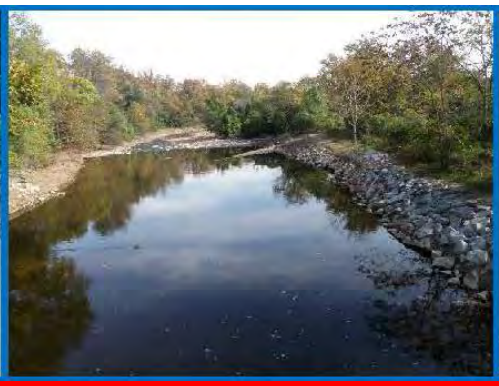
Anacostia Watershed Restoration, Prince George's County, Maryland

ECOSYSTEM RESTORATION FEASIBLITY STUDY AND INTEGRATED ENVIRONMENTAL ASSESSMENT

DRAFT REPORT (INTERIM) AND APPENDICES

JUNE 2016



US Army Corps of Engineers
Baltimore District

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DRAFT FINDING OF NO SIGNIFICANT IMPACT
Aquatic Ecosystem Restoration Feasibility Study and Environmental Assessment
Anacostia Watershed Restoration
Prince George's County, Maryland

The Baltimore District of the U.S. Army Corps of Engineers (USACE) is proposing to restore stream habitat utilizing natural channel design principles and to remove fish blockages within portions of the Anacostia River watershed in Prince George's County, Maryland. The recommended plan will restore degraded aquatic ecosystem structure and function within stream segments in Northeast Branch, Sligo Creek, Northwest Branch, Paint Branch, and Indian Creek. 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, USACE entered into a Feasibility Cost Sharing Agreement with the Prince George's County to conduct this study. In compliance with the National Environmental Policy Act (NEPA) of 1969, as amended, USACE has prepared a feasibility report with integrated environmental assessment (EA) to evaluate the environmental impacts of aquatic ecosystem restoration in the Anacostia River watershed in Prince George's County.

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 of in-stream habitat. The recommended plan will restore approximately 6.9 miles of in-stream habitat on six stream reaches, approximately 4 miles of fish passage, and connect a network of approximately 14 miles of 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 Northwest Branch. Currently, river herring access only about 21 percent of their historical range on Northwest Branch and 10 percent on Northeast Branch. With this plan, river herring access to approximately 83 percent on Northwest Branch and 90 percent on Northeast Branch will be facilitated. For resident fish and benthic macroinvertebrates, habitat improvements resulting from the recommended plan will include increasing diversity of depth and velocity conditions and stabilizing substrate to support species diversity and abundance. 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.

Restoration of in-stream physical habitat will utilize natural channel design principles. Stream corridors will be restored through the placement of in-stream structures, such as J-hooks, cross vanes, W-weirs, and step pools for grade control and riffle/pool restoration. Nested cross vanes will be used to ameliorate fish blockages. In-stream restoration is expected to result in increased reconnection of the streams with their floodplains, potentially aiding wetland reestablishment.

The proposed work 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 micro-organisms that are unable to relocate from the area. These populations are expected to reestablish upon completion of the construction. For all work, adverse impacts to waters of the United States and other resources will

be minimized to the extent practicable. Appropriate and practical steps to minimize potential adverse impacts will be incorporated into the project, such as avoiding wetland areas, minimizing tree removal, sequencing construction activities, stabilizing exposed soils, and replanting areas with native vegetation.

The project will observe all applicable state and federal requirements. In accordance with Maryland Department of the Environment (MDE) regulations, in-stream work will be conducted in dewatered conditions through the use of temporary cofferdams and pumps. To minimize adverse impacts to migratory species (anadromous fish spawning) and resident aquatic organisms, project activities will adhere to time of year restrictions to avoid in-stream work between February 15 and June 15, as recommended by the National Marine Fisheries Service and the Maryland Department of Natural Resources.

The majority of the project work will be confined to the area in between the stream banks, and is not expected to result in adverse impacts to cultural resources. Any access roads or staging areas will not include subsurface excavation and will be confined to previously disturbed areas when possible. Coordination with the Maryland Historical Trust (State Historic Preservation Office) regarding these impacts is ongoing and will be finalized for the final report.

Upon reviewing the EA, I find that the potential negative impacts to the watershed associated with the implementation of the project will be minimal and short-term in nature. The project will produce a net beneficial impact to the watershed and stream network of the Anacostia River. The accompanying environmental assessment supports the conclusion that the project does not constitute a major Federal action affecting the quality of the human environment. Therefore, an environmental impact statement is not necessary to implement the recommended restoration measures for aquatic ecosystem restoration in Prince George's County, Maryland.

Edward P. Chamberlayne, Ph.D., .P.E.
Colonel, U.S. Army
Commander and District Engineer

Date: _____

EXECUTIVE SUMMARY

This draft 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, USACE entered into a Feasibility Cost Sharing Agreement with the 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 tentatively selected plan (TSP) 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 1-5). 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 1-8). 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 twenty-three 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 3-2). 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. Potential management measures were identified to meet project objectives and were combined into alternatives that were screened based on planning constraints and considerations, community and ecosystem restoration benefits, impacts, cost, implementability, and sustainability. The two alternatives that best met project objectives were carried forward, including no action and natural channel design.

For the natural channel design alternative, concept-level design alternatives (approximately 10 percent design level) and associated parametric (preliminary) 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 were included into cost effective/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 TSP. Plans were initially screened based on cost effectiveness. The recommended TSP, 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 (Figure 3-4). The TSP will be finalized following consideration of comments received during report review, including agency and public review, Agency Technical Review, and USACE Headquarters Review. Additionally, the TSP could be reduced if costs increase upon further design and the incremental benefit is subsequently not considered to be worth the investment. Specifically, with the development of more detailed designs and costs (and rerun of CE/ICA), the entirety of the Plan NW-C and NE-A may not be supported. Stream sites 9 and/or site 13 could be removed from the TSP.

Plan NW-C + NE-A restores 6.9 miles of in-stream habitat, 4.3 miles of fish passage, and connects 13.5 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 Northwest Branch. With this plan, 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. For resident fish and benthic macroinvertebrates, habitat improvements resulting from the TSP will include increasing diversity of depth and velocity conditions and stabilizing substrate to support species diversity and abundance. 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. Since the purpose of this project is aquatic ecosystem restoration, no compensatory mitigation is required for the TSP.

The majority of the project work will be confined to the area in between the stream banks, and is not expected to result in adverse impacts to cultural resources; however, coordination with the Maryland Historical Trust (State Historic Preservation Office) regarding these impacts is ongoing and will be finalized for the final report. Any access roads or 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 TSP 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 ARP goals. The Urban Waters Federal Partnership is also supported by reconnecting urban areas with their waterways.

Project first cost of the TSP is $37,300,000 (fiscal year 2016 price level). Operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) expenses are expected to be minimal and are estimated at $13,500 per year. The federal portion of the estimated first cost is $24,245,000. The non-federal sponsors' portion of the required 35 percent cost share of total project first costs is $13,055,000, which includes 100 percent of the real estate costs (land, easements, rights-of-way, and relocations).

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ACRONYMS AND ABBREVIATIONS

ARP	Anacostia Restoration Plan
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
LERRD's	Lands, easements, rights-of-way and relocations and disposal/borrow areas
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
NE-A	Plan A for the Northeast Branch alternatives (a component of the tentatively selected plan)
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
NW-C	Plan C for Northwest Branch alternatives (a component of the tentatively selected plan)
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
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

1 INTRODUCTION

This draft feasibility report and integrated environmental assessment (EA) is an interim 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 draft feasibility report recommends a tentatively selected plan (TSP) for implementation of aquatic ecosystem restoration to restore in-stream habitat and fish passage in six stream reaches in the Anacostia River watershed 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

Human alteration of the Anacostia River watershed has resulted in significant degradation of aquatic ecosystems. The purpose of this study is to restore ecological function, structure, and health in selected stream reaches in the Anacostia River watershed in Prince George's County.

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 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.

1.3.1 Federal Interest and 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).

The Anacostia watershed restoration, including USACE involvement, represents one of the few national examples of successful urban watershed restoration. Figure 1-1 illustrates the national and regional significance of the TSP. 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). 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).

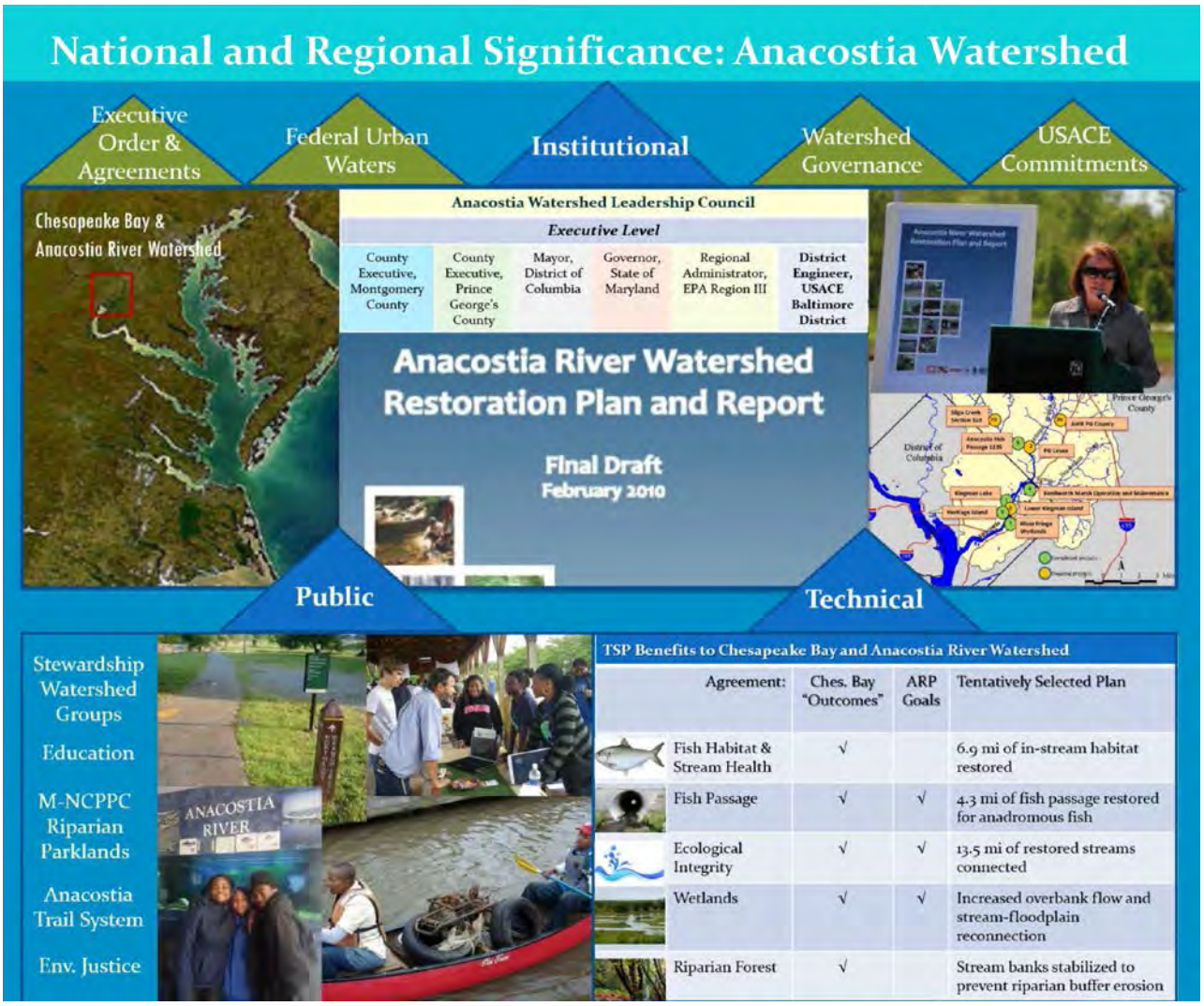


Figure 1-1. National and regional significance of the Chesapeake Bay and Anacostia River watershed.

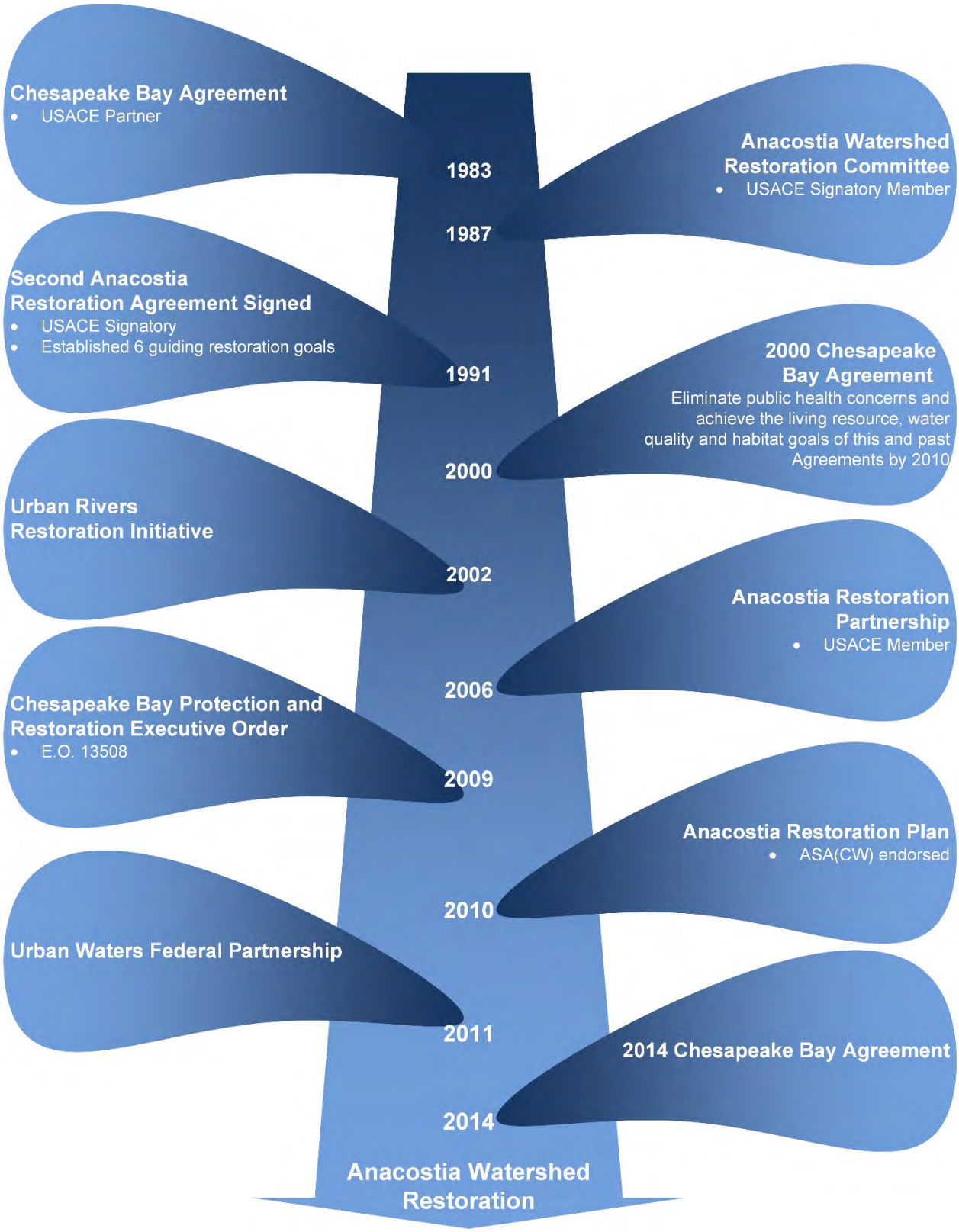


Figure 1-2. Federal commitments in the Anacostia River watershed.

1.3.1.1 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.

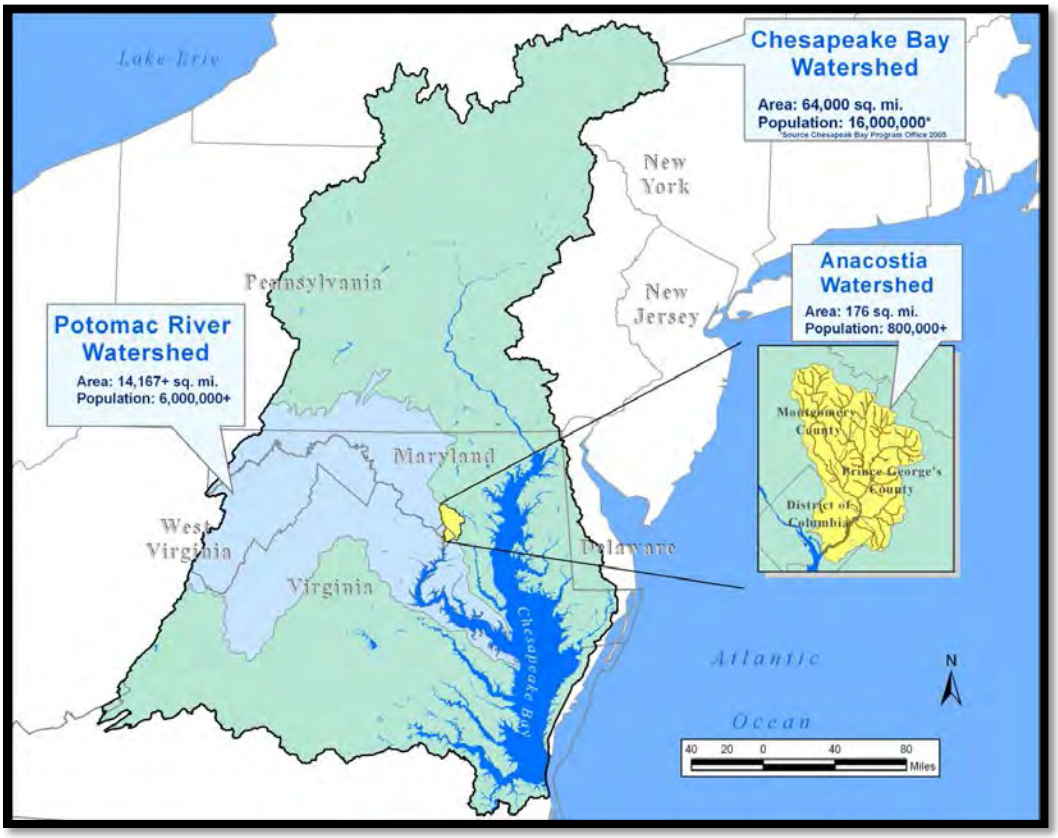


Figure 1-3. Location of the Anacostia River watershed within the Chesapeake Bay watershed.

1.3.1.2 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 the following "outcomes" which are supported by the TSP 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 TSP 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).

1.3.1.3 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, 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.

1.3.2 Institutional and Public Significance

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 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.

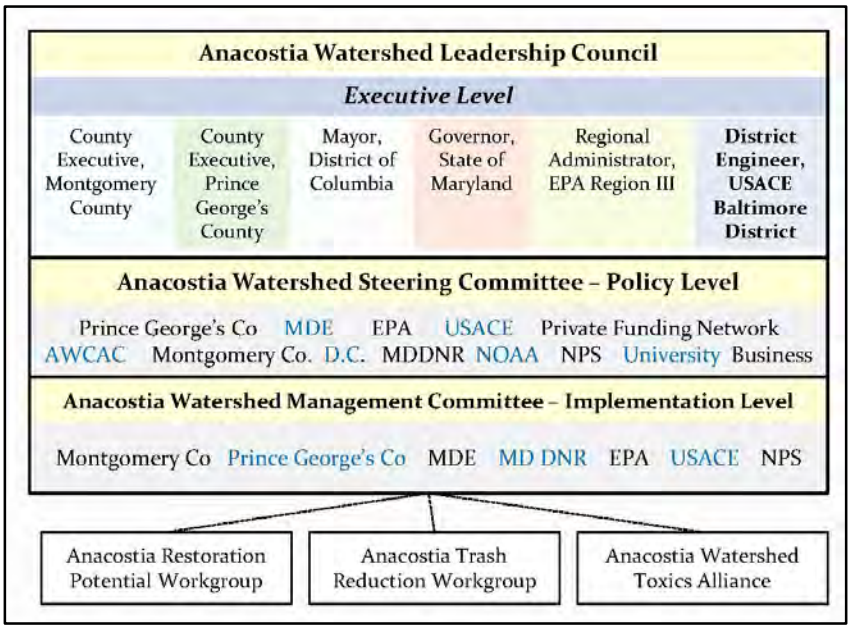


Figure 1-5. Elements of the Anacostia Watershed Restoration Partnership (from MWCOG 2009), with USACE role at Executive Level in bold font.

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 (see Section 1.4) 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. 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.

1.3.3 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). 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.

1.4 Study Scope

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.

1.4.1 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. 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). A brief description of the subwatersheds is provided in Appendix A and existing conditions for the subwatersheds are described in Section 2. The selection process for the stream reaches is described in Section 3, and the details of the existing and proposed conditions for the stream sites included in the TSP are discussed in Section 5.

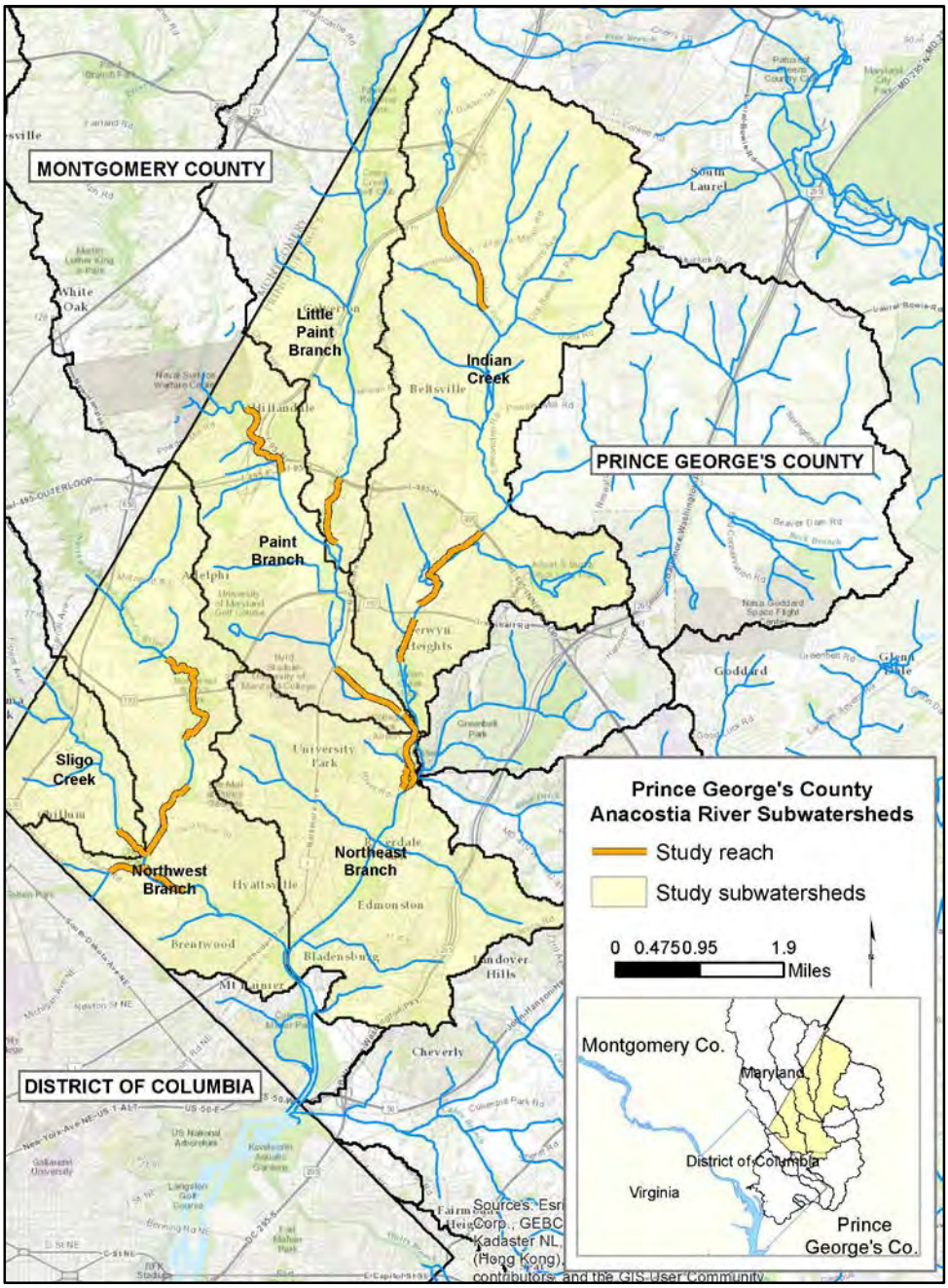


Figure 1-6. Anacostia River watershed and subwatersheds in Prince George's County, MD.

1.5 Prior Studies, Reports, and Water Projects

Numerous studies and projects, including for ecosystem restoration, flood risk mitigation, and navigation, have been completed by USACE in the Anacostia River watershed. Figure 1-7 and Table 1-1 provide descriptions and locations of a subset of more recent projects and studies within the watershed. This study area is shown on the map (Figure 1-7) and Table 1-1 as location "3b". Some of the projects shown were presented as candidate restoration projects in the ARP. A more extensive table of USACE reports on the Anacostia River watershed is located in Appendix A.

