for each pier for each direction was reflected separately.)							
USR 08.11.1 Steel Bar Reinforcement (Pier)	21,534.00	LB	0	0	0	19,381	19,381
(Note: 2 Piers)							

Currency in US dollars

Description	Quantity	UOM	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectCost
USR 08.11.2 Steel Bar Reinforcement (Pier)	21,534.00	LB	0	0	0	19,381	19,381
(Note: 2 Piers)							
08.12 Epoxy Coated Reinforcing Steel (New Deck) 63' x 34.5'	**1.00**	**EA**	**0**	**0**	**0**	**73,030**	**73,030**
(Note: There are two lanes, east and west bound bridge openings and therefore 2 New Decks - 1 for each direction.)							
USR 08.12.1 Epoxy Coated Reinforcing Steel (New Deck) 63' x 34.5'	34,776.00	EA	0	0	0	36,515	36,515
(Note: 2 Decks)							
USR 08.12.2 Epoxy Coated Reinforcing Steel (New Deck) 63' x 34.5'	34,776.00	EA	0	0	0	36,515	36,515
(Note: 2 Decks)							
08.13 Epoxy Coated Reinforcing Steel (Existing Deck) 63.33' x 34.5'	**1.00**	**EA**	**0**	**0**	**0**	**73,414**	**73,414**
(Note: There are two lanes, east and west bound bridge openings and therefore 2 existing Decks to be replaced - 1 for each direction.)							
USR 08.13.1 Epoxy Coated Reinforcing Steel (Existing Deck) 63.33' x 34.5'	34,959.00	EA	0	0	0	36,707	36,707
(Note: 2 Decks)							
USR 08.13.2 Epoxy Coated Reinforcing Steel (Existing Deck) 63.33' x 34.5'	34,959.00	EA	0	0	0	36,707	36,707
(Note: 2 Decks)							
15 Floodway Control and Diversion Structures	**1.00**	**EA**	**796,175**	**309,580**	**844,409**	**270,341**	**2,220,505**
Ellington Agricultural Center Detention Structure	**1.00**	**EA**	**796,175**	**309,580**	**844,409**	**270,341**	**2,220,505**
(Note: The Ellington Agricultural Center Detention alternative is located on Sevenmile Creek at river mile 3.67 at the Ellington Agriculture Center Entrance Bridge. The measure captures 7.9 square miles, 45% of Sevenmile Creek's total watershed. The detention structure will replace the existing entrance bridge and therefore must accommodate traffic across it's crest. The new structure has two lanes, one in each direction and has an approximately 1 foot high concrete curb as a guard rail on the upstream and downstream side of with a 32-foot crest. The RCC structure is 17 feet high and 100 feet long. The RCC structure will have a smaller culvert opening that will restrict the flow during the flood and retain water to minimize flooding downstream. The new low level outlet will be replaced with a CONSPAN Arch that has a 20 feet opening at the base with the total opening area of 160 square feet to pass normal flow and require no manual or mechanical operation. The RCC will be abutted to the compacted-earth embankment on either side.)							
001 Mob & Site Prep Work	**1.00**	**EA**	**0**	**0**	**0**	**30,000**	**30,000**
(Note: Abstracted from a similar job (Murfree Springs Trashrack with simlar scope and equipment))							
USR 01 Mob & Site Prep Work	1.00	LS	0	0	0	30,000	30,000
(Note: Abstracted from a similar job (Murfree Springs Trashrack with simlar scope and equipment))							
002a Demolition of Asphalt Pavement - Ellington	**450.00**	**CY**	**42,535**	**15,730**	**0**	**1,426**	**59,691**
RSM 024113175500 Demolish, remove pavement & curb, concrete, rod reinforced, 7" to 24" thick, remove with backhoe, excludes hauling	450.00	CY	40,356	14,051	0	0	54,407
HNC 312316440205 Excavate and load, bank measure, medium material, 3/4 C.Y. bucket, wheeled loader	495.00	LCY	937	337	0	0	1,274
(Note: 450 CY plus 10% swell = 495 LCY)							
USR 01 Disposal/Dump Fee	495.00	LCY	0	0	0	1,426	1,426
(Note: Quote from American Farms in Nashville (John Stevenson) 450 CY plus 10% swell = 495 LCY)							
RSM 312323201066 Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 12 C.Y. truck, cycle 10 miles, 35 MPH, excludes loading equipment	495.00	LCY	1,242	1,342	0	0	2,584
(Note: 450 CY plus 10% swell = 495 LCY)							
002b Demolition of Asphalt Pavement - Edmonson	**675.00**	**CY**	**63,805**	**23,597**	**0**	**2,140**	**89,541**
RSM 024113175500 Demolish, remove pavement & curb, concrete, rod reinforced, 7" to 24" thick, remove with backhoe, excludes hauling	675.00	CY	60,534	21,077	0	0	81,611
HNC 312316440205 Excavate and load, bank measure, medium material, 3/4 C.Y. bucket, wheeled loader	743.00	LCY	1,406	506	0	0	1,912
(Note: 675 CY plus 10% swell = 743 LCY)							
USR 01 Disposal/Dump Fee	743.00	LCY	0	0	0	2,140	2,140
(Note: Quote from American Farms in Nashville (John Stevenson). 675 CY plus 10% swell = 743 LCY)							
RSM 312323201066 Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 12 C.Y. truck, cycle 10 miles, 35 MPH, excludes loading equipment	743.00	LCY	1,865	2,014	0	0	3,879
(Note: 675 CY plus 10% swell = 743 LCY)							
003 Excavation - Stilling Basin	**720.00**	**BCY**	**3,712**	**3,027**	**0**	**2,696**	**9,435**
HNC 312316440205 Excavate and load, bank measure, medium material, 3/4 C.Y. bucket, wheeled loader	720.00	BCY	1,363	490	0	0	1,853
USR 01 Disposal/Dump Fee	936.00	LCY	0	0	0	2,696	2,696
(Note: Quote from American Farms in Nashville (John Stevenson) 720 CY plus 30% swell = 936 LCY)							
RSM 312323201066 Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 12 C.Y. truck, cycle 10 miles, 35 MPH, excludes loading equipment	936.00	LCY	2,349	2,537	0	0	4,886
(Note: 720 CY plus 30% swell = 936 LCY)							
004a Aggregate Base - Ellington	**1,750.00**	**TON**	**5,501**	**4,372**	**36,134**	**0**	**46,008**
RSM 321123232012 Base course drainage layers, aggregate base course for roadways and large paved areas, alternate method to figure base course, crushed stone, 3/4"maximum size, 9" deep	1,750.00	TON	2,114	807	36,134	0	39,055
RSM 312323201066 Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 12 C.Y. truck, cycle 10 miles, 35 MPH, excludes loading equipment	1,167.00	LCY	2,929	3,164	0	0	6,092
(Note: 1167 CY = conversion from 1,750 Tons at a factor of 1.5 Tons/CY)							
RSM 312323235620 Compaction, 3 passes, 6" lifts, riding, sheepsfoot or wobbly wheel roller	1,167.00	ECY	458	401	0	0	860
(Note: 1167 CY = conversion from 1,750 Tons at a factor of 1.5 Tons/CY)							
004b Aggregate Base - Edmonson	**1.00**	**EA**	**8,251**	**6,556**	**54,202**	**0**	**69,008**
RSM 321123232012 Base course drainage layers, aggregate base course for roadways and large paved areas, alternate method to figure base course, crushed stone, 3/4"maximum size, 9" deep	2,625.00	TON	3,171	1,210	54,202	0	58,583
RSM 312323201066 Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 12 C.Y. truck, cycle 10 miles, 35 MPH, excludes loading equipment	1,750.00	LCY	4,392	4,744	0	0	9,136
(Note: 1,750 = conversion from 2,625 Tons at a factor of 1.5 Tons/CY)							
RSM 312323235620 Compaction, 3 passes, 6" lifts, riding, sheepsfoot or wobbly wheel roller	1,750.00	ECY	687	602	0	0	1,289
(Note: 1,750 = conversion from 2,625 Tons at a factor of 1.5 Tons/CY)							
005a Asphalt - Ellington (Cost Book)	**1,897.00**	**TON**	**78,903**	**51,844**	**140,928**	**0**	**271,675**
RSM 321216131920 Plant-mix asphalt paving, bridge approach, wearing course, over 800 tons, 2" thick, no hauling included	1,897.00	TON	16,953	4,581	140,928	0	162,462
RSM 320117201500 Flexible pavement patches, roadway, light traffic, hot asphalt haul truck, 8 C.Y. truck per day	136.00	DAY	61,950	47,263	0	0	109,213

Currency in US dollars

Description	Quantity	UOM	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectCost
(Note: 8 CY/Truck = (Factor of 1.75 Tons/CY) = 14 tons/truck. 1,897 Tons Asphalt @14 tons/asphalt truck = 136 days (2-3 trucks can be used since working in different areas))							
005b Asphalt - Edmonson (Cost Book)	**2,942.00**	**TON**	**122,405**	**80,432**	**218,561**	**0**	**421,398**
RSM 321216131920 Plant-mix asphalt paving, bridge approach, wearing course, over 800 tons, 2" thick, no hauling included	2,942.00	TON	26,292	7,105	218,561	0	251,958
RSM 320117201500 Flexible pavement patches, roadway, light traffic, hot asphalt haul truck, 8 C.Y. truck per day	211.00	DAY	96,113	73,327	0	0	169,440
(Note: 8 CY/Truck = (Factor of 1.75 Tons/CY) = 14 tons/truck. 2,942 Tons Asphalt @14 tons/asphalt truck = 211 days (2-3 trucks can be used since working in different areas))							
006a Clay Fill - Ellington	**20,943.00**	**CY**	**116,409**	**95,893**	**81,225**	**0**	**293,527**
USR 01 Fill (Clay) - Material Cost	20,943.00	CY	0	0	81,225	0	81,225
(Note: American Farms - John Stevenson of $3.55/CY (located approximately 5 miles away) = Applying a shrinkage factor (30%) in obtaining 16,110 ECY equals 20,943 CY to be purchased.)							
RSM 312323142440 Backfill, structural, clay, 80 H.P. dozer, 300' haul, from existing stockpile, excludes compaction	20,943.00	LCY	49,211	18,081	0	0	67,292
(Note: American Farms - John Stevenson of $3.55/CY (located approximately 5 miles away) = Applying a shrinkage factor (30%) in obtaining 16,110 ECY equals 20,943 CY to be purchased.)							
RSM 312323131700 Backfill, bulk, 6" to 12" lifts, dozer backfilling, compaction with sheepsfoot roller	16,110.00	ECY	14,637	21,039	0	0	35,676
(Note: 20,943 LCY to 16,110 ECY)							
RSM 312323201066 Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 12 C.Y. truck, cycle 10 miles, 35 MPH, excludes loading equipment	20,943.00	LCY	52,561	56,773	0	0	109,335
(Note: American Farms - John Stevenson of $3.55/CY (located approximately 5 miles away) = Applying a shrinkage factor (30%) in obtaining 16,110 ECY equals 20,943 CY to be purchased and hauled.)							
006b Clay Fill - Edmonson	**6,013.00**	**CY**	**33,422**	**27,532**	**23,321**	**0**	**84,275**
USR 01 Fill (Clay) - Material Cost	6,013.00	CY	0	0	23,321	0	23,321
(Note: American Farms - John Stevenson of $3.55/CY (located approximately 5 miles away) = Applying a shrinkage factor (30%) in obtaining 4625 ECY equals 6,013 CY to be purchased.)							
RSM 312323142440 Backfill, structural, clay, 80 H.P. dozer, 300' haul, from existing stockpile, excludes compaction	6,013.00	LCY	14,129	5,191	0	0	19,320
(Note: American Farms - John Stevenson of $3.55/CY (located approximately 5 miles away) = Applying a shrinkage factor (30%) in obtaining 4625 ECY equals 6,013 CY to be purchased.)							
RSM 312323131700 Backfill, bulk, 6" to 12" lifts, dozer backfilling, compaction with sheepsfoot roller	4,625.00	ECY	4,202	6,040	0	0	10,242
(Note: 6,013 LCY to 4,625,110 ECY)							
RSM 312323201066 Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 12 C.Y. truck, cycle 10 miles, 35 MPH, excludes loading equipment	6,013.00	LCY	15,091	16,300	0	0	31,391
(Note: American Farms - John Stevenson of $3.55/CY (located approximately 5 miles away) = Applying a shrinkage factor (30%) in obtaining 4625 ECY equals 6,013 CY to be purchased and hauled.)							
007 Permanent Erosion Mat	**1.00**	**EA**	**1,511**	**357**	**1,652**	**0**	**3,521**
RSM 312514160060 Synthetic erosion control, nylon, 3 dimensional geomatrix, 9 mil thick	900.00	SY	1,511	357	1,652	0	3,521
008 Articulated Block	**1.00**	**EA**	**319,289**	**0**	**287,207**	**0**	**606,496**
RSM 042210230250 Concrete block, decorative, embossed one side, 2000 psi, 12" x 8" x 16", includes mortar and horizontal joint reinforcing every other course, excludes scaffolding, grout and vertical reinforcing	41,400.00	SF	319,289	0	287,207	0	606,496
009 Temporary and Permanent Seeding	**1.00**	**EA**	**432**	**239**	**1,179**	**4,160**	**6,010**
RSM 329219143800 Seeding athletic fields, seeding rye, fine textured, with mulch and fertilizer, 10 lb. per M.S.F., hydro or air seeding	26.00	MSF	432	239	1,179	0	1,850
USR 01 Temporary Seeding	26.00	MSF	0	0	0	4,160	4,160
(Note: Abstracted from a similar job (Metro Center Levee))							
010 Concrete Conspan Culvert	**1.00**	**LF**	**0**	**0**	**0**	**229,920**	**229,920**
(Note: 25' x 8' Arch Conspand Culvert at 48 LF)							
USR 01 Concrete Conspan Culvert (includes installation)	48.00	LF	0	0	0	229,920	229,920
(Note: Received a quote for the 25' x 8' Arch Conspan Culvert (48 LF), as follows: Arch Conspan Culvert at a material price of $140,000 plus and installation quote of $89,920 provided by:Joseph M. Spain, P.E. CONTECH Engineered Solutions, LLC 5552 Franklin Road, Suite 202] Nashville, TN 37220 Off: 615-221-1170 Mob: 615-210-5650 Fax: 615-221-1171 jspain@conteches.com www.ContechES.com. This price includes the sub mark-up but will receive the Prime's subwork mark-up.)							
30 Engineering and Design (E&D)	**1.00**	**EA**	**0**	**0**	**0**	**1,008,945**	**1,008,945**
USR 01 E&D on CLIN Item #08 - Bridges	1.00	LS	0	0	0	336,496	336,496
(Note: 20% of the Contract Cost = $1,682,478 x 20% = $336,496)							
USR 02 E&D on CLIN Item #15 - Flooway Control and Diversion	1.00	LS	0	0	0	672,449	672,449
(Note: 20% of the Contract Cost = $3,362,243 x 20% = $672,449)							
31 Supervision & Administration (S&A)	**1.00**	**EA**	**0**	**0**	**0**	**504,472**	**504,472**
USR 01 S&A on CLIN Item #08 - Bridges	1.00	LS	0	0	0	168,248	168,248
(Note: 10% of the Contract Cost = $1,682,478 x 10% = $168,248)							
USR 02 S&A on CLIN Item #15 - Flooway Control and Diversion	1.00	LS	0	0	0	336,224	336,224
(Note: 10% of the Contract Cost = $3,362,243 x 10% = $336,224)							

Currency in US dollars

Description	Quantity	UOM	DirectCost	SubCMU	CostToPrime	PrimeCMU	ContractCost
Indirect Costs			22,466,907	285,804	4,188,787	855,934	23,608,645
01 Lands and Damages	1.00	EA	16,981,807	0	0	0	16,981,807
01 Ellington Agricultural Detention - Real Estate Costs	1.00	EA	476,387	0	0	0	476,387
03 Non-Structural Alternative	1.00	EA	16,505,420	0	0	0	16,505,420
01 Buy-Out	1.00	EA	13,966,320	0	0	0	13,968,320
02 Demolition and Removal	1.00	EA	1,800,000	0	0	0	1,800,000
03 Raise	1.00	EA	737,100	0	0	0	737,100
02 Relocations	1.00	EA	68,700	0	0	0	68,700
01 Ellington Agricultural Detention - Relocation Cost	1.00	EA	31,000	0	0	0	31,000
02 Briley Parkway Bridge Modification - Relocation Cost	1.00	EA	37,700	0	0	0	37,700
08 Bridges	1.00	EA	1,682,478	0	1,682,478	0	1,682,478
Briley Parkway Bridge Modification	1.00	EA	1,682,478	0	1,682,478	0	1,682,478
08.05 Mob/DeMob	1.00	EA	140,000	0	140,000	0	140,000
08.1 Demolition/Disposal	1.00	EA	79,380	0	79,380	0	79,380
08.15 Excavation	14,400.00	CY	188,944	0	188,944	0	188,944
08.2 Concrete Class A (Abutment)	1.00	EA	33,300	0	33,300	0	33,300
08.3 Concrete Class A (Pier)	1.00	EA	79,200	0	79,200	0	79,200
08.4 Concrete Class D (New Deck) 63' x 34.5'	1.00	EA	137,550	0	137,550	0	137,550
08.5 Concrete Class D (Existing Deck) 63.33' x 34.5'	1.00	EA	137,550	0	137,550	0	137,550
08.6 Concrete Parapet Single Slope (New)	1.00	EA	55,440	0	55,440	0	55,440
08.7 Concrete Parapet Single Slope (Existing)	1.00	EA	55,880	0	55,880	0	55,880
08.8 Bridge Beam	1.00	EA	564,480	0	564,480	0	564,480
08.9 H Pile 10X42(Abutment)	1.00	EA	18,648	0	18,648	0	18,648
08.10 Steel Bar Reinforcement (Abutment)	1.00	EA	6,901	0	6,901	0	6,901
08.11 Steel Bar Reinforcement (Pier)	1.00	EA	38,761	0	38,761	0	38,761
08.12 Epoxy Coated Reinforcing Steel (New Deck) 63' x 34.5'	1.00	EA	73,030	0	73,030	0	73,030
08.13 Epoxy Coated Reinforcing Steel (Existing Deck) 63.33' x 34.5'	1.00	EA	73,414	0	73,414	0	73,414
15 Floodway Control and Diversion Structures	1.00	EA	2,220,505	285,804	2,506,309	855,934	3,362,243
Ellington Agricultural Center Detention Structure	1.00	EA	2,220,505	285,604	2,506,309	855,934	3,362,243
001 Mob & Site Prep Work	1.00	EA	30,000	0	30,000	12,371	42,371
002a Demolition of Asphalt Pavement - Ellington	450.00	CY	59,691	0	59,691	24,615	84,305
002b Demolition of Asphalt Pavement - Edmonson	675.00	CY	89,541	0	89,541	36,924	126,466
003 Excavation - Stilling Basin	720.00	BCY	9,435	0	9,435	3,891	13,326
004a Aggregate Base - Ellington	1,750.00	TON	46,008	0	46,008	18,972	64,980
004b Aggregate Base - Edmonson	1.00	EA	69,008	0	69,008	28,457	97,466
005a Asphalt - Ellington (Cost Book)	1,897.00	TON	271,675	112,031	383,706	88,614	472,320
005b Asphalt - Edmonson (Cost Book)	2,942.00	TON	421,398	173,773	595,171	137,450	732,621
006a Clay Fill - Ellington	20,943.00	CY	293,527	0	293,527	121,043	414,570
006b Clay Fill - Edmonson	6,013.00	CY	84,275	0	84,275	34,752	119,027
007 Permanent Erosion Mat	1.00	EA	3,521	0	3,521	1,452	4,972
008 Articulated Block	1.00	EA	606,496	0	606,496	250,102	856,599
009 Temporary and Permanent Seeding	1.00	EA	6,010	0	6,010	2,478	8,488
010 Concrete Conspan Culvert	1.00	LF	229,920	0	229,920	94,813	324,733
30 Engineering and Design (E&D)	1.00	EA	1,008,945	0	0	0	1,008,945
31 Supervision & Administration (S&A)	1.00	EA	504,472	0	0	0	504,472

Currency in US dollars

Description	Quantity	UOM	DirectCost	JOOH	HOOH	Profit	PrimeCMU	ProjectCost
Owner Costs			22,466,907	333,076	255,358	280,894	855,934	23,608,645
01 Lands and Damages	1.00	EA	16,981,807	0	0	0	0	16,981,807
01 Ellington Agricultural Detention - Real Estate Costs	1.00	EA	476,387	0	0	0	0	476,387
03 Non-Structural Alternative	1.00	EA	16,505,420	0	0	0	0	16,505,420
01 Buy-Out	1.00	EA	13,968,320	0	0	0	0	13,968,320
02 Demolition and Removal	1.00	EA	1,800,000	0	0	0	0	1,800,000
03 Raise	1.00	EA	737,100	0	0	0	0	737,100
02 Relocations	1.00	EA	68,700	0	0	0	0	68,700
01 Ellington Agricultural Detention - Relocation Cost	1.00	EA	31,000	0	0	0	0	31,000
02 Briley Parkway Bridge Modification - Relocation Cost	1.00	EA	37,700	0	0	0	0	37,700
08 Bridges	1.00	EA	1,682,478	0	0	0	0	1,682,478
Briley Parkway Bridge Modification	1.00	EA	1,682,478	0	0	0	0	1,682,478
08.05 Mob/DeMob	1.00	EA	140,000	0	0	0	0	140,000
08.1 Demolition/Disposal	1.00	EA	79,380	0	0	0	0	79,380
08.15 Excavation	14,400.00	CY	188,944	0	0	0	0	188,944
08.2 Concrete Class A (Abutment)	1.00	EA	33,300	0	0	0	0	33,300
08.3 Concrete Class A (Pier)	1.00	EA	79,200	0	0	0	0	79,200
08.4 Concrete Class D (New Deck) 63' x 34.5'	1.00	EA	137,550	0	0	0	0	137,550
08.5 Concrete Class D (Existing Deck) 63.33' x 34.5'	1.00	EA	137,550	0	0	0	0	137,550
08.6 Concrete Parapet Single Slope (New)	1.00	EA	55,440	0	0	0	0	55,440
08.7 Concrete Parapet Single Slope (Existing)	1.00	EA	55,880	0	0	0	0	55,880
08.8 Bridge Beam	1.00	EA	564,480	0	0	0	0	564,480
08.9 H Pile 10X42(Abutment)	1.00	EA	18,648	0	0	0	0	18,648
08.10 Steel Bar Reinforcement (Abutment)	1.00	EA	6,901	0	0	0	0	6,901
08.11 Steel Bar Reinforcement (Pier)	1.00	EA	38,761	0	0	0	0	38,761
08.12 Epoxy Coated Reinforcing Steel (New Deck) 63' x 34.5'	1.00	EA	73,030	0	0	0	0	73,030
08.13 Epoxy Coated Reinforcing Steel (Existing Deck) 63.33' x 34.5'	1.00	EA	73,414	0	0	0	0	73,414
15 Floodway Control and Diversion Structures	1.00	EA	2,220,505	333,076	255,358	280,894	855,934	3,362,243
Ellington Agricultural Center Detention Structure	1.00	EA	2,220,505	333,076	255,358	280,894	855,934	3,362,243
001 Mob & Site Prep Work	1.00	EA	30,000	4,500	3,450	3,795	12,371	42,371
002a Demolition of Asphalt Pavement - Ellington	450.00	CY	59,691	8,954	6,864	7,551	24,615	84,305
002b Demolition of Asphalt Pavement - Edmonson	675.00	CY	89,541	13,431	10,297	11,327	36,924	126,466
003 Excavation - Stilling Basin	720.00	BCY	9,435	1,415	1,085	1,194	3,891	13,326
004a Aggregate Base - Ellington	1,750.00	TON	46,008	6,901	5,291	5,820	18,972	64,980
004b Aggregate Base - Edmonson	1.00	EA	69,008	10,351	7,936	8,730	28,457	97,466
005a Asphalt - Ellington (Cost Book)	1,897.00	TON	271,675	40,751	31,243	34,367	88,614	472,320
005b Asphalt - Edmonson (Cost Book)	2,942.00	TON	421,398	63,210	48,461	53,307	137,450	732,621
006a Clay Fill - Ellington	20,943.00	CY	293,527	44,029	33,756	37,131	121,043	414,570
006b Clay Fill - Edmonson	6,013.00	CY	84,275	12,641	9,692	10,661	34,752	119,027
007 Permanent Erosion Mat	1.00	EA	3,521	528	405	445	1,452	4,972
008 Articulated Block	1.00	EA	606,496	90,974	69,747	76,722	250,102	856,599
009 Temporary and Permanent Seeding	1.00	EA	6,010	902	691	760	2,478	8,488
010 Concrete Conspan Culvert	1.00	LF	229,920	34,488	26,441	29,085	94,813	324,733
30 Engineering and Design (E&D)	1.00	EA	1,008,945	0	0	0	0	1,008,945
31 Supervision & Administration (S&A)	1.00	EA	504,472	0	0	0	0	504,472

Currency in US dollars

Description	ManHours	EQHours	CrewHours	CrewCost
Crew Summary	**15,384.53**	**8,429.52**	**7,952.88**	**1,083,482**
08 Bridges	**1,312.00**	**1,152.00**	**1,152.00**	**121,581**
Briley Parkway Bridge Modification	**1,312.00**	**1,152.00**	**1,152.00**	**121,581**
08.15 Excavation	**1,312.00**	**1,152.00**	**1,152.00**	**121,581**
	1.50	*1.00*		*100.53*
GOV CODFB10R 1 eqoprmed + 1 loader, F/E, wheel, 4WD, 1.00 CY	480.00	320.00	320.00	32,171
MIL B-LABORER Laborers, (Semi-Skilled)	0.50			
MIL B-EQOPRMED Equip. Operators, Medium	1.00			
GEN L40Z4380 LOADER, FRONT END, WHEEL, ARTICULATED, 1.25 CY (0.9 M3) BUCKET, 4X4		1.00		
	1.00	*1.00*		*107.46*
RSM B34B B34B	832.00	832.00	832.00	89,410
MIL B-TRKDVRHV Truck Drivers, Heavy	1.00			
GEN T50Z7710 DUMP TRUCK, HIGHWAY, 16 - 20 CY (12.2 - 15.3 M3) DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4		1.00		
15 Floodway Control and Diversion Structures	**14,072.53**	**7,277.52**	**6,800.88**	**961,901**
Ellington Agricultural Center Detention Structure	**14,072.53**	**7,277.52**	**6,800.88**	**961,901**
002a Demolition of Asphalt Pavement - Ellington	**788.50**	**633.00**	**183.00**	**50,592**
	1.50	*1.00*		*100.53*
GOV CODFB10R 1 eqoprmed + 1 loader, F/E, wheel, 4WD, 1.00 CY	16.50	11.00	11.00	1,106
MIL B-LABORER Laborers, (Semi-Skilled)	0.50			
MIL B-EQOPRMED Equip. Operators, Medium	1.00			
GEN L40Z4380 LOADER, FRONT END, WHEEL, ARTICULATED, 1.25 CY (0.9 M3) BUCKET, 4X4		1.00		
	1.00	*1.00*		*107.46*
RSM B34B B34B	22.00	22.00	22.00	2,364
MIL B-TRKDVRHV Truck Drivers, Heavy	1.00			
GEN T50Z7710 DUMP TRUCK, HIGHWAY, 16 - 20 CY (12.2 - 15.3 M3) DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4		1.00		
	5.00	*4.00*		*314.14*
RSM B38 B38	750.00	600.00	150.00	47,122
MIL B-EQOPRMED Equip. Operators, Medium	1.00			
MIL B-LABORER Laborers, (Semi-Skilled)	1.00			
MIL B-EQOPRLT Equip. Operators, Light	1.00			
MIL B-LABORER Laborers, (Semi-Skilled)	2.00			
GEN H25Z3680 HYDRAULIC EXCAVATOR, ATTACHMENT, MATERIAL HANDLING, BUCKET, 36" (914 MM) PAVEMENT REMOVAL (ADD TO 75,000 LB (34,019 KG) HYDRAULIC EXCAVATOR)		1.00		
GEN H25Z3685 HYDRAULIC EXCAVATOR, ATTACHMENT, CONCRETE PULVERIZER, 3,000 LB (1360 KG) W/POINT (ADD TO 26,000-36,000 LB (11,793-16,329 KG) HYDRAULIC EXCAVATOR)		1.00		
GEN L40Z4400 LOADER, FRONT END, WHEEL, ARTICULATED, 3.50 CY (2.7 M3) BUCKET, 4X4		1.00		
GEN L50Z4640 LOADER/BACKHOE, WHEEL, 1.10 CY (0.84 M3) FRONT END BUCKET, 14.6' (3.7 M) DEPTH OF HOE, 24" (0.61 M) DIPPER, 4X4		1.00		
002b Demolition of Asphalt Pavement - Edmonson	**1,182.79**	**949.53**	**274.53**	**75,891**
	1.50	*1.00*		*100.53*
GOV CODFB10R 1 eqoprmed + 1 loader, F/E, wheel, 4WD, 1.00 CY	24.77	16.51	16.51	1,660
MIL B-LABORER Laborers, (Semi-Skilled)	0.50			
MIL B-EQOPRMED Equip. Operators, Medium	1.00			
GEN L40Z4380 LOADER, FRONT END, WHEEL, ARTICULATED, 1.25 CY (0.9 M3) BUCKET, 4X4		1.00		

Currency in US dollars

Description	ManHours	EQHours	CrewHours	CrewCost
	1.00	*1.00*		*107.46*
RSM B34B B34B	33.02	33.02	33.02	3,549
MIL B-TRKDVRHV Truck Drivers, Heavy	1.00			
GEN T50Z7710 DUMP TRUCK, HIGHWAY, 16 - 20 CY (12.2 - 15.3 M3) DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4		1.00		
	5.00	*4.00*		*314.14*
RSM B38 B38	1,125.00	900.00	225.00	70,683
MIL B-EQOPRMED Equip. Operators, Medium	1.00			
MIL B-LABORER Laborers, (Semi-Skilled)	1.00			
MIL B-EQOPRLT Equip. Operators, Light	1.00			
MIL B-LABORER Laborers, (Semi-Skilled)	2.00			
GEN H25Z3680 HYDRAULIC EXCAVATOR, ATTACHMENT, MATERIAL HANDLING, BUCKET, 36" (914 MM) PAVEMENT REMOVAL (ADD TO 75,000 LB (34,019 KG) HYDRAULIC EXCAVATOR)		1.00		
GEN H25Z3685 HYDRAULIC EXCAVATOR, ATTACHMENT, CONCRETE PULVERIZER, 3,000 LB (1360 KG) W/POINT (ADD TO 26,000-36,000 LB (11,793-16,329 KG) HYDRAULIC EXCAVATOR)		1.00		
GEN L40Z4400 LOADER, FRONT END, WHEEL, ARTICULATED, 3.50 CY (2.7 M3) BUCKET, 4X4		1.00		
GEN L50Z4640 LOADER/BACKHOE, WHEEL, 1.10 CY (0.84 M3) FRONT END BUCKET, 14.6' (3.7 M) DEPTH OF HOE, 24" (0.61 M) DIPPER, 4X4		1.00		
003 Excavation - Stilling Basin	**65.60**	**57.60**	**57.60**	**6,079**
	1.50	*1.00*		*100.53*
GOV CODFB10R 1 eqoprmed + 1 loader, F/E, wheel, 4WD, 1.00 CY	24.00	16.00	16.00	1,609
MIL B-LABORER Laborers, (Semi-Skilled)	0.50			
MIL B-EQOPRMED Equip. Operators, Medium	1.00			
GEN L40Z4380 LOADER, FRONT END, WHEEL, ARTICULATED, 1.25 CY (0.9 M3) BUCKET, 4X4		1.00		
	1.00	*1.00*		*107.46*
RSM B34B B34B	41.60	41.60	41.60	4,471
MIL B-TRKDVRHV Truck Drivers, Heavy	1.00			
GEN T50Z7710 DUMP TRUCK, HIGHWAY, 16 - 20 CY (12.2 - 15.3 M3) DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4		1.00		
004a Aggregate Base - Ellington	**99.15**	**72.93**	**65.09**	**8,891**
	1.50	*1.00*		*144.51*
RSM B10G B10G	8.07	5.38	5.38	778
MIL B-EQOPRMED Equip. Operators, Medium	1.00			
MIL B-LABORER Laborers, (Semi-Skilled)	0.50			
GEN R45Z5580 ROLLER, VIBRATORY, SELF-PROPELLED, DOUBLE DRUM, PADDED DRUM, 13 TON (11.8 MT), 84" (2.1 M) WIDE, SOIL COMPACTOR		1.00		
	1.00	*1.00*		*107.46*
RSM B34B B34B	51.87	51.87	51.87	5,574
MIL B-TRKDVRHV Truck Drivers, Heavy	1.00			
GEN T50Z7710 DUMP TRUCK, HIGHWAY, 16 - 20 CY (12.2 - 15.3 M3) DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4		1.00		
	5.00	*2.00*		*323.75*
USR B36 B36	39.22	15.69	7.84	2,539
MIL B-EQOPRMED Equip. Operators, Medium	2.00			
MIL B-LABORER Laborers, (Semi-Skilled)	2.00			
MIL B-LABORER Laborers, (Semi-Skilled)	1.00			
GEN A10Z0044 CHIP SPREADER, TOWED, 8' (2.4 M) WIDE, (ADD 35,000 LB (15,876 KG) GVW TRUCK)		1.00		

Labor ID: NLS2012 EQ ID: EP14R03 Currency in US dollars TRACES MII Version 4.2

Description	ManHours	EQHours	CrewHours	CrewCost
GEN T15Z6520 TRACTOR, CRAWLER (DOZER), 181-250 HP (135-186 KW), POWERSHIFT, LGP, W/UNIVERSAL BLADE		1.00		
GEN R45Z5674 ROLLER, VIBRATORY, SELF-PROPELLED, DOUBLE DRUM, SMOOTH, 2.7 TON (2.5 MT), 47"(3.8 M) WIDE, ASPHALT COMPACTOR		0.00		
004b Aggregate Base - Edmonson	**148.71**	**109.38**	**97.61**	**13,333**
RSM B10G B10G	*1.50* 12.10	*1.00* 8.07	8.07	*144.51* 1,166
MIL B-EQOPRMED Equip. Operators, Medium	1.00			
MIL B-LABORER Laborers, (Semi-Skilled)	0.50			
GEN R45Z5580 ROLLER, VIBRATORY, SELF-PROPELLED, DOUBLE DRUM, PADDED DRUM, 13 TON (11.8 MT), 84" (2.1 M) WIDE, SOIL COMPACTOR		1.00		
RSM B34B B34B	*1.00* 77.78	*1.00* 77.78	77.78	*107.46* 8,358
MIL B-TRKDVRHV Truck Drivers, Heavy	1.00			
GEN T50Z7710 DUMP TRUCK, HIGHWAY, 16 - 20 CY (12.2 - 15.3 M3) DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4		1.00		
USR B36 B36	*5.00* 58.82	*2.00* 23.53	11.76	*323.75* 3,809
MIL B-EQOPRMED Equip. Operators, Medium	2.00			
MIL B-LABORER Laborers, (Semi-Skilled)	2.00			
MIL B-LABORER Laborers, (Semi-Skilled)	1.00			
GEN A10Z0044 CHIP SPREADER, TOWED, 8' (2.4 M) WIDE, (ADD 35,000 LB (15,876 KG) GVW TRUCK)		1.00		
GEN T15Z6520 TRACTOR, CRAWLER (DOZER), 181-250 HP (135-186 KW), POWERSHIFT, LGP, W/UNIVERSAL BLADE		1.00		
GEN R45Z5674 ROLLER, VIBRATORY, SELF-PROPELLED, DOUBLE DRUM, SMOOTH, 2.7 TON (2.5 MT), 47"(3.8 M) WIDE, ASPHALT COMPACTOR		0.00		
005a Asphalt - Ellington (Cost Book)	**1,404.72**	**1,193.57**	**1,114.39**	**116,150**
RSM B25B B25B	*12.00* 316.72	*4.00* 105.57	26.39	*694.41* 18,328
MIL B-EQOPRMED Equip. Operators, Medium	4.00			
MIL B-LABORER Laborers, (Semi-Skilled)	1.00			
MIL B-LABORER Laborers, (Semi-Skilled)	7.00			
GEN R45Z5670 ROLLER, VIBRATORY, SELF-PROPELLED, DOUBLE DRUM, SMOOTH, 2.7 TON (2.5 MT), 47"(3.8 M) WIDE, ASPHALT COMPACTOR		2.00		
GEN R30Z5640 ROLLER, STATIC, SELF-PROPELLED, PNEUMATIC, 9 TIRES, 14 TON (12.7 MT), 68" (1.7 M) WIDE		1.00		
GEN A30Z0640 ASPHALT PAVER, 10.0' (3.1 M) WIDE, SELF PROPELLED, W/19' (5.8 M) SCREED EXTENSION, WHEEL		1.00		
RSM B34A B34A	*1.00* 1,088.00	*1.00* 1,088.00	1,088.00	*89.91* 97,823
MIL B-TRKDVRHV Truck Drivers, Heavy	1.00			
GEN T50Z7700 DUMP TRUCK, HIGHWAY, 10 - 13 CY (7.6 - 9.9 M3) DUMP BODY, 35,000 LBS (15,900 KG) GVW, 2 AXLE, 4X2		1.00		
005b Asphalt - Edmonson (Cost Book)	**2,179.19**	**1,851.73**	**1,728.93**	**180,192**
RSM B25B B25B	*12.00* 491.19	*4.00* 163.73	40.93	*694.41* 28,424
MIL B-EQOPRMED Equip. Operators, Medium	4.00			
MIL B-LABORER Laborers, (Semi-Skilled)	1.00			
MIL B-LABORER Laborers, (Semi-Skilled)	7.00			
GEN R45Z5670 ROLLER, VIBRATORY, SELF-PROPELLED, DOUBLE DRUM, SMOOTH, 2.7 TON (2.5 MT), 47"(3.8 M) WIDE, ASPHALT COMPACTOR		2.00		

Currency in US dollars

Description	ManHours	EQHours	CrewHours	CrewCost
GEN R30Z5640 ROLLER, STATIC, SELF-PROPELLED, PNEUMATIC, 9 TIRES, 14 TON (12.7 MT), 68" (1.7 M) WIDE		1.00		
GEN A30Z0640 ASPHALT PAVER, 10.0' (3.1 M) WIDE, SELF PROPELLED, W/19' (5.8 M) SCREED EXTENSION, WHEEL		1.00		
	1.00	*1.00*		*89.91*
RSM B34A B34A	1,688.00	1,688.00	1,688.00	151,769
MIL B-TRKDVRHV Truck Drivers, Heavy	1.00			
GEN T50Z7700 DUMP TRUCK, HIGHWAY, 10 - 13 CY (7.6 - 9.9 M3) DUMP BODY, 35,000 LBS (15,900 KG) GVW, 2 AXLE, 4X2		1.00		
006a Clay Fill - Ellington	**2,055.17**	**1,852.22**	**1,680.38**	**191,555**
	1.50	*2.00*		*192.35*
RSM B10D B10D	257.76	343.68	171.84	33,053
MIL B-EQOPRMED Equip. Operators, Medium	1.00			
MIL B-LABORER Laborers, (Semi-Skilled)	0.50			
GEN R40Z5670 ROLLER, VIBRATORY, TOWED, SINGLE DRUM, SHEEPSFOOT, 25.5 TON (23.1 MT), 72" (1.8 M) WIDE, SHEEPSFOOT (ADD TOWING UNIT)		1.00		
GEN T15Z6520 TRACTOR, CRAWLER (DOZER), 181-250 HP (135-186 KW), POWERSHIFT, LGP, W/UNIVERSAL BLADE		1.00		
	1.50	*1.00*		*101.21*
RSM B10L B10L	866.61	577.74	577.74	58,474
MIL B-LABORER Laborers, (Semi-Skilled)	0.50			
MIL B-EQOPRMED Equip. Operators, Medium	1.00			
GEN T15Z6435 TRACTOR, CRAWLER (DOZER), 50-75 HP (37-56 KW), POWERSHIFT, W/UNIVERSAL BLADE		1.00		
	1.00	*1.00*		*107.46*
RSM B34B B34B	930.80	930.80	930.80	100,027
MIL B-TRKDVRHV Truck Drivers, Heavy	1.00			
GEN T50Z7710 DUMP TRUCK, HIGHWAY, 16 - 20 CY (12.2 - 15.3 M3) DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4		1.00		
006b Clay Fill - Edmonson	**590.06**	**531.79**	**482.45**	**54,997**
	1.50	*2.00*		*192.35*
RSM B10D B10D	74.00	98.67	49.33	9,489
MIL B-EQOPRMED Equip. Operators, Medium	1.00			
MIL B-LABORER Laborers, (Semi-Skilled)	0.50			
GEN R40Z5670 ROLLER, VIBRATORY, TOWED, SINGLE DRUM, SHEEPSFOOT, 25.5 TON (23.1 MT), 72" (1.8 M) WIDE, SHEEPSFOOT (ADD TOWING UNIT)		1.00		
GEN T15Z6520 TRACTOR, CRAWLER (DOZER), 181-250 HP (135-186 KW), POWERSHIFT, LGP, W/UNIVERSAL BLADE		1.00		
	1.50	*1.00*		*101.21*
RSM B10L B10L	248.81	165.88	165.88	16,789
MIL B-LABORER Laborers, (Semi-Skilled)	0.50			
MIL B-EQOPRMED Equip. Operators, Medium	1.00			
GEN T15Z6435 TRACTOR, CRAWLER (DOZER), 50-75 HP (37-56 KW), POWERSHIFT, W/UNIVERSAL BLADE		1.00		
	1.00	*1.00*		*107.46*
RSM B34B B34B	267.24	267.24	267.24	28,719
MIL B-TRKDVRHV Truck Drivers, Heavy	1.00			
GEN T50Z7710 DUMP TRUCK, HIGHWAY, 16 - 20 CY (12.2 - 15.3 M3) DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4		1.00		
007 Permanent Erosion Mat	**30.86**	**20.57**	**10.29**	**1,593**
	3.00	*2.00*		*154.83*
RSM B80A B80A	30.86	20.57	10.29	1,593

Currency in US dollars

Description	ManHours	EQHours	CrewHours	CrewCost
MIL B-LABORER Laborers, (Semi-Skilled)	3.00			
GEN T40Z7010 TRUCK OPTION, FLATBED, 8' (2.4 M) x 16' (4.9 M) (ADD 25,000 LB (11,340 KG) GVW TRUCK)		1.00		
GEN T50Z7400 TRUCK, HIGHWAY, 25,000 LB (11,340 KG) GVW, 4X2, 2 AXLE (ADD ACCESSORIES)		1.00		
008 Articulated Block	**5,520.00**	**0.00**	**1,104.00**	**262,034**
	5.00	*0.00*		*237.35*
RSM D8 D8	5,520.00	0.00	1,104.00	262,034
MIL B-BRKLAYR Bricklayers	3.00			
MIL B-BRKLAYRH Bricklayers, (Semi-Skilled) (Laborer)	2.00			
009 Temporary and Permanent Seeding	**7.80**	**5.20**	**2.60**	**594**
	3.00	*2.00*		*228.42*
RSM B81 B81	7.80	5.20	2.60	594
MIL B-EQOPRMED Equip. Operators, Medium	1.00			
MIL B-TRKDVRHV Truck Drivers, Heavy	1.00			
MIL B-LABORER Laborers, (Semi-Skilled)	1.00			
GEN L15Z3880 LANDSCAPING EQUIPMENT, HYDROSEEDER, 3,000 GAL (11,356 L) TRUCK MOUNTED		1.00		
GEN T50Z7580 TRUCK, HIGHWAY, 45,000 LB (20,412 KG) GVW, 6X4, 3 AXLE (ADD ACCESSORIES)		1.00		

Currency in US dollars

Description	ManHours	BaseWage	TaxableFringe	Payroll	WCI	NonTaxFringe	Subsistence	Total	LaborType
Labor Rates	**15,384.5327**	**508,182.99**	**205,174.19**	**103,600.25**	**53,703.03**	**0.00**	**0.00**	**870,660.46**	
08 Bridges	**1,312.0000**	**42,589.44**	**18,446.40**	**9,112.65**	**4,336.88**	**0.00**	**0.00**	**74,485.37**	
Briley Parkway Bridge Modification	**1,312.0000**	**42,589.44**	**18,446.40**	**9,112.65**	**4,336.88**	**0.00**	**0.00**	**74,485.37**	
08.15 Excavation	**1,312.0000**	**42,589.44**	**18,446.40**	**9,112.65**	**4,336.88**	**0.00**	**0.00**	**74,485.37**	
MIL B-EQOPRMED Equip. Operators, Medium	320.0000	*34.7500* 11,120.00	*15.1500* 4,848.00	2,384.02	1,132.35	*0.0000* 0.00	*0.0000* 0.00	*60.8887* 19,484.37	Journeyman
MIL B-LABORER Laborers, (Semi-Skilled)	160.0000	*30.9600* 4,953.60	*9.0700* 1,451.20	956.24	504.43	*0.0000* 0.00	*0.0000* 0.00	*49.1591* 7,865.46	Journeyman
MIL B-TRKDVRHV Truck Drivers, Heavy	832.0000	*31.8700* 26,515.84	*14.6000* 12,147.20	5,772.39	2,700.11	*0.0000* 0.00	*0.0000* 0.00	*56.6533* 47,135.54	Journeyman
15 Floodway Control and Diversion Structures	**14,072.5327**	**465,593.55**	**186,727.79**	**94,487.60**	**49,366.15**	**0.00**	**0.00**	**796,175.09**	
Ellington Agricultural Center Detention Structure	**14,072.5327**	**465,593.55**	**186,727.79**	**94,487.60**	**49,366.15**	**0.00**	**0.00**	**796,175.09**	
002a Demolition of Asphalt Pavement - Ellington	**788.5000**	**25,697.67**	**9,164.24**	**5,204.88**	**2,468.26**	**0.00**	**0.00**	**42,535.05**	
MIL B-EQOPRLT Equip. Operators, Light	150.0000	*34.3300* 5,149.50	*15.1500* 2,272.50	1,108.10	494.61	*0.0000* 0.00	*0.0000* 0.00	*60.1648* 9,024.71	Journeyman
MIL B-EQOPRMED Equip. Operators, Medium	161.0000	*34.7500* 5,594.75	*15.1500* 2,439.15	1,199.46	537.38	*0.0000* 0.00	*0.0000* 0.00	*60.6878* 9,770.74	Journeyman
MIL B-LABORER Laborers, (Semi-Skilled)	150.0000	*31.9600* 4,794.00	*9.0700* 1,360.50	918.87	460.46	*0.0000* 0.00	*0.0000* 0.00	*50.2255* 7,533.83	Foreman
MIL B-LABORER Laborers, (Semi-Skilled)	305.5000	*30.9600* 9,458.28	*9.0700* 2,770.89	1,825.81	908.47	*0.0000* 0.00	*0.0000* 0.00	*48.9802* 14,963.45	Journeyman
MIL B-TRKDVRHV Truck Drivers, Heavy	22.0000	*31.8700* 701.14	*14.6000* 321.20	152.64	67.34	*0.0000* 0.00	*0.0000* 0.00	*56.4691* 1,242.32	Journeyman
002b Demolition of Asphalt Pavement - Edmonson	**1,182.7889**	**38,547.77**	**13,746.90**	**7,807.59**	**3,702.51**	**0.00**	**0.00**	**63,804.77**	
MIL B-EQOPRLT Equip. Operators, Light	225.0000	*34.3300* 7,724.25	*15.1500* 3,408.75	1,662.16	741.91	*0.0000* 0.00	*0.0000* 0.00	*60.1648* 13,537.07	Journeyman
MIL B-EQOPRMED Equip. Operators, Medium	241.5111	*34.7500* 8,392.51	*15.1500* 3,658.89	1,799.27	806.10	*0.0000* 0.00	*0.0000* 0.00	*60.6878* 14,656.78	Journeyman
MIL B-LABORER Laborers, (Semi-Skilled)	225.0000	*31.9600* 7,191.00	*9.0700* 2,040.75	1,378.30	690.70	*0.0000* 0.00	*0.0000* 0.00	*50.2255* 11,300.75	Foreman
MIL B-LABORER Laborers, (Semi-Skilled)	458.2556	*30.9600* 14,187.59	*9.0700* 4,156.38	2,738.75	1,362.72	*0.0000* 0.00	*0.0000* 0.00	*48.9802* 22,445.44	Journeyman
MIL B-TRKDVRHV Truck Drivers, Heavy	33.0222	*31.8700* 1,052.42	*14.6000* 482.12	229.11	101.08	*0.0000* 0.00	*0.0000* 0.00	*56.4691* 1,864.73	Journeyman
003 Excavation - Stilling Basin	**65.6000**	**2,129.47**	**922.32**	**455.63**	**204.54**	**0.00**	**0.00**	**3,711.96**	
MIL B-EQOPRMED Equip. Operators, Medium	16.0000	*34.7500* 556.00	*15.1500* 242.40	119.20	53.40	*0.0000* 0.00	*0.0000* 0.00	*60.6878* 971.00	Journeyman
MIL B-LABORER Laborers, (Semi-Skilled)	8.0000	*30.9600* 247.68	*9.0700* 72.56	47.81	23.79	*0.0000* 0.00	*0.0000* 0.00	*48.9802* 391.84	Journeyman
MIL B-TRKDVRHV Truck Drivers, Heavy	41.6000	*31.8700* 1,325.79	*14.6000* 607.36	288.62	127.34	*0.0000* 0.00	*0.0000* 0.00	*56.4691* 2,349.11	Journeyman
004a Aggregate Base - Ellington	**99.1538**	**3,204.69**	**1,314.24**	**674.68**	**307.81**	**0.00**	**0.00**	**5,501.41**	
MIL B-EQOPRMED Equip. Operators, Medium	21.0673	*34.7500* 732.09	*15.1500* 319.17	156.95	70.32	*0.0000* 0.00	*0.0000* 0.00	*60.6878* 1,278.53	Journeyman

Labor ID: NLS2012 EQ ID: EP14R03 Currency in US dollars TRACES MII Version 4.2

Description	ManHours	BaseWage	TaxableFringe	Payroll	WCI	NonTaxFringe	Subsistence	Total	LaborType
		30.9600	*9.0700*			*0.0000*	*0.0000*	*48.9802*	
MIL B-LABORER Laborers, (Semi-Skilled)	18.3768	568.94	166.68	109.83	54.65	0.00	0.00	900.10	Journeyman
		31.9600	*9.0700*			*0.0000*	*0.0000*	*50.2255*	
MIL B-LABORER Laborers, (Semi-Skilled)	7.8431	250.67	71.14	48.05	24.08	0.00	0.00	393.93	Foreman
		31.8700	*14.6000*			*0.0000*	*0.0000*	*56.4691*	
MIL B-TRKDVRHV Truck Drivers, Heavy	51.8667	1,652.99	757.25	359.85	158.77	0.00	0.00	2,928.86	Journeyman
004b Aggregate Base - Edmonson	**148.7051**	**4,806.21**	**1,970.99**	**1,011.84**	**461.64**	**0.00**	**0.00**	**8,250.67**	
		34.7500	*15.1500*			*0.0000*	*0.0000*	*60.6878*	
MIL B-EQOPRMED Equip. Operators, Medium	31.5986	1,098.05	478.72	235.41	105.47	0.00	0.00	1,917.65	Journeyman
		30.9600	*9.0700*			*0.0000*	*0.0000*	*48.9802*	
MIL B-LABORER Laborers, (Semi-Skilled)	27.5640	853.38	250.01	164.74	81.97	0.00	0.00	1,350.09	Journeyman
		31.9600	*9.0700*			*0.0000*	*0.0000*	*50.2255*	
MIL B-LABORER Laborers, (Semi-Skilled)	11.7647	376.00	106.71	72.07	36.11	0.00	0.00	590.89	Foreman
		31.8700	*14.6000*			*0.0000*	*0.0000*	*56.4691*	
MIL B-TRKDVRHV Truck Drivers, Heavy	77.7778	2,478.78	1,135.56	539.62	238.09	0.00	0.00	4,392.04	Journeyman
005a Asphalt - Ellington (Cost Book)	**1,404.7165**	**44,906.62**	**19,399.30**	**8,462.66**	**6,134.24**	**0.00**	**0.00**	**78,902.81**	
		34.7500	*15.1500*			*0.0000*	*0.0000*	*61.2137*	
MIL B-EQOPRMED Equip. Operators, Medium	105.5722	3,668.63	1,599.42	693.28	501.14	0.00	0.00	6,462.46	Journeyman
		31.9600	*9.0700*			*0.0000*	*0.0000*	*50.7953*	
MIL B-LABORER Laborers, (Semi-Skilled)	26.3930	843.52	239.38	142.51	115.23	0.00	0.00	1,340.64	Foreman
		30.9600	*9.0700*			*0.0000*	*0.0000*	*49.5271*	
MIL B-LABORER Laborers, (Semi-Skilled)	184.7513	5,719.90	1,675.69	973.26	781.34	0.00	0.00	9,150.19	Journeyman
		31.8700	*14.6000*			*0.0000*	*0.0000*	*56.9389*	
MIL B-TRKDVRHV Truck Drivers, Heavy	1,088.0000	34,674.56	15,884.80	6,853.61	4,736.54	0.00	0.00	61,949.52	Journeyman
005b Asphalt - Edmonson (Cost Book)	**2,179.1861**	**69,665.15**	**30,095.33**	**13,128.48**	**9,516.26**	**0.00**	**0.00**	**122,405.21**	
		34.7500	*15.1500*			*0.0000*	*0.0000*	*61.2137*	
MIL B-EQOPRMED Equip. Operators, Medium	163.7287	5,689.57	2,480.49	1,075.18	777.20	0.00	0.00	10,022.44	Journeyman
		31.9600	*9.0700*			*0.0000*	*0.0000*	*50.7953*	
MIL B-LABORER Laborers, (Semi-Skilled)	40.9322	1,308.19	371.25	221.02	178.70	0.00	0.00	2,079.16	Foreman
		30.9600	*9.0700*			*0.0000*	*0.0000*	*49.5271*	
MIL B-LABORER Laborers, (Semi-Skilled)	286.5252	8,870.82	2,598.78	1,509.40	1,211.75	0.00	0.00	14,190.76	Journeyman
		31.8700	*14.6000*			*0.0000*	*0.0000*	*56.9389*	
MIL B-TRKDVRHV Truck Drivers, Heavy	1,688.0000	53,796.56	24,644.80	10,322.88	7,348.61	0.00	0.00	96,112.85	Journeyman
006a Clay Fill - Ellington	**2,055.1669**	**67,315.90**	**28,345.12**	**14,282.19**	**6,465.69**	**0.00**	**0.00**	**116,408.90**	
		34.7500	*15.1500*			*0.0000*	*0.0000*	*60.6878*	
MIL B-EQOPRMED Equip. Operators, Medium	749.5779	26,047.83	11,356.11	5,584.41	2,501.89	0.00	0.00	45,490.24	Journeyman
		30.9600	*9.0700*			*0.0000*	*0.0000*	*48.9802*	
MIL B-LABORER Laborers, (Semi-Skilled)	374.7890	11,603.47	3,399.34	2,239.92	1,114.51	0.00	0.00	18,357.23	Journeyman
		31.8700	*14.6000*			*0.0000*	*0.0000*	*56.4691*	
MIL B-TRKDVRHV Truck Drivers, Heavy	930.8000	29,664.60	13,589.68	6,457.86	2,849.28	0.00	0.00	52,561.42	Journeyman
006b Clay Fill - Edmonson	**590.0582**	**19,327.04**	**8,138.16**	**4,100.55**	**1,856.36**	**0.00**	**0.00**	**33,422.12**	
		34.7500	*15.1500*			*0.0000*	*0.0000*	*60.6878*	
MIL B-EQOPRMED Equip. Operators, Medium	215.2092	7,478.52	3,260.42	1,603.32	718.31	0.00	0.00	13,060.57	Journeyman
		30.9600	*9.0700*			*0.0000*	*0.0000*	*48.9802*	
MIL B-LABORER Laborers, (Semi-Skilled)	107.6046	3,331.44	975.97	643.10	319.98	0.00	0.00	5,270.49	Journeyman
		31.8700	*14.6000*			*0.0000*	*0.0000*	*56.4691*	

Currency in US dollars

Description	ManHours	BaseWage	TaxableFringe	Payroll	WCI	NonTaxFringe	Subsistence	Total	LaborType
MIL B-TRKDVRHV Truck Drivers, Heavy	267.2444	8,517.08	3,901.77	1,854.13	818.07	0.00	0.00	15,091.05	Journeyman
007 Permanent Erosion Mat	**30.8571**	**955.34**	**279.87**	**184.42**	**91.76**	**0.00**	**0.00**	**1,511.39**	
		30.9600	*9.0700*			*0.0000*	*0.0000*	*48.9802*	
MIL B-LABORER Laborers, (Semi-Skilled)	30.8571	955.34	279.87	184.42	91.76	0.00	0.00	1,511.39	Journeyman
008 Articulated Block	**5,520.0000**	**188,784.00**	**73,250.40**	**39,121.74**	**18,132.70**	**0.00**	**0.00**	**319,288.84**	
		34.2000	*13.2700*			*0.0000*	*0.0000*	*57.8422*	
MIL B-BRKLAYR Bricklayers	3,312.0000	113,270.40	43,950.24	23,473.04	10,879.62	0.00	0.00	191,573.30	Journeyman
		34.2000	*13.2700*			*0.0000*	*0.0000*	*57.8422*	
MIL B-BRKLAYRH Bricklayers, (Semi-Skilled) (Laborer)	2,208.0000	75,513.60	29,300.16	15,648.69	7,253.08	0.00	0.00	127,715.54	Journeyman
009 Temporary and Permanent Seeding	**7.8000**	**253.71**	**100.93**	**52.95**	**24.37**	**0.00**	**0.00**	**431.96**	
		34.7500	*15.1500*			*0.0000*	*0.0000*	*60.6878*	
MIL B-EQOPRMED Equip. Operators, Medium	2.6000	90.35	39.39	19.37	8.68	0.00	0.00	157.79	Journeyman
		30.9600	*9.0700*			*0.0000*	*0.0000*	*48.9802*	
MIL B-LABORER Laborers, (Semi-Skilled)	2.6000	80.50	23.58	15.54	7.73	0.00	0.00	127.35	Journeyman
		31.8700	*14.6000*			*0.0000*	*0.0000*	*56.4691*	
MIL B-TRKDVRHV Truck Drivers, Heavy	2.6000	82.86	37.96	18.04	7.96	0.00	0.00	146.82	Journeyman

Currency in US dollars

Description	ConditionType	EQHours	Total
Equipment Rates		**8,429.5208**	**370,124.70**
08 Bridges		**1,152.0000**	**60,545.14**
Briley Parkway Bridge Modification		**1,152.0000**	**60,545.14**
08.15 Excavation		**1,152.0000**	**60,545.14**
GEN L40Z4380 LOADER, FRONT END, WHEEL, ARTICULATED, 1.25 CY (0.9 M3) BUCKET, 4X4	Average	320.0000	*30.6193* 9,798.17
GEN T50Z7710 DUMP TRUCK, HIGHWAY, 16 - 20 CY (12.2 - 15.3 M3) DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4	Average	832.0000	*60.9940* 50,746.96
15 Floodway Control and Diversion Structures		**7,277.5208**	**309,579.55**
Ellington Agricultural Center Detention Structure		**7,277.5208**	**309,579.55**
002a Demolition of Asphalt Pavement - Ellington		**633.0000**	**15,729.92**
GEN H25Z3680 HYDRAULIC EXCAVATOR, ATTACHMENT, MATERIAL HANDLING, BUCKET, 36" (914 MM) PAVEMENT REMOVAL (ADD TO 75,000 LB (34,019 KG) HYDRAULIC EXCAVATOR)	Average	150.0000	*2.2331* 334.96
GEN H25Z3685 HYDRAULIC EXCAVATOR, ATTACHMENT, CONCRETE PULVERIZER, 3,000 LB (1360 KG) W/POINT (ADD TO 26,000-36,000 LB (11,793-16,329 KG) HYDRAULIC EXCAVATOR)	Average	150.0000	*14.4248* 2,163.73
GEN L40Z4380 LOADER, FRONT END, WHEEL, ARTICULATED, 1.25 CY (0.9 M3) BUCKET, 4X4	Average	11.0000	*30.6193* 336.81
GEN L40Z4400 LOADER, FRONT END, WHEEL, ARTICULATED, 3.50 CY (2.7 M3) BUCKET, 4X4	Average	150.0000	*53.8932* 8,083.98
GEN L50Z4640 LOADER/BACKHOE, WHEEL, 1.10 CY (0.84 M3) FRONT END BUCKET, 14.6' (3.7 M) DEPTH OF HOE, 24" (0.61 M) DIPPER, 4X4	Average	150.0000	*23.1238* 3,468.57
GEN T50Z7710 DUMP TRUCK, HIGHWAY, 16 - 20 CY (12.2 - 15.3 M3) DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4	Average	22.0000	*60.9940* 1,341.87
002b Demolition of Asphalt Pavement - Edmonson		**949.5333**	**23,596.57**
GEN H25Z3680 HYDRAULIC EXCAVATOR, ATTACHMENT, MATERIAL HANDLING, BUCKET, 36" (914 MM) PAVEMENT REMOVAL (ADD TO 75,000 LB (34,019 KG) HYDRAULIC EXCAVATOR)	Average	225.0000	*2.2331* 502.44
GEN H25Z3685 HYDRAULIC EXCAVATOR, ATTACHMENT, CONCRETE PULVERIZER, 3,000 LB (1360 KG) W/POINT (ADD TO 26,000-36,000 LB (11,793-16,329 KG) HYDRAULIC EXCAVATOR)	Average	225.0000	*14.4248* 3,245.59
GEN L40Z4380 LOADER, FRONT END, WHEEL, ARTICULATED, 1.25 CY (0.9 M3) BUCKET, 4X4	Average	16.5111	*30.6193* 505.56
GEN L40Z4400 LOADER, FRONT END, WHEEL, ARTICULATED, 3.50 CY (2.7 M3) BUCKET, 4X4	Average	225.0000	*53.8932* 12,125.96
GEN L50Z4640 LOADER/BACKHOE, WHEEL, 1.10 CY (0.84 M3) FRONT END BUCKET, 14.6' (3.7 M) DEPTH OF HOE, 24" (0.61 M) DIPPER, 4X4	Average	225.0000	*23.1238* 5,202.86
GEN T50Z7710 DUMP TRUCK, HIGHWAY, 16 - 20 CY (12.2 - 15.3 M3) DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4	Average	33.0222	*60.9940* 2,014.16
003 Excavation - Stilling Basin		**57.6000**	**3,027.26**
GEN L40Z4380 LOADER, FRONT END, WHEEL, ARTICULATED, 1.25 CY (0.9 M3) BUCKET, 4X4	Average	16.0000	*30.6193* 489.91
GEN T50Z7710 DUMP TRUCK, HIGHWAY, 16 - 20 CY (12.2 - 15.3 M3) DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4	Average	41.6000	*60.9940* 2,537.35
004a Aggregate Base - Ellington		**72.9339**	**4,371.74**
GEN A10Z0044 CHIP SPREADER, TOWED, 8' (2.4 M) WIDE, (ADD 35,000 LB (15,876 KG) GVW TRUCK)	Average	7.8431	*4.1564* 32.60

Currency in US dollars

Description	ConditionType	EQHours	Total
GEN R45Z5580 ROLLER, VIBRATORY, SELF-PROPELLED, DOUBLE DRUM, PADDED DRUM, 13 TON (11.8 MT), 84" (2.1 M) WIDE, SOIL COMPACTOR	Average	5.3810	*74.5987* 401.41
GEN R45Z5674 ROLLER, VIBRATORY, SELF-PROPELLED, DOUBLE DRUM, SMOOTH, 2.7 TON (2.5 MT), 47"(3.8 M) WIDE, ASPHALT COMPACTOR	Average	0.0000	*15.5326* 0.00
GEN T15Z6520 TRACTOR, CRAWLER (DOZER), 181-250 HP (135-186 KW), POWERSHIFT, LGP, W/UNIVERSAL BLADE	Average	7.8431	*98.7070* 774.17
GEN T50Z7710 DUMP TRUCK, HIGHWAY, 16 - 20 CY (12.2 - 15.3 M3) DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4	Average	51.8667	*60.9940* 3,163.55
004b Aggregate Base - Edmonson		**109.3764**	**6,556.08**
GEN A10Z0044 CHIP SPREADER, TOWED, 8' (2.4 M) WIDE, (ADD 35,000 LB (15,876 KG) GVW TRUCK)	Average	11.7647	*4.1564* 48.90
GEN R45Z5580 ROLLER, VIBRATORY, SELF-PROPELLED, DOUBLE DRUM, PADDED DRUM, 13 TON (11.8 MT), 84" (2.1 M) WIDE, SOIL COMPACTOR	Average	8.0692	*74.5987* 601.95
GEN R45Z5674 ROLLER, VIBRATORY, SELF-PROPELLED, DOUBLE DRUM, SMOOTH, 2.7 TON (2.5 MT), 47"(3.8 M) WIDE, ASPHALT COMPACTOR	Average	0.0000	*15.5326* 0.00
GEN T15Z6520 TRACTOR, CRAWLER (DOZER), 181-250 HP (135-186 KW), POWERSHIFT, LGP, W/UNIVERSAL BLADE	Average	11.7647	*98.7070* 1,161.26
GEN T50Z7710 DUMP TRUCK, HIGHWAY, 16 - 20 CY (12.2 - 15.3 M3) DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4	Average	77.7776	*60.9940* 4,743.97
005a Asphalt - Ellington (Cost Book)		**1,193.5722**	**51,844.18**
GEN A30Z0640 ASPHALT PAVER, 10.0' (3.1 M) WIDE, SELF PROPELLED, W/19' (5.8 M) SCREED EXTENSION, WHEEL	Average	26.3930	*117.5690* 3,103.00
GEN R30Z5640 ROLLER, STATIC, SELF-PROPELLED, PNEUMATIC, 9 TIRES, 14 TON (12.7 MT), 68" (1.7 M) WIDE	Average	26.3930	*26.3882* 696.46
GEN R45Z5670 ROLLER, VIBRATORY, SELF-PROPELLED, DOUBLE DRUM, SMOOTH, 2.7 TON (2.5 MT), 47"(3.8 M) WIDE, ASPHALT COMPACTOR	Average	52.7861	*14.8055* 781.53
GEN T50Z7700 DUMP TRUCK, HIGHWAY, 10 - 13 CY (7.6 - 9.9 M3) DUMP BODY, 35,000 LBS (15,900 KG) GVW, 2 AXLE, 4X2	Average	1,088.0000	*43.4404* 47,263.19
005b Asphalt - Edmonson (Cost Book)		**1,851.7287**	**80,431.97**
GEN A30Z0640 ASPHALT PAVER, 10.0' (3.1 M) WIDE, SELF PROPELLED, W/19' (5.8 M) SCREED EXTENSION, WHEEL	Average	40.9322	*117.5690* 4,812.35
GEN R30Z5640 ROLLER, STATIC, SELF-PROPELLED, PNEUMATIC, 9 TIRES, 14 TON (12.7 MT), 68" (1.7 M) WIDE	Average	40.9322	*26.3882* 1,080.13
GEN R45Z5670 ROLLER, VIBRATORY, SELF-PROPELLED, DOUBLE DRUM, SMOOTH, 2.7 TON (2.5 MT), 47"(3.8 M) WIDE, ASPHALT COMPACTOR	Average	81.8643	*14.8055* 1,212.04
GEN T50Z7700 DUMP TRUCK, HIGHWAY, 10 - 13 CY (7.6 - 9.9 M3) DUMP BODY, 35,000 LBS (15,900 KG) GVW, 2 AXLE, 4X2	Average	1,688.0000	*43.4404* 73,327.45
006a Clay Fill - Ellington		**1,852.2179**	**95,893.50**
GEN R40Z5670 ROLLER, VIBRATORY, TOWED, SINGLE DRUM, SHEEPSFOOT, 25.5 TON (23.1 MT), 72" (1.8 M) WIDE, SHEEPSFOOT (ADD TOWING UNIT)	Average	171.8400	*23.7257* 4,077.03
GEN T15Z6435 TRACTOR, CRAWLER (DOZER), 50-75 HP (37-56 KW), POWERSHIFT, W/UNIVERSAL BLADE	Average	577.7379	*31.2970* 18,081.48
GEN T15Z6520 TRACTOR, CRAWLER (DOZER), 181-250 HP (135-186 KW), POWERSHIFT, LGP, W/UNIVERSAL BLADE	Average	171.8400	*98.7070* 16,961.81
GEN T50Z7710 DUMP TRUCK, HIGHWAY, 16 - 20 CY (12.2 - 15.3 M3) DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4	Average	930.8000	*60.9940* 56,773.18

Labor ID: NLS2012 EQ ID: EP14R03 Currency in US dollars TRACES MII Version 4.2

Description	ConditionType	EQHours	Total
006b Clay Fill - Edmonson		**531.7870**	**27,531.73**
GEN R40Z5670 ROLLER, VIBRATORY, TOWED, SINGLE DRUM, SHEEPSFOOT, 25.5 TON (23.1 MT), 72" (1.8 M) WIDE, SHEEPSFOOT (ADD TOWING UNIT)	Average	49.3333	*23.7257* 1,170.47
GEN T15Z6435 TRACTOR, CRAWLER (DOZER), 50-75 HP (37-56 KW), POWERSHIFT, W/UNIVERSAL BLADE	Average	165.8759	*31.2970* 5,191.42
GEN T15Z6520 TRACTOR, CRAWLER (DOZER), 181-250 HP (135-186 KW), POWERSHIFT, LGP, W/UNIVERSAL BLADE	Average	49.3333	*98.7070* 4,869.55
GEN T50Z7710 DUMP TRUCK, HIGHWAY, 16 - 20 CY (12.2 - 15.3 M3) DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4	Average	267.2444	*60.9940* 16,300.30
007 Permanent Erosion Mat		**20.5714**	**357.34**
GEN T40Z7010 TRUCK OPTION, FLATBED, 8' (2.4 M) x 16' (4.9 M) (ADD 25,000 LB (11,340 KG) GVW TRUCK)	Average	10.2857	*1.2399* 12.75
GEN T50Z7400 TRUCK, HIGHWAY, 25,000 LB (11,340 KG) GVW, 4X2, 2 AXLE (ADD ACCESSORIES)	Average	10.2857	*33.5015* 344.59
009 Temporary and Permanent Seeding		**5.2000**	**239.26**
GEN L15Z3880 LANDSCAPING EQUIPMENT, HYDROSEEDER, 3,000 GAL (11,356 L) TRUCK MOUNTED	Average	2.6000	*51.4690* 133.82
GEN T50Z7580 TRUCK, HIGHWAY, 45,000 LB (20,412 KG) GVW, 6X4, 3 AXLE (ADD ACCESSORIES)	Average	2.6000	*40.5553* 105.44

Labor ID: NLS2012 EQ ID: EP14R03 Currency in US dollars TRACES MII Version 4.2

Abbreviated Risk Analysis

Mill Creek FRM
AFB-Draft Report

Meeting Date: October 24 2013 revised

PDT Members

Project Management:	Tom Herbert
Engineer/ Project Engineer:	Barry Moran
Cost Engineering:	Cullum Miller
Economist:	Phillip Jones
Environmental:	Matt Granstaff
Cultural Resources:	Valerie McCormack
Construction:	Jeff Hitchcock
Geotechnical :	Steve Matheny
Structural Engineer:	Soveriak In
Real Estate:	Cathy Keith

Abbreviated Risk Analysis

Project (less than $40M): **Mill Creek FRM**
Project Development Stage: AFB-Draft Report
Recommended Plan: AD (Briley Bridge + NS-12)

Total Construction Contract Cost = $ 35,729,240

	WBS	Potential Risk Areas	Contract Cost		% Contingency	$ Contingency	Total
1	08 ROADS, RAILROADS, AND BRIDGES	Demolition	$ 72,100		33.33%	$ 24,033	$ 96,133
2	08 ROADS, RAILROADS, AND BRIDGES	Excavation	$ 115,200		33.33%	$ 38,400	$ 153,600
3	08 ROADS, RAILROADS, AND BRIDGES	Pier Construction / Span Replacement	$ 483,700		37.50%	$ 181,388	$ 665,088
4	15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Buyout/Acquistion - 216 Structures	$ 28,108,800		10.42%	$ 2,928,000	$ 31,036,800
5	15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Removal - 216 Structures	$ 6,091,200		14.58%	$ 888,300	$ 6,979,500
6			$ -		0.00%	$ -	$ -
7			$ -		0.00%	$ -	$ -
8		Item Name	$ -		0.00%	$ -	$ -
9		Item Name	$ -		0.00%	$ -	$ -
10		Item Name	$ -		0.00%	$ -	$ -
11		Item Name	$ -		0.00%	$ -	$ -
12		**Remaining Construction Items**	**$ 402,940**	*1.2%*	4.17%	$ 16,789	$ 419,729
13	30 PLANNING, ENGINEERING, AND DESIGN	**Planning, Engineering, & Design**	$ 195,300		8.33%	$ 16,275	$ 211,575
14	31 CONSTRUCTION MANAGEMENT	**Construction Management**	$ 260,000		4.17%	$ 10,833	$ 270,833

Totals				
Total Construction Estimate	$ 35,273,940	11.56%	$ 4,076,910	$ 39,350,850
Total Planning, Engineering & Design	$ 195,300	8.33%	$ 16,275	$ 211,575
Total Construction Management	$ 260,000	4.17%	$ 10,833	$ 270,833
Total	$ 35,729,240		$ 4,104,018	$ 39,833,258

Mill Creek FRM
AFB-Draft Report
Abbreviated Risk Analysis

Meeting Date: revised

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4

Risk Element	Potential Risk Areas	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Project Scope						
PS-1	Demolition	Some elements of scope are incomplete for AFB, need to verify conditions of the existing spans and abutment on the west bank.	The likelihood is likely because of the lack of structural reviews of existing span slated for removal.	LIKELY	Significant	4
PS-2	Excavation	Scope could change based upon fill conditions.	The likelihood is unlikely due to known construction requirements on similar bridges.	Unlikely	Marginal	1
PS-3	Pier Construction / Span Replacement	Some elements of scope are incomplete for AFB, need to verify conditions of the existing fill, design elements of the new bridge, and abutment on the west bank.	This issue is unlikely due to known site conditions and current design.	Unlikely	Critical	3
PS-4	Buyout/Acquistion - 216 Structures	Sponsor input could mean adjustments to the total number of structures recommended.	The likelihood is very unlikely that the sponsor will change their minds on project scope at this stage.	Very Unlikely	Marginal	0
PS-5	Removal - 216 Structures	Number of structures could change based on sponsor participation. Unknowns exists, for example asbestos removal.	This issue is very unlikely due to the level of data obtained on these strucutures	Very Unlikely	Significant	1
PS-6	0			Very Unlikely	Negligible	0
PS-7	0			Very Unlikely	Negligible	0
PS-8	Item Name			Very Unlikely	Negligible	0
PS-9	Item Name			Very Unlikely	Negligible	0
PS-10	Item Name			Very Unlikely	Negligible	0
PS-11	Item Name			Very Unlikely	Negligible	0
PS-12	Remaining Construction Items		Issue has been taken into account by design team and will therefore only have negligible effect. Scope could be reduced based on the amount of available funding after approval of letter report by ASA	LIKELY	Negligible	1
PS-13	Planning, Engineering, & Design	No real concerns at this time	Changes are likely but have been anticipated with the appropriate contingency. Scope could be reduced based on the amount of available funding after approval of letter report by ASA	LIKELY	Negligible	1
PS-14	Construction Management	No real concerns at this time	Changes are likely but anticipated with proper contingency. Scope could be reduced based on the amount of available funding after approval of letter report by ASA	LIKELY	Negligible	1

Acquisition Strategy

AS-1	Demolitio n	Unkown aquisition stategy could affect construction estimate, bid competition and contract award.	Assuming the work completed would be constructed by a small business could account for higher contractor markups and risks in the contingences. Proper contingency has been put in place to offset this.	LIKELY	Marginal	2
AS-2	Excavatio n	Unkown aquisition stategy could affect construction estimate, bid competition and contract award.	Assuming the work completed would be constructed by a small business could account for higher contractor markups and risks in the contingences. Proper contingency has been put in place to offset this.	LIKELY	Marginal	2
AS-3	Constructi on / Span Replacem	Unkown aquisition stategy could affect construction estimate, bid competition and contract award.	Assuming the work completed would be constructed by a small business could account for higher contractor markups and risks in the contingences. Proper contingency has been put in place to offset this.	LIKELY	Marginal	2
AS-4	quistion - 216 Structure	Staging buyout of 216, would need to coordinated over several years to limit impacts to the market and surrounding neighborhoods.	allows for 3 year acquisition	Very Unlikely	Marginal	0
AS-5	Removal - 216 Structures	Staging buyout of 216, would need to coordinated over several years to limit impacts to the market and surrounding neighborhoods.	The plan allows for 3 year acquisition strategy.	Unlikely	Significant	3
AS-6	0			Very Unlikely	Negligible	0
AS-7	0			Very Unlikely	Negligible	0
AS-8	Item Name			Very Unlikely	Negligible	0
AS-9	Item Name			Very Unlikely	Negligible	0
AS-10	Item Name			Very Unlikely	Negligible	0
AS-11	Item Name			Very Unlikely	Negligible	0
AS-12	Remaining Construction Items	N/A	Assuming the work completed would be constructed by a small business could account for higher contractor markups and risks in the contingences.	Very Unlikely	Negligible	0
AS-13	Planning, Engineering, & Design	Unkown aquition stategy could affect construction estimate, bid competition and contract awward.	Assuming the work completed would be constructed by a small business could account for higher contractor markups and risks in the contingences. Work on the greenway will follow previous lessons learned on similar Stones	Unlikely	Marginal	1
AS-14	Construction Management	Unkown aquition stategy could affect construction estimate, bid competition and contract awward.	Assuming the work completed would be constructed by a small business could account for higher contractor markups and risks in the contingences. Work on the greenway will follow previous lessons learned on similar Stones	Unlikely	Marginal	1

Construction Complexity

CC-1	Demolition	Interaction between contractor and flow of traffic needs to be well defined.	Design elements of removing one span and leaving remaining span for traffic flow could require alterations in final design.	Unlikely	Significant	3
CC-2	Excavation	Grade and Terrain could play a significant role in any impacts to the remaining span.	Design elements of removing one span and leaving remaining span for traffic flow could require alterations in final design.	LIKELY	Significant	4
CC-3	Pier Construction / Span Replacement	Design elements for new span placement on existing bridge.	Impacts are likely due to the complexity of design / construction impacts on existing spans/piers.	LIKELY	Significant	4
CC-4	Buyout/Acquistion - 216 Structures	No real concerns at this time	Simple process that is well-known to USACE and local sponsor.	Very Unlikely	Negligible	0
CC-5	Removal - 216 Structures	No real concerns at this time	Simple process that is well-known to USACE and local sponsor.	Very Unlikely	Negligible	0
CC-6	0			Very Unlikely	Negligible	0
CC-7	0			Very Unlikely	Negligible	0
CC-8	Item Name			Very Unlikely	Negligible	0
CC-9	Item Name			Very Unlikely	Negligible	0
CC-10	Item Name			Very Unlikely	Negligible	0
CC-11	Item Name			Very Unlikely	Negligible	0
CC-12	Remaining Construction Items	No real concerns at this time	No real concerns at this time	Unlikely	Negligible	0
CC-13	Planning, Engineering, & Design	No real concerns at this time	No real concerns at this time	Very Unlikely	Negligible	0
CC-14	Construction Management	No real concerns at this time	No real concerns at this time	Very Unlikely	Negligible	0

Volatile Commodities

VC-1	Demolition	No real concerns at this time	Contingency has taken ranging fuel prices for equipment and transport has to be taken into consideration.	Unlikely	Marginal	1
VC-2	Excavation	Haul costs / disposal areas could have impacts.	Contingency has taken ranging fuel prices for equipment and transport has to be taken into consideration.	LIKELY	Marginal	2
VC-3	Pier Construction / Span Replacement	Asphalt/Concrete/Reinforcing Steel, fluctuating costs are concern (petroleum).	No real concerns at this time	LIKELY	Marginal	2
VC-4	Buyout/Acquistion - 216 Structures	Housing market fluctuations.	Likely to occur, but impacts could be high or low depending upon market trends.	LIKELY	Marginal	2
VC-5	Removal - 216 Structures	Housing market fluctuations.	No real concerns at this time	LIKELY	Marginal	2
VC-6	0			Very Unlikely	Negligible	0
VC-7	0			Very Unlikely	Negligible	0
VC-8	Item Name			Very Unlikely	Negligible	0
VC-9	Item Name			Very Unlikely	Negligible	0
VC-10	Item Name			Very Unlikely	Negligible	0
VC-11	Item Name			Very Unlikely	Negligible	0
VC-12	Remaining Construction Items	No real concerns at this time	Contingency has taken ranging fuel prices for equipment and transport has to be taken into consideration.	LIKELY	Negligible	1
VC-13	Planning, Engineering, & Design	No real concerns at this time	No real concerns at this time	Very Unlikely	Negligible	0
VC-14	Construction Management	No real concerns at this time	No real concerns at this time	Very Unlikely	Negligible	0

Quantities						
Q-1	Demolition	Preliminary design phase and no quantities provided for the projected amt of demolition	This issue has been taken to account and while unlikely, cost overruns may be possible depending upon the type of material encountered during excavation	LIKELY	Marginal	2
Q-2	Excavation	Quantities could vary to account for grade and slope of the new cross section, if there are any scope changes. Any design changes could impact that.	This issue has been taken to account and while unlikely, cost overruns may be possible depending upon the type of material encountered during excavation	Unlikely	Marginal	1
Q-3	Pier Construction / Span Replacement	Quantities could vary to account for grade and slope of the new cross section, if there are any scope changes. Any design changes could impact that.	Design may change but since a conservative unit cost was used the impact will only be marginal	LIKELY	Marginal	2
Q-4	Buyout/Acquistion - 216 Structures	Quantities for the number of buyout/acquisition are at an early phase	No real concerns at this time	Unlikely	Marginal	1
Q-5	Removal - 216 Structures	Quantities for the number of buyout/acquisition are at an early phase	No real concerns at this time	Unlikely	Marginal	1
Q-6	0			Very Unlikely	Negligible	0
Q-7	0			Very Unlikely	Negligible	0
Q-8	Item Name			Very Unlikely	Negligible	0
Q-9	Item Name			Very Unlikely	Negligible	0
Q-10	Item Name			Very Unlikely	Negligible	0
Q-11	Item Name			Very Unlikely	Negligible	0
Q-12	Remaining Construction Items	No real concerns at this time	No real concerns at this time	Very Unlikely	Negligible	0
Q-13	Planning, Engineering, & Design	No real concerns at this time	No real concerns at this time	Very Unlikely	Negligible	0
Q-14	Construction Management	No real concerns at this time	No real concerns at this time	Very Unlikely	Negligible	0

Fabrication & Project Installed Equipment						
FI-1	Demolition	N/A	N/A	Unlikely	Negligible	0
FI-2	Excavation	N/A	N/A	Unlikely	Negligible	0
FI-3	Pier Construction / Span Replacement	Pre-stressed girders, guardrails, etc. Minimal impacts.	N/A	Unlikely	Negligible	0
FI-4	Buyout/Acquistion - 216 Structures	N/A	N/A	Very Unlikely	Negligible	0
FI-5	Removal - 216 Structures	N/a	N/A	Very Unlikely	Negligible	0
FI-6	0			Very Unlikely	Negligible	0
FI-7	0			Very Unlikely	Negligible	0
FI-8	Item Name			Very Unlikely	Negligible	0
FI-9	Item Name			Very Unlikely	Negligible	0
FI-10	Item Name			Very Unlikely	Negligible	0
FI-11	Item Name			Very Unlikely	Negligible	0
FI-12	Remaining Construction Items	N/A	N/A	Very Unlikely	Negligible	0
FI-13	Planning, Engineering, & Design	N/A	N/A	Very Unlikely	Negligible	0
FI-14	Construction Management	N/A	N/A	Very Unlikely	Negligible	0

Cost Estimating Method

CE-1	Demolition	Preliminary design phase and no quantities provided for the projected amt of demolition	Preliminary parametric pricing used and could differ as more is known	LIKELY	Marginal	2
CE-2	Excavation	Unit price for excavation was abstracted from similar work for common earth	No boring holes provided at this early phase and the material is assumed to be common earth. If rock is encountered in the excavation the unit price would be higher.	Unlikely	Critical	3
CE-3	Pier Construction / Span Replacement	Preliminary design phase and no specific quantities for pier design or CY of decking concrete provided	Preliminary parametric pricing used and could differ as more is known. However, our $137/SF of bridge deck was abstracted and more conservative than TDOT's average abstract price of $100/SF.	Unlikely	Marginal	1
CE-4	Buyout/Acquistion - 216 Structures	Reliant on gross appraisals and sponsor appraisal figures.	Appraisals could vary relative to accepted offer amounts.	LIKELY	Marginal	2
CE-5	Removal - 216 Structures	Removal costs are well established in working with this sponsor.	No real concerns at this time	Very Unlikely	Marginal	0
CE-6	0			Very Unlikely	Negligible	0
CE-7	0			Very Unlikely	Negligible	0
CE-8	Item Name			Very Unlikely	Negligible	0
CE-9	Item Name			Very Unlikely	Negligible	0
CE-10	Item Name			Very Unlikely	Negligible	0
CE-11	Item Name			Very Unlikely	Negligible	0
CE-12	Remaining Construction Items	No real concerns at this time	No real concerns at this time	Very Unlikely	Negligible	0
CE-13	Planning, Engineering, & Design	Only preliminary design and assumptions at this time.	Further design and analysis will be needed and may increase the cost in this area.	LIKELY	Marginal	2
CE-14	Construction Management	No real concerns at this time	No real concerns at this time	Very Unlikely	Negligible	0

External Project Risks

EX-1	Demolition	Impacts to scope changes (changed condition) would be significant.	No real concerns at this time	LIKELY	Marginal	2
EX-2	Excavation	Public safety as external risk to construction practices.	The area closest to the river could be affected with the rising pool but it would be a minimal area of the construction area. If cultural resources are discovered it could affect the schedule and process of construction. As affect	Unlikely	Significant	3
EX-3	Pier Construction / Span Replacement	TDOT bridge schedule in current planning process. Should TDOT ultimately recommend major design changes.	No real concerns at this time	LIKELY	Significant	4
EX-4	Buyout/Acquistion - 216 Structures	Participation of selected homes in the buyout. Determined by voluntary basis.	No real concerns at this time	Very Unlikely	Negligible	0
EX-5	Removal - 216 Structures	No real concerns at this time	No real concerns at this time	Very Unlikely	Negligible	0
EX-6	0			Very Unlikely	Negligible	0
EX-7	0			Very Unlikely	Negligible	0
EX-8	Item Name			Very Unlikely	Negligible	0
EX-9	Item Name			Very Unlikely	Negligible	0
EX-10	Item Name			Very Unlikely	Negligible	0
EX-11	Item Name			Very Unlikely	Negligible	0
EX-12	Remaining Construction Items	No real concerns at this time	No real concerns at this time	Very Unlikely	Negligible	0
EX-13	Planning, Engineering, & Design	No real concerns at this time	No real concerns at this time	Very Unlikely	Negligible	0
EX-14	Construction Management	No real concerns at this time	No real concerns at this time	Very Unlikely	Negligible	0

Mill Creek FRM
AFB-Draft Report
Abbreviated Risk Analysis

Typical Risk Elements	Potential Risk Areas: Demolition	Excavation	Pier Construction / Span Replaceme	Buyout/Acquistion - 216 Structures	Removal - 216 Structures	0	0	Item Name	Item Name	Item Name	Item Name	Remaining Construction Item	Planning, Engineering, & Design	Construction Management
Project Scope	4	1	3	-	1	-	-	-	-	-	-	1	1	1
Acquisition Strategy	2	2	2	-	3	-	-	-	-	-	-	-	1	1
Construction Complexity	3	4	4	-	-	-	-	-	-	-	-	-	-	-
Volatile Commodities	1	2	2	2	2	-	-	-	-	-	-	1	-	-
Quantities	2	1	2	1	1	-	-	-	-	-	-	-	-	-
Fabrication & Project Installed Equipment	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cost Estimating Method	2	3	1	2	-	-	-	-	-	-	-	-	2	-
External Project Risks	2	3	4	-	-	-	-	-	-	-	-	-	-	-

<u>Civil Works Work Breakdown Structure</u> (CWWBS)
Reference ETL 110-2-573 03 Sep 08, Table 2-1.

01 LANDS AND DAMAGES
01 18 GENERAL REVALUATION REPORT (GRR)
01 19 LIMITED REVALUATION REPORT (LRR)
01 20 PROJECT DESIGN MEMORANDUM
01 21 FEATURE DESIGN MEMORANDUM
01 23 CONSTRUCTION CONTRACT(S) DOCUMENTS
02 RELOCATIONS
02 01 ROADS, Construction Activities
02 02 RAILROADS, Construction Activities
02 03 CEMETERIES, UTILITIES, AND STRUCTURES, Construction Activities
03 RESERVOIRS
04 DAMS
04 01 MAIN DAM
04 02 SPILLWAY
04 03 OUTLET WORKS
04 04 POWER INTAKE WORKS
04 05 AUXILIARY DAMS
04 06 MUNICIPAL AND INDUSTRIAL WATER DELIVERY FACILITIES
05 LOCKS
06 FISH AND WILDLIFE FACILITIES
06 01 FISH FACILITIES AT DAMS
06 02 FISH HATCHERY, (Including Trapping and Release Facilities)
06 03 WILDLIFE FACILITIES AND SANCTUARIES
07 POWER PLANT
07 01 POWERHOUSE
07 02 TURBINES AND GENERATORS
07 03 ACCESSORY ELECTRICAL EQUIPMENT
07 04 MISCELLANEOUS POWER PLANT EQUIPMENT
07 05 TAILRACE
07 06 SWITCHYARD
08 ROADS, RAILROADS, AND BRIDGES
08 01 ROADS
08 02 RAILROADS
09 CHANNELS AND CANALS (Except Navigation Ports and Harbors)
09 01 CHANNELS
09 02 CANALS
10 BREAKWATERS AND SEAWALLS
11 LEVEES AND FLOODWALLS
11 01 LEVEES
11 02 FLOODWALLS
12 NAVIGATION, PORTS AND HARBORS
12 01 PORTS
12 02 HARBORS
13 PUMPING PLANT
14 RECREATION FACILITIES
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES
16 BANK STABILIZATION
17 BEACH REPLENISHMENT

18 CULTURAL RESOURCE PRESERVATION
19 BUILDINGS, GROUNDS, AND UTILITIES
20 PERMANENT OPERATING EQUIPMENT
30 PLANNING, ENGINEERING, AND DESIGN
30 11 PROJECT COOPERATION AGREEMENT
30 12 PROJECT MANAGEMENT PLAN
30 18 GENERAL REEVALUATION REPORT (GRR)
30 19 LIMITED REEVALUATION REPORT (LRR)
30 20 PROJECT DESIGN MEMORANDUM
30 21 FEATURE DESIGN MEMORANDUM
30 23 CONSTRUCTION CONTRACT(S) DOCUMENTS
30 24 VALUE ENGINEERING ANALYSIS DOCUMENTS
30 25 PROJECT OR FUNCTIONAL ELEMENT CLOSEOUT
30 26 PROGRAMS AND PROJECT MANAGEMENT DOCUMENTS
31 CONSTRUCTION MANAGEMENT
31 12 PROJECT MANAGEMENT PLAN
31 23 CONSTRUCTION CONTRACT(S) DOCUMENTS
31 26 PROGRAMS AND PROJECT MANAGEMENT DOCUMENTS
32 HAZARDOUS AND TOXIC WASTE
32 01 MOB, DEMOB & PREPARATORY WORK
32 02 SYSTEMS STARTUP/OPERATIONS/MAINTENANCE
32 03 INSTITUTIONAL ACTIONS
32 04 SURFACE WATER CONTROL
32 05 COLLECTION & INJECTION OF GROUND WATER
32 06 COLLECTION & DISPOSAL OF WASTES
32 07 CONTAIN & RESTORE CONTAMINATED GROUND WATER
32 08 CONTAINMENT FOR WASTES
32 10 TREAT-WASTES/CONTAMINATED SOIL & WATER
32 11 AIR POLLUTION AND LANDFILL GAS CONTROL
32 12 INNOVATIVE TECHNOLOGIES
32 13 SUPPORTING FACILITIES
32 14 PRIME CONTRACTOR'S INDIRECT COST

APPENDIX C, ATTACHMENT D
HTRW REPORT

EXECUTIVE SUMMARY
HTRW ASSESSMENT MEASURES IN THE MILL CREEK PROJECT AREA, NASHVILLE, TN
SEPTEMBER 2013

INTRODUCTION

The U.S Army Corps of Engineers (USACE) Nashville District (CELRN) is preparing a feasibility study for Mill Creek Nashville, Tennessee. Environmental reviews of measures or proposed project areas are conducted to identify any Hazardous, Toxic, and Radioactive Waste (HTRW) problems in and around each measure or proposed project site. If an HTRW issue is identified during any stage of a project, including feasibility, the project delivery team shall avoid or plan around the HTRW issue where practicable in accordance with USACE ER 1165-2-132. It should be noted that during the preconstruction, engineering and design phase, and within six months of any land acquisition and easement agreements of any property, CELRN shall perform a Phase Ia Environmental Site Assessment for each land parcel acquisition and easement according to All Appropriate Inquiries (AAI) 40 Code of Federal Regulations (CFR) 312.20.

