THREE FORKS of BEARGRASS CREEK
LOUISVILLE, KENTUCKY
ECOSYSTEM RESTORATION
FEASIBILITY STUDY

***Source: The Beargrass PDT during field work on the South Fork.**

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Executive Summary

The non-Federal sponsor (NFS), Louisville Metropolitan Sewer District requested that the Louisville District, United States Army Corps of Engineers (USACE) initiate a study to ascertain the feasibility of restoring instream, wetland, and riparian areas for Beargrass Creek in Louisville, KY. This Integrated Feasibility Report (IFR) documents whether a project is warranted for Federal participation based on a feasibility level assessment of estimated costs, potential benefits, and possible environmental impacts of various alternatives, all of which follow the USACE planning and policy guidelines. The IFR contains an Environmental Assessment pursuant to 40 C.F.R. 1501.5. The purpose of the proposed project is ecological restoration that would provide habitat of the highest form and function for various fish and wildlife species. The need for the proposed project is due to past human induced disturbances within the watershed that have altered and/or modified natural biological processes and have reduced flora and fauna biodiversity. These induced disturbances include altered hydrology and hydraulics, increased colonization of invasive species, urbanization pressures, and fragmentation of the ecosystem.

Aquatic ecosystem restoration would re-establish and repair wetland, riparian, and instream habitat within the Beargrass Creek watershed, in turn increasing localized plant and animal species richness and diversity. The 60-square-mile study area is located in Louisville, Jefferson County, KY, and encompasses the entire Beargrass Creek watershed in northeast Louisville. Study area parcels are numerous and owned by a variety of property owners, including the NFS and Louisville. Historically, the Three Forks of Beargrass Creek meandered through forested areas and wetlands but has been highly manipulated due to urbanization over the last 100 years. Currently, land use adjacent to Beargrass Creek includes single- and multi-family residential, vacant, farmland, parks and open space, public and semi-private, commercial, and industrial uses.

Due to the size and complexity of the study area, the initial site selection began with over 200 locations throughout the watershed. Through site screening and iterative plan formulation, the final array of alternatives was composed of 14 alternatives. These 14 alternatives generated approximately 16,000 combinations of plans in the Institute for Water Resources Planning Suite. The Project Delivery Team (PDT), utilizing decision criteria from the Four Accounts (National Economic Development, Regional Economic Development, Environmental Quality and Other Social Effects), selected a cost-effective plan as the Recommended Plan. This plan will restore 620 acres of habitat including 72 acres of wetland habitat and 8.8 miles of stream at 12 sites within the watershed. The plan also includes the removal of 18 connectivity barriers throughout the watershed. The overall benefits of the plan are an increase of 297 Average Annual Habitat Units. The Recommended Plan also includes implementation of recreational features at seven sites to improve stream access, trails, and viewsheds for the public along Beargrass Creek. At least five years of monitoring and adaptive management will be implemented to ensure success of the Recommended Plan.

The Recommended Plan will provide scarce habitat in an urban setting and set an example of ecosystem restoration success in a degraded system that can be followed by other cities with similar issues. Louisville's historical ties to the creek offer an opportunity for education regarding stream health and for recreational experiences that increase quality of life, provide public health benefits, and foster stewardship in the community as well other positive sociological effects. Because of the watershed's location near the Ohio River and the Mississippi Flyway, this restoration work will also provide aquatic habitat for numerous aquatic species and migratory birds.

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The project is expected to result in approximately $106,555,000 in construction expenditures across the region. These expenditures are expected to occur between 2025 and 2031. Of this total expenditure, $95,490,000 will be added to the economy within the local impact area. The Recommended Plan has also been determined to have no adverse impacts to the environment in addition to the total 620 acres of habitat that will be restored with this Plan. Lastly, it is anticipated that the Plan will have positive impacts to the local community, which was quantified through an Other Social Effects analysis.

Based on 2022 price levels, the estimated project first cost is $121,135,000 which includes monitoring and adaptive management costs of $1,389,000 and will be cost shared 65/35 between USACE and the NFS. In accordance with the cost share provisions in Section 103(c) if the Water Resources Development Act (WRDA) of 1986, as amended (33 U.S.S. 2213 (c)), the federal cost share of the project is estimated to be $72,436,000 and the non-federal share is estimated to be $48,701,000. USACE will complete the design and implementation phase, which includes additional design studies, development of plans and specifications, contracting for construction, overall supervision during construction, preparation of an operation and maintenance manual, and participation in a portion of the post construction monitoring.

No significant issues were raised during scoping meetings or the public and agency review period for the project.

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1.0 Introduction

1.1 Study Authorization

Authority for Three Forks of Beargrass Creek, Kentucky – Ecosystem Restoration Feasibility Study is contained in a resolution adopted on May 5, 1987, by the Committee on Environment and Public Works of the United States Senate. This resolution reads as follows:

"RESOLVED BY THE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS OF THE UNITED STATES SENATE, that the Board of Engineers for Rivers and Harbors, created under Section 3 of the Rivers and Harbors Act, approved June 12, 1902, be, and is hereby requested to review the report of the Chief of Engineers of the comprehensive flood control plan for the Ohio and lower Mississippi Rivers, published as Flood Control Committee Document Numbered 1, 75th Congress, and other pertinent reports, with a view to determining the advisability of providing additional improvements for flood control and allied purposes in the Metropolitan region of Louisville, Kentucky, with particular reference to existing and potential flooding problems in the Pond Creek, Mill Creek, Beargrass Creek, and Floyds Fork drainage basins."

1.2 Report Organization

This document has been divided into 10 primary chapters, each dealing with a specific subject area relating to the project components, alternatives, and planning process. Chapters noted below by an asterisk (*) are compliant with and required by the Council on Environmental Quality's Regulations for Implementing the National Environmental Policy Act (NEPA).

- Chapter 1*, Introduction: provides background information concerning the purpose of and need for the study, authorization, study status, and the scope of the study. This chapter also notes relevance and integration of other related studies and reports.
- Chapter 2*, Affected Environment: provides a detailed presentation of the existing environmental conditions within the study area. This chapter also includes a complete discussion of environmental resources that would be affected by implementation of project alternatives.
- Chapter 3*, Project Background: describes the resource significance of the project.
- Chapter 4*, Plan Formulation: describes public involvement, problems and opportunities, plan formulation overview, description of measures and measure development, development of alternatives.
- Chapter 5*, Alternatives Evaluation: explains habitat evaluation, cost-effectiveness and incremental cost analysis, final array of alternatives and selection of National Ecosystem Restoration (NER) plan.
- Chapter 6*, Environmental Impacts: action vs no action evaluation of final array of alternatives.
- Chapter 7, Recommended Plan: summarizes the environmental, economic, and social benefits and costs of plan.
- Chapter 8, Remaining Reviews, Approvals, Implementation, and Schedule: identifies the estimated project timeline for future actions, defines commitments and

responsibilities, and verifies the fulfillment of procedural notice and review requirements.
- Chapter 9, Recommendation: letter of support from Commander.
- Chapter 10, References: lists references including studies, reports, analyses, and other reference materials used in the preparation of this report.

1.3 Purpose and Need

USACE has a central role to play in ecosystem restoration projects that have a nexus to water, as other federal agencies have missions focused on upland habitat. The primary purpose of this project is to restore habitat within the Beargrass Creek watershed which aligns with the Louisville District mission to "deliver solutions and manage resources supporting regional and national requirements…," as well as the Environmental Operating Principals of USACE (adopted in 2002):

1. Strive to achieve environmental sustainability
2. Recognize the interdependence of life and the physical environment
3. Seek balance and synergy among human development activities and natural systems
4. Continue to accept corporate responsibility and accountability under the law
5. Seek ways and means to assess and mitigate cumulative impacts to the environment
6. Build and share an integrated scientific, economic, and social knowledge base
7. Respect the views of individuals and groups interested in USACE activities

Wetland, riparian, and riverine ecosystems are threatened nationally due to human interference (Soule, 1986). These diverse areas provide habitat for a wide range of aquatic flora and fauna. Over the past century, land adjacent to streams and rivers in Louisville, Kentucky, was converted from native wetland and bottomland hardwood forests to residential and industrial land uses. Through this process of development in and around Louisville, nearly all the wetland habitat along Beargrass Creek was drained and/or filled to facilitate new industrial, commercial, and residential areas. Channelization of the stream to increase conveyance of flood waters has reduced availability of riparian and instream habitat. These changes in land use have created an urbanized watershed with a severely altered hydrologic regime, degraded geomorphic form, and altered ecological structure. The compounded effects of these impairments justify the need for ecological improvement.

In response, the purpose of this project is to address ecosystem scarcity and connectivity issues of the watershed. This, in turn, will have notable social impacts at the local and regional levels. Figure 1 illustrates an area of Cherokee Park on Middle Fork Beargrass Creek prior to the major development occurring in and around Louisville where locals and tourists alike have visited for over a century.

Aquatic ecosystem restoration would re-establish and repair wetland, riparian, and instream habitat within the Beargrass Creek watershed, in turn increasing localized plant and animal species richness and diversity. This project has great potential to restore riparian corridors that provide habitat for three federally threatened and endangered species of bat: gray bat, Indiana bat, and northern long-eared bat. Restoration of habitat along Beargrass Creek near its confluence with the Ohio River could improve habitat suitability for ten different species of federally listed freshwater mussels. Each of these species relies on a host fish species to carry their microscopic larvae (glochidia) in the early stages of the mussel's life cycle. Restoration of instream channel features would improve aquatic habitat to support a diverse assemblage of host fishes for mussel species. Wetland and bottomland hardwood forest restoration would provide habitat for resident waterfowl and increase both quality and quantity of stop-over refugia for migratory birds utilizing the Mississippi Flyway.

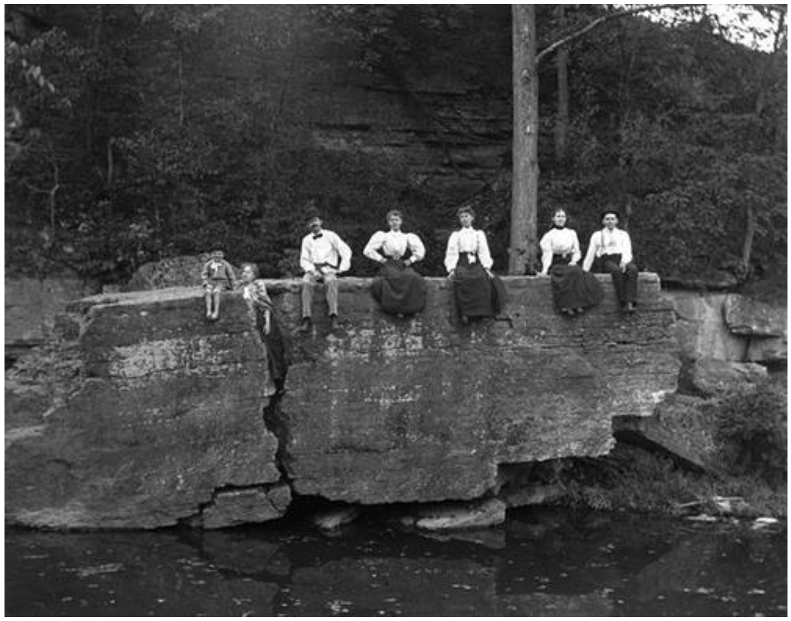

Figure 1 Big Rock at Cherokee Park in 1936. Photo credit - The Olmsted Conservancy

In addition to improving the ecological integrity of the watershed, recommendations from this study could improve the natural visual landscape of Cherokee Park and surrounding neighborhoods that are listed on the National Register of Historic Places (NRHP). This project provides an opportunity to reestablish the aesthetic qualities of Beargrass Creek through Cherokee Park, which was designed in 1891 by world renowned landscape architect Frederick Law Olmsted. At that time, Olmsted had already designed Central Park in New York City, the U.S. Capitol Grounds, and the Biltmore Estate Grounds. However, what is considered his greatest achievement was the concept of a system of parks connected by tree-lined parkways. The park system of Cherokee, Iroquois, and Shawnee parks in Louisville is one of four park systems designed by Olmsted. It is the most fully realized and last park system design of his career (Olmsted Parks Conservancy).

Beargrass Creek is the focal point of Cherokee Park, and the surrounding neighborhoods were established to compliment the landscape and topography, which were shaped by the creek. Cherokee Park was designed as a pastoral setting to exemplify this region of Kentucky and was a response to rapid industrialization of the 19th century. Restoring the stream would reestablish the natural resources that inspired Olmsted's original design plans and preserve the historic significance of this region.

Beargrass Creek is well-acknowledged by the public as an ecological asset and source of pride at national, state, and local levels. In 2019, the Congress of New Urbanism used the South Fork of Beargrass Creek as a case study for their 27th national conference on blending green space with innovative urban development. State recognition of the watershed is exemplified by the Beargrass Creek State Nature Preserve, Kentucky Waterways Alliance, and water quality reports by the Division of Water. Locally, the Louisville Metro Government consistently highlights the community and ecological value of the watershed directly through the Louisville Metropolitan Sewer District (MSD) Watershed Master Plan, but also indirectly through planning initiatives related to Cherokee Park, Tyler Park, Olmsted Parkways, Louisville Zoo, Waterfront Botanical Gardens, and Metro Park's Naturalization Master Plan. Non-profit entities such as the Beargrass Creek Alliance, Beargrass Creek Watershed Council and Salt River Watershed Watch compose a substantial force of volunteers dedicated to improving the ecological health of the watershed.

This project also has potential to improve access to green space for low-income and minority populations. While numerous studies cite the positive physical and mental health impacts of living near and having access to green space (Reid et al, 2017, and Triguero-Mas, 2015), there are many communities in the watershed where green space is sparse. In particular, work on the concrete channel and in the headwaters of the South Fork would positively impact underserved populations in Louisville.

Together with various master plans, public parks, nature preserves, and local watershed alliances, the Beargrass Creek watershed provides an environmental science and ecosystem restoration case study that strengthens educational opportunities for academic institutions and universities. Bellarmine University, University of Louisville, and Louisville Male High School use the watershed as an outdoor classroom to educate students on the impacts of urbanization on ecological balance. An ecosystem restoration project of this magnitude and significance would allow for students to monitor biological responses to restoration measures and add hands-on learning experiences to public and private school curricula.

1.4 Watershed Location and Location of Study Area

1.4.1 Watershed Description and Location

The Beargrass Creek system contains three major sub-watersheds: the South Fork (27 square miles), the Middle Fork (25 square miles), and the Muddy Fork (7 square miles). The forks converge just east of downtown Louisville before discharging into the Ohio River (Figure 2).

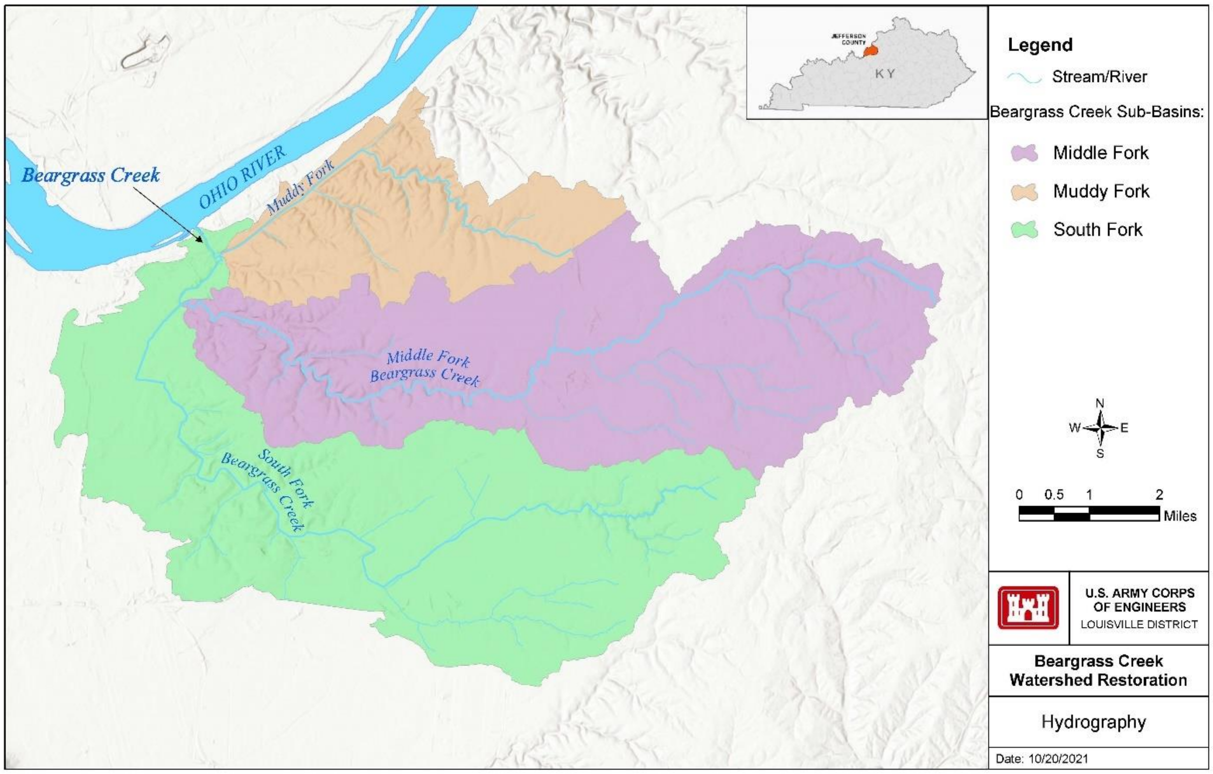

Figure 2 Beargrass Creek watershed boundaries

The South Fork has its headwaters above Bardstown Road and the Buechel neighborhood. It runs generally north through the Audubon Park and Germantown neighborhoods to its convergence with the Middle Fork near the Butchertown and Irish Hill neighborhoods. The Middle Fork begins in the Middletown area. It runs through St. Matthews and Seneca and Cherokee parks to its convergence with the South Fork. The combined South and Middle forks flow northward from this convergence through the Butchertown neighborhood. The Muddy Fork begins near Windy Hills in eastern Louisville. It flows along I-71 to where it converges with the combined South and Middle forks just before discharging into the Ohio River (Figure 3).

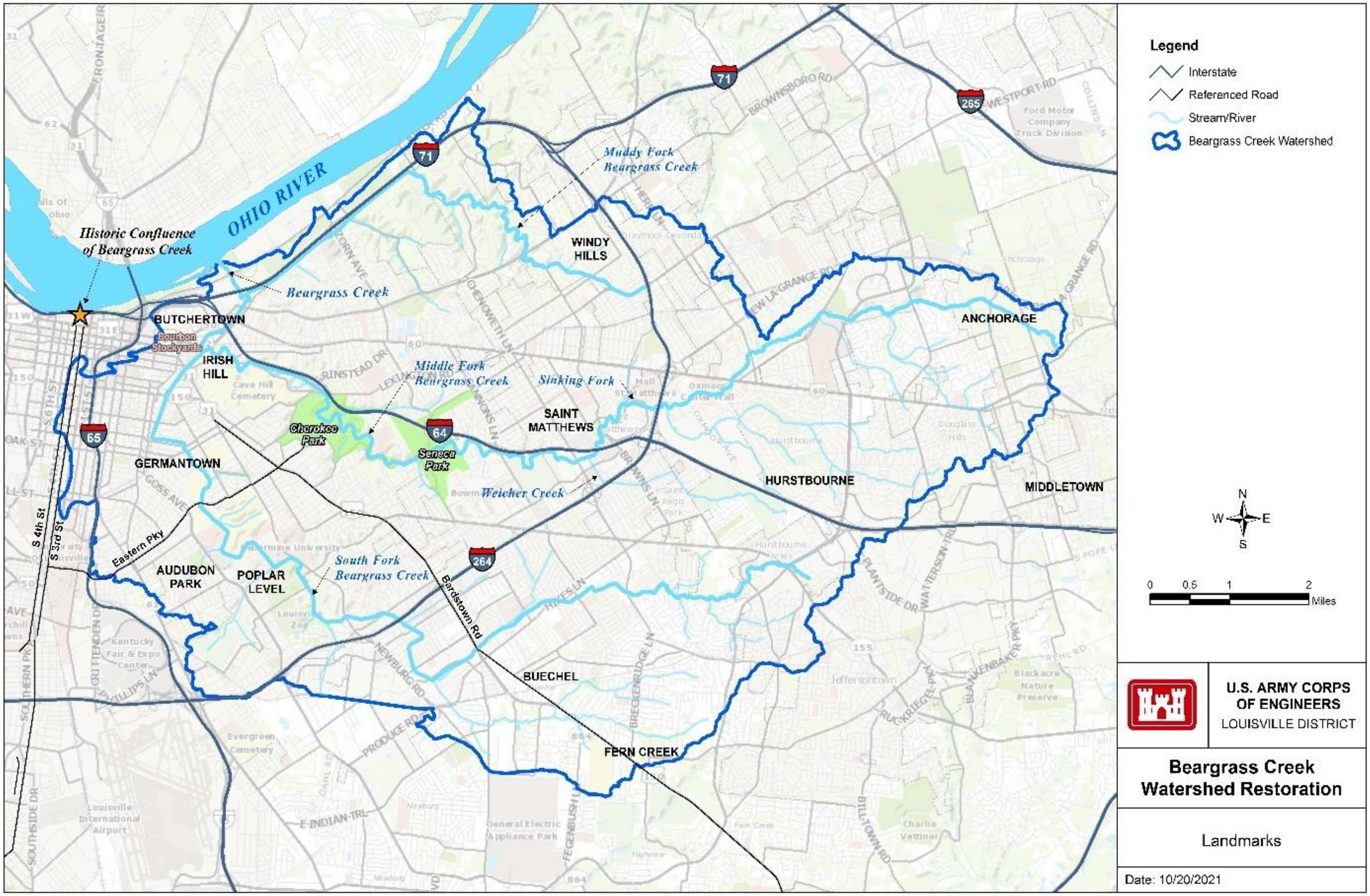

Figure 3 Historic confluence, neighborhoods, and landmarks within the Beargrass Creek watershed

1.4.2 Location of Study Area

The study area is within the Louisville Metropolitan area which encompasses all of Jefferson County, Kentucky. It is the most populous county in the commonwealth with 617,790 residents in Louisville (U.S. Census, 2019). The Beargrass Creek watershed takes up a 60-square-mile area of Jefferson County just east of downtown and includes the South, Middle and Muddy forks (Figure 3).

1.4.3 Historic Conditions

Beargrass Creek has a history of anthropogenic influence dating back to the 1800s during the early development of the city. In the 1850s, the stream's confluence with the Ohio River was re-routed from its original location between 3rd and 4th Streets (Figure 3) to what is known as Beargrass Creek Cut-off two miles east near Towhead Island due to heavy pollution causing unpleasant sights and smells. This also allowed easier access for trade along the Ohio River and docking before boats reached the Falls of the Ohio.

Water-based industries such as slaughterhouses, distilleries, and meat packing houses set up operation between the 1800s and mid 1900s on the banks of the creek. Prior to regulation, many businesses and residents dumped waste directly into the creek. Combined sewers began to be constructed in the 1920s to carry wastewater and stormwater runoff. In the late 1930s, the South and Middle forks were straightened and dredged to form deep channels as a flood protection measure. Many areas in the most urbanized parts of the watershed were straightened and converted into concrete channels by the city, most notably the 2.5-mile section of the South Fork that runs from Eastern Parkway to the Butchertown neighborhood (Figure 4).

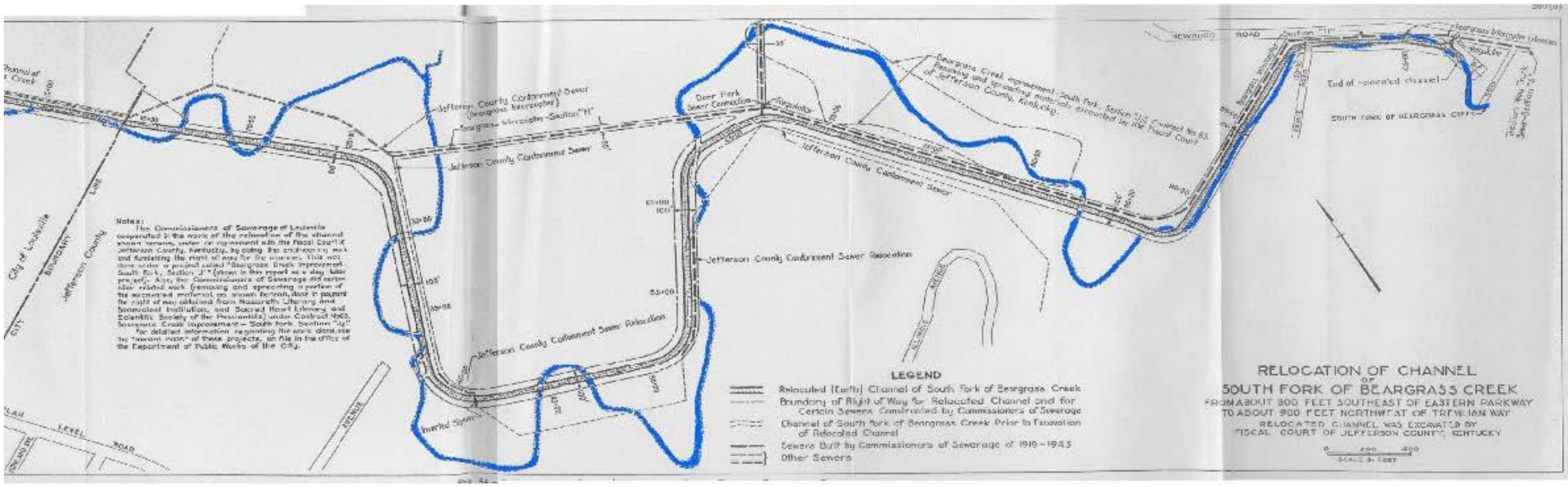

Figure 4. Historical meanders of the South Fork of Beargrass Creek (blue), which were replaced with a concrete channel from Eastern Parkway to the Butchertown neighborhood.

The project's non-federal sponsor (NFS), Louisville MSD, inherited the City's combined system sewers in 1947 from the Commissioners of Sewers, followed by the stormwater drainage system in 1987 from the City of Louisville and Jefferson County, taking on the challenge of maintaining and improving waterways.

1.5 Study/Project Participants and Coordination

The NFS is Louisville MSD. Since the signing of a Consent Decree with the US EPA (United States Environmental Protection Agency), MSD has invested over $1 billion in wastewater projects across the county, aimed at reducing combined and sanitary sewer overflows (CSOs and SSOs, respectively). MSD has completed 24 of the 25 gray infrastructure (i.e. dams, floodwalls, pipes) and green infrastructure (solutions to flooding/climate change that mimic natural processes) projects (outlined in the Consent Decree) within the combined sewer system, reducing the residual average annual overflow volume by 5 billion gallons per typical year to date. The Waterway Protection Tunnel, which will be completed in 2022, will have the capacity to store up to 55 million gallons and provide safe, clean waterways by preventing 439 million gallons of pollution from entering the Ohio River and Beargrass Creek in a typical rainfall year. When fully implemented, these combined system projects are modeled to achieve 95% capture and treatment of wet weather combined sewerage, which exceeds the 85% Presumption Approach criteria in EPA's CSO Control Policy. Additionally, 74% of the separate sanitary sewer system projects as enumerated in the Consent Decree are complete and have eliminated 82% of modeled SSO volumes for a 2-year design storm. These projects have reduced wet weather mean E-coli concentrations by approximately 70% in Middle Fork and South Fork of Beargrass Creek since 2010 based on grab sample data (Figure 5). In addition to Consent Decree projects, MSD remains engaged with community partners to provide ecological restoration such as the Hilliard-Musselman Stream Restoration Project off Grinstead Drive, just north of the Cave Hill site.

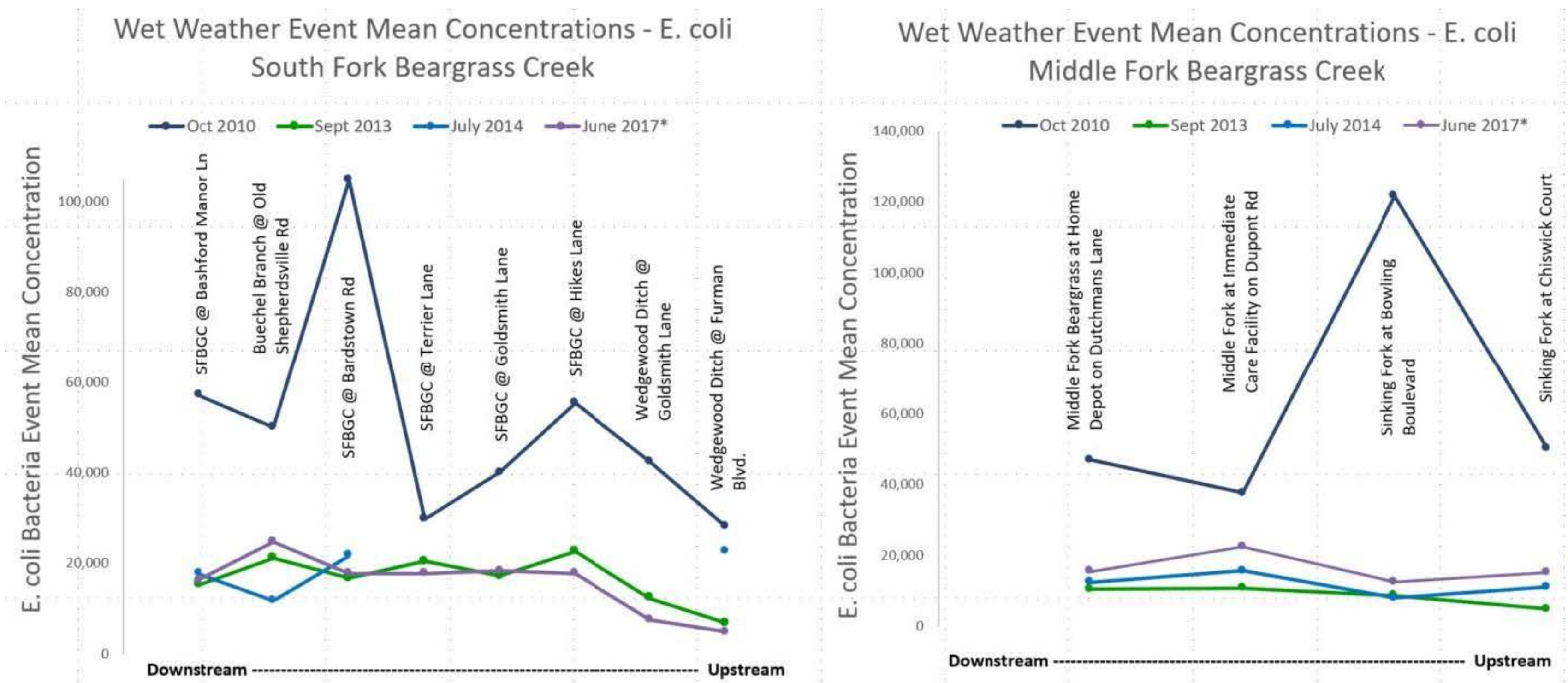

Figure 5. Beargrass Creek Wet Weather Water Quality Improvements

The primary stakeholders identified during development of this study include, but are not limited to the Louisville Metro Government, City of St. Matthews, Office of Kentucky Nature Preserves, Archdiocese of Louisville, Kentucky Waterways Alliance, Louisville Nature Center, and University of Louisville. USACE is the lead federal agency under the National Environmental Policy Act (NEPA) and this report serves as an integrated Environmental Assessment pursuant to 40 C.F.R. 1501.5. Through the development of this study, USACE worked closely with the NFS, the U.S. Fish & Wildlife Service (USFWS), the Commonwealth of Kentucky Department of Natural Resources (KDNR), various county and municipal agencies, and local ecosystem restoration support groups to develop the most environmentally beneficial and most cost-effective project that achieves the study goals and objectives.

1.6 Related Studies and Reports

The reports discussed below were used during this study to assess existing and future conditions of the watershed. Some provided background information that informed the scoping phase and gave the team important data to make decisions on the problems and opportunities within the study area. Others helped to inform forecasting of future conditions with and without the project implementation. Later in the planning process the information from these reports were used qualitatively during plan selection and for the formulation of the recreation portion of this plan.

1.6.1 U.S. Army Corps of Engineers

- 1997. USACE. Metropolitan Region of Louisville, Kentucky Study, Interim Reconnaissance Report-Beargrass Creek Basin. This document reports the results of a reconnaissance level investigation of water resource problems in the Beargrass Creek Basin in Jefferson County, Kentucky, to determine whether there is a potential federal interest in providing improvements to the watershed that would alleviate flooding and other water resource problems.
- 2002. USACE. Beargrass Creek Wetland Restoration Area, Preliminary Restoration Plan. Prepared in partnership with Louisville Metro Government. This is an approved Preliminary Restoration Plan that proposed restoration of the aquatic ecosystem along a stretch of Beargrass Creek from the MSD pump station to the creek's confluence with the Ohio River, approximately 3,000 linear feet. This project proposed the creation of a wetland area at Eva Bandman Park, containing 11 acres of riparian forest and 2 acres of aquatic area with a viewing platform.
- 2017. USACE. Beargrass Creek Trail Conceptual Shared Use Path and Ecological Restoration Report. Prepared in partnership with Louisville Metro Parks and Recreation. This report proposes improvements to the existing shared use path along the downstream reach of the Middle Fork of Beargrass Creek, as well as improvement and preservation of creek buffer zones, wetlands, and urban tree canopy.
- 2019. USACE. Buechel Branch Watershed Hydrologic and Hydraulic Model Development. Prepared in partnership with Louisville and Jefferson County Metropolitan Sewer District. This study performed a review of existing models and floodplain mapping and utilized current hydraulic modeling to access existing and fully developed conditions of Buechel Branch, a tributary in the South Fork of Beargrass Creek watershed. The report also developed modified conditions and performed a floodway analysis for floodway development and mapping.

1.6.2 Individual, Local, and Agency Reports

- 2011. Commonwealth of Kentucky. Total Maximum Daily Load for Fecal Coliform Six Stream Segments within the Beargrass Creek Watershed. Prepared by Commonwealth of Kentucky Energy and Environment Cabinet, Division of Water. This plan identified potential load and wasteload reductions that could be potentially used to satisfy the water quality standards for Beargrass Creek.
- 2016. MSD. State of the Streams: 2016 Water Quality Synthesis Report. Prepared by Louisville and Jefferson County Metropolitan Sewer District. This report reflects monitoring data at 27 Long Term Monitoring sites on Beargrass Creek, maintained by MSD and is focused on the conditions of fish, aquatic insects, algae, stream habitat, bacteria, nutrients, total suspended solids, trace metals, stream flow, dissolved oxygen, dissolved oxygen, and water temperature of the streams in the Louisville community.
- 2017. MSD. Fish Assessment Report. Prepared by Redwing Biological Services, Inc. This report displays the results of fish monitoring at 27 Long Term Monitoring sites in and around Jefferson County during the sampling period of October 2017.
- 2017. MSD. Macroinvertebrate Community Assessment Report. Prepared by Redwing Biological Services, Inc. This report displays the results of macroinvertebrate sampling at 27 Long Term Monitoring sites in and around Jefferson County during the period of May and June 2017.
- 2018. Redwing Biological Services, Inc. Beargrass Creek Water Quality Assessment. Focus Area Habitat Maps. The report is a series of maps showing natural woodland, maintained park space, and wildlife activity at focus areas along Beargrass Creek to identify priority monitoring sites.
- 2019. MSD. Connecting Beargrass Creek: South Fork. Prepared by The Congress for the New Urbanism in partnership with MSD and Kentucky Waterways Alliance. This plan proposes ecosystem and recreation improvements to areas along the South Fork of Beargrass Creek.
- 2019. MSD. Long-Term Monitoring Network:Algae Component, Algae Results for the 2013, 2015, and 2017 Sampling Events. Prepared by Stantec. This report summarizes algae monitoring methods and data collected in 2013, 2015, and 2017.

1.6.3 Concurrent Project and Studies

- MSD Middle Fork Water Quality Project 319 Grant: This project is funded by the EPA focused on water quality improvements and not specifically ecosystem and habitat restoration. Proposed projects may have primary or secondary effects that would improve the ecosystem health due to the connection between ecosystem health and water quality. As for future with and without project assumptions, related to future improvements of potential ecosystem restoration sites evaluated as part of this study, no projects were identified that have potential impacts from the EPA 319 grant at this time.
- MSD Water Quality Project at Grinstead Drive: This project is focused on water quality improvement through removal of invasive species, native species planting, and restoration of the stream corridor at a tributary of the Middle Fork. MSD worked with

the Louisville Jefferson County Environmental Trust to restore an area held in conservation easement that will help support native plant and animal species through water quality improvement. While these improvements have secondary positive impacts, the overall impact to the watershed will be negligible in future with and without project scenarios.

- Butchertown/Nulu/Phoenix Hill Neighborhood Plan: This plan is in draft form and, at the time of this report, was under public review. The plan aims to outline the priorities, strengths, and goals of the Butchertown, Nulu, and Phoenix Hill neighborhoods, where a portion of the South Fork is located. The plan emphasizes the importance of the creek historically and to surrounding neighborhoods. The plan includes connections to the creek, as well as educational opportunities and a recreational component in a greenway along the creek and is complimentary of the recommendations from this study.

1.6.4 Existing Water Resource Projects

- The Louisville Metro Flood Protection System was implemented by USACE in the 1950s and consists of a levee and floodwall system and numerous pump stations that protect the city from Ohio River floodwaters. The South Fork of Beargrass Creek passes under the Beargrass Creek Pump Station, which protects the South and Middle forks and their tributaries from Ohio River backwater flooding. The Muddy Fork is not protected from Ohio River flood events and experiences backwater flooding annually. Historically, USACE recognizes the impact of flooding on Beargrass Creek and importance of maintaining navigation on the Ohio River as is borne out through the substantial investments made by the federal government into these two systems. The stream’s connectivity with the Ohio River provides a unique opportunity to provide improvements to the ecosystem in the lower portions of the watershed when considering the highly regulated nature of the Ohio River. The system is operated and maintained by MSD. USACE and MSD are currently working together on a feasibility study to repair and replace portions of the project that are aging and in need of updates.
- Ohio River Navigation Project: Beargrass Creek is a tributary to the Ohio River, which is operated for navigation purposes by USACE. McAlpine Locks & Dam is located on the Ohio River approximately 2 miles downstream of the confluence of Beargrass Creek. McAlpine Locks & Dam is used to hold a normal pool on the Ohio River between elevations of 419.7 and 420.5 feet NGVD29, which extends backwater up Beargrass Creek about 1.25 miles.
- MSD currently has two ongoing basin projects and one tunnel project within the Beargrass Creek watershed. The Clifton Heights and Logan/Breckinridge Street storage basins both store storm and sewer water and protect Beargrass Creek from combined sewer overflows. The Waterway Protection Tunnel extension runs from Grinstead Drive at Interstate 64 and travels north west to meet the existing tunnel at Story Ave. When the tunnel is operational (planned for 2022), the above ground site will serve as a trailhead for the existing Beargrass Creek Trail (Figure 3).

2.0 Affected Environment

The following sections describe the existing conditions within the study area for a suite of environmental resources. This provides a baseline to compare the potential impacts that may result from implementation of the proposed alternatives. General descriptions are provided first, followed by descriptions of each fork, when applicable. Some resources cannot be described by reach, such as air quality. Chapter 5 describes alternative impacts on the environment.

2.1 Geology Seismology, Soils and Minerals

2.1.1 Summary Qualitative Climate Change Assessment

A summary of the detailed qualitative climate change assessment (Appendix E) highlights the important information gleaned from the assessment using the tools provided by the Climate Preparedness and Resilience Community of Practice (CPR CoP). The assessment is heavily based upon a literature review of research conducted in the Ohio River Region, the 4th National Climate Assessment, and CPR CoP tools to evaluate observed and projected trends/vulnerabilities including the Climate Assessment Tool (CHAT), the Nonstationarity Detection Tool (NSD), and the Vulnerability Assessment (VA) Tool.

Summary of Historic Trends in Hydrometeorology

Based on the literature review, there is consistent consensus among the available sources supporting trends of increasing, historically observed temperatures within the region. Observed changes in historic precipitation and streamflow have more uncertainty associated with them. There are substantial indications that increasing trends in rainfall have occurred. These trends appear to be validated by analysis of observed rainfall data collected within the project area as statistically significant increasing trends were found in the spring and autumn seasonal average precipitation datasets.

Significant changes in urban streamflow have also been observed by the nonstationarity detection tool as well as by the climate hydrology assessment tool; however, these changes are largely attributed to changes in land use and urbanization and cannot be attributed solely to the impact of anthropogenic climate change. Other nearby stream gages outside of the project area, such as Floyds Fork at Fisherville, which did not experience the same extent of urban development, do not exhibit the same increasing trends or nonstationarities within their periods of record. No trends were found within the period of record reported along the Ohio River at Louisville. Therefore, the observed changes in streamflow detected within the streamflow records collected along tributaries to the Ohio River are thought to be caused largely by the localized, rapid urban development and changes to land usage within the interior drainage area beginning in the 1950s, and the future hydrologic condition within the study area will likely be held constant due to local regulations on development that MSD has in place. MSD requires all new development to provide mitigation for increased runoff, as well as floodplain compensation for development in both the existing and fully developed floodplains.

Summary of Projected Trends in Hydrometeorology

Regarding projected future trends, there is generally a consensus of increasing trends in temperature and precipitation. Additionally, the frequency of intense storms is projected to increase. These changes will likely vary seasonally, with greater increases in the winter and spring months. While there is less consensus regarding trends in streamflow, an assessment of projected mean annual maximum monthly streamflows within the study area demonstrates evidence of increasing streamflow peaks. However, it should be noted that substantial uncertainty exists within future climate projections, which is effectively illustrated by the range of General Circulation Model (GCM) peak annual streamflow projections shown in Figure 1-27 (Appendix E) which indicates that each of the 93 climate projections included in this figure's range can be considered equally likely to occur.

Results from the USACE Vulnerability Assessment tool were analyzed for the project area and found no outstanding vulnerabilities compared with other HUCs across the continental United States. While the project area is not within the top 20% of vulnerable HUCs nationally, that does not imply that vulnerability to climate change does not exist. The VA tool indicates that the percent of freshwater plant communities at risk, combined with the rainfall/runoff elasticity, intra-annual variability of runoff, and biological condition of macroinvertebrate are driving ecosystem restoration vulnerability. Likewise, vulnerability for the flood risk reduction business line is driven by future streamflow and precipitation.

Summary of Residual Risk/Implications to the Study Area

Beargrass Creek flows into the Ohio River and is a part of the HUC 0514 Lower Ohio Watershed. In addition to being affected locally, the Beargrass Creek Watershed is affected regionally due to the backwater on the Ohio River. Generally, the literature supports trends of increasing temperatures and precipitation in the region. Additionally, projected climate change trends for the HUC 0514 watershed and region estimate a mean annual air temperature increase from 0 to 14.4°F by the latter half of the 21st century. Most studies project increases in precipitation, especially during the winter and spring seasons, and most projections trend toward more intense precipitation events which results in more common floods and droughts. The observed streamflow from the CHAT has not historically been increasing, but the streamflow from the CHAT is projected to increase. Risks associated with the projected climate change were discussed in the different literature and are summarized in the sub-sections and table below.

Residual Risk/Implications for Ecosystem Restoration

The projected increase in the mean annual air temperature can allow for the ranges of less temperate plant species to expand northward and replace more temperate species. Warmer air temperatures will also affect the movement and interactions between different types of organisms. Warmer air temperatures can also misalign ecosystem phenology and negatively impact native or rare species. Higher temperatures and drought periods will increase evapotranspiration and could stress ecosystem restoration efforts. The projected increased intensity of rainfall events and droughts can make it difficult for wetlands to survive and can disrupt riverine communities. Without connected floodplains, higher flows and increased flooding can be devastating to stream habitats as increased stream bank and bed scouring occurs. The potential increased flow can be beneficial for fish reproduction but can be detrimental to mussels and fish as stream scouring occurs. Additionally, higher turbidity can stress organism reproduction. Higher precipitation can restore greater connectivity for wetlands but can also increase the rate of eutrophication and eventual sedimentation of the wetlands, shortening the lifespan of these habitats. Extreme precipitation and flooding can lead to increased sediment loads and nutrient runoff, affecting the water quality of the streams. Drought and extreme heat can lead to tree and aquatic life mortality. Prolonged inundations can create anoxic conditions leading to mortality in plant communities and aquatic life. Temperature and precipitation change can lead to an increase of more resilient invasive species and a decrease in native species, which will in turn lead to less biodiversity.

Residual Risk/Implications for Flood Risk Reduction

An increase in temperatures will cause more precipitation to be rain than snow which can lead to an increase in streamflow. The growing number of extreme rainfall events is stressing deteriorating infrastructure in the Southeast United States. Many transportation and stormwater systems have not been designed to withstand these events, which poses a greater risk of failure to these systems. Statistical methods have been developed for defining climate risk and frequency analysis that incorporate observed and/or projected changes in extremes. However, these methods have not yet been widely incorporated into infrastructure design codes, risk assessments, or operational guidelines. Because the CHAT on the observed data shows no significant trend, assessments conducted on infrastructure designs that use recent historic data may underestimate potential risks.

Vulnerability Assessment Indicators

The vulnerability assessment focused on the ecosystem restoration and flood risk reduction business lines as these business lines directly relate to the study project and can be affected by future with or without project. The most significant indicators contributing to the ecosystem restoration vulnerability score pertain to the conditions of the ecosystem such as the percent of at-risk freshwater plant communities (contribution ~38.5%) and the biological condition of the macroinvertebrate (contribution ~10.6%), as well as the hydrologic conditions such as the rainfall/runoff elasticity (contribution ~20%), and the intra-annual variability of runoff (contribution ~14%). The most significant indicators contributing to the flood risk reduction vulnerability score pertain to the hydrologic conditions such as the flood magnification factor, both local and cumulative, (contribution ~71.2%) and the large elasticity between rainfall and runoff (contribution ~21.2%).

It is important to note that, despite the potential risk due to the projected climate change, most ecosystem restoration project implementations would relieve some of the residual risk for the ecosystem restoration and flood risk reduction business lines. Designs should be flexible and resilient enough to accommodate the potential effects of climate change.

Table 1 displays the residual risk table to the project due to climate change. This table lists potential climatic triggers, hazards, harms, and approximate qualitative likelihood of occurrence. The table is primarily focused on the business line of interest, ecosystem restoration, however that is not to say that other USACE business lines will not be impacted by climate change. Because this qualitative analysis is focused on the Beargrass Creek Ecosystem Restoration study, only generic project features have been identified within the table. The right-most column of the table indicates the qualitative likelihood that an event will occur, these are based largely upon the findings within the literature review and various climate assessment tool outputs.

Table 1 Residual Risk Table for the Beargrass Creek Ecosystem Restoration Study

Feature or Measure	Trigger	Hazard	Harm
Riparian and riverine implementations	Frequent drought periods, higher temperatures Increased precipitation Increased extreme precipitation events	Future evapotranspiration may be larger than present Future rates of eutrophication can be higher than present Increased duration and intensity of flooding	Riparian implementations could have difficulty surviving in drought; riverine implementations could have disrupted connectivity Increased rates of filling of riparian implementations and shortening lifespan of these habitats Riparian project implementations could have difficulty surviving in extreme flood conditions.
Riverine aquatic habitat	Increased extreme precipitation events and increased streamflow	Future velocities may be larger than present and increased stream bank scouring	Establishment of a normal life cycle would be more difficult. Normal life cycle includes spawning, embryo and larva, and juvenile development. Additionally, could stress the reproductive and feeding processes of adult species. Temporary changes to streams through bank erosion or channel reforming; however, species will temporarily adjust and then return to normal riverine state once the system returns to a dynamic equilibrium.
Aquatic organisms and plant communities	Increased temperatures Increased temperatures Increased extreme precipitation events	Phenology can be misaligned Frequent drought and extreme heat periods Increased duration and intensity of floods	Organisms dependent on certain phases of plant cycles and seasonal timing will be stressed when phenology of the plant community changes. Tree and aquatic life mortality Prolonged inundations can lead to lack of oxygen leading to mortality in plant communities and aquatic life
Native vegetation	Overall increase in precipitation, and more frequent extreme precipitation and drought events	Stress native vegetation	Could result in loss of native vegetation/biodiversity and the re-establishment of invasive species better suited for future hydrologic conditions
Floodwater storage area	Increased urbanization within existing flood prone areas	Increased urbanization leads to further development of flood prone areas	Increased development within flood prone areas increases flood damages and frequency of flooding.

2.1.1 Topography, Geology, and Soils

The study area is in the Outer Bluegrass Region, which is generally characterized by underlying fossiliferous limestone, dolomite, and shale of the Ordovician geological age. The study area lies within the Ohio River Alluvium physiographic region of Kentucky. Deposits in the county include limestone, shale, dolomite, lacustrine, and alluvial deposits. The Ohio River Alluvium is primarily made up of Pleistocene glacial outwash material and unconsolidated alluvium, which consists of sand, gravel, clay, and silt. Regionally, the lithology is comprised of a 5- to 45-foot thick layer of clay, silt, and fine sand that overlays sand and gravel containing discontinuous lenses of clay. Beneath the aquifer are relatively tight shale and limestone bedrock.

The topography of the study area can be obscured by the extensive urban and suburban development. The topography of the project area is essentially a gently southwestward sloping surface from a high of 751 feet on the east to around 404 feet near the Ohio River. The highest point in the Beargrass Creek watershed is in the upper reaches of the Middle Fork. Sinkholes are the most common karst feature found within the watershed, with the most occurring within the Muddy Fork watershed. A map generated by the Kentucky Groundwater Data Repository of known sinkholes in the Beargrass Creek watershed is in Appendix F. Figure 6 shows the terrain and elevation of the watershed.

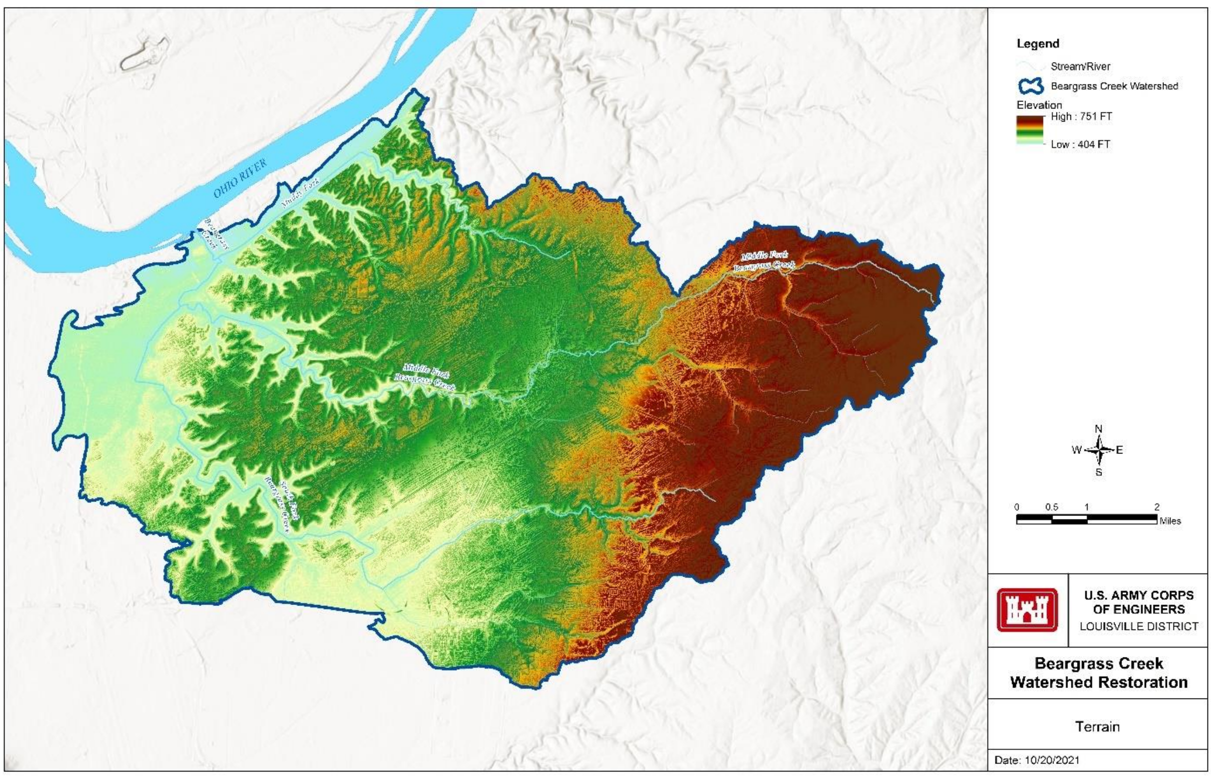

Figure 6 Terrain map of the Beargrass Creek Watershed

The Ohio River floodplain is relatively narrow near the mouth of Beargrass Creek but widens substantially to the south and southwest. Floodplains of the Three Forks of Beargrass Creek are shown in Figure 7.

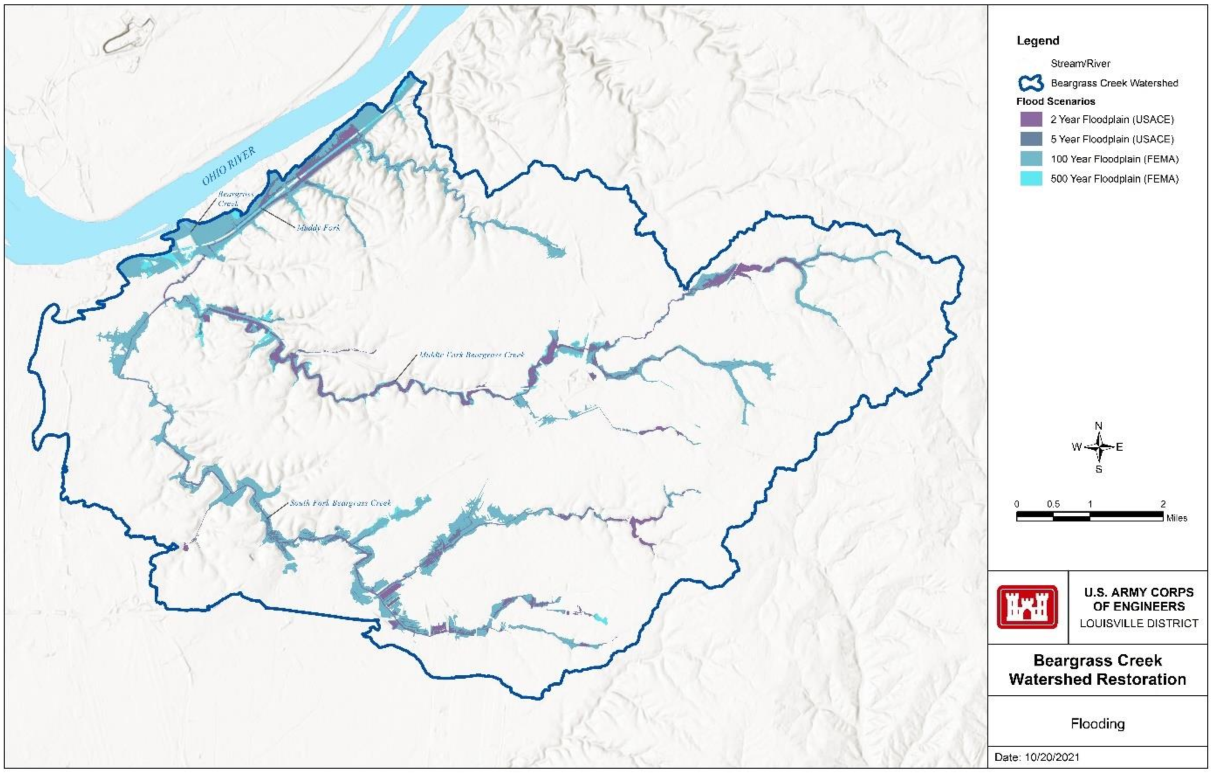

Figure 7 Floodplains of the Three Forks of Beargrass Creek

As the study area is mostly developed land, most soils in the study area are classified as urban land, with varying amounts of Udorthents and Udarents soil complexes with slopes ranging from 0 - 12% slope. The Natural Resources Conservation Service (NRCS) Web Soil Survey provides soil data and information produced by the National Cooperative Soil Survey. NRCS Soil Survey maps for the project area are located in Appendix F.

2.1.2 Seismicity and Faults

Louisville lies between two fault zones. The New Madrid Seismic Zone—located to the west of the study area in western Kentucky—is the most active fault in the central and eastern United States. This zone is a source of continuing small and moderate earthquakes, and it poses a significant risk for a major earthquake. To the east is the Lexington Fault Zone, which is related to the origin of the stresses that upbowed the Cincinnati Arch, deep beneath the surface of Kentucky. According to the Kentucky Geological Survey (2019a), Louisville is not located in an active seismic zone, but has experienced three earthquakes with magnitudes greater than 3.0 since records have been kept.

2.2 Air Quality

2.2.1 Environmental Setting

The U.S. Environmental Protection Agency (US EPA) Office of Air Quality Planning and Standards has set National Ambient Air Quality Standards (NAAQS) for six principal pollutants, called "criteria" pollutants. They are carbon monoxide, nitrogen dioxide, ozone, lead, particulates of 10 microns or less in size (PM-10 and PM-2.5), and sulfur dioxide. Ozone is the only parameter not directly emitted into the air but forms in the atmosphere when three atoms of oxygen (O^3) are combined by a chemical reaction between oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight. Motor vehicle exhaust and industrial emissions, gasoline vapors, and chemical solvents are some of the major sources of NOx and VOC, also known as ozone precursors. Strong sunlight and hot weather can cause ground-level ozone to form in harmful concentrations in the air.

As of December 31, 2021, Jefferson County had nonattainment status for 8-hour ozone. The county was in attainment for all other criteria pollutants (US EPA, 2020). Louisville's 8-hour ozone (2015 standard) classification was "marginal"—the least severe classification.

2.3 Land Use

2.3.1 Land Management and Administrative Agencies and Organizations

The largest land manager in the study area is Louisville Metro. As of 2020, the Metro Parks system had 120 parks covering more than 13,000 acres, and the nation's largest municipal urban forest in Jefferson Memorial Forest. MSD owns and maintains many smaller parcels for sewer infrastructure within the watershed.

2.3.2 Applicable General Plans

Louisville Metro's comprehensive plan, called Plan 2040, went into effect on January 1, 2019. Plan 2040 was developed to guide Louisville's growth and development over the next 20 years. The plan updates and builds upon its predecessor, Cornerstone 2020, while recognizing changing conditions and shifting community priorities.

Within the Community Form Plan element of Louisville Metro's comprehensive plan, there are five overarching goals that are supported by a series of objectives and action-oriented policies to help frame the community's vision for land use and development. One goal of the existing plan that is directly applicable to the current study is to enhance neighborhoods by protecting and integrating open space, watersheds, and other natural resources. The stated objectives of this goal are:

a. Environmental impacts of development are diminished.
b. Environmentally sensitive areas are preserved and/or enhanced.
c. Open spaces are integrated into development, where appropriate.
d. The built environment provides connections to parks, recreation, and natural resources.

2.3.3 Land Use in the Study Area

Greater than 60 percent of the Louisville area has been developed to some extent, which has greatly modified the existing natural resources within the city. Land use adjacent to Beargrass Creek includes single- and multi-family residential, vacant, farmland, parks and open space, public and semi-private lands, and commercial and industrial land types (Figure 8). Land use adjacent to the upstream reach of the Middle Fork includes high-usage park and single-family residential areas. Land use adjacent to the downstream part of the Middle Fork study reach includes limited-use park, recreational, and commercial areas. A biking and walking path on Middle Fork Beargrass Creek, beginning just upstream from its confluence with South Fork Beargrass Creek, extends over a mile. Land use adjacent to the upstream reach of the South Fork includes moderate-use park and recreational areas, open areas, and limited residential and commercial areas. Land use adjacent to the downstream reach of the South Fork includes the highest concentration of commercial and industrial usage (Figure 8).