In addition to the ARP and projects shown above, other recent USACE studies include the *Anacostia Federal Facilities Impact Assessment* (1997) and *Stormwater Pollution Prevention and Retrofit Planning Study for Federal Facilities in Prince George's County* (1998), undertaken under Section 219. 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.

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 have also included wetland creation and construction of stormwater management ponds.

Two of the most recent reports relevant to the Anacostia River watershed in Prince George's County include the ARP (AWRP, 2010; as described in Section 1) and *Restoration Plan for the Anacostia River Watershed in Prince George's County* (PGDOE, 2014). PGDOE, Washington Suburban Sanitary Commission (WSSC), and other entities have undertaken several stream restoration projects in the Anacostia River watershed and vicinity, including on Paint Branch and Indian Creek. These efforts have included wetland restoration, fish barrier modification, and tree plantings in riparian zones.

PGDOE 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 (see Section 2.2.3). Biological data are also collected to address questions related to the status and trends of stream and watershed ecological conditions. In addition to stream restoration projects, a large number of water quality improvement projects are being implemented in Prince George's County. These are further described in Section 2, and together with the in-stream habitat restoration provided by the TSP, constitute a comprehensive restoration strategy for the Anacostia River watershed.

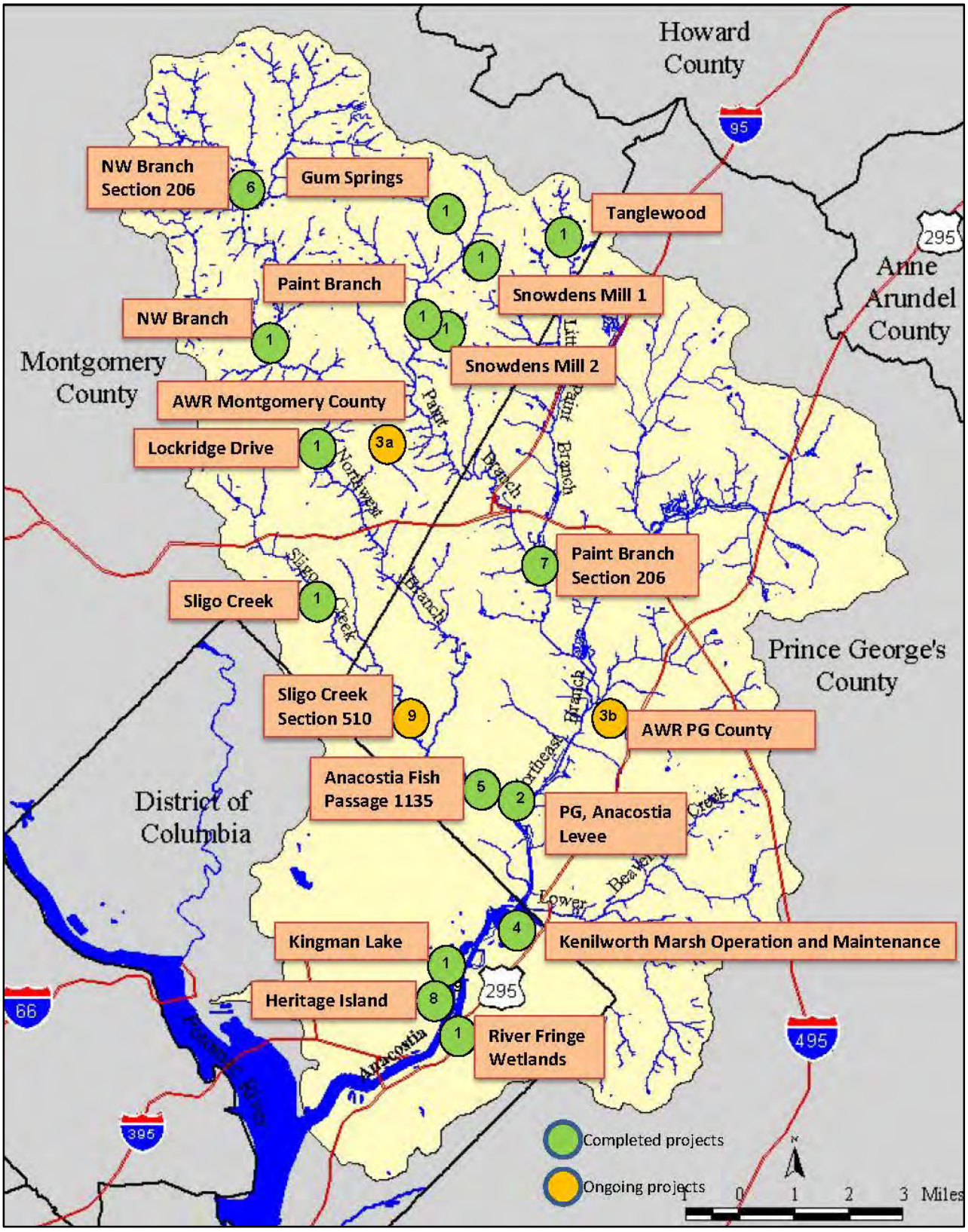


Figure 1-7. Subset of USACE projects in the Anacostia River watershed.

Table 1-1. Descriptions of USACE projects (as of September 2015) shown in Figure 1-7.

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 will rehabilitate two bio-retention facilities at two elementary schools and install vernal pools and stormwater management practices in the lower Sligo Creek subwatershed in Prince George's County. Anticipated completion date is fall 2016.

1.6 *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.

1.6.1 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 by USACE for 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 1-8 illustrates some of the problems within the stream reaches of study. The problems and opportunities are described in detail in following sections.

1.6.1.1 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).

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 that processes of stream meandering have not yet caused natural self-recovery of heterogeneous in-stream habitat conditions, especially in the stream segments channelized by USACE or others. These streams contain lengthy reaches with uniformly shallow depths, inadequate woody debris, and homogenous habitat conditions. The assessment found that habitats greater than 1.6 feet (0.5 meters) in depth were very limited in distribution. This is almost entirely an artifact of channelization that eliminated meanders, shortened water flow lengths, and as such has eliminated these habitat types. Areas of faster current (1 foot/second) were also very limited.

Figure 1-8. 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. Excess sediment deposition and formation of large sediment bars (site 5). D. Homogeneous habitat conditions as a result of USACE channelization (site 3).

1.6.1.2 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 1999–2003 and the second in 2010–2013. 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). 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. Accordingly, when seeking to benefit the full assemblage of fish species likely to have occurred in a stream under historic natural conditions, the best approach is to attempt to restore the full range of all the physical parameters of unaltered habitat. Spatially uniform depths and velocities provide relatively poor fish habitat (USACE, 2000) 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).

1.6.1.3 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.

1.6.2 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. 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 species[1] expected to occur with comprehensive watershed restoration (Table 1-2). 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

[1] Report focused on taxa, which for the purposes of this study are synonymous with species.

restoration includes both physical habitat improvements as provided by the TSP, and water quality and flow improvements that are currently ongoing by other agencies. Table 1-2 shows the potential taxa increases from existing and future without project (FWOP) conditions for non-migratory and migratory fish. Forecasts identify that all streams in the study area have the potential for increased fish diversity with comprehensive restoration.

Table 1-2. Fish species richness under existing conditions and with comprehensive restoration.

		Number of Fish Taxa[1]		
Site No.	**Stream segment**	**Existing and FWOP conditions[3]**	**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.
[3] Existing and FWOP conditions are assumed to be similar (see text in Section 2.5)
**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*), adult brown trout (*Salmo trutta*), 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) identified that the study streams have the potential to achieve fully functioning geomorphology with proper stream restoration techniques. 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, including storm-water best management practices 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.

1.7 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.

1.7.1 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'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[2] 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.

   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 effective 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.**

[2] 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.

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 (further described in Section 3).

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.

1.7.2 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 project (USACE, 1975) on Northwest Branch, Northeast Branch, Paint Branch, and Indian Creek.

1.7.3 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 difficultly with reestablishment of healthy forest understory (due to deer browsing).
3. Minimize impacts to actively used recreational space, or mitigate adverse impacts.

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 TSP 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 TSP. 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 for CO since 1996. In 2016, it is expected that Prince George's County will be in full attainment for CO (i.e., will come out of maintenance status).

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	Chilllum 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 each range 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. Conceptual designs 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. The impervious nature of roads affects both water quality and quantity. Large volumes of runoff enter stream courses during precipitation events, typically carrying pollutants into stream systems. The environmental modeling performed for this project (Section 3 and Appendix B) includes a measure of the distance between the stream site and the nearest road, which is used as a proxy for urban stressors on the stream. 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.

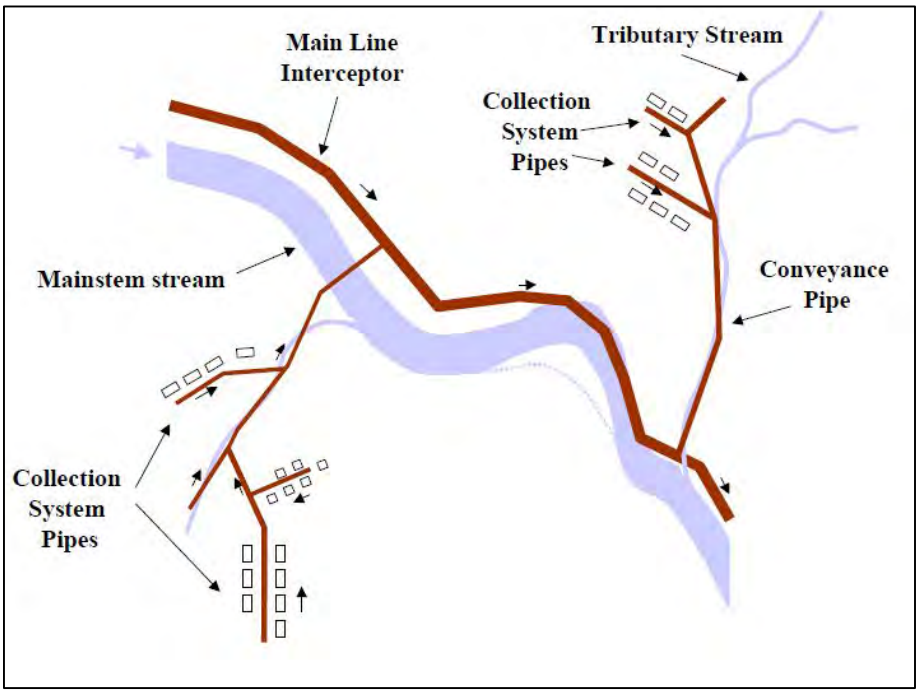


Figure 2-1. Schematic of a gravity-flow sewer system (from Ken Belt, USDA).

2.2 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). Section 3 describes the site selection process, and Section 5 describes the existing conditions for each of the sites included in the TSP.

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). USACE field assessments conducted for this study in 2014 and 2015 found that processes of stream meandering have not yet caused natural self-recovery of heterogeneous in-stream habitat conditions in the channelized stream segments. Channelized study area streams armored with hard materials show a greater range of physical habitat conditions than do those 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 4.

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. The vertical and lateral instability observed in these systems indicates these streams are still in a state of adjustment. 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 Categories I, II, III, and IV waters, which include (Code of Maryland Regulations [COMAR] 26.08.02.08 O):

Use Category	Designated Use and Description
I	Water Contact Recreation and Protection of Non-Tidal Warmwater 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 percent 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 mandated completion of construction for sewer improvements by December 2015, although other activities may still be underway. 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.

Currently there are 26 listings for the Prince George's County portion of the Anacostia Watershed in Maryland's list of impaired waters. Listed impairments 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 2.5.3.

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 is 40 percent, equivalent to a grade of "F".

2.3 Biological Resources

2.3.1 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 1.3.3, 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, 38th 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. 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 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."

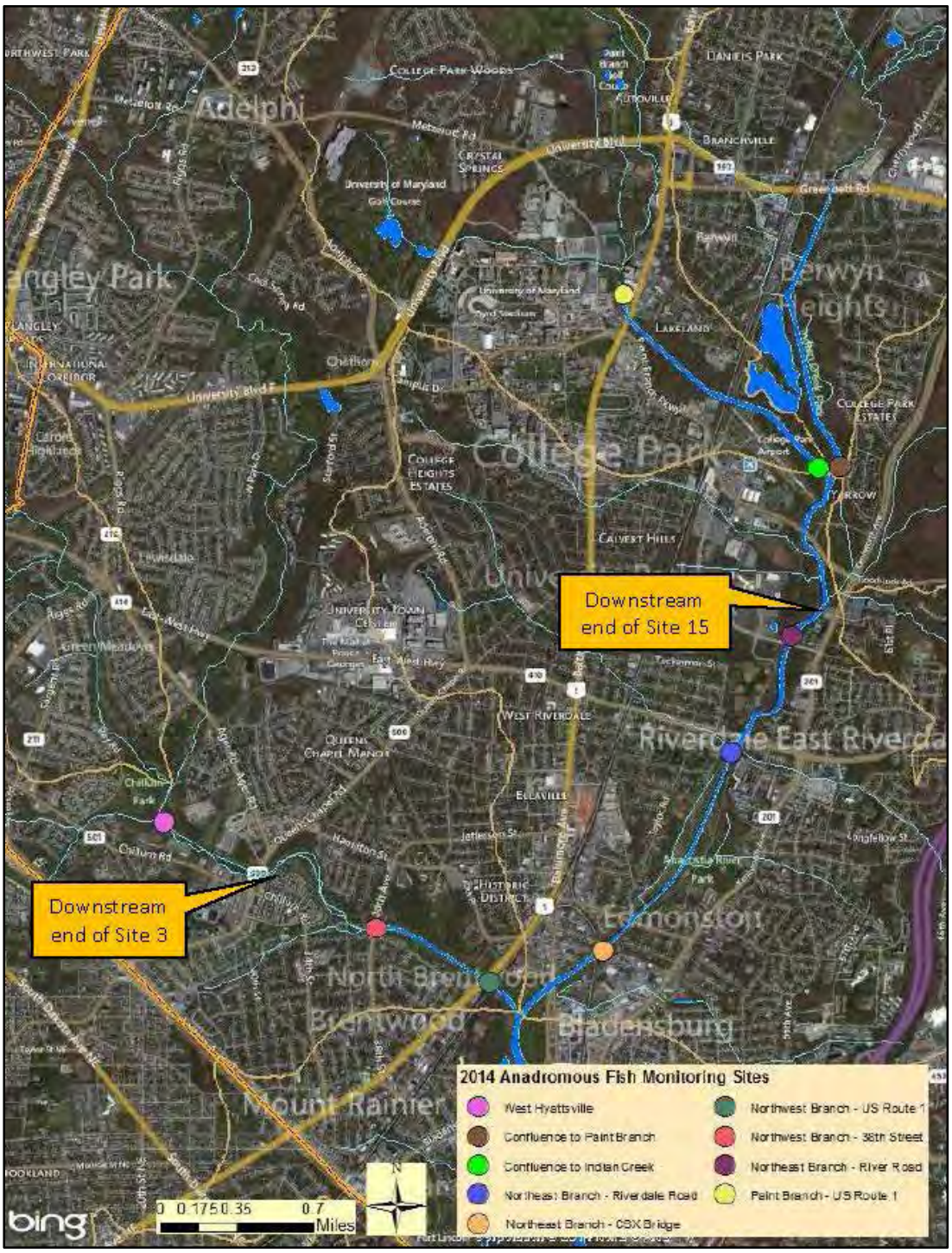


Figure 2-2. MWCOG migratory fish monitoring sites on Northwest and Northeast Branches (from MWCOG, 2014). Study sites 3 and 15 shown for context.

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 1.6, 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 performed in 2014 to 2015 indicate 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.

2.3.2 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. These blockages 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. As discussed in Section 2.3.1, 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).

2.3.3 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).

2.3.4 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. Field surveys with MD DNR will be

conducted in the summer of 2016 to delineate the exact locations of this plant. The potential impacts to this species from project implementation are discussed in Section 5.

2.3.5 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 2-4. 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 2-4. 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 (Table 2-5). 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 2-4. 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 2-5. Description of riparian vegetation at each stream site.

Site	Stream Name	Description of Riparian Vegetation
1	Indian Creek at I-95	The upper half of site 1 has a forested buffer and is classified as a palustrine forested wetland. The lower half has some adjacent forest buffer, but also runs along developed properties.
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.
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.
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 road/interstate crossings fragment the forested buffer.
9	Sligo Creek	The riparian corridor is forested as site 9 flows through Chillum Park, but width varies with buffer width increasing downstream.
10	Northwest Branch	Site 10 has a narrow, forested edge on one bank, but one bank is lawn with some trees.
11	Indian Creek	The upper portion of site 11 has a continuous, forested buffer, and is largely classified as palustrine forested wetland. 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.
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 on one bank of approximately 800 ft of the lowest portion of the reach.
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.
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.

2.4 Community Setting

2.4.1 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).

2.4.2 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 2-6.

Table 2-6. 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, Hyattsville	77	11.16	16.16
Site 5 - Paint Branch, College Park	32	11.10	48.28
Site 7 - Paint Branch at I-95	61	10.57	16.29
Site 9 - Sligo Creek, Hyattsville	85	7.94	12.69
Site 10 - Chillum Road Tributary, Hyattsville	79	7.73	11.94
Site 11 - Indian Creek, College Park	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, Calvert Rd	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.

2.4.3 Schools

Schools located within 1640 feet (500 meters) from the project stream reaches are shown in Table 2-7.

Table 2-7. Schools within 1640 feet (500 meters) of proposed streams segments.

Site Number - Stream Name	School Name	Distance from Segment (m)
Site 1 - Indian Creek I-95	Martin Luther King Jr. Middle School	277
Site 1 - Indian Creek I-95	Kids in His Care Daycare	299
Site 3 - Northwest Branch Hyattsville	Rosa Parks Elementary	173
Site 5 - Paint Branch	Paint Branch Elementary	230
Site 5 - Paint Branch	University of Maryland	275
Site 12 - Little Paint Branch	Childway	280

2.4.4 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 2-8 shows parks located within 1640 feet (500 meters) from the proposed project stream reaches.

Many of the parks adjacent to the project streams 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 2-8. Parks within 1640 (500 meters) of proposed stream segments.

Site Number - Stream Name	Park Name	Distance from Segment (m)
Site 3 - Northwest Branch/Upstream FRM	Huerich Park Turf Field	190
Site 5 - Paint Branch	Lake Artemesia Natural Area	0
Site 5 - Paint Branch	Paint Branch Stream Valley Park	0
Site 7 - Paint Branch I-95	Paint Branch Park	0
Site 10 - Northwest Branch/Chillum Road Tributary	Michigan Park Hills Neighborhood Playground	160
Site 12 - Little Paint Branch	Cherry Hill Recreation Center	85
Site 12 - Little Paint Branch	Paint Branch Golf Course	0
Site 15 - Northeast Branch	Tennis Center at College Park	240
Site 15 - Northeast Branch	Ellen Linson Swimming Pool	295
Site 15 - Northeast Branch	Herbert Wells Ice Rink	50
Site 15 - Northeast Branch	Calvert Road Disc Golf	100

2.4.5 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 2.4.4. For purposes of regulation, noise is measured in dBA or A-weighted decibels. This unit uses a logarithmic scale and weights sound frequencies. Table 2-9 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 2-9. 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

2.4.6 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). In 2012, 413 historic sites, 136 historic resources, and three county-designated historic districts were listed for Prince George's County (MNCPPC, 2012). Many historic landmarks along the Anacostia tributaries are linked by the Anacostia Tributary Trail System including the College Park Airport and Aviation Museum, Adelphi Mill, the Rossborough Inn at the University of Maryland, and the George Washington House.

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 information received from the Maryland Historical Trust (MHT), State Historic Preservation Office (SHPO), 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. Coordination with the MHT, is ongoing to confirm the area of potential effects and identify locations for field work.

2.4.7 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 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).

2.5 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) described in Sections 2.1 to 2.4 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.

2.5.1 Climate

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 (Najjar et al. 2010). 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).

Based on the USACE Watershed Climate Vulnerability Assessment (maps.crrel.usace.army.mil), the Potomac River watershed (HUC 0207) is not vulnerable to climate change. No USACE business line under any climate change scenario is projected to be vulnerable to projected climate change. The annual maximum daily discharge at Northeast Branch Anacostia River at Riverdale, MD (which is downstream of all project sites) shows an increasing trend from 1938 through 2014. USACE's online Climate Hydrology Assessment Tool indicates that the annual maximum daily discharge has a statistically significant increase while the largest annual three-day maximum discharge is not statistically significant at the $p<0.05$ level (http://corpsmapu.usace.army.mil/cm_apex/f?p=313:2:0::NO).

The Climate Hydrology Assessment Tool also shows a projected significant trend in the mean of 93 climate-change hydrology models for annual maximum monthly flows in the Potomac River watershed. 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). Absent stream restoration, the predicted increase in intensity of precipitation may cause higher peak flows and accelerate stream erosion within the watershed's streams.

2.5.2 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 best management practices 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.

2.5.3 Water Quality

In 2011, Prince George's County developed a countywide WIP in response to the Chesapeake Bay TMDL set by EPA in 2010. 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 2-10 shows the percent reductions required to meet TMDLs in the Anacostia River watershed in Prince George's County.

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.

Table 2-10. Percent reductions required for the Anacostia River watershed in Prince George's County (from PGDOE, 2014).

Pollutant	Percent 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%

2.5.4 Stream Geomorphic Condition

Streams in the project area appear to be adjusting 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. Improved water quality of stormwater runoff will be required with redevelopment, with some minor quantity control also expected. Although erosive flows may be mitigated to some extent, the streams will remain unstable absent a geomorphic restoration project. Erosion will continue for decades to centuries as streams attempt to adjust, with potential implications for continued loss of riparian area and degradation of aquatic habitat.

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. Additionally, 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.

2.5.5 Fish and Benthic Integrity

Improvements in water quality and flow are ongoing as described, which could result in small improvements in fish and benthic IBI scores. However, habitat in the study streams is also a limiting factor. 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. 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. Over

the period of analysis the streams will not likely establish a dynamic equilibrium that maintains habitat complexity and results in increases in species abundance and diversity.

2.5.6 Fish Passage

The project stream sites include four fish blockages as described in Section 2.3.2. 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. Furthermore, new blockages could be created as in-stream utilities are unearthed by erosive flows. As discussed in Section 1.3.3, 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, and their contributions to local ecosystems, will not increase.

2.5.7 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. 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. Along the project streams wetlands are expected to persist, but no additional wetland acreage or improvements to connection with the floodplain are expected.

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 TSP 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. Absent project restoration, unstable geomorphic conditions continue to erode stream banks resulting in some tree loss.

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 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 TSP.

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 TSP. This process is illustrated in Figure 3-1, where the left side of the figure shows the site selection and screening process (described in Section 3.1) and the right side of the figure shows the evaluation of management measures and alternatives and the selection of the TSP (described in Sections 3.2 through 3.7). 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 twenty-three 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 1.7. 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);
5. Located on primarily public lands with forest cover or existing riparian buffer.

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. The planning consideration to prioritize activities on public land was based on the past experience of the sponsor working in the Anacostia River watershed, who found it 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.