PURPOSE AND PROJECT DESCRIPTION

The purpose of the HTRW assessment portion of the feasibility study is to identify HTRW concerns in and around the Mill Creek feasibility study measures that may impact the alternatives. According to USACE engineer regulation ER 1165-2-132 (June 1992) the feasibility report will document the HTRW impact or potential. The report will either conclude that there is no known HTRW, or that HTRW has been identified. If HTRW is identified, the report will also describe what actions are being taken toward avoidance.

The Environmental Section of the Engineering and Construction Branch (EC-E) conducted a visual inspection where practicable and conducted an environmental records review for each measure or proposed project site to identify HTRW concerns. The 11 measures and proposed project areas are as follows:

- Damage Center 1 – proposed channel improvements to Mill Creek Miles 4.8 – 6.2.
- Damage Center 2 – proposed channel improvements to Mill Creek Miles 6.9 - 7.9.
- Damage Center 3 – Mill Creek Miles 11.7 - 12.1, currently no proposed projects.
- Damage Center 4 – proposed channel improvements to Mill Creek Miles 10.8 – 11.3.
- Ellington Agriculture Center Culvert and Drainage Improvements to Sevenmile Creek Miles 3.7 – 4.2.
- Old Hickory Detention Structure at Mill Creek Mile 18.0.
- Sevenmile Edmondson Pike area – residential non-structural area near Sevenmile Creek Miles 1.9 – 3.1.
- Sevenmile Elysian Fields area – residential non-structural area near Sevenmile Creek Miles 0.5 – 1.25.

- Sorghum Branch Willard Drive area – residential non-structural area near Sorghum Branch Creek Miles 1.7 – 2.7.
- Whittenmore Branch Benzing Road area – residential non-structural area near Whittenmore Branch Creek Miles 0.5 – 1.8.
- Wimpole Drive – residential non-structural area near Mill Creek Miles 5.1 - 6.1.

FINDINGS AND CONCLUSIONS

HTRW SUMMARY FOR STRUCTURAL PROJECT SITES

There are five stretches of Mill Creek and one stretch of Seven Mile Creek of which are potential channel or structural improvement areas. The following subsections summarize HTRW findings for the six potential channel or structural improvement areas.

Damage Center #1

Damage Center 1 Mill Creek Miles 4.8 – 6.2. Damage Center 1 is mostly residential with the most downstream portion being a heavy commercial area of Murfreesboro Road and East Thompson Lane. Currently operating facilities which are environmentally registered or regulated are all currently in compliance. There are potential historic gas stations and dry cleaners which were mostly located on the downstream portion of Damage Center 1, which may or may not have impacted Mill Creek in the past. Without environmental records for the historic gas stations and dry cleaners, EC-E cannot determine potential impact from the potential historic gas stations and dry cleaners upon Mill Creek without further field investigation. If there is a proposed project to be conducted at Damage Center 1, because of the 40 historic gas stations and dry cleaners and the heavy commercial area around Murfreesboro Road, it is recommended that Mill Creek Miles 4.8 – 4.9 and the commercial area on Murfreesboro Road and East Thompson Lane be avoided. If a proposed project in the vicinity of Creek Mile 4.8 – 4.9 is unavoidable, E&E should conduct a field investigation near this portion of Mill Creek to determine the nature of contamination and impact to Damage Center 1.

There are two active gas stations near Creek Mile 4.8 - 4.9. Mapco Express and Kwik Tobacco Market gas stations have no current records of releases or spills as of September 2013. If there is a future leak or spill from Mapco Express or Kwik Tobacco Market, that spill or leak may impact Damage Center 1. If work around Creek Mile 4.8-4.9 is unavoidable, prior to any work starting in Damage Center 1, CELRN should contact the Tennessee Department of Environmental Conservation Division of Underground Storage Tanks (TDEC UST) and request Freedom of Information Act (FOIA) records for Mapco Express TDEC UST Facility Number 5190938 and for Kwik Tobacco Market TDEC UST Facility Number 519791 to ensure the gas stations' continued compliance.

Damage Center #2

Damage Center 2 is Mill Creek Miles 6.7 – 7.9. Damage Center 2 was undeveloped until the 1970s when there was an increase in densely populated residential areas in the vicinity, as well as the development of Space Park, I-24 and Briley Parkway. There are multiple facilities listed in federal, state and other environmental databases. The listed facilities are currently in compliance. Some facilities have environmental violations, but corrected the violations and are currently in compliance. There are no known current environmental conditions that would impact the proposed work at Damage Center 2.

Damage Center #3

Damage Center 3 is Mill Creek Miles 11.7 – 12.1. There are no measures or proposed project sites in Damage Center 3. EC-E did not conduct an HTRW evaluation for Damage Center 3 and surrounding area. There is a current Environmental Data Resources (EDR) records search, but was not evaluated or summarized. If there is a measure or proposed project in Damage Center 3 in the future, an HTRW evaluation shall be conducted prior to future work.

Damage Center #4

Damage Center 4 is Mill Creek Miles 10.8 – 11. 3. There are U.S. Environmental Protection Agency (USEPA) and TDEC regulated industries on the left bank of Damage Center 4 including Waste Management (formerly Systech) and R&L Carriers (formerly Roadway Express). Systech at 1640 Antioch Pike had multiple compliance inspections for groundwater contamination. Roadway Express at 3240 Franklin Limestone Road had been issued multiple notices of violation and, a confirmed Leaking Underground Storage Tank (LUST) which contaminated groundwater, is located adjacent to Mill Creek Mile 11.3, and has a National Pollutant Discharge Elimination System (NPDES) permitted outfall which discharges treated groundwater (for solvents and petroleum) into Mill Creek near Creek Mile 11.3.

It is recommended to avoid work in Mill Creek at Damage Center 4. If work is unavoidable at Damage Center 4, it is recommended to avoid the left bank and the NPDES permitted outfall near Creek Mile 11, and approach Mill Creek from the right bank where Vulcan Quarry is located. Before any proposed project starts in Damage Center 4, CELRN should contact USEPA and request FOIA records for Systech EPA ID# TND000772277 to ensure Systech or current business at 1640 Antioch Pike in continued compliance, contact TDEC and request FOIA records for Waste Management at 1428 Antioch Pike Facility ID #SWP190001077 and Waste Management 3211 Franklin Limestone Road Facility ID #TRF190001410 to ensure continued compliance, and contact TDEC and request FOIA records or the Roadway Express NPDES permitted outfall TNG830158 to determine continued compliance.

Ellington Agricultural Center Culvert and Drainage Improvements

Ellington Agricultural Center culvert is in the Sevenmile Creek area and located at Sevenmile Creek Mile 3.7. The area surrounding the channel and culvert is Ellington Agricultural Center on the left bank and a greenway on the right bank. The environmental record search and site visit did not indicate an environmental liability or condition within the Ellington Agricultural Center subject area that would interfere with the proposed projects along Sevenmile Creek near Ellington Agricultural Center.

Old Hickory Detention Structure

The proposed Old Hickory Detention Structure is near Mill Creek Mile 18. The area is currently an open farm field with residential neighborhoods surrounding the field. There is an underground natural gas pipeline and natural gas pump station running northeast to southwest and located on the west side of the field, there is an underground sewer line running northeast to southwest and located in the center of the field. The environmental record search and site visit did not indicate an environmental liability or condition within the proposed Old Hickory Detention Structure area adjacent to Mill Creek Mile 18 that would interfere with the proposed project site.

HTRW SUMMARY FOR NON-STRUCTURAL PROJECTS SITES

There are five stretches of Mill Creek and tributaries which are potential non-structural flood reduction projects where it is possible that structures in the floodway may be buyouts. The following subsections summarize HTRW findings for the six potential non-structural flood reduction areas.

Sevenmile, Edmondson Pike

Sevenmile Edmondson Pike area is a well established residential area near Sevenmile Creek Miles 1.9 – 3.1. The environmental record search revealed potential Historical Auto Stations, Historical Cleaners, Resources Conservation and Recovery Act (RCRA) Non-Generators (NonGen/NLR), and drycleaners. These facilities are either not currently in use, are residential homes at this time, or are downstream of the subject area. Therefore, they are not considered to be an environmental concern towards the subject area because they are not in use or unlikely to impact the subject area. All federal and state listed sited are downstream of the subject area, and therefore not believed to be an environmental concern towards the subject area because they are unlikely to impact the site. The environmental records review and site visit did not indicate a recognizable environmental liability or condition within the Sevenmile Creek – Edmondson Pike area.

Sevenmile, Elysian Fields

This is a well established residential area near Sevenmile Creek Miles 0.5 – 1.25. All Federal and State records were found to be downstream, have no record of violations, and/or have a tank closure status. All historic auto stations and historic drycleaners were determined to have never been an auto station or drycleaner, to be closed, and/or to not be adjacent to the subject area. All RCRA NonGen/NLR sites were found to not have any violations and the priority cleaners was found to be in remediation and not adjacent to the subject area. The environmental records review and site visit did not indicate a recognizable environmental liability or condition within the Sevenmile Creek – Elysian Fields subject area that would interfere with the proposed work along Sevenmile Creek

Miles 0.5 – 1.25. The HTRW analysis does not extend further upstream than Creek Mile 1.25.

Sorghum Branch – Willard Drive

This is a well established residential area around Sorghum Branch Creek Miles 1.7 – 2.7. The environmental record search indicated environmental sites which are not adjacent to the subject area, do not exist, are residential structures, not in the same tributary system as Sorghum Branch or downstream of Sorghum Branch Creek Mile 1.7. The environmental records review and site visit did not indicate a recognizable environmental liability or condition within the Sorghum Branch Creek Miles 1.7 – 2.7.

Whittenmore Branch

This is a residential and small rural area near Whittenmore Branch Creek Mile 0.5 – 1.8. During the site visit on 27 August 2013, an illegal trash dump site was seen near 229 Benzing Road. The dumped material appears to be household trash and old furniture which are not an HTRW concern. The environmental record search indicated environmental sites which are not adjacent to the subject area, are incompliance, or downstream of Whittenmore Branch Creek Mile 0.5. The environmental records review and site visit did not indicate a recognizable environmental liability or condition within the Whittenmore Branch Creek Miles 0.5 – 1.8.

Wimpole Drive

Wimpole Drive is a residential street adjacent to Mill Creek Miles 5.2 – 6.2. Wimpole Drive is a well maintained residential area with an Urban Garden on the western portion of the street adjacent to Mill Creek. An illegal trash pile was seen during the site visit on 26 August 2013 including a rubber mat, a TV and trash bags. The trash does not appear to be an HTRW concern. There are no recognizable environmental conditions seen in the EDR records search or site visit that would interfere with any non-structural projects on Wimpole Drive.

PHASE I ENVIRONMENTAL SITE ASSESSMENT
HTRW ASSESSMENT MEASURES IN THE MILL CREEK PROJECT AREA, NASHVILLE, TN
SEPTEMBER 2013

Table of Contents

HTRW ASSESSMENT MEASURES IN THE MILL CREEK PROJECT AREA, NASHVILLE, TN SEPTEMBER 2013

1.0 INTRODUCTION

U.S. Army Corps of Engineers (USACE) Nashville District (CELRN) is preparing a feasibility study for Mill Creek Nashville, Tennessee. Environmental reviews of measures or proposed project areas are conducted to identify any Hazardous Toxic and Radioactive Waste (HTRW) problems in and around each measure or proposed project site. If an HTRW issue is identified during any stage of a project, including feasibility, the project delivery team shall avoid or plan around the HTRW issue where practicable in accordance with USACE engineering regulation ER 1165-2-132. It should be noted that during the preconstruction, engineering and design phase, and within six months of any land acquisition and easement agreements of any property, CELRN shall perform a Phase Ia Environmental Site Assessment for each land parcel acquisition and easement according to All Appropriate Inquiries (AAI) 40 Code of Federal Regulations (CFR) 312.20.

2.0 PURPOSE AND PROJECT DESCRIPTION

The purpose of the HTRW assessment portion of the feasibility study is to identify HTRW concerns in and around the Mill Creek feasibility study measures that may impact the alternatives. According to USACE engineer regulations ER 1165-2-132 (June 1992) the feasibility report will document the HTRW impact or potential. The report will either conclude that there is no known HTRW, or that HTRW has been identified. If HTRW is identified, the report will also describe what actions are being taken toward avoidance.

The Environmental Section of the Engineering and Construction Branch (EC-E) conducted a visual inspection where practicable and conducted an environmental records review for each measure or proposed project site to identify HTRW concerns. The 11 measures and proposed project areas are as follows:

- Damage Center 1 – proposed channel improvements to Mill Creek Miles 4.8 – 6.2.
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- Damage Center 3 – Mill Creek Miles 11.7 - 12.1, currently no proposed projects.
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- Whittenmore Branch Benzing Road area – residential non-structural area near Whittenmore Branch Creek Miles 0.5 – 1.8.
- Wimpole Drive – residential non-structural area near Mill Creek Miles 5.1 - 6.1.

3.0 **REPORT ORGANIZATION**

The HTRW report is organized by measure or proposed project site. Within each report section there are site description and site visit observations, environmental record review, and conclusions specific to each measure or proposed project site. The site descriptions are based on site visit observations during 26-29 August 2013. EC-E contracted Environmental Data Resources Inc (EDR) to perform a standard environmental database records search (USEPA, state, local and tribal), Sanborn Fire Insurance Maps, historic topographic maps, historic aerial maps, and historic city directories for the surrounding area up to one-mile radius from each measure or proposed project. The record search fulfills the environmental records search requirements of AAI 40 CFR 312, American Standard Testing Methods (ASTM)-E1527 and ASTM-E1528. The EDR, Inc records search results are voluminous, and are not included in Appendix C, Attachment D. The EDR, Inc records are available electronically at CELRN-EC-E.

4.0 **DAMAGE CENTER #1**

4.1 SITE DESCRIPTION

Damage Center 1 on Mill Creek is located between Mill Creek Mile 4.8 – 6.2 with approximate coordinates N36.125943, W-86.718156. There is the Murfreesboro Road Bridge located at approximately Mile 4.85. During the site visit on 26 August 2013, the downstream area Mile 4.8 – 5.0 is where Murfreesboro Road crosses over Mill Creek, and there is a small grocery store, motel, restaurant, Auto Zone store, small strip mall with businesses that are not expected to be an HTRW concern, and Crescent Plaza with restaurants, clothing store, Dollar General, an empty store, and a Walgreens. None of the adjacent businesses are expected to cause an HTRW condition on Mill Creek. The upstream portion between Mile 5.0 and 6.3 has well established residential areas on both sides of the Creek. Wimpole Drive is on the right bank and is a residential area which was established in the 1950s. On the left bank is a residential area established between the 1950s and 1970s. On the western portion of Damage Center 1 near Mile 5.7 – 6.0 Insterstate-24 is adjacent to Mill Creek. During the site visit on 26 August 2013, there were no recognizable environmental concerns in Mill Creek at the portions we could access along this stretch. There was one 55-gallon drum labeled "power cleaning fluid" next to the back door of the closed office supply store, and the back door faces Mill Creek. The drum was in good condition with no signs of leaks or spills.

4.2 RECORDS REVIEW

The following sub-sections summarize the results of the environmental database searches.

4.2.1 Federal Database Search

EDR searched federal environmental databases including Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Resources Conservation and Recovery Act (RCRA), National Priority List (NPL), Mines, Department of Defense (DOD), Department of Energy (DOE) and National Pollutant Discharge Elimination System (NPDES) databases. There are four federally listed environmental sites within proximity of Damage Center 1.

Safety Kleen at 215 Whitsett Street is approximately 1.75 miles west of Mill Creek Mile 6.8, and approximately 0.8 miles WSW of Mile 5.9. Safety Kleen is registered as a RCRA CORRACTS (Corrective Action Activity site), is classified as a treater, storer or disposer of hazardous waste, and is classified as a large quantity generator of hazardous waste, such that more than 1000 kg of hazardous waste is generated at this site. Safety Kleen opened in 1989 and handles waste batteries. Tennessee Department of Environmental Conservation (TDEC) issued Safety Kleen many notices of violation from 1990 through 2005 and all notices of violation have achieved compliance. Safety Kleen contaminated groundwater in the 1990s and achieved contaminated groundwater control and human exposures control in 1998, and is in long term monitoring status of groundwater. Because groundwater contamination is currently in control and Safety Kleen is 0.8 miles from Damage Center 1, and is not adjacent to Damage Center 1, it is unlikely that Safety Kleen will impact any activity in Damage Center 1.

There are three sites that are registered as RCRA-Conditionally Exempt Small Quantity Generator of Hazardous Waste (CESQG) meaning the business generates less than 100 kg of hazardous waste or less than 1 kg of acutely hazardous waste per month. Exxon Mobil 1083 Murfreesboro Road, @ Your Service 304 E. Thompson Lane, and Prestige Cleaners 304 E Thompson Lane (EDR record states incorrectly 1100 Murfreesboro Road) are listed. The Exxon Mobil at the listed address is no longer in business and was replaced by a Walgreens, and the most recent update with the USEPA RCRA database was 2007. Exxon Mobil is no longer at this location and no longer generates hazardous waste. @ Your Service has an automatic carwash drive-through, has self-serve car wash bays, and a sign that says "National Car Wash". There are no violations or releases listed for @ Your Service. Prestige Cleaners is located in the front portion of the building where @ Your Service is located and appears to be a retail dry cleaner. There are no violations or releases listed for Prestige Cleaners. It is unlikely that these RCRA-CESQGs would impact Damage Center 1 because the Exxon Mobil is closed and does not generate hazardous waste, @ Your Service and Prestige Cleaners have no records of violations or releases, and all of the RCRA-CESQG are located at the most downstream portion, Creek Mile 4.8 - 4.9.

The above federally listed sites are in compliance, not adjacent, no longer in business, no longer a generator of hazardous waste, all records of violation have achieved compliance, and/or have no current records of violation. Therefore, it is not believed that any federally listed sites have had an environmental impact towards the Damage Center 1 subject area.

4.2.2 State Database Search

EDR searched state environmental databases including hazardous waste, solid waste, voluntary cleanup, leaking Underground Storage Tanks (USTs), USTs, and engineering controls for the subject area and surrounding properties up to one mile. There are five sites listed with USTs or leaking USTs within ½ mile of Damage Center 1.

The five sites with state registered USTs or leaking USTs are 304 E Thompson Lane, 1083 Murfreesboro Road, 109/619 Millwood Dr, 1090 Murfreesboro Road, and 1174 Murfreesboro Road. 304 Thompson was a gas station from 1955 through 1994 when the last of 9 USTs were taken permanently out of use. In November 1994, when UST closure procedures were taking place, it was discovered that there was a petroleum release from this site. The current status of the USTs and leaking USTs is that all USTs are permanently closed or removed and the gas station (formerly owned by BP, Amoco, and Gulf) case is closed with no further action. Currently 304 E Thompson Lane is a car wash and dry cleaner as summarized in the previous section. 1083 Murfreesboro Road is currently a Walgreens, but prior to that it was an Exxon Mobil gas station. In 1993, 2000 and 2005, TDEC discovered a release or spill from this location. All the spills have been addressed, and the spill cases are closed. The four Exxon Mobil USTs were permanently closed in 2006. 109 Millwood Drive had one leaking UST in 1997, and the leak has been addressed and the case is closed. There were three TDEC registered USTs at 109/619 Millwood Drive and were categorized as permanently out of use in 1997. Phone correspondence on 11 Sept 2013 at 12:58 with Tonya Spence Casson at the Tennessee Department of Environmental Conservation Division of Underground Storage Tanks (TDEC UST) Nashville Field Office confirmed UST removal in 1997 and there was no further action required. 109/619 Millwood Drive was opened as Kwik Tobacco Market gas station in 2001 with one pump outlet and two USTs, and the current USTs have no known leaks or violations. 1090 Murfreesboro road has been a gas station as early as 1946. There was a release in 1989, the release was addressed and the case is closed. This is currently an active Mapco Express with three active USTs and do not have any records of uncontrolled releases. 1174 Murfreesboro Road was a gas station from 1975 through 1995 with five USTs. The USTs were permanently closed in 1995. This location is currently a used auto sales lot with no visible auto service bays or gas station. In 1995 there was a former gas station that was closed and a release was discovered. The release was addressed and the case was closed. 1174 Murfreesboro Road is over ½ mile from Mill Creek.

It is unlikely any of the closed UST sites will impact Damage Center 1 because any known spill or release has been addressed and TDEC has closed the case, and the current business do have any environmental violations, and all of the UST and former UST sites are located near the most downstream area, Creek Mile 4.8 - 4.9 of the Damage Center. The Mapco Express and Kwik Tobacco Market gas stations are currently in use, and have no current records of releases or spills as of September 2013. If there is a future leak or spill from Mapco Express or Kwik Tobacco Market, that spill or leak may impact Damage Center 1. Before any proposed project starts in Damage Center 1, CELRN should contact TDEC UST and request Freedom of Information Act (FOIA) records for Mapco Express TDEC UST Facility Number 5190938 and for Kwik Tobacco Market TDEC UST Facility Number 519791 to ensure the gas stations' continued compliance.

4.2.3 Tribal Database Search

EDR searched tribal leaking UST, UST, voluntary cleanup, and landfill databases for the subject area and surrounding properties up to one mile. The property search and radius search revealed no tribal registered sites within one mile of the subject property.

4.2.4 Other Environmental Databases Search

EDR searched local and other environmental databases including brownfields, landfills, hazardous sites, local land records, emergency release, RCRA Non-Generators (NonGen), dry cleaners, lead, Polychlorinated Biphenyls (PCBs), and manufacture gas plants for Damage Center 1 and up to one-mile radius.

There are 7 RCRA non-hazardous waste generators within ¼ mile of Damage Center 1. All of the RCRA non-hazardous waste generators are not adjacent to Mill Creek, do not presently generate hazardous waste, and have no known environmental violations.

There are 23 potential historic gas station or services stations within ¼ mile of the Damage Center 1. For the majority of the potential historic gas stations or service station, there is no data available because they were either shutdown prior to the TDEC UST registry, or they were never a gas station. A few of the listed potential gas stations were closed with no further action required by TDEC UST. Most of listed sites are either not adjacent to Damage Center 1, or are on Murfreesboro Road, which is on the most downstream portion of Damage Center 1. Without environmental compliance records for most of the potential historic gas stations USTs, EC-E is unable to determine the likelihood of past or residual impact to Damage Center 1 without further field investigation.

There are 17 potential and historic dry cleaners within ¼ mile of Damage Center 1. The 17 sites include current dry cleaners with no violations, coin operated laundry, retail cleaning equipment sales, and potential historic cleaners. The majority of the sites are on or near Murfreesboro Road which is the most downstream stretch of Damage Center 1. Without environmental compliance records for most of the potential historic dry cleaners, EC-E is unable to determine the likelihood of past or residual impact to Damage Center 1 without further field investigation.

Due to the probability of contamination from the 40 historic gas stations and dry cleaners near the downstream portion of Damage Center 1, it is recommended that Mill Creek Miles 4.8 – 4.9 and the commercial area on Murfreesboro Road and East Thompson Lane be avoided. If a proposed project in the vicinity of Creek Mile 4.8 – 4.9 is unavoidable, EC-E should conduct a field investigation near this portion of Mill Creek to determine the nature of contamination and impact to Damage Center 1.

4.2.5 Fire Insurance Sanborn Map

Two Fire Insurance Sanborn maps, 1957 and 1963 were discovered through the EDR search for Damage Center 1 and vicinity. The 1957 and 1963 is the intersection of East Thompson Lane and Murfreesboro Road. In both Sanborn maps, there was a drive-in movie theater adjacent to Mill Creek where the Crescent Shopping Plaza is now. On the west corner of the intersection is a retail building built in 1954 with a large parking lot surrounding the area. This is currently a Family Dollar store and previously an H.G. Hills grocery store. On the north corner of the intersection was a gas station and auto repair, and is currently the Mapco Express gas station. On the northeast side of Murfreesboro Road and south of Mill Creek, there was a row of shops and residential structures, which is a Taco Bell and a coin operated laundry and are not expected to be an HTRW concern. Adjacent and to the south of Mill Creek was a gas station in both 1957 and 1963, and the structure is currently a restaurant. There is no EDR record of this gas station or USTs, so it is likely the gas station went out of business prior to the 1980s when TDEC required USTs to be registered with the State of TN. The condition of any remaining USTs at this location is unknown.

4.2.6 Historic Topographic Maps

Nine historic topographic maps, 1903, 1932, 1952, 1957, 1968, 1979, 1983, 1997 and 1999 were discovered through the EDR search of the subject tract and vicinity. In 1903 and 1932, Mill Creek at Damage Center 1 and adjacent area were sparsely populated and there appeared to be open land. In 1952, 1957 and 1968, only a small north portion of Damage Center 1 appears on the map. There is a progressive growth of larger commercial buildings near Damage Center 1 on Murfreesboro Road and E Thompson Lane, and indication of urban areas growing around in the vicinity. The 1968 and 1979 topo map indicates Wimpole Road is a fully developed urban area, and the northern part of Damage Center 1 is a heavy commercial area. The 1983 topo map shows heavy urban areas, and what appears to be the buildings similar to the Crescent Shopping Plaza. The 1997 and 1999 topo maps no longer show structures, only heavy urban zones.

4.2.7 Historic Aerial Photographs

Twelve historic aerial photos, 1951, 1959, 1963, 1974, 1987, 1992, 1999, 2006, 2007, 2008, 2010, and 2012 were discovered through the EDR search of the subject tract and vicinity. The aerial photos are of good quality and most features are easy to distinguish. The 1951 aerial shows the land surrounding Damage Center 1 is mostly rural agriculture with the beginning of Wimpole Road on the north portion, but there are no houses on the street, and possibly a drive-in movie theater at the corner of Murfreesboro Road and Thompson Lane adjacent to Mill Creek. In 1959, the areas to the north and east of Mill Creek are still forest or agricultural, and the residential area of Wimpole Road and vicinity are nearly fully developed. The 1963 aerial shows the north side of Mill Creek being residentially developed, Wimpole Road and south is heavily residentially developed, Murfreesboro Road is being commercially developed, and the drive-in movie theater is still next to Mill Creek. The 1974, 1987, 1992, and 1999 aerials are similar, with the residential areas north and south of Mill Creek being fully residentially developed, Murfreesboro Road being commercially developed, and the drive-in movie theater has been replaced by commercial buildings and parking areas. In 2006, 2007, 2008 and 2010 show that Wimpole Road residential structures from Creek Mile 5.7 – 5.8 have been removed, and the photo edge ends there. In 2012, it appears that Wimpole Road between Creek Mile 5.7 – 5.8 is being prepared as the Hands on Nashville (HON) Urban Garden.

4.2.8 City Directory Search

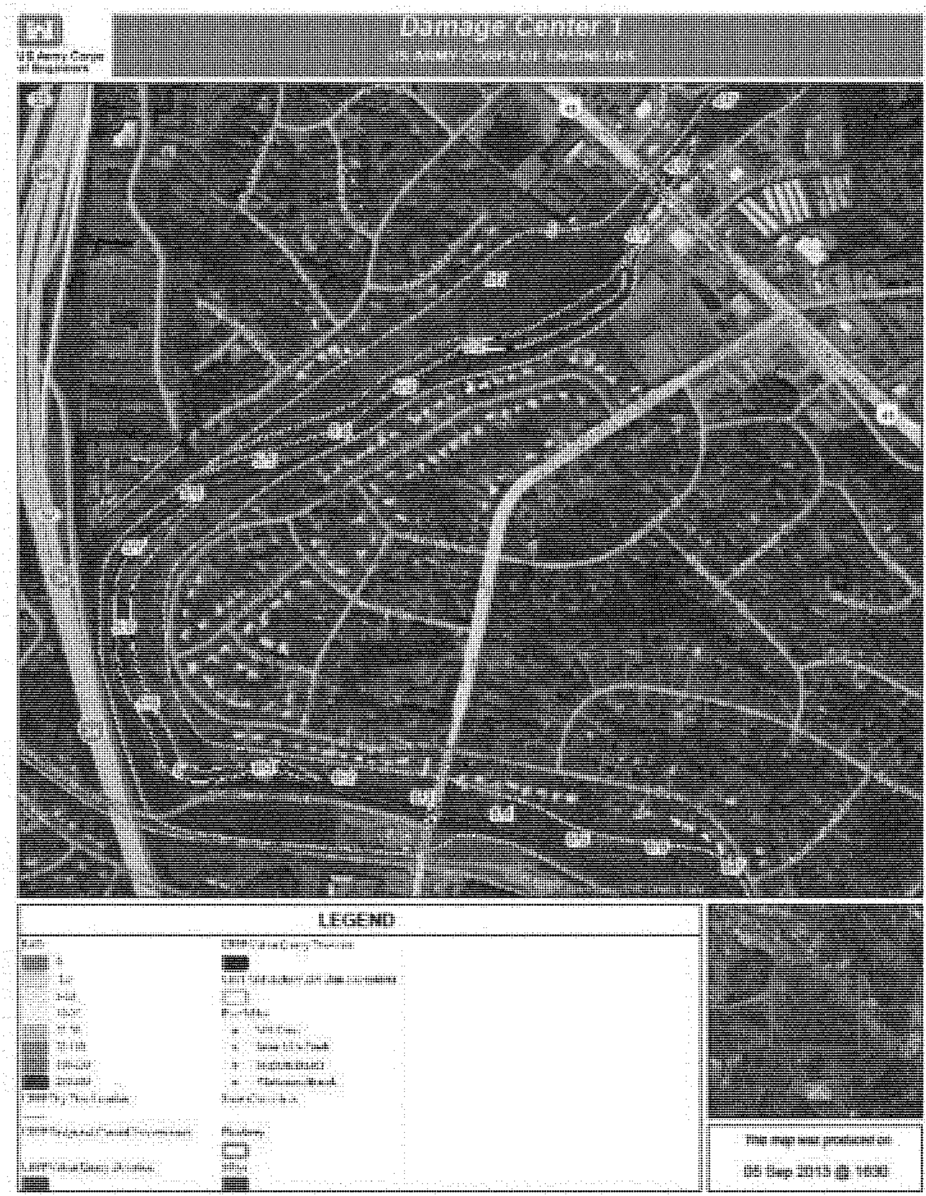
A City Directory Search was conducted for the subject area and vicinity for periodic intervals from 1908 through 2012, with data returned for 1946 periodically through 2012, with the majority of results from the most recent 20 years. The City Directory search indicates that the area has a wide range of uses from residential to commercial. No large heavy industry was indicated in the City Directory Search that would indicate a recognizable environmental condition that was not already identified in the federal, state and local environmental records.

4.3 CONCLUSIONS

Damage Center 1 is a residential area with the most downstream portion being heavily commercialized around Murfreesboro Road and East Thompson Lane. All environmentally registered or regulated operating facilities are currently in compliance. There are potential historic gas stations and dry cleaners which were mostly located on the downstream portion of Damage Center 1, which may or may not have impacted Mill Creek. Without environmental records for the historic gas stations and dry cleaners, EC-E cannot determine potential impact from the potential historic gas stations and dry cleaners upon Mill Creek without further field investigation. It is recommended that Mill Creek Miles 4.8 – 4.9 and the commercial area on Murfreesboro Road and East Thompson Lane be avoided during any proposed work because of the 40 historic gas stations and dry cleaners and the heavy commercial area around Murfreesboro Road. If a proposed project in the vicinity of Creek Mile 4.8 – 4.9 is unavoidable, EC-E should conduct a field investigation near this portion of Mill Creek to determine the nature of contamination and impact to Damage Center 1.

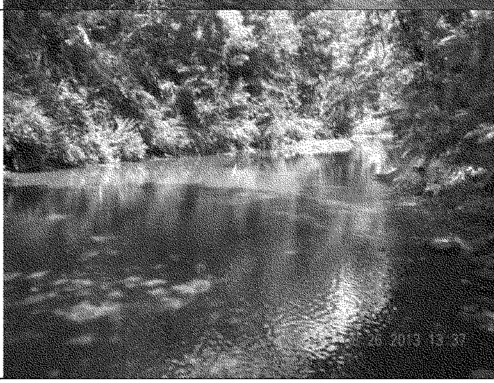
The Mapco Express and Kwik Tobacco Market gas stations, located near Creek Mile 4.8, are currently in use and have no current records of releases or spills as of September 2013. If there is a future leak or spill from Mapco Express or Kwik Tobacco Market, that spill or leak may impact Damage Center 1. If work around Creek Mile 4.8 – 4.9 is unavoidable, prior to any work starting in Damage Center 1, CELRN should contact TDEC UST and request FOIA records for Mapco Express TDEC UST Facility Number 5190938 and for Kwik Tobacco Market TDEC UST Facility Number 519791 to ensure the gas stations' continued compliance.

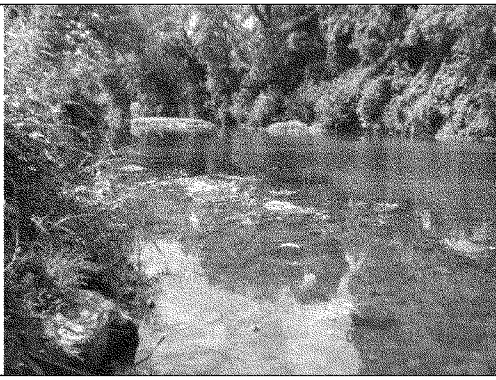
4.4 SITE MAP



4.5 SITE PHOTOS

	1. Standing on the right bank at Creek Mile 4.85 facing downstream towards the northeast looking at the Murfreesboro Pike Bridge located at Creek Mile 4.8
	2. Standing on the right bank at Creek Mile 4.85 facing upstream towards the southwest looking at Mill Creek
	3. Standing on the Murfreesboro Pike Bridge located at Creek Mile 4.8 facing upstream towards the southwest

	4. Standing on the Murfreesboro Pike Bridge located at Creek Mile 4.8 facing downstream towards the northeast
	5. Standing on the right bank at Creek Mile 5.1 facing downstream towards the northeast looking at Mill Creek
	6. Standing on the right bank at Creek Mile 5.1 facing upstream towards the southwest looking at Mill Creek

	7. Standing on the left bank at Creek Mile 6.3 facing downstream towards the west looking at Mill Creek

5.0 DAMAGE CENTER #2

5.1 SITE DESCRIPTION

Damage Center 2 on Mill Creek is located between Mill Creek Mile 6.9 and 7.9 with approximate coordinates N36.108522, W-86.709992. The downstream portion is near where Briley Parkway crosses Currey Road. On the left bank between Mile 6.9 and 7.7 is a railroad track and on both the left and right banks are well established residential areas built in the 1950s. From Mile 7.5 – 7.9 there is Space Park Road with multiple warehouses on the right bank, and Interstate 24 on the left bank. During the site visit on 26 August 2013, the warehouses were neat, clean and no signs of spills or leaks. On the north portion of the warehouse area, there were rail road ties, which may be treated with creosote, piled next to Mill Creek in the tree line. Besides the rail tie pile, there were no recognizable environmental conditions seen in the Damage Center 2 stretch of Mill Creek.

5.2 RECORDS REVIEW

The following sub-sections summarize the results of the environmental database searches.

5.2.1 Federal Database Search

EDR searched federal environmental databases including CERCLA, RCRA, NPL, Mines, DOD, DOE and NPDES databases. There are two federally listed environmental sites within proximity of Damage Center 2.

ESB Inc, 147 Space Park South is adjacent to Mill Creek Mile 8.15, which is approximately ¼ mile upstream from a potential channel improvement area from Mile 7.4 – 7.9. ESB Inc is listed as Comprehensive Environmental Response, Compensation and Liability Information System (CERLCIS) No Further Remedial Action Planned (NFRAP), and ESB Inc has been either removed or archived from the listing of CERCLIS sites. ESB Inc was discovered for CERCLIS evaluation in 1980. USEPA conducted a CERCLIS Preliminary Assessment in 1985, determined ESB Inc did not qualify for the NPL, and archived and removed ESB Inc from CERCLIS consideration. ESB Inc is classified as a non-generator of hazardous waste, and there are no violations listed for ESB Inc. It is unlikely ESB Inc would impact any proposed project in Damage Center 2 because ESB Inc was evaluated in 1985 and it was determined to not be a candidate for the CERCLIS list, they do not presently generate hazardous waste, and there are no know violations.

Averitt Express, One Averitt Express Drive, is listed as a RCRA Small Quantity Generator of Hazardous Waste (SQG), and is located ¼ mile to the west of Creek Mile 7.3, the north portion of Damage Center 2. Averitt Express generates less than 1000 kg of hazardous waste per month. TDEC issued four notices of violation on 26 December 2007 for violations due to pre-transport, federal or state statute, universal water and used oil violations. On 19 May 2008, TDEC conducted a follow up inspection and determined that all violations were corrected and Averitt Express achieved compliance for the four violations. It is unlikely Averitt Express would impact any proposed project in Damage Center 2 because Averitt Express has been in compliance since 2008, there are no documented releases to the environment, and the facility is not adjacent to Damage Center 2.

5.2.2 State Database Search

EDR searched state environmental databases including hazardous waste, solid waste, voluntary cleanup, leaking USTs, USTs, and engineering controls for the subject area and surrounding properties up to one mile. Within ½ mile of Damage Center 2 are two former Leaking Underground Storage Tank (LUST) sites.

Regions Operation Center, 550 Metroplex Drive is approximately 0.3 miles south of Creek Mile 8.4 and 0.6 miles southeast from a proposed channel improvement area Creek Mile 7.9. Regions Operation Center had a detected a petroleum leak in 1988, remedial action was overseen by TDEC, and the release was determined to be cleaned up, and the case is closed with no further action. Regions Operation Center currently has two active USTs with reinforced fiberglass construction for diesel storage. There are no notices of violation for the two active USTs. The 1988 release is unlikely to impact Damage Center 2 because Regions Operation Center is not adjacent to Mill Creek, the 1988 petroleum leak was determined to be cleaned up and the case closed with no further action, and is over ½ mile from a proposed channel improvement area.

Contract Packaging, 1201 Antioch Pike is approximately 0.15 miles from Mill Creek Mile 9 and over 1 mile from a proposed channel improvement area. Contract Packaging had one UST which was closed in 1988. TDEC determined that the release was cleaned up and the case is closed with no further action. It is unlikely that Contract Packaging would impact Damage Center 2 because Contract Packaging is not adjacent to Mill Creek, the release in the 1980s was determined to be closed with no further action, and is over 1 mile from any proposed channel improvement area,

5.2.3 Tribal Database Search

EDR searched tribal leaking UST, UST, voluntary cleanup, and landfill databases for the subject area and surrounding properties up to one mile. The property search and radius search revealed no tribal registered sites within one mile of the subject property.

5.2.4 Other Environmental Databases Search

EDR searched local and other environmental databases including brownfields, landfills, hazardous sites, local land records, emergency release, RCRA NonGen, dry cleaners, lead, PCBs, and manufacture gas plants for Damage Center 2 and up to one-mile radius.

There are 10 RCRA non-generators listed to be within ¼ mile of Damage Center 2 with one located on Currey Road, and 9 located in the Space Park. Colormasters Inc is located at 954 Currey Road and is located over ¼ mile from Mill Creek near Creek Mile 7.5. Colormasters Inc was a small quantity generator of hazardous waste from 2001 to 2003, became a non-generator of hazardous waste in 2006, and currently does not generate hazardous waste. No violations were found for Colormasters. Coit Drapery and Carpet Cleaner Inc, Ramo Manufacturing, Beck/Arnley Worldparts Corp, Wolfe and Sons Sheet Metal Co, ESB Inc, Express Warehousing Sys Inc, Fromp Village, Lavergne Supplement

Company, and Thompkins Motor Lines Inc were or are located in the Space Park area. Colormasters Inc is located at 954 Currey Road. Coit Drapery and Carpet Cleaners Inc, Beck/Arnley Worldparts, Corp, Wolfe and Sons Sheet Metal Co, EBS Inc, Express Warehousing Sys Inc, Fromp Village Inc, Lavergne Supplement Company, and Tompkins Motor Lines Inc are verified non-generators of hazardous waste, do not presently generate hazardous waste and have no violations found. Ramo Manufacturing Inc is a verified non-generator of hazardous waste and does not presently generate hazardous waste. Ramo Manufacturing Inc had one violation issued by TDEC in 1993 for record keeping and/or reporting. It is unlikely that the 10 companies would impact Damage Center 2 because all of the RCRA non-generators do not generate hazardous waste, no violations were found for all but one company, and the one violation was for record keeping and/or reporting and not for an uncontrolled release.

5.2.5 Fire Insurance Sanborn Map

No Fire Insurance Sanborn map was discovered through the EDR search for the subject tract and vicinity. The lack of Fire Insurance Sanborn maps indicate that this subject properties and surrounding area were not developed commercially or industrially, nor developed into a high density residential area before 1977.

5.2.6 Historic Topographic Maps

Seven historic topographic maps, 1903, 1932, 1952, 1958, 1979, 1983, and 1999 were discovered through the EDR search of the subject tract and vicinity. In 1903 and 1932, Mill Creek at Damage Center 2 and adjacent area were open land with open river bank land. In 1932, the BM rail line was present to the east of Mill Creek at Damage Center 2. In 1952, there is little change from the 1932 topo map. The 1968 topo map shows that I-24 and Briley Parkway were constructed and active, there is a road built into the Space Park area, but no structures are indicated in the Space Park area, and much of the surrounding area is designated urban land. The 1979 topo map indicates that the Space Park industrial area with the current configuration of structures was built and in operation and the majority of the surrounding area to Damage Center 2 is designated urban land. The 1983 topo map is similar to the 1979 map. The 1999 topo map shows only the largest Space Park structures, and the majority of adjacent land to Mill Creek is urban land.

5.2.7 Historic Aerial Photographs

Twelve historic aerial photos, 1951, 1959, 1963, 1974, 1987, 1992, 1999, 2006, 2007, 2008, 2010, and 2012 were discovered through the EDR search of the subject tract and vicinity. The aerial photos are of good quality and most features are easy to distinguish. The 1951 aerial shows the land surrounding Damage Center 2 is mostly rural agriculture with a residential area to the east on Currey Road. In 1959, the areas to the north and east of Mill Creek have dense residential areas, to the west and south is open land or agricultural and further to the northwest is evidence of a quarry. There is a road extending from the east residential area in to open land (where Space Park is now) and it is possible that a residential development was planned there. In 1963, there appears to be more residential development on both sides of Mill Creek, and the Space Park area still has a road, but there is no development in the area. In 1974, large industrial buildings have been built in the Space Park area, I-24 and Briley Parkway were built and active, there is no further residential development and the quarry is in the south west quadrant of the I-24 and Briley Parkway interchange. The 1987 aerial is similar to the 1974 aerial. In 1992, most of the area is similar to 1974, except where the quarry was located, it appears to be an industrial area with buildings surrounded by a parking lot. The 1999, 2006, 2007, 2008 and 2012 aerials are approximately the same showing the Space Park industrial area, and dense residential areas adjacent to Damage Center 2.

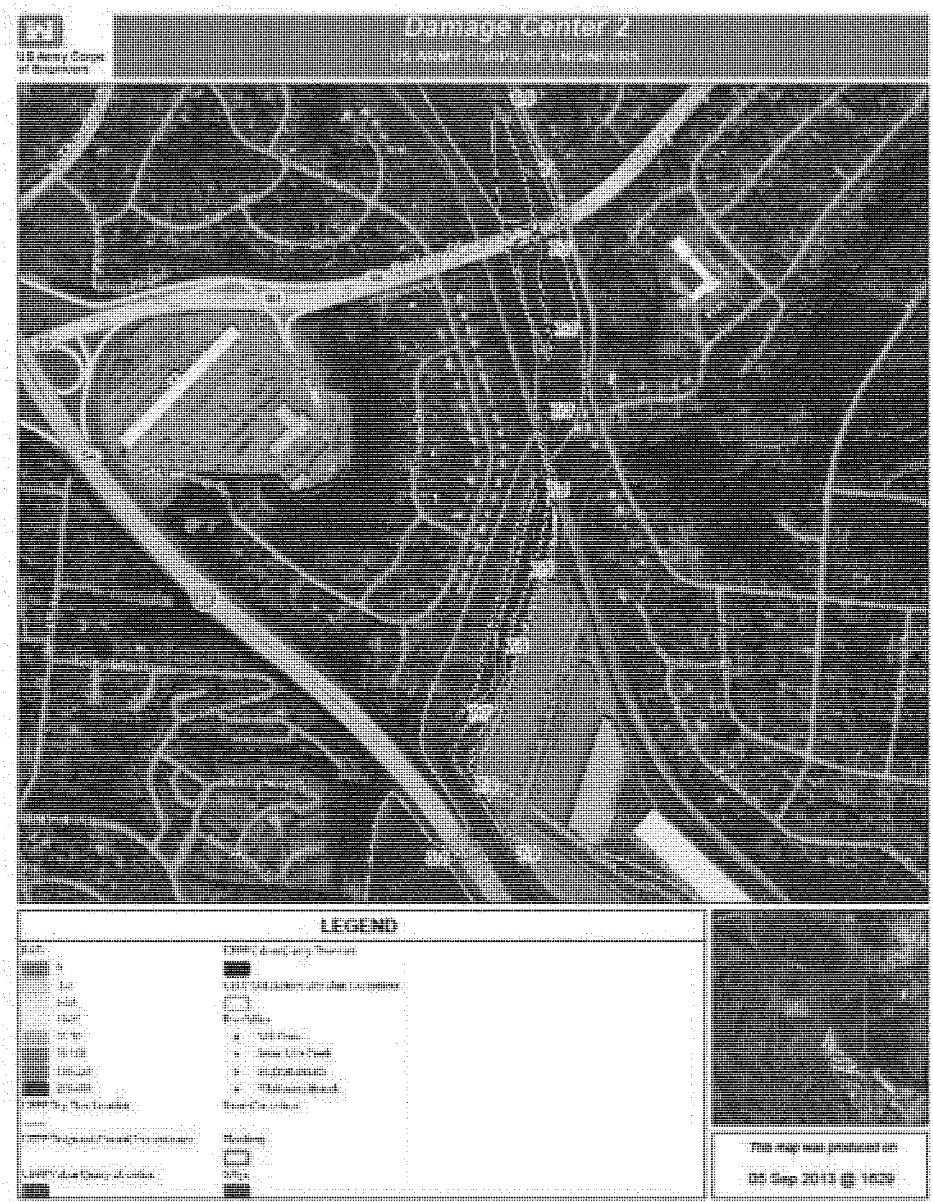
5.2.8 City Directory Search

A City Directory Search was conducted for the subject area and vicinity for periodic intervals from 1908 through 2012, with data returned for1975 through 2012. The City Directory search indicates that Space Park is an industrial area with a wide variety of commercial business in the various buildings associated with Space Park. City Directories were not searched but there were no results from 1908 through 1971 for Space Park which indicates that Space Park was not fully developed or not occupied prior to 1971.

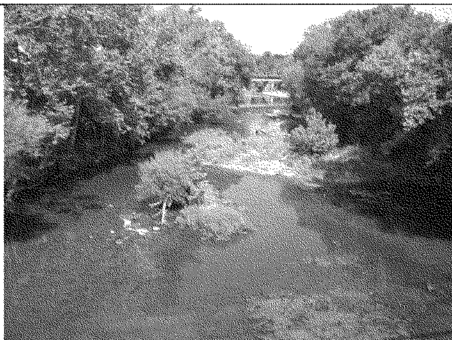
5.3 CONCLUSIONS

Damage Center 2 was undeveloped until the 1970s when there was an increase in densely populated residential areas in the vicinity, as well as the development of Space Park, I-24 and Briley Parkway. There are multiple facilities listed in federal, state and other environmental databases. The listed facilities are currently in compliance. Some facilities have environmental violations, but the violations were corrected and are currently in compliance. There are no known current environmental conditions that would impact the proposed work at Damage Center 2.

5.4 SITE MAP



5.5 SITE PHOTOS

	1. Standing on the Space Park Dr Bridge at Creek Mile 8.15 facing upstream towards the east, looking at a railroad bridge that is located at approximately Creek Mile 8.33
	2. Standing on the Space Park Dr Bridge at Creek Mile 8.15 facing downstream towards the west, looking at Mill Creek
	3. Standing on the right bank near Mile 7.5 facing south looking at unused railroad ties which are likely treated with creosote

6.0 DAMAGE CENTER #3

6.1 SITE DESCRIPTION

Damage Center 3 is on Mill Creek located between Mill Creek Mile 11.7 and 12.1. There are no measures or proposed projects in Damage Center 3 as of 29 August 2013. Because there are no measures or proposed project, no HTRW analysis was developed for Damage Center 3.

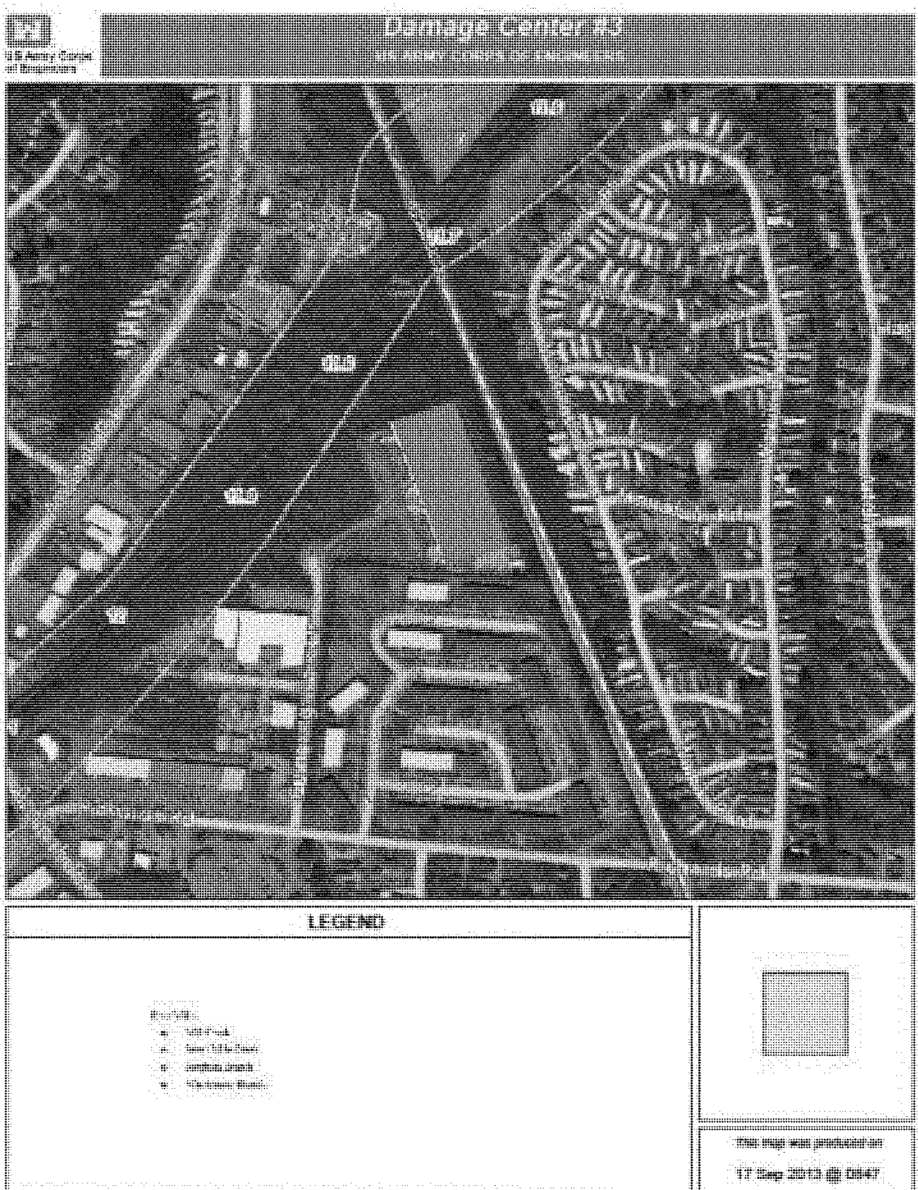
6.2 RECORDS REVIEW

There are no proposed projects in Damage Center 3 as of 29 August 2013. An EDR records search was conducted, but was not evaluated or summarized. If there is a measure or proposed project in Damage Center 3 in the future, EDR records shall be evaluated and summarized.

6.3 CONCLUSION

There are no measures or proposed project sites in Damage Center 3. EC-E did not conduct an HTRW evaluation for Damage Center 3 and surrounding area. There is a current EDR records search which was not evaluated or summarized. If there is a measure or proposed project in Damage Center 3 in the future, an HTRW evaluation shall be conducted prior to future work.

6.4 SITE MAP



6.5 SITE PHOTOS

	1. Standing on the right bank of Mill Creek near Creek Mile 11.65 facing northeast, looking at former residential water, sewer and electrical stickups
	2. Standing on the right bank at approximately Creek Mile 11.6, facing upstream towards the southwest, looking at the railroad bridge located at Creek Mile 11.7
	3. Standing on the Antioch Pike Bridge at Creek Mile 12.1, facing downstream towards the northeast

7.0 DAMAGE CENTER #4

7.1 SITE DESCRIPTION

Damage Center 4 is on Mill Creek located between Mill Creek Mile 10.8 and 11.3 with approximate coordinates N36.083379, W-86.680348. North and downstream of Damage Center 4 is Ezell Road Park and Greenway. Vulcan Quarry is located along the right bank, and mines crushed stone and gravel aggregate at this location. During the site visit on 27 August 2013, EC-E was unable to gain access to property to confirm the type of operations at the quarry. On the left bank between Mile 10.9 an 11.1 is a warehouse business park. During the site visit on 27 August 2013, EC-E saw Waste Management company office and truck parking near Mile 10.9 and the abandoned rail road bridge. The abandoned rail road bridge has river debris such as logs and tree branches lodged on, and in the structure. At the Waste Management side of the abandoned rail road bridge was a 4 inch PVC pipe extending into the creek with an industrial 4 inch water hose extending to the road surface (See section 7.5, photo 4). On the left back from Mile 11.1 – 11.3 is R+L Carrier company. R+L appears to be a trucking transport company, and has an asphalt parking area, a loading warehouse, and truck service bays. During the site visit on 27 August 2013, near Mile 11.3, between the service bays and Mill Creek was a sign saying UST Remediation Tracking #TNG830158 (See photos 5 and 6 in Section 7.5). This is an NPDES permitted outfall to Mill Creek with water discharge being from a UST remediation system from the former Roadway Express Terminal which appears to now be R+L Carrier.

7.2 RECORDS REVIEW

The following sub-sections summarize the results of the environmental database searches.

7.2.1 Federal Database Search

EDR searched federal environmental databases including CERCLA, RCRA, NPL, Mines, DOD, DOE and NPDES databases. The Damage Center 4 subject area was not identified in any of the Federal Databases searched for this project. Approximately ¼ mile south of Damage Center 4, there is one federally listed site, Systech Nashville/pre-treatment located at 1640 Antioch Pike. Systech was formerly known as Clean Harbors Antioch, Safety Kleen, Laidlaw Environmental Services, and Tricil Environmental Services. Systech is listed in four federal databases including CERCLIS NFRAP, RCRA CORRACTS, RCRA non-CORRACTS Transporter, Storer or Disposer (TSD) of hazardous waste), and RCRA Generator Large Quantity Generator of hazardous waste (LQG). Systech was under multiple phases of environmental compliance inspections and RCRA facility assessment starting in 1984. In 1999, under USEPA oversight, it was determined that there was a hazardous waste release to ground water. In 1999 health exposures were not under control and a corrective action date of 2008 was imposed. In 2008, USEPA verified that current human exposures are under control, and migration of contaminated groundwater is under control, so the corrective action process was terminated with no further action required. There are no records of violations from 2008 to present. Systech is currently in compliance, but before any proposed project starts in Damage Center 4, CELRN should contact USEPA and request FOIA records for Systech

EPA ID# TND000772277 to ensure Systech or current business at 1640 Antioch Pike is in continued compliance.

7.2.2 State Database Search

EDR searched state environmental databases including hazardous waste, solid waste, voluntary cleanup, leaking USTs, USTs, and engineering controls for the subject area and surrounding properties up to one mile. The Damage Center 4 subject area was not identified in any of the State Databases searched for this project. Within ½ mile of Damage Center 4 are Tennessee State listed sites including categories of waste facility/landfill, historic LUST, and state registered USTs.

There are two locations listed for solid waste transferring and processing, by Waste Management, and the addresses are 1428 Antioch Pike, and 3211 Franklin Limestone Road. The Antioch Pike location was a solid waste processing and transfer center and in 1990 became a transfer center only. The Franklin Limestone Road location is a solid waste processing and transfer center. No violations are listed for either location.

There are two LUST sites within ½ mile of Damage Center 4, Roadway Express (formerly Roadway Express, now R+L Carriers) at 3240 Franklin Limestone Road, and Meguiar's at 3258 Ezell Pike. Meguiar's is in complete tank closure status with TDEC oversight. Currently TDEC is overseeing the on-going Roadway Express LUST corrective action. The Roadway Express LUST corrective action includes discharging processed contaminated groundwater through an NPDES permitted remediation outfall (See photos 5 and 6 in Section 7.5) into Mill Creek. The NPDES permitted outfall is registered with TDEC, and the NPDES Permit Tracking Number is TNG830158. EC-E contacted TDEC's Bill Duffle on 19 September 2013. Mr. Duffle stated that remediation at Roadway Express is currently ongoing to treat ground water for solvents and petroleum products by using vacuum extraction pump, air stripper, and carbon filter processes. The NPDES permit TNG830158 was issued in July 2013 to allow for treated groundwater to be discharged to Mill Creek. It is possible that the Roadway Express LUST has impacted Mill Creek, and the NPDES outfall of processed groundwater may impact Mill Creek currently and in the future. It is recommended to avoid the area around Roadway Express (R & L Carrier) and vicinity of Mill Creek left bank near Creek Mile 11.3.

There are two registered UST sites within ¼ mile of Damage Center 4. Roadway Express had two USTs (other than the LUST) which were closed in 1992 and have had no recorded violations. Tricil Environmental Services at 1640 Antioch Pike had three concrete USTs which are all permanently out of use and have had no recorded violations.

The closed USTs have no violations, so they are unlikely to impact Damage Center 4. Before any proposed project starts in Damage Center 4, CELRN should contact TDEC and request FOIA records for Waste Management at 1428 Antioch Pike Facility ID #SWP190001077 and Waste Management 3211 Franklin Limestone Road Facility ID #TRF190001410 to ensure continued compliance. The Roadway Express NPDES permitted outfall should be avoided. Before any proposed project starts in Damage

Center 4, CELRN should contact TDEC and request FOIA records or the NPDES permitted outfall TNG830158 to determine continued compliance.

7.2.3 Tribal Database Search

EDR searched tribal leaking UST, UST, voluntary cleanup, and landfill databases for the subject area and surrounding properties up to one mile. The property search and radius search revealed no tribal registered sites within one mile of the subject property.

7.2.4 Other Environmental Databases Search

EDR searched local and other environmental databases including brownfields, landfills, hazardous sites, local land records, emergency release, dry cleaners, lead, PCBs, and manufacture gas plants for Damage Center 4 and up to one-mile radius.

There are two RCRA non-generators listed to be within ¼ mile of Damage Center 4, Check-Printers at 1530 Antioch Pike, and YRC Inc (formerly Roadway Express, now R+L Carriers) 3240 Franklin Limestone Road. Check-Printers does not presently generate hazard waste, TDEC conducts periodic compliance inspections, and there are no known violations at Check-Printers. YRC Inc (formerly Roadway Express, now R+L Carriers) does not presently generate hazardous waste, but was categorized as a small and large quantity generator of hazardous waste between 1994 and 2008. TDEC issued multiple Notices of Violation to YRC (formerly Roadway Express, now R+L Carriers) in 2005, and 2007 for general non-compliance, and used-oil violations. YRC (formerly Roadway Express, now R+L Carriers) is listed in Section 7.2.2 of this report, and is currently in corrective action.

Systech 1640 Antioch Pike is listed as a NY (New York) Manifest and an EPA COR ACTION (Corrective Action) site. For the NY Manifest site, there is no record available at this time, only that Systech was either a generator, transporter, storage facility or disposer of hazardous waste coming from or going to the State of New York. EPA COR ACTION is a USEPA designation for facilities expected to need corrective action, but the facilities are not currently or do not currently need corrective action. In 2008, USEPA verified that current human exposures are under control, and migration of contaminated groundwater is under control, so the corrective action process was terminated with no further action required. There are no records of violations from 2008 to present.

Martinez Paint and Body Shop 3879 Franklin Limestone Road is listed as an auto station and is within ¼ mile of Damage Center 4. There are no notices of violation, but operations at this business may include hydraulic fluid, paints, and solvents.

Systech is currently in compliance, but before any proposed project starts in Damage Center 4, CELRN should contact USEPA and request FOIA records for Systech EPA ID# TND000772277 to ensure Systech or current business at 1640 Antioch Pike in continued compliance. The YRC Inc (formerly Roadway Express, now R+L Carriers) currently has no violations, but does have current groundwater remediation and an NPDES permitted outfall as listed in 7.2.2 of this report. Any work near YRC Inc (formerly Roadway Express, now R+L Carriers) should be avoided.

7.2.5 Fire Insurance Sanborn Map

No Fire Insurance Sanborn map was discovered through the EDR search for the subject tract and vicinity. The lack of Fire Insurance Sanborn maps indicate that this subject properties and surrounding area were not developed commercially or industrially, nor developed in a high density residential area before 1977.

7.2.6 Historic Topographic Maps

Seven historic topographic maps, 1903, 1932, 1952, 1958, 1979, 1983, and 1999 were discovered through the EDR search of the subject tract and vicinity. In 1903 and 1932, Damage Center 4 and surrounding area are open land with little development. In 1932 there was an active rail spur where an abandoned rail bridge near Mile 10.9, and Franklin Limestone Road was present. In 1952, there is indication that the quarry on the right bank is established, and there was a quarry on the left bank near Creek Mile 10.9. Ezell Park to the north was Central State Hospital land with no buildings on it. In 1968, the rail spur was abandoned, and a Mill Creek gauging station was present at the Franklin Limestone Bridge at Creek Mile 11.1. Damage Center 4 is still sparsely populated, and the area direct west of Antioch Pike is marked as urban area. The 1979 topographic map is approximately the same as 1968. In 1983, there are three new industrial building on the left bank, which are likely Roadway Express near Mile 11.2. There is a new industrial building on the right bank where Vulcan Quarry office building is now. More areas around Damage Center 4 are indicated as urban areas. The 1999 topo map indicates the hospital grounds is now a detention center, there are more industrial building at Vulcan Quarry, and the majority of land surrounding Damage Center 4 is designated urban area which abuts the left bank.

7.2.7 Historic Aerial Photographs

Twelve historic aerial photos, 1951, 1959, 1963, 1974, 1987, 1992, 1999, 2006, 2007, 2008, 2010, and 2012 were discovered through the EDR search of the subject tract and vicinity. The aerial photos are of good quality and most features are easy to distinguish. From 1951 through 1963, Damage Center 4 is rural farm land with rock quarry to the west of Mile 10.8 and downstream where Vulcan Quarry is located. In 1974, there appears to be industrial buildings on the right bank near Mile 10.9 through 11, on the left bank from Mile 11. 1 through11.3, the left bank adjacent to Mill Creek from Mile 10.9 to 11.I appears to be farm land, and the quarry areas on both sides of Mill Creek are still the same as in earlier aerials. 1974, 1987 and 1992 aerials look similar around Damage Center 4. In 1999, the farm land on the left bank between Mile 10.9 and 11.1 is replaced by an industrial warehouse sized building, and denuded or paved parking area surrounding the building, and right bank upstream is still forested while further distances is dense residential, or heavy industrial. The 2006, 2007, 2008, 2010 and 2012 aerial photos are similar to the 1999 aerial.

7.2.8 City Directory Search

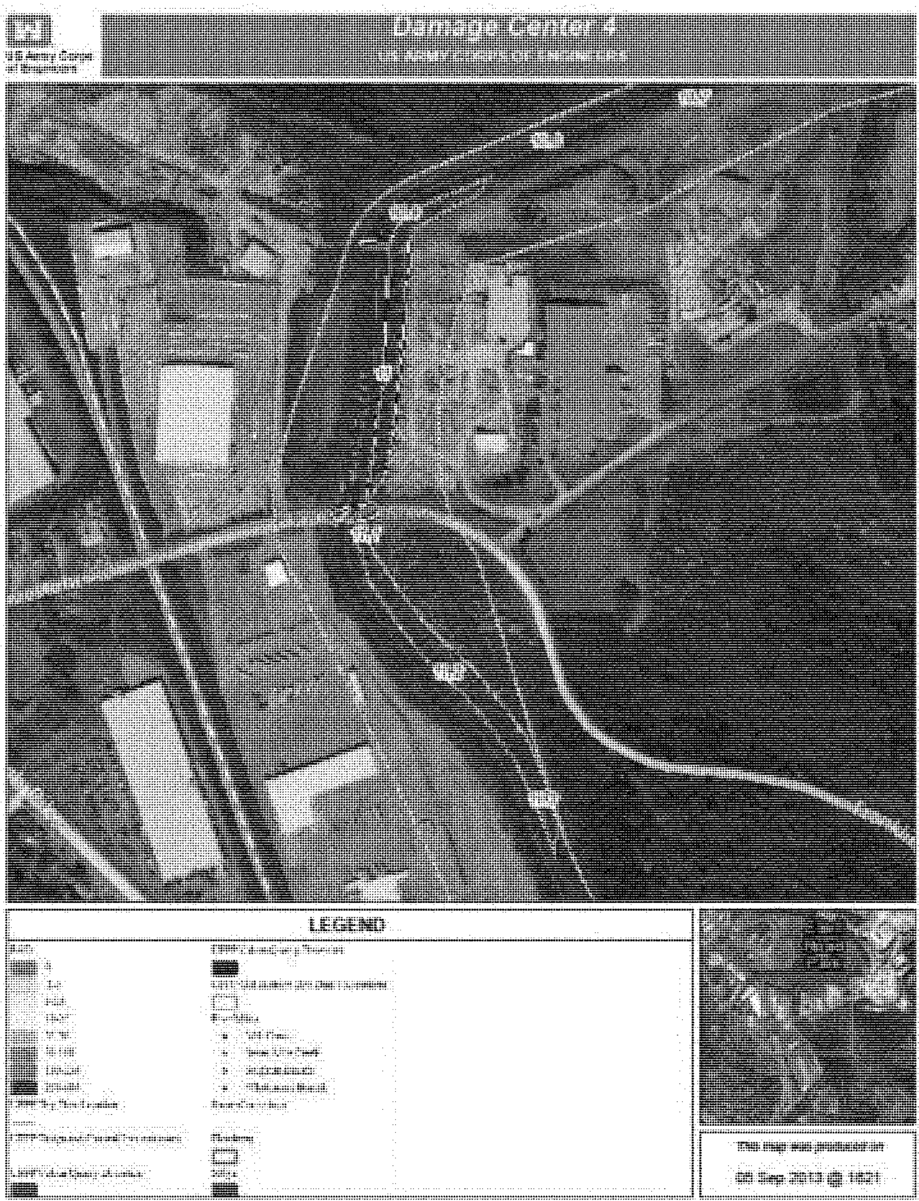
A City Directory Search was conducted for the subject area and vicinity. A city directory for the subject area and vicinity revealed no recognizable environmental concerns. All property listings were residential dating back to 1966.

7.3 CONCLUSIONS

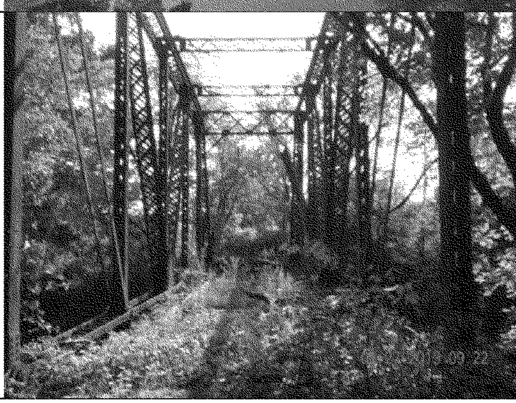
There are USEPA and TDEC regulated industries on the left bank of Damage Center 4 including Systech and Roadway Express. Systech at 1640 Antioch Pike had multiple compliance inspections for groundwater contamination. Roadway Express at 3240 Franklin Limestone Road had been issued multiple notices of violation and, a confirmed LUST which contaminated groundwater, is located adjacent to Mill Creek Mile 11.3, and has a NPDES permitted outfall which discharges treated groundwater (for solvents and petroleum) into Mill Creek near Creek Mile 11.3.

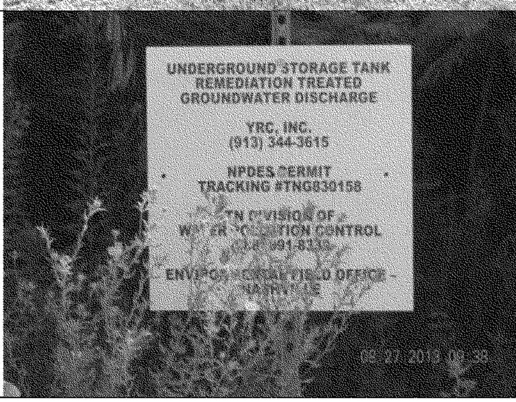
It is recommended to avoid work in Mill Creek at Damage Center 4. If work is unavoidable at Damage Center 4, it is recommended to avoid the left bank and the NPDES permitted outfall near Creek Mile 11, and approach Mill Creek from the right bank where Vulcan Quarry is located. Before any proposed project starts in Damage Center 4, CELRN should contact USEPA and request FOIA records for Systech EPA ID# TND000772277 to ensure Systech or current business at 1640 Antioch Pike in continued compliance, contact TDEC and request FOIA records for Waste Management at 1428 Antioch Pike Facility ID #SWP190001077 and Waste Management 3211 Franklin Limestone Road Facility ID #TRF190001410 to ensure continued compliance, and contact TDEC and request FOIA records or the Roadway Express NPDES permitted outfall TNG830158 to determine continued compliance.

7.4 SITE MAP



7.5 SITE PHOTOS

	1. On the Franklin Limestone Road Bridge at Creek Mile 11.1 facing downstream towards the north
	2. On the Franklin Limestone Road Bridge at Creek Mile 11.1 facing downstream towards the south
	3. On the left bank at the old rail road bridge near Creek Mile 10.9 facing east

	4. On the left bank at the old rail road bridge near Creek Mile 10.9 looking down. There is a flexible hose which is connected to a PVC pipe that leads into Mill Creek
	5. On the left bank at approximately Creek Mile 11.3 looking at the NPDES outfall #TNG830158 for the UST remediation treated groundwater of Roadway Express
	6. A close up photo of the sign for the NPDES outfall #TNG830158

8.0 ELLINGTON AGRICULTURAL CENTER CULVERT AND DRAINAGE IMRPOVEMENTS ALONG EDMONDSON PIKE

8.1 SITE DESCRIPTION

This is a culvert within Sevenmile Creek that crosses an unnamed road that serves as the eastern access road for the Ellington Agricultural Center off of Edmondson Pike. This proposed project also includes drainage improvements along Edmondson Pike just south of the eastern entrance to the Ellington Agricultural Center. Ellington Agriculture Center is along the left bank of Sevenmile Creek and a greenway path is along the right bank with no structures along it. The culvert project location is approximately 7 miles southeast of downtown Nashville at coordinates N36.062312, W-86.742095. This culvert is south of Whitfield Park and approximately 500 feet west of Edmondson Pike at Sevenmile Creek Mile 3.7. This culvert has two support spans that are in Sevenmile Creek which block debris during high water events and restrict flow along the creek (See photo 3 in section 8.5). A water line crosses that culvert on the downstream side. This water line would have to be considered if this culvert were to be replaced. The drainage improvements along Edmondson Pike are proposed to help prevent water from backing up onto Edmonson Pike during high water events. This proposed drainage improvement location is east of Sevenmile Creek Mile 3.9 along Edmonson Pike at approximate coordinates N36.059117, W-86.74147. No recognizable environmental concerns were observed during the site recon on 29 August 2013.

8.2 RECORDS REVIEW

The following sub-sections summarize the results of the environmental database searches.

8.2.1 Federal Database Search

EDR searched federal environmental databases including CERCLA, RCRA, NPL, Mines, DOD, DOE and NPDES databases. The subject area and vicinity were not identified in any of the Federal Databases searched for this project.

8.2.2 State Database Search

EDR searched state environmental databases including hazardous waste, solid waste, voluntary cleanup, leaking USTs, USTs, and engineering controls for the subject area and surrounding properties up to one mile. The subject area and vicinity were not identified in any of the State Databases searched for this project.

8.2.3 Tribal Database Search

EDR searched tribal leaking UST, UST, voluntary cleanup, and landfill databases for the subject area and surrounding properties up to one mile. The property search and radius search revealed no tribal registered sites within one mile of the subject property.

8.2.4 Other Environmental Databases Search

EDR searched local and other environmental databases including brownfields, landfills, hazardous sites, local land records, emergency release, dry cleaners, lead, PCBs, and manufacture gas plants for the subject tract and up to one-mile radius. The property search and radius search revealed two US Historical Auto Stations within ¼ mile of the subject property. One of which is located at 5104 Greentree Drive and is within the subject area, the latter is located at 705 Brent Glen Place and is ¼ mile upstream from the subject area. These locations are currently residential homes and therefore either the locations are no longer auto stations or the locations never were auto stations but rather mailing addresses. It is likely these were mailing addresses because the historic aerial photos do not show evidence of auto stations at these locations. Both sites are not believed to be an environmental concern towards the subject area because they are not currently in use.

8.2.5 Fire Insurance Sanborn Map

No Fire Insurance Sanborn map was discovered through the EDR search for the subject tract and vicinity. The lack of Fire Insurance Sanborn maps indicate that this subject properties and surrounding area were probably not developed commercially or industrially, nor developed in a high density residential area prior to 1977.

8.2.6 Historic Topographic Maps

Seven historic topographic maps, 1903, 1932, 1952, 1968, 1979, 1983, and 1999 were discovered through the EDR search of the subject tract and vicinity. There is no evidence of any large industry in the vicinity of the subject property that would impact the property environmentally. Historic topographic maps may be seen in.

8.2.7 Historic Aerial Photographs

Fourteen historic aerial photos, 1951, 1957, 1959, 1963, 1974, 1981, 1987, 1992, 1999, 2006, 2007, 2008, 2010, and 2012 were discovered through the EDR search of the subject tract and vicinity. The aerial photos quality range from poor to good and most features are hard to distinguish. The subject area appears to be mostly rural farm land in the 1951 photo including the Caldwell Estate which preceded the Ellington Agricultural Center. The aerial photograph shows residential structures and neighborhoods being built around 1957. The Ellington Agricultural Center was founded in 1963 and can be seen in the 1963 aerial photograph. Neighborhoods and other residential homes that exist today are mostly built and well established by 1974. The subject area is still a residential area today as the remaining aerial photographs depict. There is no evidence of any large industry in the vicinity of the subject property that would impact the property environmentally.

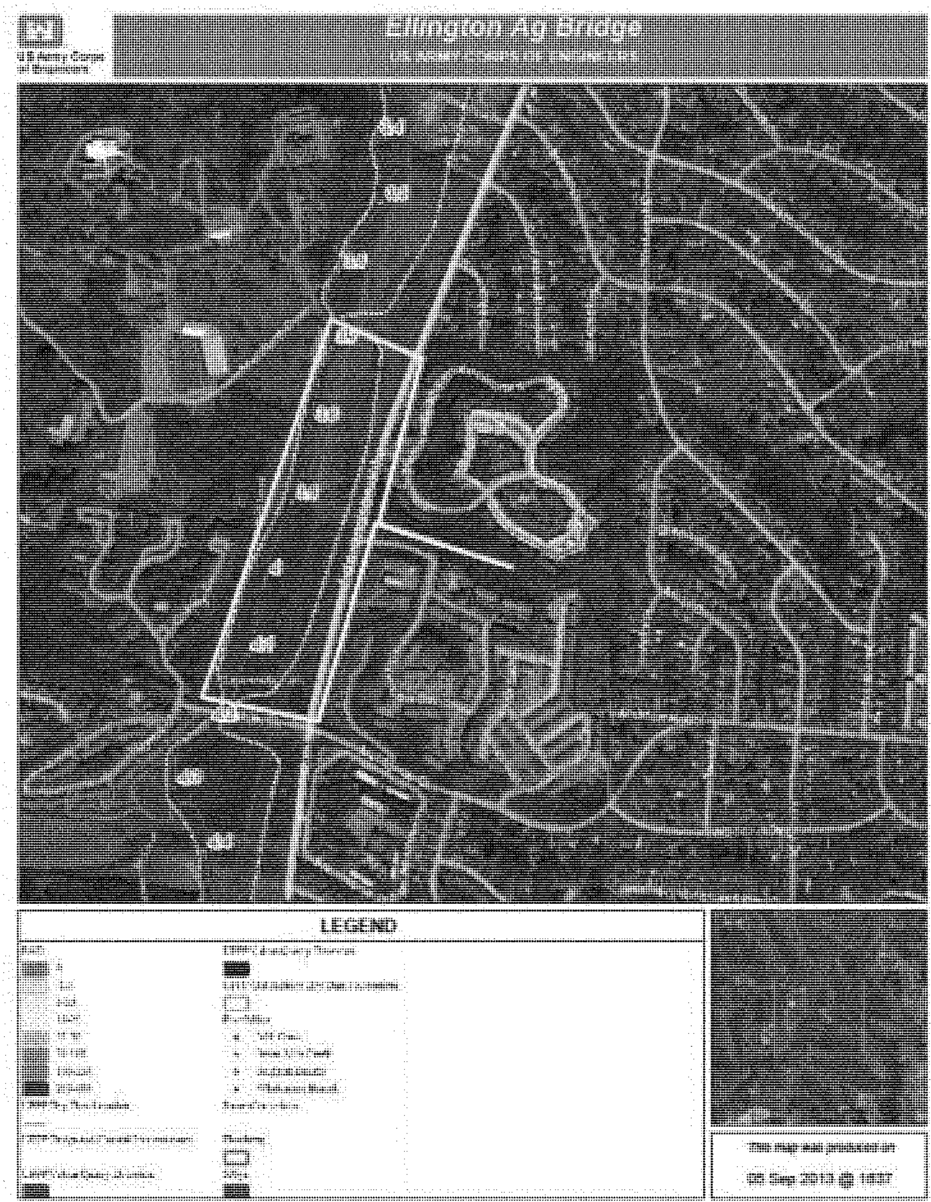
8.2.8 City Directory Search

A City Directory Search was conducted for the subject area and vicinity. A city directory for the subject area and vicinity revealed no recognizable environmental concerns. All property listings were residential dating back to 1908.

8.3 CONCLUSIONS

The environmental record search and site visit did not indicate an environmental liability or condition within the Ellington Agricultural Center subject area that would interfere with the proposed projects along Sevenmile Creek near Ellington Agricultural Center.

8.4 SITE MAP



8.5 SITE PHOTOS

	1. Standing on Bridge/Culvert (Ellington Ag Center access road from Edmondson Pike) on Sevenmile Creek Mile 4.2 facing upstream towards the south
	2. Standing on Bridge/Culvert (Ellington Ag Center access road from Edmondson Pike) on Sevenmile Creek Mile 4.2 facing downstream towards the north
	3. Standing on Bridge/Culvert (Ellington Ag Center access road from Edmondson Pike) on Sevenmile Creek Mile 4.2 facing upstream and looking down at the creek debris that is collecting and blocking the culvert flow path

9.0 OLD HICKORY DETENTION STRUCTURE

9.1 SITE DESCRIPTION

The proposed Old Hickory Detention Structure is near Mill Creek Mile 18. It is approximately 8 mile southeast of downtown Nashville at coordinates N36.015661, W-86.687965. It is currently an open field use for farming hay. Mill Creek flows along the eastern and southern portion of the field and to the west is Lennox Village and Sugar Valley residential neighborhoods. The proposed site and field are north of Culbertson Road and south of Baker Drive. Within the field is a natural gas pump station (See photo 2 in Section 9.5) and located on the west side of the field, there is an underground sewer line running northeast to southwest and located in the center of the field. The natural gas pump station has a fenced in gravel area that is accessible off of Kirkfield Drive. No recognizable environmental concerns were observed during the site recon on 27 August 2013. However, the pipeline and sewer would have to be considered during the design phase of this proposed plan were to be carried through.

9.2 RECORDS REVIEW

The following sub-sections summarize the results of the environmental database searches.

9.2.1 Federal Database Search

EDR searched federal environmental databases including CERCLA, RCRA, NPL, Mines, DOD, DOE and NPDES databases. The subject area and vicinity were not identified in any of the Federal Databases searched for this project.

9.2.2 State Database Search

EDR searched state environmental databases including hazardous waste, solid waste, voluntary cleanup, leaking USTs, USTs, and engineering controls for the subject area and vicinity up to one mile. The subject area and vicinity were not identified in any of the State Databases searched for this project.

9.2.3 Tribal Database Search

EDR searched tribal leaking UST, UST, voluntary cleanup, and landfill databases for the subject area and surrounding properties up to one mile. The property search and radius search revealed no tribal registered sites within one mile of the subject property.

9.2.4 Other Environmental Databases Search

EDR searched local and other environmental databases including brownfields, landfills, hazardous sites, local land records, emergency release, dry cleaners, lead, PCBs, and manufacture gas plants for the subject area and up to one-mile radius. The subject area and vicinity were not identified in any local or other environmental databases.

9.2.5 Fire Insurance Sanborn Map

No Fire Insurance Sanborn map was discovered through the EDR search for the subject tract and vicinity. The lack of Fire Insurance Sanborn maps indicate that this subject properties and surrounding area were probably not developed commercially or industrially, nor developed in a high density residential area prior to 1977.

9.2.6 Historic Topographic Maps

Seven historic topographic maps, 1903, 1932, 1952, 1968, 1979, 1983, and 1999 were discovered through the EDR search of the subject tract and vicinity. All of the topo maps show this area to be a fairly flat open area next to Mill Creek. The 1903 topo shows one unpaved road with one structure on the property, and it does not appear in the 1932 topo map. In 1968 through the most current topo map of 1999, the natural gas pipeline is in place and is located on the western portion of the subject area. There is no evidence of any large industry in the vicinity of the subject property that would impact the property environmentally.

9.2.7 Historic Aerial Photographs

Twelve historic aerial photos, 1951, 1959, 1963, 1974, 1987, 1992, 1999, 2006, 2007, 2008, 2010, and 2012 were discovered through the EDR search of the subject tract and vicinity. The aerial photos are of good quality and most features are easy to distinguish. The subject area is rural farm land in all aerial map years. The 1963 aerial shows a white stripe on the left portion of the subject area, and the white stripe is likely where the natural gas pipeline is located. The 1999 aerial shows the subject area is farm land, as well as surrounding area. The 2006, 2007, 2008 and 2010 aerials are similar and show some densely populated residential areas surrounding the subject area which is still farm land. There is a road and a square area where there is a gas pipeline pump station. The 2012 aerial is similar to the 2006 through 2010 aerials except for the light colored strip of land going through the center of the subject area, and that strip is the new sewer line for the area. There is no evidence of any large industry in the vicinity of the subject property that would impact the property environmentally.

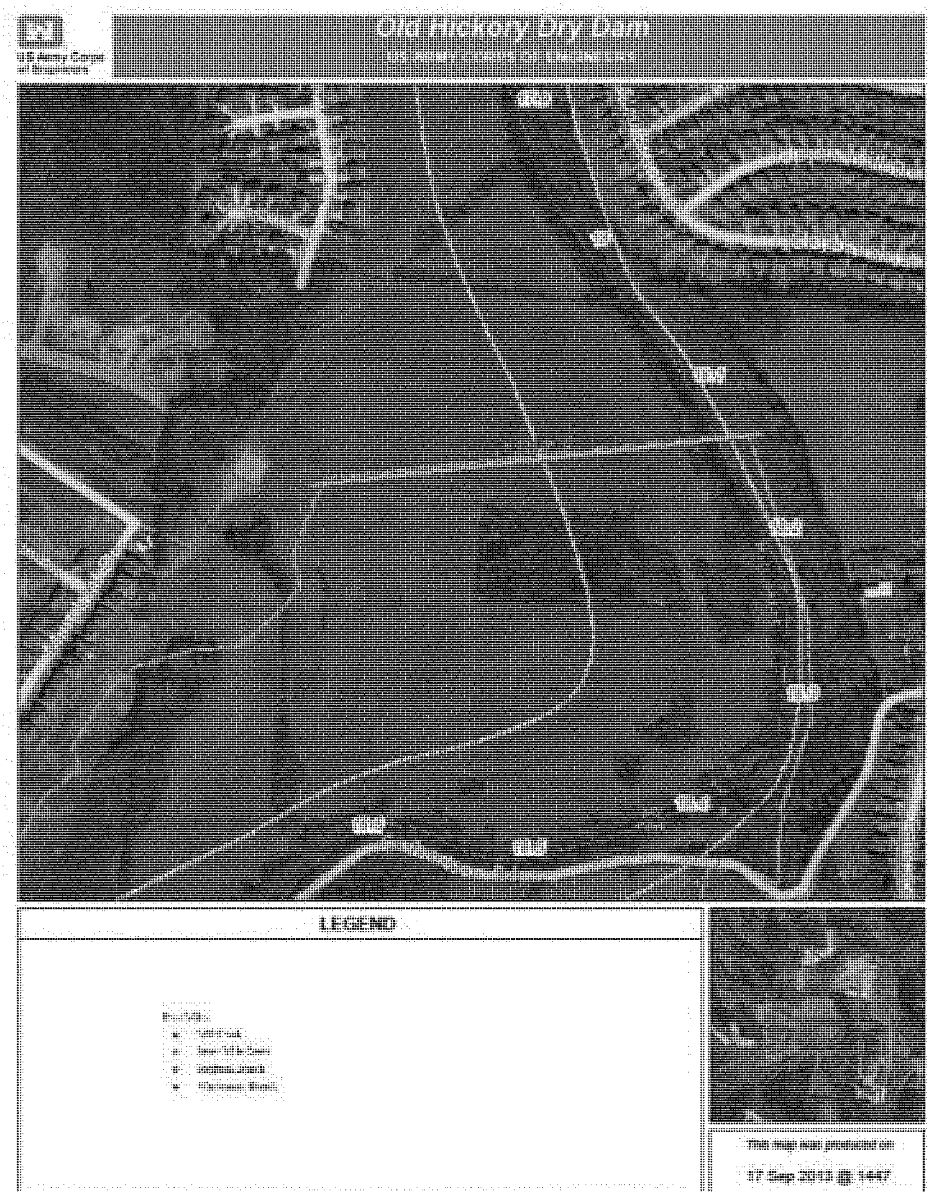
9.2.8 City Directory Search

A City Directory Search was conducted for the subject area and vicinity periodically from 1980 through 2013, and results were returned for 2007 and 2013. The city directory results indicate that the subject area and vicinity is residential, and there are no industrial or commercial entries. A city directory for the subject area and vicinity revealed no recognizable environmental concerns.

9.3 CONCLUSIONS

The environmental record search and site visit did not indicate an environmental liability or condition within the proposed Old Hickory Detention Structure area adjacent to Mill Creek Mile 18 that would interfere with the proposed project site.

9.4 SITE MAP



9.5 SITE PHOTOS

<table>
<tr><td></td><td>1. Standing on the west side of the field on the left bank near Mill Creek Mile 18.15 facing east looking at field proposed to become a detention structure</td></tr>
<tr><td></td><td>2. Standing on the west side of the field on the left bank near Mill Creek Mile 18.15 facing west looking at a natural gas pump station</td></tr>
<tr><td></td><td>3. Standing next to the fence at the natural gas pump station</td></tr>
</table>

10.0 SEVENMILE – EDMONDSON PIKE

10.1 SITE DESCRIPTION

This is a residential non-structural area located approximately 6.5 miles southeast form downtown Nashville along Sevenmile Creek Miles 1.9 – 3.1. It includes an area of homes along Miner and Suter Drive, on the western portion, and Edmondson Pike, on the eastern side. Toward the north of the residential area on the right bank of Sevenmile Creek is Wentworth Caldwell Sr. Park. Briarwood Drive is on the southern portion of the residential area and is accessible via Edmondson Pike. South of Briarwood Drive is Whitfield Park which is outside of the assessed area. Sevenmile Creek flows northeast into Mill Creek which eventually reaches the Cumberland River. The area consists of residential homes that appear to have been built between the 1960s and 1970s. Prior to that, the area was open fields, possibly used for farming. Located off of Edmondson Pike and adjacent to Wentworth Caldwell Sr. Park is an electrical substation which is not an environmental concern. No recognizable environmental concerns were observed during the site recon on 28 August 2013.

10.2 RECORDS REVIEW

The following sub-sections summarize the results of the environmental database searches.

10.2.1 Federal Database Search

EDR searched federal environmental databases including CERCLA, RCRA, NPL, Mines, DOD, DOE and NPDES databases. The subject area was not identified in any of the Federal Databases searched for this project.

Outside of the subject area but within a ¼ mile of the subject area, one RCRA-LQG and one RCRA-CESQG were identified. They RCRA sites are Park Ave Cleaners, 4122 Nolensville Road Nashville, TN 37211 (RCRA-CESQG) and Southern Hills Medical Center, 391 Wallace Road Nashville, TN 37211 (RCRA-LQG). Both of the RCRA listed sites are downstream from the subject area and therefore, regardless of their RCRA status, they are not believed to be an environmental concern towards the subject area because they are unlikely to impact the site.

10.2.2 State Database Search

EDR searched state environmental databases including hazardous waste, solid waste, voluntary cleanup, leaking USTs, USTs, and engineering controls for the subject area and surrounding properties up to one mile. The subject area was not identified in any of the State Databases searched for this project.

Outside of the subject area but within ¼ mile of the subject area the property search and radius search revealed seven USTs and six Historic (HIST) USTs. Outside of the subject area but within ½ mile of the subject area, the property search and radius search revealed six LUSTs, 8 LUST Trust Funds (TRUSTs), and three HIST_LUSTs CO.

All LUST and UST sites are downstream from the subject area and therefore, regardless of their State status, they are not believed to be an environmental concern towards the subject area because they are unlikely to impact the site.

10.2.3 Tribal Database Search

EDR searched tribal leaking UST, UST, voluntary cleanup, and landfill databases for the subject area and surrounding properties up to one mile. The property search and radius search revealed no tribal registered sites within one mile of the subject property.

10.2.4 Other Environmental Databases Search

EDR searched local and other environmental databases including brownfields, landfills, hazardous sites, local land records, emergency release, dry cleaners, lead, PCBs, and manufacture gas plants for the subject tract and up to one-mile radius. The property search and radius search revealed fifteen US Historic Auto Stations, six Historic Cleaners, four RCRA NonGen/NLR and one drycleaner within ¼ mile of the subject property.

Within the subject area, only one of the fifteen Historical Auto Stations was identified. This location, 4982 Edmondson Pike Nashville, TN 37211, was viewed on 28 August 2013 and was a residential home. Therefore, either the location is no longer an auto station or the location never was. Based on historical aerial photographs, it is likely that this location was never an auto station, rather it is possible it was just a mailing address. Within the subject area, only two of the six Historical Cleaners were indentified. These locations, 4958 and 4954 Edmondson Pike Nashville, TN 37211, are currently apartments/townhomes. Outside of the subject area, only one site, 5104 Greentree Drive Nashville, TN 37211, is upstream of the subject area. This site is listed as a Historical Auto Station but is currently a residential home. Based on historical aerial photographs, it is likely that this location was never an auto station, rather it was likely just a mailing address.

All of the listed Historical Auto Stations, Historical Cleaners, RCRA NonGen/NLR, and drycleaners are either not currently in use, are residential homes at this time, or are downstream of the subject area. Therefore, they are not believed to be an environmental concern towards the subject area because they are not in use or unlikely to impact the subject area.

10.2.5 Fire Insurance Sanborn Map

No Fire Insurance Sanborn map was discovered through the EDR search for the subject tract and vicinity. The lack of Fire Insurance Sanborn maps indicate that this subject properties and surrounding area were probably not developed commercially or industrially, nor developed in a high density residential area prior to 1977.

10.2.6 Historic Topographic Maps

Seven historic topographic maps, 1903, 1932, 1952, 1968, 1979, 1983, and 1999 were discovered through the EDR search of the subject tract and vicinity. There is no evidence of any large industry in the vicinity of the subject property that would impact the property environmentally.

10.2.7 Historic Aerial Photographs

Twelve historic aerial photos, 1957, 1959, 1963, 1974, 1987, 1992, 1999, 2006, 2007, 2008, 2010, and 2012 were discovered through the EDR search of the subject tract and vicinity. The aerial photos are of good quality and most features are easy to distinguish. The subject area is rural farm land until around 1963, when the aerial photograph shows residential structures and neighborhoods being built. The neighborhoods that exist today are mostly built and well established by 1974. The subject area is still a residential area today as the remaining aerial photographs depict. There is no evidence of any large industry in the vicinity of the subject property that would impact the property environmentally.

