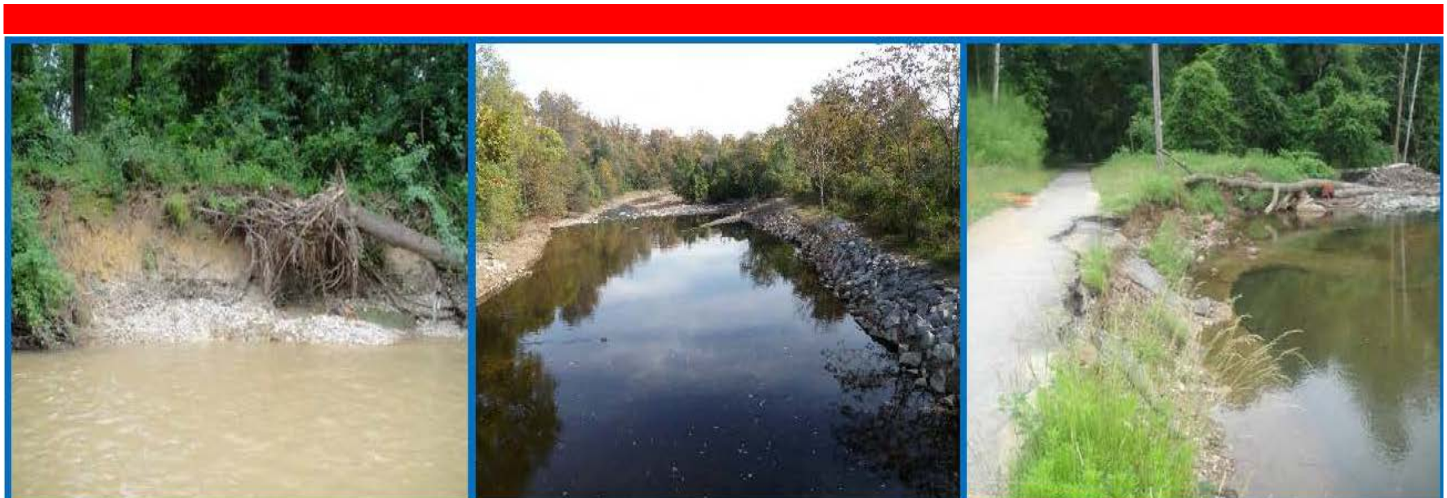
Anacostia Watershed Restoration Prince George's County, Maryland

ECOSYSTEM RESTORATION FEASIBLITY STUDY AND INTEGRATED ENVIRONMENTAL ASSESSMENT

FINAL REPORT AND APPENDICES

OCTOBER 2018



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EXECUTIVE SUMMARY

This feasibility study report and integrated environmental assessment presents alternatives for restoring degraded aquatic ecosystem structure and function in the Anacostia River watershed in Prince George's County, Maryland. This study is being conducted under the authority of a 1988 resolution of the House Committee on Public Works and Transportation to evaluate watershed improvements. In 2014, United States Army Corps of Engineers (USACE) entered into a Feasibility Cost Sharing Agreement (FSCA) with Prince George's County to conduct this study.

This study has been evaluated pursuant to the National Environmental Policy Act (NEPA) of 1969, as amended, and an environmental assessment (EA) is integrated within this report. The proposed solution for stream restoration will have no significant adverse impacts on the quality of the natural and human environment. The recommended plan provides substantial aquatic ecosystem restoration within the stream reaches and contributes to a comprehensive watershed restoration strategy.

The Anacostia River watershed encompasses approximately 176 square miles, located entirely within the Washington, D.C. metropolitan area. The drainage area within Prince George's County is approximately 86 square miles, accounting for almost one half of the total Anacostia River watershed (Figure 1-3). The Anacostia River flows through Maryland and then the District of Columbia into the Potomac River and Chesapeake Bay. The Anacostia River watershed in Prince George's County is highly urbanized with large areas of impervious surface cover.

Human alteration of the natural landscape in the Anacostia River watershed has severely degraded stream ecosystems. Biological communities in the Anacostia River are degraded due to sediment and in-stream habitat related stressors, such as channel alteration (including channelization by USACE for flood risk management), channel erosion and instability, scouring and transport of suspended sediments, fish blockages, and alterations of riparian buffer zones (Figure 1-11). Resident fish species and abundance are significantly decreased from historical levels. Anadromous fish species of concern, primarily alewife and blueback herring, which once inhabited the study stream reaches in abundance are no longer able to access their historical spawning grounds. Currently, river herring access only about 20 percent of their historical range on Northwest Branch and 10 percent on Northeast Branch.

Approximately 23 miles of stream (18 stream segments) were evaluated for restoration potential throughout the Anacostia River watershed in Prince George's County. Based on site selection criteria (Section 3.1), approximately 11 miles of stream (10 stream segments) were selected for further study (Figure 1-7). These segments are located in six Anacostia River subwatersheds, including Sligo Creek, Northwest Branch, Paint Branch, Indian Creek, Little Paint Branch, and Northeast Branch. Primary project objectives include restoring in-stream physical habitat in the selected stream reaches and enhancing aquatic ecosystem resilience by restoring fish passage and longitudinal connectivity. Twenty-four potential management measures were identified to meet project objectives and were combined into six alternatives that were screened based on planning constraints and considerations, ecosystem restoration benefits, impacts, cost, implementability, and sustainability. The alternatives that best met project objectives were carried forward, including natural channel design. The no action alternative was also carried forward as a basis for comparison.

For the natural channel design alternative, concept-level design alternatives and associated parametric costs were prepared for each stream reach. Ecosystem restoration benefits for these were calculated, including for two in-stream habitat metrics, which were based on the Maryland Biological Stream Survey's (MBSS) Physical Habitat Index (PHI). The PHI is a model used to quantify the quality of important in-stream habitat metrics. This use of this model was coordinated with the USACE National Ecosystem Restoration Planning Center of Expertise and approved by USACE Headquarters. The ecosystem restoration benefits and costs for the no action and design alternatives for fifteen stream segment combinations, were included into cost effectiveness/incremental cost analyses (CE/ICAs) to identify the most cost effective alternative plans for stream restoration.

In accordance with the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (USWRC, 1983) plans were evaluated for cost effectiveness; contributions to planning objectives; significance of outputs; and acceptability, completeness, efficiency, and effectiveness were used to recommend the plan. Plans were initially screened based on cost effectiveness. The recommended plan, Plan NW-C + NE-A (Figure 3-9), was selected from the final array of plans because it most completely meets the planning objectives to restore aquatic habitat and increase connectivity. Plan NW-C + NE-A consists of the restoration of in-stream habitat in six stream reaches, including three in the Northwest Branch subwatershed and three in the Northeast Branch subwatershed.

The recommended plan restores 7 miles of in-stream habitat, 4 miles of fish passage, and connects 14 miles of previously restored habitat. The plan removes fish blockages on Northwest Branch and Sligo Creek providing anadromous fish species of concern access to their historical range on Northwest Branch and facilitating the migration of fish to higher quality habitat upstream of Northeast Branch. For resident fish and benthic macroinvertebrates, habitat improvements resulting from the plan will include increasing diversity of depth and velocity conditions and stabilizing substrate to support species diversity and abundance. With removal of fish blockages and substantial improvements in in-stream aquatic habitat, river herring access to historical spawning grounds will increase from approximately 20 percent to 83 percent on Northwest Branch and from 10 percent to 90 percent on Northeast Branch; thereby, contributing to increases in the populations of these fish. As a component of comprehensive watershed restoration, which includes water-quality improvements being conducted by other agencies, habitat improvements are expected to lead to increased indices of biotic integrity for fish and benthic organisms.

The recommended plan will not have an adverse impact on any threatened or endangered species or their critical habitat. Project construction will result in localized, short-term, and minor detrimental environmental impacts to water quality, air quality, and noise levels; in-stream work will cause unavoidable destruction of some common aquatic organisms. All adverse effects will be minimized through utilization of best management practices and activities will be conducted according to state and federal requirements. Project impacts are temporary in nature and habitat will be replaced in kind or better; therefore, no compensatory mitigation is required. The majority of the project work will be confined to the area in between the stream banks, and based on cultural resource surveys is not expected to result in adverse impacts to cultural resources. Access roads and staging areas will not include subsurface excavation and will be confined to previously disturbed areas when possible.

In addition to restoring habitat, the proposed restoration enhances federal investments by connecting to previous USACE stream restoration, including on Paint Branch (Continuing Authorities Program Section 206) and Northwest Branch (Continuing Authorities Program Section 1135). Furthermore, the recommended plan restores aquatic ecosystems that were directly degraded by a USACE flood risk management project implemented on Northwest Branch, Northeast Branch, Paint Branch, and Indian Creek in the 1970s. Restoration of the Anacostia River watershed, as a contributing subwatershed to the Chesapeake Bay, supports Executive Order 13508 for restoration of the Chesapeake Bay, the Chesapeake Bay Program outcomes, and the Anacostia Restoration Plan (ARP) goals. The Urban Waters Federal Partnership is also supported by reconnecting urban areas with their waterways.

Project first cost of the recommended plan is $34,106,000 (fiscal year 2019 price level). Operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) expenses are expected to be minimal and are estimated at $22,000 per year. The federal portion of the estimated first cost is $22,169,000. The non-federal sponsors' portion of the required 35 percent cost share of total project first costs is $11,937,000, which includes 100 percent of the real estate costs (land, easements, rights-of-way, and relocations).

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Table of Contents

EXECUTIVE SUMMARY iii
Table of Contents vii
Figures xi
Tables xiii
Appendices xiv
1 *INTRODUCTION 1
1.1 Study Authority 1
1.2 Study Sponsor 1
1.3 Purpose and Need 2
1.4 Federal Interest and Resource Significance 2
1.4.1 Institutional and Public Significance 5
1.4.2 Technical Significance 10
1.5 Study Scope 11
1.5.1 Study Area 12
1.6 Prior Studies, Reports, and Water Projects 15
1.7 Problems and Opportunities 23
1.7.1 Problems 23
1.7.2 Opportunities 26
1.8 Project Objectives, Constraints, and Considerations 29
1.8.1 Planning Objectives 29
1.8.2 Planning Constraints 30
1.8.3 Planning Considerations 30
2 *AFFECTED ENVIRONMENT 33
2.1 Physical Environment 33
2.1.1 Climate and Air Quality 33
2.1.2 Geology, Topography, and Soils 34
2.1.3 Land Use and Land Cover 36
2.1.4 Infrastructure 38
2.2 General Hydrologic Setting 39
2.2.1 Stream Geomorphic Condition 40
2.2.2 Water Quality Standards and Listings 41
2.2.3 Water Quality Impairments 42

2.3 Hydraulic and Hydrologic Setting of Study Stream Reaches 43
2.3.1 Existing Conditions for Northwest Branch and Tributaries 44
2.3.2 Existing Conditions for Northeast Branch and Tributaries 45
2.4 Biological Resources 48
2.4.1 Fish and Benthic Integrity 48
2.4.2 Fish Passage 51
2.4.3 Wildlife 52
2.4.4 Rare, Threatened and Endangered Species 53
2.4.5 Riparian Vegetation (Wetlands & Forest) 53
2.5 Community Setting 59
2.5.1 Population and Demographics 59
2.5.2 Environmental Justice 59
2.5.3 Schools 61
2.5.4 Parks and Recreation 61
2.5.5 Aesthetics and Noise 63
2.5.6 Cultural Resources 63
2.5.7 Hazardous, Toxic, and Radioactive Waste 64
2.6 Future-Without-Project Conditions 65
2.6.1 Climate 65
2.6.2 Population and Demographics 67
2.6.3 Water Quality 67
2.6.4 Stream Geomorphic Condition 68
2.6.5 Fish and Benthic Integrity 69
2.6.6 Fish Passage 69
2.6.7 Riparian Vegetation (Wetlands and Forest) 70
3 *PLAN FORMULATION 71
3.1 Site Selection 72
3.2 Summary of Management Measures 79
3.3 Summary of Initial Array of Alternatives 83
3.4 Evaluation and Comparison of the Initial Array of Alternatives 84
3.5 Quantification of Project Benefits and Costs for Conceptual Analysis 85
3.5.1 Conceptual Site Design Descriptions 86
3.5.2 Quantifying the Benefits of Ecosystem Restoration 86

3.5.3 Estimating Conceptual Costs ... 91
3.5.4 Cost Effectiveness Analysis ... 93
3.6 Plan Comparison and Recommendation ... 100
3.6.1 Comparison of Alternatives for the Northwest and Northeast Branches ... 101
3.6.2 The Recommended (NER) Plan ... 104
3.6.3 Key Benefits of the Recommended Plan ... 107
3.7 Confirming the Recommended Plan ... 108
4 PLAN IMPLEMENTATION ... 111
4.1 Plan Components ... 111
4.1.1 Feasibility Level Design and Modeling ... 111
4.1.2 Post-Project Monitoring ... 129
4.1.3 Adaptive Management ... 131
4.2 Local Cooperation ... 134
4.3 Cost Estimates and Cost Sharing ... 136
4.4 Project Implementation Schedule (Draft) ... 137
4.5 Design and Construction ... 138
4.6 Real Estate ... 139
4.7 Operation, Maintenance, Repair, Replacement, Rehabilitation (OMRRR) ... 139
4.8 Project-Specific Considerations ... 140
4.9 Project Uncertainty and Risk ... 141
5 *ENVIRONMENTAL IMPACTS AND COMPLIANCE ... 143
5.1 Physical Environment ... 144
5.1.1 Climate and Air Quality ... 144
5.1.2 Geology, Topography, and Soils ... 145
5.1.3 Land Use and Land Cover ... 145
5.1.4 Infrastructure ... 146
5.2 Hydrologic Setting ... 146
5.2.1 Stream Geomorphic Condition ... 146
5.2.2 Water Quality ... 148
5.3 Hydraulic and Hydrologic Setting of Study Stream Reaches ... 149
5.3.1 Northwest Branch and Tributaries –Permanent, Direct Impacts ... 149
5.3.2 Northeast Branch and Tributaries – Permanent, Direct Impacts ... 150
5.3.3 Direct Impacts (Temporary) ... 151

5.3.4 Indirect Impacts (Permanent) ... 152
5.4 Biological Resources ... 152
5.4.1 Fish and Benthic Integrity ... 152
5.4.2 Fish Passage ... 153
5.4.3 Wildlife ... 153
5.4.4 Rare, Threatened, and Endangered Species ... 154
5.4.5 Riparian Vegetation (Wetlands and Forest) ... 154
5.5 Community Setting ... 158
5.5.1 Population and Demographics ... 158
5.5.2 Environmental Justice ... 159
5.5.3 Schools ... 159
5.5.4 Parks and Recreation ... 159
5.5.5 Aesthetics and Noise ... 161
5.5.6 Cultural Resources ... 161
5.5.7 Hazardous, Toxic, and Radioactive Waste ... 163
5.6 Cumulative Impacts ... 163
5.7 Environmental Compliance ... 167
5.8 Public Involvement and Agency Coordination ... 169
5.8.1 Study Notification & Updates ... 169
5.8.2 Public Review of the Draft Report ... 170
6 CONCLUSIONS ... 171
7 RECOMMENDATIONS ... 173
8 REFERENCES ... 177

* Section headings in this document marked with an asterisk indicate National Environmental Policy Act (NEPA) required content

Figures

Figure 1-1. National and regional significance of the Chesapeake Bay and Anacostia River watershed. ... 3
Figure 1-2. Federal commitments in the Anacostia River watershed. ... 4
Figure 1-3. Location of the Anacostia River watershed within the Chesapeake Bay watershed. ... 5
Figure 1-4. Anacostia River subwatershed citizen groups. ... 8
Figure 1-5. Elements of the Anacostia Watershed Restoration Partnership (from MWCOG 2009), with USACE role at Executive Level in bold font. ... 8
Figure 1-6. Anacostia River watershed and subwatersheds in Prince George's County, MD. ... 13
Figure 1-7. Stream sites in Prince George’s County selected for study. ... 14
Figure 1-8. Subset of USACE projects in the Anacostia River watershed. ... 19
Figure 1-9. Anacostia Restoration Plan projects within the study subwatersheds (data provided by MWCOG, 2017). ... 21
Figure 1-10. PGDOE stormwater capital improvement projects completed or in constriction since 2003. ... 22
Figure 1-11. Problems in the study stream reaches. A. Erosion along study stream reach (site 13) undermining a pedestrian trail system. B. Concrete sill inhibiting fish migration upstream on Northwest Branch (site 3). C. Homogeneous habitat conditions as a result of USACE channelization (site 3). D. Excess sediment deposition and formation of large sediment bars (site 5). ... 24
Figure 2-1. Schematic of a gravity-flow sewer system (from Ken Belt, USDA). ... 39
Figure 2-2. MWCOG migratory fish monitoring sites on Northwest and Northeast Branches (from MWCOG, 2014). Study sites 3 and 15 shown for context. ... 50
Figure 2-3. Fish blockages on Northwest Branch (site 3) and Sligo Creek (site 9). ... 52
Figure 2-4. Field verified wetlands in the project area at site 11, Indian Creek. ... 58
Figure 2-5. EJ Index for the general study area (USEPA, 2017). ... 60
Figure 3-1. Plan formulation for Anacostia watershed restoration, Prince George's County, Maryland... 72
Figure 3-2. Project area and selected stream reaches in Prince George's County, Maryland. ... 78
Figure 3-3. Aggregate benefits for each project site. ... 92
Figure 3-4. Northwest and Northeast Branch subwatershed boundaries for the formulation of site alternatives. ... 95
Figure 3-5. CE/ICA graph for Northwest Branch showing best buy plans. ... 98
Figure 3-6. CE/ICA graph for Northeast Branch showing best buy plans. ... 99
Figure 3-7. Alternative Plans NW-A, NW-B, and NW-C for Northwest Branch and NE-A for Northeast Branch. ... 103
Figure 3-8. The recommended plan, Plan NW-C + NE-A. ... 105
Figure 3-9. Future-with-project estimation of stream quality for anadromous fish utilization. ... 106
Figure 4-1. Sheet index and spatial reference for feasibility level design drawings and descriptions. ... 117
Figure 4-2. Design Sheet #105 - An example of structures, contouring, and clearing for Site 3 and Site 9, at the confluence of Sligo Creek (left) and Northwest Branch (right). ... 123
Figure 4-3. Design Sheet #143 - An example of structures, contouring, and clearing for Site 13 on Northwest Branch. ... 124
Figure 4-4. Design Sheet #154 - An example of structures, contouring, and clearing for Site 11 on Indian Creek. ... 125

Figure 4-5. Design Sheet #123 - An example of structures, contouring, and clearing for Site 5 on Paint Branch. 126
Figure 4-6. Design Sheet #131 - An example of structures, contouring, and clearing for Site 15 on Northeast Branch. 127
Figure 5-1. LOD and wetland 11-B. 156
Figure 5-2. Contributions from USACE and others to a comprehensive restoration strategy for the Anacostia River watershed. 166

Tables

Table 1-1. Reports produced by USACE related to work within the Anacostia River watershed. 16
Table 1-2. Descriptions of USACE projects (as of September 2015) shown in Figure 1-8. 20
Table 1-3. Fish species richness under existing conditions and with comprehensive restoration. 27
Table 2-1. Primary soil types, prime farmland classification, and hydric rating for the study sites. 35
Table 2-2. Land use classification (percent) for the portion of each of the study subwatersheds* in Prince George's County (data from NLCD, 2006). 37
Table 2-3. Percentage of impervious surface cover category within the Prince George's County portion of the study subwatersheds* (data from NLCD, 2011)... 38
Table 2-4. Physical Habitat Index scores for the study stream sites... 51
Table 2-5. Acres of wetlands (NWI) and forest (MWCOG, 2000) in the Prince George's County portion of the study subwatersheds*. 54
Table 2-6. Description of riparian vegetation and wetlands at each stream site. 55
Table 2-7. Percentage of minorities and low income families and persons in the census tracts adjacent to the project stream sites (data from US Census, 2013). 60
Table 2-8. Schools within 1,640 feet (500 meters) of proposed streams segments. 61
Table 2-9. Parks within 1,640 ft (500 meters) of proposed stream segments. 62
Table 2-10. Typical Noise Levels and Subjective Impressions.. 63
Table 2-11. Percentage reductions required for the Anacostia River watershed in Prince George's County (from PGDOE, 2014). 68
Table 3-1. Site selection criteria for stream reaches considered for study 75
Table 3-2. Characteristics of the project stream reaches selected for study. 77
Table 3-3. Ecosystem restoration management measures that meet the project objectives. 80
Table 3-4. Criteria and metrics used for evaluation and comparison of initial array of alternatives. 84
Table 3-5. Comparison of alternatives. 85
Table 3-6. Steps in the assessment of stream physical habitat. 87
Table 3-7. Predicted post-restoration improvement in physical habitat scores for epibenthic substrate and in-stream habitat for the selected design alternatives... 89
Table 3-8. Future-without-project (FWOP) and future -with-project (FWP) changes in PHI scores and best achievable PHI score for the selected conceptual design alternatives... 90
Table 3-9. Average annual (AA) costs and benefits used in the CE/ICAs. 97
Table 3-10. Outputs (ecosystem restoration benefits) and costs for Northwest Branch CE/ICA best buy plans. 98
Table 3-11. Outputs (ecosystem restoration benefits) and costs for Northeast Branch CE/ICA best buy plans. 99
Table 3-12. The approximate historical, current, and with-project ranges of anadromous fish............. 107
Table 3-13. Revised SHUs for all alternatives (* indicates alternatives in the recommended plan) 109
Table 4-1. Descriptions and typical sections for in-stream structures. 112
Table 4-2. Results of SIAM with two different methods for Northwest Branch.................................... 115
Table 4-3. Results of SIAM with two different methods for Northeast Branch..................................... 116
Table 4-4. Monitoring parameters, success criteria, and timeframes for monitoring. 130
Table 4-5. Monitoring cost breakdown for physical habitat and biological sampling. 131
Table 4-6. Monitoring cost breakdown for topographic surveys. 131

Table 4-7. Monitoring cost breakdown for wetland and vegetation monitoring. 131
Table 4-8. Contingency (adaptive management) costs. 133
Table 4-9. Cost apportionment – Federal and non-Federal responsibilities. 137
Table 4-10. Average annual costs and benefits. 137
Table 5-1. Summary of construction emissions for implementation of the recommended plan. 145
Table 5-2. Area of Capper Crampton* lands and impacts to park facilities. 160
Table 5-3. Federal environmental protection statutes and other requirements requiring consideration. 167

Appendices

Appendix A. Existing Conditions
- A-1: Subwatershed Existing Conditions
- A-2: Existing Conditions – Fish Species and Sample of Habitat Requirements (Tables)
- A-3: Baseline Ecological Conditions of Candidate Restoration Reaches (Tetra Tech)
- A-4: Hazardous, Toxic, and Radioactive Waste Summary
- A-5: Cultural Resources Evaluation
- A-6: Anacostia Restoration Plan Candidate Restoration Projects
- A-7: Indian Creek Site Visit Summary for Stellaria Alsine Reconnaissance
- A-8: Field Report for Wetland Assessments, November 2017

Appendix B. Plan Formulation and Environmental Benefits Model

Appendix C. Environmental Compliance
- C-1: U.S. Fish and Wildlife Service Coordination Act Report
- C-2: U.S. Fish and Wildlife Service Planning Aid Report
- C-3: Endangered Species Act Determination
- C-4: Nationwide Permit #27 Aquatic Habitat Restoration, Establishment, and Enhancement
- C-5: Clean Air Act General Air Quality Conformity Analysis
- C-6: Agency Correspondence

Appendix D. Public Involvement

Appendix E. Engineering
- E-1: Civil Engineering Appendix
- E-2: Hydrology and Hydraulics Appendix
- E-3: HEC-RAS Model Appendix & Attachment
- E-4: Sediment Impact Assessment Model Appendix
- E-5: Feasibility Level Design Drawings
- E-6: Concept Level Design Drawings
- E-7: Cost Engineering Products

Appendix F. Economics Analysis

Appendix G. Real Estate Plan

Appendix H. Adaptive Management Plan

ACRONYMS AND ABBREVIATIONS

ARP	Anacostia Restoration Plan
ASTM	American Society for Testing and Materials
ATRW	Anacostia Trash Reduction Work Group
AWCAC	Anacostia Watershed Citizens Advisory Committee
AWRC	Anacostia Watershed Restoration Committee
AWRP	Anacostia Watershed Restoration Partnership
AWTA	Anacostia Watershed Toxics Alliance
B-IBI	Benthic Index of Biotic Integrity
BMPs	Best management practices
CAP	Continuing Authorities Program
CBP	Chesapeake Bay Program
CE/ICA	Cost effectiveness/incremental cost analysis
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CO	Carbon monoxide
CRPs	Candidate Restoration Projects
D.C.	District of Columbia
DOI	Department of Interior
DOT	Maryland Department of Transportation
EA	Environmental assessment
EO	Executive Order
EO 13508	Chesapeake Bay Protection and Restoration Executive Order
EPA	U.S. Environmental Protection Agency
F-IBI	Fish Index of Biotic Integrity
FS	Feasibility study
FWOP	Future-without-project
FWP	Future-with-project
IBI	Index of Biotic Integrity
HTRW	Hazardous, Toxic, and Radiological Waste
LERR’s	Lands, easements, rights-of-way, and relocations
MBSS	Maryland Biological Stream Survey
MII	Micro-Computer Aided Cost Estimating System Second Generation
MDDNR	Maryland Department of Natural Resources
MDE	Maryland Department of the Environment
MHT	Maryland Historical Trust
MNCPPC	Maryland-National Capital Park and Planning Commission
MS4	Municipal Separate Storm Sewer System (Permit)

MWCOG	Metropolitan Washington Council of Governments
NAAQS	National Ambient Air Quality Standards
NCD	Natural channel design
NCPC	National Capital Planning Commission
NE-A	Plan A for the Northeast Branch alternatives
NEPA	National Environmental Policy Act of 1969
NER	National Ecosystem Restoration
NGO	Non-governmental organizations
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NO_2	Nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NRHP	National Register of Historic Places
NW-C	Plan C for Northwest Branch alternatives
NW-C + NE-A	The tentatively selected plan, including plans NW-C and NE-A
O_3	Ozone
O&M	Operation and maintenance
OMRR&R	Operation, maintenance, repair, rehabilitation, and replacement
Pb	Lead
PED	Preconstruction, engineering, and design
PGDOE	Prince George's County Department of the Environment
PHI	Physical Habitat Index
$PM_{2.5}$	Particulates
PPA	Project partnership agreement
SHA	Maryland State Highway Administration's
SHPO	State Historic Preservation Office
SO_2	Sulfur dioxide
SR3	Sewer Repair, Replacement, and Rehabilitation
TSP	Tentatively selected plan
TMDLs	Total Maximum Daily Loads
UMD	University of Maryland
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WIP	Watershed Implementation Plan
WRDA	Water Resource Development Act
YOY	Young of the year

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1 *INTRODUCTION

This feasibility report and integrated environmental assessment (EA) is a product of the study authority described below and documents the results of an aquatic ecosystem restoration study of streams within the Anacostia River watershed in Prince George's County, Maryland. This study was conducted jointly by the U.S. Army Corps of Engineers (USACE) and Prince George's County, Maryland.

A Section 905(b) report, *Anacostia River and Tributaries, Maryland and the District of Columbia, Comprehensive Watershed Plan,* was completed in July 2005 and recommended that USACE conduct a comprehensive investigation of watershed problems. The resulting *Anacostia River Watershed Restoration Plan* (ARP) was completed in February 2010, and identified over 3,000 candidate projects for the restoration of the Anacostia River watershed, including projects that USACE could potentially implement. Three-hundred and ninety-six potential ecosystem restoration projects that represented possible USACE-led efforts were identified in Prince George's County. This study was initiated to further evaluate these and other opportunities for watershed restoration in Prince George's County.

This report includes the environmental, engineering, and socioeconomic information utilized in formulating the recommended environmental restoration plans, and provides the basis for recommending the preparation of final designs and construction of these projects. The report includes documentation to meet the requirements of the National Environmental Policy Act (NEPA) of 1969, as amended, and serves as the NEPA compliance document. The report is considered an integrated EA because all information required for an EA is included within the report. The integrated EA addresses specific impacts (both beneficial and adverse) of the recommended restoration plans. Report contents denoted with an asterisk (*) are NEPA required content.

1.1 Study Authority

The Anacostia Watershed Restoration, Prince George's County, Maryland Study is being conducted under the authority of a September 8, 1988 resolution of the House Committee on Public Works and Transportation. That resolution reads as follows:

> *"Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, that the Board of Engineers for Rivers and Harbors is hereby requested to review the report of the Chief of Engineers on the Anacostia River and Tributaries, District of Columbia and Maryland, published as House Document No. 202, 81st Congress, 1st Session, with a view to determining if further improvements for flood control, navigation, erosion, sedimentation, water quality and other related water resources needs are advisable at this time."*

1.2 Study Sponsor

This study is being conducted in partnership with Prince George's County, Maryland, which entered into a Feasibility Cost Sharing Agreement on January 13, 2014. The primary point of contact on behalf of the non-federal sponsor is the Prince George's County Department of the Environment (PGDOE).

1.3 Purpose and Need

The purpose of the recommended plan is to restore ecological function, structure, and health in selected stream reaches in the Anacostia River watershed in Prince George's County. Restoration is needed because human alteration of the Anacostia River watershed has resulted in significant degradation of the watershed's aquatic ecosystems over time. Once supportive of the lifecycle needs of anadromous fish, these ecosystems are now unsuitable or inaccessible to their use.

1.4 Federal Interest and Resource Significance

USACE has a long history in the Anacostia River watershed, dating back to the founding of Washington, D.C. Early USACE work included making the land habitable and suitable for construction of the city and navigation on the mainstem of the Anacostia River. Historically, the Anacostia played a critical role in enabling significant economic development in the region, but as a result became engineered and industrialized. The Anacostia River flows through low-income and minority urban areas, and in the shadow of the Potomac River has been called America's "Forgotten River" (Arnold et al., 2015).

Efforts to restore the Anacostia River watershed began nearly three decades ago. Since that time, local, state, and Federal Government agencies, as well as environmentally-oriented non-governmental organizations and dedicated private citizens have contributed significant resources toward watershed restoration. Formal cooperation between government agencies came with the signing of the Anacostia Watershed Agreement in 1987 (of which USACE Baltimore District was an original signatory member) and the formation of the Anacostia Watershed Restoration Committee (AWRC). In 2006, the AWRC was reorganized into the Anacostia Watershed Restoration Partnership (AWRP) with an updated vision for the restoration of the watershed (Section 1.4.1.4.)

The Anacostia watershed restoration, including USACE involvement, represents an example of the improvements to urban watershed health that can be achieved through comprehensive restoration. Figure 1-1 illustrates the national and regional significance of the recommended plan. Due in large part to the Anacostia Watershed Agreement, numerous federal commitments and actions have been made within the past 30 years, culminating in current federal efforts to restore urban streams in the watershed (Figure 1-2).

This report directly supports the habitat goals of the ARP and the Chesapeake Bay Protection and Restoration Executive Order (EO 13508). The significance of the fish and wildlife resources of the Chesapeake Bay is widely recognized by the institutional, public, and technical sectors. As the largest estuary of U.S., the Chesapeake Bay watershed extends into six states (Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia) and encompasses all of the District of Columbia. The following subsections describe components of resource significance as prescribed in the Economic and Environmental Principles and Guidelines for Water Related Resources Implementation Studies (Water Resources Council, 1983).

Figure 1-1. National and regional significance of the Chesapeake Bay and Anacostia River watershed.

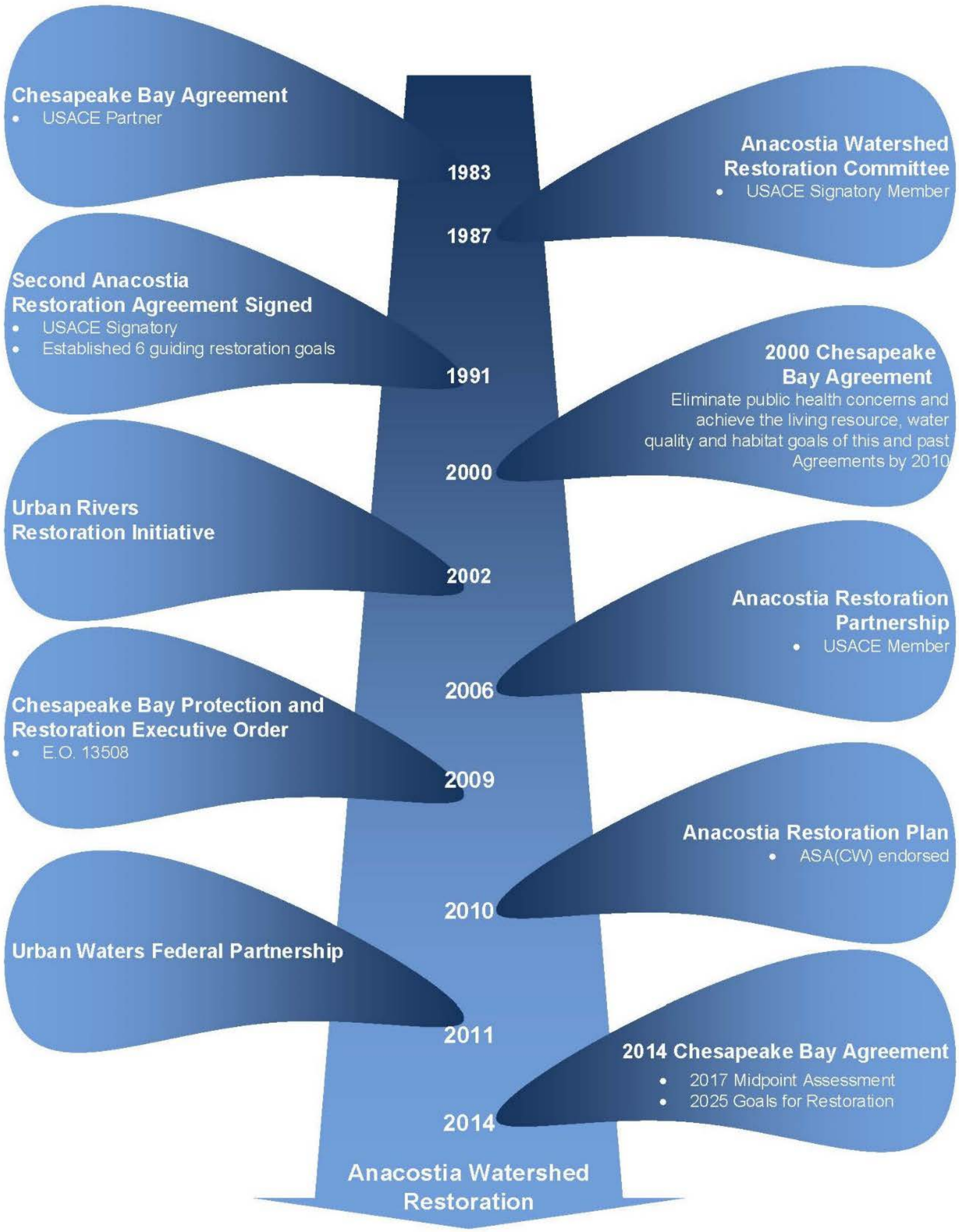

Figure 1-2. Federal commitments in the Anacostia River watershed.

1.4.1 Institutional and Public Significance

1.4.1.1 Executive Order 13508, Chesapeake Bay Protection and Restoration

On May 12, 2009, President Obama issued EO 13508 to protect and restore the Chesapeake Bay and its watershed. The EO declared the Chesapeake Bay a "national treasure" and recognized that there are many nationally significant assets owned by the Federal Government in the Chesapeake Bay and its watershed such as public lands, facilities, military installations, parks, forests, wildlife refuges, monuments, and museums. The EO directed the Federal Government to exercise a greater leadership role to restore this ecological, economic, and cultural resource. The Federal Leadership Committee for the Chesapeake Bay, designated by EO 13508, includes representatives from the U.S. Environmental Protection Agency (EPA) and the Departments of Agriculture, Commerce, Defense (including USACE), Homeland Security, Interior, and Transportation.

In order to achieve restoration success of the Chesapeake Bay and show measurable results at the basin scale, the Bay's contributing watersheds must be restored from degraded conditions. To align with the national vision to restore the Chesapeake Bay and continue the restoration effort in the Anacostia River watershed, USACE, Baltimore District was identified in the Chesapeake Bay EO Action Plan (FLCCB, 2014) to continue feasibility studies for the Anacostia River watershed for Montgomery and Prince George's Counties, Maryland. Figure 1-3 shows the location of the Anacostia River watershed within the Chesapeake Bay watershed.

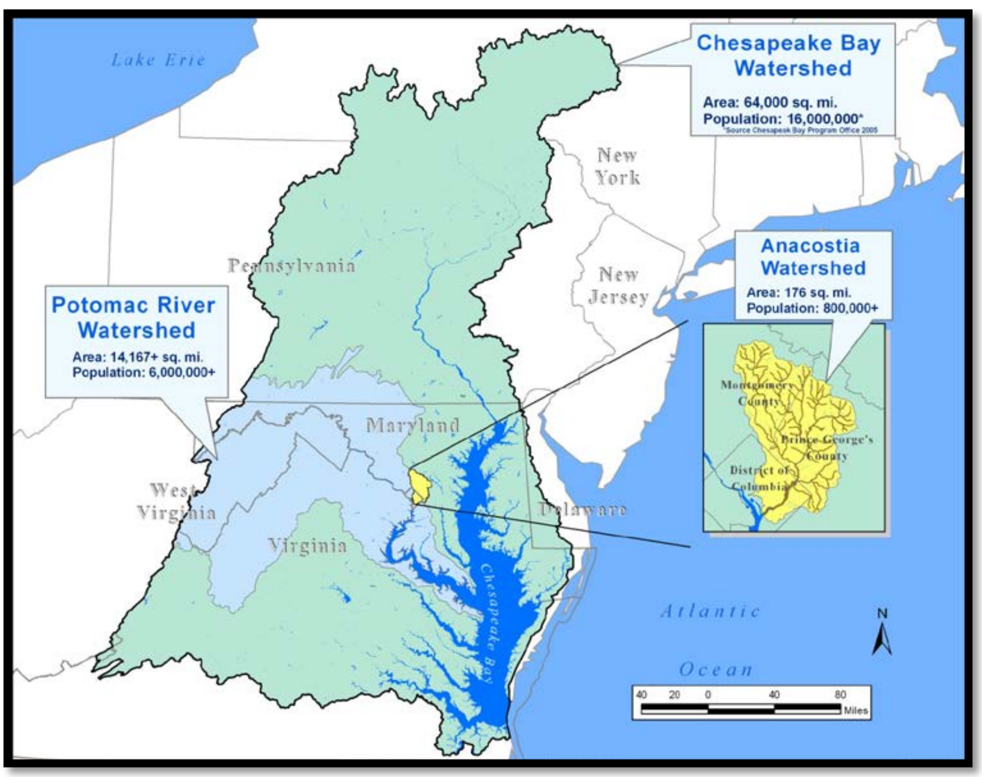

Figure 1-3. Location of the Anacostia River watershed within the Chesapeake Bay watershed.

1.4.1.2 Chesapeake Bay Program

The Chesapeake Bay was the first estuary targeted by Congress for restoration and protection (CBP, 2012). The Chesapeake Bay Program (CBP) was established in 1983. The CBP is a regional partnership of government agencies and organizations with EPA as the lead federal agency for coordination of restoration efforts and strategy implementation. There are 18 federal agencies listed as CBP partners (including USACE), as well as 26 academic institutions, 35 non-governmental organizations (NGOs), and at least six other partners.

There have been a number of agreements since 1983 for the purpose of guiding Chesapeake Bay restoration. These include the Chesapeake Bay Agreement of 1983, the 1987 Chesapeake Bay Agreement, the 2000 Chesapeake Bay Agreement, and the recently signed 2014 Chesapeake Bay Watershed Agreement. Through the 2014 Chesapeake Bay Watershed Agreement, the partnership has recommitted its efforts to restoration of the Bay and its watershed. This report is consistent with the vision of the Bay Agreements, which has guided the CBP. The 2014 Chesapeake Bay Watershed Agreement includes "goals" and "outcomes" for Bay restoration (ecosystem and water quality) with a mid-point assessment in 2017 and target restoration date of 2025. The following "outcomes" are supported by the recommended plan for the Anacostia River watershed restoration in Prince George's County:

- **Fish Habitat –** Improve effectiveness of fish habitat conservation and restoration efforts;
- **Fish Passage –** Increase available habitat to support sustainable migratory fish populations; restore historical migratory routes for migratory fish, such as alewife herring (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), hickory shad (*Alosa mediocris*), American eel (*Anguilla rostrata*) and brook trout (*Salvelinus fontinalis*).
- **Stream Health –** Improve stream health and function throughout the watershed.

Related to Chesapeake Bay restoration, the plan recommended by this study also directly supports the *USACE Civil Works Strategic Plan for 2014-2018*, Civil Works Strategic Goal 4: Restore, Protect, and Manage Aquatic Ecosystems to Benefit the Nation. (USACE, 2015a). Goal 4, Objective 4.1 is to restore aquatic habitat to a more natural condition in ecosystems whose structures, functions, and dynamic processes have become degraded, with an emphasis on restoring nationally significant habitat, including the Chesapeake Bay (USACE, 2015a).

1.4.1.3 Urban Waters Federal Partnership and EPA's Urban Waters Initiative

The Urban Waters Federal Partnership reconnects urban communities, particularly those that are overburdened or economically distressed, with their waterways by improving coordination among federal agencies and collaborating with communities to improve and promote the economic, environmental, and social benefits of our Nation's water systems (UWFP, 2011). The partnership is led by the Department of the Interior and EPA and includes twelve federal agencies that work together to align programs, activities, and expertise supporting local initiatives. USACE is one of the initiative's federal partners. Ms. Jo-Ellen Darcy, former Assistant Secretary of the Army for Civil Works, signed the partnership agreement and has stated USACE's commitment to assisting in securing more vibrant and sustainable urban waters.

The strategic framework for this program includes an objective for restoration and protection of urban waters. The Anacostia River watershed is one of the initial seven locations in the country selected for help from the Urban Waters Federal Partnership. Human communities in the watershed have been harmed or weakened by many manifestations of socio-economic inequality, including environmental injustices that placed low-income and minority populations in close proximity to pollution and intensive land uses (Arnold et al., 2015). The Anacostia River watershed was selected for the Urban Waters program because it is one of the most urbanized watersheds in the U.S.; however, it holds enormous potential to provide abundant natural beauty, habitat, and recreational amenities. The Urban Federal Waters Partnership supports the ARP, which highlights the unprecedented regional and multijurisdictional commitment to restore environmental, economic, and social benefits for the river and the watershed, and to enhance the vitality of communities in the District of Columbia and Maryland's Montgomery and Prince George's Counties.

1.4.1.4 Watershed Governance

Over the past several decades, watershed governance institutions have emerged in response to the environmental and social unsustainability of the degraded Anacostia River watershed. Watershed-focused groups of area residents have collaborated to address these harms and multi-jurisdiction, multi-agency, multi-stakeholder partnerships have been created to govern the watershed with attention to ecological and social issues (Arnold et al., 2015). Most of the major tributaries of the Anacostia River have their own sub-watershed citizen advisory groups (Figure 1-4). The largest of these groups, the Anacostia Watershed Society (AWS) was founded in 1989 with a vision to protect and restore the Anacostia River and its watershed communities. AWS conducts numerous educational events and undertakes projects such as stream restoration, stormwater best management practices (BMPs) and retrofits, and others throughout the watershed. In 2013, more than 8,000 people participated in AWS programs and projects (AWS, 2014).

Multi-agency watershed partnerships have arisen to address watershed issues in or involving the Anacostia River watershed, including: Agreement of Federal Agencies on Ecosystem Management in the Chesapeake Bay; Anacostia Ecosystem Initiative; Anacostia Waterfront Initiative; Anacostia Watershed Citizens Advisory Committee; Anacostia Watershed Management Committee; Anacostia Watershed Restoration Partnership; Anacostia Watershed Steering Committee; Anacostia Watershed Toxics Alliance; Clean Rivers, Green District Green Infrastructure Partnership; Chesapeake Bay Program; Chesapeake Bay Watershed Agreement; Urban Rivers Restoration Initiative; Urban Waters Federal Partnership; and various subwatershed partnerships (Arnold et al., 2015).

Federal agencies have had a long-standing interest in the restoration of the Anacostia River watershed, including through participation in the Anacostia Watershed Restoration Partnership (Figure 1-5). AWRP was formalized in 2006 to oversee a restoration vision and track restoration success. At the executive level, the District Engineer of USACE Baltimore District serves on the leadership council, along with the Governor of the State of Maryland, the Mayor of the District of Columbia, County Executives for Montgomery and Prince George's Counties, and the Regional

Administrator for EPA Region III. In 2010, the AWRP released the ARP. USACE Baltimore District played a major role in the development of this watershed restoration plan.

Figure 1-4. Anacostia River subwatershed citizen groups.

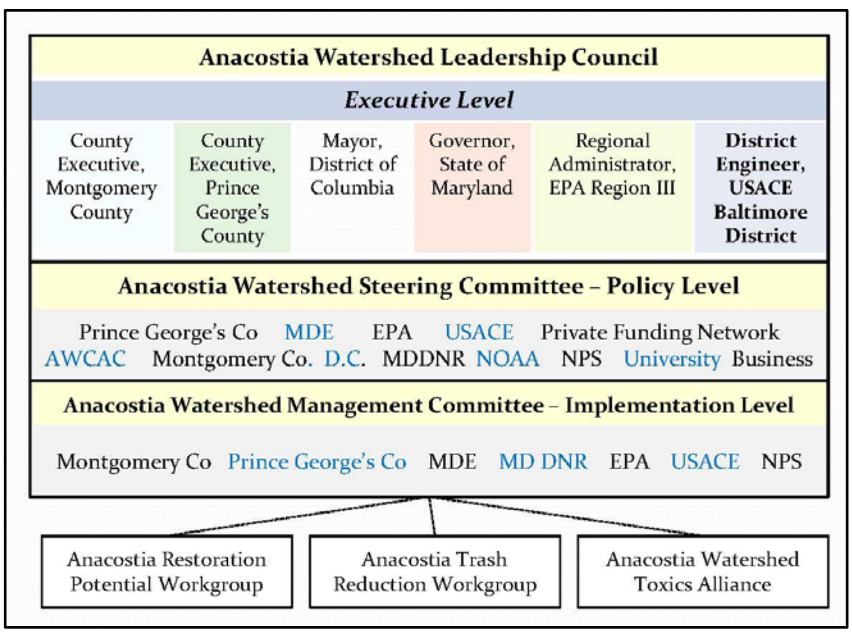

Figure 1-5. Elements of the Anacostia Watershed Restoration Partnership (from MWCOG 2009), with USACE role at Executive Level in bold font.

Following the release of the ARP in April 2010, affirmation and support of the direction for future restoration actions were noted in letters to the USACE Baltimore District Commander from each of the executive leaders associated with the AWRP. In a letter dated June 21, 2010, the Honorable Martin O'Malley, then Governor of Maryland, stated that "we believe that implementation of the ARP recommendations will result in major improvements in the quality of the Anacostia River and its tributaries. We also believe that this plan can serve as a model of how Federal, state, and local governments can work together to restore an urban watershed." Furthermore, in a letter dated June 11, 2010, the Honorable Jack B. Johnson, former Prince George's County Executive, noted that "we endorse the actions recommended by the [ARP] and look forward to working with [USACE] and other agencies on the implementation of the ARP…."

Over the past 30 years, many agencies have worked toward restoration of the Anacostia River watershed. U.S. Fish and Wildlife Service (USFWS) Chesapeake Bay Field Office has conducted studies aimed at documenting the magnitude and effects of impacts from chemical contaminants in the tidal river. Working with partners, USFWS biologists have also provided substantial support towards restoration, including serving on the Anacostia Watershed Toxics Alliance and the Leadership Council for a Cleaner Anacostia. USFWS and the District of Columbia's Department of Energy and Environment have conducted stream restoration projects within the watershed. One recent project includes restoration of Watts Branch completed in 2011. The project restored and stabilized a stream system that was eroding by an estimated 1,500 tons per year (USFWS, 2011). In combination with other projects to improve water-quality the projects resulted in about a one-third reduction in total suspended solids, along with other nutrient loading reductions, which supported improved water quality and corresponding habitat quality (USEPA, 2013).

Restoration efforts such as this support the six river restoration goals identified in the ARP (AWRP, 2010). Prior USACE-led aquatic ecosystem restoration projects (Section 1.6) in the Anacostia River watershed and the ongoing studies for stream restoration in Prince George's and Montgomery Counties support at least three of the ARP goals, including goals two, three, and four. Goals two, three, and four can be implemented under USACE mandates, whereas the other goals (e.g., for water quality) are the responsibility of other agencies. The AWRP watershed restoration goals are to:

1. Dramatically reduce pollutant loads
2. Protect and restore ecological integrity
3. Improve fish passage
4. Increase wetland acreage
5. Expand forest cover
6. Increase public and private participation

In addition to restoration opportunities, USFWS and other federal agencies have promoted efforts to increase recreation within the Anacostia River watershed. The U.S. National Park Service (NPS) has helped to obtain funding for a riverside trail along the Anacostia River, and more broadly, the DOI has developed new Urban Initiatives and Urban Refuge Programs to encourage urban residents to enjoy the natural resources of the Anacostia River.

1.4.2 Technical Significance

The Anacostia River watershed currently supports approximately 55 species of fish, 24 amphibian species, 31 reptile species, 30 mammal species, and an estimated 225 resident and non-resident bird species (MWCOG, 2010). These species include both fish and bird species of state and federal conservation concern. In addition, there are approximately 443 plant species representing 249 genera in 94 families found within the Anacostia River watershed (Teague et al., 2006). However, as a result of anthropogenic disturbances in the watershed, the diversity of species supported by the Anacostia River is greatly diminished compared to historical levels prior to extensive development and urbanization of the watershed.

The stream reaches included in this study historically provided important spawning and nursery habitat for anadromous fish, including alewife herring (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), hickory shad (*Alosa mediocris*), white perch (*Morone americana*), sea lamprey (*Petromyzon marinus*) and striped bass (*Morone saxatalis*), as well as catadromous American eel (*Anguilla rostrata*). These herring, shad, and the American eel are fish species of interest in the USFWS Northeast Region, as well as species specifically identified as target species for the fish passage outcome of the 2014 Chesapeake Bay Agreement. Anadromous fish are also Trust Resources for both USFWS and National Oceanic and Atmospheric Administration Species (NOAA). Trust resources include migratory birds, species listed under the Endangered Species Act, inter-jurisdiction fishes, marine mammals, wetlands, and USFWS/NOAA lands. Species of interest or species of concern is an informal term that refers to those species that might be in need of concentrated conservation actions. Such conservation actions vary depending on the health of the populations and degree and type of threats.

Historically, the anadromous fish listed above migrated from the Atlantic Ocean and Chesapeake Bay into the freshwater non-tidal Anacostia tributaries to spawn (MWCOG, 2010). American shad were once one of the east coast’s most abundant and economically important fish (Cummins, 2012). American shad and hickory shad were documented in the Northeast Branch and Northwest Branch of the Anacostia River watershed in Prince George’s County. Alewife and blueback herring were present in the tributaries of the Northwest and Northeast Branches up to the extent of their historical range at the fall line (on the west side of Prince George’s County) or watershed boundary (on east side of the watershed). The inputs of ocean derived energy (nutrients) from anadromous fish migration into the upstream tributaries of the Anacostia was a tremendous boon for stream ecology and constituted a major food source for many animals including other fish and migratory birds. Use of these streams for anadromous fish spawning likely had a significant contribution toward sustaining large populations of herring and shad in the Potomac River basin (Cummins, 2016).

The abundance of shad began to decline with increasing human population growth in the 1800s and overfishing in the 19th and 20th centuries. Between 1831 and 1850, fisherman caught 41,000 metric tons of shad in the Chesapeake Bay watershed each year. By the 1970s this declined to just 1,000 metric tons (CBP, 2015). In 1980 Maryland closed its commercial shad fishery. Commercial landings of river herring peaked in the late 1960s, declined rapidly through the 1970s and 1980s, and have remained at levels less than 3 percent of the peak over the past decade. NOAA designated river herring as species of concern in 2006. In Maryland, recreational and commercial river herring landings were prohibited in 2012. Findings of the 2012 Benchmark Stock Assessment for River Herring (ASMFC, 2012) concluded the overall coast-wide population of river herring (alewife and blueback herring) stocks on the Atlantic coast is depleted to near historic lows. The "depleted" determination was used instead of "overfished", because many factors are contributing to the declining abundance of river herring, including fish passage limitations, predation, water quality, and climate change. In May 2015, partially to prevent an endangered species listing, NOAA Fisheries released the River Herring Conservation Plan with the goals of increasing public awareness and fostering cooperative research and conservation efforts to restore river herring along the Atlantic coast (ASFMFC, 2015).

In addition to anadromous fish, American eel, also a fish species of conservation concern in the USFWS's Northeast Region, occurs in the Anacostia River watershed. American eel is a catadromous fish living in the freshwaters of the watershed and spawning in the Sargasso Sea of the Atlantic Ocean. The 2012 benchmark stock assessment and peer review concluded that the American eel population is at or near historically low levels due to a combination of overfishing, habitat loss, food web alterations, predation, turbine mortality, and other factors (ASMFC, 2015).

Currently, man-made barriers constructed in the study area along the lower portions of Anacostia River tributaries prevent fish migrations. In addition, degraded in-stream habitat has likely limited the ability of fish to fulfill the full range of their lifecycle needs, specifically spawning. The aquatic ecosystem restoration actions proposed in this study will support increases in migratory fish populations by removing physical barriers to open passage for migration and by restoring in-stream habitat to conditions suitable for anadromous fish utilization. Splintered migratory corridors will be connected, allowing fish to access higher quality habitat upstream.

The pairing of massive efforts by others to address water quality improvements with the proposed habitat restoration effort is a significant opportunity to combine efforts to restore species, habitat diversity, and connectivity to the Anacostia River watershed.