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	Criteria 5: Public Lands	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	√	√	√	√	√	

Reach	Subwatershed	Status	Criteria 1: Degraded habitat	Criteria 2: Improvement potential	Criteria 3: No downstream fish blockage	Criteria 4: Cumulative Benefits	Criteria 5: Public Lands	Notes
Chillum Road Tributary (Site 10)	Northwest Branch	Selected	√	√	√	√	√	
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	√	√	√		√	
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.
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 (mi)
Northwest Branch			
Northwest Branch – Hyattsville (Site 3)	35.6	3	1.38
Northwest Branch - Chillum Rd Tributary (Site 10)	2.02	1	0.40
Northwest Branch - Riggs Rd (Site 13)	34.1	3	1.46
Sligo Creek			
Sligo Creek (Site 9)	11.2	2	0.42
Northeast Branch			
Northeast Branch – Calvert Rd Disc Golf Park (Site 15)	69.2	4	1.04
Indian Creek			
Indian Creek -I-95 (Site 1)	2.52	1	1.32
Indian Creek – College Park (Site 11)	27.4	4	1.98
Paint Branch			
Paint Branch (Site 5)	31.1	3	1.30
Paint Branch –I-95 (Site 7)	16.4	2	1.11
Little Paint Branch			
Little Paint Branch (Site 12)	10.5	2	0.86

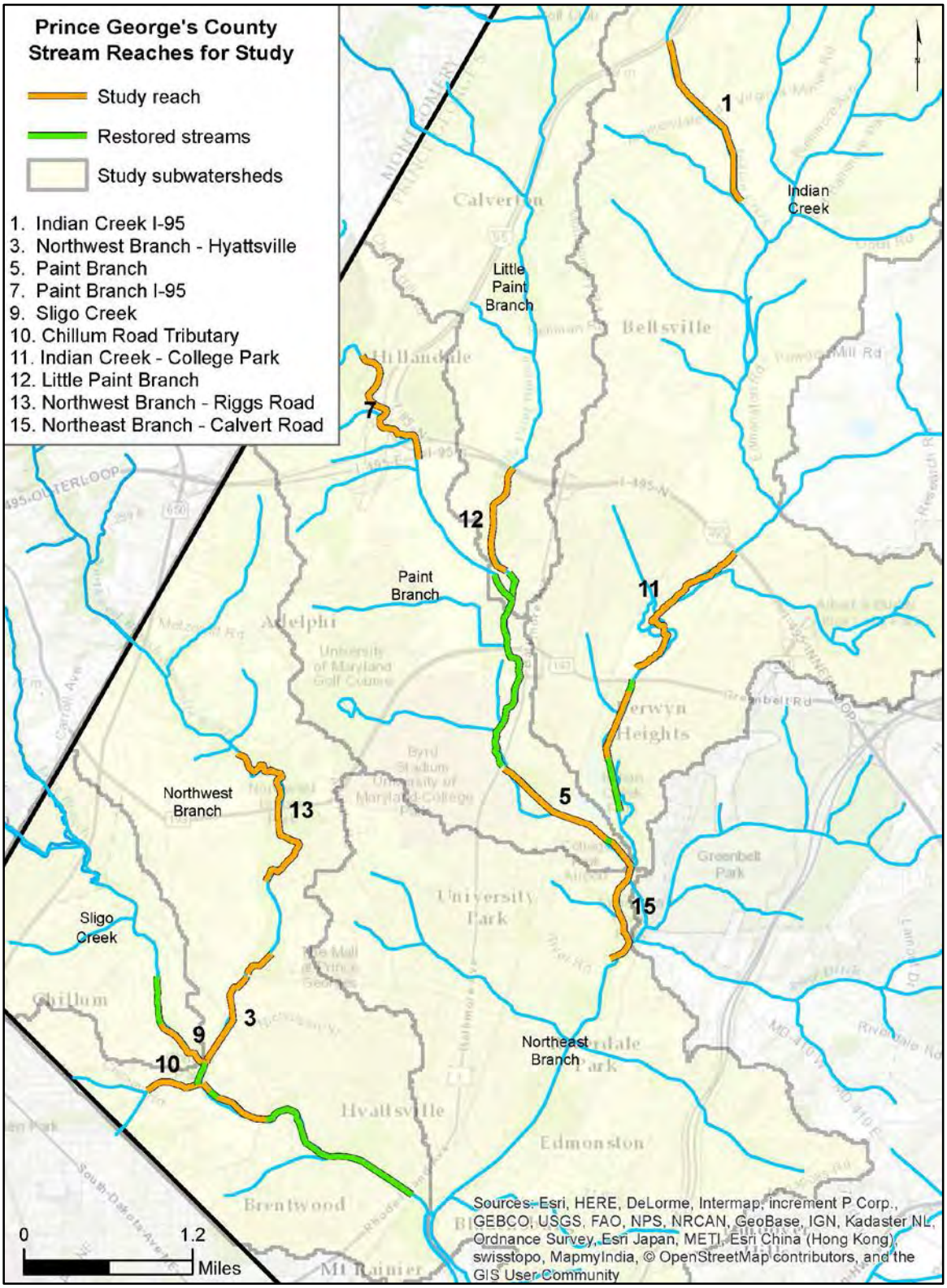


Figure 3-2. Project area and selected stream reaches in Prince George's County, Maryland.

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 (Table 3-3) following the development of project problems, opportunities, objectives, constraints, and considerations. Over the course of the planning process, project objectives evolved into the objectives identified in Section 1.7; however, objectives initially included in-stream habitat restoration, fish passage, wetland restoration, and enhancement of connectivity.

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

- Natural channel design
- Legacy sediment removal
- Hard design
- Streambank Stabilization (USACE Engineer and Research Development Center)
- Regenerative stormwater conveyance

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.

After conceptual designs for each potential restoration reach were developed, these measures were reexamined to determine whether additional alternatives could be generated. No additional measures were identified that met planning objectives and did not violate planning constraints. The potential project reaches were spatially constrained by adjacent private properties that preclude the use of some measures. Other measures require the removal of mature trees. While some measures may provide stream stability and prevention of bank erosion (such as concrete and gabion structures), they are not formulated for ecosystem benefits. Measures for wetland restoration were considered because the project objectives initially included wetland restoration as a secondary objective. However, because formulation for wetlands was secondary, it was later determined that the available data were not sufficient to model (quantify) wetland benefits for evaluation in the cost effectiveness analysis; therefore, the objective for wetland restoration was removed. However, the projects are expected to contribute to the reconnection of streams with the adjacent floodplains. This will increase wetted area and potentially aid in the reestablishment of wetlands.

Table 3-3. Ecosystem restoration management measures for the objectives*.

Measure	Objective			
	Stream Restoration	Fish Passage	Wetland Restoration*	Connectivity
Floodplain				
Create New	●		●	●
Reconnect by lowering bank	●		●	●
Reconnect by raising stream	●		●	●

Measure	Objective			
	Stream Restoration	Fish Passage	Wetland Restoration*	Connectivity
Vegetation (riparian and in-stream)	●		●	
Habitat				
Root wads	●			
Boulders	●			
Riffles/Pools	●			●
Lunkers and “man-made objects”	●			
Coarse Woody Debris	●		●	
Grade Control Structure				●
Step Pools	●	●	●	●
Weirs	●		●	●
Vanes	●		●	●
J-Hooks	●		●	●
Riffle grade control	●	●		●
Connection				
Fish Ladder		●		●
Step Pools	●	●		●
Blanketing				
Rip-Rap	●			
Gabion Basket				
Concrete channel excavation (mid-channel)	●	●		●
Concrete channel modification (baffles)	●			●
Imbricated Rip-Rap	●			
Pipe Daylighting	●			●
Stream Relocation	●	●	●	●
Infrastructure Relocation	●	●	●	●

Measure	Objective			
	Stream Restoration	Fish Passage	Wetland Restoration*	Connectivity
Riparian Invasive Species Removal			●	●
*The initial objective for wetland benefits was removed over the course of the planning process, and fish passage and connectivity were combined into one objective.				

3.3 *Summary of Initial Array of Alternatives

Alternatives are a set of one or more management measures functioning together to address planning objectives. The following alternatives, which include combinations of the management measures presented above, were evaluated:

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

Alternative 2a: Natural Channel Design

- Natural Channel Design measures – in-stream habitat improvement at all segments
- Stream restoration (opportunities may include Indian Creek I-95, Indian Creek-College Park, Paint Branch, Paint Branch I-95, Little Paint Branch, Lower Northwest Branch, Northeast Branch) in concert with wetland restoration (floodplain reconnection)
- Floodplain reconnection
- Stream relocation
- Partial removal of concrete in channelized stream reaches or addition of in-stream structures within concrete channels
- Daylight pipes
- Fish passage provision at blockages within segments
- Invasive plant species removal

Alternative 2b: Natural Channel Design with Major Infrastructure Modification

- This alternative includes all the measures included in Alternative 2a
- Relocation or movement of existing major infrastructure such as bridges and roads to provide habitat improvement (riparian reforestation, improved stream geometry)
- Removing concrete completely from channelized stream reaches

Alternative 2c: Natural Channel Design without Concrete Channel Alteration

- This alternative includes all the measures included in Alternative 2a
- Concrete channels are not altered

Alternative 3: Hard Design

- Use of rip-rap, gabion baskets, and concrete matting

- Stream restoration (opportunities may include Indian Creek I-95, Indian Creek-College Park, Paint Branch, Paint Branch I-95, Little Paint Branch, Lower Northwest Branch, Northeast Branch) in concert with wetland restoration (floodplain reconnection)
- Stream relocation
- Fish passage improvement: step pools or fish ladder
- Invasive plant species removal

Alternative 4: Streambank Stabilization

- Use of ERDC Streambank Stabilization techniques for stream restoration
- Stream restoration (opportunities may include Indian Creek I-95, Indian Creek-College Park, Paint Branch, Paint Branch I-95, Little Paint Branch, Lower Northwest Branch, Northeast Branch) in concert with wetland restoration (floodplain reconnection)
- Stream relocation
- Partial removal of concrete in channelized stream reaches or addition of in-stream structures within concrete channels
- Daylight pipes
- Fish passage improvement: step pools or fish ladder
- Invasive plant species removal

Alternative 2b, Natural Channel Design with Major Infrastructure Modification, was not evaluated further due to challenges in implementation. Based on past experience in the watershed and the high cost that would accompany road and bridge relocation this alternative was unsupported by the sponsor and SHA. Additionally, alteration of concrete channels and the resulting effects on flood water conveyance were determined unacceptable by the project team and PGDOE.

3.4 *Evaluation and Comparison of Array of Alternative Plans

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
Ecosystem Benefit	Yes/Neutral/No	Creation of stream complexity to support habitat diversity
Ecosystem Impact	High/Low	Long-term negative impact to natural features within project area (e.g. trees, bedrock)
Community Impacts (Surrounding Built Environment)	High/Low	Alteration to flooding; recreation space & trails; public utilities; infrastructure
Cost	$ / $$ / $$$	General “low” ($100s/lf), “medium” ($200s/lf), “high” ($300s/lf)

Criteria	Metric	Definition
Implementability	+ 0 -	Implemented in a reasonable timeframe with reasonable technology
Durability/Sustainability	High/Med/Low	Measure of OMRR&R sustainability and practicality.

Table 3-5. Comparisons of alternatives.

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

Based on this comparison array, Alternatives 2a and 2c best met the project objectives for ecosystem restoration. The natural channel design alternatives offer ecosystem restoration benefits with low environmental impact while being implementable and sustainable. However, since Alternative 2c is lower in cost, and the sponsor was not in favor of concrete channel alteration, Alternative 2c was carried forward to the final array. 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

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 effective/ incremental cost analysis (CE/ICA), project costs and ecosystem restoration benefits must be determined.

For Alternative 2c, Natural Channel Design without concrete channel alteration, the team developed conceptual designs, parametric cost estimates, and a quantification of ecosystem restoration outputs

(benefits). These were used to evaluate the cost-efficiency of the plans and to identify Best Buy plans, as described in Section 3.5.4.

3.5.1 Conceptual Design Alternatives

For Alternative 2c, two concept-level design alternatives (10-percent design level) were developed for the stream miles proposed for restoration at each of the 10 sites. This resulted in 20 total designs. These designs differ based on the number of in-stream structures used, the types of materials used, and the plan for relocation of the channel and/or floodplain work.

The planning process went through several iterations. Initially, both design alternatives for each site were included in a cost effectiveness analysis. As the planning process progressed, one conceptual design alternative per site was selected for input into the final cost effectiveness analyses for the recommendation of the selected plan. The selection of the conceptual design alternative for each site was based on site constraints that became known during the planning process (e.g. rare plant at site 11 and landfills adjacent to site 5) or on an initial evaluation of cost effectiveness. Table 3-6 shows the conceptual design alternatives that were input into the final CE/ICA for evaluation of the TSP. The full set of conceptual designs are shown in Appendix E, and Section 4 includes figures and descriptions illustrating the designs that are included in the TSP. As designs progress to feasibility level, significant detail will be added to the designs, including the locations and details of the in-stream features.

Table 3-6. Number of conceptual design alternative used in the final cost effectiveness analysis for each site.

Site Number	Conceptual Design Alternative
1	2
3	2
5	2
7	2
9	2
10	2
11	2
12	1
13	1
15	2

3.5.2 Quantifying the Benefits of Ecosystem Restoration

Quantifying the ecosystem restoration benefits of restoration 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 3-7). 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 3-7. Steps in the assessment of stream 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. Physical habitat quantity was determined using stream length and stream order (Strahler, 1957). 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 dewatered 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 3.5.2.5.

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 remain less than needed for decades. However, since stream assessments (by MD DNR 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. Absent

a geomorphic restoration project, future-without-project geomorphic conditions are assumed to be roughly equivalent to current conditions with continuing instability and erosion.

With-project projections account for changes in reach habitat quantity and quality. 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 3-8 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. Riffles will be well developed and stable to allow for full colonization potential.

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 3-9 summarizes the future-without-project (FWOP) and future-with-project (FWP) PHI for the conceptual design alternatives input into the final CE/ICAs for each of the ten sites evaluated. As shown, PHI scores are expected to increase 24 to 54 percent over pre-restoration conditions, representing substantial habitat lift. Because of the highly degraded initial conditions of some of the stream reaches, and the inability to affect certain variables in the PHI score (including remoteness and watershed area), some of the FWP scores are still in the lower PHI score categories post-restoration. 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 3-8. 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
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 possible (note that these are unrealistic conditions). From the scores in Table 3-9 it can be seen that without being able to affect the above noted variables and based on the highly degraded initial conditions of the streams, the best achievable PHI scores are still in lower categories for some of the stream sites. The best achievable PHI scores acknowledge the urban environment and indicate that outside of the remoteness variable, substantial improvement in physical habitat is expected.

Table 3-9. 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	37	54	46	72
5	36	55	53	74
7	37	54	46	76
9	39	60	54	80
10	54	63	17	86
11	24	46	92	68
12	35	52	49	74
13	41	60	46	77
15	54	70	30	88

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.

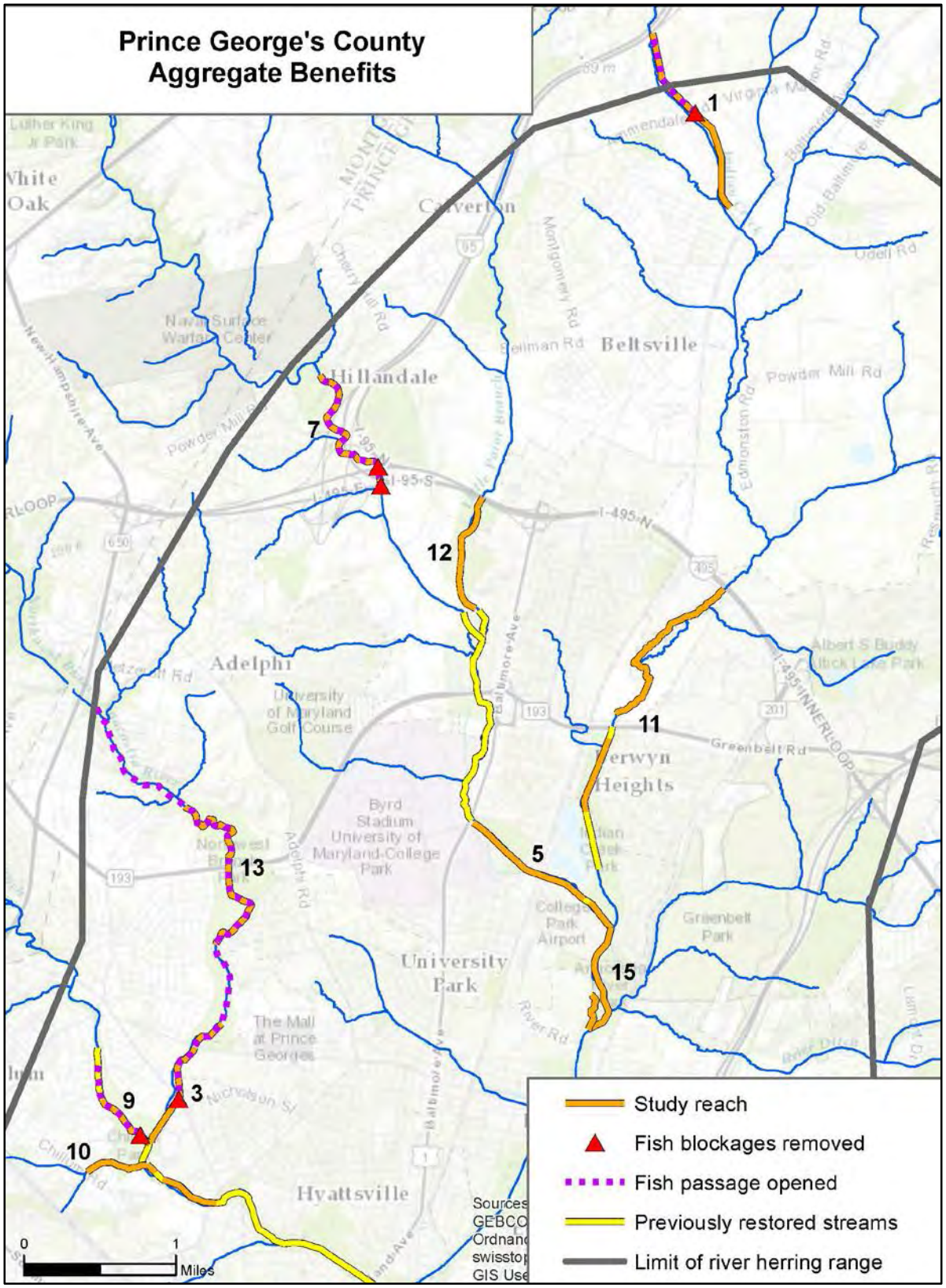


Figure 3-3. Aggregate benefits for each project site.

3.5.3 Estimating 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 CAP project from 2012 (both USACE construction projects). The 2012 estimate was escalated to fiscal year 2016 costs using the Civil Works Construction Cost Index System. As a result of the uncertainty in the costs related to the preliminary phase of site design, 25 percent contingency was applied to the construction costs. The estimated costs are contingent upon agency technical review. Additionally, once project designs are advanced into the feasibility phase, costs will be refined significantly using Micro-Computer Aided Cost Estimating System Second Generation (MII). Further information on the cost estimates is included in Appendix G.

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. 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. Adaptive management and monitoring will occur over the first five years of the project. These costs are shown in Appendix I. The value of lands, easements, rights-of-way and relocations (LERR), as well as administrative acquisition expenses, will be refined based upon finalization of the selected plan designs. Real Estate costs are considered to be minimal due to the project areas being within the existing streambed/streambank and floodplain, and therefore undevelopable. Additionally, the majority of parcels adjacent to the stream sites are on public lands, resulting in reduced costs for real estate. At this preliminary stage, a nominal, representative value of $10,000 per acre is used for the required perpetual Channel Improvement Easement, which will be located within the floodplain. For planning purposes, a draft Real Estate Plan including representative real estate costs for each site, including administrative acquisition costs, is located in Appendix H.

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, software application was used to compete the CE/ICA analyses (USACE, 2015b). The outputs of CE/ICA are used as one factor in the selection of a TSP.

Initial plan formulation included the input of all project sites separately into CE/ICA. However, as the study progressed and additional understanding was gained about problems and opportunities, objectives were revised and CE/ICA was rerun based on the revised objectives. The current objectives (see Section 1.7) 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 the revised 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.

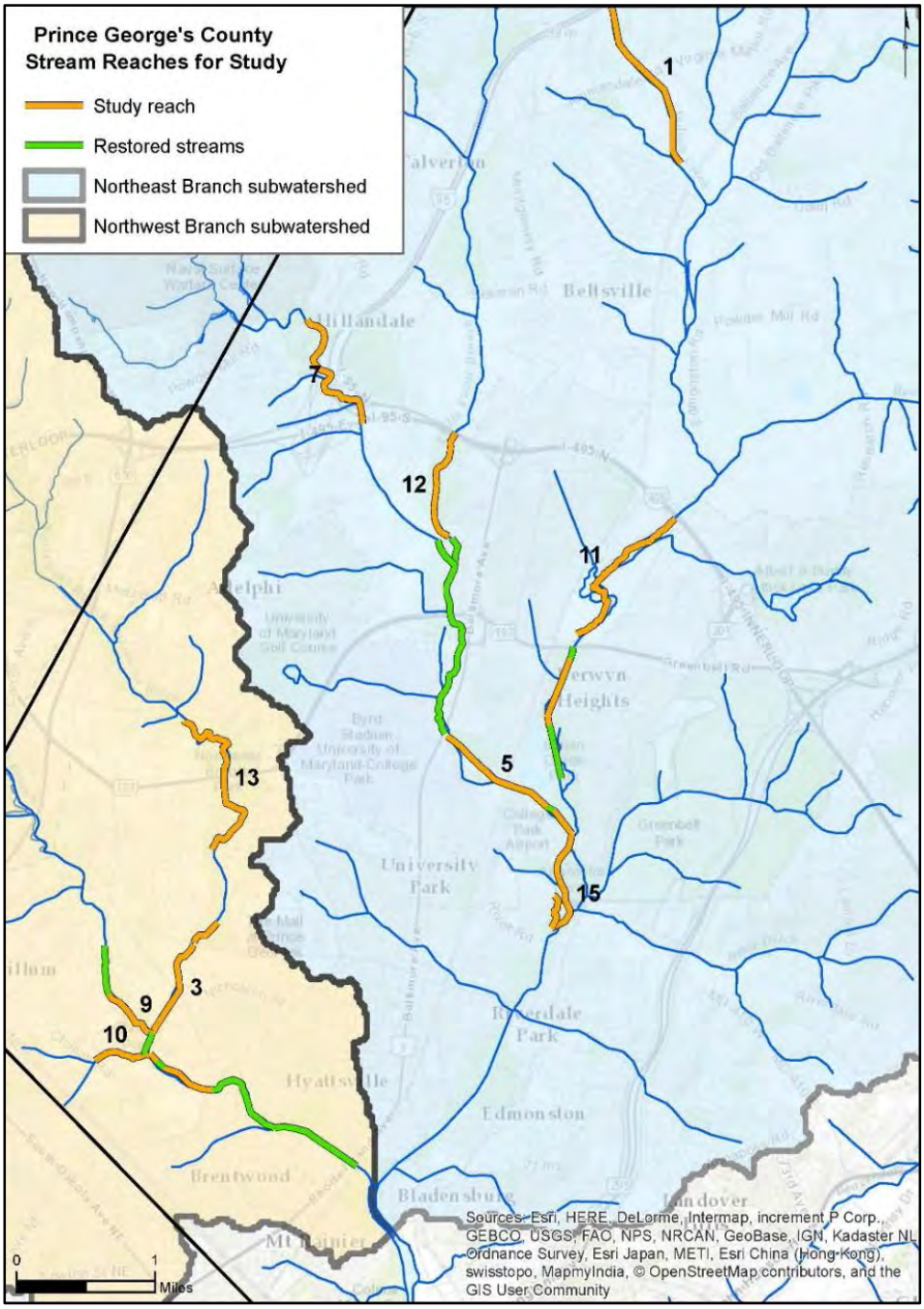


Figure 3-4. Northwest and Northeast Branch subwatershed boundaries for the formulation of site alternatives.

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).

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 3-10 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 3-10. Average annual (AA) costs and benefits used in the CE/ICAs.

Northwest Branch Alternatives	AA Project Specific SHUs	AA Aggregate SHUs	AA Costs
3 (alt 2)	2068	53679	$227,195
3 (alt 2), 9 (alt 2)	2738	58330	$288,360
3 (alt 2), 9 (alt 2), 10 (alt 2)	2860	59640	$347,921
3 (alt 2), 13 (alt 1)	5162	53679	$493,750
3 (alt 2), 9 (alt 2), 13 (alt 2)	5832	58330	$554,915
3 (alt 2), 9 (alt 2), 10 (alt 2), 13 (alt 1)	5953	59640	$614,476
Northeast Branch Alternatives	**AA Project Specific SHUs**	**AA Aggregate SHUs**	**AA Costs**
11 (alt 2), 15 (alt 2)	7975	22703	$620,034
11 (alt 2), 15 (alt 2), 5 (alt 2)	10626	63131	$960,543
11 (alt 2), 15 (alt 2), 5 (alt 2), 7 (alt 2)	12035	69507	$1,313,965
11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1)	11666	67846	$1,208,592
11 (alt 2), 15 (alt 2), 1 (alt 2)	8832	25083	$791,281
11 (alt 2), 15 (alt 2), 5 (alt 2), 1 (alt 2)	11483	65511	$1,131,791
11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2)	12523	70226	$1,379,840
11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 7 (alt 2)	13075	74222	$1,562,015
11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2), 7 (alt 2)	13932	76602	$1,733,262

3.5.4.4 CEICA 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 3-11 and 3-12 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 TSP 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.

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.

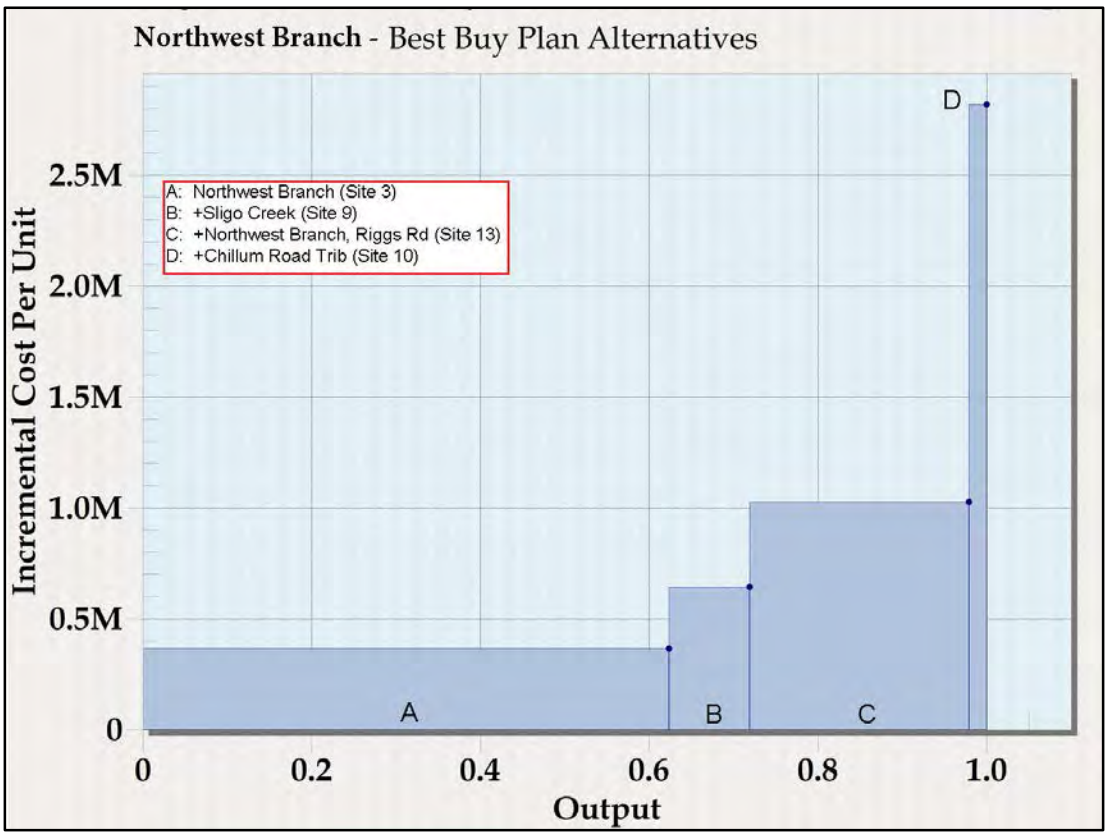


Figure 3-5. CE/ICA graph for Northwest Branch showing best buy plans.