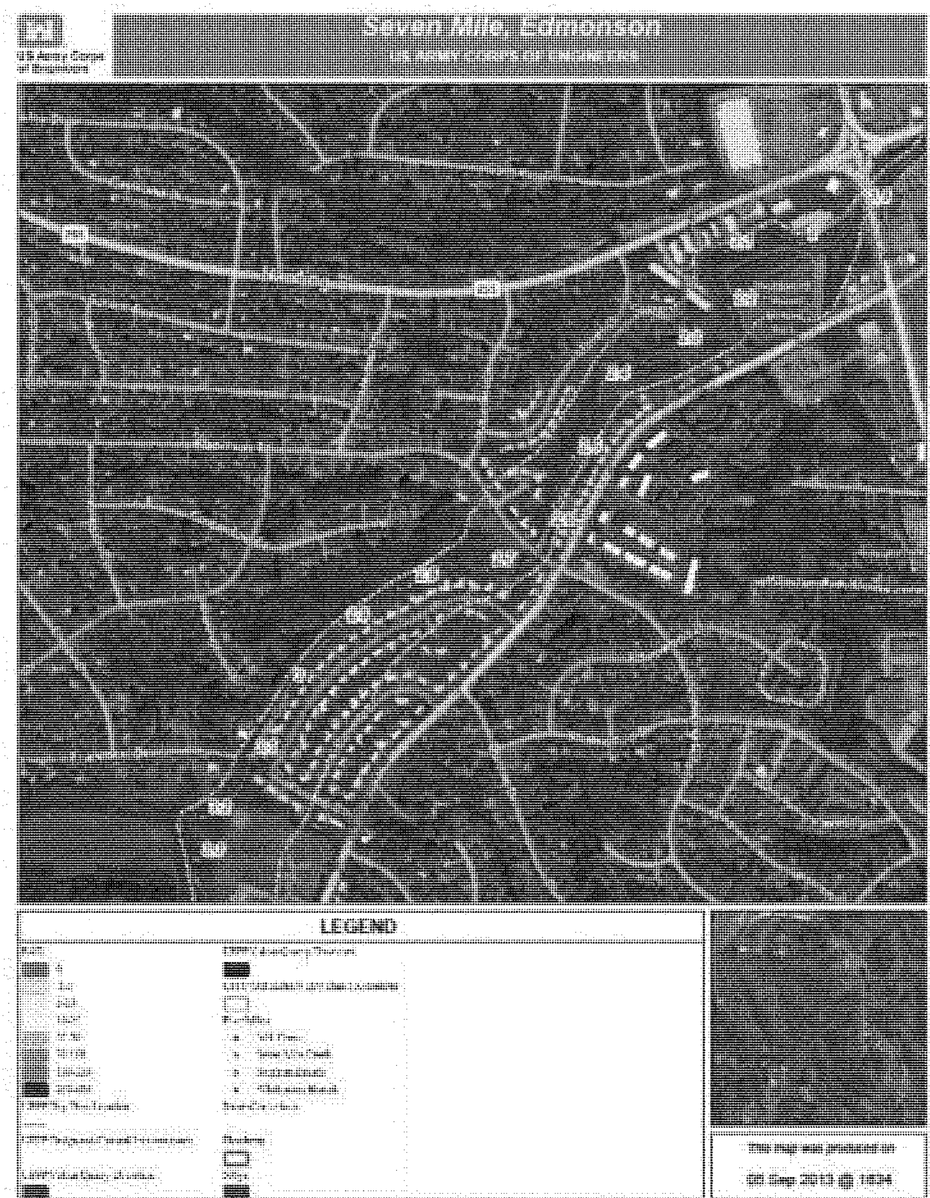
10.2.8 City Directory Search

A City Directory Search was conducted for the subject area and vicinity. A city directory for the subject area and vicinity revealed no recognizable environmental concerns. All property listings were residential dating back to 1966.

10.3 CONCLUSIONS

All of the listed potential Historical Auto Stations, Historical Cleaners, RCRA NonGen/NLR, and drycleaners are either not currently in use, are residential homes at this time, or are downstream of the subject area. Therefore, they are not considered to be an environmental concern towards the subject area because they are not in use or unlikely to impact the subject area. All federal and state listed sites are downstream of the subject area, and therefore not believed to be an environmental concern towards the subject area because they are unlikely to impact the site. The environmental records review and site visit did not indicate a recognizable environmental liability or condition within the Sevenmile Creek – Edmondson Pike subject area near Sevenmile Creek Miles 1.9 - 3.1.

10.4 SITE MAP


Seven Mile, Edmonson
US ARMY CORPS OF ENGINEERS
LEGEND
This map was produced on

10.5 SITE PHOTOS

	1. At an electrical sub-station near Sevenmile Creek Mile 2.25, on the right bank, facing northwest looking at Sevenmile Branch
	2. At an electrical sub-station near Sevenmile Creek Mile 2.25, on the right bank, facing west southwest looking at typical backyards of the Edmondson area

11.0 SEVENMILE- ELYSIAN FIELDS

11.1 SITE DESCRIPTION

This is a residential non-structural area located approximately 6 miles southeast form downtown Nashville along Sevenmile Creek Miles 0.5 – 1.25. It includes an area of homes that are along Cathy Jo Drive on the western portion and Benita Drive on the eastern side. Towards the north of the residential area and along the left bank of Sevenmile Creek is Sevenmile Court. Toward the north of the residential area on the right bank of Sevenmile Creek is Paragon Mills Park. Paragon Mills Road is on the southern portion of the residential area and crosses Sevenmile Creek near Dewain Drive. Sevenmile Creek flows northeast into Mill Creek which eventually reaches the Cumberland River. The area consists of residential homes that appear to have been built between the 1960s and 1970s. Prior to that, the area was open fields, possibly used for farming. Located between Paragon Mills Park and Sevenmile Creek, two concrete above ground storage tanks were seen (See photo 3, Section 11.5)These tanks appear to have been a part of a former Water Treatment Plant that is no longer in use. The 1963 historical aerial photograph for the area depicts what appears to be a Water Treatment Plant which did not exist in the 1959 aerial photograph. It cannot be determined when the plant stopped being used but the 1999 aerial photograph shows that the area is beginning to become overgrown with trees. No recognizable environmental concerns were observed during the site recon on 28 August 2013.

11.2 RECORDS REVIEW

The following sub-sections summarize the results of the environmental database searches.

11.2.1 Federal Database Search

EDR searched federal environmental databases including CERCLA, RCRA, NPL, Mines, DOD, DOE and NPDES databases. The subject area was not identified in any of the Federal Databases searched for this project.

Outside of the subject area but within a ½ mile of the subject area, one CERCLIS-NFRAP is present. It is ESB INC located at 147 Space Park S Nashville, TN 37211. ESB INC, is downstream and also has had no violations found. Therefore, the site is not believed to be an environmental concern towards the subject area.

11.2.2 State Database Search

EDR searched state environmental databases including hazardous waste, solid waste, voluntary cleanup, leaking USTs, USTs, and engineering controls for the subject area and surrounding properties up to one mile. The subject area was not identified in any of the State Databases searched for this project.

Outside of the subject area but within ¼ of the subject area, the property search and radius search revealed no USTs. Outside of the subject area but within ½ mile of the subject area, the property search and radius search revealed six LUSTs, three LUST TRUSTs, and one HIST_LUSTs CO. All six LUSTs are categorized as Case Closed or

Completed Tank Closure, all three LUST TRUSTs are categorized as Closed, and the HIST_LUST CO is incorporated with one of the Closed LUST TRUSTs.

Neither site is believed to be an environmental concern towards the subject area. All recognized LUSTs, LUST TRUSTs, and HIST_LUST CO within ½ mile of the subject area, are either categorized as Closed or Completed Tank Closure and no USTs were revealed within ¼ mile of subject area.

11.2.3 Tribal Database Search

EDR searched tribal leaking UST, UST, voluntary cleanup, and landfill databases for the subject area and surrounding properties up to one mile. The property search and radius search revealed no tribal registered sites within one mile of the subject property.

11.2.4 Other Environmental Databases Search

EDR searched local and other environmental databases including brownfields, landfills, hazardous sites, local land records, emergency release, dry cleaners, lead, PCBs, and manufacture gas plants for the subject area and up to one-mile radius. The property search and radius search revealed three US Historic Auto Stations, two US Historic Cleaners, two RCRA NonGen/NLR, and one priority cleaner within ½ mile of the subject area. None of the historic auto stations or historic cleaners are currently in business or adjacent to the subject area. Based on historic photographs, all of the addresses, except one, of the historic sites are residential structures of the same style of other residential structures on the same streets, so it is possible that the addresses were mailing addresses rather than auto stations or cleaner addresses. The one historic address that did not appear to be a residential structure is the former Wash Tub Coin Laundry on 4015 Travis Drive. The location of the former Wash Tub Coin Laundry is in a commercial area off of Nolensville Road and it is likely that the location was, in fact, a laundromat at one time. This location is over a ¼ mile upstream from the nearest buyout location which is along Paragon Mills Road. The properties along Paragon Mills Road do not directly back up to Sevenmile Creek and therefore it is not believed that the former Wash Tub Coin Laundry would have any environmental impact that would interfere with the nonstructural portion of this proposed project. It is unlikely that the potential historic auto stations or cleaners will cause an impact to the subject area. Neither of the two RCRA NonGen/NLR sites had any violations found and therefore are not believed to be an environmental concern towards the subject area. The one priority cleaner, U.S. $1.95 Cleaners, is listed as a Drycleaner Environmental Response Program remediation site. TDEC's Charles Rowan was contacted on 25 September 2013 to determine the status of the site and the extent of contamination. It was determined that the former U.S. $1.95 Cleaners is in the process of remediation of perchloroethene and is not adjacent to the subject area. The former U.S. $1.95 Cleaners is not believed to be an environmental concern towards the subject area because it is in the process of remediation which is overseen by TDEC and is not adjacent to the subject property.

11.2.5 Fire Insurance Sanborn Map

No Fire Insurance Sanborn map was discovered through the EDR search for the subject tract and vicinity. The lack of Fire Insurance Sanborn maps indicate that this subject properties and surrounding area were probably not developed commercially or industrially, nor developed in a high density residential area.

11.2.6 Historic Topographic Maps

Seven historic topographic maps, 1903, 1932, 1952, 1968, 1979, 1983, and 1999 were discovered through the EDR search of the subject tract and vicinity. There is no evidence of any large industry in the vicinity of the subject property that would impact the property environmentally.

11.2.7 Historic Aerial Photographs

Twelve historic aerial photos, 1951, 1959, 1963, 1974, 1987, 1992, 1999, 2006, 2007, 2008, 2010, and 2012 were discovered through the EDR search of the subject tract and vicinity. The aerial photos are of good quality and most features are easy to distinguish. The subject area is rural farm land until sometime before 1974, when the aerial photograph shows residential structures and neighborhoods. The neighborhoods that exist today are mostly built and well established by 1987. The subject area is still a residential area today as the remaining aerial photographs depict. There is no evidence of any large industry in the vicinity of the subject property that would impact the property environmentally.

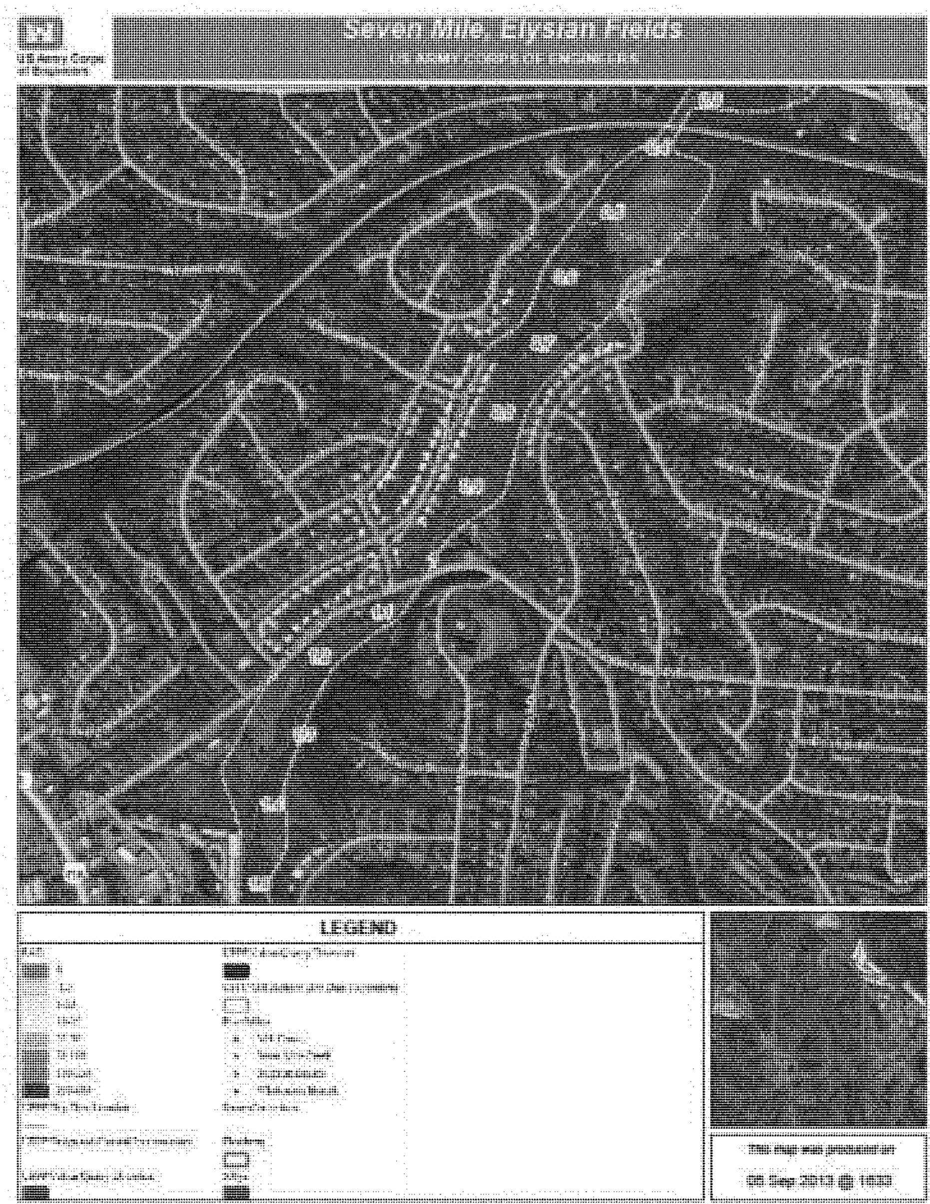
11.2.8 City Directory Search

A City Directory Search was conducted for the subject area and vicinity. A city directory for the subject area and vicinity revealed no recognizable environmental concerns. All property listings were residential dating back to 1990.

11.3 CONCLUSIONS

All Federal and State records were found to be downstream, have no record of violations, and/or have a tank closure status. All historic auto stations and historic drycleaners were determined to have never been an auto station or drycleaner, to be closed, and/or to not be adjacent to the subject area. All RCRA NonGen/NLR sites were found to not have any violations and the priority cleaners was found to be in remediation and adjacent to the subject area. The environmental records review and site visit did not indicate a recognizable environmental liability or condition within the Sevenmile Creek – Elysian Fields subject area that would interfere with the proposed work along Sevenmile Creek Miles 0.5 – 1.25. The HTRW analysis does not extend further upstream than Creek Mile 1.25.

11.4 SITE MAP


Seven Mile, Elysian Fields
US ARMY CORPS OF ENGINEERS
LEGEND
This map was produced on

11.5 SITE PHOTOS

	1. Standing on Paragon Mills Rd Bridge at Sevenmile Creek Mile 1 facing downstream towards the north
	2. Standing on Paragon Mills Rd Bridge at Sevenmile Creek Mile 1 facing upstream towards the south
	3. On the right bank of Sevenmile Creek near Creek Mile 0.6 in Paragon Mills Park facing two abandoned aboveground concrete storage tanks. It is possible these are historic water storage tanks storing water from Sevenmile Creek for the Paragon Mills area water supply

12.0 SORGHUM BRANCH – WILLARD DRIVE

12.1 SITE DESCRIPTION

This is a residential non-structural area located approximately 7 miles southeast from downtown Nashville, to the west of I-24 and along Sorghum Branch Creek Mile 1.7 to 2.7. It includes an area of homes that are along Margo Lane and West Valley Drive on the western portion and East Ridge and Creekside Drive on the eastern side. Just north of the residential area is the intersection of Harding Place and I-24. Packard Drive is on the southern portion of the residential area and crosses over Sorghum Branch near Cedar Hill Road. Sorghum Branch flows northeast into Mill Creek which eventually reaches the Cumberland River. This residential area encompasses the neighborhoods of Haywood Acres to the north and Locustwood to the south. The two neighborhoods are spilt by Haywood Lane. The area consists of residential homes that appear to have been built between the 1950s and 1960s. Prior to that, the area was open fields, possibly used for farming. No recognizable environmental concerns were observed during the site recon on 27 August 2013.

12.2 RECORDS REVIEW

The following sub-sections summarize the results of the environmental database searches.

12.2.1 Federal Database Search

EDR searched federal environmental databases including CERCLA, RCRA, NPL, Mines, DOD, DOE and NPDES databases. The subject area was not identified in any of the Federal Databases searched for this project.

Outside of the subject area but within a one mile of the subject area, one CORRACTS site exists. This site is the Systech Nashville/Pre-Treatment Center located at 1640 Antioch Pike. This site is considered to be CORRACTS because it was engaged in the treatment, storage, or disposal of hazardous waste. This particular site is nearly one mile east of the subject area along the banks of Mill Creek and is a part of a different tributary then Sorghum Branch. Therefore, it is not believed to be an environmental concern for this subject area because it cannot impact the site.

12.2.2 State Database Search

EDR searched state environmental databases including hazardous waste, solid waste, voluntary cleanup, leaking USTs, USTs, and engineering controls for the subject area and surrounding properties up to one mile. The subject area was not identified in any of the State Databases searched for this project.

Outside of the subject area but within ¼ mile of the subject area the property search and radius search revealed three USTs and three HIST USTs. Outside of the subject area but within ½ mile of the subject area, the property search and radius search revealed nine LUSTs, four LUST TRUSTs, one HIST_LUSTs CO, one Tennessee Institutional Control Site, and one Tennessee Volunteer Cleanup Program Site.

All sites are closed, downstream, and/or at a location where the topography is sloped away from Sorghum Branch. Therefore, if an environmental condition were present, it is unlikely that it would impact the subject area.

12.2.3 Tribal Database Search

EDR searched tribal leaking UST, UST, voluntary cleanup, and landfill databases for the subject area and surrounding properties up to one mile. The property search and radius search revealed no tribal registered sites within one mile of the subject property.

12.2.4 Other Environmental Databases Search

EDR searched local and other environmental databases including brownfields, landfills, hazardous sites, local land records, emergency release, dry cleaners, lead, PCBs, and manufacture gas plants for the subject tract and up to one-mile radius. The property search and radius search revealed three US Historical Auto Stations, six US Historical Cleaners, and three RCRA NonGen sites within ¼ mile of the subject area. Only one of which was identified within the subject area. It is the Freemon Carpet Service located at 304 Margo Lane Nashville, TN. This location was viewed on 27 August 2013 and was found to be a residential home. Therefore, it is not believed to be an environmental concern towards the subject area.

All of the listed Historical Auto Stations and Historical Cleaners are either not currently in use, are residential homes at this time, or are downstream of the subject area. Therefore, they are not believed to be an environmental concern towards the subject area because they are not in use or unlikely to impact the subject area. All RCRA/NonGen sites do not presently generate hazardous waste and are on the opposing side of Sorghum Branch. Therefore, if an environmental condition were present, it is unlikely that it would impact the subject area on the opposite side of the creek. These sites are not believed to be an environmental concern for this subject area.

12.2.5 Fire Insurance Sanborn Map

No Fire Insurance Sanborn map was discovered through the EDR search for the subject tract and vicinity. The lack of Fire Insurance Sanborn maps indicate that this subject properties and surrounding area were probably not developed commercially or industrially, nor developed in a high density residential area prior to 1977.

12.2.6 Historic Topographic Maps

Seven historic topographic maps, 1903, 1932, 1952, 1968, 1979, 1983, and 1999 were discovered through the EDR search of the subject tract and vicinity. There is no evidence of any large industry in the vicinity of the subject property that would impact the property environmentally.

12.2.7 Historic Aerial Photographs

Twelve historic aerial photos, 1951, 1959, 1963, 1974, 1987, 1992, 1999, 2006, 2007, 2008, 2010, and 2012 were discovered through the EDR search of the subject tract and vicinity. The aerial photos are of good quality and most features are easy to distinguish. The subject area is rural farm land until sometime before 1959, when the aerial photograph shows residential structures and neighborhoods being constructed. The neighborhoods that exist today are mostly built and well established by 1974. The subject area is still a residential area today as the remaining aerial photographs depict. There is no evidence of any large industry in the vicinity of the subject property that would impact the property environmentally.

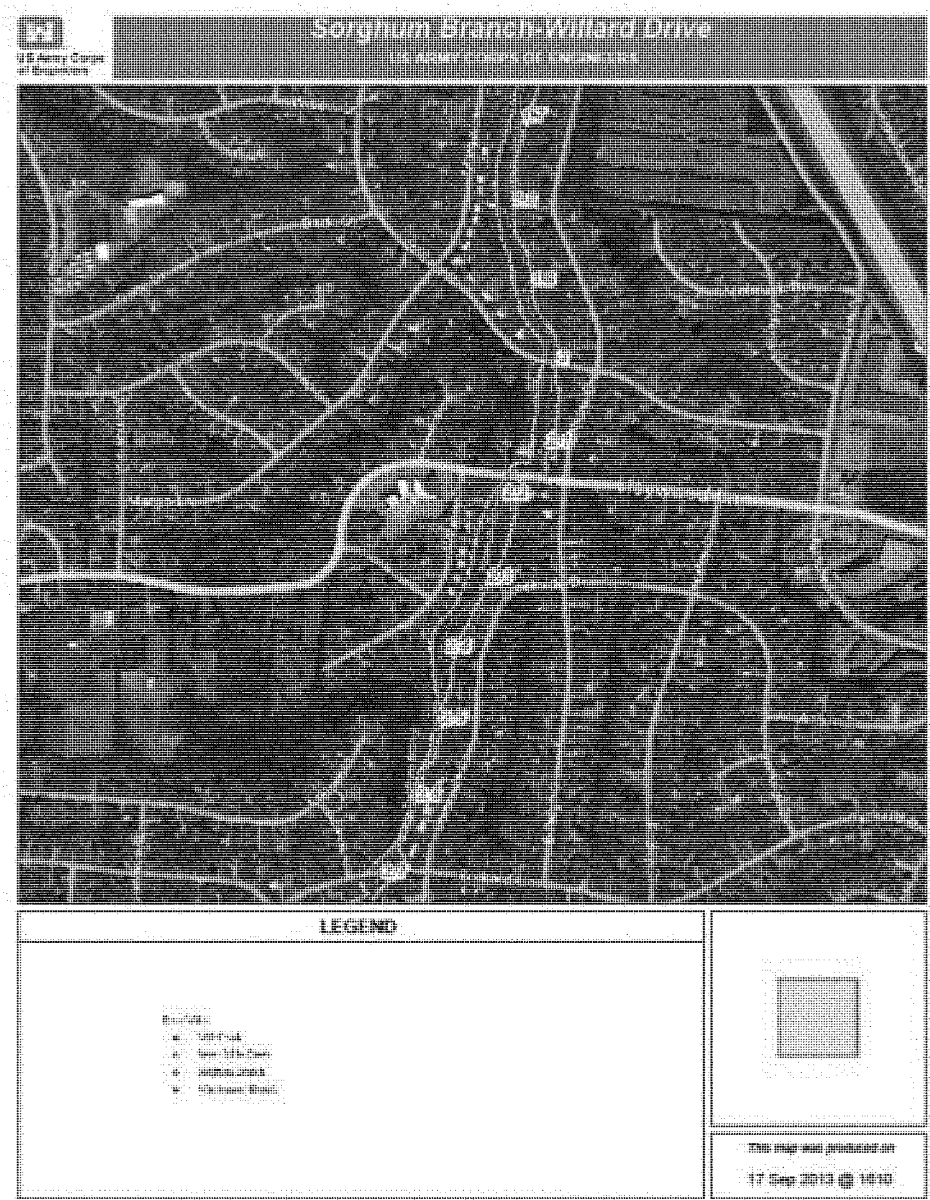
12.2.8 City Directory Search

A City Directory Search was conducted for the subject area and vicinity. A city directory for the subject area and vicinity revealed no recognizable environmental concerns. All property listings were residential dating back to 1962.

12.3 CONCLUSIONS

The environmental record search indicated environmental sites which are not adjacent to the subject area, do not exist, are residential structures, not in the same tributary system as Sorghum Branch or downstream of Sorghum Branch Creek Mile 1.7. The environmental records review and site visit did not indicate a recognizable environmental liability or condition within the Sorghum Branch Creek Miles 1.7 – 2.7.

12.4 SITE MAP


Sorghum Branch-Willard Drive
LEGEND
This map was produced on

12.5 SITE PHOTOS

There are no site photos of this proposed project area. There was no public access point to Sorghum Branch in the proposed project area, so there are no photos of Sorghum Branch. During the Site Recon, it was deemed inappropriate to photograph private homes at this time, so there is no area photo.

13.0 WHITTENMORE BRANCH – BENZING ROAD

13.1 SITE DESCRIPTION

This is a residential non-structural area located approximately 9 miles southeast form downtown Nashville between Whittenmore Branch River Miles 0.5 and 1.8. It includes an area of homes that are along Shihmen and Brook Drive, on the western portion, and Benzing Road, on the eastern side. Bell Road is on the southern portion of the residential area and crosses over Whittenmore Branch near Brookview Estates Drive. Whittenmore Branch flows northeast into Mill Creek which eventually reaches the Cumberland River. This residential area encompasses the neighborhoods of Antioch Park to the north and Whittenmore Valley to the south. The two neighborhoods are spilt by Tusculum Road. The area consists of residential homes that appear to have been built between the 1960s and 1970s. Prior to that, the area was open fields, possibly used for farming. Along Benzing Road, between Tusculum Road and Brookview Estates Drive, near 229 Benzing Rd, there appeared to be an abandoned driveway with illegal dumping of household debris, trash and old furniture (See photo 2 in Section 13.5). This illegal dump site did not appear to be an environmental concern, rather just household trash and debris, and no recognizable environmental concerns were observed during the site recon on 27 August 2013.

13.2 RECORDS REVIEW

The following sub-sections summarize the results of the environmental database searches.

13.2.1 Federal Database Search

EDR searched federal environmental databases including CERCLA, RCRA, NPL, Mines, DOD, DOE and NPDES databases. The subject area and adjacent properties up to one mile were not identified in any of the Federal Databases searched for this project.

13.2.2 State Database Search

EDR searched state environmental databases including hazardous waste, solid waste, voluntary cleanup, leaking USTs, USTs, and engineering controls for the subject area and surrounding properties up to one mile. The subject area was not identified in any of the State Databases searched for this project.

Outside of the subject area but within ¼ mile of the subject area the property search and radius search revealed three USTs and three HIST USTs. Outside of the subject area but within ½ mile of the subject area, the property search and radius search revealed six LUSTs, and one LUST TRUSTs.

All USTs are in compliance, all HIST USTs are permanently out of use, all LUSTs are categorized as Case Closed or Completed Tank Closure, and the LUST TRUST is categorized as Closed. It is unlikely that an environmental condition is present that would impact the subject area.

13.2.3 Tribal Database Search

EDR searched tribal leaking UST, UST, voluntary cleanup, and landfill databases for the subject area and surrounding properties up to one mile. The property search and radius search revealed no tribal registered sites within one mile of the subject property.

13.2.4 Other Environmental Databases Search

EDR searched local and other environmental databases including brownfields, landfills, hazardous sites, local land records, emergency release, dry cleaners, lead, PCBs, and manufacture gas plants for the subject tract and up to one-mile radius. The property search and radius search revealed four Historic Auto Stations and two Historic Cleaners within ¼ mile of the subject area. Only one of which was identified within the subject area. It is listed as a Historic Cleaners located at 115 Tusculum Road Antioch, TN 37013. This property was viewed on 27 August 2013 and was found to be a residential home. All other Historic Auto Stations and Historic Cleaners were found to be residential homes except for an auto station located at 1451 Bell Road Nashville, TN 37211. This property is currently Price's Collision Center and is almost a ¼ mile east of the subject area. There are no listed violations or reason to believe this property would have an environmental impact on the subject area.

13.2.5 Fire Insurance Sanborn Map

No Fire Insurance Sanborn map was discovered through the EDR search for the subject tract and vicinity. The lack of Fire Insurance Sanborn maps indicate that this subject properties and surrounding area were probably not developed commercially or industrially, nor developed in a high density residential area prior to 1977.

13.2.6 Historic Topographic Maps

Seven historic topographic maps, 1903, 1932, 1952, 1968, 1979, 1983, and 1999 were discovered through the EDR search of the subject tract and vicinity. There is no evidence of any large industry in the vicinity of the subject property that would impact the property environmentally.

13.2.7 Historic Aerial Photographs

Twelve historic aerial photos, 1951, 1959, 1963, 1974, 1987, 1992, 1999, 2006, 2007, 2008, 2010, and 2012 were discovered through the EDR search of the subject tract and vicinity. The aerial photos are of good quality and most features are easy to distinguish. The subject area is rural farm land until sometime before 1974, when the aerial photograph shows residential structures and neighborhoods being constructed. The neighborhoods that exist today are mostly built and well established by 1987. The subject area is still a residential area today as the remaining aerial photographs depict.

There is no evidence of any large industry in the vicinity of the subject property that would impact the property environmentally.

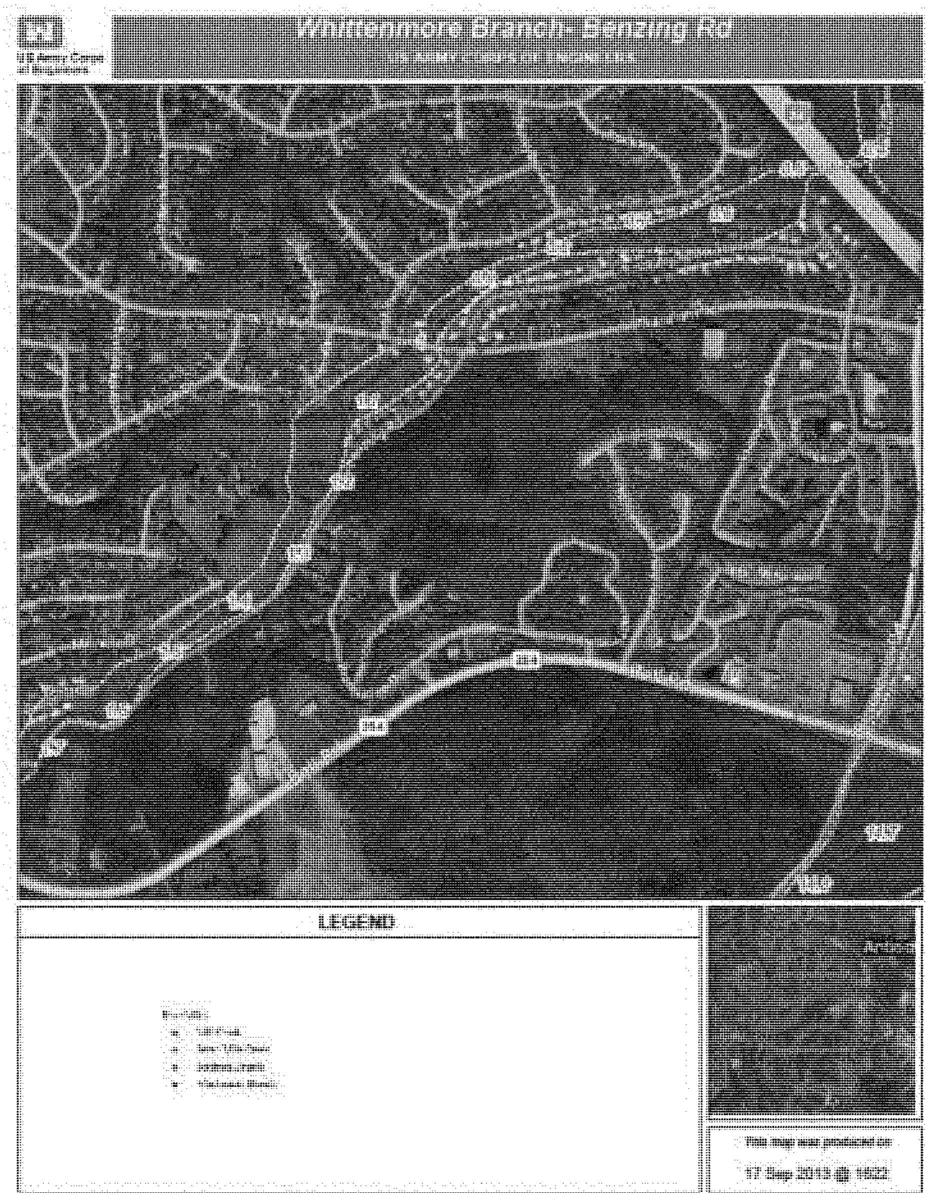
13.2.8 City Directory Search

A City Directory Search was conducted for the subject area and vicinity. A city directory for the subject area and vicinity revealed no recognizable environmental concerns. All property listings were residential dating back to 1980.

13.3 CONCLUSIONS

The environmental record search indicated environmental sites which are not adjacent to the subject area, are incompliance, or downstream of Whittenmore Branch Creek Mile 0.5. The environmental records review and site visit did not indicate a recognizable environmental liability or condition within the Whittenmore Branch Creek Miles 0.5 – 1.8.

13.4 SITE MAP


Whittenmore Branch- Benzing Rd
LEGEND
This map was produced on
17 Sep 2013 @ 1522

13.5 SITE PHOTOS

	1. Standing on the right bank of Whittenmore Branch near Creek Mile 0.6 facing north looking at Whittenmore Branch. This area approximately between Creek Mile 0.55 and 0.65 does not have residential structures and appears to be a "buy out" area after the 2010 flood
	2. On the right bank of Whittenmore Branch near 229 Benzing Rd, coordinates N36.048323, W-86.686399, is what appears to be an abandoned driveway with illegal dumping of household debris and trash bags

14.0 WIMPOLE DRIVE

14.1 SITE DESCRIPTION

Wimpole Drive is located on the right bank of Damage Center 1 on Mill Creek at Creek Mile 5.1 – 6.1 with approximate coordinates N36.12297, W-86.722469. Wimpole Drive is a well established residential area on both sides of the street. Wimpole Drive is on the right bank and is a residential area which was established in the 1950s. At approximately Creek Mile 5.6 – 5.8, adjacent to Mill Creek is an area where Metro Nashville Government has purchased properties, and leased the land to HON to create an Urban Garden and add a riparian buffer zone to Mill Creek. During the site visit on 26 August 2013, on Wimpole Drive near Creek Mile 5.1 was an illegal dump pile of household trash bags, a gymnastics mat and TV (See photo 3 in Section 14.5). This pile is likely not an HTRW issue, but no trash bags were opened to determine the content of the bags. The other parts of Wimpole Drive were well kept residential structures and property.

14.2 RECORDS REVIEW

The following sub-sections summarize the results of the environmental database searches.

14.2.1 Federal Database Search

EDR searched federal environmental databases including CERCLA, RCRA, NPL, Mines, DOD, DOE and NPDES databases. There are four federally listed environmental sites within proximity of Damage Center 1 and Wimpole Drive.

Safety Kleen at 215 Whitsett St is approximately 0.8 miles WSW of Mile 5.9 and on the left bank of Mill Creek. Because of the distance from Wimpole Drive, and being on the opposite bank, it is unlikely that Safety Kleen would impact any non-structural project sites on Wimpole Drive. See Damage Center 1 Section of this report for more detailed summary of Safety Kleen.

There are three sites that are registered as RCRA-CESQG, meaning the business generate less than 100 kg of hazardous waste or less than 1 kg of acutely hazardous waste per month. Exxon Mobil 1083 Murfreesboro Rd, @ Your Service 304 E. Thompson Lane, and Prestige Cleaners 304 E Thompson Lane (EDR record states incorrectly 1100 Murfreesboro Rd) are listed. All of the RCRA-SESQG sites are down stream of Wimpole Drive, and it would be unlikely that the RCRA-CESQGs would impact any non-structural project sites on Wimpole Drive. See Damage Center 1 Section of this report for more detailed summary of the RCRA-CESQGs.

14.2.2 State Database Search

EDR searched state environmental databases including hazardous waste, solid waste, voluntary cleanup, leaking USTs, USTs, and engineering controls for the subject area and surrounding properties up to one mile. There are five sites listed with USTs or leaking USTs within ½ mile of Damage Center 1 Wimpole Road.

The five sites with state registered USTs or leaking USTs are 304 E Thompson Lane, 1083 Murfreesboro Rd, 109/619 Millwood Dr, 1090 Murfreesboro Rd, and 1174

Murfreesboro Rd. 304 Thompson was a gas station in 1955 through 1994 when the last of 9 USTs were taken permanently out of use. All of the registered UST sites are down stream of Wimpole Drive, and it would be unlikely that the USTs would impact any non-structural project sites on Wimpole Drive. See Damage Center 1 Section of this report for more detailed summary of the five sites with state registered USTs.

14.2.3 Tribal Database Search

EDR searched tribal leaking UST, UST, voluntary cleanup, and landfill databases for the subject area and surrounding properties up to one mile. The property search and radius search revealed no tribal registered sites within one mile of the subject property.

14.2.4 Other Environmental Databases Search

EDR searched local and other environmental databases including brownfields, landfills, hazardous sites, local land records, emergency release, RCRA-non-generators, dry cleaners, lead, PCBs, and manufacture gas plants for Damage Center 1 and up to one-mile radius.

There are 7 RCRA non-hazardous waste generators downstream of Wimpole Drive, they do not generate hazardous waste, and have no known environmental violations. It is unlikely that these sites would impact any non-structural project sites on Wimpole Drive.

There are 23 potential historic gas station or services stations listed in the EDR results. For the majority of the potential historic gas stations or service station, there is no data available because they were either shutdown prior to the TDEC UST registry, or they were not a gas station. A few of the listed potential gas stations were closed with no further action required by TDEC UST. All of listed sites are either not adjacent to Wimpole Drive, or are on Murfreesboro Rd, which is down stream of Wimpole Drive. It is unlikely that any of the 23 potential historic gas stations will impact any non-structural project sites on Wimpole Drive.

There are 17 potential and historic dry cleaners listed in the EDR results. The 17 sites include current dry cleaners with no violations, coin operated laundry, retail cleaning equipment sales, and potential historic cleaners. None of the sites are adjacent to Wimpole Drive or on Murfreesboro Rd which is down stream of Wimpole Drive. It is unlikely that any of the 17 potential historic dry cleaners will impact any non-structural projects on Wimpole Drive.

14.2.5 Fire Insurance Sanborn Map

Two Fire Insurance Sanborn maps, 1957 and 1963 were discovered through the EDR search for the intersection of E Thompson Lane and Murfreesboro Rd. This section is down stream of Wimpole Drive, and any businesses in this area will not affect Wimpole Drive.

14.2.6 Historic Topographic Maps

Nine historic topographic maps, 1903, 1932, 1952, 1957, 1968, 1979, 1983, 1997 and 1999 were discovered through the EDR search of the subject tract and vicinity. In 1903 and 1932, Mill Creek at Damage Center 1 Wimpole Drive and adjacent area were sparsely populated and there appeared to be open land. In 1952, 1957 and 1968, only a small downstream area appears on the map. The 1968 and 1979 topo map indicates Wimpole Rd is a fully developed urban area. The 1983 topo map shows heavy urban areas. The 1997 and 1999 topo maps no longer show structures, only heavy urban zones.

14.2.7 Historic Aerial Photographs

Twelve historic aerial photos, 1951, 1959, 1963, 1974, 1987, 1992, 1999, 2006, 2007, 2008, 2010, and 2012 were discovered through the EDR search of the subject tract and vicinity. The aerial photos are of good quality and most features are easy to distinguish. The 1951 aerial shows the land surrounding Mill Creek near Wimpole Drive as mostly rural agriculture with the beginning of Wimpole Drive on the north portion, but there are no houses on the street. In 1959, the areas to the north and east of Mill Creek are still forest or agricultural, and the residential area of Wimpole Rd and vicinity are nearly fully developed. The 1963 aerial shows the north side of Mill Creek being residentially developed, Wimpole Rd and south is heavily residentially developed, Murfreesboro Rd is being commercially developed, and the drive-in movie theater is still next to Mill Creek. The 1974, 1987, 1992, and 1999 aerials are similar, with the residential areas north and south of Mill Creek being fully residentially developed, Murfreesboro Road being commercially developed, and the drive-in movie theater has been replaced by commercial buildings and parking areas. In 2006, 2007, 2008 and 2010 show that Wimpole Rd residential structures from Creek Mile 5.7 – 5.8 have been removed, and the photo edge ends there. In 2012, it appears that Wimpole Rd between Creek Mile 5.7 – 5.8 is being prepared as the HON Urban Garden.

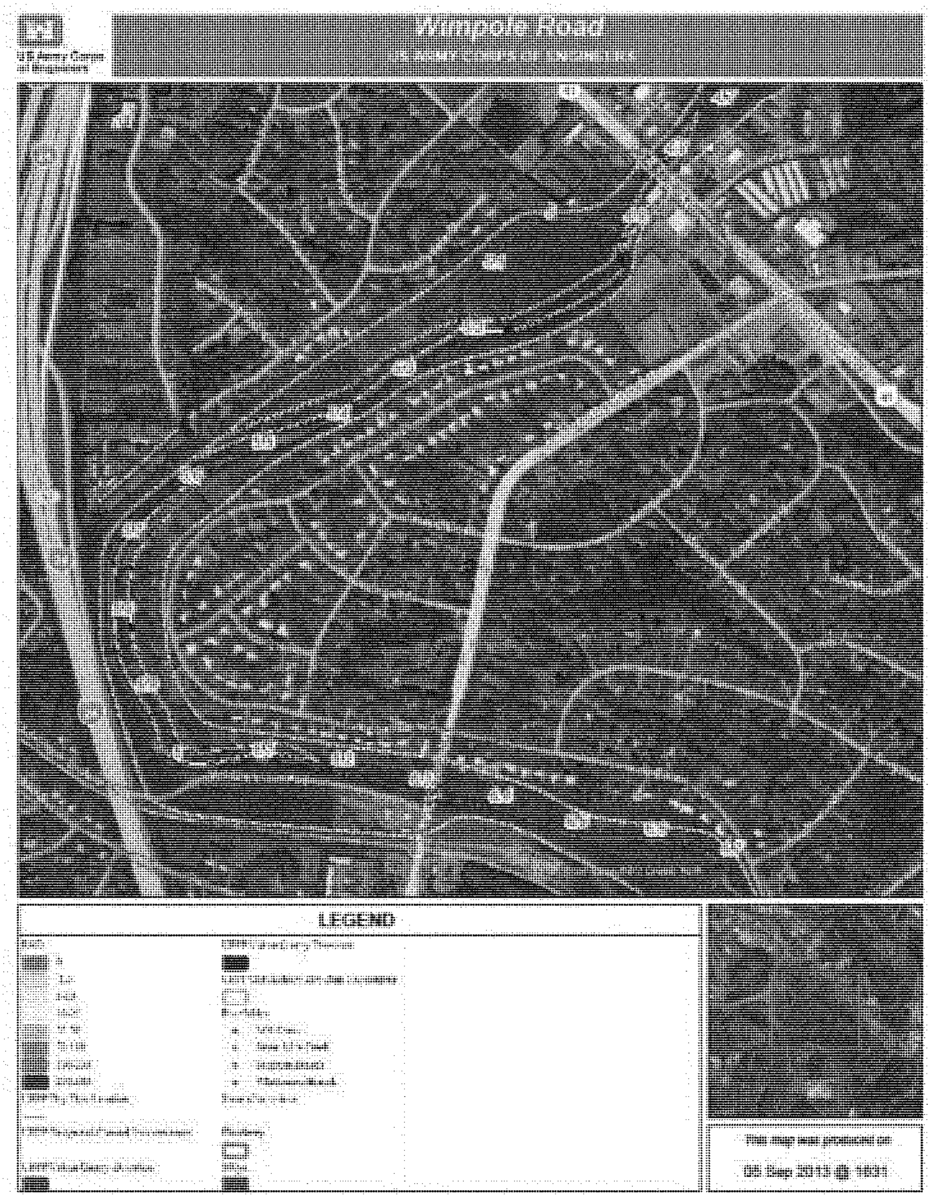
14.2.8 City Directory Search

A City Directory Search was conducted for the subject area and vicinity for periodic intervals from 1908 through 2012, with data returned for1946 periodically through 2012, with the majority of results from the most recent 20 years. The City Directory search indicates that the area has a wide range of uses from residential to commercial. No large heavy industry was indicated in the City Directory Search that would indicate a recognizable environmental condition that was not already identified in the federal, state and local environmental records.

14.3 CONCLUSIONS

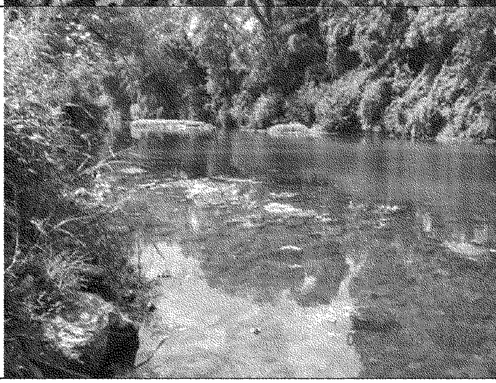
Wimpole Drive is a residential street adjacent to Mill Creek Miles 5.2 – 6.2. Wimpole Drive is a well maintained residential area with an Urban Garden on the western portion of the street adjacent to Mill Creek. An illegal trash pile was seen during the site visit on 26 August 2013 including a rubber mat, a TV and trash bags. The trash does not appear to be an HTRW concern. There are no recognizable environmental conditions seen in the EDR records search or site visit that would interfere with any non-structural projects on Wimpole Drive.

14.4 SITE MAP



14.5 SITE PHOTOS

	1. Standing on the right bank at Creek Mile 5.1 facing downstream towards the northeast looking at Mill Creek
	2. Standing on the right bank at Creek Mile 5.1 facing upstream towards the southwest looking at Mill Creek
	3. Standing on the right bank at approximately Mile 5.1 there is an illegal dump site with a TV, rubber mat, and trash bags.

	4. Standing on the right bank near Creek Mile 5.6 is the HON Urban Garden with a protected riparian buffer zone between the garden and Mill Creek.
	5. Standing on the left bank at Creek Mile 6.3 facing downstream towards the west looking at Mill Creek

15.0 HTRW FINDINGS AND CONCLUSIONS

EC-E conducted a visual inspection where practicable and conducted an environmental records review for each measure or proposed project site to identify HTRW concerns. CELRN contracted EDR, Inc to provide environmental records searches for each measure or proposed project site for Mill Creek and tributaries. The environmental records searches fulfill the records search requirements of AAI 40 CFR 312, ASTM-E1527 and ASTM-E1528. The 11 measures and proposed project areas EC-E reviewed are as follows:

- Damage Center 1 – proposed channel improvements to Mill Creek Miles 4.8 – 6.2.
- Damage Center 2 – proposed channel improvements to Mill Creek Miles 6.9 - 7.9.
- Damage Center 3 – Mill Creek Miles 11.7 - 12.1, currently no proposed projects.
- Damage Center 4 – proposed channel improvements to Mill Creek Miles 10.8 – 11.3.
- Ellington Agriculture Center Culvert and Drainage Improvements to Sevenmile Creek Miles 3.7 – 4.2.

- Old Hickory Detention Structure at Mill Creek Mile 18.0.
- Sevenmile Edmondson Pike area – residential non-structural area near Sevenmile Creek Miles 1.9 – 3.1.
- Sevenmile Elysian Fields area – residential non-structural area near Sevenmile Creek Miles 0.5 – 1.5.
- Sorghum Branch Willard Drive area – residential non-structural area near Sorghum Branch Creek Miles 1.7 – 2.7.
- Whittenmore Branch Benzing Road area – residential non-structural area near Whittenmore Branch Creek Miles 0.5 – 1.8.
- Wimpole Drive – residential non-structural area near Mill Creek Miles 5.1 - 6.1.

15.1 HTRW SUMMARY FOR STRUCTURAL AREAS

There are five stretches of Mill Creek and one stretch of Sevenmile Creek of which are potential channel or structural improvement areas. The following subsections summarize HTRW findings for the six potential channel or structural improvement areas.

15.1.1 Damage Center #1

Damage Center 1 Mill Creek Miles 4.8 – 6.2. Damage Center 1 is mostly residential with the most downstream portion being a heavy commercial area of Murfreesboro Road and East Thompson Lane. Currently operating facilities which are environmentally registered or regulated are all currently in compliance. There are potential historic gas stations and dry cleaners which were mostly located on the downstream portion of Damage Center 1, which may or may not have impacted Mill Creek in the past. Without environmental records for the historic gas stations and dry cleaners, EC-E cannot determine potential impact from the potential historic gas stations and dry cleaners upon Mill Creek without further field investigation. If there is a proposed project to be conducted at Damage Center 1, because of the 40 historic gas stations and dry cleaners and the heavy commercial area around Murfreesboro Road, it is recommended that Mill Creek Miles 4.8 – 4.9 and the commercial area on Murfreesboro Road and East Thompson Lane be avoided. If a proposed project in the vicinity of Creek Mile 4.8 – 4.9 is unavoidable, E&E should conduct a field investigation near this portion of Mill Creek to determine the nature of contamination and impact to Damage Center 1.

There are two active gas stations near Creek Mile 4.8 – 4.9. Mapco Express and Kwik Tobacco Market gas stations have no current records of releases or spills as of September 2013. If there is a future leak or spill from Mapco Express or Kwik Tobacco Market, that spill or leak may impact Damage Center 1. If work around Creek Mile 4.8 – 4.9 is unavoidable, prior to any work starting in Damage Center 1, CELRN should contact TDEC UST and request FOIA records for Mapco Express TDEC UST Facility Number 5190938 and for Kwik Tobacco Market TDEC UST Facility Number 519791 to ensure the gas stations' continued compliance.

15.1.2 Damage Center #2

Damage Center 2 is Mill Creek Miles 6.7 – 7.9. Damage Center 2 was undeveloped until the 1970s when there was an increase in densely populated residential areas in the vicinity, as well as the development of Space Park, I-24 and Briley Parkway. There are multiple facilities listed in federal, state and other environmental databases. The listed facilities are currently in compliance. Some facilities have environmental violations, but corrected the violations and are currently in compliance. There are no known current environmental conditions that would impact the proposed work at Damage Center 2.

15.1.3 Damage Center #3

Damage Center 3 is Mill Creek Miles 11.7 – 12.1. There are no measures or proposed project sites in Damage Center 3. EC-E did not conduct an HTRW evaluation for Damage Center 3 and surrounding area. There is a current EDR records search, but was not evaluated or summarized. If there is a measure or proposed project in Damage Center 3 in the future, an HTRW evaluation shall be conducted prior to future work.

15.1.4 Damage Center #4

Damage Center 4 is Mill Creek Miles 10.8 – 11. 3. There are USEPA and TDEC regulated industries on the left bank of Damage Center 4 including Waste Management (formerly Systech) and R&L Carriers (formerly Roadway Express). Systech at 1640 Antioch Pike had multiple compliance inspections for groundwater contamination. Roadway Express at 3240 Franklin Limestone Road had been issued multiple notices of violation and, a confirmed LUST which contaminated groundwater, is located adjacent to Mill Creek Mile 11.3, and has a NPDES permitted outfall which discharges treated groundwater (for solvents and petroleum) into Mill Creek near Creek Mile 11.3.

It is recommended to avoid work in Mill Creek at Damage Center 4. If work is unavoidable at Damage Center 4, it is recommended to avoid the left bank and the NPDES permitted outfall near Creek Mile 11, and approach Mill Creek from the right bank where Vulcan Quarry is located. Before any proposed project starts in Damage Center 4, CELRN should contact should contact USEPA and request FOIA records for Systech EPA ID# TND000772277 to ensure Systech or current business at 1640 Antioch Pike in continued compliance, contact TDEC and request FOIA records for Waste Management at 1428 Antioch Pike Facility ID #SWP190001077 and Waste Management 3211 Franklin Limestone Road Facility ID #TRF190001410 to ensure continued compliance, and contact TDEC and request FOIA records or the Roadway Express NPDES permitted outfall TNG830158 to determine continued compliance.

15.1.5 Ellington Agricultural Center Culvert and Drainage Improvements

Ellington Agricultural Center culvert is in the Sevenmile Creek area and located at Sevenmile Creek Mile 3.7. The area surrounding the channel and culvert is Ellington Agricultural Center on the left bank and a greenway on the right bank. The environmental record search and site visit did not indicate an environmental liability or condition within the Ellington Agricultural Center subject area that would interfere with the proposed projects along Sevenmile Creek near Ellington Agricultural Center.

15.1.6 Old Hickory Detention Structure

The proposed Old Hickory Detention Structure is near Mill Creek Mile 18. The area is currently an open farm field with residential neighborhoods surrounding the field. There is an underground natural gas pipeline and natural gas pump station running northeast to southwest and located on the west side of the field, and there is an underground sewer line running northeast to southwest and located in the center of the field. The environmental record search and site visit did not indicate an environmental liability or condition within the proposed Old Hickory Detention Structure area adjacent to Mill Creek Mile 18 that would interfere with the proposed project site.

15.2 HTRW SUMMARY FOR NON-STRUCTURAL PROJECTS SITES

There are five stretches of Mill Creek and tributaries which are potential non-structural flood reduction projects where it is possible that structures in the floodway may be buyouts. The following subsections summarize HTRW findings for the six potential non-structural flood reduction areas.

15.2.1 Sevenmile, Edmondson Pike

Sevenmile Edmondson Pike area is a well established residential area near Sevenmile Creek Miles 1.9 – 3.1. The environmental record search revealed potential Historical Auto Stations, Historical Cleaners, RCRA NonGen/NLR, and drycleaners. These facilities are either not currently in use, are residential homes at this time, or are downstream of the subject area. Therefore, they are not considered to be an environmental concern towards the subject area because they are not in use or unlikely to impact the subject area. All federal and state listed sited are downstream of the subject area, and therefore not believed to be an environmental concern towards the subject area because they are unlikely to impact the site. The environmental records review and site visit did not indicate a recognizable environmental liability or condition within the Sevenmile Creek – Edmondson Pike area.

15.2.2 Sevenmile, Elysian Fields

This is a well established residential area near Sevenmile Creek Miles 0.5 – 1.25. All Federal and State records were found to be downstream, have no record of violations, and/or have a tank closure status. All historic auto stations and historic drycleaners were determined to have never been an auto station or drycleaner, to be closed, and/or to not be adjacent to the subject area. All RCRA NonGen/NLR sites were found to not have any violations and the priority cleaners was found to be in remediation and not adjacent to the subject area. The environmental records review and site visit did not indicate a recognizable environmental liability or condition within the Sevenmile Creek – Elysian

Fields subject area that would interfere with the proposed work along Sevenmile Creek Miles 0.5 – 1.25. . The HTRW analysis does not extend further upstream than Creek Mile 1.25.

15.2.3 Sorghum Branch – Willard Drive

This is a well established residential area around Sorghum Branch Creek Miles 1.7 – 2.7. The environmental record search indicated environmental sites which are not adjacent to the subject area, do not exist, are residential structures, not in the same tributary system as Sorghum Branch or downstream of Sorghum Branch Creek Mile 1.7. The environmental records review and site visit did not indicate a recognizable environmental liability or condition within the Sorghum Branch Creek Miles 1.7 – 2.7.

15.2.4 Whittenmore Branch

This is a residential and small rural area near Whittenmore Branch Creek Mile 0.5 – 1.8. During the site visit on 27 August 2013, an illegal trash dump site was seen near 229 Benzing Road. The dumped material appears to be household trash and old furniture which are not an HTRW concern. The environmental record search indicated environmental sites which are not adjacent to the subject area, are incompliance, or downstream of Whittenmore Branch Creek Mile 0.5. The environmental records review and site visit did not indicate a recognizable environmental liability or condition within the Whittenmore Branch Creek Miles 0.5 – 1.8.

15.2.5 Wimpole Drive

Wimpole Drive is a residential street adjacent to Mill Creek Miles 5.2 – 6.2. Wimpole Drive is a well maintained residential area with an Urban Garden on the western portion of the street adjacent to Mill Creek. An illegal trash pile was seen during the site visit on 26 August 2013 including a rubber mat, a TV and trash bags. The trash does not appear to be an HTRW concern. There are no recognizable environmental conditions seen in the EDR records search or site visit that would interfere with any non-structural projects on Wimpole Drive.

16.0 **REFERENCE**

ASTM E1527-05. Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessments Process. ASTM, West Conshohoken, PA. 2005.

ASTM E1528-06. Standard Practice for Limited Environmental Due Diligence: Transaction Screen Process. ASTM, West Conshohoken, PA. 2006.

USACE ER 1165-2-132. Hazardous, Toxic and Radioactive Waste (HTRW) Guidance for Civil Works Projects. USACE Dept of Army. 26 June 1992.

U.S. EPA 2005. 40 CFR Part 312 Standards and Practices for All Appropriate Inquiries. Final Rule. FR Vol. 70, No. 210, Tuesday, 1 November 2005.

Appendix C:
Attachment E

GIS Analysis

Version 7 November 2013

INTRODUCTION

For this feasibility study and HEC-FDA analysis, a structure database was built. Due to time constraints, the level of detail for the structure's first floor elevations (FFE) presented a challenge and required a modification to the new methodology. There were several unique questions that were answered through the development of methodology to build the structure database required for HEC-FDA analysis. The first question centered on getting FFE for the 723 structures that had not previously been surveyed. Evaluation and incorporation of the structure data and first floor elevations obtained from the Nashville Unified Flood Preparedness Plan (UFPP) study was instrumental in developing the first floor elevation methodology. The final piece was utilizing the HEC-FDA data in a GIS format that would allow for alternative development and evaluation by the PDT. All of the GIS analysis was completed utilizing tools contained in ArcGIS Desktop 10.1.

STRUCTURE DATABASE

The structure database was constructed from two data sources Metro Nashville's building footprints and parcel datasets. Geospatial queries were performed on the building footprints to remove outbuildings and small additional structures from that dataset. The resulting footprint layer was spatially joined with the parcel dataset to assign assessors information to each structure. The result yielded some instances of multiple structures on single parcels. The multiple structures were mitigated by creating duplicates, which were evaluated and either removed or assigned appropriate values by percentage of the entire parcel's appraisal. . These final structures were then assigned a unique id that was utilized throughout the entire process of exports to HEC-FDA and rejoins of the resulting data. Structure ID, Damage Category, Address, Occupancy Type, Stream Name, Bank (Left or Right), Station and FFE was exported to excel for HEC-FDA analysis. After the HEC-FDA analysis was completed, the results of the HEC-FDA analysis were joined with the structure database and pertinent results recorded.

FIRST FLOOR ELEVATIONS

The FFEs were obtained by 3 methods. The first method used surveyed elevations completed during the UFPP accounting for 637 structures. The second uses recent Federal Elevation Certificates (FEC) that were obtained during the same UFPP for 65 structures. Lastly, FFEs for the final 723 structures were assigned using a 2011 LiDAR dataset collected and Geoid adjusted by the USGS resulting in an FFE type named LiDAR Adjusted FFE which yielded. This analysis was completed by gathering the LiDAR maximum value (LMV) within each building polygon, recording the value and adjusting the value based on foundation type. Utilizing the surveyed structures from the UFPP study, methodology was developed to provide baseline adjustments to the LMV dependant on foundation type. The LMV was subtracted from the surveyed FFE for each surveyed structure and categorized by foundation type resulting in a range of differences between LMV and FEE for each foundation type category. The results of this analysis are shown in Figures 1. through 5. This analysis and construction logic was utilized to establish a baseline for different foundation types and the corresponding adjustment to the LMV, which are defined and described in Table 1. There were 1425 structures identified as within the 500 yr water surface. Of those identified 637 were surveyed, 65 had FECs and 723 required the LiDAR adjusted methodology.

Ultimately, the FFE for all structures was derived using one of the three methods described above, and the number and percentages of foundation type per FFE determination method for all structures evaluated are provided in Table 2. Although Table 2. provides the results for all structures, the PDT establish the most beneficial nonstructural plan through economic analysis, which only includes a select portion of the entire structure database. The selected nonstructural plan included 216 structures of which 88% of the FFEs were defined by either survey or FEC.

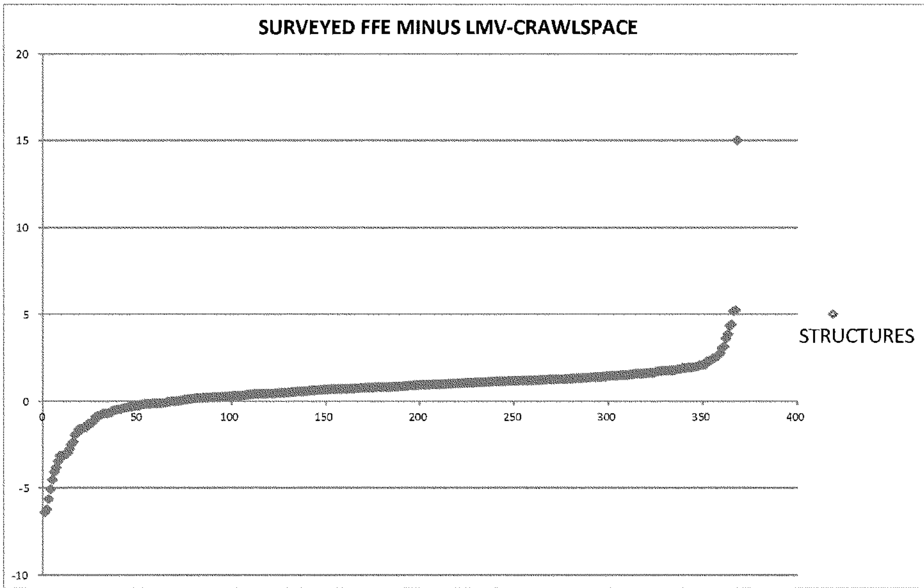


Figure 1. Structure Scatter Plot of Surveyed FFE minus LMV for Structures with Crawlspace Foundation Type

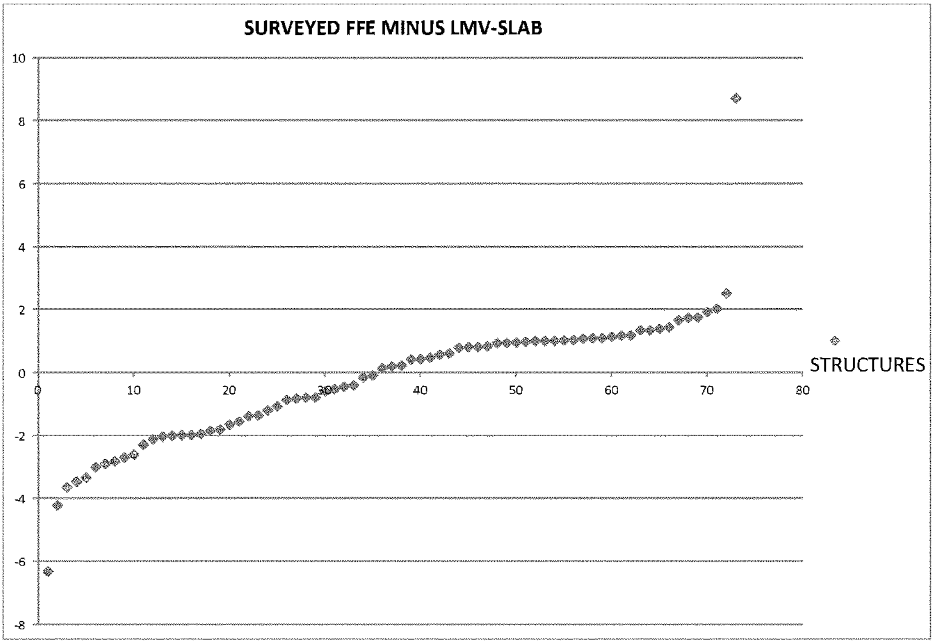


Figure 2. Structure Scatter Plot of Surveyed FFE minus LMV for Structures with Slab Foundation Type

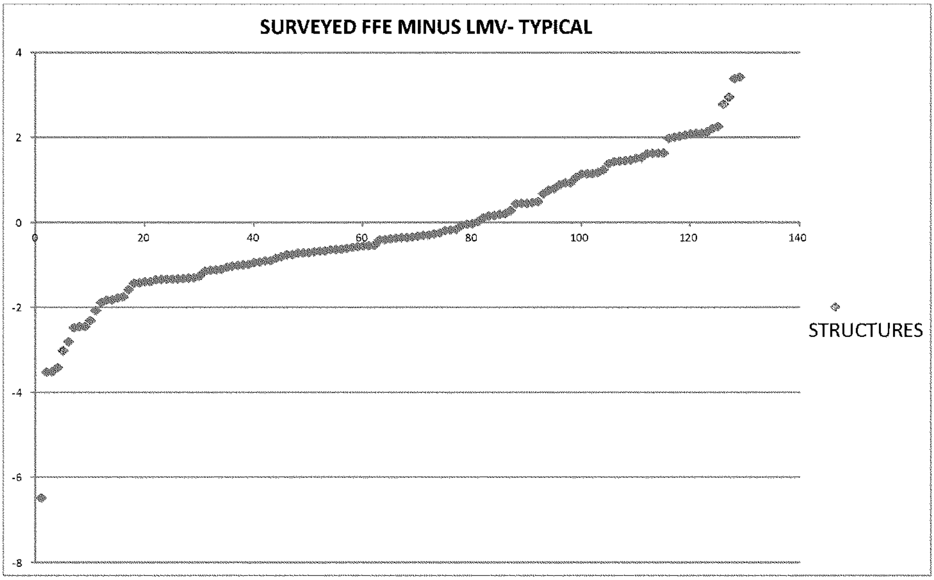


Figure 3. Structure Scatter Plot of Surveyed FFE minus LMV for Structures with Typical Foundation Type

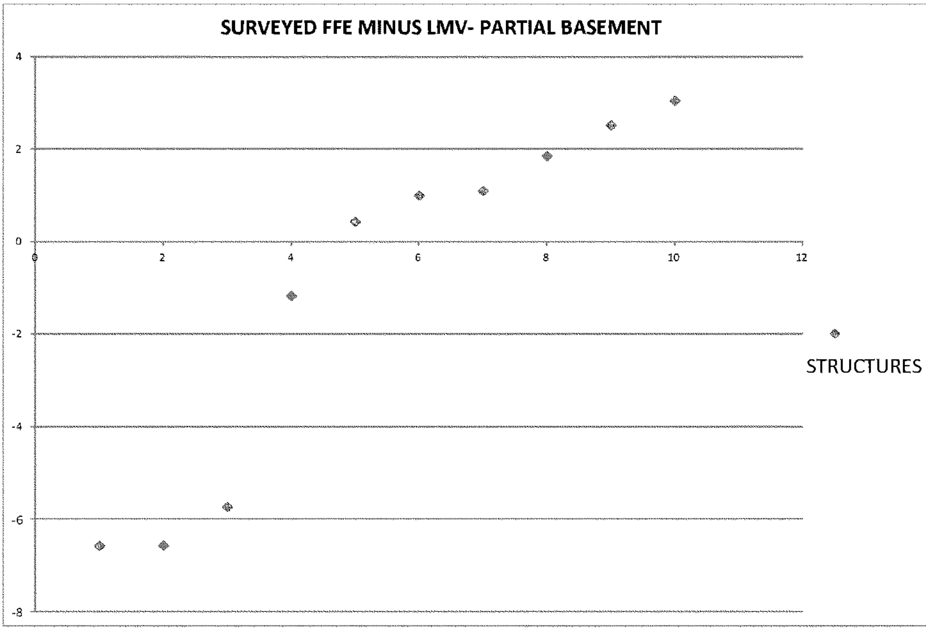


Figure 4. Structure Scatter Plot of Surveyed FFE minus LMV for Structures with Partial Basement Foundation Type

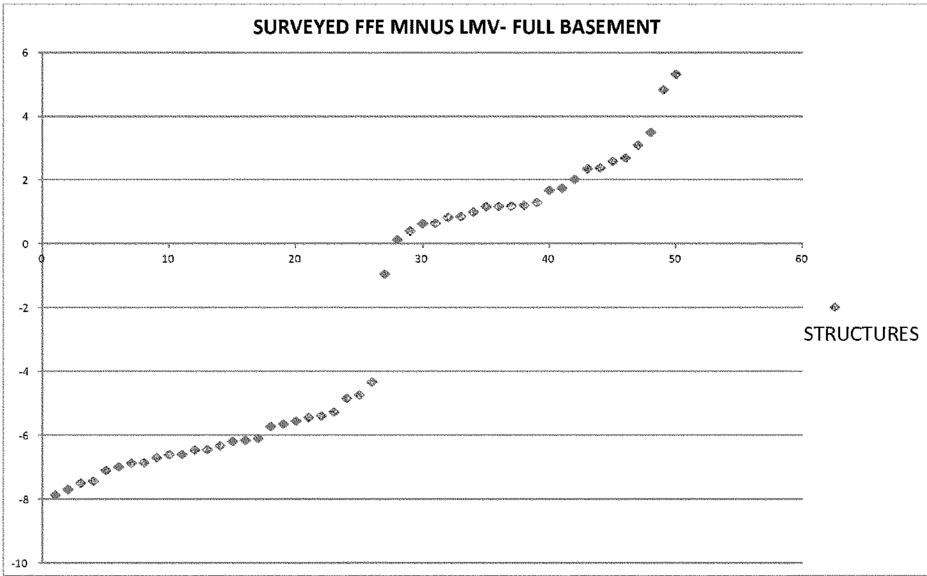


Figure 5. Structure Scatter Plot of Surveyed FFE minus LMV for Structures with Full Basement Foundation Type

Foundation Type	Adjustment to LMV	Description of Adjustment
Crawl	LMV + 1ft	Based on construction codes wood will be a minumum of 18 inches above bare earth.
Slab	LMV	Based on construction logic, slab is poured to grade.
Typical	LMV - 0.5ft	Based on surveyed structure plots.
Partial Basement	LMV	Based on surveyed structure plots.
Full Basement	LMV - 5ft	Based on surveyed structure plots.

Table 2. Foundation Type versus FFE Determination Method

Foundation Type	Surveyed	Lidar Assigned	FEC	Total	% by Foundation Type	% Surveyed or FEC
Crawl	367	443	52	862	60%	49%
Slab	72	79	3	154	11%	49%
Typical	138	135	5	278	20%	51%
Partial Basement	10	13	2	25	2%	48%
Full Basement	50	53	3	106	7%	50%
Total Structures	**637**	**723**	**65**	**1425**		**49%**

Mill Creek Environmental Documents

Appendix D

Version November 2015

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1. INTRODUCTION

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

1.1 PURPOSE OF THE STUDY

This appendix describes the economic analysis of the project measures and alternatives for providing flood risk management measures for the City of Nashville, Tennessee. The purpose is to provide comprehensive review of the methodology and results of the economic analysis performed on the FRM alternatives for the study.

1.2 STUDY AREA

Located in one of the most rapidly urbanizing areas of Middle Tennessee, the 108-square mile Mill Creek Watershed drains about 13% of Nashville, Davidson County, Tennessee and 6% of Williamson County, Tennessee. The watershed has a teardrop shape, is about 18 miles long and averages 6 miles wide. About two thirds of the watershed is within Davidson County, one third in Williamson County and a small headwater area extends into Rutherford County.

Mill Creek flows generally northward from its origin in Nolensville to its confluence with the Cumberland River in Nashville. Along the way it is fed by a number of tributaries, the most significant being Sevenmile Creek which joins Mill Creek at Mile 7.9 and has a drainage area of 17.6 square miles. Other major tributaries in Davidson County include: Collins Creek, Edmonson Branch, Franklin Branch, Holt Creek, Indian Creek, Owl Creek, Sims Branch, Sorghum Branch, Turkey Creek, and Whittemore Branch.

Sevenmile Creek originates near the Davidson-Williamson County line and flows north and east before joining Mill Creek. Sevenmile is approximately 7.3 miles long with a drainage area of 17.6 square miles, an average slope of 18.9 feet per mile, and an average 100-year floodplain width of 500 feet. Streambanks range from 3 to 9 feet high; existing channel averages 20 to 30 feet wide. Approximately half the flow is through a heavily urbanized area, while the upper half is less developed.

The aforementioned Sorghum and Whittemore Creeks were also analyzed in the Study. The study area associated with each of these tributaries is primarily residential in nature with a small amount of commercial structures. Figure 1 below displays the study area in comparison with the rest of Davidson County.

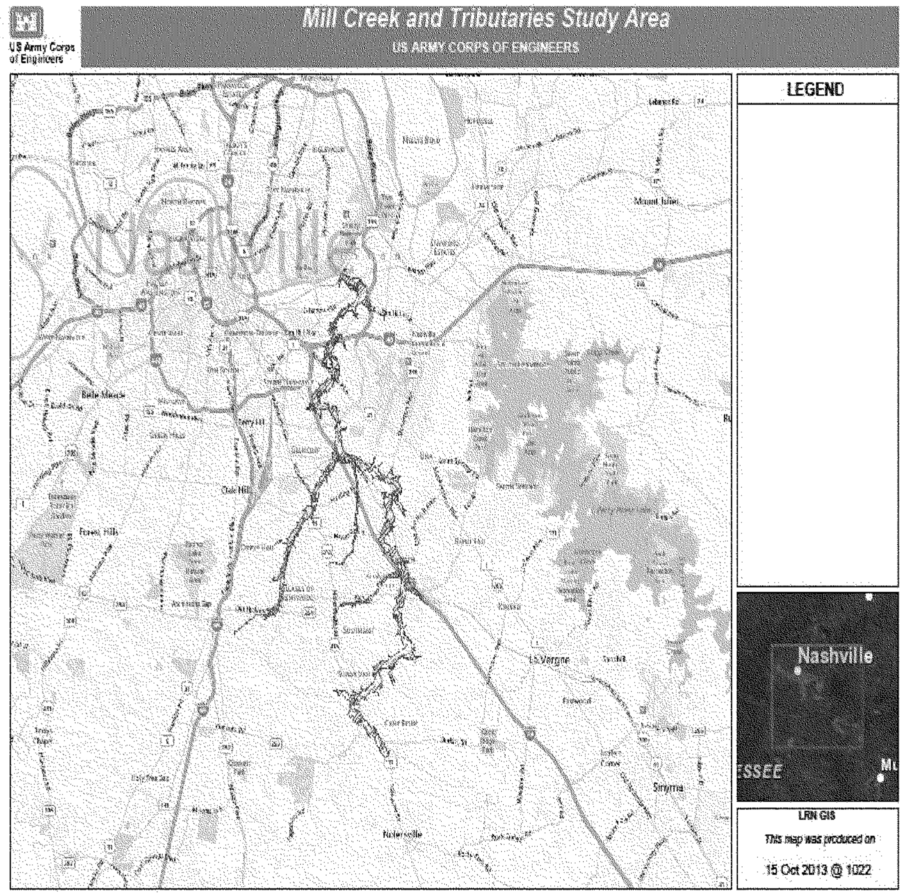


Figure 1: Mill Creek and Tributary Study Area

2. CHARACTERISTICS OF THE STUDY AREA

2.1 DEMOGRAPHIC DATA

Population is one parameter of community change. As the population in an area increases or decreases, so does the demand for infrastructure. Population estimates from the 2010 US Census shows growth in Tennessee and Davidson County is above the nation as a whole. This data is shown in

Table 1 which follows.

Table 1: Population

	Population	Population	% Population Change
Location	2000	2010	2000-2010
Davidson County	569,891	626,681	9.97%
Tennessee	5,689,283	6,346,105	11.54%
United States	281,421,906	308,745,538	9.71%
Data source: 2000 and 2010 US Census			

As shown in Table 1, Davidson County's population grew nearly 10%, while the State of Tennessee grew over 11% over the decade. The national population grew 9.71% along the same period of time. More detailed Nashville/Davidson County population characteristics are listed in Table 2.

Table 2: Population Characteristics of Nashville/Davidson County, TN

	Estimate	Percent	U.S.
Total Population	626,681		
American Indian or Alaska Native	2,091	0.3%	0.9%
Asian	19,027	3.0%	4.8%
Black or African American	173,730	27.7%	12.6%
Native Hawaiian or other Pacific Islander	394	0.1%	0.2%
Some other race	30,757	4.9%	6.2%
Two or more races	15,643	2.5%	2.9%
White	385,039	61.4%	72.4%
Mill Creek Watershed Population	**187,106**		
Age			
Under 18 years	136,391	21.8%	24%
Between 18 and 64 years	424,887	67.8%	63%
65 years and over	65,403	10.4	13%
Income (2010 Dollars)*			
Median per capita income	28,526		27,334
Median housing value (owner occupied)	166,300		188,400
Persons below poverty level		17.7%	13.8%
Unemployment rate		7.3%	7.8%
Data source: 2010 US Census *Data source: US Census 2010 American Community Survey, Selected Social Characteristics, 5-year estimates:2006-2010, Data source: US Bureau of Labor Statistics			

As Table 2 shows the population is primarily white and in general age distribution matches the Nation as a whole. Per capita income is slightly higher than the United States average and the median housing value is roughly 12% lower than the Nation's. Persons living below the poverty level and unemployment rates are higher than the rest of the country on average.

2.2 HOUSING AND FAMILIES

2.2.1 Housing

Davidson County's occupied housing unit mirrors that of the Nation as a whole. Renter occupied units in Davidson County is higher percentage wise than that of the United States. Household size and median vehicles per household is near identical. Housing data is presented in Table 3.

Table 3: Housing

	Davidson County Estimate	%	U.S. Estimate
Total Housing Units	283,978		131,701,730
Occupied housing units	259,499	91.3%	88.6
Owner occupied housing units	145,115	51.1%	57.6
Renter occupied	114,384	40.2%	30.9
Average household size	2.5		2.58
Households median vehicles	2.1		2.2
No vehicles	20431	7.3%	8.9%
1 vehicle	110320	39.2%	33.3%
2 vehicles	104411	37.1%	37.9%
3 or more vehicles	46145	16.4%	20%
Data source: US Census Quick Facts, American Community Survey, October 2012			

2.2.2 Families

Davidson County has a slightly lower average household and family size than the Nation as a whole. The county also has a lower percentage of family households and married couple households than the United States. Family data is displayed in Table 4.

Table 4: Household Data

	Davidson County	%	U.S.
Total Households	259,499	100%	116,716,292
Average Household Size	2.5	-	2.58
1 Person Households	89,503	34.49%	26.74%
2 or More Person Households	169,996	65.51	73.26%
Family Households (Families)	145,166	55.94%	66.43%
Average Family Size	3.02	-	3.14
Married-Couple Family	95,093	36.64%	48.42%
Nonfamily Households	114,333	44.06%	33.57%
Data source: 2000 and 2010 US Census			

2.3 EMPLOYMENT AND LABOR FORCE

2.3.1 Employment

The distribution of employment in Davidson County, TN is representative of the Nation as a whole, except for lower percentages in manufacturing and construction and greater percentages in arts, entertainment and recreation industries, as shown in Table 5.

Table 5: Total and Part-Time Employment by Major Industry Sector by Place of Work, 2010

Employment	Davidson County Estimate	U.S Estimate
Employed population 16 years and over	325,346	141,833,331
Percent Distribution by Employment Sector		
Agriculture, forestry, fishing and hunting, and mining	0.3%	1.9%
Construction	5.3%	7.1%
Manufacturing	7.9%	11.0%
Wholesale trade	1.9%	3.1%
Retail trade	10.8%	11.5%
Transportation and warehousing, and utilities	4.0%	5.1%
Information	3.5%	2.4%
Finance and insurance, and real estate and rental and leasing	7.1%	7.0%
Professional, scientific, and management, and administrative and waste management services	13.0%	10.4%
Educational services, and health care and social assistance	24.4%	22.1%
Arts, entertainment, and recreation, and accommodation and food services	12.3%	8.9%
Other services, except public administration	4.8%	4.9%
Public administration	4.7%	4.8%
*Data source: US Census 2010 American Community Survey, Selected Social Characteristics, 5-year estimates:2006-2010.		

2.3.2 Labor Force

General employment statistics for Davidson County, Tennessee are similar to the Nation as a whole, as seen in Table 6.

Table 6: Employment Status

	Davidson County Estimate	%	U.S. Estimate
Population 16 Years and Over	492,422		238,733,844
In Labor Force	338,685	68.8%	65.0%
Employed	312,839	63.5%	59.4%
Unemployed	25,371	5.2%	5.1%
Not in Labor Force	153,737	31.2%	35.0%
*Data source: US Census 2010 American Community Survey, Selected Social Characteristics, 5-year estimates:2006-2010.			

3. ECONOMIC EVALUATION PROCEDURES, ASSUMPTIONS, AND METHODOLIGIES

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

The economic justification of an alternative was determined by comparing the expected annual benefits to the expected annual costs. If the annual benefits for an alternative exceed the annual costs, then the alternative was considered economically justified. In such cases, the benefit-to-cost ratio (BCR) was greater than 1.0. For this analysis, the expected annual cost of an alternative was determined by considering a number of factors, including construction cost, timing of construction period, and interest during construction, and operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) costs. The costs were based on an October 2015 price level, a period of analysis of 50-years, and were annualized to an annual equivalent cost using FY 2015 Federal Discount Rate of 3.375%. The expected annual cost for an alternative was subtracted from the expected annual benefit to compute the net annual benefit.

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

3.1 HYDROLOGIC AND HYDRAULIC MODELING FOR ECONOMIC EVALUATIONS

Refer to Hydrology and Hydraulics (H&H) Appendix for information on the hydrologic and hydraulic input into the Hydrologic Engineering Center – Flood Damage Analysis software (FDA) version 1.2.4 model.

3.1.1 Base and Most Likely Future Economic Modeling

For the Mill Creek and tributary study, the year the proposed project is expected to be in operation (the base year) was set at 2018. The most likely future year was set at 2058. Local floodplain management ordinances will mitigate most hydrologic impacts from increased development. The H&H Appendix will provide documentation of the development of future without project conditions.

3.2 First Floor Elevations

To identify the structures to include in the study, the 500yr water surface sharefiles were overlaid with the Metro Nashville building footprint layer, identifying 1,455 structures. A unique structure ID was defined by utilizing stream number, bank and object number. All of the first floor elevations of the structures in the study area were obtained by one of three methods. That is to say that first floor elevations were obtained for a 100% sample of the structure inventory. None were inferred by statistical analysis. In the Mill Creek Basin flood risk management study a total of 1,455 structures were assigned first floor elevations. Of these 725 had received fist floor elevation certificates from Metropolitan-Davidson County's property assessor's offices. Ten (10) were surveyed by the Nashville District and 720 structures were assigned a FFE via Lidar. All structures in the SID were accounted for by the aforementioned measures. The analysis was completed by performing zonal statistics based on the LiDAR elevation within the building footprint. The max value was recorded for each structure and analysis on the foundation type and previously surveyed first floors. This analysis was utilized to establish a baseline for different foundation types and the corresponding adjustment to the building max elevation. Those values were: Crawl=ZonalMax+1ft, Slab=ZonalMax, Typical=ZonalMax-.5ft, Partial Basement=ZonalMax, and Full Basement=ZonalMax-5ft.

3.3 Structure and Contents

The purpose of the structure inventory was to collect data on residential and nonresidential structures located in the Study area. Structures were numbered on its respective stream starting downstream and moving upstream. Structures added later were numbered as they were added, irrelevant of their position on a stream. Each residential structure in the structure inventory database (SID) was assigned a vehicle in the SID and given the same identifying number as the structure with a "v" at the end of the number.

3.3.1 Data Collection

The structure database was constructed from the following data sources. Building footprints were obtained from Metro Nashville and geospatial queries were performed to remove outbuildings and small additional structures from that dataset. The remaining footprint layer was spatially joined with the Metro Nashville Assessor's office parcel dataset. Analysis was performed to mitigate multiple structures on single parcel improvements assessment. This data was then exported to excel for the FDA analysis.

3.3.2 Residential Structures

Residential structures were classified first by whether they are a single or multi-family home then structures were delineated by number of stories and presence of basement.

Structures for the four (4) streams were sorted by stream, damage category, and structure occupancy type. Depreciated replacement value estimates were made with the Marshall and Swift Estimator were made for a stratified 20% sample that was selected by the aforementioned criteria that the structures were sorted by. To avoid estimating the same general valued type of structure, it was attempted to estimate lower, middle and higher-end valued structures in each damage category and occupancy type. Samples were taken from each stream; however some streams had more residential than commercial type structures and vice versa. Data from Metro-Davidson County's property tax records provided pertinent information such as the effective age, roof type, exterior type, and general condition which was input into the Marshall and Swift Estimator.

Table 7 displays residential structure occupancy type, structure count and depreciated structure value by stream.

Content values of residential structures were calculated based on US Army Corps of Engineers Economic Guidance Memorandum #04-01. FDA assumes content value to be 100% of structure value which was employed for this analysis. The Institute for Water Resources (IWR) generic residential depth damage functions was used for the analysis.

3.3.3 Commercial and Industrial Structures

Non-residential structure values were retrieved initially from Metro Davidson County's tax assessor's office and are from the 2011 assessment. These values were used as reference points while actual depreciated replacement costs were calculated using Marshall and Swifts Commercial and Agriculture Estimator to October 2014 price levels for all non-residential structures. Structures were categorized by damage categories. The counts of non-residential structures along with total depreciated replacement costs per category are displayed in Table 8. Content values and depth-damage curves for non-residential structures were estimated using generic curves developed by IWR. Each specific curve is assigned a percentage factor to account for contents. Non-residential depth-damage functions used in this analysis are displayed in Table 9 below. A small number of structures with large content values were inventoried during a 2009 Mill Creek analysis. These content values were brought up to FY 2015 level using the Civil Works Construction Cost Index System (CWCCIS) indices.

Table 7: Residential Structures

Structure Occupancy Type	Structure Count	Structure DPR Values $=1,000's
Mill Creek		
SFR - 1 Story No Basement	289	23,811.5
SFR - 1 Story With Basement	68	5,361.8
SFR - 2 Story No Basement	110	9,836.8
SFR - 2 Story With Basement	1	45.5
SFR - Split Level No Basement	97	6,527.5
SFR - Split Level With Basement	5	612.0
MFR – Apartments	39	33,348.7
Mobile Homes	61	724.0
Mill Creek Total	670	80,267.8
Seven Mile Creek		
SFR - 1 Story No Basement	208	18,277.3
SFR - 1 Story With Basement	30	2,650.4
SFR - 2 Story No Basement	10	1,263.0
SFR - 2 Story With Basement	1	197.0
SFR - Split Level No Basement	38	3,703.8
SFR - Split Level With Basement	1	218.3
MFR – Apartments	95	2,791.2
Seven Mile Creek Total	383	29,101.0
Sorghum Branch		
SFR - 1 Story No Basement	31	2,362.1
SFR - 1 Story With Basement	13	991.9
SFR - Split Level No Basement	5	498.4
MFR – Apartments	11	18,983.9
Sorghum Branch Total	60	22,836.3
Whittemore Branch		
SFR - 1 Story No Basement	84	5,436.9
SFR - 1 Story With Basement	10	860.3
SFR - 2 Story No Basement	10	867.5
SFR - Split Level No Basement	32	2,480.7
Whittemore Branch Total	136	9,645.4

Table 8: Non-Residential Structures

Mill Creek		
Damage Category Type	**Structure Count**	**Structure DPR Values $=1,000's**
Commercial	169	120,961.2
Industrial	19	25,635.2
Public	3	3,795.0
Mill Creek Total	191	150,391.4
Seven Mile Creek		
Commercial	18	18,439.3
Public	1	30.0
Seven Mile Creek Total	19	18,469.3
Sorghum Branch		
Commercial	5	6,124.5
Industrial	1	4,960.0
Public	1	189.5
Sorghum Branch Total	7	11,274.0
Whittemore Branch		
Public	2	450.7
Whittemore Branch Total	2	450.7

After initial runs of the FDA software, damages to several structures within the Mill Creek and Tributaries 500-/year footprint appeared to not represent historic damages. The following list identifies the actions taken to evaluate, confirm, and redefine the data utilized in the structure inventory.

Approximately 20 structures were field surveyed to confirm a valid first floor elevation (FFE) was being employed. FFE's for certain structures were adjusted in the SID.

Structure values for a small number of structures were readdressed and edited accordingly.

River stations were reviewed for a small number of structures to ensure correct data was being used in the analysis.

Describe the shapes of the various distributions used in HEC-FDA. - Distribution shapes used in the Mill Creek Basin study are as follows: Uncertainty distributions of structure values, first floor elevations and content-to-structure value ratios for all structures used a normal distribution, which is bell-shaped in nature. Occupancy type uncertainty distributions of single family residential structures and automobiles are also normal distributions. Occupancy type uncertainty distributions for all non-residential and multi-family residences are triangular distributions. These had an upper limit and lower limit and the best estimate that creates the “triangle”, which is usually not symmetrical in nature.

The occupancy types (i.e. depth-damage functions) used in the study were originally developed and constructed with uncertainty described by the distributions. These were based on statistical analysis of empirical data conducted by the Corps’ Institute of Water Resources for single family residential and automobile functions, which are normal distributions. These were based on expert elicitation conducted by the New Orleans District for multi-family and non-residential functions, which have triangular distributions. The occupancy types were imported with the distributions already in-place and applied in the study with their original distributions. First floors elevations (FFE) and structure values used normal distributions because it is thought that values above and below the best estimates are equally likely.. Since a majority of the first floor elevations were either provided by Metropolitan-Davidson County or the District using conventional level, a standard deviation of 0.03 feet was used, which is displayed in EM 1110-2-1619 Table 6-5. Due to the uncertainty in non-residential structure values, a 20% standard deviation was used for this type structure. Single family residential structures used a 15% standard deviation in the structure value for the analysis.