1.5 Study Scope

The Anacostia River watershed spans approximately 176 square miles, located entirely within the Washington D.C. metropolitan area. The drainage area within Prince George's County is approximately 86 square miles, accounting for almost one half of the total Anacostia River watershed. The Anacostia River flows through Maryland and then the District of Columbia into the Potomac River. The Potomac River is an American Heritage River, which ultimately drains to the Chesapeake Bay. Water quality and habitat in the Anacostia River watershed are degraded as a result of anthropogenic alterations to the natural landscape. While much has been accomplished over the past several decades to restore this important urban watershed in and around our nation's capital, the river and its tributaries remain ecologically stressed.

In February 2010, USACE in partnership with the Metropolitan Washington Council of Governments (MWCOG), along with other local jurisdictions and state and local resource agencies, completed the ARP. The ARP is a systematic 10-year restoration plan for environmental and ecological restoration within the entire Anacostia River watershed. The public and all levels of government have demonstrated their interest and commitment to restoring the watershed's ecological integrity and function. The ARP identifies more than 3,000 restoration opportunities within each of the river's 14 primary subwatersheds and the tidal river reach. These projects are identified as "candidate restoration projects" and represent opportunities within the following restoration strategies: stormwater retrofits; stream restoration; wetland creation/restoration; fish blockage removal/modification; riparian reforestation; riparian meadow creation; street tree and riparian invasive management; trash reduction; and parkland acquisition. Of these projects, fish blockage removal/modification, riparian reforestation, invasive management, stream restoration, and wetland creation/restoration represent strategies that could be implemented by USACE under current policy directives.

The ARP identified 396 potential aquatic ecosystem restoration projects in Prince George's County that met the USACE mission. Following a scoping meeting in October 2011 with PGDOE, Maryland-National Capital Park and Planning Commission (MNCPPC), and MWCOG, restoration efforts were focused on the potential for connecting restored stream segments, wetland restoration, and amelioration of fish blockages, the results of which would be systematic stream restoration with cumulative benefits. The team also identified that land ownership would be a strong consideration for site selection, concentrating on sites located on public property. As a result of land ownership, larger mainstem segments were the focus, which primarily lie in riparian parkland. Additionally, potential restoration locations were based on the location of ARP Candidate Restoration Projects (CRPs). Most of the sites selected for this study include at least one ARP CRP and some sites connect multiple CRPs (i.e., small stream segments identified for restoration in the ARP). In some cases potential restoration sites that were overlooked by the ARP were also included.

1.5.1 Study Area

The study area includes the Anacostia River watershed in Prince George's County. About half of the total area of the Anacostia River watershed is within Prince George's County. The watershed in Prince George's County falls primarily within the Coastal Plain physiographic province; however, small sections of the study stream reaches lie within the transition zone with the Piedmont province.

The study area includes six subwatersheds (Figure 1-6) in the non-tidal portion of the Anacostia River watershed, including Northwest Branch, Sligo Creek, Northeast Branch, Indian Creek, Paint Branch, and Little Paint Branch. Subwatershed divisions are based on those used in the ARP. Figure 1-7 shows the stream reaches selected for study in orange (see selection criteria in Section 3) and the connection to previously restored stream reaches (green). The Anacostia River watershed in Prince George's County is highly urbanized. About half of the total area of the Anacostia River watershed in Prince George's County consists of developed area, including low to high intensity residential, commercial, and industrial uses (MDDNR, 2005a). Existing conditions for the stream reaches is included in Section 2, with brief descriptions of the subwatersheds in Appendix A.

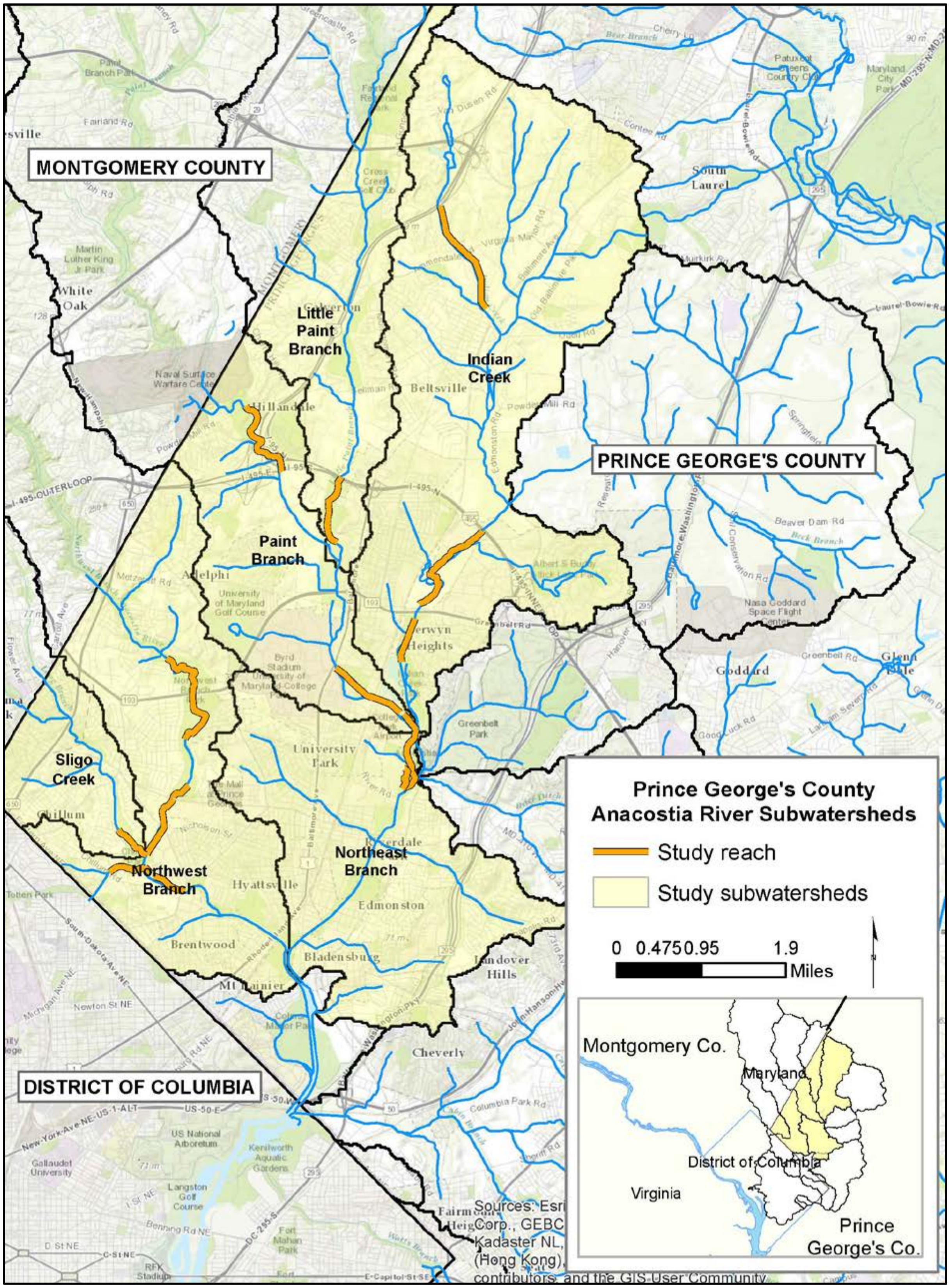

Figure 1-6. Anacostia River watershed and subwatersheds in Prince George's County, MD.

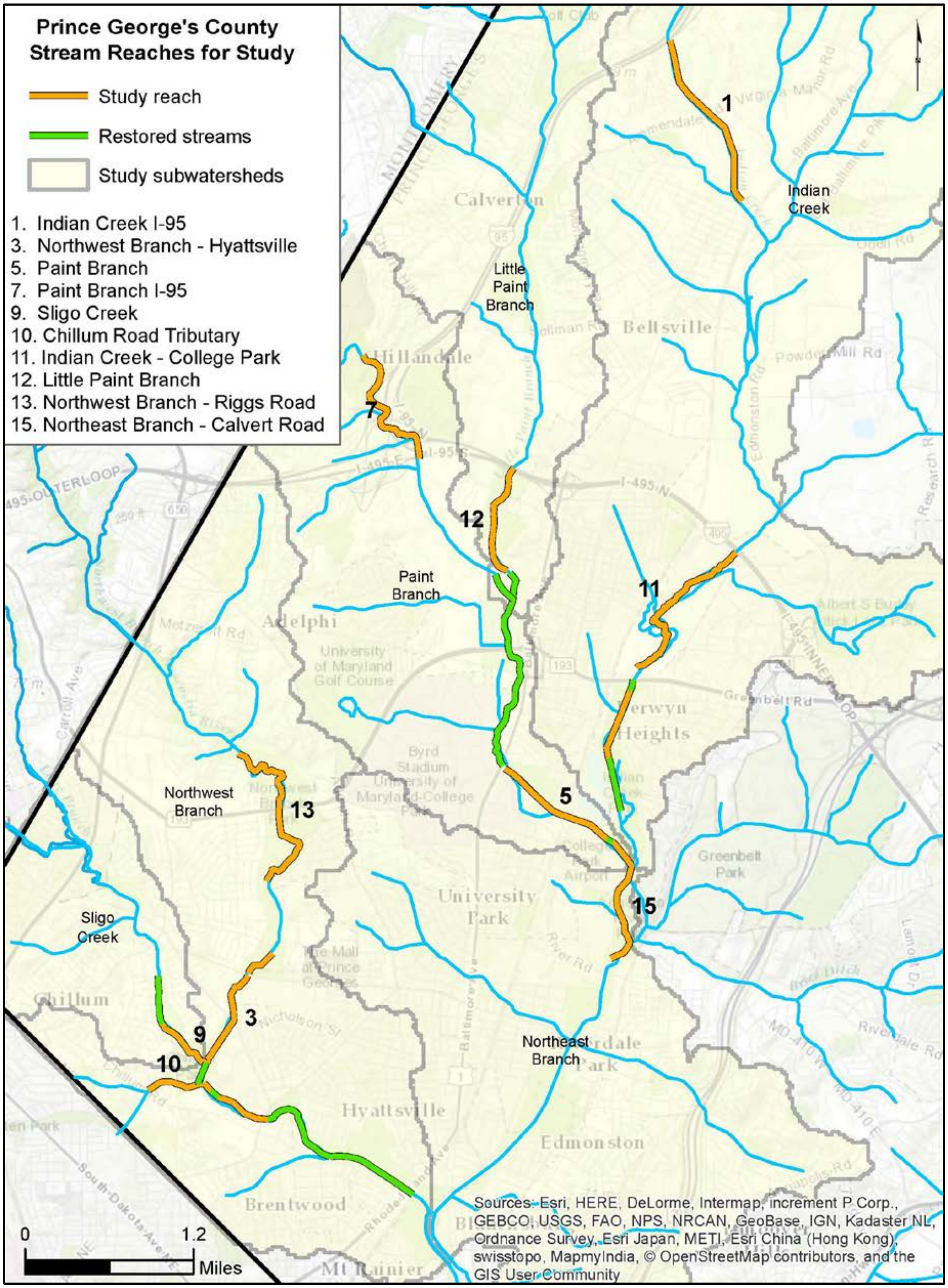

Figure 1-7. Stream sites in Prince George's County selected for study.

1.6 Prior Studies, Reports, and Water Projects

Since 1876, with the survey of the eastern branch of the Anacostia River, numerous studies and projects, including for ecosystem restoration, flood risk mitigation, and navigation, have been completed by USACE in the Anacostia River watershed (Table 1-1). Many of the early studies in the watershed focused on navigation related improvements along the mainstem Anacostia and on flood risk management near the confluence of the Northwest and Northeast Branches; whereas, more recently, attention has shifted toward ecosystem restoration opportunities. Figure 1-8 and Table 1-2 provide descriptions and locations of a subset of more recent projects and studies, primarily for ecosystem restoration, within the watershed. This study area is shown on Figure 1-8 and Table 1-2 as location “3b”. The most recently completed project is the Sligo Creek Section 510 project constructed in early 2017. USACE in coordination with PGDOE, completed projects to manage stormwater runoff and improve water quality at Ridgecrest Elementary School and Cesar Chavez Elementary School in Prince George’s County within the Sligo Creek subwatershed.

As discussed in Section 1.4, the ARP is the most recent comprehensive report documenting the problems and opportunities within watershed. Many agencies and citizen groups are working toward the goals outlined in this plan. In response to the ARP, Prince George’s County produced *Restoration Plan for the Anacostia River Watershed in Prince George’s County* (PGDOE, 2014) outlining efforts to support the ARP. In the past few years, significant efforts have been undertaken by PGDOE and other agencies and jurisdictions to support the ARP, primarily focused on water quality improvements and stormwater management. Figure 1-9 shows the locations of restoration projects that support the ARP and are located within the study subwatersheds. The projects shown in Figure 1-9 include those that have either been completed or are currently in the design phase. Restoration efforts include stormwater retrofits, fish blockage removal/modification, riparian reforestation/meadow creation, stream restoration, and trash reduction.

Prince George’s County maintains an interactive map, the Clean Water Map (http://www.princegeorgescountymd.gov/682/Maps), for accessing information on environmental restoration projects and water quality data. Figure 1-10 shows a map generated from this website illustrating stormwater capital improvement projects, which have been completed or constructed since 2003. These projects include major installations of BMPs (e.g., bioretention, filter swales, catch basins), green streets and low impact development, stream restoration, and wetland restoration to reduce pollutant runoff and stormwater quantity to streams. In addition to these, the County is also installing hundreds of small-scale urban BMPs. County retrofit projects in various stages cover over 2,800 acres of impervious area in Prince George’s County (PGDOE, 2016). PGDOE also conducts stream monitoring activities throughout the county, including long term water quality monitoring for the Maryland Department of the Environment’s National Pollutant Discharge Elimination System (NPDES), Municipal Separate Storm Sewer System (MS4) program (Section 2.2.3). Biological data are also collected to address questions related to the status and trends of stream and watershed ecological conditions.

As part of the Maryland State Highway Administration’s (SHA) environmental stewardship and compensatory mitigation program, SHA has implemented restoration projects within the watershed. These projects include stream restoration on Northwest Branch and Paint Branch as mitigation for the Woodrow Wilson Bridge and the InterCounty Connector, a toll road that runs through the Anacostia River watershed in Prince George’s and Montgomery Counties. The stream restoration on Paint Branch is in an area designated as a Special Protection Area with a reproducing population of brown trout. Mitigation actions also included wetland restoration. On federal land, restoration actions in Prince George's County undertaken by others include stream restoration on the U.S. Department of Agriculture's Beltsville Agricultural Center north of College Park, Maryland, in the Little Paint Branch subwatershed. Additionally, the Washington Suburban Sanitary Commission (WSSC) is currently operating under a consent order to replace and repair sewer lines (Section 2.2.3). As a result they have recently performed in-stream improvements, including on Sligo Creek, Indian Creek, and Northeast Branch, for the purposes of utility asset protection or repairs.

Table 1-1. Reports produced by USACE related to work within the Anacostia River watershed.

Date	Document/ Annual Report	Subject	Recommendations
1876	House Exec. 94-44/1	Survey of Eastern Branch (Anacostia River)	Describes waterway & estimates cost of channel between Navy Yard and Bladensburg.
1888	1889 Annual Report page 993	Preliminary Examination of the Eastern Branch of Potomac River (Anacostia River)	Opinion of Lt. Col. Hains on improvement of Eastern Branch to Bladensburg. Unfavorable-not worthy of improvement.
1890	House Exec 347-51/1	Channel improvement – mouth to Navy Yard	Requests from the Navy Department to deepen channel to Navy Yard.
1891	House Exec. 30 52/1	Preliminary Examination and Survey, Bladensburg	Recommends channel from mouth and Navy Yard 20 ft. deep, 200 ft. wide; reclamation of adjacent marshes.
1898	House Doc. 87-55/3	Plans for reclamation of marshes	Submits plans and costs for reclamation of flats between mouth and District Line.
1903	House Doc. 194 59/1	Title to lands embracing Anacostia River Flats, mouth to District Line	Describes U.S. properties bordering on Anacostia River. Opinions as to title of lands.
1910	Senate Doc. 462-61/2	Ownership of land and riparian rights along Anacostia River	Opinions of Special Counsel to District of Columbia on ownership of lands and riparian rights.
1911	Senate Doc. 19-63/1	Public and private rights	Supplement to Report of 1910.
1916	House Doc. 1357-64/1	Report of Board of Engineers proposing a modification of the projects for the reclamation & development of the Anacostia River & Flats, D.C.	Features of the report include dam across river at Massachusetts Ave forming a lake extending upstream to District line; construction of river walls from dam downstream to Anacostia Bridge.

Date	Document/ Annual Report	Subject	Recommendations
1923	Senate Doc. 37-68/1	Report and recommendations on the Reclamation and Development of the Anacostia River & Flats	Determined the desirability of continuing park project with same features as outlined in H. Doc. 1357-64/1.
1934	House Doc. 101-73/1	Flood control measures protection of Bladensburg Bolling Field and Naval Air Station	Concurred in general with improvements.
1935	House Doc 22-74/1	Washington Harbor project including Anacostia River channel to 2,100 feet above Anacostia Bridge	Recommended combining Anacostia and Potomac River Project at Washington DC into Washington Harbor project.
1949	House Doc. 202-81/1	Review of Report on Preliminary Examination & Surveys of Anacostia River & Tributaries, DC and MD, for flood control and navigation	Recommended adoption of project for improvement of Anacostia River Basin to provide for channel, levees and boat basin.
1968	Detailed Project Report	Anacostia River and Tributaries, Prince George's County, MD Local Flood Protection Project	Recommended construction of channel modifications on Northwest and Northeast Branches and tributaries.
1990	Reconnaissance Report	Review of water resource related problems and opportunities	Recommended cost share feasibility study for fish and wildlife habitat restoration.
1992	Section 1135 Report	Anadromous Fisheries Restoration	Requested authorization to modify existing Corps project.
1993	Section 1135 Report	Habitat Restoration	Requested authorization to modify existing Corps project.
1994	Integrated Feasibility Report and Final EIS Section 206 Report	Anacostia River and Tributaries DC and MD	Recommended wetland, stream and riparian habitat restoration in the Anacostia Basin.
2000	Section 206 Report	Habitat Restoration in the Northwest Branch of the Anacostia River	Recommended wetland, stream and riparian habitat restoration in the Anacostia Basin.
2001	Section 206 Preliminary Restoration Plan	Habitat Restoration at Lower Anacostia Park	Recommended habitat restoration.
2001	Section 1135 Preliminary Restoration Plan	Marsh Restoration at Heritage Island	Recommended habitat restoration.
2001	Section 206 Preliminary Restoration Plan	Habitat Restoration at Fort Chaplin and Fort DuPont	Recommended habitat restoration.
2002	Section 1135 Preliminary Restoration Plan	Habitat Restoration on Lower Kingman Island	Recommended habitat restoration.

Date	Document/ Annual Report	Subject	Recommendations
2002	Section 206 Preliminary Restoration Plan	Paint Branch Anadromous Fish Passage and Stream Restoration	Recommended habitat restoration.
2002	Anacostia Federal Facilities Impact Assessment	Assessed Adverse Impacts of Federal Facilities	Recommended pollution prevention, habitat restoration and best management practices.
2002	Section 1135 Report	Restoration of Heritage Island Marsh	Recommended marsh restoration.
2006	Section 206 Report	Paint Branch Fish Passage & Stream Restoration Project	Recommended stream, wetland, and riparian habitat restoration.
2010	Watershed Assessment	Anacostia Restoration Plan	Recommended actions by numerous stakeholders for restoration of the Anacostia River Watershed.

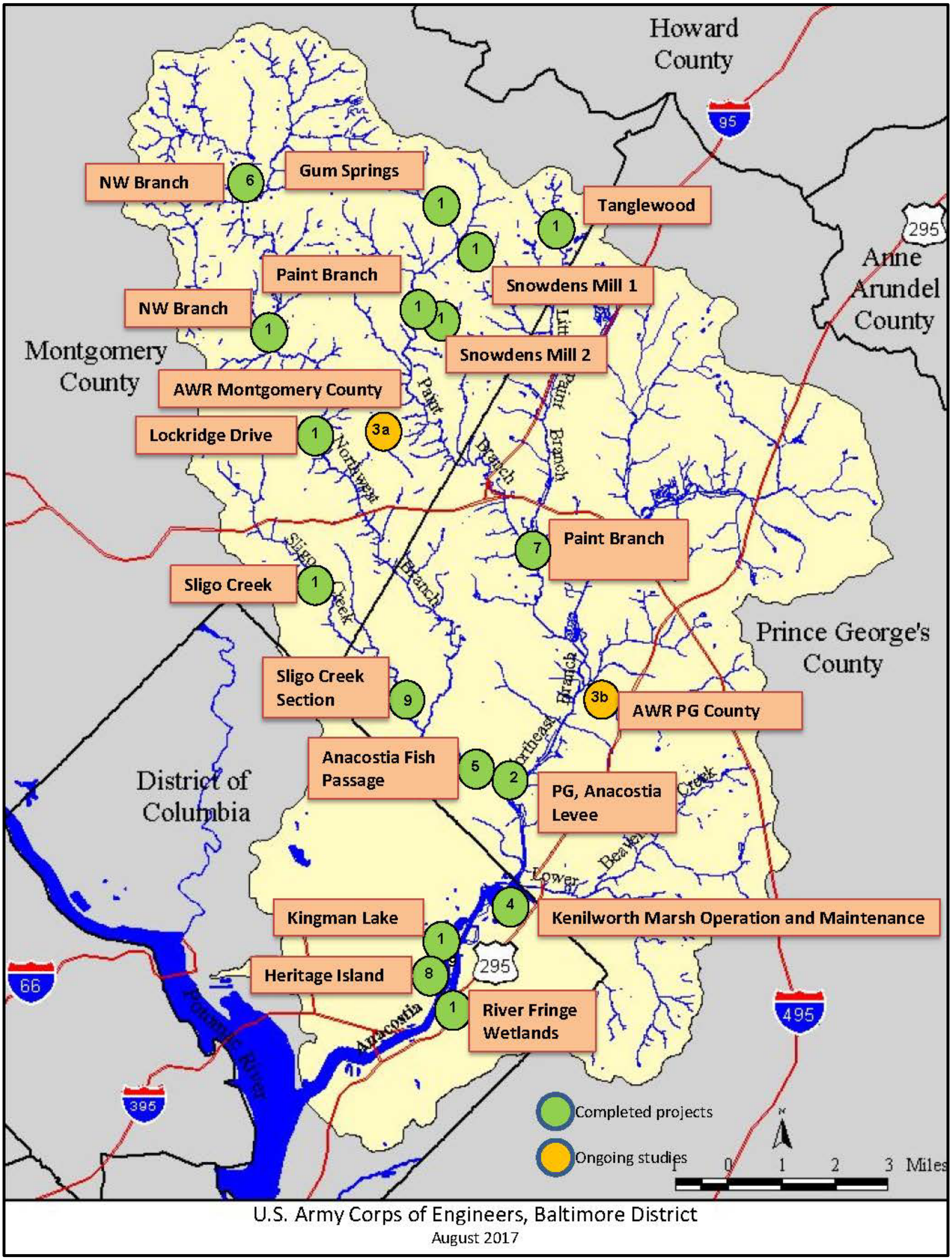

Figure 1-8. Subset of USACE projects in the Anacostia River watershed.

Table 1-2. Descriptions of USACE projects (as of September 2015) shown in Figure 1-8.

1 **Anacostia River and Tributaries D.C Section 206:** The Corps has performed actions at 10 sites as part of an environmental restoration study. These actions included creation of two wetlands, development of five storm-water management projects, and restoration of six stream reaches. Sponsors include Montgomery County, the District of Columbia, and the National Park Service.

2 **Anacostia Flood Risk Management:** Project consists of four levee systems: Edmonston-Bladensburg, Hyattsville-Riverdale, Brentwood, and Colmar Manor. The Corps sent FEMA positive Levee System Evaluation reports for certification of these systems. Sponsors include Prince George's County and the Maryland-National Capital Park and Planning Commission. The AWS has worked with the Corps on riparian meadow restoration along the Northwest Branch and wetland system creation at Bladensburg Waterfront Park within leveed areas.

3a **Montgomery County Section 206 Study:** The Corps is investigating potential restoration sites in Montgomery County as identified in the 2010 Anacostia Watershed Restoration Plan. Primary objectives are to restore in-stream habitat, remove fish barriers, and restore floodplain wetlands. Sponsor is Montgomery County.

3b **Prince George's County General Investigation Feasibility Study:** The Corps is investigating potential restoration sites in Prince George's County as identified in the 2010 Anacostia Watershed Restoration Plan. Primary objectives are to restore in-stream habitat and remove fish barriers. Sponsor is Prince George's County.

4 **Kenilworth Marsh Operation and Maintenance:** The Corps dredged approximately 150,000 cubic yards of sediment out of the Federal navigation channel in the Anacostia River and used the material to raise the elevation of Kenilworth Marsh to a height that would support wetland vegetation. The restoration created 32 acres of high-quality habitat for fish and wildlife. National Park Service maintains the area that is part of Kenilworth Aquatic Gardens.

5 **Anacostia Fish Passage Section 1135:** The Corps made modifications to the existing flood risk management project to restore fish and wildlife habitat including opening 5.2 miles of fish habitat and improving in-stream habitat along approximately 11,000 linear feet. The project was completed in 1996 and transferred to Prince George's County for operation and maintenance.

6 **Northwest Branch Section 206:** Project addresses restoration measures along the Northwest Branch in Montgomery County. This project enhances and protects 5 acres of riparian forest buffer, 4 miles (23 acres) of stream, and 3 acres of vernal pools through the restoration of seven sites. Activities included enhancing the stream buffer by restricting livestock access, planting buffers, stabilizing eroding stream banks, adding and enhancing in-stream habitat, and improving fish passage. Montgomery County and the Maryland-National Capital Park and Planning Commission are the sponsors.

7 **Paint Branch Section 206:** Project includes 6 miles of migratory fish passage for blueback and alewife herring and approximately 1 mile of stream habitat for resident and migratory fish to spawn. The aquatic ecosystem was stabilized and restored through reconnecting the stream to its floodplain, channel realignment and strategic placement of in-stream structures. The sponsor is the Prince George's County Department of the Environment. The Corps also worked closely with the Maryland-National Capital Park and Planning Commission.

8 **Heritage Island Section 1135:** The Corps completed restoration of 10 acres of tidal marsh wetlands at Heritage Island. The sponsor is the District of Columbia.

9 **Sligo Creek Section 510:** The Corps rehabilitated two bio-retention facilities at two elementary schools and installed vernal pools and stormwater management practices in the lower Sligo Creek subwatershed in Prince George's County. Completed in 2017.

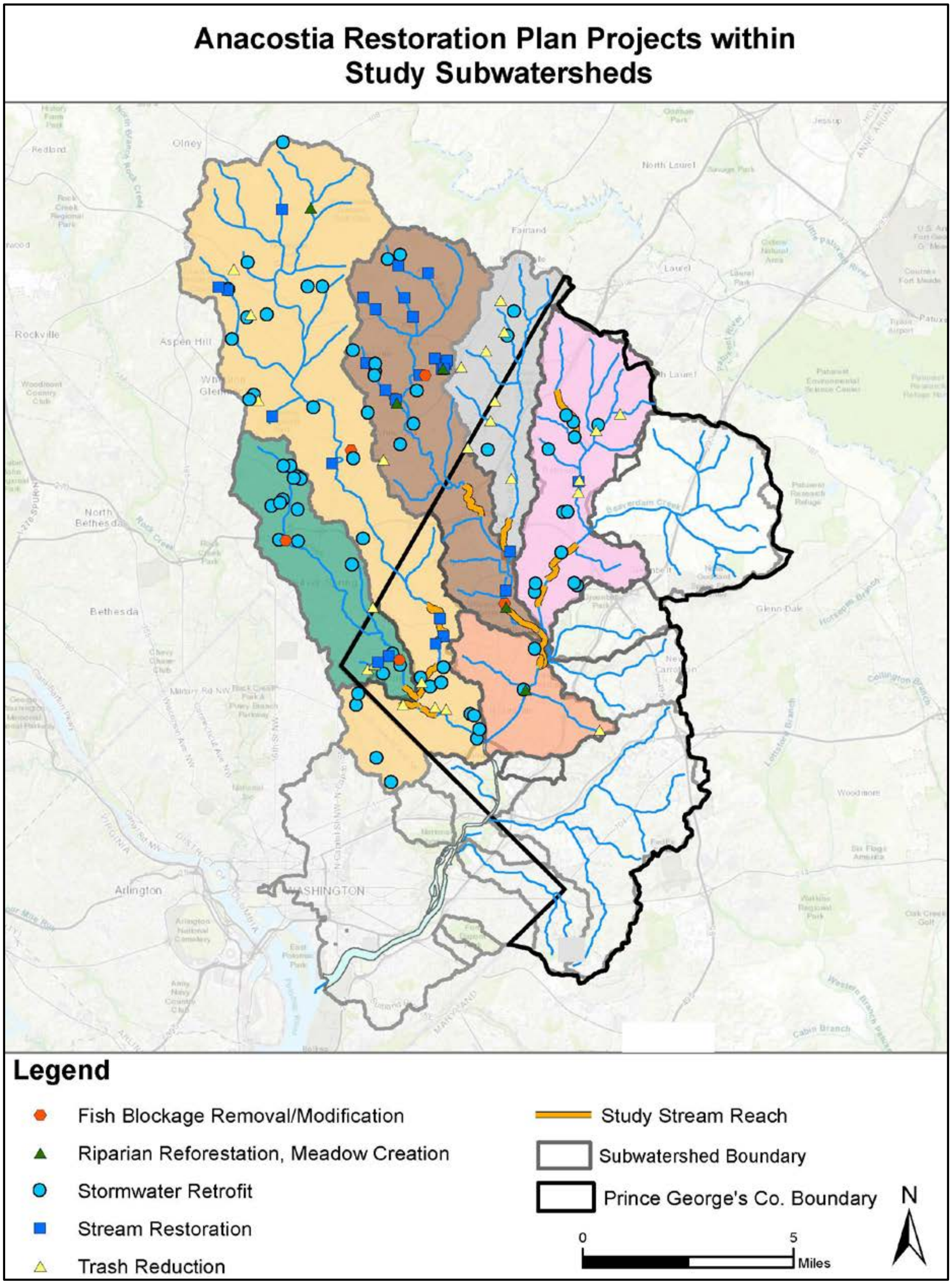

Figure 1-9. Anacostia Restoration Plan projects within the study subwatersheds (data provided by MWCOG, 2017).

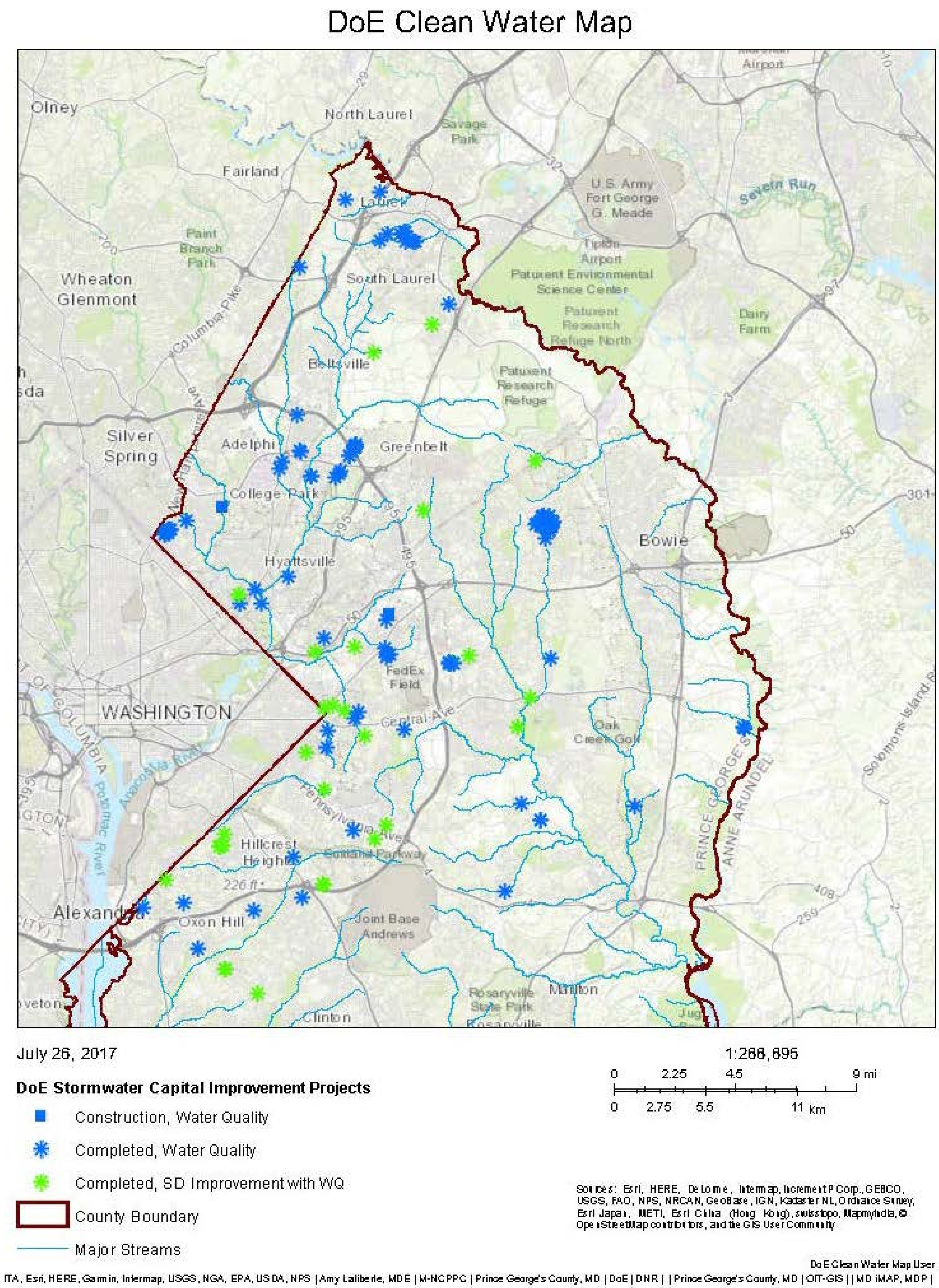

Figure 1-10. PGDOE stormwater capital improvement projects completed or in constriction since 2003.

1.7 Problems and Opportunities

This section presents the results of the first step of the USACE Planning Process, the specification of water and related land resources problems and opportunities in the study area. The problems and opportunities identified below form the basis for formulation of the project's objectives and constraints, which are discussed in Section 1.7.

1.7.1 Problems

The problems in the study area can be summarized as:

1. Physical stream habitat in the study area has been degraded through changes in the hydrologic regime and through direct anthropogenic alteration, including implementation of projects by USACE for the purpose of flood risk management.
2. Fish blockages in the watershed prevent anadromous fish from accessing habitat for spawning. Currently, river herring utilize only about 21 percent of their historical range on Northwest Branch and 10 percent on Northeast Branch.
3. Degraded habitat and water quality results in poor biological conditions as evidenced by poor index of biotic integrity scores in the study area.
4. Over 4,000 acres of riparian forest and wetlands in the watershed have been lost.

Figure 1-11 illustrates some of the problems within the stream reaches of study. The problems and opportunities are described in detail in following sections.

1.7.1.1 Urbanization and Channelization

Stream ecosystems in the study area within the Anacostia River watershed have been indirectly degraded by human alteration of the natural landscape, and directly impacted by human activities in streams and floodplain. From the colonial era through the early 20th century, excess erosion from clearing/logging, agricultural practices, and (to a limited extent) mining land uses generated substantial quantities of sediment that were delivered to area streams by runoff. Mill dams in valleys trapped a substantial portion of this sediment, filling floodplain wetlands and transforming stream character. Decline of the aquatic health of the watershed accelerated rapidly in the late 19th century to the present with increased urbanization.

Urbanization of the watershed converted natural landscapes to impervious surfaces. Anthropogenic impervious surfaces are manmade surfaces that are or nearly are impenetrable by water, such as sidewalks, driveways, roads, parking lots, and rooftops. Urbanization has resulted in excessive runoff, reduction in groundwater recharge, poor water quality, loss of riparian areas, habitat loss, and degradation of ecological habitat (AWRP, 2010). In stream channels, cross-sectional enlargement of a channel through incision (rapid channel deepening) and/or widening is a common response to urbanization. Accelerated bank erosion and bank failure occur, leading to downstream sedimentation and loss of fish habitat as well as loss of heterogeneity of in-stream benthic habitat due to siltation and scour of coarser bed material.

Many area streams, particularly in the lower reaches of the Anacostia River watershed near the District of Columbia, were channelized or piped accompanying 20th century urbanization to increase development opportunities along streams. In Prince George's County, USACE contributed directly to habitat alteration through flood risk management projects implemented in the 1970s (USACE, 1968). These projects altered channel geometry that significantly changed the basic mechanics of the streams and adversely impacted habitat and species diversity. Stream channels were straightened and some were contained (within a levee system) on the lowermost portions of Sligo Creek, Northwest Branch, Paint Branch, Indian Creek and the Northeast Branch (USACE, 1968; MWCOG, 2010). Substantial acreage of wetlands were lost as a result of this clearing and construction (MDDNR, 2005a).

Historical channelization, including both channel straightening and armoring with rock, concrete, and gabion baskets, is identified as an important stressor impacting stream aquatic biodiversity throughout Maryland (MDDNR, 2005d). Field assessments conducted by USACE for this study in 2014 and 2015 found lengthy reaches with uniformly shallow depths, inadequate woody debris, and homogenous habitat conditions, particularly in the reaches channelized by USACE.

Figure 1-11. Problems in the study stream reaches. A. Erosion along study stream reach (site 13) undermining a pedestrian trail system. B. Concrete sill inhibiting fish migration upstream on Northwest Branch (site 3). C. Homogeneous habitat conditions as a result of USACE channelization (site 3). D. Excess sediment deposition and formation of large sediment bars (site 5).

1.7.1.2 Degraded Habitat

Degraded habitat conditions affecting aquatic life in the Anacostia River watershed and the stream reaches of study include the effects of channelization, loss of riparian forests, channel erosion and instability, and scouring and transport of sediments. Due to the high percentage of impervious surface area in the watershed and the large area drained by MS4 drainage (44,000 acres in Prince George's County), flows entering streams are highly erosive, causing changes in channel morphology and degrading habitat. Additionally, direct runoff of pollutants from impervious surfaces adversely affects river water quality (USACE, 2010).

Peer-reviewed scientific literature establishes a link between highly urbanized landscapes and degradation in the aquatic health of non-tidal stream ecosystems (MDE, 2012). A number of reports have been produced by the MDDNR, MDE, and PGDOE to describe stream conditions in the Prince George's County portion of the Anacostia River watershed (e.g., MDDNR 2005a, MDDNR 2005b, MDDNR 2005c). Additionally, as required by Section 303(d) of the Clean Water Act, MDE identifies impaired stream reaches. This determination is supported by a biological stressor analysis (MDE, 2012). The results of these analyses indicate that the Anacostia River in Maryland is biologically impaired. Data suggest that the degradation of biological communities in the Anacostia River watershed is strongly influenced by urban land use and its concomitant effects: altered hydrology and elevated levels of chlorides, sulfates, and conductivity from impervious surface runoff.

Since 1999, Prince George's County has conducted two rounds of a countywide bioassessment study, the first in 1999 to 2003 and the second in 2010 to 2013. Results of biological sampling in the Anacostia River watershed indicate degraded biological conditions in stream ecosystems (PGDOE, 2014; MDE, 2012). Habitat stressors and biological assessments of the streams in the Anacostia River watershed in 1990 and in 2000 found that the primary stressor to the fish communities in the Northeast and Northwest Branches of the watershed was habitat quality rather than stream chemistry (MDDNR, 2001). Habitat quality refers to the physical structure within the stream (presence or absence and stability of structure) that is supportive of biological production and integrity. Stressors to benthic macroinvertebrates include both episodic changes in water chemistry and instability of bottom substrates, primarily associated with scouring flows due to flashy discharges from the current hydrologic character of the urbanized drainage areas (AWRP, 2010).

For fish, simplified in-stream velocity and depth conditions accompanying channelization reduces the capability of streams to support the complete natural fish assemblage as well as the suite of life history stages of resident fish. Spatially uniform depths and velocities provide relatively poor fish habitat (USACE, 2000b) and are correlated with lower Fish Indices of Biotic Integrity (F-IBI) (MDDNR, 2005d).

Biological communities are also degraded by alteration of riparian buffer zones (MDE, 2012). Riparian buffer zones including forests and wetlands provide important water quality and nutrient cycling functions to streams. It is estimated that more than 4,000 acres of nontidal wetlands have been lost from the Anacostia watershed due to both the suburban sprawl of the last five decades and earlier urban development and agricultural activity; this represents greater than 60 percent of the historical nontidal wetland acreage. More than 90 percent of the nontidal wetland acreage loss has occurred from the Coastal Plain portion of the watershed and has been concentrated in the lower reaches of Northwest Branch, Northeast Branch and Lower Beaverdam Creek subwatersheds (MWCOG, 2009h).

Additionally, disturbance of the natural landscape has enabled the establishment of invasive species in the watershed, within both aquatic and terrestrial habitats. The northern snakehead fish (*Channa argus*), native to China, is already present within the study streams and is a concern to the aquatic environment. A number of exotic, invasive plant species have been identified within the project area, primarily including kudzu (*Pueraria lobata*), bamboo (*Bambusoideae*), Japanese honeysuckle (*Lonicera japonica*), Japanese stiltgrass (*Microstegium vimineum*), Japanese barberry (*Berberis thunbergii)*, and mile-a-minute (*Persicaria perfoliata*). Invasive species are a threat as they can outcompete native species and reduce diversity.

1.7.1.3 Fish Blockages

Fish migration and movement in the Anacostia River watershed in Prince George's County is limited by numerous physical barriers and by poor quality in-stream habitat and/or unfavorable flow conditions. Prominent fish blockages within the watershed prevent anadromous fish such as herring and shad from accessing habitat in their historical range for spawning. Historically, river herring utilized Northwest Branch and Sligo Creek for migration and spawning up to the fall line (geological boundary between the Piedmont Plateau and Coastal plain physiographic provinces) on Northwest Branch. Currently, river herring access only about 21 percent of their historical range on Northwest Branch and 10 percent on Northeast Branch. Additionally, as discussed above, unfavorable habitat and/or flow conditions may inhibit fish movement into the study stream reaches.

1.7.2 Opportunities

The primary opportunities (from which the project objectives are formulated) for aquatic ecosystem restoration in the study area are to:

1. Restore stream ecosystem habitat, function, and quality in and along the Anacostia River and tributaries.
2. Restore fish passage in the Anacostia River watershed.
3. Produce cumulative aquatic ecosystem benefits in the Anacostia River watershed by connecting to existing stream restoration projects.

In addition, secondary opportunities may exist to:

1. Restore habitat in reaches previously damaged by USACE.
2. Restore non-tidal wetland habitat, function, and quality in and along the Anacostia River and tributaries.
3. Provide increased natural resource based recreation and educational opportunities along the Anacostia River.
4. Manage invasive vegetation in riparian areas of the Anacostia River and its tributaries.

A wide array of fish species with diverse habitat requirements historically inhabited the study area (Appendix A-2). The opportunity exists to restore a broad range of in-stream habitat characteristics in the study streams, allowing for increases in fish assemblage diversity and abundance. Regional fishery experts summarized the fish species historically and currently present in subwatersheds of the Anacostia River Watershed and forecast the potential number of non-migratory fish taxa expected to occur with comprehensive watershed restoration. These findings were summarized in a series of "baseline condition" reports prepared by MWCOG for the ARP in 2009 (AWRP, 2010), and are still appropriate for use in this study. Comprehensive watershed restoration includes both physical habitat improvements as provided by the recommended plan, and water quality and flow improvements that are currently ongoing by other agencies. Table 1-3 shows the potential taxa increases from existing conditions for non-migratory and migratory fish. The opportunity exists for increased fish diversity in the study streams, with comprehensive restoration.

Table 1-3. Fish species richness under existing conditions and with comprehensive restoration.

		Number of Fish Taxa[1]		
Site No.	**Stream segment**	**Existing Conditions**	**With Restoration**	**Potential Increase**
1	Indian Creek – I-95	22	25 to 30	3 to 8
3	Northwest Branch – Hyattsville	36	40 to 47	4 to 11
5	Paint Branch	27	30 to 42[2]	3 to 15
7	Paint Branch I-95	18	20 to 25	2 to 7
9	Sligo Creek	14	20 to 27	6 to 13
10	Chillum Road**	9	5 to 12	0 to 3
11	Indian Creek - College Park	18	25 to 30	7 to 12
12	Little Paint Branch	17	25 to 32	8 to 15
13	Northwest Branch - Riggs Rd	36	40 to 50	4 to 14
15	Northeast Branch	43	45 to 54	2 to 11

Source data: [1] From MWCOG, 2009a-f for portion of subwatershed in which stream segment lies for resident fish, anadromous fish added to the number in this reference; [2]MWCOG, 2015.
**Data specific to stream segment not available, nearby Tacoma Branch used as analogue.

Investigations have shown that capitalizing on opportunities for stream restoration within the Anacostia River watershed leads to documented improvements in stream habitat, usage of that habitat by fish, and species diversity (MCDEP, 2013; USEPA, 2013; MDOT, 2006). In addition to increases in fish species, monitoring of a variety of stream restoration and stabilization projects in Northwest Branch by MCDEP found that the percent of individual fish constituting less tolerant fish species increased following stream restoration projects by about 5 to 10 percent. Tolerance refers to the ability of a fish to tolerate disturbances to the environment, including both water quality and physical habitat disturbance (Meador and Carlisle, 2007). This indicates that less tolerant fish species benefit from more stable and complex habitat conditions due to restoration (MCDEP, 2013; USEPA, 2013). A few of the less tolerant species expected to benefit from habitat restoration in some of the project reaches include rosyside dace (*Clinostomus funduloides*), American brook lamprey (*Lethenteron appendix*), margined madtom (*Noturus insignis*), and Potomac sculpin (*Cottus girardi*) (MWCOG, 2015). Benthic macroinvertebrate diversity and variety of functional feeding groups are also expected to increase, thereby resulting in improvements in IBI scores for fish and benthic life.

Prior to 1990, only three fish species were present in Sligo Creek in Montgomery County, including blacknose dace, creek chub, and goldfish (all tolerant generalist species). As an example of what can be achieved with comprehensive restoration, as of 2015, monitoring indicates the presence of 12 to 17 naturally sustaining fish species in Sligo Creek, including habitat specialists. This significant improvement is the result of comprehensive restoration, including stream restoration, BMPs and stormwater management on adjacent lands, and low impact design, occurring from 1990 to the early 2000's. As a result, F-IBI scores have steadily increased and benthic macroinvertebrates have become more abundant and diverse, helping to support increased fish populations (MCDEP, 2012). Some of these fish species required reintroduction; however, post-restoration monitoring illustrates that in combination with water quality improvements, in-stream restoration creates a positive and sustainable response.

Monitoring completed by the Maryland Department of Transportation (DOT) as part of Woodrow Wilson Bridge mitigation evaluated the effects of restoration of fish passage (blockage removal, some including riffle grade control structures and step pool structures) and stream restoration (MDOT, 2006). Pre-restoration conditions were documented, as well as year 1 and 2 following construction, along many of the same streams in this USACE study (Northwest Branch, Sligo Creek, Indian Creek, and Little Paint Branch). Macroinvertebrate community ratings typically improved and fish species diversity increased from 36 to 40 species. Physical habitat metrics (in-stream habitat, epibenthic substrate) improved at the majority of sites (poor ratings improved to marginal and marginal improved to sub-optimal). These results document that increases in the number of species and physical stream habitat improvements can be achieved by stream restoration measures.

Finally, recent USFWS field assessments (see USFWS Planning Aid Report, Appendix C) of two study streams identified that these streams have the potential to achieve fully functioning geomorphology with proper stream restoration techniques. They concluded that in conjunction with increased stability and diversity of bedforms, if water quality can be improved, the segments should be able to achieve biologic lift (improvement). Currently, in response to regulations to manage TMDLs, numerous water-quality improvements are underway by other agencies, including storm-water BMPs and low impact development. The funding for local governments is currently focused on meeting these regulatory requirements for water quality and not on in-stream habitat improvements. However, improving fish and benthic IBI scores depends on the combination of water-quality and in-stream habitat improvements.

1.8 Project Objectives, Constraints, and Considerations

The goals of the project are to restore aquatic ecosystems in the selected stream reaches, enhance migratory fish movement upstream, and to connect functional habitat for fish. The project seeks to contribute to a comprehensive restoration strategy by addressing in-stream habitat restoration while other agencies focus on water-quality improvements. Planning objectives are based on the identified problems and opportunities. Planning constraints are restrictions that limit the extent of the planning process; whereas, planning considerations are factors that will help to guide decisions.

The federal objective of water and related land resources project 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 USACE objective in ecosystem restoration planning is to contribute to national ecosystem restoration (NER). Contributions to national ecosystem restoration (NER outputs) are increases in net quantity and/or quality of desired ecosystem resources (USACE, 2000). This is further discussed in Section 3.

1.8.1 Planning Objectives

The USACE planning process is an iterative process. Objectives were refined throughout the process in order to incorporate the team's improved understanding of the study area's problems and opportunities. The planning objectives include the following:

1. **Restore physical habitat within streams with degraded aquatic conditions in the mainstem and tributaries of both the Northwest and Northeast Branch subwatersheds[1] of the Anacostia River in Prince George's County.**

   In order to minimally satisfy this planning objective, restoration of in-stream habitat in both the Northwest and Northeast Branches and tributaries of the Anacostia River must occur. The specification of both branches of the Anacostia River reflects the ecosystems approach needed to provide a comprehensive solution for restoration of the watershed, given the interconnected nature of hydrologic systems. USACE guidance for ecosystem studies recommends that projects be undertaken in the context of "ecosystem benefits", which would include the watershed as a whole, rather than what is specific to a single stream reach. Furthermore, in order to aid populations of anadromous fish, passage and habitat in both branches of the river must be restored. In summary, ecosystem restoration success for this study has been defined by the team as restoring physical habitat in both subwatersheds. Improving only one branch of the subwatershed would not provide a solution to achieve comprehensive watershed restoration as previously defined.

[1] For the purposes of this study, the Northwest Branch and Northeast Branch subwatersheds are delineated from the confluence of the Northwest and Northeast Branches at the Anacostia River. Therefore, the Northwest Branch subwatershed includes also the Sligo Creek subwatershed and the Northeast Branch subwatershed includes also the Paint Branch, Little Paint Branch, and Indian Creek subwatersheds.

For this objective, the difference between future-with and -without-project conditions will be measured by changes in the Physical Habitat Index (PHI). Through in-stream restoration, parameters for stream physical habitat (i.e., fish and benthic habitat) quality will be improved resulting in an increased PHI. These parameters are described in Section 3. This objective is included as the "Project-Specific In-Stream Habitat Benefits" metric for the calculation of stream habitat units and utilized in the cost effectiveness incremental cost analysis (CE/ICA) described in Section 3.

2. **Enhance aquatic ecosystem resilience by restoring fish passage for migratory and non-migratory fish and connecting existing higher quality habitat in the mainstem and tributaries of both the Northwest and Northeast Branch subwatersheds of the Anacostia River in Prince George's County.**

   Similar to the first objective, restoration of passage and connectivity on both the Northwest and Northeast Branches and tributaries of the Anacostia River must occur in order to minimally meet this objective. This objective includes the removal of fish blockages to open fish passage for non-migratory and migratory fish and the enhancement of longitudinal connectivity achieved by linking the restored study reaches to previously restored stream segments. Fish passage and connectivity provide the same functional benefits to fish by providing continuity of suitable habitat and access to high quality habitat upstream. This objective is included as the "Aggregate Benefits" metric used in the CE/ICA (Section 3.5.2).

Initially, there was also a planning objective to restore riparian wetlands adjacent to the study streams; however, with the available information, these benefits were not quantifiable. Although the objective was removed, stream restoration will reconnect streams with the adjacent floodplain, thereby supporting the reestablishment of riparian wetlands.

1.8.2 Planning Constraints

The planning constraints include the following:

1. Avoid negative impacts to bedrock and natural features that provide excellent aquatic habitat.
2. Avoid impacts to public utilities and infrastructure.
3. Adhere to design constraints imposed by the existing USACE flood risk management (FRM) project (USACE, 1975) on Northwest Branch, Northeast Branch, Paint Branch, and Indian Creek so as not to alter the project purpose of the existing FRM projects.
4. Avoid impacts to state and federal threatened and endangered species.

1.8.3 Planning Considerations

The planning considerations include the following:

1. Prioritize restoration activities on public lands to the greatest extent possible.

2. Minimize impacts to forest during construction because of high ecological value of mature native woody vegetation and difficulty with reestablishment of healthy forest understory (due to deer browsing).
3. Minimize impacts to actively used recreational space, or restore this space to pre-impacted conditions.

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2 *AFFECTED ENVIRONMENT

This section provides an overview of the existing watershed conditions and future-without-project (no-action) conditions used for the analyses conducted for this study. The description of existing and future-without-project conditions contained in this section includes conditions most relevant to the evaluation of project alternatives. Further description of existing conditions can be found in Appendix A and in the ARP (AWRP, 2010). Impacts of the recommended plan on the human environment can be found in Section 5.

Existing conditions represent the current conditions within the watershed, whereas the future-without-project conditions are watershed conditions without implementation of the recommended plan. This study evaluates the future-without-project conditions and the alternatives and benefits over a 50-year period of analysis. The base year (the year when the proposed project is expected to be operational) for the period of analysis is 2021, with the period of analysis continuing to 2071. The following sections describe the general existing and future conditions.