Table 3-11. 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)	Project Specific SHUs	Aggregate SHUs	Incremental Cost/Output (K)
No Action	-	0	$0	-	0	0	-
NW-A	3	7,285	$227,200	0.62	2,068	53,679	$364
NW-B	3, 9	9,526	$288,400	0.72	2,738	58,330	$642
NW-C	3, 9, 13	17,216	$554,900	0.98	5,832	58,330	$1,026
NW-D	3, 9, 13, 10	19,312	$614,500	1.00	5,953	59,640	$2,819

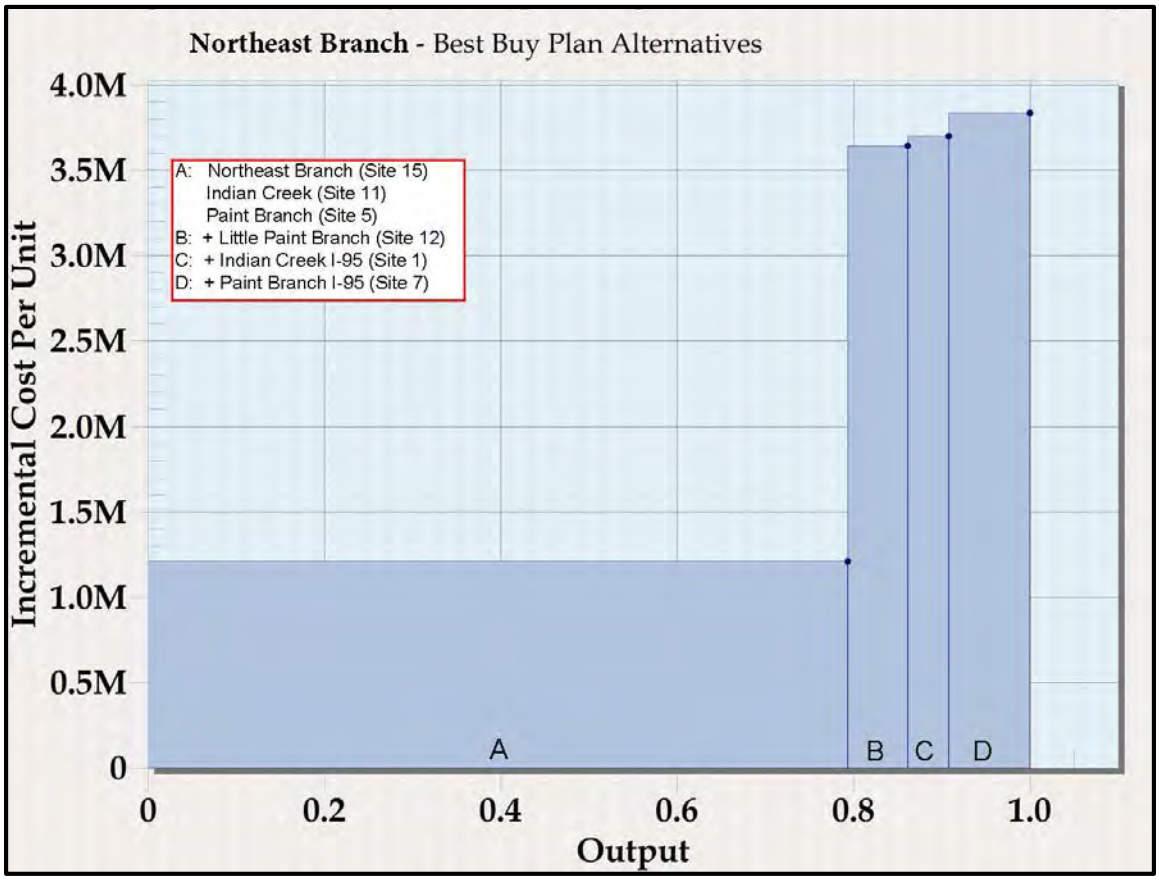


Figure 3-6. CE/ICA graph for Northeast Branch showing best buy plans.

Table 3-12. 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)	Project Specific SHUs	Aggregate SHUs	Incremental Cost/Output (K)
No Action	-	0	$0	-	0	0	-
NE-A	15, 11, 5	18,946	$960,500	0.79	10,626	63,131	$1,211
NE-B	15, 11, 5, 12	23,476	$1,208,600	0.86	11,666	67,846	$3,643
NE-C	15, 11, 5, 12, 1	30,434	$1,379,800	0.91	12,523	70,226	$3,698
NE-D	15, 5, 11, 12, 1, 7	36,310	$1,733,300	1.00	13,932	76,602	$3,835

3.6 *Plan Selection

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). Selecting the NER plan requires careful consideration of the plan that meets planning objectives and constraints and reasonably maximizes the

environmental benefits while passing tests of CE/ICA, significance of outputs, acceptability, completeness, efficiency, and effectiveness. Based on an evaluation of these factors, and as described below, Plan NW-C + NE-A is the Tentatively Selected Plan (TSP). The TSP will be finalized following consideration of comments received during review of this report, including agency and public review, Agency Technical Review, and USACE Office of Water Project Review. Additionally, it is possible that with the development of more detailed designs and costs (and rerun of CE/ICA), the entirety of the Plan NW-C + NE-A may not be supported. Specifically, site 9 and/or site 13 could be removed from the TSP.

The following sections describe the evaluation of the plans that resulted in the recommendation of Plan NW-C + NE-A as the TSP.

3.6.1 Recommended Plan for Northwest Branch and Tributaries

Based on the CE/ICA for the Northwest Branch and tributaries (Figure 3-5 and Table 3-11), Plan D was eliminated from further consideration. There is a large increase in incremental cost per output when moving from Plan C to D, and little environmental benefit above Plan C for the added cost. As a result, Plan D was eliminated from further consideration.

From an economic standpoint, Plans A through C can be justified. Plan A is the most cost-effective. This alternative includes site 3 on the mainstem of Northwest Branch, which contains the removal of a fish blockage that opens almost four miles of stream for anadromous fish. From Table 3-11 it is evident that Plan A has the vast majority of the ecosystem restoration benefits, and therefore the lowest incremental cost per output.

In addition to site 3, Plan B includes site 9 on Sligo Creek. Site 9 incorporates 0.6 mile of fish passage by removal of a fish blockage on Sligo Creek. In a highly urban area characterized by fragmentation, this contribution has great value. Removal of this blockage equates to opening an additional 10 percent of the historical range of anadromous fish on Northwest Branch and tributaries (measured from the confluence with Northeast Branch to the historical range of anadromous fish at the fall line). The restoration of site 9 has been shown to be cost effective (and best buy) because of the high degree of habitat lift that would be realized at the site (54 percent difference between future-without and future-with-project conditions). Additionally, since site 9 is contiguous to site 3, cost savings are recognized for working on these two sites together.

In addition to the sites included in Plan B, Plan C includes site 13. Site 13 is highly unstable, with severe bank erosion such that the stream is undermining walking trails, utilities, and pedestrian bridges. While fish passage would be open to fish upstream of site 3, restoration of site 13 would enhance these benefits by providing higher quality habitat for anadromous fish utilization (e.g. spawning, nursery, etc.).

Based on the above, Plans A through C are selected for further consideration in the final array of plans. These plans are referred to as Plans NW-A, NW-B, and NW-C.

3.6.2 Recommended Plan for Northeast Branch and Tributaries

Based on the CE/ICA, Plan A, the combination of sites 15, 11, and 5, is the most cost-effective, providing the greatest increase in ecosystem restoration benefits (Figure 3-6). Plans B through D are difficult to justify based on the large jump in incremental cost per output. There is little environmental benefit for

the added costs for these plans. It should also be noted that while sites 15 and 11 are the building block for the Northeast Branch alternatives (see logic in Section 3.5.4), the combination of site 15 and 11 was a cost effective plan, but not a best buy plan; therefore, this combination does not appear on the CE/ICA graph of best buy plans (see explanation of cost effective versus best buy plans in Section 3.5.4.3).

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. Both sites 11 and 5 contribute large quantities of sediment downstream to site 15. 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). In addition, aquatic ecosystems at sites 15, 11, and 5 were all directly degraded by USACE flood risk management projects.

Based on the above, Plan A is selected for further evaluation in the final array of plans. This plan is referred to as Plan NE-A.

3.6.3 Detailed Analysis of the Final Array of Alternative Plans

The final array of plans is shown in Table 3-13, and includes the plans for the Northwest and Northeast Branch subwatersheds separately as well as combined. Criteria used to evaluate the final array of plans includes the four Principles and Guidelines (WRC, 1983) accounts, contributions to the planning objectives, completeness, effectiveness, efficiency, and acceptability, and other factors. Figures 3-7 and 3-8 show the sites included in each of the plans in Table 3-13.

Table 3-13. The final array of plans.

Plan	Sites Included	Total Restoration Length (mi)	Fish passage (by blockage removal) (mi)	Connectivity (mi)	Project Specific SHUs	Aggregate SHUs	Total Project Costs ($K)
No Action	-	0	0	0	0	0	$0
NW-A	3	1.4	3.7	6.0	2,068	53,679	$5,586
NW-B	3, 9	1.8	4.3	6.8	2,738	58,330	$7,090
NW-C	3, 9, 13	3.3	4.3	6.8	5,832	58,330	$13,644
NE-A	15, 11, 5	3.6	0	6.5	10626	63,131	$23,618
NW-A + NE-A	3, 15, 11, 5	5.0	3.7	12.5	12,694	116,810	$29,204
NW-B + NE-A	3, 9, 15, 11, 5	5.4	4.3	13.5	13,364	121,461	$30,708
NW-C + NE-A	3, 9, 13, 15, 11, 5	6.9	4.3	13.5	16,458	121,461	$37,262

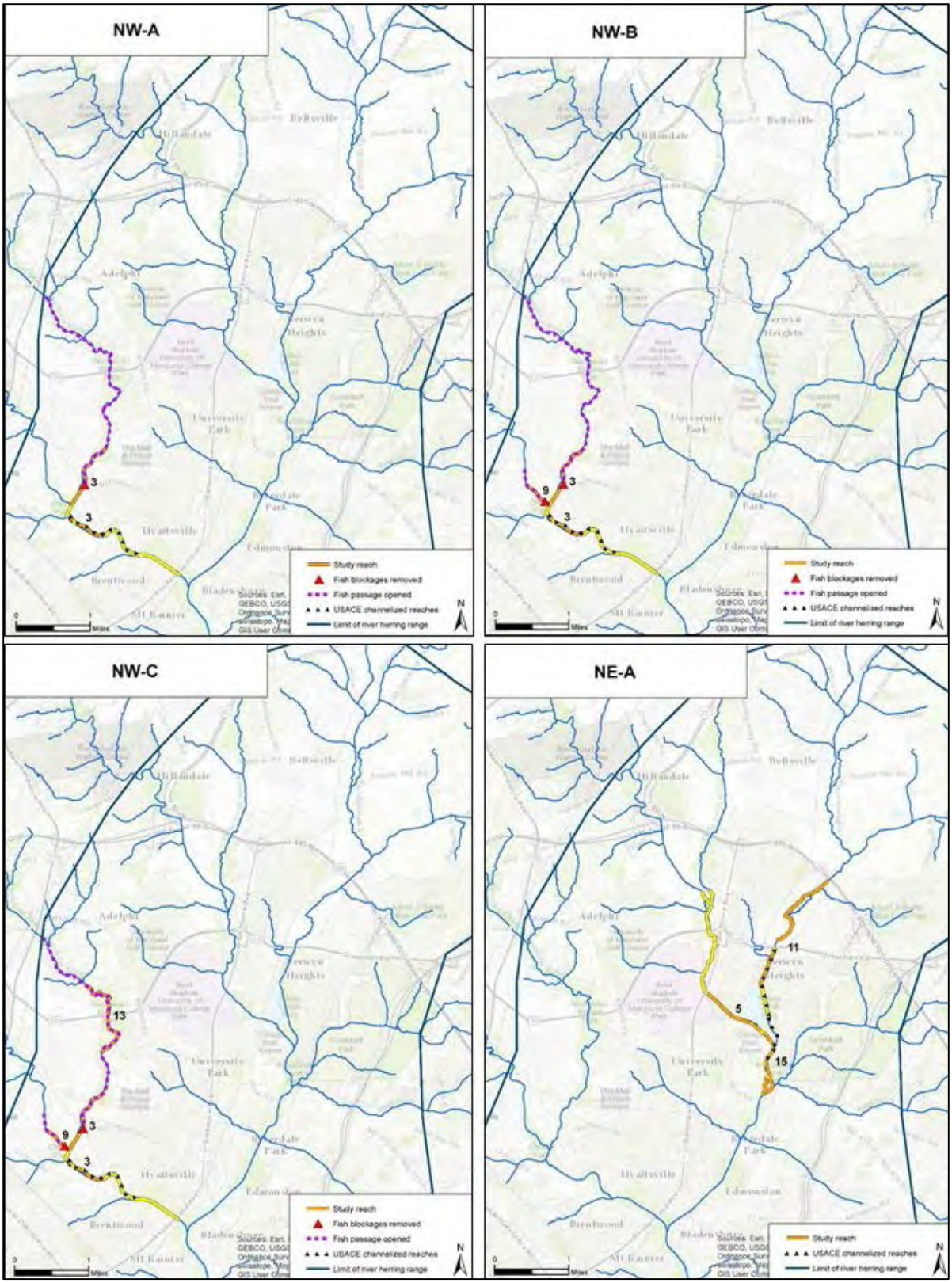


Figure 3-7. Plans providing a solution for a single subwatershed, including NW-A, NW-B, and NW-C in the Northwest Branch subwatershed and NE-A in the Northeast Branch subwatershed.

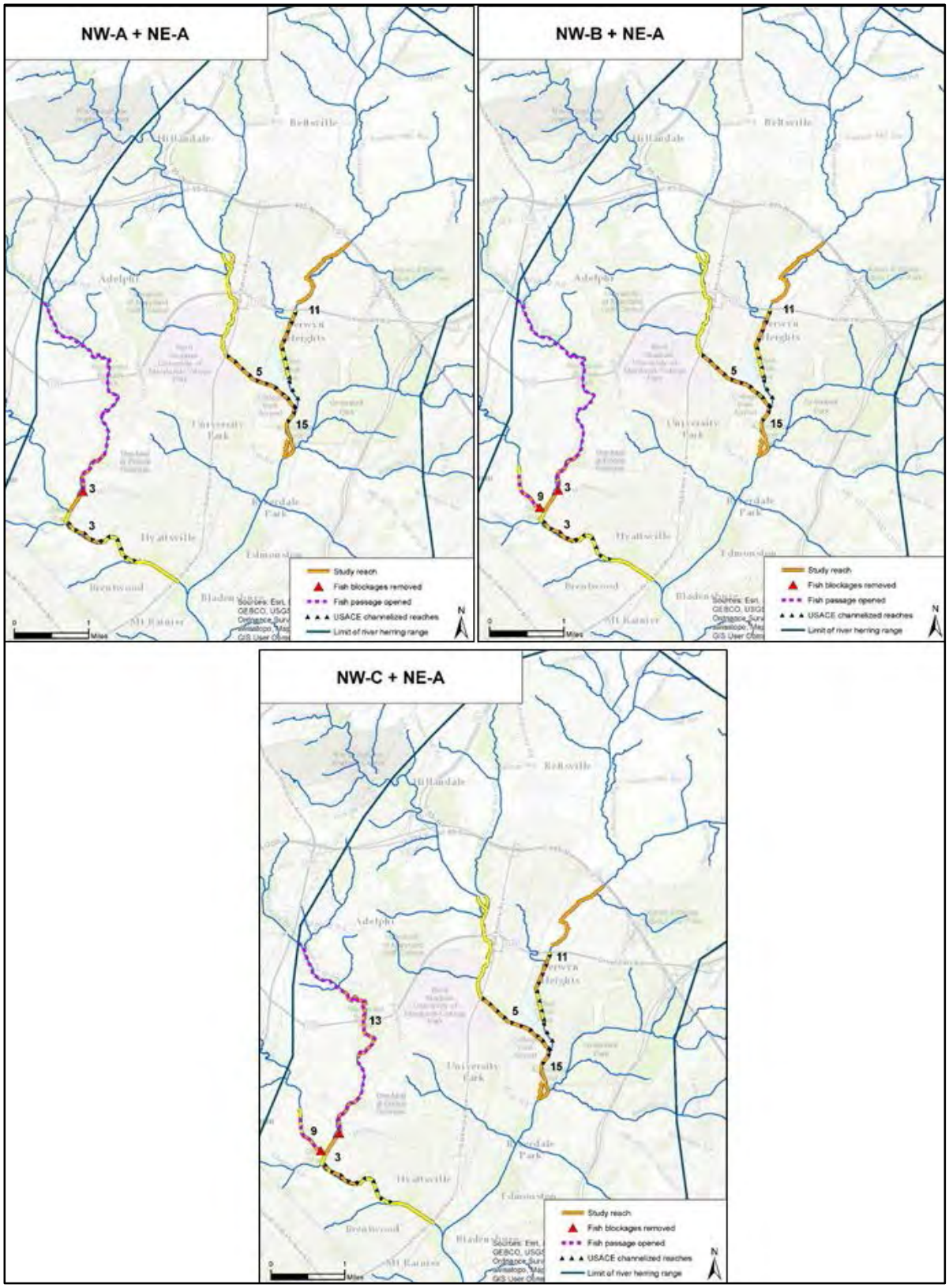


Figure 3-8. Plans providing a solution for both the Northwest and Northeast Branch subwatershed, including plans NW-A + NE-A, NW-B + NE-A, and NW-C + NE-A.

3.6.3.1 Evaluation of the Four Accounts

For the final array of plans, Table 3-16 shows the evaluation of the four accounts as prescribed by the Principles and Guidelines. For both the National Economic Development and Regional Economic Development accounts there are no quantifiable benefits from these plans. For the Environmental Quality account there are varying levels of restoration of aquatic habitat, fish passage, and connectivity. As shown in Table 3-16, Plan NW-C + NE-A is the most costly plan of those in the final array of plans, but it also includes the most stream segments and significant environmental outputs in terms of Project-Specific and Aggregate benefits. The ecosystem restoration benefits of the project are discussed in below sections, including with regards to the planning objectives and the criteria of completeness and effectiveness. Per CE/ICA guidance, "while it is acceptable to ultimately choose the plan with the largest output or lowest cost, these reasons should not be the only decision-making criteria. Incremental costs and benefits must be evaluated to help make the decision as to whether or not the extra increment is worth the difference (in either cost or outputs) between it and the next smallest alternative. The results of this analysis, together with a documented assessment of the significance and scarcity of the resources the project is trying to improve, among other criteria, will help to answer the question, 'Is it worth it?' (USACE, 2002)." Therefore, additional criteria, as shown in Tables 3-14 to 3-16 are considered to recommend the TSP.

For the Other Social Effects account, while not quantifiable, benefits include improved aesthetics, recreational fishing, 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.

3.6.3.2 Contributions to Planning Objectives

The alternative plans were evaluated to determine whether they minimally meet the two planning objectives. As previously described, in order to meet the planning objectives, restoration of both the Northeast and Northwest Branches and tributaries is required.

The planning objectives for this study are:

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

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.

Table 3-14. Does the objective minimally satisfy the planning objectives?

Alternative Plan	Restore in-stream physical habitat in both NW and NE Branch subwatersheds:	Restore fish passage and connectivity in both NW and NE Branch subwatersheds:
No Action	No	No
NW-A	No	No
NW-B	No	No
NW-C	No	No
NE-A	No	No
NW-A + NE-A	Yes	Yes
NW-B + NE-A	Yes	Yes
NW-C + NE-A	Yes	Yes

*see further detail in Table 3-16

Without the restoration of both the Northwest and Northeast Branches and tributaries, the planning objectives are not met. Therefore, the lowest level plan to minimally meet the objectives by restoring both subwatersheds is NW-A + NE-A. In addition, selecting a plan from only the Northwest Branch does not completely satisfy the objective for connectivity, while selecting a plan from only the Northeast Branch does not completely satisfy the objective for fish passage. However, while NW-A + NE-A minimally meets the objectives, above this plan, NW-C + NE-A best meets the planning objectives by contributing the highest level of aquatic ecosystem restoration. This is shown in Tables 3-13 and 3-16 and discussed below with respect to the criteria of completeness and effectiveness.

No formal targets were established for the objectives. While targets have been set by the Anacostia Restoration Partnership, these targets are not based on ecological requirements, but rather on the restoration that can be reasonably achieved with given resources and as a means of evaluating watershed restoration progress. The study team was also unable to find scientific literature to support the establishment of a target, since, in general, it is desirable to restore as many stream miles as possible, especially when connecting a splintered migratory corridor.

3.6.3.3 Completeness, Effectiveness, Efficiency, and Acceptability

Completeness, effectiveness, efficiency, and acceptability are the four evaluation criteria specified in the Principles and Guidelines. These criteria 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.

The four criteria are shown in Table 3-15. A No-Action plan does not meet any of the criteria as lack of restoration maintains the status quo, allowing in-stream habitat to further deteriorate as described in the future-without-project conditions in Section 2. All the plans in the final array are efficient as they meet the tests of CE/ICA and have been determined to be best buy plans. All of the plans are acceptable as they are feasible and conform to applicable laws, regulations, and policies. In addition, the 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 TSP. Acceptability for the TSP will be confirmed following agency and public comment.

Table 3-15. Does the plan meet the criteria?

Alternative	Completeness	Effectiveness	Efficiency	Acceptability
No Action	No	No	No	No
NW-A	No	No	Yes	Yes
NW-B	No	No	Yes	Yes
NW-C	No	No	Yes	Yes
NE-A	No	No	Yes	Yes
NW-A + NE-A	Yes	Yes	Yes	Yes
NW-B + NE-A	Yes	Yes	Yes	Yes
NW-C + NE-A	Yes	Yes	Yes	Yes

*see further detail in Table 3-16

The plans that do not address both the Northwest and Northeast Branches and tributaries (plans NW-A, NW-B, NW-C, NE-A) are neither complete nor effective. Given the interconnected nature of hydrologic systems, these plans to do not account for all necessary investments or actions to realize the planned effects and to alleviate the specified problems. Completeness and effectiveness for the plans addressing both the Northwest and Northeast Branches and tributaries are discussed below.

NW-A + NE-A: This plan is a combination of the first plans from the Northwest and Northeast Branches CE/ICAs. The plan includes site 3 on Northwest Branch, and sites 15, 5, and 11 on Northeast Branch (Figure 3-8). This plan is complete and effective because it proposes a solution that restores habitat (5.0 miles), fish passage (3.7 miles), and connectivity (12.5 miles) on both branches. In addition, the plan connects to an additional 10.8 miles of good quality habitat upstream on Northeast Branch, which is not accounted for in the Aggregate Benefits metric.

The plan addresses the largest component of fish passage on Northwest Branch by removing the blockage on site 3. Removal of this blockage allows fish to migrate up to the extent of their natural range on Northwest Branch. This plan also restores site 15, which is the critical junction at the Paint Branch-Indian Creek confluence. This plan includes sites 5 and 11, which negatively impact (through sedimentation) site 15 and downstream. In addition, aquatic ecosystems at all four of the sites in this plan were damaged by a USACE flood risk management project implemented in the 1970s. Site 5 was channelized in its entirety and significant lengths of sites 3, 11 and 15 were channelized (see Figure 3-9). For these reasons, this plan is considered complete and effective as it addresses the problems and opportunities. However, as discussed below, plans NW-B + NE-A and NW-C + NE-A can be considered more complete and effective as they further account for the necessary actions and investment to realize planned benefits.

NW-B + NE-A: This plan includes the sites in Plan NW-A + NE-A with the addition of Site 9 (Figure 3-8). Similar to the previous plan, this plan proposes a solution that restores habitat (5.4 miles), fish passage (4.3 miles), and connectivity (13.5 miles) on both Northwest and Northeast Branches. The removal of a complete anadromous fish blockage on site 9 opens up additional stream (0.6 miles) for fish passage, allowing fish to migrate almost to the extent of their natural range on Sligo Creek. While 0.6 mile may not seem significant, this represents the addition of 10% of the historical range of anadromous fish. Given the additional access for anadromous fish utilization, this plan is considered more complete and effective than plan NW-A + NE-A. In addition, because sites 9 and 3 are contiguous, there are cost savings for contracting these two sites together.