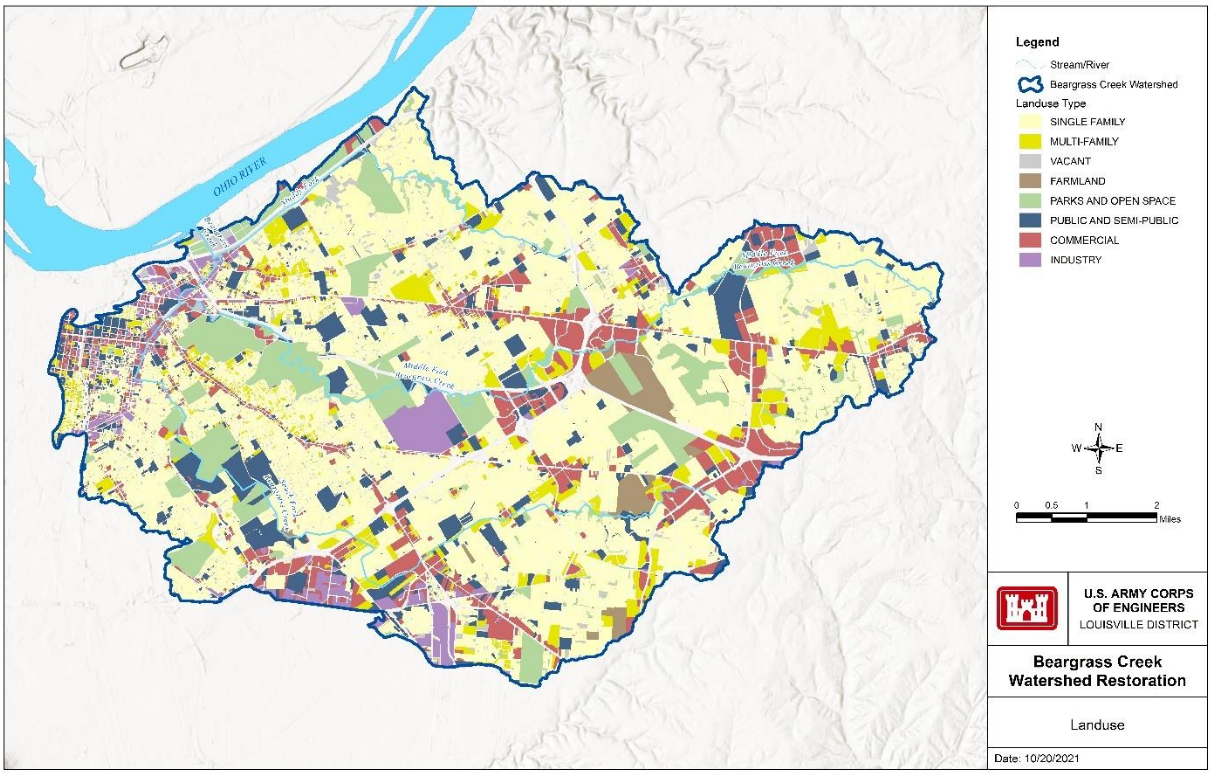

Figure 8 Land uses within the Beargrass Creek Watershed

According the Kentucky State Data Center, the population of Louisville is projected to increase by over 10% by 2040 (Ruther, 2016). While much of the study area is built out, continued population growth may result in further build out and recycling of land which could result in further detrimental impacts to aquatic and riparian ecosystems from pressures such as habitat fragmentation and increased runoff from impermeable surfaces.

2.4 Water Resources

2.4.1 Beargrass Creek

The study area consists of the Three Forks of Beargrass Creek—the Middle, South, and Muddy forks—in northcentral Jefferson County, Kentucky. The Beargrass Creek watershed (Figure 8) is the largest in the county, with a drainage area of approximately 60 square miles. From 2010-2019, average discharge of the stream at River Road in Louisville (just upstream of the confluence with the Ohio River) was 103.5 cubic feet per second (US Geological Survey, 2020).

The Three Forks of Beargrass Creek separate east of the downtown Louisville area, near the intersection of Interstates 71 and 64. The South Fork watershed covers 26.7 square-miles. This fork runs through Butchertown and Germantown, through the Poplar Level area, and eventually the Fern Creek neighborhood. The South Fork originally ran through downtown Louisville but was rerouted in the 1850s due to the city’s growing population and infrastructure needs. The original route was converted into a sewer. In the 1920s, the stretch near Germantown was placed into a concrete channel in an attempt to alleviate storm sewer issues (Figure 3, Section 1.3.1).

The Middle Fork has two branches—Weicher Creek and the Sinking Fork. Weicher Creek flows from the Hurstbourne Area, and the Sinking Fork has its headwaters near Anchorage, Kentucky. Weicher Creek and Sinking Fork merge in St. Matthews to form the Middle Fork, which flows through Cherokee Park until its confluence with the South Fork near the Bourbon Stockyards (Figure 3, Section 1.3.1). There are just over 25 square miles of land in the Middle Fork watershed, and impervious surfaces such as roads, rooftops and driveways cover about 23 percent of this watershed. The lower portion of this fork has been heavily altered by the construction of the I-64 roadway.

The Muddy Fork rises at a stone springhouse in Windy Hills and runs parallel to the Ohio River. This fork is the smallest subwatershed, covering about seven square miles, and was rerouted during the construction of I-71. Impervious surfaces cover about nine percent of this watershed (Louisville Metropolitan Sewer District, 2016).

2.4.2 Surface Water Quality

The current manipulated state of the watershed and Louisville's issues with CSOs often leads to poor water quality. Urbanization and increased impervious surfaces in the watershed have the potential to increase stormwater runoff that may be tainted with oil, chemicals, and other contaminates into the stream, often with little or no vegetative buffer to filter it (Waite et al. 2008). Figure 9 shows impervious surface area in the Beargrass Creek watershed. Data from Louisville Metro/Jefferson County Information Consortium (LOJIC) system indicates that approximately 60 percent of the South Fork watershed is covered by impervious surfaces, compared to 23 percent of the Middle Fork, and nine percent of the Muddy Fork (LOJIC, 2021). According to LOJIC’s land classification dataset, impervious surface covers approximately 13,333 acres of the total Beargrass Creek watershed, which is 39,056 acres (34.1 percent impervious area).

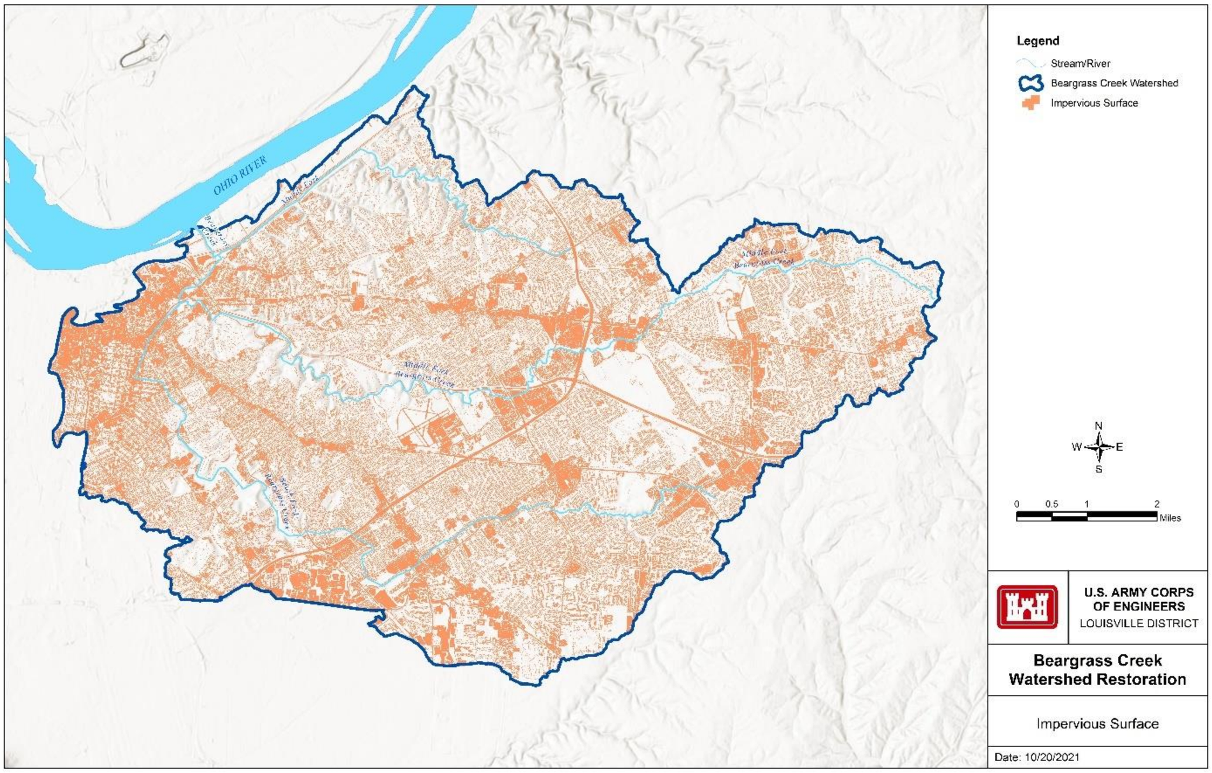

Figure 9 Impervious Surface Area in the Beargrass Creek Watershed

Additionally, CSOs release untreated sewage into the Three Forks of Beargrass Creek during heavy rain events causing decreased water quality. CSOs contain untreated or partially treated human and industrial waste, toxic materials, and debris as well as stormwater. CSOs are outlets that dump excess water from the sewers into streams and rivers, keeping the sewers from backing up into homes, businesses, and streets when it rains.

There are more than 50 CSOs along the South and Middle forks of Beargrass Creek. In places where there were severe drainage problems and no nearby creeks, large underground relief drains were constructed by the city to take water from CSOs directly to Beargrass Creek or the Ohio River. The Sneads Branch relief drain serves an area along Shelby Street from near Eastern Parkway to Kentucky Street, and flows directly into the South Fork of Beargrass Creek.

MSD's Integrated Overflow Abatement Plan (IOAP), written in 2005 and amended in 2009, addresses both CSOs and SSOs that discharge to Beargrass Creek and the Ohio River during wet weather events, with the vast majority of the overflow volume coming from the CSOs. The Long-Term Control Plan (LTCP) portion of the IOAP addresses CSOs, and the Sanitary Sewer Discharge Plan (SSDP) addresses SSOs. To date, MSD has completed 24 of the 25 LTCP projects, and 47 of the 63 SSDP projects. Anticipated improvements to water quality from the completed projects are currently being monitored by MSD and reported regularly through the MSD Synthesis Reports. Only some of these projects impact Beargrass Creek. Table 2 below summarizes the pre-IOAP, current conditions, and post-IOAP conditions along the Three Forks of Beargrass Creek during a Typical Year related to CSOs.

Table 2 Beargrass Creek Combined Sewer Overflow Summary.

Scenario	# of Active CSOs	Typical Year Overflow Volume (MG)	Typical Year Range of Ind. CSO Occurrence	Typical Year Approximate Min. Rainfall Depth for CSO Occurrence (inches)
Pre-IOAP	43	1140	0-72	0.1
Current	40	412	0-71	0.1
Post IOAP	38	71	0-7	1.0

**Numbers are current but do not reflect planned project improvements*

SSO volumes, modeling, and mitigation are based on discrete, three-hour cloudburst events rather than the typical year. While SSOs can impact water quality, they have a negligible impact on stream volumes and flow rates. SSO values for SSOs along the Three Forks of Beargrass Creek are provided in Table 3.

Table 3 Beargrass Creek Sanitary Sewer Overflows Summary

Scenario	# of Active SSOs (2-year)	2-Year (1.8 inches), 3-hour) App. Overflow Volume (MG)	10-Year (2.6 inches, 3-hourhour Rain App. Overflow Volume (MG)
Pre-IOAP	99	21	75
Current	43	4	36
Post IOAP	0	0	20

Since the signing of its consent decree with US EPA, MSD has completed hundreds of wastewater projects across the county aimed at reducing CSOs. Aquatic ecosystem restoration of Beargrass Creek is not a requirement of the consent decree; however ecosystem improvements would complement and support MSD's existing projects. Many of these projects include constructing numerous storage basins across the city. In lieu of these disruptions, construction of the Waterway Protection Tunnel is underway, which will achieve the same goal as the combined separate storage basins. The tunnel has storage capacity of 55 million gallons and will provide safe clean waterways by preventing 439 million gallons of pollution from entering the Ohio River and Beargrass Creek in a typical rainfall year. The Kentucky 2010 303(d) Report identified 35.8 miles of stream segments in the Beargrass Creek watershed as not supporting the designated use of primary contact recreation (swimming) due to fecal coliform impairment (Kentucky Division of Water, 2010). These included 13.6-, 15.3-, and 6.9mile segments of the South Fork, Middle Fork and Muddy Fork of Beargrass Creek, respectively. Although the main stem of Beargrass Creek (i.e., the 1.8-mile segment downstream of the confluence with Muddy Fork) was not listed for fecal coliforms in the 2010 303(d) report, compliance of this segment with the associated water quality standards was verified as part of the overall total maximum daily load (TMDL) analysis. According to the report, sources of the fecal coliform impairment in the watershed included municipal point sources, urban runoff/storm sewers, land disposal, combined sewer and sanitary sewer overflows.

MSD, in cooperation with the United States Geological Survey (USGS), operates a Long-Term Monitoring Network (LTMN) to collect physical, chemical, and biological data about streams in the Louisville area. In 2016, MSD released the State of the Streams Report, which focused on the conditions of fish, aquatic insects, algae, stream habitat, bacteria, nutrients (nitrogen and phosphorus), total suspended solids (sediment in water), trace metals, stream flow, dissolved oxygen, and water temperature of the streams in our community, and whether or not these were improving. MSD has been collecting data at 27 LTMN sites since 1999. Seven of the sites are located within the Beargrass Creek watershed (Figure 10).

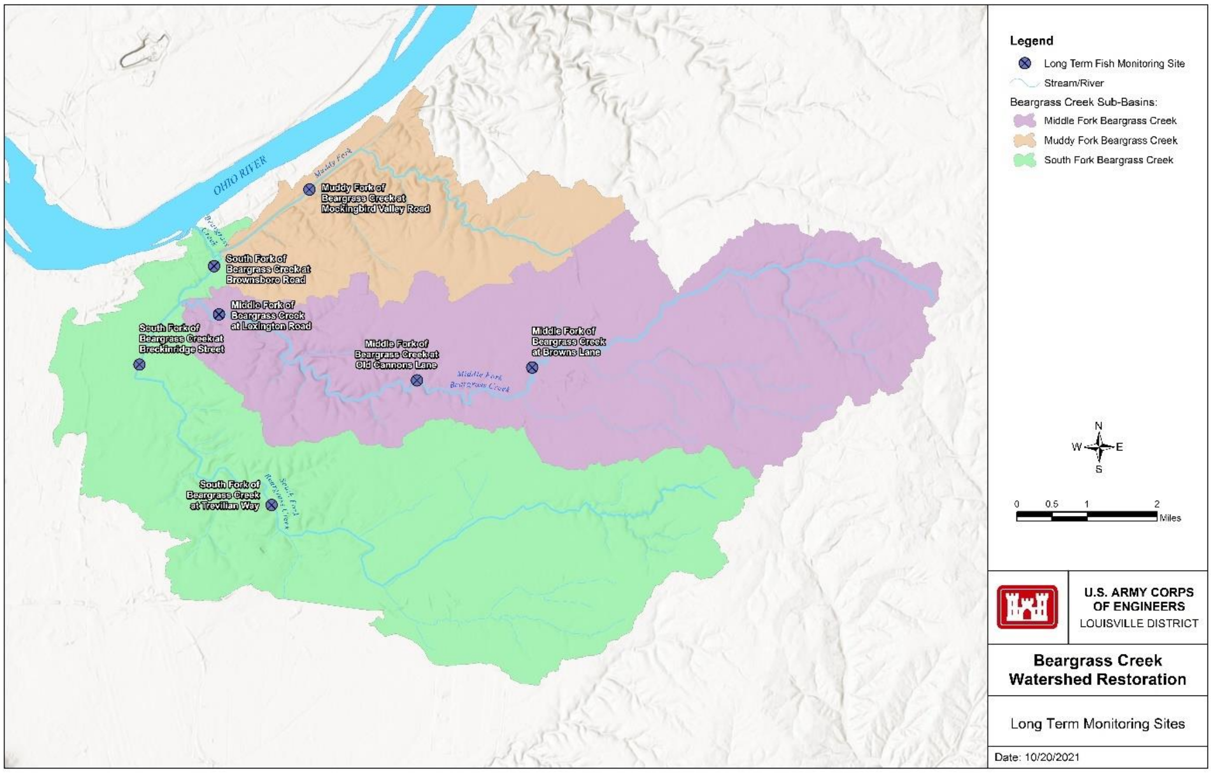

Figure 10 MSD Long-term Monitoring Network sites in the Beargrass Creek watershed.

Muddy Fork

Kentucky, like many other states, does not have numeric criteria for nutrients or suspended solids. For MSD's 2016 report, 2006 to 2015 data for each site were compared to the range of concentrations from all sites, and used the following thresholds:

- Total Nitrogen: 0.9 milligrams per liter
- Nitrate: 1.32 milligrams per liter
- Phosphorus: 1.35 milligrams per liter
- Suspended Solids: 12 milligrams per liter

Sites were classified as good, fair, or poor for nutrients and suspended solids based on the percent of samples above the thresholds:

- Good: < 29% above the threshold
- Fair: between 29% and 48% above the threshold
- Poor: > 48% of samples above the threshold

According to MSD water quality sampling conducted in 2015 (most current sampling data) at the Mockingbird Valley Road sampling station on the Muddy Fork (Figure 10), nitrogen, phosphorus, ammonia, suspended solids, and trace metal concentrations were low. Dissolved oxygen was good [100 percent of days above five parts per million (PPM)] and showed an improving trend over time, and temperature was good (100 percent of days below 31.7°C).

The Kentucky Division of Water (DOW) has established water quality criteria for fecal coliform bacteria to reduce the risk of infection for people using the water. The criteria require collection of at least five stream samples each month during the May 1 through October 31 recreation season. The criteria require the geometric mean of five bacteria samples for each month to be less than 200 bacteria colonies for swimming and less than 1,000 bacteria colonies for wading, boating, or fishing. The 2015 sampling indicated fecal coliform concentrations were elevated (geometric mean above 1,000 colonies) but stable (MSD, 2016), and exceeded the DOW water quality criteria.

Middle Fork

MSD utilizes three sampling locations on the Middle Fork—Browns Lane (Figure 10), which drains 15.2 square miles, Old Cannons Lane, which drains 18.9 square miles, and Lexington Road, which drains 24.8 square miles. Sampling in 2015 at Browns Lane indicated Total nitrogen, phosphorus, ammonia, suspended solids, and trace metal concentrations were low, and nitrate concentrations were elevated. Kentucky does not have numeric criteria for nutrients or suspended solids. Fecal coliform bacteria concentrations were in exceedance of DOW water quality criteria and were some of the highest in Louisville (MSD, 2016).

At Old Cannons Lane (Figure 10), total nitrogen, ammonia, phosphorus, and suspended solids concentrations were low, and nitrate concentrations were elevated. Trace metal concentrations (cadmium, copper, lead, and zinc) exceeded aquatic life criteria more often than most other monitoring sites. Dissolved oxygen was good and improving; water temperature was good. Fecal coliform bacteria concentrations were consistently elevated.

At Lexington Road (Figure 10), nitrate, ammonia, and total nitrogen concentrations were low, however phosphorus and suspended solids concentrations were elevated. Metals concentrations exceeded aquatic life criteria more often than other monitoring sites. Dissolved oxygen was fair (90 percent of days above five PPM) and improving; water temperature was good. Fecal coliform bacteria concentrations were elevated but improving.

South Fork

MSD monitors water quality and flow at three sites in the South Fork watershed—Trevilian Way (Figure 10), which drains 17.2 square miles, Schiller Avenue, which drains 22.8 square miles, and Brownsboro Road, which drains 51.5 square miles including the Middle Fork. MSD moved the Schiller Avenue site downstream to Breckinridge Street in 2015 because the Schiller Avenue site was not accessible during construction of a nearby wet weather basin. Data from the two sites was integrated for this assessment.

At the Trevilian Way site in 2015, data collected by MSD indicated nitrate, ammonia, phosphorus, and trace metal concentrations were low, and total nitrogen and suspended solids were moderate. Dissolved oxygen was fair and stable; water temperature was good. Fecal coliform bacteria concentrations were some of the highest in Louisville (MSD, 2016).

At Schiller Avenue (Figure 10), Nitrogen, ammonia, and phosphorus concentrations were low; however, suspended solids were moderate. Cadmium and lead exceeded aquatic life criteria more often than other sites. Dissolved oxygen was poor (< 90% of days above five PPM) and declining (the percent of days that dissolved oxygen was above five PPM decreased by ten percent or more); water temperature was good. Fecal coliform bacteria concentrations were some of the highest in Louisville, and were getting worse. Since temperature readings were good at his site, we can infer that organic pollution, like fecal coliform, likely plays a significant role in reducing dissolved oxygen levels. Kentucky's water quality criteria for dissolved oxygen specify no readings less than four PPM, and the 24-hour average reading must be above five PPM.

At Brownsboro Road (Figure 10), Total nitrogen, ammonia, phosphorus, and suspended solids were low, and nitrate concentrations were classified as moderate. Cadmium and lead exceeded aquatic life criteria more often than other sites. Fecal coliform bacteria concentrations were some of the highest in Louisville, but were improving.

2.4.3 Groundwater

The vast extent of impervious surfaces in the city like roads, parking lots, and rooftops prevent rain and snowmelt from infiltrating into the ground. Most of the rainfall and snowmelt remains above the surface, where it runs off rapidly in unnaturally large amounts.

Storm sewer systems concentrate runoff into smooth, straight conduits, which increases velocity and erosional power of the water as it travels underground. When this runoff leaves the storm drains and empties into a stream, its increased volume and power can quickly erode streambanks, damaging streamside vegetation and degrading aquatic and riparian habitats. These increased storm flows carry sediment loads from construction sites and other denuded surfaces and eroded streambanks. They often carry higher water temperatures from streets, roof tops, and parking lots, which are harmful to the health and reproduction of aquatic life. The loss of infiltration from urbanization may also cause profound groundwater changes such as reduced water tables and slower recharge rates. Although urbanization leads to increases in flooding during and immediately after wet weather, in many instances it results in lower stream flows during dry weather.

The Ohio River alluvium aquifer is the most dependable source of groundwater in Louisville. Domestic wells drilled in the alluvium are generally drilled to a depth of 100 feet below ground surface and can produce approximately 1,000 gallons of water per minute. In the upland areas of the rest of Jefferson County (30% of the county), most drilled wells will not produce enough water for a dependable domestic supply unless they are drilled along drainage lines, in which case they may produce enough water except during dry weather (Kentucky Geological Survey, 2019b). Some natural springs occur within the watershed, as well as karst features like sinkholes. Maps of sinkholes and springs in the Beargrass Creek watershed generated by the Kentucky Groundwater Data Repository are located in Appendix F.

2.5 Biological Resources

Biological resources within the proposed study footprint have been impacted due to channelization and intense development within the watershed. According to the LOJIC (2021) land classification dataset, approximately 90% of the Beargrass Creek watershed has been developed to some extent, which has greatly modified the existing natural resources and available habitat within the area.

2.5.1 Vegetation

Before development of the study area, a diversity of habitats including floodplain and upland forest, Bluegrass savannah, canebrakes, and wetlands would have likely comprised much of the watershed. The vegetative landscape has since been fragmented for agricultural uses and urban development. Only slim corridors of floodplain forest still exist in the Beargrass Creek watershed and consist of common bottomland tree species such as box elder (*Acer negundo*), silver maple (*Acer saccharinum*), sugar maple (*Acer saccharum*), hickories (*Carya* spp.), ash (*Fraxinus* spp.), sycamore (*Platanus occidentalis*), and cottonwood (*Populus deltoides*). Figure 11 shows tree canopy density within the watershed. Areas with the best quality canopy tend to be in the park areas such as Cherokee and Seneca parks on the lower Middle Fork, Joe Creason Park on the lower South Fork, and the Indian Hills neighborhood around the middle reaches of the Muddy Fork. The South Fork and the Middle Fork upstream of Seneca Park are generally lacking significant canopy density.

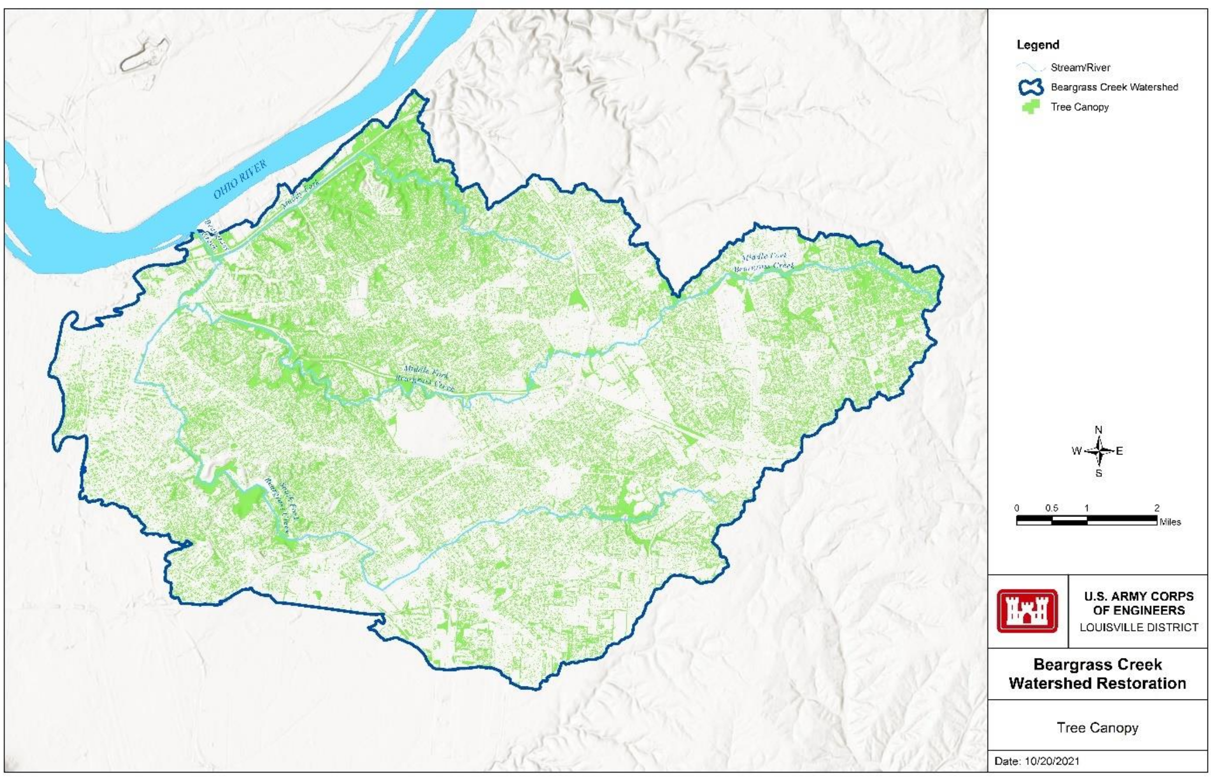

Figure 11 Tree Canopy in the Beargrass Creek Watershed

The disturbance of habitats within the watershed has also facilitated the introduction and spread of invasive plant species. Some of the most abundant invasive species include Japanese honeysuckle

(*Lonicera japonica*), porcelain berry (*Ampelopsis glandulosa*), English ivy (*Hedera helix*), winter creeper (*Euonymus fortunei*), oriental bittersweet (*Celastrus orbiculatus*), bush honeysuckle (*Lonicera maackii*), privet (*Ligustrum sinense*), multiflora rose (*Rosa multiflora)*, tree of heaven (*Ailanthus altissima*), ground ivy (*Glechoma hederacea*), chickweed (*Stellaria media*), and Japanese stilt grass (*Microstegium vimineum*).

Muddy Fork

Vegetation in the Muddy Fork watershed is comprised of sporadic forest with an abundance of invasive species typical of disturbed and developed landscapes. Field assessments of the riparian vegetation at potential restoration sites indicated that the suburban development has impaired vegetation along theriparian corridors. Portions of the Muddy Fork watershed contain good quality forest canopy. However, the understory and herbaceous ground layers have been adversely impacted from development and invasive species infiltration. A qualitative assessment of the riparian condition was conducted at six sites on the Muddy Fork and resulted in an average score of 7.5 out of a possible 20 (see Appendix B for complete data sets). This score indicated the riparian zones are of marginal quality and exhibited significant loss of some ecological functions. While this was the lowest score among the forks, the Muddy Fork contained the fewest sample sites, and its average was largely influenced by poor scores near highly developed areas. The assessment included aspects important to riparian form and function including buffer development, canopy structure, and invasive vegetation dominance.

Middle Fork

The Middle Fork contains pockets of healthy forest and riparian zones, especially in Cherokee and Seneca parks. However, impacts from urban development and invasive species have degraded much of the watershed outside of these larger parks. A qualitative assessment of the riparian condition was conducted at 23 sites on the Middle Fork and resulted in an average score of 9.04. While this was the highest score among the forks, the score still indicated marginal quality of the riparian zones. Field assessment data sheets are provided in Appendix B.

South Fork

The South Fork is the most negatively impacted of the Forks due to intense residential and commercial urbanization. The best quality vegetation exists near the Beargrass Creek State Nature Preserve, but invasive species dominate the South Fork watershed due to the heavy levels of disturbance. A qualitative assessment of the riparian condition was conducted at 24 sites on the South Fork and resulted in an average score of 8.1, indicating marginal health of the riparian zones. Field assessment data sheets are provided in Appendix B.

2.5.2 Wildlife

Wildlife in the Beargrass Creek watershed is typical of urban environments, although small, isolated pockets of natural habitat and the proximity of the city to natural areas do provide occurrences of wildlife not typically associated with urban areas. Numerous small and large mammals utilize the riparian corridors and green spaces within the watershed. These include species such as whitetail deer, cottontail rabbit, raccoon, opossum, striped skunk, woodchuck, muskrat, gray squirrel, and fox squirrel.

Somewhat more secretive and less noticeable are the grey fox, red fox, coyote, and numerous species of mice, moles, shrews, and bats.

Amphibians and reptiles can also be found within or adjacent to the study area. Salamander species include slimy and long tail salamanders, red-spotted newt, and mudpuppy. Frogs and toads in this area include bullfrog, leopard frog, green frog, pickerel fog, spring peeper, gray tree frog, American toad, fowler's toad, and eastern narrow mouth toad. Several species of snakes and turtles also commonly utilize the area. These include common snapping turtle, red-eared slider, common box turtle, eastern spiny softshell, rough green snake, black rat snake, and northern water snake.

Because of its proximity to the Ohio River and position in Mississippi Flyway, the Beargrass Creek watershed plays host to numerous bird species. The species that utilize habitats within the study area change throughout the year as birds use the area to rest while on their migration routes. Neotropical migrants can be plentiful in the late spring and summer including warblers, vireos, grosbeaks, and sparrows. Woodpeckers, ducks, and hawks are more abundant in the fall and winter. Restoration of floodplain forests is a priority in this region because they are utilized as staging areas for migratory waterfowl and serve as breeding grounds for species like the wood duck.

2.5.3 Fish

Fish communities within the Three Forks of Beargrass Creek have been greatly impacted by the adverse effects to the stream from surrounding development and urbanization. Poor water quality and decreased habitat quantity and quality have contributed to the decline in health of the stream's fish communities. Species that currently inhabit the streams are those that are relatively hardy generalists and can persist in less than ideal conditions. A fish community assessment of seven sites within the Forks completed in 2017 by Redwing Ecological Services, Inc. for MSD described fish communities as "fair" at three sites, "poor" at two sites, and "very poor" at one site.

Connectivity is defined as the degree to which habitats allow animal movement and other natural processes. Longitudinal connectivity (up- and downstream) influences the movement of sediment, nutrients, carbon, and aquatic organisms through a river system. The connectivity of a stream is an important indicator of its health. Highly fragmented stream systems generally have less biodiversity and abundance of native fish species than free flowing systems.

Artificial barriers that have the potential to prevent movement of fish include dams, weirs, bridges, and culverts. The extent to which a structure forms a barrier to fish passage depends on several factors including the structure's size, the flow regime of the waterway, the fish species present, their movement patterns and the location of the structures in relation to those patterns. The presence of potential barriers to connectivity in the Beargrass Creek watershed is shown in Figure 12.

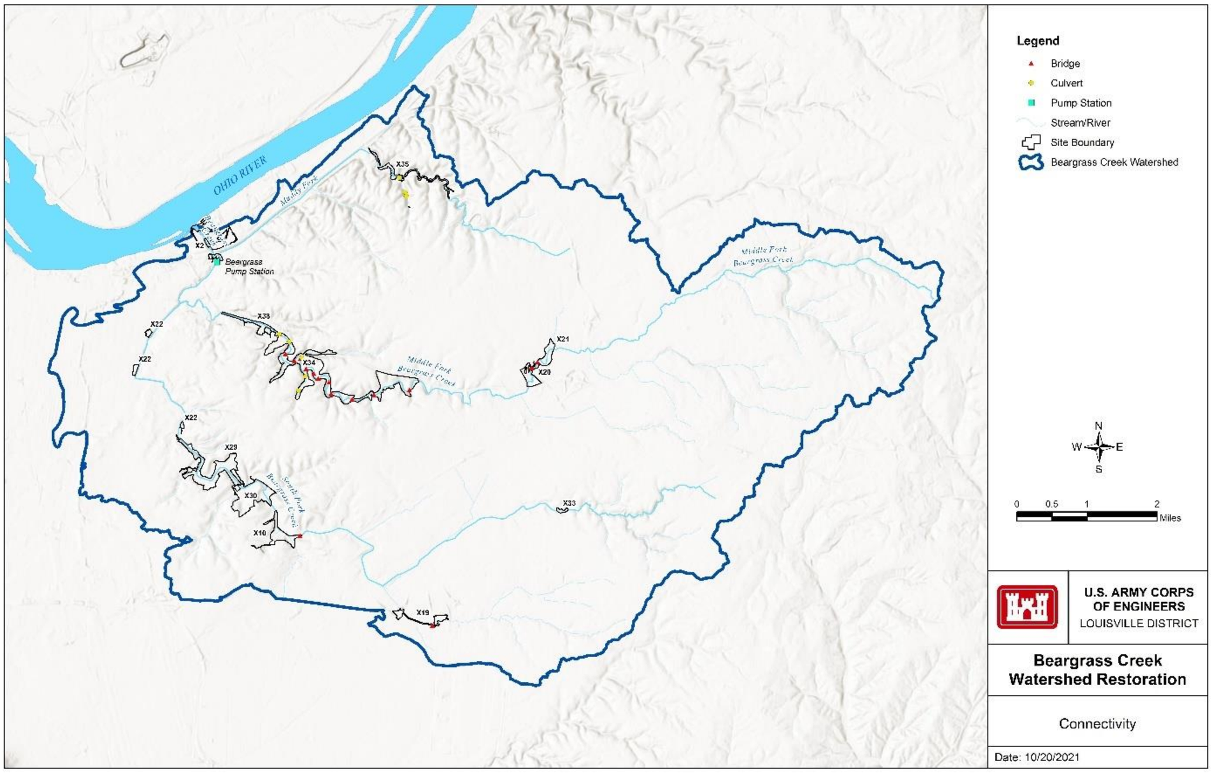

Figure 12 Potential Barriers to Aquatic Connectivity in the Beargrass Creek Watershed

Muddy Fork

According to MSD (2016) the health of the fish communities was fair in 2015, highly variable from year to year, with a declining trend. Poor aquatic macroinvertebrate and algal communities are factors affecting fish in the Muddy Fork. An analysis of the long-term sampling data from seven sampling events between 2002 and 2017 suggested that Muddy Fork has the best fish community among the forks.

Middle Fork

The health of fish communities was fair and improving in 2015 at the Browns Lane sampling site. At Old Cannons Lane and the health of fish communities was fair and declining. At Lexington Road, community health was poor, and the data indicated a positive trend in health. Despite healthy algal communities at each site, aquatic insect communities, which are an important food source for fish, were graded as fair. In the Middle Fork, long-term sampling data suggests the upstream sites had the best fish assemblages with decreasing conditions occurring downstream.

South Fork

In 2015, at the Trevilian Way sampling location, the health of fish communities was characterized as fair and improving. At Schiller Avenue, the health of fish communities was not assessed in 2015 due to construction but has been declining according to past data collection. At Brownsboro Road, the health of fish communities was poor and improving. Despite fair to excellent algal communities, aquatic insect communities were graded as poor at all sites and declining at Brownsboro and Schiller Avenue sites. Long-term sampling data suggests the South Fork generally has the poorest fish community among the Forks, and like the Middle Fork, fish community health decreased while going downstream. The Brownsboro Road sampling station on the South Fork had the poorest fish community of all the Beargrass Creek sites.

Table 4 lists species observed (*n*=41) in a 2017 fish survey for MSD's long-term monitoring sites on the Muddy Fork (one sample site), Middle Fork (three sample sites), and South Fork (three sample sites). All species encountered are considered to be native to the watershed.

Table 4 Observed fish species in a 2017 survey (Redwing, 2017).

Species	Common Name	Species	Common Name
Atheriniformes		**Ictaluridae**	
Atherinidae		*Ameiurus natalis*	Yellow Bullhead Catfish
Labidesthes sicculus	Brook Silverside	*Noturus flavus*	Stonecat
Cypriniformes		**Scorpaeniformes**	
Cyprinidae		**Cottidae**	
Campostoma anomalum	Stoneroller	*Cottus carolinae*	Banded Sculpin
Carassius auratus	Goldfish	**Perciformes**	
Cyprinella spiloptera	Spotfin Shiner	**Centrachidae**	
Hybopsis amblops	Bigeye Chub	*Ambloplites rupestris*	Rock Bass
Luxilus chrysocephalus	Striped Shiner	*Lepomis gulosus*	Warmouth
Lythrurus umbratilis	Redfin Shiner	*Lepomis cyanellus*	Green Sunfish
Notropis atherinoides	Emerald Shiner	*Lepomis macrochirus*	Bluegill
Notropis boops	Bigeye Shiner	*Lepomis megalotis*	Longear Sunfish
Notropis photogenis	Silver Shiner	*Lepomis microlophus*	Redear Sunfish
Notropis stramineus	Sand Shiner	*Micropterus dolomieu*	Smallmouth Bass
Ericymba buccata	Silverjaw Minnow	*Micropterus punctulatus*	Spotted Bass
Pimephales notatus	Bluntnose Minnow	*Micropterus salmoides*	Largemouth Bass
Semotilus atromaculatus	Creek Chub	*Pomoxis annularis*	White Crappie
Catostomidae		**Percidae**	
Catostomus commersoni	White Sucker	*Etheostoma blennioides*	Greenside Darter
Hypentelium nigricans	Hog Sucker	*Etheostoma caeruleum*	Rainbow Darter
Minytrema melanops	Spotted Sucker	*Etheostoma flabellare*	Fantail Darter
Moxosotoma duquesnei	Black Redhorse	*Etheostoma nigrum*	Johnny Darter
Moxosotoma erythrurum	Golden Redhorse	*Etheostoma spectabile*	Orangethroat Darter
Cypriniodontiformes		*Etheostoma zonale*	Banded Darter
Fundulidae		**Sciaenidae**	
Fundulus notatus	Blackstripe Topminnow	*Aplodinotus grunniens*	Freshwater Drum
Poeciliidae			
Gambusia affinis	Mosquitofish		

2.5.4 Special Status Species

Lists of threatened, endangered, and species of special concern are maintained by USFWS. Under the Endangered Species Act (ESA) of 1973 (16 U.S.C. §§ 1531-1544), endangered species are defined as any species in danger of extinction throughout all or portions of its range. A threatened species is any species likely to become endangered in the foreseeable future. The ESA defines critical habitat of the above species as a geographic area that contains the physical or biological features that are essential to the conservation of a particular species and that may need special management or protection.

An official list of federally protected species was generated using the USFWS Information for Planning and Consultation(IPaC) website. The list from the Kentucky Ecological Field Office is included in Appendix F. The list (Table 5) included 15 species that could potentially be affected by activities near the study area. The presence of a species on the list does not indicate presence within the study area.

Table 5 Federally listed species that could potentially be affected by activities near the study area, according to the U.S. Fish and Wildlife Services

Group	Common Name	Scientific Name	Status
Mammals	gray bat	*Myotis grisescens*	Endangered
	Indiana bat	*Myotis sodalis*	Endangered
	northern long-eared bat	*Myotis septentrionalis*	Threatened
Birds	least tern	*Sterna antillarum*	Endangered
Mussels	clubshell	*Pleurobema clava*	Endangered
	fanshell	*Cyprogenia stegaria*	Endangered
	Northern riffleshell	*Epioblasma torulosa rangiana*	Endangered
	orangefoot pimpleback	*Plethobasus cooperianus*	Endangered
	pink mucket	*Lampsilis abrupta*	Endangered
	rabbitsfoot	*Quadrula cylindrica cylindrica*	Threatened
	ring pink	*Obovaria retusa*	Endangered
	rough pigtoe	*Pleurobema plenum*	Endangered
	sheepnose mussel	*Plethobasus cyphyus*	Endangered
	spectaclecase	*Cumberlandia monodonta*	Endangered
Plants	running buffalo clover	*Trifolium stoloniferum*	Endangered

The mussels on this list were included because of Beargrass Creek's proximity to the Ohio River. There are no recent or historical records of the 10 mussel species in Beargrass Creek. The least tern is also not known to occur in the watershed but does use sand and gravel bars in open areas and along large rivers like the Ohio River for nesting.

The Beargrass Creek watershed lies within the range of three federally listed bat species. USFWS classifies a portion of the Muddy Fork watershed as "known summer 1 habitat" for Indiana bats and northern long-eared bats, which means Indiana bat maternity habitat and/or northern long-eared bat summer habitat occurs in the area (USFWS 2015). These bats have the potential to utilize dead, dying, or damaged trees along the stream corridors for roosting in the summer months.

The Office of Kentucky Nature Preserves maintains list of stated listed species by county in which they occur. The list species of conservation concern that have historical records in Jefferson County is presented in Table 6. The presence of a species on the list does not indicate presence within the study area.

Table 6 State listed species that could potentially be affected by activities near the study area, according to the Kentucky Office of Nature Preserves (2021)

Group	Scientific Name	Common Name	State Status*
Fishes	*Alosa alabamae*	Alabama Shad	S1
Reptiles	*Clonophis kirtlandii*	Kirtland's Snake	S2
Crayfishes	*Faxonius jeffersoni*	Louisville Crayfish	S1
Plants	*Leavenworthia exigua*	Tennessee Gladecress	SNR
	Leavenworthia exigua var. laciniata	Kentucky Gladecress	S1S2
	Trifolium stoloniferum	Running Buffalo Clover	S2S3
Mammals	*Myotis grisescens*	Gray Myotis	S2
	Myotis sodalis	Indiana Myotis	S1S2
Mussels	*Plethobasus cyphyus*	Sheepnose	S1
	Pleurobema clava	Clubshell	S1
	Potamilus capax	Fat Pocketbook	S1
Insects	*Pseudanophthalmus troglodytes*	Louisville Cave Beetle	S1

* S1 = Critically imperiled, S2 = Imperiled, S3 = Vulnerable, SNR = Unranked. A numeric range rank (e.g., S2S3) is used to indicate any range of uncertainty about the status of the species.

2.5.5 Waters of the United States

The study area encompasses waters of the United States as defined under the Clean Water Act. These jurisdictional areas also include wetlands and other special aquatic sites. The Three Forks of Beargrass Creek are considered waters of the United States. The discharge of dredged or fill materials into waters of the United States is regulated pursuant to Section 404 of the Clean Water Act.

All sizable wetland complexes that once existed in the study area have been drained and/or filled during the urban development. Some small, isolated wetlands do exist within Beargrass Creek watershed, but most are of moderate quality at best. No wetland delineation has been completed to date to identify jurisdictional wetlands. For planning purposes, the USFWS National Wetland Inventory (NWI) was consulted. According to the NWI, there are three different types of wetlands present within the study area. Ponds and riverine habitat comprise essentially all wetlands present. There are a few small, isolated forested/shrub wetlands scattered around the watershed. One emergent wetland was identified by the NWI, but it has since been converted to soccer fields.

Although NWI maps are not definitive regarding the presence or absence of wetlands, they are useful as an initial planning tool. Figure 13 shows wetlands within the watershed, according to the NWI.

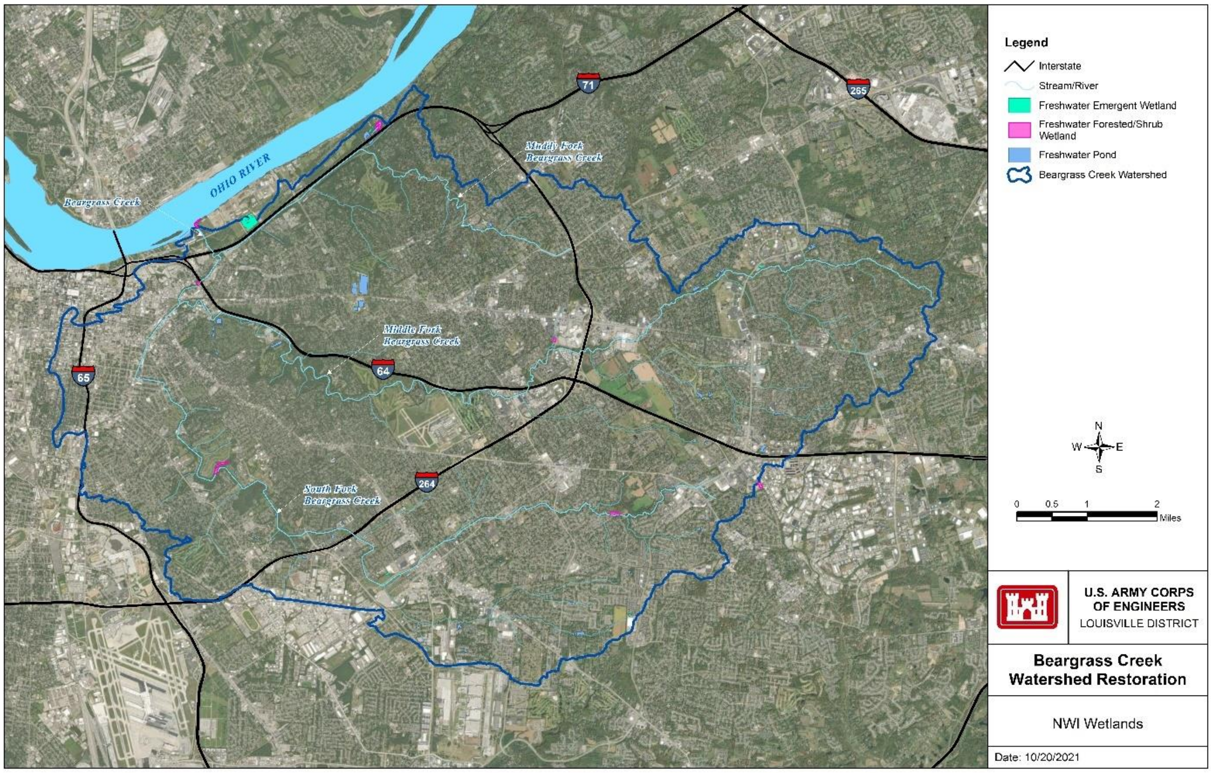

Figure 13 National Wetlands Inventory Mapped Wetlands

2.5.6 Significant Ecological Areas and Wildlife Corridors

Preserved areas of habitat in the watershed like Cherokee Park on the lower Middle Fork and the Beargrass State Nature Preserve on the South Fork act as islands of biodiversity in the metropolitan area. Due to their size, these areas provide wildlife refuge from anthropogenic disturbances and are critical to maintain life history requirements of native species. While highly fragmented, the Three Forks of Beargrass Creek are likely play a critical role as corridors for movement of both terrestrial and aquatic species in an otherwise urban landscape (Beier and Noss, 1998). These wildlife corridors allow plant and animal species to move between the larger islands of habitat. This ability for species to migrate regionally makes the entire ecosystem more resilient to natural disasters, climate change, disease, and other issues that might affect native species in the area. Additionally, the study area is located directly adjacent to the Ohio River, which acts as a larger wildlife corridor for migratory and resident wildlife.

2.6 Cultural Resources

A number of steps were taken in an effort to identify cultural resources within the Study Area. USACE searched the online database of the NRHP maintained by the National Park Service, the Kentucky Office of State Archaeology (OSA), and USACE GIS files to identify any previously recorded archaeological sites and above ground structures located within any of the Study Areas. Review of the online database maintained by the National Park Service identified 20 NRHP listed historic properties and eight historic districts within a 0.5-mile radius of the Study Areas. NRHP properties along the South Fork include: Eclipse Woolen Mill, Hadley Mary Alicia House, Hope Worsted Mills, Howard Getty’s House, Klotz

Confectionary Company, Leslie Abbott House, L&N Steam Locomotive No.152, Nelson Distillery Warehouse, Paget House and Heigold House façade, Schneikert Valentine House, St. Frances of Rome School, St. Therese Roman Catholic Church, School, and Rectory, Steam Engine Company No.4 and No. 10, Wirth, Lang & Company/The Louisville Leather Company Tanner Building. Historic Districts along the South Fork are the Phoenix Hill Historic District and portions of the Highland Historic District. NRHP Properties along the Middle Fork include: Brown Theodore House, Cave Hill Cemetery/Cave Hill National Cemetery, Commodore Apartment Building, Olmsted Park System of Louisville, and Peterson-Dumesnil House. Historic districts along the Middle Fork include: Crescent Hill Historic District, Clifton Historic District, Oxmoor Historic District, Cherokee Triangle Area Residential District, Gardencourt Historic District, and Highlands Historic Districts. The only Historic District along the Muddy Fork is the Mockingbird Valley Historic District and no NRHP properties were identified along this fork.

A search of the OSA database identified ten previously recorded archaeological sites either located within or adjacent to the Study Areas. These sites are listed in Table 7.

Table 7 Previously recorded archaeological sites located within or adjacent to the Study Areas. Data taken from Kentucky Office of State Archaeology [database accessed December 10, 2020]

Site Number	Cultural Affiliation/ Site Type	NRHP Status
15Jf22	Open Habitation without Mounds	Not Assessed
15Jf27	Late Archaic Indeterminate Open Habitation without Mounds	Not Assessed
15Jf28	Indeterminate Prehistoric Open Habitation without Mounds	Not Assessed
15Jf30	Middle Archaic/Early-Middle Woodland/Late Prehistoric Open Habitation without Mounds (Cemetery)	Not Assessed
15Jf553	Historic Euro-American 1851-1900	Not Assessed
15Jf592	Historic Euro-American 1801-1950 Open Habitation without Mounds	Inventory site (does not meet NR criteria)
15Jf645	Late Prehistoric Indeterminate/ Historic Euro-American 1801-1950 Open Habitation without Mounds	Not Assessed
15Jf668	Late Woodland/Late Prehistoric Indeterminate/ Historic Euro-American 1801-1950 Open Habitation without Mounds	Considered Eligible but not nominated by SHPO
15Jf734	Early Archaic Indeterminate/Indeterminate Prehistoric/ Historic Euro-American 1801-1950	Not Assessed
15Jf820	Indeterminate Prehistoric/ Historic Euro-American 1801-1950	Not Assessed

Portions of the Study Area have previously been surveyed. There have been 20 different archaeological investigation within the Beargrass Creek Watershed listed in Table 8.

Table 8 Previous Archaeological Investigations that occurred within the Study areas of the Three Forks of the Beargrass Creek Feasibility Study

Author	**Date**	**Title**
Ball	1998	*A Phase I Cultural Resources Reconnaissance of the Proposed Beargrass Creek Local Flood Protection Project, Jefferson County, Kentucky*
Esarey	1992	*Phase I Cultural Resources Survey of 12 City Blocks in the 50-acre Municipal Harbor/Thurston Park Section of the Proposed Waterfront Redevelopment Project, Louisville, Jefferson County, Kentucky*
Glover & Clover	1977a	*An Archaeological Survey of the Proposed New Sewer Pumping Station in Louisville (Northern Jefferson County), Kentucky (056-013)*
Granger & Smith	2006	*An Archaeological Subsurface Reconnaissance at the Proposed Location of the WFIA-AM Radio Tower at 900 River Road (Louisville Metro), Jefferson County, Kentucky.*
Herndon & Faberson	2007	*Archaeological Monitoring of Geotechnical Borings for the Proposed Kennedy Bridge Interchange Area of the Ohio River Bridges Project in Jefferson County, Kentucky: Phase 1 through 5.*
Thomas & Bybee	2015	*An Archaeological Survey of the Proposed Clifton Heights Combined Sewer Overflow Storage Basin and Associated Infrastructure, Jefferson County, Kentucky.*
Pool	2019	*Cultural Historic Determination of Eligibility Survey for the Louisville Reach and Louisville Gas and Electric Building in Jefferson County, Kentucky.*
Evans	1998	*Phase I Archaeological Reconnaissance of the Whipps Mill Road Flood Control Facility, Jefferson County, Kentucky*
Wetzel & Bader	2009	*Phase I Archaeological Survey for the Proposed Whipps Mill Bike and Pedestrian Improvements at A.B. Sawyer Park Jefferson County, Kentucky*
DelCastello	2006	*An Archaeological Survey of the Proposed Construction of the Center for Preventative Medicine, University of Louisville, Jefferson County, Kentucky.*
Russell et al.	2011	*An Archaeological Survey for the Proposed Construction of the Jeffersontown Force Main, Pump Station, and Upper Billtown Interceptor in Jefferson County, Kentucky.*
Stottman &Schlarb	2008	*An Archaeological Survey of a Trail at Joe Creason Park (15Jf734) Jefferson County, Kentucky.*
Bader & Hardesty	1991	*A Phase I Archaeological Reconnaissance of Three Segments of the North County Sewer System in Jefferson County, Kentucky.*
Prybylski	2007	*A Phase I Archaeological Survey for the Proposed Crossings at Irish Hill Development, Louisville, Jefferson County, Kentucky.*
Curran	2011	*A Cultural Resources Survey of the Proposed I-64/Grinstead Drive Combined Sewer Overflow Storage Basin Development in Jefferson County, Kentucky.*
Bybee	2016	*An Archeological Survey of the Proposed CSO 125 Strom Water Separation Project, Jefferson County, Kentucky.*

Author	Date	Title
Wilson & Bybee	2016	*An Archaeological Survey of Additional Areas for the Proposed I-64/ Grinstead Drive Combined Sewer Overflow Basin Project in Jefferson County, Kentucky.*
Stephenson	2008	*A Phase I Cultural Resources Survey for the Proposed Expansion of the Calvary Cemetery in Jefferson County, Kentucky*
Curran	2013	*An Archaeological Survey of the Proposed Nightingale Road Pump Station and Storage Basin Development in Jefferson County, Kentucky.*
Henderson	1988	*Archaeological Assessment of the Beargrass Creek State Nature Preserve.*
Janzen & Hedgepeth	1988	*A Cultural Resources Assessment of the Corps of Engineers Permit Area for the Willow Lake Commercial Development, Jefferson County, Kentucky*
Bader & Hardesty	1991	*A Phase I Archaeological Reconnaissance of Three Segments of the North County Sewer System in Jefferson County, Kentucky.*
McKelway	1995	*Historic and Prehistoric Archaeology at Falls Harbor, Jefferson County, Kentucky.*

USACE has consulted with the Kentucky State Historic Preservation Office (KY-SHPO), Tribal Nations, and Consulting Parties on a Programmatic Agreement (PA) that outlines the phased approached to identify historic properties and the mitigation stipulations to resolve adverse effects to historic properties and archaeological sites that have the potential to be eligible for or listed on the NRHP located within the APE. The PA was executed between the KY-SHPO and USACE on September 8, 2021. A final copy of the PA and copies of all agency and Tribal communications can be found in Appendix G.

2.7 Noise

Changes in noise are typically measured and reported in units of A-weighted decibels (dBA), a weighted measure of sound level. Noise ranging from about 10 dBA for the rustling of leaves to as much as 115 dBA (the upper limit for unprotected hearing exposure established by the Occupational Safety and Health Administration) is common in areas where there are sources of recreational activities, construction activities, and vehicular traffic. Primary sources of noise at the study area include traffic on nearby streets and highways (typically between 50 and 60 dBA at 100 feet), residential and commercial maintenance equipment such as mowers, railways, and air traffic. Noise monitoring was not conducted as a part of this study. Existing noise levels vary greatly within the watershed and at the proposed restoration sites depending upon the adjacent land uses. Levels are generally lower along stretches of the stream that are that farther away from highways and urban development.

2.8 Recreational, Scenic, and Aesthetic Resources

Muddy Fork

Approximately 2.5 miles of the Muddy Fork were straightened and channelized during the construction of Interstate 71. This greatly reduced the aesthetic nature of the lower half of the stream. However, the upper half of the Muddy Fork still maintains some scenic appeal with its high sinuosity, occasional riffles, and relatively healthy forest canopy. The lower reach of the Muddy Fork can be used for kayaking or canoeing, although access is limited.

Middle Fork

Of the forks, the Middle Fork provides the most outdoor recreational opportunities due in large part to the presence of Seneca and Cherokee parks (Figure 14), both of which are very popular parks designed by Frederick Law Olmsted. The parks are 531.5 acres and 389.1 acres, respectively, and both parks offer numerous features including golf courses, baseball fields, basketball courts, biking, cross country trails, field hockey, soccer fields, volleyball, horseback riding trails, picnic tables, playgrounds, and walking paths.

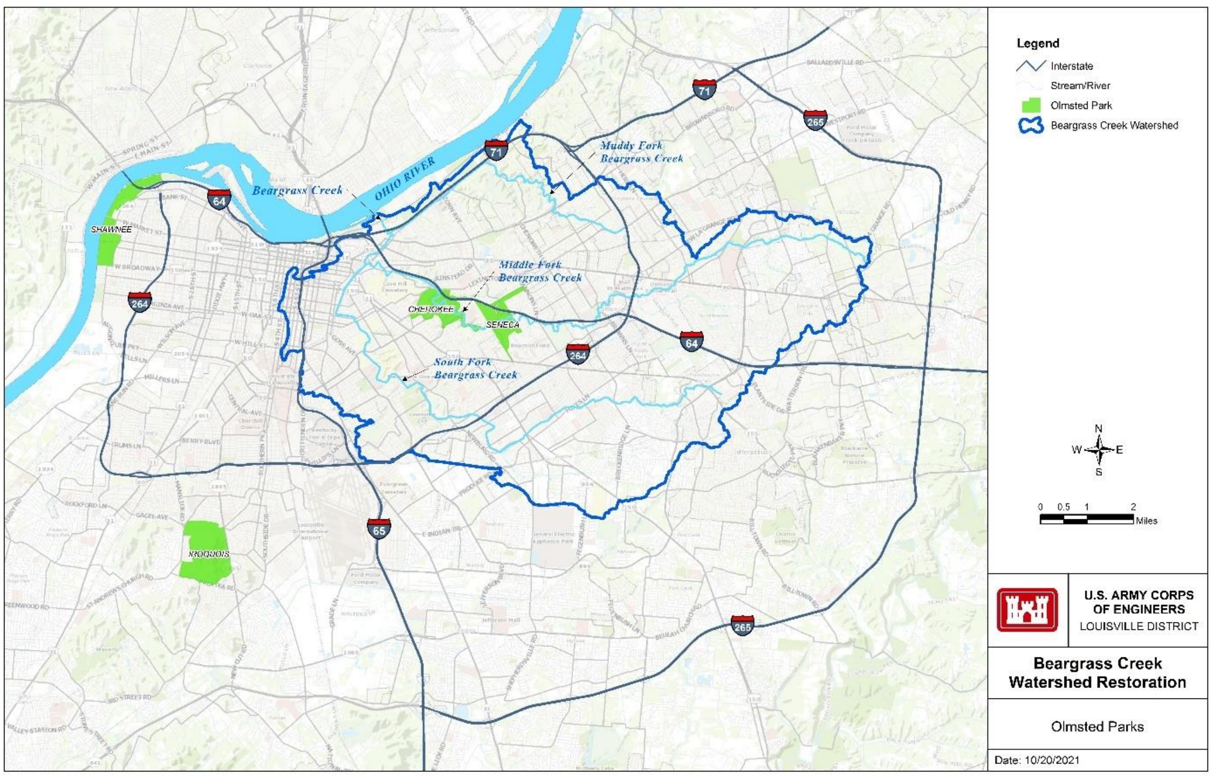

Figure 14 Olmsted Parks in Louisville, KY

The main attraction of Cherokee Park is a 2.3-mile scenic loop, with separate lanes for vehicle traffic and recreational users. The park was also designed by Olmsted and provides a pastoral setting amid rolling hills, open meadows and woodlands of the Beargrass Creek valley. The hills and mature forest along the Middle Fork in Cherokee Park offer some of the most scenic views in the city.

Seneca Park, which boasts a more formal design than Cherokee, has an 18-hole golf course and has 500,000 visitors annually, according to The Trust for Public Land, placing it in the top 100 municipal parks in the United States.

Farther upstream on the Middle Fork, the City of St. Matthews owns and maintains two smaller parks that offer outdoor recreation opportunities for the public. Brown Park (28 acres) is located just a few blocks away from Arthur K. Draut Park (24.4 acres), which allows visitors to walk between each, utilizing the public sidewalk system.

Brown Park contains asphalt walking trails that meander through wooded areas along the Middle Fork and offers educational opportunities such as interpretive, multi-layered stone columns that represent geological periods of limestone formation in region. The park also includes a pavilion with picnic tables, play area, and open green spaces.

Arthur K. Draut Park was developed to be utilized for water retention after heavy rain events, but also offers outdoor recreational opportunities during dry periods. When dry, the park is available for walking, jogging or relaxing in the green space.

South Fork

The South Fork has experienced more degradation from urbanization than the other forks. Because of this, it has lost much of its scenic and aesthetic qualities. Isolated sections that have maintained moderately healthy riparian zones do offer some aesthetic appeal against the backdrop of the residential and commercial development. The Louisville Nature Center manages the Beargrass Creek State Nature Preserve and offers outdoor recreational and educational opportunities including gardens, nature play areas, and a bird blind for bird viewing. The Preserve consists of 41 acres of urban forest with 3.1 miles of public trails.

Louisville's 62-acre Joe Creason Park is located adjacent to the Nature Center. The park is a popular spot for bird watchers and joggers and has nine tennis courts. The park is adjacent to the Louisville Zoo, which exhibits more than 1,100 animals on 130 acres, providing an excellent opportunity for conservation education.