2.1 Physical Environment

2.1.1 Climate and Air Quality

2.1.1.1 Climate

The Anacostia River watershed has a humid, temperate, and semi-continental climate with mild winters and warm, humid summers. Data for the period of record from 1981 to 2010 for three data stations within the watershed indicate that the warmest temperatures occur in July and August when the average temperature is approximately 78°F. The coldest months are January and February with an average temperature of 35°F (NOAA, 2011). For Prince George's County, 30-year average annual precipitation is 39.74 inches. On average, winter is the driest season with 8.48 inches of precipitation, and summer is the wettest with 10.44 inches of precipitation (PGDOE, 2014). The greatest rainfall intensities occur in summer with severe thunderstorms, and in early fall during hurricane season. These storms produce high intensity precipitation, but are of short duration and limited in spatial extent, typically not spanning the entire watershed area. For the period from 1981 to 2013, data from a NOAA weather station in Beltsville, Maryland, within the Anacostia River watershed in Prince George's County, indicates that precipitation in the form of snow or sleet averaged 15 inches per year, equivalent to approximately 1.5 inches of rain. However, total snowfall can vary considerably from year to year (NOAA, 2014).

2.1.1.2 Air Quality

Under the Clean Air Act amendments of 1990, the EPA Office of Air Quality Planning and Standards has set National Ambient Air Quality Standards (NAAQS) for six principal pollutants, called "criteria" pollutants. They include carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), lead (Pb), particulates ($PM_{2.5}$), and sulfur dioxide (SO_2). For Prince George's County, only ozone does not attain the air quality standard. Areas that are designated in non-attainment of the ozone standard are further classified, in order of increasing severity, as Incomplete Data, Marginal, Moderate, Serious, Severe, and Extreme. The designation for Prince George's County, Maryland, is considered Moderate under the 8-hour standard.

On October 6, 2014 EPA published a Final Rule in the Federal Register approving the State of Maryland's request to re-designate the Maryland region of the Washington DC-MD-VA Nonattainment Area for the annual $PM_{2.5}$ national ambient air quality standards (NAAQS) to Attainment status. The DC area includes Charles, Frederick, Montgomery and Prince George's counties in Maryland. The rule became effective on November 5, 2014. Although now in attainment status for $PM_{2.5}$, these areas are in maintenance for the next twenty years. Prince George's County has been in maintenance status for CO since 1996.

2.1.2 Geology, Topography, and Soils

The Anacostia River Watershed spans two physiographic provinces, the Piedmont Plateau and the Atlantic Coastal Plain, which reflect differences in geological composition and topography. The Prince George's County portion of the watershed primarily lies within the Coastal Plain Province. The stream segments selected for study in this project are primarily within the Coastal Plain Province, however, the upstream end of the Paint Branch segment is located at the transition zone between the Piedmont and Coastal Plain Provinces. Both physiographic provinces are described below.

The Piedmont Plateau Province is composed of hard, crystalline igneous and metamorphic rocks and extends from the Coastal Plain westward to Catoctin Mountain, the eastern boundary of the Blue Ridge Province. Bedrock in the eastern part of the Piedmont consists of schist, gneiss, gabbro, and other highly metamorphosed sedimentary and igneous rocks of probable volcanic origin (MGS, 2014). These rocks range in age from Precambrian to late Paleozoic. Bedrock is often exposed in the channel beds of streams in the Piedmont, and river sections are steeper with coarser sediment than those of streams in the Coastal Plain Province (Devereux et al., 2010). Soils of the Piedmont are mostly finer-grained micaceous silt loams (MWCOG, 2010). Stream bed materials are predominantly gravel to cobble-sized sediments (ARWP, 2010).

The Atlantic Coastal Plain Province is comprised of sedimentary rocks of fluvial, deltaic, estuarine, and marine origin, deposited since the beginning of the Cretaceous Period, 144 million years ago (MDDNR, 1987). These generally unconsolidated sediments, including gravel, sand, silt, and clay, form a wedge that thins out onto the crystalline Piedmont to the west, and thickens eastward to more than 8,000 feet in thickness at the Atlantic Ocean coastline (Csato, et al., 2013; MGS, 2014). The Coastal Plain Province has flatter topography and lower gradient streams with finer bed materials. Thicker soil zones than in the Piedmont, tend to be present. The highest elevation in the Coastal Plain is 400 feet above mean sea level (AWRP, 2010), and slopes in the Coastal Plain are usually less than 8 degrees (USGS, 2007). River valleys are incised into the Coastal Plain alluvium. The river valleys consist of gently dipping beds, and locally, Tertiary terraces on either side of the main channels (USGS, 2007).

The fall line, the geomorphologic break between the hard, crystalline rocks of the Piedmont and the softer sedimentary rocks of the Coastal Plain, roughly parallels U.S. Route 29/Colesville Road. Small to medium sized cataracts or waterfalls are present along the fall line as water moves down in elevation from the Piedmont to the Coastal Plain. These features are present in Sligo Creek, Northwest Branch, Paint Branch, and Little Paint Branch, and act as natural barriers for anadromous fish such as alewife and blueback herring (AWRP, 2010).

Soil maps for Prince George's County (USDA, 2014) indicate that soils adjacent to most of the project streams (Table 2-1) include the following classifications: Codorus and Hatboro soils (CF), Codorus-Hatboro-Urban land complex (Ch), Zekiah and Issue soils (ZS), and Udorthents, highway (UdaF). The CF association consist of loamy alluvial material that occurs mainly on stream floodplains. The Ch land complex consists of Codorus and Hatboro series soils with an equal component of soils in community development. This component includes fill material to facilitate the construction of buildings, streets, and parklands, etc. The Indian Creek project site primarily consists of the ZS soils, which consist of loamy alluvium present on floodplains and drainage ways. Human emplaced materials also border some of the stream sites, especially close to the highways (e.g., soil classification UdaF at Paint Branch at I-95). Hydric soils account for about 16 percent of the Anacostia River watershed in Prince George's County (MDDNR, 2005a). Table 2-1 shows the hydric rating for soils adjacent to the study stream sites, which range from partially hydric to nonhydric.

Table 2-1. Primary soil types, prime farmland classification, and hydric rating for the study sites.

Site	Stream Name	Primary Soil Map Units (Symbol)	Prime Farmland	Hydric Rating*
1	Indian Creek at I-95	Zejiah and Issue (ZS)	No	60
3	Northwest Branch	Codorus and Hatboro (CF) Codorus-Hatboro-Urban land complex (Ch)	No No	40 30
5	Paint Branch	Codorus and Hatboro (CF) Codorus-Hatboro-Urban land complex (Ch) Fallsington-Urban Land Complex (FbB)	No No No	40 30 55
7	Paint Branch at I-95	Codorus and Hatboro (CF) Udorthents, highway (UdaF) Glenelg-Wheaton-Urban land complex (GfB)	No No No	40 0 0
9	Sligo Creek	Codorus and Hatboro (CF) Codorus-Hatboro-Urban land complex (Ch)	No No	40 30
10	Chillum Road Tributary	Issue –Urban land complex (Iu)	No	10
11	Indian Creek	Zejiah and Issue (ZS) Udorthents, reclaimed gravel pits (UdgB)	No No	60 0
12	Little Paint Branch	Codorus and Hatboro (CF)	No	40
13	Northwest Branch Riggs Rd	Codorus and Hatboro (CF) Codorus-Hatboro-Urban land complex (Ch)	No No	40 30
15	Northeast Branch Calvert Rd	Codorus and Hatboro (CF) Codorus-Hatboro-Urban land complex (Ch)	No No	40 30

*Hydric rating indicates the proportion of the map unit that meets the criteria for hydric soils. A rating of 66-99 percent indicates "Predominantly hydric" soils; 33 to 66 percent indicates "partially hydric" soils; 1 to 33 percent indicates "predominantly nonhydric"; 0 percent indicates "nonhydric".

Table 2-1 also shows the soil unit farmland classification. Prime farmland is defined as land with the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and that is available for these uses per National Resource Conservation Service regulation, 7USC 4201(c)(1)(A). None of the map units adjacent to the study sites are classified as prime farmland.

2.1.3 Land Use and Land Cover

Europeans settled the Anacostia River watershed in the 1600s and each successive wave of colonization resulted in clearing of forest to make way for agriculture, livestock activities, and development. Intense deforestation and land use alteration related to urbanization have triggered the ecological problems present today. Development of the landscape has resulted in loss of forest and wetland habitats, habitat fragmentation, and alteration of natural drainage patterns and stream flow leading to increases in erosion and sedimentation (ARWP, 2010).

Much of the development in the watershed occurred prior to regulations that now require riparian buffers or stormwater management practices. Streams were paved over, piped, channelized, and rip-rapped thereby changing the physical stream hydrology and leading to degraded conditions (MWCOG, 2008). In its natural state, the lower Anacostia (tidal portion) was covered with wetlands associated with the Anacostia River estuary, delta, and floodplain. Over 90 percent of those wetlands have been lost (Csato et al., 2013).

The Anacostia River watershed in Prince George’s County is largely urban, with a high percent of impervious surface area (Table 2-2). Present ecological conditions in the Anacostia River watershed are similar to those faced in other urban systems, including lack of stormwater management; loss and degradation of forest, wetland, stream, and riparian habitat; pollution from nutrients, chemical contamination, sediment, and trash; and loss of species diversity (AWRP, 2010).

A GIS analysis using data from the National Land Cover Database (NLCD, 2006) for the portion of the study subwatersheds (subwatershed divisions are based on those used in the ARP, as shown in Figure 1-6) in Prince George’s County indicates the predominant land use is developed space, primarily low to high intensity, but also including open space. Table 2-2 shows land use classifications for each of the study subwatersheds. Forests and cultivated crop land is also significant in some of the subwatersheds.

The Federal Government is a substantial landowner in the Anacostia River watershed. Federal land holdings account for approximately 15 percent of the watershed, encompassing 16,000 acres. This does not include federal holdings in the District of Columbia. In the Prince George’s County portion of the watershed, federal lands include the Beltsville Agricultural Research Center (9,177 acres), Greenbelt Park (1,141 acres), Goddard Space Flight Center (1,276 acres), Rowley Secret Service Training Center (496 acres), and a portion of the Adelphi Laboratory Center. The stream reaches of study are on park land owned by MNCPPC and/or are bordered by forested, residential, institutional (schools), and transportation (roads) land uses.

Table 2-2. Land use classification (percent) for the portion of each of the study subwatersheds* in Prince George's County (data from NLCD, 2006).

	Northwest Branch		Northeast Branch			
Class Name	**Northwest Branch**	**Sligo Creek**	**Northeast Branch**	**Indian Creek**	**Paint Branch**	**Little Paint Branch**
Wetlands	3.2	0.6	1.6	6.0	4.3	4.3
Cultivated Crops/Pasture	0.1	0.0	0.0	7.8	8.3	10.1
Shrub/Scrub	0.2	0.0	0.1	1.3	0.2	1.6
Grassland/Herbaceous	0.2	0.6	0.0	6.1	0.1	0.1
Forest	7.8	10.1	4.9	12.3	16.6	17.3
Open Space/Barren Land	0.1	0.0	0.0	1.5	0.4	0.5
Developed, Open Space	20.8	26.6	19.4	19.9	27.7	22.6
Developed, Low to High Intensity	67.6	62.1	73.9	45.0	42.4	43.5

* Subwatershed divisions are based on those used in the ARP, and as shown in Figure 1-6.

Typical urban, industrial, and high-density residential areas are predominantly impervious, whereas rural areas have very low percent imperviousness. The Anacostia River watershed is highly urbanized and percent impervious land cover has increased significantly in the past several decades. Impervious cover is of particular environmental concern because it limits groundwater recharge and promotes rapid stormwater runoff following precipitation events. Reduced groundwater recharge decreases baseflow in streams during warm season months when streams are sustained by groundwater discharge. This reduction in baseflow reduces the available area and quality of aquatic habitat. During storm events, streams with high degrees of impervious surface area in their watersheds tend to be "flashy," meaning that water levels rise rapidly after a precipitation event, and floodwaters are carried quickly downstream. The increased quantity and velocity of stormwaters draining to the stream network causes streams to erode either through lateral cutting or incision. The tributaries in the Anacostia River watershed exhibit this characteristic.

Both the type of urbanization and percentage of impervious cover are strong measures of anthropogenic stressors on stream habitats (Stranko et al., 2008). Surfaces can have varying degrees of imperviousness. Table 2-3 shows the percentage of impervious surface cover present in each subwatershed. Most stream quality indicators decline when the watershed exceeds 10 percent impervious surface cover, with severe degradation expected beyond 25 percent (CWP, 2003).

Table 2-3. Percentage of impervious surface cover category within the Prince George's County portion of the study subwatersheds* (data from NLCD, 2011).

	Northwest Branch		Northeast Branch			
Impervious Cover Category	**Northwest Branch**	**Sligo Creek**	**Northeast Branch**	**Indian Creek**	**Paint Branch**	**Little Paint Branch**
0%	11.6	11.2	6.6	35.1	29.8	33.8
1 to 10 %	14.6	16.3	11.7	13.1	20.6	15.0
11 to 25 %	15.0	18.3	16.7	12.6	13.1	14.5
26 to 100%	58.8	54.1	65.0	39.2	36.5	36.7

* Subwatershed divisions are based on those used in the ARP, and as shown in Figure 1-6.

2.1.4 Infrastructure

Infrastructure is the set of engineered systems designed to support human populations, and includes roads, railroads, sewer systems, water lines, and power lines. Infrastructure is concentrated in urban areas and can exert influence on the character of stream systems, thereby affecting aquatic ecosystems as described below. Designs included in Section 4.1.1 and Appendix E show roads and utilities (sewer and water) adjacent to the study streams.

2.1.4.1 Transportation Systems

The project stream reaches are located in highly urban areas in Prince George's County, primarily inside the Capital Beltway (I-495). As a result, there are extensive networks of roads within the subwatersheds of study. Major highways in the study area include Interstate 95, which joins with Interstate 495 in College Park. Three of the study sites, Paint Branch at I-95 (site 7), Little Paint Branch (site 12), Indian Creek at I-95 (site 1), and Indian Creek (site 11) are located in close proximity to either I-95 or I-495. In addition, U.S. Route 1, a major north-south roadway, runs close to some of the project sites. Other transportation systems in the project area include Metro rail, buses, and trains.

2.1.4.2 Public Utilities

Sanitary sewer service is provided to 1.8 million residents in Montgomery and Prince George's Counties by WSSC, an agency established by the Maryland General Assembly in 1918. WSSC operates 5,400 miles of sewer mains, treating 180 million gallons of wastewater daily. There are six wastewater treatment plants and 47 wastewater pumping stations within the service area (WSSC, 2014). The sewer system is primarily a gravity system; therefore, a majority of the pipes follow streambeds at the lowest elevation in the basin. A schematic of a gravity sewer system is shown in Figure 2-1. At some stream reaches, armoring of sewer infrastructure (i.e., placement of large rocks to protect infrastructure within stream beds) is evident. Maps of sewer infrastructure at the selected stream sites identify that most streams have sewer lines running parallel, at or under, the stream channel for long distances. The presence of sanitary sewer infrastructure in stream beds not only affects water quality, but can also cause fish blockages. Where piping runs under and perpendicular to a stream bed, in-stream erosion can expose buried utilities, creating new fish blockages.

Water is supplied to 1.8 million residents in Montgomery and Prince George's Counties mainly by the WSSC. Two surface water impoundments on the Patuxent River, including Tridelphia Lake at Brighton in Montgomery County and Rocky Gorge reservoir in Laurel, Prince George's County, supply more than 11 billion gallons of water annually. The majority of households in the selected stream reach locations are supplied by WSSC water supply. There are a few locations where buried water supply infrastructure intersects the selected reaches. Other utilities in the area include Baltimore Gas and Electric, Washington Gas, and PEPCO Electric Service.

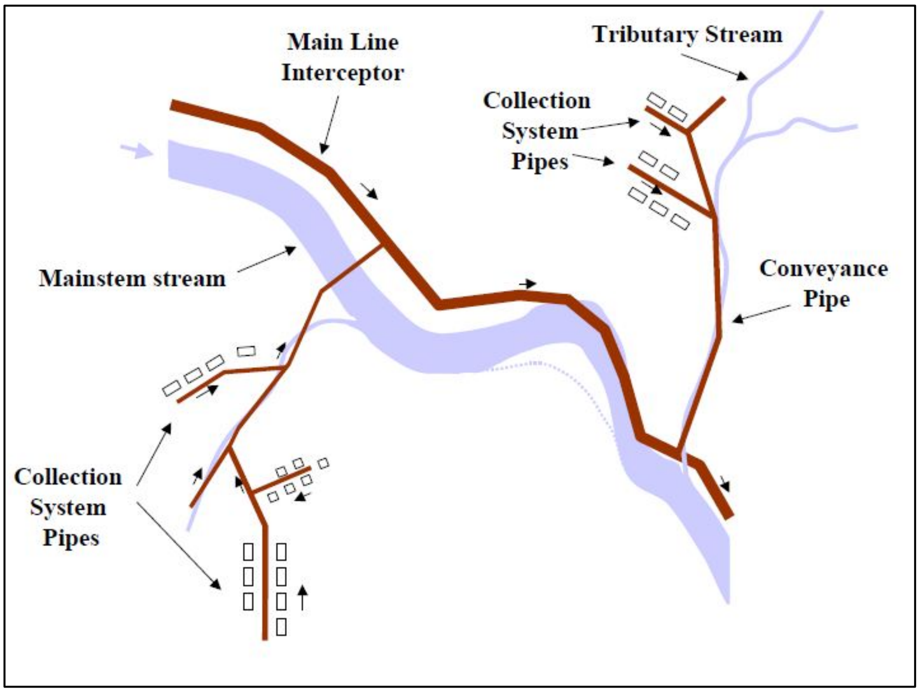

Figure 2-1. Schematic of a gravity-flow sewer system (from Ken Belt, USDA).

2.2 General Hydrologic Setting

The headwaters of the Anacostia River watershed originate in Montgomery and Prince George's Counties, Maryland. Twenty-three major and medium-size tributaries, with a combined stream channel length of approximately 293 miles, are located in the watershed (MWCOG, 2008). The two largest tributaries of the Anacostia River are the Northeast Branch and Northwest Branch, contributing approximately 70 percent of the mainstem Anacostia River flow. These tributaries converge in Bladensburg to form the mainstem Anacostia River. Downstream from the confluence of the Northwest and Northeast Branches the river is mostly channelized and is considered to be a freshwater tidal river (AWRP, 2010). From the confluence at Bladensburg, the river flows southward into the District of Columbia and joins the Potomac River at Hains Point.

Anacostia River subwatersheds selected for potential stream restoration projects under this study include Northwest Branch, Indian Creek, Paint Branch, Little Paint Branch, Sligo Creek, and Northeast Branch (Figure 1-6). Selected stream reaches range from first to fourth stream order

(Strahler method). General hydrologic conditions are described in this section and existing conditions specific to each study reach are described in Section 2.3.

2.2.1 Stream Geomorphic Condition

Over time, anthropogenic activity has significantly altered the hydrology and morphology of the Anacostia watershed. The study subwatersheds are highly urbanized with the majority of land in the watershed drained by MS4 drainage. In the Maryland portion of the watershed, 9,500 acres drain directly to the Anacostia River and tributaries, and the remaining 82,600 acres are drained via MS4 outfalls. Prince George's County has 44,000 acres of MS4 drainage county-wide (PGDOE, 2014).

In addition to hydrologic changes due to industrialization and urbanization, several of the stream systems within the subwatersheds of study were significantly altered through channelization. Stream channelization is noted to be an important stressor to stream biota (MDE, 2012a). Streams in Prince George's County were historically channelized locally for agricultural and milling purpose in the 17th to early 20th centuries. Streams were further channelized in the later 20th century by USACE for flood risk management purposes and in association with installation of sanitary sewer infrastructure in the stream valleys.

A major flood risk management project was implemented in the 1970s by USACE on Northwest Branch, Northeast Branch, Paint Branch, and Indian Creek. The project altered channel geometry (through widening and deepening) and pattern (through realignment or relocation), which significantly changed the basic mechanics of the streams and impacted habitat diversity. Channelization included channel straightening and armoring with rock, concrete, and gabion baskets and/or creation of a homogenous earthen trapezoidal channel. Although not well documented, it is likely that WSSC channelized portions of other study stream reaches, including Sligo Creek (MNCPP, 1981). WSSC work may have included systematic stabilization of stream banks with large rock during emplacement of sanitary sewer infrastructure that runs underneath and/or parallel to the stream beds. Substantial acreage of wetlands, including 713 acres along Northeast Branch and Northwest Branch, and 134 acres along Indian Creek and Paint Branch have been lost as a result of urbanization and channelization (MDNR, 2005a).

The current state of in-stream habitat and geomorphic condition was evaluated by USACE field assessments as well as a USFWS assessment (2015). Channelized study area streams armored with hard materials show a greater range of physical habitat conditions than do the channelized segments of the study area within earthen trapezoidal channels. Generally within the USACE channelized reaches of Paint Branch (site 5) and Indian Creek (site 11), habitat assessment found that depths greater than 1.6 feet (0.5 meters) were very limited in distribution. This is almost entirely an artifact of channelization that eliminated meanders and shortened water flow lengths. Areas of faster current (>1 foot/second; 0.3 meters/second) were also very limited. While coastal plain streams in this region naturally possessed slow velocities in their low-gradient sections, loss of velocity in the channelized reaches also occurs as result of increased bottom friction in those channelized streams that have uniformly shallow conditions. Additionally, all of the study streams locally possess a high degree of bank and/or bed erosion, resulting in downstream sedimentation. Details of the existing geomorphic condition specific to each study segment are provided in Section 2.3.

USFWS assessed the in-stream conditions at the project locations on Paint Branch and Little Paint Branch, using their Function-Based Rapid Stream Assessment (USFWS, 2015). USFWS identified that floodplain connectivity and bedform diversity are the main contributors to impairment in all of the stream segments. Floodplain connectivity represents the vertical stability of the stream. Diverse bedforms, particularly in the form of pools (both pool-to-pool spacing and pool depth variability), play a significant role in dissipating energy and creating habitat diversity. Their observations note incised streams, likely as a result of urbanization, which increases runoff and therefore contributes to channel enlargement. Increases in the stream power (energy) can also cause headcuts, which were observed. Severe vertical and lateral instability was observed in these systems. The USFWS report summarizing their field assessments and the Stream Function Pyramid are provided in the USFWS Planning Aid Report in Appendix C.

2.2.2 Water Quality Standards and Listings

In Maryland, water quality standards are set by MDE. MDDNR is responsible for the collection of samples and assessment of water quality data (MDE, 2012a). Water quality standards are set in accordance with the Federal Water Pollution Control Act as amended, more commonly known as the “Clean Water Act” (33 U.S.C. §§1251-1387), and state agencies report compliance to the EPA. Water bodies that do not meet water quality standards are reported in Maryland’s Section 303(d) listing for impairment. States are required to develop TMDLs for impaired water bodies. A TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards.

The Anacostia River mainstem and tributaries (MD Basin # 02140205) have been variously designated as Use Class I, II, III, and IV waters, which include (Code of Maryland Regulations [COMAR] 26.08.02.08 O):

Use Class	Designated Use and Description
I	Water Contact Recreation and Protection of Non-Tidal Warm water Aquatic Life: The minimum standard for all waters throughout the State; protects waterways for recreation, fishing, and aquatic life use.
II	Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting: Protected for shellfish harvesting and consumption.
III	Non-Tidal Cold Water: Protected to maintain natural trout populations
IV	Recreational Trout Waters: Protected for put-and-take trout fishing

*all categories can have a “P” designation if also used for Public Water Supply

In the Prince George’s County portion of the Anacostia River Watershed, surface waters are categorized as Use I, III, or IV. All study sites except Paint Branch at I-95 (site 7) and Northwest Branch (site 13 and part of site 3) are categorized as Use I. The upper portion of Paint Branch supports wild (naturally reproducing) brown trout above the Capital Beltway; however, individual brown trout can be found a short distance downstream of the beltway. Therefore, Paint Branch is classified as Use III from site 7 upstream. Widely regarded as the Anacostia’s highest quality stream system, Paint Branch has cold, clean waters that are relatively sediment free and shaded by riparian forests. Northwest Branch is classified as Use IV for having the support of recreational trout populations (MDE, 2014; Galli et al., 2010).

2.2.3 Water Quality Impairments

The Anacostia River Watershed has historically been characterized by poor water quality due to alteration of the natural landscape and pollution from increasing development. This degradation began in the 1600s when colonists deforested portions of the watershed for farming. With decreasing riparian buffers and increasing agriculture, sedimentation became a large problem. Throughout the 18th and 19th centuries, developing industry and a growing population led to increased runoff, erosion, sedimentation, and pollution. The watershed has a high percentage of impervious surface cover, as shown for the study subwatersheds in Table 2-3. Impervious areas negatively influence the biotic integrity of streams because of increased velocity and quantity of flow, subsequent deterioration of channel stability and aquatic habitat, and increases in the quantities of chemicals that are transported (USGS, 2007). Over time the watershed has become polluted with sediment, nutrients, organic matter, bacteria, heavy metals, organic chemical contaminants, and trash. Along with in-stream habitat conditions, water quality is a factor limiting improvement in fish and benthic resources.

In addition to degradation of aquatic systems by urbanization and industrial discharges, aging sanitary sewer infrastructure has impacted aquatic health. Untreated sewage contributes high levels of bacteria to the environment and exacerbates low dissolved oxygen conditions, causing mortality of fish and aquatic plants. As part of a 2006 EPA Consent Decree, WSSC is required to rehabilitate and replace the leaking, undersized, and aging sewer lines in the Maryland Portion of the Anacostia River watershed within 12 years (from 2006). The Sewer Repair, Replacement, and Rehabilitation (SR3) program has improved the condition of the wastewater collection system with actions such as pipe lining, relocation, and replacement; manhole repairs; other types of repairs; actions to minimize blockages; protecting sewer lines and manholes exposed by stream erosion utilizing stream geomorphic and traditional engineering techniques; and sewer main, manhole and house connection reconstruction and replacement (WSSC, 2014). The consent decree initially mandated completion of construction for sewer improvements by December 2015; however, given the scope of the repairs needed, an extension was granted to 2019. The decree also includes a water quality management plan for the tributaries of the Anacostia River to identify areas and sources of concern (AWRP, 2010).

The NPDES MS4 program administered by MDE requires large urban jurisdictions to control pollution in stormwater to the maximum extent practicable, thereby improving water quality in streams. MDE reissued a NPDES permit to Prince George’s County in 2014. This permit covers stormwater discharges from the storm drain system owned or operated by Prince George’s County. Permit requirements include implementing comprehensive stormwater management programs for addressing runoff from new and redevelopment projects, restoring urban areas where there is currently little or no stormwater management, and working toward meeting stormwater waste load allocations for local water resources and Chesapeake Bay. Also included in the permit are conditions that require the County to possess the necessary legal authority to control stormwater discharges, map the storm drain system, monitor urban runoff, and eliminate illicit discharges to the storm drain system.

Listed impairments in the Prince George's County portion of the Anacostia Watershed in Maryland include (listing years in parentheses): nutrients (1996), sediments (1996), fecal bacteria – non-tidal waters (2002), impacts to biological communities – non-tidal waters (2002), toxics – polychlorinated biphenyls (PCBs) in fish tissue in tidal waters (2006) and trash/debris (2006). The TMDL for total suspended solids/sediment was approved by EPA in 2012. Fecal bacteria TMDLs for MD tidal and non-tidal areas of the Anacostia were established in 2006. A multi-jurisdictional TMDL for PCBs in the tidal portions of the Potomac and Anacostia Rivers were established jointly by DC, MD and VA in 2007. A watershed-wide TMDL for nutrients/biochemical oxygen demand (BOD), addressing the listings for those impairments to the Anacostia in their respective jurisdictions, were established jointly by DC and MD in 2008 (MDE, 2015).

On December 29, 2010, the EPA established the Chesapeake Bay TMDL, which sets pollution limits for nitrogen, phosphorus, and sediment across Bay jurisdictions. In response, Prince George's County developed a Watershed Implementation Plan (WIP) to identify how these limits will be met. This is further discussed in Section 2.6.3.

In 2016, the results of Phase I Remedial Investigation/Feasibility Study (RI/FS) of contamination in the tidal portion of the Anacostia River were released by the District of Columbia Department of Energy and Environment (DOEE). The study focused on the tidal Anacostia from the mouth of the river with the Potomac upstream to the confluence of Northeast and Northwest Branches. The study indicates the presence of pollutants in river sediments, pore water, fish tissues, including PAHs, PCBs, TPH, and heavy metals, among others, such that elevated risks exist for human health and ecological receptors. A Phase II investigation is ongoing, with the purpose to evaluate potential remedial alternatives to address unacceptable human health and ecological risks (DOEE, 2016). Additionally, clam biomonitoring over the past two decades indicates chlordane contamination present throughout the Anacostia River watershed, including in Sligo Creek. Use of chlordane was banned in 1983, so the presence of chlordane indicates legacy contamination (Phelps, 2011).

The AWS monitors the health of the Anacostia River Watershed and creates yearly report cards. The AWS measures water quality parameters, grades the current condition, and reports the trend compared to previous data. For 2014, the score rated from 0 to 100 percent (100 percent being the best rated), with trends in parentheses are: dissolved oxygen 48 percent (improving), fecal bacteria 69 percent (improving), water clarity 43 percent (static), chlorophyll 61 percent (improving), submerged aquatic vegetation 0 (static), stormwater runoff volume 49 percent (degrading), chemical contaminants 14 percent (static), and trash 41 percent (improving). The grade for overall health was 40 percent, equivalent to a grade of "F". The most recent grade (2017) for overall heath is 49%, indicating marked improvement over the past few years.

2.3 Hydraulic and Hydrologic Setting of Study Stream Reaches

This section describes the existing hydraulic and hydrologic conditions specific to each of the ten stream reaches of study. Biological resources are described in Section 2.4. Figure 1-7 shows the location of each of these sites within the Anacostia River watershed in Prince George's County. Descriptions below are organized by major subwatershed as defined in the objectives in Section 1.8. The field observations described below were conducted by USACE civil and hydraulic engineers from 2014 to 2016.

2.3.1 Existing Conditions for Northwest Branch and Tributaries

2.3.1.1 Northwest Branch (Site 3)

Northwest Branch is an entrenched system in an urbanized area that experiences frequent flashy flows. The reach studied is approximately 1.38 miles (7,286 feet) in length, located on the mainstem of Northwest Branch, approximately from Queens Chapel Road to north of East-West Highway (MD Route 410). The drainage area for the reach is approximately 49 square miles. Much of the lower portion of Northwest Branch was channelized by USACE in the 1970s for flood risk management, including 600 feet of the study reach. The stream was realigned, widened, and deepened upstream and downstream of the Queens Chapel Road Bridge for a total distance of 5,610 feet (USACE, 1975); thereby removing habitat complexity. The reconstruction of the stream consisted of the alteration of the natural stream channel into a trapezoidal channel with an 80 foot bottom width, extending 3,940 feet upstream from the 38th Avenue Bridge along a new alignment. Here the channel transitions to a width of 70 feet under the Queens Chapel Road Bridge, continuing upstream for about 3,500 feet. The channel was designed to accommodate flows of 5,000 cubic feet per second upstream of Queen's Chapel Road and 8,000 cubic feet per second downstream of Queen's Chapel Road.

Some of the bridges within the site 3 reach are tightly angled (i.e., are skewed) relative to the direction of flow. This creates back eddies and bed and bank erosion. High sinuosity upstream of the bridges is directly related to the existing hydraulic opening (i.e., backwater caused by constriction during high flow). Spot bank armoring is present along the reach and a number of riffle grade controls exist to improve potential fish passage. USACE and MWCOG have identified a blockage for anadromous fish downstream of Ager Road, just upstream of the confluence with Sligo Creek. Utility crossings (sewer, gas, and water lines) within the stream act as grade control structures, without which the stream would have become even more entrenched and less stable. Along the reach, there are long, deep pools loaded with soft sediment. Additionally, a thick layer of sand has been deposited on both sides of the floodplain, indicating out of bank activity from larger storms.

2.3.1.2 Sligo Creek (Site 9)

Sligo Creek is a tributary to Northwest Branch. The study reach starts at the confluence with Northwest Branch and extends upstream for 0.42 mile (2,218 feet). The reach has a drainage area of 11 square miles. Northwest Branch is highly entrenched (U-shape channel) and carries a significant volume of flow compared to Sligo Creek. During flood events, Northwest Branch acts as a hydraulic dam forcing back eddies within Sligo Creek toward its confluence, and creating a wide, shallow stream. A fish blockage consisting of a steel weir with a one foot drop is present on Sligo Creek upstream of the Northwest Branch confluence.

Field observations indicate that the stream has shifted laterally to the left due to deposition on the right side of the channel (where the stream originally flowed). The right bank of the upper portion of the stream near the baseball field is severely eroded. This may be due to the shape of a riffle grade control that directs the flow (velocity vector) to the toe of the embankment. Point bars on the left side of the stream are expected to further increase the erosion potential at the right toe of the embankment. This is a very urban environment with turbulent flow. Additionally, almost the entirety of the stream system has been channelized with boulders on both banks, defining a wide engineered channel.

2.3.1.3 Chillum Road Tributary (Site 10)

The drainage area for this reach is approximately 1 square mile. This stream is a tributary to the mainstem Northwest Branch, entering the mainstem downstream of the mainstem-Sligo Creek confluence. The stream is highly unstable and has steep vertical banks. There is little hydrologic connection with the floodplain, even at very high flow. The upper watershed is a concrete channel that carries a lot of debris to this reach. A metal sanitary sewer line crosses the stream, suspended in the air with attached rock.

2.3.1.4 Northwest Branch, Riggs Road (Site 13)

This site is located at the transition between the Piedmont and Coastal Plain physiographic provinces. The project stream reach has a drainage area of 35 square miles and a length of 1.46 miles (7,708 feet). This system is severely incised and experiencing major lateral erosion. There have been some spot fixes to protect existing utilities; however, utilities continue to be undermined. Lateral erosion is so severe that the adjacent pedestrian trail is being undermined. Just upstream of the reach, a bridge at Riggs Road consists of an undersized concrete arch that acts to dam the stream. A utility line crosses the stream under the bridge at Riggs Road, which maintains the stream grade to prevent headcutting until the stream crosses under the power lines downstream. At the power line crossing, vegetation is controlled (removed), which has resulted in severe erosion and the uprooting of many trees. Downstream of the power line crossing, the high sinuosity in the upstream portion of the reach is not natural and is caused by the bridge at MD 193. The bridge acts as a hydraulic dam creating erosive back eddies on alternating sides of the stream upstream of the bridge, resulting in increased sinuosity.

2.3.2 Existing Conditions for Northeast Branch and Tributaries

2.3.2.1 Indian Creek (Site 11)

Upstream Segment

The stream channel is wide and flat along the upper reach and turns into a narrow and constricted area at MD 193. The drainage area for this reach is 29 square miles and the reach length is 1.98 miles (9,843 feet). Historically, this area had a substantial network of wetlands. Over the last half century, this area was converted to an upland housing community on one side and a metal scrap yard on the other side.

Abandoned and active sand and gravel operations are present within the subwatershed. The Indian Creek subwatershed contributes the highest suspended sediment load of all the subwatersheds to the Anacostia River (MWCOG, 2009i). A large intact area of forested wetland is still present in the upstream valley. Downstream of MD 193, substantial channelization was implemented by USACE for flood risk management purposes, including straightening the reach. Some channel alteration is also visible upstream of MD 193. A concrete plant on one side of the stream has clearly dumped excess concrete into the stream. During the site visit, a network of exposed pipes (mostly metal) was observed that are not shown on GIS maps of utility lines. There are many braided channels carrying a lot of sediment. The vegetation here is primarily invasive. There are two stormwater outfalls that have created a gully. One of these gullies is next to a large sized pond that is covered with invasive vegetation. At the end of this reach, the concrete channel upstream of a four cell box culvert (MD Route 193) acts to pond water and create pooled conditions.

Downstream Segment

This is a channelized system with washed out riffle grade controls at the outfall of the four cell box culvert transitioning into an entrenched system with vertical banks. The stream reach was channelized by USACE for flood risk management in the 1970s. The flood risk management project created a trapezoidal channel 30 feet wide extending upstream from the confluence with Paint Branch to Greenbelt Road (a distance of approximately 7,600 feet). The channel was designed to accommodate flows of 1,000 cubic feet per second. Mature trees and invasive vegetation are present on the right bank, which is disconnected from the stream. There is a sewer line and housing on the left bank. The stream crosses Berwyn Road through a single span bridge. Severe bank erosion is present on the left bank downstream of the bridge. There are grout bags placed around the bridge abutment to protect the bridge from scour.

2.3.2.2 Indian Creek at I-95 (Site 1)

At the upstream end of the selected reach, Indian Creek crosses I-95 through two 11 foot by 8 foot box culverts and daylights in a wooded area. The stream is entrenched and is experiencing bank and bed erosion. Some trees are uprooted due to lateral erosion. Further downstream there are two large areas with many dead trees, which may be due to beaver activity. During a 2014 site visit near Ammendale Road, a beaver dam was present. Frequent flooding could have oversaturated some of the trees, causing mortality and resulting in a bare area. A gully is present resulting from erosion from flow from an inlet at Gordon Avenue, just downstream of Flash Drive. The stream then crosses Ammendale Road through a triple box culvert to a regional pond for flood control. The pond conveys the flow through a row of gabion baskets and then under the embankment via two concrete circular pipes. Downstream of this area, the stream is channelized through a monastery and then becomes relatively scenic with good tree canopy and native vegetation (primarily ferns) on the floodplain. The last portion of project reach is a concrete channel that was constructed by USACE in the 1960s to reduce flooding. Three shallow ponds next to each other at the right bank are separated from the residential neighborhood by a berm. It is assumed that the ponds were excavated in order use the fill for levee construction in 1960s.

2.3.2.3 Paint Branch (Site 5)

The drainage area for site 5 is 31 square miles and the reach length is 1.3 miles (6,864 feet), extending upstream from the confluence with Indian Creek. Previous USACE activities for flood risk management have impacted the entirety of the study reach. The flood risk management project altered this site into a trapezoidal channel 50 feet wide, and 135 feet wide at the CSX railroad bridge. Upstream of the CSX railroad bridge (at the north end of the College Park airport), Paint Branch was realigned into a new channel to the east of the historical channel for its entire length to Baltimore Avenue (USACE, 1975). The channel was designed to accommodate 2,500 cubic feet per second from US Route 1 to the railroad bridge, and 3,000 cubic feet per second downstream from the railroad bridge. Approximately 400 feet upstream of the Paint Branch-Indian Creek confluence, a two foot deep structure of steel sheet piling and riprap was constructed to maintain acceptable grade. This has been partially removed to allow fish passage. The project also removed vegetation in the floodway up to the railroad bridge.

Based on the presence of channel-parallel berms, it is likely that excavated material from past channel alterations was placed parallel to the channel along much of the stream. Currently, the stream flows primarily through an earthen channel with minimal stabilization. The stream is very unstable and there is sediment loading throughout the system. During the site visit, it was noted that there are a number of alternating transverse bars that divert the flow such that the toe of the bank is being undermined and trees are being uprooted. The stream is very wide in some areas and sediment has formed islands creating a braided system. The coarse sediment provides some protection, but during high flows cobble sized sediment becomes mobilized. The stream habitat has been simplified by the historic channelization and there are long reaches with homogenous habitat conditions. Conditions are drastically different in the vicinity of woody debris jams. In these places, habitat is heterogeneous, but unstable.

2.3.2.4 Paint Branch at I-95 (Site 7)

The drainage area for this reach is 16 square miles. The upper portion of this reach is located at the transition between the Piedmont physiographic province and the Coastal Plain province. The reach starts downstream of Powder Mill Road (MD 212, at a concrete bridge with a 38 foot span) and extends to downstream to I-495. There are eight stream crossings, four of which are box culverts and the others are bridges. Two of the culverts act as fish blockages, but contain fish ladder like structures constructed by the Maryland State Highway Administration in the late 1990s. Siltation of these structures and constant debris jams have altered the function of the fish passage structures. A maintained right-of-way for a high power electric line results in a lack of vegetation to hold the banks together. A portion of the stream is lined with concrete at the outer bound of I-95 to protect the bridge piers. Many trees are being uprooted, causing sediment loading and a maintenance problem.

2.3.2.5 Little Paint Branch (Site 12)

The drainage area for this reach is 11 square miles. A section of this stream between I-495 and Cherry Hill Road was channelized when the Capital Beltway (I-495) was constructed. The stream has very high width-depth ratio and the active channel is overloaded with coarse sediment upstream of Cherry Hill Road. During the field visit, a day after a minor rainfall event, the floodplain showed signs of out-of-bank activity. Downstream of Cherry Hill Road the stream is more sinuous, but then becomes channelized. The excess sediment is creating lateral erosion and local scour. A good portion of the concrete sewer line is exposed in the channel very close to the pedestrian trail.

2.3.2.6 Northeast Branch, Calvert Road (Site 15)

Site 15 has a drainage area of 70 square miles and reach length of 1.04 miles (5,323 feet). The stream reach is entirely channelized and stabilized with boulders. The upper portion of this channelization was conducted by USACE (USACE, 1975). Channelization for flood risk management consisted of widening and deepening and varied amounts of overbank clearing. The project consisted of the creation of a 50 foot wide trapezoidal channel starting 540 feet upstream of the Calvert Road Bridge and extending to the Paint Branch-Indian Creek confluence and into sites 5 and 11 (described above). Most of the suspended sediment and some of bed sediment load that moves through lower portion of Indian Creek (site 11) is deposited in this reach causing alternating bars (sediment loading) and a shallow wide channel with homogeneous habitat. There are five locations where utilities cross the stream creating small vertical drops. Under the River Road Bridge, sheet pile was placed across the stream to provide grade control. A vertical drop of a half foot to one foot is present here. Fish passage would be blocked, except that a notch has been cut into the center of the stream to provide passage. However, this collects sediment and traps debris. This stream system is powerful (high energy) during high flow. The banks along the entirety of the project reach have been armored with revetment.

2.4 Biological Resources

2.4.1 Fish and Benthic Integrity

The Anacostia watershed in Prince George's County is home to more than 55 species of freshwater fish, representing nearly every family of freshwater fish known in Maryland; however, historical fish assemblages in the subwatersheds were larger and more diverse. Appendix A-2 summarizes the fish species reported in the study stream reaches and the subwatersheds of study. Detailed information on the fish and benthic integrity of the Anacostia River watershed and subwatersheds of study can also be found in the ARP and each of its subwatershed appendices (AWRP, 2010; MWCOG, 2009b-g).

As described in Section 1.4, the project stream reaches historically provided important spawning and nursery habitat for anadromous fish, including alewife herring (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), hickory shad (*Alosa mediocris*), white perch (*Morone americana*), sea lamprey (*Petromyzon marinus*) and striped bass (*Morone saxatalis*), as well as catadromous American eel (*Anguilla rostrata*). Herring, shad, and eel were historically present in abundant populations in the Potomac and Anacostia basins. Documentation from the 1830s indicates that it was not uncommon for fisherman to pull 4,000 shad or 300,000 herring in one seine haul at the mouth of the Anacostia (Cummins, 2012). Alewife and blueback herring were historically present in all the study stream reaches, while shad would have been found in the mainstem of the Northwest and Northeast Branches. Currently, anadromous fish are absent in the study stream reaches.

Freshwater mussels were historically found in the Anacostia River watershed (MDDNR, 2010), however water quality impairments have resulted in small populations currently only existing in the tidal Anacostia River (Ashton and Sullivan, 2016). Mussels utilize specific anadromous fish and eels to transport their larvae upstream where they are distributed; however, anadromous fish are currently inhibited from migrating into the upstream portions of the watershed.

Anadromous fish monitoring is performed annually by MWCOG to determine the presence or absence of anadromous fish and the strength and extent of fish migration (MWCOG, 2014). In 2014, MWCOG staff sampled nine sites for anadromous fish, including on Northwest Branch at U.S. Route 1, 38^{th} Street, and upstream in West Hyattsville. The Northeast Branch was surveyed at River Road, Riverdale Road, and from the CSX Bridge to U.S. Route 1. The Paint Branch was surveyed at US Route 1 and at the confluence of Paint Branch and Indian Creek. The monitoring locations on Northwest Branch at West Hyattsville and on Northeast Branch at the Paint Branch-Indian Creek confluence are within study stream reaches 3 and 15, respectively (Figure 2-2).

Over the past three monitoring seasons, for the first time since 1999-2004, schools of river herring (greater than 100 individuals) have been observed on Northwest Branches at U.S. Route 1, with smaller numbers seen up to 38th Street (just downstream of study site 3). Large numbers of shad have been observed at least up to U.S. Route 1. In spring 2017, herring were observed up to Queen's Chapel Road. On Northeast Branch, river herring and shad have been routinely observed up to River Road (just downstream of study reach 15), but in 2017, were observed in Indian Creek up to Berwyn Road for the first time since 2005. Additionally, in 2017, herring were observed for the first time in about 10 years in Lower Beaverdam Creek. For shad, both young of the year (YOY) and adult fish were observed, indicating that spawning occurred in the vicinity (MWCOG, 2013; MWCOG, 2014). The presence of these fish potentially demonstrates the success of the implementation of various Mid-Atlantic States conservation plans (including the ARP), and previous fish passage projects and habitat improvements, including by USACE.

In addition to migratory fish species, resident fish and benthic macroinvertebrates species abundance and diversity has been negatively impacted within the Anacostia River watershed by habitat degradation and poor water quality. Habitat degradation, especially channelization, has simplified the in-stream habitat (i.e., reduced variety of channel bedforms) leading to reduced diversity of fish and macroinvertebrates. The USACE flood risk management project implemented in the 1970s to channelize portions of Northwest Branch, Northeast Branch, Indian Creek, and Paint Branch dramatically impacted aquatic ecosystems. The final environmental impact statement (USACE, 1971) for this project states,

> *"The streams will be widened and straightened…this procedure not only removes most of the cover and food available to the wildlife, but all of the natural fauna within the stream. A straight channel with uniform slope and cleared banks is relatively biologically unproductive when compared to a stream such as the ones described above. The gains in flood protection will require the reduction of natural environmental values in the sections of the streams which are as yet natural in character."*

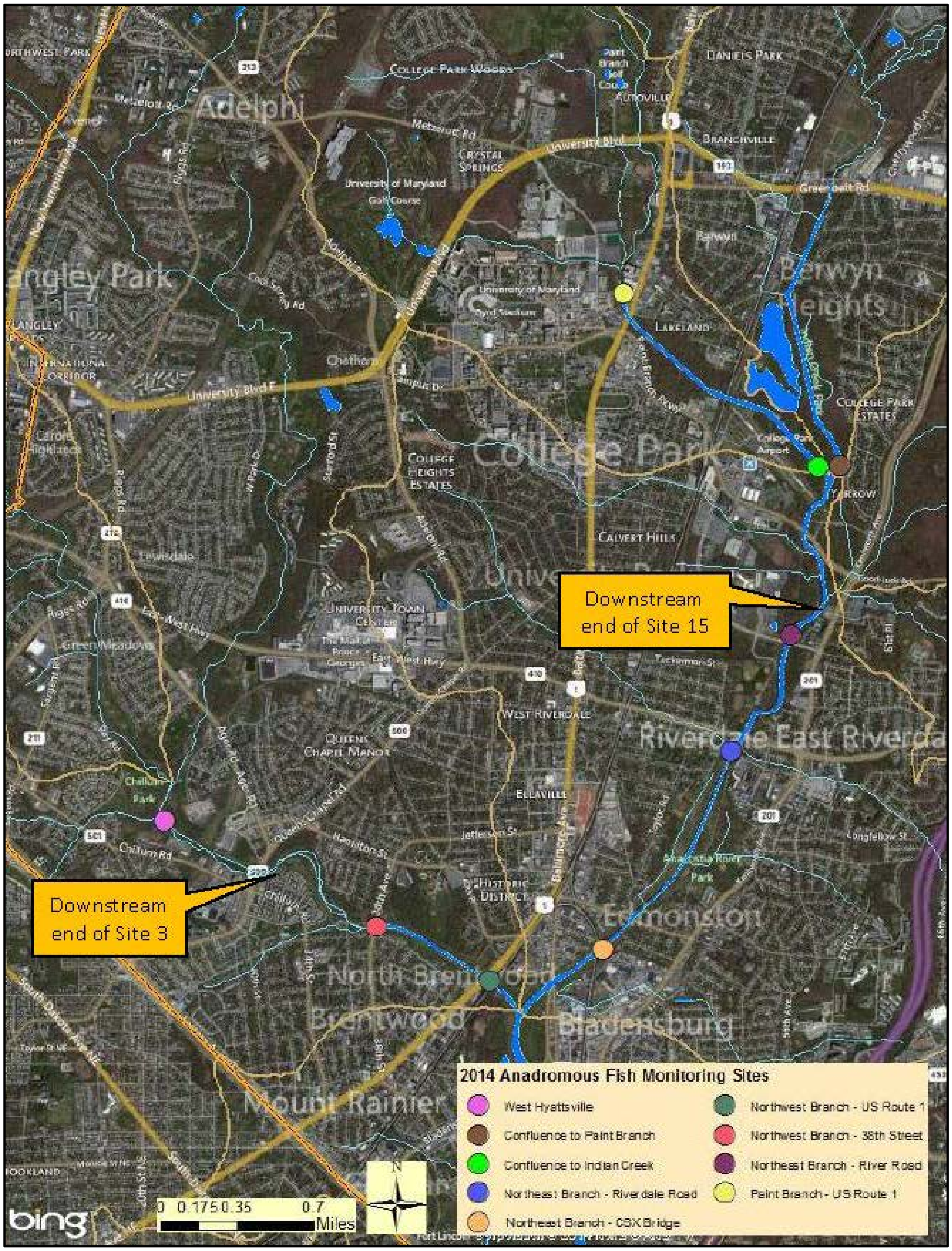

Figure 2-2. MWCOG migratory fish monitoring sites on Northwest and Northeast Branches (from MWCOG, 2014). Study sites 3 and 15 shown for context.

The variety of species that historically inhabited the streams of the study area thrived under very diverse habitat conditions. The habitat requirements and characteristics of species with published Habitat Suitability Index Models are summarized in Appendix A. This summary includes resident fish, diadromous fish, and estuarine fish species. A broad range of habitat needs is reflected. For example, species that prefer swift currents include the longnose dace, whereas sunfishes prefer sluggish, quiet waters. Cover is important to most species, but their use of riffles and pools varies; some species require in-water vegetation while others do not. Substrate requirements also vary. Bluegills prefer fine substrates compared to the coarse substrate needs of longnose dace. Because the study streams have been simplified, these diverse conditions have been lost.

As discussed in Section 1.7, a biological stressor evaluation performed by MDE and MD DNR (MDE, 2012) identified stressors related to poor water quality, altered hydrology, and degraded in-stream habitat. Degraded habitat conditions resulting from sediment and flow parameters include bar formation (representing the presence of excess sediment), channel alteration, and poor to marginal epifaunal substrate (MDE, 2012).

USACE field assessments, including measurement of the Physical Habitat Index (MDDNR, 2003) were performed in 2014 to 2015. The physical habitat index (a score out of 100) is an assessment of current habitat conditions for fish and benthic organisms. These scores are shown in Table 2-4 and indicate that current physical habitat conditions are poor. Additionally, USACE field assessments observed channelization (homogenous depth, velocity, and substrate conditions), poor to marginal in-stream habitat structure, poor to marginal riffle-run quality, and concrete/gabion presence as in-stream habitat parameters tied to poor stream biological condition.

Table 2-4. Physical Habitat Index scores for the study stream sites.

Site	Physical Habitat Index Score (out of 100)
1	55
3	36
5	35
7	37
9	39
10	54
11	25
12	35
13	37
15	41

2.4.2 Fish Passage

The ARP identified several fish blockages within and adjacent to the study stream segments. Man-made, rather than natural, fish blockages are of interest in this study. Many mapped blockages are relatively small or partial blockages that block upstream fish passage during low flow periods. The blockages of greatest concern obstruct upstream passage by anadromous fish seeking to reach upstream spawning grounds in the late winter/early spring. Fish blockages are considered by MDDNR to be vertical drops of 1 foot or more. These blockages obstruct anadromous fish even when flow is relatively high. Herring and shad are primarily affected by the blockages in the study streams, whereas American eel are likely to be able to navigate over or around blockages of this magnitude.

The fish blockages within the project reaches are formed by durable infrastructure (large pipes, concrete and steel structures). Within the selected stream segments, including on Sligo Creek (Site 9) and Northwest Branch, Hyattsville (Site 3), there are fish blockages that limit anadromous fish movement upstream. These blockages, shown in Figure 2-3, include an approximately 1 foot high concrete sill on Northwest Branch and a 1 foot high sheet pile on Sligo Creek. Other partial or complete blockages are located on Indian Creek and on Paint Branch (concrete under the bridges for the Capital Beltway I-495/95). A fish blockage downstream of the selected stream segments on Northwest Branch (included in the ARP as candidate fish blockage removal project NW-L-04-F-9) was recently ameliorated. Additionally, a blockage created by a WSSC emergency sewer line repair on Indian Creek was recently repaired. The blockages on the stream study reaches were field verified by USACE staff as well as identified within the ARP and by regional fisheries experts at MWCOG. Further description of fish blockages can be found in Appendix B.

Currently, river herring utilize only about 21 percent of their historical range on Northwest Branch and 10 percent on Northeast Branch. River herring and shad (including YOY) have recently been observed close to the downstream end of the project sites. It is unknown at this time whether these successes can be attributed to completed stream restoration and fish blockage removal projects on these streams. Anadromous fish passage projects were previously completed on Northwest and Northeast Branches by USACE (USACE, 1992) and for SHA mitigation.

Figure 2-3. Fish blockages on Northwest Branch (site 3) and Sligo Creek (site 9).

2.4.3 Wildlife

The *Anacostia Watershed Environmental Baseline Conditions and Restoration Report* (2010) documents that, although much degraded, the watershed provides habitat for many species of plants and animals. The Anacostia Watershed Society maintains lists of birds, mammals, amphibians, and reptiles within the watershed. Currently they list 233 bird species, 61 amphibian and reptile species, and 35 species of mammals. These lists, which include the conservation status of the species defined by the MDDNR are shown in the USFWS Planning Aid Report provided in Appendix C. Bird species include migratory birds that are strongly affiliated with stream and riparian habitat (see Appendix C for more details).