NW-C + NE-A: In addition to the sites included in previous plans, plan NW-C + NE-A includes site 13 (Figure 3-8). The stream reach at site 13 is incised and has severe bank erosion and instability. The pedestrian trail system, a pedestrian bridge, and utilities in and adjacent to the stream are being severely undermined. Restoration of this site will alleviate these conditions, including sedimentation downstream, and enhance habitat for anadromous fish able to migrate upstream as a result of the blockage removal on site 3. As a result, plan NW-C + NE-A is the most complete and effective as it accounts for all necessary investments or actions to ensure the realization of the planned effects and most fully alleviates the problems and opportunities.

Table 3-16. Evaluation of the final array of alternative plans.

	No-Action	Plan: NW-A	Plan: NW-B	Plan: NW-C	Plan: NE-A	Plan: NW-A + NE-A	Plan: NW-B + NE-A	Plan: NW-C + NE-A
	Evaluation of the Four Accounts							
1. NED	No benefits	No quantifiable benefits	No quantifiable benefits	No quantifiable benefits	No quantifiable benefits	No quantifiable benefits	No quantifiable benefits	No quantifiable benefits
2. Environmental Quality	No benefits	Total length restored: 1.4 miles on Northwest Branch Fish passage opened (by blockage removal): 3.7 miles Length of habitat connected: 6.0 miles on Northwest Branch only	Total length restored: 1.8 miles on Northwest Branch Fish passage opened (by blockage removal): 4.3 miles Length of restored habitat connected: 6.8 miles on Northwest Branch only	Total length restored: 3.3 miles on Northwest Branch Fish passage opened (by blockage removal): 4.3 miles Length of restored habitat connected: 6.8 miles on Northwest Branch only	Total length restored: 3.6 miles on Northeast Branch Fish passage opened (by blockage removal): 0 miles Length of restored habitat connected: 6.5 miles on Northeast Branch only	Total length restored: 5.0 miles on both Northwest and Northeast Branches Fish passage opened (by blockage removal): 3.7 miles Length of restored habitat connected: 12.5 miles on both Northwest and Northeast Branches	Total length restored: 5.4 miles on both Northwest and Northeast Branches Fish passage opened (by blockage removal): 4.3 miles Length of restored habitat connected: 13.5 miles on both Northwest Branch and Northeast Branches	Total length restored: 6.9 miles on both Northwest and Northeast Branches Fish passage opened (by blockage removal): 4.3 miles Length of restored habitat connected: 13.5 miles on both Northwest Branch and Northeast Branches
3. Regional Economic Development	No benefits	No quantifiable benefits	No quantifiable benefits	No quantifiable benefits	No quantifiable benefits	No quantifiable benefits	No quantifiable benefits	No quantifiable benefits
4. Other Social Effects	No impacts	Positive impacts for aesthetics, recreational fishing, educational opportunities, and overall community health. No adverse environmental justice impacts.	Positive impacts for aesthetics, recreational fishing, educational opportunities, and overall community health. No adverse environmental justice impacts.	Positive impacts for aesthetics, recreational fishing, educational opportunities, and overall community health. No adverse environmental justice impacts.	Positive impacts for aesthetics, recreational fishing, educational opportunities, and overall community health. No adverse environmental justice impacts.	Positive impacts for aesthetics, recreational fishing, educational opportunities, and overall community health. No adverse environmental justice impacts.	Positive impacts for aesthetics, recreational fishing, educational opportunities, and overall community health. No adverse environmental justice impacts.	Positive impacts for aesthetics, recreational fishing, educational opportunities, and overall community health. No adverse environmental justice impacts.
	Contributions to Planning Objectives – Does the Plan minimally meet the planning objectives? **[No = does not minimally meet the objective; Yes (+) = minimally meets the objective; Yes (++) = better meets the objective; Yes (+++) = best meets the objective]**							
Objective 1: Restore in-stream habitat in NE and NW Branch subwatersheds	None	No Restores 1.4 miles of in-stream habitat on NW Branch. Does not restore habitat on NE Branch.	No Restores 1.8 miles of in-stream habitat on NW Branch. Does not restore habitat on NE Branch	No Restores 3.3 miles of in-stream habitat on NW Branch. Does not restore habitat on NE Branch	No Restores 3.6 miles of in-stream habitat on NE Branch. Does not restore habitat on NW Branch.	Yes (+) Restores 1.4 miles of in-stream habitat on NE Branch and 3.6 miles of habitat on NW Branch.	Yes (++) Better meets the objective. Restores 1.8 miles of in-stream habitat on NE Branch and 3.6 miles of habitat on NW Branch.	Yes (+++) Best meets the objective. Restores 3.3 miles of in-stream habitat on NE Branch and 3.6 miles of habitat on NW Branch.
Objective 2: Enhance ecosystem resilience – restore fish passage and connectivity in NE and NW Branch subwatersheds	None	No Restores 6.0 miles of fish passage and connectivity on NW Branch. Does not enhance connectivity on NE Branch. Restores suitability of an existing connection and expands functional areas with a splintered migratory corridor.	No Restores 6.8 miles of fish passage and connectivity on NW Branch. Does not enhance connectivity on NE Branch. Restores suitability of an existing connection and expands functional areas with a splintered migratory corridor.	No Restores 6.8 miles of fish passage and connectivity on NW Branch. Does not enhance connectivity on NE Branch. Restores suitability of an existing connection and expands functional areas with a splintered migratory corridor.	No Restores 6.5 miles of fish passage and connectivity on NE Branch. Does not address fish passage on NW Branch. Creates a nodal connection (site 15) between existing habitat areas within a corridor. Restores suitability of an existing connection and expands functional areas with a splintered migratory corridor.	Yes (+) Restores 6.0 miles of fish passage and connectivity on NW Branch and 6.5 miles on NE Branch. Creates a nodal connection (site 15) between existing habitat areas within a corridor. Restores suitability of an existing connection and expands functional areas with a splintered migratory corridor.	Yes (++) Restores 6.8 miles of fish passage and connectivity on NW Branch and 6.5 miles on NE Branch. Creates a nodal connection (site 15) between existing habitat areas within a corridor. Restores suitability of an existing connection and expands functional areas with a splintered migratory corridor.	Yes (+++) Best meets the objective. Restores 6.8 miles of fish passage and connectivity on NW Branch and 6.5 miles on NE Branch. Restores habitat upstream of site 3 blockage for anadromous fish utilization (Site 13) Creates a nodal connection (site 15) between existing habitat areas within a corridor. Restores suitability of an existing connection and expands functional areas with a splintered migratory corridor.

	No-Action	Plan: NW-A	Plan: NW-B	Plan: NW-C	Plan: NE-A	Plan: NW-A + NE-A	Plan: NW-B + NE-A	Plan: NW-C + NE-A
	Evaluation of the Four P&G Criteria – Does the Plan meet the criterion? **[No = does not meet the criterion; Yes (+) = meets the criterion; Yes (++) = better meets the criterion; Yes (+++) = best meets the criterion]**							
1. Completeness	Not complete	No Solution is incomplete as it only addresses restoration of the Northwest Branch. Additional investment is required to realize planned effects on Northeast Branch.	No Solution is incomplete as it only addresses restoration of the Northwest Branch and tributary. Additional investment is required to realize planned effects on Northeast Branch.	No Solution is incomplete as it only addresses restoration of the Northwest Branch and tributary. Additional investment is required to realize planned effects on Northeast Branch.	No Solution is incomplete as it only addresses restoration on the Northeast Branch and tributaries. The realization of planned effects may not be achieved without removal of fish blockages on Northwest Branch.	Yes (+) With the removal of a major blockage on Northwest Branch, the restoration of the nodal connection on Northeast Branch (site 15), and restoration of the sites contributing to downstream damages at site 15 (sites 11 and 5), the plan accounts for actions to ensure realization of planned effects. However, this solution is not as complete as that for NW-C + NE-A, because additional investment is needed to alleviate the fish blockage at Sligo Creek (Site 9) and restore upstream habitat at site 13.	Yes (++) With the removal of blockages on Northwest Branch and Sligo Creek (site 9), the restoration of the nodal connection on Northeast Branch (site 15), and restoration of the sites contributing to downstream damages at site 15 (sites 11 and 5), the plan accounts for actions to ensure realization of planned effects. However, this solution is not as complete as that for NW-C + NE-A because poor habitat upstream of the fish blockage at site 3 still exists (site 13).	Yes (+++) Solution is most complete. With the removal of blockages on Northwest Branch and Sligo Creek (site 9), restoration of instability and erosion at site 13, restoration of the nodal connection on Northeast Branch (site 15), and restoration of the sites contributing to downstream habitat degradation at site 15 (sites 11 and 5), the plan accounts for all actions to ensure realization of planned effects.
2. Effectiveness	Not effective	No Solution is not effective as problems and opportunities on Northwest Branch (fish blockages) and Northeast Branch (unfavorable conditions at critical junction) still exist.	No Solution is not effective as problems and opportunities on Northwest Branch (unfavorable conditions at critical junction and poor upstream habitat) still exist.	No Solution is not effective as problems and opportunities on Northwest Branch (unfavorable conditions at critical junction and poor upstream habitat) still exist.	No Solution is not effective as problems and opportunities on Northwest Branch (fish blockages) still exist.	Yes (+) Problems and opportunities on both the Northwest Branch (fish blockage at site 3) and Northeast Branch (unfavorable conditions at critical junction and poor upstream habitat) are mostly alleviated. However, this plan is not as effective as plan NW-C + NE-A, because the opportunity to remove a fish blockage at site 9 still exists and poor habitat exists upstream of site 3 (at site 13). This plan includes restoration of all four sites damaged by USACE FRM project.	Yes (++) Problems and opportunities on Northwest Branch (fish blockages at sites 3 and 9) and Northeast Branch (unfavorable conditions at critical junction and poor upstream habitat) are addressed. However, this plan is not as effective as plan NW-C + NE-A, because poor habitat upstream of the fish blockage on site 3 still exists (at site 13). This plan includes restoration of all four sites damaged by USACE FRM project.	Yes (+++) Problems and opportunities on Northwest Branch (fish blockages at sites 3 and 9 and erosion and instability at site 13) and Northeast Branch (unfavorable conditions at critical junction and poor upstream habitat) are addressed. This plan also includes restoration of all four sites damaged by USACE FRM project.
3. Efficiency	Not efficient	Yes (+++) Cost effective & best buy plan.	Yes (+++) Cost effective & best buy plan.	Yes (+++) Cost effective & best buy plan.	Yes (+++) Cost effective & best buy plan.	Yes (+++) Cost effective & best buy plan.	Yes (+++) Cost effective & best buy plan.	Yes (+++) Cost effective & best buy plan.
4. Acceptability	Accepted as status quo	Yes (+++) Is feasible and complies with applicable laws and policies.	Yes (+++) Is feasible and complies with applicable laws and policies.	Yes (+++) Is feasible and complies with applicable laws and policies.	Yes (+++) Is feasible and complies with applicable laws and policies.	Yes (+++) Is feasible and complies with applicable laws and policies.	Yes (+++) Is feasible and complies with applicable laws and policies.	Yes (+++) Is feasible and complies with applicable laws and policies.

3.7 *The Recommended Tentatively Selected Plan

Alternative Plan NW-C + NE-A (Figure 3-9) is the recommended TSP and the National Ecosystem Restoration (NER) plan. The NER plan reasonably maximizes environmental benefits considering cost effectiveness and incremental cost analyses, significance of outputs, completeness, efficiency, effectiveness, and acceptability. The TSP will be finalized following consideration of comments and may be revised with the development of more detailed designs and costs. Additionally, the TSP could be reduced if costs increase upon further design and the incremental benefit is subsequently not considered to be worth the investment. Specifically, with the development of more detailed designs and costs (and rerun of CE/ICA), the entirety of the Plan NW-C and NE-A may not be supported. Stream sites 9 and/or site 13 could be removed from the TSP.

The TSP, NW-C + NE-A, 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 3-10 shows future-with-project conditions for stream quality and fish utilization. The restoration proposed, which is at the downstream end of the Northwest and Northeast Branch subwatersheds will facilitate fish movement and utilization of 13.3 miles of restored streams (including restored study sites and previously restored streams) and 10.8 miles of higher quality habitat upstream in the Northeast Branch subwatershed and into the Upper Beaverdam Creek subwatershed.

Table 3-17 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 4.3 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.

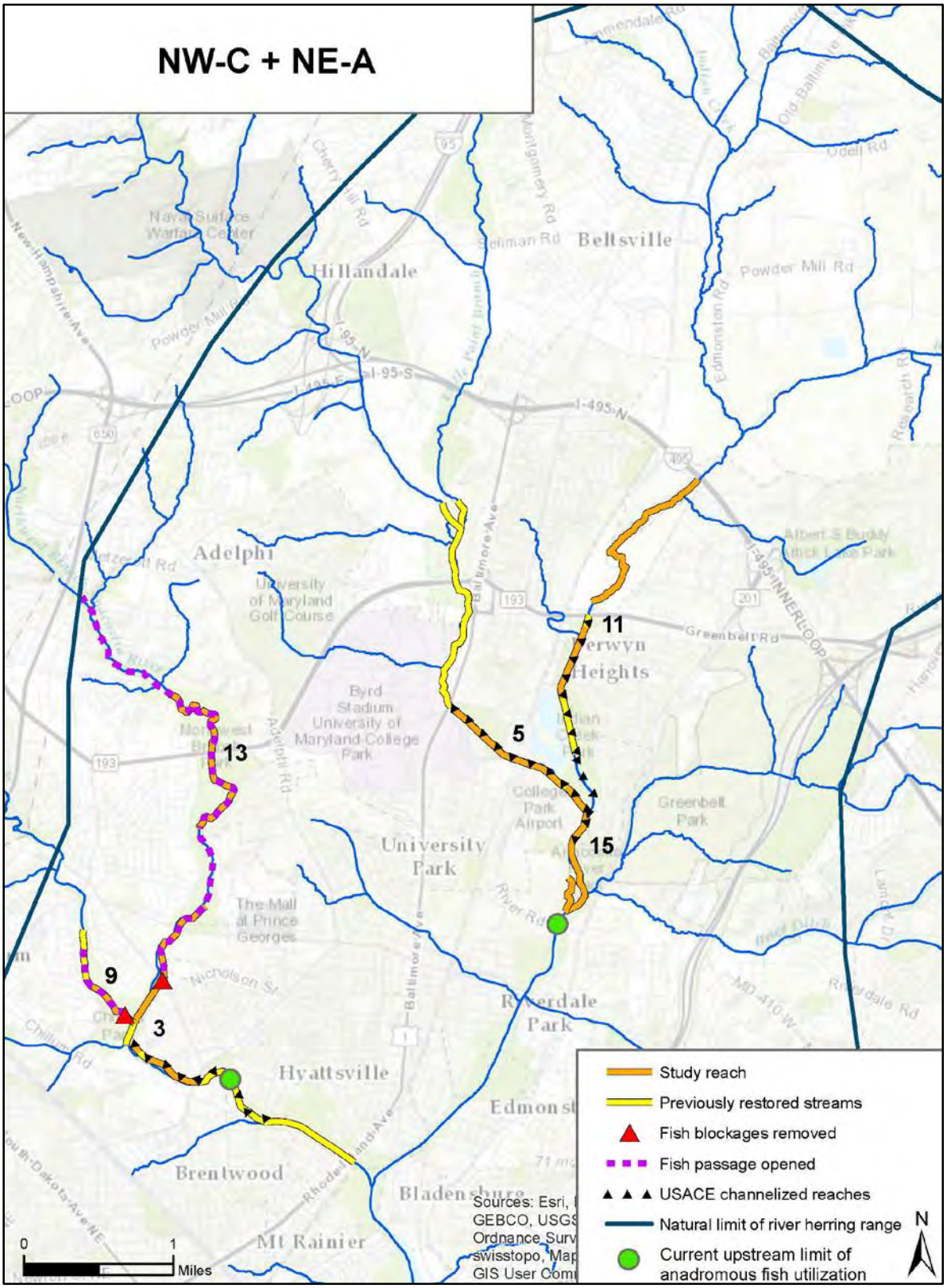
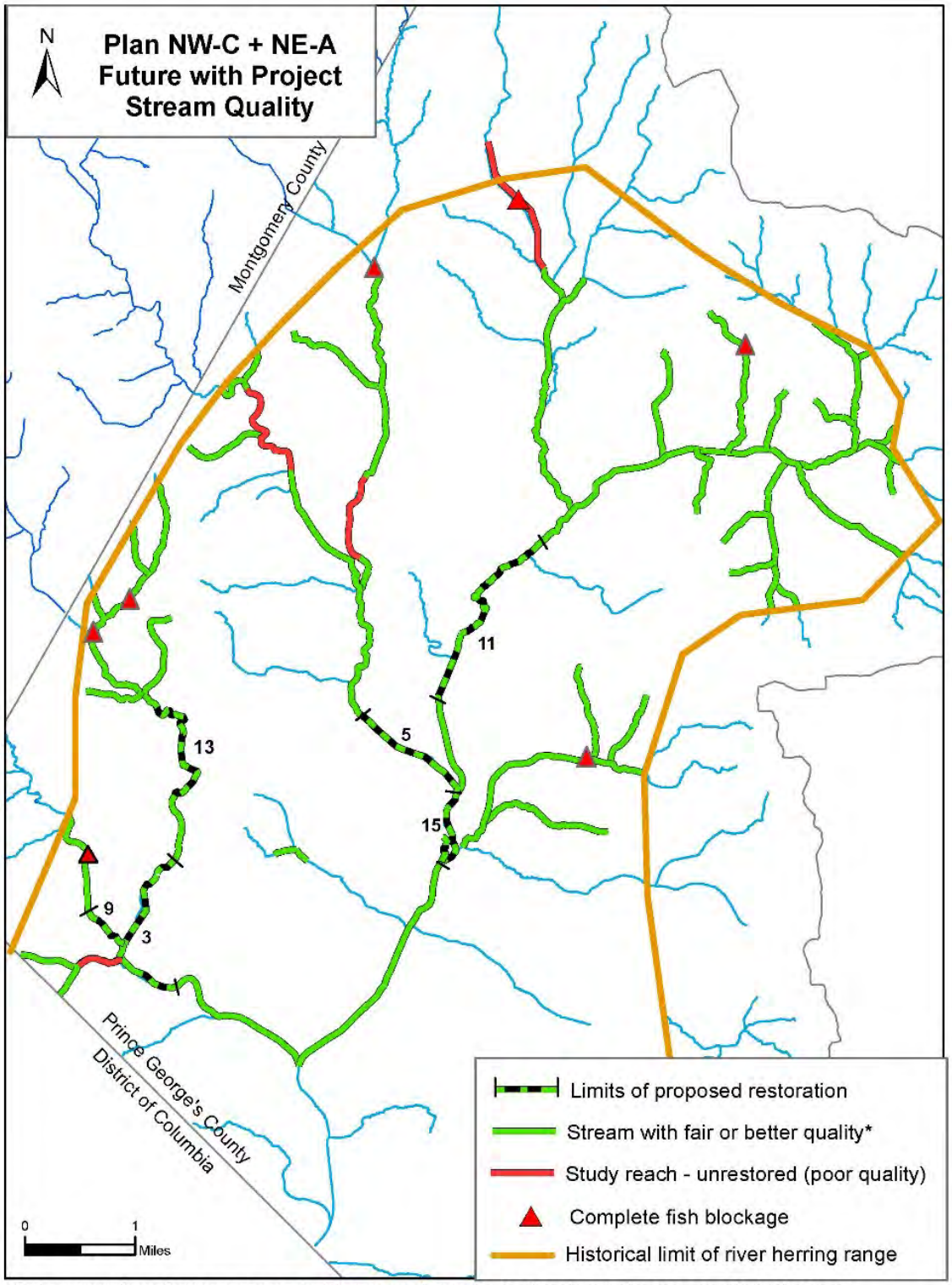


Figure 3-9. The recommended TSP, Plan NW-C + NE-A.



*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 3-10. Future-with-project estimation of stream quality for anadromous fish utilization.

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 3-9) 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.

Table 3-17. The approximate historical, current, and with-project ranges of anadromous fish.

	Historical Range (mi)	Currently Utilized (mi)	With Project (mi)
Northwest Branch	6.2	1.3 (21%)	5.2 (83%)
Northeast Branch	23.1	2.3 (10%)	20.9 (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, created 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.

3.7.1 Summary of the Benefits of the Tentatively Selected Plan

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

- Restores **6.9 miles** of in-stream habitat in Northeast and Northwest Branches;
- Restores **4.3 miles** of fish passage through blockage removal;
- Reduced fragmentation and increases resilience in a splintered migratory corridor by connecting **13.5 miles** of restored habitat and linking to **10.8 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 damaged 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.

4 PLAN IMPLEMENTATION

This Section presents plan components, including conceptual designs and implementation considerations.

4.1 Plan Components

4.1.1 Conceptual Site Designs and Descriptions

As described in Section 3.6, two conceptual site design alternatives, at a design level of 10 percent, were generated for each study site. However, as further information was gained about the study sites some of the designs were removed from consideration. Designs that were removed based on site specific factors include conceptual design #1 for site 5 based on the HTRW issues discussed in Sections 2 and 5, and conceptual design #1 for site 11 as a result of the presence of a rare plant on the floodplain (discussed in Sections 2 and 5). As discussed in Section 3, several planning iterations were conducted, including multiple runs of CE/ICA. Initial runs of CE/ICA identified which conceptual design for each site was most effective. The final CE/ICA input only the most cost effective designs for each site. This section includes the description of the design alternatives from an engineering standpoint for each of the sites in the TSP (Table 4-1). Predicted changes in in-stream habitat (biologic conditions) were described in Section 3.5.2 with further detail in Appendix B.

Descriptions of all of the conceptual design alternatives input into the final CE/ICA, including those not included in the TSP, can be found in Appendix E. Appendix E also includes the two conceptual design drawings (large format) for each site. It is important to note that as the study moves into the feasibility phase the conceptual designs (and costs) will be refined significantly to include the specific location and types of features and to identify impacts to property and infrastructure. Agency and public comments will be strongly considered in development of the final designs.

Table 4-1. Sites and conceptual design alternatives in the TSP.

Study Site No.	Conceptual Design Alternative Selected
3	2
5	2
9	2
11	2
13	1
15	2

4.1.1.1 Northwest Branch Subwatershed and Tributaries

4.1.1.1.1 Northwest Branch (Site 3)

Existing Condition

Northwest Branch is an entrenched system in an urbanized area that experiences frequent flashy flows. The study reach is approximately 1.38 miles (7,286 ft) 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 35.6 square miles. Much of this reach was channelized by USACE in the 1970s for flood risk management. 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). 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 8,000 cubic feet per second upstream of Queen's Chapel Road and 5,000 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.

Proposed Design

Increased system stability will be provided to enhance habitat for fish and benthic organisms and reduce maintenance at utility crossings. This design includes minimal stream relocation. Appropriately placed armor stone will protect and guide flood flows away from eroded areas. Approximately 22 in-stream structures, including cross vanes, J-hook vanes, and W-weirs, are proposed to maintain grade and provide better connection with the floodplain. Fish passage is inhibited at Ager Road by utilities encased in concrete, forming a concrete sill with a one foot drop. Nested cross-vanes (made up of a set of upstream angled boulders) downstream of the fish blockage will provide fish passage by constricting flow and raising the water surface elevation. These will include a W-weir on Northwest Branch below its confluence with Sligo Creek. Figure 4-1 shows the conceptual site design in the TSP for site 3.

Figure 4-1. Conceptual designs for Northwest Branch (site 3) and Sligo Creek (site 9). Note: Chillum Road (site 10) is not in the TSP.

4.1.1.1.2 Sligo Creek (Site 9)

Existing Condition

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 11.2 square miles (7,168 acres). 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. Figure 4-2 shows the toe erosion and destabilization of some of the trees at the top of the bank. 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.

Proposed Design

Thirteen in-stream structures are needed to improve geomorphic stability and fish passage, including cross vanes and J-hooks. A nested cross vane downstream of the fish blockage will provide fish passage at all flows. The last structure is proposed to be a J-hook that leads to a deep pool before Sligo Creek joins the Northwest Branch. Figure 4-1 shows the conceptual design for Sligo Creek.

Figure 4-2. Flow direction at riffle grade structure on Sligo Creek.

4.1.1.1.3 Northwest Branch, Riggs Road (Site 13)

Existing Condition

This site is located at the transition between the Piedmont and Coastal Plain physiographic provinces. The project stream reach has a drainage area of 34.1 mi^2 (21,824 ac) and a length of 1.46 mi (7,708 ft). The reach starts at Riggs Road and ends approximately 500 feet downstream of Drexel Street. This system is severely incised and experiencing major lateral erosion causing the pedestrian trail system running parallel to the stream to be undermined. There have been some spot fixes to protect existing utilities; however, this system is extremely unstable. The high sinuosity in this system is not natural, and is caused by the stress from excess stormwater runoff and sedimentation. There is an undersized concrete arch and the sewer/water line maintains the grade until it reaches the high power electric area. The high degree of bank erosion has caused many trees to become uprooted.

Proposed Design

While erosive flows are expected to be mitigated by new stormwater requirements to some extent, the restoration will be designed to manage erosive flows through the alteration of channel dimension, pattern, and profile. Forty-eight structures are proposed to create a stable system. Stream relocation will be required in a few places to provide proper channel dimension and profile. Restoration of a more stable system will require increasing the channel cross sectional area while

raising the bed to improve conveyance, reduce stress and improve habitat diversity. The sinuosity will be reduced to increase stability. Restoration of this site will reduce sediment load downstream by eliminating bank erosion. Figure 4-3 shows the concept design for site 13.