2.9 Hazardous, Toxic and Radioactive Waste

The terms "hazardous materials" refers to any item or agent (biological, chemical, radiological, or physical) which has the potential to cause harm to humans, animals, or the environment, either by itself or through interaction with other factors. Issues associated with hazardous materials typically center around waste streams, underground storage tanks (USTs), above ground storage tanks (ASTs), and the storage, transport, use, and disposal of pesticides, fuels, lubricants, hazardous toxic and radioactive waste (HTRW) and other industrial substances. When such materials are improperly used, they can threaten the health and well-being of wildlife species, habitats, soil and water systems, and humans.

USACE policy prohibits the use of Civil Works funds to respond to concerns associated with HTRW and requires appropriate investigation to identify potential HTRW concerns early in planning and development of a civil works project. Several actions were conducted to identify any HTRWs or potential contamination on lands in and adjacent to the proposed project site, including structures and submerged lands, which could impact, or be impacted by project implementation.

Multiple environmental databases and related records were searched and reviewed for information regarding current and former land use indicating storage, disposal or use of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulated substances, toxic chemical releases, water discharge permit compliance, hazardous waste handling processes, and Superfund status. Sanborn Fire Insurance Maps were accessed to identify the historic uses of the sites nearer to downtown Louisville. The assessment did not indicate significant concerns from potentially HTRW contamination at any of the proposed restoration sites. Reports for each site are located in Appendix F.

2.10 Socioeconomics and Environmental Justice

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (Executive Order, 1994), directs federal agencies to identify and address, as appropriate, disproportionately high, and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low-income populations. When conducting NEPA evaluations, USACE incorporates Environmental Justice (EJ) considerations into both the technical analyses and the public involvement in accordance with the U.S. Environmental Protection Agency (US EPA) and the Council on Environmental Quality guidance (CEQ, 1997).

The CEQ guidance defines “minority” as individual(s) who are members of the following population groups: American Indian or Alaskan native, Asian or Pacific Islander, Black, not of Hispanic origin, and Hispanic. The Council defines these groups as minority populations when either the minority population of the affected area exceeds 50% of the total population, or the percentage of minority population in the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographical analysis.

The US EPA online EJ Screen environmental justice mapping tool was used to assess the environmental and demographic indicators within the Beargrass Creek watershed. The full EJ Screen Report is located in the Appendix F. Figure 15 compares environmental and demographic indicators of the study area with the other block groups within the state, EPA region, rest of the U.S.

The screening indicated the watershed ranked higher than 82% of block groups in the U.S. for exposure to wastewater discharge. All other EJ indexes were below the 50 percentiles when compared to the rest of the U.S.

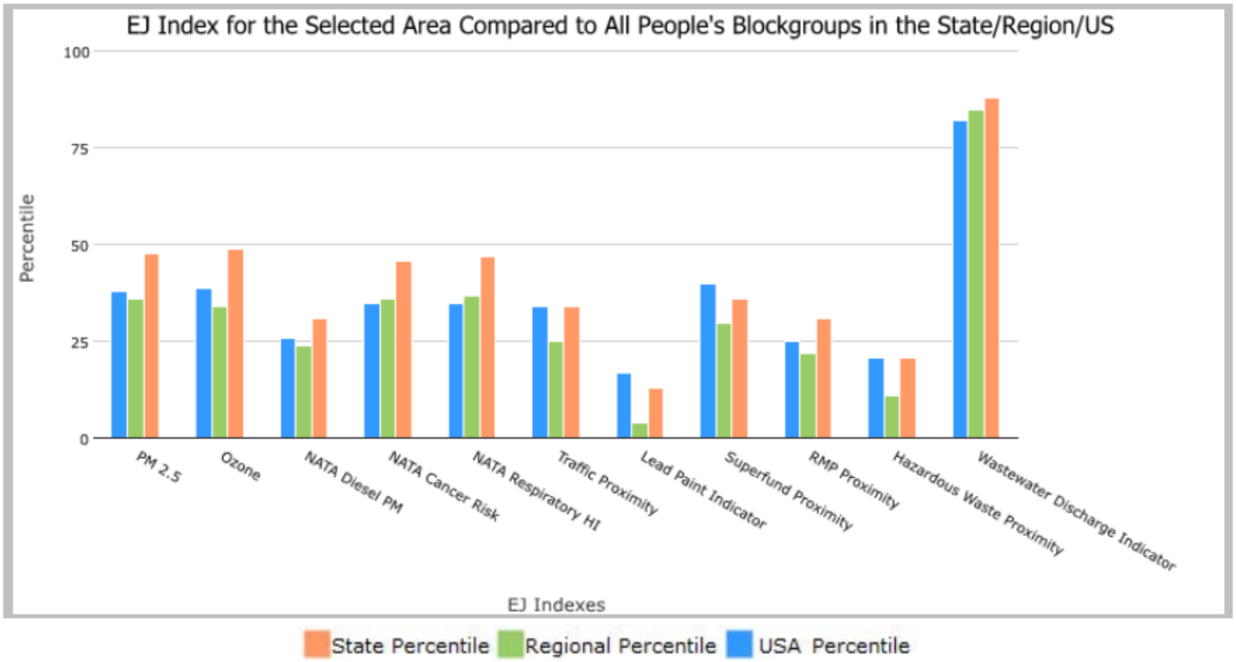

Figure 15 Values for Environmental and Demographic Indicators and EJSCREEN Indexes for the Beargrass Creek Watershed

According to the 2014-2018 American Community Survey (ACS) estimates, the approximate population within the Beargrass Creek watershed is 219,000, with 22% of the total population being composed of the previously defined minority groups. Per capita income of that same area was estimated to be $39,000 per year. Figure 16 shows median household income data in Jefferson County, Kentucky. Approximately 31% of the population in the watershed is under the age of 18 years old. Appendix F contains the EJ Screen ACS summary report generated for the watershed.

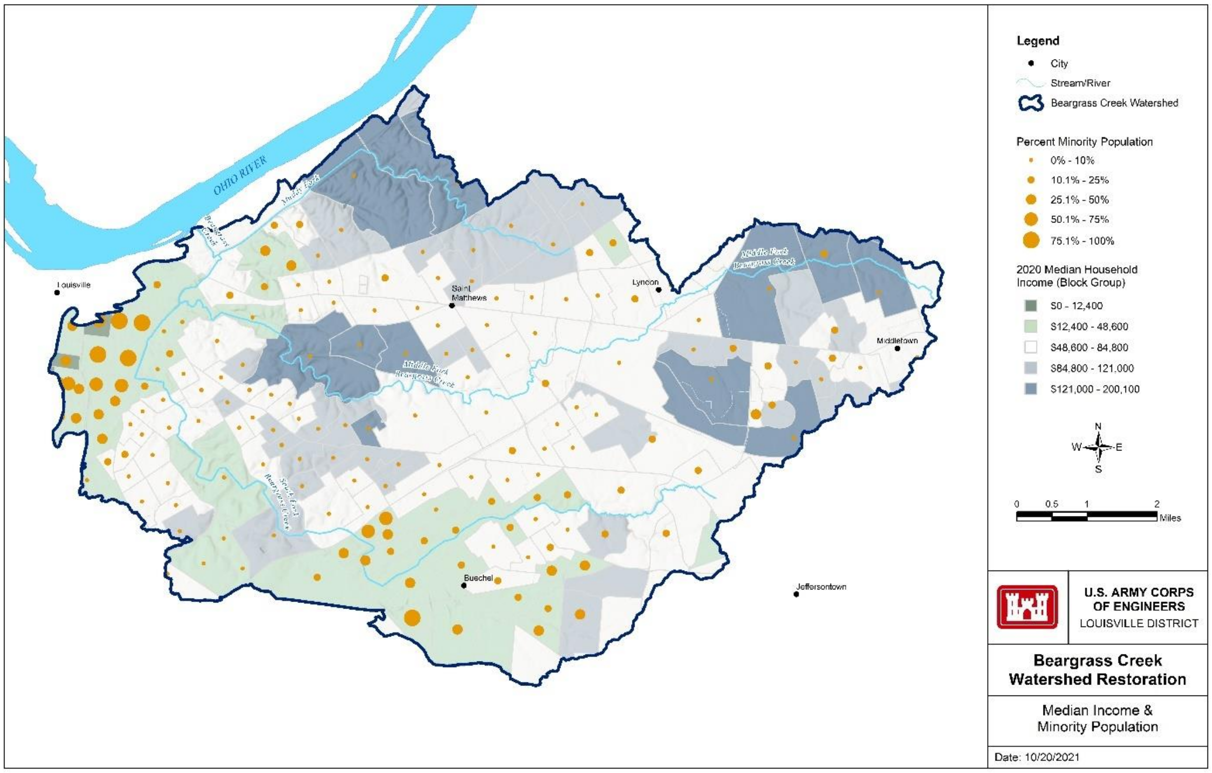

Figure 16 Percent Minority Population and Median Household Income for Jefferson County, Kentucky

3.0 Study Background

3.1 Resource Significance

For many ecosystem restoration projects, outputs are difficult to measure in terms of monetary benefit. Without this option, other criteria must be considered for evaluating and justifying restoration projects in the planning process. One criterion for measuring the benefits of these projects is "significance." This significance is categorized in terms of technical, institutional, and public (Apogee Research, Inc for USACE, 1997).

3.1.1 Technical Recognition

Nationally, there is a scarcity of healthy urban watersheds. Scarcity is a measure of a resource's relative abundance within a specified geographic range. Generally, scientists consider a habitat or ecosystem to be rare if it occupies a narrow geographic range or occurs in small groupings. Unique resources, which are unlike any others found within a specified range, may also be considered significant, as are resources that are threatened by interference from both human and natural causes (Soule, 1986).

yet, the project looks promising to such landowners as Dr. and Mrs. Armand E. Cohen, whose four-acre wooded lot on Newburg Road is bisected by the new channel.

"The old creek flooded every time there was a good rain, all the way from Bernheim's Lake to my own pond, and on down the valley," said Dr. Cohen. He once kept a pony and mule in the woodlot, but gave them up for a tractor after rescuing both animals from breast-deep floodwaters.

Marshy and Swampy

"All of this country through here was marshy and swampy back in George Rogers Clark's day, I've heard some of the old men of the neighborhood say," he noted. "We've even heard there used to be beavers and all sorts of game through here."

One result already apparent to Mrs. Charles C. Krebs, whose home is next door to the Cohens', is that "You can see all across the valley now."

This visible result—opening up of the valley visually—has been a mixed blessing. Some of the landowners hate to see the giant sycamores being chopped and bulldozed out of the old creek bed. But most of them interviewed confess they'll prefer the new ditch to the old creek—providing it lives up to its advance billing as a flood-control measure.

Farther upstream, part of "Haylands Farm," the 70-acre property of contractor Gil Whittenberg, has benefited somewhat—but not from the widening. Whittenberg has hauled hundreds of loads of dirt and rubble from a downtown building project to raise the level of his bottomland level with Gardiner Lane. Later, the widening should provide more dirt for even more filling.

May Hurt Parkway

However, the whole project may end up by either forestalling or increasing the cost of a long-dreamed-of Beargrass Parkway up this valley.

Various city plans have proposed a handsome, wide parkway up this valley from Eastern Parkway to Bardstown Road or farther. The current improvements will certainly make the land more expensive, if such a parkway is ever built.

When the present job is finished—which should be by December 31—the Metropolitan Sewer District will have converted the South Fork from a meandering, partly ditched and sometimes overgrown creekbed into a giant flume. This project starts at a point about 1,000 feet north of Trevilian Way (opposite Bellarmine College); and runs south to the city boundary near Gardiner Lane.

If you drive out you can see the size of the job. The creek now is 26 feet wide at the bottom, nine to 12 feet deep, sides sloping at a ratio of 1½ to 1, and a 100-foot right-of-way (which also includes the recently installed 42-inch sanitary sewer from Appliance Park into the city's sewers.)

This part of the job cost $104,000. (A 1951 estimate by Soil

Figure 17 1953 Courier-Journal Article Excerpt

Beargrass Creek represents both a scarce habitat and a habitat threatened by human development. It is difficult to find a reach of the stream that has been unaffected by the historical and current development patterns in Louisville. The stream that once meandered through a landscape scattered with wetlands is now channelized and manipulated to provide suitable land to build subdivisions and to provide for a fast exodus of floodwaters. In a 1953 Courier-Journal article ( ) titled "Improved Beargrass Creek Drainage Gives Land a Boost," the plans to deepen and channelize the stream to decrease flooding along the South Fork are explained. In the article, the authors talk about the once marshy lands along the stream and how the plans include the removal of giant sycamores from the riparian zone.

This article is just one example of the past management of the stream and surrounding land. With restoration such as planting of native plants, reestablishment of natural meanders and the reestablishment of floodwater access to the floodplain, the habitat that once existed can be returned to some of its former function. A restored Beargrass Creek would be an example of a healthy balance between human development in an urban watershed and nature at its highest form and function.

3.1.2 Institutional Recognition

There are several Acts and Executive Orders that support habitat restoration in Beargrass Creek such as:

- Endangered Species Act of 1973, as amended (16 USC 1531 et seq.)
- Migratory Bird Treaty Act of 1918, as amended (16 USC 703 et seq.)
- Responsibilities of Federal Agencies to Protect Migratory Birds (E.O. 13186)
- Clean Water Act of 1977, as amended (33 USC. 1251 et seq.)
- Invasive Species (E.O. 13112)
- Nonindigenous Aquatic Nuisance Prevention & Control Act of 1990, as amended (16 U.S.C. 4701 et seq.)
- National Invasive Species Act of 1996 (Public Law 104 – 332)
- Protection of Wetlands (E.O. 11990)
- Protection and Enhancement of Environmental Quality (E.O. 11514)
- Floodplain Management (E.O. 11988)
- Preparing the United States for the Impacts of Climate Change (E.O. 13653)

There are also other partnerships and organizations that are supported by the efforts of this study. The Ohio River Basin Fish Habitat Partnership was formed to protect, restore, and enhance priority habitat for fish and mussels in the watersheds of the Ohio River Basin. This partnership includes a multitude of state and federal agencies, including USACE.

The Ohio River Basin Alliance (ORBA) advocates for the ecological health and economic well-being in the Ohio River Basin. ORBA includes representatives from over 80 member organizations, including local, state, and federal agencies, as well as industry, academia, and not-for-profit organizations. A recent Planning Assistance to States study with Ohio River Valley Water Sanitation Commission (ORSANCO) and ORBA, titled the Plan for the Ohio River Basin 2020-2025, looked for goals and strategies to improve the ecology of the entire Ohio River Basin. Improvements to Beargrass Creek are an excellent way to meet some of these goals and leverage federal funds.

3.1.3 Public Recognition

The Beargrass Creek watershed is in an urban environment and therefore touches many communities, giving it high visibility and recognition by the residents of Louisville. Historically, Beargrass Creek spurred development because of the need for clean water for Louisville's growing industrial businesses. That development led to a dense urban environment around much of the watershed.

As discussed in Chapter 1, the Middle Fork flows through Cherokee Park, one of three parks designed by Frederick Law Olmsted in Louisville in 1891, which consisted of Cherokee, Iroquois, and Shawnee parks (Figure 14, Section 2.8), all of which are connected by scenic tree lined parkways. The location and design of these parks were chosen because they exemplified three distinguishing landscapes found in Louisville. Cherokee Park was designed to represent the landscape surrounding Beargrass Creek.

Additionally, there are several Master Plans and Projects that include or focus on Beargrass Creek, including:

- Louisville Metro Comprehensive Plan
- Louisville MSD 2017 Watershed Master Plan
- The Master Plan for Louisville's Olmsted Parks and Parkways
- The Congress for the New Urbanism's South Fork Legacy Project 2019
- Louisville Zoo Master Plan
- Metro Parks Naturalization Plan
- Butchertown, Phoenix Hill, and Nulu Neighborhood Plan
- The Waterfront Botanical Gardens Master Plan

There are also multiple local environmental groups working for a cleaner, more sustainable watershed. These include the Beargrass Creek Alliance and the Kentucky Waterways Alliance.

3.2 Southeastern Riparian Ecosystem Significance

3.2.1 Scarce/Rare Southeastern Riparian Ecosystems

Scarce resources in the historic and/or current area of Beargrass Creek include caves and springs, canebrakes, and bedrock streams confluent to the Ohio River. Canebrakes, for example, have been reduced to less than 2% of their former area and are considered a critically endangered ecosystem in the Southeastern US (Pratt and Brantley, 1997). This native plant was likely once prominent in this region, especially along big river floodplains like the Ohio River, as well as in the floodplains of tributaries, like Beargrass Creek.

Representation is a measure of a resource's ability to exemplify the natural habitat or ecosystems within a specified range. The presence of a large number and percentage of native species, the presence of undisturbed habitat, and the absence of exotic species are all examples of representation. Examples of representation within the Beargrass Creek watershed include Cherokee Park and the Oxmoor Farm wetland on the Middle Fork. These are representative of the once abundant wetland habitats in Kentucky. Beargrass Creek Nature Preserves is another example of a high-quality habitat within the study area and is located next to Joe Creason Park on the South Fork.

There are several habitat examples in the study area that would support significant species if restored. Karstic caves and springs, canebrake, wetlands, bedrock streams and riparian woodland are all examples of habitat that once existed within the Beargrass Creek watershed.

3.2.2 Biological Diversity

There are several state- or federally-listed threatened and endangered species recorded in Jefferson County (though not all in the study area) that would typically utilize riparian or stream habitats, including the least tern Louisville crayfish, and Kirtland's snake (Tables 4 and 5, Section 2.5.4). The federally-listed Indiana, gray, and Northern long-eared bats also occur in the region and do rely on habitat provided by Beargrass Creek for foraging of insects and roosting.

3.2.3 Status and Trends

Status and Trends measures the relationship between previous, current, and future conditions. The current condition of Beargrass Creek as compared to historical conditions is highly degraded due to years of development and alteration of the stream. The future without project conditions would remain relatively the same as current conditions because the stream corridor is confined and most areas within the watershed are already developed. Therefore, it can be assumed that invasive species will continue to spread and fortify their presence without any maintenance or removal.

Implementation of a federal ecosystem restoration project (i.e., future with project condition) would not fully restore the stream to its historical conditions due to the constraints of the urban environment. However, targeted restoration could substantially improve currently degraded habitats and provide benefits through connectivity of existing and restored habitat. Targeted habitat restoration could also improve downstream habitat (e.g., reduced sediment loading) and water quality. These actions, while not fully restoring the stream to its historical conditions, will improve the current conditions and exemplify the restoration that is possible within an urban watershed.

3.2.4 Habitat Connectivity

Connectivity is the measure of a resource's connection to other significant natural habitats. There are 10 species of threatened and endangered mussels in the Ohio River region where Beargrass Creek discharges to the Ohio River. The Ohio River and Beargrass Creek are strongly connected with an interchange of species between these two aquatic environments. An example of this interchange and dependency is with glochidia, the larval form of fresh mussels. These larvae attach to gills and rely on fish to travel to small streams for spawning and habitat. This allows the mussels to broaden their range and makes it easier for populations to rebound. Migratory birds also need connected habitats. Black Crowned Night Herons as well as the Sand Hill Crane are good examples found in the southeastern US and frequent the study area.

3.2.5 Importance of Restoring a More Natural Hydrologic Regime and Geographic Character

Urban development and the subsequent channelization of the stream has had major hydrologic impacts as the city has become more urbanized. Restoring the historic character and the more natural hydrologic regime of the Forks goes hand in hand with restoring habitat. A natural hydrologic regime provides more stable flows and less variation between base flows and storm flows. In the hydrologic regime's current state, storm flows are more frequent and extreme, making habitat unstable and less likely to support diverse species. Restoration of these natural flows would make the stream more suitable for aquatic life, improve long-term habitat stability, and improve water quality.

4.0 Plan Formulation

Plan formulation is an iterative process resulting in the development, evaluation, and comparison of alternative plans to address identified study problems by achieving the outlined objectives. The Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) (1983) established four accounts to facilitate the evaluation and display of the effects of alternative plans. These accounts are national economic development (NED), environmental quality (EQ), regional economic development (RED), and other social effects (OSE). These four accounts encompass all significant effects of a plan on the human environment as required by NEPA (42 U.S.C. 4321 et seq.). As required by Section 122 of the Flood Control Act of 1970 (Pub. L. 91-611, 84 Stat. 1823), all four accounts were considered in the selection of the Recommended Plan.

Plan formulation for ecosystem restoration (ER) presents a challenge because alternatives have non-monetary benefits. To facilitate the plan formulation process, the methodology outlined in USACE Engineering Circular 1105-2-404, "Planning Civil Work Projects under the Environmental Operating Principles," 1 May 2003 was used. The steps in the methodology are summarized below:

1. Identify a primary project purpose. For this portion of the study, ecosystem restoration (ER) is identified as the primary purpose. Alleviating local drainage or water quality issues are not purposes of this project.
2. Formulate management measures to achieve planning objectives and avoid planning constraints, where measures are the building blocks of alternative plans.
3. Formulate, evaluate, and compare an array of alternatives to achieve the primary purpose (ER) and identify cost-effective plans.
4. Perform an incremental cost assessment on the cost-effective plans to support selection of the National Ecosystem Restoration (NER) plan.

4.1 Public Involvement

The development of the proposed restoration study has resulted from a systematic process of evaluating the stream's existing conditions and any associated problems and opportunities, then identifying objectives to help solve the problems and measures for realizing those opportunities. Due to the visibility of the stream and its value as a community asset, public, agency and stakeholder input was very important during the scoping phase of the study as is shown in Figure 18 from a public meeting in November 2019.

Figure 18 Photos from the public meeting held on 14 November 2019

The public comment period for this draft report is also an important opportunity to receive feedback from community stakeholders and the public on the draft Integrated Feasibility Report, as well as Tribal nations that could possibly have traditional cultural resources in the area. The public comment period took place in April-May of 2021. The report was posted for a 30-day public comment period on the Louisville District homepage and distributed to pertinent agencies for comment. A letter was received from MSD, as well as concurrence letters from two agencies. No general public comments were received. A full list of agencies that received the report for comment, MSD's letter, and comments from the agency meeting can be found in Appendix H.

4.1.1 Beargrass Creek Ecosystem Restoration Feasibility Study Workshops

A total of three workshops were held during the scoping phase of the feasibility study. The first took place on October 10, 2019, for community stakeholders that included groups such as MSD, Kentucky Waterways Alliance, Beargrass Creek Alliance, Louisville Metro Government, University of Louisville, River City Paddle Sports, Kentucky Division of Water, and Natural Resources Conservation Service. These groups were chosen for their intimate knowledge and previous and on-going work within the watershed. The intent of this meeting was to identify gaps in the evaluation of the problems and opportunities in the watershed, brainstorm initial management measures, and draw from local knowledge and expertise. The group was subdivided into three focus groups for each sub-watershed in Beargrass Creek. Maps were provided that facilitated the collection of input from stakeholders on site specific restoration opportunities and local expertise in the watershed.

The second and third workshop meetings were targeted to agencies and the public, both held on November 14, 2019. The goals of the public meetings were to provide a venue for the public to supply input into the planning process, draw from local knowledge and expertise and provide constructive feedback on the problems, opportunities, objectives, and constraints that had been scoped to that point.

The public was shown examples of past USACE ecosystem projects and possible management measures, given a history of Beargrass Creek, and asked to participate in a map exercise to find gaps in the existing problems and opportunities. Figure 19 illustrates some of the feedback received from the public participants. The focus of this exercise was to relate these ideas to locations within the watershed that would assist the team with site selection. This workshop was attended by over 50 members of the public.

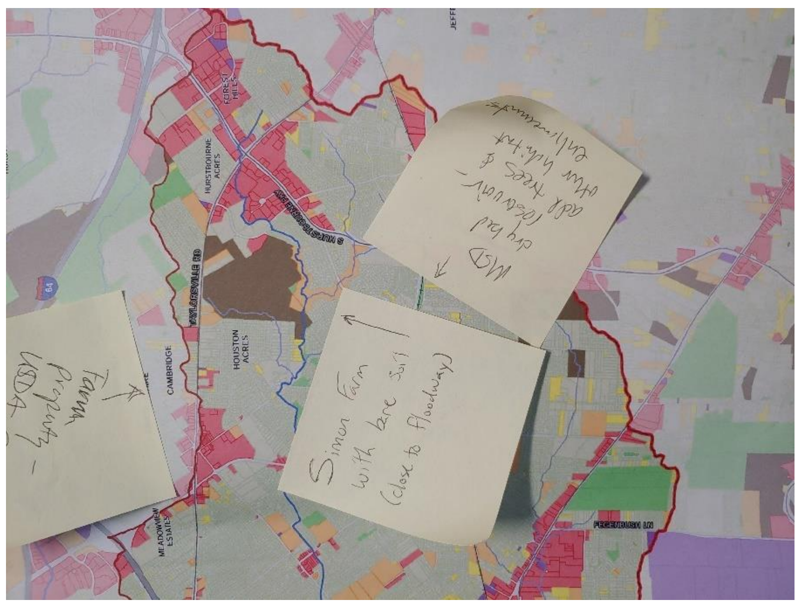

Figure 19 Public Comments on a Beargrass Map at the Public Meeting

The agency workshop was held the same day and was geared toward local, state, and federal agencies with interest in ecosystem restoration. Agency components such as USFWS, Kentucky Department Fish and Wildlife Resources, the Great Lakes and Ohio River Division (LRD), National Ecosystem Planning Center of Expertise (ECO-PCX), MSD (NFS) and Louisville District Project Delivery Team (PDT) were all in attendance. During this meeting, the team went through a series of preliminary sites to elucidate discussion on site selection evaluation and criteria, management measure evaluation and criteria, and key risks and uncertainties. Figure 20 below shows all entities that participated in the scoping phase of the study.

The specific issues and opportunities discussed at the public meeting are listed below:

- Opportunities at confluence for recreation and restoration
- Public education opportunities
- Excessive bank erosion
- Lack of riparian zone along steep reaches
- C-Cell tower leg in Muddy Fork causing erosion
- LGE bank stabilization
- Big parcel of land on River Road recently donated to Collegiate
- Restore outfall streams that draw to Muddy Fork
- Abundance of honeysuckle at a portion of Muddy Fork close to I-71
- Connect golf course to maintain park area
- Remove cement blocks from Belvedere and repurpose
- Improve straightened channel to more natural state
- Reconnections to floodplain where possible
- Native tree canopy wherever possible
- Reintroduce beavers where appropriate
- Safe spaces to access the water: stream walk, paint/photography, education

Figure 20 Entities that participated in the Scoping Process

4.2 Summary of Problems and Opportunities

Problem and opportunity statements were framed in terms of the federal objective and the specific study planning objectives. Problems and opportunities were defined in a manner that does not preclude the consideration of all potential alternatives and does not include discussion of potential solutions. The problem and opportunity statements provided below were evaluated and modified at multiple times during plan formulation, therefore accounting for the dynamics of the iterative planning process.

4.2.1 Problems

Currently, the Three Forks of Beargrass Creek are completely contained within urbanized Jefferson County. Significant portions of the creeks have been channelized to obtain faster flow and increased capacity during floods. Loss of riparian zones and associated wetlands have resulted in instream habitat degradation, loss in resiliency and morphology of natural banks, reduced natural organic inputs (woody debris/leaves/insects), and poor water quality. Concrete channels further eliminate instream habitat in affected areas, result in elevated water temperatures that exceed thermal limits for most aquatic life and reduce connectivity between upstream and downstream reaches. Accordingly, riparian, wetland and stream ecosystems have been severely impacted with reduced abundance, diversity, and health of aquatic and riparian organisms. Figure 21 illustrates some of the current issues observed within Beargrass Creek watershed.

Specific preliminary problems are summarized below:

1. Loss of Fluvial-geomorphic Processes (Riverine Habitat): The degradation of the physical shapes of waterways, their water and sediment transport processes, and the landforms they create.
    a. Loss of cut and fill alluviation (actively meandering and migrating)
    b. Abnormal sediment inputs, transport, and substrate sorting
    c. Instability of banks, streambank armoring, and lack of native vegetation
    d. Loss of habitat features (e.g., riffles, pools)
    e. Flow velocities homogenized (hydraulics)
    f. Presence of foreign debris and loss of natural organic debris (e.g., large wood)
    g. Loss of stream / floodplain access
    h. Elevated water temperatures due to lack of deep pools

2. Degradation of Hydrologic Regime: Negative variations in the state and characteristics of the stream such as the quantity and dynamics of waterflow or connection to groundwater bodies.
    a. 9 to 60% impervious surface across watershed
    b. Natural hydrologic inputs altered
    c. Flashy urban hydrography with extremely high flood flows
    d. Loss of hydrologic periods
    e. Fragmentation of channel by culverts, abutments, and channelization

3. Loss of Riparian Zone: A decrease in the size and quality of the plant habitats along the banks of the stream.

a. Reduced extent of riparian buffers
b. Habitat fragmentation
c. Loss of riparian inputs (large woody debris, leaf litter, insects/other food)

4. Loss of Species Richness (riverine and riparian native species): A decrease in the number of species within the region.
   a. Extirpation through physical removal; development/agriculture
   b. Loss in remnant areas via invasive species and other degradation
   c. Fragmentation of stream channels and riparian zones

Figure 21 Example of common problems seen in Beargrass Creek. Top left- concrete channel on the South Fork, Bottom left- Channel incision on the Middle Fork, and Right- Channelization and loss of riparian zone on the Muddy Fork

4.2.2 Opportunities

Opportunities are benefits, or positive aspects, for the community or environment that can be achieved in addition to the study objectives. Opportunities may not necessarily be related to the study objectives, but they may be achieved in the process of meeting the objectives. Below are major opportunities for the Beargrass Creek study:

1. Increase native species richness/abundance of riverine, wetland and riparian communities
2. Increase aquatic habitats appropriate to unique local conditions
   a. Ephemeral and perennial streams
   b. Ohio River floodplain
   c. Sloped wetlands and springs
   d. Riverine and palustrine
   e. Karstic and calcareous formations
3. Increase amount of viable and connected stream habitats

4. Increase extent of riparian habitats
    a. Abandoned and/or flooded lands
    b. Detention/retention basins
    c. Parks and agricultural lands
    d. MSD/Metro lands, easements, and rights of way
    e. Natural areas and preserves
5. Realign/move aging MSD infrastructure to support habitat restoration
6. Foster a clean, safe place to play and live
    a. Improved recreation and community engagement with watershed
    b. Education areas that provide nature and information
    c. Provide public access to streams and other wetlands
    d. Site stewardship programs
7. Improve water quality

4.3 Summary of Planning Objectives and Constraints

4.3.1 Federal Objective

The federal objective of water and related land resources planning is to contribute to the restoration, conservation, and management of environmental resources in accordance with numerous national environmental statutes, applicable executive orders, and other Federal planning requirements and policies. The use of the term "federal objective" should be distinguished from planning/study objectives, which are more specific in terms of expected or desired outputs, whereas the federal objective is considered more of a national goal. Water and related land resources project plans shall be formulated to alleviate problems and take advantage of opportunities in ways that contribute to study objectives and to the federal objective. Contributions to national improvements are increases in the net value of the national output of goods, services, and ecosystem integrity as well as ecosystem services that are or are not marketable.

Protection of the nation's environment is achieved when damage to the environment is eliminated or avoided and important cultural and natural aspects of our nation's heritage are preserved. Various environmental statutes and executive orders assist in ensuring that water resource planning is consistent with protection. The objectives and requirements of applicable laws and executive orders are considered throughout the planning process in order to meet the federal objective. The following laws and executive orders that specifically provided guidance for this study are not limited to, but include:

- Safeguarding the Nation from the Impacts of Invasive Species (E.O. 13751)
- Nonindigenous Aquatic Nuisance Prevention & Control Act of 1990, as amended (16 U.S.C. 4701 et seq.)
- National Invasive Species Act of 1996 (Public Law 104 – 332)
- Endangered Species Act of 1973, as amended (16 USC 1531 et seq.)
- Fish and Wildlife Coordination Act, as amended (16 USC 661)
- Migratory Bird Treaty Act of 1918, as amended (16 USC 703 et seq.)
- Responsibilities of Federal Agencies to Protect Migratory Birds (E.O. 13186)
- Clean Water Act of 1977, as amended (33 USC. 1251 et seq.)
- Clean Air Act of 1970, as amended (42 USC 7401)

- National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.)
- Resource Conservation and Recovery Act of 1976, as amended (42 USC 6901, et seq.)
- Protection and Enhancement of Environmental Quality (E.O. 11514)
- Floodplain Management (E.O. 11988)
- Protection of Wetlands (E.O. 11990)
- Wild and Scenic Rivers Act of 1968 (16 USC 1271-1287 Public Law 90-542 82 Stat. 906)

4.3.2 Specific Planning Objectives

Planning objectives are statements that describe the desired result(s) of the planning process by refining the problems identified into achievable actions. Objectives must be clearly defined and flexible (non-prescriptive). They should be supported by information on the effect desired (quantified and/or qualified), the subject of the objective (what will be changed), the location where the expected result will occur, the timing and duration of the effect (50 years). The planning objectives presented below are directly related to the problems identified in the previous sections.

1. Reestablish quality and connectivity of riverine habitats

All three forks of Beargrass Creek have experienced channel realignment, bank erosion, loss of alluvial processes, homogenized flow velocities, etc. The South Fork in particular has been dramatically modified with nearly 3 miles of concrete channel designed to increase conveyance of floodwaters. These modifications are specific to impeding riverine hydraulics, sediment transport and substrate sorting, which results in a loss of structural habitat heterogeneity (e.g., homogenized geomorphology). The effects desired by meeting this objective are to provide riverine functions and/or structure to restore, connect and sustain habitats. The targeted location of these effects would be within stream channel. These effects would be sustained over the life of the project and optimistically in perpetuity. This objective seeks to reestablish natural fluvial-geomorphic parameters (hydraulics/substrates/floodplain connectivity) and structure (morphology/habitat) to support riverine and riparian habitats within the study area. Improvement is measured via the predicted increase in quality of riverine habitat as evaluated by the Qualitative Habitat Evaluation Index for Louisville Streams (QHEILS).

2. Reestablish quality and connectivity of riparian and wetland habitats

Beargrass Creek watershed is a highly urbanized system. Impervious surfaces, land use change, habitat fragmentation, the disruption of ecological inputs, etc. have all contributed to degraded riparian zones. Existing riparian buffer zones are impaired in terms of width, connectivity and/or species composition. The effect desired by meeting this objective is to return tracts of healthy native riparian vegetation with increased species richness of insect, amphibian, reptile, bird, and mammal species. The targeted location of these effects would be within the riparian zone and supporting communities. These effects would be sustained over the life of the project and optimistically in perpetuity. This objective seeks to reestablish native riparian plant community species richness and structure for resident and transient riparian animal species. Improvement is measured via the Simple Model for Urban Riparian Function (SMURF) habitat restoration planning model developed by the USACE Engineer Research and Development Center (ERDC) using parameters from various accepted models from state and federal agencies.

4.3.3 Planning Constraints

Planning constraints represent restrictions that limit the extent of the planning process. The planning constraints considered for the study are as follows:

- Avoid areas of potential contamination and potentially contaminated sediments
- Avoid inducing local flooding
- Avoid impacting railroad and transportation infrastructure

The cause of these constraints is almost entirely due to the alterations made to the watershed since the settling of the surrounding area and subsequent development of homes, businesses and supporting infrastructure. Urbanization has channelized much the system to make way for development that now physically constrains the streams riparian zone. Since the stream has also been altered to move stormwater out of the city as quickly as possible, any changes to the system such as restoration of natural substrate, for example, must be cautious of inducing flooding. With the growth of the city occurring since the late 1800s, there are also many areas with known and potential contamination from unregulated development. All these constraints have been recognized and considered throughout plan formulation to decrease risk and costs and avoid impacting vital infrastructure.

4.4 Conceptual Ecosystem Model

USACE typically follows a conceptual ecosystem/habitat model (Figure 22) that breaks down components into functions of hazard(s), performance, and consequences. These three concepts are utilized to illustrate mechanisms of change, which focus the effectiveness of potential ecosystem alternatives under consideration for federal investment.

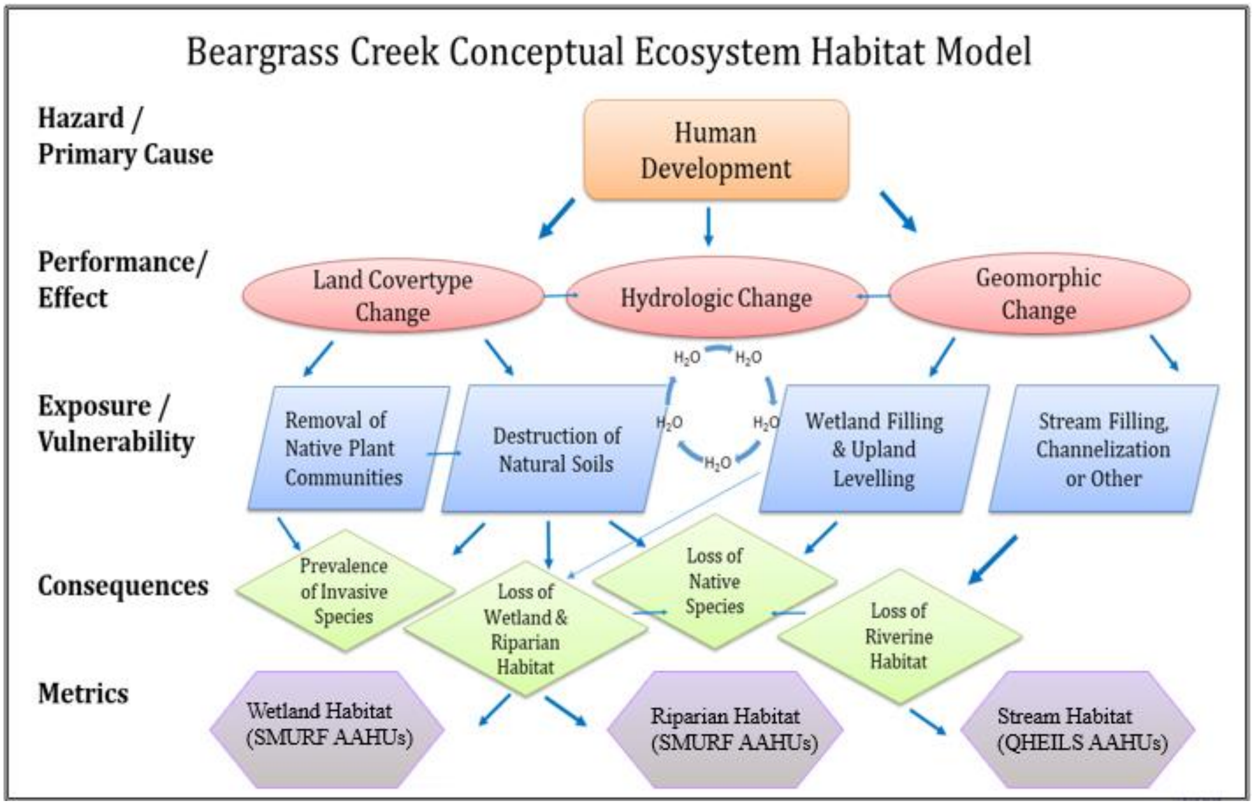

Figure 22 Conceptual Ecosystem Habitat Model showing process for Average Annual Habitat Units (AAHUs)

Hazard

The hazard, or potential cause for harm, refers to the major land use changes caused by development, which is described in Section 4.2.

Performance

Performance refers to the system's reaction to the hazard, or how the Beargrass Creek ecosystem changed, or is anticipated to change based on major land use, hydrologic and geomorphic changes. Performance in this study is primarily tied to land use change and channelization of the river. A description of the existing system's performance in terms of ecological function is presented in Chapter 2: Affected Environment.

Consequences

Consequences are measured in terms of metrics such as economic damage, acreage of habitat lost, value of crops damaged, etc. This study specifically looks at the consequences of lost native species and replacement by non-native species due to losses in native stream, riparian and supporting wetland habitat. These consequences would specifically be measured QHEILS for the stream zone and the SMURF for riparian and wetland zones.

4.5 Plan Formulation Overview

The complex nature of this study with multiple sites that would eventually be combined to generate the Recommended Plan created a challenge as far as plan formulation and terminology. In order to address this complexity, the team approached plan formulation by first identifying and a selecting an array of sites and then beginning the alternative development. The following text and figures lay out the overall plan formulation strategy, and details are provided in subsequent sections.

The Beargrass Creek watershed presented many opportunities for ecosystem restoration actions, and four iterative rounds of screening were used to reduce 266 potential sites to 21 sites for USACE consideration (See Section 4.6).

The following process was used to develop site-scale alternatives (Figure 23). First, all potential measures such as demolition, grading, placement of native rock structures, etc., were screened for combinability to create general families of restoration actions. These generalized approaches were then applied at each of the 21 sites based on the site level technical feasibility, the Planning and Guidance (P&G) criteria, Operations and Maintenance (O&M) requirements, and the potential for ecological lift. This resulted in the site-scale alternatives array. Additional information on these steps is found in Sections 4.7-4.9.

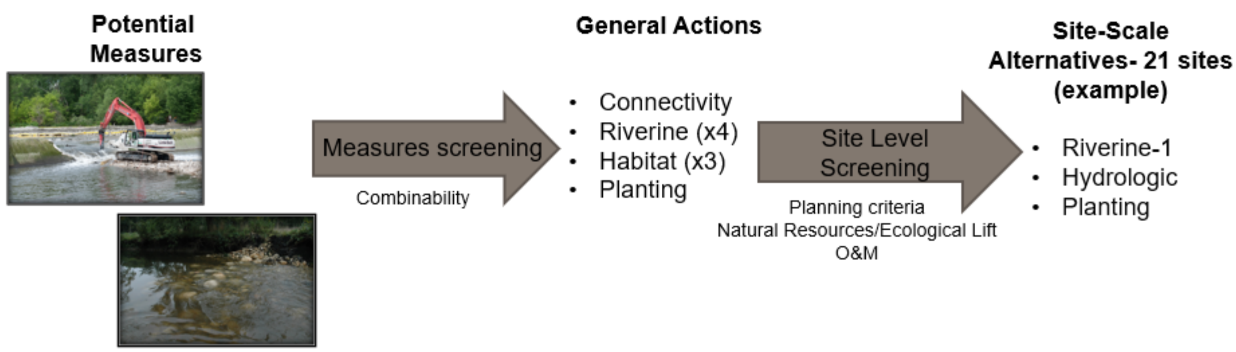

Figure 23 Plan formulation from measures or "building blocks" to the site-scale alternatives creation

At each of the 21 sites, all combinations of site-scale alternatives were considered (e.g., no action, riverine only, planting only, riverine and planting), based on established criteria for the combinability of actions (Section 4.9 and Appendix B). Across all 21 sites, there were 235 combinations of actions. Costs and benefits were assessed for each combination of actions. These combinations were subjected to Cost-Effectiveness and Incremental Cost Analysis (CEICA) at each site (Figure 24). This analysis resulted in 7 "no action" recommendations and 14 sites with recommended restoration actions that would be carried forward to the watershed scale CEICA. See Appendix B for additional detail.

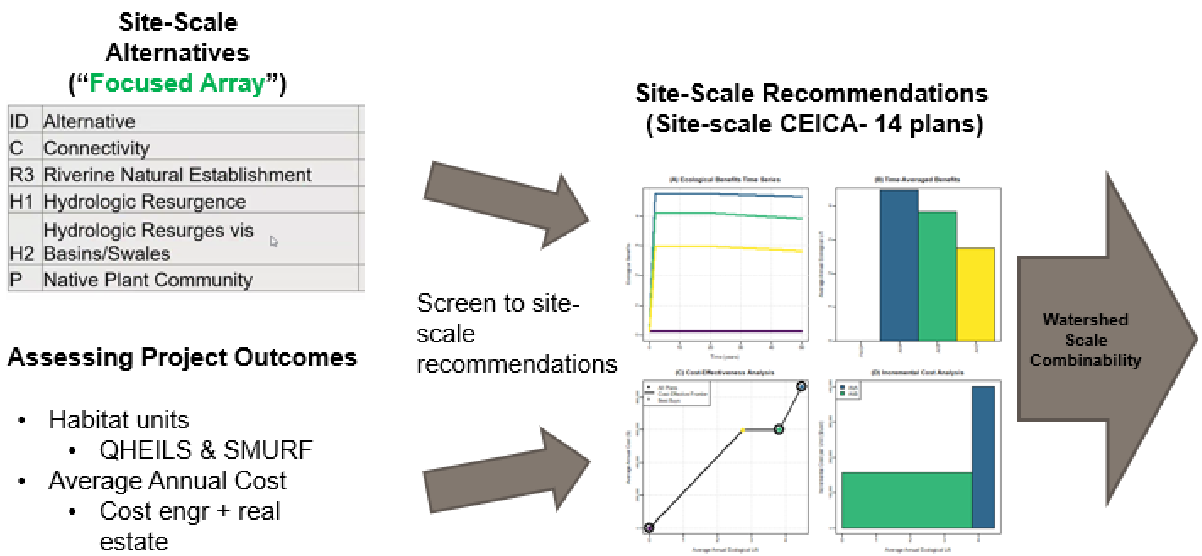

Figure 24 Plan formulation from focused array to watershed scale comparison

As shown in Figure 25, the last step in the plan formulation process was a watershed scale comparison of all possible combinations of the 14 sites with restoration recommendations. This resulted in 16,384 possible watershed-scale plans. The team identified the Recommended Plan utilizing decision criteria based on the four accounts (discussed later in Chapter 5 and Appendix B).

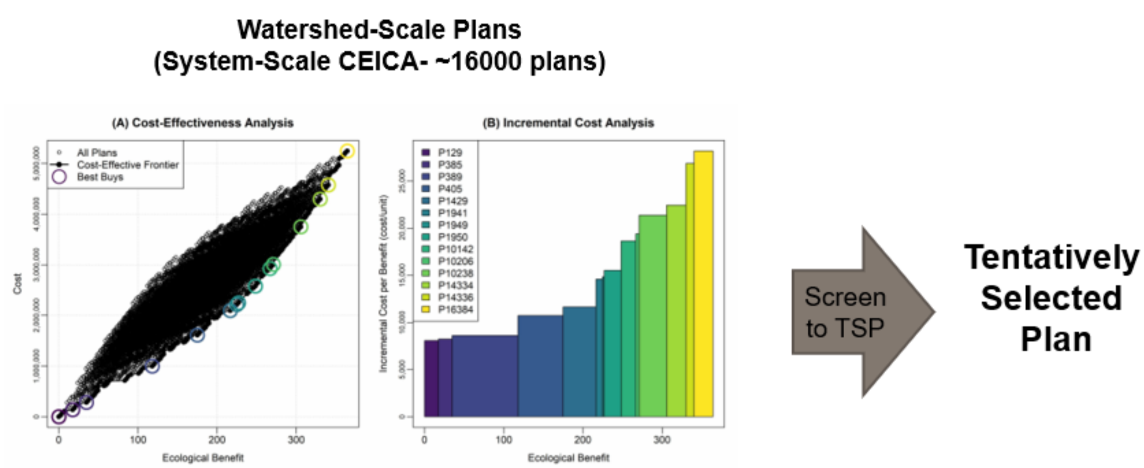

Figure 25 Plan formulation from watershed-scale comparison to Recommended Plan

4.6 Site Identification and Selection

The goal of this analysis was to analyze the Beargrass Creek watershed to acquire an initial array of locations that would be best suited for aquatic ecosystem restoration (ER) utilizing USACE expertise within policy limitations (ER 1105-2-100). Below (Figure 26) is an overview of the site screening process from the initial analysis to the focused array of sites for alternative application.

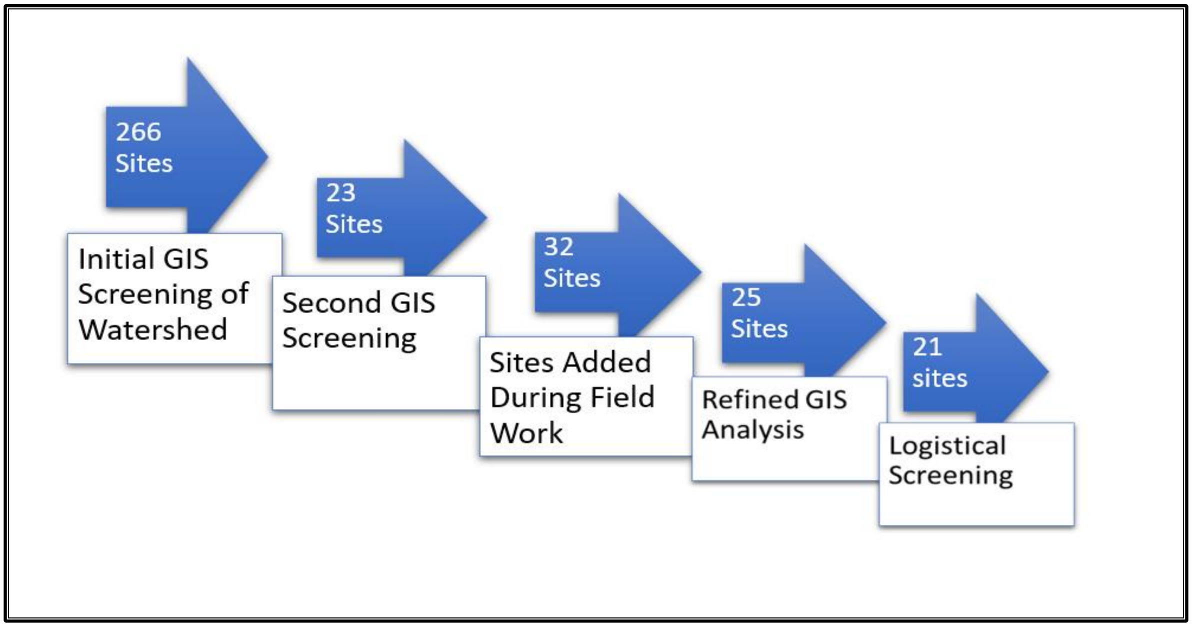

Figure 26 Overview of site selection process

4.6.1 First Round of Site Screening

An aerial based Geographic Information Systems (GIS) analysis of the Beargrass Creek watershed was completed to identify all potential restoration spaces within the watershed. Additional sites were identified during the meetings referenced above. Criteria presented in Table 9 specifically looked for traits that would make a site more viable for habitat restoration. Available national, county, and municipal geospatial data were utilized to fulfill the criteria needs. Most boundaries for sites were based on existing county data features such as land use, roads, property lines, watershed boundaries, stakeholder ownership, land designations, etc. Smaller sites that were touching each other or closely separated by features that do not significantly fragment the sites from each other were grouped to generate a larger site. Ultimately, 266 open space parcels were generated.

Table 9 Summary of site screening criteria and scoring

#	Screening Criteria	Score	Description
A	Potential restoration acrerage (based on site polygon size)	6	greater than 25 acres
		4	between 10 & 25 acres
		2	between 3 & 9 acres
		0	less than 3 acres
B	Proximity to existing stream or wetland (based on USGS streams coverage)	6	stream or wetland within site
		4	directly riparian to water touching
		2	between 51 & 100 feet
		0	over 100 feet
C	% of site that is hydric soil or fluvequents (based on NRCS soil mapping)	6	75 - 100%
		4	50 - 74%
		2	25 - 54%
		0	0 - 24%
D	Number of potential cover types & edaphic conditions (based on NRCS soil mapping)	6	5 or more
		4	3 - 4
		2	1 - 2
		0	0
E	Available Impervious Surface Conversion	6	75 - 100%
		4	50 - 74%
		2	25 - 54%
		0	0 - 24%
F	Connectivity (addressing site issues would restore connectivity)	6	within ¼ mile buffer
		4	between ¼ & ½ mile buffer
		3	between ½ & 1 mile buffer
		0	over 1 mile buffer
G	Proximity to an existing natural area (based on state nature preserves data)	6	within ¼ mile buffer
		4	between ¼ & ½ mile buffer
		2	between ½ & 1 mile buffer
		0	over 1 mile buffer
	Maximum Points	42	
	Minimum Points	0	

4.6.2 Second Round of Site Screening

Since it is not practical to restore every open space parcel within the watershed, a set of criteria was developed by the PDT and NFS that was aimed to identify those sites with most potential for ER utilizing measurable geospatial data.

An ArcGIS spatial analysis was conducted to score each site based on the criteria shown in Table 9. An initial round of scoring was performed to ensure criteria and results had reliability. As shown in Table 9, the criteria were given a possible score range of 0-6, which was intended to assess the sites' opportunity for restoration, with 0 being none and 6 being optimal. This enabled utilization of a quantitative geospatial tool to find the best opportunities from the original 266 sites that were identified from the meetings and land use evaluation (Figure 27, Figure 28). The scoring threshold for screening was decided by looking at a natural breakpoint in frequencies which resulted in a cutoff score of 30 points. This screening took place in two iterations and screened 243 sites, leaving 23 sites for further evaluation.

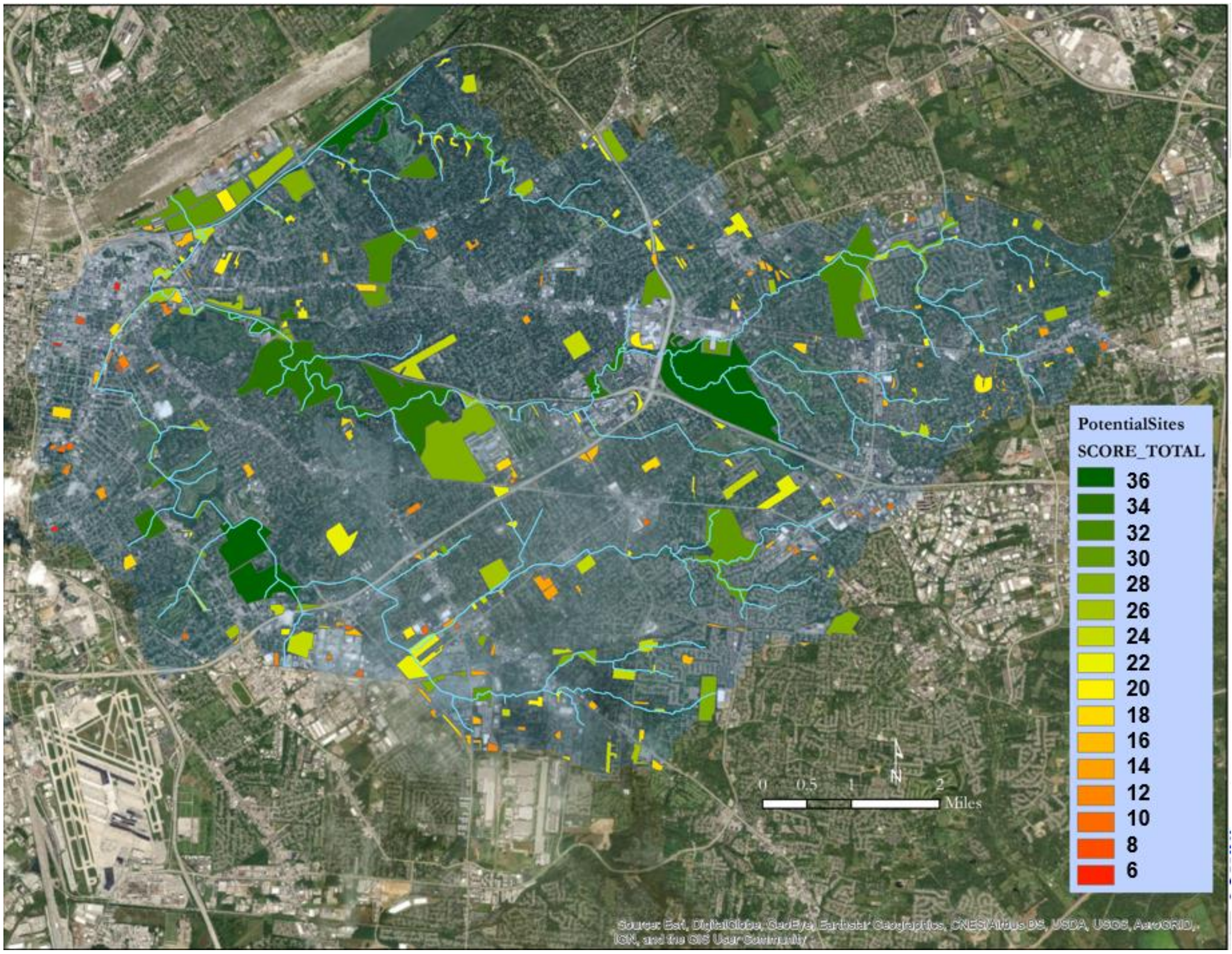

Figure 27 Full array of sites

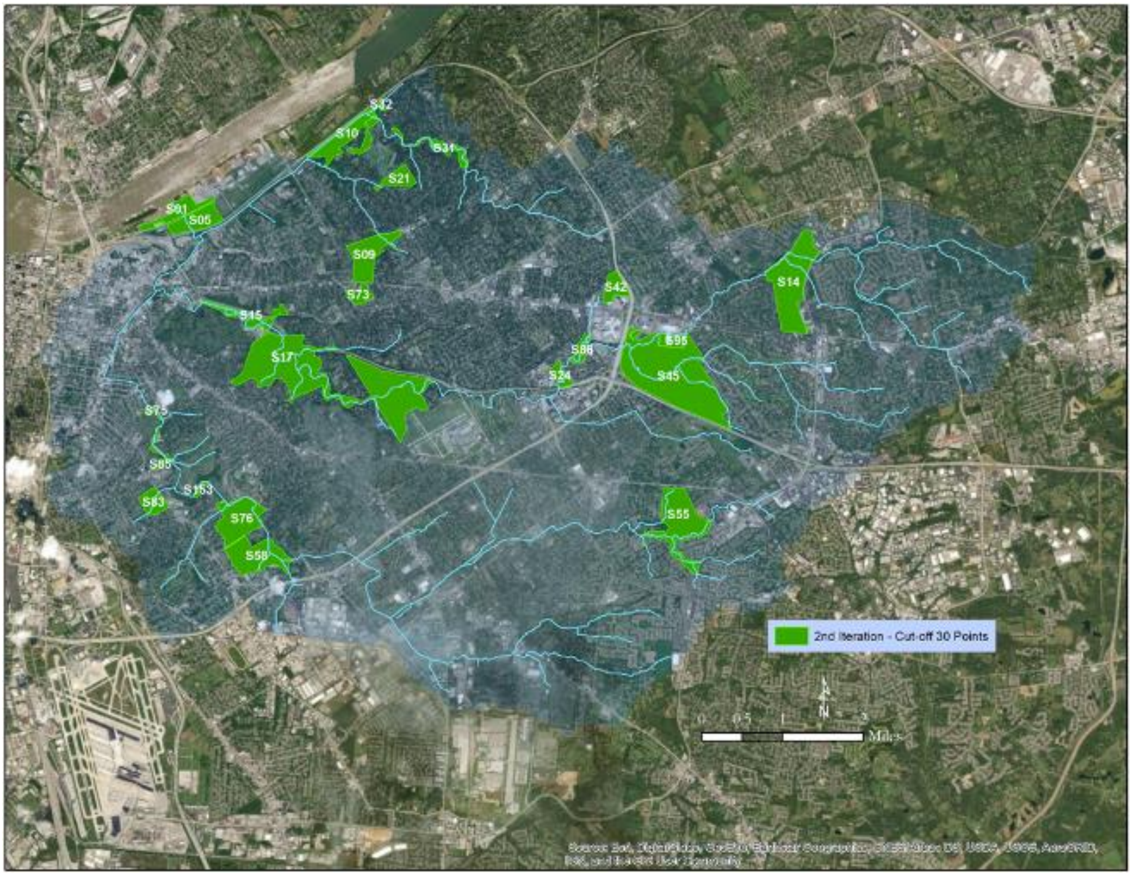

Figure 28 Remaining Sites after Geospatial Analysis

4.6.3 Third Round of Site Screening

The next iteration of GIS screening took place after the PDT performed field work and had a knowledge of the sites from an “on the ground” perspective. Sites were added that the team felt would offer good opportunities for habitat lift that had not been captured previously. After these additions, the total site count was 32. The team then performed adjustments to site boundaries based on technical expertise and feasibility of work. This refinement was meant to improve the accuracy of the third round of screening.

This third round of screening with GIS used the same criteria as the second round (Table 9). However, the point system was adjusted from 0-6 points to 0-3 points for each criterion to facilitate more straightforward scoring by the PDT. This resulted in a potential total score of 21, however the highest realized score for any site was 15. The team chose a cutoff score of 10 for deciding to screen a site (i.e., sites that scored less than half the total possible points were screened), which resulted in the screening of an additional seven sites (Table 10).