2.4.4 Rare, Threatened and Endangered Species

The northern long-eared bat (*Myotis septentrionalis*), a federally listed threatened species, occurs in the Anacostia River watershed. The northern long-eared bat is found across much of the eastern and north central United States and all Canadian provinces from the Atlantic coast west to the southern Northwest Territories and eastern British Columbia. White-nose syndrome, a fungal disease known to affect bats, is currently the predominant threat to this bat, especially throughout the Northeast United States where the species has declined by up to 99 percent from pre-white-nose syndrome levels at many hibernation sites. There are no current records of the northern long-eared bat in the project vicinity (USFWS, 2015).

A state listed endangered plant exists on the floodplain adjacent to one of the project stream reaches (Site 11, Indian Creek). The trailing stitchwort (*Stellaria alsine*) is an annual that inhabits the periodically inundated braided side channels at the site. MD DNR Wildlife and Heritage Service determined that there is a record of the state-listed American brook lamprey (*Lampetra appendix*) documented for a portion of the Northwest Branch that overlaps with the project sites 3 and 13. The potential impacts to these species from project implementation are discussed in Section 5.

2.4.5 Riparian Vegetation (Wetlands & Forest)

USACE and the EPA define wetlands as areas inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (LaBranche, et al., 2003). It is estimated that since European settlement more than 4,000 acres of non-tidal wetlands have been lost from the Anacostia watershed, representing greater than 60 percent of the historical non-tidal wetland acreage. More than 90 percent of the non-tidal wetland acreage loss has occurred from the Coastal Plain portion of the watershed (MWCOG, 2010). It is estimated that 713 acres of wetlands along Northeast Branch and Northwest Branch and 134 acres along Paint Branch and Indian Creek were lost due to flood risk management projects (MDDNR, 2005a), including by USACE. Existing forested wetlands are generally within parkland owned by MNCPPC.

There is a large range (tens to several thousands of acres) in estimates of wetlands remaining in the Prince George's County portion of the watershed; however, several sources estimate up to 2,000 acres (MDDNR, 2005a; MDE, 2015). Table 2-2 shows wetlands as a percentage of total land use in the Prince George's County portion of each study subwatershed based on the National Land Cover Dataset (Prince George's County portion). Acres of wetlands within the portion of the study subwatersheds in Prince George's County, estimated from the National Wetlands Inventory (NWI, 2014), is shown in Table 2-5. Remaining wetlands are assumed to be drier than they were in times of less urbanization, since the hydrologic connection with the stream is through groundwater alone, due to a lack of overbank flooding (MDDNR, 2005a).

Table 2-5. Acres of wetlands (NWI) and forest (MWCOG, 2000) in the Prince George's County portion of the study subwatersheds*.

Vegetation Type	Northwest Branch	Sligo Creek	Northeast Branch	Indian Creek	Paint Branch	Little Paint Branch
Wetlands (acres)	93	0	93	744	188	148
Forest (acres)	1118	330	1143	2952	1349	1097

* Subwatershed divisions are based on those used in the ARP, as shown in Figure 1-6.

Riparian vegetation is a major source of energy and nutrients for stream communities. Riparian forests regulate stream temperatures and provide valuable wildlife habitat. Many of the tributaries in the Anacostia River watershed run through forested riparian buffers owned by MNCPPC or SHA. Acres of forest within the portion of the study subwatersheds in Prince George's County, estimated from satellite imagery of tree canopy cover (MWCOG, 2009), is shown in Table 2-5. Forests in Prince George's County are protected by the Forest Conservation Act, which aims to minimize the loss of Maryland's forest resources during construction activities. Also, due to pressure from deer browsing and competition from invasive exotic species, forest succession is problematic and the removal of trees for project construction or other activities is highly discouraged.

Table 2-6 describes riparian vegetation adjacent to each of the stream reaches, including wetlands based on either field surveys (for sites in the recommended plan) or on NWI maps. Field work was conducted for the sites within the recommended plan. In November 2017, wetlands were verified within the project limits of disturbance at sites 3, 9, 11, 15, and parts of 5 and 13. Existing wetlands delineations from Regulatory (NAB) were used for sites 13 and 5. No wetlands were identified within the project area at sites 3, 9, 13, 5, and 15. At site 11, three distinct wetland systems were identified (Figure 2-4). The wetlands differ in character and quality. The first (11A) at 0.5 acre is palustrine forested with red maple (*Acer rubrum*), green ash (*Fraxinus pennsylvanica*), basswood (*Tilia Americana*), sycamore (*Platanus occidentalis*), and sweetgum (*Liquidambar styraciflua*). The invasive, Japanese stiltgrass (*Microstegium vimineum*), is also present. This wetland is somewhat degraded, receives stormwater runoff from adjacent impervious surfaces, and is disconnected from the stream. The second wetland, approximately six acres in size (11B), is a palustrine emergent wetland dominated by a dense stand of common reed (*Phragmites australis*) with a pond in the center fed by stormwater runoff and groundwater. Approximately, one acre of this wetland is located within the limits of disturbance (LOD). Wetland 11C is a palustrine emergent wetland, approximately 0.2 acre in size. This wetland is within the floodplain of the stream. A description of impacts to wetlands from the project is located in Section 5.

Invasive species are often a feature of riparian habitats in urban settings. Site investigations for the project identified the presence of a number of species at stream reaches being considered for restoration. These species are identified in Table 2-6 and primarily include Japanese knotweed (*Fallopia japonica*), bush honeysuckle (*Caprifoloaceae*), kudzu (*Pueraria*), bamboo (*Bambusoideae*), Japanese hop (*Humulus japonicas*), motherwort (*Leonurus cardiaca*), Tree of Heaven (*Ailanthus altissima*), Japanese honeysuckle (*Lonicera japonica*), white mulberry (*Morus alba*), phragmites (*Phragmites australis*), Japanese stiltgrass (*Microstegium vimineum*), Japanese barberry (*Berberis thunbergii)*, mile-a-minute (*Persicaria perfoliata*), fig buttercup (*Ficaria verna*), rose of Sharon (*Hibiscus syriacus*).

Table 2-6. Description of riparian vegetation and wetlands at each stream site.

Site	Stream Name	Description of Riparian Vegetation[1]	Wetlands[2]
1	Indian Creek at I-95	The upper half of site 1 has a forested buffer and is classified by NWI as a palustrine forested wetland. The lower half has some adjacent forest buffer, but also runs along developed properties. Invasive Species Present: Japanese knotweed (1Cm).	North of Ammendale Road, one palustrine phragmites wetland, one palustrine forested wetland with broad-leaved deciduous trees. South of Ammendale Road, a small, excavated palustrine wetland borders the segment. PEM5A, PFO/SS1A, PUBFx
3	Northwest Branch	There is a narrow band of discontinuous, riparian forest through most of site 3. In some areas, there is a wider forested track on one side of the stream and/or no buffer on the opposite bank. Invasive Species Present: Japanese knotweed (3Ccst and present in Heurich Park), bush honeysuckle (3Ccpg), kudzu (3Ccp and downstream of Agar Road, at Nicholson Road, and in Kirkwood Neighborhood Park).	No wetlands identified by field verification.
5	Paint Branch	The upper portion of site 5 runs through a forested tract of Paint Branch Park, and the lower portion flows through a forested portion of Indian Creek Park. The middle of the reach has little to no riparian vegetation where it is crossed by 54th Avenue. Invasive Species Present: Bamboo (present downstream of Route 1 below pedestrian bridge and below pedestrian bridge south of Lake Artemesia), Japanese honeysuckle, bush honeysuckle, and garlic mustard.	No wetlands identified by field verification or delineations submitted to Regulatory Branch.
7	Paint Branch at I-95	Most of site 7 has a broad, forested riparian corridor as it flows through Powder Mill Community Park. Numerous	One forested wetland with broad-leaved deciduous trees where the segment

Site	Stream Name	Description of Riparian Vegetation[1]	Wetlands[2]
		road/interstate crossings fragment the forested buffer. Invasive Species Present: None recorded.	runs through Powder Mill Community Park. PFO1A
9	Sligo Creek	The riparian corridor is forested as site 9 flows through Chillum Park, but width varies with buffer width increasing downstream. Invasive Species Present: Japanese hop (9Cg), motherwort (9Cg), Tree of Heaven (Ailanthus) (9Cg).	No wetlands identified by field verification.
10	Northwest Branch	Site 10 has a narrow, forested edge on one bank, but one bank is lawn with some trees. Invasive Species Present: Multiflora.	No wetlands identified by field verification.
11	Indian Creek	The upper portion of site 11 has a continuous, forested buffer that contains palustrine forested (0.7 acre) and emergent (6 acres) wetlands. The middle portion has a narrow, discontinuous, forested buffer as it runs along developed complexes. The lower portion has a largely continuous forested buffer on one bank. The opposite bank is a mix of open park, ball fields, and trees. Invasive Species Present: bush honeysuckle (11Ccc; also present upstream of Greenbelt Road), Rose of Sharon (11Ccc), Japanese honeysuckle and white mulberry (present upstream of Greenbelt Road); phragmites, Japanese barberry, and mile-a-minute (located west of Springhill Drive); Japanese knotweed; Japanese stiltgrass (*Microstegium vimineum*).	Three wetlands identified by field verification. Site 11A - Palustrine forested wetland; Site 11B – palustrine emergent wetlands dominated by *Phragmites* with an open water pond, and Site 11C – palustrine emergent wetland.
12	Little Paint Branch	The majority of site 12 has a broad, continuous forested buffer as it travels through Cherry Hill Road Community Park and Paint Branch Park. There is no buffer	Most of this site has surrounding palustrine, forested wetlands that are temporarily flooded.

Site	Stream Name	Description of Riparian Vegetation[1]	Wetlands[2]
		on one bank of approximately 800 ft of the lowest portion of the reach. Invasive Species Present: None recorded.	PFO1A
13	Northwest Branch	Except for a cleared right-of-way, the upper portion of site 13 runs through Northwest Branch Park and has a forested buffer until it crosses University Boulevard. The middle part of the site has a narrow, disconnected tree buffer as it runs along ball fields and through developed area. The lower portion has a forested buffer on both banks. Invasive Species Present: Fig buttercup (13Cc); Bamboo present downstream of Adelphi Mills.	No wetlands identified by field verification.
15	Northeast Branch	There is a broad forested buffer on the upper 500 ft of site 15 followed by an open segment. The area immediately above Paint Branch Parkway has a buffer on one bank, but the other bank is only tree-lined. Below Paint Branch Parkway, site 15 has a fairly continuous, broad forested buffer. Invasive Species Present: Bamboo.	No wetlands identified by field verification.

[1]Code in parentheses for invasive species denotes habitat segment as coded in Appendix B.
[2]Following selection of the recommended plan, field surveys were completed by USACE (November 2017) at sites included in the recommended plan. For those sites, not included (1, 7, 10, and 12), the description provided above is from NWI. Based on results of the field surveys, it was found that there are fewer wetlands at these sites than reflected by NWI.
*NWI WETLAND CLASSIFICATIONS:
PFO1A – Palustrine, forested, broad-leaved deciduous. Temporarily flooded.

Figure 2-4. Field verified wetlands in the project area at site 11, Indian Creek.

2.5 Community Setting

2.5.1 Population and Demographics

According to the U.S. 2010 Decennial Census (Census, 2010), Prince George's County, Maryland, reached a population of 863,420 in 2010, reflecting a 7 percent increase over the previous 10 years. Prince George's County is the third largest jurisdiction in the D.C. metropolitan area. The median age is 34.9 with 236,577 people under 19 years old and 81,161 people 65 years or older. Of the total population, 48.1 percent are male and 51.9 percent are female. Minorities account for approximately 85 percent of the total population, compared with roughly 39.5 percent of Maryland's total population. African Americans make up 64 percent of the total population of Prince George's County, followed by Caucasians (15 percent), Hispanics (15 percent), Asians and Pacific Islanders (4 percent), and Other/Multi-racial (2 percent). The median household income was $69,947 and the per capita income was $30,657 (PGDOP, 2011).

2.5.2 Environmental Justice

For the census tracts adjacent to the study stream sites, minorities and low income populations account for a higher than average (for Maryland) percentage of the total population (US Census, 2013). These demographics are shown in Table 2-7. Communities most impacted by environmental harms and risks are referred to as "environmental justice communities". Factors that identify environmental justice communities include disproportionate exposure to environmental hazards and increased vulnerability to these hazards. USEPA's environmental justice screening tool (EJSCREEN; https://ejscreen.epa.gov/mapper/) suggests that the general area containing the surrounding the study sites may be considered an environmental justice community. Figure 2-5 shows the Environmental Justice (EJ) Index for the area population, relative to the state, region, and country. The EJ Index is a combination of environmental and demographic information (low income, minority, and other vulnerable populations) that can help identify communities that may have a high combination of environmental burdens and vulnerable populations (USEPA, 2017). EJ Indexes (except for the "waste water discharge" indicator) are elevated for the study area. This shows that the area population generally has higher environmental risk/burden/proximity relative to the rest of the state, region, and country.

Table 2-7. Percentage of minorities and low income families and persons in the census tracts adjacent to the project stream sites (data from US Census, 2013).

Site Number – Stream Name	Minorities* (% of total population)	Low-Income** (% of families)	Low-Income** (% of all people)
Site 1 - Indian Creek at I-95	51	0.56	3.94
Site 3 - Northwest Branch	77	11.16	16.16
Site 5 - Paint Branch	32	11.10	48.28
Site 7 - Paint Branch at I-95	61	10.57	16.29
Site 9 - Sligo Creek	85	7.94	12.69
Site 10 - Chillum Road Tributary	79	7.73	11.94
Site 11 - Indian Creek	54	10.13	19.77
Site 12 - Little Paint Branch	49	13.58	29.58
Site 13 - Northwest Branch, Riggs Rd	75	8.96	16.42
Site 15 - Northeast Branch	39	8.37	20.60

*Defined as "non-Hispanic white"
**Defined as percentage of people or families whose income was below the poverty level in the past 12 months before survey.

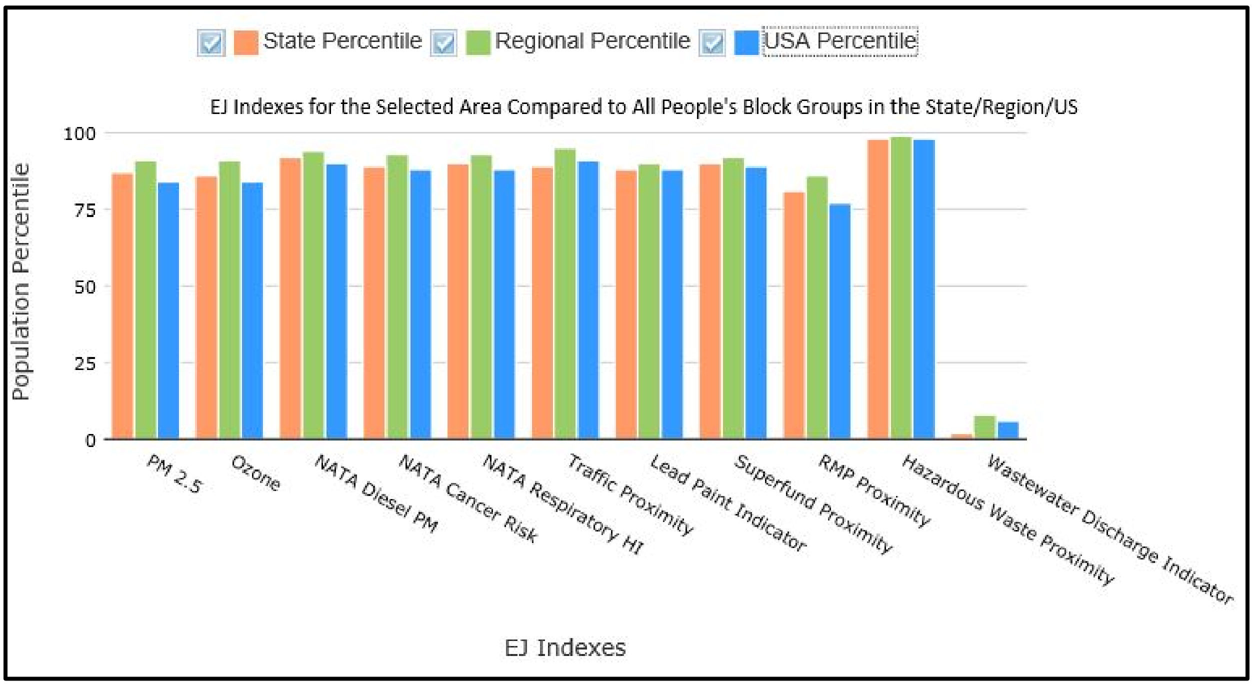

Figure 2-5. EJ Index for the general study area (USEPA, 2017)

2.5.3 Schools

Schools located within 1,640 feet (500 meters) from the project stream reaches are shown in Table 2-8.

Table 2-8. Schools within 1,640 feet (500 meters) of proposed streams segments.

Site Number - Stream Name	School Name	Distance from Segment (ft)
Site 1 - Indian Creek at I-95	Martin Luther King Jr. Middle School	900
Site 1 - Indian Creek at I-95	Kids in His Care Daycare	980
Site 3 - Northwest Branch	Rosa Parks Elementary	570
Site 5 - Paint Branch	Paint Branch Elementary	760
Site 5 - Paint Branch	University of Maryland	900
Site 12 - Little Paint Branch	Childway	920

2.5.4 Parks and Recreation

Parks in Prince George's County are primarily owned and managed by MNCPPC, NPS, or local municipalities. There are 591 parks in Prince George's County, covering 27,319 acres. Of this area, 8,533 acres are developed with the remaining 18,786 acres designated as undeveloped parkland and stream valley parkland (PGDPR, 2014). Prince George's County contains four national protected areas including Fort Washington Park, Greenbelt Park, Patuxent Wildlife Research Refuge, and Piscataway Park. The Patuxent Wildlife Research Refuge is maintained by the USFWS while the other three fall under the auspices of the NPS. Table 2-9 shows parks located within 1640 feet (500 meters) from the proposed project stream reaches.

Many of the parks adjacent to the project streams are owned and administered by MNCPPC. These contain trails within the Anacostia Tributary Trail System that are heavily used for recreation and transportation. The trail system includes 18 miles of trails along the tributaries of the Anacostia River. The continuous greenway along the Anacostia River and its tributaries traverses a variety of natural environments from woodlands to open fields and includes many stream valleys and non-tidal wetlands where activities such as fishing, biking, bird watching, camping, and horseback riding can be enjoyed (MNCPPC, 2012). The USFWS notes three recreational fishing hotspots in the Anacostia River watershed along project stream reaches: Northeast Branch (site 15), Paint Branch (site 5), and Northwest Branch (site 13) (USFWS, 2015; see Appendix C).

Table 2-9. Parks within 1,640 ft (500 meters) of proposed stream segments.

Site Number - Stream Name	Park Name	Distance from Segment (ft)
Site 3 - Northwest Branch	Huerich Park Turf Field	620
Site 3 - Northwest Branch	Northwest Branch Stream Valley Park	0
Site 5 - Paint Branch	Lake Artemesia Natural Area	0
Site 5 - Paint Branch	Paint Branch Stream Valley Park	0
Site 7 - Paint Branch at I-95	Paint Branch Stream Valley Park	0
Site 7 - Paint Branch at I-95	Powder Mill Park	100
Site 9 - Sligo Creek	Sligo Creek Stream Valley Park	0
Site 9 - Sligo Creek	Green Meadows Park	0
Site 10 - Chillum Road Tributary	Northwest Branch Stream Valley Park	0
Site 10 - Chillum Road Tributary	Chillum Park	0
Site 10 - Chillum Road Tributary	Michigan Park Hills Neighborhood Playground	530
Site 11 - Indian Creek	Indian Creek Stream Valley Park	0
Site 11 - Indian Creek	Berwyn Heights Sports Park	30
Site 12 - Little Paint Branch	Cherry Hill Recreation Center	280
Site 12 - Little Paint Branch	Cherry Hill Road Park	0
Site 12 - Little Paint Branch	Paint Branch Golf Course	0
Site 12 - Little Paint Branch	Paint Branch Stream Valley Park	0
Site 13 - Northwest Branch, Riggs Rd	Northwest Branch Stream Valley Park	0
Site 13 - Northwest Branch, Riggs Rd	Adelphi Manor Park	0
Site 13 - Northwest Branch, Riggs Rd	Lane Manor Park	0
Site 15 - Northeast Branch	Paint Branch Stream Valley Park	0
Site 15 - Northeast Branch	Anacostia River Stream Valley Park	0
Site 15 - Northeast Branch	Tennis Center at College Park	790
Site 15 - Northeast Branch	Ellen Linson Swimming Pool	970
Site 15 - Northeast Branch	Herbert Wells Ice Rink	160
Site 15 - Northeast Branch	Calvert Road Disc Golf	330

2.5.4.1 Capper Crampton Parkland

The U.S. Capper Crampton Act was enacted on May 29, 1930 and provided $4.5 million for acquisition of land in the stream valleys of Montgomery County and Prince George's County along the Cabin John River, Rock Creek, Sligo Creek, the Northwest Branch, the Anacostia River, and Indian Creek. In these areas, the Act provided for the comprehensive development of a park and playground system, to be administered by the MNCPPC. Portions of the following Capper-Crampton parks are within this project's study area: Sligo Creek Stream Valley Park, Northwest Branch Stream Valley Park, Paint Branch Stream Valley Park, Indian Creek Stream Valley Park, and Anacostia River Stream Valley Park. The Capper Crampton Act requires the National Capital Planning Commission (NCPC) to formally review all changes to "park use". A change in "park use" is generally considered a change from open space (natural use) for natural or recreational use to a non-recreational use.

2.5.5 Aesthetics and Noise

In an effort to maintain the county's natural beauty, a concerted effort has been made to set aside land for developed and undeveloped open space. Parklands are discussed above in Section 2.5.4. For purposes of regulation, noise is measured in dBA or A-weighted decibels. This unit uses a logarithmic scale and weights sound frequencies. Table 2-10 shows typical noise levels and corresponding impressions. Because the project area within Prince George's County, Maryland, is primarily urban, noise sources of concern include vehicle and air traffic, construction, and everyday residential activities, such as mowing the lawn. Potential impacts to aesthetics and noise for the stream restoration projects presented in this document are provided in Section 5.

Table 2-10. Typical Noise Levels and Subjective Impressions.

Source	Decibel Level	Subjective Impression
Normal breathing	10	Threshold of hearing
Soft whisper	30	---
Library	40	Quiet
Normal conversation	60	---
Television audio	70	Moderately loud
Ringing telephone	80	---
Snowmobile	100	Very loud
Shouting in ear	110	---
Thunder	120	Pain threshold

2.5.6 Cultural Resources

Prince George's County has rich cultural and natural resources within the Anacostia River watershed, particularly in the historic corridor created by the Washington-Baltimore Turnpike (predecessor to Route 1 in some areas) and the Route 1 corridor (MNCPPC, 2012). The dendritic drainage pattern of the Anacostia watershed and its deep water access to the Potomac and the Chesapeake Bay had a profound impact on early settlement and subsequent land development. Highly productive ecotones such as well-drained areas adjacent to streams and wetlands were a focus of prehistoric settlement and resource extraction, and therefore have a high probability of containing significant archaeological sites. Those early linkages and their significance to Maryland history are reflected in the present day location of roadways, towns, protected historic landmarks, protected open spaces, and the Anacostia Tributary Trail System (MNCPPC, 2012).

The County's Historic Preservation Ordinance protects three categories of properties that meet specific criteria of historical or architectural significance, all of which are listed in the Inventory of Historic Resources: historic sites, historic resources, and historic districts. The historic site and historic district designation process is codified in the ordinance in Subtitle 29-109, 29-118, 29-119, and 29-120.01. Properties can be added to the inventory through the process identified in the ordinance. In 2012, 413 historic sites, 136 historic resources, and three county-designated historic districts were listed for Prince George's County (MNCPPC, 2012). Additionally, there are 82 properties listed in the National Register of Historic Properties. These include historic properties along the Anacostia tributaries linked by the Anacostia Tributary Trail System, such as the College Park Airport and Aviation Museum, Adelphi Mill, the Rossborough Inn at the University of Maryland, and the George Washington House.

In response to a project study notice, a letter was received from Maryland Historical Trust (MHT), the State Historic Preservation Office (SHPO), on June 15, 2015. The letter indicated that proposed restoration work would be unlikely to have an adverse effect on cultural resources in the stream study reaches including Indian Creek at I-95 (site 1), Indian Creek (site 11), Paint Branch at I-95 (site 7), Paint Branch (site 5), Northeast Branch (site 15), and Chillum Road Tributary (site 10). Due to the identification of archaeological sites, both historic and prehistoric, in the vicinity of the other four sites, MHT states that field surveys may be needed for Northwest Branch at Hyattsville (site 3), Northwest Branch at Riggs Road (site 13), Sligo Creek (site 9), and Little Paint Branch (site 12).

Following receipt of this letter and in accordance with Section 106 of the National Historic Preservation Act of 1966 (as amended), a preliminary examination of areas of potential effect in the Anacostia River Watershed in Prince George's County was undertaken in 2014 and 2015. Maryland databases were searched for known archeological and historic resources in the project vicinity. Based on these searches, as well as field visits and the information received from the MHT, some historical properties and/or archaeological sites were identified in the vicinity of the proposed sites. A description of known historical resources is included in Appendix A. Impacts from the recommended plan are described in Section 5.

2.5.7 Hazardous, Toxic, and Radioactive Waste

As required by USACE Engineering Regulation 1165-2-132, the team facilitated early identification and appropriate consideration of hazardous, toxic, and radioactive waste (HTRW) in the study area. An extensive set of reports were generated for each project area to assess the likelihood of existing HTRW concerns. The reports generated are intended to meet EPA's Standards and Practices for All Appropriate Inquiries (40 CFR Part 312) and the American Society for Testing and Materials (ASTM) Standard Practice for Environmental Site Assessments (E 1527-13). The search included evaluation of aerial photos, topographic maps, state and federal environmental databases, land records, and other relevant databases. A summary of these reports is included in Appendix A.

Evaluation of these reports and appropriate follow-up coordination indicates that the only site with a potential HTRW concern is site 5, Paint Branch in College Park. Upstream of the railroad tracks adjacent to the College Park Airport, Paint Branch runs parallel to the boundary of Landfill Area 3A and 1B on property owned by University of Maryland (UMD). In September 1991, EPA issued a Corrective Action permit to UMD requiring them to investigate potential releases from various solid waste management units. Subsequently, areas identified with soil contamination were remediated. Groundwater investigations showed low levels of dioxin and methane in the landfills.

EPA concluded that the concentrations of dioxins and methane in the groundwater, coupled with the low risk of human exposure, would not pose a risk to human health and the environment under current conditions. The selected remedy is natural attenuation, for which groundwater monitoring is ongoing. UMD registered a groundwater use restriction with Prince George's County, which prohibits the use of groundwater beneath the site for drinking water purposes. Furthermore, activities including excavation, grading, dewatering, and sheeting or shoring are prohibited within the landfill boundaries (USEPA, 2015). Further information on the impacts of the project on this site can be found in Section 5.

2.6 Future-Without-Project Conditions

This report evaluates the future-without-project conditions (no-action alternative) and the alternatives and benefits over a 50-year period of analysis. The base year for the project (year when the proposed project is expected to be operational) is 2021. Some of the existing conditions (e.g., some aspects of physical environment and community setting) are not expected to undergo significant change during the period of analysis.

Future-without-project conditions are described below for those aspects of the watershed that are expected to change and are relevant to the recommendation of the proposed projects. Of primary importance, within the watershed in Prince George's County, PGDOE is working toward meeting the TMDLs discussed in Section 2.2. These efforts include improvements to water quality and stormwater flow through the use of BMPs, retrofits, stream restoration, and capital improvements. The Clean Water Map (http://www.princegeorgescountymd.gov/682/Maps) can be used to view completed, ongoing, and planned improvements within the County.

2.6.1 Climate

A synthesis of peer-reviewed climate change literature for the Mid-Atlantic region (USACE, 2015c), based on the identification and detection of climate trends in recent historical record, indicates the following trends observed over the past century: increases in the annual temperature in the Mid-Atlantic Region (particularly over the past 40 years), with an increase in the number of extreme heat days and a decrease in the number of extreme cold days; and increased precipitation and occurrence of extreme storm events. However, despite the increased precipitation in the region, there is no evidence of significant increases in streamflow over the same period. This is potentially attributed to seasonal differences in the timing of the changes in precipitation versus streamflow.

Predictions by general circulation models indicate consensus that regional air temperatures will increase sharply upward over the next century. There is less consensus on precipitation and streamflow, although most studies project an increase in both and particularly in extreme high events. There is moderate consensus that peak flows will increase in the region through the 21st century, although low flows are projected to decrease (USACE, 2015c).

Precipitation volume and intensity has increased in the mid-Atlantic region of the Chesapeake watershed over the last century and these trends are projected to continue to the end of the 21st century (NOAA, 2013; Najjar et al., 2010). Simulations for the Chesapeake Bay watershed through the year 2100 predict increased precipitation amounts in winter and spring, as well as increased intensities of precipitation, Nor'easters (though their frequency may decrease), and tropical storms. By 2030, annual mean precipitation may increase by up to 4 percent, with increases of up to 15 percent by 2095 (Najjar et al., 2010).

It is expected that increased air temperatures and frequencies of drought, particularly in the summer months, will result in increased stream water temperatures, potentially affecting dissolved oxygen levels. Higher average and extreme temperatures combined with an increased annual rainfall in the region may lead to higher peak flows as well as more frequent low flows (USACE, 2015c).

Based on the USACE Watershed Climate Vulnerability Assessment, the Potomac River watershed (HUC 0207) is not in the top 20 percent of vulnerability ratings, but is still expected to experience changes related to climate change, as identified above. Vulnerability associated with the ecosystem restoration business line is primarily driven by: a high percentage of wetland and riparian plant communities at risk of extinction, a high elasticity between runoff and precipitation, and a relatively low number of macroinvertebrate populations within the watershed.

Over the past 76 years (1938 through 2014), USACE's online Climate Hydrology Assessment Tool (USACE, 2016a), indicates a statistically significant increasing trend for the annual maximum daily discharge at Northeast Branch Anacostia River at Riverdale, MD (Site Number 1649500; downstream of all project sites).. This has contributed to erosive flows within the watershed (Section 2.6.4). The hydrology assessment tool also projects increasing future trends in annual max monthly flows through the remainder of the 21st century.

A commonly applied assumption in water resource management is stationarity, which means that historic observations cover the range of variability that can be reasonably expected; whereas, nonstationarity indicates that past conditions (variability) may not represent future conditions. The USACE Nonstationarity Detection Tool (USACE, 2016b) for Northeast Branch Anacostia River at Riverdale, MD, detects significant nonstationarities, including an increasing trend in annual peak streamflow, starting around the mid to late 1960s. However, it is difficult to attribute increases in streamflow to a single factor, including changing climate, since the watershed underwent rapid population increases and urbanization during this timeframe. Additionally, stream reaches upstream of this station location were channelized in the early 1970s.

Factors which increase vulnerability in the project area are primarily related to urbanization. Large areas of impermeable surface yields flashy stormwater discharges and increases water quality impairment. Additionally, increased air temperatures and greater frequency of summer-time drought, related to climate change, are likely to increase water temperatures and the potential for dissolved oxygen limitations. In the future, an increasingly erratic climate could increase the potential and magnitude of many of these vulnerabilities. It should be noted, however, that the subwatersheds of study are already highly urbanized with limited potential for additional large scale development. In addition, the study stream reaches are located in protected parkland with riparian vegetation to mitigate water quality contamination and stream temperatures.

Based on this assessment, and the fact that methods of translating climate change impact uncertainty for an engineering-based analysis do not currently exist, potential increases in peak flows were accounted for in the hydrologic modeling performed for this project (Appendix E).

2.6.2 Population and Demographics

The population of Prince George's County is expected to increase by about 5 percent between 2015 and 2030, to a total population of 944,550 (MDP, 2014). This percentage increase is expected within the study area as well. Much of the project area is already built-out; therefore, impacts of population growth on the stream reaches will not likely be significant within the 50-year period of analysis. New and redeveloped properties will be required to meet regulatory mandates for stormwater controls and BMPs and are expected to improve stormwater management. Therefore, there should not be a significant change in flows as a result of redevelopment for population increases.

2.6.3 Water Quality

In 2011, Prince George's County developed a countywide WIP in response to the Chesapeake Bay TMDL set by EPA in 2010. In 2014, the TMDL was incorporated into the water quality goal of the Chesapeake Bay Watershed Agreement (Section 1.4.1). The WIP addresses TMDLs established by MDE on behalf of EPA for bacteria, sediment, nutrients, and trash, and focuses on achieving the maximum practicable reductions. The projects and actions outlined in the WIP for the Anacostia River watershed in Prince George's County are expected to reduce nutrient inputs to streams and reduce peak flows. In addition, as part of Prince George's County's NPDES Permit, the County is developing local restoration plans to address each EPA-approved TMDL with stormwater waste load allocations. A restoration plan for the Anacostia River Watershed in Prince George's County was released toward this purpose in December 2014 that focused on reductions of nutrients (nitrogen and phosphorus), fecal coliform bacteria, sediment, PCB's, and trash.

The Prince George's County WIP and the Anacostia River Restoration Plan for Prince George's County include final target loads that will allow Maryland to meet requirements for the Chesapeake Bay TMDL. Sixty percent of the target loads must be achieved by 2017, while 2025 is the deadline for achieving final target loads. Implementation of these target loads and associated reduction in pollution will result in some immediate improvements in water quality and eventually in 100 percent attainment of the waste load allocations for sediment, nutrient, and trash. Thus, the magnitude of degraded water quality as a stressor to aquatic ecosystems is expected to diminish into the future. Table 2-11 shows the percentage reductions required to meet TMDLs in the Anacostia River watershed in Prince George's County. In state fiscal year 2016, County reductions from structural and non-structural water quality treatments within the Anacostia watershed included 950 lbs/year total nitrogen, 506 lbs/yr total phosphorus, 317,106 lbs/yr total suspended solids, 13,539 lbs/yr biological oxygen demand, and 10,516 most probably number of bacteria per year (MPN B/yr) bacteria. These reductions will be ramping up in future years in order to meet TMDLs. In state fiscal year 2016, within the Prince George's County portion of the watershed, there were 85 capital improvement projects to treat 1,134 acres of impervious area in planning, design, or construction (PGDOE, 2016).

The lag time between implementation of management actions and resultant improvement in stream ecological condition will vary for different pollutants and modes of transport (STAC, 2012). However, immediate water quality improvements are expected for the more mobile constituents (e.g., nitrogen), with improvements escalating to 2025 and through the 50-year period of analysis. Additional information on the WIP for Prince George's County can be found here: http://www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Documents/FINAL_PhaseII_Report_Docs/Final_County_WIP_Narratives/PG_WIPII_2012.pdf.

Table 2-11. Percentage reductions required for the Anacostia River watershed in Prince George's County (from PGDOE, 2014).

Pollutant	Percentage Reduction to Stormwater
Nutrients (nitrogen, phosphorus), biochemical oxygen demand	Biochemical oxygen demand: 58% Total Nitrogen: 81% Total phosphorus: 81.2%
Fecal coliform bacteria (enterococci)	Northeast Branch/Northwest Branch 80.3% Tidal: 99.3%
Sediment, total suspended solids	85%
Polychlorinated biphenyls (PCBs)	Northeast Branch: 98.64% Northwest Branch: 98.1%
Trash	100%

2.6.4 Stream Geomorphic Condition

Streams in the project area appear to be reacting to changes in land use as evidenced by excessive erosion, incision, and patterns of sediment deposition. Streams channelized by USACE and other entities remain in a straightened condition with homogeneous habitat conditions decades after the streams were channelized. MDE has established stringent stormwater regulations related to channel-protection volume that are applicable to new development and redevelopment. BMPs and retrofits discussed in Section 2.6.3 will also reduce the quantity of stormwater flow and potentially decrease peak flows.

Although erosive flows may be mitigated to some extent, the streams will remain unstable absent a geomorphic restoration project, with potential implications for continued loss of riparian area and degradation of aquatic habitat. The streams exist within a constrained urban landscape, therefore excessive erosion could eventually cause loss of property and structures (i.e., roads, bridges, buildings, recreational facilities). The severe erosion of the bed and banks of the study stream reaches contributes to the sedimentation of the lower Anacostia River. High concentrations of suspended sediment has harmful effects on aquatic organisms and affects the usefulness (embeddedness) of their habitat for spawning and other lifecycle needs. Without bed and bank stabilization, these conditions are likely to continue over the period of analysis. An evaluation of aerial photos of the project area (sites in the recommended plan) showing unstable streambanks and trees that are being undermined by erosion, indicates that at least ten acres of riparian vegetation would be lost over the period of analysis from streambank erosion.

Over the period of analysis, it is possible that other entities or organizations will undertake stream restoration within the watershed or stream reaches of study. SHA maintains a list of stream sites that could be used for mitigation purposes if needed. In March 2016 a Public-Private Partnership Agreement between the Maryland Department of Transportation, the Maryland Transit Administration, and Purple Line Transit Partners LLC was signed for the construction of the Purple Line, an above ground extension to the Washington D.C. metro. Restoration of two stream sites in the Anacostia River watershed in Prince George's County are being evaluated for mitigation purposes, including Paint Branch and Cattail Branch. The stream reach being evaluated on Paint Branch overlaps with a portion of site 5, from the CSX Bridge downstream to the Paint Branch-Indian Creek confluence. Following the signing of the Public-Private Partnership Agreement, a lawsuit was filed contending that the D.C. Metro's ridership decline and safety issues could impact the success of the Purple Line and a new environmental study was ordered. A stay on that ruling was granted by an appeals court in July 2017 and construction began in August 2017; however, uncertainty still remains for the project mitigation as neither MDE nor USACE through their Regulatory capacity have authorized the mitigation project to date. More information on the Purple line can be found here: http://www.purplelinemd.com/en/about-the-project/project-overview.

Recently, Prince George's County was considering multi-use development at the current location of the D.C metro adjacent to Indian Creek (site 11), including restoration of a tributary of Indian Creek. This development was associated with the County's bid for relocation of the Federal Bureau of Investigation (FBI) to this location. However, this is less likely now that the decision not to relocate the FBI has been made by the General Services Administration.

2.6.5 Fish and Benthic Integrity

As described above, significant improvements in water quality are expected over the period of analyses as a result of regulatory mandates. This will result in improvements in fish and benthic IBI scores. However, in addition to water quality, habitat quality in the study streams is also a limiting factor, particularly in the stream reaches channelized and straightened by USACE. Without habitat restoration, IBI scores will continue to be limited. Sedimentation and lack of diverse habitat conditions likely contribute to low species abundance, richness, and poor trophic composition, all of which factor into IBI scores. Suspended sediment limits light transmission into the stream and affects aquatic vegetation growth and the health of benthic organisms, which form the base of the food chain. Unstable bed and bank materials limits the quality of the habitat available for fish and benthic organisms. Thus, in the absence of stream restoration efforts, even with improvements in water quality, generalist species are likely to persist in these streams over the 50-year period of analysis. Streams will not likely establish a dynamic equilibrium that maintains habitat complexity and results in increases in species abundance and diversity.

2.6.6 Fish Passage

The project stream sites include four fish blockages as described in Section 2.4.2. Without restoration of the project reaches, these fish passage blockages are likely to persist over the 50-year period of analysis, limiting the return of anadromous fish species to their historical range. In-stream sewer and water utilities are prevalent within the stream banks parallel to the stream and crossing the stream within the streambed in many locations. Without stabilization of the stream bed and banks, new blockages could be created as in-stream utilities are unearthed by erosive flows. As discussed in Section 1.4, large populations of herring and shad historically migrated from the Atlantic Ocean and Chesapeake Bay into the freshwater non-tidal Anacostia tributaries to spawn (MWCOG, 2010). In addition to being environmentally important to the transfer of nutrients from the ocean to upstream ecosystems, these were some of the east coast's most abundant and economically important fish. Without-project, populations of these fish in this portion of the Anacostia River watershed, and their contributions to local ecosystems, will not increase and could decline due to the creation of new fish blockages or deterioration of existing stream habitat conditions.

2.6.7 Riparian Vegetation (Wetlands and Forest)

The historical hydrologic regime that supported wetlands included a combination of groundwater and surface water from overbank flooding of the streams and connection through the hyporheic zone (zone within the streambed where surface water and groundwater mix). This hydrology has been altered by land conversion, first to agriculture and then to urban land use. Without restoration activities, this component of natural hydrology will not be restored. In many locations along the study stream reaches, the stream has become excessively incised, thereby losing the hyporheic connection with the floodplain. Additionally, along the project streams, wetlands located close to the streambanks (i.e., wetlands 11A and 11B) are in danger of erosion. Over the period of analysis, no additional wetland acreage or improvements to connection with the floodplain are expected; therefore, if not eroded, existing wetlands may persist, but reestablishment of historical wetlands is unlikely.

The extent of forest along the stream reaches is unlikely to change significantly over the period of analysis, as it is generally mature forest in public ownership, used as parkland. Additionally, the stream segments within the recommended plan are all located within the Developed Tier identified in the MNCPPC Land Preservation, Parks and Recreation Plan (MNCPPC, 2012). This plan notes that it is increasingly difficult to acquire parkland in the Developed Tier. Furthermore, as described in Section 2.5.4, much of the study area was acquired under the Capper Crampton Act. Alteration of this land from a natural use requires review and approval from the NCPC. Absent project restoration, unstable geomorphic conditions would continue to erode stream banks resulting in the loss of mature trees and the cohesion provided by their roots. Erosion would also be expected to result in the loss of riparian habitat and wetlands adjacent to the stream. As discussed in Section 2.6.4, an evaluation of aerial photos of the project area (sites in the recommended plan) showing unstable streambanks and trees that are being undermined by erosion, indicates that at least ten acres of riparian vegetation would be lost over the period of analysis from streambank erosion.

Riparian vegetation along some length of almost all of the stream reaches includes invasive plant species (Section 2.4.5). Due to their rapid growth rate and ease of seed germination and dispersal, over time, invasive vegetation outcompetes and eliminates native vegetation. With disturbance of native vegetation, it is likely that these species will spread over the 50-year period of analysis.

3 *PLAN FORMULATION

Plan formulation is the process of building plans that meet the planning objectives and avoid planning constraints. Plan formulation for the Anacostia Watershed Restoration, Prince George's County, feasibility study has been conducted in accordance with the six-step planning process described in Economic and Environmental Principles and Guidelines (P&G) for Water and Related Land Resources Implementation Studies (USWRC, 1983) and the Planning Guidance Notebook (ER 1105-2-100; USACE, 2000). The six steps in the iterative plan formulation process are:

1. Specify water and related land resources problems and opportunities;
2. Inventory and forecast existing conditions;
3. Formulate alternative plans;
4. Evaluate alternative plans;
5. Compare alternative plans;
6. Select the recommended plan.

Section 1 in this report outlines the problems and opportunities and introduces the planning objectives, constraints, and considerations. Section 2 discusses existing and future conditions. The following sections describe the plan formulation and selection process (steps 3 through 6, above), including the site selection process, combination of management measures and evaluation of alternatives, and the selection of the recommended plan. For the selection of a plan, a tentatively selected plan (TSP) is identified. Following positive agency and public review, this plan is endorsed as the recommended plan. The plan formulation process is illustrated in Figure 3-1. Additional information on plan formulation can be found in Appendix B.

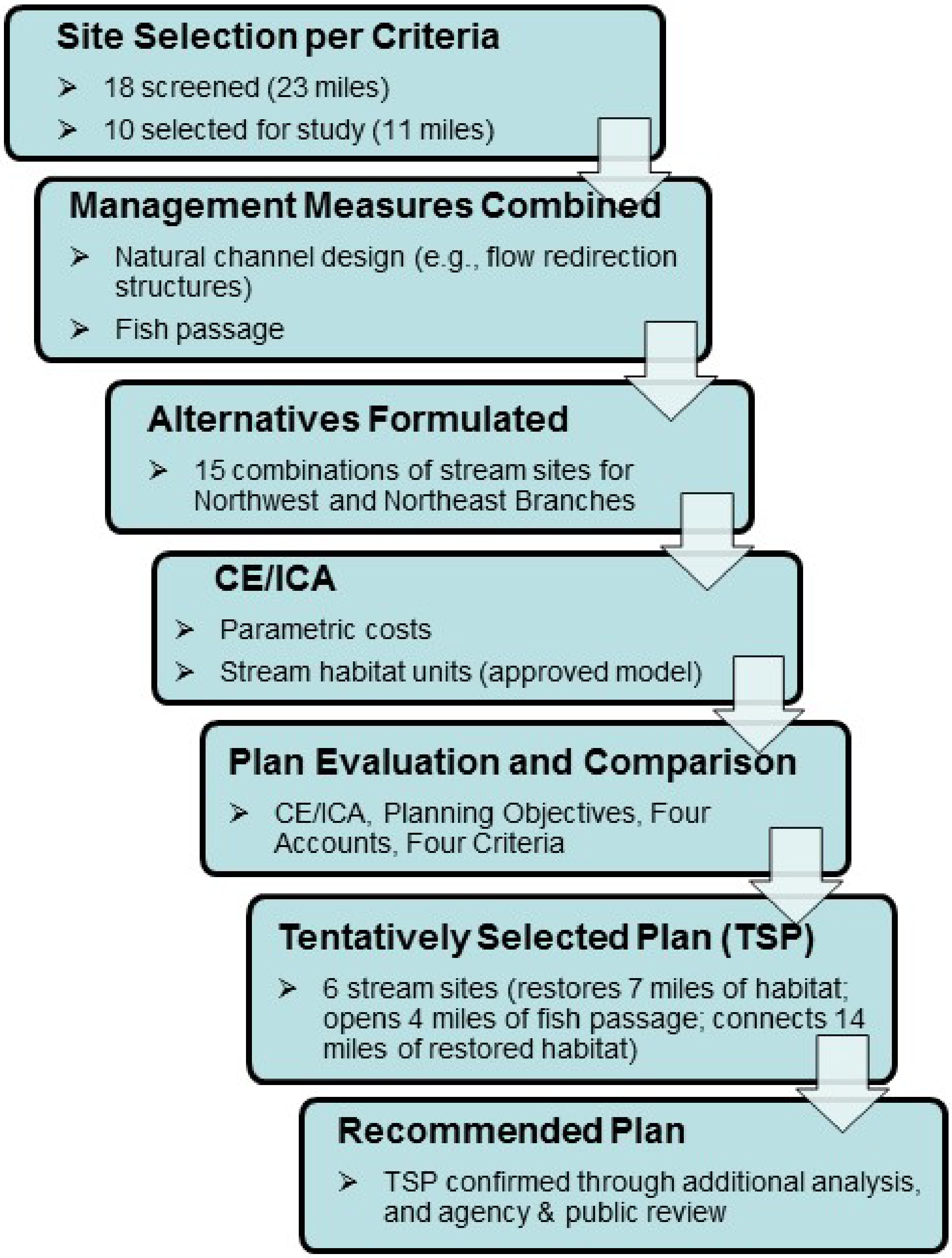

Figure 3-1. Plan formulation for Anacostia watershed restoration, Prince George's County, Maryland.

3.1 Site Selection

Fish passage and stream and wetland restoration projects identified within the ARP were the starting point for site evaluation. The project team evaluated potential sites based on existing site data and field visits. Approximately 23 miles of stream (18 stream segments) were evaluated for study throughout the Anacostia River watershed in Prince George's County, including the tidal portion. Based on site selection criteria discussed below (and in Appendix B), approximately 11 miles of stream (10 stream segments) were selected for potential restoration (Figure 3-2). The stream segments selected for potential restoration projects are sites that have the potential for habitat lift, and the opportunity for project implementation when working within the planning constraints and considerations identified in Section 1.8. Ten stream segments in six subwatersheds were selected based on the following criteria and working within the planning constraints and considerations. In addition to the planning constraints and considerations, selection criteria included:

Criteria No.

1. Aquatic habitats are degraded (fish and/or benthic IBI are poor);
2. The stream reach has potential for restoration by USACE projects;
3. Sites are not upstream from fish blockages that cannot be removed with restoration actions (i.e., large culverts or stormwater management features);
4. Opportunity to connect with other restored reaches (providing cumulative benefits).

Criterion 2 was based on a "yes" or "no" judgment as to whether a stream could be improved by USACE actions. Sites were not selected if improvement was constrained by factors that would not be affected by a USACE project. For example, sites were not selected if located downstream of large commercial or industrial developments that would adversely impact water quality such that habitat restoration would have little impact on aquatic life. Selecting sites upstream of large industrial or commercial areas also avoids illicit (i.e., non-stormwater) discharges to the stormwater system that could contribute to poor quality streams. Sites were also not selected if stream habitat was judged to be good, such that there was a danger of doing more harm than good if restoration was implemented.

Table 3-1 shows the stream reaches that were considered during the site selection process and the primary criteria used in the selection process. Where cells in Table 3-1 are blank, the criterion was either neutral or not assessed due to immediate elimination based on another criterion. Appendix B provides further information on all the reaches considered for selection and a description of the general habitat condition, initial outline of potential restoration opportunities, and assessment of considerations for selected stream reaches.

Sites that met most of the above criteria were selected (Table 3-2 and Figure 3-2) for detailed study. Real estate was also considered to some extent as based on the past experience of the sponsor working in the Anacostia River watershed, it was difficult to obtain real estate easements for work on private property.

In order to provide continuous high quality aquatic habitat, stream reaches were selected to connect to other restored segments as much as possible. Previously restored segments can be seen in green on Figure 3-2.

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Table 3-1. Site selection criteria for stream reaches considered for study

(√ = criteria met; x= criteria not met; blank = neutral). Sites "not selected" were not selected for further investigation under this study.

Reach	Subwatershed	Status	Criteria 1: Degraded habitat	Criteria 2: Improvement potential	Criteria 3: No downstream fish blockage	Criteria 4: Cumulative Benefits	Notes
Indian Creek – I-95 (Site 1)	Indian Creek	Selected	√	√	√		
Indian Creek Upstream of –I-95	Indian Creek	Not selected	√	×	×		Disconnection by large culverts and concrete channels.
Lower Beaverdam Creek – Cabin Branch	Lower Beaverdam Creek	Not selected	√	×			Legacy chemical contamination; industrial pollution.
Northwest Branch – Hyattsville (Site 3)	Northwest Branch	Selected	√	√	√	√	
Northwest Branch – Upstream of University Blvd	Northwest Branch	Not selected	×	×			Habitat conditions are good.
Paint Branch (Site 5)	Paint Branch	Selected	√	√	√	√	
Dueling Creek/Colmar Manor Wetlands	Tidal	Not selected	√	×			Project actions could do little to restore ecological function.
Paint Branch – I-95 Interchange (Site 7)	Paint Branch	Selected	√	√	√		
Cross Creek	Little Paint Branch	Not selected	√	×	×		Crosses many private parcels and downstream of retention basins.
Sligo Creek (Site 9)	Sligo Creek	Selected	√	√	√	√	
Chillum Road Tributary (Site 10)	Northwest Branch	Selected	√	√	√	√	

Reach	Subwatershed	Status	Criteria 1: Degraded habitat	Criteria 2: Improvement potential	Criteria 3: No downstream fish blockage	Criteria 4: Cumulative Benefits	Notes
Indian Creek – College Park (Site 11)	Indian Creek	Selected	√	√	√	√	
Little Paint Branch (Site 12)	Little Paint Branch	Selected	√	√	√	√	
Northwest Branch: Riggs Rd (Site 13)	Northwest Branch	Selected	√	√			Blockage downstream on site 3. For anadromous fish benefits, this site is dependent on removal of blockage on site 3.
William Wirt Middle School	Briers Mill Run	Not selected	√	×		√	Severe water quality problems (sewage). Sewage infrastructure work needed.
Northeast Branch: Calvert Road Disc Golf Park (Site 15)	Northeast Branch	Selected	√	√	√	√	
Dueling Creek	Tidal	Not selected	√	×			Upstream underground. Tidal area stable. Limited potential given stream crossings/culverts/ pavings.
Quincy Manor	Northeast Branch	Not selected				×	Severe real estate restrictions. Isolated from other restoration efforts.
Indian Creek: Calvert Road Disc Golf North	Indian Creek	Not selected	×				Habitat conditions are good.

Table 3-2. Characteristics of the project stream reaches selected for study.