Figure 4-3. Concept design for Northwest Branch, site 13.

4.1.1.2 Northeast Branch Subwatershed and Tributaries

4.1.1.2.1 Indian Creek (Site 11)

Existing Condition – Upstream Segment

This area 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 27.4 mi^2 (17,536 ac) and the reach length is 1.98 mi (9,843 ft). 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. Prince George's County is currently considering a proposal for a multi-use development at the current site of the D.C. metro adjacent to Indian Creek.

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, 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.

Existing Condition – 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 ft). 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.

Proposed Design – Upstream Segment

A total of 23 in-stream structures (log/stone) are proposed to provide a functional and stable system. In-stream utilities will be investigated beforehand and protected with structures. The area surrounding outfalls within the stream reach will be configured to mitigate erosive flows and prevent erosion. Originally, there were plans to enhance the braided stream system with the creation of small wetland ponds; however, due to the presence of a rare plant on the floodplain, restoration work will be required to remain within the stream channel. The stream close to MD193 will be designed to convey flood flows effectively and yet maintain stability. Riffle grade control will be provided to offset the skewed angle of the box culvert and MD 193. A large pond may be deepened at the downstream end of this reach if possible (this will be determined following plant surveys). Figure 4-4 shows the conceptual design for the upstream portion of site 11.

Proposed Design – Downstream Segment

A more sinuous system will be achieved by using nine structures upstream of Berwyn Road. The stream will be raised as possible to provide connectivity with its right floodplain and add aesthetic value to the community. Figure 4-5 shows the conceptual design for the downstream portion of site 11.

Figure 4-4. Concept design for upstream portion of Indian Creek (site 11).

Figure 4-5. Concept design for downstream segment of Indian Creek (site 11).

4.1.1.2.2 Paint Branch (Site 5)

Existing Condition

The drainage area for site 5 is 31.1 mi^2 (19,904 ac) and the reach length is 1.3 mi (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 at the Indian Creek confluence, widening upstream to 135 feet. 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 from 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 spoil 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. Boulders have been placed for stabilization in the vicinity of sewer infrastructure and bridges. 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 which 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.

Proposed Design

The stream will remain at its existing location. An alternate concept design included adding sinuosity and reactivation of historical flow paths; however, that concept design (design #1) was not shown to be cost effective per CEICA and was constrained by the HTRW conditions described in Section 2. Twenty-five in-stream structures will be used to reconnect the stream with its floodplain. A W-weir will be used on the upstream side of the railroad crossing, and a cross vane placed on the downstream side to provide grade control, fish passage and reduce the potential for debris jams. Figure 4-6 shows the conceptual design for site 5.

As discussed in Section 2.5.4, restoration on Paint Branch, from the CSX Bridge downstream to the Paint Branch-Indian Creek confluence, is being considered as mitigation for impacts from the proposed construction of the Washington D.C. metro Purple Line. Once additional certainty is gained on the likelihood of the mitigation project to move forward, a determination will be made on whether to remove this portion of site 5 from the TSP. Should this reach be removed from the TSP, federal costs for the plan will be reduced, but it is expected that similar environmental benefits will be achieved for this site through implementation of the mitigation project.

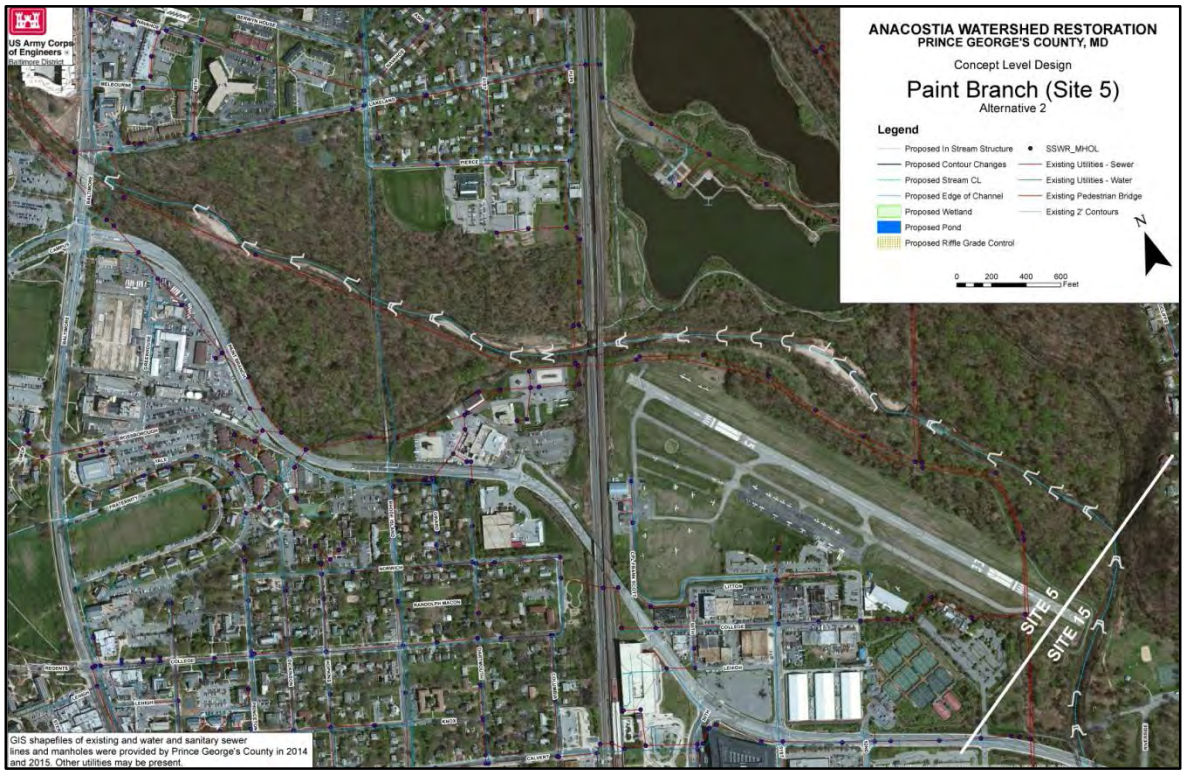


Figure 4-6. Concept design for Paint Branch, site 5.

4.1.1.2.3 Northeast Branch, Calvert Road (Site 15)

Existing Condition

Site 15 has a drainage area of 69.2 mi^2 (44,288 ac) and reach length of 1.04 mi (5,323 ft). 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 and some of bed load that efficiently move through lower portion of Indian Creek (site 11) ends in this reach causing alternating bars (sediment loading) and a shallow wide channel with homogeneous habitat. There are five sanitary/water crossings that pose stability and fish passage issues. The most challenging crossing is under the River Road Bridge where sheet-pile has been used to provide grade control. This system is powerful (high energy) during high flow. The banks along the entirety of the project reach have been armored with revetment.

Proposed Design

Seventeen structures will be used to provide stability and continuous fish passage at all flows. The tributary that enters the reach along this length will be stabilized to create a diversity of habitat

conditions, including providing shelter for fish and creating wetland buffers. Structures will be placed at bridges to include woody material to improve potential fish habitat. Figure 4-7 shows the conceptual design for site 15.

Figure 4-7. Concept design for Northeast Branch, site 15.

4.1.2 Adaptive Management and Monitoring Plan

The preliminary Adaptive Management and Monitoring Plan is included in Appendix I. The plan identifies and describes the monitoring and adaptive management (contingency) activities proposed for the project and estimate their cost and duration. The plan will be further developed in the preconstruction engineering and design (PED) phase as specific design details are made available. Costs for adaptive management and monitoring are included in total project costs (Table 4-2), and are included within the construction costs shown in Table 4-3.

The primary intent of the Monitoring and Adaptive Management Plan is to develop monitoring and 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 plan for monitoring the success of the ecosystem restoration. The preliminary Adaptive Management Plan was developed in accordance implementation guidance for WRDA 2007. 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. Section 2039 also directs that a contingency plan (Adaptive Management

Plan) be developed for all ecosystem restoration projects to make corrections to the project if planned benefits are not being realized.

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 (See Section 5.4). This schedule will be finalized in the final FS report.

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 35 percent of total project costs as further specified below:

    1. Provide 25 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

    2. Provide, during the first year of construction, any additional funds necessary to pay the full non-federal share of design costs;

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

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

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

c. 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. Shall 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;

e. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

f. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation features, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable federal and state laws and regulations and any specific directions prescribed by the Federal Government;

g. 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;

h. 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;

i. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative

Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;

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

k. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-federal sponsor with prior specific written direction, in which case the non-federal sponsor shall perform such investigations in accordance with such written direction;

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

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

n. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

4.3 Cost Estimates and Cost Sharing

The fully funded cost of the project, with escalation will be included in the final report after the development of the total project cost summary. Table 4-2 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 escalated to fiscal year 2016 price levels. The table includes costs associated with project construction and real estate considerations. At this stage in project planning, cost contingency is high, because designs are at a conceptual level and impacts to real estate are not yet detailed. The total project costs, including 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 all LERR and all operation and maintenance (O&M) costs. The LERR costs are applicable to the non-federal share of the initial costs. For example, the total LERR costs ($967,000) 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 ($967,000) combined with the minimum 5 percent cash contribution ($652,750) does not exceed 35 percent of the total project costs. An additional cash contribution of $11,435,250 is required to bring the non-federal contribution to 35 percent of total project costs.

Table 4-3 presents the project costs and benefits annualized over a 50-year period.

Table 4-2. Cost apportionment – Federal and non-Federal responsibilities

Total Project Cost (rounded)	**$ 37,300,000**
Non-Federal Share (minimum 35%)	**$ 13,055,000**
5% Cash minimum	$ 652,750
100% LERRs	$ 967,000
Cash Balance	$ 11,435,250
Total Non-Federal Share (35%)	**$ 13,055,000**
Federal Share (65%)	**$ 24,245,000**

Fiscal Year 2016 Price Levels

Table 4-3. Average annual costs and benefits.

Federal Discount Rate FY16 = 3.125%, 2016 Price Levels, Capital Recovery Factor = 0.039793, 50-Year Period of Analysis			
Element	**NE-A**	**NW-C**	**Total**
Total Project First Cost	$ 23,617,672	$ 13,644,157	**$ 37,261,829**
Average Annual Costs			
Construction	$ 939,817	$ 542,941	
Avg. Annual Interest	$ 12,148	$ 7,018	
OMRR&R	$ 8,578	$ 4,955	
Total Average Annual Cost	**$ 960,543**	**$ 554,915**	**$ 1,515,458**
Average Annual Benefits			
Project Specific SHUs	10,626	5,832	**16,458**
Aggregate SHUs	63,131	58,330	**121,461**
Total SHUs	**73,757**	**64,161**	**137,919**

As useful information for the non-federal sponsor, with the non-federal portion of the initial construction costs for the TSP (approximately $13.055M) for about 6.9 miles of stream restoration plus the 50-percent cost share requirement for the feasibility study (approximately $1.5M), Prince George's County will invest roughly $14.56M into the implementation of the TSP. Using the conversion of 100 linear feet of stream restoration equal to one impervious acre treated (per MDE, 2014), approximately 36,400 linear feet of stream restoration as identified in the TSP is equal to 364 impervious acres treated. Therefore, Prince George's County's investment is comparable to approximately $40,000 per impervious acre treated toward its current MS4 requirements. This figure is consistent with and may represent a cost savings based on planning level unit cost estimates for implementing stormwater best management practices in Maryland counties, such as new suburban bioretention ranging from approximately $50,000 per impervious acre treated (UMCES, 2011).

4.4 Project Implementation Schedule (Draft)

A preliminary implementation schedule was developed for the TSP. The 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 - 2017
- Project Construction Authorization – 2018 (assuming WRDA every two years)
- PPA Executed – Same year as Project Construction Authorization
- Plans and Specifications Development – 2 years from PPA execution

- Real Estate Acquisition – 1.5 years from PPA execution
- Construction – Starts 1 year after plans and specifications are finalized

4.5 Design and Construction

The conceptual designs for the sites included in the TSP are described in Section 4.1. These designs and the feasibility level designs currently in development 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 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;
g. Improve aesthetic value; and
h. Allow public access to the stream and recreational opportunities per landowner agreement.

Following final approval of the TSP, 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 that accompanies the final feasibility report will identify and describe in detail 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 sites and design alternatives in the TSP are shown in Table 4-4. Appendix H includes a draft Real Estate Plan and table showing real estate costs for all sites and design alternatives. The real estate plan and costs will be updated for the final feasibility report once designs are better defined.

Preliminary real estate costs were estimated based on the conceptual designs (10 percent design level). As a result of the current level of design, contingency added to the estimated costs is 25 percent. The project streams are largely located on parkland owned by MNCPPC, so cost estimates assume there will be no required Public Law 91-646 residential or commercial relocations. 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 H, although a few lots require further investigation to determine ownership.

Feasibility level designs will be developed to avoid impacts to utilities or other infrastructure, so it was assumed that there will be no required utility or facility relocations. Since property impacts have not been detailed at this level of design, the cost estimates conservatively assumed the project will impact property from 30 feet off the centerline of the stream on both sides. The recommended estate for this project is a perpetual Channel Improvement Easement and Temporary Work Area (staging) Easement (3 years). It is assumed that the MNCPPC will enter into a Memorandum of Understanding with the non-federal sponsor to provide the required real estate.

Table 4-4. Total and site specific land and administrative costs for real estate.

Reach ID	Design alt	Land[1] and Administrative[2] Costs	25% Contingency	Total ($)
3	Alt 2	110,344	27,586	137,930
5	Alt 2	218,884	54,721	273,605
9	Alt 2	33,623	8,406	42,028
11	Alt 2	204,160	51,040	255,200
13	Alt 1	130,923	32,731	163,654
15	Alt 2	76,019	19,005	95,024
			TOTAL RE COSTS	**967,441**

[1]Value is based on $10,000 per acre nominal value for Perpetual Channel Improvement Easement. Temporary Work Area Easements (construction access and staging) have not been identified.

[2]Administrative costs for providing LERR based on $5,000 per parcel not owned by non-federal sponsor or MNCPPC.

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

Minimal annual O&M of the completed project is expected. The project will be inspected once a year after the project is completed. Additional maintenance may be required after major storm events for the removal of possible debris in the stream channel. Post-construction adjustments for purposes of optimization will be performed under the Adaptive Management Plan. The non-federal sponsor is responsible for the cost and performance of O&M of the completed project.

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 include 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.

MD DNR stated that the Paint Branch is a designated Use III stream (Nontidal Cold Water) that supports wild (naturally reproducing) brown trout above the Capital Beltway; however, individual brown trout can be found a short distance downstream of the beltway. Because brown trout are

highly sensitive to changes in habitat including sedimentation and changes in water temperature, MD DNR stated that no in-stream work should be conducted during the Use III restriction period of October 1st through April 30th. 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 1 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.

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 state-listed endangered Trailing Stitchwort. This occurrence could potentially be impacted by any proposed construction work associated with stream restoration. As a result, MD DNR recommended the USACE Baltimore District to coordinate with the Wildlife Heritage Service further if restoration efforts do occur in the Indian Creek site. Coordination with the Wildlife Heritage Service indicates that the in-stream restoration work (as opposed to work on the floodplain) will have little impact on Trailing Stitchwort. USACE will work with MD DNR as feasibility level designs progress.

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

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. Direct, indirect, temporary, and cumulative impacts of the proposed actions are considered. Table 5-1 lists the projects considered in this impacts analysis. The impacts analysis conservatively includes all the sites (3, 9, 13, 15, 5, and 11) that will potentially be in the selected plan; however, the TSP could be reduced if costs increase upon further design and the incremental benefit is subsequently not considered to be worth the investment. Specifically, with the development of more detailed designs and costs (and rerun of CE/ICA), the entirety of the Plan NW-C and NE-A may not be supported. This section also identifies issues that require additional consideration, including coordination with the public and government agencies.

Table 5-1. Restoration projects considered in the impacts analysis.

Stream Name	Site	Site Location	Project Description
Northwest Branch and Tributaries			
NW Branch – Hyattsville	3	Stream channel	Restore approximately 1.38 miles of stream channel using 22 in-stream structures and remediate fish passage. Primarily in-stream work, minimum stream relocation.
Sligo Creek	9	Stream channel	Restore 0.40 miles of stream channel using 13 in-stream structures, including amelioration of one fish blockage. Primarily in-stream work.
Lower NW Branch – Riggs Road	13	Stream channel	Restore 1.46 miles of stream channel using 48 in-stream structures and some stream relocation. Primarily in-stream work.
Northeast Branch and Tributaries			
Indian Creek – College Park	11	Stream channel and limited floodplain work at downstream end of upper segment near MD193	Restore 1.98 miles of stream channel using 31 in-stream structures to provide better fish passage; deepen two ponds. Potential for some floodplain work (to enhance stream-floodplain reconnection) per coordination with MD DNR.

Stream Name	Site	Site Location	Project Description
Paint Branch	5	Stream channel	Restore 1.30 miles of stream channel using 25 in-stream structures. Primarily in-stream work.
Northeast Branch - Calvert Road Disc Golf Park	15	Stream channel, limited floodplain work	Restore 1.04 miles of stream channel using 17 structures and improve fish passage. Some floodplain work at tributary.

Direct impacts are those that will 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 will 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 5.7.

To limit the length of this document, only the aspects of the affected environment that will be impacted are discussed in this section. For example, some aspects of the physical environment, including geology, topography, soils, and overall land use within the study subwatersheds will not be impacted by the project. In addition, most aspects of the community setting will not be impacted.

If these projects are not implemented (the no action alternative), streams will continue to be geomorphically unstable. Portions of the streams will 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 Air Quality

Direct impacts: Construction of the projects will 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 will 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 5-2 summarizes the emissions impacts in tons per year (TPY) for ozone and $PM_{2.5}$, including precursors. Impacts on air quality will be short-term, minor, and localized.

Indirect impacts: No long term impacts to air quality will occur.

Table 5-2. Summary of construction emissions for implementation of the TSP.

Pollutant	Emissions per Stream Site (TPY)	Emissions Project Total (TPY)	Annual Limit (de minimus) (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 Infrastructure

Direct impacts: At the project sites, impacts to existing infrastructure will 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 work will be planned to minimize impacts by working around existing utilities. Sewage, gas, electric, and water supply infrastructure has been mapped and will be evaluated prior to construction to ensure that work can be performed without damages. It is not expected that construction vehicle movements associated with the proposed work will have any impact on public roads, as heavy vehicles currently utilize these roads regularly. Any damage to private roads will be repaired. As the project moves forward into feasibility level design, additional detail will become known regarding infrastructure impacts. Coordination will 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 protection to existing in-stream infrastructure (e.g., through geomorphic stabilization of the stream) and existing roads and bridges, no other indirect impacts to infrastructure are expected.

5.2 Hydrologic Setting

5.2.1 Stream Character

Direct Impacts: Stream reaches will be permanently altered with the installation of in-stream structures such as J-hooks, cross vanes, W-weirs, and step pools for grade control and riffle/pool restoration. The stream reaches will be impacted to varying degrees based on the number of structures implemented: site 3 – 22 structures, site 9 – 13 structures, site 13 – 48 structures, site 11

– 23 upstream structures and 9 downstream structures; site 5 – 25 structures, and site 15 – 17 structures. In-stream structures will permanently cover the stream bed where installed. Installation of grade controls will 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 will not obstruct normal sediment transport within the stream since the rocks will only cause minor reductions in channel width.

Channel realignment and construction of floodplain benches will be performed at some of the sites. Sites 3 and 13 are projected to have some degree of permanent channel relocation which would result in a long-term alteration to the stream course.

A mix of nested cross vanes and weirs are proposed to ameliorate fish blockages and 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.

Topographic changes will largely be confined to the stream channel and floodplain. In the limited cases where the channel is to be moved laterally as part of geomorphic restoration work (sites 3 and 13), floodplain elevation may be reduced by up to several feet over lengths of hundreds of feet to create a new channel. In these situations, the existing channel may be filled. Where the channel is stabilized in place, the channel may be deepened by up to several feet and narrowed by up to tens of feet. Grade control structures will be placed in-stream to maintain the desired streambed elevation. At sites where stream-floodplain reconnection will be enhanced (sites 3, 5, and 11) (potentially recreating wetland areas), floodplain elevation may be reduced by up to several feet to create depressions. The total area of channel and floodplain to be raised or lowered has not been estimated at this time. These areas shall be consistent with the general character of natural wetland areas occurring in the regional area. At sites where existing infrastructure is to be protected, rocks placed to protect structures will 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 will be restored to their original condition (e.g. replanted) or other condition (per discussion with the land owner) after construction is completed.

Materials required to reconnect streams with their floodplains will 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 will be in place to reduce the movement and loss of sediment from the construction site. Temporary access crossings will 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: 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 will be reduced. In-stream utilities will be protected to locally reduce streambed and bank erosion in the vicinity of infrastructure. Following project implementation, stream geomorphic restoration structures (e.g. cross-vanes, j-hook structures, etc.) will 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) will encourage natural formation of riffles and enhance in-stream habitat. Bank erosion rates will be reduced, which will result in a reduction of sediment transported downstream. Bank slope will gradually become less steep at its toe as material accumulates.

Slightly lower stream temperatures are expected to result from implementation of the project, since the channel will generally be narrower and deeper and the banks will be stabilized, allowing for greater vegetative growth and shading along the banks. Project implementation is expected to result in increased groundwater recharge, and reduced bed and bank erosion.

In some locations, additional volume will be created on the floodplain to allow for deposition of stream sediments during flood events. Improvement of floodplain connectivity and deposition of fine-grained sediments will contribute to wetland development at the sites. The stream geomorphic restoration work is expected to increase connectivity between the channel and floodplain and slow the velocity of water reaching the stream, thereby increasing stream baseflow and providing conditions where wetlands may reestablish in the floodplains.

Flows in the vicinity of in-stream engineered structures will be altered somewhat with both protected (lower velocity) and scoured areas created by the structures. Higher flows will be fully conveyed within the channel and floodplain. The project will be designed such that there will be no increased flooding of human structures or properties. Hydrologic and hydraulic modeling will be conducted to plan specific locations of structures and confirm the acceptability of the designs during Feasibility and PED phases. If the project is determined to have an impact on the elevation of the 100 year floodplain near any human structure of concern, the project will be modified by altering project configuration, excavation depth, or plantings to eliminate this concern. The project will be designed to comply with all applicable requirements for floodplain management regulations. In addition, designs will adhere to the constraints (design flows) of the existing USACE flood risk management project on Northwest Branch, Northeast Branch, Indian Creek, and Paint Branch.

Temporary: Restoration work will cause temporary, 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 will result in short-term displacement of all micro-organisms, benthic invertebrates, and fish. The restoration projects will likely alter stream erosional and depositional processes during construction by stream bed dewatering and or local emplacement of temporary structures. In limited cases, some restoration actions may result in permanent relocation of some parts of a stream reach. The project will be coordinated with the appropriate agencies to secure all permits as necessary.

5.2.2 Water Quality

The proposed project and its impact will adhere to the general and regional terms and conditions of Nationwide Permit #27 (NW27), *Aquatic Habitat Restoration, Establishment, and Enhancement Activities* (Appendix C). 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. All applicable permits will be obtained prior to project construction.

Direct Impacts: Minor short-term detrimental impacts to water quality will occur during stream geomorphic construction work as a consequence of increased turbidity created during construction from activities. Although not expected as sites are upstream of large industrial areas, legacy pollutants buried in the sediments could become mobilized when sediments are disturbed. If a flooding event occurs during construction, it is likely that exposed earth at the site will be vulnerable to erosion, thereby increasing the turbidity of the floodwaters.

Indirect Impacts: Once constructed, stream geomorphic restoration is expected to produce benefits in water quality within the stream reaches and watershed by promoting dynamically stable streams and reducing excess in-stream erosion. Reconnection of streams with their floodplains will 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 will be improved as a consequence of sediment settling out on the floodplain; pollutants associated with these sediment particles will be stored on the floodplain and potentially removed by vegetation, thereby reducing pollution to the stream.

Temporary Impacts: Minor short-term detrimental impacts will occur when stone is placed along the bed or banks as a result of increased turbidity. Stream flow by-pass pipes around construction areas, sediment and erosion control measures, construction sequencing, and other best management practices will limit turbidity and water quality impacts as much as possible.

5.3 Biological Resources

5.3.1 Fish and Benthic Integrity

Direct Impacts: Sessile or slow-moving animals in the path of discharges, equipment, and construction materials will 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 will likely avoid the construction site. 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. Motile aquatic animals will return to temporarily impacted aquatic areas that are restored by the project. Time-of-year restrictions on in-water construction are required by MDE to minimize impacts on aquatic life that spawns at that time (see Section 4.8). It is possible that 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 will be minimal. The project will be coordinated with USFWS, MDE, and MDDNR as necessary for consultations and to secure required permits.

Indirect Impacts: Some turbidity may be generated during construction activities but it is expected to have minimal impact on aquatic life, as discussed above. Overall, stream geomorphic

restoration work is expected to benefit aquatic organisms by improving water quality, increasing baseflow, enhancing habitat quality, and increasing habitat diversity. Restored streams will provide greater spawning and resident habitat for aquatic organisms. Habitat features will be more stable over time, and excess fine-grained sediment will not negatively affect riffle habitat. Remediation of fish passage blockages on sites 3 and 9 will open additional spawning areas for migratory fish and allow resident fish greater opportunities for movement. Restoration will improve habitat conditions for anadromous fish species such as herring and shad, and aquatic community health will 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) will 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).