Table 10 Results of refined GIS screening (with screened sites in red)

SITE ID	COMMON NAME / NOTES	SITE SCORE
X2	Confluence	15
X5	Oxmoor Farm	15
X22	Concrete Channel	15
X24	Oxmoor Country Club	15
X34	Cherokee and Seneca Parks	15
X4	Shelby Campus	14
X8	Houston Acres Farm / Riparian	14
X9	Clark Park Riparian	14
X10	Alpaca Farm / Zoo Riparian	14
X11	Collegiate Donated Riparian Zone	14
X15	Buechel Park Restoration	14
X19	South Fork / Newburg Rd Riparian	14
X20	Brown Park Wetland / Riparian	14
X25	Audubon Riparian Zone	14
X29	Eastern Creason Connector	14
X30	Beargrass Creek State Nature Preserve / Joe Creason Park	14
X38	Cave Hill Corridor	14
X21	Arthur Draut Park Wetland / Riparian	13
X32	Buechel Bypass	13
X36	I-64 Corridor-Upstream of Seneca	13
X37	Lyndon Corridor	13
X28	Hurstbourne Country Club	12
X31	Champions Trace	12
X35	Muddy Fork and tributaries	12
X33	MSD Basin habitat improvements	11
X3	Seneca Headwater Island	10
X16	Breckenridge Ln Riparian BLHF	10
X27	Seneca High School	10
X1	Crescent Hill Golf Course Wetland Project	9
X17	Farm - Hurstbourne Pkwy	9
X23	Oxmoor Corridor	9
X14	Goldsmith Lane Impervious Surface Removal	7

4.6.4 Fourth Round of Site Screening

The fourth and last round site screening was based on potential for habitat lift and real estate acquisition risk. Each site received a score from the PDT of 1-3 for each criterion based on the list below:

- Potential Habitat Lift - Based on previous PDT discussions and potential for habitat lift
  - 1-Low potential
  - 2-Med potential
  - 3-High potential
- Real Estate Acquisition Risk

- 1-Privately owned and low potential for partnership/acquisition
- 2-Privately owned and good potential for partnership/acquisition
- 3-Public/Partner owned

The screening results are shown in

Table 11, which displays the scoring for both criteria with the screened sites highlighted in red. It was decided by the PDT that sites that scored a combined total of less than four points for both criteria would be screened.

Table 11 Screening scores for sites (with screened sites in red)

SITE NUMBER	SITE NAME	REAL ESTATE	HABITAT LIFT	TOTAL
X34	Cherokee and Seneca Parks	3	3	6
X9	Clark Park Riparian	3	3	6
X10	Alpaca Farm / Zoo Riparian	3	3	6
X15	Buechel Park Restoration	3	3	6
X30	Beargrass Creek State Nature Preserve / Joe Creason Park	3	3	6
X2	Confluence	2	3	5
X5	Oxmoor Farm	2	3	5
X19	South Fork / Newburg Rd Riparian	3	2	5
X29	Eastern Creason Connector	2	3	5
X21	Arthur Draut Park Wetland / Riparian	2	3	5
X4	Shelby Campus	2	2.5	4.5
X31	Champions Trace	2	2.5	4.5
X33	MSD Basin habitat improvements	2.5	2	4.5
X22	Concrete Channel	1	3	4
X24	Oxmoor Country Club	2	2	4
X8	Houston Acres Farm / Riparian	2	2	4
X11	Collegiate Donated Riparian Zone	2	2	4
X20	Brown Park Wetland / Riparian	2	2	4
X28	Hurstbourne Country Club	2	2	4
X35	Muddy Fork and tributaries	1	3	4
X38	Cave Hill Corridor	2	2	4
X32	Buechel Bypass	1	2.5	3.5
X37	Lyndon Corridor	1	2.5	3.5
X36	I-64 Corridor-Upstream of Seneca	1	2	3
X25	Audubon Riparian Zone	1	1	2

This iteration screened out an additional four sites, leaving the focused array of sites that was utilized for alternative application (Figure 29).

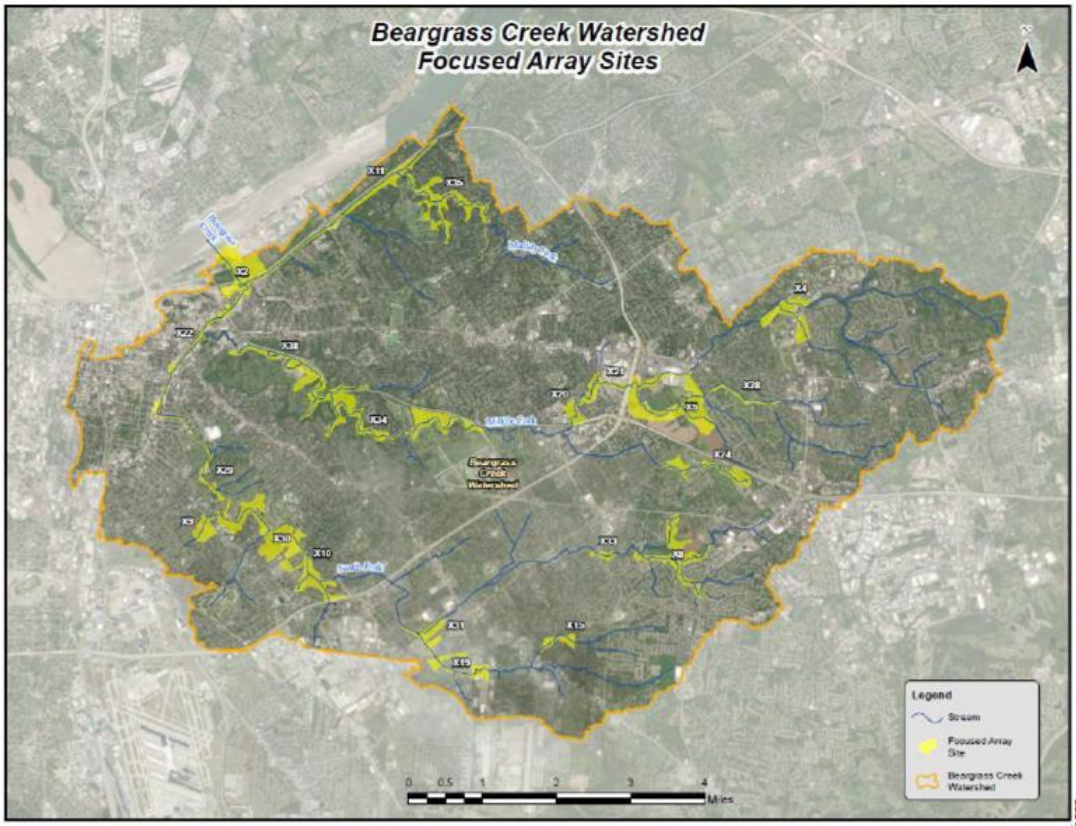

Figure 29 Twenty-one Focused Array Sites used for Alternative Formulation

4.7 Management Measures as Building Blocks

Management measures are features or activities that can be implemented at a specific geographic location to address all or a portion of the identified study problems. Measures can directly address the hazards, the way the hazards behave (perform), or indirectly address them through eliminating or reducing the consequences.

The following measures have been frequently used in past restoration projects within the USACE Lakes and Rivers Division (LRD) area. These measures were developed in a fashion so that parametric costs could be applied for plan formulation purposes. As such, these measures can be used as building blocks to develop an array of alternatives, which could then have costs estimated based on which measures are included in each alternative.

Measures are either natural, nature-based, or structural per Section 1184 of the Water Resources Development Act of 2016. The management measures were grouped into three categories: hydrogeomorphic measures, native plant community measures, or adaptive management measures. A total of 12 management measures were developed, with potential benefits and costs quantified for each. These measures were then combined with other measures to develop alternatives that could be implemented to solve the specified planning objectives at the site level for all 21 potential restoration sites. Appendix H includes the conceptual application of the preliminary alternatives for these 21 sites and chapter 4 of Appendix C contains design detail at the site level. The problems and benefits associated with these measures are summarized below (Table 12) and each measure is described technically in the following sections.

Table 12 Summary of problems addressed and benefits provided for each measure.

Measure	Problems Addressed	Benefits Provided
Demolition	• Instream barriers for fish passage • Structures impeding other restoration efforts	• Restore instream connectivity • Remove structures within floodplain or on banks that will enable plantings, wetland creation, access to floodplain, etc.
Excavation	• Geomorphology of land is not suitable for wetland creation	• Allows for wetland creation and wetland plant community establishment • Excavated soil can be used on site
Grading	• Stream does not have access to floodplain • Bank erosion	• Lays banks back so that increased flows are allowed into the floodplain
Native Rock Structures	• Lack of instream habitat for fish and insects	• Creates instream habitat
Large Woody Debris	• Lack of instream habitat for fish and insects	• Creates instream habitat
Water Control Structures	• Lack of wetland habitat • Flooding issues • Erosion issues	• Creates wetland habitat • Allows control over amount and duration of water being held
Invasive Species Removal	• Hindrance for native species • Low quality habitat	• Allows for native species growth that might have otherwise been outcompeted
Soil Amendments	• Flood issues • Soil not conducive to wetland function	• Allows creation of wetland habitat where it might not have existed otherwise
Native Plantings	• Low quality or lack of habitat • Lack of vegetation and increase erosion issues	• Restored native habitat • Stabilized soils
Native Plant Establishment	• Native planting growth and establishment may be disrupted	• Creation of stable habitat • Soil stabilization
Adaptive Management Measures	• Failure of other measures to perform	• Ability to reestablish restoration efforts in the face of uncertainty
Best Management Practices	• Risk of damage to project features during construction	• Decreased risk of damage to project features

4.7.1 Hydrogeomorphic Measures

The following is a list of potential measures that were considered for repairing and creating the hydrogeomorphic setting(s) for native communities.

4.7.1.1 Demolition – This measure entails those activities associated with the removal of structures within the channel, bank, and floodplain zones. An example of a past demolition measure implementation is provided in Figure 30. Specific structures that could be removed include but are not limited to dams, weirs, bridge abutments, retaining walls, improved channels, pipes, outfalls, and other defunct infrastructure. Specific materials to be removed under this measure include but are not limited to large foreign debris, concrete, asphalt, metal, angular riprap, gabion baskets, and geotextile fabrics. All materials removed would be appropriately reused, recycled, or disposed of.

Figure 30 Demolition of a Low Head Dam

4.7.1.2 Excavation – This measure consists of modifying the planform of the stream channel, the physical pattern of the stream, or other earthen topography. Reconfiguration may include introducing braded threads in low gradient systems, reshaping the cross-sectional area, constructing wetlands, relocating a stream off-line from the current location, and/or adjusting the riffle/pool sequences to provide bedform diversity and habitat. Reshaping of the cross-sectional area may be achieved using instream structures or by grading the bed and banks to specified bankfull dimensions. Adjustments to sinuosity can be used to adjust channel slope. In some cases, relocation may be used as an opportunity to avoid infrastructure or reconnect to a floodplain. Large to small construction equipment would be utilized to excavate and fill


Figure 31 Excavation of Lagoon

material to establish the proposed channel or topography. An example of a past excavation measure implementation is provided in Figure 31. All materials would be reused on site to create diverse geomorphologies; stockpiled for reuses by others; and/or disposed of appropriately. This measure is typically coupled with grading.

4.7.1.3 Grading – This measure includes the movement of earthen materials to achieve required geomorphologic and hydrologic conditions for native communities. Large to small earth moving machines would be utilized to spread, smooth, and undulate surface soils to specific elevation as required by the targeted native plant community. An example of a past grading measure implementation is provided in Figure 32. This measure would typically be combined with excavation to provide final elevation, and/or soil amendments to ensure proper incorporation into surficial soils.

Figure 32 Grading Riverbank to Mimic Natural Shapes and Morphology

4.7.1.4 Native Rock Structures – This measure includes the placement of rock/stone into the stream channel to provide required geomorphologies and substrates for native stream community. This measure would be more applicable to those channel reaches that exhibit higher stream velocities. Large to small construction machinery would place rock slabs, boulders and/or cobbles that are of the same make up and general shapes as natural reaches with similar gradient. An example of a past native rock structure measure implementation is provided in Figure 33. Rock/stone materials would take on various configurations as necessitated by the particular stream parameters present at the restoration site. Different configurations of rock structures would include but not be limited to slab-rock, riffle, boulder cluster, j-hook, cross-vein, and cobble bar. All stone structure materials would be appropriately sized based on in-channel parameters. All materials would be sourced for local permitted sources to

Figure 33 Boulder and Cobble Riffle Placement

ensure clean and inert materials. This measure is combinable with a variety of measures as it can add critical habitat and stability components.

Figure 34 Large Woody Debris Structure and Soil Terracing

4.7.1.5 Large Woody Debris Structures – This measure includes the placement of woody material into the stream channel or into wetlands for habitat and stability components. Structures include large woody debris, brush run, log-vanes, log cluster riffles, point bar logs, log drops, woody debris drops, toe wood, rootwads, log steps, and others. An example of a past large woody debris structure measure implementation is provided in Figure 34. This measure would be more applicable to those channel reaches that exhibit lower stream velocities and wetlands. Large woody debris consists of trees, their major branches, their rootwads, and combinations of such. Typically, larger trees (20+ diameter at breast height) removed for excavation, grading or native plant community restoration are retained and utilized. These structures may consist of one to many trees placed into the stream channel and bank zones in various configurations to provide habitat and temporary stability. Depending on the forces exhibited in the area targeted, large woody debris may or may not need to be keyed into and/or tethered to the stream floor or earthen bank.

4.7.1.6 Water Control Structures – This measure includes modification to or creation of water control structures to stabilize hydroperiodicity of palustrine wetlands (Figure 35). This measure would help to support native plant communities and wildlife habitat. Structures would promote wildlife passage and would not create hydrological surface disconnection. This measure is combinable with a variety of measures and can help to provide critical hydrology for native plant communities.

Figure 35 A Water Control Structure Used to Stabilize Hydroperiod as part of the Chicago District's Indian Ridge Marsh Ecosystem Restoration in Chicago, IL.

4.7.2 Native Plant Community Measures

Figure 36 Removal of Cottonwoods and Ash from Globally Imperiled Ridge and Swale

4.7.2.1 - Invasive Species Removal – This measure includes the complete removal of non-native weeds and the selective removal of native weeds in areas that are not treated with other clearing measures, such as excavation, grading, or some demolition activities. An example of a past native plant community measure implementation is provided in Figure 36. Methods for removing invasive plant species include but are not limited to clearing and grubbing, mowing, burning, flooding, broad-cast herbicide application, spot-treatment herbicide application, etc. This measure is a one-time initial application or an initial series of applications to provide conditions for native plantings; this measure is not the same as those small spot treatment applications under the Native Plant Establishment measure (see section 4.7.2.3).

4.7.2.2 - Soil Amendments – This measure includes the addition of inorganic and/or organic materials to site soils to provide the required conditions for native plant communities. Inorganic materials would primarily include sand or small gravel and potentially other components such as crushed mussel shells or limestone fines (lime). An example of a past soil amendment measure implementation is provided in Figure 37. Organic materials would primarily include leaf litter compost, leaf litter, wood chips, saw dust, etc. These materials would be spread over the top of the site as the final elevation grade or incorporated into the specified depths of soil by disking or during implementation of grading measures.

Figure 37 Spreading Organic Compost

4.7.2.3 - Native Plantings – This measure includes the procurement and planting of native plant species. Native planting lists would be specifically developed per plant community type specifying the rates of native seed, live root stock, live plugs, and live tree/shrub containers. An example of a past native plantings measure implementation is provided in Figure 38. Current potential for plant community general types includes aquatic bed, swamp, meadow, woodland, and forest.

Figure 38 Planting Native Wetland Plugs

4.7.2.4 - Native Plant Establishment – This measure includes those elements required to establish and maintain newly created or restored plant communities. Specific elements include but are not limited to invasive species management, depredation control, protective fencing, limited short-term watering, general plant survival, growth, and coverage, etc.

4.7.3 Adaptive Management Measures

Figure 39 Common Carp and Canada Geese Protection for Newly Planted Wetlands Plugs

A 5-year monitoring and adaptive management contract would ensure recruitment and establishment of native communities (abiotic and biotic) is successful. All hydrogeomorphic work would be accomplished within the first several months of the contract to allow establishment and monitoring time. Options would be placed in the contract for future adaptive management measures that could be exercised at any point of the contract duration, but most frequently in years 3, 4 and 5. These may include but are not limited to changing or adjusting features to achieve the required hydrology, hydraulics and/or geomorphology; additional native plant treatments; or other improvements. All adaptive management decisions and exercising of contract options would be driven by monitoring. Figure 39 provides an example of an adaptive management measure. To be conservative, three adaptive management options would be included under this measure for high, medium, and low adaptive adjustment needs. These would be Option A – for more intensive adjustments of geomorphology or hydrology costing approximately $75,000; Option B – for more moderate adjustments of habitat and/or additional plantings costing approximately $25,000; Option C – for minor habitat adjustments or additional plantings costing approximately $10,000.

4.7.4 Best Management Practices

This measure would include practices that have been successful in implementing and sustaining restoration. A wide variety of approaches can be utilized for successful restoration such as allowing sufficient time for self-generating processes to resume, practicing monitoring protocols, and emphasizing process repair over structural replacement (Gann & Lamb, 2006).

4.8 Measure screening

Measures were screened based on completeness and technical feasibility to obtain the desired outcome of each of the preliminary alternatives. While no measures were eliminated, some were screened under each of the given alternatives if they were unnecessary to achieve that alternative. The resulting table (Table 13) was the total suite of alternatives and comprising building block measures.

The screening of measures was an iterative process that was site dependent, due to the complexity and size of the watershed. Utilizing the total suite of measures, each of the possible alternatives (Table 14) was evaluated at each site. The measures that applied to that alternative at that specific site were compiled to create that site-specific alternative. These alternatives are described in more detail in Section 4.9.1.

Table 13 Total suite of measures and preliminary alternatives

	Alternative								
Measure	**C**	**R1**	**R2**	**R3**	**R4**	**H1**	**H2**	**H3**	**P**
Demolition	X	X	X	X	X		X		
Excavation	X				X	X	X	X	
Grading	X		X	X	X	X	X	X	
Water Control Structures								X	
Native Rock Structures	X	X	X	X	X				
Large Woody Debris		X	X	X	X				
Invasive Species Removal									X
Soil Amendments									X
Native Plantings									X
Native Community Establishment									X
Adaptive Management	X	X	X	X	X	X	X	X	X
Best Management Practices	X	X	X	X	X	X	X	X	

Table 14 Alternative abbreviation summary

Abbreviation	Alternative
C	Connectivity
R1	Instream Habitat Only
R2	Instream Habitat and Floodplain Connectivity
R3	Natural Riverine Establishment
R4	Sculpted Riverine Establishment
H1	Hydrologic Resurgence
H2	Hydrologic Resurgence Via Basins/Swales
H3	Hydrologic Resurgence Via Water Control Structures
P	Native Plant Community Restoration

4.9 Development of Alternatives

Alternatives were developed under a four-pronged approach, using the preceding measures as building blocks. One Connectivity (C), four Riverine habitat (R), three Riparian hydrology (H) and one Native Plant Communities (P) alternatives were developed that could be applied to any given reach or site with differing amounts of effort and measures. Table 15 below gives a summary of the alternative categories (or general actions) and their combinability.

The Connectivity alternative is combinable with any of the other alternatives, and the Riverine alternatives are dependent on this alternative, if necessary. Dependency is based on the logic that if aquatic organisms cannot gain access to a restored habitat, then the plan is incomplete and inefficient.

Table 15 Alternative summaries

Alternative Category or "General Action"	Number of Alternatives	Description	Combinability	Dependencies
Connectivity (C)	1	Elimination of instream fragmentation points	R/H/P	NA
Riverine Habitat (R)	4	Restoring natural fluvial geomorphology to stream reaches	C/H/P, Not combinable with each other for same reach but combinable for different reaches within same site	Can be dependent on C
Riparian Hydrology (H)	3	Restoring natural hydrologic function to riparian areas	C/R/P, Not combinable with each other for same riparian area within a site	NA
Native Plant Communities (P)	1	Planting of native species and removal of invasive species	C/R/H	NA

4.9.1 Preliminary Array of Alternatives

As stated in Section 4.6, the preliminary alternatives were formed by combining applicable measures to reach each of the desired descriptions as defined in Table 15.

4.9.2.1 Connectivity of Riverine Habitats (C) – This alternative would entail eliminating fragmentation points within the river channel of all Three Forks of the Beargrass Creek system, including those specific to connection with the Ohio River. All fragmentation points and types were identified by GIS analysis and by field assessments during summer 2020 by PDT members. Measures included in this alternative would address structures or features that fragment habitat and impeded dispersal of aquatic species. These fragmenting structures or features generally include perched culverts, bridge abutments, structure footings, weirs, cross channel pipes, foreign debris jams, online detention basins, piped reaches, and chronically dry reaches of stream. Specific measures considered include removal of structures/features (demolition) or bypassing structure/feature (i.e. geomorphic/grading). Figure 40 illustrates an example where a connectivity issue exists.

Figure 40 Connectivity Barrier on the South Fork

4.9.2.2 Riverine Habitat Restoration Alternatives (R1, R2, R3, R4) – These alternatives are applied to select reaches of stream channel throughout the entire watershed, including those riparian sites identified for alternative analyses. Figure 41 shows the riverine reaches identified during the 2020 summer sampling season that would be assessed for restoration treatments. These points are existing MSD access sites, and while not all were located within the prioritized sites, these assessments allowed the team to get an overall characterization of the stream throughout the watershed. The field assessments of points outside of prioritized sites resulted in the addition of sites that were overlooked in the scoping phase.

Riverine alternatives (R1 – R4) are not combinable with each other for the same reach, can be combinable with different reaches within the same site, and are combinable with Connectivity and Riparian alternatives. This alternative is dependent on the Connectivity alternative, if necessary. Some alternative components may require dependency on native plants (P) for proper function, such as under R4 (see below for details).

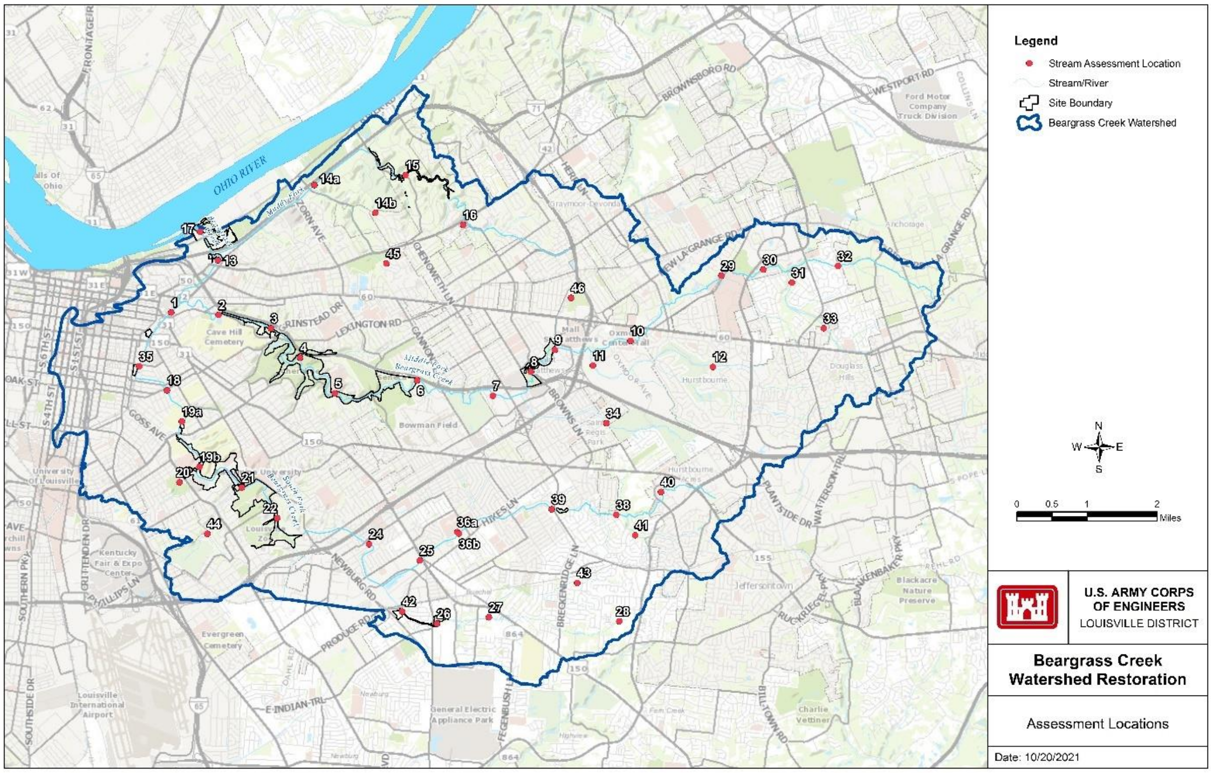

Figure 41 Locations where the Project Delivery Team took Field Assessments in the Summer of 2020

<u>R1 Instream Habitat Only</u> – This alternative would maintain the current channel alignment and hydraulic and geomorphic conditions while placing low-profile riffle, slab rock, boulder, cobble, and large woody debris structural habitats. These would be placed directly on the stream/ditch bed and banks with different configurations for areas of aggradation (i.e., sediment accumulation) and erosion; ensuring there is no induced movement to the stream channel alignment.

<u>R2 Instream Habitat and Floodplain Connectivity</u> – This alternative would maintain the current channel alignment while grading banks to reconnect the river to the floodplain and installing medium-profile riffle, boulder, cobble, and large woody debris structural habitat on bed and on bank. The furthest extent of the floodplain grading would be the location for the excess material's beneficial reuse. This includes creating micro-drainage divides and gaps for surface water connectivity, rerouting and natural drainage patterns. It is not practical or necessary to fund extensive erosion control blankets for this activity in large areas; spot treatments of coir logs and fabric would be utilized in target zones on the new banks until native cover crop or plant community vegetation establishes.

<u>R3 Natural Riverine Establishment</u> – This alternative would entail inducing certain stream reaches to erode their own banks to jump start meandering and migration or allow the stream to continue as it is already recovering (Figure 42). The stream's alignment would initially be the same as the existing alignment but would be subject to natural channel migration over longer periods of time. For more active interventions, this process would specifically be induced by placing sacrificial large woody debris and/or rock structures in the stream channel; the structures would eventually become bank or stream habitat. These structures would intentionally direct flow into the bank to cause a moderate to high rate

of erosion and deposition. This natural process is termed cut and fill alluviation. This process naturally creates and sustains riverine habitats including but not limited to oxbows, backwaters, islands, riffles, pools, undercut banks, substrates, sandy point bars, and large woody debris inputs. This alternative also considers the use of rock structures to ensure the stream safely enters and exits from the reach/site. To make this alternative more feasible from an acceptability aspect, elements of floodplain grading are included to greatly reduce the amount of material eroded and moved within the wetted stream channel.

Figure 42 Setback Levees to allow Restoration via Natural Processes

R4 Sculpted Riverine Establishment – This alternative would re-establish a more appropriate meander pattern for a given channel based on site setting, constraints, and geomorphologic parameters. Proposed design solutions should allow for the channel to adjust over time while maintaining a dynamic equilibrium. Manual creation of riffles and pools, in addition to placement of appropriate instream rock and/or woody structures, would increase the quantity and diversity of available habitat immediately following construction as well as establish grade control. Instream structures would help maintain the stability of the channel, provide time for native plant communities to establish, and create long term stability and habitat. Stream dynamic equilibrium would be controlled with large woody debris, rock structures and native plant communities. This alternative also includes the use of rock structures to ensure the stream safely enters and exits from the site. Figure 43 illustrates an example of the implementation of an R4 Sculpted Riverine Establishment alternative.

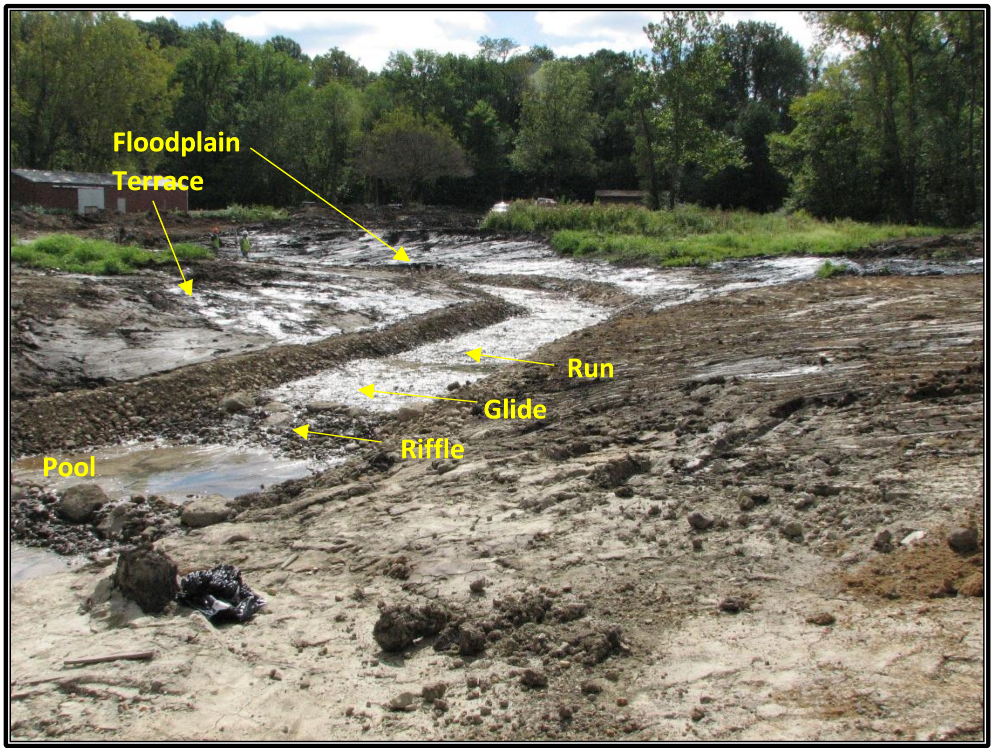

Figure 43 Example of Stream Sculpting on Little Calumet River at Red Mill Pond ER

Figure 44 Example of excavation of a basin/swale structure

4.9.2.3 Riparian Hydrology Alternatives (H1, H2, H3) – These alternatives are applied to the riparian zone sites selected for alternative analyses. Figure 29 in section 4.6 above shows the selected sites that have moved forward to the alternatives screening phase. These sites also represent the selected stream reaches chosen for alternative development. Riparian hydrology alternatives H1, H2 and H3 are combinable with each other, and can be combined with Connectivity, Riverine or Native Plant Community alternatives. Figure 44 provides an example of a riparian hydrology alternative implementation of a basin/swale structure.

<u>H1 Hydrologic Resurgence</u> – This alternative would resurge natural surface and subsurface hydrology and hydroperiodicity via strategically installing backwater valves, removing drain tiles and/or filling and plugging of unnatural ditches. This would permanently disable the existing drain tile system. Backwater

valves may be necessary to avoid potential off-site flooding effects and have benefits to assist in plant community distributions, planting schemes, and drainage pattern development. Drain tiles would be permanently disabled at some point during the 5-year construction period by grouting the valves shut or being completely removed. This alternative also includes the filling or plugging of minor internal ditches.

H2 Hydrologic Resurgence Via Basins/Swales – This alternative would resurge natural surface and subsurface hydrology and hydroperiodicity by excavating and/or grading swaths of landscape down to the normal water table, primarily to alleviate past filling impacts. This alternative also includes a low number of flexible acres for low-intensity grading to adjust topography to further refine hydrologic expression once other alternatives or components are implemented.

H3 Hydrologic Resurgence via Water Control Structure – This alternative would both induce surface hydrology and stabilize or moderate extreme hydrologic fluctuations. A stoplog style water control structure would be utilized for off-stream channel and palustrine wetlands. Control structures for in-line stream channel placement would consist of a fixed elevation riffle, or a fixed elevation hybrid riffle with embedded stoplog structure to allow both fish passage and the ability to draw down wetlands for hydroperiod support. This measure would maintain more consistent water levels and promote different marsh or swamp types and other fringing wetland types (e.g., sedge meadow, wet prairie). Water levels could also be raised or lowered for vegetation management purposed including drawdowns to allow for easier access or flooding for control of unwanted invasive and opportunistic plant species.

Considerations: The use of control structures can be successful if properly maintained and operated for the project life cycle (period of analysis). O&M tasks to ensure the structures are operating to maximize wetland hydrology would include inspection after every flood event, monthly routine inspections during the growing season, and an operation plan that is adhered to. Therefore, future risk of failure, and operations and maintenance costs would be higher for this alternative. The moment the control structure no longer functions as the hydrologic life support, or is removed, the plant community will change.

4.9.2.4 Native Plant Community Restoration (P) – This alternative includes invasive species elimination, planting of native plant materials, and associated establishment activities required to restore a healthy native plant community (Figure 45). All invasive and opportunistic plant species would be initially removed with any combination of clearing, grubbing, herbicide

Figure 45 Example of native plant community

application, flooding, mowing, and prescribed burning. Targeted species for removal include, but are not limited to, Japanese honeysuckle, porcelain berry, English ivy, winter creeper, oriental bittersweet, bush honeysuckle, privet, multiflora rose, tree of heaven, ground ivy, chickweed, and Japanese stilt grass. This alternative would also seed and plant native species of local genotype. Feasibility level planting lists per community type were developed for cost purposes and would be refined during the design phase. Warranties and substitutions for plant materials and survival would be included. Establishment activities would include spot herbicide treatments, mowing, prescribed burns, herbivory control and temporary watering for some plug, tree, and shrub species.

4.9.3 Site Level Alternative Formation and Screening

Next the PDT applied the alternatives summarized in Table 15 above to the 21 individual sites. The No action alternative within each site was also included. In total 210 alternatives were developed.

Preliminary alternatives were screened utilizing relevant USACE planning guidance and compared against the No Action alternative. Screening criteria utilized were Completeness (C), Effectiveness (E), Efficiency (EFF), Acceptability (A) (the four criteria established in the P&G (1986)), Natural Resources Effects (NR), and Sustainability requirements (O&M).

Completeness (C): The completeness metric was scored based on how well the alternative can be implemented due to site constraints or existing conditions. Factors that affected this included probability of land acquisition and ability of the alternative to create suitable habitat.

Effectiveness (E): This metric was scored on how well the alternative addressed the problems, opportunities, objectives, and constraints that were identified during the scoping phase of the project.

Efficiency (EEF): The efficiency metric was scored based on the potential cost of the given alternative. Factors that were included in this scoring were the anticipated land acquisition costs (private vs public land) and anticipated costs of alternative implementation (R4 much more extensive than R1).

Acceptability (A): This metric was scored on how acceptable the alternative might be to the NFS, as well as the greater community. Scoring was based on the goals of MSD and public comment from scoping meetings.

Natural Resources Effects (NR): This metric was scored based on the potential for habitat lift for the given alternative. Factors considered were acreage and extent of degradation of the habitat at the site.

Sustainability requirements (O&M): O&M is scores were based on the amount of O&M requirements needed to keep the alternative features in place and functioning for the life of the project. For example, alternatives such as native planting would score lower on a site that had constraints such as an interstate nearby than a site that is less constrained and more suitable for native species.

Each screening criterion was assigned a qualitative score ranging from 0–4 to differentiate between alternative plans, with a higher score being more favorable. Overall scores for each alternative were compared and cutoffs for screening were determined by natural breaks in scoring frequencies. The highest possible score was 24 and the lowest possible score was 6. The natural breaks differed for each site so screening cutoffs were decided on a site-by-site basis.

This screening analysis was used to guide decisions on which of the developed alternatives would be retained for further detailed cost-effectiveness analysis. The detailed screening matrix that provides both rational and screening scores is presented in Appendix H.

Based on this screening iteration, 85 alternatives within the 21 sites were screened from further consideration. One-hundred twenty-five individual alternatives within the 21 sites remained. Table 16 in Section 5.0 below shows the remaining alternatives by site after this screening.

4.10 Designs

Once the alternatives per site were screened, the remaining alternatives were conceptually applied to each site utilizing firsthand knowledge, topography, land use, existing conditions, and historical plant communities. Figure 46 shows the conceptual alternative map for site X2. Team members developed a conceptual map for all 21 sites (Appendix H).

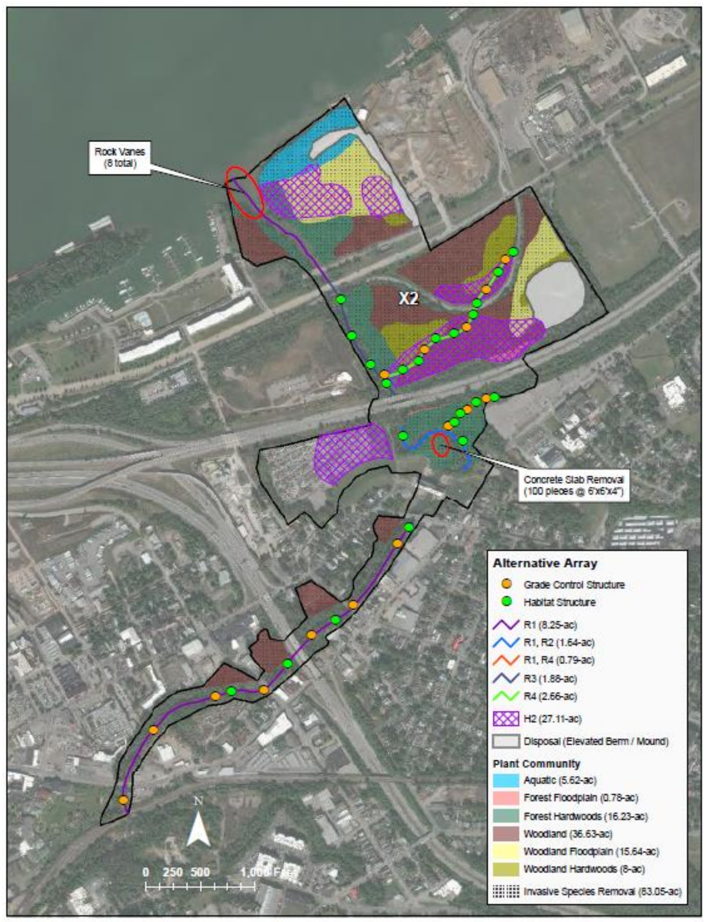

Figure 46 Example of Conceptual Alternatives Array at Site X2, the Confluence

Design assumptions were made to develop a conceptual design based on the proposed measures shown on the conceptual alternative maps for each site. The conceptual designs were developed to estimate quantities. Detailed design analyses, such as geotechnical and scour investigations were not performed. These detailed engineering designs, as well as additional modeling, data collection and analysis will be completed after the feasibility study. The quantities and associated costs represent a baseline that will be refined in future phases. Additional design information and drawings can be found in the appendices. The project delivery team made assumptions to develop the conceptual design and quantities, including:

- Cross sections for the proposed R work units were developed based on existing available digital elevation model information.

- R work unit cross sections were connected to form a proposed surface to develop earthwork quantities.
- H2 work units would have a net balance of earthwork. The H2 areas would be graded to better detain water.
- Existing vegetation in H2 and R work units would be cleared and grubbed to allow for grading operations.
- H2 work units will receive plantings after grading work is complete.
- Proposed H2 work units at existing MSD basins would not reduce available storage capacity. Existing MSD basins were designed for flood control, which will not be changed.
- Erosion control would be included throughout the project.
- Invasive species removal and would be included in conjunction with proposed planting work units.
- Impacts to existing levees would be avoided.
- New access roads and construction laydown areas will have gravel surfacing where heavy truck haul traffic is expected.

5.0 Alternatives Evaluation and Comparison

The site-scale alternatives were combined as described in Section 4.9. The following table lists the site-scale alternatives and number of combinations at each site.

Table 16 Number of alternative combinations at each site.

Site	Site Name	Site-Scale Alternatives	Number of Alternative Combinations
X2	Confluence	FWOP, R1, R2, R3, R4, H2, P	15
X4	Shelby Campus	FWOP, C, R1, R3, R4, H2, P	12
X5	Oxmoor Farm	FWOP, C, R3, H1, P	6
X8	Houston Acres Farm	FWOP, C, R2, R4, P	6
X9	Clark Park	FWOP, C, R2, P	4
X10	Alpaca Farm / Zoo	FWOP, C, R1, R2, R4, H2, H3, P	20
X11	Collegiate	FWOP, R1, R2, H2, P	9
X15	Buechel Park	FWOP, C, R3, R4, H3, P	9
X19	South Fork / Newburg Rd	FWOP, R1, R4, H2, H3, P	15
X20	Brown Park	FWOP, R1, R2, H2, H3, P	15
X21	Arthur Draut Park	FWOP, R1, R2, R3, R4, H2, H3, P	25
X22	Concrete Channel	FWOP, R1, R2, H2, P	9
X24	Oxmoor Country Club	FWOP, C, R3, H2, P	6
X28	Hurstbourne Country Club	FWOP, C, R2, P	4
X29	Eastern / Creason Connector	FWOP, C, R1, R2, R3, R4, P	10
X30	Joe Creason Park	FWOP, C, R1, R2, R4, H2, H3, P	20
X31	Champions Trace	FWOP, C, R1, H3, P	6
X33	MSD Basin	FWOP, R2, H2, H3, P	10
X34	Cherokee / Seneca Parks	FWOP, C, R1, R2, R3, R4, H2, P	15
X35	Muddy Fork and Tributaries	FWOP, C, R1, R2, H2, P	9
X38	Cave Hill Corridor	FWOP, R2, H2, H3, P	10

Monetary costs and ecological benefits were developed for each combination of site-scale actions. Sections 5.1 and 5.2 briefly document the methods for estimating costs and computing ecological benefits, and additional detail may be found in Appendix B and Appendix C.

The cost-effectiveness and incremental cost analysis (CEICA) was then applied to identify recommended restoration actions at the site-scale, which identified 14 sites for further consideration. Full justifications for site selection are provided in Appendix B. For these sites, alternatives were evaluated to ensure they meet the planning objectives and compared against the National Economic Development (NED), Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE) accounts. The CEICA on the watershed scale identified the final array of plans that were then evaluated and compared to ultimately select the Recommended Plan including 12 sites.

5.1 Costs

Cost estimates were developed based on the conceptual designs at each site. Appendix C describes the assumptions, unit costs, and price levels developed for the measures and alternatives.

Project first cost currently represents an estimate inclusive of real estate, restoration actions, pre-construction engineering and design, construction management, monitoring, and adaptive management. Monitoring and adaptive management are currently assumed to comprise 2% of total project first cost and spread over a five-year window. Interest during construction was computed based on project first costs minus the 2% for monitoring and adaptive management with an assumed construction duration of 12-months for all actions. The FY21 federal discount rate (2.50%) was used to annualize project first cost (presented in FY22 price levels), interest during construction, and monitoring and adaptive management expenses over a 50-year planning horizon (base year 2025). Table 17 provides an example of early cost estimates for Site-X10.

Table 17 Example cost summary for the Alpaca Farm / Zoo site (X10).

Site	Alternative	Project First Cost ($)	Average Annual Cost ($)
X10	FWOP	0	**0**
X10	C	1,022,000	**36,000**
X10	R1	291,000	**10,000**
X10	R2	3,472,000	**123,000**
X10	R4	7,470,000	**265,000**
X10	H2	768,000	**27,000**
X10	H3	688,000	**24,000**
X10	**P**	**9,187,000**	**325,000**

Utility relocations were estimated with assistance from the Hydrology and Hydraulics (H&H) PDT member by performing a visual survey to determine the likelihood and impact of utilities being encountered and ranking them as low, medium, or high. A percentage was then determined, based on the overall construction cost (including contingency), level of identified risk through the visual survey, and what information was known about the utilities (pipe size, depth, etc.). These costs were better refined as the possible alternatives and sites were further screened.

The other costs to be included were Preconstruction, Engineering, & Design and Construction Management. These costs were applied as percentages based upon past/similar projects and are 18% and 8% respectively.

5.2 Ecological Benefits

The overarching purpose of the USACE aquatic ecosystem restoration mission is "to restore significant structure, function and dynamic processes that have been degraded." (ER 1165-2-501). For many USACE studies, ecosystem structure and function are quantified using "habitat units" (HU). This metric combines the size of an ecosystem (typically acres) with the quality of the system (a multi-metric index from 0 to 1 where 0 is unsuitable and 1 is ideal). For Beargrass Creek, habitat units were calculated separately for riverine and riparian outcomes that align with the planning objectives. Sections 5.2.1-5.2.4 outline calculation of habitat units with additional detail in model reports (McKay et al. 2021ab).

5.2.1 Ecological Models

The riverine and riparian study objectives are assessed separately using two different ecological models, the Qualitative Habitat Evaluation Index for Louisville Streams (QHEILS, pronounced "quails," McKay et al. 2021a) and the Simple Model for Urban Riparian Function (SMURF, McKay et al. 2021b). These models are applied to separate study areas (i.e., nonoverlapping channel and riparian polygons), and thus are treated separately throughout the analysis. This section briefly describes each tool to provide readers with context on how ecological benefits are assessed. Further details can be found in the model documentation referenced, which are also included as Attachments D and E within Appendix B.

QHEILS is simple tool for assessing stream outcomes relative to macrohabitat, geomorphology, and longitudinal connectivity (USACE single use approval on March 1, 2021). The macrohabitat module is adopted from the Qualitative Habitat Evaluation Index (QHEI), which is a rapid stream assessment protocol originally developed for applications in Ohio (Rankin 2006). QHEI has been approved for use on multiple USACE ecosystem restoration studies and evaluates stream ecosystem integrity relative to six primary dimensions: substrate (20 points), instream cover (20 points), channel morphology (20 points), bank erosion and riparian zone (10 points), relative distribution of habitat types (20 points), and channel gradient (10 points). Each factor is assessed independently through a series of field observations, visual assessments, desktop analyses, and scoring procedures. The second module of QHEILS assesses geomorphic condition of urban streams relative to channel incision and the degree of floodplain connectivity. The third module of QHEILS quantifies connectivity of the system relative to aquatic organism passage (20 points) and material transport (20 points). Overall ecosystem quality is assessed as the average of the 0 to 1 index derived from each module. This habitat quality metric is combined with an assessment of channel area (in acres) to compute "habitat units."

Instream assessments such as QHEILS and QHEI often include riparian variables (such as the riparian zone metric above); however, these assessments are inherently focused on in-channel processes and outcomes. As such, we applied a separate rapid assessment technique to assess the integrity of riparian ecosystems. The SMURF (McKay et al. 2021) was designed for application in the Beargrass Creek study (USACE regional certification on March 22, 2021) and its watershed context. The SMURF addresses three major categories of outputs: (1) indirect effects of riparian zones on instream processes, (2) riparian areas as important providers of native faunal habitat, and (3) riparian zones as ecological corridors and sources of resilience in highly disturbed areas. The model uses data collected through a combination of rapid field assessment protocols and desktop geospatial assessments, which are applied independently to left and right bank riparian zones. SMURF outputs are calculated by assessing left and right banks independently and multiplied by the bank area to obtain habitat units. To get total habitat units for each site, the left and right bank habitat units were summed.

5.2.2 Existing Condition

QHEILS and SMURF were applied to each restoration site to assess the existing conditions at that location. A large-scale field campaign was executed in summer 2020 to assess locations in the Beargrass Creek watershed. Some assessment points were screened out of additional analyses, and some assessment points were combined into larger areas based on logical mobilization actions for restoration. When multiple sites were combined, the inputs to the QHEILS and SMURF were averaged across the number of locations. Table 18 summarizes the existing conditions associated with each restoration site in terms of "habitat units" (HU) for the channel, left bank riparian zone, and right bank riparian zone.

Table 18 Habitat units associated with the existing condition at each restoration site.

Site Number	QHEILS Channel (HU)	SMURF Left Bank (HU)	SMURF Right Bank (HU)	Total (HU)
X2	9.1	6.8	18.4	**34.4**
X4	0.9	10.2	17.5	**28.7**
X5	3.9	20.4	8.4	**32.7**
X8	2.6	30.5	33.0	**66.1**
X9	0.2	5.5	1.5	**7.1**
X10	1.2	1.7	8.7	**11.6**
X11	1.5	17.5	16.6	**35.6**
X15	0.6	0.6	0.5	**1.7**
X19	0.9	3.8	1.2	**5.9**
X20	0.8	1.7	0.7	**3.3**
X21	2.9	2.3	5.8	**11.0**
X22	1.6	1.5	1.0	**4.2**
X24	2.5	0.8	7.1	**10.4**
X28	1.2	0.7	0.1	**2.0**
X29	4.3	23.3	16.3	**43.9**
X30	1.4	35.3	1.0	**37.8**
X31	1.8	0.9	0.4	**3.1**
X33	0.4	2.6	0.5	**3.5**
X34	5.0	25.6	32.4	**62.9**
X35	1.9	17.6	23.1	**42.6**
X38	**2.2**	**1.1**	**4.1**	**7.4**

5.2.3 Future without Project

The future without project (FWOP) condition is a dynamic state, particularly in a world of rapid change associated with land use, invasive species, climate, and other factors. MSD's Stormwater Quality Management Plan lays out stormwater management activities to comply with the Stormwater Quality Program permit and is designed to improve stormwater quality through eight programs areas including public education, monitoring and discharge detection and elimination. While this program could potentially have a positive impact on water quality in the FWOP condition, it was decided by MSD and USACE that these impacts alone would not directly impact ecosystem habitat quality.

Three main factors were considered in forecasting how the FWOP could deviate from the existing condition. Notably, all three factors have considerable uncertainty, and rather than introducing additional uncertainty, the FWOP mirrored the existing condition, unless there were compelling reasons to deviate.

Land use change: Urban systems often undergo rapid land use development. This factor includes site-specific changes based on known development plans (e.g., Oxmoor Farms) and mirrors assumptions made by the engineering teams regarding long-term developmental trajectories in the basin.

Project completion: A variety of entities are currently undertaking water management actions that could influence restoration sites. However, projects are at varying stages of planning and significant uncertainty exists in implementation. Ongoing projects from the NFS (MSD) were included, but none of these actions include proposed restoration sites.

Climate change: Over the life of the project, temperature in the region is expected to increase, and precipitation is anticipated to increase in the winter/spring and decrease in the summer/fall. These changes were used to adjust variables in the riparian assessment based on a few qualitative factors. Detrital processes were assumed to accelerate under increased temperature. Organic matter retention, embeddedness, and bank erosion are all anticipated to be negatively impacted by increasingly flashy stream hydrology as a result of precipitation changes. Effects of climate on all other variables were deemed too uncertain to justify altered forecasts.

5.2.4 Alternative Forecasting

Restoration alternatives typically have differential effects on ecosystems through time. For instance, an alternative installing rock features within a stream may begin providing benefits relatively quickly compared to riparian forest restoration. For Beargrass Creek, five assessment points through time were deemed appropriate for adequately capturing the trajectories of these systems in response to restoration.

- Year-0: Captures the state of the ecosystem prior to any action. Assumed to be equivalent to the existing condition assessment.
- Year-2: Addresses the initial response of the stream following construction and the initial accrual of benefits. Only the QHEILS is assessed at this time period, given longer time scales for riparian response.
- Year-10: Assumes the initial riparian canopy response has occurred with growth to the mid-story size and addresses instream habitat and assumes partial to full functionality depending upon criterion. This time period also corresponds with the end of the USACE adaptive management horizon.
- Year-20: Captures the growth of the riparian zone to a young forest with maturing of forest structure and arrival of overstory. Only the SMURF is applied at this time period, given the assumed consistency in performance of in-channel features from years 10-50.
- Year-50: Assesses the state of the system at the end of the design life. This time period assumes riparian forests have matured with fully functioning dynamics (e.g., gap processes are included) and instream habitat has stabilized and meets full functionality of performance metrics.

Existing condition values served as the basis for all assessments of temporal trajectories and alternatives. The existing condition was modified through a set of agreed upon guidelines to be applied uniformly across sites (Appendix B, Tables B6 & B7). The scoring “rubric” differed for each model input (e.g., deadfall vs. buffer flowpaths), each type of action (e.g., R1 vs. P), and each point in time (e.g., Year-10 vs. Year-50). For each action, both riparian and riverine variables may be altered, but no variables are altered by both actions to avoid “double counting” of benefits.

The rubric specifies a percent improvement in the remaining ecological degradation at a site. The metric value for a given alternative and time is then computed based on the following equation and examples.

$$X_{alt} = X_{existing} + \Delta_{rubric}(X_{max} - X_{existing})$$

Where X_{alt} is the value of metric X for a given alternative and time, $X_{existing}$ is the existing condition value for the metric X, Δ_{rubric} is the percent improvement in the remaining ecological condition at a site, and X_{max} is the maximum value for the metric X.

Example 1: $X_{existing} = 13$, $\Delta_{rubric} = 0.5$, and $X_{max} = 20$

$$X_{alt} = 13 + 0.5(20 - 13) = 16.5$$

Example 2: $X_{existing} = 2$, $\Delta_{rubric} = 0.5$, and $X_{max} = 20$

$$X_{alt} = 2 + 0.5(20 - 2) = 11$$

Example 3: $X_{existing} = 18$, $\Delta_{rubric} = 0.5$, and $X_{max} = 20$

$$X_{alt} = 18 + 0.5(20 - 18) = 19$$

Example 4: $X_{existing} = 13$, $\Delta_{rubric} = 0.8$, and $X_{max} = 20$

$$X_{alt} = 13 + 0.8(20 - 13) = 18.6$$

Table 19 below shows an example of calculated habitat units for future with and without project for site X10.

Table 19 Example of habitat units for the Alpaca Farm / Zoo site (X10)

Site	Alternative	Year	QHEILS	SMURF Left	SMURF Right
X10	FWOP	0	1.2	1.7	8.7
X10	FWOP	2	1.2	NA	NA
X10	FWOP	10	1.2	1.7	8.7
X10	FWOP	20	NA	1.7	8.6
X10	FWOP	50	1.2	1.7	8.5
X10	C	0	1.2	1.7	8.7
X10	C	2	1.6	NA	NA
X10	C	10	1.6	1.7	8.7
X10	C	20	NA	1.7	8.6
X10	C	50	1.6	1.7	8.5
X10	R1	0	1.2	1.7	8.7
X10	R1	2	1.2	NA	NA
X10	R1	10	1.2	1.7	8.9
X10	R1	20	NA	1.8	9.1
X10	R1	50	1.2	1.8	9.2
X10	R2	0	1.2	1.7	8.7
X10	R2	2	2.2	NA	NA
X10	R2	10	2.3	2.0	9.9
X10	R2	20	NA	2.0	10.0
X10	R2	50	2.3	2.0	10.0
X10	R4	0	1.2	1.7	8.7

Site	Alternative	Year	QHEILS	SMURF Left	SMURF Right
X10	R4	2	2.5	NA	NA
X10	R4	10	2.5	2.1	10.2
X10	R4	20	NA	2.1	10.2
X10	R4	50	2.5	2.0	10.1
X10	H2	0	1.2	1.8	8.7
X10	H2	2	1.2	NA	NA
X10	H2	10	1.2	2.4	9.6
X10	H2	20	NA	2.5	9.7
X10	H2	50	1.2	2.6	10.0
X10	H3	0	1.2	1.7	8.7
X10	H3	2	1.2	NA	NA
X10	H3	10	1.2	1.7	9.6
X10	H3	20	NA	1.8	9.7
X10	H3	50	1.2	1.8	10.0
X10	P	0	1.2	2.4	9.3
X10	P	2	1.2	NA	NA
X10	P	10	1.2	30.0	21.6
X10	P	20	NA	30.7	22.0
X10	P	50	1.2	31.8	22.7

5.2.5 Benefit Annualization

Restoration benefits and costs are distributed across the planning horizon. For instance, the ecological benefits of a riparian planting scheme may not be realized until the trees reach a certain size or height threshold. Annualization provides a mechanism for consistent comparison of benefits and costs. Ecological outputs are assessed at multiple time periods as described above, and benefits are computed as the time-averaged quantity over the planning horizon. Benefits are annualized by computing the area under the benefits curve and dividing by the duration of the planning horizon. A linear trajectory is assumed between all time periods.

Benefits are annualized separately for the channel (QHEILS), left riparian zone (SMURF), and right riparian zone (SMURF). For this study the total habitat at a site is computed as the sum of these three habitat outputs, which used non-overlapping assessment areas. For each alternative, net benefits were computed over the FWOP condition to reflect the change in ecological condition associated with the restoration expenditure. This “lift” in benefits provides a consistent baseline for comparison. Table 20 provides an example of annualized benefits associated with Site-X10, which is derived from the temporally distributed data in Table 19 above.

Table 20 Example of average annual habitat units for the Alpaca Farm / Zoo site (X10).

Site	Action	QHEILS Channel	SMURF Left Bank	SMURF Right Bank	Total Benefits	Ecological Lift
X10	FWOP	1.2	1.7	8.6	11.5	0.0
X10	C	1.5	1.7	8.6	11.8	0.3
X10	R1	1.2	1.8	9.0	12.1	0.5
X10	R2	2.3	2.0	9.9	14.1	2.6
X10	R4	2.5	2.0	10.0	14.5	3.0
X10	H2	1.2	2.4	9.7	13.3	1.8
X10	H3	1.2	1.8	9.7	12.7	1.1
X10	P	1.2	28.1	20.9	50.2	38.7

5.3 Cost-Effectiveness and Incremental Cost Analysis

Cost-effectiveness and incremental costs analyses (CEICA) provide decision support tools for transparently informing restoration decisions. Cost-effectiveness analysis provides a mechanism for examining the efficiency of alternative actions. For any given level of investment, the agency wants to identify the plan with the most return-on-investment (i.e., the most environmental benefits for a given level of cost or the least cost for a given level of environmental benefit). An “efficiency frontier” identifies all plans that efficiently provide benefits *on a per cost basis*.

Incremental cost analysis is conducted on the set of cost-effective plans. This technique sequentially compares each cost-effective plan to all higher cost plans to reveal changes in unit cost as output levels increase and eliminates cost-effective plans that do not efficiently provide benefits on an incremental unit cost basis. Specifically, this analysis examines the slope of the cost-effectiveness frontier to isolate how the unit cost ($/unit) increases as the magnitude of environmental benefit increases. Incremental cost analysis is ultimately intended to inform decision-makers about the consequences of increasing unit cost when increasing benefits (i.e., each unit becomes more expensive). Plans emerging from incremental cost analysis efficiently accomplish the objective relative to unit costs and are typically referred to as “best buys.” Importantly, all “best buys” are cost-effective, but all cost-effective plans are not best buys.

CEICA was applied multiple ways for the multi-site Beargrass Creek restoration project. First, recommendations were made at the site-scale (e.g., Alt-A at Site-1). Second, all combinations of site-scale recommendations were combined to develop different portfolios of projects at the watershed-scale (e.g., Alt-A at Site-1 and Alt-C at Site-2). At both scales, restoration recommendations were made to “reasonably maximize environmental benefits,” per USACE policy (USACE 2000). In general, CEICA was interpreted through five guiding questions to identify a recommended alternative:

- Does this alternative meet the planning objectives? Specifically, actions would ideally incorporate both riverine and riparian benefits.
- Which alternative/plan provides a “good” investment relative to increasing incremental unit cost? Specifically, increases in marginal cost could discourage a recommendation.
- Which alternative/plan has the lowest overall unit cost (i.e., $/AAHU)? Overall unit cost is an important metric for agencywide budgeting decisions and “roll-up” of restoration outcomes.

This metric also strongly drives watershed scale site prioritization, so effort was made to avoid site-scale recommendations with high overall unit cost.
- Which alternative/plan is cost affordable relative to other sites and overall project limitations?
- What other qualitative decision factors are important? The Planning Guidance Notebook (USACE 2000) suggests that recommendations be made in light of non-linearities in the cost-benefit data, incremental cost associated with additional investment, and qualitative benefits not captured by ecological models. Additionally, alternatives (or sites) may provide disproportionate benefits relative to economic outcomes, other social effects, or other USACE or MSD mission areas.

This section provides an overview of how CEICA was applied to make restoration recommendations at the site-scale. Then, a watershed-scale analysis is presented to identify the Recommended Plan. Cost and ecological benefits provide the primary inputs to CEICA, and a summary of all inputs for the site level CEICA can be found in Appendix B. Throughout this section, project first costs are presented in FY22 levels and were annualized over a 50-year period of analysis (base year 2025) using the FY21 federal discount rate of 2.5%, which was current at the time of analysis.

5.3.1 Site-Scale CEICA

At each site, multiple alternatives were developed varying in their conceptual basis, costs, and benefits. CEICA was then applied to compare alternatives at each site to identify both cost-effective (CE) and best buy (BB) alternatives. For each site, the logic of decision-making was to visually examine CEICA results side-by-side, default to a decision array of best buy plans from incremental cost analysis, and then explore other cost-effective plans if appropriate.

For each site, the project development team met multiple times to discuss site-scale recommendations, including diverse perspectives from planning, engineering, environmental, real estate, cultural resources, project management, and the NFS. CEICA data were synthesized with other qualitative factors (e.g., model gaps, recreation potential, local interest, known real estate acquisition issues, local economic impact) to arrive at a preliminary recommended action. Each recommendation is accompanied by the supporting decision logic at the site. Notably, incremental cost values are calculated from unrounded habitat units and costs, which may lead to minor rounding errors relative to manual calculations. Detailed benefits, costs, and decision logic are presented in Appendix B for all sites, and an example for site-X2 is presented here to demonstrate the decision-making process writ-large.

Site X2 is a 171-acre river corridor near the confluence of Beargrass Creek with the Ohio River. This site has approximately 1.9-miles of river channel, and the area is surrounded by public spaces at Eva Bandman Park, the Waterfront Botanical Gardens, and Louisville Champions Park. The area near the confluence is a strategic focus of multiple organizations, and plans may complement left bank restoration actions by the Botanical Garden. The site is a key point for paddling access, and actions here have the potential for NED benefits associated with marina dredging and debris management. Six restoration actions were identified as potentially appropriate at this location, specifically:
- R1: Creates instream habitat through the addition of rock or woody debris structures, primarily focused on the main branch of Beargrass Creek.
- R2: Reduces channel incision by grading streambanks to bank heights at the bankfull depth based on regional curves and incorporating floodplain benches that provide connectivity

between the stream and floodplain. This alternative also includes the creation of instream habitat features (R1).