Reach	Drainage Area (mi^2)	Stream Order (Strahler)	Length of stream studied (mi)
Northwest Branch			
Northwest Branch – Hyattsville (Site 3)	48.8	3	1.38
Northwest Branch - Chillum Rd Tributary (Site 10)	1.2	1	0.40
Northwest Branch - Riggs Rd (Site 13)	34.6	3	1.46
Sligo Creek			
Sligo Creek (Site 9)	10.7	2	0.42
Northeast Branch			
Northeast Branch – Calvert Rd Disc Golf Park (Site 15)	70.0	4	1.04
Indian Creek			
Indian Creek -I-95 (Site 1)	2.6	1	1.32
Indian Creek – College Park (Site 11)	29.3	4	1.98
Paint Branch			
Paint Branch (Site 5)	31.3	3	1.30
Paint Branch –I-95 (Site 7)	16.4	2	1.11
Little Paint Branch			
Little Paint Branch (Site 12)	10.6	2	0.86

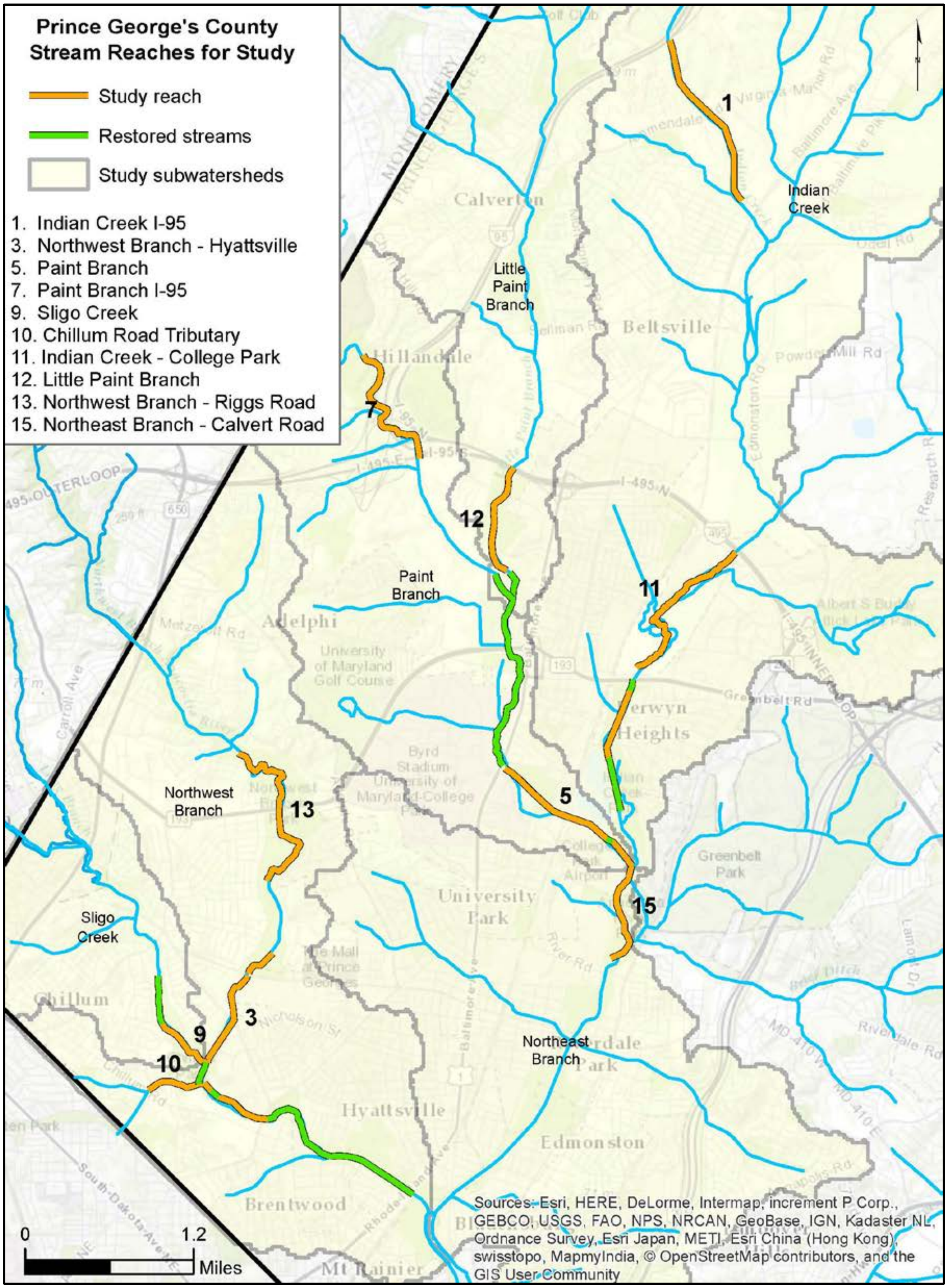


Figure 3-2. Project area and selected stream reaches in Prince George's County, Maryland.

3.2 Summary of Management Measures

Potential management measures (i.e., features that can be implemented at the project reaches to address planning objectives) were identified following the development of project problems, opportunities, objectives, and considerations. Project constraints were developed after initial measures and alternatives were devised.

Management measures for several restoration design philosophies were considered, including for:

- Natural channel design[2] - Restoration of a stream by engineering changes to mimic natural conditions; achieved through the use of in-stream features and structures (e.g., floodplain reconnection, rock or log vanes, weirs, grade control structures, in-stream benches).
- Legacy sediment removal - Removal of decades of sediment accumulation caused by increased sediment supply from uplands during land use changes and sediment trapping behind dams (e.g., mill dams).
- Hard design - Characterized by optimizing channel stability through the use of hard armoring including gabion baskets, rip-rap, and concrete matting.
- Streambank stabilization (USACE Engineer and Research Development Center (ERDC) techniques) - Largely designed to address streambank erosion through the use of rigid or stone armoring, manufactured covers, side slope protection including stone toe or other structural measures.

Some design philosophies and/or management measures were determined to not meet the project objectives or were eliminated based on other rationale. Legacy sediment removal was eliminated, because upon initial evaluation largescale sediment removal actions would likely require significant removal of mature trees and also result in conflicts with existing infrastructure, both of which oppose the planning constraints and considerations discussed in Section 1.8.

Management measures that were determined to meet project objectives are shown in Table 3-3. There are multiple types of stream restoration, wetland restoration, and fish passage measures that could potentially be implemented. These measures can be combined over the length of a stream segment to achieve different restoration objectives. In some locations, the choice of measures may be constrained by adjacent private properties or the presence of mature trees, for example. Although wetland restoration is not an explicit project objective, measures to reconnect streams with the adjacent floodplain were evaluated. Topographic changes along stream banks could increase wetted area and potentially aid in the reestablishment of wetlands. Management of invasive species is also considered a measure to enhance aquatic ecosystem health. Figures showing typical sections for the natural channel design structures are included in Section 4.1.

[2] In this report, reference to "natural channel design" includes the use of quantitative hydrologic and hydraulic analyses (e.g., sediment transport) and modeling to support the development of the engineering designs.

Table 3-3. Ecosystem restoration management measures that meet the project objectives.

Measure and Description	Objective	
	1. Stream Restoration	2. Fish Passage/ Connectivity
Floodplain Reconnection – Reconnection of a stream with the floodplain.		
Create new - New floodplain reduces stream channel stress and catches suspended sediment.	●	●
Reconnect by lowering bank - Reconnecting the stream to the floodplain by lowering the bank to restore the stream's natural hydrology.	●	●
Reconnect by raising stream - Reconnecting the stream to the floodplain by raising the stream bed to restore the stream's natural hydrology.	●	●
Vegetation Management - Removal of invasive species within the project area. This measure includes a one-time planting of native plant species adjacent to the stream.	●	
Habitat Creation – Placement of rocks, woody debris, or structures to restore habitat.		
Root wads - Placement of tree trunks with roots attached and soil removed to stabilize the stream bank.	●	
Boulders - Large rocks placed to stabilize stream bank.	●	
Riffles/Pools - Placement of rocks, pebbles, etc., and or grading in a flowing stream to form alternating areas of relatively shallow and deep water, in order to support a variety of fish and invertebrate species.	●	●
Lunkers and "man-made objects"- Crib-like, wooden structures installed along the toe of a stream bank to restore overhead bank cover and resting areas/refuge for fish.	●	
Coarse Woody Debris- Placement of fallen dead trees and the remains of large branches on the stream bank and in the stream. "Coarse" is defined as 2.5–20 cm. Provides habitat and refuge for fish in a stream.	●	
Grade Control & Flow Redirection Structures - Redirect flow away from banks, reduce channel slope, and provide stream diversions. Made of concrete, rocks, logs, etc.		

Measure and Description	Objective	
	1. Stream Restoration	2. Fish Passage/ Connectivity
Step Pools - channel-spanning pools and boulder/cobble steps that cause subcritical flow in the pool and supercritical flow over the steps. They occur in gradients in the range of 5 and 20%.	●	●
Vanes - guide the flow away from bank, to reduce bank erosion, promote local sedimentation, and encourage vegetation growth. Made up of a set of upstream angled lines of boulders, connected by a section of smaller rocks upstream. While water usually covers the shorter section during normal flows, the taller sections deflect flow away from the banks of the stream. Flow is diverted over the rock walls and concentrated down the center of the channel. The scouring associated with high flow velocities in the center of the channel and the "waterfalling" over the structure itself creates a deep, elongated pool.	●	●
Weirs - similar to a cross-vane in that both sides are vanes directed from the bankfull bank upstream toward the bed with similar departure angles. Enhances fish habitat and stabilizes stream banks.	●	●
J-Hooks- an upstream pointing line of rocks that originates at one bank and terminates somewhere in the middle of the stream. These direct flow to the center of the channel, taking stress off banks, and allowing for re-vegetation.	●	●
Riffle grade control- placement of natural stone or other erosion resistant elements across the channel to form a hard point.	●	●
Fish Passage/Connectivity – Measures to facilitate fish passage.		
Fish Ladder - placement of a structure on or around artificial and natural barriers (to facilitate diadromous fishes' natural migration).		●
Step Pools- See definition above.	●	●

Measure and Description	Objective	
	1. Stream Restoration	2. Fish Passage/ Connectivity
Rip-Rap – Placement of rock or other hard material to armor shorelines and streambeds.	●	
Imbricated Rip-Rap – Placement of large (2-3 foot long) boulders arranged like building blocks to stabilize the entire streambank. Void spaces between the rocks that lie below the waterline provide hiding and cover areas for fish.	●	
Concrete channel excavation, mid-channel - Removal of concrete channel and grading to produce a stream channel with natural geomorphic features. Excavation and fill is required to restore a stable plan form and channel cross-section. Excavation also focuses on the development of a stable streambed profile and requires the construction of riffle-pool or step-pool complexes. Grading and reshaping existing stream banks can provide a stable angle of repose.	●	●
Concrete channel modification - baffles - Energy dissipation/velocity reduction by modifying channel at the end sill with baffles/blocks.	●	●
ERDC Streambank Stabilization – Streambank stabilization through structural measures, including rigid or stone armoring, manufactured covers, structural side slope protection such as stone toe or revetments.	●	
Pipe Daylighting - Eliminating a pipe to create an open stream channel.	●	●
Stream Relocation - Relocation of the stream outside its natural or historic channel and movement of the built environment to accommodate the new stream channel (barriers, utilities, infrastructure).	●	●
Infrastructure Relocation – identification and deactivation of existing infrastructure to support project objectives. This consists of rerouting/relocating utilities as possible to facilitate fish passage. For example, this includes relocation of elements of the built environment, including roads, bridges, bridge abutments, etc., to enable project objectives to be met.	●	●

3.3 Summary of Initial Array of Alternatives

Alternatives are a set of one or more management measures functioning together to address planning objectives. Alternatives were developed by combining compatible measures. For example, "soft" measures (use of natural channel design structures) were not included in an alternative with "hard" measures (rip-rap or concrete matting), and varying levels of infrastructure and concrete removal/modifications were considered. The following alternatives, which include combinations of the management measures presented in Table 3-3, were evaluated:

Alternative 1: Future-Without-Project (FWOP: No Action)

No action or the future-without-project (FWOP) condition considers all actions, plans, and programs that would be implemented in the future to address problems and opportunities in the absence of a USACE project. Details on FWOP conditions are provided in Section 2.6.

Alternative 2a: Natural Channel Design

- "Soft" measures (natural channel design) to stabilize streambeds and banks through the use of riffle grade control and flow redirection structures, and to restore habitat through placement of in-stream structures created with rocks and woody debris (see "habitat creation" and "grade control and flow redirection" in Table 3-3).
- Floodplain reconnection
- Stream relocation
- Partial concrete channel excavation and/or modification (removal of concrete in channelized stream reaches and/or at transportation crossings or addition of in-stream structures within concrete channels)
- Pipe daylighting
- Fish passage/connectivity (fish passage facilitation)
- Vegetation management (invasive plant species removal)

Alternative 2b: Natural Channel Design with Major Infrastructure Modification

- All the measures included in Alternative 2a
- Infrastructure relocation (major relocations including bridges and roads to provide habitat improvement such as riparian reforestation or improved stream geometry
- Complete concrete channel excavation

Alternative 2c: Natural Channel Design without Concrete Channel Alteration

- All the measures included in Alternative 2a
- No concrete channel excavation or modification

Alternative 3: Hard Design

- "Hard" measures (rip-rap or imbricated rip-rap) for stream stabilization
- Floodplain reconnection
- Stream relocation
- Grade control and flow redirection
- Fish passage/connectivity (fish passage facilitation)

- Vegetation management (invasive plant species removal)

Alternative 4: Streambank Stabilization

- ERDC Streambank Stabilization techniques (stabilization through rigid structural measures)
- Floodplain reconnection
- Stream relocation
- Grade control and flow redirection
- Partial concrete channel excavation and/or modification (removal of concrete in channelized stream reaches and/or at transportation crossings or addition of in-stream structures within concrete channels)
- Pipe daylighting
- Fish passage/connectivity (fish passage facilitation)
- Vegetation management (invasive plant species removal)

Alternative 2b, Natural Channel Design with Major Infrastructure Modification, was not evaluated further due to challenges in implementation and because it includes a measure that violates the project constraint for impacts to infrastructure. Based on the high cost that would accompany road and bridge relocation, as well as the potential effects on flood water conveyance, this alternative was determined to be unacceptable by the project team.

3.4 Evaluation and Comparison of the Initial Array of Alternatives

The alternatives, excluding Alternative 2b, were carried forward for comparison and evaluation. Table 3-4 identifies the criteria and metrics developed for the comparison. Table 3-5 shows the comparison of alternatives using these criteria.

Table 3-4. Criteria and metrics used for evaluation and comparison of initial array of alternatives.

Criteria	Metric	Definition
In-stream Functional Benefit	Yes/Neutral/No	Creation of stream complexity to support habitat diversity
Negative Environmental Impact	High/Neutral/Low	Long-term negative impact to natural features within project area (e.g., trees, bedrock)
Community Impacts (Surrounding Built Environment)	High/Neutral/Low	Alteration to flooding; recreation space & trails; public utilities; infrastructure
Cost	$ / $$ / $$$	General "low" ($100s/lf), "medium" ($200s/lf), "high" ($300s/lf)
Implementability	+ 0 -	Implemented in a reasonable timeframe with reasonable technology

Criteria	Metric	Definition
Durability/Sustainability	High/Med/Low	Measure of OMRR&R sustainability and practicality.

Table 3-5. Comparison of alternatives.

Criteria	Alt 1 FWOP (No Action)[1]	Alt 2a Natural Channel Design (NCD)	Alt 2c NCD w/o Concrete Channel Alteration	Alt 3 Hard Design	Alt 4 Streambank Stabilization
In-Stream Functional Benefit	Neutral	Yes	Yes	Neutral/No	Neutral
Negative Environmental Impact	Neutral	Low	Low	High	Low
Community Impacts (Surrounding Built Environment)	Neutral	High	Low	Low	Low
Cost	N/A	$$$	$$	$$	$
Implementability	N/A	+	+	+	+
Durability/Sustainability	N/A	High	High	Med	High

[1]By definition, the no action alternative does not have impacts or benefits different to those of the future-without-project condition. Impacts and benefits are therefore rated as neutral with other criteria not applicable (N/A).

Based on this comparison array, Alternatives 3 and 4 do not meet project objectives because they have net neutral or no positive in-stream functional benefits, thus they were dropped from further consideration. While Alternatives 3 and 4 can reduce sedimentation and will provide bank stability, use of hard features such as bank armoring and covers have little net positive impact on aquatic habitat. Alternatives 2a and 2c best met the project objectives for ecosystem restoration; however, the alteration of concrete channels in Alternative 2a has a high potential community impact with respect to increasing flood risk and the alteration of infrastructure at transportation crossings. The natural channel design alternatives offer ecosystem restoration benefits with low environmental impact while being implementable and sustainable, but since Alternative 2c is lower in cost with similar environmental benefits and lower community impact, Alternative 2c was carried forward. FWOP (No Action) was carried forward for purposes of comparison to with-project conditions. The final array of alternatives is:

- FWOP (No-Action)
- Alternative 2c: Natural Channel Design without concrete channel alteration

3.5 Quantification of Project Benefits and Costs for Conceptual Analysis

The recommendation of a plan for restoration of the study sites is based on the cost effectiveness of the restoration options, as well as other factors. In order to evaluate cost effectiveness in the cost effectiveness/ incremental cost analysis (CE/ICA), project costs and ecosystem restoration benefits were determined. For input into the CE/ICA, the team developed conceptual designs, parametric cost estimates, and a quantification of ecosystem restoration outputs (benefits). Initially, two designs were developed per reach, but the differences in the design features (number and location) were so minor, that one of the designs per reach was dropped. These were used to evaluate the cost-efficiency of the plans, to identify Best Buy plans, and to select the TSP. Following agency endorsement of the TSP, feasibility level designs were generated and used for finalization of costs and benefits and confirmation of the recommended plan as described in Section 3.7.

3.5.1 Conceptual Site Design Descriptions

For Alternative 2c, concept-level designs were developed for the stream miles proposed for restoration at each of the 10 sites. The conceptual designs consisted of drawings for each site at the 10 percent design level. These designs show the estimated location and types of structures, but do not include exact number of structures or quantities of material, which were defined at a higher level of design. Costs and benefits for the designs were included in the cost effectiveness analysis described in Section 3.5.4. Descriptions of all of the conceptual designs input into the CE/ICA can be found in Appendix E. Appendix E also includes the conceptual design drawings (large format) for each site. Once designs were advanced in the feasibility-level design phase (35%), the designs were refined significantly to include the specific location and types of features and to identify impacts to property, infrastructure, and the environment. The feasibility level designs for sites in the recommended plan are described in Section 4.1.1 and included in Appendix E.

3.5.2 Quantifying the Benefits of Ecosystem Restoration

Quantifying the ecosystem restoration benefits includes an assessment of the changes in habitat quality between future-without and future-with-project conditions, and a quantification of the area being restored. A physical habitat assessment was performed to assess quality changes, as described in subsequent sections.

3.5.2.1 Physical Habitat Index: In-Stream Habitat Quality

Maryland Biological Stream Survey (MBSS) procedures (MDDNR, 2003) for Physical Habitat Index (PHI) were chosen to assess current habitat conditions because they have been extensively utilized by MBSS and PGDOE since the 1990s and thus allow for ready comparison of previous to current conditions. Recently, PGDOE, through contracts with Tetra Tech, has utilized the protocols to assess existing conditions at one location on each project site (see Appendix A). Use of MBSS procedures for this study was coordinated with USACE National Ecosystem Restoration Planning Center of Expertise and approved for one time use on February 24, 2015, pursuant to USACE Engineering Circular 1105-2-412. Stream habitat assessment progressed through a sequence of steps (Table 3-6). Appendix B, Environmental Modeling, includes the USACE Model Documentation and a description of the methodology for PHI scoring, data inputs, and maps of the stream segments surveyed.

Table 3-6. Steps in the assessment of stream physical habitat.

Step	Location	Assessment Step
1	Office & Field	Subdivide project stream sites into representative reaches based on habitat conditions.
2	Field	Assess stream reach habitat condition at representative 75 m section.
3	Office	Compute PHI
4	Office	Quantify Existing Stream Habitat
5	Office	Forecast future stream habitat for with and without project conditions
6	Office	Quantify changes in habitat between future-with and -without-project conditions

Streams that possess a range of varying habitat conditions along their length can be divided into reaches at break points between differing habitat conditions. Appendix B presents information on the division of the project streams into reaches for sampling. Within each reach containing different habitat conditions, a representative 75 m length was measured along the channel thalweg and sampled (field assessed) per MBSS procedures (MDDNR 2013; Appendix B), and the data recorded onto MBSS data sheets (MBSS Summer Habitat Data Sheet, Appendix B).

Following the PHI procedures and guidance, seven habitat parameters were scored in the field – percent shading, embeddedness, epibenthic substrate, in-stream habitat, total number of in-stream woody debris/rootwads, erosion extent and severity, and riffle quality (Piedmont physiographic province only). Except for number of woody debris/rootwads and severity of erosion, individual parameters can score from 0 to 20. Total numbers of in-stream and on-bank woody debris and rootwads are counted, and the length and severity of erosion (none to severe) is estimated. For the other parameters, the worst possible habitat score is zero, and the best possible score is 20. The PHI procedures divide the total score into distinct narrative classes ranging from poor to optimal. The data are entered into spreadsheets in the office, and these parameters are then used to produce a total habitat quality score for the reach. This score ranges from zero to 100. Further details on the metrics within the PHI and the way scores are calculated are contained in Appendix B.

3.5.2.2 Stream Habitat Units: Quantifying In-Stream Habitat Benefits

Quantifying stream habitat requires consideration of habitat quantity and quality. Quality of habitat within the project streams is captured by the PHI score, described above. For the initial CE/ICA and selection of the TSP, physical habitat quantity was determined using stream length and stream order (Strahler, 1957); however, this was amended for verification of the recommended plan (Section 3.7). Stream order shows a close correlation to stream width, depth, wetted perimeter, and volume, and is simpler to determine/measure. Empirical relationships between dimensions of bankfull channel geometry and discharge or drainage area have been established for coastal plain streams in Maryland (USFWS, 2003). Based on these equations and drainage area for the project streams, a fourth order stream is about four times wider than a first order stream, thereby supporting the use of stream order as a surrogate for width (see Appendix B for details). Stream lengths were determined from field GPS data and GIS data. Stream order for reaches was interpreted from maps and aerial photographs. Stream length was multiplied by stream order to generate a single number representing habitat quantity. In cases where stream reaches are piped or contained within a concrete channel, that reach is considered as having zero habitat quantity under existing conditions.

The total habitat available within a reach is represented by the simple equation, where habitat quantity is the stream order times the stream length (in feet) and habitat quality is the PHI:

Habitat Quantity x Habitat Quality = Stream Habitat Units (SHUs in feet)

For a segment, total habitat availability is the simple sum of SHUs for all the reaches within the segment. SHUs are expected to accrue upon project completion and have been annualized over the project life (AASHU).

To measure the contribution of alternative plans to the project objectives and to perform the cost effectiveness analysis, two metrics were calculated for use in the CE/ICA: 1) “Project Specific In-Stream Benefits” and 2) “Aggregate Benefits.” The Project Specific In-Stream Benefits (as presented above) and the Aggregate Benefits metrics use the above equation for calculation of SHUs. However, the Project Specific In-Stream Benefits metric includes only benefits from restoration specifically at the project sites; whereas, the Aggregate Benefits metric incorporates fish passage (opened through removal of physical blockages) and connectivity (connection of project reaches to existing restoration projects). Quantification of Aggregate Benefits is described in Section 3.5.2.

3.5.2.3 Future Projections

Projections for the future-without-project conditions assume that stream water quality improves over the 50-year evaluation period due to implementation of regulatory mandates and best management practices as described in Section 2. While stormwater retrofits and upgrades will help address stormwater quantity, it is expected that stormwater runoff quantity control will still remain less than needed. However, since stream assessments (by MDDNR and USACE) have shown that, especially in the channelized stream reaches, poor habitat is the major stressor in the study stream reaches, habitat improvements are expected to result in improved aquatic health with or without stormwater or water quality changes.

With-project PHI projections account for changes in reach habitat quantity and quality. Based on findings of habitat assessments of other previously restored reaches in the Anacostia River watershed (MCDEP, 2013), it is expected that in-stream habitat quality of existing erosion can be improved significantly. Future-with-project PHI scores were projected by considering stream metrics in good quality streams within the watershed. Improvements in relevant metrics in a stream recently restored by USACE (Paint Branch) were considered. In cases where a surface stream’s length will change with-project, stream habitat quantity also changes. Possible changes in stream length could occur via either increasing or decreasing stream sinuosity. Changes in other physical metrics including width, depth, wetted perimeter, and volume could change, but due to difficulty accurately determining these over a stream segment length, and the use of stream order as a proxy to represent these stream attributes, these changes are not determined.

For habitat quality, individual PHI metrics that can be affected by restoration are generally improved from poor or marginal to sub-optimal or optimal. For example, Table 3-7 shows changes in scores for "epibenthic substrate" and "in-stream habitat," which are reflective of habitat stability and diversity for benthic life and fish, respectively. Improvement in the "in-stream habitat" metric reflects increases in the stability and relative quantity and variety of habitat that are available to fish for refuge, feeding, or spawning. Restoration will improve this metric by providing a high degree of hypsographic complexity (variety of depth conditions) and range of particle sizes. Through improvement in the "epibenthic substrate" metric, the microhabitat stability and diversity of hard substrate (e.g., rocks, snags) available for macroinvertebrates will increase, thereby increasing the number and variety of these organisms. The majority of segments lay in the Coastal Plain which naturally has an abundance of stream sediment and may naturally lack riffles. In recognition of this natural condition, embeddedness from excess sediment or presence of riffles is not included in the PHI calculation for streams within the Coastal Plain. The PHI does consider presence of hard, stable substrate. Future substrate conditions with-project were forecast based upon findings of habitat assessments of other previously restored reaches in the Anacostia River watershed (Appendix B).

Restoration will also result in improvement in other metrics. The numbers of in-stream rootwads and woody debris will increase. Increased woody debris will facilitate the establishment of a variety of flow and depth conditions, provide cover and resting areas for fish, trap and collect organic materials, and provide channel stability. Erosion severity will generally improve from moderate to minimal, reflecting increased bank stability and decreased sedimentation. The project streams generally lie in wooded settings; therefore, there is minimal opportunity for improvement in the percent shading score. While the habitat quality of the buffer area may be improved through plantings, invasive species control, or similar measures, these efforts would not appreciably change the shading.

Table 3-8 summarizes the future-without-project (FWOP) and future-with-project (FWP) PHI for the conceptual design alternatives input into the CE/ICAs for each of the ten sites evaluated. As shown, PHI scores are expected to increase 17 to 84 percent over pre-restoration conditions, representing substantial habitat lift. Due to the immutable characteristics of the site location and urban setting, variables such as remoteness and watershed area could not be improved. As a result, FWP conditions have best achievable PHI scores under 100. Remoteness is measured as the distance from the stream segment to a road and is a proxy for urbanization (i.e., indicative of land use patterns and water quality). Tables in Appendix B provide all metric scores and resulting PHI FWP scores for Piedmont and Coastal Plain stream reaches as projected for all design alternatives.

Table 3-7. Predicted post-restoration improvement in physical habitat scores for epibenthic substrate and in-stream habitat for the selected design alternatives.

Site	Epibenthic Substrate		In-Stream Habitat (fish)	
	FWOP	FWP	FWOP	FWP
1	M/SO	SO	M/SO	SO
3	P/M/SO	SO	P/M/SO/O	SO/O
5	M/SO	SO	P/M/SO/O	SO/O
7	M	SO	M	SO
9	M	SO	M/O	SO/O
10	M	SO	M/SO	SO

Site	Epibenthic Substrate		In-Stream Habitat (fish)	
	FWOP	FWP	FWOP	FWP
11	P/M	SO	P/M	SO
12	M/SO	SO	P/M	SO
13	P/M/O	SO/O	M/SO	SO
15	M/SO	SO	M/SO	SO

(FWOP – future-without-project; FWP – future-with-project; P-poor; M-marginal; SO-sub-optimal; O-optimal)

3.5.2.4 PHI Sensitivity Analysis

To evaluate the sensitivity of PHI score to variables that cannot be affected by restoration, including watershed area and remoteness, best achievable PHI scores were calculated. To do this, all other metrics were set to optimal, and assumptions were made that there is no erosion and the maximum amount of woody debris calculable is possible. The best achievable PHI scores shown in in Table 3-8 acknowledge the urban environment and indicate that outside of the remoteness variable, substantial improvement in physical habitat is expected.

Table 3-8. Future-without-project (FWOP) and future -with-project (FWP) changes in PHI scores and best achievable PHI score for the selected conceptual design alternatives.

Site	FWOP PHI	FWP PHI	% Increase	Best Achievable PHI
1	55	73	33	93
3	36	54	50	71
5	35	55	57	73
7	37	54	46	75
9	39	60	54	80
10	54	63	17	86
11	25	46	84	68
12	35	52	49	74
13	37	57	54	74
15	41	58	41	75

3.5.2.5 Quantifying Aggregate Benefits

In order to capture the total benefits from implementing the recommended stream restoration projects, the Aggregate Benefits metric incorporates both fish passage (passage opened through removal of a physical fish blockage) and connectivity (connection of project reaches to already existing restoration projects), combined with the project-specific in-stream habitat benefits. This metric captures the value provided by connecting habitat improved under these projects to existing restoration, as well as the value of opening stream courses upriver of project sites to fish passage.

Further information on the plan formulation for the Aggregate Benefits metric can be found in Appendix B.

The same equation was used to quantify SHUs for Aggregate Benefits as was used for the Project Specific In-stream benefits: Habitat quantity x PHI. Habitat quantity for aggregate benefits used 1) the length of the stream that would be accessible for fish following removal of a fish blockage at a project site and/or 2) the length of stream that has been restored by other efforts and is connected to reaches under consideration for restoration by this investigation. To capture habitat quality, PHI data for the stream reaches where aggregate benefits extend were obtained from existing MBSS and/or Tetra Tech monitoring sites or from post-project monitoring performed by the project owner. Figure 3-3 provides an illustration of the stream study sites and their associated Aggregate Benefits, with fish passage benefits shown by a purple dashed line and connected previously restored streams shown in yellow.

3.5.2.6 Quantifying Total Habitat Outputs (Stream Habitat Units)

The total ecosystem restoration benefits include both the SHUs from Project Specific In-Stream Benefits and the Aggregate Benefits. Section 3.5.4 presents how the two metrics were combined for the CE/ICA. The combined benefit constitutes the project benefits that are compared in CE/ICA to inform plan selection.

3.5.3 Estimating Conceptual Costs

Parametric cost estimates were prepared for the 10 percent level concept designs. These costs included advanced design, construction, and construction management. Linear foot parametric costs were estimated based on concept cost estimates contained in 2012 bid data for Northwest Branch Package 2 and for the Paint Branch Continuing Authorities Program (CAP) project from 2012 (both USACE construction projects). These packages were chosen for the parametric cost estimate because they incorporated the same in-stream structures proposed for this project and included similar project dimensions (e.g., the Paint Branch CAP project is contiguous with this project's site 5). The 2012 estimate was escalated to fiscal year 2016 costs using the Civil Works Construction Cost Index System. These conceptual level costs, as described previously, were used for the economic analysis to select the TSP. Following endorsement of the TSP, costs were updated using MII (Section 3.7 and Appendix E). The current project cost estimate is based on costs for fiscal year 2019.

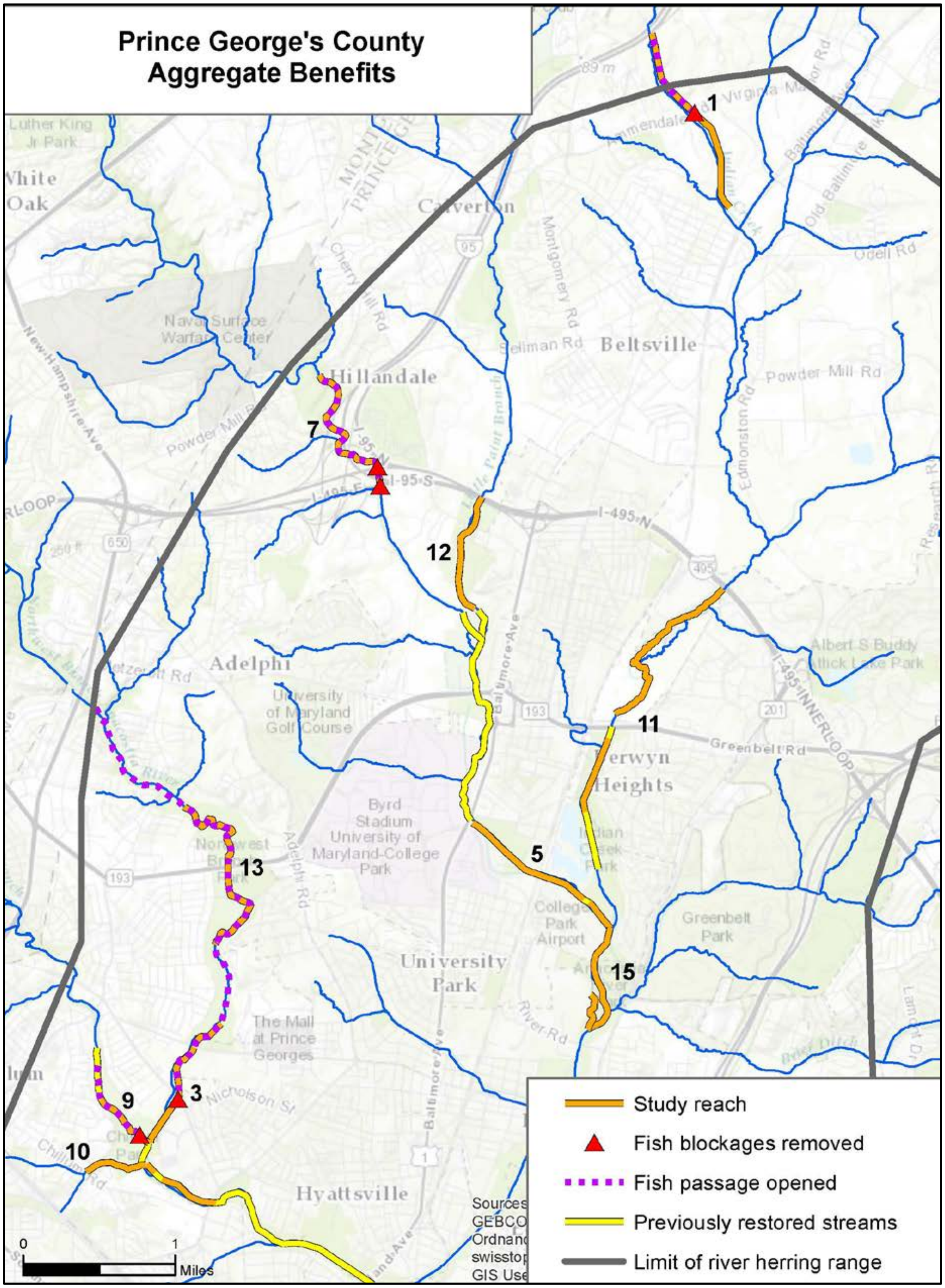


Figure 3-3. Aggregate benefits for each project site.

Previous investigations of economy of scale cost-savings for constructing multiple sites for the nearby Great Seneca Muddy Branch Watershed Study determined that these savings were on the order of about four percent. That amount is within the uncertainties of the parametric cost estimates and is comparatively small compared to overall project cost. For the conceptual level costs, the four percent cost savings was applied for the combination of some sites located in close proximity, including for construction of Paint Branch-Calvert Road (sites 5 and 15) and Northwest Branch-Sligo Creek and/or Chillum Rd (sites 3, 9, and/or 10). Preliminary real estate costs and adaptive management/monitoring costs were also included into the costs used in CE/ICA.

For the CE/ICA used to select the TSP, because designs were at a conceptual level, cost estimates included a level of contingency that is based on project risks and uncertainties. An abbreviated risk analysis was performed to estimate the effects associated with design uncertainties including for construction elements (e.g., numbers of structures), quantities of materials, level of analyses, schedule, etc. Further information on the risk analysis is included in Appendix E.

3.5.4 Cost Effectiveness Analysis

USACE policy requires the use of an incremental cost analysis for all ecosystem restoration projects or mitigation plans. The purpose of the cost effectiveness/incremental cost analysis is to discover and display variation in cost and output, and to identify and describe those plans that have the lowest incremental cost per unit output (USACE, 2000). The IWR Planning Suite, certified version 2.0.1, software application was used to complete the CE/ICA analyses (USACE, 2015b). The outputs of CE/ICA are used as one factor in the selection of a recommended plan.

The planning objectives (see Section 1.8) specify restoration of in-stream habitat in both the Northwest and Northeast Branch subwatersheds of the Anacostia River watershed in Prince George's County. This reflects the ecosystem approach needed to provide a comprehensive solution for restoration of the watershed, given the interconnected nature of hydrologic systems. USACE guidance for ecosystem studies recommends that projects be undertaken in the context of "ecosystem benefits", which would include the watershed as a whole, rather than what is specific to a single stream reach. Restoration of both branches of the Anacostia River is needed to achieve a solution for ecosystem restoration that realizes the planned benefits, especially for anadromous fish attempting to access upstream habitat.

Based on these objectives, sites were combined into alternatives (combinations of sites) for both the Northwest Branch and Northeast Branch subwatersheds (Figure 3-4). The formulation of the alternatives was based on ecological dependencies identified by the project team (explained below). Separate CE/ICAs were run for each subwatershed. The following alternatives were formulated for input into CE/ICA, based on the logic described below:

Northwest Branch	**Northeast Branch**
3	11, 15
3, 9	11, 15, 5
3, 9, 10	11, 15, 5, 12
3, 13	11, 15, 5, 7
3, 9, 13	11, 15, 1
3, 9, 10, 13	11, 15, 5, 1
	11, 15, 5, 12, 1
	11, 15, 5, 12, 7
	11, 15, 5, 12, 7, 1

3.5.4.1 Logic for Alternatives Formulation – Northwest Branch

1. Sites 9 and 10 are dependent on site 3, because:
   a) Sites 9 and 10 are hydrologically connected and contiguous to site 3.
   b) Site 3 is downstream of sites 9 and 10. Unfavorable flow conditions and homogeneous habitat in the downstream portion of site 3 could inhibit fish movement upstream.

2. Anadromous fish movement to site 13 and upstream is dependent on fish blockage removal at site 3; therefore, site 13 is dependent on site 3.

3.5.4.2 Logic for Alternatives Formulation – Northeast Branch

1. All alternatives must include sites 11 and 15, because these sites are interdependent:
   a) As a result of excess sediment transport from site 11 downstream to site 15, site 11 strongly influences habitat conditions at site 15; therefore, site 11 must be restored to realize benefits at site 15.
   b) For fish passage, site 11 is dependent on site 15. Site 15 is the critical connection at the confluence of Paint Branch and Indian Creek and must be restored to fully realize upstream benefits. Homogenous habitat, flow conditions, and a partial fish blockage at site 15 may inhibit fish movement upstream into Indian Creek and Paint Branch.
   c) Sites 5 and 15 are contiguous, however sediment from site 5 affects site 15 to a lesser extent than sediment from site 11.

2. To maximize the potential for anadromous fish movement upstream, alternatives include downstream sites before upstream sites may be included.

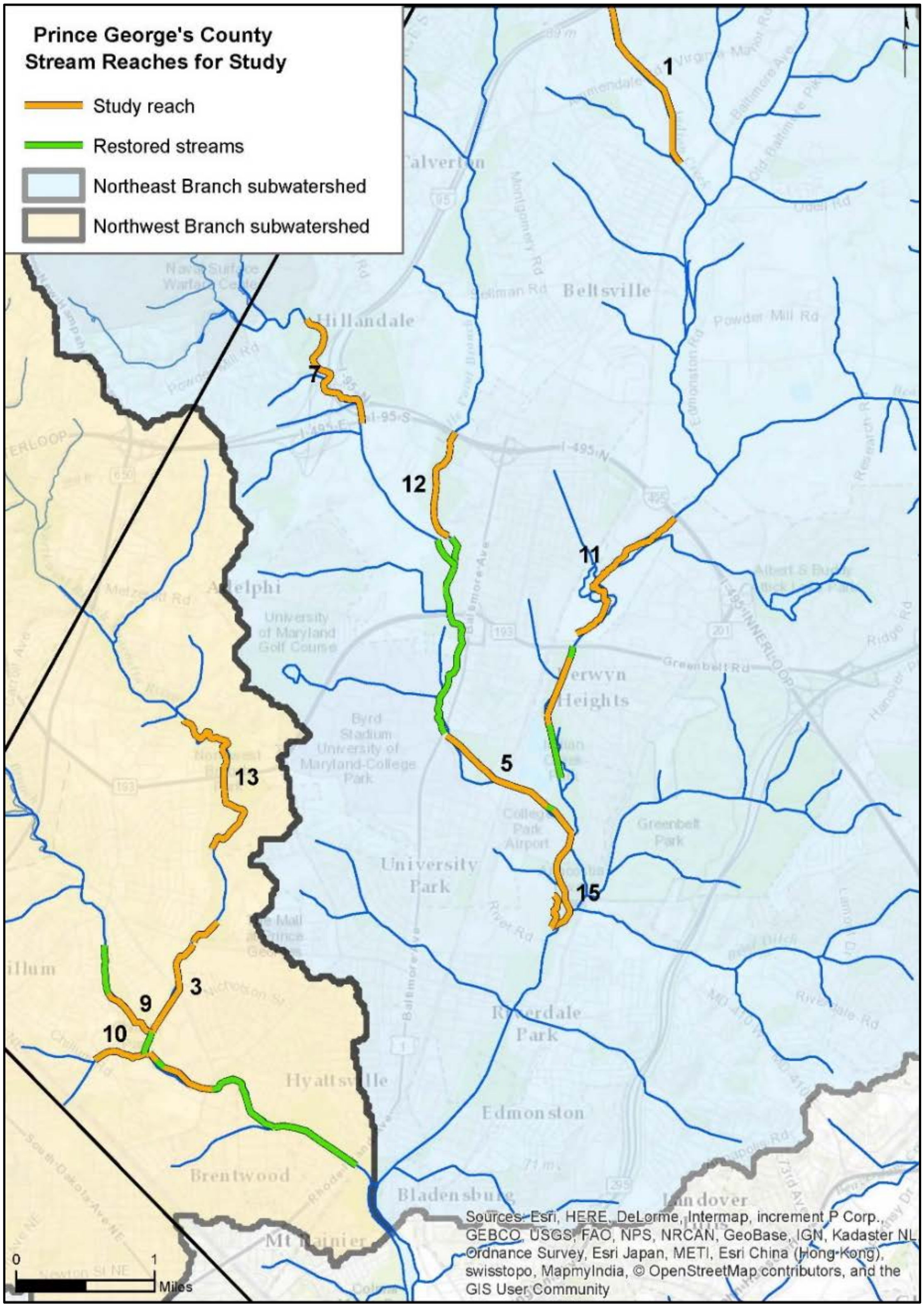


Figure 3-4. Northwest and Northeast Branch subwatershed boundaries for the formulation of site alternatives.

3.5.4.3 Cost Effectiveness/Incremental Cost Analysis Inputs

As described above, two CE/ICAs were run, one for the Northwest Branch alternatives and one for the Northeast Branch alternatives. CE/ICA evaluates the cost effectiveness of each of the alternative plans, and identifies and eliminates economically irrational solutions. Plans are considered to be “cost effective” when no other plan provides the same environmental output level for less cost, or, no other plan provides a higher output level for the same or less cost. “Best buy” plans are a subset of cost effective plans that have the greatest increase in output for the least increase in cost (lowest incremental costs per output). The CE/ICA was run using the costs and benefits described in Sections 3.5.2 and 3.5.3 in order to select the TSP. Costs and benefits were updated following agency endorsement of the TSP and the development of feasibility level designs.

CE/ICA requires comparison of costs and benefits in average annual terms. Accordingly, total investment costs and maintenance costs were annualized over a 50-year period of analysis, using a 3-1/8 percent discount rate, and October-2015 (fiscal year 2016) price levels. Likewise, benefits were annualized over a 50-year period of analysis. Restoration actions will improve habitat immediately following the completion of construction, with benthic macroinvertebrates expected to recolonize immediately after construction and fish species moving back into stream reaches within months. For the projects economic analysis, full benefits are assumed to be realized after one year following construction. More detailed information on the annualization of costs and benefits can be found in the Economic Appendix (Appendix F). Table 3-9 shows the average annual costs and average annual environmental benefits input into each CE/ICA.

Average annual ecosystem restoration benefits input into each of the two CE/ICAs include benefits for the two metrics described in Section 3.5.2: Project Specific In-Stream Benefits and Aggregate Benefits. While both of these metrics are measured in SHUs, the SHUs are not equivalently comparable, since one is measured based on area that will be restored, whereas the other is based on previously restored area. Since it is not appropriate to simply add the two metrics together for evaluation purposes, a combined normalized score was calculated. Within the Planning Suite software, using the two metrics for each separate branch, each metric was normalized using the maximum amount for the appropriate branch and added together with equal weighting to obtain a raw weighted score in a range of 0 to 1. The combined benefit was calculated as follows for each branch:

$$Northwest\ Branch\ Combined\ Benefits = 0.5 \times \frac{\sum In\ Stream\ Benefit}{5953} + 0.5 \times \frac{\sum Aggregate\ Benefit}{59640}$$

$$Northeast\ Branch\ Combined\ Benefits = 0.5 \times \frac{\sum In\ Stream\ Benefit}{13932} + 0.5 \times \frac{\sum Aggregate\ Benefit}{76602}$$

In these two equations, the numerator is the sum of the benefits for a given alternative and the denominator is the maximum possible SHUs for the subwatershed (i.e., total SHUs for the highest level alternative). The CE/ICAs were then performed using the combined benefits (called the "Combined Index") and the average annual cost for each alternative plan to determine the most cost-effective and efficient (best-buy) alternatives for both Northwest and Northeast Branch.

Table 3-9. Average annual (AA) costs and benefits used in the CE/ICAs.

Northwest Branch Alternatives	AA Project Specific SHUs	AA Aggregate SHUs	AA Costs
3	2068	53679	$227,195
3, 9	2738	58330	$288,360
3, 9, 10	2860	59640	$347,921
3, 13	5162	53679	$493,750
3, 9, 13	5832	58330	$554,915
3, 9, 10, 13	5953	59640	$614,476
Northeast Branch Alternatives	**AA Project Specific SHUs**	**AA Aggregate SHUs**	**AA Costs**
11, 15	7975	22703	$620,034
11, 15, 5	10626	63131	$960,543
11, 15, 5, 7	12035	69507	$1,313,965
11, 15, 5, 12	11666	67846	$1,208,592
11, 15, 1	8832	25083	$791,281
11, 15, 5, 1	11483	65511	$1,131,791
11, 15, 5, 12, 1	12523	70226	$1,379,840
11, 15, 5, 12, 7	13075	74222	$1,562,015
11, 15, 5, 12, 1, 7	13932	76602	$1,733,262

3.5.4.4 CE/ICA Results

For the Northwest Branch CE/ICA, six alternatives (in addition to the no action plan) were evaluated in the CE/ICA. Of these, all plans were identified as being cost effective and four were best buy, in addition to the No-Action alternative. For the Northeast Branch CE/ICA, nine alternatives (in addition to the no action alternative) were evaluated in the CE/ICA. Of these, all plans were identified as being cost effective and four were best buy, in addition to the No-Action alternative. Figures 3-5 and 3-6 and Tables 3-10 and 3-11 show the best buy plans using the "Combined Index" for the Northwest and Northeast Branch CE/ICAs, respectively.

These best buy plans represent the most efficient means of achieving each given level of benefit among all the identified cost-effective plans. The recommended plan for a project is usually chosen from the array of best buy plans determined using the CE/ICA, since the benefits for each of these plans are maximized compared to all the other plans under consideration for that project. The benefit output is the "Combined Index," shown from 0 to 1. The 0 to 1 range is necessary as a result of the normalization required for the multi-metric analysis.

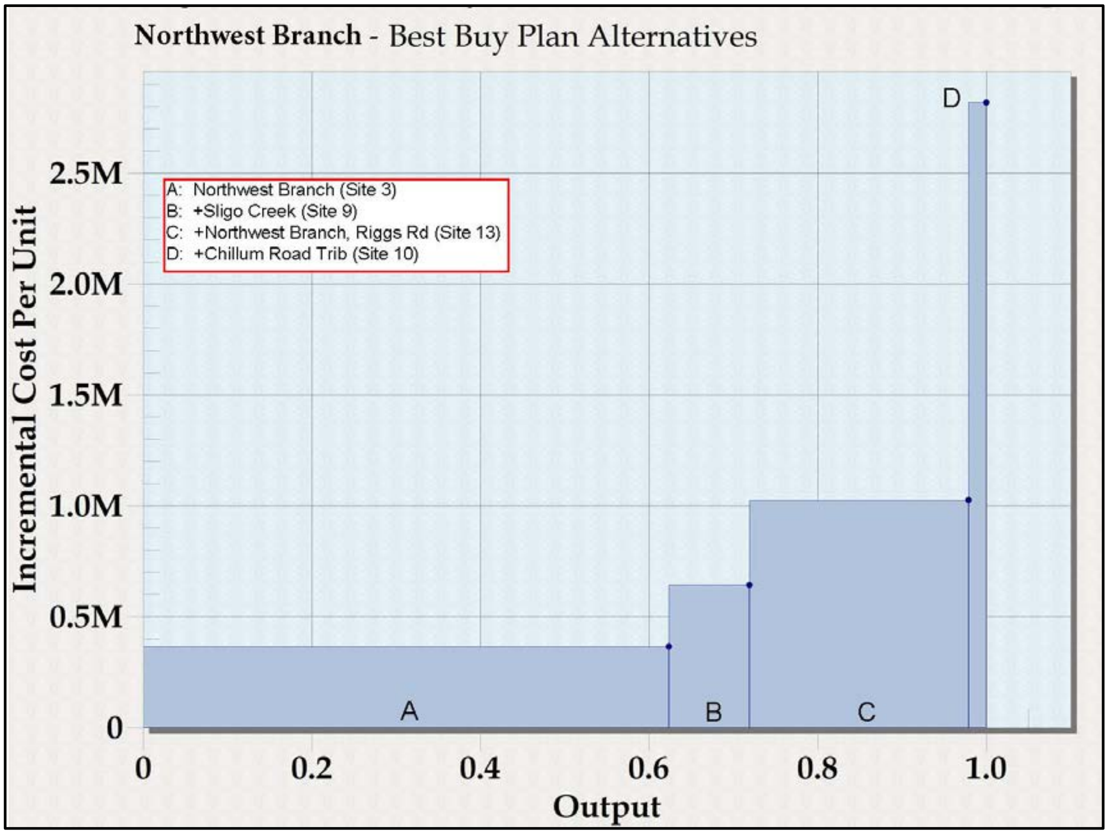


Figure 3-5. CE/ICA graph for Northwest Branch showing best buy plans.

Table 3-10. Outputs (ecosystem restoration benefits) and costs for Northwest Branch CE/ICA best buy plans.

Plan	Sites Included	Total Restoration Length (ft)	Average Annual Costs	Combined Index (0-1)	Incremental Cost	Incremental Output	Incremental Cost/Output (K)
No Action	-	0	$0	-	$0	0	-
NW-A	3	7,285	$227,200	0.62	$227,200	0.62	$364
NW-B	3, 9	9,526	$288,400	0.72	$61,200	0.10	$642
NW-C	3, 9, 13	17,216	$554,900	0.98	$266,500	0.26	$1,026
NW-D	3, 9, 13, 10	19,312	$614,500	1.00	$59,600	0.02	$2,819

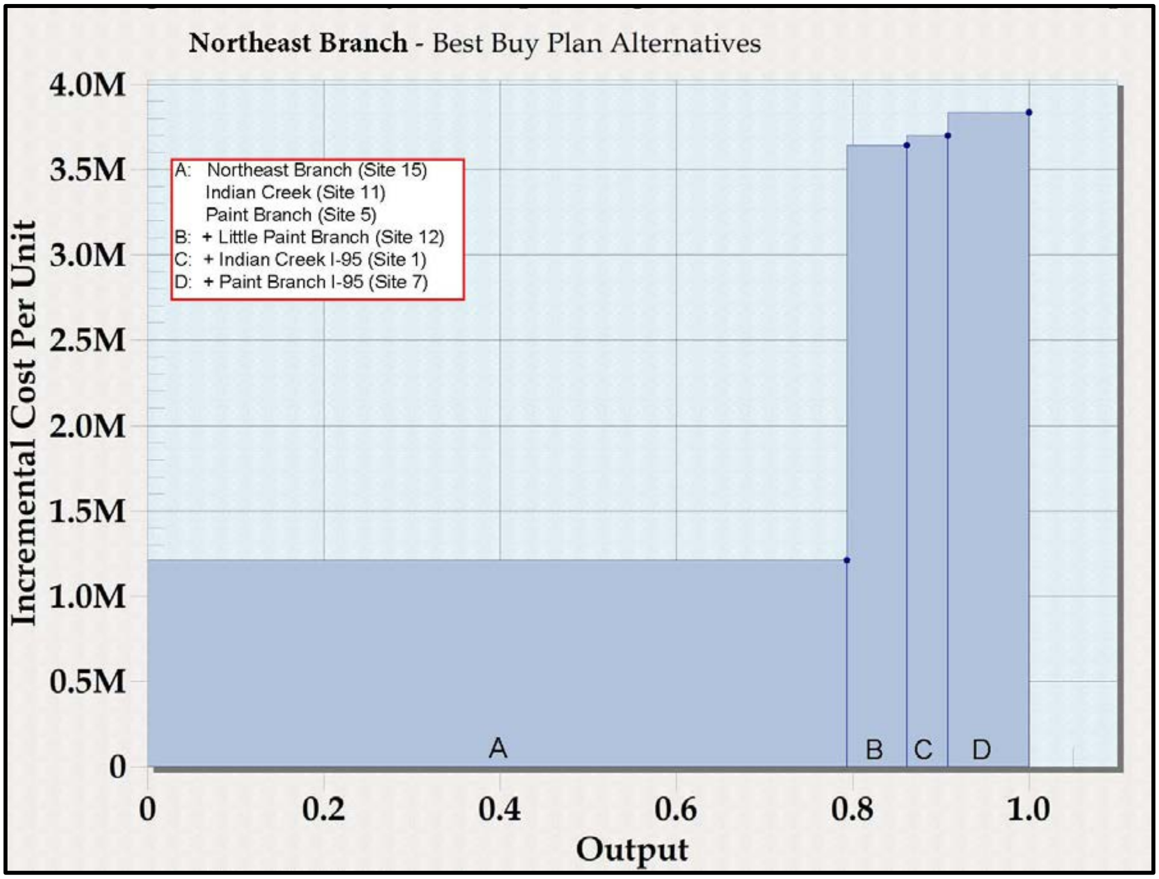


Figure 3-6. CE/ICA graph for Northeast Branch showing best buy plans.

Table 3-11. Outputs (ecosystem restoration benefits) and costs for Northeast Branch CE/ICA best buy plans.