Table 9: Non-Residential Depth-Damage Functions

Cloth-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0	0	0	8.3	11.4	13.9	17.2	21.4	26.9	31.5	34.3	37.2	41.2	43.2	45.1
		STL	0	0	0	0	4.8	6	7.8	10.6	13.9	18.1	23.1	26.2	28.8	31.6	33.3	35.1
		STU	0	0.6	0.8	1.4	14.9	18.3	21.3	26.6	30.8	36.7	42.1	44.8	47.8	52.7	55	56.6
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0	12.3	29	38.4	46.3	55.4	70	79	89	95.7	97.9	97.9	99.3
		CTL	0	0	0	0	8.1	19.1	31	40	47	61.4	69.3	81.4	86.4	92.6	95.6	96.4
		CTU	0	0	0	0	17.4	37.4	46.7	54.9	65	80	85.6	95	96.4	97.9	99.3	99.3
		Struct	N		0.03		N		20		T	45	10	10		-901		
Conv-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0	0	0.3	10.2	14.1	18.5	21.9	28.7	35.5	40	44.4	49.5	53.3	54.5	56
		STL	0	0	0	0	6	8.4	11.2	14.4	20	26.3	30.7	35.9	39.1	43.4	45.4	46.9
		STU	0	0.8	0.8	1.3	16.5	20.8	25.4	29.8	35.7	41.9	47.2	53	55.9	59.5	61.1	62.5
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0	11.6	23.1	32.1	39.9	52.9	70.7	79.3	88	94.1	95.7	97.1	98.6
		CTL	0	-0.1	-0.1	0	6.5	15.1	21.6	28.4	37.6	55.6	65.7	71.6	78.1	80.4	81.3	81.4
		CTU	0	0	0	0	18.6	30.4	40.1	50	64	78.6	87.9	94.4	97.7	98.6	100	100
		Struct	N		0.03		N		20		T	34	10	10		-901		
Fast food-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0	0	0	10.4	14.4	19.9	25.6	32.8	41.6	47.1	52	56.9	60.5	63.4	65.1
		STL	0	0	0	0	6	8.6	12.6	18.7	23.5	33.3	40.4	45.8	49.6	53.3	57.4	58.4
		STU	0	0.8	0.8	1.2	17.7	22.7	28.9	38.1	43.4	51.3	56.8	61.4	66.4	70.2	72.2	73.2
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0	10.6	21.3	29.4	38.6	52.7	62.6	73	79.3	88.3	94.9	98.6	98.6
		CTL	0	0	0	0	5	15	21.4	28.7	39.9	49.4	65.4	72.9	82.9	88	94.3	94.3
		CTU	0	0	0	0	16.4	31.3	38.4	51.4	62.3	72.7	79.6	83.6	95.7	98	98.6	98.6
		Struct	N		0.03		N		20		T	27.2	10	10		-901		

Grocery-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0	0	0.1	7.1	10.1	13	16.4	20.8	26.7	30.6	34.4	37.8	41.5	43.3	45.5
		STL	0	0	0	0	4.1	5	6.9	9.7	13.3	17.8	21.9	25.8	28.4	31.4	33.3	35
		STU	0	0.8	0.8	1.5	13.4	16.5	20.1	25.6	30	35.8	41.2	44.7	48.3	52.6	54.6	56.7
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0	24	30.7	36.8	40.9	52.9	64	75.4	87.3	98.9	100	100	100
		CTL	0	0	0	0	17.9	23.9	30.7	36.4	45.3	53.9	67.1	77.1	92.3	94.1	95	95
		CTU	0	0	0	0.2	26.8	35.9	42.1	48.6	63.3	74	87.6	94.7	99.4	100	100	100
		Struct	N		0.03		N		20		T	70	10	10		-901		
Med-Pre-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0.3	0.7	1.3	8.4	12.8	16.3	21	27.9	37.2	40.9	51.9	56.6	61.7	66	67.8
		STL	0	0	0	0	4.7	7.2	9.7	14.5	19.3	27.2	31.5	39.6	45.1	52.6	56.1	59.3
		STU	0	1.1	1.4	2.9	14.4	17.9	22.9	28.8	36.3	44.8	49.9	58.8	63.5	68.7	71.3	73.4
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0	9	14.3	18.4	26.9	40.4	57.1	67.3	75.4	82.3	91.3	96.3	96.9
		CTL	0	0	0	0	5.6	10.3	15	21.9	32.8	46.8	59.1	66.3	73.8	83.8	91.9	92.5
		CTU	0	0	0	0	13.9	21.3	26.9	42.5	52.6	63.3	75	82.3	86.9	94.1	98.1	99.4
		Struct	N		0.03		N		20		T	69.2	10	10		-901		
Office-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0.4	0.4	0.9	9.3	12.3	14.9	17.5	22.2	26.8	30.7	34.7	41.2	46.5	49.4	53.6
		STL	0	0.3	0.3	0.4	5.1	6.9	9.2	11.6	15.4	18.7	22	25.4	30.7	34.5	37.9	39.3
		STU	0	1.1	1.1	2	14	18	21.6	25.4	30.3	35.3	41	44.1	50.3	57.7	60.4	64.6
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0.7	0.7	1	14.3	20	26	34.3	45.4	55	63.9	73.3	76.4	83.4	89.3	91.4
		CTL	0	0.5	0.6	0.7	7.3	13.6	17.9	23.7	34.3	43.6	51.9	59.7	64.4	73.6	79.3	81.9
		CTU	0	1.2	1.3	1.5	22.1	29.3	33.6	41.4	54.6	63.6	71.4	79.6	82.9	85.7	92.1	96.4
		Struct	N		0.03		N		20		T	18.1	10	10		-901		
Office-Pre-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0.8	0.8	1.6	9.9	13.5	16.8	19.4	25.4	30.5	33.5	38.6	45.7	51.1	55	59.1
		STL	0	0.3	0.3	0.4	5.2	7.5	10.3	13.4	18.3	22	24.2	29.1	34.4	39.8	43.7	44.7
		STU	0	1.5	1.5	3.2	14.4	18.4	23.6	27.8	34	39.9	43.8	47.6	55.1	62.4	65.7	70.1
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0.7	0.7	1	14.3	20	26	34.3	45.4	55	63.9	73.3	76.4	83.4	89.3	91.4
		CTL	0	0.5	0.6	0.7	7.3	13.6	17.9	23.7	34.3	43.6	51.9	59.7	64.4	73.6	79.3	81.9
		CTU	0	1.2	1.3	1.5	22.1	29.3	33.6	41.4	54.6	63.6	71.4	79.6	82.9	85.7	92.1	96.4
		Struct	N		0.03		N		20		T	20.8	10	10		-901		
Pub-rec-Eng	PUB	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0	0	0	8.1	11.9	15.4	20.2	26	32.2	36.8	40.7	43.4	47.4	49.4	51.6
		STL	0	0	0	0	4	5.8	8.5	11.8	16.9	23.3	28	32	34.7	38	39.7	41.7
		STU	0	0.6	0.8	1.6	14.4	18.4	22	27.9	34.5	40.4	45.6	49.8	52.2	57.1	58.9	60.6
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0	16.9	25.7	31.4	43.7	62.7	72.9	80	84	91.1	95	95	95
		CTL	0	0	0	0	9.1	17.9	24.4	33.1	50	66	71.3	77.9	85.7	88.6	90.9	91.4
		CTU	0	0	0	0	22.4	32.7	44.1	54.3	71.6	81.6	86.1	89.9	95.3	95.9	97.9	97.9
		Struct	N		0.03		N		20		T	24.6	10	10		-901		
Pub-school-Eng	PUB	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0	0	0.1	7	9.7	12.4	15.3	18.9	24	27.9	31	34.8	39.1	40.8	43
		STL	0	0	0	0	3.8	4.4	6	8.3	10.9	15	18	21.3	24	26	27.4	29.1
		STU	0	0.6	0.8	1.7	12.9	15.8	19.4	23	27.3	33.1	38.4	41.2	45.8	51.3	53.2	55

		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0.4	11.7	16.4	21.9	28.9	40.9	57.7	63.3	70.7	79.3	84.3	87.1	87.1
		CTL	0	0	0	0	7.2	11.6	15.7	23.7	32.9	44.4	50.7	58.4	70.6	74.3	76.4	77.9
		CTU	0	0	0	0.7	16.2	21.6	29.1	35.7	50.9	67	74.3	78.3	84	88	90	90
		Struct	N		0.03		N		20		T	6.5	10	10		-901		
Rec-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0	0	0	8.1	11.9	15.4	20.2	26	32.2	36.8	40.7	43.4	47.4	49.4	51.6
		STL	0	0	0	0	4	5.8	8.5	11.8	16.9	23.3	28	32	34.7	38	39.7	41.7
		STU	0	0.6	0.8	1.6	14.4	18.4	22	27.9	34.5	40.4	45.6	49.8	52.2	57.1	58.9	60.6
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0	16.9	25.7	31.4	43.7	62.7	72.9	80	84	91.1	95	95	95
		CTL	0	0	0	0	9.1	17.9	24.4	33.1	50	66	71.3	77.9	85.7	88.6	90.9	91.4
		CTU	0	0	0	0	22.4	32.7	44.1	54.3	71.6	81.6	86.1	89.9	95.3	95.9	97.9	97.9
		Struct	N		0.03		N		20		T	24.6	10	10		-901		
Rest.-Pre-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0.3	0.3	1.9	14.8	19.4	25.3	32.4	41	49.6	56.3	63.9	67.2	71.3	72.7	73.5
		STL	0	0	0	0.5	8.9	13.1	18.1	24.8	33	40.3	47	55.6	59.6	64.4	66.3	67
		STU	0	1.7	1.7	3.6	21.7	26.4	35.5	42.1	49.9	58.4	64.9	71.4	76	77.4	79.1	79.7
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0	17.1	27.7	35.9	48.9	57.3	71.9	79.7	84.9	92.9	93.4	94.3	94.3
		CTL	0	0	0	0	10.7	20.4	27.9	37.3	45.6	63.3	72.1	78.3	86.3	90	90.9	91.4
		CTU	0	0	0	0	22.9	34.6	42.9	52.1	63.7	78.4	86.6	90	96.3	97.1	97.1	97.1
		Struct	N		0.03		N		20		T	25.8	10	10		-901		
Ser.-related-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0	0	0.1	7	9.7	12.4	15.3	18.9	24	27.9	31	34.8	39.1	40.8	43
		STL	0	0	0	0	3.8	4.4	6	8.3	10.9	15	18	21.3	24	26	27.4	29.1
		STU	0	0.6	0.8	1.7	12.9	15.8	19.4	23	27.3	33.1	38.4	41.2	45.8	51.3	53.2	55
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0.4	11.7	16.4	21.9	28.9	40.9	57.7	63.3	70.7	79.3	84.3	87.1	87.1
		CTL	0	0	0	0	7.2	11.6	15.7	23.7	32.9	44.4	50.7	58.4	70.6	74.3	76.4	77.9
		CTU	0	0	0	0.7	16.2	21.6	29.1	35.7	50.9	67	74.3	78.3	84	88	90	90
		Struct	N		0.03		N		20		T	66	10	10		-901		
Wrehouse-Eng	COM	Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		S	0	0	0	0	7.1	10.2	13.3	16.7	20.4	25.5	29.7	32.8	35.5	39.6	42.5	44.5
		STL	0	0	0	0	3.6	4.5	6.2	8.9	11.9	15.9	19	22.4	24.6	26.7	29.2	30.8
		STU	0	0.6	0.8	1.6	13.6	17	20.6	25	28.7	35.1	40.4	43.3	46.2	51.2	53.9	55.9
		Stage	-2	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
		C	0	0	0	0	13.4	20.7	27.6	33.7	47.4	56.9	65.6	73.6	81.3	88.4	91.6	93.6
		CTL	0	0	0	0	7.1	12.3	19.3	25.4	35.7	48.3	57.3	65.9	74.9	81.4	84.1	88.1
		CTU	0	0	0	0	21.1	28	35.6	45.6	57	67.7	76	82.4	89.7	94.1	98.3	99.3
		Struct	N		0.03		N		20		T	83.8	10	10		-901		

3.3.4 Vehicles

Each residential structure was assigned 1 vehicle per structure with a value of $10,000. Values were ascertained using interviews with Metropolitan Davidson County Clerk's office to establish an estimate of per vehicle value. Each vehicle was input into the SID as pseudo structures at the same location as the residence it represented with a FFE of

3 feet below the residential structure itself. PDT elevation surveys and site analysis resulted in the decisions on vehicle FFE and structure FFE. With approximately 160 floodway structures and another approximately 100 structures in the 2 or 5 year flood event elevations, the typical FFE for the study area is going to be 3' above grade, taking into account crawl space, basements, etc. Additionally, structures along Edmondson Pike, Suter Dr, Paragon Mills Rd, Benzing Rd, and Wimpole Dr, located on the creek side of the street, generally maintain structure FFEs below road grade. The slope of the terrain there determines that the residents there park in the rear of the structures, which based upon the slope can be as much as 10' below grade. Based upon the survey data (over 90% of structures have been surveyed) the PDT determined that a 3' below FFE for vehicles is a valid estimate. The key determining factors for that are the terrain and the significant number of structures that are built on downslopes towards the creek. Automobile depth-damage functions with uncertainty were obtained from IWR. Further detail on structure database methodology is provided in the Geospatial Information Systems (GIS) Appendix. The depth-damage function used for vehicles is displayed in Table 10, which follows.

Table 10: Vehicle Depth-Damage Function

Vehicles	Stage	0	0.5	1	2	3	4	5	6	7	8	9	10
	S	0	5.2	24.1	41.9	57.6	71.4	83.1	92.5	97	99.4	100	100
	SN	0	5.2	4.2	3.3	2.8	2.6	3	3.8	4.2	4.4	4.7	4.7
	Struct	N		3		N		30			-901		

3.4 Reach Characteristics Figure 2 represents Mill Creek and tributary damage reaches. Table 11 illustrates the delineation of the reaches and lists the reaches by title, description and river station while Figure 2 gives a visual representation of the streams and assorted reaches within the study area. Table 12 displays number of structures by damage category with total depreciated replacement value per reach per stream.

Table 11: Streams and Reaches Included in the Mill Creek Study Area

Stream	Reach Name	Station Reference	Downstream Station	Upstream Station	Description
Mill_Creek	MC Reach 1	Miles	0.145	3.983	Massman Dr / Wilhagen Rd (Mile 0.145 to 3.983)
Mill_Creek	MC Reach 2	Miles	3.983	4.863	Murfreesboro Pike (Mile 3.983 to 4.863)
Mill_Creek	MC Reach 3	Miles	4.863	7.343	Wimpole Drive / Thompson Lane (Mile 4.86 to 7.34)

Stream	Reach Name	Station Reference	Downstream Station	Upstream Station	Description
Mill_Creek	MC Reach 4	Miles	7.343	10.557	Space Park/Harding Industrial (Mile 7.34 to 10.56)
Mill_Creek	MC Reach 5	Miles	10.557	14.533	Antioch Pike (Mile 10.56 to 14.53)
Mill_Creek	MC Reach 6	Miles	14.533	17.358	Above Bell Road (Mile 14.53 to 17.36)
Mill_Creek	MC Reach 7	Miles	17.358	21.120	Above Old Hickory Blvd (Mile 17.36 to 21.12)
Sevenmile Creek	SM Reach 1	Feet	0	6,606	Paragon Mills (Mile 0.00 to 1.25)
Sevenmile Creek	SM Reach 2	Feet	6,606	11817	Nolensville Rd (Mile 1.25 to 2.24)
Sevenmile Creek	SM Reach 3	Feet	11,817	19,439	Blackman Rd (Mile 2.24 to 3.68)
Sevenmile Creek	SM Reach 4	Feet	19,439	27,802	Above Ellington Ag Center (Mile 3.68 to 5.26)
Sevenmile Creek	SM Reach 5	Feet	27,802	37,112	Above Old Hickory Blvd (Mile 5.26 to 7.03)
Sorghum Branch	SB Reach 1	Feet	0	19,254	Sorghum Branch (Mile 0.00 to 3.65)
Whittemore Branch	WB Reach 1	Feet	0	18,589	Whittemore Branch (Mile 0.00 to 3.52)

Table 12: Structure Inventory by Stream and Reach

Mill Creek						
Reach	Number of Structures in Reach	Residential	Commercial	Industrial	Public	Structure Values $'s=1,000's
MC-1	258	214	32	12	0	51,551.7
MC-2	40	22	18	0	0	17,723.8
MC-3	188	179	9	0	0	20,044.4
MC-4	68	37	25	6	0	67,391.7
MC-5	166	82	80	1	3	41,127.1
MC-6	124	124	0	0	0	11,000.7
MC-7	16	12	4	0	0	6,729.7
	860	670	168	19	3	215,569.1

Reach	Number of Structures in Reach	Residential	Commercial	Industrial	Public	Structure Values $'s=1,000's
Seven Mile Creek						
SM-1	119	118	0	0	1	9,165.3
SM-2	129	112	17	0	0	19,564.1
SM-3	135	135	0	0	0	13,004.2
SM-4	10	9	1	0	0	4,027.4
SM-5	7	7	0	0	0	1,354.4
	400	381	18	0	1	47,115.4
Sorghum Branch						
SB-1	67	60	5	1	1	17745.3
Whittemore Branch						
WB-1	138	136	0	0	2	10,456.1

3.5 Damage Calculations

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

3.6 Without Project Condition

3.6.1 Structures, Content, and Vehicle: EAD and Single Event Damages

Expected Annual Damages (EAD) was calculated for damages to structures, contents and vehicles by the FDA software model. Table 13 displays the existing and future without project estimates of EAD's as calculated in FDA for each stream by reach. Table 14 displays EAD's for existing and future without project conditions by damage category.

Table 13: Equivalent Annual Damages, Existing and Future Without Project

Mill Creek		
Reach	Existing WOP EAD's $ = 1,000's	FWOP EAD's $ = 1,000's
MC-1	282.27	307.36
MC-2	253.19	323.43
MC-3	358.87	408.32

Reach	Existing WOP EAD's $ = 1,000's	FWOP EAD's $ = 1,000's
MC-4	891.77	956.99
MC-5	326.41	353.89
MC-6	20.30	21.72
MC-7	110.99	114.95
Total	2243.80	2,486.66
Seven Mile Creek		
SM-1	730.58	713.74
SM-2	477.72	488.87
SM-3	735.62	759.33
SM-4	210.76	214.02
SM-5	1.09	17.24
Total	2155.76	2,193.20
Sorghum Branch		
SB-1	389.35	389.35
Whittemore Branch		
WB-1	387.68	387.68

Table 14: EAD's by Stream and Damage Category

Sevenmile Creek					
EAD's by Damage Category					
$'s = 1,000's					
	Commercial	Industrial	Public	Residential/Vehicle	Total
Existing Conditions	56.52	0.00	1.83	2,097.41	2,155.76
Future Conditions	57.89	0.00	1.98	2,133.33	2,193.20
Mill Creek					
EAD's by Damage Category					
$'s = 1,000's					
	Commercial	Industrial	Public	Residential/Vehicle	
Existing Conditions	1,576.73	133.70	3.62	529.45	2,243.50
Future Conditions	1,753.98	146.08	4.19	582.41	2,486.66
Sorghum Branch					
EAD's by Damage Category					
$'s = 1,000's					
	Commercial	Industrial	Public	Residential/Vehicle	
Existing Conditions	9.77	0.00	0.00	379.58	389.35
Future Conditions	9.77	0.00	0.00	379.58	389.35
Whittemore Branch					
EAD's by Damage Category					
$'s = 1,000's					
	Commercial	Industrial	Public	Residential/Vehicle	
Existing Conditions	0.00	0.00	0.65	387.03	387.68
Future Conditions	0.00	0.00	0.65	387.03	387.68
Mill Creek and Tributaries					
EAD's by Damage Category					
$'s = 1,000's					
	Commercial	Industrial	Public	Residential/Vehicle	
Existing Conditions	1,643.02	133.70	6.10	3,393.47	5,176.29
Future Conditions	1,821.64	146.08	6.82	3,482.35	5,456.89

Without project estimates of single-event damages in each of the streams reaches in the study area for specified events are displayed in Table 15, which follows.

Table 15: Single Event Damages, Future Without Project Condition

Mill Creek								
	Annual Chance Exceedance (Recurrence Interval) Damages							
	0.5 (2-Year)	0.2 (5-Year)	0.1 (10-Year)	0.04 (25-Year)	0.02 (50-Year)	0.01 (100-Year)	0.005 (200-Year)	0.002 (500-Year)
Reach MC-1								
Damage ($)	0	0	3.57	19.22	1,240.60	7,707.51	16,144.87	28,006.45
Structures (#)	0	0	2	7	22	66	345	438
Reach MC-2								
Damage ($)	123.53	337.91	627.84	857.14	1,143.32	2,082.71	3,223.43	6,155.22
Structures (#)	1	1	1	3	4	29	40	58
Reach MC-3								
Damage ($)	168.73	305.74	691.84	1107.92	1788.94	2903.42	4221.08	6593.78
Structures (#)	23	36	67	95	133	200	260	325
Reach MC-4								
Damage ($)	0	1.36	7.38	26.35	4,989.22	25,415.56	38,557.59	58,770.83
Structures (#)	0	1	3	7	27	60	71	86
Reach MC-5								
Damage ($)	23.56	38.73	402.07	1,589.80	3,110.83	4,892.18	8,199.70	15,731.12
Structures (#)	3	7	35	67	104	148	181	214
Reach MC-6								
Damage ($)	0	0	4.91	22.35	58.88	129.51	288.33	885.16
Structures (#)	0	0	3	6	11	34	82	164
Reach MC-7								
Damage ($)	44.84	76.11	179.53	179.53	295.88	362.22	1810.1	3168.34
Structures (#)	6	10	12	13	16	18	21	22
Total								
Damage ($)	360.66	759.85	1917.14	3802.31	12627.67	43493.11	72445.1	119310.9
Structures (#)	33	55	123	198	317	555	1000	1307

Table 16 Continued: Single Event Damages, Future Without Project Condition

Seven Mile Creek								
	Annual Chance Exceedance (Recurrence Interval) Damages							
	0.5 (2-Year)	0.2 (5-Year)	0.1 (10-Year)	0.04 (25-Year)	0.02 (50-Year)	0.01 (100-Year)	0.005 (200-Year)	0.002 (500-Year)
Reach SM-1								
Damage ($)	439.05	681.39	1,034.98	1,538.04	1,538.04	2,484.59	3,048.74	4,111.94
Structures (#)	86	113	132	153	163	177	191	222
Reach SM-2								
Damage ($)	221.83	335.65	828.27	1,183.96	1,553.54	2,012.62	2,311.83	3,014.65
Structures (#)	34	65	91	122	158	164	179	206
Reach SM-3								
Damage ($)	344.86	616.63	1,195.07	1,966.01	2,741.16	3,558.85	4,357.96	5,670.82
Structures (#)	75	138	196	226	241	247	258	265
Reach SM-4								
Damage ($)	198.66	225.26	240.4	262.15	277.22	290.69	307.55	323.66
Structures (#)	4	4	4	4	5	6	10	10
Reach SM-5								
Damage ($)	0	6.37	32.51	81.25	108.92	144.38	182.63	219.37
Structures (#)	0	5	7	8	8	8	10	13
Total								
Damage ($)	1,204.40	1,865.30	3,331.23	5,031.41	6,218.88	8,491.13	10,208.71	13,340.44
Structures (#)	199	325	430	513	575	602	648	716
Sorghum Branch								
	Annual Chance Exceedance (Recurrence Interval) Damages							
	0.5 (2-Year)	0.2 (5-Year)	0.1 (10-Year)	0.04 (25-Year)	0.02 (50-Year)	0.01 (100-Year)	0.005 (200-Year)	0.002 (500-Year)
Reach SB-1								
Damage ($)	228.30	425.06	662.39	876.95	1,002.06	1,197.16	1,400.40	1,646.55
Structures (#)	33	51	61	66	68	72	77	81
Whittemore Branch								
	Annual Chance Exceedance (Recurrence Interval) Damages							
	0.5 (2-Year)	0.2 (5-Year)	0.1 (10-Year)	0.04 (25-Year)	0.02 (50-Year)	0.01 (100-Year)	0.005 (200-Year)	0.002 (500-Year)
Reach WB-1								
Damage ($)	227.72	366.69	577.73	876.06	1,226.46	1,575.64	1,927.68	2,477.29
Structures (#)	40	58	91	123	154	174	186	204
Mill Creek Basin								
	Annual Chance Exceedance (Recurrence Interval) Damages							
	0.5 (2-Year)	0.2 (5-Year)	0.1 (10-Year)	0.04 (25-Year)	0.02 (50-Year)	0.01 (100-Year)	0.005 (200-Year)	0.002 (500-Year)
Damage ($)	2,021.08	3,416.90	6,488.49	10,586.73	21,075.07	54,757.04	85,981.89	136,775.18
Structures (#)	305	489	705	900	1114	1403	1911	2308

3.6.2 Other Damages

3.6.2.1 Emergency Protection Measures
Emergency costs are incurred by government agencies in the aftermath of flood events and were determined using procedures developed in a study by the U.S. Army Engineer District, Louisville, Kentucky. This study, titled Flood Damage Report for Frankfort, Kentucky, July 1981, provided a basis for estimating these types of costs. Emergency costs were computed using a unit cost for each structure based on the number of structures by frequency in the FDA program which was being considered for non-structural measures. Given that total expected annual damage for emergency costs equaled less than $1,000 for involved structures and the differences among plans was insignificant, calculation of emergency costs for alternative plans was not included in the analysis, but can be added later if resources permit and added value is identified.

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

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

3.3.2.3 National Flood Insurance Program Costs
National Flood Insurance Program (NFIP) administrative costs are applicable under the guidance of Economic Guidance Memorandum (EGM) 06-04 dated 6 April 2006. The aforementioned EGM for 2006 lists an average cost of policy is $192. This cost per policy will be incorporated in the non-structural portion of the analysis on the 80 structures being bought out. None of the structural measures eliminated the need for individual policies.

4. Benefit Analysis

4.1 Non-Structural Analysis

4.1.1 Plan A

As per ER 1105-2-100 analysis of the non-structural (NS) measure was conducted concurrently with structural measures. To analyze the benefits of non-structural residential buyouts plans, the study manager, economist, and GIS specialist used FDA output and GIS to identify and analyze "footprint" potential residential buyouts. Structures used in the non-structural measure provided the best overall BCR which matched maximizing buyouts while keeping social and physical connectivity in the forefront of the selection process. This was in keeping with the local sponsors wishes concerning the non-structural measure. A more in-depth description of the selection process can be found in main body of the report. Specific methodology and assumptions for the non-structural analysis are presented in the following paragraphs.

The NS analysis was developed entirely within the HEC-FDA certified model. To account for NS benefits it was required to make additional HEC-FDA runs with the SID adjusted to account for buyouts and raises. Residential structures which are identified to be bought were removed from the NS HEC-FDA model. Structures which are to be raised had the first floor elevation in the SID adjusted to 1-foot above the 100-year event. This adjusted first floor elevation was ascertained within the HEC-FDA detailed output from the original HEC-FDA analysis. The NS SID was then run within the HEC-FDA model and compared to the with project conditions where applicable and to the without project conditions for those streams where the structural measure did not apply. Damages from this model run were then subtracted from the original HEC-FDA analysis damages to produce NS benefits for the study. A total of 216 residential structures were identified as potential buyouts using the aforementioned criteria.

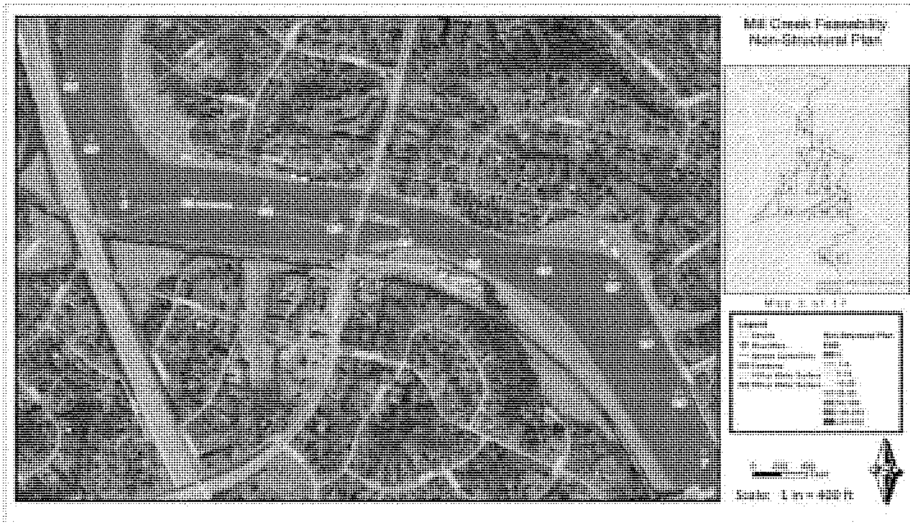


Figure 2: Example of Non-Structural Buyouts

Economic project costs for the non-structural measure was established by taking Metro Davidson County's full appraised value for the residential structure with an additional $28,130 added to account for relocation and administrative costs incurred. Costs were annualized using the appropriate discount rate of 3.3750% and a 50-year project life.

The total project costs for the recommended plan are based upon the gross appraisal values for the improved structure and lands to be purchased. As stated above, removal or demolition costs also factor into the total project cost. The gross appraisals used for the cost estimate take into account not only the structure value, but also the comparisons of all recently sold properties in the general area. Therefore, the gross appraisals are not limited to floodway/floodplain structures. This meets the requirements spelled out in general guidance of WRDA 1999, Section 219, Items 3a-3b. The appraised/improved values take into account the neighborhood as a whole, not the individual structure. Referencing the Section 219 guidance above, the flood-free structures factored into the gross appraisals. In addition to the above description, Real Estate regulations require payment-reimbursement of buyouts to depend upon these gross appraisals. The Real Estate plan describes these requirements and associated costs in further detail.

The aforementioned 216 structures considered for being bought out were also analyzed incorporating raising the residential structure to meet the requirements of FEMA and Metro Davidson County. Of the 216 considered 15 were built on slab and were unable to be raised and 1 structure would have had to have been raised 14 feet which is 2 feet higher than3 the Non-Structural PCX in Omaha suggests. Thus the raising measure considered 198 structures.

EAD's for the 198 structures was calculated in the same manner described in Section 4.1.1 Buyouts of this appendix. While FEMA has requirements to raise to the 100-year event plus 1-foot Metro Davidson County requires raising to the 100-year event plus 4-feet. Using "FDA Detailed Output" the appropriate amount the structure had to be raised was calculated for each of the 198 structures to meet Metro Davidson County's requirements. Amount of raise ranged from 0.76 feet to a high of 14.49 feet. Average amount of raising for the 9 structures was 5.53 feet.

The cost to estimate residential structures was calculated by utilizing equations based upon structure square footage. The equations are displayed in Table 17 which follows.

Table 17: Estimated Cost to Elevate Residential Structures

Estimated Cost to Elevate One-Story Residential Structures		
Square Foot Range	**Cost to Elevate Without Basements**	**Cost to Elevate With Basements**
0 - 1,250	1,000*(2.43*Raising Elevation+62.50)	1,000*(3.10*Raising Elevation+87.50)
1,250 - 1,750	1,000*(2.53*Raising Elevation+65.50)	1,000*(3.23*Raising Elevation+91.00)
1,750 - above	1,000*(2.87*Raising Elevation+72.00)	1,000*(3.53*Raising Elevation+101.00)
Estimated Cost to Elevate Two-Story Residential Structures		
Square Foot Range	**Cost to Elevate Without Basements**	**Cost to Elevate With Basements**
0 - 1,250	1,000*(3.07*Raising Elevation+71.00)	1,000*(3.77*Raising Elevation+96.00)
1,250 - 1,750	1,000*(3.17*Raising Elevation+74.50)	1,000*(3.87*Raising Elevation+100.50)
1,750 - above	1,000*(3.50*Raising Elevation+82.50)	1,000*(4.33*Raising Elevation+110.50)

Table 18 below displays the selected non-structural measure with total number of structures selected. As seen in the table the buyout measure generates over $953,000 in net benefits and eliminates a majority of the residual risk for the structures considered. A further description of the iterations of the non-structural analysis is discussed in detail in the main body of the report.

Table 18: Non-Structural Analysis

Mill Creek and Tributaries	
Non-Structural Analysis	
$=1,000's, Interest Rate 3.375%	
	Plan A
Total Structures	**90**
Total Without Project Damages	**5,456.89**
Total Annual Benefits	**1,751.60**
Total Project Costs	19,162.00
Total Annual Cost	798.62
Benefit Cost Ratio	**2.19**
Net Annual Benefits	**952.98**

4.2 Structural Measures Analysis
In the plan formulation process, varieties of structural measures were created and analyzed using the FDA model. Several structural measures were eliminated for either lack of performance or identified as cost prohibitive. All plans analyzed which were eliminated are discussed in more detail in the main body of this report. The following paragraphs provide a brief description of the structural measures carried forward.

Plan B – Ellington Agricultural Center Bridge Modification
A detention site was selected on Sevenmile Creek at river mile 3.7 located at the Ellington Agriculture Center Entrance Bridge. The measure captures 7.9 square miles, 45% of Sevenmile Creek total watershed. The low level outlet will pass normal flow and require no manual or mechanical operation. The embankment would act as a weir or spillway for flows exceeding the 5-year frequency event. The design of this structure targets reductions in the more frequent (less than a 50-year) flood events. The embankment section will be a combination of roller compacted concrete and compacted-earth. The HEC-HMS model used to calculate frequency discharges for future conditions was modified to represent the storage and outflow characteristics of the proposed measure. The resulting “with project” discharges were then placed in the calibrated HEC-RAS models to calculate frequency-flood profiles structural measures.

Figure 3, which follows shows the site of the Ellington Bridge modification site.

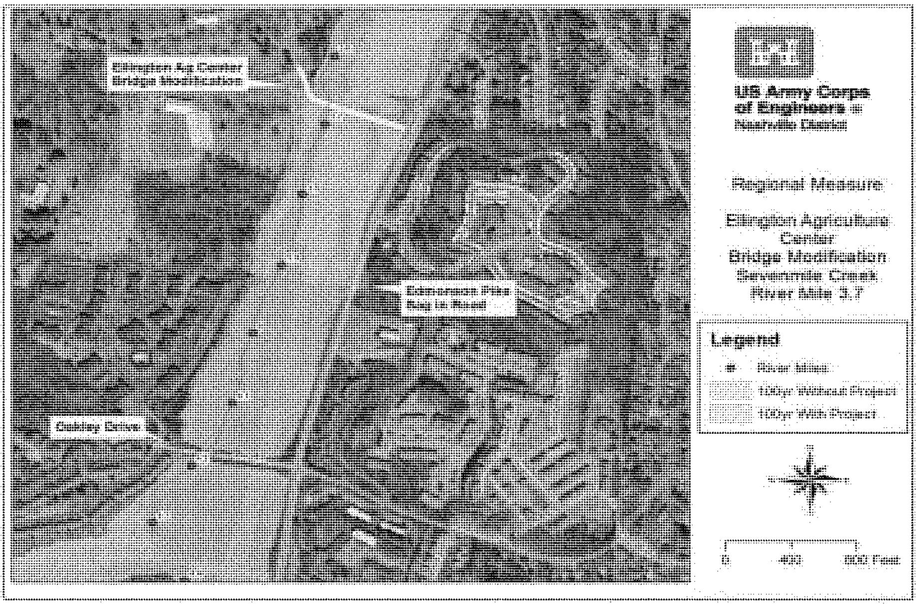


Figure 3: Plan B - Ellington Agricultural Center Bridge Modification Measure

Plan C - RCC Structure Old Hickory Boulevard

Regional approaches can often produce more economical and effective results than numerous small flood damage reduction projects. The regional detention structures recommended in the 1985 study are impractical today because the storage areas, the natural river valley upstream, have been partially developed. A new site was selected on Mill Creek at river mile 18.0, approximately 0.6 miles upstream from Old Hickory Boulevard and 1.2 miles upstream from the previous detention site. The measure captures 43.0 square miles, 40% of total Mill Creek watershed. The low level outlet will pass normal flow and require no manual or mechanical operation. The embankment acts as a weir or spillway for flows exceeding the 10-year frequency event. The embankment section will be Roller Compacted Concrete and have a vertical upstream face, a 1:1 downstream face with a 15-foot top width. The HEC-HMS model used to calculate frequency discharges for future conditions was modified to represent the storage and outflow characteristics of the proposed measure. The resulting "with project" discharges were then placed in the calibrated HEC-RAS models to calculate frequency-flood profiles.

Figure 4 shows the RCC structure on Old Hickory Boulevard. Table 19 displays the performance of the RCC structure.

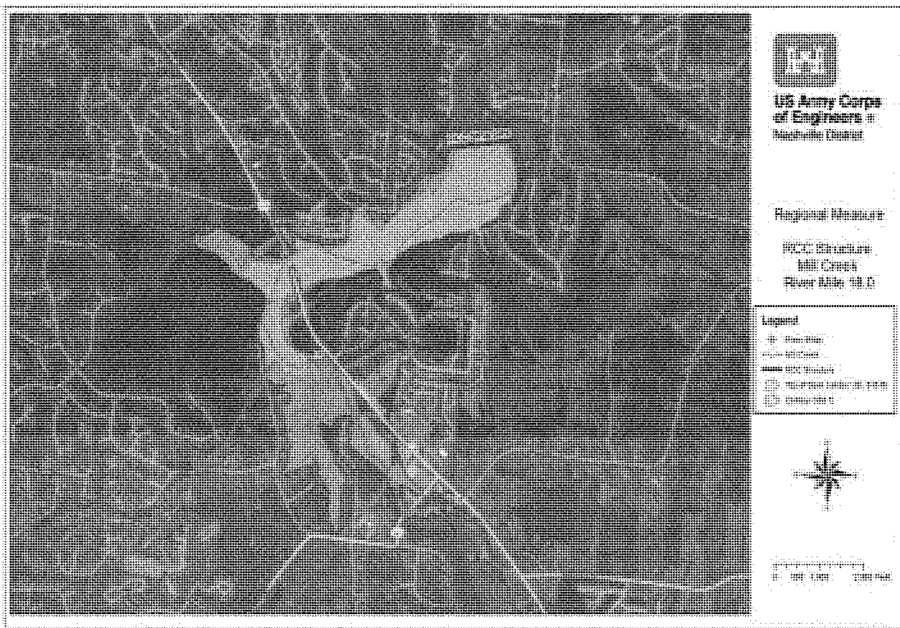


Figure 4: Plan C - RCC Structure Old Hickory Boulevard

Plan D2 – Briley Parkway Bridge Modification

Bridges with significant head loss in target damage centers were removed from the future conditions hydraulic models to evaluate water surface reductions and added benefits. Modifications to hydraulic model (HEC-RAS) cross-section geometry in the vicinity of selected bridges were made to reflect their removal. The intent was to locate bridges that could either be removed or modified to reduce flood damages. Mill Creek bridges included Murfreesboro Road (RM 4.814), Thompson Lane (RM 6.333), Briley Parkway (RM 7.059), CSX Railroad (RM 7.3), Space Park South Drive (RM 8.173), and abandoned railroad (RM 10.915), Franklin Limestone Road (RM 11.083), CSX Railroad RM 11.695 and Antioch Pike (RM 12.096). The HEC-RAS water surface profiles (.wsp files) were then used by the economist to calculate added benefits (reductions in Estimated Annual Damages). Briley Parkway was the only bridge modification to move forward past preliminary screening. The Briley Parkway bridge modification would include widening the east and west bound bridge openings by a minimum of 60 feet. Figure 5 which follows shows the Briley Parkway Bridge modification measure.

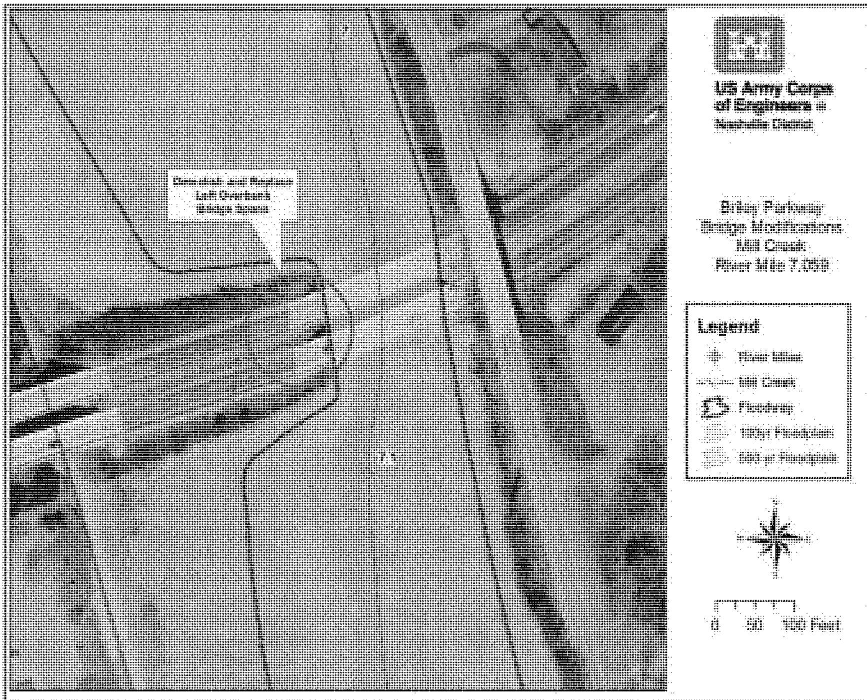


Figure 5: Plan D - Briley Parkway Bridge Modification Near Space Park

Plan E – Wimpole Drive Channel Improvement

Channel modifications were analyzed along Mill Creek in the vicinity of the Wimpole Drive residential damage center. The Wimpole Drive channel modifications included a 100-foot high-flow along the left and right overbanks between river mile 4.9 and 6.2 (Figure 10). The bench elevation would be approximately 5 to 8 feet above channel bottom. The future conditions hydraulic models were modified to include these channel modifications. Table 19 displays the performance of all structural measures.

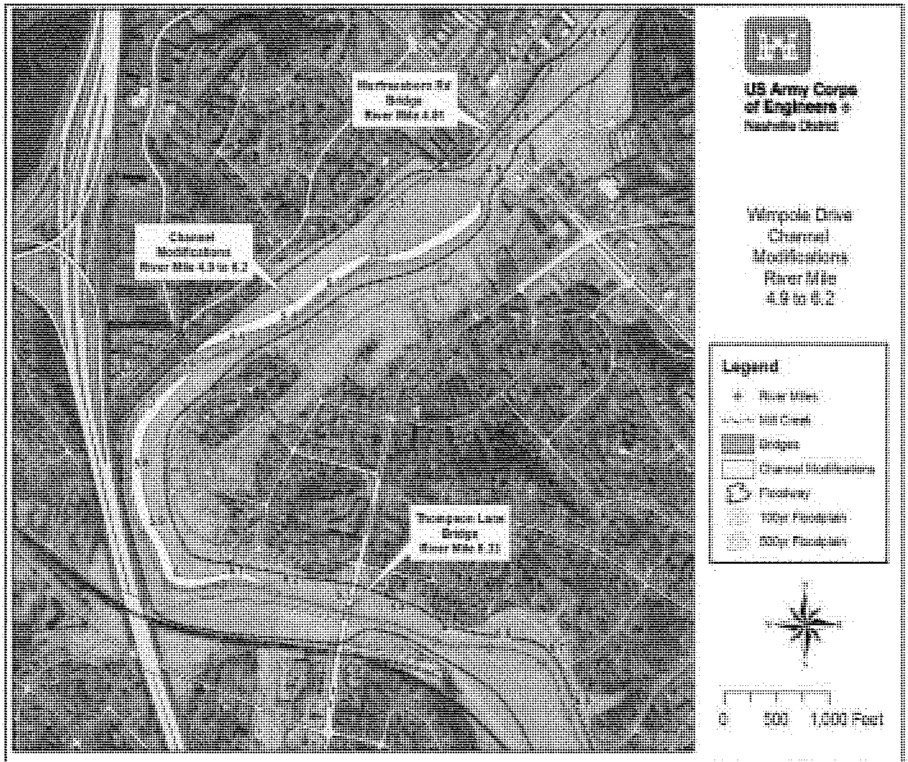


Figure 6: Plan E - Wimpole Drive Channel Modifications

Plan F – Vulcan Quarry

Stormwater diversion into the Vulcan quarry on the right bank of Mill Creek (between river mile 10.2 and 10.6) was evaluated. The measure captures 67 square miles, 62% of total Mill Creek watershed. The quarry alternative includes a diversion structure at river mile 10.25 that backs floodwaters into a gate/tunnel structure at river mile 10.36 spilling into the quarry (Figure 11). The measure is designed to start spilling into quarry at the 10-year frequency flood event. Flood hydrographs generated from the future conditions HEC-HMS model were used as input into an unsteady flow HEC-RAS model developed for the quarry alternative. Output hydrographs from the unsteady flow model were then put back into the HEC-HMS model to calculate the downstream frequency-flood discharges used in HEC-RAS.

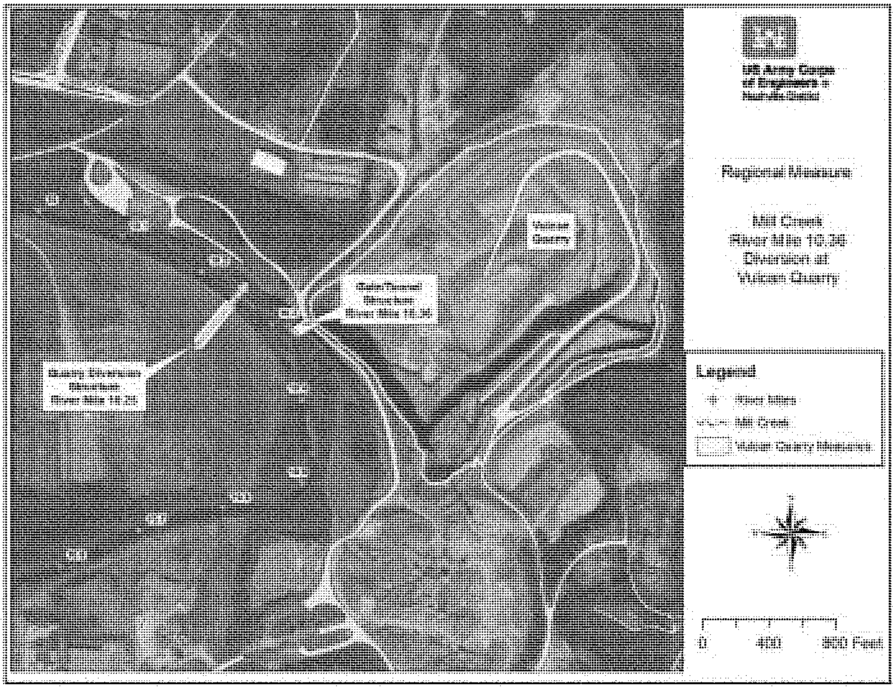


Figure 7: Plan F - Vulcan Quarry Diversion

Table 19 displays the cost, benefits, and economic performance of structural measures considered.

Table 19: Structural Analysis

Mill Creek and Tributaries Structural Analysis $=1,000's, Interest Rate 3.375%					
	Plan B	Plan C	Plan D	Plan E	Plan F
Total FWOP Damages	**5,456.89**	**5,456.89**	**5,456.89**	**5,456.89**	**5,456.89**
Total Annual Benefits	420.00	850.30	218.60	184.70	535.10
Annual NS Benefits*	0.00	0.00	0.00	0.00	0.00
Annual Structural Benefits	420.00	850.30	218.60	184.70	535.10
Total Project Costs	3,819.00	16,984.74	3,073.70	9,287.80	22,303.90
Non-Structural Costs	0.00	0.00	0.00	0.00	0.00
Structural Costs	6312.00	16,083.00	3,030.00	9,050.20	21,172.90
Interest During Construction	256.00	901.74	43.70	237.60	1,131.00
Total Annual Costs	311.11	832.88	142.45	442.09	1,054.57
Annual Cost	273.74	707.88	128.10	387.09	929.57
Annual O&M Cost	37.37	125.00	14.35	55.00	125.00
Benefit Cost Ratio	1.35	1.02	1.53	0.42	0.51
Net Annual Benefits	108.89	17.42	76.15	-257.39	-519.47

4.3 Alternative Analysis

Non-structural and structural measures were combined to create alternatives to maximize benefits where possible. The aforementioned FDA outputs were incorporated with the non-structural measure in the following manner. Section 4.1 Non-structural Analysis describes how NS benefits were accrued. Table 20 displays the alternative analysis for the Mill Creek Study.

Table 20: Alternative Analysis

Mill Creek and Tributaries Alternative Analysis $=1,000's, Interest rate 3.375%							
	Plan BA	Plan CA	Plan DA	Plan EA	Plan BC	Plan CD	Plan BDA
Total FWOP Damages	**5,456.89**	**5,456.89**	**5,456.89**	**5,456.89**	**5,456.89**	**5,456.89**	**5,456.89**
Total Annual Benefits	**2,171.60**	**2,601.90**	**1,970.20**	**2,942.30**	**1,262.66**	**1,068.90**	**2,390.20**
Annual NS Benefits*	1,751.60	1,751.60	1,751.60	2,757.60	0.00	0.00	1,751.60
Annual Structural Benefits	420.00	850.30	218.60	184.70	1,262.66	1,068.90	638.60
Total Project Costs	**28,002.60**	**35,245.00**	**22,192.00**	**54,063.80**	**23,552.74**	**20,058.44**	**28,780.32**
Non-Structural Costs	19,162.00	19,162.00	19,162.00	42,503.40	0.00	0.00	19,162.00
Structural Costs	6,312.00	16,083.00	3,030.00	9,050.20	22,395.00	19,113.00	9,342.00
IDC	2,528.60	**	**	2,510.20	1,157.74	945.44	276.32
Total Annual Costs	**1,204.44**	**1,593.91**	**939.25**	**2,308.23**	**1,143.61**	**975.98**	**1,251.20**
Annual Cost	1,167.07	1,468.91	924.90	2,253.23	981.61	835.98	1,199.48
Annual O&M Cost	37.0	125.00	15.0	55.00	162.00	140.00	52.0
Benefit Cost Ratio	**1.80**	**1.63**	**2.10**	**1.27**	**1.10**	**1.09**	**1.91**
Net Annual Benefits	**967.16**	**1,007.99**	**1,030.95**	**634.07**	**119.05**	**92.92**	**1,139.00**

*Includes NFIP Costs – 15.30 and Vehicle Damages 657.30
** IDC included in costs

Plan BDA (non-structural measure, Space Park Briley Bridge Modification, Ellington B1`ridge) is the alternative which optimizes net annual benefits and is the NED or tentatively selected plan. Alternative BDA reduces annual without project damages by over 43% and is a true representative of a regional plan for the Mill Creek basin. Since the flood of 2010 Davidson County developed and installed an exceptional flood warning system. Davidson County's FWEEP is now being used as an example by other municipalities throughout the state of Tennessee. It is estimated that their flood warning system could alleviate up to another 10% of the residual EAD's not addressed by Plan BDA.

Table 22 presents the benefit cost analysis for the NED plan and includes interest during construction (IDC) and annual operations and maintenance (O&M) costs.

Table 21: NED Plan (Plan BDA)

Mill Creek and Tributaries	
Tentatively Selected Plan - BDA	
$'s = 1,000's, Discount Rate = 3.125%	
Total FWOP Damages	**5,456.89**
Total Annual Benefits	**2,390.20**
Annual NS Benefits*	1,751.60
Annual Structural Benefits	638.60
Total Project Cost	**28,780.32**
Non-Structural Cost	19,162.00
Structural Cost	9,342.00
Interest During Construction	276.32
Total Annual Cost	**1,196.97**
Annual Cost	1,145.25
Annual O&M Costs	51.72
Benefit Cost Ratio	**2.00**
Net Annual Benefits	**1,193.23**

*Includes NFIP Costs – 15.30 and Vehicle Damages 657.30

4.4 Risk and Uncertainty

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

4.4.1 First Floor Elevations
Identification of first floor elevations (FFE) was discussed in Section 3.2 of this appendix. Error associated with deriving FFE's was incorporated in FDA after the DQC of this document following guidelines set forth respectively as to how the FFE was derived.

4.4.2 Structure Value
As described earlier in this appendix structure values were initially obtained from Metro Davidson County's Tax Assessor's office. Sampling of each structure type was then input into Marshall and Swift's Residential and Commercial Estimator to establish depreciated replacement costs. Error associated with the structure values were entered as normal distribution with a 2.5 percent standard deviation.

4.4.3 H&H Exceedance Probability Functions
Functions were derived and provided by H&H Branch using the "Graphical from WSP" function using Log Pearson III statistics with a period of 20 to 46 year equivalent record length within the FDA program for each reach, respectively.

4.4.4 H&H Stage-Discharge Function
Functions were derived and provided by the H&H Branch using the "Retrieve from WSP" function using Normal Distribution. Defined uncertainty was calculated for each reach within each stream for without project and all measures considered with the standard deviation of error being entered into the FDA program as defined by the H&H engineer.

5. Cost Analysis

5.1 Project Cost Estimates
Cost estimates were calculated by the Nashville Districts Cost Estimating Branch and provided to the economist. The Cost Estimating Appendix gives an in-depth description of procedures and assumptions in the calculation of the estimates.

5.2 Operations and Maintenance
Operations and maintenance schedules were developed by PDT members from cost estimating, design and planning and are incorporated in the analysis.

5.3 Interest During Construction
Construction schedules were not developed at the time this appendix was being prepared, but will be incorporated to all measures and alternatives at a later date.

The following formula will be used:

IDC = (((1+r)^(n*12)-1)/r))*(p/(n*12))-p; where r=monthly interest rate, n=construction period of months, and p=total project costs.

Interest during construction was calculated for the final array of measures/alternatives using FY 2015 discount rate of 3.375%. Construction periods were developed by the PDT. The NED plan had a period of construction of 36 months for the structural measures and the non-structural portion did not require IDC due to contracts being un 12 months. All other structural measures IDC was calculated with a 24-month construction period.

6. Analysis of Economic Viability

6.1 Economic Analysis Sensitivity

Table 22 below displays the economic viability performed on the NED plan (Plan BDA) using the current discount rate of 3.375% and the OMB rate of 7.0% to test the viability of the economic analysis.

Table 23 displays the sensitivity of the NED plan (BDA) when compared with different NS participation rate and with other structural alternatives. Plan BDA with 100% participation out performs in terms of annual net benefits all other plans including structural alternatives. The most likely NS participation rate of 74%, as displayed combined with BD still out performs structural measures.

Table 22: Economic Analysis Viability

Mill Creek and Tributaries		
NED Plan (Plan BDA) Alternative Viability Analysis		
$=1,000's, Discount Rate 3.125%		
	Plan BDA 3.375% Interest Rate	Plan BDA 7.0% Interest Rate
Total FWOP Damages	**5,456.89**	**5,456.89**
Total Annual Benefits	2,390.20	2,390.20
Annual NS Benefits*	1,751.60	1,751.60
Annual Structural Benefits	638.60	638.60
Total Project Costs	28,780.32	28,780.32
Non-Structural Costs	19,192.00	19,162.00
Structural Costs	9,342.00	9,342.00
Interest During Construction	276.32	276.32
Total Annual Costs	**1,196.97**	**2,137.14**
Annual Cost	1,145.25	2,085.42
Annual O&M Cost	51.72	51.72
Benefit Cost Ratio	**2.00**	**1.12**
Net Annual Benefits	**1,193.23**	**253.06**

*Includes NFIP Costs – 15.30 and
Vehicle Damages 657.30

Table 23: Economic Sensitivity Analysis

Mill Creek and Tributaries			
Tentatively Selected Plan Sensitivity Analysis			
$'s = 1,000's, Discount Rate = 3.125%			
	Plan BDA NED Plan	Alt. BC	Alt. CD
Total Annual Benefits	2,390.20	**1,262.66**	**1,068.90**
Annual NS Benefits	1,751.60	0.00	0.00
Annual Structural Benefits	638.60	1,262.66	1,068.90
Total Project Cost	28,780.32	**23,552.74**	**20,058.44**
NS Cost	19,162.00	0.00	0.00
Structural Cost	9,342.00	22,395.00	19,113.00
IDC	276.32	1,157.74	945.44
Total Annual Cost	**1,196.97**	**1,087.23**	**975.18**
Annual Cost	1,145.25	937.23	798.18
Annual O&M Costs	51.72	150.00	177.00
Benefit Cost Ratio	**2.00**	**1.16**	**1.10**
Net Annual Benefits	**1,193.23**	**175.43**	**93.72**

6.2 Monte Carlo Analysis of Viability

This viability test will be included prior to ATR using FDA information and guidelines set forth in ER-11058-2-101.

7. Financial Analysis

7.1 Cost apportionment

Cost apportionment and cost share requirements are discussed fully in section 4.6 of the main body of the report.

7.2 Ability to Pay Analysis
Metro-Davidson County is not be eligible for a reduction in their share due to the ability to pay analysis. .

7.3 Financial Capability
Metro Davidson County, Tennessee has stated that it is capable and will to cost share in the project. Davidson County has an exemplary history in cost sharing projects with the Nashville District and no reason exists that it will continue in the future.

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

U.S. ARMY CORPS OF ENGINEERS
NASHVILLE DISTRICT

FINDING OF NO SIGNIFICANT IMPACT

Mill Creek Flood Risk Management Study
Integrated Feasibility Report and Environmental Assessment
Nashville, Tennessee

The U. S. Army Corps of Engineers, Nashville District (Corps) has conducted an environmental analysis in accordance with the National Environmental Policy Act of 1969, as amended. The Corps addressed the effects of the recommended plan in the Final Integrated Feasibility Report and Environmental Assessment (IFR/EA), dated July 2015, for the Mill Creek Flood Risk Management Study, Nashville, Davidson County, Tennessee, which is incorporated herein by reference. The purpose of the study is to analyze potential solutions for the flooding problems within the Mill Creek watershed. The recommended plan includes the following actions:

- Construct a 377-acre-foot capacity storm water detention basin at mile 3.67 on Sevenmile Creek;
- Modify the Briley Parkway bridge and widen the Mill Creek channel at mile 7.1;
- Raise nine residential structures in-place above the 1-percent change flood elevation; and,
- Purchase and remove 80 frequently damaged residential structures located in the regulated floodway of Mill Creek and its tributaries.

2. In addition to the "no action" alternative, a wide variety of flood risk management measures were developed that would address one or more of the planning objectives. The recommended plan, Plan BDA, was ultimately determined to be the National Economic Development (NED) Plan and the environmentally-preferred alternative. The NED plan provides the greatest net benefits of any of the considered alternatives. The recommended plan also leaves considerably less residual risk in the floodplain than other plans in the final array.

3. All practicable means to avoid and minimize adverse environmental effects have been incorporated into the recommended plan. The recommended plan will not result in any significant direct or indirect impacts, causing only minimal and temporary adverse impacts during construction to water quality, aquatic resources, terrestrial resources, socioeconomics, noise, navigation, recreation and scenic resources. Therefore, no compensatory mitigation is required.

4. Due to potential impacts to the Nashville crayfish the Corps entered into formal consultation with U.S. Fish and Wildlife Service (USFWS). A Biological Assessment was sent to USFWS on August 28, 2014. A final Biological Opinion (BO) was received from USFWS on March 23, 2015. The USFWS' BO states that the preferred alternative would not likely jeopardize the continued existence of the Nashville crayfish with the implementation of the BO.

5. Section 106 of the National Historic Preservation Act (NHPA) of 1966, as amended, was initiated with the State Historic Preservation Office (SHPO), American Indian Tribes with an ancestral connection to Davidson County, Metropolitan Nashville and Davidson County Historical Commission, and other consulting parties on February 14, 2013. In a letter dated February 11, 2015, SHPO concurred with the Corps determination that "the project will not adversely affect any property that is eligible for listing in the National Register." Section 106 of the NHPA concluded with a "no adverse effect to historic properties" determination.

6. Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations, was signed on February 11, 1994. The order requires Federal agencies to promote "nondiscrimination in Federal programs substantially affecting human health and the environment." The Corps documented no disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority and low-income populations. The proposed action is in compliance with Executive Order 12898 for Environmental Justice.

7. I have reviewed the final IFR/EA and the public and agency comments, in light of the general public interest. 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.

14-MAR-16

DATE

Stephen F. Murphy
Lieutenant Colonel, U.S. Army
District Commander

Mill Creek Scoping Notice

Appendix D

Version 12 February 2014

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO
ATTENTION OF

Project Planning Branch

TO ALL INTERESTED PARTIES:

The Corps of Engineers, Nashville District, is completing a feasibility study to investigate flood risk management measures within the Mill Creek watershed in Davidson County, Tennessee. The Metropolitan Government ofNashville and Davidson County (Metro) is the project sponsor. This project, which was originally scoped in 2003 and now rescoped following the May 2010 flood event, is moving forward with a primary flood risk management analysis and secondary ecosystem restoration consideration.

The Mill Creek watershed is located in parts of Davidson, Williamson, and Rutherford counties and drains nearly 70,000 acres (108 square miles). A vicinity and watershed map (Figure 1) of the proposed study area is enclosed. The watershed supports many plants, fish, and wildlife including the Nashville Crayfish *(Orconectes shoupi)*, an endangered species. The stream corridor offers important esthetic and recreational opportunities such as fishing, bird watching, nature study, and paddlecraft use.

The Mill Creek study would use computer models to depict hydrology, aquatic habitat, and water quality processes occurring in the watershed. The study would also consider storm water management, future development, floodplain mapping, endangered species protection, stream bank stabilization, water quality impacts from point and non-point sources, and stream corridor habitat enhancement. The study aims to predict and minimize flood damage in a way that protects, maintains, and restores the ecologically sensitive Mill Creek and its tributaries.

Alternatives to be analyzed would include those identified during the initial 2003 screening analysis, as well as alternatives analyzed in support of Metro's Unified Flood Preparedness Plan initiative. Preliminary flood risk management alternatives that would be considered include non-structural measures such as vegetative berms, expanding floodways and natural habitat, flood water storage basins, and raising or removal of structures from the floodway and/or floodplain. Structural measures evaluated would include floodwalls, bridge improvements, and quarry diversion and associated gate/tunnel structures. Changes to existing land use practices such as establishment of water quality buffers would be considered to protect stream corridors; these corridors could also include public parks or other passive recreational features.

In accordance with the National Environmental Policy Act (NEPA) and applicable implementing regulations, an Environmental Assessment would be prepared to evaluate viable alternatives for this proposal as an integral part of this planning study. We are soliciting public and agency comments concerning environmental issues that should be addressed in the course of

the NEPA process. We encourage comments not only about the immediate project area, but also of plans or proposals for any other development that may impact or influence project resources.

This letter also serves to initiate the public involvement requirements of Section 106 of the National Historic Preservation Act of 1966, as amended. Section 106, implemented by regulations at 36 CFR 800, requires the Corps of Engineers to consider the effects of its undertakings on historic properties. If required, appropriate architectural and archeological investigations would be conducted within those areas affected by the proposed activities and resulting findings would be coordinated with the Tennessee State Historic Preservation Officer and other consulting parties.

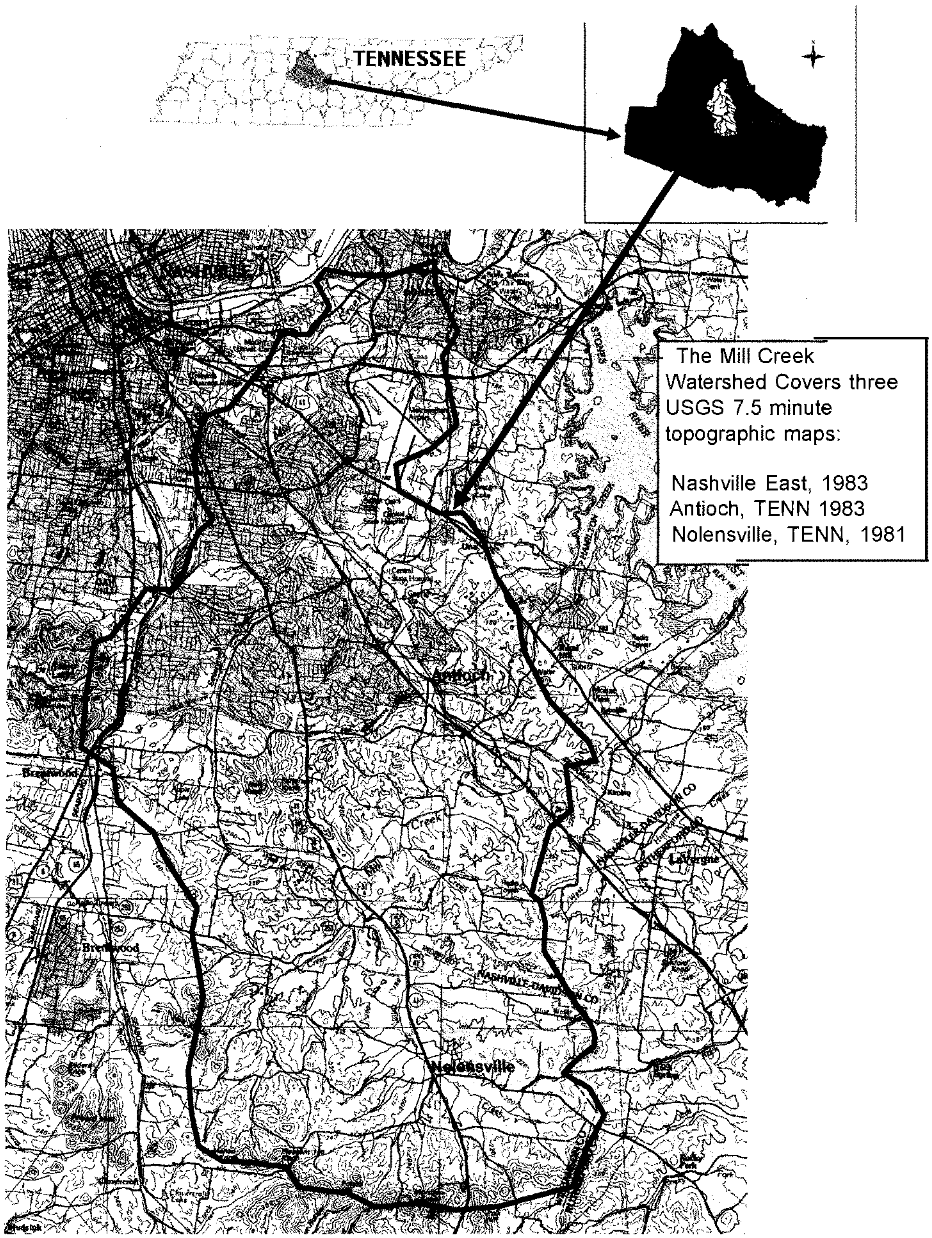
The public and local, state and federal agencies are invited to submit written comments to this scoping no later than 15 March 2013. Please note that there would be other opportunities for comments during the planning phase at future public workshops and circulation of the NEPA document for public comment. Workshops are being planned, however, times, dates, or locations have not been determined. Once set, this information will be shared through media and the Corps website-www.lrn.usace.army.mil.

You may mail comments to the Nashville District, U.S. Army Corps of Engineers, P.O. Box 1070 (PM-P), Nashville, TN 37202-1070, ATTN: Planning Branch (Mark Vaughan), direct comments via phone at (615) 736-7850, or email to mark.k.vaughn@usace.army.mil. Information may also be obtained by contacting Mr. Porter Williams, Project Manager at (615) 736-7635.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Figure 1. Vicinity and Watershed Map for the Mill Creek Watershed in Tennessee.



Vaughn, Mark K LRN

From: Dixson, Brigham [Brigham.Dixson@mail.house.gov]
Sent: Tuesday, February 19, 2013 3:09 PM
To: Vaughn, Mark K LRN
Subject: Mill Creek Project

Mr. Vaughn:

I am with Congressman Blackburn's office in Frnaklin, TN. The Congressman's Senior Advisor asked that you let him know if there would be anything occurring in Nolansville as a result of the project to investigate flood risk management in Tennessee. His email is steve.allbrooks@mail.house.gov.

Please contact him and not me as I will not be in this office following today.

Thank you,

Briggs Dixson

Vaughn, Mark K LRN

From: Williams, Porter LRN
Sent: Friday, March 01, 2013 12:50 PM
To: Vaughn, Mark K LRN
Subject: RE: Mill Creek- Reporter (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

The Tennessean. She indicated that she was more concerned with Williamson County though.

D. Porter Williams, E.I.
Civil Engineer, Project Manager
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District

(615)736-7635

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

-----Original Message-----
From: Vaughn, Mark K LRN
Sent: Friday, March e1, 2e13 11:52 AM
To: Williams, Porter LRN
Subject: RE: Mill Creek - Reporter (UNCLASSIFIED)

Thanks Porter and keep any comments coming my way. Who was Ms. Burch representing?

Mark Vaughan
Biologist
Project Planning Branch
US Army Corps of Engineers
615-736-785e

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

-----Original Message-----
From: Williams, Porter LRN
Sent: Thursday, February 28, 2e13 3:52 PM
To: Vaughn, Mark K LRN
Cc: Carrington, Craig D LRN
Subject: Mill Creek - Reporter (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Mark,

I don't think this counts for a seeping notice response, but a reporter, Bonnie Burch, called just a few minutes ago to ask a few questions about the Mill Creek study. She had gotten wind of it from the seeping notice, and just wanted to get some more background on the study and ask what kind of responses we were looking for out of the seeping notice. I told her basically any input that any agency, organization, or agency had related to Mill Creek flooding.

Let me know if we need further documentation on this one.

Best,

D. Porter Williams, E.I.

Civil Engineer, Project Manager

Project Planning Branch

U.S. Army Corps of Engineers

Nashville District

(615) 736-7635

Internet: http://www.lrn.usace.army.mil <http://www.lrn.usace.army.mil/>

Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

Vaughn, Mark K LRN

From: McCormack, Valerie J LRN
Sent: Friday, March 01, 2013 11:12 AM
To: Vaughn, Mark K LRN
Cc: Williams, Porter LRN
Subject: FW: USAGE-Nashville Mill Creek, Davidson Co TN. Feasibility (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Mark,
Below is a response to UKBCI for Mill Creek.
The 1e6 letter requests a phased approach, which will require continued consultation once some locations are identified.
Thanks,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District

(615) 736 - 7847

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

-----Original Message-----
From: Lisa LaRue-Baker - UKB THPO [mailto:ukbthpo-larue@yahoo.com]
Sent: Wednesday, February 27, 2e13 11:25 AM
To: McCormack, Valerie J LRN
Cc: lstapleton@unitedkeetoowahband.org
Subject: Re: USACE-Nashville Mill Creek, Davidson Co TN. Feasibility (UNCLASSIFIED)

Thank you Valerie, we look forward to receiving future communications on this project!

Lisa C. Baker
Acting THPO
United Keetoowah Band of Cherokee Indians in Oklahoma
PO Box 746
Tahlequah, OK 74465

c 918.822.1952
ukbthpo-larue@yahoo.com

Please FOLLOW our historic preservation page and LIKE us on FACEBOOK
<https://Www.facebook.com/pages/United-Keetoowah-Band-of-Cherokee-Indians-in-Oklahoma-Historic-Preservation/199767846834850>

--- On Mon, 2/25/13, McCormack, Valerie J LRN <Valerie.J.McCormack@usace.army.mil> wrote:

From: McCormack, Valerie J LRN <Valerie.J.McCormack@usace.army.mil>
Subject: USACE-Nashville Mill Creek, Davidson Co TN. Feasibility (UNCLASSIFIED)
To: ''ukbthpo-larue@yahoo.com" <ukbthpo-larue@yahoo.com>
Date: Monday, February 25, 2013, 3:09 PM

Classification: UNCLASSIFIED
Caveats: NONE

Dear Lisa,

Please find attached a NEPA scoping letter and NHPA Section 106 initiation letter. These were sent to Chief Wickliffe on Feb. 15, 2012. This study will identify flood risk reduction measures (eg. channel widening, levees, or diversions)within Mill Creek Watershed in southern Davidson County, Tennessee. As the "measures" are identified, and combined into "alternatives", we will continue 106 consultation regarding identification of historic properties and cultural resources and potential effects to historic properties.

Please disregard the response date on the Scoping Notice, as this email is getting out late.

Please feel free to email or call if you have questions or need additional information.

And thanks again for the kind words.

Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District

(615)736 - 7847

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

Vaughn, Mark K LRN

From: McCormack, Valerie J LRN
Sent: Monday, March 11, 2013 8:20 AM
To: Vaughn, Mark K LRN
Subject: FW: Mill Creek Watershed, Davidson, Williamson and Rutherford Counties, TN (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Mark,
I'm not sure who is taking Mill Creek during your absence. I'll retain this email and share with Biologist if the project moves ahead while you are out.
NRN---
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District

(615)736 - 7847

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

-----Original Message-----
From: Lisa LaRue-Baker - UKB THPO [mailto:ukbthpo-larue@yahoo.com]
Sent: Sunday, March 10, 2013 4:11 PM
To: McCormack, Valerie J LRN
Cc: lstapleton@unitedkeetoowahband.org
Subject: Mill Creek Watershed, Davidson, Williamson and Rutherford Counties, TN

The United Keetoowah Band of Cherokee Indians in Oklahoma has reviewed your project under Section 106 of the NHPA, and at this time have no comments or objections. However, if any human remains are inadvertently discovered, please cease all work and contact us immediately.

Lisa C. Baker
Acting THPO
United Keetoowah Band of Cherokee Indians in Oklahoma
PO Box 746
Tahlequah, OK 74465

c 918.822.1952
ukbthpo-larue@yahoo.com

STATE OF TENNESSEE

DEPARTMENT OF ENVIRONMENT AND CONSERVATION

Division of Natural Areas
Natural Heritage Program
7th Floor L&C Tower
401 Church Street
Nashville, Tennessee 37243
Phone 615/532-0431 Fax 615/532-0046

March 13, 2013

ATTN: Planning Branch (Mark Vaughn)
Nashville District, U.S. Army Corps of Engineers
P.O. Box 1070 (PM-P)
Nashville, TN 37202-1070

Subject: USACE Flood Risk Management Study
Mill Creek Watershed
Davidson County, Tennessee
Rare Species Database Review

ATTN: Planning Branch (Mark Vaughn):

Thank you for your correspondence requesting a rare species database review in support of the planned investigation of flood risk management measures within the Mill Creek watershed in Davidson County, Tennessee.

We have reviewed the state's natural heritage database with regard to the watershed boundaries, and we find that the following rare species have been observed previously inside or within one mile of the Mill Creek watershed. Note that the data summarized below include rare species observations from Davidson County as well as the more upstream parts of the watershed(* = inside Mill Creek watershed):

Type	Scientific Name	Common Name	Global Rank	St. Rank	Fed. Prot.	St. Prot.	Habitat
Invertebrate Animal	Orconectes shoupi*	Nashville Crayfish	G1G2	S1S2	LE	E	1st-order & larger streams, generally with bedrock bottom, under slabrock; endemic to Mill Creek watershed; Davidson & William. cos.
Invertebrate Animal	Sphalloplana buchanani*	A Cave Obligate Planarian	G1G2	SI	--	Rare, Not State Listed	Aquatic cave obligate; northern Central Basin; Davidson County; taxonomy poorly understood.
Other (Ecological)	Heron rookery*	Heron Rookery	GNR	SNR	--	Rare, Not State Listed	

Type	Scientific Name	Common Name	Global Rank	St. Rank	Fed. Prot.	St. Prot.	Habitat
Vascular Plant	Allium stellatum	Glade Onion	GS	SI	--	E	Glades
Vascular Plant	Anemone caroliniana	Carolina Anemone	GS	S1S2	--	E	Glades And Cedar Woodlands
Vascular Plant	Astragalus tennesseensis	Tennessee Milk-vetch	G3	S3	--	S	Glades
Vascular Plant	Dalea foliosa	Leafy Prairie-clover	G2G3	S253	LE	E	Rocky Washes In Glades
Vascular Plant	Echinacea tennesseensis	Tennessee Coneflower	G2	S2	DM	E	Ordovician Limestone Glades
Vascular Plant	Elymus svensonii	Svenson's Wild-rye	G3	S2	--	E	Rocky Bluffs
Vascular Plant	Hydrastis Canadensis*	Goldenseal	G4	53	--	S-CE	Rich Woods
Vascular Plant	Hydrocotyle americana	American Water-pennywort	GS	51	--	E	Wet Soils And Pools
Vascular Plant	Juglans cinerea	Butternut	G4	53	--	T	Rich Woods And Hollows
Vascular Plant	Leavenworthia exigua var. exigua*	Glade-cress	G4T3	S3S4	--	S	Glades
Vascular Plant	Panax quinquefolius	American Ginseng	G3G4	S3S4	--	S-CE	Rich Woods
Vascular Plant	Paysonia densipila*	Duck River Bladderpod	G3	S3	--	T	Cultivated Fields
Vascular Plant	Perideridia americana	Thicket Parsley	G4	52	--	E	Cedar Barrens
Vascular Plant	Phemeranthus calcaricus*	Limestone Fame-flower	G3	S3	--	S	Glades
Vascular Plant	Phlox bifida ssp. stellaria	Glade Cleft Phlox	GS?T3	S3	--	T	Glades
Vascular Plant	Ranunculus aquatilis var. diffusus	White Water-buttercup	GSTS	SI	--	E	Ponds And Streams
Vascular Plant	Stellaria fontinalis*	Water Stitchwort	G3	53	--	S	Seeps And Limestone Creek Beds
Vertebrate Animal	Acipenser fulvescens	Lake Sturgeon	G3G4	SI	--	E	Bottoms of large, clean rivers and lakes.
Vertebrate Animal	Etheostoma luteovinctum*	Redband Darter	G4	S4	--	D	Limestone streams; Nashville Basin & portions of Highland Rim.

We suggest that these species be taken into consideration as the flood risk management study is developed. We ask that you coordinate this project with the Tennessee Wildlife Resources Agency (Rob Todd, rob.todd@tn.gov, 615-781-6577) to ensure that legal requirements for protection of state listed rare animals are addressed. Additionally, we ask that you contact the U.S. Fish and Wildlife Service Field Office, Cookeville, Tennessee (931-525-4970) for comments regarding federally listed species.

For stabilization of disturbed areas, the Tennessee Natural Heritage Program advocates the use of native trees, shrubs, and warm season grasses, where practicable. Care should be taken to prevent re-vegetation of disturbed areas with plants listed by the Tennessee Exotic Pest Plant Council as harmful exotic plants: http://www.tneppc.org/

Please keep in mind that not all of Tennessee has been surveyed and that a lack of records for any particular area should not be construed to mean that rare species necessarily are absent. For information regarding species protection status and ranks, please visit http://www.tn.gov/environment/na/pdf/Status&Ranks.pdf.

To assist in determining whether rare species are located at a given site, the Tennessee Natural Heritage Program has implemented a publicly accessible website where rare species data lists by county, quadrangle, watershed, and MS4 boundaries can be obtained: http://environment-online.state.tn.us:8080/pls/enf_reports/f?p=9014:3:3875605994273657.

Thank you for considering Tennessee's rare species throughout the planning of this study. Should you have any questions, please do not hesitate to contact David at (615) 532-0441 or david.withers@tn.gov.

Sincerely,

Chelsea L. Broach
Interim Data Manager

David Ian Withers
Natural Heritage Zoologist

Vaughn, Mark K LRN

From: Holliman, Daniel [Holliman.Daniel@epa.gov]
Sent: Friday, March 15, 2013 12:48 PM
To: Vaughn, Mark KLRN
Subject: Mill Creek watershed feasibility study

Mr. Vaughn,

We've reviewed the scoping notice sent to us regarding the Mill Creek watershed feasibility study and have no comments at this time. Please send us a copy of the EA when available for us to review. Thanks for providing us an opportunity to review.

Regards,

Dan Holliman

USEPA Region 4 | NEPA Program Office

61 Forsyth Street SW | Atlanta, GA 30303

tel 404.562.9531 | holliman.daniel@epa.gov <mailto:holliman.daniel@epa.gov>

Region 4 NEPA: http://www.epa.gov/region4/opm/nepa/index.html <http://www.epa.gov/region4/opm/nepa/index.html>

Vaughn, Mark K LRN

From: Robbie Sykes [robbie_sykes@fws.gov]
Sent: Friday, March 15, 2013 10:34 AM
To: Vaughn, Mark K LRN
Cc: sandra_silvey@fws.gov; rob.todd@tn.gov
Subject: Mill Creek Watershed feasibility study

Mark,

The Service has reviewed the scoping letter for the COE, Nashville District feasibility study to investigate flood risk management measures within the Mill Creek watershed in Davidson County, Tennessee. As you are aware, the federally endangered Nashville crayfish occurs throughout the entire Mill Creek watershed. Additionally, this is the only watershed where this species is known to occur. Since this study is in the very early stages, the Service will likely have more relevant comments once the project moves further along.

At this time, we do not have any pertinent comments other than any alternative that would modify or impact waterways could adversely affect the Nashville crayfish. Therefore, we request that you keep our office informed as the process moves forward and let us know of any upcoming workshops that might be useful for our agency to attend.

Thanks,

Robbie Sykes
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
446 Neal Street
Cookeville, TN 38501
(tele. 931/525-4979)
(fax. 931/528-7075)

Vaughn, Mark K LRN

From: Vaughn, Mark KLRN
Sent: Monday, March 25, 2013 2:03 PM
To: Vaughn, Mark KLRN
Subject: Mill Creek- Scoping Comments- Margaret Castro

Margaret Castro - margie1670@gmail.com

Provide draft EA/FONSI for review and comment

Received via phone on 22 March 2013 - 668-1430

Mark Vaughan
Environmental Protection Specialist
Operations Division
US Army Corps of Engineers
615-736-7984

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Vaughn, Mark K LRN

From: Vaughn, Mark K LRN
Sent: Friday, April 12, 2013 12:53 PM
To: Vaughn, Mark K LRN
Subject: FW: Mill Creek General Investigative Study- Scoping Notice
Attachments: Mill Creek GI Study- Signed Scoping Letter.pdf

Vaughn, Mark K LRN

Received contact via phone on 13 April 2013

Mrs. McArther - mcartherndd@united.net

6649 Nolensville Road, Brentwood, TN 37027

Provided scoping notice, and send draft EA/FONSI for discussion when available

Phone - 776-2393

Original
Message---
-- From:
Vaughn,
Mark K LRN
Sent: Friday, April
12, 2013 12:47 PM
To:
'mcartherndd@united.ne
t'
Subject: Mill Creek General Investigative Study - Scoping Notice

Good Afternoon - provided is information requested regarding scoping notice sent out for agency and public review regarding proposed general investigative study on Mill Creek. I will add your contact information to others who have inquired to provide additional information as the study progresses.

Thanks

Mark Vaughan
Environmental Protection Specialist
Operations Division, Nashville District
US Army Corps of Engineers
615-736-7984

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

Project Planning Branch **October 30, 2014**

TO ALL INTERESTED PARTIES:

The U. S. Army Corps of Engineers, Nashville District (Corps) has prepared a Draft Integrated Feasibility Report, which included a Draft Environmental Assessment (EA), for the Mill Creek Flood Risk Management Study, Nashville, Davidson County, Tennessee. The purpose of this report is to analyze potential solutions for the flooding problems in the Mill Creek watershed. The report documents a Federal interest in implementation of structural and non-structural measures that address flood risk management.

This report authorized by the U.S. House Committee on Transportation and Infrastructure resolution adopted September 14, 1995. The report presents the flood risk management problems and opportunities within the Mill Creek watershed as well as the measures and alternatives considered to reduce damages within the region. The economic analysis for each management measure and alternative is documented and a tentatively selected plan is recommended. The study was conducted in conjunction with the Metropolitan Government of Nashville and Davidson County (Metro) serving as the non-Federal sponsor, and the Corps.

A wide variety of flood risk management measures were developed that would address one or more of the planning objectives. Plan BDA was ultimately determined to be the National Economic Development (NED) Plan and is the Tentatively Selected Plan that provides the greatest net benefits. Plan BDA also leaves less residual risk in the floodplain than other plans considered in detail. Plan BDA is described below.

- **Plan BDA – Ellington Detention Basin, Briley Bridge and Channel Modification and Non-Structural Plan** - This plan maximizes the net annual benefits and provides significant residual flood risk reduction while being cost effective. Plan BDA included 5-year flood protection by selecting residential structures for raise-in-place or buyout and removal. The plan combined a structural measure of a detention basin at Sevenmile Creek targeting minor to moderate floods from the 10-year flood to the 25 year flood. Damage reduction is also experienced up to the 100-year flood. The plan also includes bridge and channel modifications at Briley Parkway targeting moderate flood damages from the 10-year event to the 50 year event.

The recommended plan, Plan BDA, has an investment cost of $24,781,900 and a benefit-to-cost ratio (BCR) of 2.49 at October 2013 price levels and an interest rate of 3.5 percent.

Plans A, B, and D are considered as plans that may be built separately or independent of one another and therefore were evaluated independently in the environmental assessment as schedule or funding levels could impact the order of construction. The EA evaluated the following action alternatives:

- Plan A – Nonstructural Alternative – buyout and/or raising of approximately 90 homes within the floodway. A floodway is defined as the channel of a river or stream and the parts of the floodplain adjoining the channel that are reasonably required to efficiently carry and discharge the flood water or flood flow of a river or stream.

- Plan B – Ellington Agricultural Center Detention Structure – raising of the existing East Access Road approximately seven feet and installing a new bridge over Sevenmile Creek.

- Plan D – Briley Bridge Modification – removal of embankment fill in floodplain, above ordinary high water, and installation of a new bridge pier.

- No Action Alternative – current/existing conditions would continue throughout the Mill Creek Watershed.

The EA revealed no significant direct or indirect impacts from the NED Plan. The NED Plan would cause minimal and temporary adverse impacts during construction to water quality, aquatic resources, terrestrial resources, socioeconomics, noise, recreational and scenic resources. Temporary short-term impacts to the federally listed species, the Nashville Crayfish (*Orconectes shoupi*), are likely due to work within and adjacent to Sevenmile Creek (Plan B) and Mill Creek (Plan D). Formal Endangered Species Act consultation with the U.S. Fish and Wildlife Service (USFWS) is ongoing and would be finalized prior to signing of a Finding of No Significant Impact (FONSI) statement. At this time, no mitigation for impacts to wetland and stream would be required.

The recommended plan has the potential to remove nearly half of the expected annual damages associated with Mill Creek and tributary flooding. The proposed action is in compliance with the Clean Air Act and Executive Order 12898 for Environmental Justice. None of the alternatives described in this EA would disproportionately place any adverse environmental, economic, social, or health impacts on minority and low-income populations.

This letter serves as a Notice of Availability for reviewing the Draft Integrated Feasibility Report, to include the EA, and unsigned FONSI. This document is prepared pursuant to the National Environmental Policy Act (NEPA), Council on Environmental Quality Regulations (40 CFR 1500-1508), and the USACE implementing regulation, ER 200-2-2, 1988, *Policies and Procedures for Implementing NEPA*.

Electronic copies of the documents can be found at: http://www.lrn.usace.army.mil/Media/PublicNotices.aspx; hard copies can be provided upon request.

Please submit any written comments **no later than 30 days from the above date** to ensure consideration in the EA. Send your written comments to the address above, ATTN: CELRN-PM-P Thomas Herbert (Project Manager) or Matthew Granstaff (Biologist), or email your comments to CorpsLRNPlanningPublicCom@usace.army.mil. Your participation is greatly appreciated.

Sincerely,

Russ Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Figure 1. Mill Creek Watershed Map.

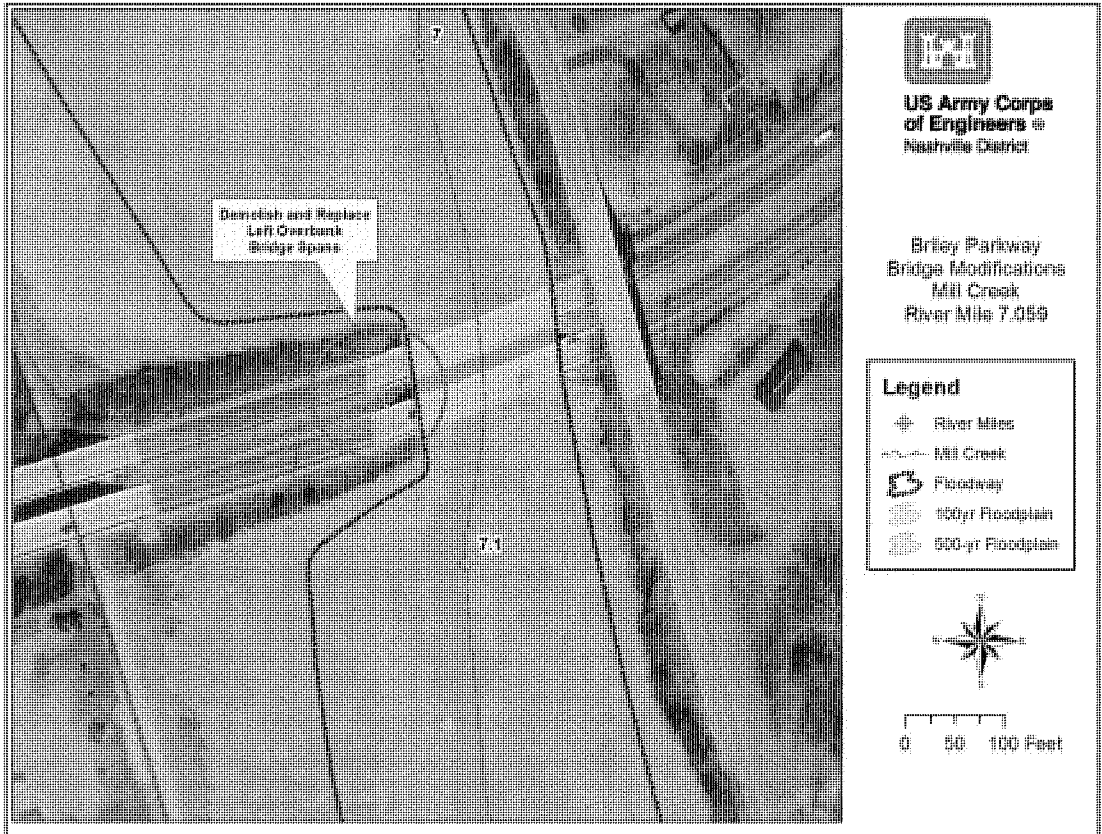


Figure 2. Plan D - Briley Parkway Bridge Modifications

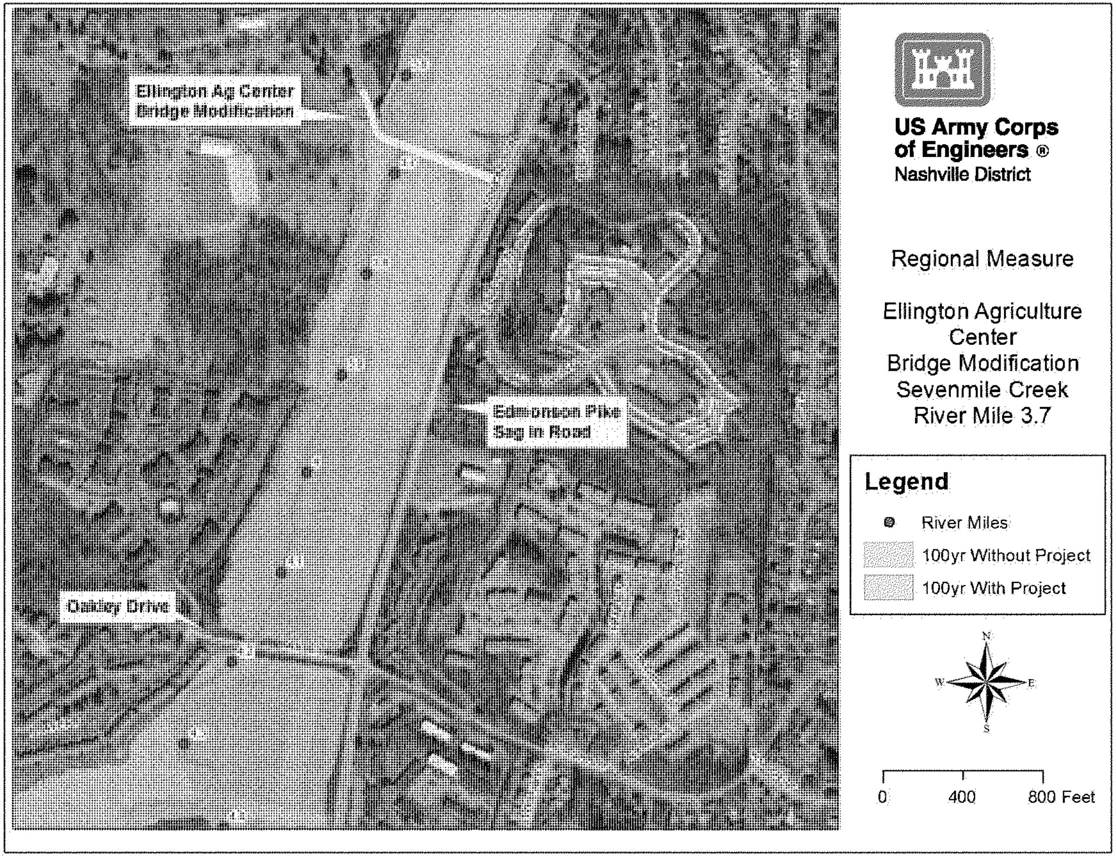


Figure 3. Plan B - Ellington Ag Center Bridge Modifications

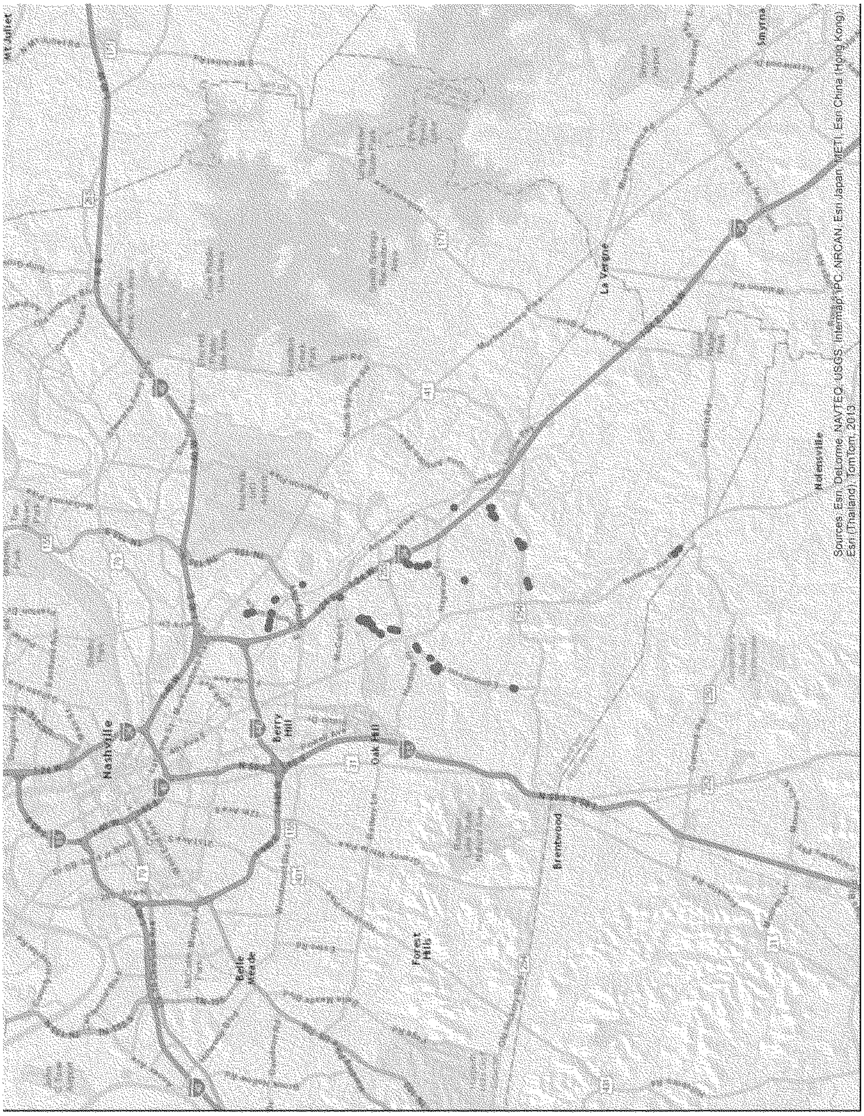


Figure 4. Plan A - Nonstructural Measure

From: Kendra Abkowitz
To: Granstaff, Matthew LRN; LRN Planning Public Communication
Subject: [EXTERNAL] RE: Mill Creek Integrated Feasibility Report Public Review (NOA) (UNCLASSIFIED)
Date: Wednesday, December 10, 2014 9:07:46 AM

Hi Matthew,

TDEC has reviewed the draft Mill Creek Integrated Feasibility Report. We have no specific comments to add, but did want to alert you to a typo we identified in the following sentence on page 99:

"O. shoupi is found in a wide range of environments but typically are found in first order or perennial streams that are predominantly gravel comprised of gravel and limestone bedrock with scattered flattened limestone slabs and rocks and have be located in both pools and riffles areas (Withers)."

Which should be:

"O. shoupi is found in a wide range of environments but typically are found in first order or perennial streams that are predominantly gravel comprised of limestone bedrock with scattered flattened limestone slabs and have been located in both pools and riffles areas (Withers)."

Thank you for the opportunity to review and provide comments.