- R3: Initiation of natural geomorphic processes. This technique was not selected for the proposed optimized project sites primarily due to its small ecological risk in comparison with other cost-effective plans.
- R4: Reestablishes the channel through incorporating channel meanders off-line from the current alignment, incorporates floodplain connectivity, and includes instream habitat features such as rock or woody structures.
- H2: Modification or creation of large wetland features.
- P: Extensive planting of hardwood, floodplain, and woodland forests.

These 6 actions were combined based on a set of specified relationships regarding dependency between alternatives (Section 4.9), which resulted in 15 site-scale alternatives. Benefits and costs were computed additively for each alternative, and CEICA were applied to these data. The following figure and tables (Figure 47, Table 21, Table 22) summarize the incremental cost analysis for the 4 best buy alternatives as well as the results for all 15 alternatives, which also indicates whether or not the alternatives are cost-effective or best buys.

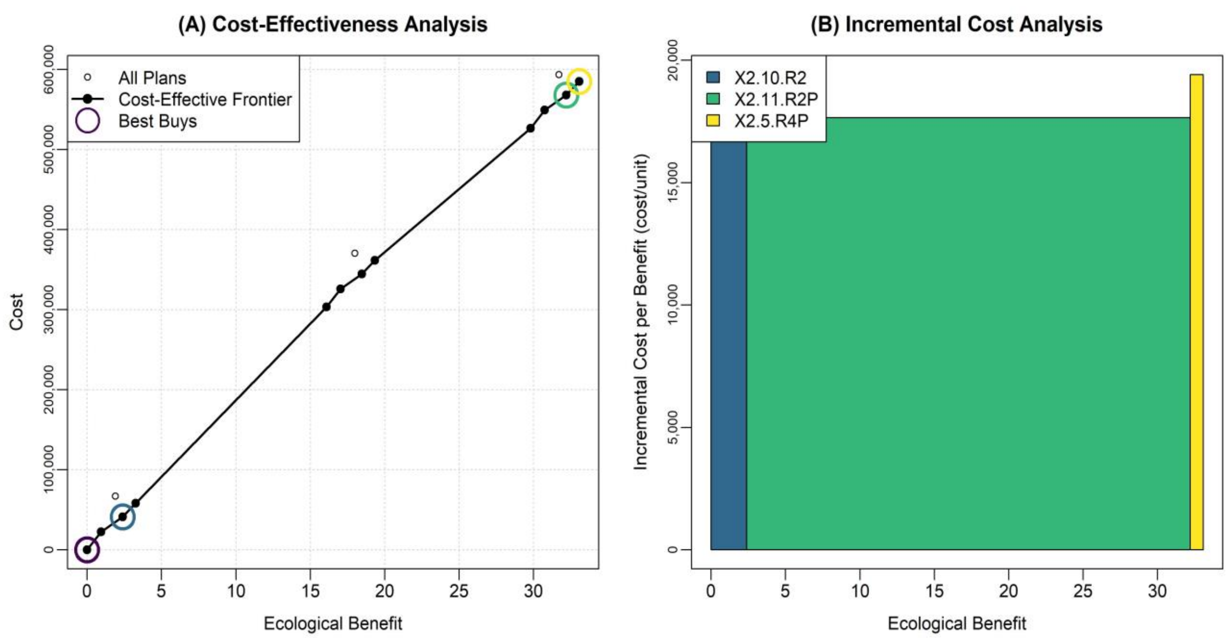

Figure 47 Example of CEICA summary for X2 (Confluence)

Table 21 Example of alternative summary table for X2 (Confluence)

Alt	Lift (AAHU)	Average Annual Cost ($)	Unit Cost ($/AAHU)	Project First Cost ($)	CE?	BB?
X2.1.	0	0	NaN	0	1	1
X2.2.P	29.8	526,500	17,700	14,865,000	1	0
X2.3.H2	16.1	303,300	18,900	8,564,000	1	0

X2.4.R4	3.3	58,400	17,900	1,648,000	1	0
X2.5.R4P	33.1	584,900	17,700	16,513,000	1	1
X2.6.R4H2	19.3	361,700	18,700	10,211,000	1	0
X2.7.R3	0.9	22,700	24,100	642,000	1	0
X2.8.R3P	30.8	549,300	17,900	15,507,000	1	0
X2.9.R3H2	17	326,100	19,100	9,206,000	1	0
X2.10.R2	2.4	41,400	17,400	1,170,000	1	1
X2.11.R2P	32.2	568,000	17,600	16,035,000	1	1
X2.12.R2H2	18.5	344,800	18,700	9,733,000	1	0
X2.13.R1	1.9	67,000	35,300	1,891,000	0	0
X2.14.R1P	31.7	593,500	18,700	16,756,000	0	0
X2.15.R1H2	18	370,300	20,600	10,455,000	0	0

Table 22 Example of incremental cost summary for X2 (Confluence)

Alt	Lift (AAHU)	Average Annual Cost ($)	Overall Unit Cost ($/AAHU)	Inc Unit Cost ($/AAHU)	Project First Cost ($)
X2.1.	0	0	NaN	0	0
X2.10.R2	2.4	41,400	17,400	17,400	1,170,000
X2.11.R2P	32.2	568,000	17,600	17,700	16,035,000
X2.5.R4P	33.1	584,900	17,700	19,400	16,513,000

Based on these data and team input, the recommended action at this site is X2.12.R2H2. The decision logic for this alternative is as follows:

- The planning objectives for the Beargrass Creek study emphasize the importance of both riverine and riparian outcomes. Thus, only the two largest best buys meet the planning objectives (i.e., X2.11.R2P and X2.5.R4P), both of which represent a large jump in total project cost over the next lowest cost best buy (X2.10.R2).
- Given that the best buy alternatives for this site were costly, the team reviewed the cost-effective plans to determine if a small alternative could be recommended that would still meet the planning objectives for a lower cost.
- Four cost-effective alternatives were identified with intermediate cost (i.e., X2.3.H2, X2.6.R4H2, X2.9.R3H2, and X2.12.R2H2). Three of these offer both riverine and riparian benefits and meet the planning objectives (i.e., X2.6.R4H2, X2.9.R3H2, and X2.12.R2H2).
- Of these three plans, X2.12.R2H2 is recommended due to qualitative benefits associated with floodplain reconnection, known geomorphic issues in the reach, and the potential for complementary actions by other entities at the Botanical Garden (i.e., near the footprint of X2.9.R3H2). The X2.12.R2H2 alternative is also conceptually consistent with both riparian and channel actions in overlapping areas, thus protecting both investments. The X2.12.R2H2 alternative also avoids potential real estate challenges, which are concentrated around the

areas proposed in the X2.6.R4H2 alternative, and is compatible with a recreational component due to the location of the plan within the site.

This overall flow of logic and incremental justification was applied at each of the 21 sites. The "no action" alternative is recommended at 7 of these sites. Table 23 below summarizes the alternative recommendations and justifications for recommendations for all 21 sites, showing screened or "no action" sites in red.

Table 23 Focused array site screening summary with red text indicating screened sites

Site	Site Name	Recommend Alt	Justification Highlights for Recommendation
X2	Confluence	R2H2	Cost-effective, Meets both objectives, Avoids real estate issues, Recreation potential
X4	Shelby Campus	CR4P	Best buy, Meets both objectives, Alleviates connectivity issue central to site
X5	Oxmoor Farm	No Action	Affordability concerns, Real estate costs greater than 25% of project first cost
X8	Houston Acres Farm	P	Lowest overall unit cost of all best buys, Good existing instream quality justifies P only
X9	Clark Park	No Action	Small site, Small investment better suited to localized partnership
X10	Alpaca Farm / Zoo	CR2P	Best buy, low overall cost unit, large footprint, potential for partnership
X11	Collegiate	No Action	Constrained site, concerns over efficacy of planting actions along freeway
X15	Buechel Park	No Action	Benefits deemed too small to warrant USACE action, isolated site
X19	South Fork / Newburg Rd	R1H2	Cost-effective, Low overall cost unit and affordable, MSD owned, Actions align with MSD management strategy
X20	Brown Park	R2P	Cost-effective, Prior restoration work requires repair, potential network to X21 site
X21	Arthur Draut Park	R2P	Lowest cost best buy that meets both objectives, potential network to X20
X22	Concrete Channel	H2	Cost-effective, Very high social benefits, potential intersection with other current studies
X24	Oxmoor Country Club	No Action	Disconnected site, real estate issues
X28	Hurstbourne Country Club	No Action	Disconnected site, real estate issues
X29	Eastern Creason Connector	CR4P	Best buy, meets both planning objectives, strong stakeholder interest, recreation potential
X30	Nature Preserve	CR4P	Lowest cost best buy that meets both objectives, Good connectivity to other major sites
X31	Champions Trace	No Action	Technical challenges, constrained site, potential conflicting project footprints
X33	MSD Basin	H2	Lowest cost best buy plan, Potential synergy with ongoing MSD activities at site
X34	Cherokee/Seneca Parks	CR2P	Lowest cost best buy that meets both objectives, Very large site, big ecological and social impact
X35	Muddy Fork and Tributaries	CR2H2	Lowest cost best buy that meets both objectives, potential for hydrologic actions to provide offsite benefits
X38	Cave Hill Corridor	R2H2	Lowest cost best buy that meets both objectives, important site connectivity

5.3.2 Final Array of Site-Scale Alternatives

Table 24 summarizes the costs and benefits of the 14 recommended site level alternatives. The recommended actions vary widely in costs ($1.0M-$20.3M project first) and benefits (2.4-83.2 AAHUs). This range of outcomes provides an opportunity to examine effective combinations of actions at the watershed-scale. This list includes the confluence site, one site on the Muddy Fork, seven on the South Fork, and five on the Middle Fork. A detailed description of sites and decision logic can be found in Appendix B and conceptual maps can be found in Appendix H.

Table 24 Final array summary table

Site	Recommend Alternative	Ecological Lift (AAHU)	Average Annual Cost ($)	Project First Cost ($)
X2 – Confluence	R2H2	18.5	344,800	9,733,000
X4 – Shelby Campus/AB Sawyer	CR4P	24.5	548,800	15,493,000
X8 – Houston Acres	P	23.8	670,200	18,920,000
X10 – Alpaca Farm	CR2P	41.6	484,600	13,682,000
X19 – Newburg Rd	R1H2	7.9	115,700	3,266,000
X20 – Brown Park	R2P	17.3	142,500	4,024,000
X21 – Draut Park	R2P	17.4	140,800	3,974,000
X22 – Concrete Channel	H2	4.3	83,600	2,361,000
X29 – Eastern Creason Connector	CR4P	34.7	741,300	20,927,000
X30 – Nature Preserve	CR4P	57.1	613,200	17,312,000
X33 – MSD Basin	XH2	2.4	35,700	1,009,000
X34 – Cherokee and Seneca Park	CR2P	83.2	717,700	20,262,000
X35 – Muddy Fork and Tributaries	CR2H2	10.4	279,300	7,885,000
X38 – Cave Hill	R2H2	21.3	331,700	9,364,000

NOTE Project first costs are presented in FY22 levels and were annualized over a 50-year period of analysis (base year 2025) using the FY21 federal discount rate of 2.5%. These are the costs calculated at the time of the CEICA.

Table 25 summarizes the improvements from of each of the final array alternatives by site. For sites that included a hydrologic action, native planting acres were the same as wetland acres due to the native plant seeding that is required for wetlands creation. For all sites, natural material would be reused on-site (e.g., earthen material from bank grading would be used to enhance or create wetland areas). This would minimize hauling costs, as well as disruptions to local traffic and adverse impacts to air quality, as the number of construction vehicles leaving and entering the site would be reduced. Any material encountered that cannot be reused on site, such as steel culvert pipes, concrete, etc., would be hauled to an existing approved landfill location. For the safety of the public, temporary fencing and signage would be installed to restrict access to the restoration sites during construction. Extra security measures may be utilized at sites in which public access is generally more prevalent, such as the sites within parks.

Table 25 Alternative Effects Summary

Alt#	Site	Recommend Alternative	Connectivity Barriers Removed (#)	Restored Stream (Linear Feet)	Restored Stream (Acres)	Wetlands (Acres)	Invasive Species Removal (Acres)	Native Plantings (Acres)
1	X2 – Confluence	R2H2	0	1,068	1.64	27.11	0	27.11
2	X4 – Shelby Campus/AB Sawyer	CR4P	2	4,304	1.53	0	43.5	43.5
3	X8 – Houston Acres	P	0	0	0	0	94.17	94.17
4	X10 – Alpaca Farm	CR2P	3	4,913	2.81	0	52.47	74.49
5	X19 – Newburg Rd	R1H2	0	4,489	3.07	11.87	0	11.87
6	X20 – Brown Park & X21 Draut Park	R2P	0	2,155	1.21	0	55.02	67.18
7	X22 – Concrete Channel	H2	0	0	0.00	10.96	0	10.96
8	X29 – Eastern Creason Connector	CR4P	3	4,549	2.77	0	86.4	97.17
9	X30 – Nature Preserve	CR4P	1	3,830	2.28	0	91.6	117.43
10	X33 – MSD Basin	XH2	0	0	0	4.23	0	4.23
11	X34 – Cherokee and Seneca Park	CR2P	5	12,951	8.69	0	202.98	248.66
12	X35 – Muddy Fork and Tributaries	CR2H2	7	8,717	2.38	16.3	0	16.3
13	X38 – Cave Hill	R2H2	0	3,335	2.07	15.06	0	15.06

Note These figures represent the alternatives at the time of the analysis and have since been updated due to plan optimization.

5.3.3 Watershed-Scale CEICA

USACE policy specifies that restoration plan selection should seek to "reasonably maximize environmental benefits" (USACE 2000). As described at the beginning of Section 5.3, CEICA results were interpreted through five main lenses: the degree to which a plan has met planning objectives, increasing marginal cost, overall unit cost, affordability, and qualitative decision factors not captured in cost and benefit estimates.

The Beargrass Creek feasibility study ultimately seeks to recommend a suite of restoration actions at the watershed scale to address both riverine and riparian ecological degradation. Portfolio planning presents a technical challenge to restoration teams faced with examining thousands, millions, or billions of potential combinations of actions. For instance, all combinations of restoration actions at the 14 remaining sites produces $2.95*10^{15}$ combinations of actions. Even a reduced analysis examining only best buy actions produces 89,579,520 combinations. These logistical and computational realities often lead to simplifying assumptions associated with portfolio analysis at a watershed-scale.

For this study, a "winners compete" approach to CEICA was used, which examines all combinations of site-scale recommendations. The benefit of this method is that it preserves the nuanced thinking about alternatives at the site-scale, which may be obscured at the watershed-scale. This technique also provides a numerically feasible set of plans. The drawback of this approach is that is does not comprehensively search the solution space. However, the qualitative factors involved in site-scale decision making were deemed more important than searching a larger number of watershed plans.

The recommendations at the 14 remaining sites were combined into 16,384 watershed plans. Ecological outcomes and monetary costs were computed for each plan as the sum of site-scale benefits. Plans range widely in investment cost and ecological benefit (i.e., $0-147.6M and 0-352 AAHUs). These plans were subjected to CEICA to identify efficient and effective portfolios of actions (Figure 48). This analysis identified 133 cost-effective plans and 15 best buy plans at the watershed-scale. Incremental unit cost increases from $0-34,300 / AAHU with increasing investment (Table 26).

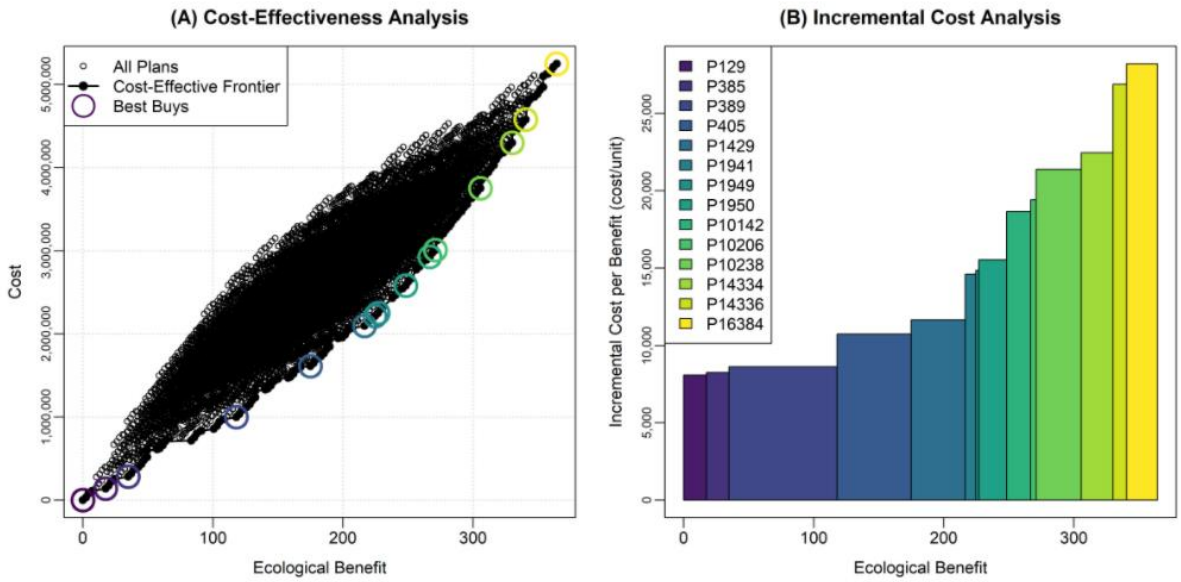

Figure 48 Cost-Effectiveness and Incremental Cost Analysis results for the watershed analysis

Below is a summary of all best buy plans that resulted from the watershed scale CEICA (Table 26).

Table 26 CEICA summary of best buys for the watershed scale analysis

Plan	Sites Included	Lift	Avg Ann Cost ($)	Project First Cost ($)	Unit Cost ($/AAHU)	Incremental Unit Cost ($/AAHU)
P1	No Action	0.0	0	0	NaN	0
P129	X21	17.4	140,800	3,974,000	8,100	8,100
P385	X20, X21	34.7	283,300	7,998,000	8,200	8,200
P389	X20, X21, X34	117.9	1,001,000	28,259,000	8,500	8,600
P405	X20, X21, X30, X34	175.0	1,614,100	45,571,000	9,200	10,700
P1429	X10, X20, X21, X30, X34	216.6	2,098,700	59,253,000	9,700	11,700
P1941	X10, X19, X20, X21, X30, X34	224.5	2,214,400	62,519,000	9,900	14,600
P1949	X10, X19, X20, X21, X30, X33, X34	226.9	2,250,200	63,528,000	9,900	14,900
P1950	X10, X19, X20, X21, X30, X33, X34, X38	248.3	2,581,900	72,892,000	10,400	15,500
P10142	X2, X10, X19, X20, X21, X30, X33, X34, X38	266.7	2,926,600	82,626,000	11,000	18,700
P10206	X2, X10, X19, X20, X21, X22, X30, X33, X34, X38	271.0	3,010,200	84,986,000	11,100	19,400

P10238	X2, X10, X19, X20, X21, X22, X29, X30, X33, X34, X38	305.7	3,751,500	105,914,000	12,300	21,400
P14334	X2, X4, X10, X19, X20, X21, X22, X29, X30, X33, X34, X38	330.2	4,300,200	121,407,000	13,000	22,400
P14336	X2, X4, X10, X19, X20, X21, X22, X29, X30, X33, X34, X35, X38	340.5	4,579,500	129,291,000	13,400	26,900
P16384	X2, X4, X8, X10, X19, X20, X21, X22, X29, X30, X33, X34, X35, X38	364.3	5,249,700	148,212,000	14,400	28,200

Note These figures represent the alternatives at the time of the analysis and have since been updated due to plan optimization.

For Beargrass Creek, six "best buy" watershed-scale plans were identified as an initial decision array. The initial decision array was narrowed to this range of six watershed plans bracketed by Plan 10142 and Plan 14336. Plan 10142 was the lowest cost best buy plan to include site X22 (Concrete Channel) which was considered one of the most socially valuable and visible sites in the final array. Plan 14336 was the highest cost best buy considered due to the inclusion of X8 (Houston Acres) in the next best buy plan that caused a large jump in total project cost while only meeting one of the planning objectives. This site also was not considered socially valuable due to its location and lack of accessibility. A full list of cost-effective plans analyzed can be found in Appendix B.

Below is a summary of the analysis of the six best buy plans included in the decision array.

- *Plan 110142 (X2 + X10 + X19 + X20 + X21 + X30 + X33 + X34 + X38)*: This plan includes actions at nine restoration sites in the Middle and South Fork. The plan has low overall unit cost ($11,000/AAHU). This plan is the first that incorporates actions at X2 at the confluence of the forks, which is an extremely high visibility location with important ecologically connectivity to South, Middle, and Muddy Fork. This plan is the smallest plan that is ecologically acceptable.

- *Plan 10206 (X2 + X10 + X19 + X20 + X21 + X22 + X30 + X33 + X34 + X38)*: This plan incorporates small-scale actions along X22, which is a centrally located concrete channel near downtown Louisville. Ecological models are likely to be undervaluing the benefit of restoration actions in this extremely degraded system. The site is of high social importance, and the site has been a focal point for river revitalization plans associated with the Congress on New Urbanism. The overall unit cost remains very low ($11,100/AAHU), and the incremental unit cost is very similar to the prior plan ($19,400/AAHU). This plan provides 74% of the potential ecological benefits in the watershed at 57% of the investment cost, indicating an efficient investment.

- *Plan 10238 (X2 + X10 + X19 + X20 + X21 + X22 + X29 + X30 + X33 + X34 + X38)*: This plan adds X29 to the recommendation. Ecological benefits increase significantly from this action (34 AAHUs). The increase in overall and incremental unit cost is deemed "worth the investment" at this location, particularly considering significant ecological benefits. X29 is near X30, so the inclusion of this site is likely to have synergistic ecological effects not accounted for in analyses. This site also has known stakeholder interest, willing landowners, and the potential for complementary actions by other entities. The plan also crosses thresholds in ecological benefits and project first cost (i.e., it is less the first plan greater than 300 AAHUs and $100 million.

- *Plan 14334 (X2 + X4 + X10 + X19 + X20 + X21 + X22 + X29 + X30 + X33 + X34 + X38)*: This plan adds restoration actions at site X4, which increases the total ecological benefit above 300 AAHUs. This site is at an educational institution and likely provides opportunities relative to education and site maintenance. The site occurs in a portion of the watershed not reached by other sites, and thus, this site reaches a different segment of the community.

- *Plan 14336 (X2 + X4 + X10 + X19 + X20 + X21 + X22 + X29 + X30 + X33 + X34 + X35 + X38)*: This plan incorporates actions at X35, which represents the only site on the Muddy Fork. This plan occurs at a threshold in incremental unit cost (i.e., Plan 14334 was $22,400/AAHU). This plan is the largest plan that is worth the investment cost.

- *Plan 16384 (X2 + X4 + X8 + X10 + X19 + X20 + X21 + X22 + X29 + X30 + X33 + X34 + X35 + X38)*: This plan includes all sites with recommended actions by incorporating X8. Only minor riverine actions were considered at this site because of the quality of existing instream conditions and the constraint of an onsite dam. This action is not deemed “worth the investment” considering these constraints relative to increased incremental unit cost.

Again, the addition of X22 to the watershed level plan (Plan 10206) was identified as an important USACE-MSD contribution to a high visibility restoration priority for the region. Adding X29 (Plan 10238) provides significant ecological benefits both in quantitative and qualitative terms via 34 AAHUs and connectivity to Site-X30, respectively. Plan 10238’s set of 11 sites represent a large amount of ecological lift (305 AAHUs) that are incrementally justified, but these sites do not include actions on all three branches of Beargrass Creek (i.e., Muddy Fork is absent). X4 is somewhat distantly located on the Middle Fork and does not represent a known priority for local partners. X35 incorporates actions on the Muddy Fork and provides hydrologic benefits anticipated to benefit other sections of the stream. Furthermore, X35 is the only site on the Muddy Fork, and the overall planning goal of restoring the Three Forks of Beargrass Creek would not be accomplished without this site.

Given this context, a cost-effective plan was identified that includes all actions in Plan 10238 along with site-X35. Plan 10240 addresses major sources of ecological degradation throughout the watershed and efficiently obtains ecological benefits at a low unit cost ($12,800/AAHU). The incremental unit cost from P10238 to P14334 (the next best buy) would have been $22,400, and the incremental unit cost from P10238 to P10240 (the Recommended Plan) is $26,900. The added value of ensuring restoration on each of the three forks of Beargrass Creek and therefore more fully addressing the problems and opportunities within the watershed, is deemed worth this increase in incremental unit cost.

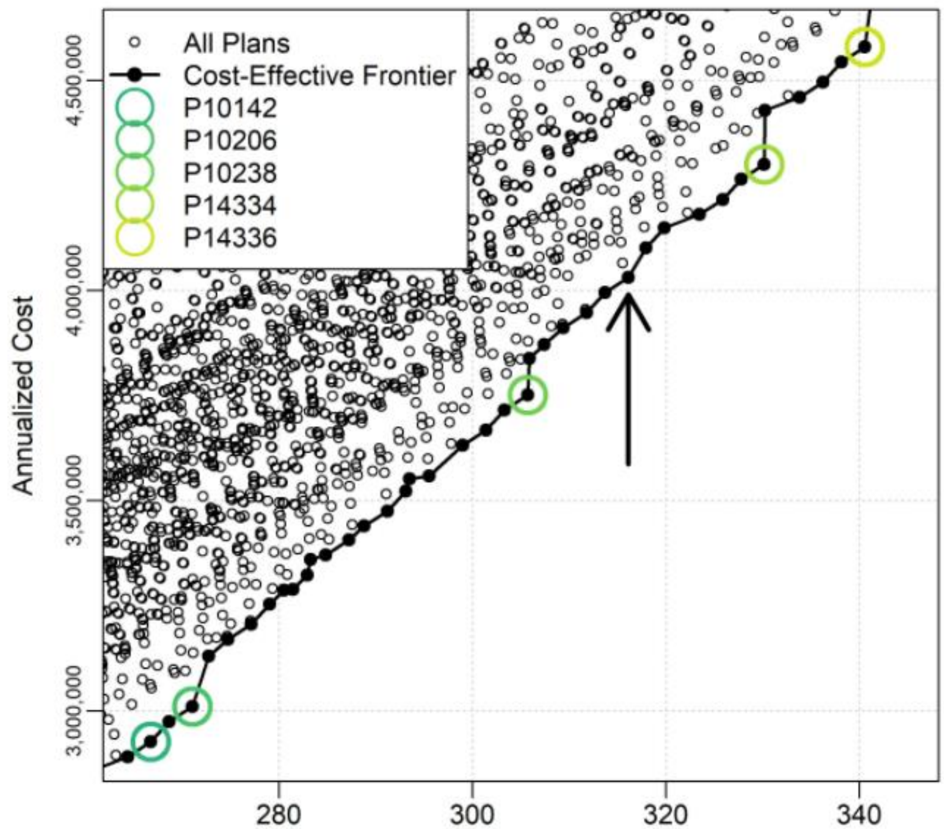

Figure 49 Cost-Effective Recommended Plan

Based on the watershed-scale CEICA, the Recommended Plan is P10240. This watershed-scale plan includes 12 restoration sites at the confluence of the forks (X2), Alpaca Farm and Louisville Zoo (X10), Newburg Road (X19), Brown Park (X20), Arthur Draut Park (X21), a concrete channel near downtown Louisville (X22), the Eastern-Creason Connector (X29), Joe Creason Park (X30), a small MSD Basin (X33), Cherokee and Seneca Parks (X34), a neighborhood along the Muddy Fork (X35), and the Cave Hill Corridor (X38).

5.4 Comparison by National Objectives and the Four Accounts

In the 1970 Flood Control Act, Congress identified four equal national accounts for use in water resources development planning. They are national economic development (NED); regional economic development (RED); environmental quality (EQ); and social well-being (OSE, other social effects). Policy in the 1970s regarded making contributions to only two of these, NED and EQ, as national objectives. Now, as stated in the Comprehensive Documentation of Benefits in Decision Documents, dated 5 Jan. 2021, all four accounts must be equally considered in plan formulation. This policy updated previous procedures and emphasized and expanded upon policies and guidance to ensure the USACE decision framework considers, in a comprehensive manner, the total benefits of project alternatives, including equal consideration of economic, environmental, and social categories.

The federal objective of water and related land resources planning is to contribute to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other federal planning requirements.

The four categories, known as the System of Accounts as suggested by the U.S. Water Resources Council, address long-term impacts and are defined in such a manner that each proposed plan can be easily compared to the No Action plan and other alternatives. Collectively, the four accounts are required to include all significant effects of a plan on the human environment.

The PDT screened plans utilizing the habitat lift and cost but also incorporated Other Social Effects (OSE), as well as rationale based on qualitative discussion on Regional Economic Development (RED) and technical aspects of the overall Environmental Quality (EQ) impacts and National Economic Development (NED) considerations. The resulting "social unit" (discussed later in this section) was a semi-quantitative measure of comprehensive impact which focused on OSE. However, it provided a secondary decision criterion for the RED, EQ, and NED accounts and was used to verify the selection of the Recommended Plan.

OSE was measured within the metrics of local social impacts to the community. The scoring also included aspects related to the RED account such as the potential support to employment in the local area. Alternatives were also evaluated to confirm that they did not induce local flooding, as well as identify their potential to reduce flood impacts to adjacent structures (NED). EQ was considered within the technical category that scored alternatives based on the impacts to habitat scarcity and connectivity. The metrics utilized in the OSE table are can be found in Table 27 below. The table includes aspects from the other accounts that were used as a second and supporting decision criterion beyond the NED, RED, and EQ analysis.

Table 27 OSE metrics included criteria from all four accounts as a secondary decision criterion beyond the NED, RED and EQ analysis.

Category	Sub-Category	Optimal 20 19 18 17 16	Suboptimal 15 14 13 12 11	Marginal 10 9 8 7 6	Poor 5 4 3 2 1
Logistical	Real Estate	All parcels owned by NFS	All parcels owned by NFS and public entity	Most parcels owned by public entity	Most parcels owned by private entity
	Access (constuctability)	Nearby public roadways and lands available to utilize for construction, no issues with topography	Topography is conducive to access but private properties surrounding	Topography is not ideal but access can be found in other ways, such as creating access roads that circumavigate steep terrain	Topography not conducive to good access, private property and obstructions
	HTRW issues	No known historical uses that may have contributed to contamination, very little uncertainty	No known historical uses that may have contributed to contamination, high levels of uncertainty	Known historical uses but resources for mitigation are present	Known historical uses that would have contributed to contamination
Economic	Employment	Ten or more businesses directly adjacent to stream	5-9 businesses directly adjacent to stream	1-4 businesses directly adjacent to stream	0 businesses directly adjacent to stream
	Potential	Located in accessible area with good visibility, nearby neighborhoods and businesses, restoration action will provide good potential for outdoor and paddlesport activities	Restoration action will provide good potential for outdoor and paddlesport activities but not accessible or visible	Accessible and visible but not a lot of opportuntiy for outdoor or paddlesport	Restoration action will not provide an opoortunity for paddlesport or outdoor activities, poor visibility and access
	Impact to local flooding	Vast improvement in flooding conditions based on H&H modeling	Slight improvement in flooding conditions based on H&H modeling	Flooding conditions stay the same based on H&H modeling	Flooding induction present based on H&H modeling
Social	Visibility	Good connecivity and accessibility to surrounding neighborhoods, included in other current plans with opportunity for aesthetic improvements	Some connections to surrounding neighborhoods but potential to improve, possibly included in current plans, aesethic improvement possible	Little accessibility to surrounding neighborhoods, little potential for improvement, not included in plans, aesthetic improvement unlikely	No accessibility from surrounding neighborhoods, little or no connection ro current plans, no aesthetic opportunity
	Environmental Justice	Located near low income or minority populations with little to no green infrastructure within 5 min walk	Located near low income or minority populations, very little green infrastrucutre within 5 min walk	No low income or minority populations present, some green infrastructure within 5 min walk	No low income or minority populations present, good network green infrastructure already within 5 min walk
	Recreation & Education	Predicted water quality improvements and points of access, adjacent to schools, churches, etc	Predicted some water qualilty improvements, some opportunity for points of access, schools, churches, etc nearby but not adjacent	Predicted minimal water qualilty improvements, very little opportunity for points of acces, schools, churches, etc nearby but not adjacent	No water quality improvements or potential to provide access points
	Community Support	Site specifically targeted at stakeholder and public meetings, broad interest across city	Some interest at public/ stakeholder meetings, surrounding neighborhood thinks project is important	Little interest a stakeholder/public meetings, some interest at neighborhood level	No interest at public/stakeholder meetings, no interest from local neighborhood
Technical	Scarcity	Habitat is extremely scarce, and restoration substantially reduces local scarcity (e.g., >50% over current reach condition).	Habitat is extremely scarce, and restoration reduces local scarcity (e.g., 25-50% over current reach condition).	Habitat is somewhat scarce, and project reduces local scarcity (e.g., 0-25% over current condition).	Habitat is common and/or project does not measurably reduce local scarcity.
	Connectivity	Makes critical direct physical connection between existing habitat areas or establishes a network of interconnected habitat.	Creates a nodal connection between existing habitat areas.	Restores suitability of existing connection. Expands area within corridor or home range.	Provides minor expansion to existing habitat.

5.4.1 National Economic Development (NED) Benefits

The plan is justified by the NED account as quantified by the CEICA results. Two separate CEICA screenings were conducted during plan selection: the site scale screening and the final watershed scale screening to reach the Recommended Plan. The CEICA results allowed the team to recommend the plan that maximizes habitat lift, as well as being cost-effective.

Additionally, as evident from the results of the H&H analysis, not only do the proposed alternatives not represent a significant flood risk, but they will also most likely result in reduced flood risk. A flood inundation analysis was performed, and it was found that nearly 50 structures will be saved from damages in a 500-year flood scenario with project. This analysis is discussed in more detail in Section 7.5. These flood risk management benefits are also discussed in the H & H Appendix (D) and show that the proposed plan will provide both environmental and flood risk management benefits along with regional economic development and other social benefits.

The proposed plan also includes recreation features at seven of the project sites, which will improve access to and quality of recreation in the watershed. At some sites, features like birding platforms and trails will create recreation opportunities where there currently is little to no access for the surrounding communities. The proposed features and their benefits are discussed in detail in Section 7.3.

The OSE table also scored each alternative in the final array with an economic score that semi-quantitatively assessed the benefits from flood reduction, alongside benefits to the regional economy. These scores were based on H&H modeling and reflect that, while none of the sites had a negative impact to flooding, others did result in flood reductions.

5.4.2 Environmental Quality (EQ) Benefits

The Planning Manual describes environmental quality as "favorable changes in the ecological, aesthetic, and cultural attributes of natural and cultural resources." Adverse effects within these categories can also be included in this assessment. Appendix F contains the comparison of environmental quality between No Action and the final array of alternatives. Resource and use types that were assessed in this document (Chapter 5) include the following:

- Geology, Soils, Seismic Hazards, or Mineral Resources
- Air Quality
- Land Use
- Water Resources
- Biological Resources
- Cultural Resources
- Traffic and Circulation
- Noise
- Recreation and Public Access
- Aesthetics
- Public Health and Safety, including HTRW
- Utilities and Public Services
- Socioeconomics and Environmental Justice

Any recommendation for federal investments in water resources to address identified water resources needs must be justified by the public benefits when compared to costs. Choosing the Recommended Plan/NER plan was iterative and evolved over the course of field reviews, quantitative and qualitative analysis and risk and uncertainty in plan comparison. Cost is also a factor along with the lift in habitat units from FWOP to FWP.

In all cases, ecological restoration will improve the biological diversity on degraded landscapes, increase the population and distribution of rare and threatened species, enhance landscape connectivity, increase the availability of environmental goods and services, and contribute to the improvement of human well-being. These are additional, non-market-economic benefits derived from habitat improvements.

Within the OSE table, the technical significance contains criteria related to improvements of EQ. USACE defines the significance of an ecosystem relative to institutional, public, and technical dimensions. Technical significance is a factor in determining the competitiveness of a USACE project in performance budgeting, and two criteria were adapted as a qualitative metric of site significance (EC-11-2-206, USACE 2014). These criteria measured the habitat scarcity and connectivity of the alternatives.

5.4.3 Regional Economic Development (RED) Benefits

RED examines economic impacts – principally, changes to income and employment – across a regional economic area, rather than impacts to the nation as a whole (NED). The study area for RED is the Louisville metropolitan area, which is home to 617,790 people (U.S. Census 2019). Louisville is the largest city in the state of Kentucky and is the 29th largest city in the United States. An influx of federal construction dollars is expected to support jobs and income in the region, and an improved watershed would bolster existing businesses and encourage further development in the area.

Since the Beargrass Creek watershed is in a densely populated urban area, there are many opportunities for economic growth associated with the plan. The Louisville Loop is a multi-use path that will eventually circumnavigate the city of Louisville with 100 miles of trail, connecting neighborhoods, businesses, and greenspace throughout the city. The confluence site of the Beargrass Creek plan is directly connected to the existing waterfront portion of the trail, which is approximately 12 miles long and passes through Waterfront Park. This 85-acre park was once an industrial wasteland that has been developed into 85-acres of greenspace hosting about 2.2 million visitors a year. The park hosts events such as the Forecastle Festival, an annual Fourth of July event, and events surrounding the Kentucky Derby. Waterfront Park also contains the Big Four Pedestrian Bridge, a one-mile pedestrian and biking bridge across the Ohio connecting the city of Louisville with Jeffersonville, IN. About 1.5 million people cross the bridge annually, making it a major tourist attraction (Waterfront Park website).

Additionally, the Big Four connects with the Indiana Greenway that travels from Jeffersonville to New Albany, providing another five miles of trail that leads through the Falls of the Ohio State Park and the future Origin Park, a planned 500-acre park with event space, biking and walking trails, paddling trails, meadows and wetlands, and views of the Louisville skyline.

The plan will improve the integrity and identity of the Beargrass Creek watershed and will give many people the opportunity to enjoy quality greenspace within an urban area. The improvements to the creek and the connections to existing greenspace provide ample opportunity for recreation and education about the history of Louisville and its relationship with Beargrass Creek.

RED analysis of the Recommended Plan was completed using a USACE-certified regional economic impact modeling tool called RECONS (Regional ECONomic System) that provides estimates of regional and national employment and other economic measures. This analysis was limited to the impacts of project implementation and is discussed in detail in Section 7.4.

The OSE table also scored the alternatives on their proximity to existing business and their potential to attract additional business. Sites were scored higher if they were already in a location with businesses adjacent and lower scores were given to sites with few or no businesses adjacent. Additionally, sites were given a score on business “potential” that was based on accessibility and the alternative’s potential for attracting outdoor or water sports.

5.4.4 Other Social Effects (OSE) Benefits

Other social effects were qualitatively utilized for decision-making throughout the plan selection process. Discussions during plan selection at the site and watershed scales included social benefits such as community support and visibility, inclusion in or proximity to current plans or developments, and proximity and accessibility to minority or low-income neighborhoods. The full qualitative justifications from alternative selection at the site and watershed scale are summarized in 5.6.1 and discussed more thoroughly in Appendix B.

Within the OSE table the social outcomes category assessed benefits of sites relative to community-oriented outcomes like visibility, equity, recreation and education, and stakeholder support. This assessment used information gathered from the community at the initial public and stakeholder meetings, input from MSD, both formal and informal mapping analysis and general local knowledge to place a value on a site's benefit to the community across the four subcategories:

- Visibility: Connectivity and accessibility to surrounding neighborhoods and inclusion in local planning efforts
- Environmental Justice: Spatial relationship to low or minority populations
- Recreation and Education: Predicted water quality improvements and spatial relationship to schools, churches, etc.
- Community Support: Interest level across the city gaged from public and stakeholder meetings

5.4.5 Social Units

Table 28 below shows the normalized OSE scores for the sites included in the final array. Within USACE studies, OSE is typically measured solely qualitatively. While the PDT made the plan selection utilizing this strategy, the OSEs were also assessed using semi-quantitative metrics relative to four categories of outcomes related to logistics, economics, social factors, and technical issues used in agency budgeting. This semi-quantitative analysis was used to verify and support the selection of the Recommended Plan by assigning a clear, holistic value on each site alternative.

The logic of each factor is summarized in Table 27 above. Each category was assessed using a consistent constructed scale of 0 to 20, where 0 is undesirable and 20 is desirable. While a more empirical approach would be preferred (e.g., a stakeholder survey indicating community support), these simple scoring metrics have been used effectively to distinguish outcomes in other USACE projects (McKay et al., 2021). Each metric was scored for the recommended alternative at the 14 remaining sites (data in Appendix H). The raw data were summed for each category and normalized from 0 to 1 for consistent comparison across categories (Table 28).

Table 28 Overall other social effects outcomes summed across categories and normalized from 0 to 1. * These scores represent the sites at the time of the analysis and have been updated for the final report to reflect optimization.

	Rest Name	Fork	Recommended Alternative	Total Site Area (ac)	Logistic (Norm)	Economic (Norm)	Social (Norm)	Technical (Norm)	Total	Units
X2	Confluence	South	CR2H2	170.6	0.583	0.667	0.775	0.850	0.719	122.7
X4	Shelby Campus	Middle	CR4P	81.7	0.833	0.500	0.462	0.750	0.636	52.0
X8	Houston Acres Farm	South	P	130.4	0.667	0.317	0.525	0.325	0.458	59.7
X10	Alpaca Farm	South	CR2P	79.3	0.717	0.700	0.662	0.750	0.707	56.1
X19	South Fork / Newburg Rd	South	CR1H2	44.5	0.683	0.550	0.600	0.475	0.577	25.7
X20	Brown Park	Middle	CR2P	30.4	0.650	0.533	0.612	0.600	0.599	18.2
X21	Arthur Draut Park	Middle	CR2P	40.0	0.550	0.700	0.562	0.600	0.603	24.1
X22	Concrete Channel	South	H2	47.1	0.617	0.900	0.950	0.525	0.748	35.2
X29	Eastern / Creason Connector	South	CR4P	97.8	0.517	0.667	0.738	0.775	0.674	65.9
X30	Joe Creason Park	South	CR4P	121.3	0.900	0.733	0.712	0.775	0.780	94.6
X33	MSD Basin	South	H2	11.8	0.933	0.417	0.488	0.550	0.597	7.0
X34	Cherokee / Seneca Parks	Middle	CR2P	267.1	0.767	0.833	0.662	0.750	0.753	201.1
X35	Muddy Fork and Tributaries	Muddy	CR2H2	127.9	0.550	0.383	0.538	0.575	0.512	65.5
X38	Cave Hill Corridor	Middle	R2P	52.1	0.617	0.700	0.712	0.625	0.664	34.6

While simple, these OSE metrics clearly distinguish sites across each category. Logistical factors are generally challenging at sites with many landowners (e.g., X21, X29, X35). Economic development and social outcomes are generally highest at high profile sites in major parks and downtown (e.g., X22, X30, X34). Technical significance was highest at sites with large footprints and large-scale restoration actions. Overall, these analyses indicate that some sites are consistently important relative to social outcomes (e.g., X2, X10, X22, X30, and X34), whereas others consistently provide lower social benefits (e.g., X8, X19, X20, X21, X33).

As stated above, OSE metrics are typically used within USACE as qualitative decision factors. A recent coastal erosion study in Barrow, Alaska, however, used CEICA to assess non-monetary social effects related to community resilience. CEICA is applied in this study to examine the OSE metrics described above relative to investment cost. Drawing from the example of ecological habitat analyses, a quantity-quality metric of social outcomes was computed as a secondary decision criterion. The “quality” of a site relative to social issues was assessed as the overarching metric. The total site area was used as a proxy for the “quantity” of social outcomes. All things being equal, this assumes that a site with a larger area is socially more beneficial than a smaller site. The overall metric is referred to here as a “social unit” (SU). While imperfect, this crude indicator may provide a general assessment of the relative social benefits at a given restoration site. Average annual cost and social units were input to CEICA, and model outcomes are shown below for system-scale combinations of actions. This analysis provides a few important observations about social outcomes in Beargrass Creek study area.

- The priority order of sites relative to CEICA of social outcomes is (Table 29): X22, X2, X34, X35, X19, X33, X21, X30, X20, X10, X38, X4, X8, and X29.
- The incremental unit cost of social outcomes increases rapidly beyond Plan 8927, which includes X2, X19, X21, X22, X30, X33, X34, and X35. Collectively, these sites provide 67% of social benefits at 46% of the project first cost. The efficiency of these actions could indicate that these are the most effective restoration investments from a social standpoint.
- The results generally align with the ecologically focused analyses presented above with a few exceptions. High social benefits are consistent at sites X2, X22, X30, and X34, and low social benefits are consistent at sites X8 and X20. Mixed results at sites X10, X19, X33, and X35 could be an effect of low project costs or large total project areas rather than social processes.

Table 29 below shows the array of Best Buy plans but also includes the NER Plan (in bold). This plan provides social benefits throughout the watershed and efficiently obtains social benefits at a low unit cost ($5,400/SU). While the incremental unit cost is somewhat higher than the Best Buy plans ($13,900 /SU), the team concurred that this was justified by the ecological benefit and ecological cost efficiency provided in the initial and primary analysis.

Table 29 Combined Social Unit summary of Best Buy and NER (in bold) watershed scale plans

Plan	Sites Included	Soc Ben	Avg Ann Cost ($)	Project First Cost ($)	Unit Cost ($/SU)	Incremental Unit Cost ($/SU)
P1	No Action	0.0	$0	$0	NaN	$0
P65	X22	35.2	$83,600	$2,361,000	$2,400	$2,400
P8257	X2, X22	157.9	$428,400	$12,094,000	$2,700	$2,800
P8261	X2, X22, X34	359.0	$1,146,000	$32,356,000	$3,200	$3,600
P8263	X2, X22, X34, X35	424.5	$1,425,300	$40,240,000	$3,400	$4,300
P8775	X2, X19, X22, X34, X35	450.2	$1,541,000	$43,506,000	$3,400	$4,500
P8783	X2, X19, X22, X33, X34, X35	457.2	$1,576,700	$44,515,000	$3,400	$5,100
P8911	X2, X19, X21, X22, X33, X34, X35	481.3	$1,717,500	$48,489,000	$3,600	$5,800
P8927	X2, X19, X21, X22, X30, X33, X34, X35	575.9	$2,330,700	$65,801,000	$4,000	$6,500
P9183	X2, X19, X20, X21, X22, X30, X33, X34, X35	594.1	$2,473,200	$69,825,000	$4,200	$7,800
P10207	X2, X10, X19, X20, X21, X22, X30, X33, X34, X35	650.2	$2,957,800	$83,507,000	$4,500	$8,600
P10208	X2, X10, X19, X20, X21, X22, X30, X33, X34, X35, X38	684.8	$3,289,500	$92,871,000	$4,800	$9,600
P14304	X2, X4, X10, X19, X20, X21, X22, X30, X33, X34, X35, X38	736.8	$3,838,300	$108,364,000	$5,200	$10,600
P10204	**X2, X10, X19, X20, X21, X22, X29, X30, X33, X34, X35, X38**	**750.7**	**$4,030,900**	**$113,799,000**	**$5,400**	**$13,900**
P16352	X2, X4, X8, X10, X19, X20, X21, X22, X30, X33, X34, X35, X38	796.5	$4,508,400	$127,284,000	$5,700	$10,400
P16384	X2, X4, X8, X10, X19, X20, X21, X22, X29, X30, X33, X34, X35, X38	862.4	$5,249,700	$148,212,000	$6,100	$11,200

Note: Figures represent numbers used at the time of the CEICA. Costs and benefits of the Recommended Plan were later updated during optimization.

5.4.6 Principles and Guidelines

The Principles and Guidelines criteria were utilized early in the screening process to perform the first round of alternative screening at the site level. Plan formulation tables were created for the initial array of 21 sites. Each alternative was given a score of 0-4 for completeness, effectiveness, efficiency, and acceptability. O&M and natural resources (potential for habitat lift) were also scored with this screening exercise. Decision logic was recorded for every score and cutoffs for screening were decided by finding the natural break point in frequencies.

Additionally, these criteria were covered in other steps of screening later in the process. The two rounds of CEICA ensured the cost efficiency of the Recommended Plan, as well as the effectiveness since benefits would be maximized. The OSE analysis also covered completeness and acceptability when weighing logistical issues such as access or technical issues such as connectivity of habitat.

5.5 Verifying the CEICA Results with Other Decision-Making Methods

A qualitative decision method is presented that compares sites to each other based on professional opinion (i.e., pairwise comparison). For this analysis only the 14 restoration sites with proposed actions are included (Section 5.3.2) with the assumption that the sites must first meet ecological objectives before addressing secondary outcomes.

5.5.1 Pairwise Comparison

Intangible benefits and costs are well-acknowledged challenges in decision-making (Saaty 2008), and recent USACE guidance explicitly acknowledges the potential importance of qualitative factors in agency choices (James 2020, James 2021). A spectrum of decision-making methods exists for comparing, combining, and synthesizing diverse information (Linkov et al. 2009), but USACE decisions tend to emphasize quantitative criteria and qualitative methods are infrequently applied. This section presents a qualitative decision-making technique, pairwise comparison, as a means to verify and support more rigorous quantitative approaches shown in Section 5.3.

At the simplest level, pairwise comparison is a dichotomous choice. Would you rather sit or stand? Is coffee or tea better? A sophisticated suite of methods exists for using pairwise choice to develop weights for multiple criteria (Saaty 2008). However, for this application, we use the simplest notion of directly comparing alternative restoration sites. Four project team members were presented with a pairwise choice experiment for each of the 14 sites with recommended action. Team members represented different organization perspectives (e.g., project management, planning, and engineering) and different disciplinary backgrounds (biology, landscape architecture, engineering, economics). For each combination of sites, an analyst had to choose their preferred action in light of assessed ecological benefits and costs as well as qualitative factors such as watershed position, known stakeholders support, and professional judgments of the efficacy of restoration actions. The number of pairwise "wins" provides a simple metric of the relative importance of a site. For instance, a site with 13 "wins" would indicate that the site is consistently preferred over all other sites. The average number of pairwise "wins" across the four team members was computed for each site and is summarized below in Table 30.

Table 30 Summary of the pairwise comparison process

Site	Avg Number of Pairwise "Wins" (max 13)	Pairwise Rank	Ecological Rank	Social Rank	Average Rank
X2	10.3	3	9	2	4.7
X4	2.0	14	12	12	12.7
X8	3.0	11	14	13	12.7
X10	7.0	7	5	10	7.3
X19	4.0	10	6	5	7.0
X20	2.3	12	2	9	7.7
X21	4.8	9	1	7	5.7
X22	9.8	4	10	1	5.0
X29	8.8	5	11	14	10.0
X30	10.8	2	4	8	4.7
X33	2.3	12	7	6	8.3
X34	12.3	1	3	3	2.3
X35	5.3	8	13	4	8.3
X38	8.8	5	8	11	8.0

The results of the pairwise comparisons clearly distinguish between sites. Five sites were consistently preferred (X2, X22, X29, X30, and X34). Conversely, four sites were consistently not represented in preferences (X4, X8, X20, and X33). These results largely confirm prior analyses from CEICA with ecological and social inputs. The rank order of sites from the three methods were used as a consistent scale for comparing analyses. Some sites effectively meet ecological objectives but underperform in social and intangible factors (e.g., X20). Whereas other sites may not provide ecological benefits as efficiently, but they are enormously important socially (e.g., X2). The average rank across these three diverse assessments provides a simple assessment of the general level of expected outcomes. For instance, X34 is a large-scale restoration project in the high-profile location of Cherokee and Seneca Parks, and this site is identified by all three analyses as crucial. Conversely, sites X4 and X8 are ranked low in all three analyses.

5.6 Selection of the Recommended Plan

Based on Sections 5.3 and 5.4, the Recommended Plan is P10240. This watershed-scale plan includes 12 restoration sites at the confluence of the forks (X2), Alpaca Farm and Louisville Zoo (X10), Newburg Road (X19), Brown Park (X20), Arthur Draut Park (X21), a concrete channel near downtown Louisville (X22), the Eastern-Creason Connector (X29), Joe Creason Park (X30), a small MSD Basin (X33), Cherokee and Seneca Parks (X34), a neighborhood along the Muddy Fork (X35), and the Cave Hill Corridor (X38). Collectively these actions provide 297 AAHUs at an average annual cost of $4,303,000 and a project first cost of $121,135,000.

This section summarizes the sites included in this plan (5.6.1), develops a recreational plan associated with these sites (5.6.2), and presents detailed cost data (5.6.3).

5.6.1 Site Descriptions

This section provides a brief qualitative overview of each site in the Recommended Plan. Notably, X20 and X21 are adjacent locations with similar restoration actions, and these sites will be presented as a single site for the remainder of this document.

5.6.1.1 X2 - Confluence (R2H2)

This site is located where the stream meets the Ohio River. The site contains a public park, the MSD pump station, a portion of the Beargrass Creek greenway and is located adjacent to the Waterfront Botanical Gardens. Due to is location and features, this site has high visibility and recreation potential. The recommendation includes the R2 alternative that would add in native rock structures and woody debris, as well as grade banks to allow access to the floodplain along approximately 1070 linear feet of stream near the pump station, as well as two areas of H2 and some native plantings. Weirs would be constructed at the mouth of the stream to control sediment and erosion and concrete slabs near the pump station that were dumped will be removed. This alternative was chosen because it was cost-effective at the site scale, meets both objectives, and would provide social benefits due to its location.

5.6.1.2 X10 - Alpaca Farm (CR2P)

This site is located on the South Fork adjacent to the zoo and just upstream of the Joe Creason site. It consists of some property owned by Louisville Metro, as well as private property. The chosen plan consists of the addition of riffles to overcome culverts that pose as barriers to fish and other aquatic organisms. Instream work will include native rock structure and woody debris placement and bank grading to open the stream up to the floodplain. Approximately 44,900 linear feet of stream would be restored by this alternative. The alternative also includes invasive removal and native plantings throughout the site. This plan was chosen because it is a best buy with low overall unit cost that provides both instream and riparian benefits and offers opportunity for intangible benefits associated with its location next to the Louisville Zoo.

5.6.1.3 X19 - Newburg Rd (R1H2)

This site is composed of two MSD owned basins located upstream on the South Fork, as well as a portion of stream that connects them. The proposal includes retrofitting the existing basins to plant native wetlands plants to create a more natural wetland area, and instream improvements to improve the connection between the basins. Approximately 4,490 linear feet of stream and 12 acres of wetlands would be restored by this alternative. This is a cost-effective plan at an intermediate cost level and provides both instream and riparian benefits.

5.6.1.4 X20/X21 – Brown and Draut Park (R2P)

These two parks are located on the Middle Fork and are owned by the City of St. Matthews. Both sites have historic restoration work that is proposed to be updated as well as native planting and invasive removal throughout. Approximately 2,150 linear feet of stream would be restored by this alternative. This was a cost-effective plan at the Brown Park site and a best buy at Draut Park that was recommended because of the benefits of improving the connectivity of the two sites with instream and riparian work. These sites were evaluated separately at the site level but were viewed as one site for the watershed analysis.

5.6.1.5 X22 – Concrete Channel (H2)
This site is the 2.5-mile concrete stretch of the South Fork that has been channelized. The H2 alternative was chosen for this site for the relatively high degree of habitat benefits, by way of islands along the channel that would be created despite the comparatively high incremental and overall costs. Approximately 6 acres of wetlands would be restored by this alternative. This plan is cost-effective and offers large social benefits since the site is located in a dense urban neighborhood with high visibility and proximity to downtown.

5.6.1.6 X29 - Eastern Creason Connector (CR4P)
This site is located between sites X22 and X30 on the South Fork. Three riffles will be added to eliminate connectivity issues along this reach and a portion of the stream will be sculpted utilizing the R4 alternative. Approximately 4,550 linear feet of stream would be restored by this alternative. This site will also have work done to plant native species and remove invasive species on approximately 96 acres. The alternative is a best buy and meets both planning objectives. This site also has strong stakeholder interest and opportunity for recreation and educational aspects due to the proximity of schools, churches, and other community center establishments.

5.6.1.7 X30 - Nature Preserve (CR4P)
This site is located just upstream of site X29 and proposed the same alternative that would improve connectivity between the sites. Approximately 3,830 linear feet of stream would be restored by this alternative. Plantings and invasive removal throughout with one large barrier removal, as well as channel resculpting is proposed here. Being an active city park and a nature preserve, this site has high visibility and opportunity to enhance the recreation and educational features. This alternative was a lowest cost best buy and meets both planning objectives.

5.5.1.8 X33 – MSD Basin (H2)
This site is composed of one MSD owned basin located upstream on the South Fork. The proposal includes retrofitting the existing basin to plant native wetlands plants to create a more natural wetland area. Approximately 3 acres of wetlands would be restored by this alternative. This is a cost-effective plan at an intermediate cost level.

5.6.1.9 X34 – Cherokee and Seneca Park (CR2P)
This is the largest site and contains two active parks, both are considered historic. The alternative includes the addition of riffles to eliminate instream barriers at four points along the stream reach, native plantings on about 230 acres, invasive removal on over 180 acres and instream improvements with floodplain access. Approximately 12,950 linear feet of stream would be restored by this alternative. This plan was the lowest cost best buy and meets both objectives and the plan offers opportunities to enhance recreational aspects of this highly visible city park.

5.6.1.10 X35 – Muddy Fork and Tributaries (CR2H2)
This location is the only site selected on the Muddy Fork; however, it is the second largest site overall. The recommendation is to add riffles to eliminate barriers at seven locations along the stream with R2 instream work and floodplain connectivity impacting 8,970 linear feet of stream. H2, wetland creation is also proposed on about 7 acres that will have positive impacts on the Muddy Fork downstream of the site. This plan was the lowest cost, cost-effective plan and met both objectives.

5.6.1.11 X38 – Cave Hill (R2H2)

This site is located just downstream of the X34 site on the Middle Fork. This site is highly channelized and located along a major expressway. The chosen plan was the lowest cost best buy and meets both objectives, providing instream R2 work that aligns with the creation of 9 acres of plantings with some wetlands creation. This site provides important connectivity to upstream Middle Fork sites and actions would be complementary to other community management actions. Approximately 3,330 linear feet of stream would be restored by this alternative.

5.6.2 Recreation Plan

While recreation is ancillary to ecosystem restoration, recreation can be included in an ecosystem restoration plan if its cost remains under 10% of the total project cost. USACE and the NFS recognize the value and importance of recreation to the local and regional community of Louisville. Recreation features that would complement and enhance the ecosystem improvements were discussed and considered throughout the process, but the recreation plan was not formally created until after the selection of the Recommended Plan.

The conceptual recreation features were chosen based on existing recreation features or plans and opportunities to connect to or further improve those features. Additionally, some features were chosen to fill a need where the availability of such a feature may not be readily available. Public input also played a part in the selection of features. All conceptual recreation features are contingent on compatibility with ecosystem restoration features.

With the Beargrass Creek watershed's location in a dense urban area, the social and economic benefits to the local and regional community are numerous. There are direct and indirect benefits to the communities where the recreation features are proposed. The direct benefits would include:

- Improved access to the stream for surrounding communities
- Enhanced quality and quantity of trails for multiple users
- Improved viewsheds of the stream
- Improved public health benefits related to access to green space
- Opportunity for recreation related/adjacent business and eco-tourism
- Opportunity for education about the stream's history

The communities surrounding Beargrass Creek have investment in the health of the stream and access from neighborhoods for recreational and educational purposes. The direct benefits to these communities would enhance access to green space, viewsheds, and boost recreation related business and tourism.

Beyond the adjacent communities, the restoration and additional recreation features would also have an impact on the larger population of Louisville. For instance, the trail enhancements and connections at the Confluence site that connect to the Cave Hill site would be adding to the Louisville Loop trail system, a 200-mile multi-use trail that loops the metro area. This trail is still under construction; however, the portion that follows the waterfront is complete and stretches over 20 miles from southwest Jefferson County to east of downtown.

Other recreational features will be addressing underserved areas such as the MSD basin sites that are in lower income areas that are in need of better access to greenspace. Additionally, the Eastern Creason Connector trail will be connecting several neighborhoods that currently do not have safe pedestrian access between them due to the arterial roads that dissect this part of the city. Chapter 7 contains a detailed description of the selected features of the recreation plan.

5.7 National Ecosystem Restoration (NER) Plan

After completion of all analysis and screening and application of decision criteria, the PDT selected P10240 as the NER Plan and Recommended Plan. This watershed-scale plan includes 12 restoration sites at the confluence of the Forks (X2), Alpaca Farm and Louisville Zoo (X10), Newburg Road (X19), Brown Park (X20) / Arthur Draut Park (X21), a concrete channel near downtown Louisville (X22), the Eastern-Creason Connector (X29), Joe Creason Park (X30), a small MSD Basin (X33), Cherokee and Seneca Parks (X34), a neighborhood along the Muddy Fork (X35), and the Cave Hill Corridor (X38).