Plan	Sites Included	Total Restoration Length (ft)	Average Annual Costs	Combined Index (0-1)	Incre-mental Cost	Incre-mental Output	Incremental Cost/Output (K)
No Action	-	0	$0	-	$0	0	-
NE-A	15, 11, 5	18,946	$960,500	0.79	$960,500	0.79	$1,211
NE-B	15, 11, 5, 12	23,476	$1,208,600	0.86	$248,100	0.07	$3,643
NE-C	15, 11, 5, 12, 1	30,434	$1,379,800	0.91	$171,200	0.05	$3,698
NE-D	15, 5, 11, 12, 1, 7	36,310	$1,733,300	1.00	$353,500	0.09	$3,835

A sensitivity analysis was performed on the weighting of the parameters combined in the multi-metric analysis. While equal weighting was used for the CE/ICAs, the effect on the results of the analyses were considered with use of 100 percent weight on In-Stream benefits (0 percent weight on Aggregate benefits), and 75 percent weight on In-Stream benefits (25 percent weight on Aggregate benefits). The results of both of these analyses identify best buy plans with the same sites as those identified in the tentatively selected plan using equal weighting. Weighting of 25 percent on In-Stream benefits (75 percent on Aggregate benefits) was not evaluated because it did not make sense to place less weight on the project currently being evaluated and higher weighting on previously implemented projects. More detailed information regarding the sensitivity analysis on the CE/ICA can be found in Appendix F.

While each of the best buy plans shown are all cost-effective and efficient, it still needs to be determined if the benefits outweigh the additional costs to achieve the next increment of benefit. In determining this, it is helpful to compare the differences in incremental costs and incremental benefits among the various plans. The steps in the selection of a plan are discussed in Section 3.6. Plan selection is Step 6 in the USACE planning process.

3.6 Plan Comparison and Recommendation

The USACE objective in ecosystem restoration planning is to contribute to national ecosystem restoration (NER). Contributions to national ecosystem restoration (NER outputs) are increases in net quantity and/or quality of desired ecosystem resources (USACE, 2000). Criteria used to evaluate the plans includes the four P&G accounts (WRC, 1983) of National Ecomonic Development, Environmental Quality, Regional Economic Development, and Other Social Effects; contributions to the planning objectives; and the P&G criteria of completeness, effectiveness, efficiency, and acceptability. Completeness, effectiveness, efficiency, and acceptability are defined below:

Completeness – the extent to which a given alternative plan provides and accounts for all necessary investments or actions to ensure the realization of the planned effects.

Effectiveness – the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.

Efficiency – the extent to which an alternative plan is the most cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the nation’s environment.

Acceptability – the workability and viability of the alternative plan with respect to acceptance by the State and local entities, tribes, and the public and compatibility with existing laws, regulations, and policies.

As described above, the CE/ICA was conducted with the Northeast Branch and Northwest Branch grouped separately for evaluation due to the specific dependencies and connectedness that further influences within-branch performance. Alternatives that were both cost effective and best buy were then evaluated based on the significance of outputs, acceptability, completeness, efficiency, and effectiveness, and other criteria to identify the NER Plan, and to select a Recommended Plan. Although the branches of the Anacostia River were evaluated separately using a CE/ICA, a combined plan, one alternative from the Northeast Branch and one alternative from the Northwest Branch, was ultimately recommended. The inclusion of both branches of the Anacostia River reflects the ecosystem approach needed in order to provide a comprehensive solution for restoration of the watershed, given the interconnected nature of hydrologic systems. Furthermore, in order to maximize benefits for anadromous fish passage and habitat, both branches of the river must be restored.

3.6.1 Comparison of Alternatives for the Northwest and Northeast Branches

Alternatives were first compared based on the results of the CE/ICA. For the Northwest Branch and tributaries (Figure 3-5 and Table 3-10), Plan NW-A, which includes site 3 on the mainstem of Northwest Branch, is cost effective and a best buy. This plan meets the project objectives, and includes the removal of a fish blockage that opens almost four miles of stream for anadromous fish, allowing anadromous fish to migrate up to the extent of their natural range on Northwest Branch. Plan NW-B adds site 9, which incorporates 0.6 mile of fish passage by removal of a fish blockage on Sligo Creek. The removal of this blockage is significant in that it will allow fish to migrate almost to the extent of their natural range on Sligo Creek, opening an additional 10 percent of the historical range of anadromous fish on Northwest Branch and tributaries. Due to the additional access for anadromous fish utilization, this plan better meets the project objectives than Plan NW-A, and is considered more complete as it encompasses a more comprehensive restoration project for the Northwest Branch and therefore entire watershed. Plan NW-C adds site 13. The stream reach at site 13 is incised and has severe bank erosion and instability. Restoration of this site will stabilize the stream and reduce sedimentation downstream, which, if not restored, could eventually cause enough detrimental impact that the habitat value of a restored reach 3 is greatly reduced. This will also serve to enhance fish passage benefits provided by site 3 (downstream), by providing higher quality habitat upstream for anadromous fish utilization (e.g. spawning, nursery, etc.). As such, Plan NW-C is considered to better meet the project objectives than the previous two alternatives, and is considered to be more complete. Plan NW-D adds site 10. Although Plan NW-D is slightly more effective and complete than Plan NW-C, there is a large increase in incremental cost per output when moving from Plan NW-C to NW-D, and there is little environmental benefit above Plan NW-C for the added cost. Therefore, Plan NW-D does not reasonably maximize environmental benefits considering cost effectiveness and incremental cost analyses. Figure 3-7 illustrates plans NW-A, NW-B, and NW-C.

Based on the CE/ICA for the Northeast Branch (Figure 3-6 and Table 3-11), Plan NE-A (Figure 3-7), the combination of sites 15, 11, and 5, is a cost effective plan and a best buy. Although all of the plans meet the project objectives to some extent, plans NE-B through NE-D demonstrate an extremely large jump in incremental cost per output and would not be considered to reasonably maximize environmental benefits. Plan NE-A, the restoration of sites 15, 11, and 5, is an optimal combination because it restores a critical junction at the Paint Branch-Indian Creek confluence (site 15) and also restores the two sites (11 and 5) contributing to the degradation of habitat at site 15 through downstream sediment input. Sediment impacts on aquatic ecosystems and migratory fish are well documented and include adverse impacts on swimming, growth, disease tolerance, and mortality; reduction in habitat quality, particularly spawning habitats affecting eggs and developing larvae; forcing modification of migration patterns; and reduction of food availability (i.e., primary production, plants and benthic invertebrates); and altering predatory efficiency (Brunton, 1985; Chapman, 1988; Alabaster and Lloyd, 1980; Gregory and Northcote, 1993; Robertson et. al, 2006).

Furthermore, aquatic ecosystems at sites 15, 11, and 5 were all directly degraded by USACE flood risk management (FRM) projects. The FRM projects at these sites converted natural streams into straight trapezoidal channels with little habitat diversity. Restoration of sites 15 and 11 will allow migratory fish to access the higher quality Upper Beaverdam Creek subwatershed. The Upper Beaverdam Creek subwatershed is not heavily populated and has the lowest level of imperviousness of all the Anacostia River subwatersheds resulting in the highest quality streams. In addition, site 5 on Paint Branch connects upstream to a completed USACE Continuing Authorities Program (CAP) Section 206 stream restoration project and better upstream habitat quality.

For the four accounts prescribed by the P&G, significant levels of restoration of aquatic habitat, fish passage, and connectivity would be provided under the Environmental Quality account for plans NW-C and NE-A. The National Economic Development account is not applicable. Regional Economic Development for these two plans would be provided through local construction but was not quantified as these benefits would not be significant. For the Other Social Effects account, while not quantifiable, benefits for NW-C and NE-A include improved educational opportunities and community health. Improvement of the aquatic and riparian condition of the streams within the MNCPPC's park systems translates to enhanced community health through creation of safer places for people to meet, recreate, and explore nature. The Anacostia Trail System adjacent to most of the stream sites is heavily used by the public for transportation and recreation. Improving greenways along these trails will increase community pride and potentially reduce negative human behaviors. There will be no negative adverse human health or environmental effects to minority or low income populations based on actions undertaken for this project, thereby supporting Executive Order 12898 for environmental justice.

In consideration of the P&G criteria, plans NW-C and NE-A are both cost effective and best buy plans and were considered the most efficient after analysis. These plans are acceptable as they are feasible and conform to applicable laws, regulations, and policies. In addition, these plans address ARP's candidate restoration projects (CRPs). The ARP CRPs are important components of the restoration effort underway by numerous agencies, watershed groups, and public volunteers. Appendix A includes a table showing ARP CRPs addressed by the sites in the recommended plan. Plans NW-C and NE-A are also considered complete plans as they account for all necessary investments or actions to ensure the realization of the planned effects within both subwatersheds. Plans NW-C and NE-A also meet the project objectives and avoid the project constraints. The combination of Plans NW-C and NE-A reflects the systems approach needed to provide a comprehensive solution for restoration of a larger portion of the watershed.

As a result of the comparison described in the preceding paragraphs, the combined plan NW-C + NE-A (Figure 3-8) was identified as the National Ecosystem Restoration (NER) Plan as it meets the planning objectives and constraints, reasonably maximizes environmental benefits while passing tests of cost effectiveness and incremental cost analyses, acceptability, completeness, efficiency, and effectiveness. The benefits of Plan NW-C + NE-A will provide significant restoration of habitat in the Anacostia River watershed.

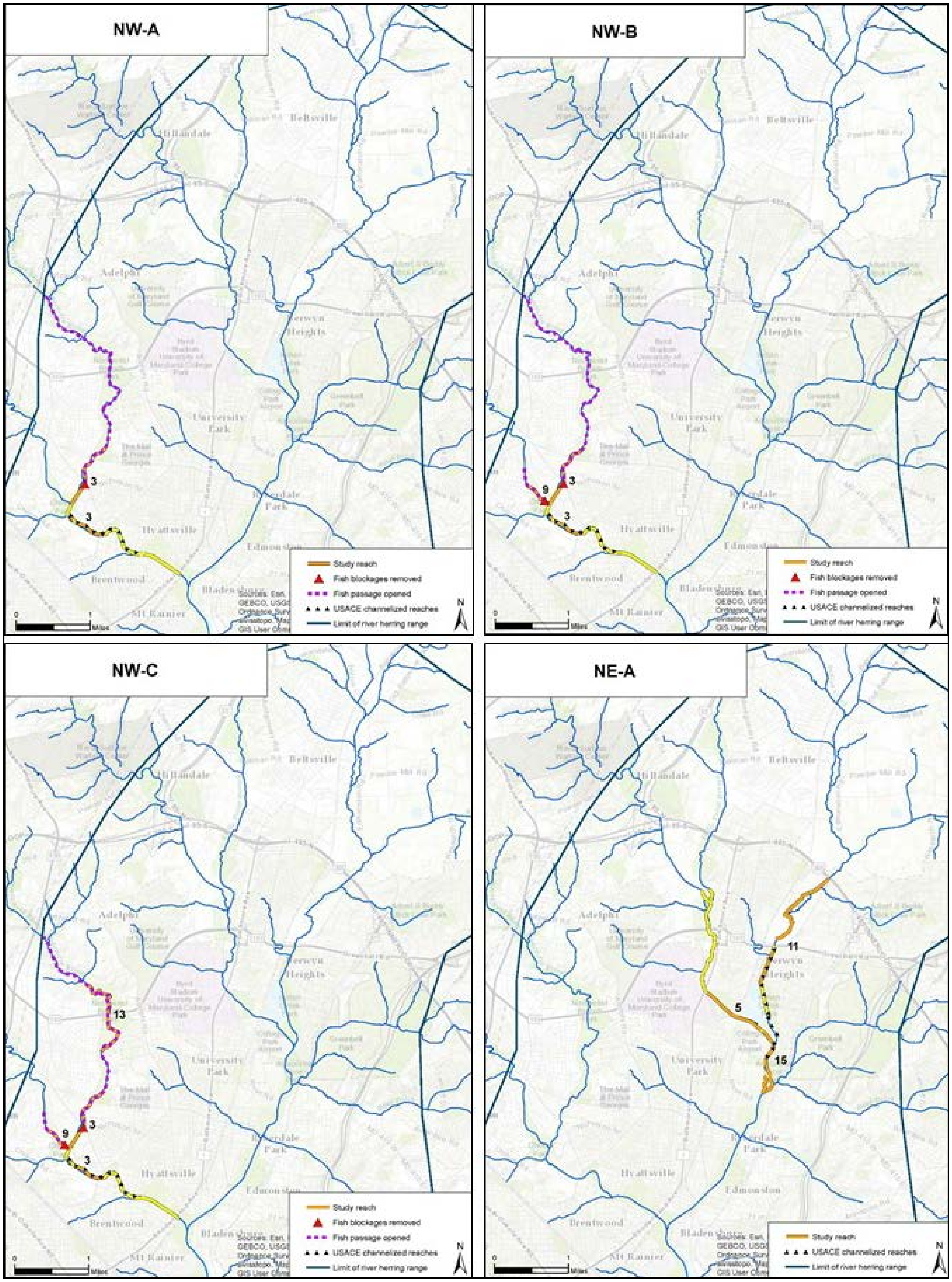


Figure 3-7. Alternative Plans NW-A, NW-B, and NW-C for Northwest Branch and NE-A for Northeast Branch.

3.6.2 The Recommended (NER) Plan

The recommended plan, NW-C + NE-A (Figure 3-8), includes sites 3, 9, and 13 in the Northwest Branch subwatershed and sites 11, 5, and 15 in the Northeast Branch subwatershed. With this plan, a comprehensive solution for the Northwest and Northeast Branch subwatersheds is proposed. The project stream reaches are located in a highly urbanized area of Prince George's County, where impervious cover is high and stream ecosystems have been fragmented over time by anthropogenic influences. Connectivity, or the connection of habitat patches, has long been recognized as a fundamental factor in determining the distribution of species (MacArthur and Wilson, 1967; Levin, 1974; Merriam, 1984). Plan NW-C + NE-A maximizes longitudinal connectivity by opening fish passage and connecting to streams that have been previously restored (including by USACE), thereby increasing the resilience of the aquatic system.

Figure 3-9 shows future-with-project conditions for stream quality and fish utilization. The restoration, which is at the downstream end of the Northwest and Northeast Branch subwatersheds will facilitate fish movement and utilization of approximately 14 miles of restored streams (including restored study sites and previously restored streams) and 11 miles of higher quality habitat upstream in the Northeast Branch subwatershed and into the Upper Beaverdam Creek subwatershed.

Table 3-12 shows the approximate length of stream historically available for anadromous fish migration (see table footnotes) compared to the length currently utilized by anadromous fish and the length of stream that will be more readily available for utilization (migration and spawning) following project restoration. The proposed restoration at sites 3 and 9 will eliminate fish blockages on both Sligo Creek and the mainstem of Northwest Branch, thereby opening approximately 4 miles of fish passage, including up to the historical limit of anadromous fish on Northwest Branch. On Northeast Branch, the restoration of site 15 will restore a critical nodal connection at the confluence of Paint Branch and Indian Creek. Restoration of this junction is important for the realization of the planned benefits upstream and to remediate habitat conditions at the site 15, including a sheet pile weir that, while not a complete blockage, may inhibit fish movement upstream.

Notably, over the past three monitoring seasons, for the first time since 1999-2004, schools of river herring (greater than 100 individuals) have been observed on Northwest Branch (see Figure 3-8) at U.S. Route 1, with smaller numbers seen up to 38th Street (just downstream of study site 3). Large numbers of shad have been observed at least up to U.S. Route 1. On Northeast Branch, river herring and shad have been observed up to River Road (just downstream of study reach 15). For shad, both young of the year (YOY) and adult fish were observed, indicating that spawning occurred in the vicinity (MWCOG, 2013; MWCOG, 2014). The presence of these fish potentially demonstrates the success of the implementation of various Mid-Atlantic States conservation plans (including the ARP), and previous fish passage projects and habitat improvements, including those implemented by USACE. With-project restoration will facilitate the movement of these fish upstream and increase the suitability of habitat for river herring spawning, nursery, and migration from 21 percent to 83 percent on Northwest Branch and from 10 percent to 90 percent on Northeast Branch, thereby helping to restore sustainable anadromous fish populations in the watershed. Additionally, with increases in fish passage and herring populations, there is a chance that fresh water mussel populations could increase in these streams.

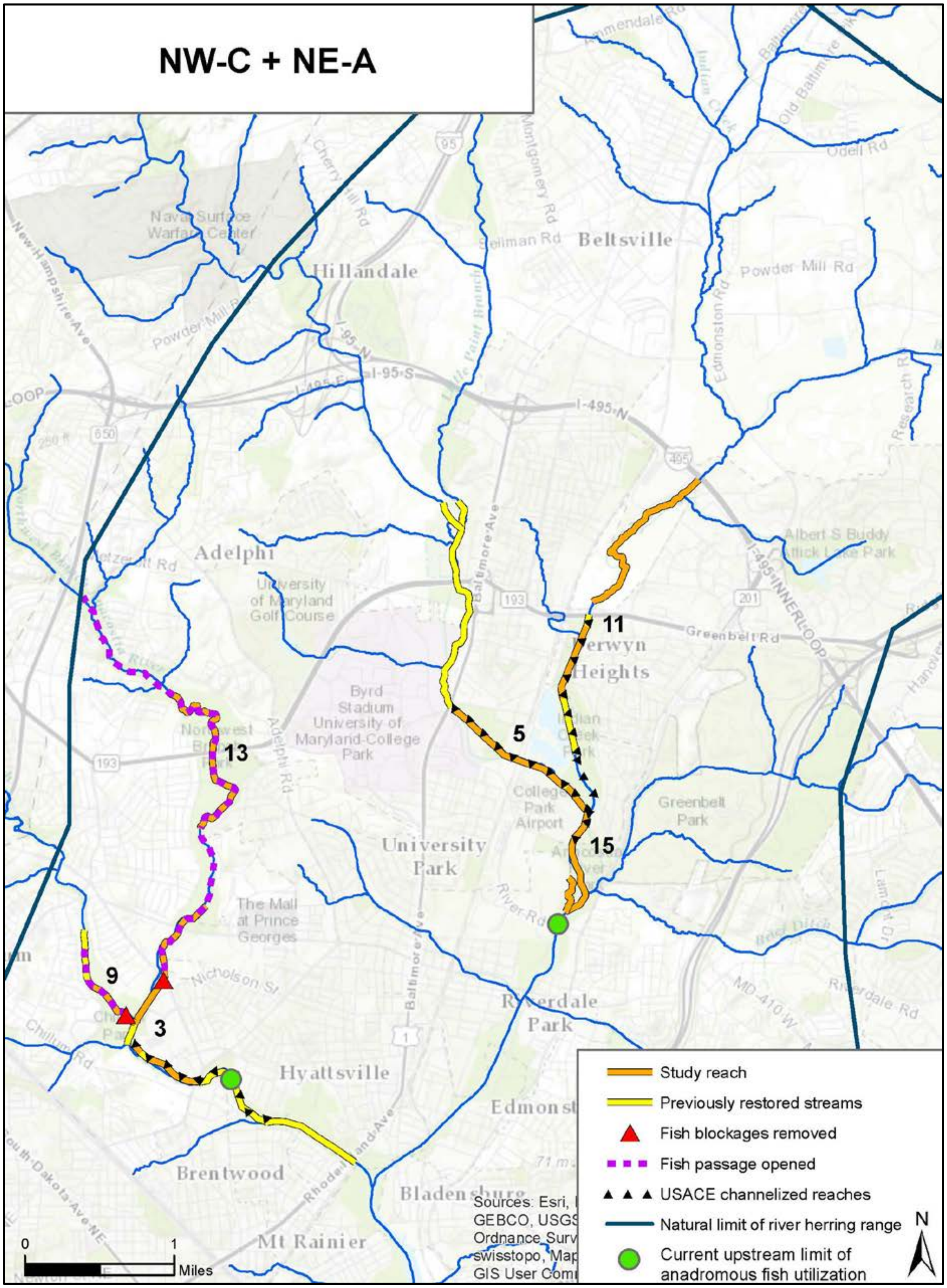
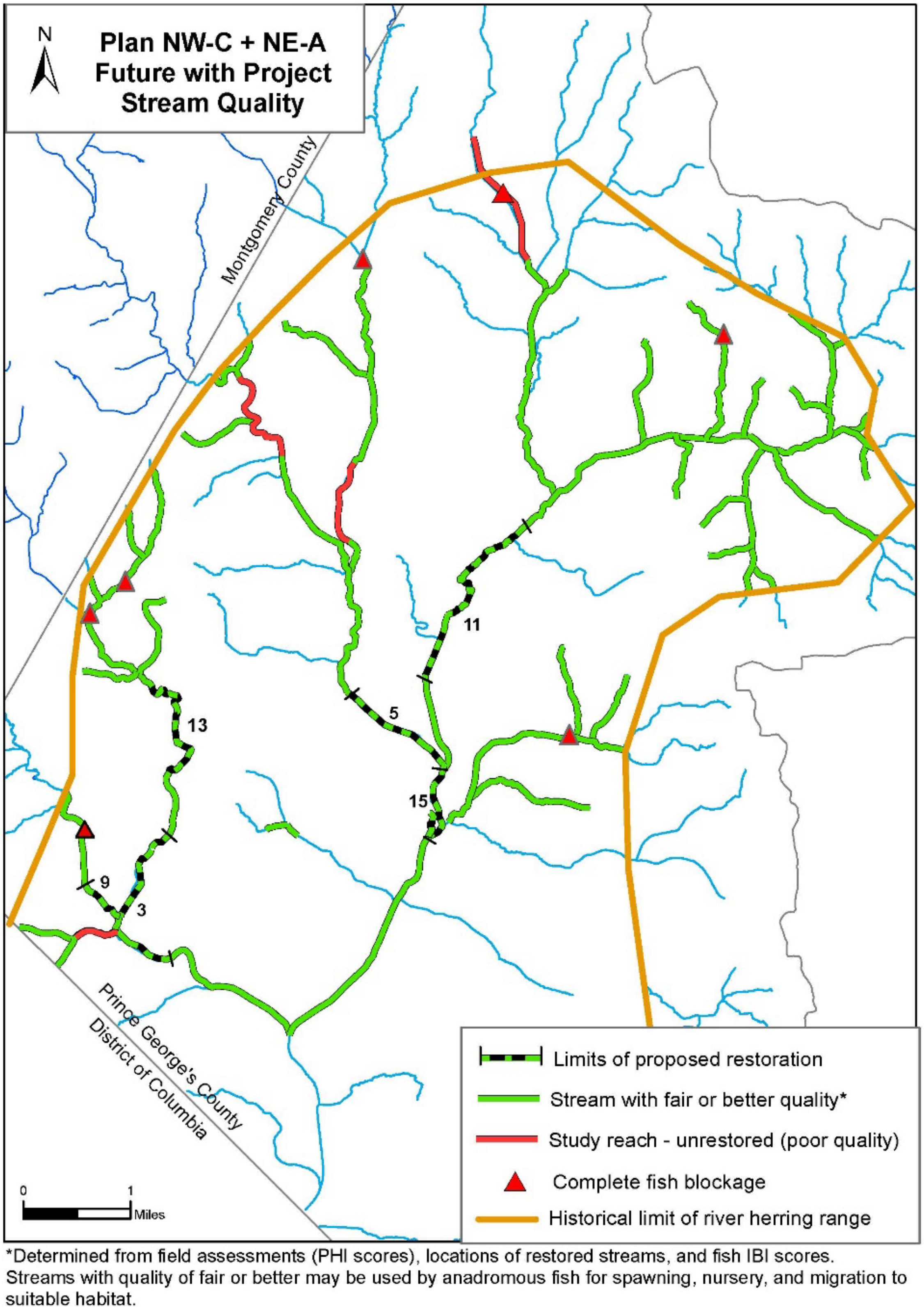


Figure 3-8. The recommended plan, Plan NW-C + NE-A.



*Determined from field assessments (PHI scores), locations of restored streams, and fish IBI scores. Streams with quality of fair or better may be used by anadromous fish for spawning, nursery, and migration to suitable habitat.

Figure 3-9. Future-with-project estimation of stream quality for anadromous fish utilization.

Table 3-12. The approximate historical, current, and with-project ranges of anadromous fish.

	Historical Range (mi)	Currently Utilized (mi)	With Project (mi)
Northwest Branch	6	1 (21%)	5 (83%)
Northeast Branch	23	2 (10%)	21 (90%)
Length of historical range measured from the confluence of the Northwest and Northeast Branches to the fall line in the west or the boundary of the Anacostia watershed in the east. Length currently utilized is based on MWCOG monitoring data. With project length estimated based on removal of blockages and restoration of habitat at sites that might limit upstream migration.			

In addition to the benefits provided for anadromous fish, riffles and pools, restored through the use of natural channel design, will form a diversity of aquatic habitats that provide the foundation for many of the biological and water quality functions that natural streams provide. Macroinvertebrates find habitat around rocks and coarse substrate, filtering food from the water column, and providing the base of the food chain. Fish utilize the pools and the overhead cover provided for protection and cooler water temperatures. The hyporheic zone, areas of the streambed and near stream aquifers through which stream water flows, has been identified as critically important in stream nutrient cycling, in moderating stream temperature regimes, and in creating unique habitats within streams. With increased stability provided by restoration activities, the streams are expected to establish a dynamic equilibrium that maintains habitat complexity and results in increases in species abundance and diversity.

Although wetland benefits could not be quantified for use in the CE/ICA, the project is expected to contribute to the reconnection of streams with their floodplains. This will increase wetted area and potentially aid in the reestablishment of wetlands. Implementing this project in the near term will help to restore aquatic communities through nutrient cycling and water retention, and will provide benefits to riparian wildlife including birds and amphibians.

3.6.3 Key Benefits of the Recommended Plan

The key contributions of the recommended plan, NW-C + NE-A, are summarized below:

- Restores approximately **7 miles** of in-stream habitat in Northeast and Northwest Branches;
- Restores approximately **4 miles** of fish passage through blockage removal;
- Reduced fragmentation and increases resilience in a splintered migratory corridor by connecting approximately **14 miles** of restored habitat and linking to **11 miles** of higher quality habitat upstream;
- Restores supportive habitat for river herring migration, spawning, nursery, and refuge and increases the availability of stream for anadromous fish utilization from approximately 21

to 83 percent on Northwest Branch and from 10 to 90 percent on Northeast Branch, thereby contributing to sustainable fish populations;

- Restores habitat at a critical node at the Paint Branch-Indian Creek confluence;
- Restores in-stream habitat at all four sites degraded by a 1970s USACE flood risk management project;
- Enhances prior federal investments by incorporating USACE restoration projects (e.g., Paint Branch CAP Section 206, Northwest Branch CAP Section 1135);
- Supports the Chesapeake Bay Executive Order, Chesapeake Bay Program outcomes, and Anacostia Restoration Plan goals by restoring habitat, fish passage, and wetlands in the Bay's contributing subwatersheds;
- Supports the Federal Urban Waters Partnership by reconnecting urban areas with their waterways and improving community health and cohesion.

3.7 Confirming the Recommended Plan

Upon agency endorsement of the Recommended Plan, the project moved into the feasibility level design phase, advancing the conceptual level (10 percent) designs and associated costs for sites in the recommended plan to the feasibility level (35 percent). After updating the costs to feasibility level costs (Appendix E for construction costs and Appendix G for real estate costs) and updating the benefits to use drainage area instead of stream width as the quantity factor (Appendix B), the recommended plan was confirmed by rerunning the CE/ICAs for the Northwest and Northeast Branches. The recommended plans for both branches were confirmed as Best Buy plans (Appendix F). Table 3-13 shows the SHUs (with units of acres) for all of the project alternatives following the revision in benefits. The change in the benefits calculation did not impact the recommendation of a plan as evidenced by the revised CE/ICA (Appendix F). The project costs discussed in the following sections of this report, are based on the feasibility level costs.

Table 3-13. Revised SHUs for all alternatives (* indicates alternatives in the recommended plan)

Northwest Branch Alternatives	AA Project Specific SHUs	AA Aggregate SHUs
3	0.51	16.88
3, 9	0.72	18.30
3, 9, 10	0.76	18.70
3, 13	1.37	16.88
*3, 9, 13	1.58	18.30
3, 9, 10, 13	1.62	18.70
Northeast Branch Alternatives	**AA Project Specific SHUs**	**AA Aggregate SHUs**
11, 15	1.64	8.37
*11, 15, 5	2.34	16.05
11, 15, 5, 7	2.88	18.23
11, 15, 5, 12	2.64	17.26
11, 15, 1	1.90	9.09
11, 15, 5, 1	2.60	16.77
11, 15, 5, 12, 1	2.90	17.98
11, 15, 5, 12, 7	3.18	19.44
11, 15, 5, 12, 1, 7	3.44	20.16

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4 PLAN IMPLEMENTATION

This Section presents plan components, including designs and implementation considerations for restoration of the sites included in the recommended plan (sites 3, 9, 13, 5, 11, and 15).

4.1 Plan Components

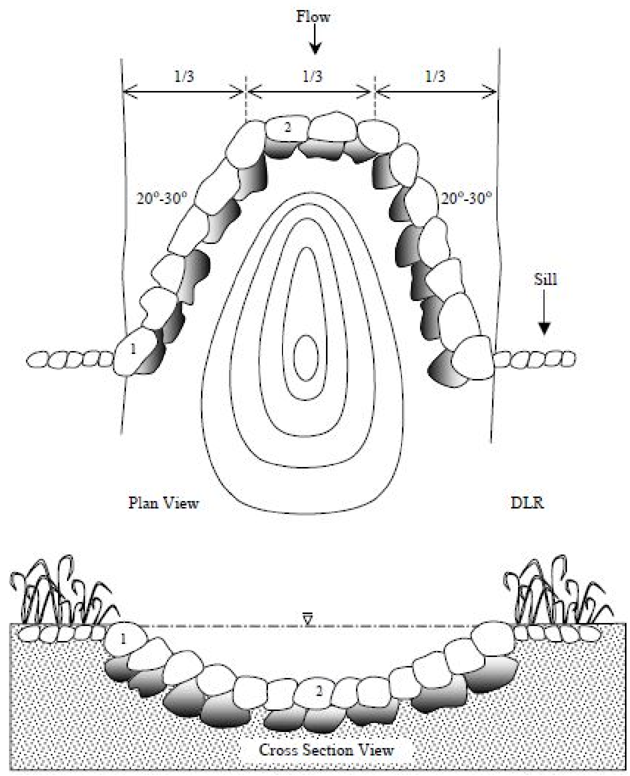
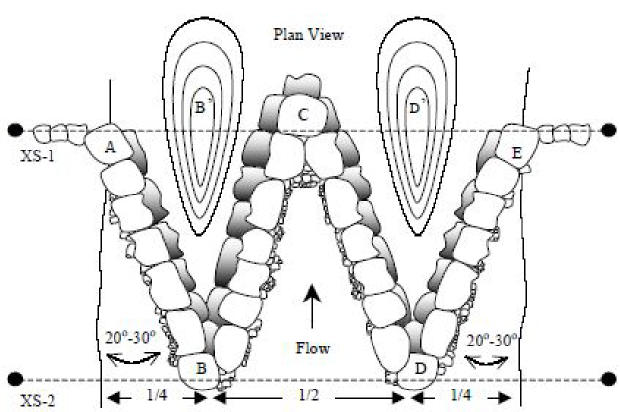
4.1.1 Feasibility Level Design and Modeling

Following review of public and agency comments, the TSP was endorsed by USACE and designs were advanced to feasibility level (35 percent design). This section includes the description of the designs from an engineering standpoint for each of the sites in the recommended plan (Table 4-1). Predicted changes in in-stream habitat (biologic conditions) were described in Section 3.5.2 with further detail in Appendix B. The full set of feasibility level design drawings are included in Appendix E. Impacts to the environment are described in Section 5.

The intention of stream restoration is to design a self-maintaining system that reduces bed and bank erosion and improves aquatic habitat. The designs will induce the formation of riffle-pool systems as appropriate to increase depth and velocity diversity, to improve potential fish habitat, and to eliminate fish barriers where they exist. Nested cross vanes will be constructed around fish blockages and utility crossings as necessary (placed on the downstream side of the crossing) to allow fish passage during all seasons. The proposed designs also include the creation of floodplain benches within the existing stream envelope to reconnect the stream with the floodplain, which will serve to reduce channel stress during higher flows. In some locations the streambed will be raised through the use of in-stream structures to aid in floodplain reconnection. HEC-RAS modeling, as described below, was performed to ensure flooding would not be induced by raising the stream bed and/or water level. Floodplain benches will be planted with native vegetation.

In-stream structures created using stone and logs will create narrower and deeper flow paths in the center of channel providing improved fish passage. The types of structures that will be used are described in Table 4-1. The in-stream structures are placed in a horseshoe formation, with the arms extended toward and tied into the banks. Geotextile is used on the upstream side of the structures behind the arms to minimize piping action during higher flow events. Structures are designed to accumulate varying sediment sizes where needed in order to meet project benefits for aquatic habitat. In locations where excessive sediment exists, sediment will not be dredged per se, but cut and fill will occur to restore a desirable channel pattern and profile.

Table 4-1. Descriptions and typical sections for in-stream structures.

Feature Description	Typical Plan and Section View
Cross vanes – rocks placed to guide the flow away from bank, to reduce bank erosion, promote local sedimentation, and encourage vegetation growth. Made up of a set of upstream angled lines of boulders, connected by a section of smaller rocks upstream. While water usually covers the shorter section during normal flows, the taller sections deflect flow away from the banks of the stream. Flow is diverted over the rock walls and concentrated down the center of the channel. The scouring associated with high flow velocities in the center of the channel and the "waterfalling" over the structure itself creates a deep, elongated pool. Cross vanes may also control the grade in meandering and step pool streams.	
W-Weir - similar to a cross-vane in that it maintains the grade of the streambed and provides aquatic habitat. The structure appears as a W formation in the downstream direction, similar to two cross-vanes joined in the center of the channel. The double-cross vane effect produces two thalwegs. The structure provides grade control, stabilizes stream banks, enhances fish habitat, and reduces bridge center pier and foundation scour.	

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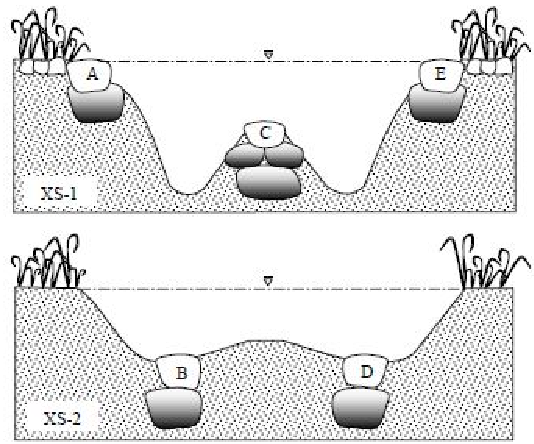
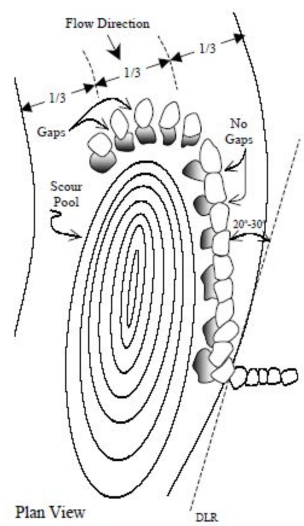
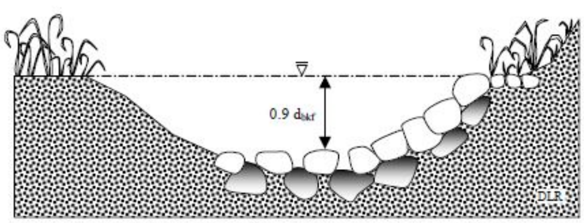
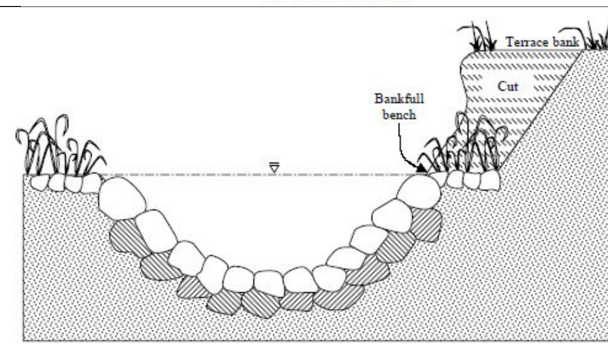
<tr><th>Feature Description</th><th>Typical Plan and Section View</th></tr>
<tr><td></td><td>
</td></tr>
<tr><td rowspan="2">J-Hooks - an upstream pointing line of rocks (or log) that originates at one bank and terminates somewhere in the middle of the stream. These direct flow to the center of the channel, taking stress off banks, and allowing for re-vegetation. Usually placed just downstream of where the stream flow encounters the streambank at acute angles.</td><td>
</td></tr>
<tr><td>

Cross Section View</td></tr>
<tr><td>Benches – For channels that are too wide and carry most of the flood flows within the channel, a flat terrace is created within a channel to reconnect the stream with its floodplain and reduce the stress of high velocity flows within the channel. Vegetation on the floodplain benches will provide stability and catch suspended sediment. Bankfull benches can also be created at bankfull elevation.</td><td>
</td></tr>
</table>

4.1.1.1 HEC-RAS Modeling

To support the development of the designs and evaluate the impacts of restoration actions on the water surface elevation (and flooding), the HEC-RAS model was run. In order to provide a geo-referenced, updated hydraulic model for the purposes of this study, a new HEC-RAS model was created for the study area. HEC-RAS, Version 5.0 was used to calculate water surface elevations for this investigation. The HEC-GeoRAS pre- and post-processor utilities were utilized to assist in the development of input data and the creation of floodplain mapping. The existing channel geometry was partially updated based on the HEC 2 model performed by Greenhorne and O'Mara, Inc. in 1993 for the Anacostia River Watershed Study. Two-foot GIS contours were also used to extend cross-sections on overbank areas. The existing channel geometry was updated based on 2-foot field run topography provided by Prince George's County in 2009. The proposed conditions geometry were modeled using the proposed profile and typical cross-sections within the limits of construction foot-print and limit of disturbance.

Appendix E contains the details for the HEC-RAS model methodology and results. Water surface elevations were evaluated for existing conditions, proposed conditions, design flood (for USACE FRM impacted reaches), and future-without-project conditions. No significant difference exists between existing and proposed water surface elevations. In general, for the 100-year storm event, the water surface elevation (WSEL) for most cross sections remained stable or decreased.

For reaches that were part of the USACE FRM project discussed previously (Sites 3, 11, 5, and 15), water surface elevations at cross-sections for relevant HEC-RAS stations were compared. In general, cross-sections exhibited a drop in water surface elevation for the proposed conditions during a 100-year storm. An evaluation of water surface elevations for these scenarios indicates that flows remain within the channel but with decreased freeboard in some cases.

4.1.1.2 HEC-RAS Sediment Impact Assessment Modeling

If not evaluated, features implemented to stabilize stream banks and reduce sediment yields to downstream areas can result in unexpected morphologic changes resulting from excessive erosion or aggradation in the channel. To assess the impact of the proposed restoration features, the Sediment Impact Assessment Model (SIAM) was run. SIAM, which is incorporated into HEC-RAS, performs reach average sediment transport computations by grain size class, and integrates the computed transport rates with flow duration information to compute an average annual sediment transport capacity in tons per year. This is compared with the average annual inflowing sediment load to evaluate sediment continuity for the reaches in the system.

Given the reaches in the recommended plan are short and the proposed improvements are spread out through the reach, the SIAM results are fairly simplistic. The comparison of the existing conditions run with the proposed conditions run indicates a trend, and, while the results yield a number, the number of tons per year, SIAM is not a sediment routing model. The bed cross-section does not update in response to the model results, and therefore the model cannot account for changing capacities in response to erosion or deposition. SIAM is only a screening tool for sediment budget assessment. The numbers reported should be treated cautiously and interpreted as general trends of surplus and deficit, not volumes of eroded or deposited material. It should also be noted that different methods analyzing the same reach go from depositional to erosional which is another is another factor to consider when looking at the results.

There are two transport methods that were selected to use within the analysis, they are the Ackers-White and Yang function methods. These two methods were selected as they were deemed more appropriate for the streams in this study as they both consider a larger range of materials that can occur within the study area. To better predict what the system would actually do, a 2D model would be needed, which is beyond the scope of this study. If it is determined that further analysis is required, a 2D model could be run during the preconstruction, engineering, and design phase of the project.

Model parameters required to run a SIAM analysis include: bed material, hydrology, sediment properties, sediment sources and hydraulics. Bed material for the sites comes from the sediment gradation curves produced from field samples taken from the stream bed and banks where materials change along the study reach. Because the project sites are relatively small and the materials are generally homogeneous, one sample for each site in the bank and bed were collected and accurately represent the study area. Appendix E details the SIAM outputs for each of the reaches in the recommended plan. SIAM predicts annual trends and is based on annualized flow durations.

4.1.1.2.1 Northwest Branch

Overall, the Northwest Branch (Sites 3, 9 and 13) shows an improved condition or a system closer to equilibrium under the with-project condition when considering the SIAM results (Table 4-2). For each of these systems with the exception of Site 13, the results show (in at least one method) a reduction in the amount of aggradation or degradation bringing the system closer to a neutral condition.

Table 4-2. Results of SIAM with two different methods for Northwest Branch.

Transport Method	Existing Conditions (tons/year)	Proposed Conditions (tons/year)	Result
Site 3			
Ackers-White	1460	2376	Improved Condition
Yang	-15900	-4635	Improved Condition
Site 9			
Ackers-White	426	-192	Negligible change, Close to Equilibrium
Yang	-3101	-1969	Improved Condition
Site 13			
Ackers-White	1054	1076	Negligible Change
Yang	741	697	Close to Equilibrium

4.1.1.2.2 Northeast Branch

The trend for the Northeast Branch (sites 5, 11 and 15) is an improvement under the with-project condition when considering the SIAM results (Table 4-3). For each of these systems, the results show (in at least one method) a reduction in the amount of aggradation or degradation bringing the system closer to a neutral system.

Table 4-3. Results of SIAM with two different methods for Northeast Branch.

Transport Method	Existing Conditions (tons/year)	Proposed Conditions (tons/year)	Result
Site 5			
Ackers-White	2300	2376	Negligible change
Yang	-12100	-5607	Improved Condition
Site 11			
Ackers-White	785	536	Negligible change
Yang	-385,000	-299,000	Improved Condition
Site 15			
Ackers-White	4102	3946	Improved Condition
Yang	-11,800	-9631	Improved Condition

4.1.1.3 Feasibility Level Design for Northwest Branch Subwatershed and Tributaries

The full set of feasibility level design drawing sheets are included in Appendix E. For spatial reference, Figure 4-1 provides an index of the design drawing sheet number, which are referred to (in parentheses) in Sections 4.1.1.3 and 4.1.1.4. Rosgen channel types (e.g., C4, Bc, etc.) referenced in the text are defined in Appendix E. To illustrate the types and locations of project structures as well as the clearing that will occur to access the project (described in Section 5), one design sheet per stream site has been included in this section (Figures 4-2 to 4-6).

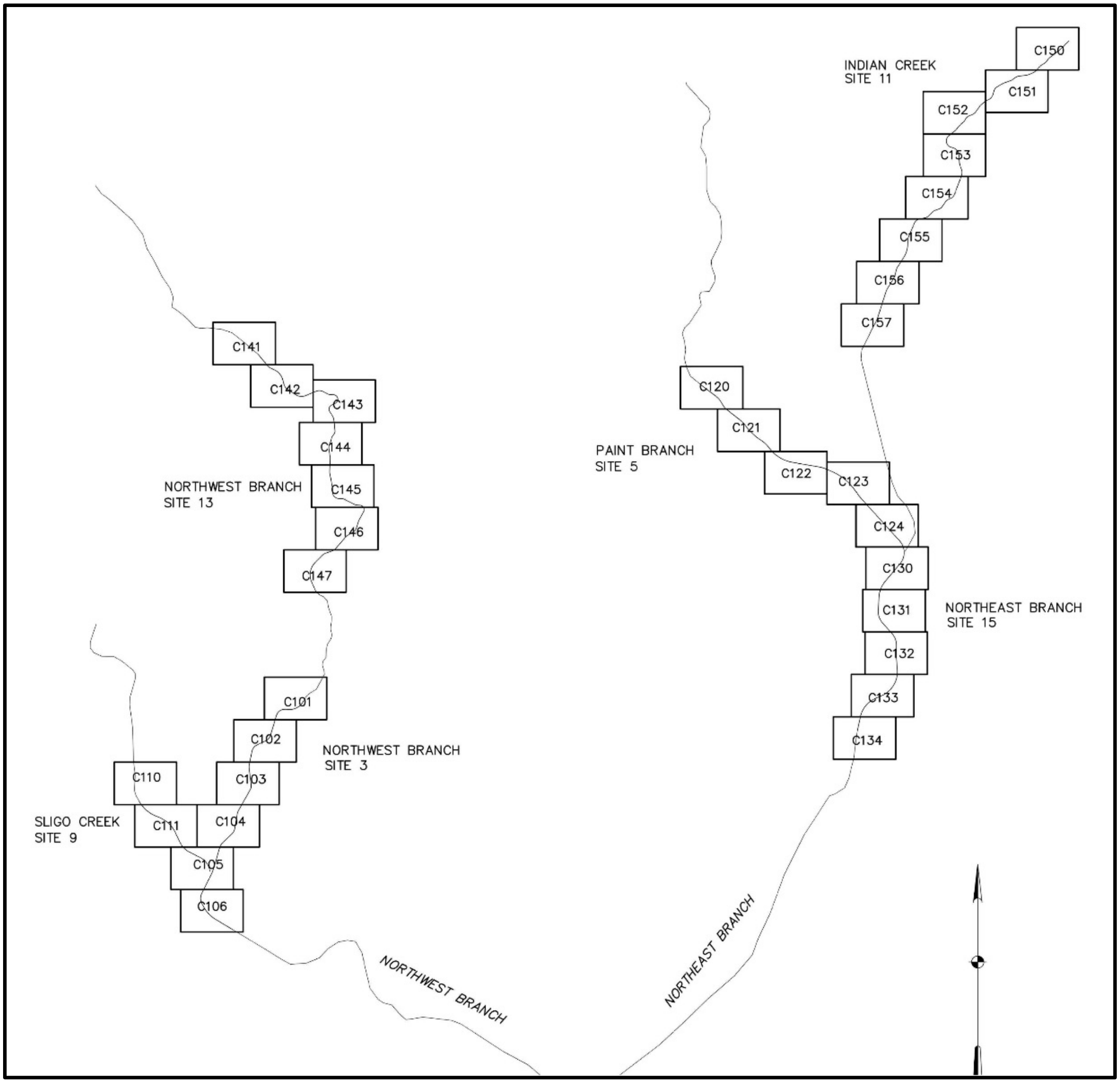


Figure 4-1. Sheet index and spatial reference for feasibility level design drawings and descriptions.

4.1.1.3.1 Northwest Branch (Site 3)

The reach starts upstream of East-West Highway, (MD Route 410), and has a total restoration length of 1.25 miles (6,600 feet). Based on the existing stream valley, a C4 channel (gravel bed stream with moderate sinuosity) is proposed. At the upstream end (C-101), the channel has been shifted slightly to the right to make room for floodplain benches, thereby reconnecting the stream with the floodplain. This also provides better conveyance, stability, diversity and reduced channel stress.

Twenty-one in-stream structures are proposed to provide bed and bank stability, maintain grade control, and reduce bank and bed erosion. These structures direct and dissipate high flow velocities into the center of channel. The structures maintain a low-gradient riffle pool system that provides for fish passage and long-term stability for low and high flows. Woody debris will be included in the design at a higher level of design to improve potential aquatic habitat.

Downstream of East-West Highway, a portion of the stream will be shifted to the left (C-102) and the pedestrian bridge located between East-West Highway and Ager Road will be relocated. The existing pedestrian bridge is skewed to the flow, constricting the hydraulic opening and causing a bottleneck and back eddies, which leads to lateral erosion. The relocation of the pedestrian bridge perpendicular to the flow will provide a better transition for flow under the Ager Road Bridge. A fish blockage caused by utilities encased in concrete is present under the Ager Road Bridge. This blockage will be ameliorated by the placement of a cross-vane downstream of the Ager Road Bridge, which will raise the streambed behind the structure to eliminate the drop at the encased concrete (C-103).

Downstream of the confluence with Sligo Creek (C-106), there are four existing riffle grade control (RGC) structures that provide protection for a number of utilities crossing the stream. This portion of the stream is part of the USACE flood control project from the 1970s. The proposed in-stream structures (three cross vanes and one J-hook) and bank grading will provide connectivity, improve the stability of the stream, and restore the depth and velocity diversity that was eliminated when the flood control project was implemented. Figure 4-2 provides one design sheets for site 3 as an illustration of the types of structures, contouring, and clearing that is proposed.

4.1.1.3.2 Sligo Creek (Site 9)

Given the slightly steeper slope of this reach, the proposed stream restoration for Sligo Creek is to create a Bc stream channel. The total restoration length of this reach is 0.47 miles (2,500 feet). Six in-stream structures are proposed to direct flow and improve stability. The furthest upstream structure close to the baseball fields (C-110 and C-111) is a modified J-hook (just downstream of an existing RGC) that will redirect the velocity vectors away from the eroding embankment on the right. Downstream of this is an existing failed cross vane constructed by WSSC (C-111). The permit for this construction (Washington Suburban Sanitary Commission/Consent Decree Project, Permit Number CENAB-OP-RMS 2011-61493) requires repair of the failed structure. It is anticipated that these repairs will occur prior to implementation of the restoration proposed by this project. Slightly downstream of the failed structure, two cross vanes are proposed to provide grade control and create a series of pools for fish resting and refuge.

Further downstream (C-105), closer to the Sligo confluence with Northwest Branch, two cross vanes are proposed. One cross vane will be placed downstream of the sheet pile that creates a fish blockage on Sligo Creek. This cross vane will ameliorate the fish blockage by raising the streambed behind the structure. This will also add stability to the system. In this vicinity, the stream is wide and shallow, causing difficulty for fish passage. The proposed structures will provide pools to improve potential fish habitat and enhance passage. Additionally, throughout the reach, within the existing stream envelope, benches will be constructed to relieve stress within the main channel. Figure 4-2 provides one design sheet for site 9 as an illustration of the types of structures, contouring, and clearing that is proposed.

4.1.1.3.3 Northwest Branch (Site 13)

A C4/E4 channel is proposed here due to the natural sinuosity created by the Piedmont-Coastal Plain physiographic province transition. This will reconnect the stream with its floodplain, utilizing a total of 32 in-stream structures for the restoration of this entrenched stream system. The total restoration length of this reach is 1.53 miles (8,100 feet). The restoration starts just upstream of the power line crossing. At the power line crossing (C-142), floodplain benches will be created on both sides of the stream, a tight meander bend will be softened (i.e., sinuosity will be reduced), and a pedestrian bridge will be relocated to reduce erosion and tree uprooting. Downstream of the power line crossing, a very tight meander will be replaced with a new more stable channel, with several cross vanes to increase stability, connectivity with the floodplain, and create a riffle-pool system for habitat complexity. Further downstream (C-143), cross vanes and J-hooks are proposed to maintain a moderately tight meander bend.

Two cross-vanes, one upstream and one downstream of the Maryland Route 193 Bridge are proposed to improve conveyance and provide stability during high and low flooding events (C-144). Extensive streambank plantings (willow cuttings) will improve aquatic habitat (i.e., root mass will provide stability and shelter for juvenile fish) in a segment of the stream that has an existing blanket of rip-rap on the bed and bank (C-145). Rip-rap will be not be removed here because it protects existing utilities and contains mature trees.

The lower portion of the project, downstream of an unnamed tributary, will be reconnected with the floodplain by constructing benches within the existing stream envelope and installing in-stream structures (cross vanes and J-hooks), modifying the stream cross-section, and raising the stream bed (C-147). This will also provide stability and improve connectivity. Figure 4-3 provides one design sheet for site 13 as an illustration of the types of structures, contouring, and clearing that is proposed.

4.1.1.4 Feasibility Level Design for Northeast Branch Subwatershed and Tributaries

4.1.1.4.1 Indian Creek (Site 11)

The total restoration length of this reach is 1.74 miles (9,200 ft). At the upstream (north) end of the reach, Indian Creek is channeled through culverts under three bridges for I-95/I-495 and Greenbelt Metro Drive (C-150). A nested cross-vane is proposed downstream of these culverts to provide grade control and to dissipate the high-energy flows through the culvert in a deep pool created by the cross vane. A higher width/depth ratio with a combination of alternating tree logs is proposed to provide for a calmer system and enhance potential fish habitat (C-150). The proposed design north of Cherrywood Court is limited by the presence of a rare (state listed endangered) plant in low-energy braided channels on the floodplain. Accordingly, the design here is largely confined to the main channel and has been discussed with MDDNR. Impacts to the plant are not expected (Section 5.4.4). Only a few structures are proposed in this area (C-151 to C-153) to maintain the natural characteristic of the stream and floodplain. Along and within the main channel, floodplain plantings with a combination of minor grading will provide additional shade and stability.

South of Cherrywood Court, as the stream gets closer to development, a single and wider channel is proposed to replace the braided system for a more controlled transition into the constrained environment. More in-stream structures, including cross-vanes and J-hooks, are proposed downstream (C-154 to C-157) to maintain stability and keep higher velocities within the channel. At the north end of a concrete plant (C-154), an existing pond (C-153) to contain stormwater outflow will be modified (deepened with invasive species removed) to improve habitat. Upstream of Greenbelt Road, adjacent to the concrete plant, a confined concrete channel exists, which will be removed (C-155). Downstream of the Branchville Road and Greenbelt Road culverts, a nested cross-vane is proposed downstream of an existing riffle grade control (C-155 and C-156). The cross-vane will have a longer left arm to direct the flow to the right, away from the eroded embankment. The design proposes a minor shift of the stream to the right to create a floodplain bench with plantings on the left side, which will increase stability and improve conveyance through the Berwyn Road single span bridge (C-157). Two nested cross-vane are proposed downstream of the Berwyn Road Bridge to improve fish passage and bed stability. The structures will reduce scour at the Berwyn Road Bridge. This portion of the reach (from Greenbelt Road down to the confluence with Paint Branch) was previously channelized by USACE. The proposed design will decrease erosion; thereby, reducing the downstream sediment load and improving the quality of fish habitat. Figure 4-4 provides one design sheets for site 11 as an illustration of the types of structures, contouring, and clearing that is proposed.