Best regards,

Kendra Abkowitz
Office of Policy and Planning
William R. Snodgrass TN Tower
312 Rosa L. Parks Avenue, 2nd Floor
Nashville, TN 37243
Office: (615) 532-8689
Email: Kendra.Abkowitz@TN.gov

-----Original Message-----
From: Granstaff, Matthew LRN [mailto:Matthew.L.Granstaff@usace.army.mil]
Sent: Thursday, October 30, 2014 3:18 PM
To: TDEC NEPA; Alan.Roberts@tn.gov; John McClurkan; Howard Symons; stacy@condemnation-law.com
Cc: Herbert, Thomas LRN; Higgs, Timothy A LRN; Carrington, Craig D LRN; Rote, Russ LRN
Subject: Mill Creek Integrated Feasibility Report Public Review (NOA) (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

To Whom it May Concern;

The U.S. Army Corps of Engineers has released the Mill Creek Integrated Feasibility Report for public review period of 30 days. Attached is a electronic copy of the Notice of Availability. If you have any question feel free to contact Tom Herbert, Project Manager (615-736-7194) and/or Matthew Granstaff, Biologist (615-736-7857) or email comments to CorpsLRNPlanningPublicCom@usace.army.mil.

Thanks,

Matthew Granstaff

Biologist
Planning Branch
U.S. Army Corps of Engineers
Nashville District

Phone:(615)736-7857
Matthew.L.Granstaff@usace.army.mil

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

Appendix D National Historic Preservation Act Compliance

Section 106 of the National Historic Preservation Act of 1966, as amended (NHPA), and its implementing regulations at 36 CFR 800 require consideration of cultural resources prior to a federal undertaking and requires consultation with the State Historic Preservation Officer (SHPO), Federally recognized tribes with a connection to the project location and other consulting parties defined at §800.3. The NHPA only affords protection to sites, buildings structures, or objects listed in or determined eligible for listing in the National Register of Historic Places (NRHP). Archival research for this project involved consulting the National Register of Historic Places, the Tennessee Historical Commission (THC) National Register and structure files, the Tennessee Division of Archaeology site and survey files, and the Metropolitan Government of Nashville and Davidson County, Historical Commission (MHC) historic landmark inventory and historic zoning district overlays. In addition, field visits included visiting the proposed project areas to identify architectural resources within the proposed project areas and surrounding viewshed, to document the degree of prior disturbance, and to undertake Phase I archaeological site identification investigations. Review of the Areas of Potential Effects and consultation with THC and MHC resulted in the identification of the Ellington Agricultural Center Campus as a National Register eligible historic district. Section 106 consultation is expected to conclude with a "no adverse effect to historic properties" determination.

Pursuant to 36 CFR 800.11 *Documentation standards* the following outlines the documentation associated with the efforts to identify historic properties and the consultation conducted to meet the USACE obligations under Section 106.

Consulting Parties

USACE identified the following consultation pursuant to 36 CFR 800.2(c).

- Tennessee Historical Commission (THC)
- Metropolitan Government of Nashville and Davidson County Historical Commission (MHC)
- Absentee Shawnee Tribe of Oklahoma
- Alabama Coushatta Tribe of Texas
- Cherokee Nation
- Chickasaw Nation
- Eastern Band of Cherokee Indians
- Eastern Shawnee Tribe of Oklahoma
- Kialegee Tribal Town
- Muscogee(Creek) Nation
- Shawnee Tribe
- Thlopthlocco Tribal Town
- United Keetoowah Tribe of Cherokee Indians

In addition, the NEPA scoping notice dated February 14, 2013 invited the public and other organizations to participate in the section 106 process. USACE received no requests to participate in the Section 106 process.

Initiation
Requests to initiate consultation under Section 106 of the National Historic Preservation Act were sent to the consulting parties on February 14, 2013.

Initiation Responses
Only one consulting party responded to the Section 106 initiation letter.

- United Keetoowah Band of Cherokee Indians-via email stated "The United Keetoowah Band of Cherokee Indians in Oklahoma has reviewed your project under Section 106 of the NHPA, and at this time have no comments or objections. However, if any human remains are inadvertently discovered, please cease all work and contact us immediately."

Consultation on the initial TSP
On May 7, 2014 the report titled *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan Davidson County, Tennessee* (USACE, April 2014) was transmitted to the consulting parties. The report assess effects on the TSP, which at that time involved the proposed buy-out of 216 residences as part of the non-structural plan, and modification to the Briley Parkway bridges as part of the structural plan. USACE proposed a Section 106 finding of "no historic properties affected"

Reponses
- THC responded, by letter dated May 28, 2014, "that the project as currently proposed MAY ADVERSELY AFFECT PROPERTIES THAT ARE ELIGIBLE FOR LISTING IN THE NATIONAL REGISTER OF HISTORIC PLACES." Follow-up telephone discussions with THC revealed that they were concerned that one neighborhood with a concentration of buy-out structures could form a National Register eligible district. We discussed the potential for a proposed project revision and would provide additional information when the revised TSP is formulated.
- MHC via email responded that "they concurred that the project would have no adverse effect on historic properties."
- Muscogee (Creek) Nation via email concurred with a finding of "no historic properties affected."
- United Keetoowah Band of Cherokee Indians via email "The United Keetoowah Band of Cherokee Indians in Oklahoma has reviewed your project under Section 106 of the NHPA, and at this time have no comments or objections. However, if any human remains are inadvertently discovered, please cease all work and contact us immediately."
- No other responses were received. Therefore the lack of response was considered concurrence pursuant to 36 CFR 800.4(d)(1) (i).

Consultation on the Revised and current TSP

In letters dated October 23, 2014, USCE provided information on the revised and current TSP to the THC and MHC. The cultural resource assessment including updates to the APE are documented in the report: *Cultural Resource Assessment for the Revised Mill Creek Feasibility Study, Tentatively Selected Plan Davidson County, Tennessee* (USACE, October 2014). This report included archaeological investigations of the proposed bridge and roadway modifications at the Ellington Agricultural Center related to the creation of a detention structures.

Responses

- In a letter dated December 9, 2014, THC responded "that the project as currently proposed MAY ADVERSELY AFFECT PROPERTIES THAT ARE ELIGIBLE FOR LISTING IN THE NATIONAL REGISTER OF HISTORIC PLACES."
- On December 18, 2014 USACE met with THC and MHC staff to obtain information regarding what properties THC was concerned. THC expressed the opinion that the Ellington Agricultural Center Campus forms a historic district. Furthermore, they stated the bridge forms a non-contributing element to the historic district; therefore, the finding should be amended to "no adverse effect to historic properties."
- In a letter dated December 22, 2014, THC responded "Based on the information provided we find that the project area contains no archaeological resources eligible for listing in the National Register of Historic Places."

Conclusion of the Section 106 Process

Following consultation with the Tennessee Historical Commission in December 2014, the document *Addendum to: Cultural Resource Assessment for the Revised Mill Creek Feasibility Study, Tentatively Selected Plan Davidson County, Tennessee Ellington Agricultural Center* (USACE, January 2015) was prepared to address the National Register eligibility of the Ellington Agricultural Center and to assess effects of the proposed detention structure. In letters dated January 26, 2015, the addendum and a finding of "no adverse effect" was submitted to MHC and THC. The *Cultural Resource Assessment for the Revised Mill Creek Feasibility Study, Tentatively Selected Plan Davidson County, Tennessee* and *Addendum to: Cultural Resource Assessment for the Revised Mill Creek Feasibility Study, Tentatively Selected Plan Davidson County, Tennessee Ellington Agricultural Center* was transmitted to the consulting federally recognized tribes on January 28, 2015. USACE will await the responses of the consulting parties within the thirty-day window prior to concluding the Section 106 process.

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO
ATTENTION OF

FEB 15 2013

Project Planning Branch

Mr. E. Patrick McIntyre, Director
Tennessee Historical Commission
State Historic Preservation Officer
2941 Lebanon Road
Nashville, Tennessee 37243-0442

Dear Mr. McIntyre:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

Please find enclosed a copy of a January 15, 2009 letter that initiated consultation under Section 106 of the National Historic Preservation Act for the flood damage reduction study of the Mill Creek Watershed. The six project areas discussed in the 2009 letter may or may not be considered for implementation in the current feasibility study. The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review.

The feasibility study and NEPA review will consider a number of measure such as improving storm water management, stream bank stabilization, bridge improvement, removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood control measure, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

The Corps requests your comments on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Enclosure

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO
ATTENTION OF

Project Planning Branch

TO ALL INTERESTED PARTIES:

The Corps of Engineers, Nashville District, is completing a feasibility study to investigate flood risk management measures within the Mill Creek watershed in Davidson County, Tennessee. The Metropolitan Government of Nashville and Davidson County (Metro) is the project sponsor. This project, which was originally scoped in 2003 and now rescoped following the May 2010 flood event, is moving forward with a primary flood risk management analysis and secondary ecosystem restoration consideration.

The Mill Creek watershed is located in parts of Davidson, Williamson, and Rutherford counties and drains nearly 70,000 acres (108 square miles). A vicinity and watershed map (Figure 1) of the proposed study area is enclosed. The watershed supports many plants, fish, and wildlife including the Nashville Crayfish (*Orconectes shoupi*), an endangered species. The stream corridor offers important esthetic and recreational opportunities such as fishing, bird watching, nature study, and paddlecraft use.

The Mill Creek study would use computer models to depict hydrology, aquatic habitat, and water quality processes occurring in the watershed. The study would also consider storm water management, future development, floodplain mapping, endangered species protection, stream bank stabilization, water quality impacts from point and non-point sources, and stream corridor habitat enhancement. The study aims to predict and minimize flood damage in a way that protects, maintains, and restores the ecologically sensitive Mill Creek and its tributaries.

Alternatives to be analyzed would include those identified during the initial 2003 screening analysis, as well as alternatives analyzed in support of Metro's Unified Flood Preparedness Plan initiative. Preliminary flood risk management alternatives that would be considered include non-structural measures such as vegetative berms, expanding floodways and natural habitat, flood water storage basins, and raising or removal of structures from the floodway and/or floodplain. Structural measures evaluated would include floodwalls, bridge improvements, and quarry diversion and associated gate/tunnel structures. Changes to existing land use practices such as establishment of water quality buffers would be considered to protect stream corridors; these corridors could also include public parks or other passive recreational features.

In accordance with the National Environmental Policy Act (NEPA) and applicable implementing regulations, an Environmental Assessment would be prepared to evaluate viable alternatives for this proposal as an integral part of this planning study. We are soliciting public and agency comments concerning environmental issues that should be addressed in the course of

the NEPA process. We encourage comments not only about the immediate project area, but also of plans or proposals for any other development that may impact or influence project resources.

This letter also serves to initiate the public involvement requirements of Section 106 of the National Historic Preservation Act of 1966, as amended. Section 106, implemented by regulations at 36 CFR 800, requires the Corps of Engineers to consider the effects of its undertakings on historic properties. If required, appropriate architectural and archeological investigations would be conducted within those areas affected by the proposed activities and resulting findings would be coordinated with the Tennessee State Historic Preservation Officer and other consulting parties.

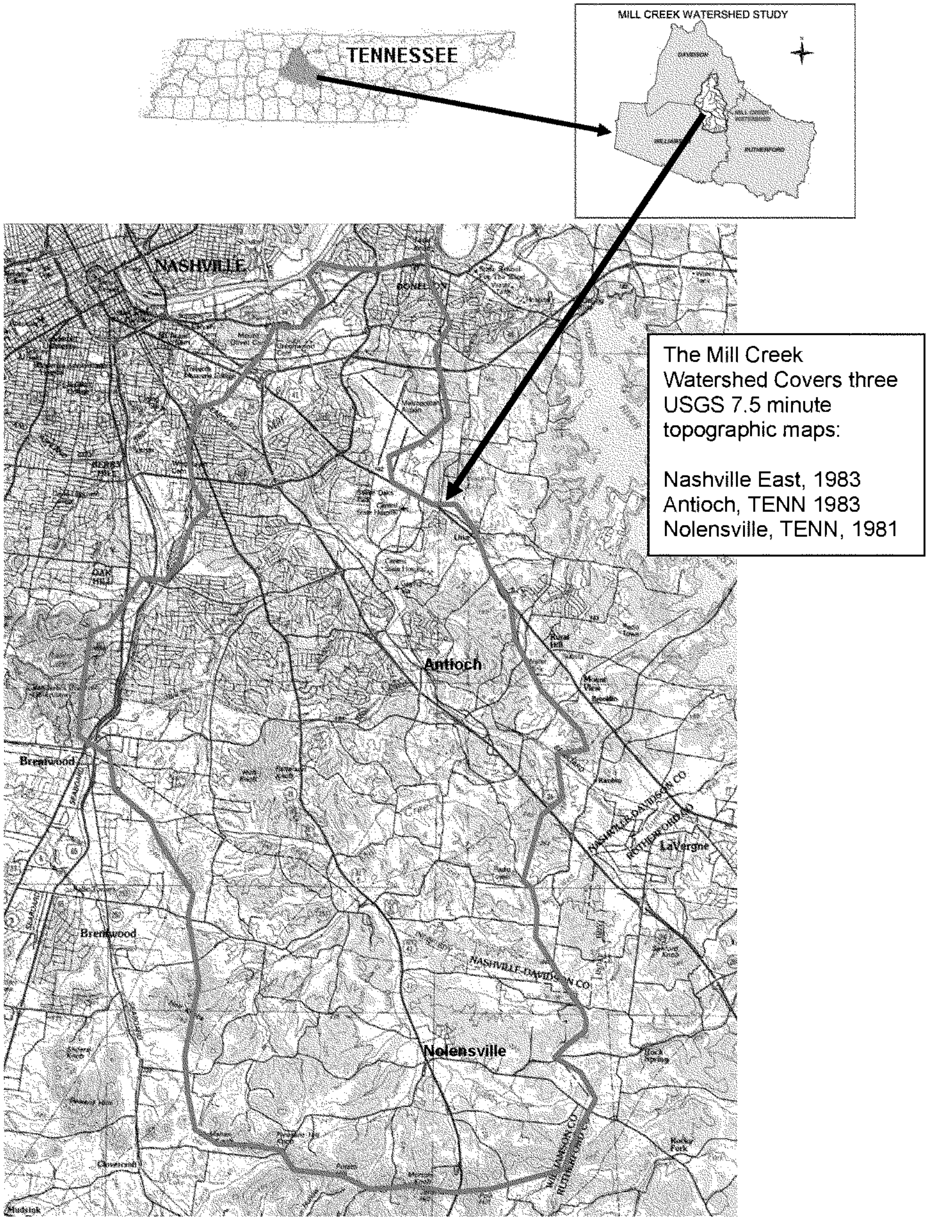
The public and local, state and federal agencies are invited to submit written comments to this scoping no later than 15 March 2013. Please note that there would be other opportunities for comments during the planning phase at future public workshops and circulation of the NEPA document for public comment. Workshops are being planned, however, times, dates, or locations have not been determined. Once set, this information will be shared through media and the Corps website—www.lrn.usace.army.mil.

You may mail comments to the Nashville District, U.S. Army Corps of Engineers, P.O. Box 1070 (PM-P), Nashville, TN 37202-1070, ATTN: Planning Branch (Mark Vaughan), direct comments via phone at (615) 736-7850, or email to mark.k.vaughn@usace.army.mil. Information may also be obtained by contacting Mr. Porter Williams, Project Manager at (615) 736-7635.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Figure 1. Vicinity and Watershed Map for the Mill Creek Watershed in Tennessee.



DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO
ATTENTION OF

FEB 15 2013

Project Planning Branch

Mr. Tim Walker, Executive Director
Metro Historical Commission
Sunnyside in Sevier Park
Nashville, Tennessee 37204

Dear Mr. Walker:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review. The Corps also requests to initiate consultation under section106 of the National Historic Preservation Act with the Metro Historical Commission.

The feasibility study and NEPA review will consider a number of measures such as improving storm water management, stream bank stabilization, bridge improvement, and removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood risk management measures, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

The Corps requests comments from Metro Historical Commission on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Enclosure

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO
ATTENTION OF

FEB 15 2013

Project Planning Branch

Chief Tarpie Yargee
Alabama-Quassarte Tribal Town
P.O. Box 187
Wetumka, Oklahoma 74883

Dear Chief Yargee:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review. The Corps also requests to initiate consultation under section106 of the National Historic Preservation Act with the Alabama-Quassarte Tribal Town.

The feasibility study and NEPA review will consider a number of measures such as improving storm water management, stream bank stabilization, bridge improvement, and removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood risk management measures, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

A copy of this letter is being forwarded to Ms. Augustine Asburry. The Corps requests comments from Alabama-Quassarte Tribal Town on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Enclosure

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

FEB 15 2013

REPLY TO
ATTENTION OF

Project Planning Branch

Principal Chief Bill John Baker
Cherokee Nation
P.O. Box 948
Tahlequah, Oklahoma 74465-0948

Dear Principal Chief Baker:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review. The Corps also requests to initiate consultation under section106 of the National Historic Preservation Act with the Cherokee Nation.

The feasibility study and NEPA review will consider a number of measures such as improving storm water management, stream bank stabilization, bridge improvement, and removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood risk management measures, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

A copy of this letter is being forwarded to Dr. Richard Allen. The Corps requests comments from Cherokee Nation on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Enclosure

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO
ATTENTION OF

FEB 15 2013

Project Planning Branch

Governor Bill Anoatubby
Chickasaw Nation
P.O. Box 1548
Ada, Oklahoma 74821-1548

Dear Governor Anoatubby:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review. The Corps also requests to initiate consultation under section106 of the National Historic Preservation Act with the Chickasaw Nation.

The feasibility study and NEPA review will consider a number of measures such as improving storm water management, stream bank stabilization, bridge improvement, and removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood risk management measures, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

A copy of this letter is being forwarded to Ms. LaDonna Brown and Ms. Virginia Nail. The Corps requests comments from Chickasaw Nation on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Enclosure

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

FEB 15 2013

REPLY TO
ATTENTION OF

Project Planning Branch

Principal Chief Michell Hicks
Eastern Band of Cherokee Indians
Qualla Boundary
P.O. Box 445
Cherokee, North Carolina 28719

Dear Chief Hicks:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review. The Corps also requests to initiate consultation under section106 of the National Historic Preservation Act with the Eastern Band of Cherokee Indians.

The feasibility study and NEPA review will consider a number of measures such as improving storm water management, stream bank stabilization, bridge improvement, and removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood risk management measures, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO
ATTENTION OF:

FEB 15 2013

Project Planning Branch

Principal Chief A.D. Ellis
Muscogee (Creek) Nation, Oklahoma
P.O. Box 580
Okmulgee, Oklahoma 74447

Dear Chief Ellis:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review. The Corps also requests to initiate consultation under section106 of the National Historic Preservation Act with the Muscogee (Creek) Nation, Oklahoma.

The feasibility study and NEPA review will consider a number of measures such as improving storm water management, stream bank stabilization, bridge improvement, and removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood risk management measures, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

A copy of this letter is being forwarded to Mr. Emman Spain. The Corps requests comments from Muscogee (Creek) Nation, Oklahoma on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Enclosure

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

A copy of this letter is being forwarded to Mr. Tyler Howe. The Corps requests comments from Eastern Band of Cherokee Indians on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Enclosure

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO
ATTENTION OF

FEB 15 2013

Project Planning Branch

Ms. Robin DuShane
Tribal Historic Preservation Officer
Eastern Shawnee Tribe of Oklahoma
P.O. Box 350
Seneca, Missouri 64865

Dear Ms. DuShane:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review. The Corps also requests to initiate consultation under section106 of the National Historic Preservation Act with the Eastern Shawnee Tribe of Oklahoma.

The feasibility study and NEPA review will consider a number of measure such as improving storm water management, stream bank stabilization, bridge improvement, removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood control measure, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

The Corps requests comments from Eastern Shawnee Tribe of Oklahoma on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Enclosure

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO
ATTENTION OF

FEB 15 2013

Project Planning Branch

Mekko Tiger Hobia
Kialegee Tribal Town
108 N. Main St.
P.O. Box 332
Wetumka, Oklahoma 74883

Dear Mekko Hobia:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review. The Corps also requests to initiate consultation under section106 of the National Historic Preservation Act with the Kialegee Tribal Town.

The feasibility study and NEPA review will consider a number of measures such as improving storm water management, stream bank stabilization, bridge improvement, and removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood risk management measures, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

The Corps requests comments from Kialegee Tribal Town on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Enclosure

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO
ATTENTION OF

FEB 15 2013

Project Planning Branch

Chairperson Ron Sparkman
Shawnee Tribe
P.O. Box 189
Miami, Oklahoma 74355

Dear Chairperson Sparkman:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review. The Corps also requests to initiate consultation under section106 of the National Historic Preservation Act with the Shawnee Tribe.

The feasibility study and NEPA review will consider a number of measures such as improving storm water management, stream bank stabilization, bridge improvement, and removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood risk management measures, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

A copy of this letter is being forwarded to Ms. Kim Jumper. The Corps requests comments from Shawnee Tribe on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Enclosure

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO
ATTENTION OF

FEB 15 2013

Project Planning Branch

Chief George Wickliffe
United Keetoowah Band of Cherokee Indians in Oklahoma
P.O. Box 746
Tahlequah, Oklahoma 74464-0746

Dear Chief Wickliffe:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review. The Corps also requests to initiate consultation under section106 of the National Historic Preservation Act with the United Keetoowah Band of Cherokee Indians in Oklahoma.

The feasibility study and NEPA review will consider a number of measures such as improving storm water management, stream bank stabilization, bridge improvement, and removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood risk management measures, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

A copy of this letter is being forwarded to Ms. Lisa LaRue-Baker. The Corps requests comments from United Keetoowah Band of Cherokee Indians in Oklahoma on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Enclosure

McCormack, Valerie J LRN

From:	Lisa LaRue-Baker - UKB THPO [ukbthpo-larue@yahoo.com]
Sent:	Sunday, March 10, 2013 4:11 PM
To:	McCormack, Valerie J LRN
Cc:	lstapleton@unitedkeetoowahband.org
Subject:	Mill Creek Watershed, Davidson, Williamson and Rutherford Counties, TN

The United Keetoowah Band of Cherokee Indians in Oklahoma has reviewed your project under Section 106 of the NHPA, and at this time have no comments or objections. However, if any human remains are inadvertently discovered, please cease all work and contact us immediately.

Lisa C. Baker
Acting THPO
United Keetoowah Band of Cherokee Indians in Oklahoma
PO Box 746
Tahlequah, OK 74465

c 918.822.1952
ukbthpo-larue@yahoo.com

Please FOLLOW our historic preservation page and LIKE us on FACEBOOK
<https://www.facebook.com/pages/United-Keetoowah-Band-of-Cherokee-Indians-in-Oklahoma-Historic-Preservation/199767846834850>

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Mr. E. Patrick McIntyre, Director
Tennessee Historical Commission
2491 Lebanon Pike
Nashville, Tennessee 37243-0442

Dear Mr. McIntyre:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County (Metro) are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the USACE sent a letter to your office initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. Land owners would volunteer to be part of the buy-out program. Following the buy-out, the buildings would be razed and future development would be prohibited in the flood plain.

The report *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan, Davidson County, Tennessee* presents historic property identification efforts for the proposed TSP and was previously provided to your office. The Briley Parkway Bridges were reconstructed in 2009 and are not eligible for listing in the National Register of Historic Places. The majority of the 216 buildings were constructed in the last 50 years, and all were constructed after c. 1940. The USACE believes that none of the structures considered independently or as part of a district are eligible for inclusion in the National Register of Historic Places.

The TSP involves minimal ground disturbance. Work at the Briley Parkway Bridges will involve removing fill from the floodway. There are no known archaeological sites in the vicinity of the 216 residences. Razing the buildings will cause minimal ground disturbance in previously disturbed areas. Therefore, the USACE recommends no further investigation of the buy-out locations. A

USACE archaeologists will review construction contracts to ensure there are no changes in procedures that could cause disturbance, which is not anticipated at this time. Therefore, the USACE recommends a finding of "no historic properties affected" for proposed TSP for the Mill Creek Feasibility study.

The USACE is also coordinating with SHPO, tribes, and other interested parties as part of the Section 106 process and the National Environmental Protection Act. The USACE requests your comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615)736-7847.

Sincerely,

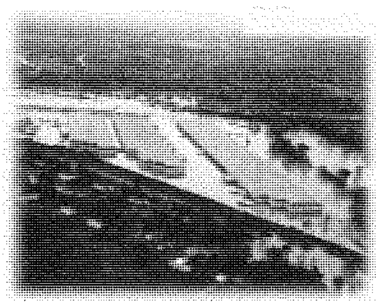
Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

US Army Corps of Engineers
Nashville District

DRAFT

Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan Davidson County, Tennessee

April 2014



For Further Information Contact:
Valerie J. McCormack, Ph.D.
U.S. Army Corps of Engineers
Nashville District
Project Planning Branch
Telephone: (615) 736-7847

TENNESSEE HISTORICAL COMMISSION
STATE HISTORIC PRESERVATION OFFICE
2941 LEBANON ROAD
NASHVILLE, TENNESSEE 37214
OFFICE: (615) 532-1550
www.tnhistoricalcommission.org

May 28, 2014

Mr. Russ Rote
COE-Nashville District
Post Office Box 1070
Nashville, Tennessee, 37202-1070

RE: COE-N, MILL CREAK DRAINAGE, WILLIAMSON, DAVIDSON COUNTY

Dear Mr. Rote:

In response to your request, received on Thursday, May 8, 2014, we have reviewed the documents you submitted regarding your proposed undertaking. Our review of and comment on your proposed undertaking are among the requirements of Section 106 of the National Historic Preservation Act. This Act requires federal agencies or applicant for federal assistance to consult with the appropriate State Historic Preservation Office before they carry out their proposed undertakings. The Advisory Council on Historic Preservation has codified procedures for carrying out Section 106 review in 36 CFR 800. You may wish to familiarize yourself with these procedures (Federal Register, December 12, 2000, pages 77698-77739) if you are unsure about the Section 106 process.

Considering available information, we find that the project as currently proposed MAY ADVERSELY AFFECT PROPERTIES THAT ARE ELIGIBLE FOR LISTING IN THE NATIONAL REGISTER OF HISTORIC PLACES. You should now begin immediate consultation with our office. Please direct questions and comments to Joe Garrison (615) 770-1092.

Sincerely,

E. Patrick McIntyre, Jr.
Executive Director and
State Historic Preservation Officer

EPM/jyg

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Mr. Tim Walker
Metro Historical Commission
Sunnyside in Sevier Park
3000 Granny White Pike
Nashville, Tennessee 37204

Dear Mr. Walker:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County (Metro) are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the USACE sent a letter to your office initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. Land owners would volunteer to be part of the buy-out. Following the buy-out, the buildings would be razed and future development would be prohibited in the flood plain.

The enclosed report *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan, Davidson County, Tennessee* presents historic property identification efforts for the proposed TSP. The Briley Parkway Bridges were reconstructed in 2009 and are not eligible for listing in the National Register of Historic Places. The majority of the 216 buildings were constructed in the last 50 years, and all were constructed after 1940. USACE believes that none of the structures considered independently or as part of a district are eligible for inclusion in the National Register of Historic Places. USACE provided the draft report to the Metro Historical Commission for an informal initial review. Dr. Tara Mielnik's comments are enclosed.

The TSP involves minimal ground disturbance. Work at the Briley Parkway Bridges will involve removing fill from the floodway. There are no known archaeological sites in the vicinity of the 216 residences. Razing the buildings will cause minimal ground disturbance in previously disturbed areas. Therefore, the USACE recommends no further investigation of the buy-out locations. A USACE archaeologists will review construction contracts to ensure there are no changes in procedures that could cause disturbance, which is not anticipated at this time. Therefore, the USACE recommends a finding of "no historic properties affected" for proposed TSP for the Mill Creek Feasibility study.

The USACE is also coordinating with tribes, local governments and other interested parties as part of the Section 106 process and the National Environmental Protection Act. The USACE requests your comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615)736-7847.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Enclosures

McCormack, Valerie J LRN

From: Mielnik, Tara (Historical Commission) [Tara.Mielnik@nashville.gov]
Sent: Friday, May 02, 2014 9:22 AM
To: McCormack, Valerie J LRN
Subject: [EXTERNAL] Mill Creek Feasibility

Valerie,

Thank you for providing the copy of the assessment for the Mill Creek Feasibility Study. This office concurs with your findings that the project as proposed would have no adverse effect of historic properties. Please let me know if you need me to provide this information in a formal hard-copy letter! J

Thank you for the opportunity to review and comment.

Sincerely,

Tara Mielnik

Tara Mitchell Mielnik, PhD

Federal Programs Coordinator

Metropolitan Nashville Historical Commission

Sunnyside in Sevier Park

3000 Granny White Pike

Nashville, TN 37204

615-862-7970 (ext 79779)

615-862-7974 (fax)

www.nashville.gov/mhc

tara.mielnik@nashville.gov

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Principal Chief Oscola Sylestine
Alabama Coushatta Tribe of Texas
571 State Park Road 56
Livingston, Texas 77351

Dear Principal Chief Sylestine:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to Alabama Coushatta Tribe of Texas initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

The USACE prepared a report titled *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan, Davidson County, Tennessee*. The USACE believes that none of the structures considered independently or as part of a district are eligible for inclusion in the National Register of Historic Places.

In addition, to the structures and buildings, the TSP involves minimal ground disturbance. Work at the Briley Parkway Bridges will involve removing fill from the floodway. There are no known archaeological sites in the vicinity of the 216 residences. Razing the buildings will cause minimal ground disturbance in previously disturbed areas. Therefore, the USACE recommends no further investigation of the buy-out locations. A USACE archaeologists will review construction contracts to ensure there are no changes in procedures that could cause disturbance, which is not anticipated at this time. Therefore, the USACE recommends a finding of "no historic properties affected" for proposed Tentatively Selected Plan for the Mill Creek Feasibility study.

A copy of this letter and supporting documentation is being forwarded to you historic preservation staff. The USACE requests the comments of Alabama Coushatta Tribe of Texas comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Chief Tarpie Yargee
Alabama-Quassarte Tribal Town
P.O. Box 187
Wetumka, Oklahoma 74883

Dear Chief Yargee:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to Alabama-Quassarte Tribal Town initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

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A copy of this letter and supporting documentation is being forwarded to you historic preservation staff. The USACE requests the comments of Alabama-Quassarte Tribal Town comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Governor George Blanchard
Absentee-Shawnee Tribe of Oklahoma
2025 S. Gordon Cooper Dr.
Shawnee, Oklahoma 74801-9381

Dear Governor Blanchard:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to Absentee-Shawnee Tribe of Oklahoma initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

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A copy of this letter and supporting documentation is being forwarded to you historic preservation staff. The USACE requests the comments of Absentee-Shawnee Tribe of Oklahoma comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Principal Chief Bill John Baker
Cherokee Nation
P.O. Box 948
Tahlequah, Oklahoma 74465-0948

Dear Principal Chief Baker:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to Cherokee Nation initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

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In addition, to the structures and buildings, the TSP involves minimal ground disturbance. Work at the Briley Parkway Bridges will involve removing fill from the floodway. There are no known archaeological sites in the vicinity of the 216 residences. Razing the buildings will cause minimal ground disturbance in previously disturbed areas. Therefore, the USACE recommends no further investigation of the buy-out locations. A USACE archaeologists will review construction contracts to ensure there are no changes in procedures that could cause disturbance, which is not anticipated at this time. Therefore, the USACE recommends a finding of "no historic properties affected" for proposed Tentatively Selected Plan for the Mill Creek Feasibility study.

A copy of this letter and supporting documentation is being forwarded to you historic preservation staff. The USACE requests the comments of Cherokee Nation comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Governor Bill Anoatubby
Chickasaw Nation
P.O. Box 1548
Ada, Oklahoma 74821-1548

Dear Governor Anoatubby:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to Chickasaw Nation initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

The USACE prepared a report titled *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan, Davidson County, Tennessee*. The USACE believes that none of the structures considered independently or as part of a district are eligible for inclusion in the National Register of Historic Places.

In addition, to the structures and buildings, the TSP involves minimal ground disturbance. Work at the Briley Parkway Bridges will involve removing fill from the floodway. There are no known archaeological sites in the vicinity of the 216 residences. Razing the buildings will cause minimal ground disturbance in previously disturbed areas. Therefore, the USACE recommends no further investigation of the buy-out locations. A USACE archaeologists will review construction contracts to ensure there are no changes in procedures that could cause disturbance, which is not anticipated at this time. Therefore, the USACE recommends a finding of "no historic properties affected" for proposed Tentatively Selected Plan for the Mill Creek Feasibility study.

A copy of this letter and supporting documentation is being forwarded to you historic preservation staff. The USACE requests the comments of Chickasaw Nation comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Principal Chief Michell Hicks
Eastern Band of Cherokee Indians
Qualla Boundary
P.O. Box 445
Cherokee, North Carolina 28719

Dear Principal Chief Hicks:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to Eastern Band of Cherokee Indians initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

The USACE prepared a report titled *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan, Davidson County, Tennessee*. The USACE believes that none of the structures considered independently or as part of a district are eligible for inclusion in the National Register of Historic Places.

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recommends a finding of “no historic properties affected” for proposed Tentatively Selected Plan for the Mill Creek Feasibility study.

A copy of this letter and supporting documentation is being forwarded to you historic preservation staff. The USACE requests the comments of Eastern Band of Cherokee Indians comments on the proposed project and finding of “no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Ms. Robin DuShane
Tribal Historic Preservation Officer
Eastern Shawnee Tribe of Oklahoma
P.O. Box 350
Seneca, MO 64865

Dear Ms. DuShane:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to Eastern Shawnee Tribe of Oklahoma initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

The USACE prepared a report titled *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan, Davidson County, Tennessee*. The USACE believes that none of the structures considered independently or as part of a district are eligible for inclusion in the National Register of Historic Places.

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A copy of this letter and supporting documentation is being forwarded to you The USACE requests the comments of Eastern Shawnee Tribe of Oklahoma comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Principal Chief George Tiger
Muscogee (Creek) Nation, Oklahoma
P.O. Box 580
Okmulgee, Oklahoma 74447

Dear Principal George Tiger:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to Muscogee (Creek) Nation, Oklahoma initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

The USACE prepared a report titled *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan, Davidson County, Tennessee*. The USACE believes that none of the structures considered independently or as part of a district are eligible for inclusion in the National Register of Historic Places.

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A copy of this letter and supporting documentation is being forwarded to you historic preservation staff. The USACE requests the comments of Muscogee (Creek) Nation, Oklahoma comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

McCormack, Valerie J LRN

From: Emman Spain [ESpain@MCN-NSN.gov]
Sent: Wednesday, June 18, 2014 12:50 PM
To: McCormack, Valerie J LRN
Subject: [EXTERNAL] Mill creek drainage in Davidson and Williamson counties, Tennessee.

Dear Ms. McCormack,

The Muscogee (Creek) Nation has received the U. S. Army Corps of Engineers, Nashville District notice of flood risk study in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. At this time we are unaware of any culturally significant sites within the project areas. We therefore concur with the finding of “no historic properties affected”. Thank you.

Emman Spain, THPO

Muscogee (Creek) Nation

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Chairperson Ron Sparkman
Shawnee Tribe
P.O. Box 189
Miami, Oklahoma 74355

Dear Chairperson Sparkman:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to Shawnee Tribe initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

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A copy of this letter and supporting documentation is being forwarded to you historic preservation staff. The USACE requests the comments of Shawnee Tribe comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Mekko George Scott
Tholpthlocco Tribal Town Oklahoma
P.O. Box 188
Okemah, Oklahoma 74859

Dear Mekko Scott:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to Tholpthlocco Tribal Town Oklahoma initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

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A copy of this letter and supporting documentation is being forwarded to you historic preservation staff. The USACE requests the comments of Tholpthlocco Tribal Town Oklahoma comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Chief George Wickliffe
United Keetoowah Band of Cherokee Indians in Oklahoma
P.O. Box 746
Tahlequah, Oklahoma 74464-0746

Dear Chief Wickliffe:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to United Keetoowah Band of Cherokee Indians in Oklahoma initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

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A copy of this letter and supporting documentation is being forwarded to you historic preservation staff. The USACE requests the comments of United Keetoowah Band of Cherokee Indians in Oklahoma comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

McCormack, Valerie J LRN

From: Lisa LaRue-Baker - UKB THPO [ukbthpo-larue@yahoo.com]
Sent: Wednesday, May 14, 2014 10:31 AM
To: McCormack, Valerie J LRN
Cc: verna; Ernestine Berry
Subject: [EXTERNAL] Re: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)

The United Keetoowah Band of Cherokee Indians in Oklahoma has reviewed your project under Section 106 of the NHPA. At this time, we have no comments or objections. However, if any human remains are inadvertently discovered, please cease all work and contact us as soon as possible.

Thank you,

Lisa C. Baker
Acting THPO
United Keetoowah Band of Cherokee Indians in Oklahoma
PO Box 746
Tahlequah, OK 74465

c 918.822.1952
ukbthpo-larue@yahoo.com

Please FOLLOW our historic preservation page and LIKE us on FACEBOOK <https://www.facebook.com/pages/United-Keetoowah-Band-of-Cherokee-Indians-in-Oklahoma-Historic-Preservation/199767846834850>

From: "McCormack, Valerie J LRN" <Valerie.J.McCormack@usace.army.mil>
To: Lisa LaRue-Baker - UKB THPO <ukbthpo-larue@yahoo.com>
Cc: verna <lstapleton@unitedkeetoowahband.org>

Sent: Tuesday, May 13, 2014 2:48 PM
Subject: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Lisa,
Please find attached a letter to Chief Wickliffe and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
Please let me know if you require additional information or would prefer a hard copy of the complete report.

Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847

Internet: http://www.lrn.usace.army.mil <http://www.lrn.usace.army.mil/>
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From:	McCormack, Valerie J LRN
Sent:	Tuesday, May 13, 2014 2:48 PM
To:	'Richard Allen'
Subject:	Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments:	CherokeeNation-Mill Creek.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dr. Allen
Please find attached a letter to Chief Baker and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
Please let me know if you require additional information or would prefer a hard copy of the complete report.

Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:48 PM
To: 'HPO@chickasaw.net'
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Chickasaw-Mill Creek.pdf; Cultural resource assessment_reduced.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear Chickasaw Historic Preservation Office:
Please find attached a letter to Governor Anoutubby and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. Photographs of all buildings over 50 years old are included in the main body of the report. Please let me know if you require additional information or would prefer a hard copy of the complete report.

Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From:	McCormack, Valerie J LRN
Sent:	Tuesday, May 13, 2014 2:48 PM
To:	Tyler B. Howe
Subject:	Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments:	Cultural resource assessment_reduced.pdf; EBCI-Mill Creek.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Tyler
Please find attached a letter to Chief Hicks and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
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Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:48 PM
To: Robin Dushane
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Cultural resource assessment_reduced.pdf; ESTOO-Mill Creek.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear Robin,
Please find attached a letter and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
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Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:48 PM
To: 'Espain@mcn-nsn.gov'
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Muscogee(Creek)-Mill Creek.pdf; Cultural resource assessment_reduced.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear Mr. Spain,
Please find attached a letter to Chief Tiger and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
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Respectfully,
Valerie

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(615)736-7847

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:47 PM
To: Kim Jumper
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Cultural resource assessment_reduced.pdf; Shawnee-Mill Creek.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear Ms. Jumper,
Please find attached a letter to Chairman Sparkman and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report. Please let me know if you require additional information or would prefer a hard copy of the complete report.

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Valerie

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Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:47 PM
To: 'Lisa LaRue-Baker - UKB THPO'
Cc: verna
Subject: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)
Attachments: Cultural resource assessment_reduced.pdf; UKBCI-Mill Creek.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Lisa,
Please find attached a letter to Chief Wickliffe and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
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Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:47 PM
To: charles coleman
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Cultural resource assessment_reduced.pdf; Thlopthlocco-Mill Creek.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear Warrior Coleman,
Please find attached a letter to Mekko Scott and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
Please let me know if you require additional information or would prefer a hard copy of the complete report.

Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:54 PM
To: Joseph Blanchard
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: ASTOO-Mill Creek.pdf; Cultural resource assessment_reduced.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Mr. Blanchard
Please find attached a letter to Governor Blanchard and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report. Please let me know if you require additional information or would prefer a hard copy of the complete report.

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Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:54 PM
To: Augustine Asbury
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: AQTT-Mill Creek.pdf; Cultural resource assessment_reduced.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Ms. Asbury,
Please find attached a letter to Chief Yargee and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
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(615)736-7847

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:54 PM
To: Bryant J. Celestine
Subject: Mill Creek Feasibility Study, Davidson County, TN (UNCLASSIFIED)
Attachments: Cultural resource assessment_reduced.pdf; ACTT-Mill Creek.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear Mr. Celestine,
Please find attached a letter to Chief Sylestine and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
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(615)736-7847

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: Lisa LaRue-Baker - UKB THPO [ukbthpo-larue@yahoo.com]
Sent: Wednesday, May 14, 2014 10:30 AM
To: McCormack, Valerie J LRN
Cc: verna; Ernestine Berry
Subject: [EXTERNAL] Re: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)

Could you please send me a copy of the Topo Map??
Thank you!

Lisa C. Baker
Acting THPO
United Keetoowah Band of Cherokee Indians in Oklahoma
PO Box 746
Tahlequah, OK 74465

c 918.822.1952
ukbthpo-larue@yahoo.com

Please FOLLOW our historic preservation page and LIKE us on FACEBOOK
<https://www.facebook.com/pages/United-Keetoowah-Band-of-Cherokee-Indians-in-Oklahoma-Historic-Preservation/199767846834850>

From: "McCormack, Valerie J LRN" <Valerie.J.McCormack@usace.army.mil>
To: Lisa LaRue-Baker - UKB THPO <ukbthpo-larue@yahoo.com>
Cc: verna <lstapleton@unitedkeetoowahband.org>
Sent: Tuesday, May 13, 2014 2:48 PM
Subject: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Lisa,
Please find attached a letter to Chief Wickliffe and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
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Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: Lisa LaRue-Baker - UKB THPO [ukbthpo-larue@yahoo.com]
Sent: Wednesday, May 14, 2014 10:31 AM
To: McCormack, Valerie J LRN
Cc: verna; Ernestine Berry
Subject: [EXTERNAL] Re: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)

The United Keetoowah Band of Cherokee Indians in Oklahoma has reviewed your project under Section 106 of the NHPA. At this time, we have no comments or objections. However, if any human remains are inadvertently discovered, please cease all work and contact us as soon as possible.

Thank you,

Lisa C. Baker
Acting THPO
United Keetoowah Band of Cherokee Indians in Oklahoma
PO Box 746
Tahlequah, OK 74465

c 918.822.1952
ukbthpo-larue@yahoo.com

Please FOLLOW our historic preservation page and LIKE us on FACEBOOK <https://www.facebook.com/pages/United-Keetoowah-Band-of-Cherokee-Indians-in-Oklahoma-Historic-Preservation/199767846834850>

From: "McCormack, Valerie J LRN" <Valerie.J.McCormack@usace.army.mil>
To: Lisa LaRue-Baker - UKB THPO <ukbthpo-larue@yahoo.com>
Cc: verna <lstapleton@unitedkeetoowahband.org>

Sent: Tuesday, May 13, 2014 2:48 PM
Subject: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

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Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Wednesday, May 14, 2014 3:11 PM
To: 'Lisa LaRue-Baker - UKB THPO'
Subject: RE: [EXTERNAL] Re: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)
Attachments: Appendix A topomaps.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Lisa,
I received your follow up message, but here are the topo maps for your reference.
Thanks,
Valerie

-----Original Message-----
From: Lisa LaRue-Baker - UKB THPO [mailto:ukbthpo-larue@yahoo.com]
Sent: Wednesday, May 14, 2014 10:30 AM
To: McCormack, Valerie J LRN
Cc: verna; Ernestine Berry
Subject: [EXTERNAL] Re: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)

Could you please send me a copy of the Topo Map??
Thank you!

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Acting THPO
United Keetoowah Band of Cherokee Indians in Oklahoma
PO Box 746
Tahlequah, OK 74465

c 918.822.1952
ukbthpo-larue@yahoo.com

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From: "McCormack, Valerie J LRN" <Valerie.J.McCormack@usace.army.mil>
To: Lisa LaRue-Baker - UKB THPO <ukbthpo-larue@yahoo.com>
Cc: verna <lstapleton@unitedkeetoowahband.org>
Sent: Tuesday, May 13, 2014 2:48 PM
Subject: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

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Caveats: NONE

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Caveats: NONE

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

October 23, 2014

Project Planning Branch

Mr. E. Patrick McIntyre
State Historic Preservation Officer
Tennessee Historical Commission
2941 Lebanon Road
Nashville, Tennessee 37246

Dear Mr. McIntyre:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County (Metro) are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson County, Tennessee. In a letter dated May 07, 2014, we provided your office with information on the Tentatively Selected Plan (TSP) and assessment of effects to historic properties in compliance with Section 106 of the National Historic Preservation Act. In a letter dated May 28, 2014, your office responded with a letter stating that the project as currently proposed "may adversely affect properties that are eligible for listing in the National Register of Historic Places"; however, specific resources that may be affected were not provided.

The USACE has revised the tentatively selected plan and there are several alterations to the proposed project. Changes include a reduction in the number of buildings proposed for removal from the flood areas from 216 buildings to 105 buildings. In addition, we have added a new structural measure to the TSP that would alter an existing roadway on Sevenmile Creek to act as a retention structure. Elevating this roadway will retain floodwaters in a 25 year event by controlling the flash flooding associated with the stream and result in lower flood elevations downstream.

The USACE has revised the cultural resource assessment report that addresses the individual proposed flood reduction measures and presents the results in the enclosed *Cultural Resource Assessment for the Revised Mill Creek Feasibility study, Tentatively Selected Plan Davidson County.* This report includes the results of archaeological Phase I investigations conducted under Tennessee Archaeological State permit no. 000819. USACE did not identify historic properties that would be directly or indirectly affected by the proposed project.

We are also consulting with Metro Historical Commission, the Tennessee Department of Transportation, and American Indian Tribes. Public involvement with this project is co-occurring with the National Environmental Policy Act coordination.

The USACE requests your review of the proposed undertaking and assessment of effects and comments on a finding of "no historic properties affected". Please contact Valerie McCormack at 615-736-7847 or Valerie.j.mccormack@usace.army.mil if you need additional information.

original signed

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Enclosure

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

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original signed

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Enclosure

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

October 23, 2014

Project Planning Branch

Mr. Tim Walker, Executive Director
Metro Historical Commission
Sunnyside in Sevier Park
3000 Granny White Pike
Nashville, Tennessee 37204

Dear Mr. Walker:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County (Metro) are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson County, Tennessee. In May 2014, we provided your office with information on the Tentatively Selected Plan (TSP) and assessment of effects to historic properties in compliance with Section 106 of the National Historic Preservation Act. In an email dated May 2, 2014, your office concurred with our assessment that the

The USACE has revised the tentatively selected plan and there are several alterations to the proposed project. Changes include a reduction in the number of buildings proposed for removal from the flood areas from 216 buildings to 105 buildings. In addition, we have added a new structural measure to the TSP that would alter an existing roadway on Sevenmile Creek to act as a retention structure. Elevating this roadway will retain floodwaters in a 25 year event by controlling the flash flooding associated with the stream and result in lower flood elevations downstream.

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original signed

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Enclosure

US Army Corps
of Engineers
Nashville District

DRAFT

Cultural Resource Assessment for the Revised Mill Creek Feasibility Study, Tentatively Selected Plan Davidson County, Tennessee

October 2014

For Further Information Contact:
Valerie J. McCormack, Ph.D.
U.S. Army Corps of Engineers
Nashville District
Project Planning Branch
Telephone: (615) 736-7847

State Permit No. 000819

TENNESSEE HISTORICAL COMMISSION
STATE HISTORIC PRESERVATION OFFICE
2941 LEBANON ROAD
NASHVILLE, TENNESSEE 37214
OFFICE: (615) 532-1550
www.tnhistoricalcommission.org

December 9, 2014

Mr. Russ Rote
COE-Nashville District
Post Office Box 1070
Nashville, Tennessee, 37202-1070

RE: COE-N, MILL CREEK DRAINAGE REMEDIATION, NASHVILLE, DAVIDSON COUNTY

Dear Mr. Rote:

In response to your request, received on Wednesday, October 29, 2014, we have reviewed the documents you submitted regarding your proposed undertaking. Our review of and comment on your proposed undertaking are among the requirements of Section 106 of the National Historic Preservation Act. This Act requires federal agencies or applicant for federal assistance to consult with the appropriate State Historic Preservation Office before they carry out their proposed undertakings. The Advisory Council on Historic Preservation has codified procedures for carrying out Section 106 review in 36 CFR 800. You may wish to familiarize yourself with these procedures (Federal Register, December 12, 2000, pages 77698-77739) if you are unsure about the Section 106 process.

Considering available information, we find that the project as currently proposed MAY ADVERSELY AFFECT PROPERTIES THAT ARE ELIGIBLE FOR LISTING IN THE NATIONAL REGISTER OF HISTORIC PLACES. You should now begin immediate consultation with our office. Please direct questions and comments to Joe Garrison (615) 770-1092.

Sincerely,

E. Patrick McIntyre, Jr.

E. Patrick McIntyre, Jr.
Executive Director and
State Historic Preservation Officer

EPM/jyg

TENNESSEE HISTORICAL COMMISSION
STATE HISTORIC PRESERVATION OFFICE
2941 LEBANON ROAD
NASHVILLE, TENNESSEE 37243-0442
OFFICE: (615) 532-1550
www.tnhistoricalcommission.org

December 22, 2014

Mr. Russ Rote
Project USACE – Nashville District
Project Planning Branch
Post Office Box 1070
Nashville, Tennessee 37202-1070

RE: COE-N, ARCHAEOLOGICAL ASSESSMENT, MILL CREEK DRAINAGE REMEDIATION, NASHVILLE, DAVIDSON COUNTY, TN

Dear Mr. Rote:

At your request, our office has reviewed the above-referenced revised plans in accordance with regulations codified at 36 CFR 800 (Federal Register, December 12, 2000, 77698-77739). Based on the information provided, we find that the project area contains no archaeological resources eligible for listing in the National Register of Historic Places.

If project plans are changed or archaeological remains are discovered during construction, please contact this office to determine what further action, if any, will be necessary to comply with Section 106 of the National Historic Preservation Act.

Your cooperation is appreciated.

Sincerely,

E. Patrick McIntyre, Jr.
Executive Director and
State Historic Preservation Officer

EPM/jmb

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

October 23, 2014

Project Planning Branch

Mr. Tim Walker, Executive Director
Metro Historical Commission
Sunnyside in Sevier Park
3000 Granny White Pike
Nashville, Tennessee 37204

Dear Mr. Walker:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County (Metro) are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson County, Tennessee. In May 2014, we provided your office with information on the Tentatively Selected Plan (TSP) and assessment of effects to historic properties in compliance with Section 106 of the National Historic Preservation Act. In an email dated May 2, 2014, your office concurred with our assessment that the

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The USACE has revised the cultural resource assessment report that addresses the individual proposed flood reduction measures and presents the results in the enclosed *Cultural Resource Assessment for the Revised Mill Creek Feasibility study, Tentatively Selected Plan Davidson County.* This report includes the results of archaeological Phase I investigations conducted under Tennessee Archaeological State permit no. 000819. USACE did not identify historic properties that would be directly or indirectly affected by the proposed project.

The USACE requests your review of the proposed undertaking and assessment of effects and comments on a finding of “no historic properties affected”. Please contact Valerie McCormack at 615-736-7847 or Valerie.j.mccormack@usace.army.mil if you need additional information.

original signed

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Enclosure

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO
Project Planning Branch

JAN 26 2015

Mr. E. Patrick McIntyre
State Historic Preservation Officer
Tennessee Historical Commission
2941 Lebanon Road
Nashville, Tennessee 37246

Dear Mr. McIntyre:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County (Metro) are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson County, Tennessee. In a letter dated October 22, 2014, we provided information regarding changes to the proposed project including information on proposed modifications to the bridge that crosses Sevenmile Creek within the Ellington Agricultural Center. In a letter dated December, 9, 2014 you replied that the project "May adversely affect properties that are eligible for listing in the National Register of Historic Places". This letter provides additional information regarding the proposed project within Ellington Agricultural Center and requests to continue consultation under Section 106 of the National Historic Preservation Act.

The proposed project involves modifying the bridge over Sevenmile Creek and raising the elevation of the Ellington Agricultural Center access road to Edmondson Pike to create a detention structure that will reduce flooding downstream along Sevenmile Creek. On December 18, 2014 Dr. Valerie McCormack of my staff met with Dr. Joseph Garrison and Ms. Peggy Nichol of your staff, and Dr. Tara Mielnik of the Metropolitan Historical Commission. Your staff expressed concerns that that the Ellington Agricultural Center Campus was not properly considered as a National Register Eligible District. In addition, discussions addressed that the bridge and access road form non-contributing elements to the Ellington Agricultural Center National Register District. The enclosed *report Addendum to: Cultural Resource Assessment for the Revised Mill Creek Feasibility Study, Tentatively Selected Plan Davidson County, Tennessee Ellington Agricultural Center* proposes Ellington Agricultural Center Campus as a historic district and evaluates the bridge and access road as non-contributing elements. In conclusion, we recommend that the proposed project would not adversely affect the Ellington Agricultural Center Campus National Register District.

The USACE requests your review and comment of the proposed undertaking and assessment of effects and comments on a finding of "no adverse effect". Please contact Dr. McCormack at 615-736-7847 or Valerie.j.mccormack@usace.army.mil if you need additional information.

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

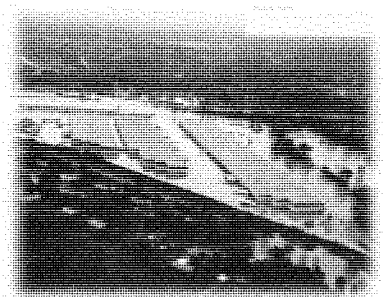
Enclosure

US Army Corps
of Engineers ®
Nashville District

DRAFT

Addendum to:
Cultural Resource Assessment for the Revised Mill Creek Feasibility Study, Tentatively Selected Plan Davidson County, Tennessee Ellington Agricultural Center

January 2015



For Further Information Contact:
Valerie J. McCormack, Ph.D.
U.S. Army Corps of Engineers
Nashville District
Project Planning Branch
Telephone: (615) 736-7847

State Permit No. 000819

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

JAN 26 2015

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Sunnyside in Sevier Park
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Dear Mr. Walker:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County (Metro) are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson County, Tennessee. In a letter dated October 22, 2014, we provided information regarding changes to the proposed project including information on proposed modifications to the bridge that crosses Sevenmile Creek within the Ellington Agricultural Center. In a letter dated December, 9, 2014 the Tennessee Historical Commission replied that the project "May Adversely affect properties that are eligible for listing in the National Register of Historic Places". This letter provides additional information regarding the proposed project within Ellington Agricultural Center and requests to continue consultation under Section 106 of the National Historic Preservation Act.

The proposed project involves modifying the bridge over Sevenmile Creek and raising the elevation of the Ellington Agricultural Center access road to Edmondson Pike to create a detention structure that will reduce flooding downstream along Sevenmile Creek. On December 18, 2014 Dr. Valerie McCormack of my staff met with Dr. Tara Mielnik of your staff, and Dr. Joseph Garrison and Ms. Peggy Nichol of the Tennessee Historical Commission (THC). THC expressed concerns that that the Ellington Agricultural Center Campus was not properly considered as a National Register Eligible District. In addition, discussions addressed that the bridge and access road form non-contributing elements to the Ellington Agricultural Center National Register District. The enclosed *report Addendum to: Cultural Resource Assessment for the Revised Mill Creek Feasibility Study, Tentatively Selected Plan Davidson County, Tennessee Ellington Agricultural Center* proposes Ellington Agricultural Center Campus as a historic district and evaluates the bridge and access road as non-contributing elements. In conclusion, we recommend that the proposed project would not adversely affect the Ellington Agricultural Center Campus National Register District.

The USACE requests your review and comments of the proposed undertaking and assessment of effects and comments on a finding of "no adverse effect". Please contact Dr. McCormack at 615-736-7847 or Valerie.j.mccormack@usace.army.mil if you need additional information.

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Enclosure

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Wednesday, January 28, 2015 8:27 AM
To: Emman Spain
Cc: McCormack, Valerie J LRN
Subject: RE: Mill creek drainage in Davidson and Williamson counties, Tennessee. (UNCLASSIFIED)
Attachments: Mill Creek - no adverse effect Jan 2015.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Mr. Spain,
Happy New Year, I hope this email finds you well.

We've made some revisions to the Mill Creek Feasibility study, a project that you reviewed last spring. Previously, the project was proposing to buy-out 216 buildings in Nashville, Davidson County. The project has been revised with a new proposal to buy-out 109 buildings (a subset of the 216) and to construct a detention structure to reduce downstream flooding. The detention structure will involve modifying an existing bridge and raising an existing access road to the Ellington Ag. Center. The water upstream of the detention structure will be held for approximately one hour. This area contains wetland and riparian plants that can easily sustain the added inundation time. We conducted Phase I level archaeological testing in the footprint of the proposed detention structure and did not identify any archaeological deposits.

The Ellington Agricultural Center Campus is eligible for listing in the National Register of Historic Places as a district under criteria b and c. The bridge and access road form non-contributing within this district, and we propose a finding of "no adverse effect to this historic properties". I've attached a revised report and addendum that includes archaeological investigations and consideration of the Ellington Agricultural Center as a historic district. In order to reduce the file size to one that is electronically transmittable, I removed the photographs of the structures that are less than 50 years old. Bookmarks are included in the .pdf to help you find the sections in the report that address the revised project and archaeological investigations.

Given the proposed changes in the project, including the proposed work within the Ellington Agricultural Center, we propose updating the prior recommendation of "no historic properties affected" to "no adverse effect".

Please let me know if you require additional information or need the complete report.
Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847

-----Original Message-----
From: Emman Spain [mailto:ESpain@MCN-NSN.gov]
Sent: Wednesday, June 18, 2014 12:50 PM
To: McCormack, Valerie J LRN
Subject: [EXTERNAL] Mill creek drainage in Davidson and Williamson counties, Tennessee.

Dear Ms. McCormack,

The Muscogee (Creek) Nation has received the U. S. Army Corps of Engineers, Nashville District notice of flood risk study in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. At this time we are unaware of any culturally significant sites within the project areas. We therefore concur with the finding of "no historic properties affected". Thank you.

Emman Spain, THPO

Muscogee (Creek) Nation

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Wednesday, January 28, 2015 8:27 AM
To: Lisa LaRue-Baker - UKB THPO
Cc: lstapleton@unitedkeetoowahband.org; eberry@unitedkeetoowahband.org; McCormack, Valerie J LRN
Subject: Mill Creek Feasibility Study, Davidson County, Tennesseee - Revisions (UNCLASSIFIED)
Attachments: Mill Creek - no adverse effect Jan 2015.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Lisa,
Happy New Year, I hope this email finds you well.

We've made some revisions to the Mill Creek Feasibility study, a project that you reviewed last spring. Previously, the project was proposing to buy-out 216 buildings in Nashville, Davidson County. The project has been revised with a new proposal to buy-out 109 buildings (a subset of the 216) and to construct a detention structure to reduce downstream flooding. The detention structure will involve modifying an existing bridge and raising an existing access road to the Ellington Ag. Center. The water upstream of the detention structure will be held for approximately one hour. This area contains wetland and riparian plants that can easily sustain the added inundation time. We conducted Phase I level archaeological testing in the footprint of the proposed detention structure and did not identify any archaeological deposits.

The Ellington Agricultural Center Campus is eligible for listing in the National Register of Historic Places as a district under criteria b and c. The bridge and access road form non-contributing within this district, and we propose a finding of "no adverse effect to this historic properties". I've attached a revised report and addendum that includes archaeological investigations and consideration of the Ellington Agricultural Center as a historic district. In order to reduce the file size to one that is electronically transmittable, I removed the photographs of the structures that are less than 50 years old. Bookmarks are included in the .pdf to help you find the sections in the report that address the revised project and archaeological investigations.

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Please let me know if you require additional information or need the complete report.
Respectfully,
Valerie

Valerie J. McCormack Ph.D.
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Nashville District
(615)736-7847

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

-----Original Message-----
From: Lisa LaRue-Baker - UKB THPO [mailto:ukbthpo-larue@yahoo.com]
Sent: Wednesday, May 14, 2014 10:30 AM
To: McCormack, Valerie J LRN
Cc: verna; Ernestine Berry
Subject: [EXTERNAL] Re: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)

Could you please send me a copy of the Topo Map??
Thank you!

Lisa C. Baker
Acting THPO
United Keetoowah Band of Cherokee Indians in Oklahoma
PO Box 746
Tahlequah, OK 74465

c 918.822.1952
ukbthpo-larue@yahoo.com

Please FOLLOW our historic preservation page and LIKE us on FACEBOOK <https://www.facebook.com/pages/United-Keetoowah-Band-of-Cherokee-Indians-in-Oklahoma-Historic-Preservation/199767846834850>

From: "McCormack, Valerie J LRN" <Valerie.J.McCormack@usace.army.mil>
To: Lisa LaRue-Baker - UKB THPO <ukbthpo-larue@yahoo.com>
Cc: verna <lstapleton@unitedkeetoowahband.org>
Sent: Tuesday, May 13, 2014 2:48 PM
Subject: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Lisa,
Please find attached a letter to Chief Wickliffe and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
Please let me know if you require additional information or would prefer a hard copy of the complete report.

Respectfully,
Valerie

Valerie J. McCormack Ph.D.
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Internet: http://www.lrn.usace.army.mil <http://www.lrn.usace.army.mil/>
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Wednesday, January 28, 2015 8:26 AM
To: Richard Allen
Cc: McCormack, Valerie J LRN
Subject: RE: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Mill Creek - no adverse effect Jan 2015.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dr. Allen,
Happy New Year, I hope this email finds you well.

We've made some revisions to the Mill Creek Feasibility study, a project that you reviewed last spring. Previously, the project was proposing to buy-out 216 buildings in Nashville, Davidson County. The project has been revised with a new proposal to buy-out 109 buildings (a subset of the 216) and to construct a detention structure to reduce downstream flooding. The detention structure will involve modifying an existing bridge and raising an existing access road to the Ellington Ag. Center. The water upstream of the detention structure will be held for approximately one hour. This area contains wetland and riparian plants that can easily sustain the added inundation time. We conducted Phase I level archaeological testing in the footprint of the proposed detention structure and did not identify any archaeological deposits.

The Ellington Agricultural Center Campus is eligible for listing in the National Register of Historic Places as a district under criteria b and c. The bridge and access road form non-contributing within this district, and we propose a finding of "no adverse effect to this historic properties". I've attached a revised report and addendum that includes archaeological investigations and consideration of the Ellington Agricultural Center as a historic district. In order to reduce the file size to one that is electronically transmittable, I removed the photographs of the structures that are less than 50 years old. Bookmarks are included in the .pdf to help you find the sections in the report that address the revised project and archaeological investigations.

Given the proposed changes in the project, including the proposed work within the Ellington Agricultural Center, we propose updating the prior recommendation of "no historic properties affected" to "no adverse effect".

Please let me know if you require additional information or need the complete report.
Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847
-----Original Message-----
From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:48 PM
To: 'Richard Allen'

Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Dr. Allen
Please find attached a letter to Chief Baker and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
Please let me know if you require additional information or would prefer a hard copy of the complete report.

Respectfully,
Valerie

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Classification: UNCLASSIFIED
Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From:	McCormack, Valerie J LRN
Sent:	Wednesday, January 28, 2015 8:25 AM
To:	HPO@chickasaw.net
Cc:	McCormack, Valerie J LRN
Subject:	RE: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments:	Mill Creek - no adverse effect Jan 2015.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear friends,

Happy New Year, I hope this email finds you well.

We've made some revisions to the Mill Creek Feasibility study, a project that you reviewed last spring. Previously, the project was proposing to buy-out 216 buildings in Nashville, Davidson County. The project has been revised with a new proposal to buy-out 109 buildings (a subset of the 216) and to construct a detention structure to reduce downstream flooding. The detention structure will involve modifying an existing bridge and raising an existing access road to the Ellington Ag. Center. The water upstream of the detention structure will be held for approximately one hour. This area contains wetland and riparian plants that can easily sustain the added inundation time. We conducted Phase I level archaeological testing in the footprint of the proposed detention structure and did not identify any archaeological deposits.

The Ellington Agricultural Center Campus is eligible for listing in the National Register of Historic Places as a district under criteria b and c. The bridge and access road form non-contributing within this district, and we propose a finding of "no adverse effect to this historic properties". I've attached a revised report and addendum that includes archaeological investigations and consideration of the Ellington Agricultural Center as a historic district. In order to reduce the file size to one that is electronically transmittable, I removed the photographs of the structures that are less than 50 years old. Bookmarks are included in the .pdf to help you find the sections in the report that address the revised project and archaeological investigations.

Given the proposed changes in the project, including the proposed work within the Ellington Agricultural Center, we propose updating the prior recommendation of "no historic properties affected" to "no adverse effect".

Please let me know if you require additional information or need the complete report.
Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847

-----Original Message-----
From: McCormack, Valerie J LRN

Sent: Tuesday, May 13, 2014 2:48 PM
To: 'HPO@chickasaw.net'
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Dear Chickasaw Historic Preservation Office:
Please find attached a letter to Governor Anoutubby and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. Photographs of all buildings over 50 years old are included in the main body of the report. Please let me know if you require additional information or would prefer a hard copy of the complete report.

Respectfully,
Valerie

Valerie J. McCormack Ph.D.
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Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Wednesday, January 28, 2015 8:25 AM
To: Tyler B. Howe
Cc: McCormack, Valerie J LRN
Subject: RE: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Mill Creek - no adverse effect Jan 2015.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear Tyler,
Happy New Year, I hope this email finds you well.

We've made some revisions to the Mill Creek Feasibility study, a project that you reviewed last spring. Previously, the project was proposing to buy-out 216 buildings in Nashville, Davidson County. The project has been revised with a new proposal to buy-out 109 buildings (a subset of the 216) and to construct a detention structure to reduce downstream flooding. The detention structure will involve modifying an existing bridge and raising an existing access road to the Ellington Ag. Center. The water upstream of the detention structure will be held for approximately one hour. This area contains wetland and riparian plants that can easily sustain the added inundation time. We conducted Phase I level archaeological testing in the footprint of the proposed detention structure and did not identify any archaeological deposits.

The Ellington Agricultural Center Campus is eligible for listing in the National Register of Historic Places as a district under criteria b and c. The bridge and access road form non-contributing within this district, and we propose a finding of "no adverse effect to this historic properties". I've attached a revised report and addendum that includes archaeological investigations and consideration of the Ellington Agricultural Center as a historic district. In order to reduce the file size to one that is electronically transmittable, I removed the photographs of the structures that are less than 50 years old. Bookmarks are included in the .pdf to help you find the sections in the report that address the revised project and archaeological investigations.

Given the proposed changes in the project, including the proposed work within the Ellington Agricultural Center, we propose updating the prior recommendation of "no historic properties affected" to "no adverse effect".

Please let me know if you require additional information or need the complete report.
Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847

-----Original Message-----
From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:48 PM

To: Tyler B. Howe
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Tyler
Please find attached a letter to Chief Hicks and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
Please let me know if you require additional information or would prefer a hard copy of the complete report.

Respectfully,
Valerie

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Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Wednesday, January 28, 2015 8:24 AM
To: Robin Dushane
Cc: McCormack, Valerie J LRN
Subject: RE: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Mill Creek - no adverse effect Jan 2015.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear Robin,

Happy New Year, I hope this email finds you well.

We've made some revisions to the Mill Creek Feasibility study, a project that you reviewed last spring. Previously, the project was proposing to buy-out 216 buildings in Nashville, Davidson County. The project has been revised with a new proposal to buy-out 109 buildings (a subset of the 216) and to construct a detention structure to reduce downstream flooding. The detention structure will involve modifying an existing bridge and raising an existing access road to the Ellington Ag. Center. The water upstream of the detention structure will be held for approximately one hour. This area contains wetland and riparian plants that can easily sustain the added inundation time. We conducted Phase I level archaeological testing in the footprint of the proposed detention structure and did not identify any archaeological deposits.

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Given the proposed changes in the project, including the proposed work within the Ellington Agricultural Center, we propose updating the prior recommendation of "no historic properties affected" to "no adverse effect".

Please let me know if you require additional information or need the complete report.
Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847

-----Original Message-----
From: McCormack, Valerie J LRN

Sent: Tuesday, May 13, 2014 2:48 PM
To: Robin Dushane
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Dear Robin,
Please find attached a letter and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
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Valerie

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Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Wednesday, January 28, 2015 8:24 AM
To: Kim Jumper
Cc: McCormack, Valerie J LRN
Subject: RE: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Mill Creek - no adverse effect Jan 2015.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear Ms. Jumper,
Happy New Year, I hope this email finds you well.

We've made some revisions to the Mill Creek Feasibility study, a project that you reviewed last spring. Previously, the project was proposing to buy-out 216 buildings in Nashville, Davidson County. The project has been revised with a new proposal to buy-out 109 buildings (a subset of the 216) and to construct a detention structure to reduce downstream flooding. The detention structure will involve modifying an existing bridge and raising an existing access road to the Ellington Ag. Center. The water upstream of the detention structure will be held for approximately one hour. This area contains wetland and riparian plants that can easily sustain the added inundation time. We conducted Phase I level archaeological testing in the footprint of the proposed detention structure and did not identify any archaeological deposits.

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Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847

-----Original Message-----
From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:47 PM

To: Kim Jumper
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Dear Ms. Jumper,
Please find attached a letter to Chairman Sparkman and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report. Please let me know if you require additional information or would prefer a hard copy of the complete report.

Respectfully,
Valerie

Valerie J. McCormack Ph.D.
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Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Wednesday, January 28, 2015 8:23 AM
To: charles coleman
Cc: McCormack, Valerie J LRN
Subject: RE: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Mill Creek - no adverse effect Jan 2015.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear Dr. Coleman,
It was wonderful to meet you earlier this month. I hope you had a nice stay in Nashville and uneventful travels home.

We've made some revisions to the Mill Creek Feasibility study, a project that you reviewed last spring. Previously, the project was proposing to buy-out 216 buildings in Nashville, Davidson County. The project has been revised with a new proposal to buy-out 109 buildings (a subset of the 216) and to construct a detention structure to reduce downstream flooding. The detention structure will involve modifying an existing bridge and raising an existing access road to the Ellington Ag. Center. The water upstream of the detention structure will be held for approximately one hour. This area contains wetland and riparian plants that can easily sustain the added inundation time. We conducted Phase I level archaeological testing in the footprint of the proposed detention structure and did not identify any archaeological deposits.

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Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847

-----Original Message-----
From: McCormack, Valerie J LRN

Sent: Tuesday, May 13, 2014 2:47 PM
To: charles coleman
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Dear Warrior Coleman,
Please find attached a letter to Mekko Scott and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
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Valerie

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Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

Appendix D National Historic Preservation Act Compliance

Summary

Section 106 of the National Historic Preservation Act of 1966, as amended (NHPA), and its implementing regulations at 36 CFR 800 require consideration of cultural resources prior to a federal undertaking and requires consultation with the State Historic Preservation Officer (SHPO), Federally recognized tribes with a connection to the project location and other consulting parties defined at §800.3. The NHPA only affords protection to sites, buildings structures, or objects listed in or determined eligible for listing in the National Register of Historic Places (NRHP). Archival research for this project involved consulting the National Register of Historic Places, the Tennessee Historical Commission (THC) National Register and structure files, the Tennessee Division of Archaeology site and survey files, and the Metropolitan Government of Nashville and Davidson County, Historical Commission (MHC) historic landmark inventory and historic zoning district overlays. In addition, field visits included visiting the proposed project areas to identify architectural resources within the proposed project areas and surrounding viewshed, to document the degree of prior disturbance, and to undertake Phase I archaeological site identification investigations. Review of the Areas of Potential Effects and consultation with THC and MHC resulted in the identification of the Ellington Agricultural Center Campus as a National Register eligible historic district. Section 106 consultation is expected to conclude with a "no adverse effect to historic properties" determination.

Pursuant to 36 CFR 800.11 *Documentation standards* the following outlines the documentation associated with the efforts to identify historic properties and the consultation conducted to meet the USACE obligations under Section 106.

Consulting Parties

USACE identified the following consultation pursuant to 36 CFR 800.2(c).

- Tennessee Historical Commission (THC)
- Metropolitan Government of Nashville and Davidson County Historical Commission (MHC)
- Absentee Shawnee Tribe of Oklahoma
- Alabama Coushatta Tribe of Texas
- Cherokee Nation
- Chickasaw Nation
- Eastern Band of Cherokee Indians
- Eastern Shawnee Tribe of Oklahoma
- Kialegee Tribal Town
- Muscogee(Creek) Nation
- Shawnee Tribe
- Thlopthlocco Tribal Town
- United Keetoowah Tribe of Cherokee Indians

In addition, the NEPA scoping notice dated February 14, 2013 invited the public and other organizations to participate in the section 106 process. USACE received no requests to participate in the Section 106 process.

Initiation

Requests to initiate consultation under Section 106 of the National Historic Preservation Act were sent to the consulting parties on February 14, 2013.

Initiation Responses

Only one consulting party responded to the Section 106 initiation letter.

- United Keetoowah Band of Cherokee Indians-via email stated "The United Keetoowah Band of Cherokee Indians in Oklahoma has reviewed your project under Section 106 of the NHPA, and at this time have no comments or objections. However, if any human remains are inadvertently discovered, please cease all work and contact us immediately."

Consultation on the initial TSP

On May 7, 2014 the report titled *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan Davidson County, Tennessee* (USACE, April 2014) was transmitted to the consulting parties. The report assess effects on the TSP, which at that time involved the proposed buy-out of 216 residences as part of the non-structural plan, and modification to the Briley Parkway bridges as part of the structural plan. USACE proposed a Section 106 finding of "no historic properties affected"

Reponses

- THC responded, by letter dated May 28, 2014, "that the project as currently proposed MAY ADVERSELY AFFECT PROPERTIES THAT ARE ELIGIBLE FOR LISTING IN THE NATIONAL REGISTER OF HISTORIC PLACES." Follow-up telephone discussions with THC revealed that they were concerned that one neighborhood with a concentration of buy-out structures could form a National Register eligible district. We discussed the potential for a proposed project revision and would provide additional information when the revised TSP is formulated.
- MHC via email responded that "they concurred that the project would have no adverse effect on historic properties."
- Muscogee (Creek) Nation via email concurred with a finding of "no historic properties affected."
- United Keetoowah Band of Cherokee Indians via email "The United Keetoowah Band of Cherokee Indians in Oklahoma has reviewed your project under Section 106 of the NHPA, and at this time have no comments or objections. However, if any human remains are inadvertently discovered, please cease all work and contact us immediately."
- No other responses were received. Therefore the lack of response was considered concurrence pursuant to 36 CFR 800.4(d)(1) (i).

Consultation on the Revised and current TSP

In letters dated October 23, 2014, USCE provided information on the revised and current TSP to the THC and MHC. The cultural resource assessment including updates to the APE are documented in the report: *Cultural Resource Assessment for the Revised Mill Creek Feasibility Study, Tentatively Selected Plan Davidson County, Tennessee* (USACE, October 2014). This report included archaeological investigations of the proposed bridge and roadway modifications at the Ellington Agricultural Center related to the creation of a detention structures.

Responses

- In a letter dated December 9, 2014, THC responded "that the project as currently proposed MAY ADVERSELY AFFECT PROPERTIES THAT ARE ELIGIBLE FOR LISTING IN THE NATIONAL REGISTER OF HISTORIC PLACES."
- On December 18, 2014 USACE met with THC and MHC staff to obtain information regarding what properties THC was concerned. THC expressed the opinion that the Ellington Agricultural

Center Campus forms a historic district. Furthermore, they stated the bridge forms a non-contributing element to the historic district; therefore, the finding should be amended to "no adverse effect to historic properties."

- In a letter dated December 22, 2014, THC responded "Based on the information provided we find that the project area contains no archaeological resources eligible for listing in the National Register of Historic Places."

Conclusion of the Section 106 Process

Following consultation with the Tennessee Historical Commission in December 2014, the document *Addendum to: Cultural Resource Assessment for the Revised Mill Creek Feasibility Study, Tentatively Selected Plan Davidson County, Tennessee Ellington Agricultural Center* (USACE, January 2015) was prepared to address the National Register eligibility of the Ellington Agricultural Center and to assess effects of the proposed detention structure. In letters dated January 26, 2015, the addendum and a finding of "no adverse effect" was submitted to MHC and THC. The *Cultural Resource Assessment for the Revised Mill Creek Feasibility Study, Tentatively Selected Plan Davidson County, Tennessee* and *Addendum to: Cultural Resource Assessment for the Revised Mill Creek Feasibility Study, Tentatively Selected Plan Davidson County, Tennessee Ellington Agricultural Center* was transmitted to the consulting federally recognized tribes on January 28, 2015. USACE will await the responses of the consulting parties within the thirty-day window prior to concluding the Section 106 process.

Section 106 Coordination and Comments

Attachment D

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO
ATTENTION OF

FEB 15 2013

Project Planning Branch

Mr. E. Patrick McIntyre, Director
Tennessee Historical Commission
State Historic Preservation Officer
2941 Lebanon Road
Nashville, Tennessee 37243-0442

Dear Mr. McIntyre:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

Please find enclosed a copy of a January 15, 2009 letter that initiated consultation under Section 106 of the National Historic Preservation Act for the flood damage reduction study of the Mill Creek Watershed. The six project areas discussed in the 2009 letter may or may not be considered for implementation in the current feasibility study. The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review.

The feasibility study and NEPA review will consider a number of measure such as improving storm water management, stream bank stabilization, bridge improvement, removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood control measure, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

The Corps requests your comments on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Enclosure

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO
ATTENTION OF

Project Planning Branch

TO ALL INTERESTED PARTIES:

The Corps of Engineers, Nashville District, is completing a feasibility study to investigate flood risk management measures within the Mill Creek watershed in Davidson County, Tennessee. The Metropolitan Government of Nashville and Davidson County (Metro) is the project sponsor. This project, which was originally scoped in 2003 and now rescoped following the May 2010 flood event, is moving forward with a primary flood risk management analysis and secondary ecosystem restoration consideration.

The Mill Creek watershed is located in parts of Davidson, Williamson, and Rutherford counties and drains nearly 70,000 acres (108 square miles). A vicinity and watershed map (Figure 1) of the proposed study area is enclosed. The watershed supports many plants, fish, and wildlife including the Nashville Crayfish (*Orconectes shoupi*), an endangered species. The stream corridor offers important esthetic and recreational opportunities such as fishing, bird watching, nature study, and paddlecraft use.

The Mill Creek study would use computer models to depict hydrology, aquatic habitat, and water quality processes occurring in the watershed. The study would also consider storm water management, future development, floodplain mapping, endangered species protection, stream bank stabilization, water quality impacts from point and non-point sources, and stream corridor habitat enhancement. The study aims to predict and minimize flood damage in a way that protects, maintains, and restores the ecologically sensitive Mill Creek and its tributaries.

Alternatives to be analyzed would include those identified during the initial 2003 screening analysis, as well as alternatives analyzed in support of Metro's Unified Flood Preparedness Plan initiative. Preliminary flood risk management alternatives that would be considered include non-structural measures such as vegetative berms, expanding floodways and natural habitat, flood water storage basins, and raising or removal of structures from the floodway and/or floodplain. Structural measures evaluated would include floodwalls, bridge improvements, and quarry diversion and associated gate/tunnel structures. Changes to existing land use practices such as establishment of water quality buffers would be considered to protect stream corridors; these corridors could also include public parks or other passive recreational features.

In accordance with the National Environmental Policy Act (NEPA) and applicable implementing regulations, an Environmental Assessment would be prepared to evaluate viable alternatives for this proposal as an integral part of this planning study. We are soliciting public and agency comments concerning environmental issues that should be addressed in the course of

the NEPA process. We encourage comments not only about the immediate project area, but also of plans or proposals for any other development that may impact or influence project resources.

This letter also serves to initiate the public involvement requirements of Section 106 of the National Historic Preservation Act of 1966, as amended. Section 106, implemented by regulations at 36 CFR 800, requires the Corps of Engineers to consider the effects of its undertakings on historic properties. If required, appropriate architectural and archeological investigations would be conducted within those areas affected by the proposed activities and resulting findings would be coordinated with the Tennessee State Historic Preservation Officer and other consulting parties.

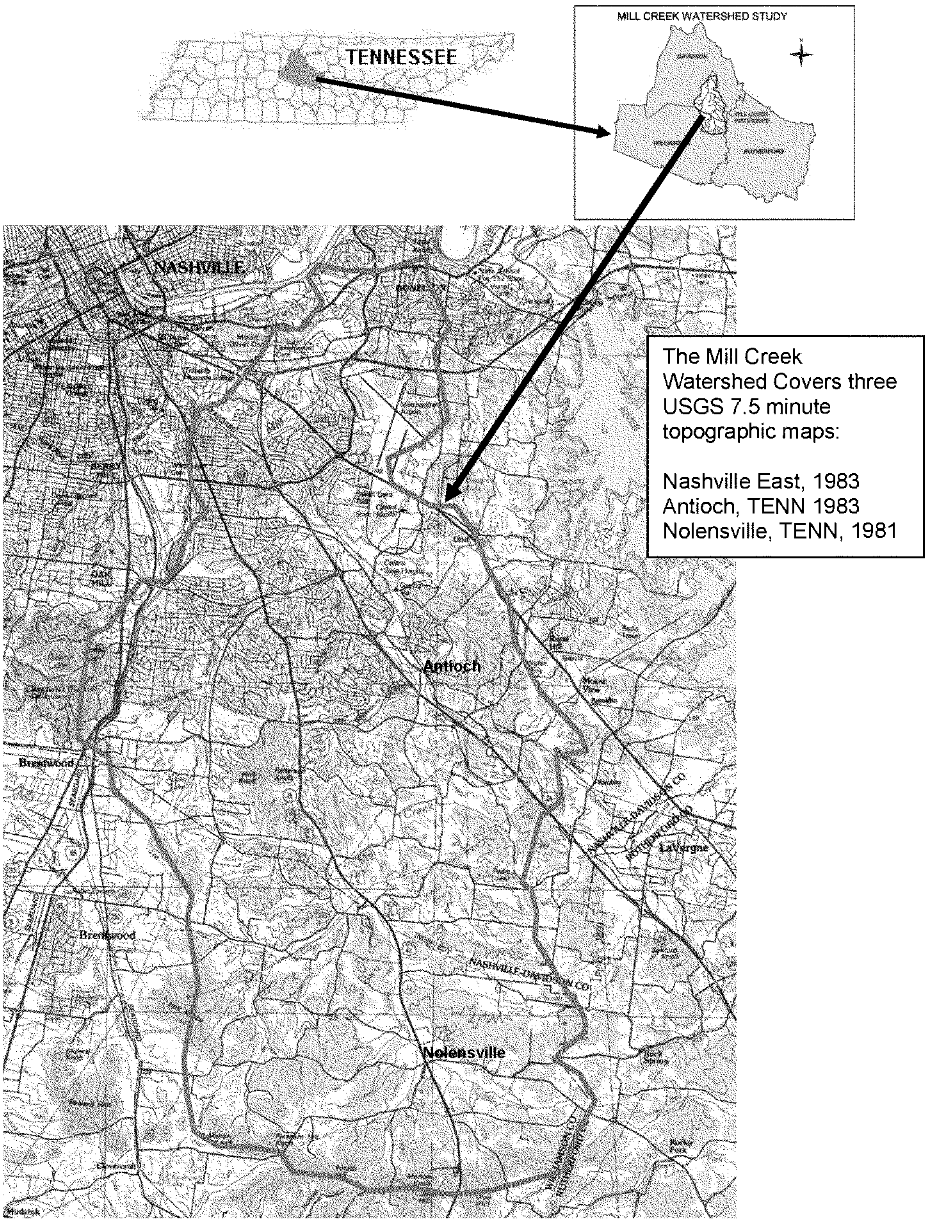
The public and local, state and federal agencies are invited to submit written comments to this scoping no later than 15 March 2013. Please note that there would be other opportunities for comments during the planning phase at future public workshops and circulation of the NEPA document for public comment. Workshops are being planned, however, times, dates, or locations have not been determined. Once set, this information will be shared through media and the Corps website—www.lrn.usace.army.mil.

You may mail comments to the Nashville District, U.S. Army Corps of Engineers, P.O. Box 1070 (PM-P), Nashville, TN 37202-1070, ATTN: Planning Branch (Mark Vaughan), direct comments via phone at (615) 736-7850, or email to mark.k.vaughn@usace.army.mil. Information may also be obtained by contacting Mr. Porter Williams, Project Manager at (615) 736-7635.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Figure 1. Vicinity and Watershed Map for the Mill Creek Watershed in Tennessee.



DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO
ATTENTION OF

FEB 15 2013

Project Planning Branch

Mr. Tim Walker, Executive Director
Metro Historical Commission
Sunnyside in Sevier Park
Nashville, Tennessee 37204

Dear Mr. Walker:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review. The Corps also requests to initiate consultation under section106 of the National Historic Preservation Act with the Metro Historical Commission.

The feasibility study and NEPA review will consider a number of measures such as improving storm water management, stream bank stabilization, bridge improvement, and removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood risk management measures, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

The Corps requests comments from Metro Historical Commission on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Enclosure

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO
ATTENTION OF

FEB 15 2013

Project Planning Branch

Chief Tarpie Yargee
Alabama-Quassarte Tribal Town
P.O. Box 187
Wetumka, Oklahoma 74883

Dear Chief Yargee:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review. The Corps also requests to initiate consultation under section106 of the National Historic Preservation Act with the Alabama-Quassarte Tribal Town.

The feasibility study and NEPA review will consider a number of measures such as improving storm water management, stream bank stabilization, bridge improvement, and removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood risk management measures, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

A copy of this letter is being forwarded to Ms. Augustine Asburry. The Corps requests comments from Alabama-Quassarte Tribal Town on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Enclosure

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO ATTENTION OF

FEB 15 2013

Project Planning Branch

Principal Chief Bill John Baker
Cherokee Nation
P.O. Box 948
Tahlequah, Oklahoma 74465-0948

Dear Principal Chief Baker:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review. The Corps also requests to initiate consultation under section106 of the National Historic Preservation Act with the Cherokee Nation.

The feasibility study and NEPA review will consider a number of measures such as improving storm water management, stream bank stabilization, bridge improvement, and removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood risk management measures, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

A copy of this letter is being forwarded to Dr. Richard Allen. The Corps requests comments from Cherokee Nation on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Enclosure

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO
ATTENTION OF

FEB 15 2013

Project Planning Branch

Governor Bill Anoatubby
Chickasaw Nation
P.O. Box 1548
Ada, Oklahoma 74821-1548

Dear Governor Anoatubby:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review. The Corps also requests to initiate consultation under section106 of the National Historic Preservation Act with the Chickasaw Nation.

The feasibility study and NEPA review will consider a number of measures such as improving storm water management, stream bank stabilization, bridge improvement, and removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood risk management measures, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

A copy of this letter is being forwarded to Ms. LaDonna Brown and Ms. Virginia Nail. The Corps requests comments from Chickasaw Nation on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Enclosure

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO ATTENTION OF

FEB 15 2013

Project Planning Branch

Principal Chief Michell Hicks
Eastern Band of Cherokee Indians
Qualla Boundary
P.O. Box 445
Cherokee, North Carolina 28719

Dear Chief Hicks:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review. The Corps also requests to initiate consultation under section106 of the National Historic Preservation Act with the Eastern Band of Cherokee Indians.

The feasibility study and NEPA review will consider a number of measures such as improving storm water management, stream bank stabilization, bridge improvement, and removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood risk management measures, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO
ATTENTION OF

FEB 15 2013

Project Planning Branch

Principal Chief A.D. Ellis
Muscogee (Creek) Nation, Oklahoma
P.O. Box 580
Okmulgee, Oklahoma 74447

Dear Chief Ellis:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review. The Corps also requests to initiate consultation under section106 of the National Historic Preservation Act with the Muscogee (Creek) Nation, Oklahoma.

The feasibility study and NEPA review will consider a number of measures such as improving storm water management, stream bank stabilization, bridge improvement, and removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood risk management measures, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

A copy of this letter is being forwarded to Mr. Emman Spain. The Corps requests comments from Muscogee (Creek) Nation, Oklahoma on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Enclosure

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

A copy of this letter is being forwarded to Mr. Tyler Howe. The Corps requests comments from Eastern Band of Cherokee Indians on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Enclosure

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO
ATTENTION OF

FEB 15 2013

Project Planning Branch

Ms. Robin DuShane
Tribal Historic Preservation Officer
Eastern Shawnee Tribe of Oklahoma
P.O. Box 350
Seneca, Missouri 64865

Dear Ms. DuShane:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review. The Corps also requests to initiate consultation under section106 of the National Historic Preservation Act with the Eastern Shawnee Tribe of Oklahoma.

The feasibility study and NEPA review will consider a number of measure such as improving storm water management, stream bank stabilization, bridge improvement, removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood control measure, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

The Corps requests comments from Eastern Shawnee Tribe of Oklahoma on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Enclosure

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

FEB 15 2013

REPLY TO
ATTENTION OF

Project Planning Branch

Mekko Tiger Hobia
Kialegee Tribal Town
108 N. Main St.
P.O. Box 332
Wetumka, Oklahoma 74883

Dear Mekko Hobia:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review. The Corps also requests to initiate consultation under section106 of the National Historic Preservation Act with the Kialegee Tribal Town.

The feasibility study and NEPA review will consider a number of measures such as improving storm water management, stream bank stabilization, bridge improvement, and removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood risk management measures, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

The Corps requests comments from Kialegee Tribal Town on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Enclosure

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

FEB 15 2013

REPLY TO
ATTENTION OF

Project Planning Branch

Chairperson Ron Sparkman
Shawnee Tribe
P.O. Box 189
Miami, Oklahoma 74355

Dear Chairperson Sparkman:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review. The Corps also requests to initiate consultation under section106 of the National Historic Preservation Act with the Shawnee Tribe.

The feasibility study and NEPA review will consider a number of measures such as improving storm water management, stream bank stabilization, bridge improvement, and removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood risk management measures, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

A copy of this letter is being forwarded to Ms. Kim Jumper. The Corps requests comments from Shawnee Tribe on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Enclosure

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

REPLY TO
ATTENTION OF

FEB 15 2013

Project Planning Branch

Chief George Wickliffe
United Keetoowah Band of Cherokee Indians in Oklahoma
P.O. Box 746
Tahlequah, Oklahoma 74464-0746

Dear Chief Wickliffe:

The U.S. Army Corps of Engineers, Nashville District is preparing a general investigation feasibility study of the Mill Creek watershed in parts of Davidson, Williamson, and Rutherford counties, Tennessee. The Corps is partnering with Metropolitan Nashville and Davidson County Government to prepare the study. Baseline information for the study was included in a 1986 report: *Metro Region of Nashville, Tennessee, Mill Creek, Final Interim Feasibility*. The drought of record (1986-87) and flood of record (2010) have occurred in the time since the base data was collected, causing the need to update the feasibility report. The feasibility report will identify flood damage reduction alternatives, ecosystem restoration alternatives and estimate costs for implementation. This information will then be used to select and implement projects.

The Corps is scoping the current study for National Environmental Policy Act (NEPA) compliance. Please find enclosed the scoping notice for your review. The Corps also requests to initiate consultation under section106 of the National Historic Preservation Act with the United Keetoowah Band of Cherokee Indians in Oklahoma.

The feasibility study and NEPA review will consider a number of measures such as improving storm water management, stream bank stabilization, bridge improvement, and removal of structures the from floodway and/or floodplain. The Corps defines these activities as undertakings with the potential to cause effects on historic properties. However, the study has not identified specific locations for flood risk management alternatives. The Corps requests implementing a phased identification and evaluation program for the Mill Creek feasibility study as defined by 36 CFR 800.4(b)(2).

As the study progresses, the Corps will consult on areas of potential effects (APE) for feasible flood risk management measures, assess the likelihood of historic properties within the APE and identify a plan for historic property identification and evaluation. Use of the phased identification and evaluation will allow the Corps to continue with this much needed flood risk management analysis, comply with the National Environmental Policy Act, and consider project effects on historic properties.

A copy of this letter is being forwarded to Ms. Lisa LaRue-Baker. The Corps requests comments from United Keetoowah Band of Cherokee Indians in Oklahoma on the proposed project and use of phased compliance to meet the Corps responsibilities under the National Historic Preservation Act. Please contact Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil if you require additional information.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Enclosure

McCormack, Valerie J LRN

From:	Lisa LaRue-Baker - UKB THPO [ukbthpo-larue@yahoo.com]
Sent:	Sunday, March 10, 2013 4:11 PM
To:	McCormack, Valerie J LRN
Cc:	lstapleton@unitedkeetoowahband.org
Subject:	Mill Creek Watershed, Davidson, Williamson and Rutherford Counties, TN

The United Keetoowah Band of Cherokee Indians in Oklahoma has reviewed your project under Section 106 of the NHPA, and at this time have no comments or objections. However, if any human remains are inadvertently discovered, please cease all work and contact us immediately.

Lisa C. Baker
Acting THPO
United Keetoowah Band of Cherokee Indians in Oklahoma
PO Box 746
Tahlequah, OK 74465

c 918.822.1952
ukbthpo-larue@yahoo.com

Please FOLLOW our historic preservation page and LIKE us on FACEBOOK
<https://www.facebook.com/pages/United-Keetoowah-Band-of-Cherokee-Indians-in-Oklahoma-Historic-Preservation/199767846834850>

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Mr. E. Patrick McIntyre, Director
Tennessee Historical Commission
2491 Lebanon Pike
Nashville, Tennessee 37243-0442

Dear Mr. McIntyre:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County (Metro) are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the USACE sent a letter to your office initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. Land owners would volunteer to be part of the buy-out program. Following the buy-out, the buildings would be razed and future development would be prohibited in the flood plain.