6.0 Evaluation of Alternative Plans and Environmental Consequences

A consequence, or effect (the terms "effects" and "impacts" may be used synonymously (40 C.F.R. § 1508.8)), is defined as a modification to the human or natural environment from the proposed action or alternatives that is reasonably foreseeable and has a reasonably close causal relationship to the proposed action or alternatives. Effects include those that occur at the same time and place as the proposed action or alternatives and may include effects that are later in time or farther removed in distance from the proposed action or alternatives.

Effects may be temporary (short-term), long lasting (long-term), or permanent. Temporary effects are defined as those that would occur during construction of one of the alternatives. Long-term effects are defined as those that would extend from the end of the construction period through some point within the project life cycle. Permanent effects are assumed to be present throughout the period of analysis.

This section evaluates the environmental effects of the no action alternative and the action alternatives. The environmental conditions for each resource are compared with future conditions for each alternative plan. Both beneficial and adverse effects are considered, including direct effects during construction and operation and indirect effects of restoration under each of the proposed alternatives along with related actions.

For this NEPA analysis, the 14 site-specific options for restoration were grouped according to the ecological issue they were designed to address. The four groups are as follows:

- Connectivity of Riverine Habitats
- Riverine Habitat Restoration
- Riparian Hydrology Restoration
- Native Plant Community Restoration

See Section 4.8 of this report for details of what measure each of these restoration efforts entails.

The following alternatives include features to restore riverine connectivity:

- Alternative 2 (X4 – Shelby Campus/AB Sawyer- CR4P)
- Alternative 4 (X10 - Alpaca Farm- CR2P)
- Alternative 8 (X29 - Eastern Creason Connector- CR4P)
- Alternative 9 (X30 - Nature Preserve- CR4P)
- Alternative 11 (X34 – Cherokee and Seneca Park- CR2P)
- Alternative 12 (X35 – Muddy Fork and Tributaries- CR2H2)

The following alternatives include features to restore riverine habitat:

- Alternative 1 (X2 - Confluence- R2H2)
- Alternative 2 (X4 – Shelby Campus/AB Sawyer- CR4P)
- Alternative 4 (X10 - Alpaca Farm- CR2P)
- Alternative 5 (X19 - Newburg Rd- R1H2)
- Alternative 6 (X20/X21 – Brown and Draut Park- R2P)

- Alternative 8 (X29 - Eastern Creason Connector- CR4P)
- Alternative 9 (X30 - Nature Preserve- CR4P)
- Alternative 11 (X34 – Cherokee and Seneca Park- CR2P)
- Alternative 12 (X35 – Muddy Fork and Tributaries- CR2H2)
- Alternative 13 (X38 – Cave Hill- R2H2)

The following alternatives include features to restore riparian hydrology:

- Alternative 1 (X2 - Confluence- R2H2)
- Alternative 5 (X19 - Newburg Rd- R1H2)
- Alternative 12 (X35 – Muddy Fork and Tributaries- CR2H2)
- Alternative 13 (X38 – Cave Hill- R2H2)

The following alternatives include features to restore native plant communities:

- Alternative 2 (X4 – Shelby Campus/AB Sawyer- CR4P)
- Alternative 4 (X10 - Alpaca Farm- CR2P)
- Alternative 6 (X20/X21 – Brown and Draut Park- R2P)
- Alternative 8 (X29 - Eastern Creason Connector- CR4P)
- Alternative 9 (X30 - Nature Preserve- CR4P)
- Alternative 11 (X34 – Cherokee and Seneca Park- CR2P)

Because these alternatives would be applied to address similar ecosystem issues (e.g., incised streams, invasive species, etc.) using similar measures within the same watershed, it was reasoned that, except where relevant special conditions exist, impacts to the environment would be similar in kind, with their magnitude largely determined by the magnitude of the disturbance from implementing the alternative. For example, riverine habitat restoration alternatives implemented on the Muddy Fork would be expected to result in similar types of environmental impacts as those expected for implementation of a riverine habitat restoration alternative on the Middle Fork. The same construction best management practices (BMPs) would be utilized at each site to minimize temporary adverse impacts to the environment. Similar long-term positive environmental impacts, such as improved aquatic biodiversity and habitats would be expected to occur at each site but may occur at different magnitudes. These differences are captured in Table 25 (Section 5.3.2), which quantifies restored linear feet of stream and acreages for each site. All sites were examined for any special features or conditions that would be relevant to the impacts from the alternatives implemented there. Variance between sites in conditions relevant to the expected impacts of implementing the alternatives is addressed within the paragraphs below.

This NEPA analysis also included effects to the environment from implementation of the recreation plan as detailed in the Recommended Plan chapter. Table 37 in Section 7.3 identifies the recreation features to be implemented at seven of the 12 Recommended Plan sites.

6.1 Geology, Seismology, and Soils

6.1.1 Connectivity of Riverine Habitats (C)

Implementation of alternatives intended to address longitudinal connectivity of streams would have no significant or long-term impact on the geology, seismology, or soils within the study area. Construction activities associated with implementing the Action Alternatives would be expected to have minor and insignificant effects to soils in the immediate site areas. The current channel alignment, hydraulic, and geomorphic conditions would be maintained by reestablishing connectivity, and no significant long-term impacts to soils would be expected. Construction BMPs would be implemented to minimize soil loss from erosion induced by construction activities. These would include silt fences, coir logs, grass mats, and construction mats and work pads if necessary.

6.1.2 Riverine Habitat Restoration (R1, R2, R4)

Implementation of alternatives intended to restore instream riverine habitat only (R1) would have no impact on the geology or seismology within the study area. These alternatives would be expected to have temporary, minor, and insignificant effects to soils in the immediate site area, as the alternative design would maintain the current channel alignment, hydraulic and geomorphic conditions. Alternatives that include more intensive restoration measures, such as bank grading and channel realignment (R2 and R4) would not have a significant impact on study area topography or underlying geology. Restoration measures under these alternatives do not propose to alter or modify distinct topographic or geologic landforms in the study area. Regrading of channel banks would result in slight changes in topography, but these changes are within the already modified topography of the stream channel.

Ground-disturbing activities during construction could result in soil erosion or loss of topsoil in areas both within the channel itself and on upland areas above the channel. Under these, ground-disturbing activities that may occur include:

- Demolition and excavation of concrete and earthen material for the construction of side channels.
- Demolition of channel walls and excavation of overbank areas at storm drain outlets for daylighting and wetland habitat creation.
- Widening of channel bed and top of banks via excavation and grading of earthen material.
- Use of heavy equipment for hauling away of concrete debris and excavated material.
- Excavation for topsoil fill and vegetation establishment on side slopes of maintenance roads and channel.

Disturbances to soil in all areas would be controlled through a suite of erosion control measures designed for construction activities. The extent of ground disturbance would be minimized prior to construction by identifying the minimum required area for staging and access routes. Staging areas and access routes would consider existing conditions and would be located where soils are not already exposed or where disturbance has already occurred. Industrial districts, parking lots, and undeveloped rural areas would provide the best locations. Some lands intended for ecosystem restoration may also be used for staging areas prior to construction of features on those sites. Areas that have aesthetic, recreational, open space, or habitat value would be avoided to the extent possible.

During construction, areas that would be disturbed within the study footprint, at staging locations, and along hauling routes would be evaluated to determine where erosion control measures would be necessary. These controls would include BMPs such as (1) the placement of straw bales or other filters that prevent soils from moving off-site during precipitation events, (2) placement of mulch or chemical stabilizers, and/or use of watering trucks where dry conditions could result in creation of fugitive dust, (3) identification of suitable locations for deposit of excavation spoils, and (4) minimization of number of truck trips or hauling distances, among others. Following construction efforts, disturbed ground would be restored with native plantings to stabilize exposed areas and return the site to aesthetically suitable conditions.

Because of these BMPs, implementation of these alternatives would result in long-term positive impacts to soils within the study area. Through the reestablishing natural flow regimes and the natural process of cut and fill alluviation, down cutting and excessive scour of streambanks would be eliminated and would lessen the erosion of soils.

6.1.3 Riparian Hydrology Restoration (H2)

Implementation of alternatives intended to restore riparian hydrology of streams would not have a significant impact on study area topography or underlying geology. Restoration measures under these alternatives do not propose to alter or modify distinct topographic or geologic landforms in the study area. Excavation for creation of swales and regrading activities would result in slight changes in topography, but these changes are within the already modified topography of the stream channel. Implementation of these alternatives would result in long-term positive impacts to soils within the study area. Restoration of the natural hydrology within the riparian zones of these stream reaches would act to restore soils by reestablishing natural nutrient and water cycles and improve or maintain diversity of native plant assemblages. These alternatives would facilitate the return of natural soil structure and health. All appropriate construction BMPs would be implemented to minimize disturbances to soils from construction activities.

6.1.4 Native Plant Community Restoration (P)

Implementation of alternatives intended to restore the native riparian plant communities would have no impact on the geology or seismology within the study area. Implementation of these alternatives would have long-term beneficial effects to soils within the study areas. Reestablishment of healthy native plant communities act to reduce erosion of soils and cultivate a healthy microbiome within the soils that better facilitate native plant growth. Any soil disturbance caused during implementation would be minimized by use of erosion control BMPs mentioned above.

6.1.5 Recreation Plan

Implementation of the recreation plan would include some minor and localized disturbances to soils from installation of features such as benches, signage, viewing platforms, and from trail enhancement, creation, and/or realignment. Erosion control measures to include seeding of native herbaceous vegetation would be implemented when necessary to minimize soil loss during and after installation of features. Implementation of these and similar recreational features would not be expected to result in significant impacts to soils, topography, geology, or seismology.

6.1.6 No Action Alternative

Under the No Action Alternative, topography and geology, soils, and seismic hazards would not be affected by construction activities since no construction would occur under this alternative. Topographic and geologic features, such as basin sediment in-fill and subsequent aggradation would persist indefinitely, subject to weathering and possibly by other effects.

Soils would continue to be eroded and deposited from fluvial processes. Soil erosion in the headwaters of the watershed would continue to result in the transport and deposition of sediment along the soft bed channel sections of the study area.

6.2 Air Quality

6.2.1 Connectivity of Riverine Habitats (C)

Machinery and equipment employed for the construction of these alternatives would release emissions, including greenhouse gases. Equipment such as dump trucks and front-end loaders would have mufflers and exhaust systems in accordance with state and federal standards. The potential impacts on air quality from construction activities would be from particulate matter (PM) (fugitive dust) and emissions from vehicle exhaust generated from earth-moving operations during construction. Overall, adverse impacts from construction would be localized, minor, and temporary. If dust generated at the work sites is deemed to be a potential problem, water will be used for dust control from earthwork activities.

Emissions from the proposed construction activity would be exempted as *de minimis*, and therefore would meet the General Conformity Criteria pursuant to Section 107 of the Clean Air Act, as amended. Though Jefferson County did not meet air quality standards for sulfur dioxide and 8-hour ozone, the proposed work is not expected to affect air quality compliance. For these reasons, implementation of alternatives intended to address longitudinal connectivity of streams would have no significant or long-term impact to air quality.

The following is a list of recommendations to attenuate air quality impacts. The recommendations, modified as appropriate, would be implemented for construction activities.

Mobile Emission Attenuating Measures:

- Provide temporary traffic controls, such as a flag person, during all phases of construction to maintain smooth traffic flow.
- Provide dedicated turn lanes for movement of construction trucks and equipment on- and off-site.
- Reroute construction trucks away from congested streets or sensitive receptor areas.
- Utilize electricity from power poles rather than temporary diesel or gasoline power generators to the extent practicable.

Fugitive Dust Attenuating Measures:

- Suspend all excavating and grading operations when wind speeds (as instantaneous gusts) 22 exceed 25 miles per hour.
- Require frequent street sweeping surrounding the study site to minimize fugitive dust emissions from track-out.
- Install wheel washers where vehicles enter and exit the construction site onto paved roads or wash off trucks and any equipment leaving the site each trip.
- Apply water three times daily, or non-toxic soil stabilizers according to manufacturer's specifications, to all unpaved parking or staging areas or unpaved road surfaces.
- Replace ground cover in disturbed areas as quickly as possible.
- Apply non-toxic soil stabilizers according to manufacturers' specifications to all inactive construction areas (previously graded areas inactive for ten days or more).

6.2.2 Riverine Habitat Restoration (R1, R2, R4)

Implementation of alternatives intended to restore instream riverine habitat would result in similar impacts as those of the connectivity alternatives. Emissions from the proposed construction would be exempted as *de minimis*, and therefore would meet the General Conformity Criteria pursuant to Section 107 of the Clean Air Act, as amended. The proposed work is not expected to affect air quality compliance and would have no significant or long-term impact to air quality.

6.2.3 Riparian Hydrology Restoration (H2)

Implementation of alternatives intended to restore riparian hydrology would result in similar impacts as those of the connectivity and riverine habitat alternatives. Emissions from the proposed construction would be exempted as *de minimis*, and therefore would meet the General Conformity Criteria pursuant to Section 107 of the Clean Air Act, as amended. The proposed work is not expected to affect air quality compliance and would have no significant or long-term impact to air quality.

6.2.4 Native Plant Community Restoration (P)

Implementation of alternatives intended to restore native plant communities would result in similar impacts as those of the connectivity and riverine habitat alternatives. Emissions from the proposed construction would be exempted as *de minimis*, and therefore would meet the General Conformity Criteria pursuant to Section 107 of the Clean Air Act, as amended. The proposed work is not expected to affect air quality compliance and would have no significant or long-term impact to air quality.

6.2.5 Recreation Plan

Implementation of the recreation plan would involve use of hand tools and or the use of small machinery and would be expected to result in negligible impacts to air quality. Emissions from the proposed construction would be exempted as *de minimis*, and therefore would meet the General Conformity Criteria pursuant to Section 107 of the Clean Air Act, as amended. Implementation of the recreation plan is not expected to affect air quality compliance and would have no significant or long-term impact to air quality.

6.2.6 No Action Alternative

There would be no construction related or operational air emissions under the No Action Alternative since no construction would occur.

6.3 Land Use

6.3.1 Connectivity of Riverine Habitats (C)

Alternatives implemented to address connectivity of riverine habitat would not result in changes to future land use, as work would be contained within the stream. Alternatives that include restoring connectivity would not encumber services or opportunities, and there would likely be no change in the land use of adjacent properties. In accordance with the applicable real estate interests, all sites selected for restoration would have to remain as such in perpetuity, so restoring the sites would also protect them from any future development efforts.

6.3.2 Riverine Habitat Restoration (R1, R2, R4)

Alternatives implemented to restore riverine habitat would not result in changes to future land use, as work would be contained within the stream or in the immediate riparian zone, adjacent to the stream. These alternatives would not encumber services or opportunities, and there would likely be no change in the land use of adjacent properties. In accordance with the applicable real estate interests, all sites selected for restoration would have to remain as such in perpetuity, so restoring the sites would also protect them from any future development efforts.

6.3.3 Riparian Hydrology Restoration (H2)

Implementing alternatives focused on restoring riparian hydrology would not result in changes to future land use, as work would occur in undeveloped stream floodplains. These alternatives would not encumber services or opportunities, and there would likely be no change in the land use of adjacent properties. In accordance with the applicable real estate interests, all sites selected for restoration would have to remain as such in perpetuity, so restoring the sites would also protect them from any future development efforts.

6.3.4 Native Plant Community Restoration (P)

Implementing alternatives focused on restoring plant communities would not result in changes to future land use, as work would occur in undeveloped stream floodplains. These alternatives would not encumber services or opportunities, and there would likely be no change in the land use of adjacent properties. In accordance with the applicable real estate interests, all sites selected for restoration would have to remain as such in perpetuity, so restoring the sites would also protect them from any future development efforts.

6.3.5 Recreation Plan

Implementation of the recreation plan would involve connecting and enhancing existing low-impact recreational uses at seven sites within the watershed. These sites already facilitate recreational uses; therefore, significant impacts to land use within the project area are not anticipated.

6.3.6 No Action Alternative

Under the No Action Alternative, no construction efforts would be undertaken and no significant impacts to land use would be expected. Future land use would continue to be regulated and guided via federal, state, regional, and local guidance, general plans, master planning, ordinances, and land use zoning plans. Land use zoning is expected to remain the same without implementation of restoration. Industrial, commercial, and residential areas would continue to occupy their current extent, or changes in zoning would be controlled via jurisdictional guidance. Continued deterioration of land use conditions could occur if parcels not utilized for restoration, such as privately owned lots or undeveloped parcels, are not rehabilitated or restored independently.

Open space, parks, and recreation would continue to be limited in the study area. Non-federal actions to introduce parks or conduct small scale restoration would incrementally increase recreational land use value to the area, but would occur slowly, incurring only minimal benefits to land use.

6.4 Water Resources

6.4.1 Connectivity of Riverine Habitats (C)

The purpose of these alternatives is to eliminate fragmentation points within the stream channels to improve the dispersal ability of aquatic species. Structures or features generally causing this fragmentation can include perched culverts, bridge abutments, structure footings, weirs, cross channel pipes, foreign debris jams, online detention basins, or piped reaches. While removal or modification of these structures would act to restore habitat and animal movement, it would not result in significant impacts to surface or groundwater resources. The installation of riffle features in place of an existing structure could act to oxygenate the water and improve dissolved oxygen concentration, which is critical for aquatic organisms.

Construction activities required to implement these alternatives could result in short-term, insignificant adverse impacts to surface water quality through increases in turbidity and suspended solids from soil disturbance. These impacts would be minimized by implementing BMPs designed to address soil loss as detailed in Section 5.1.2.

The removal of stream barriers can affect water chemistry through the mobilization of accumulated sediments and sediment-bound contaminants to downstream aquatic environments. This alternative would address connectivity barriers in the watershed that have developed as a result of perched culverts. In many cases these culverts cannot be removed so, in an effort to improve connectivity, riffles would be installed below the culvert to create a gradual stream gradient that aquatic and semiaquatic organisms can more easily traverse. These actions would have negligible effects to water quality, as accumulated sediments upstream of the barriers would not be mobilized.

During construction, hydrologic features would not be adversely affected. It is assumed that instream construction and modification of the study reaches would be conducted primarily in dry weather months (April 15 – October 31) to avoid storm flows or occur in work areas that would be adequately protected and not affect flood conveyance. In areas where instream construction would occur, diversions would be implemented to bypass dry weather flows downstream. Some areas may require dewatering during construction. Base flows supportive of beneficial uses, which protect aquatic life and human uses, may be temporarily affected in the immediate construction zone, but would not be affected upstream or downstream of the study area.

Under these alternatives, modification to the channel will not increase the maximum water surface elevation or result in substantial changes to the water velocity and circulation. During the next detailed design phase, restoration measures will be further designed to not increase flooding risk in any portion of the study area or areas downstream. Additional hydraulic analysis will be conducted, and design modifications will be implemented during the design phase to provide more detail on the channel hydraulics with the Recommended Plan in place.

Implementation of these alternatives would not be expected to significantly impact groundwater resources.

Implementation of BMPs would be guided through permitting, certification, and plan development. The proposed erosion control measures would include, but are not be limited to, the following:

- Limiting most in-channel construction to the low-flow period between April 15 and October 31 to minimize soil erosion.

- Require the construction contractor to prepare a storm water pollution prevention plan (SWPPP) consistent with the US EPA’s 2017 (or then-current) NPDES Construction General Permit. At a minimum, the SWPPP would include the following elements:

    - Work areas, staging areas, or stockpile areas that could be subject to erosion during storm events would be stabilized with erosion control measures as appropriate. These measures could typically include silt fencing, straw bales, sandbags, filter fabric, coir rolls or wattles.
    - Erosion control methods used to prevent siltation would be monitored weekly and maintained as needed.
    - Stabilize and reseed disturbed upland areas with native grasses, shrubs, and trees upon completion of construction.
    - Stationary equipment such as motors, pumps, generators, and welders located within or adjacent to the channel or basin will be positioned over drip pans.
    - Any equipment or vehicles driven and/or operated within or adjacent to the channel or basin should be checked and maintained daily, to prevent leaks. All maintenance will occur in a designated offsite area. The designated area will include a drain pan or drop cloth and absorbent material to clean up spills.

- Fueling and equipment maintenance will be done in a designated area removed from the area of the channel or basin such that no petroleum products or other pollutants from the equipment may enter these areas via rainfall or runoff. The designated area will include a drain pan or drop cloth and absorbent materials to clean up spills.
- Materials for the containment of spills (i.e., absorbent materials, silt fencing, filter fabric, coir rolls) will be identified and be available onsite prior to commencement of construction or maintenance activities.
- Any accidental spill of hydrocarbons or coolant that may occur within the work area will be cleaned immediately. Absorbent materials will be maintained within the work area for this purpose.
- No wet concrete product will come into contact with any flowing or standing water at any time. Areas where raw cement or grout are applied or where concrete curing or finishing operations are conducted would be separated from any ponded or diverted water flows by a cofferdam or silt-free, exclusionary fencing. All equipment involved with the concrete or grouting operations will be located within a contained area while using any slurry or concrete product. A protective berm or other structure will be in place prior to maintenance and/or repair activities.
- Any spill of grout, concrete, concrete curing, or wash water adjacent to or within 45 feet of the work area will be removed immediately.

6.4.2 Riverine Habitat Restoration (R1, R2, R4)

Alternatives that include restoration of instream habitat only (R1) would maintain the current channel alignment, hydraulic and geomorphic conditions while placing low-profile riffle, slab rock, boulder, cobble, and large woody debris structural habitats. Like the connectivity alternatives, this would improve habitat, but would not be expected to result in any long-term significant impacts to surface or groundwater quality.

Alternatives that include more intensive riverine habitat restoration techniques (R2 and R4) would be expected to have greater impacts from construction activities through increases in turbidity and suspended solids due the amount of required earthwork. However, these adverse impacts would be minimized by implementing BMPs designed to address soil erosion and protect water quality (as detailed in Section 6.1.2) to ensure they are temporary and insignificant.

None of the alternatives that include restoration of instream habitat would increase the maximum water surface elevation and would not increase flood damages in the study area as compared to existing conditions. As with all alternatives, these restoration measures will be further designed to not impair flood risk management functions in any portion of the study area or areas downstream during the next detailed design phase.

Implementation of these alternatives would not be expected to significantly impact groundwater resources.

6.4.3 Riparian Hydrology Restoration (H2)

Implementation of alternatives to restore riparian hydrology would result in new acres of riparian and wetland habitat within the watershed and would provide additional filtration of stormwater entering the system. The restored habitat would be expected provide benefits by helping to provide biological and chemical removal of constituents that contribute to the stream's impairment, including nitrate, ammonia, phosphorus, suspended solids, bacteria, fecal coliform, and nutrients. Improved riparian and wetland vegetation would combine to increase shading of the river, which may reduce microclimate temperatures, which in turn would allow for increased dissolved oxygen levels.

Construction activities required to implement these alternatives could result in short-term, insignificant adverse impacts to surface water quality through increases in turbidity and suspended solids from soil disturbance. These impacts would be minimized by implementing BMPs designed to address soil loss as detailed in Section 6.1.2.

Groundwater benefits from these alternatives would include increased groundwater infiltration and recharge for future water uses, though these benefits would likely not be significant.

6.4.4 Native Plant Community Restoration (P)

Healthy riparian plant communities play an important role in protecting streams from nonpoint source pollutants and in improving the quality of degraded stream water. Riparian vegetation influences stream water chemistry through diverse processes including direct chemical uptake and indirect influences such as by supply of organic matter to soils and channels, modification of water movement, and stabilization of soil (Dosskey et al. 2010). Removal of invasive plant species and restoration of native vegetation along the Three Forks of Beargrass Creek would result in a long-term beneficial impacts to surface water resources. Groundwater benefits from these alternatives would include increased groundwater infiltration and recharge for future water uses, though these benefits would likely not be significant. Construction activities required to implement these alternatives could result in short-term, insignificant adverse impacts to surface water quality through increases in turbidity and suspended solids from soil disturbance. These impacts would be minimized by implementing BMPs designed to address soil loss as detailed in Section 6.1.2.

6.4.5 Recreation Plan

Implementation of the recreation plan would include some minor and localized disturbances to soils from installation of features such as benches, signage, viewing platforms, and from trail enhancement, creation, and/or realignment. Erosion control measures to include seeding of native herbaceous vegetation would be implemented when and where necessary to minimize soil loss during and after installation of features and minimize potential impacts to water resources from stormwater runoff. Any recreational features that may involve the placement of fill into waters of the U.S. will comply with all applicable sections of the Clean Water Act to ensure water quality standards are maintained. For these reasons, implementation of the recreation plan is expected to have negligible adverse impacts to water resources within the project area.

6.5.5 No Action Alternative

Hydrologic, water quality, and groundwater conditions within the study area will continue changing based on population pressures, new and continuing regulations, and future climate conditions. The hydrologic regime in the study area will continue to be characteristic of urban environments with high peak flows and short durations, with resultant peaks in pollutants that quickly dissipate to normal levels. Although increased population density and impervious areas within the watershed, upstream of and on tributaries within the study area, could potentially increase these conditions, measures within the local, state, and federal permits are designed to curtail this potential. However, Beargrass Creek is an urbanized and degraded system, and due to pollution impacts from the urban and industrial land use activities located in the watershed, water quality problems will likely persist at measurable levels. Current climate change studies have indicated a likely increase in the frequency of extreme weather conditions in the future. These extreme weather events could compound and increase watershed peak flows.

6.5 Biological Resources

Impacts to biological resources would result from temporary construction efforts and construction of new habitat features. Impacts may include those to vegetation or wildlife resulting from site preparation, grading, bank lowering, channel widening, removal of concrete, excavation of swales, riverside plantings, removal or alteration of existing structures, and construction of new connections to water sources. The magnitude of the disturbance would determine the significance of the impact to biological resources. However, most of the effects from the construction of the restoration measures proposed under the action alternatives would be highly beneficial to biological resources over the long term.

In this section, beneficial impacts are qualitatively described for the alternatives, while also providing the quantitative measure of restoration benefits in terms of Habitat Units (HUs). Additional details regarding the calculation of HUs are provided in Section 5.1.

6.5.1 Vegetation

6.5.1.1 Connectivity of Riverine Habitats (C)

Under these alternatives, added or modified features would be contained within the stream channel. Some existing vegetation may be disturbed during construction of features by creating access for machinery. However, native plants and mature native trees would be avoided to the extent practicable. Many of the connectivity barriers are caused by road crossings and are therefore easily accessible and would not require construction of extensive access roads. Therefore, impacts to vegetation would be insignificant.

6.5.1.2 Riverine Habitat Restoration (R1, R2, R4)

During implementation of alternatives to restore riverine habitat, existing vegetation will be cleared during the course construction activities. Table 31 shows the estimated acres of vegetation clearing anticipated at each site for implementation of the riverine habitat restoration alternative and includes clearing for construction vehicle access and clearing of invasive species.

Table 31 Estimated acres of vegetation clearing at each site for riverine habitat restoration.

Site	Restoration Method	Estimated Clearing (acres)
X2 - Confluence	R2	1.26
X10 - Alpaca Farms	R2	5
X19 - Newburg Rd	R1	2.22
X20 - Brown Park	R2	.39
X21 - Arthur Draught	R2	1.94
X29 - Eastern / Creason Connector	R4	14.51
X30 - Joe Creason Park	R4	16.39
X34 - Cherokee Park	R2	10.12
X35 - Muddy Fork and Tributaries	R2	7.05
X38 - Cave Hill Corridor	R2	4.22
	Total	**63.1**

Some portions of the study area have an abundance of non-native invasive vegetation. These invasive species may spread further where construction efforts disturb soils. Increased presence of invasive weed species reduces ecological diversity and minimizes habitat value. However, restoration designs specifically call for revegetation of disturbed areas with native plant species, including those areas disturbed during the construction period. Non-native infestations would be treated either mechanically or chemically after construction is complete. Construction of the restoration features and invasive species control would remove weedy and ornamental vegetation and replace it with native riparian and wetland habitat, which would be a benefit to the river ecosystem. BMPs will be employed to limit the potential instream impacts caused by erosion and the use of herbicides at the project sites.

With the implementation of restoration measures, installation of native habitat, and control of invasive species, construction of these alternatives would not cause significant adverse impacts to vegetation. Any impacts would be minimal, localized, and short term, and would ultimately be beneficial after native habitats are restored.

6.5.1.3 Riparian Hydrology Restoration (H2)

Under these alternatives, some existing vegetation would be disturbed during construction of features, such as excavation of swales and contouring of the floodplain. Table 32 shows the estimated acres of vegetation clearing anticipated at each site for implementation of this alternative and includes clearing for construction vehicle access and clearing of invasive species.

Table 32 Estimated acres of vegetation clearing at each site for riparian hydrology restoration.

Site	Restoration Method	Estimated Clearing (acres)
X2 - Confluence	H2	20.23
X19 - Newburg Rd	H2	0
X22 - Concrete Channel	H2	0
X33 - MSD Basin	H2	1.1
X35 - Muddy Fork and Tributaries	H2	5.25
X38 - Cave Hill Corridor	H2	3.34
	Total	**29.92**

Sensitive native plant communities and mature trees would be avoided to the extent practicable. Native seed mixes suitable for wetlands and frequently flooded areas would be used to revegetate the study areas, resulting in a long-term beneficial impact to vegetation.

With the implementation of restoration measures, installation of native habitat, and control of invasive species, construction of these alternatives would not cause significant adverse impacts to vegetation. Any impacts would be minimal, localized, and short-term in nature, and would ultimately be beneficial after native habitats are restored.

6.5.1.4 Native Plant Community Restoration (P)

Alternatives that include restoration of healthy native plant communities (Alternatives 2, 3, 4, 6, 8, 9, and 11) would have direct and immediate positive, long-term impacts to the vegetative communities within the study sites. Restoration activities would entail removing invasive species, planting of native tree, shrub, and herbaceous species of local genotype at the study sites. Invasive plant species would be initially removed with any combination of clearing, grubbing, herbicide application, flooding, mowing, and prescribed burning. These Action Alternatives would provide a total of 299.6 average annual HUs. Table 33 shows the estimated acres of vegetation clearing anticipated at each site for implementation of this alternative and includes clearing for construction vehicle access and clearing of invasive species.

Table 33 Estimated acres of vegetation clearing at each site for native plant community restoration.

Site	Restoration Method	Estimated Clearing (acres)
X2 - Confluence	P	0.05
X10 - Alpaca Farms	P	8.46
X20 - Brown Park	P	0.00
X21 - Arthur Draught	P	4.33
X29 - Eastern / Creason Connector	P	13.77
X30 - Joe Creason Park	P	0.00
X34 - Cherokee Park	P	0.00
X35 - Muddy Fork and Tributaries	P	0.98
X38 - Cave Hill Corridor	P	0.61
	Total	**28.20**

6.5.1.5 Recreation Plan

Implementation of the recreation plan would include some minor and localized disturbances to vegetation from the installation of features such as benches, signage, viewing platforms, and from trail enhancement, creation, and/or realignment. No trees over three inches diameter at breast height would be removed during the bat maternity season, and disturbed areas would be revegetated with native plantings. For these reasons, adverse impacts to vegetation from implementation of the recreation plan is expected to be negligible.

6.5.1.6 No Action Alternative

While limited habitat exists within the study area supporting some native plants and wildlife, under the No Action Alternative it is anticipated that non-native species will continue to invade and that native habitat and wildlife diversity will decline. Due to the urbanization in the study area, the existing habitat and ecological functions are extremely degraded. These degraded conditions would persist with implementation of the No Action Alternative.

Without consistent maintenance, native plant and wildlife diversity would continue to decline while existing habitats would be increasingly infested by non-native species. Non-native species do not provide adequate habitat to support a diverse population of fish and wildlife. Mechanical or chemical treatment would continue to be necessary as a means of maintaining native vegetation.

6.5.2 Wildlife

6.5.2.1 Connectivity of Riverine Habitats (C)

Construction activities under these alternatives may temporarily disturb wildlife within the study areas by removing vegetation, increasing noise levels, and increasing vibration levels. Wildlife is expected to vacate the study areas and find alternate habitat nearby during construction. Construction would take place in phases, and only be performed in limited portions of the study area at any given time. Much of the wildlife inhabiting the study area are urban adapted species that are acclimated to human presence, higher noise levels, and some level of disturbance. These species may adapt more readily to the type of disruptions that occur during construction. Wildlife is expected to recolonize the construction areas after construction is complete. No significant adverse effects are expected to impact these wildlife species as a result of construction activities included in this alternative.

Wildlife movement within the study area may be disrupted during construction activities due to disturbance of vegetation, increased noise levels, and increased vibrations. Disturbance would be temporary and movement opportunities would be restored after and possibly improved by these alternatives once construction is complete.

6.5.2.2 Riverine Habitat Restoration (R1, R2, R4)

Impacts from construction of these alternatives to wildlife would be similar to those expected from the rest of the alternatives. No significant adverse effects are expected to commonly occurring wildlife species as a result of construction activities included in this alternative. Impacts to wildlife movement would be temporary and not significant, and overall, the project would be beneficial for wildlife species in the study area by restoring and expanding native habitat.

Two airports are located in the vicinity of the proposed restoration sites. The Louisville International Airport is located approximately two miles to the southwest of site X10 on the South Fork of Beargrass Creek. Bowman Field, a smaller regional airport, is located less than one-half mile to Site X34, near Seneca Park on the Middle Fork of Beargrass Creek. While restoration of riverine habitat at these locations may increase the number of birds in the area, the increase in bird population is not expected to significantly increase the likelihood of bird and airplane collisions.

6.5.2.3 Riparian Hydrology Restoration (H2)

Impacts from construction of these alternatives to wildlife would be similar to those expected from the rest of the alternatives. No significant adverse effects are expected to impact commonly occurring wildlife species as a result of construction activities included in this alternative. However, restoration and expansion of native vegetation by the project would provide additional and improved wildlife habitat and result in a long-term beneficial impact to wildlife.

Opportunities for wildlife movement would be marginally improved in this alternative. These alternatives include restoration of historic riparian habitat adjacent to the stream corridors. The restored habitat will connect to other habitats currently existing within the riparian zone in several areas. By reestablishing natural riparian hydrology, key ecological processes may be restored such as a more natural disturbance regime, scour and deposition of sediment and vegetation, nutrient cycling, biotic interactions, and colonization of new habitat areas (Opperman et al., 2007), as well as improved wildlife movement between the river and floodplain.

Similar to the riverine restoration alternatives, alternatives which propose to restore riparian hydrology, would be expected to result in marginal increases of local and migratory bird populations within the watershed. The marginal increase in bird populations is not expected to significantly increase the likelihood of bird and airplane collisions near the two local airports.

6.5.2.4 Native Plant Community Restoration (P)

Impacts from construction of these alternatives to wildlife would be similar to those expected from the rest of the alternatives. No significant adverse effects are expected to impact these commonly occurring wildlife species as a result of construction activities included in this alternative. However, restoration and expansion of native vegetation by the project would provide additional and improved wildlife habitat and result in a long-term beneficial impact to wildlife.

Two airports are located in the vicinity of the proposed restoration sites. The Louisville International Airport is located approximately two miles to the southwest of site X10 on the South Fork of Beargrass Creek. Bowman Field, a smaller regional airport, is located less than one-half mile to Site X34, near Seneca Park on the Middle Fork of Beargrass Creek. While restoration of riverine habitat at these locations may increase the number of birds in the area, the increase in bird population is not expected to significantly increase the likelihood of bird and airplane collisions.

As with the other restoration alternatives, this alternative would be expected to result in long-term marginal increases of local and migratory bird populations within the watershed. The increase in bird populations is not expected to significantly increase the likelihood of bird and airplane collisions near the two local airports.

6.5.2.5 Recreation Plan

Implementation of the recreation plan would require some minor and localized disturbances to vegetation and temporary increases in noise during installation of recreational features. The new features may attract more visitors, which could cause some wildlife to vacate the immediate area due to the increased presence of humans. However, most features would be installed within areas that currently experience recreational use and the enhancement or realignment of trails may act to reduce impacts to wildlife by better controlling pedestrian traffic. Furthermore, most wildlife present in the project area are accustom to the recurrent disturbances that are inherent within an urban environment. For these reasons, adverse impacts to wildlife from implementation of the recreation plan is expected to be negligible.

6.5.2.6 No Action Alternative

Under the No Action Alternative, it is anticipated that non-native species will continue to invade, and that native habitat and wildlife diversity will decline. Due to the urbanization in the study area, the existing degraded habitat and ecological functions would persist with implementation of the No Action Alternative.

6.5.3 Fish

6.5.3.1 Connectivity of Riverine Habitats (C)

Under these alternatives, construction activities in the river channel may result in disturbance to native fish through disturbance of habitat and invertebrate prey items, as well as through increased turbidity with potential sediment runoff into the river. Construction equipment working near the river has the potential to introduce sediment or pollutants into the water, although BMPs will be implemented to minimize this potential.

Fish may be exposed to suspended sediment concentrations during construction, which may negatively impact fish in the immediate vicinity. It is expected that most fish would avoid the immediate construction area due to increased noise levels, turbidity, and oxygen depletion resulting from increased sediment load in the river. The proposed project will implement water quality BMPs during construction (BMPs are outlined Section 6.4.1) and will operate under applicable federal and state permits, which would protect water quality and minimize impacts to fish. Any construction-related impacts to fish would be temporary and less than significant.

Barriers such as dams, perched culverts, cross channel pipes, etc., interrupt longitudinal connectivity and promote species isolation, thus affecting fish movements made for reproduction, feeding and habitat colonization purposes which may reduce genetic diversity, while possibly promoting the spread of invasive species (Falke and Gido, 2006). Improving the longitudinal connectivity of stream system should reduce these pressures on native fish populations and result in long-term benefits to fishes by allowing normal upstream and downstream fish movements to occur.

6.5.3.2 Riverine Habitat Restoration (R1, R2, R4)

Under these alternatives, construction activities would result in temporary and minor impacts to fish, similar to those of the connectivity alternatives. Impacts would also be minimized by utilizing the same BMPs and operating under applicable federal and state permits.

Restoration of riverine habitat would result in direct beneficial impacts to fish by providing refugia from high water velocities, increasing interstitial spaces for prey species, and providing ambush points for predatory fish. These alternatives would likely result in a local increase in species richness and abundance of native fish species through improved riverine hydraulics, reconnection of the river to the floodplain, and reestablishment of proper channel development. Refer to Table 25 in Section 5.3.2 for the proposed linear footage of stream to be restored at each site.

6.5.3.3 Riparian Hydrology Restoration (H2)

Under these alternatives, construction activities adjacent to the stream may result in temporary and minor impacts to fish, similar to those of the connectivity alternatives. Impacts would also be minimized by utilizing the same BMPs and operating under applicable federal and state permits.

The restored habitat would be expected to provide benefits to fish by facilitating biological and chemical removal of constituents that contribute to the stream's impairment. These alternatives would result in long-term beneficial Impacts to fish.

6.5.3.4 Native Plant Community Restoration (P)

Under these alternatives, construction activities adjacent to the stream, such as clearing and grubbing may result in temporary and minor impacts to fish, similar to those of the connectivity alternatives. Impacts would also be minimized by utilizing the same BMPs and operating under applicable federal and state permits.

A restored riparian plant community can protect streams from nonpoint source pollutants and improve the quality of degraded stream water. Removal of invasive plant species and restoration of native vegetation along the Three Forks of Beargrass Creek would result in a long-term beneficial impact to fish through improved water quality. Improved riparian vegetation would also increase shading of the river, which may reduce microclimate temperatures, allow for increased dissolved oxygen levels making these areas more inhabitable for native fish species.

6.5.3.5 Recreation Plan

Implementation of the recreation plan would include some minor and localized disturbances to soils from installation of features which could result in an increase in runoff and sedimentation of nearby stream. Erosion control measures would be implemented when and where necessary to minimize soil loss during and after installation of features, and therefore minimize potential impacts to water resources and aquatic organisms. Any recreational features that may involve the placement of fill into waters of the U.S. will comply with all applicable sections of the Clean Water Act to ensure water quality standards are maintained. For these reasons, implementation of the recreation plan is expected to have negligible adverse impacts to fish and other aquatic organisms.

6.5.3.6 No Action Alternative

Fish communities within the Three Forks of Beargrass Creek have been greatly impacted from the adverse effects to the stream from surrounding urbanization. Poor water quality and decreased habitat quantity and quality have contributed to the decline in health of the stream's fish communities. Under the No Action Alternative, the continued degradation of water quality and habitat would be expected to persist into the foreseeable future.

6.5.4 Special Status Species

6.5.4.1 Connectivity of Riverine Habitats (C)

Listed species that may potentially occur within the study site include the gray bat, Indiana bat, northern long-eared bat, and running buffalo clover. No roosting locations for the bats are known within the watershed, but suitable habitat is present for Indiana bats and northern long-eared bats which have the potential utilize riparian trees along the stream for roosting in the summer months.

The removal of trees greater than three inches diameter at breast height (DBH) would be avoided during construction activities to eliminate the potential for disturbing roosting habitat. Implementation of alternatives that restore the connectivity of riverine habitat would have no effect on the gray bat, Indiana bat, or northern long-eared bat.

Running buffalo clover grows in partially shaded woodlands along streams. Although this species is not currently known to occur at any of the study sites, there is a possibility it exists. Once areas of disturbance are identified in the design phase of this project, surveys will be completed to ensure running buffalo clover is not impacted from construction activities. For this reason, implementation of alternatives to restore the connectivity of riverine habitat may affect, but is not likely to adversely affect, running buffalo clover.

There would be no effect to designated critical habitats as there are none in any of the study areas.

6.5.4.2 Riverine Habitat Restoration (R1, R2, R4)

Alternatives implemented to restore riverine habitat would benefit endangered and threatened species if they were to colonize the study site. Restoration features would directly increase the quality of the habitat present within the Beargrass Creek watershed, which could potentially encourage colonization of the area by special status species such as the Indiana bat, northern long-eared bat, and gray bat.

Given the highly mobile nature of these bat species, a restriction on tree removal between April 1 through October 31 would be imposed to reduce any potential for harm to bats during the summer maternity season. While direct impacts to these species would be limited by these tree clearing restrictions, the loss of potential habitat from project construction could affect bat species. Implementation of this alternative would result in an estimated 16.6 acres of trees to be removed due to streambank grading and construction of access roads. Because of these impacts to habitat, USACE has determined that alternatives implemented to restore riverine habitat may affect and are likely to adversely affect the Indiana bat and the northern long-eared bat. These adverse impacts would be short-term in nature, and once implemented, alternatives to restore riverine habitat would be expected to result in long-term benefits to these species by improving the drinking water sources and increasing the abundance of aquatic emergent insects which are a source of food for bats. The restoration of riverine habitat would ultimately result in positive long-term impacts to these species.

Adverse effects to the Indiana bat would be mitigated through a payment to the Imperiled Bat Conservation Fund (IBCF), utilizing the process set forth in the Revised Conservation Strategy for Forest-Dwelling Bats in the Commonwealth of Kentucky. In a July 9, 2021, letter, USFWS agreed that the proposed project is consistent with the IBCF process, and thatUSACE has satisfied the requirements for consultation of section 7 of the Endangered Species Act for this project.

For the northern long-eared bat, USACE submitted its effects determination to USFWS using the Information and Planning and Consultation (IPaC) system. In a June 10, 2021, letter, USFWS verified that the Recommended Alternative, which includes alternatives to restore riverine habitat, is consistent what has been analyzed by USFWS in a Programmatic Biological Opinion (PBO) regarding activities that would not contribute to the loss of the northern long-eared bat, and therefore the PBO satisfies and concludes

USACE's responsibilities for this action under ESA Section 7(a)(2) with respect to the northern long-eared bat. The USFWS verification letter is included in Appendix F.

No caves would be impacted from construction of this alternative and, therefore, no impacts to gray bat roosting habitat or hibernacula would be anticipated. Because the restoration of riverine habitat would be expected to result in long-term benefits to these species USACE has determined that implementation of this alternative may affect, but is not likely to adversely affect, the gray bat.

Once more specific areas of disturbance are identified in the design phase of this project, surveys will be completed to ensure running buffalo clover is not impacted from construction activities. For this reason, USACE has determined that implementation of alternatives to restore riverine habitat may affect but is not likely to adversely affect running buffalo clover.

6.5.4.3 Riparian Hydrology Restoration (H2)

Construction activities associated with implementation of alternatives to restore riparian hydrology would have similar impacts to listed species as those alternatives to restore riverine habitat. The same tree removal restrictions would also be implemented for protection of maternal roosts, but an initial loss of habitat may occur during construction from tree removal. Implementation of this alternative would result in an estimated 7.4 acres of trees to be removed from construction of access roads and conversion of small amounts of early-successional stage forest to wetland habitat. Long-term effects to the species are expected to be beneficial due to an increase in the quality and quantity of riparian habitat and the potential increase in emergent aquatic insects from the creation of wetlands. For these reasons, USACE has determined that this alternative to restore riparian hydrology may affect, and is likely to adversely affect, the Indiana bat and northern long-eared bat.

As with the other action alternatives, adverse effects to the Indiana bat would be mitigated through a payment to the IBCF. In the July 9, 2021, letter, USFWS agreed that the proposed project is consistent with the IBCF process, and that USACE has satisfied the requirements of section 7 of the Endangered Species Act for this project.

For the northern long-eared bat, USACE submitted its effects determination to USFWS using the IPaC. In a June 10, 2021, letter, USFWS verified that the Recommended Alternative, which includes alternatives to restore riverine habitat, is consistent with activities analyzed in its PBO and therefore the PBO satisfies and concludes USACE's responsibilities for this action under ESA Section 7(a)(2) with respect to the northern long-eared bat. The USFWS verification letter is included in the Environmental Appendix F.

No caves would be impacted from construction of this alternative and, therefore, no impacts to gray bat roosting habitat or hibernacula would be anticipated. Because the restoration of riparian hydrology and wetlands would be expected to result in long-term benefits to the species, USACE has determined that implementation of these alternative may affect, but is not likely to adversely affect, the gray bat.

Pre-construction surveys for the presence of running buffalo clover would be performed to ensure no impacts to this species. Additionally, native plantings that include running buffalo clover plugs would be used for the restoration of areas deemed suitable for the species. For these reasons, USACE has determined that alternatives to restore riparian hydrology may affect, but are not likely to adversely affect, running buffalo clover.

6.5.4.4 Native Plant Community Restoration (P)

Construction activities associated with implementation of alternatives to restore native plant communities would have similar impacts to listed species as those alternatives to restore riverine habitat. The same tree removal restrictions would also be implemented for protection of maternal roosts, and any potential roost trees would be left undisturbed during the summer maternity season. Implementation of this alternative would result in an estimated 12.4 acres of trees to be removed from construction of access roads and large-scale clearing of invasive plant species to prepare for plantings of native species. For these reasons, USACE has determined that this alternative may affect, and is likely to adversely affect, the Indiana bat and northern long-eared bat.

As with the other action alternatives, adverse effects to the Indiana bat would be mitigated through a payment to the IBCF. For the northern long-eared bat, the effects determination submitted by USACE to USFWS through the IPaC system included this alternative; therefore, the June 10, 2021, PBO verification letter is also applicable for this alternative.

No caves would be impacted from construction of this alternative and no impacts to gray bat roosting habitat or hibernacula would be anticipated. Because the restoration of riparian hydrology and wetlands would be expected to result in long-term benefits to the species, USACE has determined that implementation of these alternative may affect, but is not likely to adversely affect, the gray bat.

Once more specific areas of disturbance are identified in the design phase of this project, surveys will be completed to ensure running buffalo clover is not impacted during construction. Running buffalo clover will also be included in the herbaceous seed mix for sites that include habitat preferable for the species. For these reasons, USACE has determined that implementation of this alternative may affect, but is not likely to adversely affect, running buffalo clover.

This alternative would be expected to result in an increase in the quality and quantity of riparian habitat, which would result in long-term beneficial effects to listed species.

6.5.4.5 Recreation Plan

Implementation of the recreation plan would require some minor and localized disturbances to vegetation and temporary increases in noise during installation of recreational features. The new features may attract more visitors, which could disturb any bats that may be present. However, most features would be installed within areas that currently experience recreational use and the enhancement or realignment of trails may act to reduce impacts to wildlife by better controlling pedestrian traffic. No roost locations of Indiana bat or northern long-eared bat are known at the restoration sites, and the installation of recreational features would not require the removal of any trees with a diameter greater than three inches. For these reasons, USACE has determined that implementation of the recreation plan would have no effect to the Indiana bat or northern long-eared bat.

Once more specific areas of disturbance are identified in the design phase of this project, surveys will be completed to ensure running buffalo clover is not impacted from implementation of the recreation plan. For this reason, USACE has determined that implementation of this alternative would have no effect on running buffalo clover.

6.5.4.6 No Action Alternative

Under the no action alternative, it is anticipated that non-native species will continue to invade, and that native habitat and wildlife diversity will decline. Due to the urbanization in the study area, the existing degraded habitat and ecological functions would persist with implementation of the No Action Alternative. Because none are known to occur in the study area, the No Action Alternative would have no effect to listed species.

6.6 Impacts to Waters of the United States from the Action Alternatives

The Recommended Plan consists of all four types of action alternatives in some measure. An evaluation of compliance of the Recommend Plan with Section 404 of the Clean Water Act, has been prepared (Appendix K). This evaluation finds that work in jurisdictional waters associated with the Recommended Plan would comply with Section 404 since it would meet the terms and conditions of the 2022 Department of the Army Nationwide Permit 27 for aquatic habitat restoration, establishment, and enhancement activities. Preliminary findings of compliance with Section 404 have been documented in the draft Section 404(b)(1) analysis included in Appendix K of this IFR.

6.6.1 Connectivity of Riverine Habitats (C)

No wetland delineation has been completed to date to identify jurisdictional wetlands. For planning purposes, National Wetland Inventory information was consulted. Riverine wetlands are the only wetland type of Waters of the United States (WOTUS) found in the study areas.

Construction activities for alternatives intended to address connectivity of riverine habitat would occur in the streams. Water quality BMPs will be implemented during construction (BMPs are outlined 4.8.3) and all applicable federal and state permits will be obtained prior to construction, which would minimize adverse impacts to WOTUS. Any construction-related impacts to WOTUS would be temporary and not significant.

Restoration activities implemented under this alternative would provide long-term beneficial impacts to WOTUS.

6.6.2 Riverine Habitat Restoration (R1, R2, R4)

Construction activities for alternatives intended to improve riverine habitat quality would occur in the streams. Water quality BMPs will be implemented during construction (BMPs are outlined 5.4.1) and all applicable federal and state permits will be obtained prior to construction, which would minimize adverse impacts to WOTUS. Any construction-related impacts to WOTUS would be temporary and less than significant.

Restoration activities implemented under this alternative would provide long-term beneficial impacts to WOTUS. Refer to Table 25 in Section 5.3.2 for the proposed linear footage of stream to be restored at each site.

6.6.3 Riparian Hydrology Restoration (H2)

Any construction-related impacts from alternatives implemented to restore riparian hydrology would be temporary and insignificant. Restoration activities implemented under this alternative would provide long-term beneficial impacts to WOTUS and would likely result in the creation of new wetland within the riparian zones of each fork of Beargrass Creek. Refer to Table 25 in Section 5.3.2 for the proposed acres of wetland habitat to be restored at each site.

6.6.4 Native Plant Community Restoration (P)

Any construction-related impacts from alternatives implemented to restore native plant communities would be temporary and insignificant. Restoration activities implemented under this alternative would provide long-term beneficial impacts to WOTUS.

6.6.5 Recreation Plan

Implementation of the recreation plan would include some minor and localized disturbances to soils from installation of features such as benches, signage, viewing platforms, and from trail enhancement, creation, and/or realignment. Erosion control measures would be implemented when and where necessary to minimize soil loss during and after installation of features which will minimize potential impacts to water resources from stormwater runoff. Any recreational features that may involve the placement of fill into waters of the U.S. will comply with all applicable sections of the Clean Water Act to ensure water quality standards are upheld.

6.6.6 No Action Alternative

Under the No Action Alternative, implementation of restoration features would not occur, so no impact to WOTUS would occur.

6.7 Cultural Resources

The Recommended Plan may have an effect on twenty-one NRHP listed historic properties and eight historic districts within a half mile of the project areas. The 21 NRHP listed historic properties include the Eclipse Woolen Mill, Hadley Mary Alicia House, Hope Worsted Mills, Howard Getty's House, Klotz Confectionary Company, Leslie Abbott House, L&N Steam Locomotive No.152, Nelson Distillery Warehouse, Paget House and Heigold House Facade, Schneikert Valentine House, St. Frances of Rome School, St. Therese Roman Catholic Church, School, and Rectory, Steam Engine Company No.4 and No. 10, Wirth, Lang and Company - The Louisville Leather Company Tanner Building, Brown Theodore House, Cave Hill Cemetery/Cave Hill National Cemetery, Commodore Apartment Building, Olmsted Park System of Louisville, and Peterson-Dumesnil House. The eight historic districts include the Crescent Hill Historic District, Clifton Historic District, Oxmoor Historic District, Mockingbird Valley Historic District, Cherokee Triangle Area Residential District, Gardencourt Historic District Olmsted Park System of

Louisville, and Highlands Historic Districts. In addition to the previously recorded historic properties and historic districts, ten previously recorded archaeological sites [15JF22, 15JF27, 15JF28, 15JF30, 15JF553, 15JF592, 15JF645, 15JF668, 15JF734, 15JF820] that have not been evaluated for listing to the NRHP are located within the Recommended Plan. USACE will continue to complete identification and evaluation efforts for any other currently unidentified historic properties and cultural resources within the Recommended Plan under the terms of the PA (see Appendix G for a copy of the PA). USACE and the KY SHPO agreed to develop and execute a PA outlining the delayed identification of historic properties for the project. The PA also outlines any mitigation measures for historic properties that may be affected by the project. A copy of the executed PA and copies of all agency and Tribal communications can be found in Appendix G.

6.7.1 Action Alternatives

Construction activities for any of the action alternatives considered may have an effect on historic properties including any NRHP listed historic property and any unevaluated archaeological sites.

6.7.2 No Action Alternative

Under the No Action Alternative, there would be no effect on cultural resources or historic properties.

6.8 Noise

6.8.1 Action Alternatives

Construction activities for any of the Action Alternatives would cause a minor and temporary increase in local noise levels during the day beyond the current conditions. The minor noise effects would stem from machinery utilized for grading banks, placing cobble riffles, and removal of vegetation. Long term, significant effects in terms of noise are not expected.

6.8.2 Recreation Plan

Implementation of the recreation plan would require some localized and temporary increases in noise during installation of recreational features. The new features may attract more visitors, which could increase ambient noise levels slightly when they are present. Long term, significant increases in noise are not expected.

6.8.3 No Action Alternative

Under the No Action Alternative, implementation of restoration features would not occur, so there would be no impact to noise levels.

6.9 Recreational, Scenic, and Aesthetic Resources

6.9.1 Connectivity of Riverine Habitats (C)

Construction activities for alternatives to restore connectivity of riverine habitat would cause temporary adverse impacts to recreational, scenic, and aesthetic resources of the study sites, as restoration measures are implemented. These alternatives could result in long-term beneficial impacts to scenic and aesthetic qualities of stream reaches as man-made hard structures and replaced or modified by adding more natural elevation transitions such as riffles. No effect to recreational resources is anticipated.

6.9.2 Riverine Habitat Restoration (R1, R2, R4)

Temporary impacts to scenic and aesthetic condition would occur during the construction phase of these alternatives. The proposed restoration measures under this alternative require large equipment to be present, extensive earthwork be done in some cases (R4), and mechanical removal of vegetation for bank grading. These alternatives would result in long-term beneficial impacts to scenic and aesthetic qualities of the stream reaches as they are modified to a more natural state with resultant meanders and improved channel development (formation of pools, riffles, and runs).

In areas regularly utilized for recreation, such as in the parks, where aesthetic appeal is particularly desirable, construction efforts would be streamlined to occur quickly, to avoid interfering with recreational opportunities, and to affect as small an area as possible in order to minimize impacts. Staging areas would be located away from recreation sites as much as possible. Overall, due to the temporary nature of the impacts to visual resources, and the objective of creating dramatically improved visual conditions as a result of restoration, the adverse impacts are less than significant.

6.9.3 Riparian Hydrology Restoration (H2)

Construction activities for alternatives to restore riparian hydrology would cause temporary adverse impacts to recreational, scenic, and aesthetic resources of the study sites, as restoration measures are implemented. These alternatives could result in long-term beneficial impacts to scenic and aesthetic qualities of study areas habitat is restored. No effect to recreational resources is anticipated.

6.9.4 Native Plant Community Restoration (P)

Construction activities for alternatives to restore native plant communities would cause temporary adverse impacts to recreational, scenic, and aesthetic resources of the study sites, as restoration measures are implemented. These alternatives could result in long-term beneficial impacts to scenic and aesthetic qualities of study areas habitat is restored. No effect to recreational resources is anticipated.

6.9.5 Recreation Plan

Implementation of the recreation plan would be expected to result in improved access to the stream for surrounding communities, enhanced quality and quantity of trails for multiple users, and improved viewsheds of the stream and surrounding habitats. Communities could realize direct benefits through the enhancement of access to green space and improvement of viewsheds.

6.9.6 No Action Alternative

No impacts to recreational, scenic, and aesthetic resources would occur from construction under this alternative because construction would not occur. The study sites suffer from extensive invasive plant species and degraded aquatic and terrestrial habitats. Without restoration efforts, these trends are expected to continue.

6.10 Hazardous, Toxic and Radioactive Waste

6.10.1 Action Alternatives

Project implementation is not expected to impact or be impacted by HTRW or related environmental issues. A HTRW Phase I Environmental Site Assessment (Appendix F) has been completed no HTRWs were identified in the project footprint. Phase 1 Environmental Site Assessments are intended to reduce, but may not completely eliminate, the chance of encountering issues during project implementation. Although no HTRW or Recognized Environmental Condition (REC) are anticipated on the project site based on the Phase I investigation, any issues identified during design or construction would be resolved as required by regulation (ER 1165-2-132); any response-related costs to address HTRW on the site, including determining the extent of contamination, waste disposal and other response costs would be 100% NFS cost. Any HTRW or REC identified would require resolution prior to project implementation.

Although no HTRW or REC are anticipated on the project site based on the Phase I investigation, any issues identified during design or construction would be resolved as required by regulation (ER 1165-2-132); any hazardous waste or remedial action costs would be 100 percent NFS cost. Any HTRW or REC identified would require resolution prior to project implementation. This may require adjustment of the construction schedule to allow for the remediation. If HTRW is discovered on a proposed restoration site and presents too great a risk or cost to remediate, the site may be screened from the plan or adjusted to avoid HTRW, dependent upon the connectivity of the site to other sites and its respective location within the watershed.

6.10.2 Recreation Plan

No impacts to public health and safety from release of HTRW would occur from implementation of the recreation plan.

6.10.3 No Action Alternative

No impacts to public health and safety from release of HTRW would occur from construction under this alternative because construction would not occur.

6.11 Socioeconomics and Environmental Justice

6.11.1 Action Alternatives

None of the Action Alternatives are expected to significantly affect environmental justice populations (minority and/or low-income populations) during construction. The alternatives may result in minor and temporary adverse effects, such as increased noise or dust around the construction areas, which may affect adjacent populations. However, these effects would be managed by implementing BMPs and staying within noise limits and construction periods specified in city and county plans. All populations adjacent to the construction area would be affected equally, rather than environmental justice populations being disproportionately affected. It is likely that all communities adjacent to the stream would experience similar levels of temporary adverse effects mentioned above. However, the nature of this restoration study is such that study location is entirely driven by the location of the streams and cannot be located elsewhere. Moreover, adverse effects are temporary in nature.

Furthermore, the Action Alternatives may result in beneficial impacts to socioeconomic conditions in the study area. Improved aesthetic quality of the streams, improved habitat value, improved quality and quantity of recreation resources along the streams, and improved accessibility would be the catalyst for these beneficial effects such as improvements in environmental quality (such as water quality) in the region as a result of a cleaner, active riverine system would benefit all populations in the study area.

6.11.2 Recreation Plan

Implementation of the recreation plan would be expected to result in several benefits to the local and regional community. Direct benefits to the communities where the recreation features are proposed would include improved public health benefits related to access to green space, opportunity for recreation related/adjacent business and eco-tourism, opportunity for education about the stream's history and importance.

Socioeconomic benefits would be expected to occur beyond the proposed restoration site from trail enhancements and connections within the watershed that would connect to the Louisville Loop trail system, a 200-mile multi-use trail that encircles the metro area.

Other recreational features will be addressing underserved areas such as the MSD basin sites in lower income areas that need better access to greenspace. Additionally, the Eastern Creason Connector trail would connect several neighborhoods that currently do not have safe pedestrian access between them due to the arterial roads that dissect this part of the city.

6.11.3 No Action Alternative

Due to the existing level of development, it is unlikely that changes in the local or regional economy will result in drastic changes in land use, population, or demographics in the study area. Other factors such as gentrification, poverty rates, and local businesses can affect the local economy and land uses, but no clear trends have emerged at the time of this assessment. Any changes that do occur in the period of analysis would likely be coincident with larger regional trends and would not materially alter the conditions in which an ecosystem restoration study would be constructed.

Under the No Action Alternative, environmental justice considerations would not likely be altered substantially. Income and poverty in the assessment area appear to reflect national and regional trends of slow but increasing recovery from the recent recession. Unemployment in the assessment area is below that of the City or the County. The demographics of the assessment area may shift slowly in proportion to larger regional trends, but there is no indication for large shifts in demographics over the period of analysis.