Temporary Impacts: During project construction, fish and other motile animals would likely avoid the construction site.

5.3.2 Wildlife

Direct Impacts: 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 during construction, but will likely return upon completion of the project. No permanent displacement of wildlife populations is expected. The project sites that include plantings will 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: Wildlife associated with the streams and wetlands in the area will benefit by the improved water quality and additional habitat that the restoration projects will provide.

Temporary Impacts: During project construction, wildlife would likely avoid the construction site.

5.3.3 Rare, Threatened, and Endangered Species

Direct Impacts: 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.

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. To avoid impacting populations of this plant, coordination with MD DNR indicates that only conceptual design alternative #2 is feasible. This alternative proposes work only within the main stream channel. Conceptual design alternative #1, which proposed extensive floodplain work was eliminated from further consideration. The detailed feasibility-level design will be further coordinated with MDDNR, including for access and staging areas, to ensure that impacts to the plant are avoided.

Indirect Impacts: If locations containing federally-listed or proposed, or state-listed or proposed, threatened or endangered species are identified, they will be avoided for construction activities; therefore, no indirect impacts to these species are expected. In-stream work at site 11 may alter the flow velocity within the channel, but detailed design work and modeling will ensure that the hydrology outside the channel, including inundation of the floodplain, will not affect the habitat requirements of the trailing stitchwort. Further coordination with MD DNR will be conducted as the study moves into the detailed design phase.

Temporary Impacts: Any transient species would likely avoid the construction site.

5.3.4 Riparian Vegetation (Wetlands and Forest)

As stated in Section 5.5.5, the proposed project and its impacts will adhere to the general and regional terms and conditions of NW27. All applicable permits (e.g., non-tidal wetlands) will be obtained prior to project construction.

Direct Impacts: Wetland and riparian plant communities along stream corridors provide shelter, shading to waters, detritus, and breeding and rearing areas for various fish and other aquatic organisms. In order to address geomorphic instability, removal of riparian vegetation immediately adjacent to the streams will be required for access. Site 13 currently is losing many trees due to high bank erosion. It is anticipated that following project implementation, there would be no further loss of trees at this site due to bank erosion.

In limited cases, floodplain work (i.e. to promote wetland restoration and stream reconnection with the floodplain) will be performed which will require clearing of riparian vegetation. The extent of this will be better understood when a higher level of design is reached. Prior to restoration work, existing wetlands will be delineated along the stream corridors. During construction, disturbances to wetlands and riparian vegetation that will not be altered for restoration purposes will be avoided as much as possible. All wetlands temporarily disturbed during construction will be graded to their pre-project grade and replanted with native wetland vegetation species following construction. Wetland reestablishment that may be promoted through the reconnection of streams with the adjacent floodplain will improve existing aquatic resource functions. Wetland buffers will be created at site 15. Increases in wetlands acreage and related water quality improvement will offset detrimental construction impacts. The project will be coordinated with MDE and others as appropriate to secure all permits for work affecting wetlands or riparian areas, as necessary.

Indirect Impacts: The stream geomorphic restoration work in upstream stream segments will indirectly benefit wetlands occurring along the stream corridors by promoting more frequent stream-floodplain interactions, and increasing saturated conditions in which wetland functions are promoted. However, 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. Wetland reestablishment will benefit water quality by slowing stormwater velocity, storing sediment, increasing infiltration, and removing pollutants prior to reaching the stream. Wetlands reestablished along restored stream reaches will also serve to replenish groundwater aquifers and provide important food and shelter for a variety of resident and transient wildlife, such as mammals, birds, reptiles, and amphibian species.

Temporary Impacts: No impacts anticipated.

5.4 Community Setting

Direct Impacts: Impacts of the projects on socioeconomic conditions in the area are expected to be negligible. Economic activity will 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 will be minor.

Indirect Impacts: The project recommended in this report will 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, will benefit from this project. Accordingly, no negative adverse human health or environmental effects on minority or low income populations will occur based on actions undertaken for this project; therefore, this project will 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. The TSP also supports both the Chesapeake Bay Executive Order 13508 and Urban Waters Partnership by reconnecting urban populations with nature. 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. Aesthetics and safety in the project area will be improved through reduced streambank erosion and more stable riparian woody vegetation. Improvements to water quality will also enhance the area as a livable setting for people. Stabilization of stream banks may prevent streams from causing property damage, which could have a minor positive economic impacts.

Stream and wetland restoration activities will generally 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 creation uses. Improved stream stability and habitat will benefit stream valley and park land uses overall.

Temporary Impacts: Standard health and safety practices will 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. The area will be secured from access by the public during project construction. Impacts to the safety of vehicular traffic will be minimized through careful consideration of access routes to each construction site, by construction sequencing, and by incorporating appropriate traffic management measures. Noise during construction will be produced by construction equipment and by vehicles transporting materials to and from the sites, this will 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 schedules and operating hours will be selected to avoid and minimize inconvenience to area residents.

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. Some project locations near existing trails will require the realignment and relocation of pedestrian bridges. These details will become better known during the feasibility design phase. Construction will be coordinated with MNCPPC to minimize negative effects on park users and ensure compatibility with park needs to the maximum extent practicable.

5.5 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 will 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 TSP. This letter is included in Appendix C.

Following receipt of the letter from MHT, the area of potential effects was delineated based on the conceptual site designs and further cultural review, including a search of MHT records and field visits, was performed for the sites in the TSP. Potential effects and recommendations for each site are included in Appendix A. In summary, the majority of the project work will be confined to the area in between the stream banks, and will not result in an adverse effect on cultural resources. Any access roads or staging areas will not include subsurface excavation and will be confined to previously disturbed areas when possible. Effects and recommendations for two sites in the TSP (sites 11 and 15) where floodplain work may occur are described below. Coordination with MHT regarding these recommendations is on-going and will be finalized for the final report.

5.5.1 Indian Creek (site 11)

The proposed restoration includes floodplain and in-stream restoration including the creation and/or deepening of at least one pond and controlled flooding to recreate historic wetlands. Because the creation of the pond in the floodplain would require subsurface excavation, a more in-depth look at these areas may be required, including fieldwork. However, the controlled low velocity flooding for wetland creation should not be an adverse effect requiring further investigation as it is already within the stream's floodplain and subject to intermittent submersion. No archaeological sites have been previously identified in or near the area of potential effect, nor have any archaeological surveys been conducted. The in-stream restoration will be confined to in between the stream banks, and will not result in an adverse effect on cultural resources. Any access roads or staging areas will not include subsurface excavation and will be confined to previously disturbed areas when possible.

5.5.2 Northeast Branch, Calvert Road (site 15)

The proposed floodplain contouring shown in the conceptual design (in an area less than approximately 5 acres) along the stream bank adjacent to the tributary on the southern end of the stream reach could result in an adverse effect to any unidentified archaeological resources. A mill race and archaeological "small finds" have been reported in or near the area of potential effect. A more in-depth investigation in this area is required, including fieldwork. The in-stream restoration will be confined to in between the stream banks, and will not result in an adverse effect on cultural resources. Any access roads or staging areas will not include subsurface excavation and will be confined to previously disturbed areas when possible.

5.6 Hazardous, Toxic, and Radioactive Waste

Direct impacts: As identified in Section 2.4, 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 will not impact the landfill or 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 will incorporate this constraint. It is possible that disturbance of sediments along this reach could release contaminants adsorbed to sediments. Coordination is ongoing to determine the likelihood of this occurrence; however, working in the dry may minimize these releases. Further coordination with UMD and EPA will occur prior to construction to ensure that all boundaries are sufficiently marked and avoided.

Indirect impacts: As a result of the restoration project on Paint Branch, there may be some increased connection of the stream with its floodplain. Groundwater elevations adjacent to the stream could be altered to increase water retention in the floodplain and stream banks, slowing the travel-time of groundwater reaching the stream. Coordination with EPA indicates that for purposes of the selected groundwater remediation strategy (natural attenuation) this would be a beneficial effect. No other impacts are anticipated.

5.7 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 draft report and other actions that have or may be implemented in the Anacostia River watershed.

The plan recommended in this draft feasibility report will contribute cumulatively in a beneficial manner to ongoing environmental efforts within Prince George's County. Figure 5-1 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 improve stream water quality and the overall health of the aquatic ecosystem. 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 by MDE for fecal coliform bacteria, sediment, total suspended sediment, nutrients (nitrogen and phosphorus), biological oxygen demand, polychlorinated biphenyls (PCBs), and trash.

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. 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 (most probably number B/yr) are targeted. 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 will diminish related stressors to aquatic ecosystems. 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 effort 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.

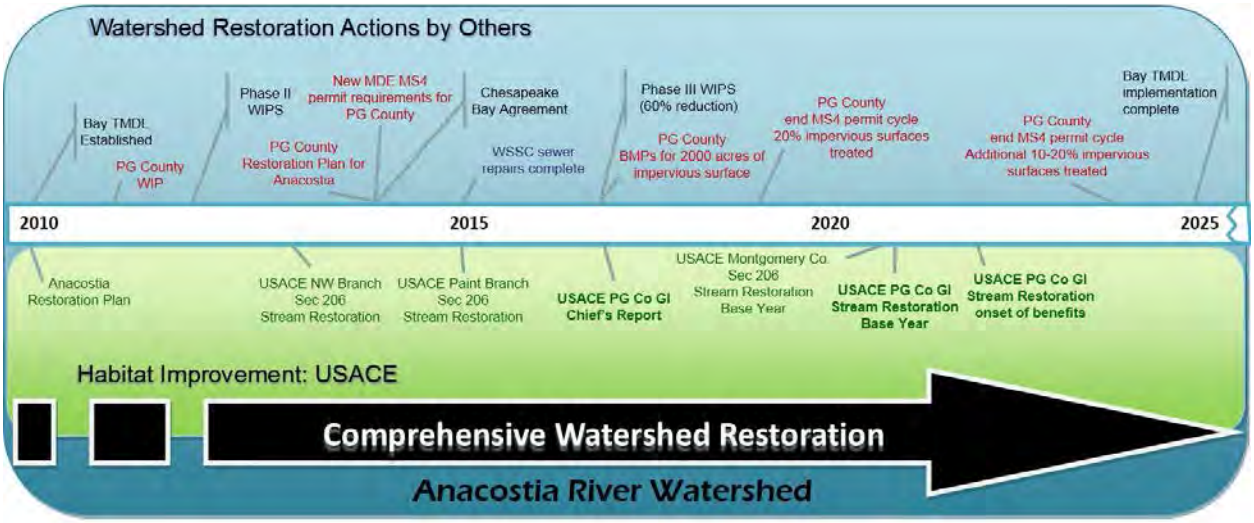


Figure 5-1. Contributions from USACE and others to a comprehensive restoration strategy for the Anacostia River watershed.

Some of the benefits for the restoration project recommended in this draft 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 will undertake stream restoration within the watershed or stream reaches of study for mitigation. For example, construction of the Purple Line or redevelopment of the property adjacent to Indian Creek (discussed in Sections 4.1), 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.

Other agencies, including WSSC and USACE have also implemented stream restoration measures that connect with the projects recommended in this report. Enhancing connectivity and fish passage will 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 will have positive effects for upstream ecosystems through nutrient transfer and will 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.

The proposed study will leverage water quality improvements and existing restoration efforts to provide habitat improvements and connectivity to the stream network. Existing restoration efforts have addressed stream reach impairments in 5.23 miles of the watershed. The TSP, including 6.9 miles of restoration on the Northwest Branch and Northeast Branch and tributaries are expected to impact stream stability and enhance aquatic habitat and fish passage, as well as have minor impacts on water quality. Combined with previous efforts to address stream reach impairments, implementation of the proposed project will provide 12.1 acres of restored stream reach in the watershed.

While stormwater retrofits and upgrades will help address stormwater quantity to some extent, it is expected that controls will not be adequate to eliminate erosive flows. Stream geomorphic conditions are expected to eventually achieve a condition of dynamic equilibrium with stormwater runoff, but this may take many decades to centuries. The geomorphic restoration proposed by this project will aid in reducing the impacts of large quantities of stormwater runoff. Green Streets and Low Impact Development retrofits will also continue to be implemented throughout the Anacostia Watershed, in order to reduce pollutant runoff and stormwater quantity to streams. At least six Green Streets projects have been constructed or are underway within the watershed.

5.8 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. Many of the listed requirements are listed as "partial" compliance as coordination is ongoing. Upon project implementation, compliance with all requirements will be full and all applicable permits will be secured as required prior to project construction. Environmental impacts are discussed in Sections 5.1 to 5.7, 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. It is noted that the Fish and Wildlife Coordination Act Report is draft until USFWS has had the opportunity to review and comment on the recommended plan. There is also 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	Partial
Archaeological and Historic Preservation Act	Partial
Archaeological Resource Protection Act	Partial
Bald and Golden Eagle Protection Act	Partial

Federal Statutes	Level of Compliance*
Clean Air Act	Partial
Clean Water Act	Partial
Coastal Barrier Resources Act	N/A
Coastal Zone Management Act	Partial
Comprehensive Environmental Response, Compensation and Liability Act	Partial
Endangered Species Act	Partial
Estuary Protection Act	N/A
Farmland Protection Policy Act	Partial
Federal Water Project Recreation Act	N/A
Fish and Wildlife Coordination Act	Partial
Flood Control Act of 1944	Partial
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	Partial
National Historic Preservation Act	Partial
North American Wetlands Conservation Act	Partial
Resource Conservation and Recovery Act	Partial
Rivers and Harbors Act	N/A
Water Resources Development Acts of 1976, 1986, 1990, and 1992	Partial
Water Resources Planning Act	Partial
Watershed Protection and Flood Prevention Act	Partial
Wild and Scenic Rivers Act	Partial
Executive Orders (EO), Memoranda, etc.	
Migratory Bird (E.O. 13186)	Partial
Protection and Enhancement of Environmental Quality (E.O. 11514)	Partial

Federal Statutes	Level of Compliance*
Protection and Enhancement of Cultural Environment (E.O. 11593)	Partial
Exotic Organisms (E.O. 11987)	N/A
Floodplain Management (E.O. 11988)	Partial
Protection of Wetlands (E.O. 11990)	Partial
Relating to Protection and Enhancement of Environmental Quality (E.O. 11991)	Partial
Environmental Justice in Minority and Low-Income Populations (E.O. 12898)	Partial
Invasive Species (E.O. 13112)	Partial
Protection of Children from Health Risks and Safety Risks (E.O. 13045)	Partial
Prime and Unique Farmlands (CEQ Memorandum, 11 August 1980)	Partial

*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.

5.9 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.

5.9.1 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 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 notice and mailing list for the study can be found in Appendix D, the Public Involvement Appendix. A 30 day public comment period will follow the release of this draft feasibility report. Following the public comment period, Appendix D will be updated with public comments and responses.

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. Coordination is ongoing with a number of agencies, including MHT and MD DNR to address cultural and environmental considerations. Additionally, coordination with the primary land owner, MNCPPC, is underway to ensure all concerns are addressed with regards to impacts to MNCPPC property. These impacts will become better known as designs progress into the next phase.

6 CONCLUSIONS

The Tentatively Selected 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). The TSP will be finalized following consideration of comments received during public and agency report review. The TSP could be reduced if costs increase upon further design and the incremental benefit is subsequently not considered to be worth the investment. It is possible that with the development of more detailed designs and costs, the entirety of the Plan NW-C + NE-A may not be supported by the cost effectiveness analysis. Specifically, stream sites 9 and/or site 13 could be removed from the TSP.

Plan NW-C + NE-A restores 6.9 miles of in-stream habitat, 4.3 miles of fish passage, and connects 13.5 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 TSP 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 $37,300,000 (2016 price level). OMRR&R expenses are expected to be minimal and are estimated at $13,500 per year. The federal portion of the estimated first cost is $24,245,000. Prince George's County's (the non-federal sponsors) portion of the required 35 percent cost share of total project first costs is $13,055,000, which includes 100 percent of the real estate costs (LERR).

The TSP 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 TSP provides substantial environmental improvements for the stream reaches of study and contributes to a comprehensive restoration strategy for the Anacostia River watershed.

7 RECOMMENDATIONS

The following outlines draft language for USACE recommendations for project approval and authorization for implementation. As stated in the report, the TSP could be reduced if costs increase upon further design and the incremental benefit is subsequently not considered to be worth the investment. Once the recommendation is solidified, following agency and public reviews, the final feasibility report will contain final language and signature (Colonel Edward P. Chamberlayne, District Engineer USACE Baltimore District) for the recommendations.

I recommend that ecosystem restoration for the Anacostia River watershed project area as generally described in the TSP 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. The estimated project first cost of the TSP is $37,300,000 (2016 price level). Minimal operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) expenses are estimated at $13,500 per year. The federal portion of the estimated first cost is $24,245,000. The non-federal sponsors' portion of the required 35 percent cost share of total project first costs is $13,055,000.

These recommendations are made with the provisions that non-federal partners shall, prior to implementation, agree to perform the following items of local cooperation, including, but not limited to:

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

- Contribute the local share of non-federal costs for initial construction and operation and maintenance over the economic life of the project, as required to serve the intended purposes.

- 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; Hold and save the United States free from claims.

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.

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Appendix A. Existing Conditions

A-1: Subwatershed Existing Conditions

A-2: Existing Conditions - Fish Species and Sample of Habitat Requirements

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: Prior Reports (Table)

A-7: Anacostia Restoration Plan Candidate Restoration Projects

A-1: Subwatershed Existing Conditions

Appendix A-1: Existing Subwatershed Conditions

Extensive information was compiled for the subwatersheds in the Anacostia River watershed for preparation of the Anacostia Restoration Plan (AWRP, 2010). An environmental baseline conditions and restoration report was prepared for the watershed in general and also for each subwatersheds (see References). Information from these reports and others is summarized below; however, for further information on conditions in each subwatershed, please refer to the appropriate report.

1.1 Subwatershed Descriptions

The Anacostia River, a tributary of the Potomac River which flows to the Chesapeake Bay, drains portions of Montgomery and Prince George's County in Maryland and the District of Columbia. The Anacostia River watershed drains approximately 176 square miles, with 17.2 percent of its drainage area in Montgomery County, 34.4 percent in Prince George's County, and 48.4 percent in the District of Columbia (AWRP. 2010). The Anacostia River watershed lies across the northwest portion of Prince George's County, and includes the municipalities of Berwyn Heights, Bladensburg, Brentwood, Capital Heights, Cheverly, College Park, Colmar Manor, Cottage City, Edmonston, Fairmount Heights, Glenarden, Greenbelt, Hyattsville, Landover Hills, Mount Rainier, New Carrollton, North Brentwood, Riverdale Park, Seat Pleasant, and University Park. The watershed also contains a large area of federal land (e.g. Beltsville Agricultural Research Center and Greenbelt Park) and state-owned land (University of Maryland) (PGDOE, 2014).

Historically, the Anacostia River watershed was a thriving center of culture for Native Americans, with highly productive ecosystems. As settlers cleared fields for agriculture, the river began to decline. Today the Anacostia River watershed is characterized by the alteration of the natural landscape, including an increase in impervious surface area and disruption of the natural hydrologic regime. The watershed is one of the most densely populated of the Chesapeake Bay subwatersheds, and as a result, suffers from poor water quality and degraded ecosystems (AWRP, 2010).

The ten streams selected for detailed evaluation in this feasibility study are located in six subwatersheds: Northwest Branch, Sligo Creek, Northeast Branch, Paint Branch, Little Paint Branch, and Indian Creek (Figure 1). The Northwest Branch originates in Montgomery County southeast of Olney, Maryland, and flows south for approximately 15 miles before entering Prince George's County and joining with the Northeast Branch. Sligo Creek has its headwaters in Montgomery County in Wheaton, then flows southeast for approximately eight miles before converging with the Northwest Branch in Hyattsville (Prince George's County).

Originating south of Burtonsville in Montgomery County, Little Paint Branch flows south for approximately nine miles before entering Prince George's County where it joins the Paint Branch. Paint Branch begins near Spencerville and flows in Montgomery County for approximately nine miles, entering Prince George's County and joining with Little Paint Branch. The confluence of Indian Creek and Paint Branch in College Park, MD, forms the Northeast Branch. The entire Indian Creek subwatershed is located in Prince George's County.

1.1.1 Northwest Branch

The Northwest Branch subwatershed is approximately 41.7 square miles (26,696 acres) in size (MWCOG, 2009c). The headwaters of Northwest Branch are in a rural area of Montgomery County and are bordered by woodland and pasture. The upper and middle reaches of the mainstem and larger tributaries flow through high quality forest buffer over an average gradient of 0.39% (MWCOG, 2009c). The lower reach flows through Prince George's County to the confluence with the Northeast Branch at Bladensburg, MD. Between the subwatershed boundary and the protected parklands within the stream valley, the middle and lower reaches, including areas within the District of Columbia, are approaching effective full build-out (i.e. maximum development potential).

A GIS analysis using data from the National Land Cover Database (NCLD, 2006) indicates the predominant land cover in the Prince George's County portion of the subwatershed is 1) low to high intensity development, 2) developed open space, and 3) forest. Fifty-eight percent of the Prince George's County portion of the subwatershed is classified as having impervious surface cover with a high degree of imperviousness (26-100% imperviousness).

Since the late 1980's many natural resources professionals working in the Anacostia watershed have monitored aquatic communities using an Index of Biotic Integrity or IBI approach. The IBI compares the fish and macroinvertebrate communities of urban streams with those of healthy reference streams, incorporating geographical, ecosystem, community, and population, as well as distribution and abundance variables that account for differences in water body size, type, and region of occurrence. Aquatic habitat conditions in the watershed are only partially supporting of reference conditions. In general, the aquatic community present in the upper Northwest Branch in Montgomery County is correspondingly healthier and more diverse than that found in the middle and lower portions of the subwatershed (MWCOG, 2009c).

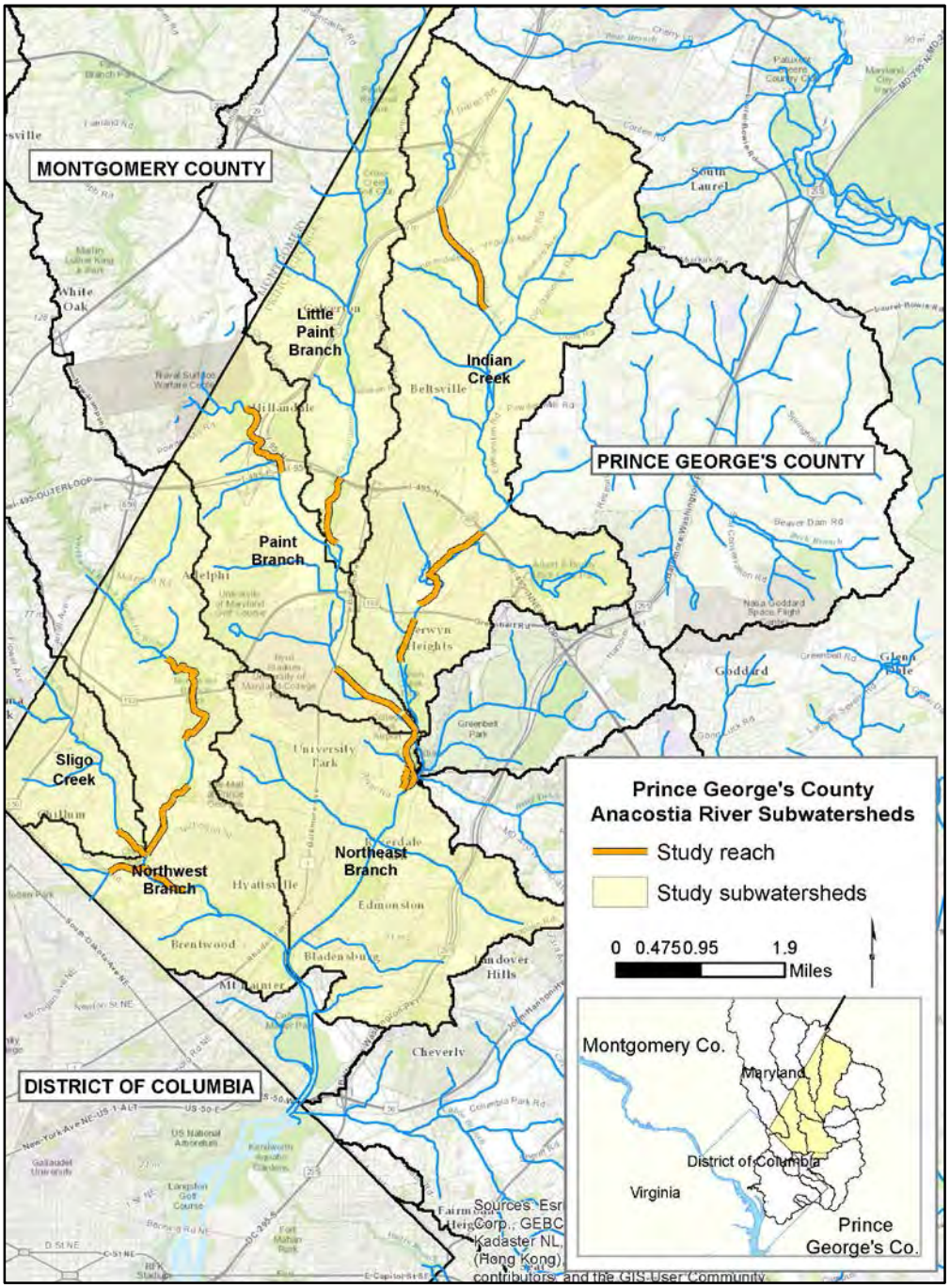

Figure 1. Study subwatersheds and stream reach locations in Prince George's County, MD.