The report *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan, Davidson County, Tennessee* presents historic property identification efforts for the proposed TSP and was previously provided to your office. The Briley Parkway Bridges were reconstructed in 2009 and are not eligible for listing in the National Register of Historic Places. The majority of the 216 buildings were constructed in the last 50 years, and all were constructed after c. 1940. The USACE believes that none of the structures considered independently or as part of a district are eligible for inclusion in the National Register of Historic Places.

The TSP involves minimal ground disturbance. Work at the Briley Parkway Bridges will involve removing fill from the floodway. There are no known archaeological sites in the vicinity of the 216 residences. Razing the buildings will cause minimal ground disturbance in previously disturbed areas. Therefore, the USACE recommends no further investigation of the buy-out locations. A

USACE archaeologists will review construction contracts to ensure there are no changes in procedures that could cause disturbance, which is not anticipated at this time. Therefore, the USACE recommends a finding of "no historic properties affected" for proposed TSP for the Mill Creek Feasibility study.

The USACE is also coordinating with SHPO, tribes, and other interested parties as part of the Section 106 process and the National Environmental Protection Act. The USACE requests your comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615)736-7847.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

TENNESSEE HISTORICAL COMMISSION
STATE HISTORIC PRESERVATION OFFICE
2941 LEBANON ROAD
NASHVILLE, TENNESSEE 37214
OFFICE: (615) 532-1550
www.tnhistoricalcommission.org

May 28, 2014

Mr. Russ Rote
COE-Nashville District
Post Office Box 1070
Nashville, Tennessee, 37202-1070

RE: COE-N, MILL CREAK DRAINAGE, WILLIAMSON, DAVIDSON COUNTY

Dear Mr. Rote:

In response to your request, received on Thursday, May 8, 2014, we have reviewed the documents you submitted regarding your proposed undertaking. Our review of and comment on your proposed undertaking are among the requirements of Section 106 of the National Historic Preservation Act. This Act requires federal agencies or applicant for federal assistance to consult with the appropriate State Historic Preservation Office before they carry out their proposed undertakings. The Advisory Council on Historic Preservation has codified procedures for carrying out Section 106 review in 36 CFR 800. You may wish to familiarize yourself with these procedures (Federal Register, December 12, 2000, pages 77698-77739) if you are unsure about the Section 106 process.

Considering available information, we find that the project as currently proposed MAY ADVERSELY AFFECT PROPERTIES THAT ARE ELIGIBLE FOR LISTING IN THE NATIONAL REGISTER OF HISTORIC PLACES. You should now begin immediate consultation with our office. Please direct questions and comments to Joe Garrison (615) 770-1092.

Sincerely,

E. Patrick McIntyre, Jr.
Executive Director and
State Historic Preservation Officer

EPM/jyg

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Mr. Tim Walker
Metro Historical Commission
Sunnyside in Sevier Park
3000 Granny White Pike
Nashville, Tennessee 37204

Dear Mr. Walker:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County (Metro) are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the USACE sent a letter to your office initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. Land owners would volunteer to be part of the buy-out. Following the buy-out, the buildings would be razed and future development would be prohibited in the flood plain.

The enclosed report *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan, Davidson County, Tennessee* presents historic property identification efforts for the proposed TSP. The Briley Parkway Bridges were reconstructed in 2009 and are not eligible for listing in the National Register of Historic Places. The majority of the 216 buildings were constructed in the last 50 years, and all were constructed after 1940. USACE believes that none of the structures considered independently or as part of a district are eligible for inclusion in the National Register of Historic Places. USACE provided the draft report to the Metro Historical Commission for an informal initial review. Dr. Tara Mielnik's comments are enclosed.

The TSP involves minimal ground disturbance. Work at the Briley Parkway Bridges will involve removing fill from the floodway. There are no known archaeological sites in the vicinity of the 216 residences. Razing the buildings will cause minimal ground disturbance in previously disturbed areas. Therefore, the USACE recommends no further investigation of the buy-out locations. A USACE archaeologists will review construction contracts to ensure there are no changes in procedures that could cause disturbance, which is not anticipated at this time. Therefore, the USACE recommends a finding of "no historic properties affected" for proposed TSP for the Mill Creek Feasibility study.

The USACE is also coordinating with tribes, local governments and other interested parties as part of the Section 106 process and the National Environmental Protection Act. The USACE requests your comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615)736-7847.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Enclosures

McCormack, Valerie J LRN

From: Mielnik, Tara (Historical Commission) [Tara.Mielnik@nashville.gov]
Sent: Friday, May 02, 2014 9:22 AM
To: McCormack, Valerie J LRN
Subject: [EXTERNAL] Mill Creek Feasibility

Valerie,

Thank you for providing the copy of the assessment for the Mill Creek Feasibility Study. This office concurs with your findings that the project as proposed would have no adverse effect of historic properties. Please let me know if you need me to provide this information in a formal hard-copy letter! J

Thank you for the opportunity to review and comment.

Sincerely,

Tara Mielnik

Tara Mitchell Mielnik, PhD

Federal Programs Coordinator

Metropolitan Nashville Historical Commission

Sunnyside in Sevier Park

3000 Granny White Pike

Nashville, TN 37204

615-862-7970 (ext 79779)

615-862-7974 (fax)

www.nashville.gov/mhc

tara.mielnik@nashville.gov

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Principal Chief Oscola Sylestine
Alabama Coushatta Tribe of Texas
571 State Park Road 56
Livingston, Texas 77351

Dear Principal Chief Sylestine:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to Alabama Coushatta Tribe of Texas initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

The USACE prepared a report titled *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan, Davidson County, Tennessee*. The USACE believes that none of the structures considered independently or as part of a district are eligible for inclusion in the National Register of Historic Places.

In addition, to the structures and buildings, the TSP involves minimal ground disturbance. Work at the Briley Parkway Bridges will involve removing fill from the floodway. There are no known archaeological sites in the vicinity of the 216 residences. Razing the buildings will cause minimal ground disturbance in previously disturbed areas. Therefore, the USACE recommends no further investigation of the buy-out locations. A USACE archaeologists will review construction contracts to ensure there are no changes in procedures that could cause disturbance, which is not anticipated at this time. Therefore, the USACE recommends a finding of "no historic properties affected" for proposed Tentatively Selected Plan for the Mill Creek Feasibility study.

A copy of this letter and supporting documentation is being forwarded to you historic preservation staff. The USACE requests the comments of Alabama Coushatta Tribe of Texas comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Chief Tarpie Yargee
Alabama-Quassarte Tribal Town
P.O. Box 187
Wetumka, Oklahoma 74883

Dear Chief Yargee:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to Alabama-Quassarte Tribal Town initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

The USACE prepared a report titled *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan, Davidson County, Tennessee*. The USACE believes that none of the structures considered independently or as part of a district are eligible for inclusion in the National Register of Historic Places.

In addition, to the structures and buildings, the TSP involves minimal ground disturbance. Work at the Briley Parkway Bridges will involve removing fill from the floodway. There are no known archaeological sites in the vicinity of the 216 residences. Razing the buildings will cause minimal ground disturbance in previously disturbed areas. Therefore, the USACE recommends no further investigation of the buy-out locations. A USACE archaeologists will review construction contracts to ensure there are no changes in procedures that could cause disturbance, which is not anticipated at this time. Therefore, the USACE recommends a finding of "no historic properties affected" for proposed Tentatively Selected Plan for the Mill Creek Feasibility study.

A copy of this letter and supporting documentation is being forwarded to you historic preservation staff. The USACE requests the comments of Alabama-Quassarte Tribal Town comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Governor George Blanchard
Absentee-Shawnee Tribe of Oklahoma
2025 S. Gordon Cooper Dr.
Shawnee, Oklahoma 74801-9381

Dear Governor Blanchard:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to Absentee-Shawnee Tribe of Oklahoma initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

The USACE prepared a report titled *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan, Davidson County, Tennessee*. The USACE believes that none of the structures considered independently or as part of a district are eligible for inclusion in the National Register of Historic Places.

In addition, to the structures and buildings, the TSP involves minimal ground disturbance. Work at the Briley Parkway Bridges will involve removing fill from the floodway. There are no known archaeological sites in the vicinity of the 216 residences. Razing the buildings will cause minimal ground disturbance in previously disturbed areas. Therefore, the USACE recommends no further investigation of the buy-out locations. A USACE archaeologists will review construction contracts to ensure there are no changes in procedures that could cause disturbance, which is not anticipated at this time. Therefore, the USACE recommends a finding of "no historic properties affected" for proposed Tentatively Selected Plan for the Mill Creek Feasibility study.

A copy of this letter and supporting documentation is being forwarded to you historic preservation staff. The USACE requests the comments of Absentee-Shawnee Tribe of Oklahoma comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Principal Chief Bill John Baker
Cherokee Nation
P.O. Box 948
Tahlequah, Oklahoma 74465-0948

Dear Principal Chief Baker:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to Cherokee Nation initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

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A copy of this letter and supporting documentation is being forwarded to you historic preservation staff. The USACE requests the comments of Cherokee Nation comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Governor Bill Anoatubby
Chickasaw Nation
P.O. Box 1548
Ada, Oklahoma 74821-1548

Dear Governor Anoatubby:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to Chickasaw Nation initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

The USACE prepared a report titled *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan, Davidson County, Tennessee*. The USACE believes that none of the structures considered independently or as part of a district are eligible for inclusion in the National Register of Historic Places.

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A copy of this letter and supporting documentation is being forwarded to you historic preservation staff. The USACE requests the comments of Chickasaw Nation comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Principal Chief Michell Hicks
Eastern Band of Cherokee Indians
Qualla Boundary
P.O. Box 445
Cherokee, North Carolina 28719

Dear Principal Chief Hicks:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to Eastern Band of Cherokee Indians initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

The USACE prepared a report titled *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan, Davidson County, Tennessee*. The USACE believes that none of the structures considered independently or as part of a district are eligible for inclusion in the National Register of Historic Places.

In addition, to the structures and buildings, the TSP involves minimal ground disturbance. Work at the Briley Parkway Bridges will involve removing fill from the floodway. There are no known archaeological sites in the vicinity of the 216 residences. Razing the buildings will cause minimal ground disturbance in previously disturbed areas. Therefore, the USACE recommends no further investigation of the buy-out locations. A USACE archaeologists will review construction contracts to ensure there are no changes in procedures that could cause disturbance, which is not anticipated at this time. Therefore, the USACE

recommends a finding of "no historic properties affected" for proposed Tentatively Selected Plan for the Mill Creek Feasibility study.

A copy of this letter and supporting documentation is being forwarded to you historic preservation staff. The USACE requests the comments of Eastern Band of Cherokee Indians comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Ms. Robin DuShane
Tribal Historic Preservation Officer
Eastern Shawnee Tribe of Oklahoma
P.O. Box 350
Seneca, MO 64865

Dear Ms. DuShane:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to Eastern Shawnee Tribe of Oklahoma initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

The USACE prepared a report titled *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan, Davidson County, Tennessee*. The USACE believes that none of the structures considered independently or as part of a district are eligible for inclusion in the National Register of Historic Places.

In addition, to the structures and buildings, the TSP involves minimal ground disturbance. Work at the Briley Parkway Bridges will involve removing fill from the floodway. There are no known archaeological sites in the vicinity of the 216 residences. Razing the buildings will cause minimal ground disturbance in previously disturbed areas. Therefore, the USACE recommends no further investigation of the buy-out locations. A USACE archaeologists will review construction contracts to ensure there are no changes in procedures that could cause disturbance, which is not anticipated at this time. Therefore, the USACE

recommends a finding of "no historic properties affected" for proposed Tentatively Selected Plan for the Mill Creek Feasibility study.

A copy of this letter and supporting documentation is being forwarded to you The USACE requests the comments of Eastern Shawnee Tribe of Oklahoma comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Principal Chief George Tiger
Muscogee (Creek) Nation, Oklahoma
P.O. Box 580
Okmulgee, Oklahoma 74447

Dear Principal George Tiger:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to Muscogee (Creek) Nation, Oklahoma initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

The USACE prepared a report titled *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan, Davidson County, Tennessee*. The USACE believes that none of the structures considered independently or as part of a district are eligible for inclusion in the National Register of Historic Places.

In addition, to the structures and buildings, the TSP involves minimal ground disturbance. Work at the Briley Parkway Bridges will involve removing fill from the floodway. There are no known archaeological sites in the vicinity of the 216 residences. Razing the buildings will cause minimal ground disturbance in previously disturbed areas. Therefore, the USACE recommends no further investigation of the buy-out locations. A USACE archaeologists will review construction contracts to ensure there are no changes in procedures that could cause disturbance, which is not anticipated at this time. Therefore, the USACE recommends a finding of "no historic properties affected" for proposed Tentatively Selected Plan for the Mill Creek Feasibility study.

A copy of this letter and supporting documentation is being forwarded to you historic preservation staff. The USACE requests the comments of Muscogee (Creek) Nation, Oklahoma comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

McCormack, Valerie J LRN

From: Emman Spain [ESpain@MCN-NSN.gov]
Sent: Wednesday, June 18, 2014 12:50 PM
To: McCormack, Valerie J LRN
Subject: [EXTERNAL] Mill creek drainage in Davidson and Williamson counties, Tennessee.

Dear Ms. McCormack,

The Muscogee (Creek) Nation has received the U. S. Army Corps of Engineers, Nashville District notice of flood risk study in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. At this time we are unaware of any culturally significant sites within the project areas. We therefore concur with the finding of "no historic properties affected". Thank you.

Emman Spain, THPO

Muscogee (Creek) Nation

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Chairperson Ron Sparkman
Shawnee Tribe
P.O. Box 189
Miami, Oklahoma 74355

Dear Chairperson Sparkman:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to Shawnee Tribe initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

The USACE prepared a report titled *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan, Davidson County, Tennessee*. The USACE believes that none of the structures considered independently or as part of a district are eligible for inclusion in the National Register of Historic Places.

In addition, to the structures and buildings, the TSP involves minimal ground disturbance. Work at the Briley Parkway Bridges will involve removing fill from the floodway. There are no known archaeological sites in the vicinity of the 216 residences. Razing the buildings will cause minimal ground disturbance in previously disturbed areas. Therefore, the USACE recommends no further investigation of the buy-out locations. A USACE archaeologists will review construction contracts to ensure there are no changes in procedures that could cause disturbance, which is not anticipated at this time. Therefore, the USACE recommends a finding of "no historic properties affected" for proposed Tentatively Selected Plan for the Mill Creek Feasibility study.

A copy of this letter and supporting documentation is being forwarded to you historic preservation staff. The USACE requests the comments of Shawnee Tribe comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Mekko George Scott
Tholpthlocco Tribal Town Oklahoma
P.O. Box 188
Okemah, Oklahoma 74859

Dear Mekko Scott:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to Tholpthlocco Tribal Town Oklahoma initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

The USACE prepared a report titled *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan, Davidson County, Tennessee*. The USACE believes that none of the structures considered independently or as part of a district are eligible for inclusion in the National Register of Historic Places.

In addition, to the structures and buildings, the TSP involves minimal ground disturbance. Work at the Briley Parkway Bridges will involve removing fill from the floodway. There are no known archaeological sites in the vicinity of the 216 residences. Razing the buildings will cause minimal ground disturbance in previously disturbed areas. Therefore, the USACE recommends no further investigation of the buy-out locations. A USACE archaeologists will review construction contracts to ensure there are no changes in procedures that could cause disturbance, which is not anticipated at this time. Therefore, the USACE recommends a finding of "no historic properties affected" for proposed Tentatively Selected Plan for the Mill Creek Feasibility study.

A copy of this letter and supporting documentation is being forwarded to you historic preservation staff. The USACE requests the comments of Tholpthlocco Tribal Town Oklahoma comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

MAY 07 2014

Chief George Wickliffe
United Keetoowah Band of Cherokee Indians in Oklahoma
P.O. Box 746
Tahlequah, Oklahoma 74464-0746

Dear Chief Wickliffe:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. In a letter dated February 15, 2013, the Corps sent a letter to United Keetoowah Band of Cherokee Indians in Oklahoma initiating Section 106 of the National Historic Preservation Act. The study has resulted in a proposed plan, which is referred to as the Tentatively Selected Plan (TSP). The USACE requests to continue consultation under Section 106.

The TSP involves two measures that would reduce flood risk and damages in the Mill Creek Basin. The first measure involves adding a new span to the Briley Parkway Bridges and removing fill from the floodway. The second measure involves the buy-out of up to 216 residential buildings in the Mill Creek drainage. The residential buy-out would be voluntary. Following the buy-out, the buildings would be razed and development would be prohibited in the flood plain.

The USACE prepared a report titled *Cultural Resource Assessment for the Mill Creek Feasibility Study, Tentatively Selected Plan, Davidson County, Tennessee*. The USACE believes that none of the structures considered independently or as part of a district are eligible for inclusion in the National Register of Historic Places.

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A copy of this letter and supporting documentation is being forwarded to you historic preservation staff. The USACE requests the comments of United Keetoowah Band of Cherokee Indians in Oklahoma comments on the proposed project and finding of "no historic properties affected. If you require additional information please contact Dr. Valerie McCormack at (615) 736-7847 or valerie.j.mccormack@usace.army.mil.

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

McCormack, Valerie J LRN

From:	Lisa LaRue-Baker - UKB THPO [ukbthpo-larue@yahoo.com]
Sent:	Wednesday, May 14, 2014 10:31 AM
To:	McCormack, Valerie J LRN
Cc:	verna; Ernestine Berry
Subject:	[EXTERNAL] Re: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)

The United Keetoowah Band of Cherokee Indians in Oklahoma has reviewed your project under Section 106 of the NHPA. At this time, we have no comments or objections. However, if any human remains are inadvertently discovered, please cease all work and contact us as soon as possible.

Thank you,

Lisa C. Baker
Acting THPO
United Keetoowah Band of Cherokee Indians in Oklahoma
PO Box 746
Tahlequah, OK 74465

c 918.822.1952
ukbthpo-larue@yahoo.com

Please FOLLOW our historic preservation page and LIKE us on FACEBOOK
<https://www.facebook.com/pages/United-Keetoowah-Band-of-Cherokee-Indians-in-Oklahoma-Historic-Preservation/199767846834850>

From: "McCormack, Valerie J LRN" <Valerie.J.McCormack@usace.army.mil>
To: Lisa LaRue-Baker - UKB THPO <ukbthpo-larue@yahoo.com>
Cc: verna <lstapleton@unitedkeetoowahband.org>

Sent: Tuesday, May 13, 2014 2:48 PM
Subject: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Lisa,
Please find attached a letter to Chief Wickliffe and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
Please let me know if you require additional information or would prefer a hard copy of the complete report.

Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847

Internet: http://www.lrn.usace.army.mil <http://www.lrn.usace.army.mil/>
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:48 PM
To: 'Richard Allen'
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: CherokeeNation-Mill Creek.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dr. Allen
Please find attached a letter to Chief Baker and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
Please let me know if you require additional information or would prefer a hard copy of the complete report.

Respectfully,
Valerie

____

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:48 PM
To: 'HPO@chickasaw.net'
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Chickasaw-Mill Creek.pdf; Cultural resource assessment_reduced.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear Chickasaw Historic Preservation Office:
Please find attached a letter to Governor Anoutubby and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. Photographs of all buildings over 50 years old are included in the main body of the report. Please let me know if you require additional information or would prefer a hard copy of the complete report.

Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:48 PM
To: Tyler B. Howe
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Cultural resource assessment_reduced.pdf; EBCI-Mill Creek.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Tyler
Please find attached a letter to Chief Hicks and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
Please let me know if you require additional information or would prefer a hard copy of the complete report.

Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:48 PM
To: Robin Dushane
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Cultural resource assessment_reduced.pdf; ESTOO-Mill Creek.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear Robin,
Please find attached a letter and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
Please let me know if you require additional information or would prefer a hard copy of the complete report.

Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
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U.S. Army Corps of Engineers
Nashville District
(615)736-7847

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:48 PM
To: 'Espain@mcn-nsn.gov'
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Muscogee(Creek)-Mill Creek.pdf; Cultural resource assessment_reduced.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear Mr. Spain,
Please find attached a letter to Chief Tiger and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
Please let me know if you require additional information or would prefer a hard copy of the complete report.

Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
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U.S. Army Corps of Engineers
Nashville District
(615)736-7847

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:47 PM
To: Kim Jumper
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Cultural resource assessment_reduced.pdf; Shawnee-Mill Creek.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear Ms. Jumper,
Please find attached a letter to Chairman Sparkman and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report. Please let me know if you require additional information or would prefer a hard copy of the complete report.

Respectfully,
Valerie

____
Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:47 PM
To: 'Lisa LaRue-Baker - UKB THPO'
Cc: verna
Subject: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)
Attachments: Cultural resource assessment_reduced.pdf; UKBCI-Mill Creek.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Lisa,
Please find attached a letter to Chief Wickliffe and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
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Respectfully,
Valerie

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Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:47 PM
To: charles coleman
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Cultural resource assessment_reduced.pdf; Thlopthlocco-Mill Creek.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear Warrior Coleman,
Please find attached a letter to Mekko Scott and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
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Respectfully,
Valerie

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Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:54 PM
To: Joseph Blanchard
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: ASTOO-Mill Creek.pdf; Cultural resource assessment_reduced.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Mr. Blanchard
Please find attached a letter to Governor Blanchard and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report. Please let me know if you require additional information or would prefer a hard copy of the complete report.

Respectfully,
Valerie

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Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:54 PM
To: Augustine Asbury
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: AQTT-Mill Creek.pdf; Cultural resource assessment_reduced.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Ms. Asbury,
Please find attached a letter to Chief Yargee and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
Please let me know if you require additional information or would prefer a hard copy of the complete report.

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Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:54 PM
To: Bryant J. Celestine
Subject: Mill Creek Feasibility Study, Davidson County, TN (UNCLASSIFIED)
Attachments: Cultural resource assessment_reduced.pdf; ACTT-Mill Creek.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear Mr. Celestine,
Please find attached a letter to Chief Sylestine and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
Please let me know if you require additional information or would prefer a hard copy of the complete report.

Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: Lisa LaRue-Baker - UKB THPO [ukbthpo-larue@yahoo.com]
Sent: Wednesday, May 14, 2014 10:30 AM
To: McCormack, Valerie J LRN
Cc: verna; Ernestine Berry
Subject: [EXTERNAL] Re: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)

Could you please send me a copy of the Topo Map??
Thank you!

Lisa C. Baker
Acting THPO
United Keetoowah Band of Cherokee Indians in Oklahoma
PO Box 746
Tahlequah, OK 74465

c 918.822.1952
ukbthpo-larue@yahoo.com

Please FOLLOW our historic preservation page and LIKE us on FACEBOOK
<https://www.facebook.com/pages/United-Keetoowah-Band-of-Cherokee-Indians-in-Oklahoma-Historic-Preservation/199767846834850>

From: "McCormack, Valerie J LRN" <Valerie.J.McCormack@usace.army.mil>
To: Lisa LaRue-Baker - UKB THPO <ukbthpo-larue@yahoo.com>
Cc: verna <lstapleton@unitedkeetoowahband.org>
Sent: Tuesday, May 13, 2014 2:48 PM
Subject: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Lisa,
Please find attached a letter to Chief Wickliffe and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
Please let me know if you require additional information or would prefer a hard copy of the complete report.

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Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: Lisa LaRue-Baker - UKB THPO [ukbthpo-larue@yahoo.com]
Sent: Wednesday, May 14, 2014 10:31 AM
To: McCormack, Valerie J LRN
Cc: verna; Ernestine Berry
Subject: [EXTERNAL] Re: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)

The United Keetoowah Band of Cherokee Indians in Oklahoma has reviewed your project under Section 106 of the NHPA. At this time, we have no comments or objections. However, if any human remains are inadvertently discovered, please cease all work and contact us as soon as possible.

Thank you,

Lisa C. Baker
Acting THPO
United Keetoowah Band of Cherokee Indians in Oklahoma
PO Box 746
Tahlequah, OK 74465

c 918.822.1952
ukbthpo-larue@yahoo.com

Please FOLLOW our historic preservation page and LIKE us on FACEBOOK
<https://www.facebook.com/pages/United-Keetoowah-Band-of-Cherokee-Indians-in-Oklahoma-Historic-Preservation/199767846834850>

From: "McCormack, Valerie J LRN" <Valerie.J.McCormack@usace.army.mil>
To: Lisa LaRue-Baker - UKB THPO <ukbthpo-larue@yahoo.com>
Cc: verna <lstapleton@unitedkeetoowahband.org>

Sent: Tuesday, May 13, 2014 2:48 PM
Subject: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Lisa,
Please find attached a letter to Chief Wickliffe and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
Please let me know if you require additional information or would prefer a hard copy of the complete report.

Respectfully,
Valerie

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Nashville District
(615)736-7847

Internet: http://www.lrn.usace.army.mil <http://www.lrn.usace.army.mil/>
Facebook: http://www.facebook.com/nashvillecorps

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Wednesday, May 14, 2014 3:11 PM
To: 'Lisa LaRue-Baker - UKB THPO'
Subject: RE: [EXTERNAL] Re: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)
Attachments: Appendix A topomaps.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Lisa,
I received your follow up message, but here are the topo maps for your reference.
Thanks,
Valerie

-----Original Message-----
From: Lisa LaRue-Baker - UKB THPO [mailto:ukbthpo-larue@yahoo.com]
Sent: Wednesday, May 14, 2014 10:30 AM
To: McCormack, Valerie J LRN
Cc: verna; Ernestine Berry
Subject: [EXTERNAL] Re: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)

Could you please send me a copy of the Topo Map??
Thank you!

Lisa C. Baker
Acting THPO
United Keetoowah Band of Cherokee Indians in Oklahoma
PO Box 746
Tahlequah, OK 74465

c 918.822.1952
ukbthpo-larue@yahoo.com

Please FOLLOW our historic preservation page and LIKE us on FACEBOOK
<https://www.facebook.com/pages/United-Keetoowah-Band-of-Cherokee-Indians-in-Oklahoma-Historic-Preservation/199767846834850>

From: "McCormack, Valerie J LRN" <Valerie.J.McCormack@usace.army.mil>
To: Lisa LaRue-Baker - UKB THPO <ukbthpo-larue@yahoo.com>
Cc: verna <lstapleton@unitedkeetoowahband.org>
Sent: Tuesday, May 13, 2014 2:48 PM
Subject: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Lisa,
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Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
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Classification: UNCLASSIFIED
Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

October 23, 2014

Project Planning Branch

Mr. E. Patrick McIntyre
State Historic Preservation Officer
Tennessee Historical Commission
2941 Lebanon Road
Nashville, Tennessee 37246

Dear Mr. McIntyre:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County (Metro) are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson County, Tennessee. In a letter dated May 07, 2014, we provided your office with information on the Tentatively Selected Plan (TSP) and assessment of effects to historic properties in compliance with Section 106 of the National Historic Preservation Act. In a letter dated May 28, 2014, your office responded with a letter stating that the project as currently proposed "may adversely affect properties that are eligible for listing in the National Register of Historic Places"; however, specific resources that may be affected were not provided.

The USACE has revised the tentatively selected plan and there are several alterations to the proposed project. Changes include a reduction in the number of buildings proposed for removal from the flood areas from 216 buildings to 105 buildings. In addition, we have added a new structural measure to the TSP that would alter an existing roadway on Sevenmile Creek to act as a retention structure. Elevating this roadway will retain floodwaters in a 25 year event by controlling the flash flooding associated with the stream and result in lower flood elevations downstream.

The USACE has revised the cultural resource assessment report that addresses the individual proposed flood reduction measures and presents the results in the enclosed *Cultural Resource Assessment for the Revised Mill Creek Feasibility study, Tentatively Selected Plan Davidson County.* This report includes the results of archaeological Phase I investigations conducted under Tennessee Archaeological State permit no. 000819. USACE did not identify historic properties that would be directly or indirectly affected by the proposed project.

We are also consulting with Metro Historical Commission, the Tennessee Department of Transportation, and American Indian Tribes. Public involvement with this project is co-occurring with the National Environmental Policy Act coordination.

The USACE requests your review of the proposed undertaking and assessment of effects and comments on a finding of “no historic properties affected”. Please contact Valerie McCormack at 615-736-7847 or Valerie.j.mccormack@usace.army.mil if you need additional information.

original signed

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Enclosure

TENNESSEE HISTORICAL COMMISSION
STATE HISTORIC PRESERVATION OFFICE
2941 LEBANON ROAD
NASHVILLE, TENNESSEE 37214
OFFICE: (615) 532-1550
www.tnhistoricalcommission.org

December 9, 2014

Mr. Russ Rote
COE-Nashville District
Post Office Box 1070
Nashville, Tennessee, 37202-1070

RE: COE-N, MILL CREEK DRAINAGE REMEDIATION, NASHVILLE, DAVIDSON COUNTY

Dear Mr. Rote:

In response to your request, received on Wednesday, October 29, 2014, we have reviewed the documents you submitted regarding your proposed undertaking. Our review of and comment on your proposed undertaking are among the requirements of Section 106 of the National Historic Preservation Act. This Act requires federal agencies or applicant for federal assistance to consult with the appropriate State Historic Preservation Office before they carry out their proposed undertakings. The Advisory Council on Historic Preservation has codified procedures for carrying out Section 106 review in 36 CFR 800. You may wish to familiarize yourself with these procedures (Federal Register, December 12, 2000, pages 77698-77739) if you are unsure about the Section 106 process.

Considering available information, we find that the project as currently proposed MAY ADVERSELY AFFECT PROPERTIES THAT ARE ELIGIBLE FOR LISTING IN THE NATIONAL REGISTER OF HISTORIC PLACES. You should now begin immediate consultation with our office. Please direct questions and comments to Joe Garrison (615) 770-1092.

Sincerely,

E. Patrick McIntyre, Jr.

E. Patrick McIntyre, Jr.
Executive Director and
State Historic Preservation Officer

EPM/jyg

TENNESSEE HISTORICAL COMMISSION
STATE HISTORIC PRESERVATION OFFICE
2941 LEBANON ROAD
NASHVILLE, TENNESSEE 37243-0442
OFFICE: (615) 532-1550
www.tnhistoricalcommission.org

December 22, 2014

Mr. Russ Rote
Project USACE – Nashville District
Project Planning Branch
Post Office Box 1070
Nashville, Tennessee 37202-1070

RE: COE-N, ARCHAEOLOGICAL ASSESSMENT, MILL CREEK DRAINAGE REMEDIATION, NASHVILLE, DAVIDSON COUNTY, TN

Dear Mr. Rote:

At your request, our office has reviewed the above-referenced revised plans in accordance with regulations codified at 36 CFR 800 (Federal Register, December 12, 2000, 77698-77739). Based on the information provided, we find that the project area contains no archaeological resources eligible for listing in the National Register of Historic Places.

If project plans are changed or archaeological remains are discovered during construction, please contact this office to determine what further action, if any, will be necessary to comply with Section 106 of the National Historic Preservation Act.

Your cooperation is appreciated.

Sincerely,

E. Patrick McIntyre, Jr.
Executive Director and
State Historic Preservation Officer

EPM/jmb

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

October 23, 2014

Project Planning Branch

Mr. Tim Walker, Executive Director
Metro Historical Commission
Sunnyside in Sevier Park
3000 Granny White Pike
Nashville, Tennessee 37204

Dear Mr. Walker:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County (Metro) are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson County, Tennessee. In May 2014, we provided your office with information on the Tentatively Selected Plan (TSP) and assessment of effects to historic properties in compliance with Section 106 of the National Historic Preservation Act. In an email dated May 2, 2014, your office concurred with our assessment that the

The USACE has revised the tentatively selected plan and there are several alterations to the proposed project. Changes include a reduction in the number of buildings proposed for removal from the flood areas from 216 buildings to 105 buildings. In addition, we have added a new structural measure to the TSP that would alter an existing roadway on Sevenmile Creek to act as a retention structure. Elevating this roadway will retain floodwaters in a 25 year event by controlling the flash flooding associated with the stream and result in lower flood elevations downstream.

The USACE has revised the cultural resource assessment report that addresses the individual proposed flood reduction measures and presents the results in the enclosed *Cultural Resource Assessment for the Revised Mill Creek Feasibility study, Tentatively Selected Plan Davidson County.* This report includes the results of archaeological Phase I investigations conducted under Tennessee Archaeological State permit no. 000819. USACE did not identify historic properties that would be directly or indirectly affected by the proposed project.

The USACE requests your review of the proposed undertaking and assessment of effects and comments on a finding of “no historic properties affected”. Please contact Valerie McCormack at 615-736-7847 or Valerie.j.mccormack@usace.army.mil if you need additional information.

original signed

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Enclosure

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

JAN 26 2015

Mr. E. Patrick McIntyre
State Historic Preservation Officer
Tennessee Historical Commission
2941 Lebanon Road
Nashville, Tennessee 37246

Dear Mr. McIntyre:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County (Metro) are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson County, Tennessee. In a letter dated October 22, 2014, we provided information regarding changes to the proposed project including information on proposed modifications to the bridge that crosses Sevenmile Creek within the Ellington Agricultural Center. In a letter dated December, 9, 2014 you replied that the project "May adversely affect properties that are eligible for listing in the National Register of Historic Places". This letter provides additional information regarding the proposed project within Ellington Agricultural Center and requests to continue consultation under Section 106 of the National Historic Preservation Act.

The proposed project involves modifying the bridge over Sevenmile Creek and raising the elevation of the Ellington Agricultural Center access road to Edmondson Pike to create a detention structure that will reduce flooding downstream along Sevenmile Creek. On December 18, 2014 Dr. Valerie McCormack of my staff met with Dr. Joseph Garrison and Ms. Peggy Nichol of your staff, and Dr. Tara Mielnik of the Metropolitan Historical Commission. Your staff expressed concerns that that the Ellington Agricultural Center Campus was not properly considered as a National Register Eligible District. In addition, discussions addressed that the bridge and access road form non-contributing elements to the Ellington Agricultural Center National Register District. The enclosed *report Addendum to: Cultural Resource Assessment for the Revised Mill Creek Feasibility Study, Tentatively Selected Plan Davidson County, Tennessee Ellington Agricultural Center* proposes Ellington Agricultural Center Campus as a historic district and evaluates the bridge and access road as non-contributing elements. In conclusion, we recommend that the proposed project would not adversely affect the Ellington Agricultural Center Campus National Register District.

The USACE requests your review and comment of the proposed undertaking and assessment of effects and comments on a finding of "no adverse effect". Please contact Dr. McCormack at 615-736-7847 or Valerie.j.mccormack@usace.army.mil if you need additional information.

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Enclosure

TENNESSEE HISTORICAL COMMISSION
2941 LEBANON ROAD
NASHVILLE, TENNESSEE 37243-0442
OFFICE: (615) 532-1550
www.tnhistoricalcommission.org

February 11, 2015

Mr. Russ Rote
Project USACE – Nashville District
Project Planning Branch
Post Office Box 1070
Nashville, Tennessee 37202-1070

RE: COE-N, BRIDGE/SEVENMILE CR. AT ELLINGTON, NASHVILLE, DAVIDSON COUNTY

Dear Mr. Rote:

Pursuant to your request, this office has reviewed documentation concerning the above-referenced undertaking received Tuesday, January 27, 2015. This is a requirement of Section 106 of the National Historic Preservation Act for compliance by the participating federal agency or applicant for federal assistance. Procedures for implementing Section 106 of the Act are codified at 36 CFR 800 (Federal Register, December 12, 2000, 77698-77739).

Considering available information, we concur that the project as currently proposed will not adversely affect any property that is eligible for listing in the National Register of Historic Places. Therefore, this office has no objection to the implementation of this project. Please direct questions and comments to Jennifer M. Barnett (615) 741-1588, ext. 105. We appreciate your cooperation.

Sincerely,

E. Patrick McIntyre, Jr.

E. Patrick McIntyre, Jr.
Executive Director and
State Historic Preservation Officer

EPM/jmb

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

JAN 26 2015

Project Planning Branch

Mr. Timothy Walker, Executive Director
Metro Historical Commission
Sunnyside in Sevier Park
3000 Granny White Pike
Nashville, Tennessee 37204

Dear Mr. Walker:

The U.S. Army Corps of Engineers, Nashville District (USACE) and the Metropolitan Government of Nashville and Davidson County (Metro) are partnering to study flood risk and identify potential solutions in the Mill Creek Drainage in Davidson County, Tennessee. In a letter dated October 22, 2014, we provided information regarding changes to the proposed project including information on proposed modifications to the bridge that crosses Sevenmile Creek within the Ellington Agricultural Center. In a letter dated December, 9, 2014 the Tennessee Historical Commission replied that the project "May Adversely affect properties that are eligible for listing in the National Register of Historic Places". This letter provides additional information regarding the proposed project within Ellington Agricultural Center and requests to continue consultation under Section 106 of the National Historic Preservation Act.

The proposed project involves modifying the bridge over Sevenmile Creek and raising the elevation of the Ellington Agricultural Center access road to Edmondson Pike to create a detention structure that will reduce flooding downstream along Sevenmile Creek. On December 18, 2014 Dr. Valerie McCormack of my staff met with Dr. Tara Mielnik of your staff, and Dr. Joseph Garrison and Ms. Peggy Nichol of the Tennessee Historical Commission (THC). THC expressed concerns that that the Ellington Agricultural Center Campus was not properly considered as a National Register Eligible District. In addition, discussions addressed that the bridge and access road form non-contributing elements to the Ellington Agricultural Center National Register District. The enclosed *report Addendum to: Cultural Resource Assessment for the Revised Mill Creek Feasibility Study, Tentatively Selected Plan Davidson County, Tennessee Ellington Agricultural Center* proposes Ellington Agricultural Center Campus as a historic district and evaluates the bridge and access road as non-contributing elements. In conclusion, we recommend that the proposed project would not adversely affect the Ellington Agricultural Center Campus National Register District.

The USACE requests your review and comments of the proposed undertaking and assessment of effects and comments on a finding of "no adverse effect". Please contact Dr. McCormack at 615-736-7847 or Valerie.j.mccormack@usace.army.mil if you need additional information.

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Enclosure

McCormack, Valerie J LRN

From:	McCormack, Valerie J LRN
Sent:	Wednesday, January 28, 2015 8:27 AM
To:	Emman Spain
Cc:	McCormack, Valerie J LRN
Subject:	RE: Mill creek drainage in Davidson and Williamson counties, Tennessee. (UNCLASSIFIED)
Attachments:	Mill Creek - no adverse effect Jan 2015.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Mr. Spain,
Happy New Year, I hope this email finds you well.

We've made some revisions to the Mill Creek Feasibility study, a project that you reviewed last spring. Previously, the project was proposing to buy-out 216 buildings in Nashville, Davidson County. The project has been revised with a new proposal to buy-out 109 buildings (a subset of the 216) and to construct a detention structure to reduce downstream flooding. The detention structure will involve modifying an existing bridge and raising an existing access road to the Ellington Ag. Center. The water upstream of the detention structure will be held for approximately one hour. This area contains wetland and riparian plants that can easily sustain the added inundation time. We conducted Phase I level archaeological testing in the footprint of the proposed detention structure and did not identify any archaeological deposits.

The Ellington Agricultural Center Campus is eligible for listing in the National Register of Historic Places as a district under criteria b and c. The bridge and access road form non-contributing within this district, and we propose a finding of "no adverse effect to this historic properties". I've attached a revised report and addendum that includes archaeological investigations and consideration of the Ellington Agricultural Center as a historic district. In order to reduce the file size to one that is electronically transmittable, I removed the photographs of the structures that are less than 50 years old. Bookmarks are included in the .pdf to help you find the sections in the report that address the revised project and archaeological investigations.

Given the proposed changes in the project, including the proposed work within the Ellington Agricultural Center, we propose updating the prior recommendation of "no historic properties affected" to "no adverse effect".

Please let me know if you require additional information or need the complete report.
Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847
-----Original Message-----
From: Emman Spain [mailto:ESpain@MCN-NSN.gov]
Sent: Wednesday, June 18, 2014 12:50 PM
To: McCormack, Valerie J LRN
Subject: [EXTERNAL] Mill creek drainage in Davidson and Williamson counties, Tennessee.

McCormack, Valerie J LRN

From: Emman Spain [ESpain@MCN-NSN.gov]
Sent: Friday, February 20, 2015 10:04 AM
To: McCormack, Valerie J LRN
Subject: [EXTERNAL] RE: Mill creek drainage in Davidson and Williamson counties, Tennessee. (UNCLASSIFIED)

Categories: Planning

Dear Ms. McCormack,
The Muscogee (Creek) Nation has received U. S. Army Corps of Engineers-Nashville District notice of the Davidson County, Mill Creek Feasibility Study revisions. After review of the study ,the Muscogee Nation concurs with the revised determination of "no adverse effect". Thank you.

Emman Spain, THPO
Cultural Preservation Office
Muscogee (Creek) Nation
P. O. Box 580
Okmulgee, OK 74447
espain@mcn-nsn.gov
(918) 732-7678

-----Original Message-----
From: McCormack, Valerie J LRN [mailto:Valerie.J.McCormack@usace.army.mil]
Sent: Wednesday, January 28, 2015 8:28 AM
To: Emman Spain
Cc: McCormack, Valerie J LRN
Subject: RE: Mill creek drainage in Davidson and Williamson counties, Tennessee. (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Mr. Spain,
Happy New Year, I hope this email finds you well.

We've made some revisions to the Mill Creek Feasibility study, a project that you reviewed last spring. Previously, the project was proposing to buy-out 216 buildings in Nashville, Davidson County. The project has been revised with a new proposal to buy-out 109 buildings (a subset of the 216) and to construct a detention structure to reduce downstream flooding. The detention structure will involve modifying an existing bridge and raising an existing access road to the Ellington Ag. Center. The water upstream of the detention structure will be held for approximately one hour. This area contains wetland and riparian plants that can easily sustain the added inundation time. We conducted Phase I level archaeological testing in the footprint of the proposed detention structure and did not identify any archaeological deposits.

The Ellington Agricultural Center Campus is eligible for listing in the National Register of Historic Places as a district under criteria b and c. The bridge and access road form non-contributing within this district, and we propose a finding of "no adverse effect to this historic properties". I've attached a revised report and addendum that includes archaeological investigations and consideration of the Ellington Agricultural Center as a historic district. In order to reduce the file size to one that is electronically transmittable, I removed the photographs of the structures that are less than 50 years old. Bookmarks are included in the .pdf to help you find the sections in the report that address the revised project and archaeological investigations.

Given the proposed changes in the project, including the proposed work within the Ellington Agricultural Center, we propose updating the prior recommendation of "no historic properties affected" to "no adverse effect".

Please let me know if you require additional information or need the complete report.
Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847
-----Original Message-----
From: Emman Spain [mailto:ESpain@MCN-NSN.gov]
Sent: Wednesday, June 18, 2014 12:50 PM
To: McCormack, Valerie J LRN
Subject: [EXTERNAL] Mill creek drainage in Davidson and Williamson counties, Tennessee.

Dear Ms. McCormack,

The Muscogee (Creek) Nation has received the U. S. Army Corps of Engineers, Nashville District notice of flood risk study in the Mill Creek Drainage in Davidson and Williamson Counties, Tennessee. At this time we are unaware of any culturally significant sites within the project areas. We therefore concur with the finding of "no historic properties affected". Thank you.

Emman Spain, THPO

Muscogee (Creek) Nation

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Wednesday, January 28, 2015 8:27 AM
To: Lisa LaRue-Baker - UKB THPO
Cc: lstapleton@unitedkeetoowahband.org; eberry@unitedkeetoowahband.org; McCormack, Valerie J LRN
Subject: Mill Creek Feasibility Study, Davidson County, Tennesseee - Revisions (UNCLASSIFIED)
Attachments: Mill Creek - no adverse effect Jan 2015.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Lisa,
Happy New Year, I hope this email finds you well.

We've made some revisions to the Mill Creek Feasibility study, a project that you reviewed last spring. Previously, the project was proposing to buy-out 216 buildings in Nashville, Davidson County. The project has been revised with a new proposal to buy-out 109 buildings (a subset of the 216) and to construct a detention structure to reduce downstream flooding. The detention structure will involve modifying an existing bridge and raising an existing access road to the Ellington Ag. Center. The water upstream of the detention structure will be held for approximately one hour. This area contains wetland and riparian plants that can easily sustain the added inundation time. We conducted Phase I level archaeological testing in the footprint of the proposed detention structure and did not identify any archaeological deposits.

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Please let me know if you require additional information or need the complete report.
Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847

Internet: http://www.lrn.usace.army.mil
Facebook: http://www.facebook.com/nashvillecorps

-----Original Message-----
From: Lisa LaRue-Baker - UKB THPO [mailto:ukbthpo-larue@yahoo.com]
Sent: Wednesday, May 14, 2014 10:30 AM
To: McCormack, Valerie J LRN
Cc: verna; Ernestine Berry
Subject: [EXTERNAL] Re: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)

Could you please send me a copy of the Topo Map??
Thank you!

Lisa C. Baker
Acting THPO
United Keetoowah Band of Cherokee Indians in Oklahoma
PO Box 746
Tahlequah, OK 74465

c 918.822.1952
ukbthpo-larue@yahoo.com

From: "McCormack, Valerie J LRN" <Valerie.J.McCormack@usace.army.mil>
To: Lisa LaRue-Baker - UKB THPO <ukbthpo-larue@yahoo.com>
Cc: verna <lstapleton@unitedkeetoowahband.org>
Sent: Tuesday, May 13, 2014 2:48 PM
Subject: Mill Creek Feasibility Study, Davidson County, Tennesseee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Lisa,
Please find attached a letter to Chief Wickliffe and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
Please let me know if you require additional information or would prefer a hard copy of the complete report.

Respectfully,
Valerie

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Classification: UNCLASSIFIED
Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Wednesday, January 28, 2015 8:26 AM
To: Richard Allen
Cc: McCormack, Valerie J LRN
Subject: RE: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Mill Creek - no adverse effect Jan 2015.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dr. Allen,
Happy New Year, I hope this email finds you well.

We've made some revisions to the Mill Creek Feasibility study, a project that you reviewed last spring. Previously, the project was proposing to buy-out 216 buildings in Nashville, Davidson County. The project has been revised with a new proposal to buy-out 109 buildings (a subset of the 216) and to construct a detention structure to reduce downstream flooding. The detention structure will involve modifying an existing bridge and raising an existing access road to the Ellington Ag. Center. The water upstream of the detention structure will be held for approximately one hour. This area contains wetland and riparian plants that can easily sustain the added inundation time. We conducted Phase I level archaeological testing in the footprint of the proposed detention structure and did not identify any archaeological deposits.

The Ellington Agricultural Center Campus is eligible for listing in the National Register of Historic Places as a district under criteria b and c. The bridge and access road form non-contributing within this district, and we propose a finding of "no adverse effect to this historic properties". I've attached a revised report and addendum that includes archaeological investigations and consideration of the Ellington Agricultural Center as a historic district. In order to reduce the file size to one that is electronically transmittable, I removed the photographs of the structures that are less than 50 years old. Bookmarks are included in the .pdf to help you find the sections in the report that address the revised project and archaeological investigations.

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Respectfully,
Valerie

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From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:48 PM
To: 'Richard Allen'

Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

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Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Wednesday, January 28, 2015 8:25 AM
To: HPO@chickasaw.net
Cc: McCormack, Valerie J LRN
Subject: RE: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Mill Creek - no adverse effect Jan 2015.pdf

Classification: UNCLASSIFIED
Caveats: NONE

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Respectfully,
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-----Original Message-----
From: McCormack, Valerie J LRN

Sent: Tuesday, May 13, 2014 2:48 PM
To: 'HPO@chickasaw.net'
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Dear Chickasaw Historic Preservation Office:
Please find attached a letter to Governor Anoutubby and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. Photographs of all buildings over 50 years old are included in the main body of the report. Please let me know if you require additional information or would prefer a hard copy of the complete report.

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Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From:	Timothy Baugh [Timothy.Baugh@chickasaw.net]
Sent:	Friday, February 06, 2015 2:09 PM
To:	McCormack, Valerie J LRN
Subject:	[EXTERNAL] FW: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments:	Mill Creek - no adverse effect Jan 2015.pdf

Hi Valerie,

The Chickasaw Nation will not be commenting on the Mill Creek project because the structures within the APE were built well after our removal to Oklahoma. We appreciate your efforts to preserve and protect significant historic properties.

Best wishes,

|Tim

Timothy G. Baugh, PhD
Tribal Historic Preservation Officer
Divison of Historic Preservation
Chickasaw Nation
P. O. Box 1548
Ada, OK 74821-1548
580.272.1106
Ext. 62211
timothy.baugh@chickasaw.net

-----Original Message-----
From: McCormack, Valerie J LRN [mailto:Valerie.J.McCormack@usace.army.mil]
Sent: Wednesday, January 28, 2015 8:25 AM
To: HPO
Cc: McCormack, Valerie J LRN
Subject: RE: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

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Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)

Classification: UNCLASSIFIED
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Classification: UNCLASSIFIED
Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Wednesday, January 28, 2015 8:25 AM
To: Tyler B. Howe
Cc: McCormack, Valerie J LRN
Subject: RE: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Mill Creek - no adverse effect Jan 2015.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear Tyler,
Happy New Year, I hope this email finds you well.

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Please let me know if you require additional information or need the complete report.
Respectfully,
Valerie

Valerie J. McCormack Ph.D.
Archaeologist
Project Planning Branch
U.S. Army Corps of Engineers
Nashville District
(615)736-7847

-----Original Message-----
From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:48 PM

To: Tyler B. Howe
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Tyler
Please find attached a letter to Chief Hicks and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
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Classification: UNCLASSIFIED
Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

McCormack, Valerie J LRN

From:	McCormack, Valerie J LRN
Sent:	Wednesday, January 28, 2015 8:24 AM
To:	Robin Dushane
Cc:	McCormack, Valerie J LRN
Subject:	RE: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments:	Mill Creek - no adverse effect Jan 2015.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear Robin,

Happy New Year, I hope this email finds you well.

We've made some revisions to the Mill Creek Feasibility study, a project that you reviewed last spring. Previously, the project was proposing to buy-out 216 buildings in Nashville, Davidson County. The project has been revised with a new proposal to buy-out 109 buildings (a subset of the 216) and to construct a detention structure to reduce downstream flooding. The detention structure will involve modifying an existing bridge and raising an existing access road to the Ellington Ag. Center. The water upstream of the detention structure will be held for approximately one hour. This area contains wetland and riparian plants that can easily sustain the added inundation time. We conducted Phase I level archaeological testing in the footprint of the proposed detention structure and did not identify any archaeological deposits.

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Archaeologist
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Nashville District
(615)736-7847

-----Original Message-----
From: McCormack, Valerie J LRN

Sent: Tuesday, May 13, 2014 2:48 PM
To: Robin Dushane
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Dear Robin,
Please find attached a letter and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
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McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Wednesday, January 28, 2015 8:24 AM
To: Kim Jumper
Cc: McCormack, Valerie J LRN
Subject: RE: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Mill Creek - no adverse effect Jan 2015.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear Ms. Jumper,
Happy New Year, I hope this email finds you well.

We've made some revisions to the Mill Creek Feasibility study, a project that you reviewed last spring. Previously, the project was proposing to buy-out 216 buildings in Nashville, Davidson County. The project has been revised with a new proposal to buy-out 109 buildings (a subset of the 216) and to construct a detention structure to reduce downstream flooding. The detention structure will involve modifying an existing bridge and raising an existing access road to the Ellington Ag. Center. The water upstream of the detention structure will be held for approximately one hour. This area contains wetland and riparian plants that can easily sustain the added inundation time. We conducted Phase I level archaeological testing in the footprint of the proposed detention structure and did not identify any archaeological deposits.

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(615)736-7847

-----Original Message-----
From: McCormack, Valerie J LRN
Sent: Tuesday, May 13, 2014 2:47 PM

To: Kim Jumper
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Dear Ms. Jumper,
Please find attached a letter to Chairman Sparkman and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report. Please let me know if you require additional information or would prefer a hard copy of the complete report.

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Caveats: NONE

McCormack, Valerie J LRN

From: McCormack, Valerie J LRN
Sent: Wednesday, January 28, 2015 8:23 AM
To: charles coleman
Cc: McCormack, Valerie J LRN
Subject: RE: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)
Attachments: Mill Creek - no adverse effect Jan 2015.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Dear Dr. Coleman,
It was wonderful to meet you earlier this month. I hope you had a nice stay in Nashville and uneventful travels home.

We've made some revisions to the Mill Creek Feasibility study, a project that you reviewed last spring. Previously, the project was proposing to buy-out 216 buildings in Nashville, Davidson County. The project has been revised with a new proposal to buy-out 109 buildings (a subset of the 216) and to construct a detention structure to reduce downstream flooding. The detention structure will involve modifying an existing bridge and raising an existing access road to the Ellington Ag. Center. The water upstream of the detention structure will be held for approximately one hour. This area contains wetland and riparian plants that can easily sustain the added inundation time. We conducted Phase I level archaeological testing in the footprint of the proposed detention structure and did not identify any archaeological deposits.

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-----Original Message-----
From: McCormack, Valerie J LRN

Sent: Tuesday, May 13, 2014 2:47 PM
To: charles coleman
Subject: Mill Creek Feasibility Study, Davidson County, Tennessee (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Dear Warrior Coleman,
Please find attached a letter to Mekko Scott and a cultural resource report for a flood damage reduction study in the Mill Creek Basin of Davidson County, Tennessee. The proposed plan is to remove fill from the Mill Creek floodway at the Briley parkway, and for the voluntary buy-out of 216 buildings. Please note, that I have removed the appendices from the report in order to get the attachments below 10 MB. The missing appendixes are A: project locations on U.S.G.S. topographic maps, and B: photographs of the 216 residential buildings. All buildings over 50 years old are included in the main body of the report.
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Caveats: NONE

Draft Fish and Wildlife Coordination Act Report
for
The Draft Integrated Feasibility Report for the Mill Creek Flood Risk Management Study

May 22, 2015

U.S. Fish and Wildlife Service
Tennessee Ecological Services Field Office
Cookeville, Tennessee
May 2015

Executive Summary

This document constitutes the Secretary of the Interior's report for the Mill Creek Flood Damage Reduction Feasibility Study in accordance with Section 2(b) of the Fish and Wildlife Coordination Act (FWCA) and is meant to accompany the U.S. Army Corps of Engineers (Corps') final Detailed Project Report. The purpose of this report is to identify and evaluate anticipated impacts of implementing the proposed project on fish and wildlife resources within the Mill Creek watershed in Davidson County, Tennessee, and to recommend conservation and mitigation measures for resource protection.

The Corps initiated this study following the May 2010 flood event in the Cumberland River which also affected the Mill Creek watershed. The Feasibility Study examines potential structural and non-structural measures in the Mill Creek watershed to reduce flood damage potential. The Service completed formal consultation pursuant to section 7 of Endangered Species Act with the U.S. Army Corps of Engineers on potential adverse effects to the federally endangered Nashville crayfish (*Orconectes shoupi*) from the proposed implementation of structural flood damage reduction projects in Mill Creek and Sevenmile Creek related to the study recommendations. Due to the urbanized character of the project area, no impacts to other federally listed species are expected to occur from implementation of the structural and non-structural measures outlined in the Feasibility Study.

The proposed project offers opportunities for both aquatic and terrestrial habitat improvement efforts in the Sevenmile Creek and Whittemore Branch sub-watersheds where flood-prone properties would be purchased and removed from the floodplain. The Service recommends that habitat enhancement activities associated with the non-structural project components include a monitoring plan to assess effectiveness of ecosystem restoration projects. The Service looks forward to assisting the Corps in the development of specifications for mitigation efforts and monitoring in these areas. The Service included monitoring terms and conditions for the structural project components in our March 23, 2015, Biological Opinion.

Table of Contents

List of Figures

Fish and Wildlife Coordination Act Report on the Mill Creek Flood Damage Reduction Feasibility Study

Introduction

This document constitutes the Secretary of the Interior's report on the Draft Integrated Feasibility Report for Mill Creek Flood Risk Management Study. It is submitted by the U.S. Fish and Wildlife Service (Service) to the U.S. Army Corps of Engineers (Corps) under the authority, and in accordance with, Section 2(b) of the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) to accompany the Corps' final Detailed Project Report. It has been coordinated with the Tennessee Wildlife Resources Agency (TWRA).

The purpose of this report is to identify and evaluate anticipated impacts of implementing the proposed project on fish and wildlife resources within the Mill Creek watershed in Davidson County, Tennessee, and to recommend conservation and mitigation measures for resource protection. This report is based on data contained within the Corp's Draft Integrated Feasibility Report, Environmental Assessment, and Biological Assessment that describes existing environmental conditions within the project area and also incorporates biological information the Tennessee Wildlife Resources Agency.

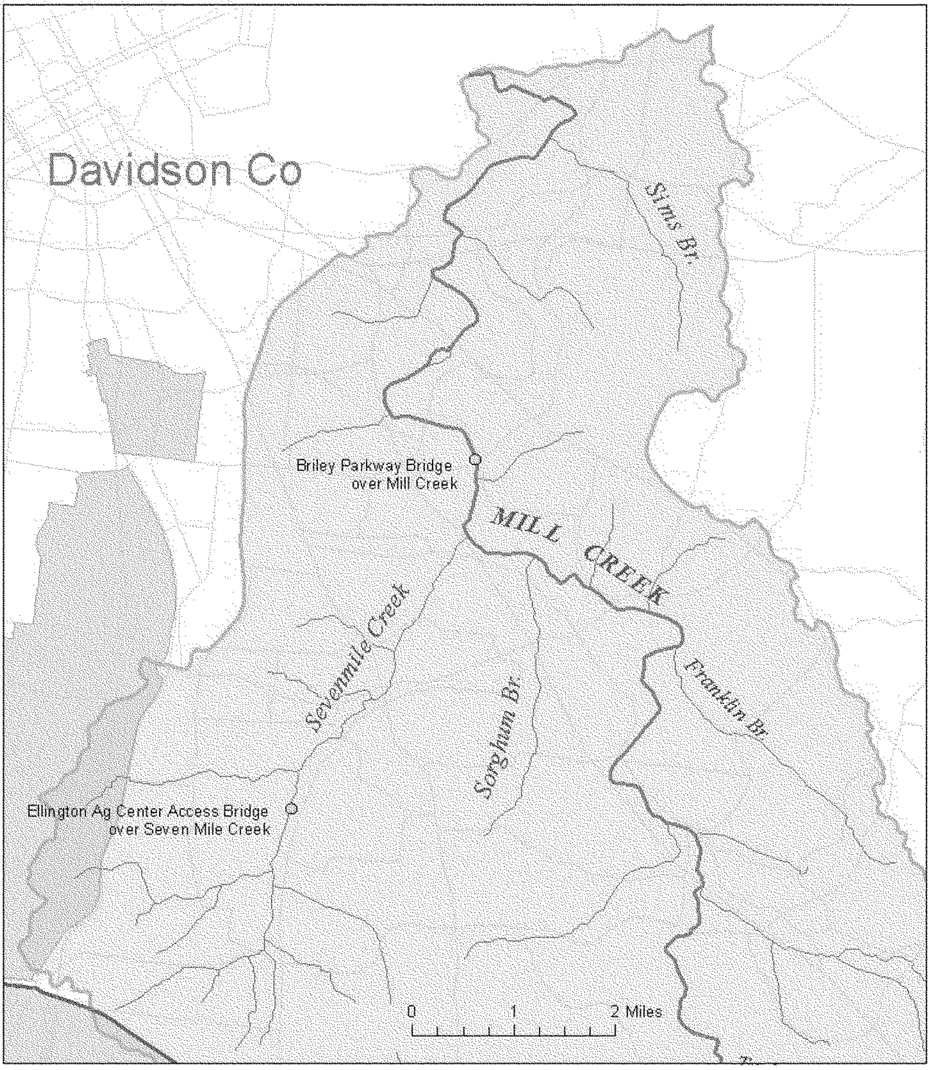
This report includes (1) background information on previous studies conducted in the Mill Creek watershed, (2) an impact analysis of the Corps' preferred plan, and (3) recommendations on conservation and mitigation measures to reduce adverse project related impacts.

Background Information

The Corps has previously conducted flood control investigations in the Mill Creek watershed (Figure 1) since the mid-1980s leading up to the current planning efforts. The Service was actively involved with the Corps in watershed planning efforts which included flood risk reduction efforts and ecosystem restoration in 2003 and 2004. Numerous development projects in the Mill Creek watershed have also documented site-specific habitat and biological conditions (USACE 1981, 1984, 1986).

The Service was not actively involved with the Corps and local sponsor in documenting existing conditions or in the development of the various plans presented in the draft Feasibility Report for the Mill Creek Flood Risk Management Study (USACE 2014). Fifteen structural measures, three regional measures, and two channel modifications were originally considered. However, this report will only consider the preferred plan, plan BDA, which is briefly described below and in more detail in USACE (2014).

Figure 1. Mill Creek Watershed and Structural Project Areas



The National Economic Development (NED) Plan is the plan that provides the greatest net benefits. Plan BDA, a combination of proposed projects that involve the Briley Parkway Bridge Modification, Ellington Ag Center Bridge Modification, Embankment and Spillway Structure, Regional Detention Basin and Outlet Structure (Figure 1), and Non-Structural Plan, provides the greatest amount of net benefits. Plan BDA also leaves considerably less residual risk in the floodplain than other plans that were included in the final array.

Plan BDA involves the modification to the Briley Parkway bridge at Mill Creek RM 7.1 (Figure 2), including the removal of approximately 6,000 yds^3 of upland fill material to accommodate widening of the bridge opening to at least 63-ft. above ordinary high water (OHW), modification to the existing Ellington Ag Center bridge over Sevenmile Creek, construction of an 800-ft. embankment to raise the elevation of the access road and which will serve as a weir with a 100-ft. spillway structure and apron, and construction of an uncontrolled open bottom concrete box culvert on Sevenmile Creek RM 3.67 (Figure 3). The outlet structure at the Ellington Ag Center will maintain normal low flows in Sevenmile Creek. Non-structural components are also included in the plan (i.e., buyout and removal of frequently flooded residential structures), including some raise-in-place residential buildings. These project components are designed to address the 1/50 Annual Chance of Exceedance (ACE) or 50-year flood event, located just downstream of the confluence of Sevenmile Creek and Mill Creek. In Mill Creek and tributaries Sevenmile Creek, Sorghum Branch, and Whittemore Branch, the 1/5 ACE equates to 90 structures that qualify for buyout or raise-in-place (Figure 4). The recommended plan has the potential to remove nearly half of the expected annual damages associated with Mill Creek and tributary flooding (USACE 2014).

These structural modifications will involve in-stream construction, removal of riparian zone vegetation, and streambank stabilization activities that will result in temporary sedimentation inputs adversely affecting habitat and water quality. Best management practices will be utilized for the non-structural components that include property removal or raising-in-place and no sedimentation or run-off is expected.

Figure 2. Briley Parkway Bridge over Mill Creek

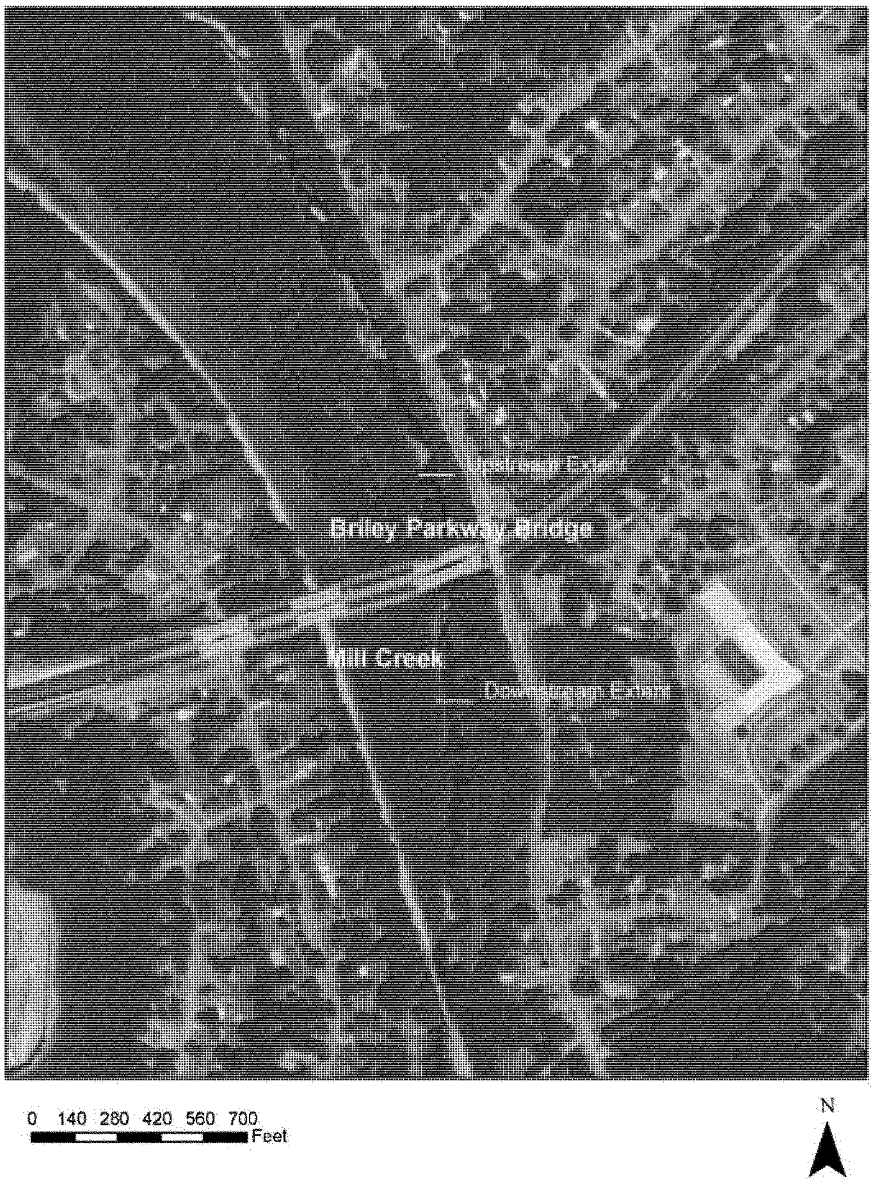
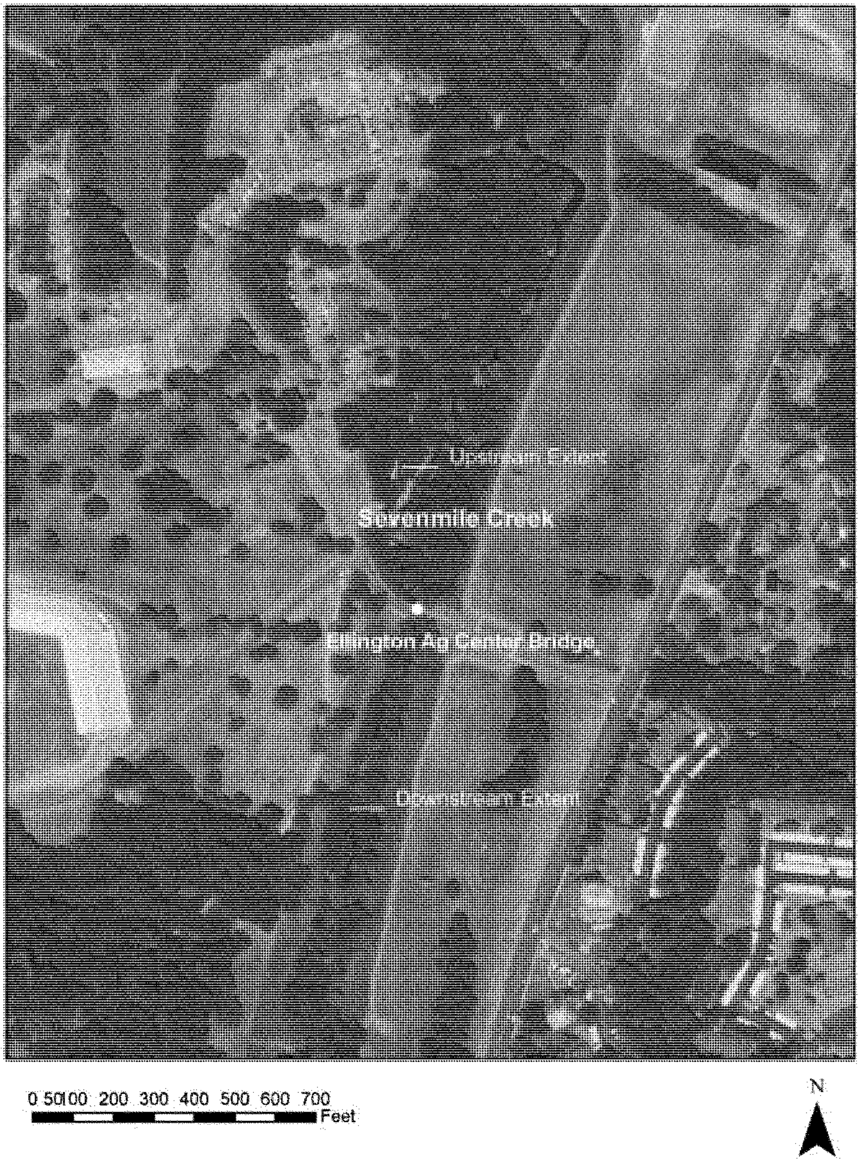


Figure 3. Ellington Ag Center Access Road Bridge



Description of the Project Area

Mill Creek flows generally northward from its origin in Nolensville to its confluence with the Cumberland River in Nashville. Along the way it is fed by a number of tributaries, the most significant being Sevenmile Creek which joins Mill Creek at River Mile (RM) 7.9 and has a drainage area of 17.5 square miles. Other major tributaries in Davidson County include: Collins Creek, Edmonson Branch, Franklin Branch, Holt Creek, Indian Creek, Owl Creek, Sims Branch, Sorghum Branch, Turkey Creek, and Whittenmore Branch. A detailed study of flooding and flood damages was not performed for the Mill Creek headwaters in Williamson County, as they elected not to co-sponsor the study. Topography in the Mill Creek Basin ranges from flat to moderately sloping along the main stem to rolling and hilly uplands which form the watershed divide. Elevations range from about 385-feet above mean sea level at the mouth to around 1200-feet in the upper extremities of the basin. The main stem is 27 miles long and falls about 280 feet in elevation from its source to its mouth. Average channel gradient is roughly 10-feet per mile in lower stream reaches and 35-feet per mile in upper stream reaches.

The Mill Creek main channel averages approximately 75 to 100-feet in width and the 100-year floodplain about 700 to 800-feet in width. The well-defined streambanks are generally 10 to 15-feet above streambed. Upper portions of Mill Creek and its headwaters flow primarily from farmland. As the stream enters Davidson County runoff characteristics become primarily suburban, changing to urban approximately halfway through the basin, with residential, commercial, industrial and open area land uses. Almost every summer, the flow of Mill Creek approaches zero at RM 22, near the Williamson/Davidson county line, and aquatic life is restricted to sometimes isolated pools. This lack of continual flow limits habitat availability and ecosystem processes and functions of Mill Creek (USACE 2014).

Sevenmile Creek originates near the Davidson-Williamson County line and flows north and east before joining Mill Creek. Sevenmile Creek is approximately 7.3 miles long with a drainage area of 17.6 square miles, an average slope of 18.9-feet per mile, and an average 100-year floodplain width of 500-feet. Streambanks range from 3 to 9-feet high; existing channel averages 20 to 30-feet wide. Approximately half the stream channel flows through a heavily urbanized area, while the upper half is less developed (USACE 2014).

The project area is located within the Inner Nashville Basin of the Interior Plateau Ecoregion. The Tennessee Department of Environment and Conservation (TDEC) characterizes this subecoregion as having thin soil, karst limestone, intermittent surface streams, and cedar glades. Solution cavities and sinkholes have developed along structurally controlled joints and near horizontal bedding planes (USACE 1986). Soil types within the project area are dominated by the Arrington silt loam series in floodplains and along creeks, as well as the Lindell-Urban Land Complex and Talbott-Urban Land Complex series in the uplands (USDA 1981).

Fish and Wildlife Resource Concerns and Planning Objectives

The Service (2015) has provided a no jeopardy biological opinion addressing short-term adverse effects from the structural modifications included in the preferred plan. However, implementation of the preferred plan is not expected to have long-lasting effects to fish and wildlife resources in the Mill Creek watershed. The project offers opportunities to restore and enhance aquatic and terrestrial habitats. The objective of the study is to reduce flood risk and improve the overall quality of life for the residents of Nashville, Tennessee and surrounding communities. The planning objectives are as follows:

• Reduce overall flood damages in the Mill Creek watershed from 2015 to 2065.

• Reduce residual risk in Mill Creek by removing property and people from the floodplain.

• Increase flood attenuation opportunities in the Mill Creek Watershed through 2065.

• Restore riparian and floodplain connections along Mill Creek and tributaries through 2065.

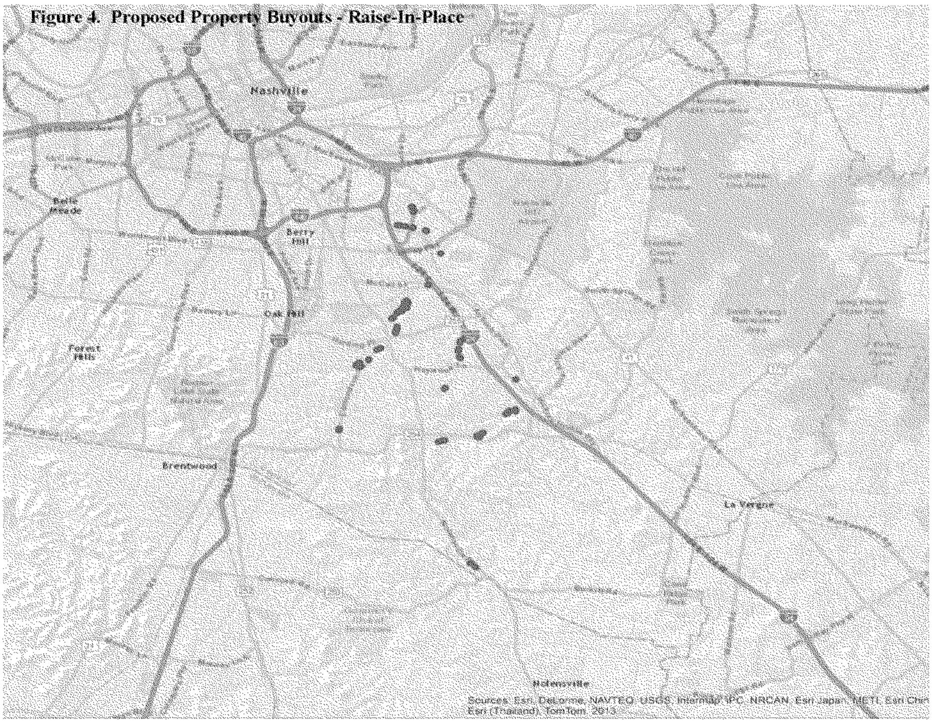


Figure 4. Proposed Property Buyouts - Raise-In-Place

Description of Fish and Wildlife Resources

Aquatic Habitats

Mill Creek and Sevenmile Creek flow over bedrock throughout most of their length. Numerous areas of cobble, slab rock, rock outcrops, and gravel riffles are present, all of which provide a variety of habitat types for different groups of aquatic animals. There are stream segments throughout the watershed, affected by road and utility infrastructure projects and residential and commercial developments, that exhibit less habitat diversity because of sedimentation and stormwater discharges.

Floating litter is common along the banks of Mill Creek and Sevenmile Creek. Mill Creek is on the State of Tennessee's 303(d) list due to nutrients, siltation, and organic enrichment/low dissolved oxygen from collection system failures and stormwater discharges from the MS4 area.

Sevenmile Creek is on the state 303(d) list due to nutrients, *Escherichia coli*, and habitat alterations from hydromodifications and stormwater discharges from the MS4 area. Whittenmore Branch is on the state 303(d) list due to habitat alterations and discharges from MS4 area (TDEC 2012).

Mill Creek supports a variety of warmwater fishes. Common species include stonerollers (*Campstoma* spp.), gizzard shad (*Dorosoma cepediamun*), sculpin (*Cottidae* spp.), shiners (Cypriniformes), darters, redhorse (*Moxostoma carinatum*), white sucker (*Catostomus commersonii*), northern hogsucker (*Hypentelium nigricans*), carp (Cyprinidae) , mooneye (Hiodontidae), and carpsucker (Catostomidae). Sport fishes include rock bass (*Amboplites rupestris*), smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*), longear sunfish (*Lepomis megalotis*), green sunfish (*Lepomis cyanellus*), catfish (Ictaluridae), and freshwater drum (*Aplodinous grunniens*). Sevenmile Creek supports a variety of darters (Percidae), minnows (Cyprinidae), smallmouth bass, bluegill, and bullhead catfish.

Benthic species commonly found in the Mill Creek watershed include several species of mayflies (Ephemeroptera), stoneflies (Plecoptera), caddisflies (Tricoptera), snails (Gastropoda), isopods (Decapoda), crayfish, midges (Diptera), damselflies (Odonota), hellgrammites (Megaloptera), Asian clam (*Corbicula fluminea*), and fingernail clams (*Sphaerium corneum*).

Terrestrial Habitats

Riparian woodland corridors are critical in maintaining an abundance of quality water to meet future demands. They have several hydrological and biological functions, including flood control, surface water storage, ground water supply recharge, and biological diversity (Dickson 1989, Gregory et al. 1991, Williams *et al.* 1997). Vegetation in riparian corridors acts as a filter trapping sediment, organics, nutrients, and pesticides from surface runoff from agricultural fields, pastures, and lawns, therefore improving water quality (Lowrance *et al.* 1984, Henley *et al.* 2000).

Riparian zone tree species in the Mill Creek watershed include oak (*Quercus* spp), hickory (*Carya* spp.), green ash *(Fraxinus pennsylvanica)*, black willow *(Salix nigra)*, tulip poplar (*Liriodendron tulipifera*), sycamore *(Platanus occ.identalis)*, American elm (*Ulmus americana*), box-elder *(Acer negundo*), Eastern red cedar *(Juniperus virginiana*), hackberry (*Celtis sp.)*, and red bud (*Cercis canadensis*),

Historically, little bluestem (*Schizachyrium scoparium*), big bluestem (*Bothriochloa laguroides*), side-oats grama (*Bouteloua curtipendula*), Eastern gammagrass (*Tripsacum dactyloides*), switchgrass (*Panicum virgatum*), and Indian grass (*Sorghastrum nutans*). Most of these native grasses have been eliminated by urban development and replaced by fescue (*Festuca* spp.), bermudagrass (*Cynodon dactylon*), and johnsongrass (*Sorghun halepense*). Typical streamside herbaceous plants included poison ivy *(Rhus toxicodendron),* blackberry *(Rubus* spp.), privet (*Ligustrum* spp.), and Japanese honeysuckle *(Lonicera japonica).*

The project area is used by both resident and migratory wildlife species that are tolerant of human activity. The riparian woodlands are used by a variety of migratory and resident passerine bird, owl, and hawk species. Some common resident bird species observed in the study area are sparrow (*Emberizidae sp.*), northern mockingbird (*Mimus polyglottos*), American robin (*Turdus migratorius*), northern cardinal (*Cardinalis cardinalis*), blue jay (*Cyanocitta cristata*), common crow (*Corvus brachyrhynchos*), American kestrel (*Falco sparverius*), and red-tailed hawk (*Buteo jamaicensis*). Mammals that may utilize these habitats and uplands in the study area include raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), opossum (*Didelphis virginiana*), coyote (*Canis latrans*), eastern cottontail (*Sylvilagus floridanus*), gray squirrel (*Sciurus carolinensis*), fox squirrel (*Sciurus niger*), and small rodents. Various species of frogs, turtles, and snakes may be found throughout the study area.

Most of the upland terrestrial habitats have been modified to some extent due to commercial and residential development pressures common in an urbanized area. There are parks and greenways within the watershed that provide relatively intact habitats for a variety of resident and migratory wildlife species.

Endangered and Threatened Species

The federally endangered Nashville crayfish (*Orconectes shoupi*) occurs within the Mill Creek and Sevenmile Creek watersheds. The Service completed a Biological Opinion on the project in March 2015 which authorized incidental take of the species during the implementation of the structural components of the preferred plan (USFWS 2015). No other federally listed species are known to occur in existing habitats within the project areas.

Preferred Plan Impacts Analysis and Discussion

The following basic assumptions were made for the future of the Mill Creek watershed, with or without project conditions:

- Some existing open spaces will be developed in the future.
- Additional industrial, commercial, and residential development will occur.
- Existing wildlife habitats will change, if not diminish. Their quality could improve with

time or deteriorate depending on natural events or changes in land use, but the amount and quality of aquatic and terrestrial habitats are expected to decrease. This will increase the demand for and stress to wildlife habitat in urban areas.

- Currently, it is assumed that the adverse effect of continued development to aquatic and terrestrial habitats could be offset as a result of specific mitigation efforts for permitted development activities in the watershed. Conversely, if the proposed project was not implemented, habitat quality would likely not improve naturally. As the riparian and upland woodlands age, the size and maturity of individual trees and stands and the height of herbaceous vegetation would increase.
- Non-native invasive species will continue to be a problem in all habitats.
- Extensive maintenance (e.g., mowing) and other current management practices in floodplains are expected to continue which would decrease habitat diversity and availability for terrestrial wildlife species.

It is difficult to predict what will happen to the project area in the future; however, implementation of the plan BDA would result in floodplains areas being cleared of structural impediments. No new development would be allowed within the project footprints through terms of the PPA and the O & M manual. This would have positive benefits to aquatic resources and wildlife by improving water quality, increasing riparian zones and improving floodplain quality with open/green space; this in turn would provide beneficial wildlife habitat by increasing connectivity of aquatic and terrestrial habitats.

There would be removal of flood prone structures and associated debris. This work in coordination with efforts of other agencies such as FEMA buyouts, watershed association/Cumberland River Compact (CRC) low impact developments, etc. would provide positive benefits to the watershed as well as water quality and land/water resources within the proposed project locations (USACE 2014).

Future Without Project

The Mill Creek watershed will continue to face development pressures, with or without implementation of the preferred plan. Without implementation of the actions included in the preferred plan, encroachment within the floodplain and riparian zones of Mill Creek and Sevenmile Creek would likely continue and periodic flooding will continue without abatement.

Recommended Fish and Wildlife Conservation Measures

The Service has evaluated this project in accordance with the guidelines and directives contained in its Fish and Wildlife Mitigation Policy (Federal Register 46(15):7644-7663; January 23, 1981). The Mitigation Policy is the basis by which the Service makes recommendations, in order of priority, to avoid, minimize, rectify, reduce or eliminate the loss over time, or compensate project-related impacts to fish and wildlife resources.

Executive Order 11990 requires all Federal agencies to "take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities." Wetlands are of national importance and have been documented as one of the most productive and important habitats for a variety of fish and wildlife species.

Executive Order 13186, directs Federal agencies to incorporate migratory bird conservation measures into their projects that are likely to have measurable negative impacts on migratory bird populations. Many birds listed in the Service's Birds of Conservation Concern 2002 (USFWS 2002) may use the upland and riparian woodland habitats in the project area.

The Service recommends that habitat restoration measures be incorporated in the final project plans for the structural and non-structural project areas with emphasis on the following:

- The natural hydrogeomorphic channel characteristics of Mill Creek and Sevenmile Creek will be restored upon completion of in-stream construction activities.

- Habitat enhancement measures (e.g., slab rock, cobble/boulders, and other in-stream structures) to improve aquatic habitats in Mill Creek and Sevenmile Creek for the federally endangered Nashville crayfish (*Orconectes shoupi*) and other aquatic species will be implemented during project implementation.

- Streambank stabilization measures will be implemented where necessary.

- Culverts in tributaries within the project area that have structural integrity issues that impede the movement of aquatic organisms shall be identified and replaced with structures that allow passage of aquatic organisms where applicable.

- Riparian zones will be re-established within the structural project footprints for the Briley Parkway Bridge over Mill Creek and Sevenmile Creek within the Regional Detention Basin comprising a mix of native tree, shrub, and herbaceous vegetation that benefit resident and migratory wildlife species.

- Floodplain and riparian zone integrity and connectivity, including re-vegetation comprising a mix of native tree, shrub, and herbaceous species that benefit resident and migratory wildlife species, will be re-established on existing properties that will be purchased or elevated within Mill Creek, Sevenmile Creek, Sorghum Branch, and Whittenmore Branch.

- Properties to be removed from the floodplain that are purchased should have deed restrictions, covenants, or conservation easements incorporated to keep those areas as restored habitats, open space, and to provide recreational and/or educational opportunities for the general public.

The Service looks forward to working the Corps in the development, design, and implementation of specific habitat restoration measures associated with the preferred plan.

Summary of Findings and Fish and Wildlife Service's Position

This draft Fish and Wildlife Coordination Act Report relies on information provided by the Corps and available as of November 2014. The Service strongly supports implementation of plan BDA. The final report may be revised to include additional project-related ionformation as it becomes available from the Corps. If any part of the final project plans change, the Service will re-evaluate the potential impacts and possibly modify our recommendations accordingly.

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
446 Neal Street
Cookeville, TN 38501

March 23, 2015

Lt. Colonel John L. Hudson, P.E.
District Engineer
Nashville District, U.S. Army Corps of Engineers
P.O. Box 1070
Nashville, Tennessee 37202-1070
Attn : CELRN - Matthew Granstaff, Project Planning Branch

Re: FWS #15-F-0141. Section 7 Consultation for the Mill Creek Flood Risk Management Study, Nashville, Tennessee. Structural and Non-structural Modifications in the Mill Creek and Sevenmile Creek Watersheds in Davidson County, Tennessee.

Dear Colonel Hudson:

This document is the biological opinion of the U.S. Fish and Wildlife Service (Service) based on our review of the Mill Creek Flood Risk Management Study and the biological assessment (BA) by the U.S. Army Corps of Engineers (USACE), Nashville District, located in the Mill Creek watershed in Davidson County, Tennessee, and their effects on the endangered Nashville crayfish (*Orconectes shoupi*) per section 7 of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.). The draft Integrated Feasibility Report and Environmental Assessment for the Mill Creek Flood Risk Management Study were received on November 17, 2014. Your request for formal consultation was received on September 2, 2014; however, a revised biological assessment was received on December 9, 2014.

This biological opinion (BO) is based on information provided in the Draft Integrated Feasibility Report and the December 9, 2014, biological assessment and other sources of information. A complete administrative record of this consultation is on file and available for review at the Service's Tennessee Ecological Services Field Office (TFO), 446 Neal Street, Cookeville, Tennessee 38501.

Consultation History

July 9, 2014	The Service and Corps had an informal meeting regarding change to the Mill Creek Flood Risk Management Study. During the meeting, non-

structural measures were determined by the Service to have "no effect" on Threatened and Endangered Species.

September 2, 2014 The Service received the initial draft BA for the Mill Creek Flood Risk Management Study, dated August 28, 2014, and the USACE request to initiate formal consultation.

October 2, 2014 The Service transmitted a formal acknowledgment letter to the USACE, Nashville District, and requests specific additional information related to the preferred alternative.

October 16, 2014 E-mail exchange between USACE and TFO staff regarding the availability of the Draft Integrated Feasibility Report for the Mill Creek Flood Risk Management Study.

November 17, 2014 USACE staff transmitted the web link for the Draft Feasibility Report and Environmental Assessment for the Mill Creek Flood Risk Management Study, dated October 2014, to TFO staff. A hard copy was subsequently delivered to the TFO.

December 9, 2014 The TFO received the revised final BA, dated November 6, 2014, from the USACE, Nashville District.

FWS Log No:	2015-F-0141	Application No:	N/A
Date Started:	December 9, 2014	Ecosystem:	Lower Tennessee/Cumberland
Applicant:	N/A	Action Agency:	U.S. Army Corps of Engineers
Project Title:	Mill Creek Flood Risk Management Feasibility Study		
County:	Davidson		

Table 1. Species and critical habitat evaluated for effects and those where the Service has concurred with a "not likely to be adversely affected" determination.

SPECIES or CRITICAL HABITAT	PRESENT IN ACTION AREAS	PRESENT IN ACTION AREAS BUT "NOT LIKELY TO BE ADVERSELY AFFECTED"
Nashville crayfish	X	

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTIONS

Action Areas:

By definition, the project action areas encompass areas where proposed activities can cause measurable or detectable changes in land, air and water or to other measurable factors that may elicit a response from the species or critical habitat addressed under the consultation. The project action areas are not limited to the footprint of the actions and should consider the chemical and physical impacts to the environment resulting from the actions.

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The action areas in this BO have been identified as the areas that would encompass the project footprints of the Briley Parkway bridge modification at Mill Creek RM 7.1 and the Ellington Ag Center bridge modification and construction of the embankment (weir) with spillway and outlet structure in Sevenmile Creek RM 3.67 in Davidson County, Tennessee, and defined upstream and downstream reaches at both project sites.

Project Description

As described in the draft Feasibility Report for the Mill Creek Flood Risk Management Study, the National Economic Development (NED) Plan is the plan that provides the greatest net benefits. Plan BDA, a combination of proposed projects that involve the Briley Parkway Bridge Modification, Ellington Ag Center Bridge Modification, Embankment and Spillway Structure, Regional Detention Basin and Outlet Structure, and Non-Structural Plan, provides the greatest amount of net benefits. Plan BDA also leaves considerably less residual risk in the floodplain than other plans in the final array.

Plan BDA involves the modification to the Briley Parkway bridge at Mill Creek RM 7.1., including the removal of approximately 6,000 yds^3 of upland fill material to accommodate widening of the bridge opening to at least 63 ft. above ordinary high water (OHW), modification to the existing Ellington Ag Center bridge over Sevenmile Creek, construction of an 800-ft. embankment to raise the elevation of the access road and which will serve as a weir with a 100-ft. spillway structure and apron, and construction of an uncontrolled open bottom concrete box culvert on Sevenmile Creek RM 3.67. The outlet structure at the Ellington Ag Center will maintain normal low flows in Sevenmile Creek. Non-structural components are also included in the plan (i.e., buyout and removal of frequently flooded residential structures), including some raise-in-place residential buildings. These project components are designed to address the 1/50 Annual Chance of Exceedance (ACE) or 50-year flood event, located just downstream of the confluence of Sevenmile Creek and Mill Creek. In Mill Creek and tributaries Sevenmile Creek, Sorghum Branch, and Whittemore Branch, the 1/5 ACE equates to 90 structures that qualify for buyout or raise-in-place. The recommended plan has the potential to remove nearly half of the expected annual damages associated with Mill Creek and tributary flooding (USACE 2014).

These structural modifications will involve in-stream construction, removal of riparian zone vegetation, and streambank stabilization activities that will result in sedimentation inputs adversely affecting habitat and water quality. In order to reduce potential adverse effects to Nashville crayfish, the following mitigative measures were proposed in the BA (USACE 2014):

1. Within 24 hours prior to any work within the stream, a search must be performed to remove any *O. shoupi* within 100 feet upstream and downstream of the proposed stream disturbance (Ellington Ag. Center Only). Installation of barriers would be in placed to reduce reentry.

2. Construction of Educational Measures at Ellington Agricultural Center. Ellington

Agricultural Center is a high use area with walking/running paths and creek access points. Construction/Installation of Educational Boards at the 2 creek access points adjacent to Ellington Agricultural Bridge would help increase awareness of the Nashville Crayfish and other species along and within Sevenmile Creek.

3. Removal of riparian vegetation shall be kept to a minimum and the disturbed area must be replanted with native vegetation. Disturbed streambanks shall be stabilized as soon as possible. Streambanks would be inspected, and replanted as needed, until vegetation is reestablished.

4. Erosion control devices shall be used to prevent stream sedimentation. Appropriate silt controls will be installed prior to beginning work on streambanks. Controls would be used singly or in combination to maximize control of sediment runoff. Silt controls would be maintained and inspected regularly to ensure proper function, and cleaned as needed. Material removed during cleaning would be placed in appropriate upland area such that runoff into the stream does not occur.

5. Cofferdams shall be constructed at Ellington Ag. Center if required 1) upstream of the work zone and the stream shall be diverted around the construction zone through appropriately sized pipe or 2) to completely encircle the work site and stream flow pumped across the dewatered area. Cofferdams would consist of clean rock, bags filled with clean sand, or temporary water-inflated dams.

6. Water pumped from the work area shall be held in settling basins or filtered prior to discharge into surface waters.

7. Construction within the Sevenmile and Mill Creek is limited to the period between May 15 and September 30.

8. Post construction monitoring would be conducted within a two year timeframe. The purpose of the monitoring would be to ensure the site has been restored to acceptable conditions and sufficient crayfish habitat is available within the construction footprint.

The action areas consist of the proposed project construction footprints and associated downstream and upstream reaches within Mill Creek RM 7.1 (Figure 1) and Sevenmile Creek RM 3.67 (Figure 2) in Davidson County, Tennessee. The approximately 300 ft. downstream reaches of both Mill Creek and Sevenmile Creek include areas where Nashville crayfish will be surveyed and removed (150 ft. downstream of the lowest disturbance point within the project footprint) prior to construction and those areas potentially affected by construction erosion and sedimentation. The approximate 300 ft. upstream reaches of Mill Creek and Sevenmile include those areas where Nashville crayfish collected from within the project footprints and downstream reaches will be relocated (minimum 150 ft) and the projected uppermost disturbance area due to competitive interactions between relocated and resident individuals. These areas (Figures 1 and 2) have been identified as the action areas for reasons that will be explained and discussed in the "EFFECTS OF THE ACTIONS" section of this consultation.