6.12 Environmental Compliance

This IFR/EA is prepared pursuant to Sec. 102(C) of the National Environmental Policy Act (NEPA), and includes compliance with other laws, regulations and Executive Orders as discussed below (Table 34).

Table 34 Summary of Project Compliance with Environmental Laws, Policies, & Regulations

Law/Policy/Regulation - Federal Acts		Compliance Action
1	Bald and Gold Eagle Protection Act	Determination of no harm. See Section 6.12.8 of this document.
2	Environmental Justice (E.O. 12898)	Construction of the proposed project would not have a disproportionately high or adverse impact on minority or low-income populations.
3	Clean Air Act of 1970, as amended (42 USC 7401)	Increase in emissions during construction would be *de minimis*, conformity determination is not required.
4	Clean Water Act of 1977, as amended (33 USC. 1251 et seq.)	The proposed restoration project will fit the terms and conditions of Nation Wide Permit 27. USACE will complete coordination with KY DOW during the Design & Implementation Phase. A Kentucky Pollutant Discharge Elimination System (KPDES) permit will be secured for construction.
5	Endangered Species Act of 1973, as amended (16 USC 1531 et seq.)	Section 7 has been satisfied as stated in the USFWS concurrence letter dated July 9, 2021.
6	Farmland Protection Policy Act (FPPA) of 1981	The act exempts prime farmlands located within existing urban areas. The Beargrass Creek study area is located within the city limits of Louisville; therefore, the proposed project is exempt from the Farmland Protection Policy Act requirements.
7	Fish and Wildlife Coordination Act (FWCA), as amended (16 USC 661)	The FWCA is considered satisfied per USFWS letter to USACE dated July 9, 2021. See Appendix F.

8	Floodplain Management (E.O. 11988)	The proposed restoration project would avoid adverse impacts associated with the occupancy and modification of floodplains and would avoid support of floodplain development.
9	Migratory Bird Treaty Act of 1918, as amended (16 USC 703 et seq.)	Appropriate methods will be enacted to protect migratory birds that may utilize habitat within the project area. See Section 6.12.7.
10	National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.)	FONSI will be signed when the final report is approved by USACE Major Subordinate Command (Ohio River and Great Lakes Division).
11	National Invasive Species Act of 1996 (Public Law 104 – 332)	The restoration project would not facilitate introduction or spread of introduced aquatic nuisance species.
12	Nonindigenous Aquatic Nuisance Prevention & Control Act of 1990, as amended (16 U.S.C. 4701 et seq.)	The restoration project would not facilitate introduction or spread of introduced aquatic nuisance species.
13	Protection and Enhancement of Environmental Quality (E.O. 11514)	This EA has been prepared to document that the proposed restoration project is in compliance with the mandates of this EO.
14	Protection of Wetlands (E.O. 11990)	No net loss of jurisdictional wetlands anticipated.
15	Resource Conservation and Recovery Act (RCRA) of 1976, as amended (42 USC 6901, et seq.)	Investigations were conducted to assess the existence, nature and extent of HTRW within the project area. No hazardous wastes, as defined under Section 3001 of the RCRA were identified.
16	Responsibilities of Federal Agencies to Protect Migratory Birds (E.O. 13186)	The proposed restoration would contribute directly to the USFWS Migratory Bird Program goals to protect, conserve, and restore migratory bird habitats.
17	Safeguarding the Nation from the Impacts of Invasive Species (E.O. 13751)	This EA has been prepared to document that the proposed restoration project is in compliance with the mandates of this EO.
18	Wild and Scenic Rivers Act of 1968 (16 USC 1271-1287 Public Law 90-542 82 Stat. 906)	Beargrass Creek is not included under this Act.

6.12.1 Endangered Species Act

Pursuant to Section 7 of the Endangered Species Act of 1973, as amended, USACE determined that the Recommended Plan would have no effect to the following listed species: least tern, clubshell, fanshell, Northern riffle shell, orangefoot pimpleback, pink mucket, rabbitsfoot, ring pink, rough pigtoe, sheepnose, and spectaclecase. While they have historically been documented nearby in the Ohio River, these species are not known from the project footprint.

The Recommended Plan will potentially result in adverse effects to forest-dwelling bat species from habitat loss associated with tree clearing. As a result, USACE has determined the Recommended Plan may affect, and is likely to adversely affect, the Indiana bat and northern long-eared bat.

Adverse effects to the Indiana bat will be mitigated through a payment to the IBCF, utilizing the process set forth in the Revised Conservation Strategy for Forest-Dwelling Bats in the Commonwealth of Kentucky. In their response letter, USFWS agreed that the Recommended Plan is consistent with the IBCF process, and that USACE has satisfied the requirements of section 7 of the Endangered Species Act for this species.

For the northern long-eared bat, USACE submitted its effects determination for the Recommended Alternative to USFWS using the Information and Planning and Consultation system. In a June 10, 2021, letter, USFWS verified that the Recommended Alternative is consistent with activities analyzed in the PBO and therefore the PBO satisfies and concludes USACE's responsibilities for this action under ESA Section 7(a)(2) with respect to the northern long-eared bat.

USFWS concurred with USACE's determinations in a letter dated July 9, 2021. This letter can be found in Appendix F.

6.12.2 Fish and Wildlife Coordination Act

The purposes of the FWCA include recognizing the contribution of wildlife resources to the nation, acknowledging the increasing public interest and awareness of wildlife resources and ensuring that wildlife conservation receives due consideration in water resources development programs (16 USC 661). Under the FWCA, USFWS provides its recommendations to USACE to consider.

The District has provided details of the Recommended Plan to USFWS for comment. In their response letter, USFWS provided comments on the Recommended Plan and confirmed that the FWCA obligation is satisfied. The letter is contained in the Environmental Appendix F. USACE will continue to work with USFWS as well as other resource agencies and wildlife experts during PED to refine project designs and incorporate the specificity needed to achieve restoration goals and including connectivity in the context of the project's constraints.

6.12.3 Environmental Justice EO 12898

The Recommended Plan would not cause adverse human health effects or adverse environmental effects on minority populations or low-income populations. Executive Order 12898 (environmental justice) requires that, to the greatest extent practicable and permitted by law, and consistent with the principles set forth in the report on the National Performance Review, each federal agency make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions, the District of Columbia, the Commonwealth of Puerto Rico, and the Commonwealth of the Mariana Islands.

The proposed alternatives are not expected to significantly affect environmental justice populations during construction. The alternatives may result in other minor and temporary adverse effects that would be managed by implementing BMPs. No populations adjacent to the construction area would be disproportionately affected. The alternatives may result in beneficial impacts to socioeconomic conditions in the study area.

6.12.4 Clean Air Act

The temporary source emissions from this project, for any alternative, are *de minimis* in terms of the NAAQSs and the State Implementation Plan. Construction emissions will not cause or contribute to any new violation of NAAQS, increase the frequency of an existing violation, or delay the attainment of standard, interim emission reduction, or other milestone. Due to the small scale and short duration of this study, a General Conformity Analysis was not completed. All construction vehicles will comply with federal vehicle emission standards. USACE and its contractors comply with all federal vehicle emissions requirements. USACE follows EM 385-1-1 for worker health and safety and requires all construction activities to be completed in compliance with federal health and safety requirements. The project is not expected to be a significant source of greenhouse gas emissions.

6.12.5 Clean Water Act

Pursuant to the Clean Water Act of 1972, as amended, USACE has determined that the discharge of dredged or fill material associated with the Recommended Plan is in compliance with Section 404 of the CWA by meeting all conditions of the existing Department of Army Nationwide Permit No. 27 for aquatic habitat restoration, establishment and enhancement activities, as described in the March 15, 2021, Federal Register, Reissuance of Nationwide Permits; Notice (86 FR 2744), Appendix A (B) (27). See Appendix K for the District’s justifications for why the Recommended Plan meets the conditions and requirements of CWA Nationwide Permit (NWP) #27.

6.12.6 National Historic Preservation Act

Section 106 of the National Historic Preservation Act of 1966, as amended, requires federal agencies to take into account the effects of their undertakings on historic properties and afford the Advisory Council on Historic Preservation a reasonable opportunity to comment on such undertakings. The procedures in 36 CFR Part 800 define how federal agencies meet these statutory responsibilities. The Section 106 process seeks to accommodate historic preservation concerns with the needs of federal undertakings through consultation among the agency official and other parties with an interest in the effects of the undertaking on historic properties, including the SHPO or Tribal Historic Preservation Officer (THPO) and any Tribe that attaches religious or cultural significance to historic properties that may be affected by an undertaking. The goal of consultation is to identify historic properties potentially affected by the undertaking, assess its effects, and seek ways to avoid, minimize or mitigate any adverse effects on historic properties.

USACE and SHPO signed a Programmatic Agreement (PA) for the Project that delays the identification of historic properties prior to the signing of the FONSI and IFR. The PA was fully executed on September 8, 2021. The identification of historic properties will be conducted during design of the Recommended Plan. A copy of the final PA can be found in Appendix G. The PA will outline the process to identify historic properties within the Recommended Plan and the mitigation of any effects to identified historic properties. Both tasks will occur prior to construction of the Project.

6.12.7 Migratory Bird Treaty Act

The Recommended Plan will enact measures that remove non-native invasive species, which can also include trees that may house migratory bird nests. However, clearing and/or control of vegetation will be conducted outside of bird migration periods. Any and all trees that have been found to contain migratory bird nests will be avoided, and appropriate methods will be enacted to move forward with the study, such as implementing timing limitations based on the species affected or intensity of breeding activity (average nesting dates are May 15th to July 15th; inspection and clearing of project areas for migratory bird nesting by qualified personnel; and prioritization of opportunities to restore habitat based on significant species needs.

6.12.8 Bald and Gold Eagle Protection Act

The Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d) prohibits the taking, possession or commerce of bald and golden eagles, except under certain circumstances. Amendments in 1972 added to penalties for violations of the act or related regulations.

Information provided to USACE by the KY Department of Fish and Wildlife Resources indicates there are no known eagle nests near any of the proposed restoration sites; therefore, no take of either bald or golden eagles is likely through any of the project alternatives addressed in this IFR/EA.

6.12.9 Executive Order 11988 -- Floodplain Management

This Executive Order requires USACE to provide leadership and take action to (1) avoid development in the base (1 in 100 annual event) floodplain (unless such development is the only practicable alternative); (2) reduce the hazards and risk associated with floods; (3) minimize the effect of floods on human safety, health, and welfare; and (4) restore and preserve the natural and beneficial values of the base floodplain. To comply with this Executive Order, the policy of USACE is to formulate projects, which to the extent possible, avoid or minimize adverse effects associated with use of the base floodplain and avoid inducing development in the base floodplain unless there is no practicable alternative.

Although the proposed actions identified in this report would occur in the floodplain, they would not encourage growth within the floodplain and would have no adverse impacts in the floodplain. The Recommended Plan is proposing to restore 1,090 acres within the riparian zone and 8.8 miles of stream, which is consistent with existing City and County policies regarding land use and flood protection. Therefore, the Recommended Plan would not induce any development in the base floodplain.

6.12.10 Executive Order 11990 -- Protection of Wetlands

Under the provisions of Executive Order 11990, agencies shall provide leadership and shall 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 for (1) acquiring, managing, and disposing of Federal lands and facilities; and (2) providing federally undertaken, financed, or assisted construction and improvements; and (3) conducting federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

The Recommended Plan would restore wetlands in the Beargrass Creek watershed and would therefore directly support the objectives of this EO.-

6.12.11 Public Interest

This draft Feasibility Report with Integrated EA was sent to federal, state, and local agencies along with the public for a 30-day period of review in April/May of 2021.

6.13 Conclusion

In accordance with the National Environmental Policy Act of 1969, 42 U.S.C. § 4321-4347, as amended, the U.S. Army Corps of Engineers has assessed the environmental impacts associated with this project. The purpose of this EA is to evaluate the impacts that would be associated with the restoration of aquatic habitat within the Three Forks of Beargrass Creek.

The assessment process indicates that the final array of alternatives would not cause significant adverse impacts on the environment. These alternatives would be expected to have long-term beneficial impacts upon the ecological, biological, social, or physical resources of this area, and would provide environmental benefits to the Louisville Region.

7.0 Recommended Plan

As described in Chapter 5, from the ~16,000 watershed plans evaluated, P10240 was identified as the Recommended/NER Plan based on CEICA of ecological outputs at the site and system scales. This recommendation was also supported through assessment of social outputs and qualitative factors not captured in purely ecological approaches. The NER plan is a cost-effective alternative from an ecological perspective, but it is not a best buy. The choice to recommend a cost-effective plan was bolstered by the regional economic impacts, the improvement in environmental quality, other social effects analysis, and pairwise analyses, which identified a larger suite of benefits associated with site X35 over sites X4 and X8. The social units also verify the selection of the Recommended Plan by representing the social benefit to the community of the combined sites. The Recommended Plan provides numerous benefits to the community. These benefits include an increase in quality of life provided by access to green space, increased opportunity for recreation, improvements to air and water quality and support for current and future community plans. Moreover, the cost-effective recommendation (P10240) also allowed restoration actions to be executed in all three tributaries of the Beargrass Creek watershed, which embodies the overarching directive to restore the "Three Forks."

7.1 Optimization of National Ecosystem Restoration Plan

Prior to the Agency Decision Milestone in September 2021, the PDT performed plan optimization with the goal of decreasing overall implementation risk. The goals of this process were:

- Decrease implementation risk based on real estate
- Decrease cost and uncertainty of implementation
- Increase overall resolution of design

The PDT performed a site-by-site analysis similar to earlier plan formulation exercises. In most cases, real estate boundaries were pulled back to the mapped floodplain extents where lands are significantly less expensive. Sites that are currently in use for active recreation (such as playing fields) were excluded. Additionally, since the initial site selection occurred, more information has been gathered on real estate acquisitions and it was decided to avoid problematic areas that had initially been included in the Recommended Plan. No alternatives were changed in this process, only the boundaries of sites already selected for the Recommended Plan. The optimization process resulted in a 15% decrease in acreage and a 11% decrease in cost, with minimal impact to benefits (Table 35 & Table 36).

Table 35 Plan optimization changes in acreage.

	ORIGINAL	UPDATE	DIFFERENCE	
Site	**Acres**	**Acres**	**Acres**	**% Decrease**
X2 - CONFLUENCE	**66.4**	**65.5**	**1.0**	**1.4%**
X10 - ALPACA FARM / ZOO RIPARIAN	**69.7**	**44.2**	**25.5**	**36.6%**
X19 - SOUTH FORK / NEWBURG RIPARIAN	**23.6**	**23.5**	**0.1**	**0.5%**
X20 - BROWN PARK WETLAND / RIPARIAN	**33.0**	**29.9**	**3.1**	**9.4%**
X21 - ARTHUR DRAUT PARK WETLAND / RIPARIAN	**39.7**	**26.6**	**13.1**	**32.9%**
X22 - CONCRETE CHANNEL	**15.1**	**12.4**	**2.7**	**18.1%**
X29 – EASTERN CREASON CONNECTOR	**115.8**	**113.6**	**2.3**	**1.9%**
X30 - BEARGRASS CREEK STATE NATURE PRESERVE / JOE CREASON PARK	**121.8**	**108.8**	**13.0**	**10.7%**
X33 - MSD BASIN	**5.4**	**4.4**	**1.04**	**19.2%**
X34 - I-64 CORRIDOR / CHEROKEE PARK	**298.6**	**278.4**	**20.2**	**6.8%**
X35 - MUDDY FORK AND TRIBUTARIES	**40.8**	**34.0**	**6.8**	**16.7%**
X38 - CAVE HILL CORRIDOR	**36.1**	**27.4**	**8.7**	**24.1%**
TOTAL	**866.0**	**768.6**	**97.5**	**14.9%**

7.2 Ecosystem Restoration Features of the NER

The plan utilizes a wide range of ecological measures to improve riverine and riparian function and connectivity. A full list of sites and associated alternatives is listed in Table 36 below. Note that the project first cost estimate was rough order of magnitude and has been updated since the selection of the Recommended Plan.

Construction activities would temporarily disrupt wildlife and human use of the project area. Long-term productivity for natural resource management would benefit considerably by implementation of this plan. Long-term productivity would be enhanced through improved stream and riparian habitat, reestablishment of wetlands, and improved longitudinal and floodplain connectivity of the stream. Overall habitat diversity would increase, and both game and nongame wildlife species would benefit. Both consumptive and non-consumptive users would realize heightened opportunities for recreational use of the restored areas. Negative long-term impacts are expected to be minimal on all ecosystems associated with the Recommended Plan.

Table 36 Summary of Recommended Plan with optimized costs

Site	Site Name	Fork	Recommended Alternative	Lift (HUs)	Average Annual Cost ($)	Unit Cost ($/AAHU)	Project First Cost	Site Area (ac)	Social Units
X2	Confluence	South	CR2H2	19.6	$243,000	12,400	$7,097,000	65.5	47
X10	Alpaca Farm	South	CR2P	23	$313,000	13,600	$8,915,000	44.2	45.7
X19	Newburgh Rd	South	CR1H2	6.8	$105,000	15,400	$3,027,000	23.5	13.1
X20	Brown Park	Middle	CR2P	14.8	$100,000	6,800	$2,797,000	29.9	16.5
X21	Arthur Draut	Middle	CR2P	12.8	$71,000	5,600	$1,969,000	26.6	15.1
X22	Concrete Channel	South	H2	1.9	$78,000	40,100	$2,285,000	12.4	11.3
X29	Eastern/Creason Connector	South	CR4P	38	$736,000	19,400	$20,558,000	113.6	75.2
X30	Joe Creason Park	South	CR4P	46.7	$624,000	13,400	$17,504,000	108.8	81
X33	MSD Basin	South	H2	1.6	$17,000	10,700	$491,000	4.4	3.2
X34	Cherokee & Seneca	Middle	CR2P	121.1	$1,381,000	11,400	$38,342,000	278.4	209.6
X35	Muddy Fork and Tributaries	Muddy	CR2H2	4.2	$330,000	78,000	$9,428,000	34.0	19.3
X38	Cave Hill Corridor	Middle	R2P	6.4	$299,000	46,700	$8,722,000	27.4	19.3
All Sites				296.9	$4,303,000	14,500	$121,135,000	768.5	556.3

NOTE Project first costs are presented in FY22 levels and were annualized over a 50-year period of analysis (base year 2025) using the FY22 federal discount rate of 2.25%. Since the selection of this plan, this cost has been updated and is reflected in the Recommended Plan numbers.

7.2.1 Recommended Plan Description

The Recommended Plan consists of 12 sites – six on the South Fork, four on the Middle Fork, one on the Muddy Fork and one on the Confluence site. The plan is a total of 769 acres and will restore 8.8 miles of stream. The plan also includes the removal of 18 connectivity barriers throughout the watershed. The overall benefits come to 297 Average Annual Habitat Units and 556 Social Units. Average annual cost is $4,303,000 with a project first cost of $121,135,000. Project first cost is presented in FY22 levels and was annualized over a 50-year period of analysis (base year 2025) using the FY22 federal discount rate of 2.25%. Figure 50 shows the locations of all sites composing the Recommended Plan.

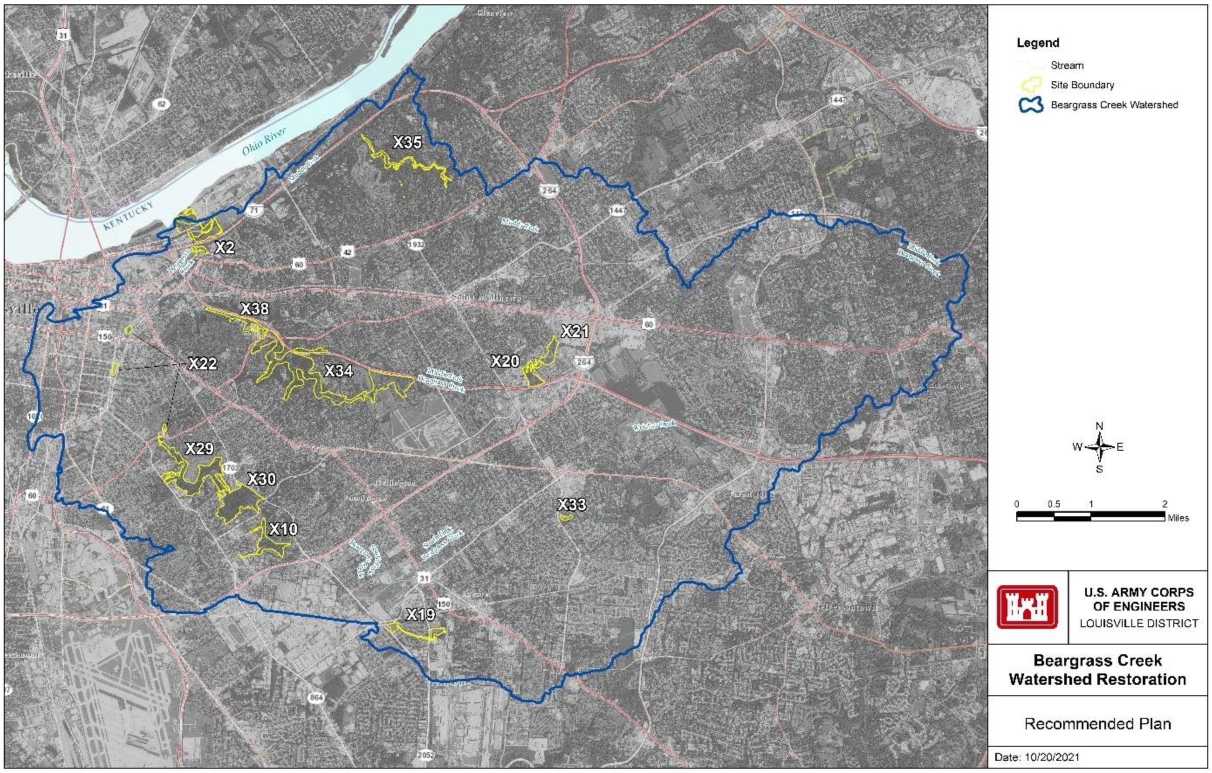

Figure 50 Mapping of All Sites included in the Recommended Plan

As discussed in previous chapters, the Recommended Plan will provide scarce habitat in a degraded urban watershed. Quality habitat in heavily populated areas is a scarce resource. This plan will not only increase the amount of habitat in the watershed, it will set an example of ecosystem restoration success in the urban environment. With the close ties of Beargrass to the history and development of the city of Louisville (as is common in many cities), there is also opportunity for education about the importance of urban stream health and a chance to foster stewardship in the surrounding community.

The Recommended Plan supports other watershed purposes outside of ecosystem restoration. Certain measures for habitat restoration such as the creation of wetlands, stream bank improvements and native plantings can have flood risk reduction benefits by adding floodwater storage and high-water access to floodplains. Water quality can be improved through removal of impervious surfaces and addition of planting that can increase filtration of water before it enters the system. Recreation opportunities are another benefit, especially considering that the project location is in an urban area within proximity to schools, trails, and parks.

Each site and recommended alternative included in the Recommended Plan is described below. The order of sites presented begins with the most upstream of each fork and works its way downstream to represent the downstream benefits of the restoration work in the upper reaches of each fork.

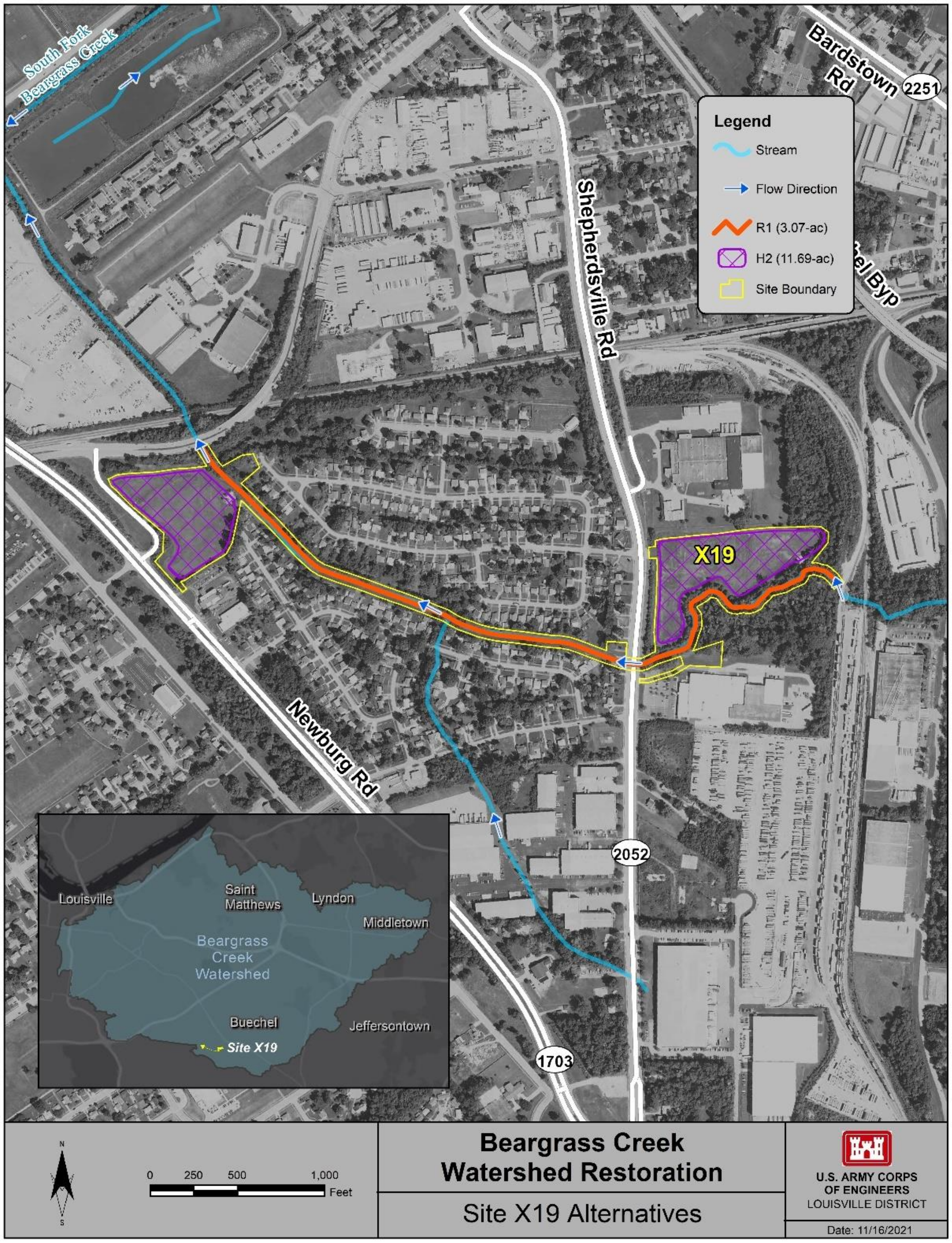

Figure 51 Conceptual Alternative Mapping for Site X19

Site X19 (Figure 51), Newburg Road, is in the upstream area of South Fork. This alternative includes retrofitting existing MSD basins with minimal excavation to create a sedge/wet meadow that will not negatively impact flood risk and planting native wetland species within the area of hydrologic resurgence. This alternative also includes placement of native rock structures and woody debris instream only between the basins to improve connectivity between the two restored basins.

Figure 52 Conceptual Alternative Mapping for Site X33

Site X33 (Figure 52), MSD Basin, is located on a tributary in the upstream area of the South Fork and includes retrofitting an existing basin. Similar to site X19, there will be minimal excavation to create a sedge/wet meadow that will not negatively impact flood risk since it is an existing basin. Appropriate native plant species would be seeded within in the basin area to create a more natural wetland area.

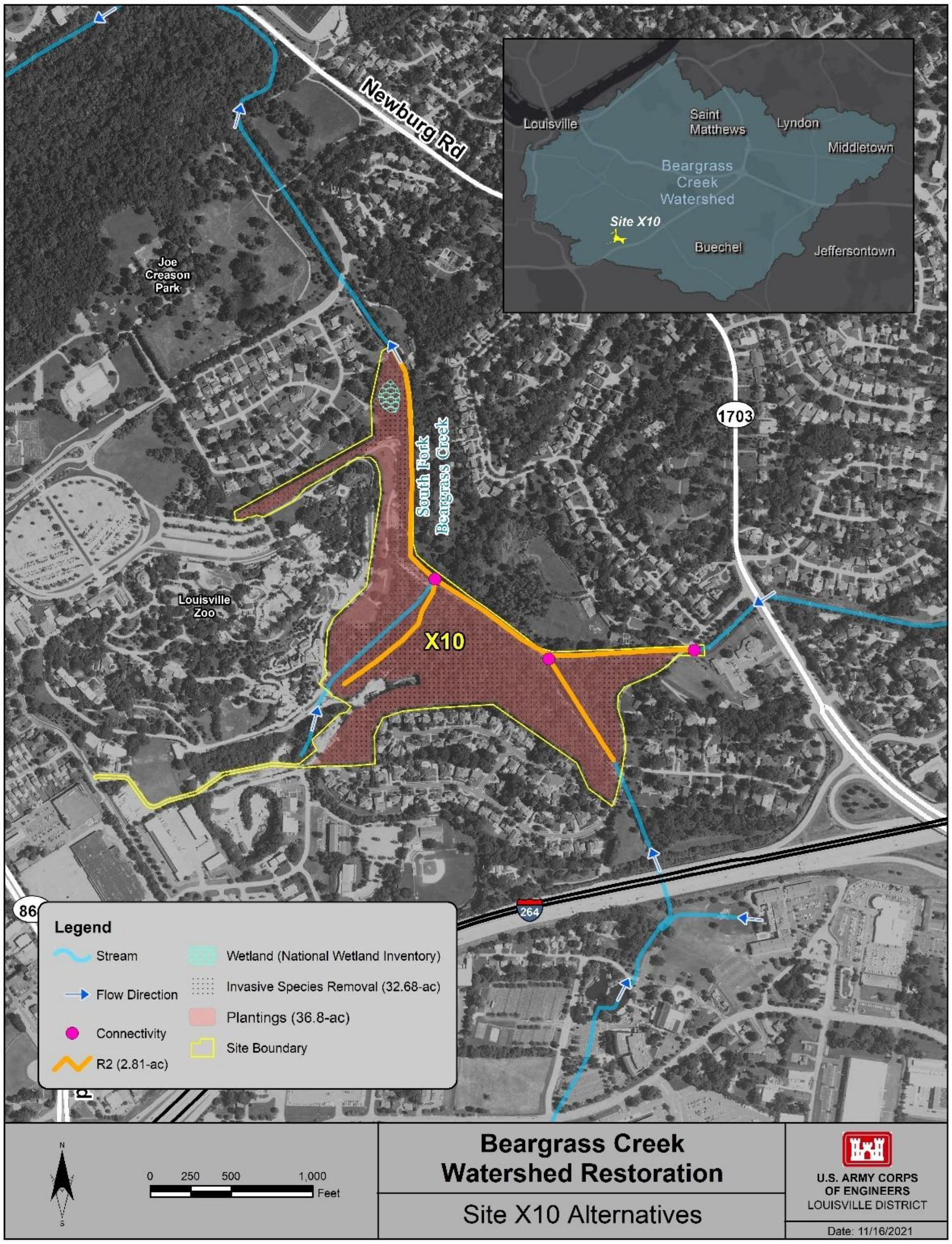

Figure 53 Conceptual Alternative Mapping for Site X10

Site X10 (Figure 53), the Alpaca/Zoo site is located just upstream of the Watterson Expressway on the South Fork. Restoration work includes 2.8 acres of R2 instream work. Instream conditions will be improved by adding native rocks structures and woody debris to overcome three identified barriers as well as grading of banks to improve floodplain connectivity. Work would also include 36.8 acres of native plantings and 32.7 acres of invasive species removal. This site also has recreation and education potential, as it is adjacent to the Louisville Zoo.

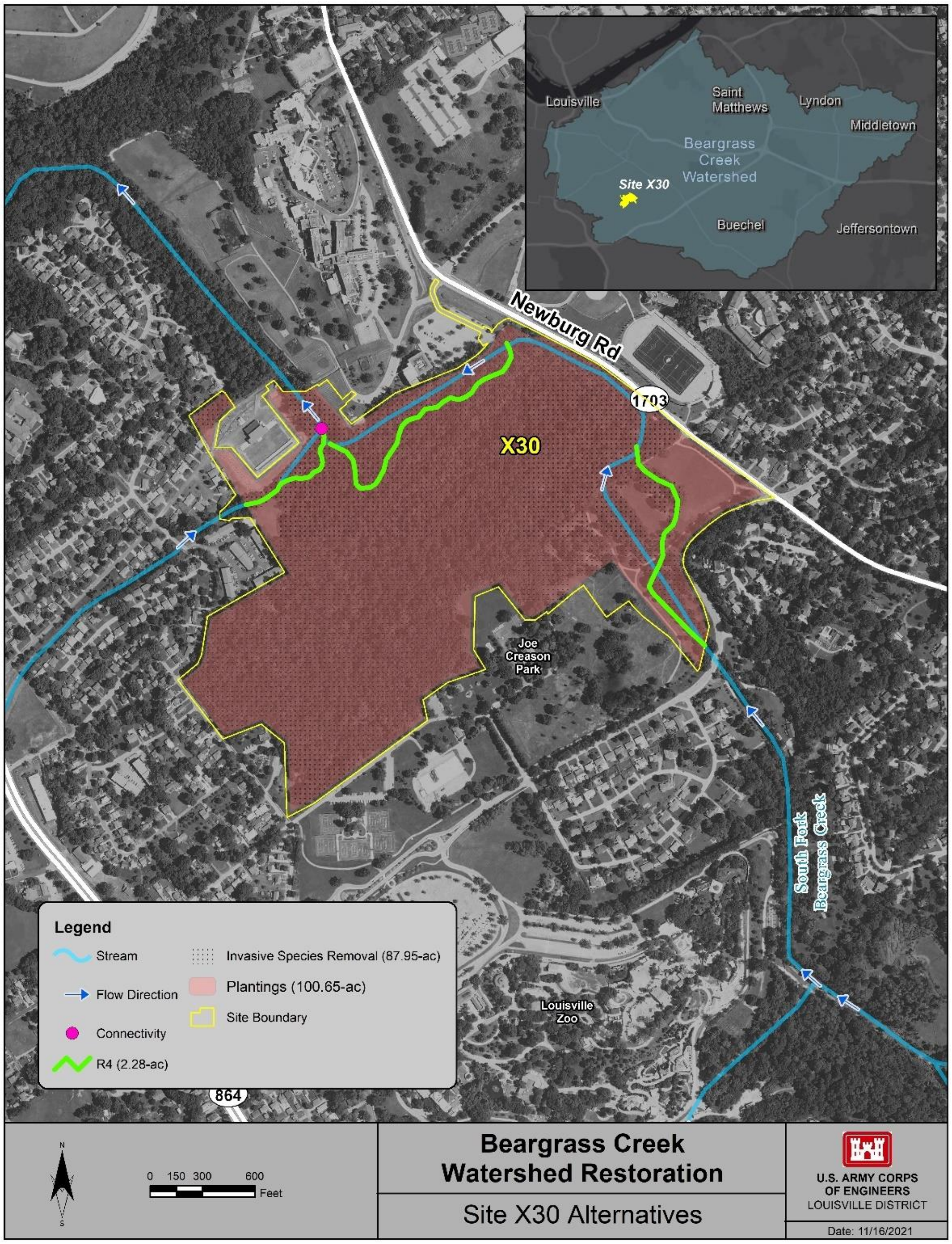

Figure 54 Conceptual Alternative Mapping for Site X30

Site X30 (Figure 54), Joe Creason Park, is located between sites X10 and X29 and includes riffles to overcome barriers. This work would include resculpting of the stream with placement of native rock structures and woody debris as well as plantings and invasive species removal. This site also provides an excellent opportunity for recreation and education, as the Beargrass Creek Nature Preserve is part of the site.

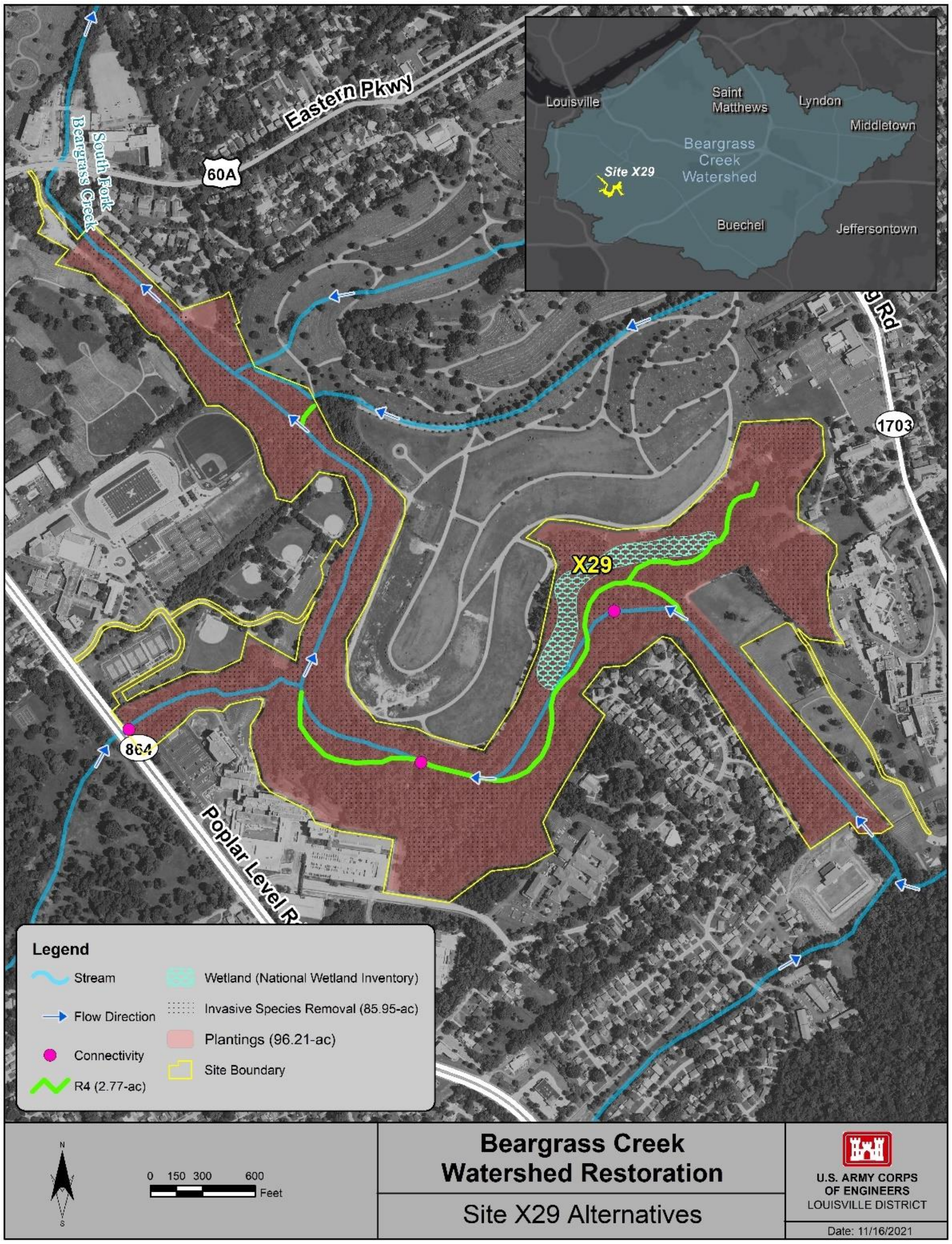

Figure 55 Conceptual Alternative Mapping for Site X29

Site X29 (Figure 55), Eastern Creason Connector, is located between X30 and X22 and includes riffles to overcome barriers at three points. Portions of the stream would be realigned with native rocks and woody debris placement, as well as plantings and invasive species removal throughout the site. This site has local interest in a recreational trail.

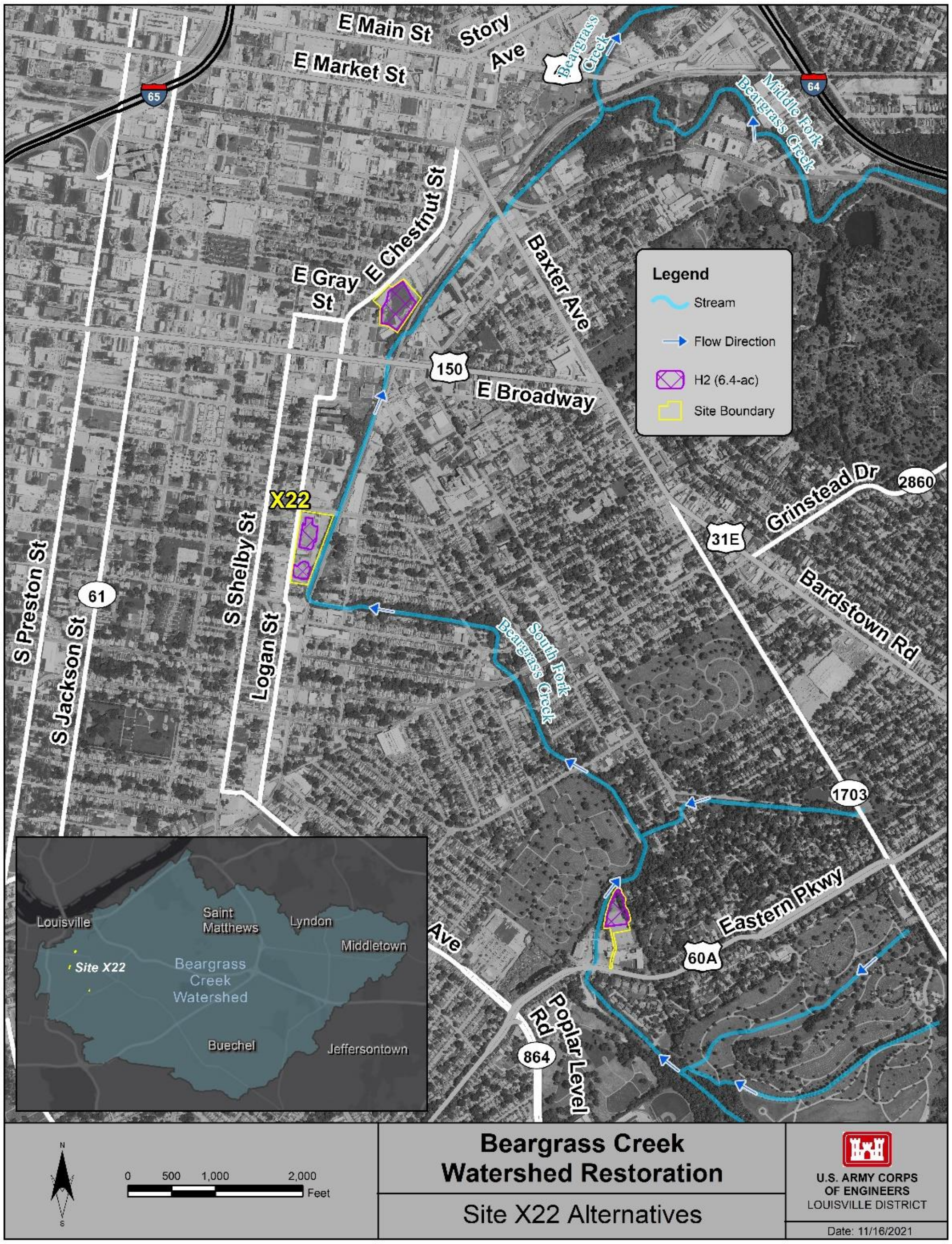

Figure 56 Conceptual Alternative Mapping for Site X22

Site X22 (Figure 56), the Concrete Channel, touches many neighborhoods and runs through the most densely populated area of all the reaches. This site includes hydrologic resurgence via basins at 4 sites along the channel. One site would include removal of a parking lot. All basins would include wetland plantings.

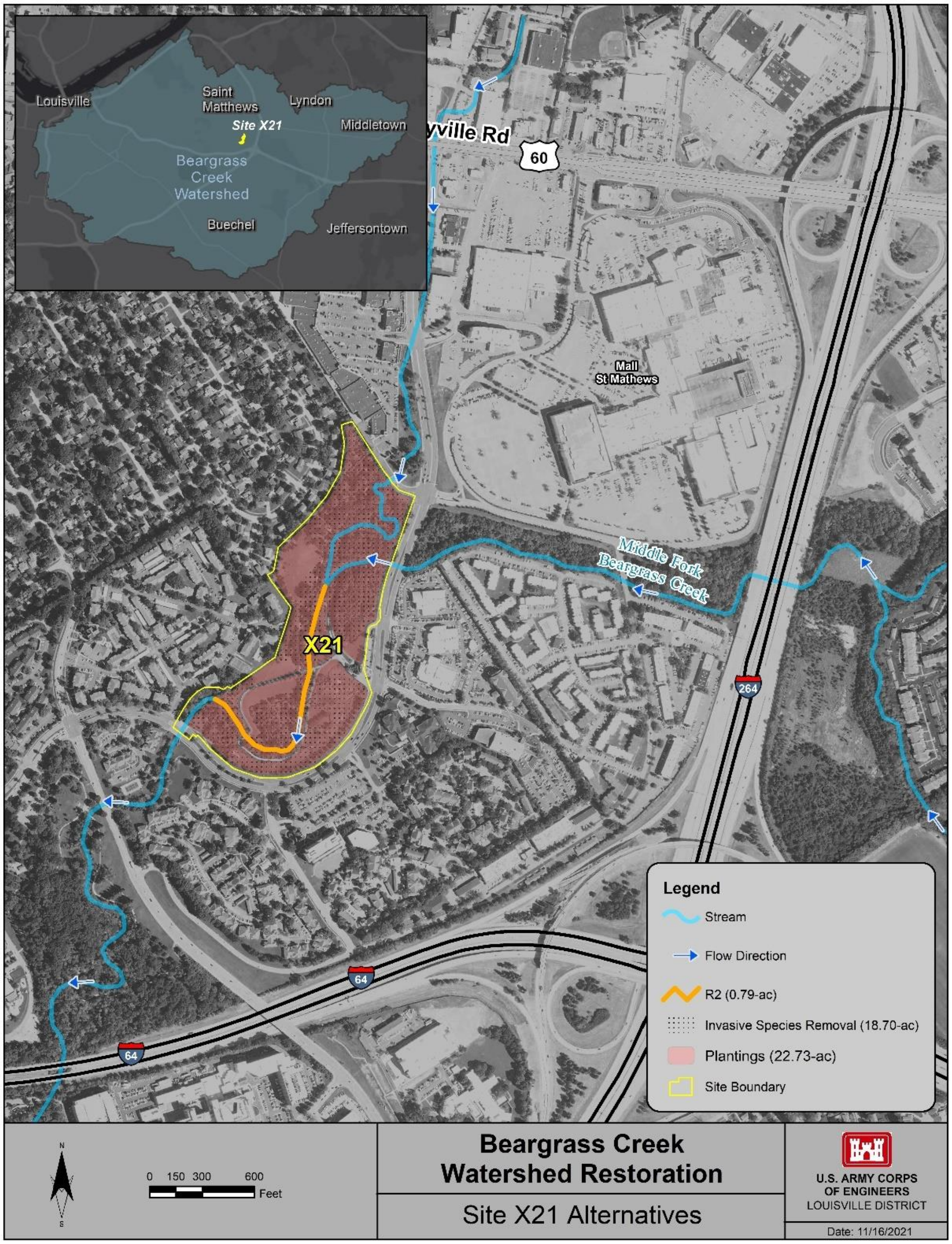

Figure 57 Conceptual Alternative Mapping for Site X21

Site 21 (Figure 57), Arthur Draut Park, is the most upstream site on the Middle Fork and proposes instream work with floodplain connectivity. This will entail some improvements to previous restoration work that has taken place such as bank stabilization. This alternative will also include some invasive species removal and native plantings throughout the riparian zone.

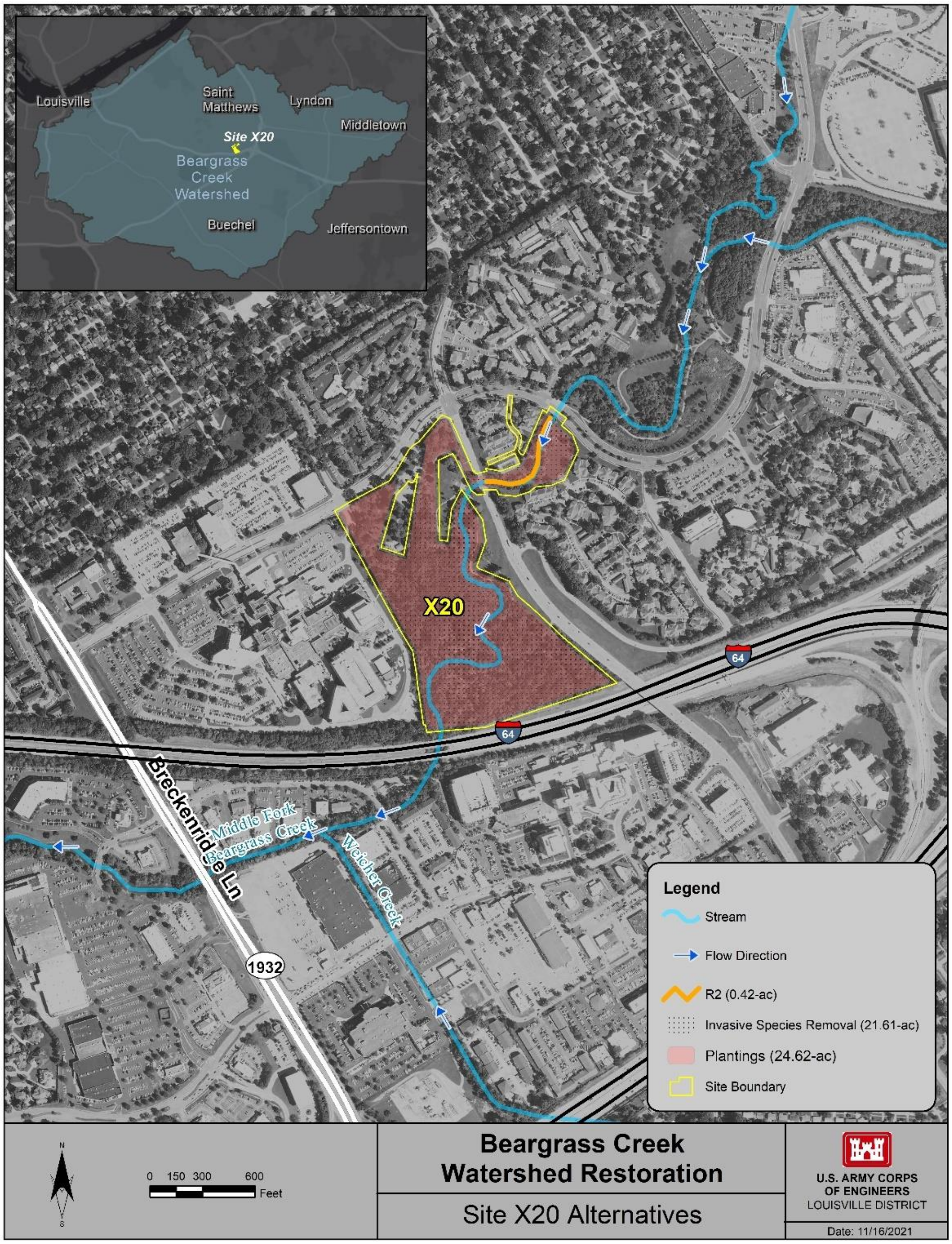

Figure 58 Conceptual Alternative Mapping for Site X20

Site 20 (Figure 58), Brown Park, is just downstream of site X21 and proposes instream work with floodplain connectivity to increase the quality of the connection between the two parks and to restore existing historic stream work. It also includes plantings and invasive species removal.

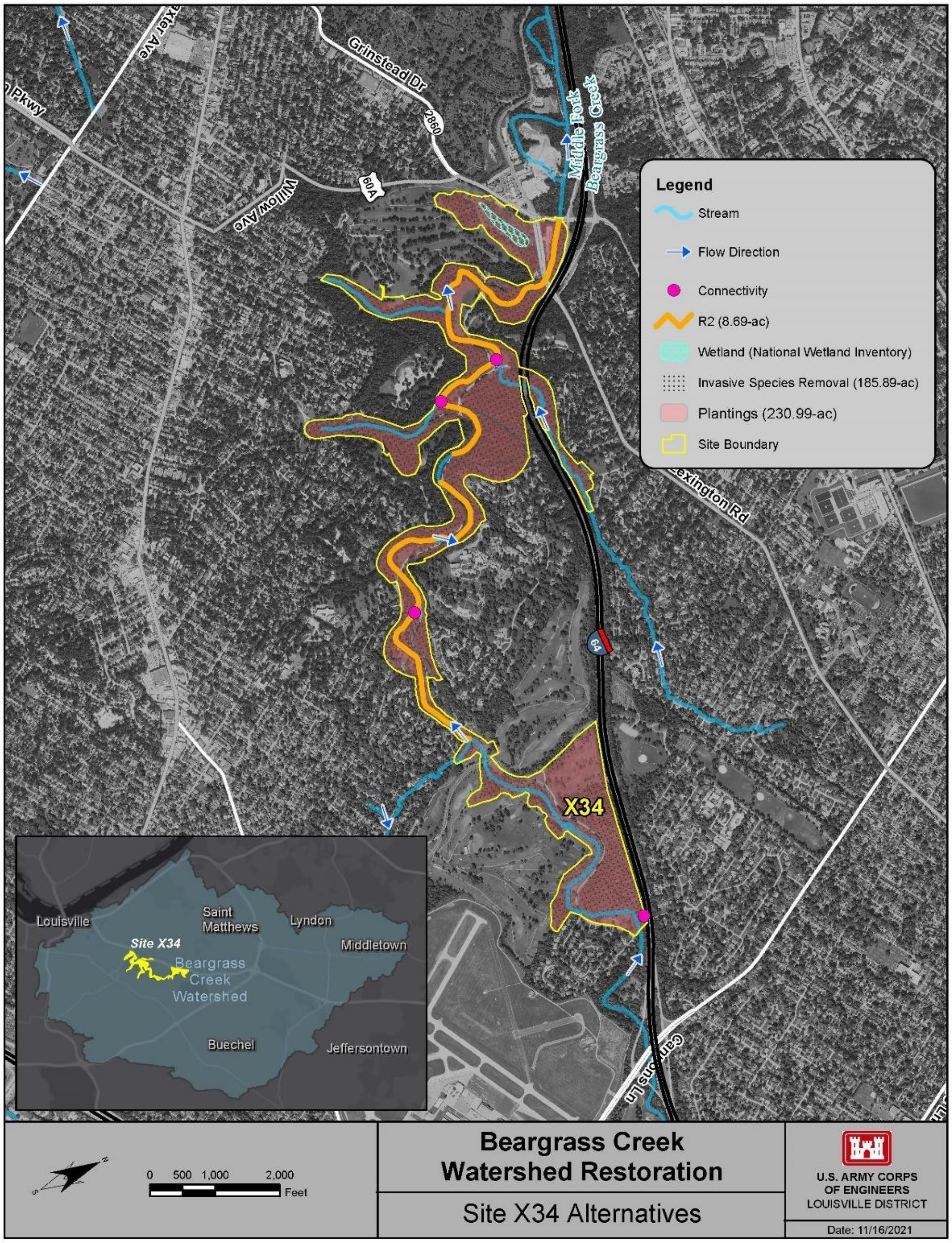

Figure 59 Conceptual Alternative Mapping for Site X34

Site 34 (Figure 59), Cherokee Park, is the largest site in the Recommended Plan and includes riffles to overcome connectivity issues in four locations, instream work and floodplain access on about half of the stream reach within the park and native plantings and invasive species removal throughout. This park is one of the most popular parks in Louisville and is one of three in the city that are part of the Olmsted design. This work would also include replacing and enhancing trails that are impacted by the restoration work.

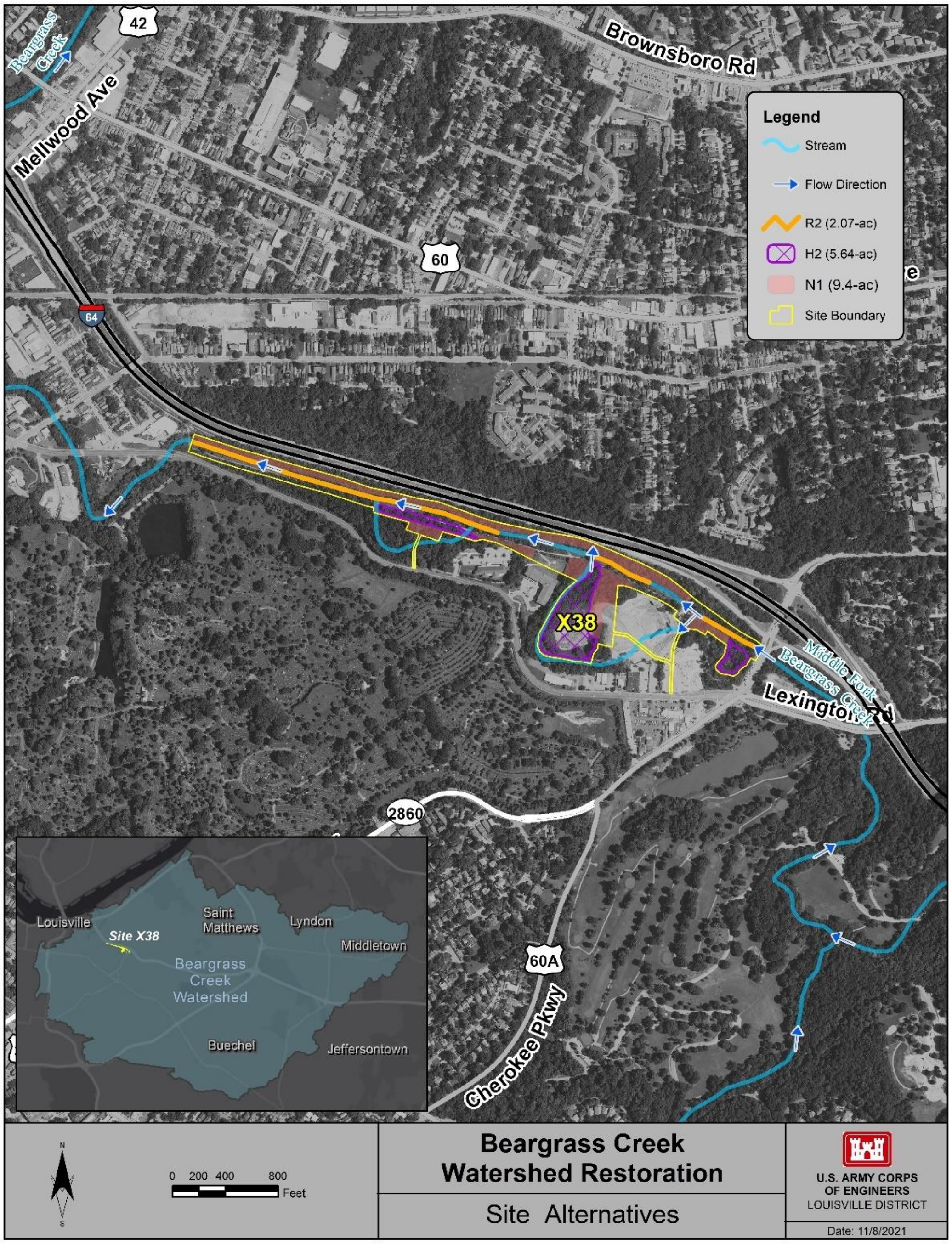

Figure 60 Conceptual Alternative Mapping for Site X38

Site 38 (Figure 60), Cave Hill, is located just downstream of Cherokee Park and includes native plantings and the addition of hydrologic resurgence via basins/swales with connectivity to the stream through bank grading and instream improvements. The basins would be excavated and planted with native wetland plants. The existing trail would have to be realigned around the basins which would enhance the trail experience.