4.1.1.4.2 Paint Branch (Site 5)

Eighteen in-stream structures are proposed for to this system to restore a functional C4 channel. The total restoration length of this reach is 1.19 miles (6,300 feet). Much of the purpose of these structures is to restore the aquatic habitat complexity that was lost when USACE straightened and channelized this reach for flood risk management purposes in the 1970s. At the furthest upstream portion of the reach, a cross-vane is proposed to maintain grade outside the existing Maryland Route 1 bridge right-of-way (C-120). This will increase the sinuosity of the stream and will add diversity of depth and velocity to the system while moving the stream away from the WSSC assets (sewer lines) located within the right bank. Several structures including cross vanes and J-hooks will improve stability (C-120 to C-122). Woody debris is proposed along this reach to improve potential aquatic habitat and enhance the aesthetics of the system to better blend in with the park setting.

A W-weir is proposed downstream of the railroad bridges (C-122) because the channel is so wide in this location and the flow is divided by a sediment bar. The W-weir will carry the base flow on one side and will become active on both sides during high flow. The weir will provide stability, as the bridge opening is twice as wide as the stream in this area. As the stream gets closer to southeast end of Lake Artemesia, the stream will be shifted away from the lake using J-hook with a cut-off sill to create a wide floodplain bench, which will prevent lateral erosion toward the lake and reconnect the stream with the floodplain (C-123).

A pedestrian bridge exists south of Lake Artemesia (bottom of C-123). Just upstream of the pedestrian bridge the stream is eroding into the right embankment behind the right bridge abutment. Dimension, pattern, and profile adjustment is necessary to eliminate the accumulation of sediment upstream of the bridge. The stream will be adjusted here using a cross-vane to direct the flow to the center of the channel and away from the banks. Sediment will be cut from the large sediment bar. The existing notched sheet pile structure downstream of the bridge will be removed (C-124). The downstream end of the reach is at the Paint Branch-Indian Creek confluence (C-130), where the Northwest Branch is formed (this is the upstream end of Northeast Branch).

As indicated in Section 2.6.4, restoration of a portion of Paint Branch is being evaluated for mitigation for the Purple Line project; however, neither MDE nor USACE through their Regulatory capacities have authorized the mitigation project to date. The status of this project will be reevaluated during preconstruction, engineering, and design (PED). Should the mitigation project move forward, this portion of Paint Branch will not be included for implementation by USACE and Prince George's County; however, this will not affect plan formulation as benefits will be retained through the accounting of aggregate benefits (connectivity). Figure 4-5 provides one design sheet for site 5 as an illustration of the types of structures, contouring, and clearing that is proposed.

4.1.1.4.3 Northeast Branch, Calvert (Site 15)

Site 15 begins at the confluence of Paint Branch and Indian Creek to form Northeast Branch (C-130), with a total restoration length of 0.89 miles (4,700 ft). The upper portion of the reach, north of Calvert Road was impacted by the USACE flood risk management project, which widened and deepened the channel. As a result of the overwidened channel, sediment bars have formed. Just downstream of the Paint Branch and the Indian Creek confluence (C-130) a W-weir will be installed at the location of a large sediment bar (and utility crossings protected by gabion baskets). This will increase habitat depth and diversity by creating a deep pool. The W-weir will carry the base flow on the right side of the weir, but during high flow events, the left side will become active.

Downstream of the weir, eight in-stream structures (five cross-vanes and three J-hooks) will provide grade control and direct the flow to the center of the stream for stabilization of the stream banks (C-130 to C-134). Existing gabion baskets within the stream at Campus Drive will be covered with sediment after the construction of a cross vane downstream of Campus Drive (C-131). The proposed structures, combined with the addition of tree logs, will enhance aquatic habitat and diversity in depth and velocities for a functional system. Additionally, floodplain benches along the stream at several locations, including at the inside of the meander bend across the stream from the MNCPPC office, north of River Road (C-133), will reconnect the stream with the flood plain. At the meander bend north of River Road, a series of small pools will be excavated on the floodplain. This area will be planted with native wetland vegetation. A cross vane placed downstream of the River Road bridge will enhance fish passage through the notched sheet pile under the River Road bridge (C-134). The reach ends just south of River Road. Figure 4-6 shows one design sheet for Site 15 as an illustration of the types of structures, contouring, and clearing that is proposed.

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Figure 4-2. Design Sheet #105 - An example of structures, contouring, and clearing for Site 3 and Site 9, at the confluence of Sligo Creek (left) and Northwest Branch (right).

Figure 4-3. Design Sheet #143 - An example of structures, contouring, and clearing for Site 13 on Northwest Branch.

Figure 4-4. Design Sheet #154 - An example of structures, contouring, and clearing for Site 11 on Indian Creek.

Figure 4-5. Design Sheet #123 - An example of structures, contouring, and clearing for Site 5 on Paint Branch.

Figure 4-6. Design Sheet #131 - An example of structures, contouring, and clearing for Site 15 on Northeast Branch.

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4.1.2 Post-Project Monitoring

Current policy for monitoring and adaptive management is presented in planning guidance, including Engineering Regulation (ER) 1105-2-100, Engineering Circular (EC) 1105-2-409, and Implementation Guidance for Section 2039 of the Water Resources Development Act of 2007 - Monitoring for Ecosystem Restoration (USACE, 2009). Per Section 2039 of the Water Resources Development Act of 2007 (WRDA 2007), feasibility studies for ecosystem restoration are required to include a plan for monitoring the success of the ecosystem restoration and to determine if the ecosystem restoration outputs/results are satisfactory or if adjustments are needed. The Monitoring Plan, included in Appendix H was developed in accordance with this guidance.

Monitoring includes the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management may be needed to attain project benefits.

Monitoring will be carried out to evaluate physical (stream habitat), biological (fish), and vegetation (wetlands, riparian vegetation) parameters. Monitoring will include up to five rounds of post-construction sampling, within ten years following completion of construction. Monitoring will occur in years 1, 3, 5, 8, and 10. Physical habitat monitoring will occur in those years to evaluate epibenthic substrate, in-stream habitat, in-stream woody debris and rootwads, erosion extent and severity. Cross-sectional topographic surveys will be conducted to evaluate channel stability. Finfish monitoring will be carried out to determine FIBI and to evaluate the success of fish blockage removal (i.e., whether river herring and other associated anadromous fish are migrating upstream of former blockages). These parameters are selected for monitoring because they are projected to be responsive to project implementation and representative of the physical and biological health of the project sites and stream networks. Appendix H provides a discussion of the success criteria, monitoring timeframes, and methods. Table 4-4 provides a summary of the parameters, success criteria, and timeframes for the monitoring effort. Success criteria include improvement in individual physical habitat parameters (MBSS Physical Habitat Index) to the sub-optimal or optimal stage (see details in Appendix H). Sampling is expected to occur during the spring of each year over multiple dates and times to capture different flows and patterns of migration. Fish sampling will be conducted using electroshocking equipment.

In addition to conducting monitoring for evaluation of whether project objectives have been achieved, monitoring will be conducted to ensure that the project meets the intent of the Nationwide Permit 27 (additional discussion in Section 5), which includes a net increase in aquatic resource functions and services. To ensure that gains are realized in terms of stream and wetlands impacts and benefits, wetlands and vegetation monitoring will be performed. This will include assessment of floodplain connectivity, vegetative cover, invasive species, and wetlands delineation (Table 4-4).

Table 4-4. Monitoring parameters, success criteria, and timeframes for monitoring.

	Parameter	Success Criteria	Monitoring Years
Physical	Epibenthic substrate	Score of >11 (sub-optimal)	1, 3, 5, 8, 10
	Instream	Score of >11 (sub-optimal)	1, 3, 5, 8, 10
	Woody debris/rootwads	Maximize	1, 3, 5, 8, 10
	Erosion extent and severity	None to minimal severity (score of 0 or 1)	1, 3, 5, 8, 10
Biological	Presence of anadromous fish above blockage	Presece	1, 3, 5, 8, 10
	F-IBI	Improved over pre-construction conditions	1, 3, 5, 8, 10
Wetlands and Vegetation	Floodplain connectivity	Bank/height ratio <1.2	AB, 5
	Vegetative cover	>85% cover in LOD	1,3,5
	Invasive species	Less than baseline	PED, 1, 3, 5
	Wetlands	Hydrology indicators present; hydric soils present; wetland vegetation dominance (greater than 50% are either OBL, FACW, and/or FAC)	PED, 5

AB=As-built, PED=Preconstruction

To evaluate the success of the stream restoration measures, collaborative monitoring efforts and information sharing would occur between the team, the non-federal sponsor, and other organizations involved in assessing the health of the stream. Prince George's County already has a sampling program for the Anacostia River watershed as part of their Biological Assessment and Monitoring Program, which assesses the health of County streams. Sites are sampled using the IBI methodology for fish and benthic macroinvertebrates. Coordination with the County will occur to align monitoring carried out to access this project with County-led annual sampling efforts.

Per Memorandum on Implementation Guidance for Section 2039 of the Water Resources Development Act of 2007, Monitoring for Ecosystem Restoration (USACE 2007), the estimated cost of the proposed monitoring program will be included in the project cost estimate and cost shared accordingly. Cost shared monitoring can (but is not required to) continue for a period of up to 10 years. For estimation of monitoring costs for this project, monitoring costs for the baseline sampling conducted by Tetra Tech in 2015 for this project were evaluated. Other costs were established in consultation with the project delivery team. A breakdown of monitoring costs are shown in Tables 4-5, 4-6, and 4-7. Monitoring costs total $570,000 plus contingency for a total cost of $664,000 (see Total Project Cost Summary in Appendix E). These costs are assumed to occur over the first ten years of the project and included in the project cost estimate accordingly.

Table 4-5. Monitoring cost breakdown for physical habitat and biological sampling.

Task	Cost (per year for all sites)
Study Mobilization	$3,000
Field Sampling	$30,000
Laboratory Processing (Sorting and Taxonomy)	$10,000
Data Entry/Management/Analysis	$11,000
Report	$14,000
ESTIMATED PER YEAR OF MONITORING	$68,000
TOTAL COST FOR 5 ROUNDS OF MONITORING	**$340,000**

Table 4-6. Monitoring cost breakdown for topographic surveys.

Task	Cost (per year for two cross sections per site)
Establish vertical control benchmark on-site*	$23,000*
Survey cross sections in field	$17,000
Office work to generate cross sections	$17,000
Generate Report	$2,900
ESTIMATED FIRST YEAR OF MONITORING	$60,000
ESTIMATED SUBSEQUENT YEAR OF MONITORING	$37,000
TOTAL COST FOR 5 ROUNDS OF MONITORINNG	**$208,000**
*required only for first year of monitoring	

Table 4-7. Monitoring cost breakdown for wetland and vegetation monitoring.

Task	Cost
Bank height ratio (in conjunction with surveys)	NA
Vegetative cover and invasive species assessment (2 people for two days in years 1 and 3; year 5*)	$10,000
Wetland Delineation - labor and post-processing (2 people for one week in year 5)	$12,000
TOTAL COST	**$22,000**
*cost included with wetlands delineation for year 5	

4.1.3 Adaptive Management

Adaptive management addresses the uncertainties about a project's performance that exist when implementation decisions are made to undertake a water resources project. This technique allows decision making and implementation to proceed with the understanding that outputs will be assessed and evaluated and that some structural or operational changes to the project may be necessary to achieve desired results. A key element of adaptive management is an appropriate monitoring program to determine if the outputs/results are satisfactory, and to determine if any adjustments are needed. The Monitoring Plan is described in Section 4.1.2.

The preliminary Adaptive Management and Monitoring Plan is included in Appendix H. The primary intent of the Adaptive Management Plan is to develop adaptive management actions appropriate for the project's restoration goals and objectives. Per Section 2039 of the Water Resources Development Act of 2007 (WRDA 2007), feasibility studies for ecosystem restoration are required to include a contingency plan (Adaptive Management Plan) for all ecosystem restoration projects in order to make corrections to the project if planned benefits are not being realized. The preliminary Adaptive Management Plan in Appendix H was developed in accordance with implementation guidance for WRDA 2007. The plan identifies and describes the adaptive management (contingency) activities proposed for the project and estimate their cost and duration. The plan will be further developed in the PED phase as specific design details are made available.

Recently completed projects have demonstrated that improvements in PHI are achievable with geomorphic stream restoration. Physical characteristics of the project such as the type of substrate, height of structures, presence of rootwads, and depth of riffle/runs can be controlled during construction, but colonization with epibenthics and embeddedness is much less certain. Monitoring will determine if ecological success has been achieved, while adaptive management actions are the contingency plan that allow for post-construction adjustments.

It is anticipated that minimal adaptive management measures would need to be taken due to the type of structures and design philosophy. The designs are intended to aid in the re-establishment of a new dynamic equilibrium for the stream, and not necessarily to lock the stream into its channel. Likely measures that may be needed are changes to elevation of structures or minor changes to structure locations. Most adaptive management actions that stem from normal conditions are anticipated to be minimal in effort; however, an unusually strong storm that occurs prior to establishment of vegetation and project features could cause damage to a project site that would need to be ameliorated. Following storm events, site visits will be performed by visual inspection to assess the stability and location of the structures.

Adaptive management activities may necessitate re-accessing the streams in order to adjust the lateral position or height of structures installed in streams to ensure proper hydrologic conditions. Similarly, if hydrologic profiles result in scouring, erosion, or sediment deposition that result in poor PHI scores or poor IBI scores structures, bank profiles, or other constructed features will require adjustment. Poor PHI scores and/or IBI scores will need to be evaluated on a case by case basis to determine what has influenced them and what actions will be required for a remedy.

Triggers for adaptive management are defined by targets set for the monitoring metrics (details in Appendix H). If monitoring determines the need for adaptive management, the technical team will be convened to discuss the necessity and type of actions. Additionally, depending on a visual assessment of the integrity of in-stream structures, the scope of the adjustment or repair will be determined. Undesirable changes in the physical habitat metrics would likely result in a minor adjustment (shifting the location or height or height of parts of a structure) to induce favorable conditions. More substantial adjustments could be made if structures are undermined or the stream shows signs of instability. The designs are geared toward functional stream channel dimensions that do not promote excessive aggregation or degradation during normal and high flood flows, but allow sediment to accumulate where desired. The proposed in-stream structures will provide grade control (bed stability) and bank stability. Cross sectional measurements and evaluation of erosion extent and severity will indicate whether instability is present. If instability is present, adaptive management actions may be needed. This will be determined on a case by case by the technical team. Adaptive management actions could be necessitated by flooding during large storm events. Structures will be visually assessed following extreme storm events. Storms have the potential to undermine structures by inducing scour around tie-in points with the bank, and by dislocating parts of the structure in the center of the channel. Furthermore, if there are significant problems with the performance and function of the project, the design would be revisited.

Monitoring for the reestablishment of wetlands will include vegetation monitoring and wetland delineations and an assessment of hydrology, hydric soils, and vegetation. If one or more of these indicators are not present in areas where wetlands were expected to reestablish, the technical team will be convened to evaluate the potential reasons preventing these conditions. Should the technical team determine that hydrology or hydric soils are the limiting factor, adjustments to the project design, including adjustments to structures that control grade or retain or redirect water could be made. Vegetation monitoring, including monitoring for cover and invasive species, will indicate whether a desirable plant community is being maintained. Because of the prevalence of invasive species in the project areas, it will be necessary to actively manage the establishment of riparian vegetation. This will be done through the planting contract, which will include a warranty for plant growth and survival for a five year time period. Plants not in a live and healthy condition shall be replaced by the contractor during this period, and a prevalence of native plants will be ensured. An analysis of the source of plant mortality and stressors will be made. Different species could potentially be planted that have a better chance of survival based on cause of mortality.

Given the uncertainty associated with the settling of structures or the potential for large storm events, contingency has been estimated for adaptive management actions that include adjustment of 100 tons of rock over 500 feet of stream per site (Table 4-8). Adjustments to structures will be made with small vehicles (e.g., bobcats) and will need to be surveyed or profiled. Adaptive management costs are estimated at $328,000 plus contingency for a total of $433,000 (see Total Project Cost Summary in Appendix E). These costs are included into project first costs and are cost shared with the non-federal sponsor.

Table 4-8. Contingency (adaptive management) costs.

Task	Cost
Vane, j-hook repairs, including 100 tons of rock Stabilization measures for in stream structures (wooden logs), 500 linear feet Site protection and erosion control measures (construction and silt fencing)	$328,000 (total for all sites)
Replanting and/or invasive species management	**
TOTAL FOR ALL SITES	**$328,000**
**To be covered under planting contract	

4.2 Local Cooperation

As the non-federal project sponsor, Prince George's County, Maryland, must enter into a contractual design agreement (DA) with USACE. The DA will carry the project through the PED phase, including development of project plans and specifications (P&S). A project management plan (PMP) will be prepared to identify tasks, responsibilities, and financial requirements of the Federal Government and non-federal sponsor during PED.

The PED phase will be followed by execution of a project partnership agreement (PPA) by Prince George's County, Maryland. The PPA will carry the project through advertisement, award, construction, and turnover to the non-federal sponsor for operation and maintenance. The construction PPA cannot be executed prior to project construction authorization by Congress. In addition, funds must be appropriated by the Federal Government and budgeted by Prince George's County to support PED and construction related activities. A draft project schedule has been established based on reasonable assumptions for the design and construction schedules, in accordance with the Administration and USACE policy requirements (Section 4.4).

The Anacostia Watershed Restoration, Prince George's County, ecosystem restoration project requires construction authorization by Congress, which most likely will be provided in a WRDA. Following Congressional authorization, the project will be eligible for construction funding. Project construction funding will be considered for inclusion in the President's budget on the basis of national priorities, magnitude of federal commitment, economic and environmental feasibility, level of local support, willingness of the non-federal partner to fund its share of the project cost, and budgetary constraints that may exist at the time of funding.

As the non-federal sponsor, Prince George's County must comply with all applicable federal laws and policies and other requirements, including but not limited to:

a. Provide, during design and construction, funds necessary to make its total contribution for ecosystem restoration equal to 35 percent of the total project cost;

b. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material as determined by the Federal Government to be required or to be necessary for the construction, operation, and maintenance of the project;

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

d. Operate, maintain, repair, rehabilitate, and replace the project at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government;

e. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

f. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

g. Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, and other evidence are required, to the extent and in such detail as will properly reflect total cost of the project, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and local governments at 32 CFR, Section 33.20;

h. 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 USC 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction or operation and maintenance of the project;

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

j. Agree, as between the Federal Government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA;

k. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, (42 U.S.C. 1962d-5b) and Section 101(e) of the WRDA 86, Public Law 99-662, as amended, (33 U.S.C. 2211(e)) which provide that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element;

l. 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. 4601- 4655) and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way necessary for construction, operation, and maintenance of the project including those necessary for relocations, the borrowing of material, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

m. Comply with all applicable Federal and state laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c));

n. Not use the project or lands, easements, and rights-of-way required for the project as a wetlands bank or mitigation credit for any other project;

o. Not use funds from other Federal programs, including any non-federal contribution required as a matching share therefore, to meet any of the non-Federal sponsor's obligations for the project unless the Federal agency providing the funds verifies in writing that such funds are authorized to be used to carry out the project.

4.3 Cost Estimates and Cost Sharing

Total project costs at fiscal year 2019 price levels are $34,106,000. The total fully funded cost of the project, with escalation through the mid-point of construction, is $38,395,000. Table 4-9 shows the apportionment of cost sharing responsibilities between the Federal Government and non-federal sponsor, Prince George's County, Maryland, based on project first costs at fiscal year 2019 price levels. The table includes costs associated with project construction and real estate considerations. The total project costs, including lands, easements, rights-of-way, and relocations (LERR), are shared on a maximum 65 percent basis by the Federal Government and a 35 percent basis by the non-federal partner. The Federal Government will design the project, prepare detailed plans/specifications and construct the project, exclusive of those items specifically required of the non-federal sponsor.

The non-federal sponsor is responsible for the relocation of bridges, all LERR, and all operation and maintenance (O&M) costs. However, the LERR costs are applicable to the non-federal share of the initial costs. For example, the total LERR costs ($1,257,000) borne by the non-federal sponsor are applicable to the 35 percent share of the total initial non-federal project costs.

In this particular case, the non-federal sponsor's responsibility for LERR costs ($1,257,000) does not exceed 35 percent of the total project costs. An additional cash contribution of $10,680,000 is required to bring the non-federal contribution to 35 percent of total project costs.

Table 4-10 presents the project costs and benefits annualized over a 50-year period.

Table 4-9. Cost apportionment – Federal and non-Federal responsibilities.

Total Project Cost (rounded)	**$ 34,106,000**
Total Federal Share (65%)	**$ 22,169,000**
Total Non-Federal Share (35% plus relocation of bridges)	**$ 11,937,000**
100% Lands and Damages	$ 360,000
100% Relocations	$ 897,000
Cash Balance	$ 10,680,000

Fiscal Year 2019 Price Levels.

Table 4-10. Average annual costs and benefits.

Federal Discount Rate FY19 = 2.875%, 2019 Price Levels, 50-Year Period of Analysis			
Element	**NE-A**	**NW-C**	**Total**
Project First Costs			
Construction	$ 13,147,000	$ 13,051,000	$ 26,198,000
Relocations	$ 897,000	$ 0	$ 897,000
Adaptive Management	$ 212,000	$ 237,000	$ 449,000
Design	$ 1,982,000	$ 1,888,000	$ 3,870,000
Real Estate	$ 108,000	$ 252,000	$ 360,000
Construction Management	$ 1,199,000	$ 1,133,000	$ 2,332,000
Total Project First Costs	**$ 17,545,000**	**$ 16,561,000**	**$ 34,106,000**
Average Annual Costs			
Construction	$ 665,800	$ 628,500	$ 1,294,300
Interest during construction	$ 7,900	$ 7,500	$ 15,400
Annual OMRR&R	$ 10,800	$ 11,200	$ 22,000
Total Average Annual Cost	**$ 684,500**	**$ 647,100**	**$ 1,331,700**
Average Annual Benefits			
Project Specific SHUs	1.58	2.34	3.92
Aggregate SHUs	18.3	16.05	34.35
Total SHUs	**19.88**	**18.39**	**38.27**

*Costs in fiscal year 2019 price levels with updated contingency, PED, and construction management assumptions.

4.4 Project Implementation Schedule (Draft)

The project implementation schedule is based on information available to date, and is largely dependent on when the project receives funding, as well as authorization through a WRDA. The current construction schedule estimates the recommended stream restoration will be complete prior to the Chesapeake Bay Executive Order goals in 2025. The estimated implementation schedule is provided below:

- Complete Feasibility Phase - 2018
- Project Construction Authorization – 2018 (earliest, assuming WRDA every two years)
- PED Phase - 2020 to 2021 (pending 2019 funding); includes design agreement and plans and specifications; non-federal sponsor secures necessary easements
- Execute PPA and begin physical construction – 2021 (pending 2019 funding)

4.5 Design and Construction

The feasibility level designs include the below engineering objectives. Additional information is provided in Appendix E. The goal of the engineering designs is to restore aquatic and riparian habitat by creating dynamically stable streams using natural stream channel (fluvial geomorphic) design techniques. It important to note that several of the study streams are part of an existing USACE flood risk management project. Therefore, restoration must maintain the benefits of this project and meet the design flows specified in the Operation and Maintenance Manual (USACE, 1975). The engineering objectives developed by the design team are to:

a. Maximize aquatic and riparian habitat;
b. Increase stability of the stream system;
c. Remove or ameliorate fish blockages;
d. Improve conveyance (water and sediment transport) through structures (e.g., bridges, culverts) crossing the stream by reducing back eddies and erosion while still meeting requirements for the existing flood risk management project;
e. Recommend culvert replacement and proper sizing for geomorphic stability where necessary (HEC-RAS modeling will be performed to design the restoration will allow identification of areas where conveyance through structures can be improved);
f. Provide self-sustaining geomorphic conditions (naturally dynamic) to reduce or eliminate the need for channel maintenance and;
g. To enhance community health by improving aesthetic value, allowing public access to the stream, and enhancing recreational opportunities per landowner agreement.

During the PED phase, an analysis of the scope, schedule, and construction (process and sequencing) for each project location will begin. Duration of construction and activity sequencing will be evaluated for the items in the scope and form the basis for the schedule for this project. Construction activities will include, but are not limited to: clearing and grubbing, cut and fill, toe stabilization, placement of structures, stabilization of substrates, stream redirection, mobilization and de-mobilization, staging, surveying, and rehabilitation of sedimentation and erosion.

The construction process will be determined once the project delivery team identifies the most impacted sites, priority sites, the direction of the construction, site entry and egress, and project security considerations. Duration of activities and the overall construction process will be outlined in scheduling software and will be used to manage progress and identify critical milestones.

The overall construction process is ultimately determined by the contractor performing the work; however, all parties involved (including the non-federal sponsor and local, state, and federal agencies) will have a stake in the process in order to achieve the highest quality project with minimal adverse impacts. Discussions with contractors and stakeholders, along with a study of the benefits, drawbacks and tradeoffs, will identify the most practical construction process to achieve the project's goal.

4.6 Real Estate

All real estate requirements are the responsibility of the non-federal sponsor. The Real Estate Plan identifies the LERRs required for the construction, O&M of the proposed project, including those required for relocations (if necessary), borrow material, and disposal of excavated material. Real estate costs for the recommended plan are shown in Table 4-9. Appendix G includes the Real Estate Plan.

Real estate costs for the recommended plan were estimated based on the limits of disturbance for the feasibility level designs (35 percent design level). Contingency of 20 percent is included in the MII cost estimate. The project streams are largely located on parkland owned by MNCPPC, and no there are no required Public Law 91-646 residential or commercial relocations. There is a parcel in site 5 with active railroad tracks; however, no construction is anticipated on this parcel and there will be no impact on the operation of the rail lines from any project features. MNCPPC is also responsible for programs related to the protection of the natural environment through the review of applications in the land development process. This agency will evaluate the impacts of the proposed plan on parks, woodlands, wildlife habitat, green infrastructure, streams, floodplains, wetlands, unsafe soils, noise, and rare, threatened and endangered species' habitats. Impacts on these resources are evaluated in Section 5. Other property owners are identified in Appendix G. It is assumed that the MNCPPC will enter into a Memorandum of Understanding with the non-federal sponsor to provide the required real estate.

There are public water, sewer, and gas lines within the project area. The proposed designs do not require utility or facility relocations. The recommended plan does include relocation (realignment) of pedestrian bridges, in sites 3 and 13. These properties are owned by MNCPPC. Costs associated with bridge realignments will be borne 100% by the non-federal sponsor (Table 4-9).

4.7 Operation, Maintenance, Repair, Replacement, Rehabilitation (OMRRR)

The features of the recommended plan are designed to be environmentally self-sustaining; therefore, minimal annual OMRRR of the completed project is expected. The recommended plan does not require specific channel forms or habitats to be maintained over the project life, thus avoiding the need for OMRRR to correct minor changes. The in-stream structures combined with the stability provided by streambank plantings are designed to withstand the stress associated with high flow events, ice and frost heaving, and scour. The structures are also designed to direct the streamflow to reduce erosion and to induce sediment accumulation to stabilize the stream bed and provide habitat benefits. The rock that will be used for construction will be dense, free from stress fractures so as to provide stability over the period of analyses. A layer of geotextile will be placed on the upstream side of the structures to eliminate piping. All the footer rocks for the structure foundations will be three feet below the stream bed to eliminate head cutting action.

Routine maintenance actions will include site inspections at each stream site annually and inspections after major storm events. Debris (e.g., log/debris jams) will be cleared as needed if affecting project performance by creating a fish blockage or inducing erosion; however, some woody debris is generally considered to be beneficial for in-stream habitat. Post-construction monitoring and adjustments for purposes of optimization for project benefits will be performed for ten years under the Monitoring and Adaptive Management Plan. The non-federal sponsor is responsible for the cost and performance of OMRRR of the completed project. Based on feasibility-level designs and associated modeling, O&M costs are estimated to be approximately $22,000 per year. A detailed O&M manual will be developed during the PED phase.

4.8 Project-Specific Considerations

During the scoping and public notice process, the USACE Baltimore District received several project specific comments from the various state and federal resource agencies, including items for consideration as the project progresses from feasibility to construction. Agency comments are included in Appendix C.

MDE's comments included that any solid waste including construction, demolitions, and land clearing debris should be properly disposed of at a permitted solid waste acceptance facility, or recycled if possible. The Waste Diversion and Utilization Program should be contacted prior to construction activities to ensure that the treatment, storage, or disposal of hazardous wastes and low-level radioactive wastes at the facility will be conducted in compliance with applicable state and federal laws and regulations. The Prince George's County Department of Permitting, Inspection, and Enforcement commented that stormwater management concept approval and site development fine grading permits are required for all of the proposed projects and 100-year floodplain approval from their office will be required.

Additionally, MD DNR advised that anadromous fish species documented in the area include river herring and sea lamprey. As a result, no in-stream work should be conducted during the Use I restriction period of March 1st through June 15th. NOAA identified a time of use restriction to avoid impacts to anadromous fish spawning from February 15 to June 15. Stringent BMPs for sediment and erosion control must be emplaced to reduce the likelihood of adverse impacts to aquatic habitat, and particularly for the protection of the state-listed American brook lamprey in Northwest Branch. In summary, all sites in the recommended plan have a time-of-year restriction from February 15 to June 15.

MD DNR, Wildlife and Heritage Service responded during the public notice process that the stream segment located in Indian Creek in the Greenbelt area is known to support a population of the state-listed endangered plant, trailing stitchwort (*Stellaria alsine*). Coordination with the Wildlife Heritage Service indicates that the in-stream restoration work proposed (as opposed to work on the floodplain) will have little impact on the plant. Field work was performed by USACE and MD DNR in July 2016 to determine the locations and existence of trailing stitchwort in this area. A summary of this field work is contained in Appendix A. Following that visit, to avoid impacting populations of this plant, MD DNR provided recommendations for the design, primarily including that stream work is permissible only within the main stream channel, on the reach north of Cherrywood Court. Because this is an annual plant, MD DNR recommended avoiding disturbance during the summer so that fruits have time to mature and disperse; however, if no work is proposed in the floodplain or side channels, this is not crucial. The feasibility level design incorporates MD DNR's recommendations, which are included in Appendix C.

MD DNR also states that project planning should aim to optimize riparian forest vegetation retention and afforestation, and management for native vegetation growth along with invasive species control. These are important factors for all restoration initiatives, but are even more in focus for the Anacostia River system, based on its designation within the State's Scenic and Wild River Program.

Maryland Historical Trust comments related to impacts to cultural resources and considerations related to HTRW are discussed in Section 5.

4.9 Project Uncertainty and Risk

Although ecosystem restoration projects are complex in nature, they are designed to improve an existing system that does not have many moving parts. In that regard, unlike vertical construction, the risk of structural failure is relatively low. An evaluation of monitoring reports for urban stream restoration projects in the study subwatersheds generally indicates that structures remain stable, or can be corrected with adaptive management actions. In addition, the consequences of failure are low, since these streams are located in parkland with a riparian buffer, so there is little risk to human life and property. To reduce the risks to life and property related to designs, HECRAS modeling was performed to evaluate changes to the water surface elevation. SIAM modeling was performed to assess the impact of the proposed restoration features on erosion and aggradation.

For the SIAM model, given the short length of the stream reaches, the SIAM results are fairly simplistic. Determining if a system is completely neutral is beyond the scope of SIAM, as it only shows a trend and cannot predict the final channel shape. The results from SIAM generally indicate an improved (i.e., more stable) condition. To predict a system response, a 2D model would be required. If it is determined that further analysis is required, a 2D model could be run during the PED phase of the project. For both the HECRAS and SAIM modeling efforts, sources of uncertainty include the numbers and locations of field measurements (cross sections and sediment samples), the currency and accuracy of existing topographic survey data, the validity of LIDAR data with respect to the stream bed elevations, and challenges with calibration of the model. Additionally, the SIAM model showed some sensitivity to the bed-bank ratio of sediment used in the inputs. Based on recommendations from SIAM experts, a ratio of 80% bank sediment and 20% bed sediment was used as the sediment load input, with 70% bank sediment and 30% bed sediment also evaluated. Results of the sensitivity analysis show sensitivity for some of the stream sites, also dependent on the method used (Yang method versus Ackers White). Given the sensitivity in some of these results, this is a source of uncertainty, which has been captured in the project risk register.

Modeling did account for potential increases in peak flows related to climate change; however, there is much uncertainty regarding these predictions. All the channel improvements would be submerged in a 2-year flood. Larger floods will have less impact on the stability of the in-stream structures.

For the aquatic ecosystem, project benefits are related to with-project improvements in the instream habitat conditions, fish passage, and connectivity. Contingency planning (i.e., monitoring and adaptive management measures) will allow for post-project adjustments to ensure that the in-stream physical habitat benefits are realized. However, the improvement of fish and benthic IBI scores depends on the combination of water quality and in-stream habitat improvements. Water quality improvements within the watershed are currently the primary focus of local jurisdictions and are expected to provide a significant improvement to stream water quality and the overall health of the aquatic ecosystem within the study area.

For this project, uncertainties were evaluated and identified as part of the cost risk analysis. Cost risk analysis is the process of identifying and measuring the cost impact of project uncertainties on the estimated total project cost. It was conducted as a joint analysis between the cost engineer and the designers and team members with specific knowledge and expertise on all possible project risks. Uncertainties included in the cost risk analysis include the potential for scope growth, given the current 35 percent design level, and uncertainties regarding the acquisition strategy (contracting plan, market condition, and competition). Construction elements are less uncertain, because the project will not have unique construction methods or special equipment and confidence in constructability is high. Details of the construction risk analysis are located in Appendix E. With regards to real estate, acquisitions required for this project are considered to be low risk, since the project will primarily be located on public parkland where development is prohibited. Should unwilling private landowners be identified within the project footprint, the design will be adjusted accordingly, with little impact to the overall design since the length of stream on private property is minimal.

5 *ENVIRONMENTAL IMPACTS AND COMPLIANCE

This section describes general potential impacts of implementing the tentative USACE National Ecosystem Restoration (NER) Plan for construction of stream geomorphic and fish passage projects at sites 3, 9, and 13 on Northwest Branch, and sites 11, 5, and 15 on Northeast Branch. Direct, indirect, temporary, and cumulative impacts of the proposed actions are considered. This section also identifies issues that require additional consideration, including coordination with the public and government agencies.

Direct impacts are those that would occur at each project site at the time of construction. Direct impacts include changes occurring during: (1) site preparation such as sediment excavation, vegetation removal, site leveling for access and staging areas, and installation of sediment and runoff controls; (2) project construction such as placement of excavated or fill material, bed and bank stabilization and habitat features such as rocks and logs; and (3) site restoration such as seeding, mulching, planting vegetation, and applying fertilizer. Indirect impacts are impacts that would occur after construction of the projects and/or are removed in distance from the direct impact locations. Cumulative impacts result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal), organization, or person undertakes such actions. Cumulative impacts are discussed separately in Section 5.6. Permanent and temporary impacts for the stream and riparian area are summarized below and discussed in more detail in following sections.

Summary of Permanent Impacts

Most of the impacts from the restoration actions are temporary; however, the restoration would result in the relocation of the stream channel along small sections of the stream at five of the six sites. Alterations to the channel width and alignment (length) are needed to restore these streams to a more natural geomorphic condition and reduce degradation, which would support substrate stability for aquatic habitat. Urbanization and channelization has changed the natural stream course and resulted in overwidened channels. Structures will be placed to divert water to reduce stress on stream banks and to encourage deposition where desirable to restore habitat and fish passage.

Restoration work will provide overall permanent benefits (Section 3.5.2) to the stream and riparian zone through increased habitat complexity, increased bed and bank stability, increased stream-floodplain reconnection (decreased incision), improvements to water quality through sediment and nutrient retention, decreased incision and the creation of floodplain benches, decreased invasive species, and increased inputs of woody debris and detritus to the stream. Sections 5.2, 5.3, and 5.4 further describe impacts to the stream and riparian zone.

Summary of Temporary Impacts

Temporary impacts (short and long-term) to the stream and riparian zone will result from construction activities for access and work within the stream. These impacts are temporary as the impacted areas (e.g., replanting) will be restored to their previous or improved condition following construction. Most of these impacts are short-term impacts, including those that will occur during construction, such as short-term adverse impacts to water quality, air quality, noise, and aquatic organisms while construction activities are ongoing. These will cease upon completion of construction. Longer-term temporary impacts are listed below. The following impacts are long-term because it will take several years for vegetation to reestablish:

- A temporary loss of upland riparian vegetation including trees and shrubs (long-term impact; 5 to 10 years) due to clearing for access and along the streambank for stream realignment (net impact of 22 acres), and
- A temporary impact (short-term; one year) to existing degraded wetlands (1 acre of emergent (phragmites) wetlands).

If the project is not implemented (the no action alternative), streams would continue to be geomorphically unstable. Portions of the streams would remain inaccessible to anadromous fish, such that they cannot return to spawn within their historical range. The no action alternative was rejected for each of these sites because the consequences of taking no action were determined to be of greater environmental harm than taking action to construct the proposed projects.

5.1 Physical Environment

5.1.1 Climate and Air Quality

5.1.1.1 Climate

No long-term or short-term impacts (direct or indirect) to the climate would occur as a result of this project. Section 2.6.1 discusses the future-without-project projections for climate change in the region and study area. Based on this assessment, and the fact that methods of translating climate change impact uncertainty for an engineering-based analysis do not currently exist, the recommendation is to treat the potential effects of climate change as occurring within the uncertainty range calculated for the current hydrologic analysis. With that consideration, the flows used in the modeling (HEC-RAS and SIAM) did incorporate an estimate of increased precipitation due to climate change. Due to an expected increasing trend in precipitation, and consequently in riverine streamflows in the Mid-Atlantic region over the next 40 years, and based on the identification and detection of climate trends in recent historical records, a conservative value of 10% was added to the existing peak flows used in the HEC-RAS modeling.

5.1.1.2 Air Quality

Direct impacts: Direct impacts would be temporary and short-term, occurring only during construction. Construction of the projects would cause temporary impacts to air quality due to exhaust from construction machinery and vehicles, as well as fugitive dust. A general air-quality conformity analysis was performed per the Clean Air Act (40 CFR Parts 51 and 93) to estimate vehicle and fugitive dust emissions. This is presented in Appendix C. Based on the conformity determination, air-quality emissions as a result of project construction would be well below the established federal conformity emission rate thresholds for non-attainment areas. The conformity analysis was performed for ozone and particulate matter ($PM_{2.5}$), as Prince George's County is in moderate non-attainment for ozone and maintenance for $PM_{2.5}$. Table 5-1 summarizes the emissions impacts in tons per year (TPY) for ozone and $PM_{2.5}$, including precursors. Impacts on air quality would be short-term, minor, and localized.

Indirect impacts: No indirect impacts to air quality would occur.

Table 5-1. Summary of construction emissions for implementation of the recommended plan.

Pollutant	Emissions per Stream Site (TPY)	Emissions Project Total (TPY)	Annual Limit (de minimis) (TPY)
NOx	5.77	34.6	100
VOCs	0.56	3.4	50
SO_2	1.95	11.7	100
$PM_{2.5}$ (exhaust)	0.44	2.6	see PM 2.5 total
$PM_{2.5}$ (fugitive dust)	N/A	11.2	see PM 2.5 total
$PM_{2.5}$ Total (exhaust and dust)	N/A	13.9	100

5.1.2 Geology, Topography, and Soils

Direct impacts: The project would have no direct impact on the geology or soil in the study area. Regional topography would not be affected. However, local topography within the stream reaches would be altered permanently be the proposed plans. Recommendations and conditions vary based on site needs. The specific proposal for each site is described in Sections 4.1.1.3 and 4.1.1.4. In general, floodplain benches would be developed at a number of sites. The location of some streams (sections of Site 3, 11, and 5) would have minor shifts in some places along the reach from current locations. Pools would be added at a number of sites (sites 9, 13, 11, and 15). The cross-section of stream would be adjusted in various places. Some stream bed would be raised at Sites 3 and 9. Sinuosity would be increased at Site 5. Minor grading is proposed for Site 11. Also at some portions of Site 11, a braided channel would be replaced by a single, wider channel. These will be permanent changes to local topography within the stream network.

Indirect impacts: The project would have no indirect impact on the geology, topography, or soil in the study area.

5.1.3 Land Use and Land Cover

Direct impacts: No change is expected to land use as a result of the project. Stream and wetland restoration activities would retain the existing land use within parks and open lands. Restored stream and wetland habitat would be located within the stream channel and associated floodplain. Project activities may have minor effects on adjacent park and open lands for stream relocation and wetland restoration. Improved stream stability and habitat would benefit stream valley and park land uses overall.

Land cover in the riparian area adjacent to the streams may be altered permanently in some places. There are un-vegetated stream banks that are targeted to receive riparian plantings. Where the stream will be shifted, some stream area would become riparian, and riparian areas would become stream. Temporary loss of vegetation may occur within the LODs. Disturbed areas will be replanted and it is expected that the vegetation would recover in areas that are converted to floodplain or riparian habitat.

Indirect impacts: No indirect impacts are expected to land use or land cover.

5.1.4 Infrastructure

5.1.4.1 Transportation Systems

Direct impacts: It is not expected that construction vehicle movements associated with the proposed work would have any impact on public roads, as heavy vehicles currently utilize these roads regularly. Any damage to private roads would be repaired. More detailed plans for avoiding infrastructure impacts would be developed during PED.

Indirect impacts: With the exception of providing permanent additional protection (i.e., decreasing potential erosion) to existing roads and bridges, no other indirect impacts to the transportation system is expected.

5.1.4.2 Public Utilities

Direct impacts: At the project sites, impacts to existing infrastructure would be avoided to the fullest extent possible. Some site locations have protected sewer, gas, electric, and water infrastructure utilities within and along stream reaches, but impacts to utilities would be avoided by working around existing utilities. Sewage, gas, electric, and water supply infrastructure has been mapped and would be evaluated prior to construction to ensure that work can be performed without damages. More detailed plans for avoiding infrastructure impacts would be developed during PED. Coordination would continue to be undertaken with utility companies and property owners to develop construction plans that minimize impacts to infrastructure and structures on properties.

Indirect impacts: With the exception of providing additional (permanent) protection to existing in-stream infrastructure (e.g., through geomorphic stabilization of the stream), no other indirect impacts to infrastructure are expected.

5.2 Hydrologic Setting

5.2.1 Stream Geomorphic Condition

Direct Impacts, Permanent: Direct impacts would be permanent. Stream reaches would be altered with the installation of in-stream habitat structures and current deflectors such as J-hooks, cross vanes, W-weirs, and step pools for grade control and riffle/pool restoration. The placement of in-stream structures would reestablish the general structure, function, and self-sustaining condition of a natural stream. Natural streams have riffle-pool sequences that maintain slope stability. In-stream structures would slow and/or divert water where needed to decrease bed and bank erosion, channel water to decrease the stress on stream banks, narrow the stream where overwidened by channelization, promote sedimentation where desirable for habitat and stability, and provide habitat diversity to support a wide assemblage of aquatic organisms.

The stream reaches would be impacted to varying degrees based on the number of structures implemented: site 3 – 21 structures, site 9 – 6 structures, site 13 – 32 structures, site 11 – 23 upstream structures and 9 downstream structures; site 5 – 18 structures, and site 15 – 17 structures. In-stream structures would permanently cover the stream bed where installed. Installation of grade controls would permanently raise the stream bed. Placement of stone to armor the stream bed or banks for protection from erosive stream flows may be necessary. Rock placed to stabilize the stream bank would not obstruct normal sediment transport within the stream since the rocks would only cause minor reductions in channel width.

Channel realignment and construction of floodplain benches would be performed at some of the sites to improve channel stability. In many cases, the realignment occurs within the existing channel envelope (banks) by shifting the stream (active channel) within an overwidened channel and creating adjacent floodplain benches. Sites 3, 9, 13, 11, and 15 are projected to have some degree of permanent channel relocation which would result in a long-term, but relatively minor, alteration to the stream course. In most places the alignments are small adjustments to short lengths of the stream. These adjustments can be seen on the feasibility level design drawings in Appendix E. The following geomorphic channel designs are proposed:

- Site 3 - Based on the existing stream valley, a C4 channel (gravel bed stream with moderate sinuosity),
- Site 9 - Given the slightly steeper slope of this reach, a Bc stream channel,
- Site 13 - Due to the natural sinuosity created by the Piedmont-Coastal Plain physiographic province transition, a C4/E4 channel, and
- Site 5 - A functional C4 channel.

Additionally, at site 11, upstream of Greenbelt Road, a confined concrete channel would be removed.

A mix of nested cross vanes and weirs are proposed to ameliorate fish blockages and/or provide continuous fish passage at sites 3, 5, 9, and 15. At these sites, stream elevation would be permanently altered to provide for fish passage over existing blockages. Hydraulic modeling has indicated that changes to the elevation of the stream bed would not adversely affect the water surface elevation (i.e., induce flooding).

Topographic changes would largely be confined to the stream channel and floodplain. Changes in floodplain topography at some sites (e.g., 3, 15, and 11) are necessary to provide hydraulic stability, but also have the benefit of enhancing stream-floodplain reconnection. At some locations, the streams will be relocated along short lengths to increase stream stability and restore natural geomorphic condition and historical in-stream habitat. The locations where the stream is shifted from, or where topography is changed, will be restored as riparian area and/or floodplain benches. Where existing infrastructure is to be protected, rocks placed to protect structures would increase streambed and floodplain elevations by up to several feet where the structures are located. At staging sites, local grading may be done to facilitate temporary storage of equipment and access to the stream. Staging areas would be restored to their original condition (e.g., replanted, except with native instead of invasive vegetation) after construction is completed.

Materials required to reconnect streams with their floodplains would mostly be derived from the existing stream channel or floodplain to reach the appropriate cut and fill balance. In the event that the project location is flooded by a storm event during construction, implementation of erosion and sediment control best management practices would be in place to reduce the movement and loss of sediment from the construction site. Temporary access crossings would adhere to local sediment and erosion control requirements and be suitably bridged, culverted, or otherwise designed and constructed to withstand and prevent the restriction of high flows and to maintain low flows.

Indirect Impacts, Permanent: Permanent, *i*ndirect impacts would occur during construction and following construction. Following project implementation, in-stream habitat restoration structures (e.g., cross-vanes, j-hook structures, etc.) would alter erosional and depositional features within the stream, facilitating creation of a deeper, narrower channel and/or wider terraces/floodplains. Placement of structures and or fill materials (e.g., large cobbles) would encourage natural formation of riffles and enhance in-stream habitat. Bank erosion rates would be reduced, which would result in a reduction of sediment transported downstream. Bank slope would gradually become less steep at its toe as material accumulates.

The stream geomorphic restoration work is expected to increase connectivity between the channel and floodplain and slow the velocity of water reaching the stream, potentially increasing stream baseflow and providing conditions where wetlands may reestablish in the floodplains.

5.2.2 Water Quality

The proposed project meets the general and regional terms and conditions of Nationwide Permit #27 (NW27), *Aquatic Habitat Restoration, Establishment, and Enhancement Activities* (Appendix C). The proposed project is focused on ecosystem restoration and providing a demonstrated functional lift to the targeted habitats, and will be compliant with all federal regulations. In the State of Maryland, MDE determined that NW27 is consistent with the State’s Coastal Zone Management Program (Section 307 of the Coastal Zone Management Act of 1972, as amended) and issued Water Quality Certification (Section 401 of the Clean Water Act) for aquatic habitat restoration. Therefore, as long as the terms and conditions of the NW27 and MDE's permit requirements are met, no additional Clean Water Act Section 404(b)(1) analysis is required. Any other applicable permits will be obtained prior to project construction.

5.2.2.1 Water Quality Standards and Listings

Direct Impacts: No changes are anticipated to the current water quality standards and listings as a result of the project.

Indirect Impacts: No changes are anticipated to the current water quality standards and listings as a result of the project.

5.2.2.2 Water Quality Impairments

Direct Impacts, Temporary: Direct impacts would be temporary, and short-term. Minor detrimental impacts to water quality would occur during stream geomorphic construction work as a consequence of increased turbidity created during construction from activities. Stream flow by-pass pipes around construction areas, sediment and erosion control measures, construction sequencing, and other best management practices would limit turbidity and water quality impacts as much as possible. If a flooding event occurs during construction, it is likely that exposed earth at the site would be vulnerable to erosion, thereby increasing the turbidity of the floodwaters.

Indirect Impacts, Permanent: Indirect impacts are expected to be permanent. Once constructed, stream geomorphic restoration is expected to produce benefits in water quality within the stream reaches and watershed by promoting a balanced equilibrium within streams and reducing excess in-stream erosion. Reconnection of streams with their floodplains would cause minor improvements in water quality in the receiving stream by intercepting and filtering surface water flow from land adjacent to the floodplain. Water quality of floodwaters delivered to the wetlands during overbank flooding events would be improved as a consequence of sediment settling out on the floodplain; pollutants associated with these sediment particles would be stored on the floodplain and potentially removed by vegetation, thereby reducing pollution to the stream.

5.3 Hydraulic and Hydrologic Setting of Study Stream Reaches

Sections 4.1.1.3 and 4.1.1.4 provide a description of the feasibility level designs and changes that are proposed within each stream reach. The feasibility level design drawings are included in Appendix E. Section 5.2.1 presents a summarized discussion of alterations to the geomorphic conditions expected from the proposed plan. The proposed restoration plans would have direct and permanent positive impacts on the hydraulic and hydrologic setting of the selected stream reaches.

Direct impacts are presented for each unique site. Sections 5.3.3 and 5.3.4 present a description of indirect and temporary impacts that applies to all sites.

As a result of the project, there would be improvement in the quality of the instream habitat. Stream function would increase and there would be an increase in acreage of connected floodplain habitat. The new design aims to allow for the development of a dynamic and diverse aquatic habitat.

5.3.1 Northwest Branch and Tributaries –Permanent, Direct Impacts

5.3.1.1 Northwest Branch (Site 3)

Proposed work for Site 3 is the restoration of approximately 1.25 miles (6,600 feet) of stream channel. Approximately 2.2 acres of floodplain would be reconnected to the restored stream corridor. At the upstream end, a channel realignment would reconnect the stream with the floodplain. This also provides better conveyance, stability, diversity and reduced channel stress. Approximately twenty-one in-stream structures are proposed to provide bed and bank stability, maintain grade control, and reduce bank and bed erosion. The structures maintain a low-gradient riffle pool system that provides for fish passage and long-term stability for low and high flows.

The pedestrian bridge located between East-West Highway and Ager Road that constricts the hydraulic opening and causes a bottleneck and back eddies would be relocated. The relocation of the pedestrian bridge perpendicular to the flow would provide a better transition for flow under the Ager Road Bridge.

Downstream of the confluence with Sligo Creek the stream is part of the USACE flood control project from the 1970s. The proposed in-stream structures would increase the depth and velocity diversity that was eliminated when the flood control project was implemented.

5.3.1.2 Sligo Creek (Site 9)

The total restoration length of this reach is 0.47 mile (2,500 feet). Approximately 1.1 acres of floodplain would be reconnected to the restored stream corridor. Proposed in-stream structures are designed to redirect velocity vectors from eroding banks, provide grade control, and create a series of pools for fish resting and refuge. Downstream near the Sligo confluence with Northwest Branch, a cross vane is proposed to address an existing fish blockage. In this vicinity, the stream is wide and shallow, causing difficulty for fish passage. The proposed structures would provide pools to improve potential fish habitat and enhance passage.

5.3.1.3 Northwest Branch, Riggs Road (Site 13)

The total restoration length of this reach is 1.53 miles (8,100 feet). Restoration at this site will reduce incision, serving to reconnect the stream with its floodplain. Approximately, 1.5 acres of floodplain would be reconnected to the restored stream corridor. At this site, meander bends would be adjusted and in-stream structures are proposed to provide a more stable channel, increase connectivity with the floodplain, and create a riffle-pool system for habitat complexity. The existing tight meanders where the bends will be reduced is related to a disturbed channel pattern and is not consistent with the channel pattern for a stream with this slope. The straightening of the channel in these locations restores the stream to a more stable configuration for this geomorphic setting, which is expected to reduce the current active lateral erosion, decrease sedimentation and increase the stability of the substrate for aquatic habitat. Two cross-vanes, one upstream and one downstream of the Maryland Route 193 Bridge are proposed to improve conveyance and provide stability during high and low flooding events.

5.3.2 Northeast Branch and Tributaries – Permanent, Direct Impacts

5.3.2.1 Indian Creek (Site 11)

The total restoration length of this reach is 1.74 miles (9,200 ft). Approximately, 10.9 acres of floodplain would be reconnected to the restored stream corridor. In the northern portion of the project area, there will be a minor decrease in stream sinuosity. The channel here is over-widened and sediment is being deposited in unstable mid-channel bars. To promote changes in sediment deposition in order to restore stable aquatic habitat, the channel geometry and pattern need adjustment. A nested cross-vane is proposed downstream of the upstream culverts to provide grade control and to dissipate the high-energy flows through the culvert in a deep pool created by the cross vane. A higher width/depth ratio with a combination of alternating tree logs is proposed to provide for a calmer system and enhance potential fish habitat. The proposed design north of Cherrywood Court would keep flows largely confined to the main channel due to the presence of a rare plant. South of Cherrywood Court, as the stream gets closer to development, a single and wider channel is proposed to replace the braided system for a more controlled transition into the constrained environment. Proposed downstream designs call for the deepening of two man-made ponds, and excavation in the western floodplain to enhance floodplain connectivity.