STATUS OF THE SPECIES/CRITICAL HABITAT

Species/critical habitat description

The Nashville crayfish (*Orconectes shoupi)* was listed as an endangered species on September 26, 1986 (51 FR 34410 34412). Because the entire known range of the species is contained within the boundaries of Metropolitan Nashville, where significant residential and commercial development had occurred prior to its listing and was anticipated to continue into the foreseeable future, it was determined that designation of critical habitat would substantially increase the potential for take of the species; therefore, critical habitat was not designated for the Nashville crayfish (U.S. Fish and Wildlife Service 1989).

The Nashville crayfish is endemic to the Mill Creek drainage in Davidson and Williamson counties, Tennessee. The species is currently known to occur in Mill Creek and its tributaries, including Collins Creek, Owl Creek, Edmonson Branch, Sims Branch, Sevenmile Creek, Sorghum Branch, Whittemore Branch, Turkey Creek, Indian Creek, Holt Creek, four unnamed tributaries to Mill Creek, and one unnamed tributary to Owl Creek.

There are historic collection records of Nashville crayfish in streams outside of the Mill Creek drainage. Records from the South Harpeth River in Davidson County, Tennessee, and Big Creek (Elk River tributary) in Giles County, Tennessee, however, are thought to be based on "bait bucket" introductions of the species, and Nashville crayfish records from Richland Creek (O'Bara et al. 1985; Bouchard 1976, 1984) in Davidson County (Cumberland River system), Tennessee, were later discovered to be misidentifications (Bouchard, 1988, personal communication). Originally thought to solely be a stream-dwelling species, Nashville crayfish have also recently been collected from impoundments, overflow pools adjacent to Mill Creek and small, intermittent tributaries in the Mill Creek watershed; those specific locations have been included in the life history discussion below.

The Nashville crayfish is a relatively large species, growing up to 7 inches (in) in length. Body coloration is variable, ranging from green to dark brown. Many individuals have an area of lighter coloration on the dorsal shell that forms a "saddle" on the back. The shell ends anteriorly in a sharp point between the eyes. It has thickened ridges on its rostrum, four pair of walking legs, and two elongated chelae with distinct orange and black tips (U.S. Fish and Wildlife Service 1989; O'Bara et al. 1985). Size of carapace lengths ranges from 0.3 to 4.7 centimeters (cm) (0.12 to 1.9 in) (Carpenter 2002).

Life History

Little is known about the life history of the Nashville crayfish. It is assumed that its life history traits are similar to other crayfish species. Most common stream-dwelling species of crayfish (non-burrowing and non-cave-dwelling species) live an average of four to five years (Bergey, et al. 2005). Raccoons, fish and reptiles are the primary crayfish predators. Crayfish are omnivorous, feeding on a variety of plant and animal material, including algae, insects, worms, fish eggs, snails and mussels.

Cook and Walton (2008) attempted to describe habitats used by the species, but because of a severe drought during their 2007 study, their models may only reflect habitats used during stress periods. Their study indicated habitat variables important to Nashville crayfish include cover (rock area) and depth, and that the most important microhabitat variables for the species are habitat unit and area. Males were more often found between depths of 0.05 and 0.15 meters (m) or 0.16 to 0.49-feet (ft), whereas females were more often found in depths greater than 0.30 m (0.98 ft). Males occurred most often at greater depths (over 0.2 m or 0.66 ft) when seasons were combined than during spring (0.05 m and 0.15 m). Algae can be a significant variable in predicting the presence of females, especially during egg laying and brooding (Whitledge and Rabeni 1997). The probability of finding a female increased when canopy was absent, algae cover was 30 percent (%) or more within a depth of 0.25-square meter (m^2) or 2.69 square feet (ft^2), and with cover rocks greater than 0.02 m^2 (2.15 ft^2).

Reproductive females are typically found under large slab rocks. Ovigerous females have been found in isolated areas near banks during spring, in preparation for brood hatching. Cover rocks of at least 0.02 m^2 (2.15 ft^2) may be important habitats for females releasing broods and for protection during molting after releasing broods (U.S. Fish and Wildlife Service 1987). Nashville crayfish were found at least 50% of the time in runs, using cover rocks with a surface area of 0.05m^2 (0.54 ft^2), and at least 50% of the time in pools, when cover rock area increased to 0.10 m^2 (1.1 ft^2). Larger rock areas may be needed in pools to decrease risk of predation, whereas smaller rock areas would provide adequate protection in runs (Cook and Walton 2008). Instream cover is also important for Nashville crayfish during the time when they are molting. Cover is aggressively defended; larger individuals drive smaller crayfish from their selected cover. Juveniles tend to inhabit areas along stream margins (Pennington, 2007, personal communication).

Individual Nashville crayfish have been found in a variety of habitat types, including gravel/cobble runs, pools with as much as 10 cm (3.9 in) of accumulated sediment, and in areas with intermittent flow. Adults tend to be solitary, seeking cover under large rocks, logs, debris, or rubble; the largest individuals generally select the largest cover available (U.S. Fish and Wildlife Service 1987).

Nashville crayfish recently collected from impoundments, overflow pools adjacent to Mill Creek and small, intermittent tributaries in the Mill Creek watershed include: (1) 809 Nashville crayfish found in a small impoundment on a tributary to Mill Creek (U.S. Fish and Wildlife Service 2011); (2) a live Nashville crayfish collected from a rock outcropping along the shoreline of a 5-acre (ac) impoundment on a Mill Creek tributary that was drained for a residential development (U.S. Fish and Wildlife Service 2011); (3) four Nashville crayfish collected from a retention pond adjacent to Owl Creek (Cook and Walton 2008); and (4) Nashville crayfish (number unknown) collected from a pond on Sims Branch (Withers, 2009, personal communication).

Male crayfish, and possibly females, have an unusual pattern of molting after reaching adulthood. Crayfish typically molt six or seven times during their first year of life and once or twice a year for the remainder of their lives. Males molt back and forth between a reproductive form (Form I) and a non-reproductive form (Form II). Reproduction begins when males change from Form II to Form I. The primary differences between Form I and Form II males are development of the claws and the shape of the reproductive organ which is known as the first pleopod, or gonopod on Form I individuals. In juvenile and Form II males, the gonopod appears to be the same color and consistency throughout its length and has more blunt and rounded features. In Form I males, at least one of the terminal elements is corneous (appears yellowish and brittle) (Georgia College 2012). According to Barrociere (1986), Nashville crayfish reach sexual maturity during early spring of the year following their hatching; Withers (2012a, personal communication) has further indicated that earlier hatched Nashville crayfish likely reach sexual maturity within their first year of life, while those hatched later in the year would be expected to reach sexual maturity during their second year of life.

The Nashville crayfish reproductive period, which includes mating, spawning, egg release, egg incubation and hatching, occurs from approximately October 1 to May 31 (Barrociere 1986). Mating in Nashville crayfish is assumed to be similar to that of other crayfish species, consisting of short exchanges of tactile and olfactory signals, after which males grasp females by their claws, turn them on their backs, and release spermatophores, which attach to the thoracic sternites (ventral surface of body segments) of the females; fertilization is therefore external, and occurs a few days or weeks after mating (Acquistapace et al. 2002). Eggs developing under the female crayfish's abdomen are guarded, a period during which females typically do not eat (Galeotti et al. 2006). Withers (2012b, personal communication) estimated the average clutch size for the Nashville crayfish at approximately 100 eggs per female. Nashville crayfish egg-laying occurs during late winter and early spring. Smart (1962) found that the female, *Cambarus longulus longulus*, a crayfish species closely related to the Nashville crayfish, carried eggs approximately 35 days from late April through late May. Barrociere (1986) noted that the period of egg laying and embryonic development of Nashville crayfish in Mill Creek occurred from late March through mid-May (Barrociere 1986).

When female crayfish are ready to lay eggs, they usually find a secure hiding place and, hence, are rarely encountered. Like other crayfish species, when the female Nashville crayfish releases her eggs, she attaches them to her swimmerets (pleopods) and is said to be 'in berry" (Georgia College 2012). Upon hatching, the juvenile crayfish remain attached to the mother by the "telson thread". Embryos develop in approximately three weeks, and the young remain attached to the pleopods of the mother for approximately another two weeks (Barrociere 1986). Throughout this period, besides providing protection, females continuously fan and groom the eggs and hatchlings (Reynolds 2002). After the juveniles molt for the second time, they are free of the mother, but stay close and cling to the mother's abdomen for several weeks through late spring until they move off on their own (Georgia College 2012).

Population Dynamics

No comprehensive data are available concerning the current status of the Nashville crayfish population, but previous surveys and studies indicate that the species persists throughout the Mill Creek drainage. Population estimates for Nashville crayfish, based on surveys conducted from July 1999 through August 2001, ranged from 1,854 to 3,217 individuals per 100 m (328 ft) at sites in mainstem Mill Creek and from 404 to 1,425 individuals per 100 m at a site in Sevenmile Creek. Overall, it was determined that population densities may at times have been as high as 1,000 to 2,000 individuals per 100 m (Carpenter 2002). Results of surveys conducted between 1988 and 2003 indicate that the Nashville crayfish occurs primarily in the middle-to-upper reaches of the

Mill Creek system. During that period, approximately 60 individuals were collected within the lower 5 river miles (mi) of Mill Creek, while more than 5,400 individuals were collected at 16 sites between Mill Creek river mile (RM) 7.5 and 20.5 (U.S. Fish and Wildlife Service 2011).

Juvenile crayfish (with lengths under 20 millimeters [0.79 in]) comprised 45% of all Nashville crayfish collected during August and September, 1998, and September of 1999, at 12 sampling sites throughout the Mill Creek watershed (O'Bara 1999). Summer (August-September) sex ratios for Nashville crayfish in the Mill Creek system varied from 0.85:1.17 male:female (46% and 54%, respectively) to approaching 1:1 male:female (50% and 50%, respectively) (O'Bara 1999; O'Bara and Mason 1990). Carpenter (2002) determined that 1,716 Nashville crayfish captured from the Mill Creek watershed over a three-year period had an overall male:female sex ratio of 0:82:1.2 (55% and 45%, respectively) comprised of 858 males, 704 females and 154 of unknown sex.

Status and Distribution

Because it is restricted in range to the Mill Creek drainage, and because of significant destruction and modification of its habitat throughout its range, the Nashville crayfish was listed as an endangered species. Habitat destruction and modification in Mill Creek and its tributaries are primarily the result of rapid urban development and consequent water quality degradation in Metropolitan Nashville. Water quality and aquatic faunal diversity have been significantly impacted by development in the lower reaches of the drainage and historically by agricultural activities in the upper portion of the drainage (51 FR 34410 - 34412).

The middle and lower reaches of the Mill Creek drainage are located within the highly urbanized area of Metropolitan Nashville. Stormwater runoff from streets and parking lots and discharges from commercial and municipal facilities have likely affected the stream and the aquatic fauna. Water quality sampling has revealed measurable levels of various heavy metals, poly-aromatic hydrocarbons, and other pollutants that could have adverse impacts on aquatic organisms. In 1989, a spill of aviation fuel occurred at the Nashville International Airport. Despite state-of-the-art measures that were in place to control such incidents (i.e., oil/water separators), the fuel entered Sims Branch, a tributary to Mill Creek. Booms were placed near the mouth of Mill Creek to prevent the fuel from entering the Cumberland River, but an inspection of Sims Branch by biologists from the TWRA and the Service revealed that the spill had affected aquatic life in the stream; dead fish and crayfish were found throughout Sims Branch (U.S. Fish and Wildlife Service 2011).

Installation of fiber optic cables in Nashville in 2000 resulted in various incidents of frack-out (i.e., fracturing of bedrock) during HDD operations, which resulted in large amounts of bentonite slurry, and possibly other pollutants, entering numerous streams in the Mill Creek watershed (U.S. Fish and Wildlife Service 2011).

Other incidents, associated with various development activities in the Mill Creek drainage, have resulted in frack-out and de-watered portions of streams. These impacts have killed aquatic species, including crayfish.

In April 2010, the TFO received a report of aircraft de-icer spilling into Sims Branch, which originates on Nashville International Airport property. Dead fish and crayfish were observed in the stream and in a pond constructed downstream from the airport.

Other potential threats to the species include the introduction of other crayfish species into Nashville crayfish habitat (e.g., bait released by fishermen or unwanted pets released by pet owners), resulting in added competition for food and shelter and potential genetics concerns (i.e, cross-breeding). These threats have been increasingly observed world-wide with other species of crayfish (Bergey et al. 2005).

A recovery plan was approved for the Nashville crayfish on August 12, 1987, and a revised plan was approved on February 8, 1989. Because its entire known range is located within a major metropolitan area, which is subject to activities that adversely affect the species and its habitat, removal of the Nashville crayfish from the legal protection of the Act is unlikely. However, the species may be reclassified to threatened status if the following criteria are met:

1. Through protection of the existing Mill Creek basin population and by reintroduction of the species into Richland Creek (Cumberland River tributary) or by discovery of an additional distinct population, there exist two viable populations.

2. A Richland Creek population or a discovered population must: (a) have been established or be self-sustaining for a minimum of ten years without augmentation from an outside source, (b) represent a significant component of the crayfish fauna throughout most of the creek, and (c) be stable or increasing in numbers and range.

3. The species and its habitat in the Mill Creek system and one other system are protected from human-related and natural threats that would be likely to cause the species' extinction in the foreseeable future.

Although the species and its aquatic habitat continue to be impacted, the Nashville crayfish persists in the Mill Creek drainage. Nashville crayfish have been collected throughout the mainstem of Mill Creek, in Sims Branch, Sevenmile Creek, Whittemore Branch, Collins Creek, Turkey Creek, Indian Creek, Owl Creek, Edmonson Branch, Sorghum Branch, Holt Creek, four unnamed tributaries to Mill Creek and an unnamed tributary to Owl Creek. A particular site may support a few to hundreds of Nashville crayfish. Originally thought to be a stream-dwelling species, Nashville crayfish have recently also been found in impoundments, overflow pools adjacent to Mill Creek, and small, intermittent tributaries in the Mill Creek watershed (Cook and Walton 2008; Withers, 2009, personal communication).

Nashville crayfish records from streams outside the Mill Creek system are believed to be based on "bait bucket" introductions or misidentifications. None of these populations are presently extant. Therefore, considering this information, in addition to the latest evidence concerning the distribution of the species, attaining the criteria contained in the species' recovery plan for reclassification of the Nashville crayfish to threatened status are not likely.

Analysis of the Species/Critical Habitat Likely to be Affected

The Nashville crayfish is the only species that will be addressed in this biological opinion. Available endangered species records do not indicate that any other federally endangered or threatened species are likely to occur in the action area.

Nashville crayfish are likely to be affected by the proposed action because they have been collected in the recent past within portions of Mill Creek and Sevenmile Creek watershed including construction and staging areas within this opinion's designated action areas (defined under "Action Areas" in "Description of the Proposed Actions"). An effects analysis is presented in the next section.

No critical habitat has been designated for the Nashville crayfish. Therefore, the proposed action would not adversely modify or destroy any designated critical habitat for the federally listed Nashville crayfish.

ENVIRONMENTAL BASELINE

Mill Creek originates in Williamson County, Tennessee, and flows in a northerly direction for approximately 27 mi. It crosses into Davidson County at approximately Mill Creek RM 20.8 and continues to flow north for approximately 20.8 mi before joining the Cumberland River at Cumberland RM 194.5. The drainage area is 108 mi^2 and is located within the Central Basin Physiographic Region, an area approximately 7,000 mi^2 in size, which is comprised predominately of Ordovician limestones and shales. Five major tributaries contribute to the system, including Owl Creek, Indian Creek, Turkey Creek, Sorghum Branch, and Sevenmile Creek.

The headwaters of Mill Creek flow primarily through rural, sparsely populated, agricultural lands. The lower reach, however, is located within the heavily developed metropolitan area of Nashville. As the city has grown, development has spread toward the headwaters of the drainage and agricultural lands have been increasingly converted to residential and commercial developments. Substrate in streams throughout the drainage consists of coarse gravel and bedrock in various combinations.

The upper reach of Mill Creek and its tributaries have been impacted by runoff from the agricultural lands through which they flow. The lower portion of the drainage has been heavily impacted by urban development. Commercial, residential and industrial developments have affected the stream and encroached on the floodplain. Potable water, gravity sewer, natural gas, electricity, cable television and telephone utility lines have been constructed along and across Mill Creek and its tributaries to provide those utilities to homes, businesses and industrial facilities.

Development activities in the Mill Creek drainage have had significant impacts on the streams and affected their aquatic communities. New construction often results in the removal of riparian vegetation and disturbance to streambeds. The headwater reach of Sims Branch, a Mill Creek tributary, was filled during construction activities at the Nashville International Airport. A significant spill of aircraft fuel into Sims Branch also occurred after completion of the new airport terminal.

By 1984, approximately 40% of the Mill Creek watershed had been developed (U.S. Army Corps of Engineers 1984). Although the upper reach of the Mill Creek drainage had not been developed at that time, agricultural activities in the upper drainage were degrading aquatic habitat and water quality (due to organic enrichment), and habitat condition was considered to be poor (U.S. Army Corps of Engineers 1981). Development continues to expand within the drainage, including within the upper reaches of Mill Creek and its tributaries, which are undergoing increasing amounts of residential development. These activities are likely resulting in continued degradation of water quality. In addition to the spill events that killed Nashville crayfish, mentioned in the "Status and Distribution" section, other kills of Nashville crayfish have also been reported periodically, likely the result of fertilizer and pesticide runoff from residential lots.

Status of the Species within the Action Areas

The action areas have been identified as the areas that would encompass the project footprints of the Briley Parkway bridge modification at Mill Creek RM 7.1 and the Ellington Ag Center bridge modification and construction of the embankment (weir) with spillway and outlet structure in Sevenmile Creek RM 3.67 in Davidson County, Tennessee. A comprehensive presence/absence study has not been performed on these reaches and the species continues to be discovered at unanticipated locations throughout the watershed (e.g., within impoundments and overflow pools). Therefore, we have assumed presence throughout the action areas.

Factors Affecting Species Environment within the Action Areas

Within the action areas, the Nashville crayfish is being affected by impacts associated with various residential, commercial, and industrial developments. Sediment from developments near streams in the action area is likely affecting the habitat of Nashville crayfish. Activities that contribute sediment discharges into stream systems can lead to the destruction of riparian vegetation, bank collapse, excessive instream sediment deposition, and increased water turbidity and temperatures. Sediment has been shown to abrade and/or suffocate bottom-dwelling algae and other organisms by clogging gills (Waters 1995).

Pollution from various municipal, commercial and industrial discharges is affecting water quality. Due to the presence of an established network of roads within the action areas, the potential exists for an accidental toxic chemical spill. Sources of such spills include potential accidents involving vehicles transporting chemicals over road crossings of streams inhabited by the Nashville crayfish. Nonpoint source runoff of contaminants (oil, de-icing chemicals, etc.) from roads also contributes to water quality degradation.

An increasing amount of development, primarily residential, as Nashville continues to expand southward is occurring in the upper reaches of the Sevenmile Creek watershed. These new developments typically result in removal of riparian vegetation, increased runoff due to increased impermeable surface, and runoff of sediment and pollutants from construction sites. The streams also continue to receive runoff of pesticides and fertilizers from home sites and the remaining agricultural lands.

Stream reaches in the lower portion of the Mill Creek watershed have been heavily impacted by urban development. Commercial, residential and industrial construction has affected the stream and encroached on the floodplain. Utility lines (potable water, gravity sewer, natural gas, electricity, cable television and telephone) have been constructed along and across Mill Creek and its tributaries to provide those services to homes, businesses and industrial facilities. These development activities have had significant effects on streams in the drainage and their aquatic communities. New construction often results in the removal of riparian vegetation and disturbance to the streambed.

Kills of crayfish have been reported periodically, including an April 2010 incident involving aircraft de-icer spilling into Sims Branch from the Nashville International Airport, a 1989 episode entailing aviation fuel entering Sims Branch from the Nashville International Airport (U.S. Fish and Wildlife Service 2011), and on other occasions, which were likely the result of runoff of fertilizers and pesticides from home lots.

Currently, 17 stream reaches in Mill Creek and its tributaries are listed as impaired on the State of Tennessee's 303(d) list (Tennessee Department of Environment and Conservation 2014). Impairment of stream reaches in the drainage is the result of low dissolved oxygen, siltation, removal of riparian vegetation, nutrient enrichment and high bacteria levels from stormwater discharges, sewage collection system failures, land development and unrestricted cattle access (Tennessee Department of Environment and Conservation 2014).

EFFECTS OF THE ACTIONS

Factors to be Considered

The proposed actions would occur in the Mill Creek and Sevenmile Creek watersheds, where the Nashville crayfish is widely distributed. Following listing of the Nashville crayfish, Service biologists worked with USACE personnel to develop protective measures for the species that would be incorporated as conditions in permits to facilitate permit issuance. Based on new information about the species' habitat, the Service determined that the standard protective measures no longer precluded the likelihood of adverse effects and the potential for take of the Nashville crayfish during construction or development activities. Routine permit applications are, therefore, now reviewed and effects evaluated on a case-by-case basis. Permit applications may cover a wide variety of actions including those described in the project description.

The proposed actions have the potential to accelerate erosion and increase sedimentation into streams, resulting in adverse effects to the aquatic environment. Use of heavy equipment to move earth, remove and place fill, and remove existing vegetation can disrupt natural drainage patterns and expose soil on streambanks and in floodplains, often resulting in increased erosion and runoff into streams. Excessive sedimentation can alter stream channel morphology and contribute to increased flooding. It can also result in increased water temperatures and oxygen demands, which can injure or kill aquatic organisms. Deposition of sediment on the channel bottom also degrades aquatic habitat by embedding substrate and smothering bottom-dwelling organisms. In addition, fines often transported to proposed work sites with gravel and riprap can be inadvertently introduced into streams, further contributing to embedding substrate and smothering organisms.

Turbidity, as induced by accelerated erosion and sedimentation, may result in further damage to aquatic systems. Increased particulate matter suspended in the water column (suspended solids) may drive mobile, aquatic organisms from the affected area by irritating gills, concealing forage and destroying vegetation that may be essential for reproductive success and survival. Turbidity also degrades water quality by reducing light penetration, pH and oxygen levels, and the buffering capacity of the water. Degraded water quality may continue far downstream from the point where erosion occurs.

Use of areas along streams for equipment cleaning and staging can also have adverse impacts on stream water quality and negatively affect aquatic species. Runoff from such areas may contain pollutants and toxicants such as oil, petroleum, de-icing solutions and detergents. These substances may result in mortality to aquatic organisms, or they may accumulate in their body tissues and result in subsequent adverse chronic effects.

Collection and relocation activities, associated with routine dredge and fill permits, call for removing crayfish from proposed project vicinities. Collection and relocation activities involve wading in streams, moving rocks, logs and other debris, and capturing Nashville crayfish with seines and dip nets. Individuals are handled, kept in buckets or coolers, and moved and released at other locations in the stream where the project work occurs. The duration of collection and relocation activities generally occur over a short-time period of several hours within a one to two-day period, based upon the scope of the proposed action. Nashville crayfish are typically required to be relocated to suitable, upstream habitat away from project disturbances and adverse effects. Although this is the most effective means of minimizing lethal take of Nashville crayfish, collection and relocation of individuals still results in incidental take in the form of capture and harassment.

This section includes an analysis of the direct and indirect effects of the proposed actions on the species and/or critical habitat and its interrelated and interdependent activities.

Proximity of the actions:

The proposed actions would occur at the existing Briley Parkway Bridge over Mill Creek at RM 7.1 (Figure 1) and at the Ellington Ag Center adjacent to and within Sevenmile Creek RM 3.67 (Figure 2) in Davidson County, Tennessee. Nashville crayfish are known to occur at these project locations. For the purposes of this opinion, the action areas are the areas that would encompass the project footprints and all areas directly and indirectly associated with and affected by construction-related activities. The action areas are not located within any critical habitat area for Nashville crayfish or any other federally listed species.

Figure 1. Briley Parkway Bridge over Mill Creek

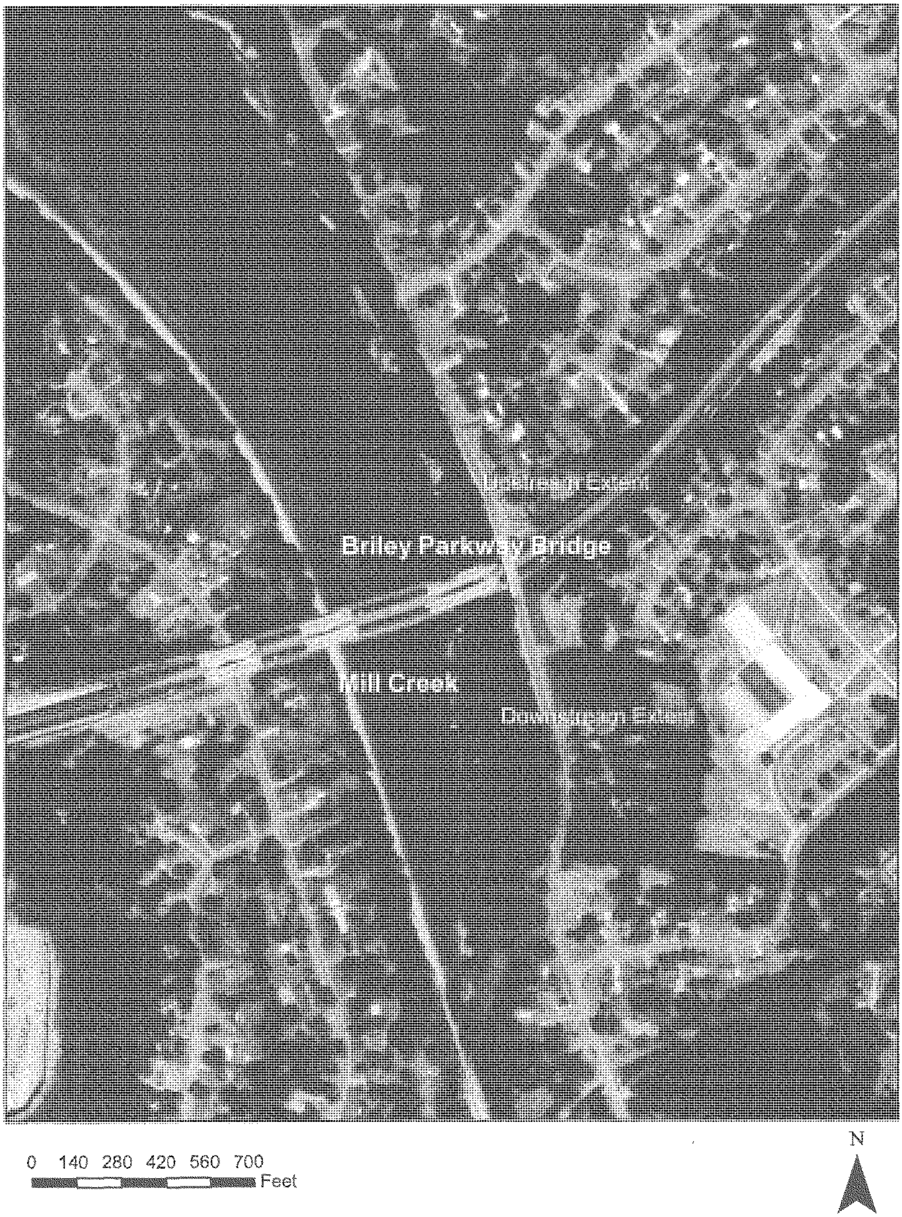
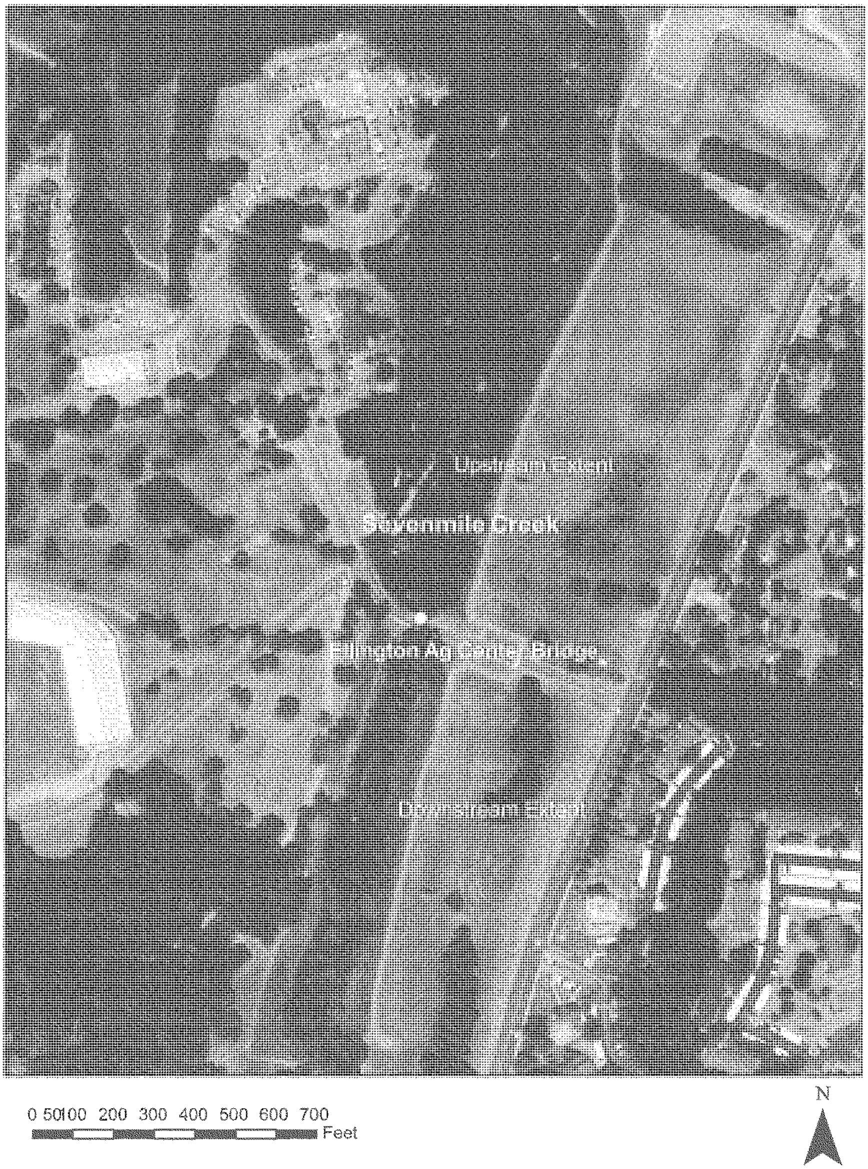


Figure 2. Ellington Ag Center Access Road Bridge



Distribution:

The action areas would encompass the individual project footprints and all areas directly and indirectly associated with and affected by the construction activities. The Service has defined the project action areas based on the known distribution of the Nashville crayfish in Mill Creek and Sevenmile Creek where construction activities would occur.

Project footprints would occupy aquatic areas below OHW and associated upland/floodplain/riparian areas above the OHW. Sites within the action areas affected by the proposed actions would include aquatic habitat, occupied by Nashville crayfish, floodplains, riparian areas, riparian areas of influence and terrestrial habitat (e.g., uplands).

Timing:

The proposed actions can be divided into essentially three phases, a pre-construction phase, construction phase, and an operations (post-construction) phase. Depending on when actual construction occurs, juvenile Nashville crayfish and/or Nashville crayfish eggs could potentially be affected during the pre-construction and construction phases. If collection and relocation of crayfish (pre-construction phase) or proposed work activities (construction phase) would occur during their reproductive period (mating, spawning, egg release, egg incubation and hatching from October 1 to May 31) or when Nashville crayfish hatchlings would occupy the action area (late spring and early summer), juveniles could be affected. Adult Nashville crayfish could occur year-round at the proposed project sites, and, therefore, could potentially be affected during the pre-construction and construction phases. The operations phase of the proposed action would occur year-round and could potentially affect Nashville crayfish at various life stages if any proposed structures would malfunction (head-cutting, streambank sloughing, substrate redistribution, etc.).

Nature of the effects:

The proposed action could have a variety of effects on individual Nashville crayfish. Depending upon when proposed construction projects would occur, the Nashville crayfish's life cycle could potentially be disturbed or disrupted. The pre-construction and construction phases would generally result in temporary effects. Effects during the operations phase of proposed projects would be unknown without adequate post-project monitoring and could be minimized if projects were properly designed, implemented and maintained.

These projects could potentially result in the following effects to Nashville crayfish: (a) direct injury or mortality as a result of individuals being collected and/or handled during the relocation process, (b) direct injury or mortality as a result of being crushed or becoming physically impaired due to instream construction activities, (c) direct injury or mortality as a result of turbidity and/or deposition of sediment, created by instream construction activities and/or construction activities within the project footprint or in the immediate vicinity of the project footprint (erosion as a result of operated heavy equipment disturbing streambank soils, removing riparian vegetation, etc.), obstructing crayfish gills, and reducing their ability to feed or grow, (d) direct injury or mortality as a result of pollutants (spills of petroleum products from hydraulic, fuel and power systems, etc., and/or concrete spills) accidentally entering streams and affecting water quality and food sources, and in turn respiration and feeding capabilities in the immediate project vicinity, (e) indirect injury downstream of project sites from turbidity and/or deposition of sediment created by instream construction activities or construction activities adjacent to the stream, compelling individuals to relocate to less suitable habitat, (f) indirect injury or mortality as a result of pollutants (spills of petroleum products from hydraulic, fuel and power systems, etc., and/or concrete spills) entering streams from construction equipment adjacent to sites, affecting water quality and food sources, and in turn respiration and feeding capabilities of individuals downstream of project construction areas, (g) indirect injury as a result of project failures (head-cutting, streambank sloughing, substrate redistribution, structural damage, etc.) during the operations phase obstructing crayfish gills, and reducing their ability to respire, (h) indirect injury as a result of being disrupted from their normal behavior patterns (including breeding, feeding, or sheltering) and becoming stressed, (i) indirect injury or mortality due to relocated crayfish competing with existing resident crayfish for shelter and food, increasing their susceptibility to predation and/or starvation, and (j) indirect reproductive loss or mortality from implementing instream work activities between October 1 and May 31 (the reproductive period for the species) and stressing adults, triggering loss of eggs and/or progeny.

Duration:

Most effects to Nashville crayfish would be temporary during the pre-construction and construction phases; however, effects resulting in mortality of the species would be permanent. Habitat loss would likely be temporary. In instances where permanent loss of Nashville crayfish habitat would occur, it would be on a very minor level. Disturbance to downstream habitat from turbidity and/or deposition of sediment would usually be temporary in nature because with proper project planning and implementation and adherence to appropriate best management practices (BMPs), these conditions should improve when construction ceases and higher flows flush the system.

The effects of potential operational (i.e., hydrological) changes would not be known until sufficient post-project monitoring has been conducted to determine if individual projects resulted in any effects to Nashville crayfish or their habitat. The operational phase could potentially include a combination of temporary, long-term duration and/or permanent effects. Temporary effects might include, increased turbidity levels downstream of completed instream work during the first several days of operation. Whereas, long-term or permanent effects might include, changes in stream hydraulics and available habitat as a result of a project. Erosion from the embankement and spillway structure and failure (head-cutting, streambank sloughing, etc.) of the proposed regional detention basin outlet structure during the operations phase could result in either temporary effects (brief episodes of turbidity and/or sedimentation to downstream locations caused by minor, temporary erosion), long-term (continued turbid conditions and flushes of sediment covering habitat downstream due to ongoing stability issues), or permanent (the character of a stream channel would be permanently changed due to catastrophic bank failure).

Disturbance frequency:

Any disturbances to the Nashville crayfish during project pre-construction and construction phases would be anticipated to be restricted to periods varying from several days to several weeks, dependent upon the individual project scope. Proposed construction activities would have the potential to alter conditions like flow, turbidity and sediment deposition. Disturbances produced during the operational phase would generally be associated with routine operations and maintenance activities (e.g., bridge scour, increased water elevations upstream associated with flood events, accumulation of woody and other debris upstream of the embankment/outlet structure and scouring of the streambed at the downstream end of the outlet structure temporarily increasing turbidity in the water column, excavation of debris and gravel accumulations upstream of the outlet structure temporarily increasing downstream sediment deposition, etc.). Disturbances during the operations phase could vary in frequency from a one-time event, multiple occurrences, frequent occurrences or be continuous, depending upon the nature of the disturbance (e.g., disturbance frequency associated with structure and bank failures and subsequent downstream turbidity and sedimentation could be continuous if bank sloughing was ongoing).

Disturbance intensity:

The disturbance intensities would be highest in the direct effect areas where: (a) Nashville crayfish would be captured for relocation during the pre-construction phase, and (b) instream construction activities would occur during the construction phase. Such activities would potentially have the greatest risk of mortality or injury to the Nashville crayfish. The disturbance intensities during the construction phase would decrease downstream from project sites because the Nashville crayfish would be greater distances from project construction, and, therefore, there would be less risk of mortality or injury to the species. The disturbance intensities during the construction phase would be lowest in project areas located on small tributaries with poor water quality and little or no suitable habitat to support Nashville crayfish.

The total number of Nashville crayfish affected from the construction and operational phases of the proposed projects on an annual basis is anticipated to be small, relative to the entire Mill Creek population.

Disturbance severity:

The disturbance severities of the pre-construction phase of these projects (collection, handling, holding and relocation of Nashville crayfish) would be minimal since they would be temporary and only occur in the immediate vicinities of permitted projects.

Disturbance severities of the project construction and operations phases would vary dependent upon a number of factors including: (a) if projects would be constructed in previously disturbed or non-disturbed areas, (b) the size of areas disturbed relative to the range-wide geographic distribution of the species in the Mill Creek watershed, (c) if projects would provide benefits to the Nashville crayfish (i.e., if the Nashville crayfish or suitable habitat is known to occur in areas where projects would be implemented and project objectives focused on enhancing that habitat), and (d) if adequate Best Management Practices (BMPs) were in place and functioning as intended.

Analyses for Effects of the Actions

Beneficial effects:

Some elements of the proposed action could result in beneficial effects to the Nashville crayfish. For example, the removal of manmade structures that have historically impacted natural channel form and function would be restored by removing potential passage impediments to the Nashville crayfish. The construction of the regional detention basin also has the potential to provide beneficial effects by potentially increasing available aquatic habitats for the species within the basin.

Direct effects:

Nashville crayfish would need to be present in the immediate vicinity of project sites in order to be directly affected by the proposed actions. These activities have the potential to directly affect Nashville crayfish and suitable habitats within the project construction areas.

Collecting and handling individuals to remove them from potential construction effects in project footprints and relocate them outside of project areas could result in direct injury or mortality. This would include accidentally injuring or killing crayfish with sampling gear (crayfish attempting to pass through the mesh of seines, dip nets or block nets and becoming impinged in the openings), stepping on crayfish and crushing or injuring them during collection efforts, injuring them when obtaining life history information, holding them out of water for too long and/or in a collection container under crowded conditions.

Direct effects to Nashville crayfish from instream construction activities in the action areas are possible. Such activities could result in crayfish, which were inadvertently not discovered and relocated from project footprints during pre-project surveys, accidently being crushed or physically impaired (e.g., loss or damage to chelipeds, pereopods, swimmerets, etc.) by heavy equipment, workers or project construction components (bridge piers, sections of culvert, etc.) resulting in injury or mortality.

The widening of the existing Briley Parkway bridge could affect any Nashville crayfish, inadvertently not collected and relocated during sweeps, due to the demolition of the left overbank bridge spans dropping into Mill Creek and potentially crushing them and the removal of approximately 6,000 yds^3 of fill material. Concrete entering streams during re-construction of piers and abutments could cause mortality to any Nashville crayfish accidently not collected and relocated from the project footprint during pre-construction sweeps. During this project, construction pads may also extend into Mill Creek to provide equipment access. Temporary constriction of the channels which could result in bed scour and deposition of gravels and cobbles, may potentially impact Nashville crayfish habitat in the vicinity of the bridge.

The placement of fill material to accommodate the construction of the 800-ft. embankment, spillway and apron, and outlet structure could create turbid conditions and/or sediment deposition obstructing the gills of Nashville crayfish and reducing their ability to feed and grow, resulting in injury or mortality. Nashville crayfish habitat could also be impacted as a result of substrate embeddedness from sediment deposition and temporary dewatering of stream channels.

Projects utilizing cofferdams cause short-term loss of habitat when areas within cofferdams are dewatered. Any Nashville crayfish inadvertently not removed and relocated, prior to construction of cofferdams and remaining within cofferdams, would be directly affected. Mortality would occur as the trench was excavated or if crayfish were trapped in dewatered areas within the cofferdams.

Work activities in riparian areas and riparian areas of influence could result in runoff of sediment into streams, creating turbid conditions and/or sediment deposition in the immediate vicinity of projects. These activities could potentially directly affect Nashville crayfish by obstructing their gills, resulting in injury or mortality. Stabilization activities through placement of rock riprap could result in direct mortality to crayfish by crushing or injuring them.

Direct effects to Nashville crayfish could also occur if pollutants (spills of petroleum products from hydraulic, fuel and power systems, etc. or concrete) accidentally entered streams from construction equipment adjacent to project sites (in equipment staging areas and on streambanks), resulting in injury or mortality.

In summary, the following direct effects to the Nashville crayfish are possible:

1. Injury or mortality as a result of handling and collection of individuals during capture and relocation.

2. Injury or mortality to individuals remaining within project construction footprints (inadvertently not collected and relocated during pre-construction sweeps), resulting in them being crushed or becoming physically impaired by instream construction activities

3. Injury or mortality as a result of turbidity and/or deposition of sediment, created by instream construction activities within project construction footprints (bridge removal and re-construction, embankment and outlet construction, cofferdam construction) and construction activities in the immediate project vicinities adjacent to the stream (removal of riparian vegetation and streambank stabilization projects in riparian areas and riparian areas of influence) obstructing crayfish gills and reducing their ability to feed or grow.

4. Injury or mortality as a result of pollutants from construction equipment accidentally entering streams in or adjacent to construction sites, affecting water quality and food sources, and in turn respiration and feeding capabilities.

5. Reproductive loss (mating, spawning, egg release, and egg incubation and hatching) as a result of implementing construction activities between October 1 and May 30, the reproductive period for the species.

The Service estimates that it is probable that Nashville crayfish could be directly affected by the proposed action because collection records indicate that Nashville crayfish have been collected throughout the action areas at various times in the recent past. Therefore, based on past occurrence records of the species, we assume that the species would likely occur in direct effect areas.

Interrelated and interdependent actions:

No interrelated and interdependent actions have been identified for this project.

Indirect effects:

The Mill Creek drainage is located in an area containing karst habitat. Nashville crayfish downstream of proposed construction sites could potentially be indirectly affected by blasting or drilling for placement of bridge pier footings which could result in the fracturing of bedrock. Fracturing bedrock in streams can result in loss of surface water flows over a portion of a stream channel, resulting in dewatered stream reaches, which in turn, may isolate Nashville crayfish habitat and create migration barriers.

Construction activities adjacent to and within Mill Creek and Sevenmile Creek could also indirectly affect Nashville crayfish by introducing sediment into streams where it could potentially create turbid conditions and/or sediment deposition downstream of projects. Removal of vegetation could increase the amount of sediment runoff into streams, impacting downstream habitat. The elimination of riparian vegetation, which stabilizes streambank soils, provides insect drop, shades streams and provides future recruitable large wood debris (a source of instream cover and organic detritus for aquatic macroinvertebrates to feed upon), may also contribute to short-term indirect effects from loss of cover, available prey, and stream function.

Instream and near stream activities have the potential to alter habitat and obstruct the gills of Nashville crayfish, residing downstream, reducing their ability to feed and grow, resulting in injury or mortality. Crayfish displaced by these disturbances might attempt to move into areas already inhabited by Nashville crayfish and compete for available food and shelter; if relocated individuals were unable to find suitable habitat, they would likely be more vulnerable to predators.

Adverse and long-term impacts to stream habitat by the alteration of natural channel form and function are possible.

Nashville crayfish downstream of proposed project construction areas could also be indirectly affected by accidental spills of petroleum products from hydraulic, fuel and power systems or concrete entering streams resulting in injury or mortality. This could occur as a result of petroleum products entering streams from project construction equipment adjacent to sites (in staging areas and operating on streambanks), affecting water quality and food sources, and in turn respiration and feeding capabilities.

Nashville crayfish could be indirectly affected during flood mitigation operations on Sevenmile Creek phase resulting in injury. If the proposed spillway and outlet structure are incorrectly engineered or installed, hydraulic changes could redistribute substrate and decrease available habitat. Potential malfunctions may cause head-cutting, scouring and streambank sloughing, resulting in increased turbidity levels and/or deposition of sediment in downstream reaches occupied by Nashville crayfish. Scouring could occur at the upstream end of the detention basin or the downstream end of the outlet, resulting in elevation differences, preventing movement of Nashville crayfish during low flows and affecting their ability to occupy other areas containing suitable habitat. The detention basin and outlet structure could accumulate debris that is carried downstream during high flow events, which could also impede passage of Nashville crayfish.

Nashville crayfish, removed from proposed construction sites and relocated to other areas, could be indirectly affected. The crayfish might potentially be relocated to sites where resident Nashville crayfish already occur at high densities, increasing competition for food and shelter. Crayfish remaining in project areas outside of cofferdams could abandon their habitat in response to construction disturbances and move into less suitable habitat.

1. Injury downstream as a result of turbidity and/or deposition of sediment, created by project construction activities taking place further upstream, compelling individuals to relocate to less suitable habitat outside of the action area.

2. Injury or mortality as a result of pollutants (spills of petroleum products from hydraulic, fuel and power systems, etc.) accidentally entering streams from project construction equipment, affecting water quality and food sources, and in turn respiration and feeding capabilities of Nashville crayfish residing downstream of project activities.

3. Injury as a result of flawed engineering designs or improper installations, resulting in failure of structural components and subsequent loss of habitat (hydraulic changes which redistribute substrate and decrease available habitat, head-cutting, streambank sloughing, etc. causing erosion and siltation to downstream habitat, surface flows leaching into bedrock fractures, or streambanks sloughing into streams.

4. Injury as a result of being disrupted from their normal behavior patterns (including breeding, feeding or sheltering) and becoming stressed.

5. Injury or mortality as a result of relocating individuals from proposed construction sites to areas inhabited by existing resident Nashville crayfish where increased competition for food and shelter could potentially result in mortality from predation and starvation.

6. Reproductive loss (mating, spawning, egg release, egg incubation and hatching) as a result of implementing pre-construction and/or construction activities between October 1 and May 31, the reproductive period for the species.

The Service believes that indirect effects from the proposed action could potentially lead to individual Nashville crayfish being affected within the action area. However, those indirect effects would not significantly reduce the Nashville crayfish population level in the action area or reduce recovery of the species.

Species' Response to Proposed Actions

<u>Numbers of individuals/populations in the action area affected</u>:
Specific information concerning the size of the existing Nashville crayfish population in Mill Creek and Sevenmile Creek is neither comprehensive nor current, but previous surveys and studies indicate that the species persists throughout these stream reaches. Population estimates for

Nashville crayfish, based on surveys conducted from July 1999 through August 2001, ranged from 1,854 to 3,217 individuals per 100 m (328 ft) at various sites containing suitable habitat in mainstem Mill Creek and from 404 to 1,425 individuals per 100 m at a site in Sevenmile Creek. Overall, it was determined that population densities may have been as high as 1,000 to 2,000 individuals per 100 m (Carpenter 2002). Results of surveys conducted between 1988 and 2003 indicate that the Nashville crayfish occurs primarily in the middle-to-upper reaches of the Mill Creek system. During that period, approximately 60 individuals were collected within the lower 5 mi of Mill Creek, while more than 5,400 individuals were collected at 16 sites between Mill Creek mi 7.5 and 20.5 (U.S. Fish and Wildlife Service 2011).

The Nashville crayfish population in Mill Creek and Sevenmile Creek cannot be accurately estimated at this time because: a) Nashville crayfish do not occur in all stream reaches within the Mill Creek drainage, b) the number of individuals occupying suitable habitat varies among stream reaches where they are known to occur, c) the most recent population estimates are based on data collected more than a decade ago (Carpenter 2002), and d) many stream reaches have never been or have not recently been surveyed.

Sensitivity to change:

Crayfish, including Nashville crayfish, have the ability to swim to other areas to avoid disturbances and associated potential effects under most circumstances (e.g.., sediment obstructing gills). However, Nashville crayfish hatchlings, which would occupy the action area during late spring through early summer, could be at risk if they would become separated from their mothers because they lack the ability to independently relocate out of harm's way during their first few weeks of life. Adult and juvenile Nashville crayfish could potentially become stranded in dewatered stream reaches as a result of bedrock being fractured during project construction. Also, crayfish relocated during collection and relocation efforts or crayfish which would move due to project disturbances could be forced to reoccupy sub-optimal habitat, potentially affecting their long-term survival.

Resilience:

Resilience relates to the characteristics of populations or a species that allow them to recover from different magnitudes of disturbance. The Nashville crayfish is assumed to be a resilient species, given its persistence in highly impacted watersheds, such as Mill Creek and Sevenmile Creek. Assuming that habitat conditions in the action areas would not appreciably change as a result of pre-construction (relocation of individuals), construction and operation of the proposed project (magnitude of disturbance would likely be low), the Nashville crayfish would be expected to recolonize the reaches disturbed by the proposed actions.

Recovery rate:

In this biological opinion, the recovery rate relates to the time required for the Nashville crayfish population to return to equilibrium after exposure to disturbance. Project disturbances would be expected to temporarily reduce the reproductive potential of the species. However, the recovery rate for Nashville crayfish would be expected to be fairly rapid (within one to two years).

CUMULATIVE EFFECTS

Cumulative effects include the effects of future state, tribal, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation under section 7 of the Act.

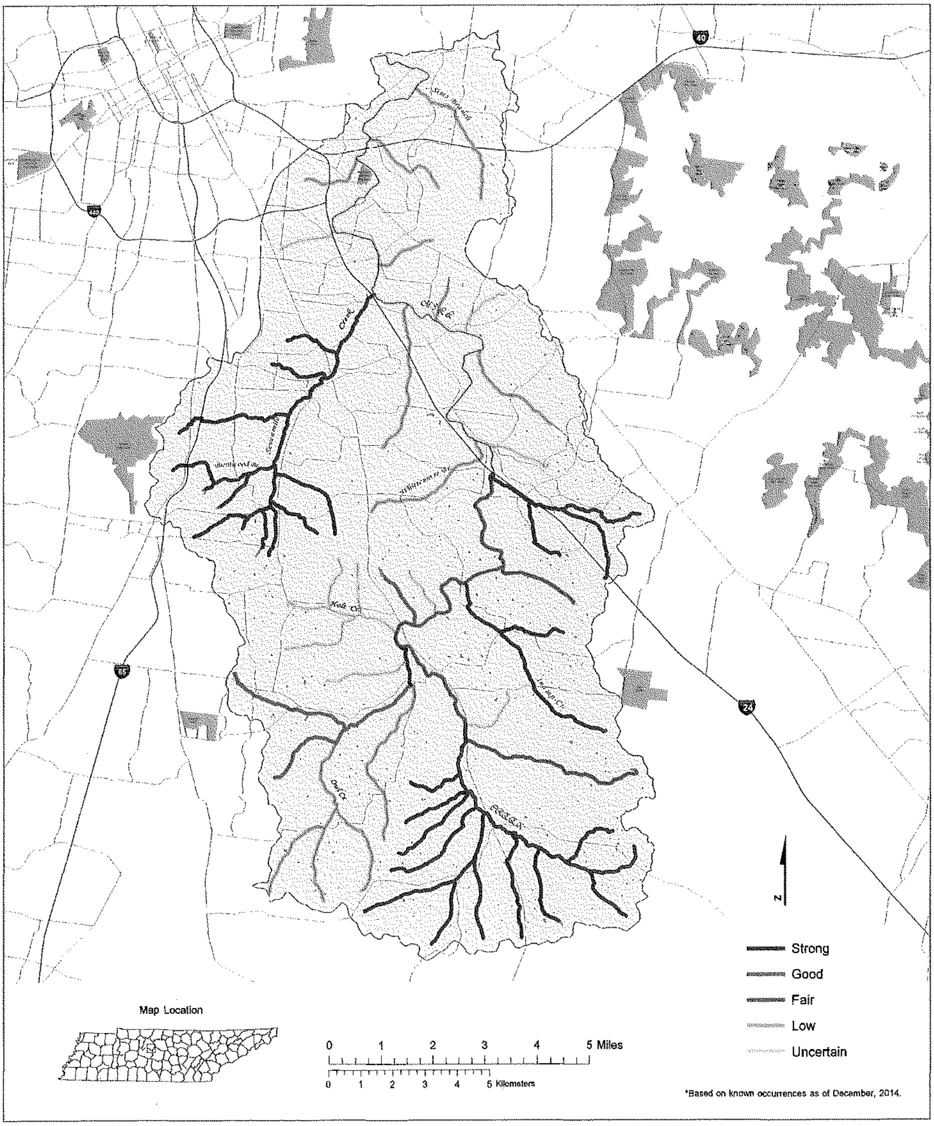
The action areas consist of the areas that would encompass the proposed project construction footprints and downstream reaches of Mill Creek RM 7.1 (Figure 1) and Sevenmile Creek RM 3.67 (Figure 2) in Davidson County, Tennessee. The Metropolitan Nashville area continues to undergo significant development. Past activities have likely been implemented within the watershed by state, local and private entities that have impacted streams and affected native fauna; such activities had no federal involvement. Additional similar activities are likely to occur in the future, and cumulative effects from these activities are likely to continue into the foreseeable future at a comparable pace. The Service is actively engaged in discussions with various entities in the Mill Creek drainage in an attempt to evaluate these types of activities and develop measures to minimize their effects.

CONCLUSION

After reviewing the current status of the Nashville crayfish, the environmental baseline for the action areas, the effects of the proposed actions, and the cumulative effects, it is the Service's biological opinion that the preferred alternative would not likely jeopardize the continued existence of the Nashville crayfish because: 1) Nashville crayfish would be relocated short distances upstream of construction activities into suitable habitat and restricted from reentering project sites during construction to minimize mortality, 2) construction activities associated with these projects would include required minimization measures to reduce the potential for Nashville crayfish mortality and permanent destruction or alteration of its habitat, 3) necessary permits would require that no instream work occur from October 1 through May 31 to assure that the Nashville crayfish's reproductive activities would not be affected and that potential effects to hatchlings would be minimized, and 4) Nashville crayfish have persisted in Mill Creek and Sevenmile Creek despite development activities and accidental spills/releases occurring for many years. Therefore, it is unlikely that the proposed projects would result in significant declines in its population.

No critical habitat has been designated for this species; therefore, none would be affected.

Figure 3. Assumed Status of Nashville Crayfish Populations



INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation under section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by the USACE, the Tennessee Department of Transportation, Metro Nashville Water Services, or their designated contractors so that they become binding conditions of any permit issued, as appropriate, for the exemption in section 7(o)(2) to apply. The USACE has a continuing duty to regulate the activities covered by this incidental take statement. If the USACE: (1) fails to assume and implement the terms and conditions or (2) fails to require contractors to adhere to the terms and conditions (T&Cs) of the incidental take statement through enforceable terms that are added to permits, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the USACE and contractors must report the progress of the actions and their impacts on the species to the Service as specified in the incidental take statement. [50 CFR Section 402.14(I)(3)]

AMOUNT OR EXTENT OF TAKE ANTICIPATED

We cannot anticipate the exact extent of incidental take of Nashville crayfish. As we have stated in previous site-specific biological opinions regarding Nashville crayfish, we expect incidental take of Nashville crayfish would be difficult to detect for the following reason(s): (1) the Nashville crayfish is a small, secretive animal, spending much of its life under cover on the stream bottom (under rocks, logs, in bedrock crevices, etc.); (2) locating a dead or injured individual would be difficult; and (3) if a dead or injured individual were found, it would be difficult to attribute death or injury to a particular project-related activity.

However, incidental take of Nashville crayfish can be anticipated from relocating individuals or from loss or degradation of suitable habitat as a result of permitted construction activities. The Service believes that if Nashville crayfish are present in the impact area of a proposed action, relocation efforts and/or destruction or alteration of habitat within the impact area would result in incidental take of the species. It should be noted that those crayfish would likely not all be lethally taken, but rather the take would most often be in the form of harm, harassment, and capture, resulting from habitat impacts and relocation of Nashville crayfish. While we cannot, at this time, quantify such take, we do request that the USACE and its contractors monitor removal and relocation sites and levels of habitat disturbance with the following assumptions.

Streams most likely to support Nashville crayfish account for a total of approximately 192 stream mi in the Mill Creek drainage, including approximately 27 mi of the Mill Creek mainstem and 165 mi of tributaries (determined from a December 2014 analysis of occupancy data performed cooperatively by the TFO and the Tennessee Department of Environment and Conservation). Figure 3 illustrates the best available information regarding population status of Nashville crayfish in the Mill Creek drainage (USFWS 2014). Stream reaches in Figure 3 are designated as "strong", "good", "fair", "low" and "uncertain", relative to the current estimated status of Nashville crayfish populations (i.e., abundance and robustness) in these areas; the status of Nashville crayfish populations is unknown in stream reaches indicated as "uncertain".

Based on recent formal consultations involving Nashville crayfish in the Mill Creek drainage (a total of nine in 2012-2013, see incidental take table in Appendix A), a typical USACE permitted project (e.g., bridge replacement, single utility line crossing, streambank stabilization, etc.) in these stream reaches impacted an average length of approximately 971 linear ft of stream (including the removal and release sites for Nashville crayfish). However, the following level of incidental take of this species can be expected to include loss of suitable habitat, relocation of individuals upstream, and sedimentation/erosion downstream. The width of the Mill Creek channel, designated as good, at the Briley Parkway bridge is approximately 100 ft. Combined with the approximate 200 ft length of fill material and bridge spans to be removed and reconstructed, approximately 20,000 ft^2 of suitable habitat would be directly affected. Adverse impacts would be expected to extend approximately 600-ft. upstream and downstream of the bridge which equates to 120,000 ft^2 of suitable habitat. Therefore, the total project impact area is estimated to be approximately 140,000 ft^2.

The channel width of Sevenmile Creek, designated as strong, is approximately 30 ft. Combined with the projected project footprint of 220 ft. (i.e., 110 ft. upstream and 110 ft. downstream of the existing bridge), approximately 6,600 ft^2 of suitable habitat would be directly affected. Adverse impacts would be expected to extend approximately 700-ft. upstream and downstream of the bridge (i.e., relocation of crayfish upstream and construction-related impacts downstream) which equates to 21,000 ft^2 of suitable habitat. Therefore, the total project impact area is estimated to be approximately 27,600ft^2.

Based on the comparatively high densities of Nashville crayfish in these areas in relation to many other areas in the Mill Creek watershed sampled by Carpenter (2002), the Service assumes that suitable habitat for Nashville crayfish exists throughout 60% of stream bottom in Mill Creek and 70% of stream bottom in Sevenmile Creek. Relocation of the species into areas already occupied by crayfish will also result in take. Crayfish vigorously defend territories. Crayfish introduced into those areas will likely be displaced and may not find suitable cover. Those individuals may disperse throughout the affected stream habitat (Mill Creek and Sevenmile Creek combined areas) to find habitat. Therefore, the Service anticipates that Nashville crayfish could be taken in 167,600 ft^2 of stream channel habitat due to project effects. The Service further estimates that all Nashville crayfish in 26,600 ft^2 of stream channel habitats would be taken in the form of lethal take; Nashville crayfish in the remaining 141,000 ft^2 impact area would be taken in the form of harassment, harm, and capture.

For this consultation, we have determined the allowable incidental take of Nashville crayfish within Mill Creek (good) and Sevenmile Creek (strong). Therefore, the Service has determined that allowable incidental take of all Nashville crayfish in approximately 1,300 linear ft of suitable habitat comprising 167,600 ft^2 would occur as outlined in Table 3.

Table 3. Anticipated incidental take by project area.

STREAM REACH	INCIDENTAL TAKE BY STREAM REACH (1)	ESTIMATED AMOUNT OF SUITABLE HABITAT AFFECTED BY PROJECTS (2)
Mill Creek RM 7.1	All Nashville crayfish within 600 linear ft	140,000 ft^2
Sevenmile Creek RM 3.67	All Nashville crayfish within 700 linear ft	27,600 ft^2

(1) Total incidental take is estimated at 1,300 linear ft of stream channel habitat.
(2) Suitable habitat is estimated to be approximately 100% of incidental take per stream reach.

In the "Analyses for Effects of the Action" section, the Service determined that the proposed action would result in incidental take of Nashville crayfish in several forms including:

(a) lethal from: 1) handling and collection of individuals during capture and relocation, 2) heavy equipment and workers performing instream work activities crushing individuals, 3) increased turbidity and/or deposition of sediment as a result of instream or near stream work activities obstructing crayfish gills and reducing their ability to feed, 4) pollutants accidentally entering the stream as a result of spills of petroleum products from construction equipment working instream, on adjacent streambanks and in staging areas, affecting water quality and food sources, and in turn respiration and feeding capabilities of individuals, and 5) relocating individuals to areas inhabited by existing resident Nashville crayfish with increased competition for food and shelter, resulting in death from predation or from fighting with other crayfish and/or starvation;

(b) harassment from: 1) handling and collection of individuals during capture and relocation, 2) increased turbidity and/or deposition of sediment as a result of construction activities compelling crayfish to relocate to less suitable habitat outside of the action area, 3) increased turbidity and/or deposition of sediment as a result of instream or near stream work activities obstructing crayfish gills and reducing their ability to feed or grow, 4) pollutants accidentally entering the stream as a result of spills of petroleum products from construction equipment working instream, on adjacent streambanks and in staging areas affecting water quality and food sources, and in turn respiration and feeding capabilities, 5) flawed engineering designs or improper installations, resulting in failure of permitted habitat modifications, channel adjustments and structures during the operations phase (post-project), 6) disruption from their normal behavior patterns (including breeding, feeding or sheltering), 7) relocating individuals to areas inhabited by existing resident Nashville crayfish with increased competition for food and shelter, 8) heavy equipment and workers performing instream work activities resulting in physical impairment, and 9) potential reproductive loss as a result of implementing construction activities during the reproductive period for the species;

(c) harm from: 1) handling and collection of individuals during capture and relocation, 2) heavy equipment and workers performing instream work activities resulting in physical impairment, 3) increased turbidity and/or deposition of sediment as a result of instream or near stream work activities obstructing crayfish gills and reducing their ability to feed or grow, 4) pollutants accidentally entering the stream as a result of spills of petroleum products from construction equipment working instream, on adjacent streambanks and in staging areas, affecting water quality and food sources, and in turn respiration and feeding capabilities, 5) potential reproductive loss as a result of implementing construction activities during the reproductive period for the species, 6) disruption from their normal behavior patterns (including breeding, feeding or sheltering), and 7) relocating individuals to areas inhabited by existing resident Nashville crayfish with increased competition for food and shelter.

(d) capture from: 1) handling and collection of individuals during capture and relocation, and 2) relocating individuals to areas inhabited by existing resident Nashville crayfish with increased competition for food and shelter.

EFFECT OF THE TAKE

In the accompanying biological opinion, we determined that this level of expected take is not likely to result in jeopardy to the Nashville crayfish and would not result in destruction or adverse modification of designated critical habitat.

Previous biological opinions, completed by the TFO for Nashville crayfish populations, which identified incidental take, have been included in the table in Appendix A.

REASONABLE AND PRUDENT MEASURES

We believe the following reasonable and prudent measures (RPMs) are necessary and minimize impacts of incidental take of Nashville crayfish:

1. The USACE must ensure that their approved and permitted contractors implement measures to minimize or eliminate effects from pre-construction and construction activities and to reduce the potential for effects during the operational phase (post-construction period) of these projects.
2. The USACE, the Tennessee Department of Transportation (TDOT), and Metro Water Services, and their contractors must ensure that the level of Nashville

crayfish take associated with individual proposed actions is adequately monitored and reported to the Service.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the USACE and its contractors must comply with the following T&Cs, which carry out the RPMs described above and outline required reporting and monitoring requirements. These T&Cs are non-discretionary.

1. Based upon the avoidance/minimization measures outlined in the USACE biological assessment and potential effects identified and discussed in the "Effects of the Action" of this biological opinion, the USACE will agree to the following conditions being implemented on permits issued for the proposed projects in Mill Creek and Sevenmile Creek to avoid or minimize project effects to the Nashville crayfish:

    a. The USACE will implement the proposed actions as described in the Draft Integrated Feasibility Report for the Mill Creek Flood Risk Management Study, the biological assessment, the biological assessment's supporting documentation, and this biological opinion and adhere to the most recent and up-to-date BMPs, including redundant Erosion Prevention and Sediment Control (EPSC) measures (i.e., double-up on EPSC measures at all streams) to help prevent materials from entering Mill Creek and Sevenmile Creek. This may include revising the required SWPPP (Storm Water Pollution Prevention Plan) as necessary throughout the duration of the project. A Spill Prevention Control and Countermeasure Plan (SPCCP) will be prepared by the construction contractor, provided to the USACE or TDOT and forwarded to the Service, prior to commencement of construction activities. This plan will include, at a minimum, a description of BMPs and preventive measures (such as personnel training, equipment inspection, and refueling procedures) to reduce the likelihood of spills and detailed mitigative measures (such as containment and clean-up) to minimize potential effects should a spill occur. The SPCCP will be prepared regardless of the volume of petroleum products and stored on site, as an added measure to protect the Nashville crayfish. USACE Quality Assurance (QA), TDOT, or Metro Water Services inspectors will conduct site visits twice weekly. Inspections will be documented and available for the Service to review upon request. This Term and Condition supports RPMs 1 and 2.

2. A qualified aquatic biologist, holding a valid U.S. Fish and Wildlife Service 10(a)(1)(A) permit to survey for Nashville Crayfish, shall collect all Nashville crayfish observed from the project footprint and from the 100-ft section of stream immediately downstream of the footprint. Crayfish will be collected and relocated prior to instream construction and within one hour of installation of project exclusion barriers (i.e., cofferdams, block nets, etc.).

a. Captured crayfish (Nashville crayfish and all other species) will be relocated into suitable habitat a minimum of 150 ft upstream of the furthest upstream project exclusion barrier. Crayfish in collection buckets will be closely monitored to prevent stress from crowding. Water in collection buckets will be changed as needed to maintain overall water quality and ensure that it is the same or close to temperatures at capture sites and acclimated to temperatures at release sites by gradually adding water from the release sites. If a crayfish appears to be severely stressed or impaired, that individual will be held until it recovers sufficiently and not released until there is some certainty that it will survive when placed back into the stream.

b. Electrofishing "will not" be employed as a collection method to minimize potential injury and mortality to crayfish. Seining and dip netting will be acceptable methods of collecting Nashville crayfish. If crayfish become impinged in the mesh openings of seines or dip nets, they will be gently removed to minimize harm.

c. A report must be provided to the Service, summarizing collection and removal activities of the species, which will include the number, form (I or II), estimated age class and sex of Nashville crayfish collected and relocated, observations of gross deformities, descriptions of any injuries or mortality (incidental take) due to relocation efforts, and identification of collection and relocation sites (specify coordinates and measured areas). A qualified biologist shall be present during all Nashville crayfish relocation activities and available as needed to monitor project construction activities. The U.S. Fish and Wildlife Service's Tennessee Ecological Service's Field Office in Cookeville, Tennessee (telephone: 931/528-6481), can provide a list of qualified aquatic biologists to assist project proponents with identifying Nashville crayfish and their habitat, collecting and relocating Nashville crayfish and monitoring construction activities, upon request.

3. Cofferdams or other methods to prevent re-entry of Nashville crayfish into project sites during instream construction will be installed upstream of areas where Nashville crayfish have been removed, immediately (within one hour) following collection and relocation of crayfish. Flows shall be diverted around the construction zone through appropriately sized piping and cofferdams should completely enclose the work site(s) to pump flows across the dewatered area(s). Cofferdams from clean (free of fines), durable rock, or bags filled with clean sand, or water-inflated temporary dams. Blocks nets are acceptable for temporary use until cofferdams are in place.

   a. If block nets are used, they will remain in place and be maintained as needed (debris will be cleaned from them and they will be checked frequently to insure that they are spanning the wetted channel and remain in upright positions with lead lines secured to stream bottoms). If crayfish become impinged in the mesh openings of block nets, they will be gently removed to minimize harm. If difficulties arise with keeping block nets upright and across streams during project construction, project proponents will immediately contact the USACE and Service to discuss optional exclusion approaches (construction of coffer dams, etc.). This T&C can be disregarded if no water is present in streams at the time of collection and relocation.

4. Removal of riparian vegetation will be kept to a minimum. Disturbed streambanks shall be stabilized as soon as possible by seeding, planting and placement of straw mulch or riprap. Use of bioengineering methods (soft, vegetative approaches) is preferred for long-term stabilization of streambanks and is recommended over excessive use of hard structures (e.g., riprap) to minimize potential impacts to Nashville crayfish and other aquatic organisms, water quality, and riparian and instream habitats. Bioengineering techniques might include, but not be limited to, use of geotextile fabrics, layering with willow cuttings, construction of brush mattresses, fascines or vegetated geogrids, joint-planting willows into riprap, and use of a stinger to plant cuttings on upper streambanks.

5. Any fill materials removed (e.g., existing wingwalls, stream bed substrate, etc.) during construction will be temporarily placed outside of the active flow channel and floodplain at a minimum distance of the first terrace to ensure that runoff into the stream from the materials does not occur. These materials will either be reincorporated into the project during construction or removed off-site immediately following completion of project construction.

6. If water is to be pumped from the instream work site(s), the water shall be held in constructed settling basins or filtered to ensure it is clean prior to its discharge into surface waters

7. An aquatic biologist or hydrologist will be present to monitor pH levels in the stream during pouring of any concrete or placement of riprap in or near streams. If spillage or leakage of concrete into streams is observed, pouring will cease immediately and will not resume until the source of the spill or leak is found, the U.S. Fish and Wildlife Service's Tennessee Ecological Service's Field Office in Cookeville, Tennessee (telephone: 931/528-6481) is notified within 24 hours of the discovered spill or leak, and corrective action is taken to prevent further spillage or leakage.

8. All instream work activities, including construction and pre-construction activities (e.g., collection and relocation of crayfish), are restricted to a June 1 through September 30 work period.

9. The USACE will ensure post-construction monitoring at project sites is conducted annually within a five-year timeframe. The purpose of the monitoring will be twofold: 1) to ensure conditions within the project footprints have been restored to acceptable conditions, so that Nashville crayfish habitat quality and amount is comparable to conditions present prior to the permitted construction, and 2) to determine whether Nashville crayfish are able to persist throughout the action area. Monitoring should commence and be documented relatively soon after completion of construction. However, the restored habitat must remain stable and undisturbed through at least three high flow events.

10. Upon locating a dead, injured, or sick individual of an endangered or threatened species, initial notification must be made to the Service's Law Enforcement Office in Nashville,

Tennessee (telephone: 615/736-5532). Additional notification must be made to the Service's TFO in Cookeville, Tennessee (telephone: 931/528-6481). Care should be taken in handling sick or injured individuals and in the preservation of specimens in the best possible condition for later analysis of cause of death or injury.

The RPMs, with their implementing T&Cs, are designed to minimize the effect of incidental take that might otherwise result from the proposed action. The Service believes that no more than all Nashville crayfish within 600 linear ft of Mill Creek and 700 linear feet of Sevenmile Creek will be incidentally taken during the pre-construction, construction, and operational phases of the projects. New project information may require the re-initiation of consultation and review of the RPMs provided. The USACE should immediately provide an explanation of any modifications to the proposed projects and review with the Service the need for possible modification of the RPMs.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs federal agencies to use their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help carry out recovery plans, or to develop information.

We offer the following conservation recommendation(s) for consideration:

1. The USACE should provide funds to monitor the Nashville crayfish and study its life history and ecological requirements. Information obtained from such monitoring studies would be valuable in directing actions and measures that provide protection to the species and its habitat during future development projects and would contribute toward recovery of the species.
2. Stream reaches identified as "low" and "fair" on Figure 3 should be prioritized by the USACE for habitat enhancement projects that should be implemented as to increase available suitable habitat for the Nashville crayfish in the Mill Creek watershed.
3. The USACE should participate in meetings with representatives from the metropolitan Nashville government, Service, TDEC, TWRA and others to develop a plan to conserve and protect aquatic habitat in the Mill Creek drainage and the Nashville crayfish. Development and implementation of such a plan would guide future development and other activities in the drainage and would contribute toward protection and recovery of the Nashville crayfish.
4. The USACE should make a concerted effort to utilize existing programs to raise awareness and promote conservation of the Nashville crayfish among private landowners, permit applicants and non-federal entities carrying out actions in the Mill Creek drainage. Mill Creek and its tributaries are under heavy development

pressure that could alter much of the aquatic habitat in the drainage and potentially drive the species to extinction. Outreach activities would be invaluable in making residents and developers in the drainage aware of the Nashville crayfish and the need to protect aquatic habitat in the Mill Creek drainage.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, the Service requests notification of the conservation recommendations carried out.

RE-INITIATION NOTICE

This concludes formal consultation on the actions outlined in the consultation request. As written in 50 CFR Section 402.16, reinitiation of formal consultation is required where discretionary USACE involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded (all Nashville crayfish within 2,000 linear ft of suitable habitat); (2) new information reveals effects of the USACE actions that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the proposed USACE projects are later modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the actions. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease until reinitiation.

For this biological opinion the incidental take would be exceeded when the take annually exceeds all Nashville crayfish within 2,000 linear feet of suitable Nashville crayfish habitat, which is what has been exempted from the prohibitions of section 9 by this biological opinion. We appreciate the cooperation of the USACE during this consultation. We would like to continue working with you and your staff regarding this action. For further coordination please contact Steve Alexander of my staff at 931/525-4980.

Mary E. Jennings — 3/23/15

Mary E. Jennings, Field Supervisor — Date

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APPENDIX A

The following list includes previous biological opinions, issued for adverse effect and completed for Nashville crayfish populations within Tennessee, which identified incidental take:

OPINIONS (year/number)	INCIDENTAL TAKE NUMBER	CRITICAL HABITAT	HABITAT
1994/1	No more than 25% of the total number of individuals present in the project area	N/A	
2002/1	No more than 2% of the total number of individuals present in the project area	N/A	
2002/1	No more than 3 individuals at each crossing	N/A	
2002/1		N/A	No more than 0.5-ac of suitable habitat
2003/1	None specified	N/A	None specified
2004/1	No more than 5 individuals	N/A	
2008/2		N/A	No more than 0.5-ac of suitable habitat
2008/2		N/A	No more than 620 linear ft of suitable habitat
2009/1		N/A	No more than 3,145 linear ft of Mill Creek affected, resulting in the loss of 315 lf of suitable habitat
2009/1		N/A	No more than 4,320 ft^2 of habitat at Mill Creek crossings or 1,120 ft^2 of habitat at the tributary crossings
2009/1		N/A	No more than the Nashville crayfish occupying 215 ft^2 of the

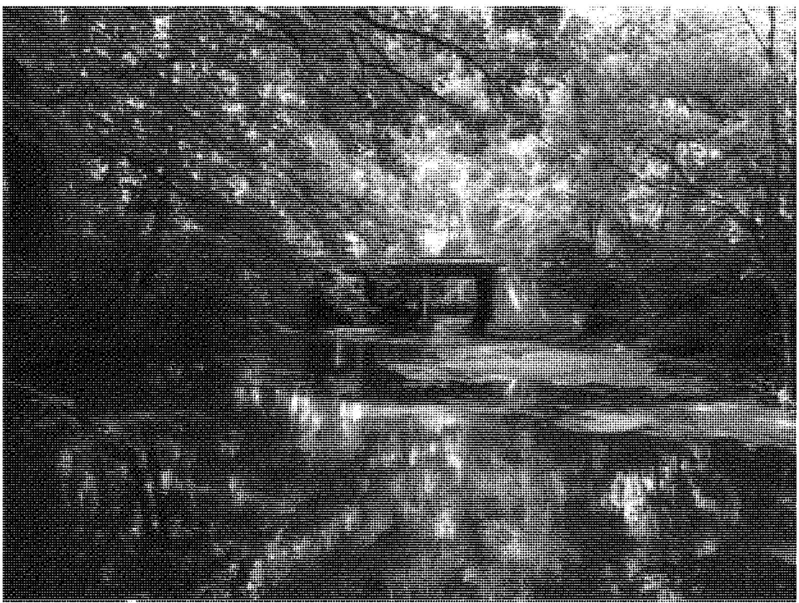
			bottom of the Sims Branch pond
2010/1		**N/A**	**No more than 1,260 ft^2 of Nashville crayfish habitat**
2011/1	**No more than 20 individuals per year as a result of collection, holding, and relocation**	**N/A**	**Loss of 0.5% of suitable habitat from which crayfish are removed at all project sites per year**
2011/1	**No more than 2 individuals**	**N/A**	
2012/5		**N/A**	**No more than 45,654 ft^2 (6,906 linear ft) Nashville crayfish habitat**
2013/4		**N/A**	**No more than 4,466 ft^2 (1,833 linear ft) Nashville crayfish habitat**

US Army Corps
of Engineers®
Nashville District

BIOLOGICAL ASSESSMENT

Mill Creek Flood Risk Management Feasibility Study
Mill Creek and Sevenmile Creek
Davidson County

20 October 2014



For Further Information
Contact:

Matthew Granstaff, Biologist
U.S. Army of Engineers
Nashville District
Project Planning Branch
Telephone: (615) 736-7857

Table of Contents

1.0 Introduction

1.1 Study Information

The U.S. Army Corps of Engineers (Corps) has developed a Feasibility Report for the Mill Creek Watershed. The purpose of this report is to analyze potential solutions for the flood risk management problems in the Mill Creek watershed, Nashville, Tennessee. The report presents the flood risk management problems and opportunities within the Mill Creek watershed as well as the measures and alternatives considered to reduce damages within the region. The study was conducted in conjunction with the Metropolitan Government of Nashville and Davidson County (Metro) serving as the non-Federal sponsor, and the Corps.

1.2 Problem

The City of Nashville experiences damages from flash floods due to historic encroachment into the floodplain. This encroachment causes a loss of flood storage capacity and insufficient flow capacity or flow restrictions along Mill Creek and its tributaries. The area along Mill Creek is heavily urbanized and includes extensive infrastructure associated with commercial, industrial, and residential developments. As the loss of floodplain storage in the watershed continues to increase, each major flood will incur damages to a larger number of structures resulting in greater economic damages to the region.

1.3 Objectives

The objective of the study was to reduce flood risk and improve the overall quality of life for the residents of Nashville, Tennessee and surrounding communities. The planning objectives are as follows:

- Reduce overall flood damages in the Mill Creek watershed from 2015 to 2065.
- Reduce residual risk in Mill Creek by removing property and people from the floodplain.
- Increase flood attenuation opportunities in the Mill Creek Watershed through 2065.
- Restore riparian and floodplain connections along Mill Creek and tributaries through 2065.

2.0 Watershed Description

Located in one of the most rapidly urbanizing areas of Middle Tennessee, the 108-square mile Mill Creek Watershed drains about 13% of Nashville, Davidson County, Tennessee and 6% of Williamson County, Tennessee. The watershed has a teardrop shape, is about 18 miles long and averages 6 miles wide. A study area map is included in Figure 1. About two thirds of the watershed is within Davidson County, one third in Williamson County and a small headwater area extends into Rutherford County.

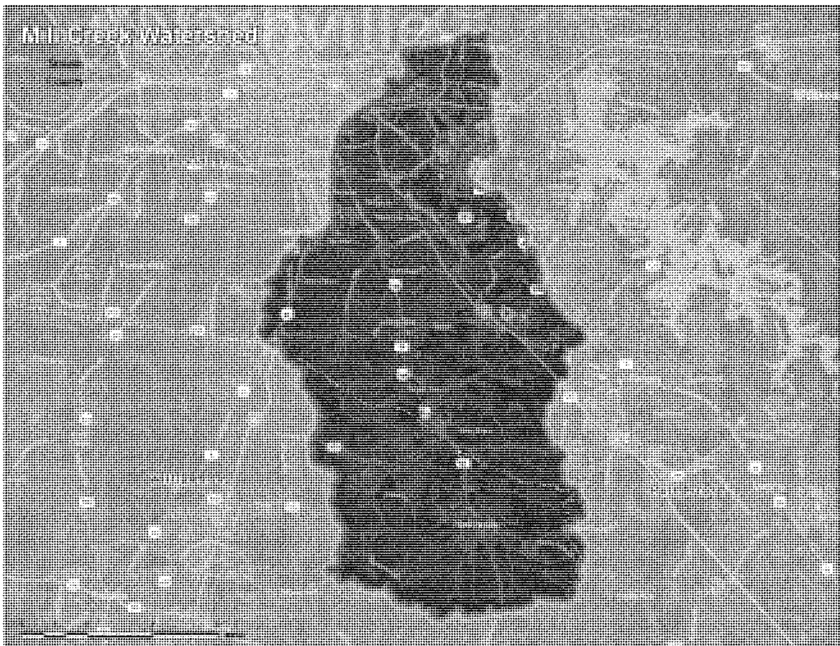


Figure 1. Mill Creek Watershed

Mill Creek flows generally northward from its origin in Nolensville to its confluence with the Cumberland River in Nashville. Along the way it is fed by a number of tributaries, the most significant being Sevenmile Creek which joins Mill Creek at River Mile (RM) 7.9 and has a drainage area of 17.5 square miles. Other major tributaries in Davidson County include: Collins Creek, Edmonson Branch, Franklin Branch, Holt Creek, Indian Creek, Owl Creek, Sims Branch, Sorghum Branch, Turkey Creek, and Whittemore Branch. A detailed study of flooding and flood damages was not performed for Williamson County, as they elected not to co-sponsor the study.

Topography in the Mill Creek Basin ranges from flat to moderately sloping along the main stem to rolling and hilly uplands which form the watershed divide. Elevations range from about 385 feet above mean sea level at the mouth to around 1200 feet in the upper extremities of the basin. The main stem is 27 miles long and falls about 280 feet from its source to its mouth. Average channel gradient is roughly 10 feet per mile in lower stream reaches and 35 feet per mile in upper stream reaches.

Mill Creek main channel averages approximately 75 to 100 feet in width and the 100-year floodplain about 700 to 800 feet in width. The well-defined streambanks are generally 10 to 15 feet above streambed. Upper portions of Mill Creek and its headwaters flow primarily from farmland. As the stream enters Davidson County runoff characteristics become primarily suburban, changing to urban approximately halfway through the basin, with residential, commercial, industrial and open area land uses. Almost every summer, the flow of Mill Creek approaches zero at RM 22, near the Williamson county line, and aquatic life is restricted to pools. This lack of continual flow inhibits habitat availability and ecosystem processes and functions of Mill Creek.

Sevenmile Creek originates near the Davidson-Williamson County line and flows north and east before joining Mill Creek. Sevenmile is approximately 7.3 miles long with a drainage area of 17.6 square miles, an average slope of 18.9 feet per mile, and an average 100-year floodplain width of 500 feet. Streambanks range from 3 to 9 feet high; existing channel averages 20 to 30 feet wide. Approximately half the stream channel is through a heavily urbanized area, while the upper half is less developed.

3.0 Project Description

The National Economic Development (NED) Plan is the plan that provides the greatest net benefits. Plan BDA, Ellington Detention, Briley Bridge Modification and Non-Structural Plan, provides the greatest amount of net benefits. Plan BDA also leaves considerably less residual risk in the floodplain than other plans in the final array.

Plan BDA combines the non-structural plan (buyout and removal of frequently flooded residential structures impacted by the 1/5 ACE or 5-year flood event, including some raise-in-place residential buildings) with a detention basin at Ellington, and bridge modification to Briley Parkway targeting the 1/50 ACE or 50-year flood event, located just downstream of the confluence of Sevenmile Creek and Mill Creek. In Mill Creek and tributaries Sevenmile Creek, Sorghum Branch, and Whittemore Branch, the 1/5 ACE equates to 90 structures that qualify for buyout or raise-in-place. The recommended plan has the potential to remove nearly half of the expected annual damages associated with Mill Creek and tributary flooding.

Table 1 lists the federally threatened and endangered species that potentially occur within Mill Creek watershed received during the initial scoping of the project. This list includes four mussels, five plants, two bats, one insect, two mammals and one crayfish. TDEC, Division of Natural Heritage (DNH) also provided a list of state species occurring inside or within one mile of the Mill Creek watershed. The species are shown in Table 2. DNH listed a heron rookery that occurs within the Mill Creek watershed; the state considers this a rare, but not state listed species/habitat.

Table 1. USFWS Listing of Threatened and Endangered Species.

Scientific Name	Common Name	Fed. Status
Dalea foliosa	Leafy Prairie-clover	LE
Astragalus bibullatus	Pyne's Ground-plum	LE
Apios priceana	Price's Potato-bean	LT
Physaria globosa	Short's Bladderpod	C
Boechera perstellata	Braun's Rockcress	LE
Plethobasus cooperianus	Orangefoot Pimpleback	LE
Lampsilis abrupta	Pink Mucket	LE
Epioblasma florentina walkeri	Tan Riffleshell	LE
Epioblasma brevidens	Cumberlandian Combshell	LE
Pseudanophthalmus insularis	Baker Station Cave Beetle	C
Orconectes shoupi	Nashville Crayfish	LE
Myotis grisescens	Gray Bat	LE
Myotis sodalis	Indiana Bat	LE
* LE= Listed Endanged, LT=Listed Threatened, C=Canidate Species, DM=Deemed Management		

Table 2. State Listed Species for Mill Creek Watershed.

Scientific Name	Common Name	State Status
Orconectes shoupi	Nashville Crayfish	E
Sphallaplana buchanari	Cave Obligate Planarian	R
Allium stellatum	Glade Onion	E
Anemone carolinana	Carolina anemone	E
Astragulus tennesseensis	Tennessee milk-vetch	S-CE
Echinacea tennesseensis	Tennessee Purple Coneflower	E
Elymus svensonii	Svenson's wild-rye	E
Hydrastis canadensis	Goldenseal	S-CE
Hydrocotyle americana	American Water-pennywort	E
Juglans cinerea	Butternut	T
Dalea foliosa	Leafy Prairie Clover	E
Leavenworthia exigua var. exigua	Gladecress	S-CE
Panax quinquefolius	American Ginseng	S-CE
Paysonia densipila	Duck River Bladderpod	T
Perideridia americana	Thicket Parsley	E
Talinum calcaricum	Limestone Fame-flower	S-CE
Phlox bifida spp. stellaria	Glade Cleft Phlox	T
* E=Endangered, T=Threatened, S-CE=Species of Concern		

Based on habitat description for each species listed above, only the Indiana bat, Price's Potato-bean, and Nashville Crayfish could be found within the proposed project areas. See Table 3 for habitat comparison. Site assessments were conducted at each proposed project location to verify/record habitat types. No suitable habitat for both the Indiana bat and Price's Potato-bean were observed during the site assessments of each proposed project location. Therefore, the Nashville Crayfish is the only T&E Species that could be found within the proposed project locations.

3.1 Nonstructural (Buyouts/Raisings)

This alternative includes the buyout and removal or raise-in-place of approximately 90 structures within the 5-year floodplain that still warrant non-structural measures following implementation of all structural measures. Of the 90 structures identified, 81 are buyouts and removals with the remaining 9 proposed to be raise-in-place. This alternative was informally discussed with the USFWS during a meeting on July 9, 2014 where it was determined to have no affect on the Nashville Crayfish. The Corps has made a "No Effect" determination for the Nonstructural Alternative (Plan A) and it is not evaluated in detail within the BA.

Proposed nonstructural are scattered along both Sevenmile Creek River Miles (RM) 1 – 1.7 (Figure 2) and Whittemore Branch RM 0.5 – 1.3 (Figure 3).

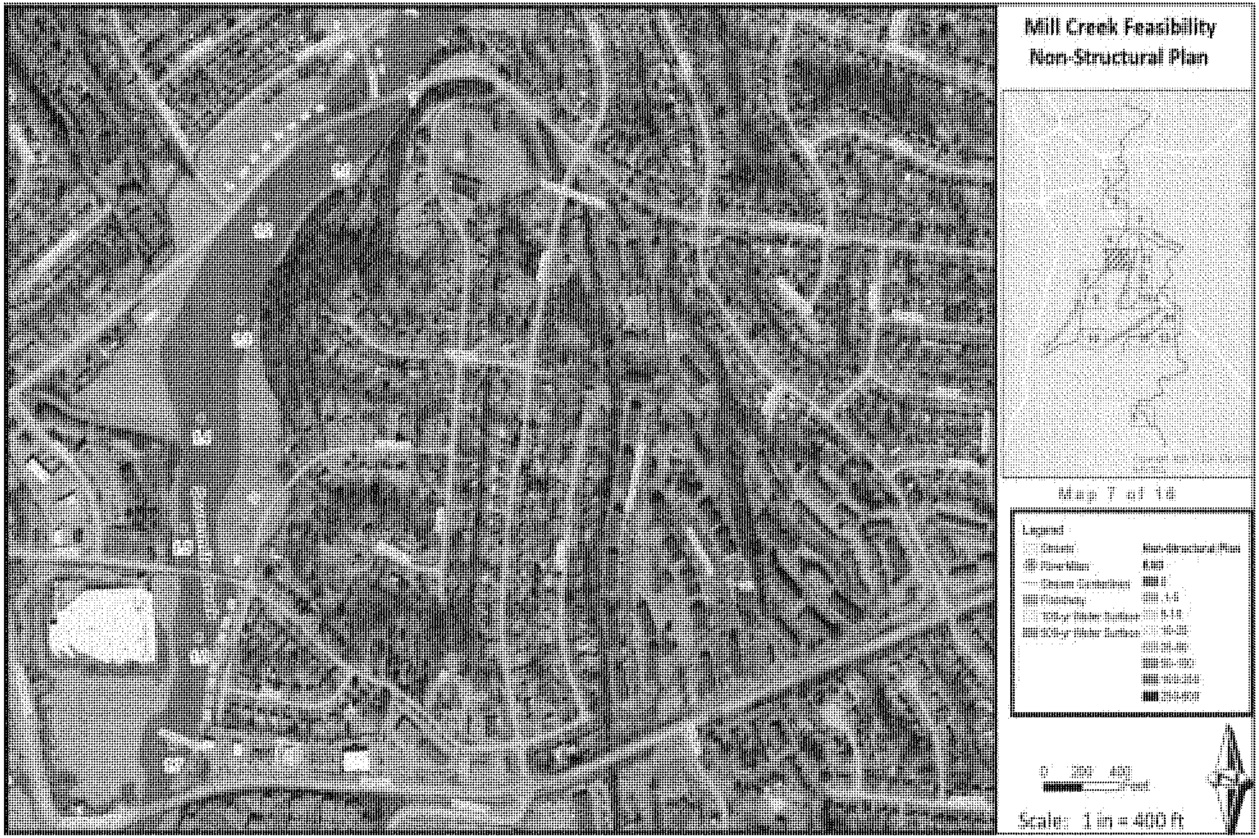


Figure 2. Buyout/Raisings along Sevenmile Creek

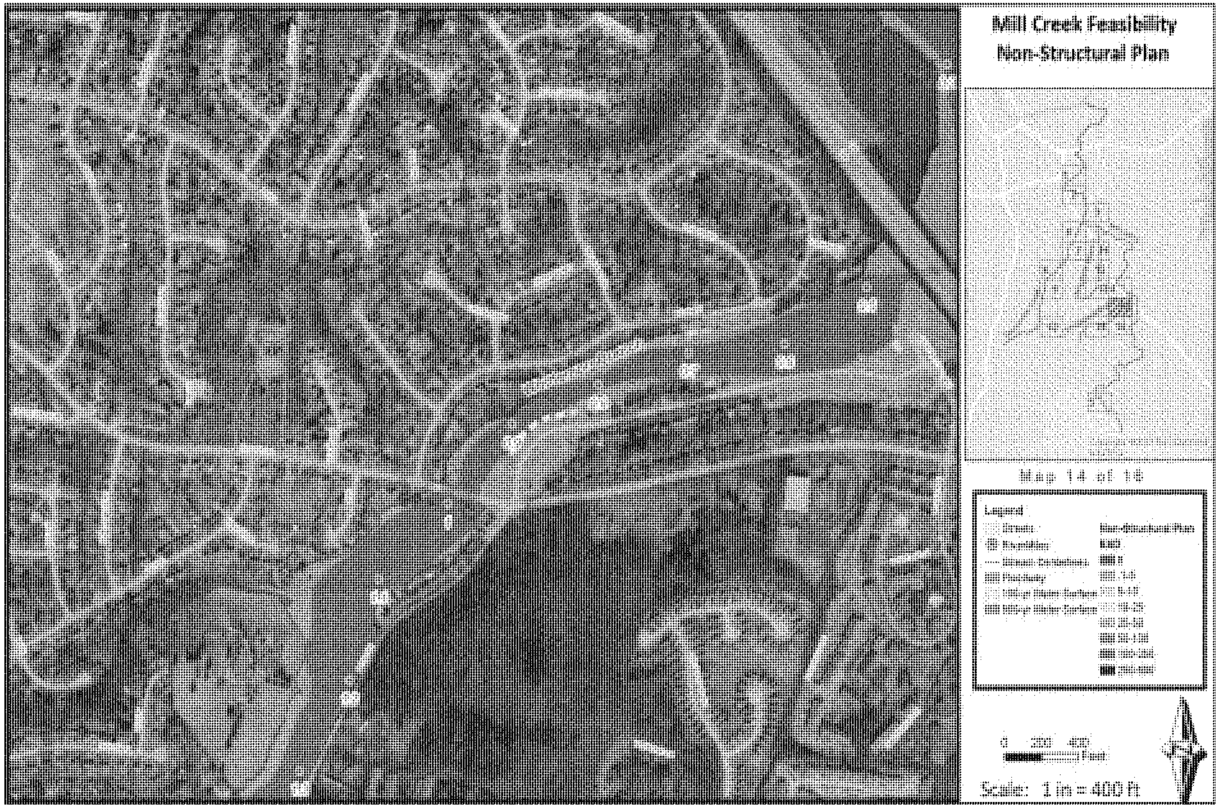


Figure 3. Buyout/Raisings along Whittemore Branch.