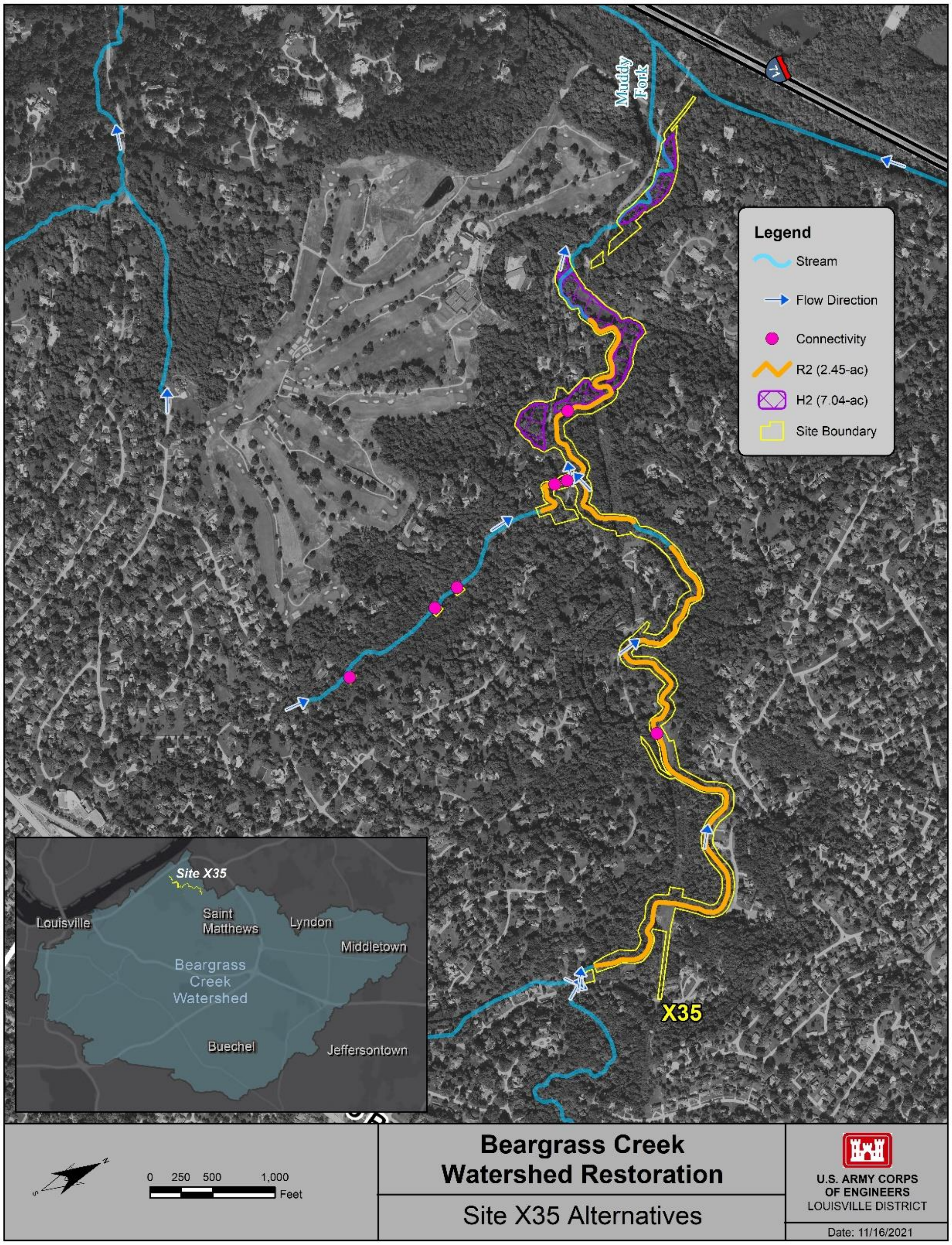

Figure 61 Conceptual Alternative Mapping for Site X35

Site 35 (Figure 61), Muddy Fork and Tributaries, is the only site on the Muddy Fork although it is the second largest site within the Recommended Plan. It includes riffles to overcome seven barriers, instream work and floodplain connectivity and a large area of hydrologic resurgence that will have major positive downstream impacts.

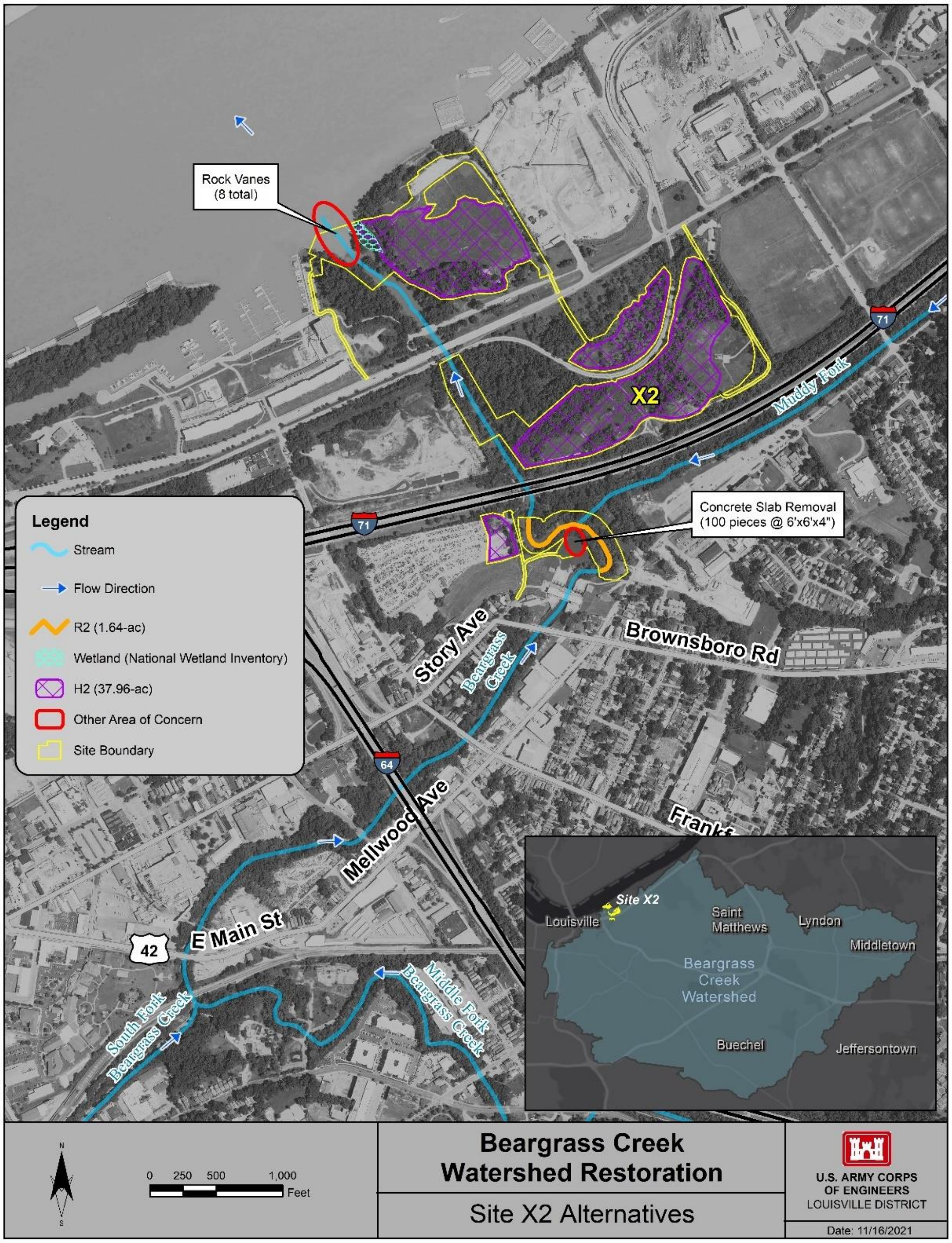

Figure 62 Conceptual Alternative Mapping for Site X2

Site X2 (Figure 62), the Confluence, is located at the mouth of the stream with the Ohio River and includes a small amount of instream work near the MSD pump station and three areas of hydrologic resurgence including removal of a portion of asphalt at the Louisville Metro Impound Lot. This site also includes removal of concrete slabs that were dumped in the riparian zone near the pump station as well as rock vanes at the mouth of the stream to control erosion.

7.3 Real Estate Considerations

The 12 sites chosen for the Recommended Plan are located throughout the eastern half of Jefferson County. Seven sites are located on the South Fork, four on the Middle Fork, and one the Muddy Fork of Beargrass Creek. While the design process will further refine the footprint of many project sites to some degree, the sites as currently envisioned encompass approximately 769 total acres. Of those, the NFS owns roughly 35 acres. The NFS will need to acquire significant interest in approximately 300 parcels of land. If total real estate costs of the Recommended Plan exceed 25% of total project costs, additional refinements may occur to real estate elements in the Recommended Plan. In addition, a non-standard estate waiver has been approved on 28 January 2022 to mitigate acquisition risk and decrease costs.

The Recommended Plan evaluated the greatest ecological restoration potential to maximize riparian and riverine lift. As such, large parcels were targeted resulting in extensive planting areas that in some cases are shown within existing forested areas or park settings which will require landowner collaboration and an understanding of land use initiatives. MSD has expressed the intent to more clearly define the proposed work extents within each site to limit the potential of unnecessary impacts, easements, and construction activities which should result in a cost reduction. MSD has also expressed the desire to explore partnership opportunities with landowners to offset the initial capital real estate and overall project costs. This exploration would focus on entities associated with significant acreage of interest and other stakeholders.

7.4 Recreation Plan

The objective of the recreation plan is to maintain and improve the quality and quantity of recreation amenities that complement the ecosystem restoration, especially in regard to promoting access and connectivity between both banks of the stream and throughout the length of the reach. The recreation plan was developed through early coordination with community stakeholders, as well as the NFS, to take advantage of existing recreation facilities, as well as proposed ecosystem restoration improvements, while complying with USACE policies and regulations pertinent to recreation improvements at ecosystem restoration projects. The recreation features will be designed and managed to avoid any negative impacts to restoration areas and are considered as an optional ad-on and as funding becomes available. The recreation plan formulated to be consistent and compatible with the NER plan includes the modification, upgrade, or creation of multi-use trails and related basic amenities.

7.4.1 Recreation Plan Formulated

The estimated cost for the recreation plan is $593,000, approximately 0.5% of the total project cost. The recreation plan formulated for the NER includes the following features listed in Table 37.

Table 37 Recreation plan description

Location	**Details about location**	**Proposed New Feature**
X2	Waterfront Park to the west (most visited park in city). New waterfront botanical building on west side of creek. Beargrass Creek Greenway connects to Louisville Loop (partially constructed 200-mile multi-use path that spans the entire city) at this site.	Boat Access Ramp at Eva Bandman Park - 150 square feet: would provide a water access point for small vessels. Pedestrian Bridge - connecting botanical gardens and greenway to east side of stream and park area
X38	Beargrass Creek Greenway runs along length of stream here, connects several neighborhoods, Girl Scout building, realignment goes with Beargrass Creek Alliance trail plans	Realign existing trail with boardwalks around new wetland areas.
X29	Local, political interest in trail in this location for several years. Trail would connect several neighborhoods that currently are separated by major roads and cemeteries. Would also provide potential access for St. Xavier High School, Norton Audubon Hospital, Earth and Spirit Center	Soft surface trail along length of stream, crossing stream at pedestrian bridge planned for 2022, benches (5)
X30	The Nature Center and Beargrass Creek Nature Preserve are located within this site. Congress for the New Urbanism 2019 South Fork Legacy Plan proposes "integration with Nature Preserve" from park. USACE plan would work to connect these enhancements with nature preserve trails.	Enhanced trail connections between TNC and Joe Creason Park
X10	The Louisville Zoo is directly adjacent to the stream with trail access. Aan outdoor classroom could be used for zoo programs to educate children about the importance of the stream. Programs could work with public and private schools.	Outdoor Classroom
X19/33	These sites on the South Fork are located in an area with limited access to green space. Birding platforms that utilize existing MSD access would offer residents easy access to wetland viewshed.	Birding Platforms (3)

Figure 63 displays the recreation plan locations. These sites were chosen as part of the recreation plan due to their location, accessibility, and opportunity for recreational improvements. While other sites may have opportunity for recreation, many already have existing recreation or future plans that the restoration work will support (X34, X20, X21, X22) or do not have the accessibility required for recreational facilities (X35).

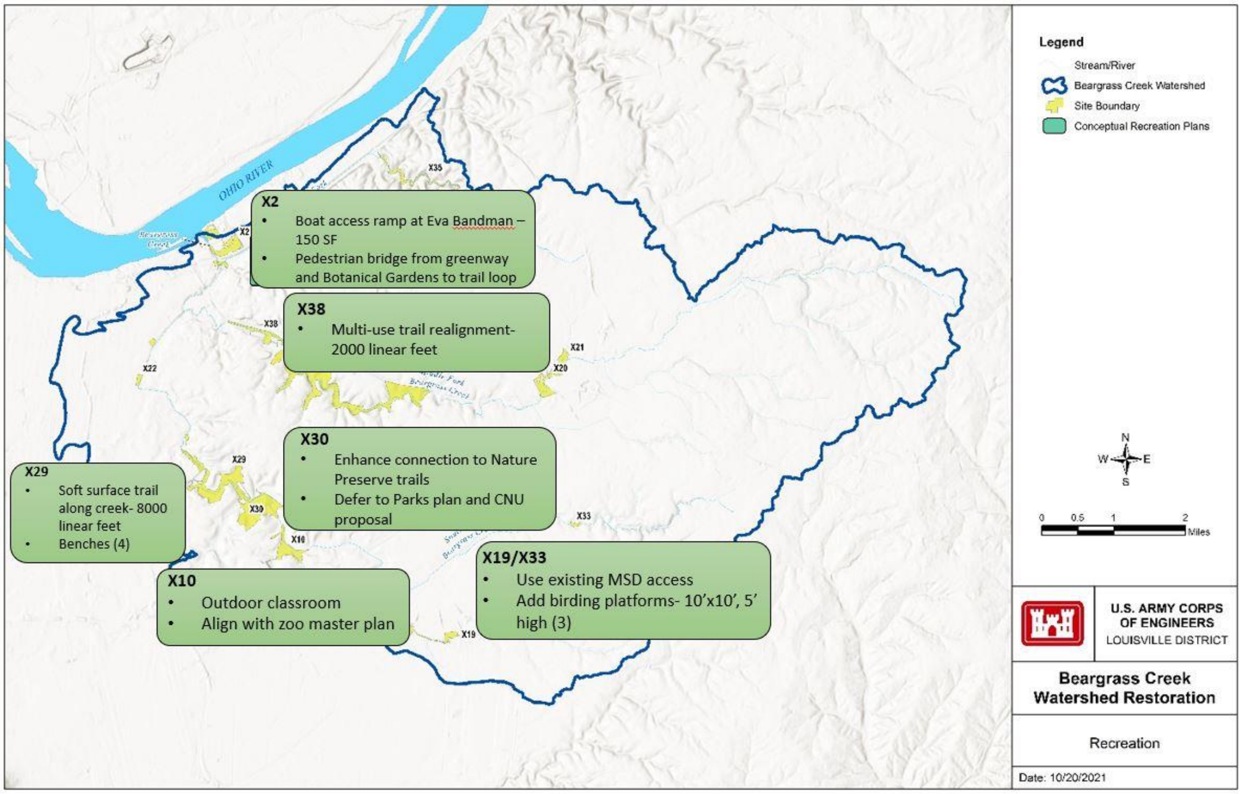

Figure 63 Recreation plan locations

7.4.2 Recreation Benefits

NED benefits from recreation opportunities created by a project are measured in terms of the recreation users' 'willingness to pay' for the recreation opportunity. Since it is not possible to directly estimate demand for the proposed recreation facilities, nor are the proposed recreation facilities an integral part of project justification, the Unit Day Value (UDV) estimation technique is utilized for estimating recreation users' willingness to pay.

The UDV relies on informed opinion and judgment to estimate the average willingness to pay of recreation users. This method considers both the quality of recreation experience and the visitation rates, while utilizing an annually published 'unit day values for recreation' contained in Economic Guidance Memorandum 22-03.

For the purposes of the proposed recreation facilities, the category of 'general recreation' is used, and the guidelines for assigning points and assigning them dollar values in EGM 22-03 were followed. The PDT evaluated each site and assigned it a score for both future with and future without project conditions in the categories of Recreation Experience, Availability of Opportunity, Carrying Capacity, Accessibility, and Environmental Quality. The point total corresponds to a Unit Day Value (EGM 22-03, and the difference between the Future Without Project and Future With Project Unit Day Value indicates the value added by the proposed features per visitor per day.

It should be noted that due to a paucity of visitation data for the sites themselves or nearby similar sites, it was determined by the PDT and affirmed by the vertical team that a UDV would be calculated for each site in the Future with Project and Future Without Project conditions to demonstrate the positive value of the proposed recreation features, and that value-added would be applied to a range of visitation figures to demonstrate a range of possible annual benefits to the nation.

The evaluation of each site's proposed recreation features is presented below.

7.4.2.1 Unit Day Value Calculations

7.4.2.1. a X2 – Confluence

At Site X2, the confluence of Beargrass Creek and the Ohio River, the proposed recreation features are a Boat Access Ramp at Eva Bandman Park that would provide a water access point for small vessels and a Pedestrian Bridge that would connect the new Waterfront Botanical Gardens and Greenway to the east side of Beargrass Creek and the park area.

The site is well-visited due to its location along the Louisville Loop, the 200-mile multi use path that will eventually encircle Louisville, and its connection with the Butchertown Greenway with visitors engaging in hiking, bicycling, and shoreline fishing. Louisville Waterfront Park and the Big 4 Pedestrian Bridge are just to the west of the site. There is a Cyclocross Track at Louisville Champions Park that hosts national events. However, there is no suitable access point for small vessels to put into the water -- currently a suboptimal maintenance access is used by visitors, but accessibility is limited and there is little available parking. Another access point is approximately half a mile downstream on the Ohio River at the Community Boathouse; however, not all visitors are comfortable paddling on the river.

In the future with project, this portion of the stream would be available to a larger number of visitors by way of the new boat ramp that will be situated next to ample parking. The new pedestrian bridge will improve greenway walking and can serve as a destination as it will allow unique views of the creek. The PDT scored the site as shown in Table 38.

Table 38 Unit Day Value estimate for Site X2

Site X2	Future With Project	Future Without Project	UDV
Recreation Experience	20	15	
Availability of Opportunity	2	2	
Carrying Capacity	10	4	
Accessibility	11	6	
Environmental Quality	9	4	
Total Recreation Points	52	31	
Value	$9.74	$6.92	$2.82

7.4.2.1. b X10 – Zoo/Alpaca

At Site X10, which is adjacent to the Louisville Zoo, an Outdoor Classroom pavilion is proposed. The site already had trail access, and the addition of an outdoor classroom would add an entirely new recreational opportunity to the area: the zoo as well as local public and private schools would use the classroom to host interpretive programs that would educate children about the stream and its importance to wildlife. The PDT scored the site as shown in Table 39.

Table 39 Unit Day Value estimate for Site X10

Site X10	Future With Project	Future Without Project	UDV
Recreation Experience	11	2	
Availability of Opportunity	1	1	
Carrying Capacity	7	3	
Accessibility	11	11	
Environmental Quality	10	3	
Total Recreation Points	40	20	
Value	$8.44	$5.91	$2.53

7.4.2.1. c X19 – MSD Basins

Two birding platforms are proposed for Site X19, located in an otherwise congested urban area with limited access to green space. There is currently no public access. The addition of these birding platforms will create recreation opportunities where there previously were none. The creation of wetlands associated with the project has the potential to attract species that are less common in other green spaces around Louisville. The PDT scored the site as shown in Table 40.

Table 40 Unit Day Value estimate for Site X19

Site X19	Future With Project	Future Without Project	UDV
Recreation Experience	3	0	
Availability of Opportunity	5	2	
Carrying Capacity	4	0	
Accessibility	4	4	
Environmental Quality	7	3	
Total Recreation Points	23	9	
Value	$6.16	$5.27	$0.89

7.4.2.1. d X29 – Eastern Creason Connector

The Eastern Creason Connector is site with the greatest opportunity for recreation benefits. The site has ample existing green space, and excellent roads all around it but due to limited access points and no trails along the reach, it remains untapped as a resource. For this site, a soft-surface trail along the length of the stream is proposed along with the addition of 5 benches. The trail would connect several neighborhoods that are currently separated by major roads and cemeteries.
The population would be able to access scenic, secluded spaces in an otherwise developed area. St. Xavier High School, St. Agnes Grade School, and the Earth and Spirit Center would suddenly have creekside recreation opportunities within a short walk of their facilities. The length of the trail would create ample space for numerous recreators and connect an historic Olmsted Parkway to Joe Creason Park.

The ecosystem restoration effort will add meanders to the stream, creating a high-quality, inviting natural environment for the many surrounding neighborhoods. The PDT scored the site as shown in Table 41.

Table 41 Unit Day Value estimate for Site X29

Site X29	Future With Project	Future Without Project	UDV
Recreation Experience	20	3	
Availability of Opportunity	7	3	
Carrying Capacity	9	1	
Accessibility	13	1	
Environmental Quality	15	6	
Total Recreation Points	64	14	
Value	$10.63	$5.57	$5.06

7.4.2.1. e X30 – Joe Creason Park/Nature Preserve

The Louisville Nature Center and Beargrass Creek Nature Preserve are located within site X30. The USACE recreation plan proposes to enhance trail connections between the Nature Center and Joe Creason Park. These plans are aligned with The Congress for the New Urbanism’s 2019 South Fork Legacy Plan.
Site X30 consists of a well-used, high-quality site with several activities, including walking trails, the Louisville Nature Center's outdoor classroom and educational programs. Connecting multiple existing trails on the site in addition to connecting with Site X29, the Eastern Creason Connector, will create a large, immersive experience in nature for visitors. The PDT scored the site as shown in Table 42.

Table 42 Unit Day Value estimate for Site X30

Site X30	Future With Project	Future Without Project	UDV
Recreation Experience	17	16	
Availability of Opportunity	4	4	
Carrying Capacity	12	10	
Accessibility	16	14	
Environmental Quality	14	11	
Total Recreation Points	63	55	
Value	$10.58	$9.99	$0.55

7.4.2.1. f X33 – MSD Basin

The PDT determined that Site X33 would provide similar value to Site X19, due to their many similarities. One birding platform is proposed for Site X33, which like X19, is in an otherwise congested urban area with limited access to green space. There is currently no public access. The addition of a birding platform will create recreation opportunities where there previously were none. The creation of wetlands associated with the project has the potential to attract species that are less common in other green spaces around Louisville. The site's UDV scores mirror those of X19. The PDT scored the site as shown in Table 43.

Table 43 Unit Day Value estimate for Site X33

Site X33	Future With Project	Future Without Project	UDV
Recreation Experience	3	0	
Availability of Opportunity	5	2	
Carrying Capacity	4	0	
Accessibility	4	4	
Environmental Quality	7	3	
Total Recreation Points	23	9	
Value	$6.16	$5.27	$0.89

7.4.2.1. g X38 – Cave Hill

The Beargrass Stream Greenway runs the length of the stream at site X38 near the historic Cave Hill Cemetery. The greenway connects several neighborhoods. There is currently running and biking on the greenway as well as some interpretive signage.

The future with project would realign the existing trail around new wetland areas and add a boardwalk to a smaller wetland area on the far east end of the site. Realignment of the currently very straight trail would increase appeal for families with children by the added variation of scenery and allow for a more engaging experience with increased potential for wildlife viewing. These plans align with the Beargrass Creek Alliance Planning Assistance to States study that proposed trail improvements and connections in this area. The addition of a boardwalk will raise the trail above wetland areas, increasing accessibility and safety. The PDT scored the site as shown in Table 44.

Table 44 Unit Day Value estimate for Site X38

Site X38	Future With Project	Future Without Project	UDV
Recreation Experience	12	4	
Availability of Opportunity	2	2	
Carrying Capacity	7	3	
Accessibility	11	11	
Environmental Quality	8	3	
Total Recreation Points	40	23	
Value	$8.44	$6.16	$2.28

7.4.2.2 Benefits Estimation

Based on the above calculations, the Future Without Project Unit Day Value for all sites combined is $45.09, and the Future With Project Unit Day Value is $60.15, showing an overall value added of $15.06 per visitor per day (Table 45).

Table 45 Unit Day Value overall summary for recreation plan

Site	UDV	Number of Daily Visitors					
		1	5	10	30	50	100
Future With Project	$60.15	$21,955	$109,774	$219,548	$658,643	$1,097,738	$2,195,475
Future Without Project	$45.09	$16,458	$82,289	$164,579	$493,736	$822,893	$1,645,785
Value Added	$15.06	$5,497	$27,485	$54,969	$164,907	$274,845	$549,690

Table 46 below displays the unit day values for each site within the recreation plan.

Table 46 Unit Day Values by site

		Daily Visitation					
Site	UDV	1	5	10	30	50	100
X2	$2.82	$1,029	$5,147	$10,293	$30,879	$51,465	$102,930
X10	$2.53	$923	$4,617	$9,235	$27,704	$46,173	$92,345
X19	$0.89	$325	$1,624	$3,249	$9,746	$16,243	$32,485
X29	$5.06	$1,847	$9,235	$18,469	$55,407	$92,345	$184,690
X30	$0.59	$215	$1,077	$2,154	$6,461	$10,768	$21,535
X33	$0.89	$325	$1,624	$3,249	$9,746	$16,243	$32,485
X38	$2.28	$832	$4,161	$8,322	$24,966	$41,610	$83,220
Point values based on EGM 22-03, updated Dec 6, 2021							

The lack of reliable visitation data makes estimating a benefit cost ratio challenging, at best. However, even given a very conservative estimate of 5 daily visitors per site both before and following construction, the recreation features are more than justified with a BCR of approximately 1.4.

To attempt a more realistic—though still potentially conservative—measure, the Trust for Public Land's 2020 Acreage and Park System Highlights data were used, which reported 1.6 million annual visitors for Louisville's Cherokee and Seneca parks. Across the two parks' approximately 740 acres, there are approximately 2,162 annual visitors per acre. As these are Louisville's two most visited parks, it would not be reasonable to expect similar visitation across the project sites, so the quantity was halved and an estimate of 1,081 visitors per acre was applied to the project sites with proposed recreation features. The same visitation is assumed in both the FWOP and FWP conditions. It should be noted that this surely underestimates the benefit to be gained at Site X29, the Eastern Creason Connector, which is largely inaccessible to the surrounding neighborhoods in the FWOP. Table 47 below summarized the benefits by site based on the estimated visitation.

Table 47 Recreation benefits by site

Site	**Unit Day Value**			**Site Area (Acres)**	**Annual Visitation (Acres x 1,081 visitors per acre)**	**Recreation Benefit**		
	Future Without Project	Future With Project	Value Added			Future Without Project	Future With Project	Value Added
X2	$6.92	$9.74	$2.82	65.3	70,589	$488,478	$687,540	$199,062
X10	$5.91	$8.44	$2.53	64.68	69,919	$413,222	$590,117	$176,895
X19	$5.27	$6.16	$0.89	22.65	24,485	$129,034	$150,825	$21,791
X29	$5.57	$10.63	$5.06	111.54	120,575	$671,601	$1,281,709	$610,108
X30	$9.99	$10.58	$0.59	103.88	112,294	$1,121,820	$1,188,073	$66,254
X33	$5.27	$6.16	$0.89	5.43	5,870	$30,934	$36,158	$5,224
X38	$6.16	$8.44	$2.28	29.03	31,381	$193,310	$264,859	$71,550
Total				402.51	435,113	$3,048,399	$4,199,283	$1,150,884

The resulting benefits were used to estimate a benefit cost ratio of 58 for the proposed recreation features, as shown in the table below. Construction first costs were annualized over 50 years (Base Year 2025) using the FY22 discount rate of 2.25% with an assumed construction duration of 3 months.

Table 48 Overall benefit summary of recreation plan

Beargrass Creek, Louisville, KY
Ecosystem Restoration
Summary of Annual Benefits and Costs
FY 2022 Price Levels
2.25% Interest Rate

	TSP
Investment Cost	
Construction First Cost	592,668
Interest During Construction	1,651
Total Investment Cost	594,319
Annual Charges	
Interest	13,372
Amortization	6,549
Total Annual Charges	19,921
Annual Benefits	
Recreation	1,150,884
Total Annual Benefits	1,150,884
Benefit vs. Cost Ratio	58
Net Benefits	1,130,963

Given the uncertainty in visitation numbers in both the existing and future conditions, the BCR for recreation features would be best understood as a range between an unlikely 1.4 and 58 or higher (Table 52).

7.5 Regional Economic Development and Economic Impacts Summary Comparison

The Principles and Guidelines (1983) established the RED account to register changes in the distribution of regional economic activity that would result from each alternative plan. In addition to the benefits accounted for within the National Economic Development (NED) account, the implementation of the Recommended Plan would result in local economic activity which is accounted for within the RED account.

The USACE Regional Economic System (RECONS) is a USACE-certified regional economic impact modeling tool that was developed to provide accurate and defendable estimates of regional economic impacts associated with USACE spending. It is the only USACE-certified Regional Economic Development model for agency wide use. RECONS incorporates impact area data, as well as multipliers, direct ratios (jobs to sales, income to sales, etc.), and geographic capture rates to estimate jobs, labor income, and other critical impacts to the local, county, and state economy. Table 49 provides an overview of the impact areas utilized for the RED analysis, which was completed for the Three Forks of Beargrass Creek Ecosystem Restoration Study. Construction expenditures were analyzed in RECONS using the

Construction Activities for Ecosystem and Habitat Restoration or Improvements (construction contracts) activity in the Environment business line. All costs are presented in FY22 price levels.

Table 49 Regional Economic Development and Economic Impacts Summary impact area

Economic Impact Areas	
Local Impact Area	Clark (IN), Floyd (IN), Harrison (IN), Scott (IN), Washington (IN), Bullitt (KY), Henry (KY), Jefferson (KY), Oldham (KY), Shelby (KY), Spencer (KY), Trimble (KY)
State Impact Area	Kentucky, Indiana

The project is expected to result in approximately $106,555,000 in construction expenditures across the region. These expenditures are expected to occur between 2025 and 2031. Of this total expenditure, $95,490,000 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The expenditures are expected to support approximately 1,780 full-time equivalent jobs and $202,256,000 in economic output in the local impact area.

More broadly, these expenditures are expected to support approximately 2,460 full-time equivalent jobs and $340,086,000 in economic output in the nation.

The share of economic impacts for each year over the construction period are directly proportional to project expenditures incurred each year. Therefore, if 20% of the construction expenditures occur in year 2025, those expenditures would be expected to support approximately 360 jobs and approximately $40,451,000 in local value added within the local impact area in that year. Table 50 outlines the impacts at the local, state, and national level.

Table 50 Economic impacts summary

Area	**Local Capture**	**Output**	**Jobs***	**Labor Income**	**Value Added**
Local					
Direct Impact		$95,490,000	1,190	$73,933,000	$50,142,000
Secondary Impact		$106,766,000	590	$35,880,000	$58,487,000
Total Impact	$95,490,000	$202,256,000	1,780	$109,813,000	$108,629,000
State					
Direct Impact		$99,035,000	1,260	$80,384,000	$53,798,000
Secondary Impact		$115,753,000	630	$37,654,000	$62,279,000
Total Impact	$99,035,000	$214,788,000	1,890	$118,038,000	$116,076,000
US					
Direct Impact		$106,502,000	1,430	$90,502,000	$62,151,000
Secondary Impact		$233,584,000	1,030	$72,527,000	$125,804,000
Total Impact	$106,502,000	$340,086,000	2,460	$163,029,000	$187,956,000
* Jobs are presented in full-time equivalence (FTE)					

Streamlined RECONS Definitions:

- Output: Economic output or total industry output is the value of production by industry for a given time period. It is also known as gross revenues or sales.
- Labor Income: Labor income represents all forms of employment earnings.
- Jobs (Employment): The work in which one is engaged; an occupation by which a person earns income. Employment includes both part-time and full-time jobs. All jobs are presented in full- time equivalence (FTE).
- Value Added: These are payments made by industry to workers, which also include interest, profits, and indirect business taxes. Value-added is an estimate of the gross regional or state product.

7.6 National Economic Development Impacts

The National Economic Development (NED) account includes information such as changes in the economic value of the national output of goods and services. It is expected that the project will result in NED benefits from recreation value added as well as the reduction of flood risk to structures in the watershed.

Recreation
Recreation benefits are quantified in Section 7.3.2.

Flood Risk Management
Without a detailed flood risk analysis, a quantitative value cannot be appropriately estimated for flood damages prevented by the Recommended Plan. However, to establish that the plan can reasonably be expected to contribute to a reduction in flood damages in the watershed, a geospatial analysis was performed to obtain a count of the structures that would be inundated across a range of flood frequency events without project and with the Recommended Plan. Inundation boundaries were provided by USACE Hydraulics and Hydrology engineers and compared against the National Structure Inventory 2.0. The inventory was checked against aerial imagery to correct for incorrectly placed structures along the three forks of the stream. Results are shown in Table 51.

Table 51 Count of flooded structures with and without project

Flood event	**Structures Inundated**	
	Without Project	With Project
2-year	26	26
5-year	71	66
10-year	157	148
20-year	300	289
50-year	638	605
100-year	1,222	1,174
200-year	1,676	1,616
500-year	2,226	2,182

7.7 Cost Summary

Table 52 summarizes the Project First Cost of the Recommended Plan. Project First Cost are escalated to the FY 2022 price level. Data for this estimate is provided in Appendix C, the Cost Appendix. These costs were developed using the MACASES version MII software. A Cost & Schedule Risk Analysis was performed on 23 March 2021 with the PDT to discuss issues or concerns with the project as a whole or for individual sites. From this risk analysis a contingency was set at the 80% confidence interval. Upon refinement of the project the risk analysis was revisited and removed any respective risk which had since been eliminated or mitigated.

Table 52 Project First Cost Share Summary Table for the Recommended Plan (FY22)

Beargrass Creek Ecosystem Restoration			
(Price Level October 2021)	Federal Costs	Non-Federal Cost	Project First Cost
Lands & Damages	-	$31,680,000	$31,680,000
Relocations	-	$10,717,000	$17,021,000
Excess LERRD over 35%*	-	$6,304,000	
Fish & Wildlife Facilities	$55,096,000	-	$55,096,000
Adaptive Management & Monitoring	$1,389,000	-	$1,389,000
Cultural Resource Preservation	$778,000	-	$778,000
Preconstruction, Engineering, & Design (PED)	$9,720,000	-	$9,720,000
Construction Management (S&A)	$4,860,000	-	$4,860,000
Total	**$72,139,000**	**$48,404,000**	**$120,542,000**
Recreation Facilities (50/50)	$297,000	$297,000	$593,000
Total Project First Cost	**$72,436,000**	**$48,701,000**	**$121,135,000**
Average Annual Cost	**$2,797,000**	**$1,506,000**	**$4,303,000**

**Excess LERRD that may be credited to the non-federal sponsor contingent on funding availability. The Project Partnership Agreement will include a deviation for the excess LERRDs*

7.7.1 Recommended Plan Cost Estimates

Table 49 presents optimized cost estimates for the 12 sites in the Recommended Plan. These numbers were refined after site optimization and represent the most up-to-date refined costs.

Table 53 Recommended Plan cost summary

Site	Description	Total (AC)	01 Lands & Damages	02 Relocations	06 Fish & Wildlife Facilities	14 Recreation	18 Cultural RSS[1]	Adaptive Management[1]	30 PED[1]	31 Construction Management[1]	Total Cost per Site
X2	Confluence	**65.3**	$2,750,809	$ 74,663	$3,101,779	$188,448	$45,509	$81,354	$569,475	$284,738	$7,097,000
X10	Alpaca Farm	**64.68**	$1,283,993	$ 2,628,276	$ 3,739,354	$31,128	$57,170	$102,199	$715,394	$357,697	$8,915,000
X19	Newburgh Road	**22.65**	$466,537		$ 2,123,043	$18,656	$19,409	$34,696	$242,871	$121,436	$3,027,000
X20	Brown Park	**27.59**	$1,515,234		$ 894,923		$17,935	$32,061	$224,427	$112,213	$2,797,000
X21	Arthur Draut	**25.11**	$112,384	$ 90,007	$ 1,494,741		$12,629	$22,576	$158,032	$79,016	$1,969,000
X22	Concrete Channel	**15.11**	$1,020,438		$ 948,994		$14,655	$26,198	$183,388	$91,694	$2,285,000
X29	Eastern/Creason Connector	**111.54**	$3,376,919	$ 2,474,500	$ 11,734,207	$130,673	$131,834	$235,670	$1,649,688	$824,844	$20,558,000
X30	Joe Creason Park	**103.88**	$1,978,048	$ 3,792,739	$ 9,313,093		$112,245	$200,652	$1,404,565	$702,283	$17,504,000
X33	MSD Basin	**5.43**	$112,704	$ 48,601	$ 224,474	$37,243	$3,148	$5,627	$39,391	$19,695	$491,000
X34	Cherokee & Seneca	**278.35**	$16,864,028	$ 4,309,798	$ 11,867,540		$245,874	$439,530	$3,076,712	$1,538,356	$38,342,000
X35	Muddy Fork andTributaries	**37.64**	$1,162,751	$ 416,240	$ 6,545,402		$60,457	$108,074	$756,519	$378,259	$9,428,000
X38	Cave Hill Corridor	**29.03**	$1,035,836	$ 3,185,693	$ 3,108,175	$186,772	$55,933	$99,987	$699,911	$349,956	$8,722,000
		786.31	**$ 31,679,681**	**$ 17,020,517**	**$ 55,095,728**	**$592,921**	**$776,798**	**$1,388,625**	**$9,720,372**	**$4,860,186**	**$121,135,000**

1 Cost distributed from lump sum pricing to infer a "per site" cost associated with each account/feature

2 Durations exclude 5 year Establishment Period

3 O&M Cost developed in the Basis of Estimate Spreadsheet - "Beargrass Creek BOE - 11-17-21.xlsx"

7.8 Plan Implementation

7.8.1 Recommended Plan

The Real Estate Plan presents the real estate requirements for the Three Forks of Beargrass Creek Ecosystem Restoration Project in accordance with ER 405-1-12. 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 information furnished by the project development team. Real estate estimates utilized in the planning phase were rough order of magnitude and calculated by looking at comparable parcels near the site. The real estate appraisal was completed in early 2021 and costs were refined as the recommended plan was optimized.

A 5-year contract with options (options would not be fulfilled if success criteria are not met before the 5th year) would be utilized to ensure successful recruitment and establishment of native communities (abiotic and biotic). All hydrogeomorphic work would be accomplished within the first several months of the contract to allow establishment and monitoring time. Options would be placed in the contract for future adaptive management measures that could be exercised at any point of the contract duration, but most frequently in years 3, 4 and 5. These may include but are not limited to changing or adjusting features to achieve the required hydrology, hydraulics and/or geomorphology; additional native plant treatments; or other improvements. All adaptive management decisions and exercising of contract options would be driven by monitoring. Monitoring and adaptive management details will be laid out in the PPA signed with the NFS. At this time, it is anticipated that MSD will remain the NFS; however, additional NFSs may be incorporated and sponsor the design and construction of individual sites as appropriate and where economically feasible. Projects will be implemented on a site-by-site basis as funding becomes available.

7.8.2 Operation and Maintenance Considerations

Once construction activities are completed, functional portions of the project will be turned over to the NFS. Operation, maintenance, repair, replacement, and rehabilitation activities (OMRR&R) would occur after the project is constructed to keep project features functioning as designed. Activities would be similar among the alternatives and vary in scale consistent with each alternative. This will include:

- Annual inspections and maintenance
- Periodic repair and/or replacement of project features
- Management of invasive species throughout the constructed restoration features and channel bottom areas within the restoration footprint
- Provision of irrigation to constructed features such as wetlands during drought. MSD will also be responsible for public education and organizing stewardship for restored habitats

The potential O&M activities were coordinated with the NFS and reflect reasonable assumptions for annual mowing, additional invasive species management (removal), trash and litter removal, and maintenance of access to each site. While these activities are not a certainty, any uncertainty will revolve around year-to-year O&M NFS budgetary constraints, changes in system after success has been achieved, invasive species proliferation and climate change. In order to decrease uncertainty, communication with the NFS will continue to better understand level of involvement.

Costs are based on the various activities identified and were developed by the Cost Engineer. The costs consider the overall acreages or linear feet of stream and assume that a consistent percentage of that space will incur cost. For example, there is 446.03 acres of Invasive Species Management initially called for across all of the sites – the O&M estimate assumes 5% (or 22.3 acres) will require annual upkeep. A detailed description and breakdown of the O&M cost are listed in Appendix C- Cost. A detailed OMRR&R Plan will be developed during implementation. The estimated annual cost for OMRR&R is $126,296 per year.

7.8.3 Detailed Design

Detailed design for the project will occur in the Preconstruction Engineering and Design (PED) phase. PED will include all technical engineering disciplines and will be completed in accordance with all required regulations and criteria. This report and appendices discuss design assumptions made during the feasibility phase and design elements that will be refined or determined during the PED phase.

Future design elements and investigations include the following:

- Hydrologic and hydraulic analysis including flood risk, two-dimensional modeling, verification of existing bridge impacts on design, wetlands, and groundwater.
- Refinement of the proposed planting work units including existing stand composition, clearing and grubbing requirements, proposed species mix, and planting density.
- Scour, erosion, and sediment transport analysis and plans.
- Geotechnical investigations including soil analysis for slope stability, infiltration, channel protection if needed, and erosion control products.
- Grading design for proposed H and R work units, and grading design for access roads where needed.
- Coordination with NFS on utility relocations and how they affect the design, materials for instream work that will focus on historical conditions and instream connectivity, and work within a reasonable buffer width that considers prioritization of preserving diverse and dense riparian areas.
- Cultural resource investigations will be performed, and avoidance or impact minimization will be incorporated into the design.

Detailed design drawings of all project work units including plans, profiles, and cross sections will be developed in PED.

In response to potential impacts due to climate change, various considerations can be made to improve features' resilience to future conditions. These conditions may include increases in variability of precipitation and changes to the frequency and magnitude of extreme flood and drought events. Variation in wetland depth and diverse native plantings improve the project's ability to be flexible to changing future conditions. Other aspects of design to increase resilience will be considered during future engineering design phases of this project.

Many risks to ecosystem function and form are expected as a result of climate change (Table 1, Section 2.1.1); however, the Recommended Plan alternatives proposed through this study enable the Beargrass Creek Watershed environment to be more resilient to the impacts of climate change. In general, these ecosystems have been evolving and adapting to changes in the environment and can shift to a changing climate in the future depending on the extent to which the climate changes. In addition to these communities' natural resilience, the alternatives proposed reduce some of the non-climate related stressors such as urbanization, invasive species, and degraded stream form and function. Reducing these stressors allows for the various plant and animal communities to be more resilient to a changing climate.

The overall objective of this study is to improve riverine and riparian habitat through higher quality native communities and better connectivity. Although, more frequent intense precipitation events are expected and could result in higher velocities and more extreme bank erosion, the implementation of the R2 and R4 alternatives would cut banks down and remove obstructions to the floodplain allowing flood waters to access the floodplain at lower elevations making the channel more resilient against increased precipitation and more frequent precipitation events. The proposed riverine alternatives should result in reduced velocities, which will protect the channel from harmful bank erosion through advancing channel evolution from a degraded channel to an ecologically improved and more sustainable state. Instream habitat features will need to be anchored-in or strategically placed to accommodate a future condition of increased streamflow. Creation and improvement of riffle-pool complexes will be valuable for biologic communities during both flood and drought events, where slow moving water and deep pools can offer shelter and relief from unforgiving conditions. This increase in habitat diversity and refugia will be of increased value in a future where stream flow and temperature conditions may be harsher than they are currently.

More frequent intense rainfall events will most likely result in greater nutrient loading to the stream. The improvements proposed to riparian areas and addition of wetland structure within the watershed will also make the system more resilient to these increased nutrient loads through natural filtering. Specifically for wetlands, the projected increase in precipitation and runoff could lead to rates of eutrophication being higher than present values. This eutrophication is driven by nutrient loading to the wetland and could increase stress of these habitats. Increased runoff, and deposition of sediment carried by this runoff, can also shorten the lifespan of wetlands as they fill in with sediment at an increased rate. Although sedimentation and eutrophication can threaten wetland habitat, it should be noted that these wetlands still act as buffers for stream habitat which would otherwise receive the sediments and nutrients were the wetlands not present.

A few of the proposed H2 alternatives include the removal of impervious surface, specifically at the confluence site (X2) and the concrete channel site (X22). Removal of impervious surface reconnects the surface to baseflow recharge, which improves the baseflow conditions within the stream. Removal of impervious surface also improves the riparian buffer around streams improving riverine habitat.

A major risk to the ecosystem from climate change is increased temperatures and is probably the most likely change based on the literature synthesis. The sites that are part of the Recommended Plan provide resilience to increased temperatures in several ways. The reduction in impervious area and increase in areas of native plant communities will help to reduce the urban heat island effects. Riparian plantings such as bottomland hardwood forest will provide shading to streams, which will allow the streams to maintain lower more normal temperatures and healthy dissolved oxygen levels. More frequent and sustained droughts are a potential risk of climate change. The improvement of the riparian areas of the streams and increased areas of wetland structure will retain water longer making the impacts of drought less severe. Consideration should be given to projected climate change when selecting plant species. Additionally, increasing the connectivity and size of natural plant communities provides corridors for migration of plant and animal populations as their ranges change in response to climate changes.

Urbanization within Beargrass Creek Watershed is relatively intense and is generally built out from a hydrologic perspective. The construction of the proposed Recommended Plan alternatives will include an easement that protects these lands in perpetuity. The addition of native trees and plant communities will return carbon back to the soil healing the soil and providing increased carbon sequestration.

Adaptive management planning is part of plan formulation and alternatives and includes a maximum of 10 years of monitoring plan prior to release of the project to the NFS. Most of the time only acute changes in weather are addressed during this adaptive management period. However, if changes resulting from climate change are observed, improvements to the implementations can be made more resilient to the observed changes. Beyond the adaptive management period, USACE will provide an Operations & Maintenance (O&M) manual where indicators of climate change and retroactive responses to climate change can be documented for the NFS.

7.8.4 Monitoring and Adaptive Management

Section 2039 of WRDA 2007, 33 U.S.C. § 2330a, directs the Secretary to ensure that when conducting a feasibility study for a project (or a component of a project) for ecosystem restoration that the recommended project can include a plan for monitoring the success of the ecosystem restoration for a period of up to ten years from completion of construction of an ecosystem restoration project. This monitoring shall be cost-shared. However, the LERRD for this project exceed the NFS's 35% responsibility, leaving remaining project costs as federal responsibility. Therefore the 65% federal portion will include all monitoring costs within the five-year monitoring period and any costs beyond that up to 10 years will be cost shared.

A monitoring plan has been developed in conjunction with the NFS and will be implemented for this project (Appendix I). Cost-shared monitoring for ecological success and adaptive management would be initiated and continue for a minimum of five years or until ecological success is achieved as defined by the Project's established success criteria, but for no longer than ten years. USACE, Louisville District, would conduct monitoring in conjunction with the NFS to determine the success of the project. Baseline data for current conditions at Beargrass Creek are detailed in this report. The monitoring plan establishes a framework for effective monitoring and adaptive management decision making in the study area, and identifies:

- A systematic approach for identifying potential Project success criteria in areas of habitat restoration

- The process for future decision-making related to management activities in the study area
- Criteria and triggers for implementation of remedial actions to meet success standards

7.8.5 Construction Phasing

Appendix C proposes a tentative construction schedule beginning in April 2025 and concluding in March 2030. During the feasibility phase and upon selection of the Recommended Plan, USACE and NFS discussed the possibility of phasing construction due to the size and complexity of the project. The proposed schedule displays phasing of the construction by site. This schedule also includes an establishment and monitoring period from March 2030 to 2035. As the feasibility study has progressed to completion, details of implementation and construction phasing have been refined, and a construction schedule has been created.

7.8.6 Environmental Operating Principles

The Recommended Plan supports USACE operating procedures by:

- Fostering sustainability as a way of life throughout the organization: The Recommended Plan contains measures that are meant to help improve and maintain the watershed in the long term and will make the Beargrass Creek system more resilient to the effects of climate change.
- Proactively considering environmental consequences of all USACE activities and acting accordingly: The PDT has modeled the Recommended Plan to ensure that there will be no negative impacts to flooding and will ensure that best practices are used during implementation to prevent or mitigate any possible consequences such as sedimentation from construction.
- Creating mutually supporting economic and environmentally sustainable solutions: The Regional Economic Development analysis (discussed in Section 7.4) in addition to the results of the habitat analysis (discussed in Chapter 5) show the support of both an economically viable plan and one that supports an increase in scarce habitat within the watershed.
- Continuing to meet our corporate responsibility and accountability under the law for activities undertaken by USACE, which may impact human and natural environments: All environmental requirements under NEPA have been met for this study.
- Considering the environment in employing a risk management and systems approach throughout the life cycles of projects and programs: The team managed a risk register throughout the scoping, site selection and plan formulation process that has assisted and will continue to assist decision making throughout the process that will decrease uncertainty and risk.
- Leveraging scientific, economic, and social knowledge to understand the environmental context and effects of USACE actions in a collaborative manner: The technical team utilized known plan formulation techniques to select the Recommended Plan including habitat unit calculation and CEICA. The team also utilized input from the community, including groups that have experience within and knowledge of the watershed.
- Employing an open, transparent process that respects views of individuals and groups interested in USACE activities: The PDT conducted public, stakeholder, and agencies scoping meetings that guided the development of the project site selection and objectives. The team also followed policy requirements for public review of the draft document.

7.8.7 Division of Plan Responsibilities

MSD has agreed to serve as the NFS for the implementation of the Three Forks of Beargrass Creek Ecosystem Restoration project. It is anticipated that additional NFSs may be added to the project to support the implementation of individual sites. The cost-sharing requirements and provisions will be formalized with the signing of the Project Partnership Agreement (PPA) between the NFS(s) and USACE prior to initiation of contract award activities. In this agreement, the NFS(s) will agree to cost sharing requirements. Based on the cost sharing requirements, the total project cost (FY22 price levels) and pertinent cost-sharing information for the restoration project are summarized in Table 52 above.

Federal Responsibilities - The estimated federal project first cost share for implementation of the project is about $72,436,000. USACE would accomplish the plans and specifications phase, which includes additional design studies and plans and specifications, contract for construction, overall supervision during construction, prepare an operation and maintenance manual, and participate in a portion of the post construction monitoring.

USACE, as it determines necessary, shall undertake actions associated with historic preservation, including, but not limited to, the identification and treatment of historic properties as those properties are defined in the National Historic Preservation Act (NHPA) of 1966, as amended.

Non-Federal Responsibilities - Prior to initiation of the site-specific design phase, the Federal Government and the NFS(s) will execute a PPA. The LERRD and OMRR&R of the project will be the responsibility of the NFS(s) for the proposed project. The estimated non-federal project first cost share for implementation of the project is about $ 48,701,000 and will be covered by LERRD credit. The NFS(s) shall, prior to implementation, agree to perform the following items of local cooperation:

1. Provide 35 percent of the separable project costs allocated to environmental restoration as further specified below:
    a) the NFS(s) shall provide the real property interests, placement area improvements, and relocations required for construction, operation, and maintenance of the Project.
    b) In providing in-kind contributions, if any, the NFS(s) shall obtain all applicable licenses and permits necessary for such work.
    c) No later than August 1st prior to each subsequent fiscal year, the Government shall provide the NFS(s) with a written estimate of the full amount of funds required from the NFS(s) during that fiscal year to meet its cost share. Contribute all project costs in excess of the USACE implementation guidance limitation of $10,000,000
    d) Provide 50 percent of costs for project recreation facilities.
2. To the extent practicable and in accordance with federal law, regulations, and policies, the Government shall afford the NFS(s) the opportunity to review and comment on solicitations for contracts, including relevant plans and specifications, prior to the Government's issuance of such solicitations; proposed contract modifications, including change orders; and contract claims prior to resolution thereof.
3. When the District Commander determines that construction of the Project, or a functional portion thereof, is complete, within 30 calendar days of such determination, the District Commander shall

so notify the NFS(s) in writing and the NFS(s), at no cost to the Government, shall operate, maintain, repair, rehabilitate, and replace the Project, or such functional portion thereof.

a) The NFS(s) shall conduct its operation, maintenance, repair, rehabilitation, and replacement responsibilities in a manner compatible with the authorized purpose of the Project and in accordance with applicable Federal laws and specific directions prescribed by the Government in the OMRR&R Manual.
b) The NFS(s) will hold and save the Government free from all damages arising from design, construction, operation, maintenance, repair, rehabilitation, and replacement of the project, except for damages due to the fault or negligence of the Government or its contractors.
c) The NFS(s) will 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), 42 U.S.C. 9601-9675, that may exist in, on, or under real property interests that the Federal government determines to be necessary for construction, operation and maintenance of the project;
d) The NFS(s) will assume, as between the Government and the NFS(s), complete performance and financial responsibility for all necessary cleanup and response actions and costs of any hazardous substances regulated under CERCLA that are located in, on, or under real property interests required for construction, operation, maintenance, repair, rehabilitation, or replacement of the project;
e) The NFS(s) will agree, as between the Government and the NFS(s), that the NFS(s) shall be considered the owner and 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.
f) The NFS(s) will agree, as between the Government and the NFS(s), that the NFS(s) shall be considered the owner and operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA; and
g) The NFS(s) will comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended, (42 U.S.C. 4630 and 4655) and the Uniform Regulations contained in 49 C.F.R Part 24, in acquiring real property interests necessary for construction, operation, and maintenance of the project including those necessary for relocations, and placement area improvements; and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.
h) The Government may enter, at reasonable times and in a reasonable manner, upon real property interests that the NFS(s) now or hereafter owns or controls to inspect the Project, and, if necessary, to undertake any work necessary to the functioning of the Project for its authorized purpose.

4. The NFS(s) shall not use Federal Program funds to meet any of its obligations under this Agreement unless the federal agency providing the funds verifies in writing that the funds are authorized to be used for the Project.
5. In addition to the ongoing, regular discussions of the parties in the delivery of the Project, the Government and the NFS(s) may establish a Project Coordination Team to discuss significant issues or actions.
6. Notwithstanding any other provision of this Agreement, the NFS(s) shall be responsible for all costs in excess of the Federal Participation Limit.

7. The NFS(s) may request in writing that the Government perform betterments on behalf of the NFS(s).

7.8.8 Non-Federal Sponsor's Financial Capability

Design and implementation phases would be cost-shared, with the NFS to provide a minimum of 35% of the total being a project first cost of $121,135,000 ($142,088,000 fully funded cost) The estimated non-federal share is approximately $48,701,000 ($49,731,000 fully funded cost). Additionally, the NFS must provide all LERRD. The NFS may receive credit toward this cost-share for work-in-kind and LERRD. Table 52 above shows the implementation costs.

The cost-sharing requirements and provisions will be formalized with the signing of the PPA between the NFS and USACE prior to initiation of contract award activities. In this agreement, the NFS will agree to cost sharing requirements.

7.9 Public Review Comments

The draft report was circulated for a 30-day public review in April/May of 2021. One comment letter was received from the Metropolitan Sewer District. No other comments were received from the public. A letter was received from US Fish and Wildlife that they concur with USACE endangered species determinations and consider the Fish and Wildlife Coordination Act to be satisfied. We also received a letter of acknowledgement from the Cherokee Nation. These letters can be read in full in Appendix H. Recommendations from the MSD letter have been incorporated into the report and included a more extensive description of the history of Beargrass Creek and discussion of water quality improvements.

7.10 NER Plan Validation

According to the USACE Civil Works Annual Program Development Manual (FY23), the purpose of Civil Works aquatic ecosystem restoration activities is to restore significant aquatic ecosystem function, structure, and dynamic processes that have been degraded. This report demonstrates that the Recommended Plan supports this mission and meets the goals and objectives set forth in the 2014-2018 Civil Works Strategic Plan:

Relevant Goals:

- Goal 1. Transform the Civil Works program to deliver sustainable water resources through Integrated Water Resources Management
- Goal 4: Restore, protect, and manage aquatic ecosystems to benefit the nation

Relevant Objectives:

- Objective 1.1 – Modernize the Civil Works project planning process
- Objective 1.3 – Improve methods of delivery in order to produce quality solutions and delivery of services, on schedule and within budget.
- Objective 4.1 - Restore aquatic habitat to a more natural condition in ecosystems in which structure, function, and dynamic processes have been degraded.

Table 54 below lists the metrics set forth to meet the relevant goals and objectives and to ensure that studies proceed efficiently to produce significant ecosystem benefits. The table demonstrates how the Recommended Plan meets each of these metrics.

Table 54 Aquatic Ecosystem Restoration Budget Ranking Criteria

Metric	**Recommended Plan Performance**
Scarcity	Riverine wetlands are a habitat listed in Section 404 (b)1 and are nationally important and relatively scarce regionally and nationally. Canebrake and Savannah Bluegrass and bottomland hardwood forest recognized by NatureServe[1]. This project will restore 72 acres of wetland habitat, 110 acres of Canebrake, 43.4 acres of Savannah Bluegrass and 120 acres of bottomland hardwood forest.
Connectivity	The Recommended Plan will eliminate 18 instream connectivity barriers throughout the watershed with natural rock structures, restoring 4 acres instream habitat connectivity within 4 separate project sites.
Special Species Status	Section 2.5.4 shows 15 federally listed species (Table 5) and 11 state listed species (Table 6) that are potentially affected by restoration activities in the project area. Native Cane and Running Buffalo Clover are two significant species recognized by NatureServe.
Hydrologic Character	The SMURF assessment measured existing conditions of hydrologic character of the creek including: • Riparian development (amount of disturbance) • Riparian quality (diversity of vegetation, invasive species presence) • Stream canopy cover The Future with Project benefits for the hydrologic component of the Recommended Plan was 284 HUs.
Geomorphic Condition	The QHEILS assessment measured existing conditions of geomorphic character of the creek including: • Stream development (riffle, run, pool complexes) • Sinuosity • Erosion The Future with Project benefits for the geomorphic component of the Recommended Plan was 13 HUs.
Self-sustaining	Annual O&M costs are $126,296. The site-level alternatives were also screened for sustainability early in the planning phase. This is discussed in more detail in Section 4.9.3.
Plan Recognition	As discussed in Section 3.1.2, the Recommended Plan is supported by several Federal Acts and Executive Orders. Regionally, the plan is supported by the missions of the Ohio River Basin Alliance, the Ohio River Valley Water Sanitation Commission, and the Ohio River Basin Fish Habitat Partnership. Specifically, the Plan for the Ohio River Basin 2020-2025 supports ecosystem restoration within the Basin.

[1] NatureServe is a non-profit organization that provides proprietary wildlife conservation-related data, tools, and services to private and government clients, partner organizations, and the public

8.0 Remaining Reviews, Approvals, Implementation, and Schedule

Section 8.2 below describes the remaining reviews and approvals required for this report. The following major milestones are currently scheduled.

District Engineer's Transmittal of Final Report Package	03 FEB 2022
Division Engineer's Transmittal of Final Report Package	15 JUN 2022
Chief of Engineer's Report Signed	05 AUG 2022

8.1 Project Partnership Agreement

Prior to advertisement for the construction contract, a PPA will be required to be signed by and between the Federal Government and the NFS(s), requiring formal assurances of local cooperation from the NFS. This agreement will be prepared and negotiated prior to the PED (Plans and Specifications) Phase.

8.2 Approval and Implementation

The study approval process will follow the steps found in PB 2018-01(S). These steps are listed below with additional general tasks for implementation:

a. The Integrated Feasibility Report, NEPA document, and appendices, along with the proposed report of the Chief of Engineers, will be circulated to state and Federal agencies and the public as directed by HQUSACE for an additional 30-Day State, Agency, and public review. The final Agency Technical review and policy compliance review will be conducted concurrently during this 30-day period.

b. Chief of Engineers' Approval – the Chief of Engineers will sign the report signifying approval of the project recommendation and will submit the Chief of Engineers' Report, the IFR, and the unsigned FONSI to the ASA(CW).

c. ASA(CW) Approval – HQ USACE team will finalize the Chiefs Report for the Chiefs signature and the FONSI for signature by the ASA(CW). The ASA(CW) will review the documents to determine the level of Administration support for the Chief of Engineers' recommendation. The ASA(CW) will formally submit the report to the Office of Management and Budget (OMB). OMB will review the recommendation to determine its relationship to the program of the President. OMB may clear the release of the Chief of Engineers' report to Congress.

d. The Recommended Plan requires congressional authorization for project construction.

e. Funds could be provided, when appropriated in the budget, for preconstruction, engineering and design (PED), upon the Division Commander's endorsement of the District Engineer's report and submittal to HQUSACE announcing the completion of the final report and pending project authorization for construction.

f. Surveys, model studies, and detailed engineering and design for PED studies will be accomplished first, and then plans and specifications will be completed, upon receipt of funds.

g. Construction would be performed with federal and non-federal funds in accordance with the PPA.

9.0 Recommendation

I have considered all significant aspects of the problems and opportunities as they relate to the project resource problems of the Three Forks of Beargrass Creek watershed. Those aspects include environmental, social, and economic effects, as well as engineering feasibility.

I recommend Alternative Plan 10240, the NER/Recommended Plan, which consists of 620 total acres of restoration (total site area 769 acres) and will restore 8.8 miles of stream. The plan also includes the removal of 18 connectivity barriers throughout the watershed. The overall benefits come to 297 Average Annual Habitat Units and 556 total Social Units. Average annual cost is $4,303,000 with a project first cost of $121,135,000 (fully funded cost of $142,330,000). All costs associated with the restoration of Three Forks of Beargrass Creek ecosystem have been considered.

In accordance with the National Environmental Policy Act of 1969, 42 U.S.C. § 4321-4347, as amended, the U.S. Army Corps of Engineers has assessed the environmental impacts associated with this plan, and the findings indicate that the proposed action is not a major federal action significantly affecting the quality of the human environment.

The recommendations contained herein reflect the 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 review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to Congress as proposals for authorization and implementation funding. However, prior to transmittal to Congress, the Non-Federal Sponsor, the Commonwealth of Kentucky, interested federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

The Non-Federal Sponsor understands its responsibilities as discussed in Section 7.6.8 above and has indicated its willingness to execute a PPA with the Federal Government for implementation of the Recommended Plan. I recommend approval of the Recommended Plan as presented in this report, with such modifications thereof as in the discretion of the Commander, HQUSACE, may be advisable.

Eric D. Crispino

Digitally signed by Eric D. Crispino
Date: 2022.02.03 12:33:15 -05'00'

Eric D. Crispino, PE, PMP
Colonel, U.S. Army Corps of Engineers
Commander, Louisville District

10.0 References

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