5.3.2.2 Paint Branch (Site 5)

The total restoration length of this reach is 1.19 miles (6,300 feet). Approximately, 2.2 acres of floodplain would be reconnected to the restored stream corridor. Much of the purpose of the proposed structures is to restore the aquatic habitat complexity that was lost when USACE straightened and channelized this reach for flood risk management purposes in the 1970s. Diversity of depth and velocity would be added to the system. A W-weir is proposed downstream of the railroad bridges because the channel is so wide in this location and the flow is divided by a sediment bar. The W-weir would carry the base flow on one side and would become active on both sides during high flow. As the stream gets closer to southeast end of Lake Artemesia, the stream would be shifted away from the lake to reconnect the stream with the floodplain. The stream at the pedestrian bridge south of Lake Artemesia would be adjusted to address eroding banks by directing the flow to the center of the channel and away from the banks.

5.3.2.3 Northeast Branch, Calvert Road (Site 15)

The proposed plan recommends restoring 0.89 miles (4,700 ft) at Site 15. Approximately, 3 acres of floodplain would be reconnected to the restored stream corridor. The upper portion of the reach, north of Calvert Road was impacted by the USACE flood risk management project, which widened and deepened the channel. Proposed alterations include installing a W-weir downstream of the Paint Branch and the Indian Creek confluence. This would increase habitat depth and diversity by creating a deep pool. The W-weir would carry the base flow on the right side of the weir, but during high flow events, the left side would become active.

Downstream of the weir, eight in-stream structures would provide grade control and direct the flow to the center of the stream for stabilization of the stream banks. The proposed structures and tree logs, would enhance aquatic habitat and diversity in depth and velocities. Additionally, floodplain benches are proposed to reconnect the stream with the flood plain. At the meander bend north of River Road, a series of small pools would be excavated on the floodplain. This serves to reduce the velocity of water coming from an upstream tributary, but will also increase the stream-floodplain connection and store fine grained sediments from flood events.

5.3.3 Direct Impacts (Temporary)

Restoration work would cause short-term, localized, and minor direct impacts to stream flow at locations where it is necessary for equipment and workers to be in the stream. Stream diversions are expected locally, and the segment of streams immediately adjacent to the project would be partially dewatered by bypassing flow around work areas through the use of temporary cofferdams and pumps. Temporary relocation would result in short-term displacement of all micro-organisms, benthic invertebrates, and fish. The restoration projects would likely alter stream erosional and depositional processes during construction by stream bed dewatering and/or local placement of temporary structures. The project will be coordinated with the appropriate agencies to secure all permits as necessary.

5.3.4 Indirect Impacts (Permanent)

Changes to the hydrologic character of the stream reaches are intended to decrease stream bank erosion, maintain stream competence (stability) in terms of sediment depositional processes and channel geomorphology, maintain channel capacity, and enhance habitat. Future down-cutting and erosion would be reduced. Restoration efforts would protect in-stream utilities by reducing streambed and bank erosion in the vicinity of the infrastructure.

In some locations, minor grading will occur on the floodplain with the primary purpose of restoring hydrology (e.g., site 15, see Section 5.3.2.3), but with the side benefit of increasing deposition of stream sediments during flood events. The stream geomorphic restoration work is expected to increase connectivity between the channel and floodplain. Flows in the vicinity of in-stream engineered habitat structures and current deflectors would be altered somewhat with both protected (lower velocity) and scoured areas created by the structures. Higher flows would be fully conveyed within the channel and floodplain. The project would be designed such that there would be no increased flooding of human structures or properties. Hydrologic and hydraulic modeling was conducted to plan specific locations of structures and confirm the acceptability of the designs (Section 4.1 and Appendix E). Based on modeling, the project would not impact the elevation of the 100 year floodplain near any human structure of concern. The project is designed to comply with all applicable requirements for floodplain management regulations. In addition, there is no impact to the existing USACE flood risk management project on Northwest Branch, Northeast Branch, Indian Creek, and Paint Branch.

5.4 Biological Resources

5.4.1 Fish and Benthic Integrity

Direct, Temporary Impacts: Sessile or slow-moving animals in the path of discharges, equipment, and construction materials would be destroyed or smothered by the placement of fill materials necessary for the permanent components of the projects. During project construction, fish and other motile animals would likely avoid the construction site. As aquatic benthic organisms are expected to recolonize temporarily disturbed or dewatered areas within a short period of time after temporary fill materials are removed following construction, these impacts are projected to be temporary. Timeframes for recolonization would vary depending on the organism, life-cycle traits, and mechanism of recolonization (e.g., downstream drift, upstream movement, migration from hyporheic zone, aerial transport) (Wallace, 1990; Mackay, 1992). Studies generally indicate that for this type of disturbance (resulting in improved habitat post-disturbance), colonization begins within days and populations may be largely recovered within several months (Gore 1979; Gore, 1982; Mackay, 1992). Generally, filter feeders tend to colonize first, followed by grazers/collectors, and predators and shredders last (Malmqvist, et. al, 1991). Motile aquatic animals would return to temporarily impacted aquatic areas that are restored by the project.

Implementation of time-of-year restrictions extending from February 15 to June 15, of any year, will help to protect anadromous fish spawning that occurs during those times. The proposed project will abide by time-of-year restrictions on in-water construction to minimize impacts on aquatic life that spawns at that time (see Section 4.8). The purpose of this project is to restore stream habitat, and therefore, all efforts will be made to protect that habitat during construction.

Additionally, MDE may require other BMPs during construction to minimize impacts to aquatic life. With the combination of the minimal diversity of existing aquatic organisms based on IBI assessments in the watershed, natural recovery potential, and BMP measures, it is anticipated that negative impacts to aquatic life from construction would be minimal. The project would be coordinated with USFWS, MDE, and MDDNR as necessary for consultations and to secure required permits.

Indirect, Temporary Impacts: Some turbidity may be generated during construction activities resulting in short-term impacts, but it is expected to have minimal impact on aquatic life, as discussed above.

Indirect, Permanent Impacts: Overall the long-term, stream geomorphic restoration work is expected to benefit aquatic organisms by permanently improving water quality, increasing baseflow, enhancing habitat quality, and increasing habitat diversity. Restored streams would provide greater spawning and resident habitat for aquatic organisms. Habitat features would be more stable over time, and excess fine-grained sediment would not negatively affect riffle habitat. Remediation of fish passage blockages on sites 3 and 9 would open additional spawning areas for migratory fish and allow resident fish greater opportunities for movement. Restoration would improve habitat conditions for anadromous fish species such as herring and shad, and aquatic community health would be improved for over 45 species of fish and numerous benthic invertebrate species. Fish species that are classified as lithophilic spawners (require clean gravel and cobbles for spawning) would have greater high quality spawning habitat from reduced fine sediment deposition in restored stream reaches.

Initially, the project team had concerns that removal of current fish blockages could aid in the establishment of invasive fish species further upstream (e.g., northern snakehead *Channa argus*); however, snakehead have already been observed well upstream of project reaches, up to the fall line at the Coastal Plain-Piedmont physiographic province boundary (meaning that this species can move beyond barriers that other species cannot).

5.4.2 Fish Passage

Direct Impacts, Permanent: Fish passage blockages would be permanently removed at sites 3 and 9. At those two sites, there is expected to be a direct impact to fish passage within those reaches. Correcting the blockage at site 3 is projected to open 3.7 miles of stream and correcting the blockage at site 9 is projected to open 0.6 miles of stream. Additionally, stream restoration improvements is expected to make 21 additional miles upstream of site 15 accessible to fish; resulting in a total of 25 miles of additional stream habitat available to fish.

Indirect Impacts, Permanent: Removing these barriers would likewise provide permanent benefit to other aquatic species that utilize these stream reaches.

5.4.3 Wildlife

Direct Impacts, Temporary: Direct Impacts would be temporary. Construction occurring during colder weather months could potentially kill any amphibians or reptiles occurring at the sites because of the poor mobility of these species in colder weather. Nesting and roosting birds and offspring in the disturbance areas may be adversely affected. Other wildlife species are expected to temporarily relocate away from project areas to avoid construction, but would likely return upon completion of the project. No permanent displacement of wildlife populations is expected. The project sites that include plantings would provide additional food for herbivorous wildlife. The project may require fencing or limit access to the plantings to attempt to minimize predation during establishment of vegetation.

Indirect Impacts, Permanent: Indirect impacts would be permanent. Wildlife associated with the streams and wetlands in the area would benefit by the improved water quality and additional habitat that the restoration projects would provide.

5.4.4 Rare, Threatened, and Endangered Species

Direct Impacts: No temporary or permanent direct impacts are anticipated to federally-listed rare, threatened, and endangered species are expected. Coordination with USFWS (see Endangered Species Act determination in Appendix C) indicates that the project is within the range of the northern long-eared bat, a federally threatened species. However, USFWS states that since forest clearing for the proposed project is minimal and there are no current records of northern long-eared bat in the project vicinity, the project as proposed is "not likely to adversely affect" the northern long-eared bat. Therefore, there are no time of year restrictions on forest clearing. Additionally, the USFWS stated that except for occasional transient individuals, no other federal proposed or listed endangered or threatened species under their jurisdiction are known to exist within the project impact area including those protected under the Migratory Bird Treaty and/or the Bald and Golden Eagle Protection Act. Transient species are expected to avoid the project site during construction.

MD DNR has identified the presence of the state listed endangered plant, trailing stitchwort (*Stellaria alsine*) at project site 11. Trailing stitchwort inhabits the low-energy, braided side channels adjacent to the main channel at site 11. As noted in Section 4.8, the feasibility level designs have incorporated recommendations made by MDDNR into the feasibility level designs. No impacts to the plant are anticipated. Additionally, as recommended, stringent BMPs would be emplaced at all sites to reduce impacts to aquatic habitat, but particularly to protect potential populations of American brook lamprey on Northwest Branch.

Indirect Impacts: If locations containing federally-listed or proposed, or state-listed or proposed, threatened or endangered species are identified, they would be avoided for construction activities; therefore, no indirect impacts to these species are expected. Further coordination with MD DNR would be conducted as the study moves into the PED phase.

5.4.5 Riparian Vegetation (Wetlands and Forest)

The impacts to riparian vegetation, described below, will result in improvements to wetlands to reduce invasive vegetation and improve hydrology (slow the velocity of water); improvements to the stability of stream-side riparian habitat, due to reducing streambank erosion and correcting the channel pattern (i.e., increasing or decreasing sinuosity as needed for stability); improvements to the health of the riparian zone due to eliminating invasive plant species and re-planting with native species; and facilitation of the re-establishment of wetlands through increased stream-floodplain connectivity.

5.4.5.1 Wetlands

The proposed project meets the general and regional terms and conditions of Nationwide Permit 27 for aquatic habitat restoration and will result in a net increase in aquatic resource functions. Planning efforts have minimized the impacts to the resource in compliance with 404(b)(1). Following field verification of wetlands, restoration designs took into account wetland locations to avoid impacting adjacent wetlands and access sites avoided wetlands completely. A WQC and CZC is issued for projects that meet the terms and conditions of NWP 27. All applicable permits (e.g., non-tidal wetlands, SEC) would be obtained prior to project construction.

In November 2017, field work was conducted by USACE to evaluate presence/absence of wetlands within the project LODs at sites 3, 9, 11, 15, and parts of 5 and 13. The field surveys found no wetlands within the project area at sites 3, 9, 13, 5, and 15. For site 11, three distinct wetlands were identified (11A, 11B, and 11C) as described in Section 2.4.5. The only impacts to wetlands would be temporary and occur to approximately 1 acre of wetlands at Site 11(B).

Access will occur in the vicinity of wetland 11A, but the wetland will be avoided. There will be no direct or indirect impacts to this wetland and access will occur in disturbed uplands adjacent to a concrete channel.

Wetland 11B (classified as palustrine forested and emergent wetland) consists of a dense stand of *Phragmites* with a pond in the center. Approximately, 1 acre of this wetland is within the LOD (Figure 5-1). A cross-vein will be constructed in the stream alongside the wetland, but no stream realignment is planned that would affect the wetland.

Wetland 11C is a palustrine emergent wetland approximately 0.2 acres in size. The current stream path would be realigned in this vicinity to reduce erosion and increase floodplain connectivity. The realignment would avoid this wetland and will prevent further stream bank erosion, which would have eventually impacted the wetlands if not addressed. Wetland delineations and functional assessments will be conducted in PED once designs are advanced to minimize wetland impacts to the greatest extent possible.

Direct, Temporary Impacts: Wetland impacts from the proposed project would be temporary and long-term, and limited to approximately a 1 acre at Site 11B. Restoration efforts include eradication of the *Phragmites*, replanting of native vegetation, and a deepening of the existing pond. Impacts include clearing to eradicate invasive vegetation. All wetlands temporarily disturbed during construction would be graded and fully restored (i.e., replanted with native wetland vegetation species following construction). It is expected that it will take several years for native wetland vegetation to become established. The impacted wetlands are expected to provide a higher function following the project as a result of removing invasive species and establishing appropriate hydrology. Deepening the existing pond would slow the velocity of the surface water runoff from adjacent developments, and would benefit the sustainability of planted native vegetation and enhance habitat for aquatic organisms. Minor grading would occur where the stream meets the wetland to promote connection between the stream and wetland.

Consistent with NWP 27, the restoration work would repair the natural function of the degraded wetland and result in a net increase in aquatic resource functions and services. The project would be coordinated with MDE and others as appropriate to secure all other permits for work affecting wetlands or riparian areas, as necessary.

Indirect, Permanent Impacts: In the long-term, the project would improve the overall functionality and sustainability of the wetland system, given that the dense phragmites will be replaced with native vegetation. Invasive phragmites outcompetes native vegetation and provides little or no food or shelter for marsh dependent wildlife. Additionally, phragmites can reduce pool habitat and raise the elevation of the wetland due to its rapid growth.

Reconnection of streams with the adjacent floodplain (by reducing stream incision) would improve existing aquatic resource functions by slowing stormwater velocity, storing sediment, increasing infiltration, and removing pollutants prior to reaching the stream. Wetlands reestablished along restored stream reaches would also serve to replenish groundwater aquifers (increase infiltration) and provide important food and shelter for a variety of resident and transient wildlife, such as mammals, birds, reptiles, and amphibian species. The wetlands at Site 11C (0.2 acres) would permanently benefit indirectly from the efforts undertaken to reduce streambank erosion.

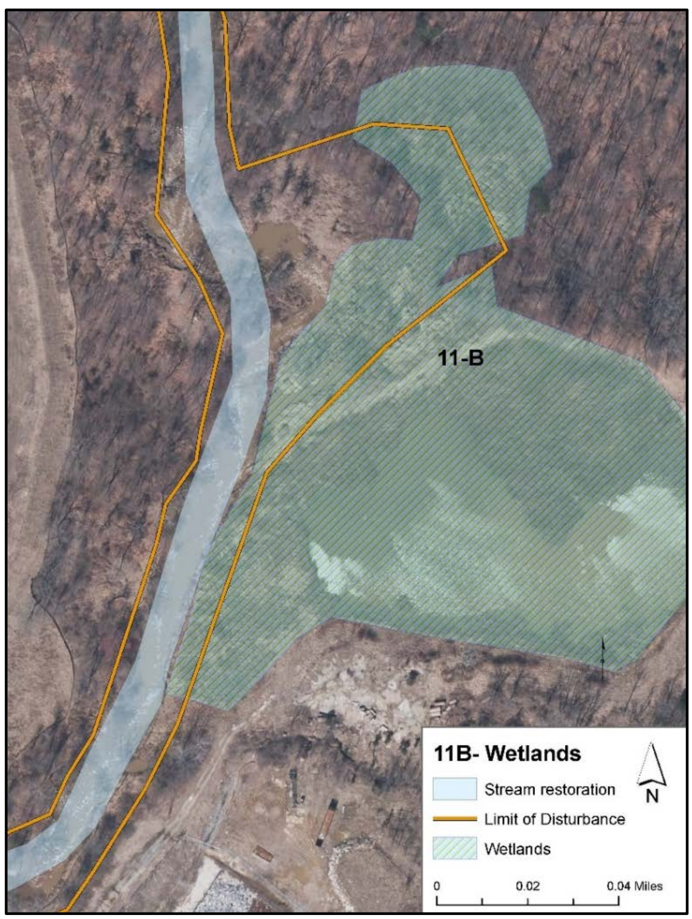

Figure 5-1. LOD and wetland 11-B.

Prior to restoration work (during PED), existing wetlands will be delineated along the stream corridors. Identified wetlands within the LOD will be marked and avoided. Efforts to minimize and avoid impacts to wetlands include minimizing areas needed for access and staging, and locating staging and access points outside wetland boundaries. At this time, no access is planned through wetland areas. Access would be achieved by traveling in the stream bed or utilizing currently disturbed areas to avoid wetlands. Also, work areas could be accessed from the opposite streambank if wetlands are not present in those areas. All wetlands within the LOD will be marked in the field to avoid any unintended impacts.

5.4.5.2 Forests

The upland riparian zone is currently a mixture of scrub/shrub, grasses and deciduous trees. Invasive shrub species are mixed in with native species (Section 2.4.5), but some locations include small areas where invasive species dominate. Upland riparian forest vegetation at the project sites are typically broad-leaved deciduous communities. Upland riparian plant communities along stream corridors provide shelter, shading to waters, detritus, and breeding and rearing areas for various fish and other aquatic organisms.

Direct, Temporary Impacts: In order to address geomorphic instability there would be temporary, but long-term (years to decades) impacts to upland riparian vegetation. Removal of riparian vegetation immediately adjacent to the streams would be required for access; however, construction methodology would aim to optimize riparian forest vegetation retention and afforestation. Work would include clearing of some of the existing riparian vegetation for stream realignment, creation of floodplain benches within incised channels, and minor grading and/or excavation to create shallow depressions and/or deepen existing pools. All riparian impacts would be temporary as vegetation would be replanted. Approximately 32 acres of upland riparian habitat located within the limits of disturbance (LOD) could potentially be cleared to access and work within the streams; however, 10 of these acres are projected to be lost to streambank erosion within the period of analysis, resulting in a net temporary impact to 22 acres of riparian vegetation. Long-term impacts (twenty years or more for trees to reach maturity) would occur within this area where trees would be cleared to access and work within the streams. The impacts from the removal and re-establishment of scrub/shrub vegetation would be a short-term impact (several years), as recovery would be achieved sooner than the replacement of mature trees. It is anticipated that following project implementation, there would be no further loss of trees at these sites as the project would stabilize current bank erosion problems. All locations where vegetation is removed will be replanted with native vegetation following completion of construction, but it will take decades for trees to grow to maturity.

Efforts will focus on minimizing the loss of mature trees and the associated long-term impacts. Preconstruction surveys will identify forested areas and specimen trees to retain mature trees and their value. Specimen trees, as defined by MDDNR (1997), are trees having a diameter measured at 4.5 feet above the ground of 30 inches or more, or trees having 75% or more of the diameter of the current state champion tree. The project cost estimate currently includes an estimate of the numbers of trees and shrubs needed at each site (Appendix E); however, this will be refined following the development of a planting plan during PED. Additionally, the planting contract will be structured to ensure survival of these plants and reduce encroachment of invasive plants. A portion of the cleared area will become stream habitat due to stream realignment.

Invasive species that reduce the ability of riparian plant communities to provide important ecological services (including habitat, shade, woody debris and leaf litter inputs to support the restored aquatic ecosystems) would be removed upon project construction and the disturbed area would be replanted with native vegetation. An invasive species management plan would be developed during the design and implementation phase of the project with specifications to ensure minimization of the spread of invasive species through best management practices, such as the cleaning of equipment to prevent seed transfer.

Indirect, Permanent Impacts: The work proposed would provide overall benefits to the stream and riparian zone through increased stream-floodplain reconnection, improvements to water quality through sediment and nutrient retention, decreased invasive species, increased bank stability, increased shading, and increased inputs of woody debris and detritus to the stream. Some riparian vegetation species may be favored at the detriment of other riparian species due to increasing saturation and floodplain interactions associated with restoration activities. Additionally, the prevention of future streambank erosion through the establishment of a more sustainable stream course would indirectly benefit riparian areas, established trees, and wetlands adjacent to the stream that would have been threatened by erosion and lost.

5.5 Community Setting

General impacts to the community setting are described below. Because the selected stream reaches are primarily located on parkland owned by MNCPPC, impacts to parks and park facilities are specifically described in Section 5.5.4.

5.5.1 Population and Demographics

Direct, Permanent Impacts: No direct, permanent changes are anticipated to population levels and demographics as a result of the project. The recommended plan does support both the Chesapeake Bay Executive Order 13508 and Urban Waters Partnership by reconnecting urban populations with nature. The project would improve overall community health and provide an improved natural resource for use to all. Aesthetics and safety in the project area would be improved through reduced streambank erosion and more stable riparian woody vegetation. Stabilization of stream banks may prevent streams from causing property damage, which could have a minor positive economic impacts.

Direct, Temporary Impacts: Standard health and safety practices would be followed at each project construction site to protect human health and ensure that safety risks to people, including construction workers and the public, are minimized. Efforts will be made to minimize impacts to the public's recreational uses of parklands adjacent to the stream, but the area would be secured from access by the public as necessary to ensure safety during project construction. Impacts to the safety of vehicular traffic would be minimized through careful consideration of access routes to each construction site, by construction sequencing, and by incorporating appropriate traffic management measures.

Indirect, Permanent Impacts: In addition to improving overall community health, all of the stream segments have the potential to serve as living classrooms for educating students of all ages. A number of schools and universities are located within close proximity (see Section 2) to these streams and the Anacostia Trail System is heavily used by the public for recreation and transportation. Improvements to water quality would also enhance the area as a livable setting for people.

5.5.2 Environmental Justice

Direct, Permanent Impacts: Impacts of the projects on socioeconomic conditions in the area are expected to be negligible.

Direct, Temporary Impacts: Economic activity would be generated by contracting for construction activities; however, because of the temporary duration of construction activities and the small magnitude of the operations compared to overall area economic activity, any economic impacts would be minor.

Indirect, Permanent Impacts: The project recommended in this report would improve the quality of the human environment and accordingly benefit populations living or working in the vicinity of the streams. All citizens in the watershed, regardless of their race or income, would benefit from this project. Accordingly, no negative adverse human health or environmental effects on minority or low income populations would occur based on actions undertaken for this project; therefore, this project would be in compliance with Executive Order 12898, dated February 16, 1994 (Environmental Justice in Minority Populations). This Executive Order directs federal agencies to identify and address the adverse human health or environmental effects of their actions on minority and low-income populations.

5.5.3 Schools

Direct, Temporary Impacts: At two sites, sites 3 and 5, there are schools located within 1640 feet (500 meters) of the stream reach. Students at Paint Branch Elementary School (near site 5) could see increased traffic of construction vehicles (trucks) from the access point on the west side of the school fields. There may also be some impact to students walking to school from potential closure of the Anacostia Trail System at this location. The University of Maryland is also located close to site 5, so there could be some impact to students if using the trail system and pedestrian bridge that crosses the stream to travel to school. Rosa Parks Elementary School near site 3 could see some increased construction traffic. This school’s parking lot borders on the stream, so fencing would be constructed to ensure the safety of all students.

Indirect, Permanent Impacts: Aesthetics and safety in the project area would be improved through reduced streambank erosion and more stable riparian woody vegetation which could contribute to improved community settings in the school vicinity. In addition to improving overall community health, all of the stream segments have the potential to serve as living classrooms for educating students of all ages.

5.5.4 Parks and Recreation

Direct, Permanent Impacts: The direct impacts to park facilities include the relocation of a number of pedestrian crossing bridges and replacement of walking paths that would be removed during construction. Table 5-2 summarizes those impacts. Sites 3, 9, and 13 would have pedestrian bridges relocated to improve stream flow. Those sites would also have replacement of trails connected with the bridges.

Indirect, Permanent Impacts: Indirect impacts would include enhanced aesthetics and safety resulting from the restoration of the streams. Parkland adjacent to the streams would be less susceptible to erosion and tree loss over time.

Direct Temporary Impacts: Construction activities may limit recreational use of park and open lands temporarily with public access at project locations likely to be restricted altogether during construction for safety reasons. LODs and access and staging areas within MNCPPC parks were limited to the greatest extent possible and are shown on the design drawings in Appendix E. For sites 3, 9, 13, and 15, temporary access/staging areas are located near or adjacent to park facilities (e.g., between baseball fields; adjacent to basketball courts or parking lots; an on open fields), which could impact the use of these fields. Temporary access roads at most the sites, except Indian Creek, extend through park property. Details regarding recommended closure of park locations would be included during the PED. Construction would be coordinated with MNCPPC to minimize negative effects on park users and ensure compatibility with park needs to the maximum extent practicable.

5.5.4.1 Capper Crampton Parklands

Estimates of the acreages of Capper Crampton parklands within the LOD for each site are provided in Table 5-2. For the purposes of this project, it was determined in consultation with the NCPC that the stream restoration proposed by this project does not constitute a change to park use under the Capper Crampton Act; therefore, the NCPC does not have review authority over this project. Changes in use that would constitute review by the National Capital Planning Commission include conversion of recreational open space (i.e., a natural use) to a non-recreational open space use. Documentation of coordination with the National Capital Planning Commission is include in Appendix C.

Table 5-2. Area of Capper Crampton* lands and impacts to park facilities.

Site	Area of Capper Crampton lands within LOD (ac)*	Park Facilities Impacted
3	19	Relocate existing pedestrian bridge on Northwest Trail and replace associated path (500 sf); staging and access in park field; one staging area adjacent to basketball court; temporary access roads through park property.
9	7	Relocate existing pedestrian bridge and associated path (300 sf); access road crosses between baseball fields.

Site	Area of Capper Crampton lands within LOD (ac)*	Park Facilities Impacted
13	19	Relocate existing pedestrian bridge and replace associated path (3000 sf); staging adjacent to two park parking lots.
15	17	Two staging areas on park property (one in open field); access road through park property.
5	20	Temporary access road and one staging area on park property.
11	6	Two access roads through park property
*Per NCPC, Capper Crampton lands are not being altered under the Act as the project does not constitute a change to park use (Section 5.5.4.1).		

5.5.5 Aesthetics and Noise

Direct, Temporary Impacts: This impact would be temporary and short-term. Noise during construction would be produced by construction equipment and by vehicles transporting materials to and from the sites. This would cause a temporary increase in noise that may detrimentally impact people in the vicinity of the project sites during the one year construction season. Construction is scheduled to last approximately 9 months at each site. Operating hours would coincide with regular work hours and will adhere to the noise ordinance for Prince George's County. Truck traffic will temporarily increase on roads in the vicinity of project sites during construction.

Indirect, Temporary Impacts: Wildlife is expected to avoid the area during construction due to noise and activity. However, this impact should be temporary. Wildlife are expected to return to the project areas following completion of construction activities.

5.5.6 Cultural Resources

Under Section 106 of the National Historic Preservation Act of 1966 (as amended), federal agencies are required to take into account the effect of their proposed undertakings on properties listed in or eligible for inclusion in the National Register of Historic Places. In Maryland, the Maryland Historical Trust (MHT) serves as Maryland's State Historic Preservation Office (SHPO) and conducts Section 106 reviews. The federal agencies must notify the Advisory Council on Historic Preservation if a project would result in adverse effects to cultural resources.

A letter from the Maryland Historical Trust (MHT) (June 15, 2015) stated that their careful review of the ten initial stream segments/reaches indicates that the projects are unlikely to have an adverse effect on cultural resources within six of the ten reaches, therefore no archeological survey work would be recommended for these reaches for Section 106 purposes. However, further evaluation of four reaches, including Little Paint Branch (site 12), Lower Northwest Branch (Riggs Road, site

13), Northwest Branch Hyattsville (site 3), and Sligo Creek (site 9), was recommended to identify impacts to existing cultural resources. Of these reaches, sites 3, 9, and 13 are in the recommended plan. This letter is included in Appendix C.

Following receipt of the letter from MHT, the area of potential effects (APE) was delineated based on site designs and further cultural review, including a search of MHT records and field visits, was performed for the sites in the recommended plan. Potential effects and recommendations for each site are included in Appendix A. As described in the records review and Phase I report in Appendix A, prior archaeological surveys and/or stream disturbance (including channelization by USACE in the 1970s) negated the need for field work at many of the stream reaches. Effects and recommendations for two sites in the recommended plan (sites 11 and 15) where floodplain excavation would occur are described below and Phase I cultural resource surveys were performed for these sites. These sites were found to be eroded through stream channel migration and/or flood erosion and scouring and neither location has the potential to contain significant archaeological resources. Correspondence with MHT on these findings is included Appendix C. A letter dated October 30, 2017, from MHT indicates their concurrence with the findings of the report and their opinion that the proposed restoration work will have no adverse effect on historic properties.

Government-to-Government consultation was also conducted with a number of Native American Tribes in accordance with the Department of Defense American Indian and Alaska Native Policy. Consultation letters were sent to the following federally recognized tribal nations: Delaware Nation, Delaware Tribe of Oklahoma, Eastern Shawnee Tribe of Oklahoma, Pamunkey Indian Tribe, Seneca-Cayuga Nation, and Tuscarora Nation. None of these tribes requested further consultation. These coordination letters are included in Appendix C.

5.5.6.1 Indian Creek (site 11)

A visual inspection of Site 11 showed that the active floodplain of Indian Creek is scored with numerous flood chutes and vernal pools separated by narrow, rounded, interstream divides, with fringe areas of palustrine forest and wetlands. During high-water events, Indian Creek becomes a braided stream at this location, which may be a result of increased run-off from surrounding urban development. The floodplain is broad with a low gradient and no evidence of levees or distinct terraces, other than the pronounced outer wall. Point bars are located within the active stream channel, and along some of the flood chutes.

A total of 19 shovel test pits (STPs) were laid out at 50’ intervals along the centerline of work to be conducted in the northern portion of the floodplain. The total area tested is 2.2 acres in size. The southern portion of the floodplain area is mapped as reclaimed gravel pits and was not investigated. Two of the STPs were not excavated because they were located in the bottoms of flood chutes where the ground surface had eroded to expose sand, gravel, and cobbles from a former stream channel. A single artifact was recovered from Site 11. A fragment of tinfoil was found in Level 2 (5 cm – 30 cm below surface) of STP #3, the upper C horizon of this STP.

Erosional processes such as flooding, scouring, and bank erosion have severely disturbed the horizontal and vertical contexts at Indian Creek, although the upper soil deposits appear to be recent alluvium. This location does not have the potential to contain significant archaeological resources and there would be no adverse impacts here from the recommended plan.

5.5.6.2 Northeast Branch, Calvert Road (site 15)

The current floodplain at Site 15 along the west bank of the Northeast Branch is considerably narrower than the floodplain at Indian Creek, with significantly steeper banks along the inside of the meander. The topography of the west bank suggests that this area has been flooded in the past, but streambank armoring in this location may have prevented or constricted more recent flooding. An unnamed tributary on the west bank of Northeast Branch has also caused significant erosion through meandering across its floodplain. One linear area of higher ground along and parallel to the west bank did not appear to have been eroded. Since this area of higher ground is slated for landscape contouring, it was subjected to archaeological investigation.

Due to the small size of the area of higher elevation, only three STPs at 50' intervals were excavated at Site 15. The area tested is approximately 0.25 acres in size. Soils in the three STPs only somewhat resembled those mapped for the area. No artifacts were recovered from any of the STPs in Area 15. This location does not have the potential to contain significant archaeological resources and there would be no adverse impacts here from the recommended plan

5.5.7 Hazardous, Toxic, and Radioactive Waste

As identified in Section 2.5.7, there is a section (approximately 400 feet) of Paint Branch (site 5) that is adjacent to UMD Landfill Area 3A and a section of approximately 100 feet adjacent to Landfill Area 1B. Coordination with EPA indicates that work in this section of the stream would not impact the landfill or RCRA Corrective Action activities unless entering the UMD property boundary. The concept design alternative selected for Paint Branch includes in-stream work only (no floodplain work) and feasibility level designs would incorporate this constraint.

A review of available data and reports obtained from EPA, including EPA's *Migration of Contaminated Groundwater Under Control, Environmental Indicator (EA) RCRIS code (CA750)*, indicates that groundwater contamination is contained on the landfill site and is not migrating to Paint Branch. The site's RCRA Facility Investigation (Buchart-Horn, 1997; ERM, 2001) documents that sampling of sediments, surface water and soil samples from Paint Branch did not show any release of Permit-list metals, volatile organic compounds (VOCs) or semivolatile organic compounds (SVOCs), as well as Permit-list VOCS or SVOCs in groundwater. Permit-list metals were reported in groundwater; however, in 1999 ERM re-sampled the Permit-list metals, including PCBs, toxins, and methane, to conclude that groundwater conditions beneath the Paint Branch Landfill Areas do not pose unacceptable risks to human health or the environment. More recent data (ERM, 2014), indicate low concentrations of MTBE at a monitoring well (PW-7) located near Paint Branch; however, these concentrations are significantly below the maximum contaminant level for drinking water. Additionally, concentrations of dissolved hydrocarbons have continued to decrease over time. Work within Paint Branch would not affect the corrective actions in place at the landfill, nor is there any indication that contaminants from landfill would negatively impact work within the stream.

5.6 Cumulative Impacts

A cumulative impact or effect occurs when the effects of an action, when added to other past, present, or reasonably foreseeable future actions, results in further environmental effects. These additional actions can be taken by the same federal agency, a different agency, or a public or private entity. A cumulative impacts analysis considers the total impacts of the proposed action and all other actions affecting that resource (regardless of who undertakes the actions) on a resource, ecosystem, or human community. The Council on Environmental Quality (CEQ) requires that cumulative impacts be examined as part of the NEPA analysis (40 C.F.R. Parts 1500-1508). This section discusses the potential cumulative impacts resulting from the stream restoration project recommended in this report and other actions that have or may be implemented in the Anacostia River watershed.

The plan recommended in this feasibility report would contribute cumulatively in a beneficial manner to ongoing environmental efforts within Prince George's County. Prince George's County has been an established, urban landscape for generations and will remain so into the future. Within that developed landscape, this project and other efforts will cumulatively provide significant, long-term improvements to the quality of the environment in the Anacostia River watershed of Prince George's County. The benefits would occur throughout the watershed, but largely within and along the stream corridors and riparian areas of the Northeast and Northwest Branches. The watershed will not be restored to natural conditions, but rather the intent is to restore the functions that the undeveloped landscape once provided. The efforts documented herein to reverse the toll of generations of development in the Anacostia River watershed area are tied to implementation of the 1983 and 2014 Chesapeake Bay Agreements, the 2009 Anacostia River Watershed Restoration Plan, the 2010 Chesapeake Bay TMDL, and the 2104 *Restoration Plan for the Anacostia River Watershed in Prince George's County.*

Figure 5-2 shows the role of USACE and others in contributing to a comprehensive restoration strategy for the Anacostia River watershed. As described in Section 2, a number of other activities in the watershed are currently the primary focus of local jurisdictions and are expected to provide a significant improvement to stream water quality and the overall health of the aquatic ecosystem within the study area. Under Prince George's County's MS4 permit issued in 2014, the County is required to manage stormwater runoff, including through the use of design features such as pre-treatment vegetation, wetland pockets and pools, flow reduction techniques, native plants, meadows, trees, permeable soils, and the creation of sinuous flow paths. Significant water quality improvements are also expected in conjunction with TMDLs established for fecal coliform bacteria, sediment, total suspended sediment, nutrients (nitrogen and phosphorus), biological oxygen demand, polychlorinated biphenyls (PCBs), and trash. The Chesapeake Bay TMDL has a target of reaching all needed pollutant (nitrogen, phosphorus, and sediment) reductions by 2025. SIAM modeling performed for this study indicates that the sites in the recommended plan will have an improved condition approaching equilibrium with regards to sediment transport, thereby reducing the volume of sediment delivered downstream due to bank instability and erosion.

Prince George's County developed the *Restoration Plan for the Anacostia River Watershed in Prince George's County* in 2014, which provides an implementation plan for reaching MS4 and TMDL goals within the County's portion of the watershed by 2030. Reductions of 81.0 % total nitrogen (lb/yr), 81.2 % total phosphorus, 85 % total suspended, 58 % biological oxygen demand (lb/yr), and 86.4 % fecal coliform bacteria MPN B/yr are targeted. Benefits to the environment are expected to be realized in the near term as projects are implemented but also past targeted dates due to a lag-time following restoration. The plan includes the following strategies and programmatic initiatives: dry pond retrofit, environmental site design practices, a pet waste campaign, urban nutrient management, street sweeping, stream restoration, tree planting, and dumpster and washing programs. The effort targets treatment of 500 to 750 acres per year in the County's portion of the Anacostia River watershed resulting in a total treatment of 9,955 acres within the MS4 area (61.6% of the total impervious area in the MS4 area). By 2030, upon completion of TMDL implementation, water quality impairments are projected to be corrected.

Continued improvement of the sanitary sewer system would diminish related stressors to aquatic ecosystems within the County's portion of the watershed. As described in Section 2, in July 2005, the WSSC entered into a consent decree regarding overflows in WSSC's wastewater collection system. The resulting 12-year plan has augmented existing efforts to identify and repair problems within the 5,400 mile sewer system in Montgomery and Prince George's Counties, Maryland. Work has occurred throughout the Anacostia watershed and construction work is largely complete. The program is helping to improve water quality by reducing overflows and leaks that can cause pathogens, bacteria, and nutrients to enter streams. Stream restoration projects enhance this work by providing reduced erosion around sewer lines and manholes.

The proposed stream restoration projects would contribute cumulatively to restoration of the Anacostia Watershed already accomplished by previous USACE projects in tidal and non-tidal waters of the Anacostia Watershed. Previous tidal restoration projects include wetlands constructed in tidal waters of the Anacostia River at Kingman Lake, Heritage Island, along the Anacostia River, and at Kenilworth Marsh (Section 1.6). These projects served to restore a portion of the substantial tidal wetlands that historically occurred there dredged and filled by USACE in the late 19th and early 20th centuries, prior to society placing the high value on these resources that it does today. The recommended plan would serve to partially restore in-stream habitat conditions in Indian Creek, Paint Branch, Northwest Branch, and Northeast Branch that had been previously degraded by the USACE Anacostia River and Tributaries FRM Project. The proposed work in this report would also contribute cumulatively to previous USACE stream restoration and fish passage within the lower Anacostia River and Northwest Branch River undertaken to improve in-stream habitat and fish passage through the USACE Anacostia River and Tributaries FRM Project and USACE Anacostia River Basin Flood Control and Navigation Project (Sections 1.6.1, 2.2.1, and 2.4).

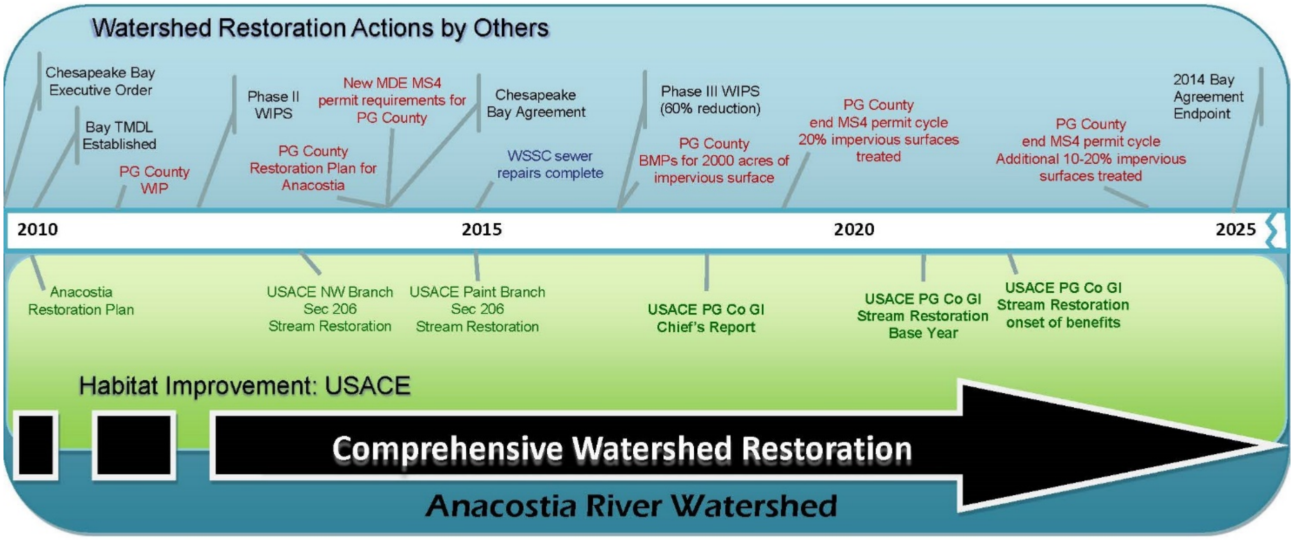

Figure 5-2. Contributions from USACE and others to a comprehensive restoration strategy for the Anacostia River watershed.

Some of the benefits for the restoration project recommended in this feasibility report are provided by removing fish blockages and connecting to previously restored stream reaches, which expands the functional habitat for fish. Past restoration projects have been undertaken as mitigation for transportation projects. These include those implemented by the SHA to offset the environmental impacts of a massive new roadway, the Inter-County Connector (ICC). The ICC restoration work includes bank stabilization, floodplain creation, riparian buffer enhancement, habitat enhancement and fish blockage removals along numerous stream reaches in Prince George's County. Over the period of analysis, it is possible that other entities or organizations would undertake stream restoration within the watershed or stream reaches of study for mitigation. For example, construction of the Purple Line (metro rail) or redevelopment of the property adjacent to Indian Creek (Sections 2.6.4), may result in mitigation projects including stream and/or wetland restoration within the watershed. Impacts of the construction of the Purple Line on the quality of the human environment are described in a final Environmental Impact Statement which can be accessed at http://www.purplelinemd.com/en/about-the-project/studies-reports/feis-document. The Purple Line would add a metro rail line from New Carrolton to Bethesda across the central portion of the watershed in Prince George's County.

Other agencies, including WSSC and USACE have also implemented stream restoration measures that connect with the projects recommended in this report. While each individual project may have a minor benefit to the environment, when compiled, the full compilation of projects results in a significant benefit. Enhancing connectivity and fish passage would allow anadromous fish, primarily blueback and alewife herring, to access and utilize their historical spawning grounds up to the limit of their natural range at the Fall Line in the west and watershed boundary in the east. Return of these fish to their natural range would have positive effects for upstream ecosystems through nutrient transfer and would provide food for migratory birds, fish, and other wildlife, as well as contribute to rebounding populations of these commercially important fish. Since mussels utilize specific anadromous fish and eels to transport their larvae upstream where they are distributed, restoration of stream habitat, removal of fish blockages, and water quality improvements could result in the reintroduction of mussels to larger areas of the Anacostia River watershed.

In summary, the extensive efforts to improve water quality being undertaken by the County and other partners, in conjunction with habitat improvement implemented by USACE, contribute significantly to the goals of the Chesapeake Bay EO and Bay Agreements by: improving the effectiveness of fish habitat conservation and restoration efforts; increasing available habitat to support sustainable migratory fish populations; restoring historical migratory routes for migratory fish, such as alewife herring (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), hickory shad (*Alosa mediocris*), American eel (*Anguilla rostrata*) and brook trout (*Salvelinus fontinalis*); and improving stream health and function throughout the watershed.

5.7 Environmental Compliance

For an activity or site to be environmentally acceptable for restoration work, the location, design, and operation must be in compliance with a number of environmental protection statutes and executive orders. Table 5-3 outlines the statutes and executive orders that are potentially applicable to the project. Upon project implementation, all applicable permits will be secured as required prior to project construction. Environmental impacts are discussed in Sections 5.1 to 5.6, with supporting environmental compliance documentation and a summary of coordination efforts located in Appendix C. Appendix C contains the Fish and Wildlife Coordination Act Report (addressing Section 2(b) of the Fish and Wildlife Coordination Act), USFWS Planning Aid Report, Endangered Species Act determination, Terms and Conditions of Nationwide Permit #27, Clean Air Act General Conformity Analysis, and agency correspondence. There is some overlapping content between the USFWS reports.

Table 5-3. Federal environmental protection statutes and other requirements requiring consideration.

Federal Statutes	Level of Compliance*
Anadromous Fish Conservation Act	Full
Archaeological and Historic Preservation Act	Full
Archaeological Resource Protection Act	N/A
Bald and Golden Eagle Protection Act	Full
Clean Air Act	Full
Clean Water Act	Full
Coastal Barrier Resources Act	N/A
Coastal Zone Management Act	Full

Federal Statutes	**Level of Compliance***
Comprehensive Environmental Response, Compensation and Liability Act	Full
Endangered Species Act	Full
Estuary Protection Act	N/A
Farmland Protection Policy Act	Full
Federal Water Project Recreation Act	N/A
Fish and Wildlife Coordination Act	Full
Flood Control Act of 1944	Full
Land and Water Conservation Fund Act	N/A
Magnuson Fishery Conservation and Management Act	N/A
Marine Mammal Protection Act	N/A
National Environmental Policy Act	Full
National Historic Preservation Act	Full
North American Wetlands Conservation Act	Full
Resource Conservation and Recovery Act	Full
Rivers and Harbors Act	N/A
Water Resources Development Acts of 1976, 1986, 1990, and 1992	Full
Water Resources Planning Act	Full
Watershed Protection and Flood Prevention Act	Full
Wild and Scenic Rivers Act	Full
Executive Orders (EO), Memoranda, etc.	
Migratory Bird (E.O. 13186)	Full
Protection and Enhancement of Environmental Quality (E.O. 11514)	Full
Protection and Enhancement of Cultural Environment (E.O. 11593)	Full
Exotic Organisms (E.O. 11987)	N/A
Floodplain Management (E.O. 11988)	Full
Protection of Wetlands (E.O. 11990)	Full

Federal Statutes	**Level of Compliance***
Relating to Protection and Enhancement of Environmental Quality (E.O. 11991)	Full
Environmental Justice in Minority and Low-Income Populations (E.O. 12898)	Full
Invasive Species (E.O. 13112)	Full
Protection of Children from Health Risks and Safety Risks (E.O. 13045)	Full
Prime and Unique Farmlands (CEQ Memorandum, 11 August 1980)	Full
*Level of Compliance: *Full Compliance (Full)*: Having met all requirements of the statute, E.O., or other environmental requirements. *Partial Compliance (Partial)*: Not having met some of the requirements at current stage of planning. Compliance with these requirements is ongoing. *Non-Compliance (NC)*: Violation of a requirement of the statute, E.O., or other environmental requirement. *Not Applicable (NA)*: No requirements for the statute, E.O, or other environmental requirement for the current stage of planning.	

5.8 Public Involvement and Agency Coordination

Water resources development studies conducted by USACE address problems and evaluate solutions that will provide benefits to the general public. NEPA and USACE planning regulations require public involvement. NEPA regulations state that in preparation of an EA, the agency shall involve environmental agencies, applicants, and the public to the extent practicable. Coordination with appropriate federal, state, regional, and local agencies is also a required part of the planning process. The intent of public involvement and agency coordination efforts undertaken during the study was to identify interested agencies and groups; encourage constructive interaction between the study team, representatives of the public, and agency representatives; and elicit and incorporate ideas, issues, and concerns important for the study area into the decision-making process. This section summarizes the public involvement and agency coordination actions undertaken during this study.

5.8.1 Study Notification & Updates

As this study arose from the Anacostia Restoration Plan, the input received during public involvement and agency coordination for the ARP were valuable for the scoping process for this study. In June 2015, a study initiation notice was released by USACE to solicit input from agencies and the public. The notice was distributed widely to announce the study, provide important background information, and request public participation. Coordination letters were sent to congressional interests, resource agencies, state and local governments, and potentially interested citizens and citizens groups. The study notice was sent to several libraries; federal, state, and local, resource agencies; congressional interests; and members of the public. Press releases were submitted to a number of media outlets and posted on social media. Additionally, study updates were provided at meetings of the Anacostia Watershed Management Committee in December 2013 and June 2015. The study initiation notice and mailing list for the study can be found in Appendix D, the Public Involvement Appendix.

Agency coordination was conducted concurrent with scoping and release of study notifications. Coordination was also conducted as required to satisfy environmental statutes and executive orders as identified in Table 5-3, and to address any agency concerns identified in response to the study notice.

5.8.2 Public Review of the Draft Report

A 30 day public comment period followed the release of the draft feasibility report and integrated environmental assessment. The public comment period ran from June 1 to June 30, 2016. A notice of availability was widely distributed to libraries; federal, state, and local, resource agencies; congressional interests; watershed groups; members of the public; and property owners. The notice was also available in Spanish. A project website was developed for download of the report and other information pertaining to the project (http://go.usa.gov/cJwx9). During the comment period, the project web page had 279 views, the press release had 87 views, and the report was viewed 76 times. The notice of availability in Spanish was viewed 73 times. Hardcopies of the report were placed at libraries in Prince George's County, including the Beltsville, Greenbelt, Hyattsville, Mount Rainier, and Bladensburg libraries. The notice of availability, mailing list, press release, and articles in the press related to the study are located in Appendix D.

Public comments were received from MD DNR, MNCPPC, USEPA, Anacostia Watershed Society, Anacostia Watershed Citizens Advisory Committee, NOAA, National Resource Conservation Service, Prince George's County, and three private citizens. In general, comments were supportive of the project. Comments from agencies provided recommendations on best management practices, time of year restrictions, and resources in the area. These recommendations have been incorporated into this report where appropriate, including into Section 4.8. Comments and response are included in Appendix D.

Since the release of the draft report, several presentations have been given to provide updates on the study. These include presentations for the Leadership Council for a Cleaner Anacostia River, Anacostia Partnership Management Committee, and the Anacostia Watershed Citizens Advisory Commission. Coordination meetings to discuss the proposed feasibility level designs were also held with Prince George's County and other major stakeholders, including MNCPPC, MWCOG, MDDNR, and NCPC.

6 CONCLUSIONS

The recommended plan for stream restoration within the Anacostia River watershed in Prince George's County, Maryland, is NW-C + NE-A. Plan NW-C + NE-A (Figure 3-9) includes restoration of aquatic habitat using natural channel design in six stream reaches, including on Northwest Branch (sites 3 and 13), Sligo Creek (site 9), Northeast Branch (site 15), Paint Branch (site 5), and Indian Creek (site 11).

Plan NW-C + NE-A restores approximately 7 miles of in-stream habitat, 4 miles of fish passage, and connects approximately 14 miles of restored habitat. The proposed plan will remove fish blockages on Northwest Branch and Sligo Creek. With-project restoration will facilitate the movement of these fish upstream and increase the suitability of habitat for river herring spawning, nursery, and migration from 21% to 83% on Northwest Branch and from 10% to 90% on Northeast Branch, thereby helping to restore sustainable anadromous fish populations in the watershed. Increased habitat diversity and stability resulting from the recommended plan will also benefit resident fish and benthic macroinvertebrates. Restoration of the Anacostia River watershed, as a contributing subwatershed to the Chesapeake Bay, supports Executive Order 13508 for restoration of the Chesapeake Bay, the Chesapeake Bay Program outcomes, ARP goals, and Urban Waters Federal Partnership.

Project first cost of the recommend plan, NW-C + NE-A, is $34,106,000 (FY 2019 price level). Annual OMRR&R expenses are expected to be minimal and are estimated at $22,000 per year. The federal portion of the estimated first cost is $22,169,000. Prince George's County's (the non-federal sponsor) portion of the required 35 percent cost share of total project first costs is $11,937,000, which includes 100 percent of the real estate costs (LERR).

The recommended plan has been evaluated pursuant to NEPA. The proposed solution for stream restoration will have no significant adverse impacts on the quality of the natural and human environment. The recommended plan provides substantial environmental improvements for the stream reaches of study and contributes to a comprehensive restoration strategy for the Anacostia River watershed.

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7 RECOMMENDATIONS

I recommend that ecosystem restoration for the Anacostia River watershed project area as generally described in the recommended plan for this report be authorized for implementation as a federal project, with such modifications thereof as in the discretion of the Commander, USACE may be advisable. I have given full consideration to all significant aspects of this recommendation in the overall public interest, including environmental, social, and economic effects, as well as engineering feasibility.

The estimated project first cost of the recommended plan is $34,106,000 (FY 2019 price level), which includes adaptive management costs of $449,000. Operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) expenses are estimated at $22,000 per year. The federal portion of the estimated first cost is $22,169,000. The non-federal sponsor's portion of the required 35 percent cost share of total project first costs is $11,937,000.

These recommendations are made with the provisions that non-federal partners shall, prior to implementation, agree to perform the items of local cooperation including:

a. Provide, during design and construction, funds necessary to make its total contribution for ecosystem restoration equal to 35 percent of the total project cost;

b. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material as determined by the Federal Government to be required or to be necessary for the construction, operation, and maintenance of the project;

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

d. Operate, maintain, repair, rehabilitate, and replace the project at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government;

e. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

f. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

g. Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, and other evidence are required, to the extent and in such detail as will properly reflect total cost of the project, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and local governments at 32 CFR, Section 33.20;

h. 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 USC 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction or operation and maintenance of the project;

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

j. Agree, as between the Federal Government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA;

k. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, (42 U.S.C. 1962d-5b) and Section 101(e) of the WRDA 86, Public Law 99-662, as amended, (33 U.S.C. 2211(e)) which provide that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element;

l. 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. 4601- 4655) and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way necessary for construction, operation, and maintenance of the project including those necessary for relocations, the borrowing of material, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

m. Comply with all applicable Federal and state laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled “Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army”; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c));

n. Not use the project or lands, easements, and rights-of-way required for the project as a wetlands bank or mitigation credit for any other project;

o. Not use funds from other Federal programs, including any non-federal contribution required as a matching share therefore, to meet any of the non-Federal sponsor’s obligations for the project unless the Federal agency providing the funds verifies in writing that such funds are authorized to be used to carry out the project.

The recommendations contained herein reflect the information available at this time and current departmental policies governing the formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of the national civil works construction program or the perspective of higher levels within the executive branch. Consequently, the recommendations may be modified before they are transmitted to Congress for authorization and/or implementation funding. However, prior to transmittal to Congress, the non-federal project partner (Prince George’s County, Maryland), interested federal agencies, and other parties will be advised of any significant modifications in the recommendations and will be afforded an opportunity to comment further.

John T. Litz, PMP
Colonel, U.S. Army
Commander and District Engineer

23 OCT 18

Date

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