3.2 Ellington Agricultural Center Regional Detention (River Mile 3.7)

A detention site was evaluated on Sevenmile Creek at RM 3.7 located at the Ellington Agriculture Center Entrance Bridge (Figure 4). The measure captures 7.9 square miles, 45% of Sevenmile Creek total watershed. A low level outlet would pass normal flow and require no manual or mechanical operation. The road embankment would act as a weir or spillway for flows exceeding the 5-year frequency event. The measure included the construction of a 19 ft tall earthen structure. The project footprint is shown in Figure 5. The design of this structure targets reduction in more frequent (less than a 50-year frequency) flood events. The embankment section would be a combination of RCC and compacted-earth.

a. Outlet Works

The outlet works would consist of an uncontrolled concrete box culvert located at the base of the structure. Sevenmile Creek within the proposed project footprint is a limestone/bedrock creek with little to no slabrock. See Figures 6 and 7 for conditions of the existing bridge. The outlet would pass normal flow and require no manual or mechanical operation. The opening would be 8 ft high and 20 feet wide (160 square feet of opening) with upstream and downstream invert elevations of 519.0 ft and 518.5 ft, respectively. The culvert barrel would be approximately 30 feet in length and be within the existing channel and flow with inlet control for the full ranges of discharges. The foundation would be on solid, non-erodible limestone. The relatively large conduit design would allow most of the debris to be flushed through the opening where a trash

Table 3. Listed Species Habitat Determination.

Scientific Name	Common Name	Habitat Type	Found within Proposed Project Footprint
Federally Listed Species			
Dalea foliosa	Leafy Prairie-clover	Cedar Glades	Habitat Not Present
Astragalus bibullatus	Pyne's Ground-plum	Cedar Glades	Habitat Not Present
Apios priceana	Price's Potato-bean	Open Woods/Forest Edge	Habitat Present
Physaria globosa	Short's Bladderpod	Rock Cliffs/Outcrops	Habitat Not Present
Boechera perstellata	Braun's Rockcress	Wooded Steep Slopes/Limestone Outcrops	Habitat Not Present
Plethobasus cooperianus	Orangefoot Pimpleback	Medium/Large Rivers	Habitat Not Present
Lampsilis abrupta	Pink Mucket	Medium/Large Rivers	Habitat Not Present
Epioblasma florentina walkeri	Tan Riffleshell	Small Rivers/Large Creeks	Habitat Not Present
Epioblasma brevidens	Cumberlandian Combshell	Large Rivers	Habitat Not Present
Pseudanophthalmus insularis	Baker Station Cave Beetle	One Cave in Davidson County	Habitat Not Present
Orconectes shoupi	Nashville Crayfish	Mill Creek Creek and Tributaries	Habitat Present
Myotis grisescens	Gray Bat	Caves	Habitat Not Present
Myotis sodalis	Indiana Bat	Caves/Trees	Habitat Present
State Listed Species			
Sphallaplana buchanari	Cave Obligate Planarian	Caves	Habitat Not Present
Allium stellatum	Glade Onion	Glade	Habitat Not Present
Anemone carolinana	Carolina Anemone	open Rocky Woods	Habitat Not Present
Astragalus tennesseensis	Tennessee Milk-Vetch	Cedar Glades	Habitat Not Present
Echinacea tennesseensis	Tennessee Purple Coneflower	Cedar Glades	Habitat Not Present
Elymus svensonii	Svenson's wild-Rye	Forest - Hardwoods	Habitat Not Present
Hydrastis canadensis	Goldenseal	Forest - Hardwoods	Habitat Not Present
Hydrocotyle americana	American Water-Pennywort	Wetland	Habitat Not Present
Juglans cinerea	Butternut	Forest - Hardwoods	Habitat Not Present
Leavenworthia exigua var. exigua	Gladecress	Glade	Habitat Not Present
Panax quinquefolius	American Ginseng	Forest - Hardwoods	Habitat Not Present
Lesquerella densipila	Duck River Bladderpod	Limestone Glades	Habitat Not Present
Perideridia americana	Thicket Parsley	Open Limestone Woods/Bluffs & Cedar Glades	Habitat Not Present
Talinum calcaricum	Limestone Fame-Flower	Limestone Glades	Habitat Not Present
Phlox bifida spp. stellaria	Glade Cleft Phlox	Cedar Glades	Habitat Not Present

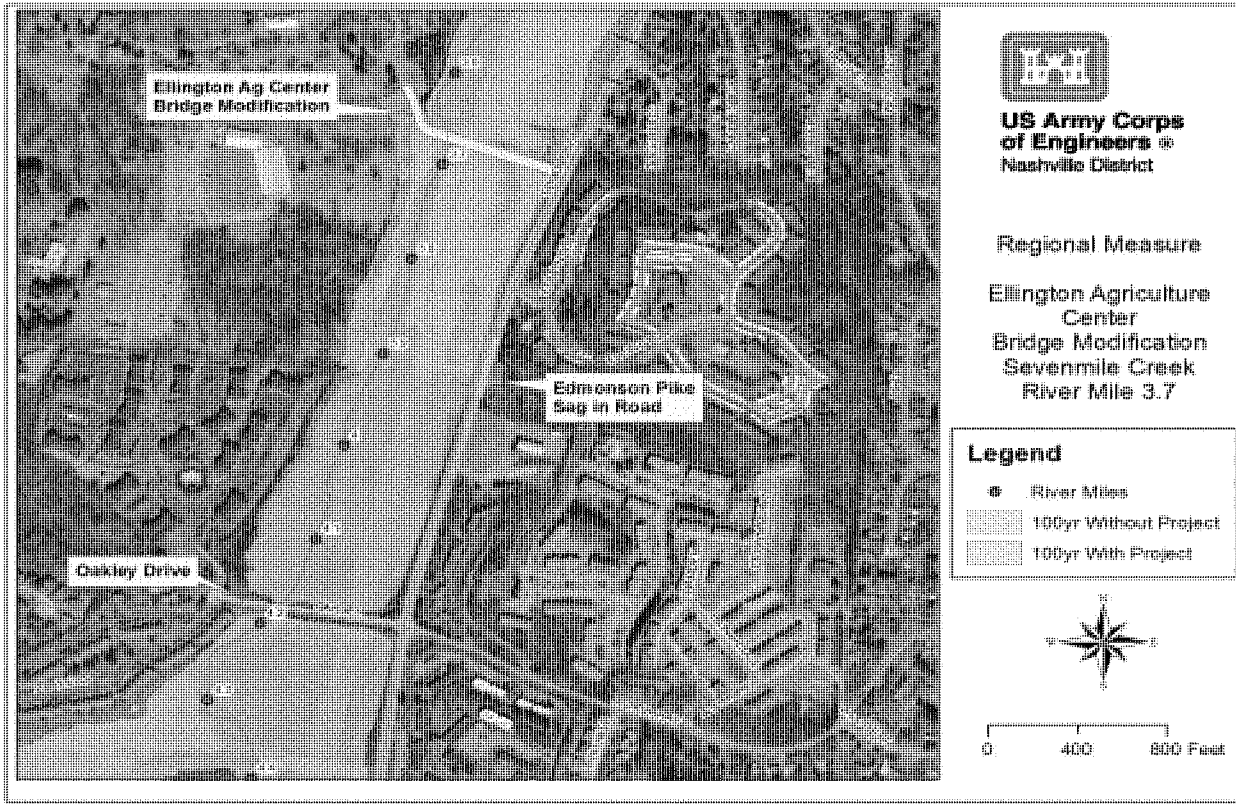


Figure 4. Ellington Ag Center Bridge Modifications.

Figure 5. Footprint of Ellington Ag Center Bridge Modification

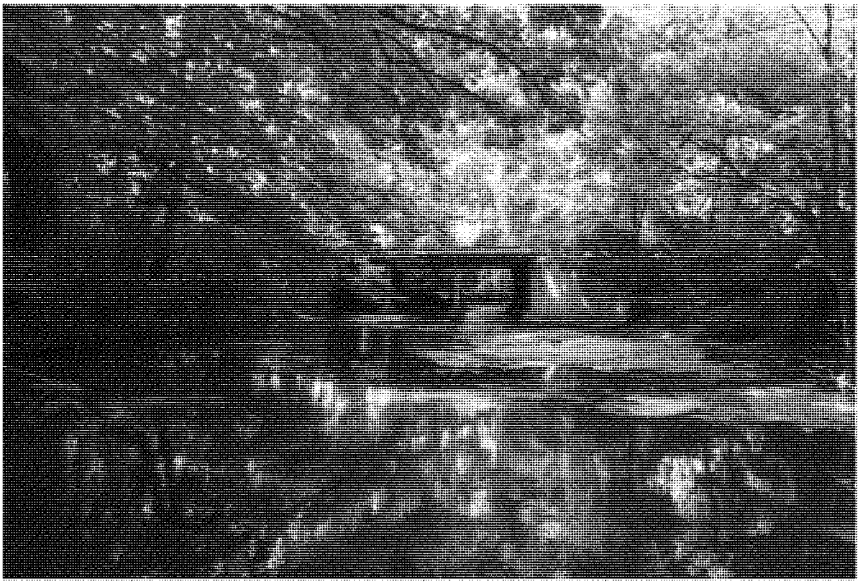


Figure 6. Photograph looking Downstream side of the Existing E. Agricultural Bridge.

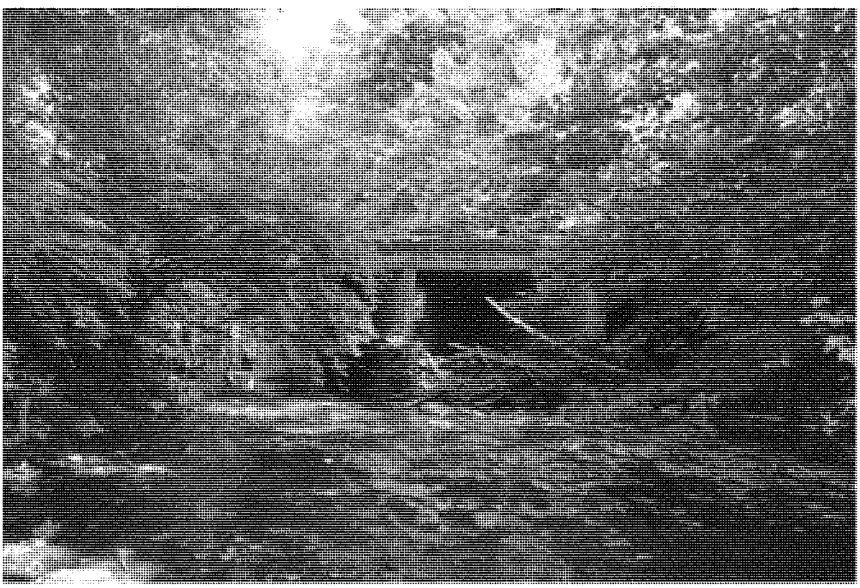


Figure 7. Photograph looking at the Upstream side of the Existing Agricultural Bridge.

rack would not be required. The maximum outlet velocity would be approximately 15 - 20 feet per second.

b. Embankment

The embankment would have a maximum height above the stream bed of 19.0 feet and act as a weir or spillway for flows exceeding the 5-year frequency flood event. The embankment section is approximately 800 feet in length at elevation 537.5 feet and designed to be overtopped and capable of passing all floods. The embankment would be earthen fill. The earthen embankment on either side of the newly constructed road would have a 3:1 side slopes. These areas would be stabilized using articulated stone allowing for natural vegetation to establish within the area.

c. Spillway

The spillway is an uncontrolled, broad-crested, 100 feet in length, with a crest elevation of 535.0 feet. A hydraulic jump energy dissipater with an apron will be used to reduce the energy of flows through the spillway. Quarry run stone or similar materials will be required for approximately 150 feet downstream of the structure to protect the channel side slopes against turbulence and high velocities caused by the energy dissipation and outlet works (Figure 8).

The HEC-HMS model used to calculate frequency discharges for future conditions was modified to represent the storage and outflow characteristics of the proposed measure. The reservoir data for the proposed measure are shown in Table 4. The resulting "with project" discharges were then placed in the calibrated HEC-RAS models to calculate frequency-flood profiles. The hydraulic structure was modeled in HEC-RAS as an inline structure. Flows were reduced in RAS just upstream from the RCC structure to reflect the flow reduction due to attenuation. The downstream effects at select damage centers are shown in Tables 5 thru 9. There are minor adverse impacts caused by the temporary ponding of water upstream from the structure including flooding of Edmonson Pike greater than previously experienced. The proposed measure includes the raising of a 500-ft section of Edmondson Pike. There are no homes or structures in the ponding area. All of the impacted lands are publically owned properties currently used for greenway and ecosystem restoration. The increased backwater effects for the 500-year frequency flood event dissipate in the vicinity of Oakley Drive at river mile 4.2. Water surface profiles for this measure for the 10-, 25-, and 50-year frequency floods are shown in Figure 9.

Table 4, Regional Detention Structure River Mile 3.67 – Reservoir Data

Storm	Discharge		Elevation		Capacity	Area
Frequency	Future	With Project	Future	With Project	With Project	With Project
(Years)	(cfs)	(cfs)	(Feet)	(Feet)	Acre-Feet	Acres
2	2,621	2,210	529.9	532.4	101	25
5	3,305	2,631	530.4	535.1	168	36
10	4,244	3,480	530.8	536.7	240	43
25	5,139	4,547	531.2	537.7	288	48
50	5,813	5,515	531.4	538.0	303	50
100	6,542	6,380	531.6	538.3	314	51
200	7,373	7,265	531.8	538.5	323	52
500	8,787	8,698	532.1	538.8	337	53

Table 5: Ellington Ag Center Bridge Modifications Downstream Effects
Suter Drive/Blackman Road
Sevenmile Creek
River Mile 2.8

Storm	Future W/O Project		Future with Project		WSEL
Frequency	Discharge	Elevation	Discharge	Elevation	Reduction
or Event	(cfs)	(feet)	(cfs)	(feet)	(feet)
2yr	3,660	510.2	3,090	509.7	-0.5
5yr	4,633	510.9	3,596	510.1	-0.8
10yr	5,899	511.8	4,348	510.7	-1.1
25yr	7,129	512.6	5,691	511.7	-1.0
50yr	8,067	513.2	7,041	512.6	-0.7
100-yr	9,051	513.8	8,299	513.3	-0.5
200-yr	10,102	514.2	9,557	513.9	-0.3
500yr	12,003	515.0	11,573	514.7	-0.2

Table 6: Ellington Ag Center Bridge Modifications Downstream Effects
Nolensville Road/Harding Place
Sevenmile Creek
River Mile 1.8

Storm	Future W/O Project		Future with Project		WSEL
Frequency	Discharge	Elevation	Discharge	Elevation	Reduction
or Event	(cfs)	(feet)	(cfs)	(feet)	(feet)
2yr	4,356	497.7	3,814	496.9	-0.7
5yr	5,498	498.9	4,636	498.0	-0.9
10yr	6,858	500.4	5,666	499.1	-1.3
25yr	8,234	502.3	6,564	500.2	-2.1
50yr	9,305	502.5	7,770	501.0	-1.5
100-yr	10,238	502.7	9,048	502.4	-0.3
200-yr	11,072	502.9	10,144	502.7	-0.3
500yr	13,236	504.0	11,707	503.1	-0.9

Table 7: Ellington Ag Center Bridge Modifications Downstream Effects
Paragons Mill Road
Sevenmile Creek
River Mile 1.1

Storm	Future W/O Project		Future with Project		WSEL
Frequency	Discharge	Elevation	Discharge	Elevation	Reduction
or Event	(cfs)	(feet)	(cfs)	(feet)	(feet)
2yr	4,806	480.2	4,302	479.7	-0.5
5yr	6,048	481.3	5,267	480.6	-0.7
10yr	7,483	482.3	6,483	481.6	-0.6
25yr	8,947	483.2	7,617	482.3	-0.8
50yr	10,098	483.8	8,332	482.8	-1.0
100-yr	11,106	484.3	9,700	483.6	-0.6
200-yr	11,978	484.7	10,880	484.2	-0.5
500yr	14,266	485.8	12,550	485.0	-0.8

Table 8: Ellington Ag Center Bridge Modifications Downstream Effects
Space Park South
Mill Creek
River Mile 7.59

Storm	Future W/O Project		Future with Project		WSEL
Frequency	Discharge	Elevation	Discharge	Elevation	Reduction
or Event	(cfs)	(feet)	(cfs)	(feet)	(feet)
2yr	11,223	458.2	10,993	458.1	-0.1
5yr	13,716	459.6	13,245	459.4	-0.3
10yr	17,241	461.8	17,024	461.7	-0.1
25yr	21,465	463.9	22,330	464.3	0.4
50yr	25,646	465.9	26,257	466.2	0.3
100-yr	30,535	468.0	30,812	468.0	0.1
200-yr	35,494	469.2	35,694	469.2	0.0
500yr	42,619	471.1	42,485	471.1	0.0

Table 9: Ellington Ag Center Bridge Modifications Downstream Effects
Massman Drive
Mill Creek
River Mile 2.35

Storm	Future W/O Project		Future with Project		WSEL
Frequency	Discharge	Elevation	Discharge	Elevation	Reduction
or Event	(cfs)	(feet)	(cfs)	(feet)	(feet)
2yr	12,062	411.0	11,833	410.8	-0.2
5yr	14,805	413.0	14,384	412.7	-0.3
10yr	18,521	415.6	17,892	415.2	-0.4
25yr	22,069	417.8	22,619	418.0	0.2
50yr	26,204	419.9	26,652	420.1	0.2
100-yr	31,076	422.1	31,296	422.2	0.1
200-yr	36,064	424.0	36,161	424.1	0.0
500yr	43,165	426.5	42,992	426.4	-0.1

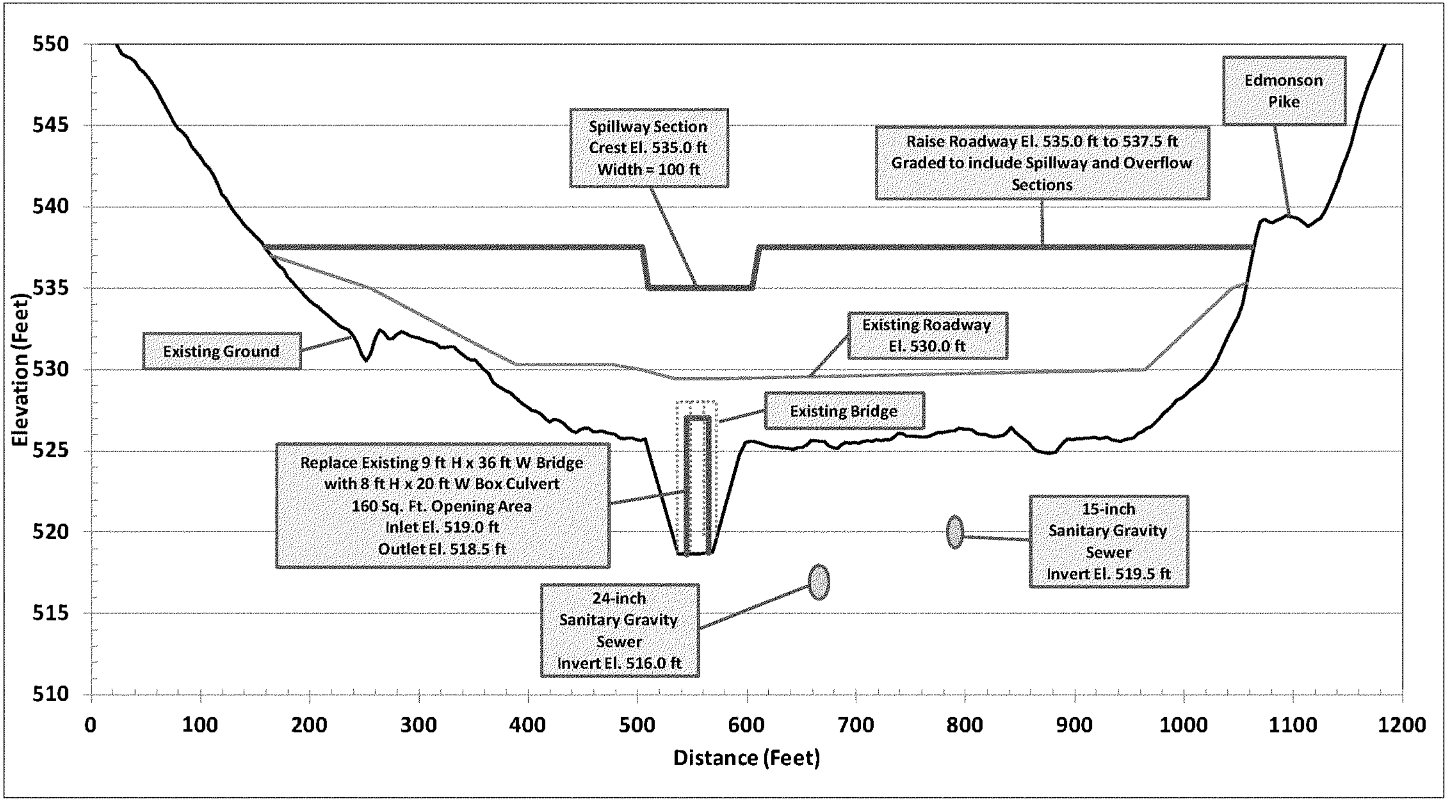


Figure 8: Cross Section Looking Downstream of Ellington Ag Center Road/Bridge Improvements

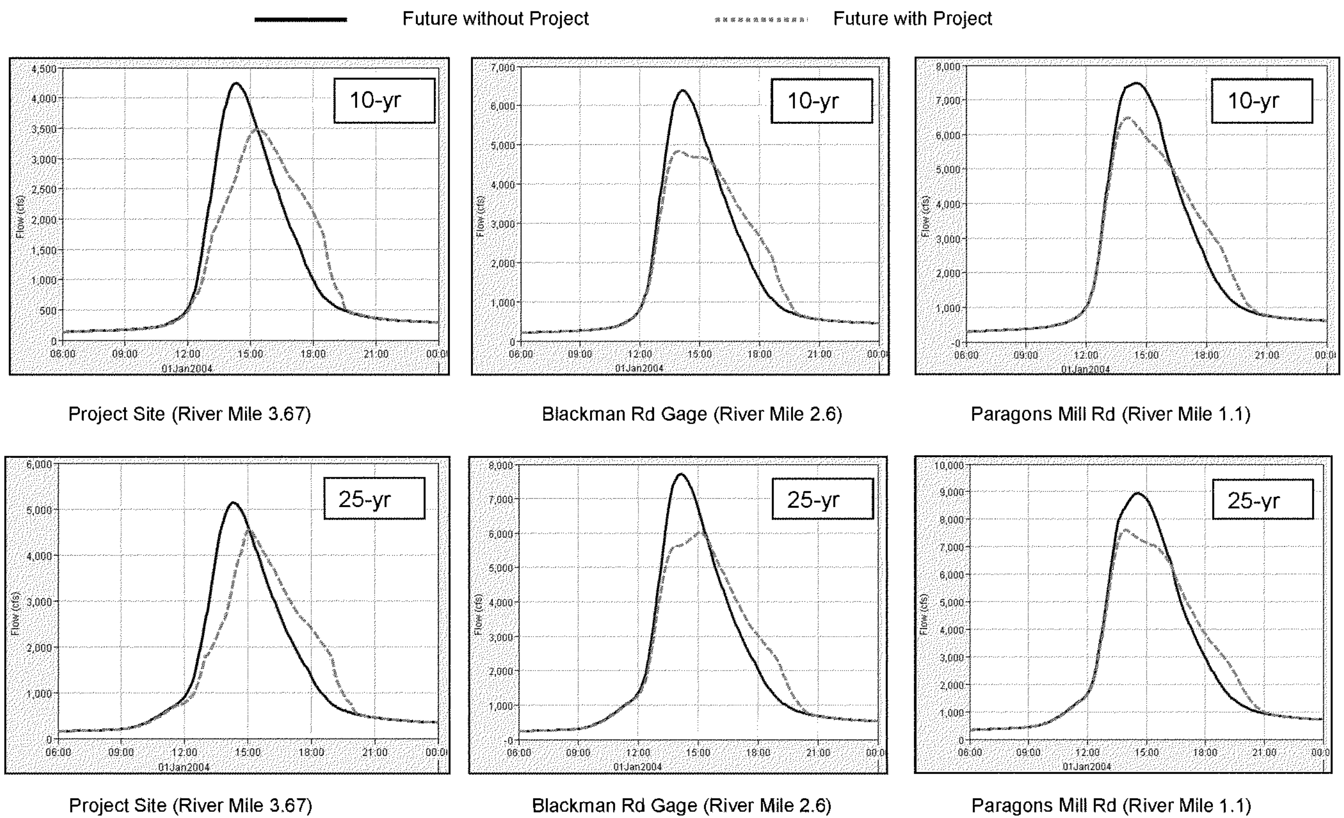


Figure 9: Ellington Agriculture Center Bridge Modifications - 10yr and 25yr Frequency-Flood Hydrographs

3.3 Briley Parkway Bridge Modification

The Briley Parkway Bridge is located on Mill Creek at RM 7.1. The Briley Parkway bridge modification would include widening the east and west bound bridge openings by a minimum of 63 feet above ordinary high water as shown in Figures 10 to reduce the head loss thru the bridge. Approximately 6,000 cubic yards of upland fill material is anticipated to be removed in order to widen the bridge opening. In addition, a new pier would be placed to help support Briley Parkway Bridge (Figure 11). Flood reductions for the Briley Parkway measure are shown in Tables 10 and 11 for select damage centers.

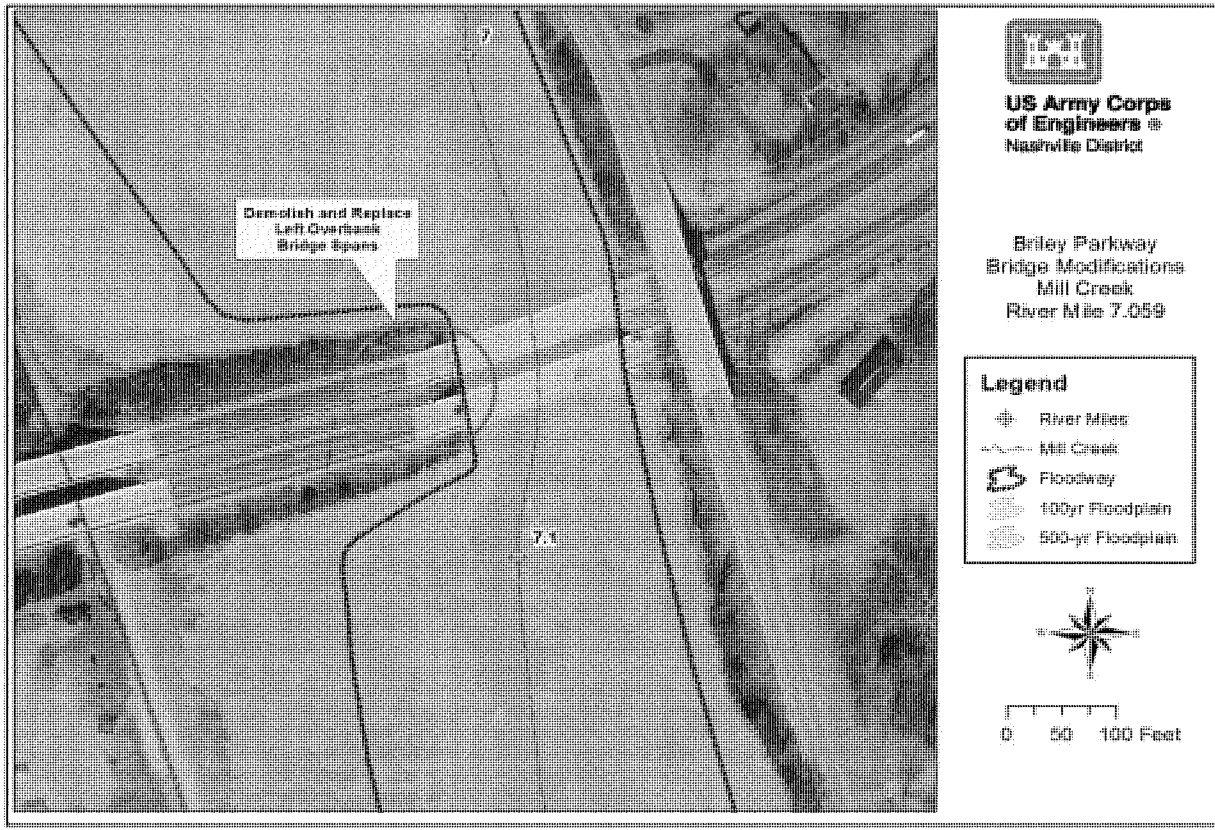


Figure 10. Briley Parkway Bridge Modification

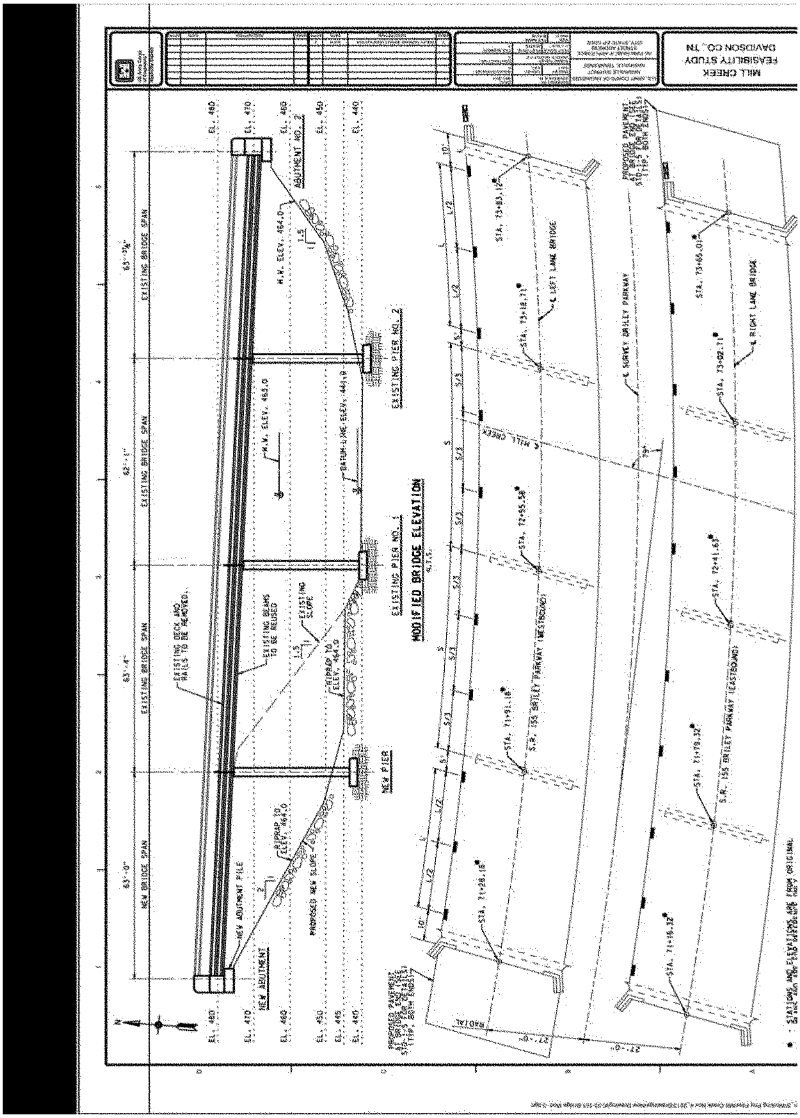


Figure 11. Briley Parkway Bridge Modifications – Typical Cross Section Looking Downstream

Table 10: Briley Parkway Bridge Modifications
Just Upstream from Briley Parkway
Mill Creek Mile 7.13

Frequency Event	Future W/O Project Elevation	Future With Project Elevation	WSEL Reduction (feet)
2yr	454.2	453.0	-1.2
5yr	455.7	454.2	-1.4
10yr	458.2	456.7	-1.5
25yr	459.9	458.1	-1.8
50yr	461.7	459.6	-2.1
100yr	463.6	461.2	-2.4
200yr	465.3	462.6	-2.7
500yr	467.3	464.4	-2.8

Table 11: Briley Parkway Bridge Modifications
Space Park South
Mill Creek Mile 7.59

Frequency Event	Future W/O Project Elevation	Future With Project Elevation	WSEL Reduction (feet)
2yr	458.2	458.0	-0.2
5yr	459.6	459.4	-0.3
10yr	461.8	461.3	-0.6
25yr	463.9	463.2	-0.7
50yr	465.9	465.0	-0.9
100yr	468.0	467.1	-0.9
200yr	469.2	468.6	-0.6
500yr	471.1	470.0	-1.1

4.0 Species Description

O. shoupi was officially named as such in 1948 by H.H. Hobbs. First collection records are dated from 1939 by R.S. Fleming where specimens were collected in Mill Creek (summarized in Withers 2005). In 1986 *O. shoupi* was listed as an endangered species by the US Fish and Wildlife Service due to its endemic presence in the Mill Creek watershed of Davidson, Williamson, and Rutherford Counties in Middle Tennessee. Historic collection records of the species occurring in the Elk River and South Harpeth River systems (Giles County and Davidson County, TN respectively) have been discounted as true occurrences and are considered "bait bucket" introductions. Another previous occurrence was listed in Richland Creek within Davidson County. However, in the 1989 revision of the Recovery Plan, USFWS states that these specimens were misidentified. Therefore, reoccurring documentation of the species inhabitation has been limited to Mill Creek and its tributaries.

Early records limited the species to Mill Creek and its largest tributaries, such as Sevenmile Creek. Research of the last two decades has shown the crayfish to also inhabit smaller tributaries of the Mill Creek watershed (Withers 2005). In addition to the known twelve primary and four secondary tributaries of Mill Creek, Withers (2005) has shown *O. shoupi* to occur in an additional eight streams. His records now reflect species occurrence at 102 locations within Davidson and Williamson Counties.

The preferred habitat includes free-flowing waters dominated by slabrock on bedrock substrate (Withers 2005). As documented in the Recovery Plan (1987), the crayfish has been found in a variety of stream habitats—gravel and cobble runs, pools with up to 10 cm of sediment, and under slabrocks and other cover. Slabrocks provide cover for females carrying eggs and young and these sites also provide shelter during molting periods. Gravel areas provide cover for juvenile animals. O'Bara (1985) stated the species' preferred habitat is within riffle-run reaches. Stark (1987), however, noted that *O. shoupi* inhabited non-moving waters more than moving waters. In 2002, approximately 800 specimens were found when an impoundment, Resha Lake, was drained as part of a housing development. In 2008 Walton found specimens in a retention pond adjacent to, but no surface hydrological connection with, Owl Creek. This, however, is considered an atypical situation. The 2007 drought could have affected the crayfish's use of an impoundment (Walton 2008).

Presence of large slab rocks as an important habitat feature has been a recurring notation by scientists studying *O. shoupi* (Miller and Hartfield 1987, O'Bara 1985, and Stark 1987). In addition, Pennington (1999 and 2000) has repeatedly stated that the availability of filamentous algae and water willow (*Justicea* spp.) are important habitat type for the success of juveniles. In his various evaluation and relocation projects, Pennington stated most specimens smaller than 35 mm and all less than 10 mm total length were collected from aquatic vegetation. Of the aquatic vegetation sampled, water willow was the most dominant habitat with crayfish inhabitation. Barrociere (1986) also commented that special attention should be given to study and preservation of vegetated coves in addition to larger limestone rocks and moderate flow conditions. Stark (1987) noted the occurrence of 60 to 90% canopy cover in areas with *O. shoupi* abundance. Barrociere (1986) commented that sampled sites that previously had riparian vegetation in earlier evaluations still supported crayfish populations upon return sampling, even with the stream sites being open and bank vegetation removed.
O. shoupi range from 0.6 cm (0.2 in) total length (TL) in young of the year to approximately 17.8 cm (7 in) TL. Body coloration varies from green to dark brown. The

most distinguishing anatomical characteristics include elongated pinchers with red or orange tips with adjacent black bands and light colored "saddle" on the carapace that extends from the posterior to anterior and terminates as lateral stripes on either side. No other saddle-bearing crayfish species have been observed in the Mill Creek watershed. The carapace terminates in a sharp point between the eyes. Distinctive gonopods are the most confirmative field identification. Larger females can be easily identified with little or no magnification by the sigmoidal cleft of the annulus ventralis (summarized from USFWS 1987 and Withers 2005).

Life history characteristics for *O. shoupi* are not well known. The species is omnivorous. Barrociere (1986) found stomach contents containing plant fragments as well as crustacean and insect remains. *O. shoupi* have been observed feeding on dead animal matter (USFWS 1987). Reproductive activity begins in late summer or early fall. At this time males change from non-reproductive (Form II) to reproductive form (Form I). Egg laying likely occurs in late winter/early spring (summarized from USFWS 1987). Embryos develop in approximately three weeks and newly hatched young remain attached to the female for an additional two weeks (Barrociere 1986).

O. shoupi are solitary and will defend their cover rocks (Miller and Hartfield 1987). Individuals seem to choose cover rock size relative to body size. Miller and Hartfield (1987) noted crayfish were agitated by extreme crowding conditions and continued to challenge other specimens. Dominance was correlated to the size of the individuals. Stark (1987) noted that larger stones harbored more than one crayfish, with individuals perhaps occupying different crevices. Competition with *Orconectes placidus* and/or *O. durelli* has been a concern mentioned regarding sustainability of *O. shoupi* populations (USFWS 1987).

In 2002 Carpenter studied the density of crayfish in the Mill Creek watershed. He acknowledged high standard errors, but estimated population densities could be as high as 1000 to 2000 per 100 meters. He also commented that the species' environmental tolerance may be greater than generally believed.

5.0 Construction Activities

Activities as a result of the proposed project mentioned in Section 2 include: bridge/road modification at Ellington Agricultural Center and Briley Parkway Bridge, bank stabilization, and riparian vegetation removal. Removal of residential homes (Plan A), would also occur but is not anticipated to generated sediment entering the river with proper BMPs in placed during removal and long-term site stabilization.

6.0 Potential Impacts

Various components of these activities have potential to affect *O. shoupi*. Direct impacts such as injury or death could occur during surveying, relocation, or construction. There are also indirect impacts that may affect the species. Land disturbance and clearing of vegetation adjacent to the streams could result in sedimentation into the waterway. Disturbance of stream substrate can also cause sedimentation downstream of the construction site. Removal of riparian vegetation has the potential to affect water quality with increased water temperatures as canopy cover is lost. Both of these can result in reduced dissolved oxygen levels and increased levels of biological oxygen demand. In addition, preferred habitat areas, such as riffles and bedrock slabs, are less desirable with sediment accumulation. Sedimentation can also trigger invertebrate drift as Anderson et al (1998) discussed in their study of pipeline crossings. This could result in loss of food source for the crayfish or push the crayfish into other areas currently occupied and lead to competition with resident individuals.

If the footprint involves dewatering, crayfish must be relocated. Ensuring total relocation of individuals is a concern. Many biologists working with crayfish have repeatedly stated it is relatively impossible to find and relocate all individuals within the area due to their elusive and secretive nature. It is very common for crayfish to be found the following day prior to starting work within the coffer-dammed areas. Handling of the specimens likely results in a period of disorientation as Miller and Hartfield (1987) noted in their study. Relocation of the crayfish to adjacent areas can lead to competition and/or crowding with individuals currently inhabiting these sites. Indirect impacts to areas adjacent to the project footprint may result from construction noise or vibrations from machinery.

7.0 Cumulative Effects

Cumulative impacts would result from the incremental impact of the proposed actions when added to those of other past, present and reasonably foreseeable future actions in the local area. Geographical boundaries for this discussion of cumulative impacts are the locations of the proposed projects describe in Section 3. Additional information pertaining to the cumulative effects of the proposed project can be found in the Draft Integrated Mill Creek Feasibility Report.

Past and Present Actions

Based on the landscape and land use of the area, development of the floodplain and floodway zones became popular in the watershed many years ago; floodplains continue to receive pressure for structural development. With increasing community growth and decreasing flood storage capacities, increased flood damages to homes and business have occurred. Additional pressures along the creeks led to many of the watershed streams being placed on the 303(d) list for poor water quality. A review of the history for the study area shows several flood events that damaged homes, businesses, and properties. As a result, Metro Nashville has worked with FEMA in the watershed to remove approximately 50 structures to date within the study area (Mill Creek Watershed). The recommended plan for this report includes: the raise in place or buyout and removal of an additional 90 structures located in the 2- and 5-year floodplains long Sevenmile Creek and Whittemore Creek; construction of a detention structure on Sevenmile Creek at RM 3.7 located at the Ellington Agriculture Center Entrance Bridge; and the Briley Parkway Bridge modification located on Mill Creek at RM 7.1.

In addition Metro Nashville has implemented ordinances regulating the amount and degree of development that is allowed along creeks and within the floodplains in attempts to reduce damages occurring from flooding and improve aquatic resources and water quality.

Several agencies and interest groups (Metro, TDEC, CRC, TNC, TDA, Nashville Zoo, watershed organizations, etc) are working in the Mill Creek watershed to reverse trends of poor water quality, high impact development and floodplain loss in addition to addressing flooding concerns. These efforts include on-the-ground implementation, ordinance/zoning and public education as measures to improve the natural and social environment in the watershed.

Reasonable Foreseeable Future Actions

Residential as well as commercial development within the Mill Creek watershed is anticipated to continue to grow until the watershed reaches carrying capacity. As areas are developed, additional damages to structures from flooding events could be expected. It is anticipated that buy-out programs through the local government and other agencies and implementation and enforcement of zoning ordinances would continue as means to further reduce damages associated with structural flooding and resource impacts. Other programs and education by watershed stakeholders as mentioned above are also expected to continue as means to improve the quality of the natural resources.

Effects on the Nashville Crayfish

Negative Effects

As mentioned in Section 6, various construction components have the potential to affect *O. shoupi*. Direct impacts such as injury or death could occur during surveying, relocation, or construction. There are also indirect impacts that may affect the species. Land disturbance and clearing of vegetation adjacent to the streams could result in sedimentation into the waterway. However, these potential impacts would be considered short-term and only during construction.

Positive Effects

A result of implementation of the proposed plans (A, B, and D) would be that floodplains areas would be cleared of structural impediments. No new development would be allowed within the project footprints through terms of the PPA and the O & M manual.

This would have positive benefits to aquatic resources and wildlife by improving water quality, increasing riparian zones and improving floodplain quality with open/green space; this in turn would provide beneficial wildlife habitat. There would be removal of flood prone structures and associated debris. This work in coordination with efforts of other agencies such as FEMA buyouts, watershed association/Cumberland River Compact (CRC) low impact developments, etc. would provide positive benefits to the watershed as well as water quality and land/water resources within the proposed project locations.

8.0 Measures to Minimize Impacts

The Recovery Plan (1987 and revised in 1989) for *O. shoupi* states it is unlikely the species would be removed from protection under the Endangered Species Act. However, down listing from endangered to threatened may be feasible. The Plan then outlines criteria that must be met prior to considering species reclassification. These include protection of existing Mill Creek basin population, reintroduction of the species into some as yet unknown historic habitat, or by discovery of an additional distinct population such that there exists two viable populations. In addition, the species and its habitat in the Mill Creek watershed and another separate and distinct population must be protected from human-related and natural threats likely to cause the species' extinction in the foreseeable future.

To date additional studies have not found an occurrence of *O. shoupi* outside of the Mill Creek watershed. Studies have identified similar watersheds as potential sites for relocation efforts (O'Bara 1999); however, no attempts have been made to move this species. In addition, no studies have undertaken the task of evaluating genetic diversity of *O. shoupi* in Mill Creek. These are areas of potential studies and evaluations. However, these actions are beyond the Corps scope and authorities and would have to be implemented by other resource agencies or universities. Withers (2005) notes that most data recently obtained has been the result of regulatory requirements associated with applications for activities within the watershed.

The following measures are presented for consideration by the USFWS as actions that could be undertaken by the Corps, the proposed project described in Section 2.
The permitted work shall be completed as expeditiously as possible and the stream restored immediately.

1. Within 24 hours prior to any work within the stream, a search must be performed to remove any *O. shoupi* within 100 feet upstream and downstream of the proposed crossing. Installation of barriers will be in placed to reduce reentry.

2. Construction of Educational Measures at Ellington Agricultural Center. Ellington Agricultural Center is a high use area with walking/running paths and creek access points. Construction/Installation of Educational Boards at the 2 creek access points adjacent to Ellington Agricultural Bridge would help increase awareness of the Nashville Crayfish and other species along and within Sevenmile Creek.

3. Removal of riparian vegetation shall be kept to a minimum and the disturbed area must be replanted with native vegetation. Disturbed streambanks shall be stabilized as soon as possible. Streambanks will be inspected, and replanted as needed, until vegetation is reestablished.

4. Erosion control devices shall be used to prevent stream sedimentation. Appropriate silt controls will be installed prior to beginning work on streambanks. Controls will be used singly or in combination to maximize control of sediment runoff. Silt controls will be maintained and inspected regularly to ensure proper function, and cleaned as needed. Material removed during cleaning will be placed in appropriate upland area such that runoff into the stream does not occur.

5. Cofferdams shall be constructed 1) upstream of the work zone and the stream shall be diverted around the construction zone through appropriately sized pipe or 2) to completely encircle the work site and stream flow pumped across the dewatered area. Cofferdams will consist of clean rock, bags filled with clean sand, or temporary water-inflated dams.

6. Water pumped from the work area shall be held in settling basins or filtered prior to discharge into surface waters.

7. Construction within the Sevenmile and Mill Creek is limited to the period between May 15 and September 30.

8. Post construction monitoring will be conducted within a two year timeframe. The purpose of the monitoring will be to ensure the site has been restored to acceptable conditions and sufficient crayfish habitat is available within the construction footprint.

9. In addition to coordination with USFWS in accordance with ESA, the Corps will coordinate with TDEC, Division of Water Pollution Control to discuss special conditions and measures that can be incorporated to provide the best protection to the aquatic environment and the *O. shoupi*.

9.0 Determination

Given the wide distribution of the Nashville Crayfish within the Mill Creek watershed, it is probable that the proposed projects, described in section 3, could impact the Nashville Crayfish and/or disturb areas of its habitat. Physical impacts to the crayfish are hard to observe and document, but could likely occur. Therefore the Corps determined a "**likely to adversely affect"** regarding the T&E species, *O. shoupi.*

10.0 Conclusion

Based on historic trends and permitted activities in the area, Mill Creek watershed will continue to incur development activities. In accordance with Section 7 of the Endangered Species Act, coordination of these applications will continue to involve the USFWS for the protection and conservation of *O shoupi,* and its habitat.

This biological assessment has provided characteristics of the crayfish and its restricted habitat of the Mill Creek watershed. In addition it has outlined current and foreseeable project activities associated with the Mill Creek Feasibility study. The Corps has determined that the proposed activities may adversely affect *O. shoupi.* With this determination, potential conservation measures have been presented that would result in avoidance and minimization of impacts to the listed species and its habitat.

This Biological Assessment is presented to the USFWS for its review and concurrence.

11.0 References

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CELRN-PM-P 15 July 2014

MEMORANDUM FOR RECORD

SUBJECT: Meeting with Peggy Shute, Robbie Sykes, and Steve Alexander (USFWS) to Discuss Changes to the Mill Creek Feasibility Report.

A meeting was held 9 July 2014 at USFWS, Cookeville Field Office, to discuss changes to the Mill Creek Feasibility Report. Changes that had occurred since the scoping notice include; Ellington Agricultural Center Bridge/Road Improvements. The proposed projects include:

1. Ellington Agricultural Center Road/Bridge Improvements
2. Briley Parkway Bridge Improvements
3. Nonstructural Measures
    a. Buyouts
    b. Raisings

The Nonstructural measure was informally discussed with the USFWS during the meeting and was determined to have no affect on the Nashville Crayfish. The Corps has made a "No Effect" determination for the Nonstructural Alternative. After further explaining the remaining proposed projects (Plans B and D) USFWS agreed that the Plans B and D would affect the Nashville Crayfish found in both Mile Creek and Sevenmile Creek.

Based on the potential impacts to the Nashville Crayfish, USFWS requested the Corps enter into Formal Consultation with USFWS and that a Biological Assessment would be required. The Corps explained the time situation regarding the proposed projects. USFWS stated that they did not for see their review of the proposed project to take the entire 120 days.

Matthew Granstaff

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

Project Planning Branch

AUG 28 2014

Ms. Mary Jennings, Field Supervisor
U.S. Fish and Wildlife Service
446 Neal Street
Cookeville, Tennessee 38501

Dear Ms. Jennings:

This letter serves as the Corps' request to initiate formal consultation under 50 C.F.R. § 402.14 (c) and Section 7 of the Endangered Species Act (ESA) as the Corps has determined that its proposed federal action, Mill Creek Flood Risk Management Study, Nashville, Tennessee, may affect, and could adversely affect the listed species, the Nashville Crayfish (*Orconectes shoupi*). The proposed projects are within the Mill Creek Watershed along Mill Creek and Sevenmile Creek, Davidson County, Tennessee. The proposed alternatives include; Measures B, D, and A.

Plan BDA combines the non-structural measure (A) (buyout and removal of frequently flooded residential structures impacted by the 1/5 Annual Chance Exceedances (ACE) or 5-year flood event, including some raise-in-place residential buildings) with a detention basin at the Ellington Agricultural Center Entrance Bridge (D), and bridge/fill modification to Briley Parkway (B) targeting the 1/50 ACE or 50-year flood event, located just downstream of the confluence of Sevenmile Creek and Mill Creek. In Mill Creek and tributaries Sevenmile Creek, Sorghum Branch, and Whittemore Branch, the 1/5 ACE equates to 90 structures that qualify for buyout or raise-in-place. The recommended plan has the potential to remove nearly half of the expected annual damages associated with Mill Creek and tributary flooding.

Each alternative was evaluated separately. Based on informal discussions with your office, it was determined that only measures B and D could have impacts to the Nashville Crayfish. Detailed descriptions of measures B and D can be found within the attached Biological Assessment (BA).

Attached to this request you will find three copies of a BA. The BA evaluates the effects of the implementation of the proposed projects on the Nashville Crayfish. This biological assessment concludes that the proposed projects (Measures B and D) would **likely to adversely affect** the Nashville Crayfish. This "likely to adversely affect" determination would be minimized by the conservation measures proposed in the BA. These proposed minimization measures in the BA are preliminary proposals.

I request that you notify the Corps if you believe that the U.S. Fish and Wildlife Service has enough information to initiate consultation, and if you concur with the

Corps' biological assessment. I further request the opportunity to review your draft Biological Opinion as provided in the regulations.

I look forward to working with you on this Section 7 process. Should you have any questions, feel free to contact Mr. Matthew Granstaff, Project Planning Branch at 615-736-7857 (email:Matthew.L.Granstaff@usace.army.mil).

Sincerely,

Russ L. Rote, P.E., PMP, CFM
Chief, Project Planning Branch

United States Department of the Interior

FISH AND WILDLIFE SERVICE
446 Neal Street
Cookeville, TN 38501

RECEIVED
to Tim Higgs
12-11-14

December 9, 2014

Colonel John Hudson
Department of the Army
Nashville District, Corps of Engineers
P.O. Box 1070
Nashville, Tennessee 37202-1070
Attn: CELRN - Matthew Granstaff

Re: File No. 2015-F-0141: Request for Initiation of Endangered Species Act Section 7 Formal Consultation Regarding the Mill Creek Flood Risk Management Feasibility Study, Mill Creek and Sevenmile Creek, Nashville, Davidson County, Tennessee

Dear Colonel Hudson:

This letter acknowledges the U.S. Fish and Wildlife Service's (Service's) November 17, 2014, receipt of your e-mail, transmitting the Biological Assessment (BA) for the Mill Creek Flood Risk Management Feasibility Study, Mill Creek and Sevenmile Creek, in Davidson County, Tennessee. The U.S. Army Corps of Engineers is initiating formal section 7 consultation under the Endangered Species Act in regards to potential adverse effects to the federally endangered Nashville crayfish (*Orconectes shoupi*) as a result of structural modifications proposed in the draft feasibility study. These proposals include modifications to the Briley Parkway Bridge over Mill Creek and the construction of a detention basin adjacent to Sevenmile Creek at the Ellington Agricultural Center. All information required of you to initiate consultation was either included in the BA or the draft feasibility study for the project. We have assigned log number FWS 2015-F-0141 to this consultation. Please refer to that number in future correspondence on this consultation.

Section 7 allows the Service up to 90 calendar days to conclude formal consultation with your agency and an additional 45 calendar days to prepare our biological opinion (unless we mutually agree to an extension) Therefore, we are required to provide you with our biological opinion no later than April 01, 2015.

As a reminder, The Endangered Species Act requires that after initiation of formal consultation, the federal action agency may not make any irreversible or irretrievable commitment of resources that limits future options. This practice insures agency actions do not preclude the formulation or implementation of reasonable and prudent alternatives that avoid jeopardizing the continued existence of endangered or threatened species or destroying or modifying their critical habitats.

If you have any questions or concerns about this consultation or the consultation process in general, please feel free to contact myself or Steve Alexander of this office at 931/525-4980, or at steven_alexander@fws.gov.

Sincerely,

Mary E. Jennings

Mary E. Jennings

Field Supervisor

Tennessee Department of Environment and Conservation
General Permit for Minor Alterations to Wetlands

Effective Date: July 1, 2010
Expiration Date: June 30, 2015

Activities Covered by this Permit:
This general permit authorizes minor alterations of up to 0.1 acre of wetlands that are degraded, of low functional capacity or in situations where the proposed area lost would result in no significant change in the function and water resource values of the larger wetland system. Cumulative wetland losses for any whole project shall not exceed a 0.25 acreage limit.

Limitations of this Permit:
Certain activities due to size, location or potential water quality impacts are not covered under this general permit. Those activities are described in this section. Activities not qualifying for authorization under this general permit may be authorized by an individual permit, provided that all requirements of the *Tennessee Water Quality Control Act of 1977* are met.

1) Activities that impact wetlands that represent a high resource value as compared to others within the ecoregion are not covered.
2) Activities where all practicable measures to avoid and minimize adverse impacts to the wetlands and other waters of the state have not been employed are not covered.
3) Activities located in a component of the National Wild and Scenic River System, a State Scenic River, waters designated as Outstanding National Resource Waters are not covered.
4) Activities located in any waterway which is identified by the department as having contaminated sediments, and the activity will likely mobilize the contaminated sediments are not covered.
5) Activities that may result in an adverse effect to a threatened or endangered species, or to designated critical habitat; or is likely to jeopardize the continued existence of a species proposed for listing as endangered or threatened without prior authorization from the U.S. Fish and Wildlife Service as required by section 7 or section 10 of the Endangered Species Act where applicable are not covered. Adverse effects comprise, but are not necessarily limited to, the following: (a) death or injury to one or more individuals that results from activities associated with an action, (b) a change in habitat quantity or quality that results from activities associated with an action that renders the habitat unsuitable for the species, or (c) activities associated with an action that disrupts normal behavior or functions of individuals.
6) Activities that may result in the take, harassment, or destruction of plant or wildlife listed as threatened or endangered or a species deemed to be in need of management, as defined and identified under Tennessee Code Annotated (TCA) 70-08-103, Tennessee Wildlife Resources Agency (TWRA) Proclamations 00-14 and 00-15, and Division of Natural Heritage (DNH) Rule 0400-6-2 or which will destroy the habitat of such species without prior authorization from TWRA and/or DNH where applicable are not covered.
7) Activities, either individually or cumulatively, that may result in degradation to waters of the state are not covered. For example, this general permit shall not be used in incremental means to combine with other projects to alter larger areas of wetland.
8) Activities that otherwise require an individual permit are not covered.

Obtaining Permit Coverage:
Coverage under this general permit may be obtained by submitting a signed and completed application (form CN-1091) to the division. Work shall not commence until written authorization from the division is received. As noted above, not all activities can be covered under this permit, and an application for coverage may be denied when appropriate.

The division will establish an expiration date for coverage under this general permit that is specific to the authorization and separate from the general permit's expiration date.

Terms and Conditions of this Permit:
All activities covered under this general permit shall comply with all terms and conditions contained hereinafter.

1) All work shall be accomplished in conformance with the accepted plans, specifications, data and other information submitted in support of the above mentioned application and the limitations, requirements, and conditions set forth herein.
2) All work shall be carried out in such a manner as will prevent violations of water quality criteria as stated in Rule 1200-4-3-.03 of the Rules of the Tennessee Department of Environment and Conservation. This includes,

but is not limited to, the prevention of any discharge that causes a condition in which visible solids, bottom deposits, or turbidity impairs the usefulness of waters of the state for any of the uses designated by Rule 1200-4-4. These uses include fish and aquatic life (including trout streams and naturally reproducing trout streams), livestock watering and wildlife, recreation, irrigation, industrial water supply, domestic water supply, and navigation.

3) Applicant is responsible for obtaining the necessary authorization pursuant to applicable provisions of §10 of *The Rivers and Harbors Act of 1899*; §404 of *The Clean Water Act* and §26a of *The Tennessee Valley Authority Act*, as well as any other federal, state or local laws.
4) Applicant is responsible for obtaining coverage under the National Pollutant Discharge Elimination System (NPDES) General Permit for Storm Water Discharges from Construction Activities for construction sites involving clearing, grading or excavation that result in an area of disturbance of one or more acres, and activities that result in the disturbance of less than one acre if it is part of a larger common plan of development or sale.
5) The wetlands alterations shall not adversely affect the functions and classified use support of adjacent wetlands or to other waters of the state.
6) Materials used in wetlands alteration projects shall be free of contaminants, including toxic pollutants, hazardous substances, waste metal, construction debris and other wastes as defined by T.C.A. 69-3-103(18).
7) The excavation and fill activities associated with the wetlands alteration shall be kept to a minimum.
8) Excavated materials, removed vegetation, construction debris, and other wastes shall be removed to an upland location and properly stabilized or disposed of in such a manner as to prevent reentry into the waterway.
9) Sediment shall be prevented from entering waters of the state. Erosion and sediment control measures shall be designed according to the size and slope of disturbed or drainage areas to detain runoff and trap sediment and shall be properly selected, installed, and maintained in accordance with the manufacturer's specifications and good engineering practices. Information on erosion and sediment control measures can be found in the department's Erosion and Sediment Control Handbook (www.tn.gov/environment/wpc/sed_ero_controlhandbook/).
10) Erosion and sediment control measures shall be in place and functional before earth moving operations begin, and shall be constructed and maintained throughout the construction period. Temporary measures may be removed at the beginning of the work day, but shall be replaced at the end of the work day.
11) Litter, construction debris, and construction chemicals exposed to storm water shall be picked up prior to anticipated storm events (e.g. forecasted by local weather reports), or otherwise prevented from becoming a pollutant source for storm water discharges (e.g., screening outfalls, daily pick-up, etc.). After use, silt fences should be removed or otherwise prevented from becoming a pollutant source for storm water discharges.
12) Clearing, grubbing and other disturbance to the riparian vegetation shall be kept at the minimum necessary for slope construction, equipment operations and project completion. Unnecessary riparian vegetation removal, including trees, is prohibited.
13) Appropriate steps shall be taken to ensure that petroleum products or other chemical pollutants are prevented from entering waters of the state. All spills shall be reported to the appropriate emergency management agency and to the division. In the event of a spill, measures shall be taken immediately to prevent pollution of waters of the state, including groundwater.
14) This general permit does not authorize impacts to cultural, historical or archaeological features or sites.
15) Failure to comply with the terms and conditions of this permit is a violation of the *Tennessee Water Quality Control Act of 1977* and is subject to penalty in accordance with T.C.A. §69-3-115.

APPROVED: Paul E. Davis   DATE: 6/28/10
Paul E. Davis, Director, Water Pollution Control

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

Project Planning Branch

Jimmy Smith
Tennessee Department of
Environment and Conservation
Division of Water Resources
William R. Snodgrass Tennessee Tower
312 Rosa L. Parks Avenue, 11th Floor
Nashville, Tennessee 37243

Mr. Jimmy Smith:

The U. S. Army Corps of Engineers, Nashville District (Corps) has prepared a Draft Integrated Feasibility Report, which included a Draft Environmental Assessment (EA), for the Mill Creek Flood Risk Management Study, Nashville, Davidson County, Tennessee. A 30 day public and agency review period was held and ended on December 1, 2014. The Tennessee Department of Environment and Conservation provided comments on the report review but this letter is requesting additional review on stream and wetland impacts. The purpose of the Corps study is to analyze potential solutions for the flooding problems in the Mill Creek watershed so that funding and authorization could be sought for construction of flood damage reduction projects.

A wide variety of flood risk management measures were developed that would address one or more of the planning objectives. Plan BDA was ultimately determined to be the National Economic Development (NED) Plan and is the recommended plan that provides the greatest net benefits. Plan BDA also leaves less residual risk in the floodplain than other plans considered in detail. Plan BDA is described below and site maps are attached.

Plan BDA – Ellington Detention Basin, Briley Bridge and Channel Modification and Non-Structural Plan - This plan maximizes the net annual benefits and provides significant residual flood risk reduction while being cost effective. Plan BDA includes 5-year non-structural flood protection component (Plan A) by selecting 89 residential structures for raise-in-place or buyout and removal. Plan BDA also combines a structural measure of a detention basin (Plan B) on a raised Ellington Agricultural Center East Access Road over Sevenmile Creek at Mile 3.7 targeting minor to moderate floods from the 10- to 25 year flood events. Damage reduction is also provided up to the 100-year flood. Plan BDA also includes bridge and high-flow channel modifications at the Briley Parkway Bridge (Plan D) at Mill Creek Mile 7.1 targeting moderate flood damages from the 10- to 50 year events.

Plans A, B, and D are considered measures that may be built collectively or separately and therefore were evaluated independently in the EA as schedule or funding levels could impact the order of construction. Based on current plans only Plan B – Ellington Agricultural Center Detention Structure would have impacts to streams and/or wetland areas. Stream and wetland impacts associated with construction and operation of the detention structure are relatively minor as described in detail in the attached Detailed Project Description. Based on our review, construction of this detention structure fits Corps Nationwide Permit conditions, once a Final Biological Opinion (for potential impacts to the Nashville crayfish) is received.

This letter serves as a request to TDEC, Division of Water Resources, for a review of the proposed project, an assessment of potential stream and wetland impacts regarding the Ellington Agricultural Center East Access Road Detention Structure, and to provide feedback on whether the project appears to be permittable. The Corps would follow-up with a formal Aquatic Resource Alteration Permit application in the future after receiving approval and funding to continue into Project Engineering and Design (PED) phase.

If you have any questions regarding the proposed project please contact Matthew Granstaff (Biologist) by phone (615)736-7587 or email Matthew.L.Granstaff@usace.army.mil. Your participation is greatly appreciated.

Sincerely,

Russ Rote, P.E., PMP, CFM
Chief, Project Planning Branch

Attachment - Detailed Project Description
TDEC Division of Water Resources Coordination

PLAN B – ELLINGTON AGRICULTURAL CENTER DETENTION STRUCTURE

Plan includes the raising of the existing East Access Road approximately seven feet and installing a new bridge over Sevenmile Creek (Figure 1, red lines show modified features).

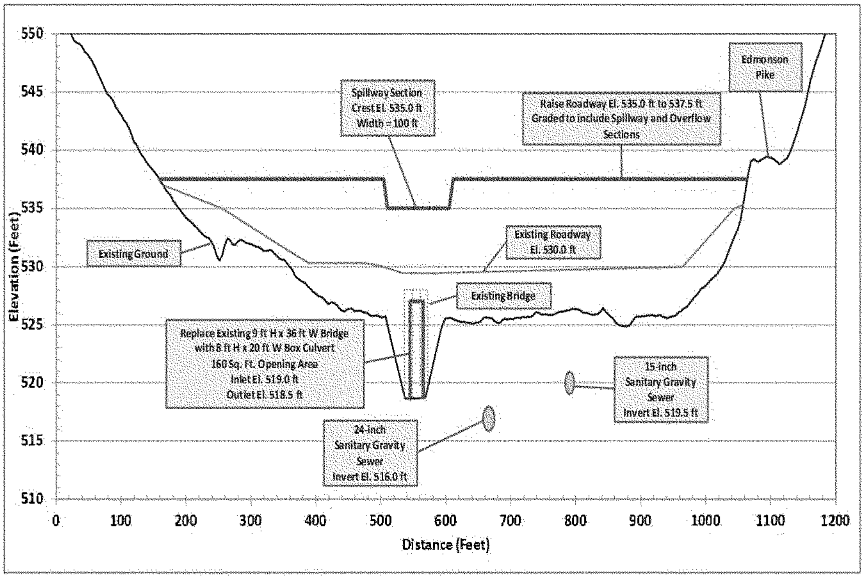

Figure 1. Proposed Design Plans for Sevenmile Creek Bridge Replacement.

DESCRIPTION OF THE EXISTING STREAM/WETLAND CHARACTERISTICS

SEVENMILE CREEK AT THE ELLINGTON AGRICULTURAL CENTER EAST ENTRANCE ROAD

Sevenmile Creek is the largest tributary of Mill Creek entering at RM 7.9 miles. Sevenmile Creek is approximately 7.3 miles long with a drainage area of 17.6 square miles, an average slope of 18.9 feet per mile, and an average 100-year floodplain width of approximately 500 feet. Sevenmile Creek is list by Tennessee Department of Environment and Conservation (TDEC) as a 303(d) list stream for the following reasons: low dissolved oxygen, total phosphorus, other anthropogenic, habitat alterations, *Echerichia coli*, and the federally listed Nashville Crayfish. Streambanks range from 3 to 9 feet high; existing channel averages 20 to 30 feet wide. The lower half of Sevenmile Creek flows through a heavily urbanized area, while the upper half is less developed.

Near the proposed project (Figure 2), Sevenmile Creek streambanks range from 6-9 feet high, channel is approximately 30 feet wide, and water depth is 6 inches to 1 foot.

Substrate in this area consists of a limestone based stream bed. The existing bridge has three openings and measures 9 feet high and 36 feet long (Figure 3).

ELLINGTON AGRICULTURAL CENTER EAST ENTRANCE ROAD WETLAND AREA

Located near the Ellington Agricultural Center East Access Road is a small, depressional wetland (Figure 2). This wetland area is approximately 0.25 acres in size, and is found within and adjacent to proposed bridge demolition and replacement. This wetland is characterized by the Cowardin Classification System and Hydrogeomorphic Wetland Classification System as a Palustrine, Forested, Broad-leaved Deciduous, Temporary Flooded – Depressional Wetland with a photograph shown in Figure 4.

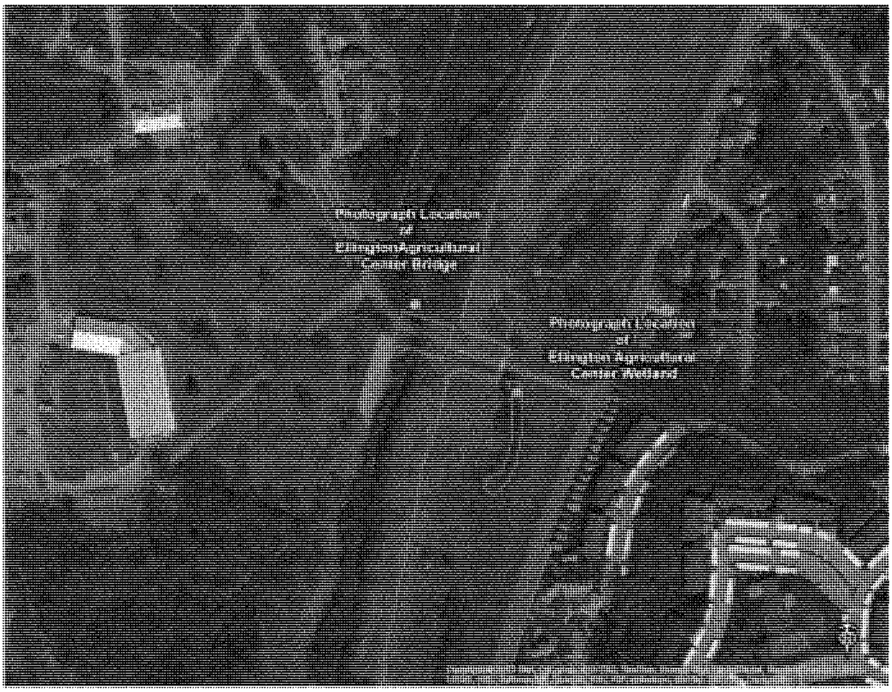

Figure 2. Photograph locations of the Bridge and Wetland within the Ellington Agricultural Center East Access Road Project Location.

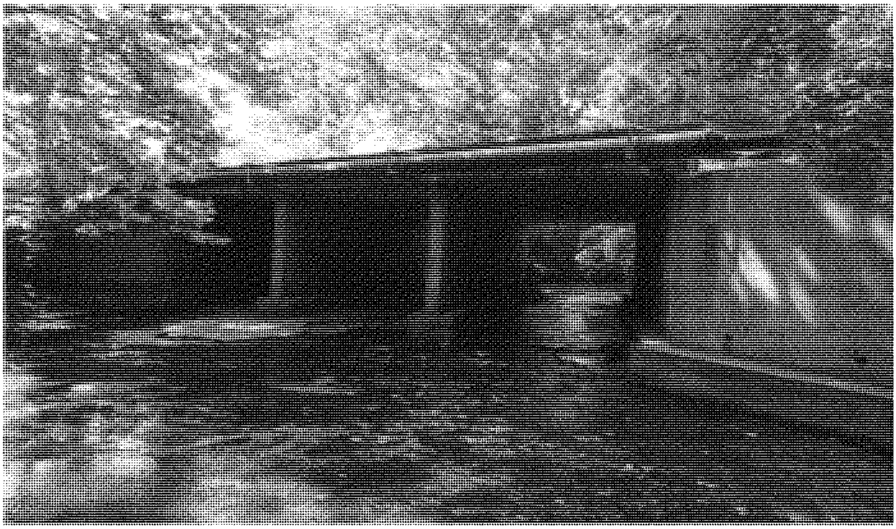

Figure 3. Photograph of the Existing Bridge to be removed on Sevenmile Creek. Photograph was taken just downstream of the Existing Bridge.

Figure 4. Photograph of the Existing Wetland along the Ellington Agricultural East Access. Photograph was taken from North Edge of Wetland Area Looking South.

DESCRIPTION OF THE PROPOSED PROJECT IMPACTS TO STREAM/WETLAND CHARACTERISTICS

SEVENMILE CREEK AT THE ELLINGTON AGRICULTURAL CENTER EAST ENTRANCE ROAD

The detention site was selected at Sevenmile Creek mile 3.67 located at the Ellington Agriculture Center East Access Bridge near Edmondson Pike. The proposed detention structure captures 7.9 square miles, 45% of Sevenmile Creek's total watershed. The detention structure would replace the existing two lane entrance bridge and must accommodate traffic across its crest. The new structure would have two lanes with approximately 1 foot high concrete curb on each side of the 30-foot crest. The structure would have a smaller culvert opening that would restrict the flow during flood events and retain water to minimize flooding downstream. The spillway would be abutted to the compacted-earth embankment on either side of the raised roadway. Existing low to normal flows of Sevenmile Creek would not be affected with the proposed measure.

Outlet Works
The outlet works would consist of an uncontrolled concrete box culvert located at the base of the structure. The outlet would pass normal flow and require no manual or mechanical operation. The opening would be 8 ft high and 20 feet wide (160 square feet of opening) with upstream and downstream invert elevations of 519.0 ft and 518.5 ft, respectively. The culvert barrel would be approximately 30 feet in length and be within the existing channel. The foundation would be on solid, non-erodible limestone. The relatively large conduit design would allow most of the debris to be flushed through the opening and a trash rack would not be required. The maximum outlet velocity would be approximately 15 - 20 feet per second (fps).

Embankment
The embankment would have a maximum height above the stream bed of 19.0 feet and act as a weir or spillway for flows exceeding the 5-year frequency flood event. The embankment section is approximately 800 feet in length at elevation 537.5 feet and designed to be overtopped and capable of passing all floods. The embankment would be compacted clay earthen fill. The earthen embankment would have 3:1 side slopes with a 30-foot top width. The downstream face of the embankment would be covered with articulated concrete blocks to protect against overtopping erosive velocities. The maximum overtopping velocities would be 23.5 fps during the storm events. Various articulated concrete block products have been designed to withstand velocities of this magnitude.

Spillway
The spillway is uncontrolled, broad-crested, 100 feet in length, and has a crest elevation of 535.0 feet. A hydraulic jump energy dissipater with an apron would be used to reduce the energy of flows through the spillway. Articulated concrete blocks would be required for approximately 20 feet downstream of the toe of the structure to protect the channel side slopes against turbulence and high velocities caused by the energy dissipation and outlet works.

Table 1 compares the differences in flow for the future without project (Future) and the future with project (With Project) conditions based on different storm frequencies. Also listed is the area and volume of the upstream detention pool at different storm frequencies. Temporary impacts are anticipated with construction, but the proposed action would also create long term benefits by reducing flows downstream during major events allowing waters to pass under the bridge in a controlled manner, thereby reducing flooding events. Sevenmile Creek channel is very stable with limestone rock bottom and established vegetated banks. There are no significant sediment aggradation or degradation problems along Sevenmile Creek.

Best management practices (BMPs) would be utilized during construction to minimize potential negative impacts to the environment. Due to the minimal and short-term duration of effects, stream impacts would only be associated with the removal/construction of a bridge.

Table 1. Regional Detention Structure River Mile 3.67 – Reservoir Data

Storm	Discharge		Elevation		Capacity	Area
Frequency	Future	With Project	Future	With Project	With Project	With Project
(Years)	(cfs)	(cfs)	(Feet)	(Feet)	Acre-Feet	Acres
2	2,621	2,210	529.9	532.4	101	25
5	3,305	2,631	530.4	535.1	168	36
10	4,244	3,480	530.8	536.7	240	43
25	5,139	4,547	531.2	537.7	288	48
50	5,813	5,515	531.4	538.0	303	50
100	6,542	6,380	531.6	538.3	314	51
200	7,373	7,265	531.8	538.5	323	52
500	8,787	8,698	532.1	538.8	337	53

ELLINGTON AGRICULTURAL CENTER EAST ENTRANCE ROAD WETLAND AREA

According to the existing plans (30 % design-level plans) impacts to approximately 0.10 acres of the 0.25 acre wetland would be unavoidable. Of the 0.10 acres impacted, approximately 0.05 acres would be considered temporary impacts with the remaining 0.05 acres being permanent impacts. Permanent impact includes fill material placed within 0.05 acres to raise the Ellington Agricultural Center East Access Road. The temporary impacts include equipment movement and construction access and these areas would be returned to grade and replanted after construction.

No compensatory mitigation for the 0.05 acres permanent impact is anticipated since it is less than 0.1 acres. Work would be completed in accordance with Corps Nationwide Permit conditions.

In the past, the Tennessee Stream Mitigation Program (TSMP) completed a mitigation project within the vicinity of Plan B. However, based on conversations with TSMP and review of mapping of TSMP project, only minor impacts to enhanced planting areas would be impacted. The vast majority of the proposed Plan B is within the existing road right-a-way and is maintained by mowing. After construction, areas outside of the maintained area would be replanted with native species following construction.

The Corps has entered into formal Section 7 Endangered Species Act coordination with the U.S. Fish and Wildlife Service (Service) regarding potential impacts to the federally listed Nashville Crayfish. The Corps submitted a Biological Assessment to the Service in September, 2014. Since the Service has submitted two drafts of their Biological Opinion (BO) to the Corps for review. Our review identified no major issues with implementation of the BO. A final BO is currently being prepared by the Service and is expected soon. Terms and Conditions of the BO would be implemented by the Corps or its contractors. No construction activities would contribute to 303d listing impairments.

CONCLUSION

The recommended plan (Plan BDA) has the potential to remove nearly half of the expected annual damages associated with Mill Creek and tributary flooding (Figure 5 - Mill Creek Watershed). Stream (new culvert) and wetland impacts (0.05 acre permanent and 0.05 acre temporary impacts) associated with the Ellington Agricultural Center East Access Road Detention Structure (Plan B) are relatively minor and fit Corps Nationwide Permit conditions, after receipt of the Final BO. No stream or wetlands are impacted by construction of Plan D - Briley Parkway Bridge modifications (Figure 6) and Plan A - Non-structural plan (Figure 7). The Corps is requesting a letter from TDEC Division of Water Resources concurring that the proposed project is permittable in order for the Corps to continue its planning study approval phase. Once approved and funding for the project is in place and a construction schedule is set, the Corps would further coordinate with TDEC for formal permitting in accordance with its ARAP process.

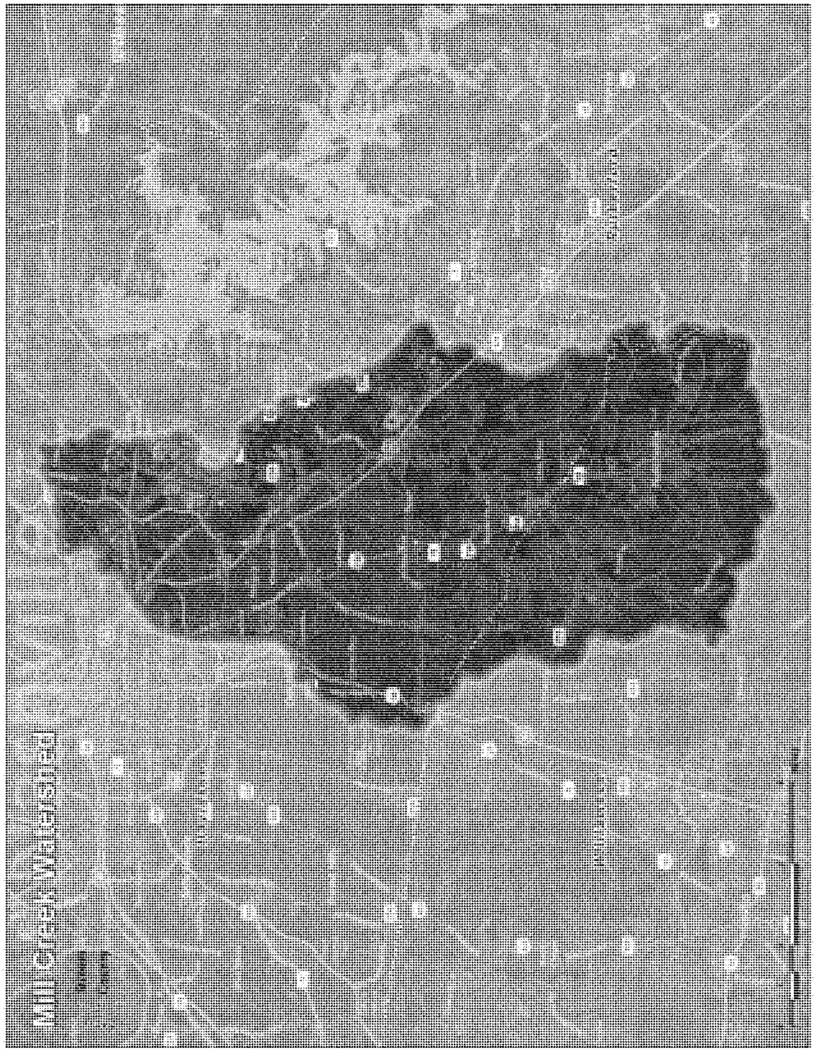

Figure 5. Mill Creek Watershed Map.

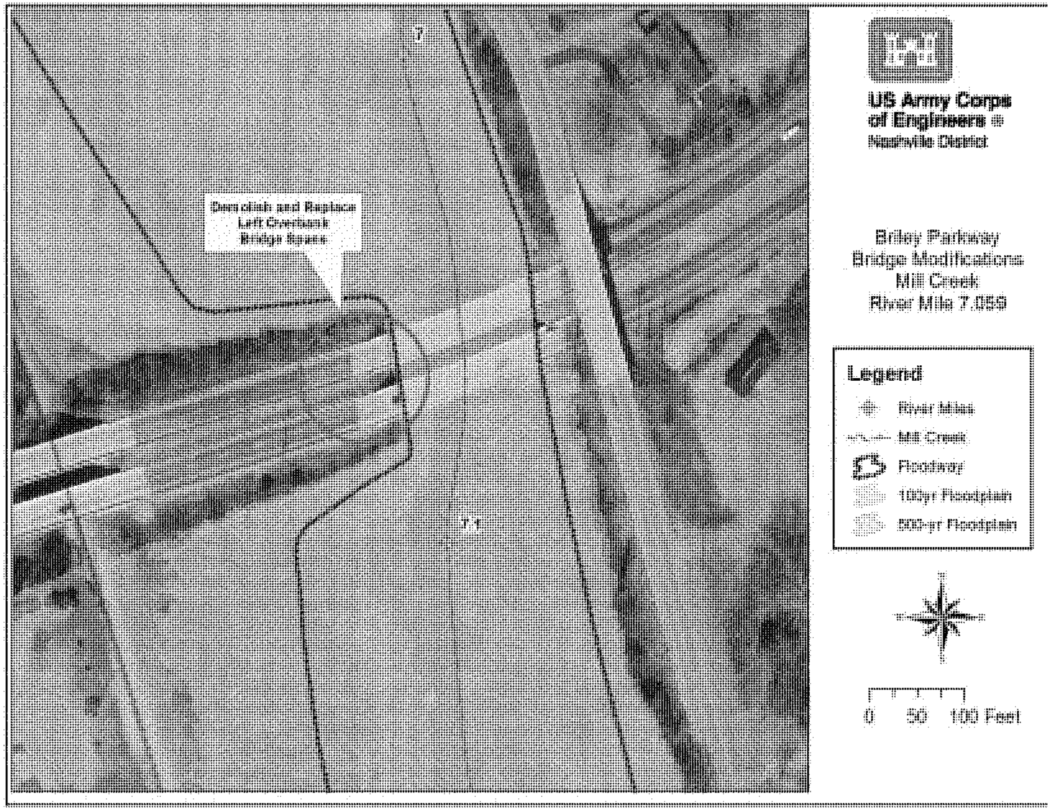

Figure 6. Plan D - Briley Parkway Bridge Modifications.

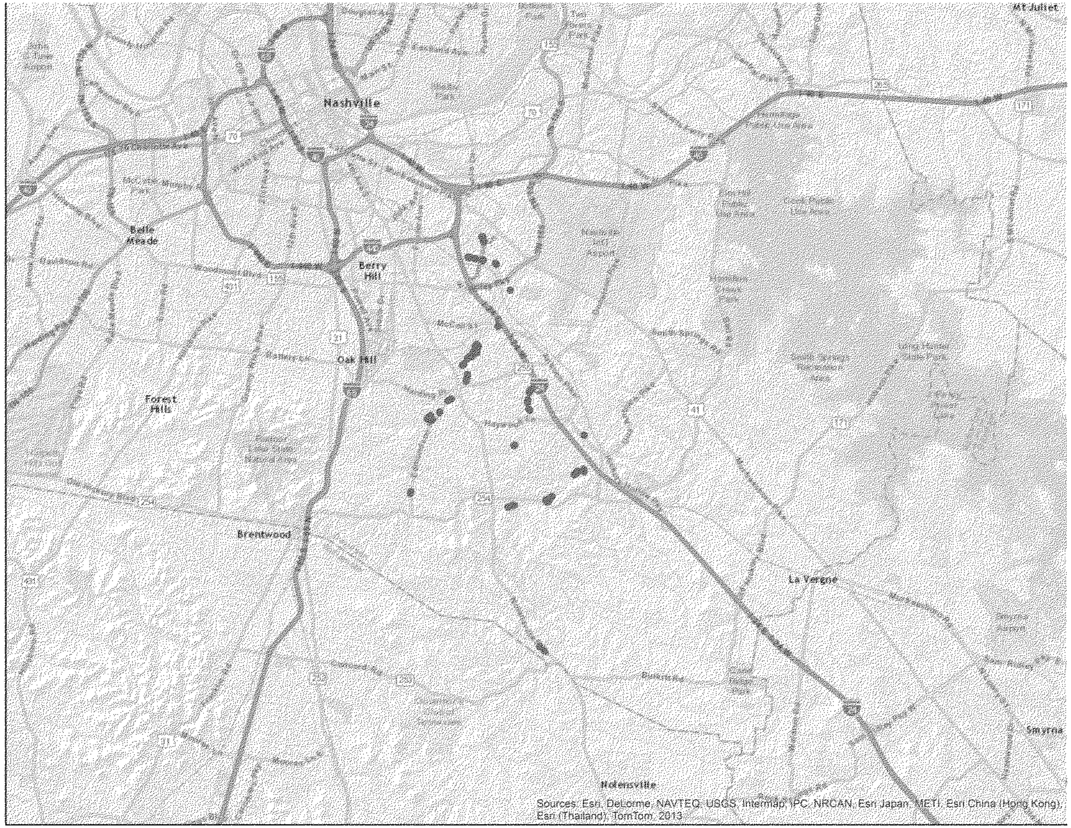

Figure 7. Plan A - Nonstructural Measures.

From: Higgs, Timothy A LRN
To: Granstaff, Matthew LRN; Rote, Russ LRN; Herbert, Thomas LRN; Carrington, Craig D LRN
Subject: FW: Mill Creek Flood Risk Management Letter (UNCLASSIFIED)
Date: Wednesday, May 20, 2015 3:13:40 PM
Attachments: TDEC Mill Creek COE comments May 2015.pdf

Classification: UNCLASSIFIED
Caveats: NONE

FYSA - Attached is a copy of the TDEC's review of Mill Creek FRM Project.

Tim Higgs
Chief, Environmental Section
Project Planning Branch
(615) 736-7863 (Work)
(615) 943-1405 (Blackberry)

-----Original Message-----
From: Jimmy R. Smith [mailto:Jimmy.R.Smith@tn.gov]
Sent: Tuesday, May 19, 2015 5:34 PM
To: Higgs, Timothy A LRN
Cc: Vena L. Jones; Robert D. Baker
Subject: [EXTERNAL] RE: Mill Creek Flood Risk Management Letter (UNCLASSIFIED)

Tim,

Here is a scan of a letter with TDEC's evaluation of the initial proposal. Like we discussed, we have some reservations, but think we can get to a permit. However, we cannot guarantee until it goes through the process. I hope this is what you need, and please let me know if you have any questions or need anything else.

Thanks - Jimmy

-----Original Message-----
From: Higgs, Timothy A LRN [mailto:Timothy.A.Higgs@usace.army.mil]
Sent: Monday, May 18, 2015 3:08 PM
To: Jimmy R. Smith
Subject: Mill Creek Flood Risk Management Letter (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Jimmy,

I appreciate you taking the time to meet with Barry Moran and I last Friday. Let me know if you have any additional questions or information needed related to the project. We went over a lot of information and tried to hit the points you were most concerned with but there is a lot of other detail on alternatives considered should it be needed. You thought you could send a letter back to us by the end of this week. I was going to request you either scan and email it directly to me or call and I can pick it up. As I mentioned, a group of Corps folks are traveling to our headquarters for a May 28th briefing and I hoped to get them a copy of the letter prior to their briefing. If it is mailed, sometime things get lost in the system here. Thanks again for you time and thoughts on the project.

Tim Higgs
Chief, Environmental Section
Project Planning Branch
(615) 736-7863 (Work)

(615) 943-1405 (Blackberry)

Classification: UNCLASSIFIED
Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF WATER RESOURCES
William R. Snodgrass Tennessee Tower
312 Rosa L. Parks Avenue, 11th Floor
Nashville, Tennessee 37243-1102

May 19, 2015

Tim Higgs
Chief, Environmental Section
Project Planning Branch
Nashville District, USCOE

RE: TDEC Response to ACOE Proposal
Mill Creek Watershed Study
Ellington Agriculture Center Regional Detention
Nashville, TN

Dear Mr. Higgs:

Thank you for your recent request for TDEC input concerning the project proposal on Sevenmile Creek at the Ellington Agriculture Center. This proposal is part of a larger project where the USCOE is proposing activities to address flooding concerns from residents in the Mill Creek watershed. Based on the information you have provided us to date, the division believes the project will have potential benefits to local residents with relatively limited impacts to water quality and instream habitat. However, some aspects of the proposal do raise concerns.

Projects for the sole purpose of flood control are typically not issued a 401 certification. The division normally requests that an applicant determine and address the primary cause of the flooding in other ways to prevent future impacts and the need for in channel alterations. We understand that options in such an urbanized region of Davidson County make alternatives limited and costly. Therefore we appreciate your multi-pronged approach to alleviate flooding that includes increasing capacity at a downstream culvert, purchasing of homes in the flood plain, and providing the stream flood plain access during frequent minor flooding events.

The Division does not promote instream treatment of stormwater, for either quality or quantity. Nor do we promote using roadways as detention weirs. Instream ponding of stormwater can create water quality issues, siltation concerns, and potential impacts to stream biology. However, the limited alternatives and minimal effects the proposal may have on Sevenmile helps mitigate these issues. The division recognizes the short reach length and duration of additional ponding, potentially beneficial flood plain access, as well as the project's protection to downstream infrastructure. We request the ACOE provide sufficient coordination with TDEC Natural Resources during the permitting phase to ensure any additional potential affects to resource values are duly compensated, including (but not limited to) activities in the vicinity that support the recovery of a federally listed endangered species, *Orconectes shoupi*.

The division will require evidence of formal coordination with USFW and TWRA to ensure protection of the species of concern (*O. shoupi*) is met. We also request a coordination letter from the Tennessee Stream Mitigation Program be provided to ensure minimization of impacts to their stream restoration site on Sevenmile Creek.

Finally, due to the division rules and process, at this time we cannot provide a firm decision as to whether a permit for a future project would be issued. Application materials and detailed, finalized construction plans along with coordination letters must be submitted to this office before a full project application review can take place. In addition the division must also provide opportunity for public participation, and take any comments provided into the decision process of whether and how to authorize the project. After application review and the potential public notice period ends, the division can then move forward with the final determination on whether to issue or deny a permit to the ACOE.

Thank you for your attention, time and consideration in this matter. Please feel free to contact me at any time with questions or concerns.

Sincerely,

Jimmy Smith
Manager, Natural Resources Unit
TDEC

Cc: Nashville District COE
Metro Water, Stormwater Division, Nashville, TN
Robbie Sykes, FWS
Rob Todd, TWRA
David Withers, TDEC Natural Areas
Kelly Laycock, EPA

BACKGROUND

WETLAND
One wetland area, approximately 0.41 acres in size, is found within and adjacent to Plan B. According to the existing plans approximately 0.10 acres of the above wetland would be unavoidable. Of the 0.10 acres impacted, approximately 0.05 acres would be considered temporary impacts with the remaining 0.05 acres resulting in permanent impacts. This wetland is characterized by the Cowardin Classification System and Hydrogeomorphic Wetland Classification System as a Palustrine, Forested, Broad-leaved Deciduous, Temporary Flooded – Depressional Wetland.

According to the existing plans, Plan BDA, would have a 0.05 acre permanent impact. This acreage (0.05) is well below the acreage threshold requiring mitigation by Tennessee Department of Environment and Conservation (TDEC) and U.S. Army Corps of Engineers (Corps). These impacts also meet TDEC's General Permit for Minor Alterations to Wetlands. This general permit authorizes minor alterations of up to 0.10 acres of wetlands that are degraded, of low functional capacity, or in situations where the proposed area lost would result in no significant change in the function and water resource value of the larger wetland system. Cumulative wetland losses for any whole project shall not exceed a 0.25 acre limit (Ref. TDEC General Permit for Minor Alteration to Wetlands). Also, the proposed project would meet the requirements of the Corps Nationwide Permit 18 – Minor Discharges.

Specific to Executive Order 11990 the proposed project, Plan BDA, minimized/avoided impacts to wetland with the footprint design to the greatest extent possible and there is no practicable alternative for the placement of fill into this wetland. Fill associated with temporary impacts (0.05 acre) would be removed and restored to existing condition further ensuring wetland impacts are minimal. Functions and benefit of the existing wetland would not be altered with a permanent loss of 0 .05 acre.

STREAM
Stream impacts would only be associated with Plan B, removal/construction of a bridge. Plans D and A would not result in any work within streams. Impacts associated with the removal/construction of a bridge would meet TDEC General Permit for Construction and Removal of Minor Road Crossings. This permit authorizes the construction and/or removal of minor road crossings. TDEC defines "minor road crossings" as a bridged or culverted roadway fill across a stream or river which results in the alteration of 200 linear feet or less of stream bed (on a single stream) or shoreline.

MITIGATION REQUIREMENTS
No mitigation is required for impacts to wetland areas and stream. Impacts meet TDEC General Permits as well as Corps Nationwide Permits. Also as stated above, the permanent wetland impacted acreage (0.05 acres) is well below the acreage threshold requiring mitigation by Tennessee Department of Environment and Conservation (TDEC) and U.S. Army Corps of Engineers (Corps). Fill associated with temporary wetland impacts (0.05 acre) would be removed and restored to existing condition further ensuring wetland impacts are minimal.

Functions and benefit of the existing wetland would not be altered with a permanent loss of 0 .05 acre.

ADAPTIVE MANAGEMENT

Current impacts meet both TDEC General Permits and Corps Nationwide permits. However, if plans where to change and additional impacts to wetlands and/or streams were unavoidable and mitigation required the Corps would obtain proper permitting from TDEC for the total acreage impacted. Unavoidable impacts would be mitigation for via an approved mitigation bank, in-lieu fee program, or permittee responsible mitigation.