1.1.2 Sligo Creek

The Sligo Creek subwatershed has a drainage area of 11.1 square miles (7,085 acres), and is located in the central western vicinity of the Anacostia River watershed. The subwatershed is located within Montgomery and Prince George's Counties (20-percent of the watershed), Maryland, and the District of Columbia. A GIS analysis using data from the National Land Cover Database (NCLD, 2006) indicates the predominant land cover in the Prince George's County portion of the subwatershed is 1) low to high intensity development, 2) developed open space, and 3) forest.

Fifty-four percent of the Prince George's County portion of the subwatershed is classified as having impervious surface cover with a high degree of imperviousness (26-100% imperviousness).

Sligo Creek flows from its headwaters in the Piedmont physiographic province into the Coastal Plain province over an average gradient of 0.72% (AWRP, 2010). Elevations in the Sligo Creek subwatershed range from 450 feet at the watershed drainage divide to 35 feet at the confluence with Northwest Branch. Sligo Creek has an average gradient of 0.72-percent over 8.3 miles of its main stem length (MWCOG, 2009b). The entire lower mainstem channel, from Riggs Road to the confluence with Northwest Branch, has been channelized and includes a levee on the northern bank associated with various flood protection projects. In addition, major portions of the Sligo Creek mainstem from University Boulevard downstream to Maple Avenue, have been armored with revetment to reduce stream bank erosion.

The condition of fish and macroinvertebrate populations in Sligo Creek has improved since the completion of the first two phases of habitat restoration in the upper third of the subwatershed in Montgomery County. These efforts, which have included controlling stormwater quantity and quality, restoring both tributary and main stem in-stream habitat, creating wetlands, reforestation, and native fish and amphibian reintroduction have resulted in aquatic habitat rankings of greater than 70% (partially supporting) of reference conditions at three main stem sampling sites. Although aquatic biota are correspondingly healthier and more diverse than during previous sampling, main stem populations remain impacted, scoring no better than 36% (moderately impaired) of reference conditions. Several physical barriers to both resident and anadromous fish movement and migration are present downstream of Riggs Road. These, as well as other barriers in Sligo Creek, have been identified and remain as a restoration challenge for this subwatershed (MWCOG, 2009b).

1.1.3 Northeast Branch

The Northeast Branch subwatershed drains approximately 7.2 square miles (4,613 acres) and is home to approximately 39,800 people. The entire subwatershed is located within Prince George's County. The Northeast Branch is formed by the confluence of Paint Branch and Indian Creek. Approximately three miles downstream, the Northeast Branch confluences with Northwest Branch near Bladensburg, Maryland, to form the Anacostia River.

A GIS analysis using data from the National Land Cover Database (NCLD, 2006) indicates the predominant land cover in the subwatershed is 1) low to high intensity development, 2) developed open space, and 3) forest. Seventy-four percent of the subwatershed is classified as having impervious surface cover with a high degree of imperviousness (26-100% imperviousness).

The Northeast Branch is in the Coastal Plain physiographic province and has an average gradient of 0.18% (MWCOG, 2009f). About 85-percent of the mainstem (south of the proposed project reaches) has been channelized and levees were constructed as part of a local flood risk management project completed by USACE (USACE, 1968).

Each of the two IBI main stem sampling stations were rated as having either non- supporting or partially supporting physical aquatic habitat conditions present. Macroinvertebrate populations in both the Northeast Branch main stem and its tributary network are rated as being poor. Main stem

fish populations were rated as being generally good. Unfortunately, tributary fish community-related sampling data is largely non-existent. In general, both main stem and tributary macroinvertebrate and fish communities remain impacted (MWCOG, 2009f).

1.1.4 Paint Branch

The Paint Branch subwatershed is approximately 20.5 square miles (13,121 acres) in size. Approximately 75-percent of the subwatershed is in Montgomery County, with the remaining 25-percent in Prince George's County. With an average mainstem gradient of 0.6-percent over 11.4 miles of the main stem, Paint Branch flows from the Piedmont physiographic province, through the Fall Line, and into the Coastal Plain. Elevations range from 560 feet at the Paint Branch/Patuxent River watershed divide to 35 feet at the confluence with the Northeast Branch, and the average gradient is 0.57% (MWCOG, 2009e).

A GIS analysis using data from the National Land Cover Database (NCLD, 2006) indicates the predominant land cover in the Prince George's County portion of the subwatershed is 1) low to high intensity development, 2) developed open space, and 3) forest. Thirty-seven percent of the Prince George's County portion of the subwatershed is classified as having impervious surface cover with a high degree of imperviousness (26-100% imperviousness).

In the Montgomery County portion of the subwatershed, Paint Branch is widely regarded as being the Anacostia's highest quality Piedmont stream system, supporting reproducing brown trout, with the Upper Paint Branch designated as a Special Protection Area by the Maryland Department of Natural Resources (MD DNR). Concurrent with the post-1989 re-establishment of a forested riparian buffer along the stream, both fish and macroinvertebrate populations in the Beltsville Agricultural Research Center main stem portion of Paint Branch have improved somewhat. Other major efforts in the subwatershed, which have included controlling stormwater quantity and quality, major stream valley park acquisition, restoring both tributary and main stem instream habitat, creating wetlands and riparian reforestation, have resulted in aquatic habitat rankings which are partially supporting of reference conditions. In general, the aquatic community present in the upper Paint Branch is correspondingly healthier and more diverse than that found in the middle and lower portions of the subwatershed. Main stem macroinvertebrate populations typically remain impacted.

1.1.5 Little Paint Branch

The Little Paint Branch subwatershed drains approximately 10.6 square miles (6,785 acres). Little Paint Branch is a tributary of the Northeast Branch of the Anacostia River. It has its headwaters in eastern Montgomery County and flows into Prince George's County to its confluence with Paint Branch, north of the University of Maryland campus over a 0.66% average gradient (MWCOG, 2009g). This subwatershed is a transitional area between the Piedmont and Coastal Plain physiographic provinces.

A GIS analysis using data from the National Land Cover Database (NCLD, 2006) indicates the predominant land cover in the Prince George's County portion of the subwatershed is 1) low to high intensity development, 2) developed open space, and 3) forest. Forty-two percent of the Prince George's County portion of the subwatershed is classified as having impervious surface

cover with a high degree of imperviousness (26-100% imperviousness). The lower portion of the subwatershed includes significant agricultural lands associated with the U.S. Department of Agriculture's Beltsville Agricultural Research Center (BARC).

Three (38 percent) out of the eight Little Paint Branch Index of Biotic Integrity (IBI) main stem sampling stations were rated as having either non-supporting or partially supporting physical aquatic habitat conditions present. With the exception of the upper main stem and Silverwood and Spray Irrigation tributaries where conditions are generally rated as being good, the condition of macroinvertebrate populations in both the middle and lower main stem and tributary network is generally poor/fair. Macroinvertebrate community conditions in the Silverwood and Spray Irrigation tributaries are generally considered to be the least impaired; whereas, those in the Galway tributary are the most impacted. Main stem fish populations were similarly rated as being fair to good. The Little Paint Branch headwaters support a relatively healthy fish community, including sensitive species such as the Least Brook lamprey. The main stem is open to both resident and migratory fishes up to I-95. Tributary fish community-related sampling data indicates that the BARC Spray Irrigation tributary supports the highest number of species (i.e., 16); whereas, the Galway tributary supports only two (MWCOG, 2009g).

1.1.6 Indian Creek

The 15-square-mile (9,600 acre) Indian Creek subwatershed is located entirely in Prince George's County. The average gradient along the subwatershed is 0.52% (MWCOG, 2009d).

A GIS analysis using data from the National Land Cover Database (NCLD, 2006) indicates the predominant land cover in the subwatershed is 1) low to high intensity development, 2) developed open space, and 3) forest. Thirty-nine percent of the subwatershed is classified as having impervious surface cover with a high degree of imperviousness (26-100% imperviousness). The upper portion of the Indian Creek subwatershed is dominated by abandoned and active sand and gravel mining operations and forest cover; much of the forest cover is classified as scrub-shrub regenerating. However, at the north end of the watershed on a former sand and gravel pit, there are plans for the construction of a 2,200 acre multi-use area (Konterra Town Center). The middle portion of the subwatershed is largely developed, featuring industrial, residential, and commercial land uses. In the lower portion of the subwatershed, long reaches of the stream have been channelized with poor parkland buffering (MWCOG, 2009d).

Two-thirds (66 percent) of the County's 12 Indian Creek IBI main stem sampling stations were rated as having either non- supporting or partially supporting physical aquatic habitat conditions present. With the exception of the lower main stem where conditions are generally rated as being good, the condition of macroinvertebrate populations in both the Indian Creek main stem and tributary network is generally fair to good (MWCOG, 2009d)

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MWCOG. 2009g. Little Paint Branch Environmental Baseline Conditions and Restoration Report. Metropolitan Washington Council of Governments, November 30, 2009.

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A-2: Existing Conditions - Fish Species and Sample of Habitat Requirements

FISH SPECIES IN STUDY SEGMENTS OR SUBWATERSHED				Collected - Subwatershed (since 1988) /Segment (since 1997)[a]									
				Indian Creek		Northwest Branch			Sligo	Paint Branch (P-Piedmont, C- Coastal Plain)		Little Paint	Northeast Branch
Common Name	**Fish Species**	**Origin**	**Tolerance**	**1**	**11**	**3**	**13**	**10***	**9**	**5**	**7**	**12**	**15***
Alewife	*Alosa pseudoharengus*	**N**	**	X		X				X-C			X
American brook lamprey	*Lampetra appendix*	N	**	X									
American eel	*Anguilla rostrata*	N	M	X	X	X	X	X	X	X	X	X	X
American shad	*Alosa mediocris*	N	**							X			X
Banded killifish	*Fundulus diaphanus*	N	**	X	X	X	X	X	X	X	X-C	X	X
Black crappie	*Pomoxis nigromaculatus*	N	T	X	X					X		X	X
Blacknose dace	*Rhinichthys atratulus*	N	M	X	X	X	X	X	X	X	X	X	X
Bluegill	*Lepomis macrochirus*	NN	M	X	X	X	X	X	X	X	X	X	X
Blue ridge sculpin	*Cottus caeruleomentum*	N	**							X-P			
Bluespotted sunfish	*Enneacanthus gloriosus*	N	**	X									
Blueback herring	*Alosa aetivalis*	N	**	X		X							X
Bluntnose minnow	*Pimephales notatus*	N	**		X	X	X	X	X	X	X	X	X
Bridle shiner	*Notropis chalybaeus*	N	**			X				X-C		X	X
Brown bullhead	*Ameiurus nebulosus*	N	M	X	X	X	X	X		X		X	X
Brown trout	*Salmo trutta*	NN	I							X			
Chain pickerel	*Esox niger*	N	M	X									X
Channel catfish	*Ictalurus punctatus*	NN	T	X									X
Comely shiner	*Notropis amoenus*	N	**			X				X-C			X
Common carp	*Cyprinus carpio*	NN	T	X	X	X				H		X	X
Common shiner	*Luxilus cornutus*	N	M	X		X	X	X		X	X	X	X
Creek chub	*Semotilus atromaculatus*	N	M	X	X	X	X	X	X	X	X	X	
Creek chubsucker	*Erimyzon oblongus*	N	M	X									X
Cutlips minnow	*Exoglossum maxillingua*	N	**	X		X	X	X	X	X	X	X	X
Eastern mosquitofish	*Gambusia holbrooki*	N	M		X	X	X	X		X		X	X
Eastern mudminnow	*Umbra pygmaea*	N	**	X	X	X	X	X		X		X	X
Eastern silvery minnow	*Hybognathus regius*	N	**		X	X			X	H-P, X-C		X	X
Fallfish	*Semotilus corporalis*	N	M	X		X	X	X		X	X	X	X
Fantail darter	*Etheostoma flabellare*	N	I			X	X	X		H-P			
Fathead minnow	*Pimephales promelas*	NN	T					X	X				X
Gizzard shad	*Dorosoma cepedianum*	N	T	X		X			X	X-C		X	X

FISH SPECIES IN STUDY SEGMENTS OR SUBWATERSHED				Collected - Subwatershed (since 1988) /Segment (since 1997)[a]									
				Indian Creek		Northwest Branch			Sligo	Paint Branch (P-Piedmont, C- Coastal Plain)		Little Paint	Northeast Branch
Common Name	**Fish Species**	**Origin**	**Tolerance**	**1**	**11**	**3**	**13**	**10***	**9**	**5**	**7**	**12**	**15***
Golden redhorse	*Moxostoma erythrurum*	NN	M	X	X								X
Golden shiner	*Notemigonus crysoleucas*	N	M	X	X	X				X		X	X
Goldfish	*Carassius auratus*	NN	**	X				X	X			X	X
Green sunfish	*Lepomis cyanellus*	N	T	X	X	X	X	X	X	X	X	X	X
Hickory shad	*Alosa mediocris*	N	**			X							X
Inland silverside	*Menidia beryllina*	N	**			X							X
Ironcolor shiner	*Notropis chalybaeus*	N	**	X		X				X		X	X
Largemouth bass	*Micropterus salmoides*	NN	T	X	X	X	X	X		X	X	X	X
Least brook lamprey	*Lampetra aepyptera*	N	**	X	X	X	X					X	
Longear sunfish	*Lepomis megalotis*	N	M	X		X				X-C		X	X
Longnose dace	*Rhinichthys cataractae*	N	M	X	X	X	X	X	X	X	X	X	X
Margined madtom	*Noturus insignis*	N	M			X				X	X	X	
Mummichog	*Fundulus heteroclitus*	N	**	X	X	X	X	X		X-C		X	X
Northern creek chub	*Semotilus atromaculatus*	N	**			X			X	X		X	X
Northern hogsucker	*Hypentelium nigricans*	N	M		X	X	X	X	X	X		X	X
Potomac sculpin	*Cottus girardi*	N	**							X-P			
Pumpkinseed	*Lepomis gibbosus*	N	M	X	X	X	X	X	X	X	X-C	X	X
Quillback	*Carpiodes cyprinus*	N	M			X							
Rainbow trout	*Oncorhynus mykiss*	NN	I			X - stocked							
Redbreast sunfish	*Lepomis auritus*	N	M	X	X	X	X	X	X	X	X	X	X
Redear sunfish	*Lepomis microlophus*	NN	M							X-C			
River chub	*Nacomis micropogon*	N	**	H									
Rosyface shiner	*Notropis rubellus*	N	M	X		X				X-C			X
Rosyside dace	*Clinostomus funduloides*	N	**	X	X	X				X	X	X	X
Satinfin shiner	*Cyprinella analostana*	N	M	X	X	X	X	X	X	X	X	X	X
Sea Lamprey	*Petromyzon marinus*	N	**	X	X	X	X	X		X	X	X	X
Sheepshead minnow	*Cyprinodon variegatus*	N	**	X									
Shorthead redhorse	*Moxostoma macrolepidotum*	N	M	X									X

FISH SPECIES IN STUDY SEGMENTS OR SUBWATERSHED				Collected - Subwatershed (since 1988) /Segment (since 1997)[a]									
				Indian Creek		Northwest Branch			Sligo	Paint Branch (P-Piedmont, C- Coastal Plain)		Little Paint	Northeast Branch
Common Name	**Fish Species**	**Origin**	**Tolerance**	**1**	**11**	**3**	**13**	**10***	**9**	**5**	**7**	**12**	**15***
Silverjaw minnow	*Notropis buccatus*	N	M	X		X	X	X	X	X		X	X
Slimy sculpin	*Cottus cognatus*	N	I								X		
Smallmouth bass	*Miropterus dolomieu*	NN	M	X		X	X	X					
Spotfin shiner	*Cyprinella spiloptera*	N	M	X		X	X	X	X	X-C		X	X
Spottail shiner	*Notropis hudsonius*	N	M	X	X	X	X	X	X	X	X	X	X
Striped bass	*Morone saxatilis*	N	**			X							X
Swallowtail shiner	*Notropis procne*	N	**	X	X	X	X	X	X	X	X	X	X
Tessellated darter	*Etheostoma olmstedi*	N	M	X	X	X	X	X	X	X	X	X	X
White perch	*Morone americana*	N	**	X		X				X-C			X
White sucker	*Catostomus commersoni*	N	T	X	X	X	X	x	X	X	X	X	X
Yellow bullhead	*Ameiurus natalis*	N	T	X	X	X	X	X	X	X	X-C	X	X
Yellow perch	*Perca flavescens*	N	M	X	X	X							X
Total species collected in study segment 1997-2010				15	19	19	25	No data	19	25	20	24	No data
Total species collected in subwatershed 1988-2009				52		54			34	47		42	54

Tolerance indicators from: Meador and Carlisle. 2007. Quantifying tolerance indicator values for common stream fish species of the United States. Ecological Indicators, Volume 7, Issue 2.

[a]Data are shown for the specific stream segement if data exists. If no data exists for the specific stream segment, data for the subwatershed are shown. Blank cells indicate no documented fish presence.

Subwatershed data from: MWCOG. 2009. ARP Subwatershed Baseline Reports

Stream segment data from: Compilation of MBSS sampling and stream monitoring by Tetra Tech.

** - No tolerance data available.

*no monitoring data available for study segments 10 and 15

		Origin: N = Native	Tolerance: M=Moderate
	Collected in subwatershed, but not necessarily in study segment	NN= Non-native	T=Tolerant
	Collected in or immediately up/downstream of study segment	I = Invasive	I=Intolerant
	Not collected, but historical presence is documented		

Summary of habitat requirements from available HSI models for representative fish assemblage.

Species	Water depth (ft)	Preferred velocity (ft/s)	Substrate Preference	Cover	Nest habitat	Notes
Resident						
Bluegill	3.3-9.8	0.03-0.16	fine gravel or sand for spawning	20-60%	quiet, shallow water; prefer fine gravel or sand	Prefer pools, >60% pools, low gradient streams
Green sunfish	.13-1.1	<0.03 (up to .82), Fry = <.16	pebbles and gravel predominate	35-80%	on gravel or sand near rocks, logs, and vegetation	typically inhabit pool area, >50% pools; <30 m wide streams
Warmouth		< .3	soft substrate; stumps, brush, or boulders common	dense	near cover in shallow, protected areas; guarded by male	inhabit slow-moving or still waters; survive extremely low DO levels
Largemouth bass	9.8-49.2	< 0.2	soft bottoms; spawn in gravel substrate	40-60%	gravel preferred; near vegetation, roots, sand, mud, cobbles	>60% pools and backwater areas for rivers/streams
Common shiner	nests in .04-.1 mm	< 0.2	unvegetated gravel, rubble, sandy-gravel	unknown if cover is important	in streams; gravel and sand; re-uses nests built by other fish	frequent pools in small to medium-sized streams; clear, cool water
Smallmouth bass	<39.4	0.3-1	clean stone, rock, or gravel	abundant	gravel or broken rock; slow current	strong cover-seeking behavior
Black crappie	shallow	<0.3	soft mud, sand, or gravel	25-85%	depressions near or in beds of vegetation on soft mud, sand, or gravel	forage in open water over deeper areas; prefer rivers with >50% of pools, backwaters, and cut-off areas
Redear sunfish	< 19.7	0-0.03	unvegetated sand, sandy-clay, mud, limestone, shells, and gravel (nests)	25-75%	mud to gravel with no vegetation; exposed to sun; often within or along water lilies and fallen trees	prefer large, clear, low gradient streams with sluggish currents and aquatic vegetation; pools
White sucker	0.5-3	<0.07	gravel for spawning	pool and streambank cover	clean, coarse sand or gravel	relatively swift, shallow waters over a gravel bottom for spawning
Longnose dace	<0.99-3.3	>1.3	coarse- gravel and rock	100%	spawn in riffles	swift flowing, steep gradient, head-water stream; prefer riffles
Common carp		<0.07	mud or silt	35-55% vegetated, >50% in pools	aquatic or submerged terrestrial vegetation	shallow, warm, sluggish, and well-vegetated waters
Creek chub	<3.3	<0.1	gravel, but found above all substrates	abundant with streambank vegetation	gravel nests in shallow water just above and below riffles	small, clear streams; streams with alternating pools (40-60%)and riffle-run areas; rubble substrate in riffles
Diadromous						
Alewife herring	2-6 3.9-4.9 2.6^	0.5-2.5 4.3-2.5 0.8^	silt (finer then sand), gravel and cobble			deep pools, slow
Alewife-juvenile	4-10	1^	sand, gravel, detritus, SAV			
Blueback herring	1-3.9 2-3.9 1.3-3.3	1-3 2-3 0-1	silt, sand, gravel, detritus			
Blueback-juvenile	4-10	1-2	(silt, sand)			
White perch	1-4.9	0-1	sand, gravel			

^no range available

A-3: Baseline Ecological Conditions of Candidate Restoration Reaches (Tetra Tech)

Baseline Ecological Conditions of Candidate Restoration Reaches in the Anacostia River Watershed

Prepared for:

Prince George's County Government
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December 30, 2015

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The appropriate citation for this report is:

Murphy, R.F. and J.B. Stribling. 2015. ***Baseline Ecological Conditions of Selected Candidate Restoration Reaches in the Anacostia River Watershed.*** **Prepared for: Prince George's County Government, Department of the Environment, Stormwater Management Division, and the US Army Corps of Engineers, Baltimore, MD. Prepared by: Tetra Tech, Inc., Center for Ecological Sciences, 10711 Red Run Blvd., Suite 105, Owings Mills, MD 21117.**

Abstract

Prince George's County, located along Maryland's Coastal Plain physiographic province, encompasses an area of approximately 1,259 km^2 and is drained by three major river basins: the Anacostia River, the Patuxent River, and the non-Anacostia portions of the Potomac River. The Anacostia watershed covers approximately 223 km^2 in the County, with the Northeast and Northwest Branches as the primary tributaries. In a collaborative effort between the Prince George's County Department of the Environment (DoE) and the US Army Corps of Engineers (USACE)-Baltimore District, 11 reaches were selected for potential future restoration activity. Assessment sites were sampled in 2015 to provide a baseline description of existing, pre-restoration conditions. Field, laboratory, and data analysis protocols were used that were consistent with those of the Maryland Department of Natural Resources' Biological Stream Survey (MBSS). In addition to benthic macroinvertebrates and fish, field data were also collected for selected field chemistry (YSI meters), and substrate particle size distribution (modified 100-particle Wolman pebble count). Using the MBSS Benthic-Index of Biotic Integrity (B-IBI), over half of the sites assessed (6 out of 11) were rated as biologically degraded (poor or very poor B-IBI rating). Site ratings using the Fish IBI scores ranged from fair to good. Physical habitat scores followed more closely with the B-IBI scores with nine of the 11 sites rated as either suboptimal. We also calculated the MBSS physical habitat index (PHI) and relative bed stability (RBS) for additional descriptors of physical habitat and stream channel quality. We conclude this report with recommendations for using additional data and analyses to strengthen this characterization of ecological baseline conditions prior to implementing restoration projects.

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Introduction

Prince George's County lies in the mid-Atlantic coastal plain of Maryland, immediately east of the Nation's capital (Figure 1). It covers 1,259 km^2 (US Census Bureau 2014), and has more than 994 kilometers of stream channels, which are drained by the Patuxent River on the east, Anacostia River in the west and northwest, Potomac River on the southwest, and Mattawoman Creek in the south. The northwestern border of the county, shared with Montgomery and Howard counties, lies roughly at the Fall Line between the Piedmont and Coastal Plain physiographic regions, although that region is better characterized as a transitional zone. Across the eastern border that is the Patuxent River, are Anne Arundel and Calvert counties; the neighbor to the south is Charles County, with Mattawoman Creek in between for part of the distance before feeding into the Potomac River. The Anacostia River watershed encompasses 223 km^2 within the county. The county ranks second in Maryland, with a total population of 904,430, on average 724 people/km^2 (US Census Bureau 2014).

For this project, we instituted field sampling, and laboratory and data analysis to characterize current ecological conditions in several locations of the Anacostia River Watershed, including on the mainstems of Northeast and Northwest branches. The primary objective of this work is to provide a comparison baseline prior to implementation of best management practices (BMPs) and/or stream channel restoration projects. The biological assessment protocols used provide credible data, and valid, defensible results to address questions related to the status and trends of stream and watershed ecological condition; problem identification; documentation of the relationship among stressors, stressor sources, and response indicators; and evaluation of environmental management activities, including restoration. The primary difference between this effort and the County's long-term biological monitoring program (see Millard et al. 2013, PG DoE 2015) is that the stream sites evaluated under this task order were not randomly selected; rather, they were targeted and specifically chosen to represent pre-restoration, baseline conditions, and to ultimately be exposed to the effects of rehabilitation projects designed to reduce ecosystem stressors. If these projects are built and succeed in stressor reduction, it is anticipated that there will be detectable positive changes in benthic and fish IBI scores and assessments, and well as in many of the physical habitat features (i.e., those characterized by the visual-based physical habitat assessment from the the rapid bioassessment protocols (RBP) [Barbour et al. 1999], the MBSS physical habitat index [PHI; Paul et al. 2003], and relative bed stability [RBS; Jessup and Kaufman 2008, Kaufmann et al. 2008]).

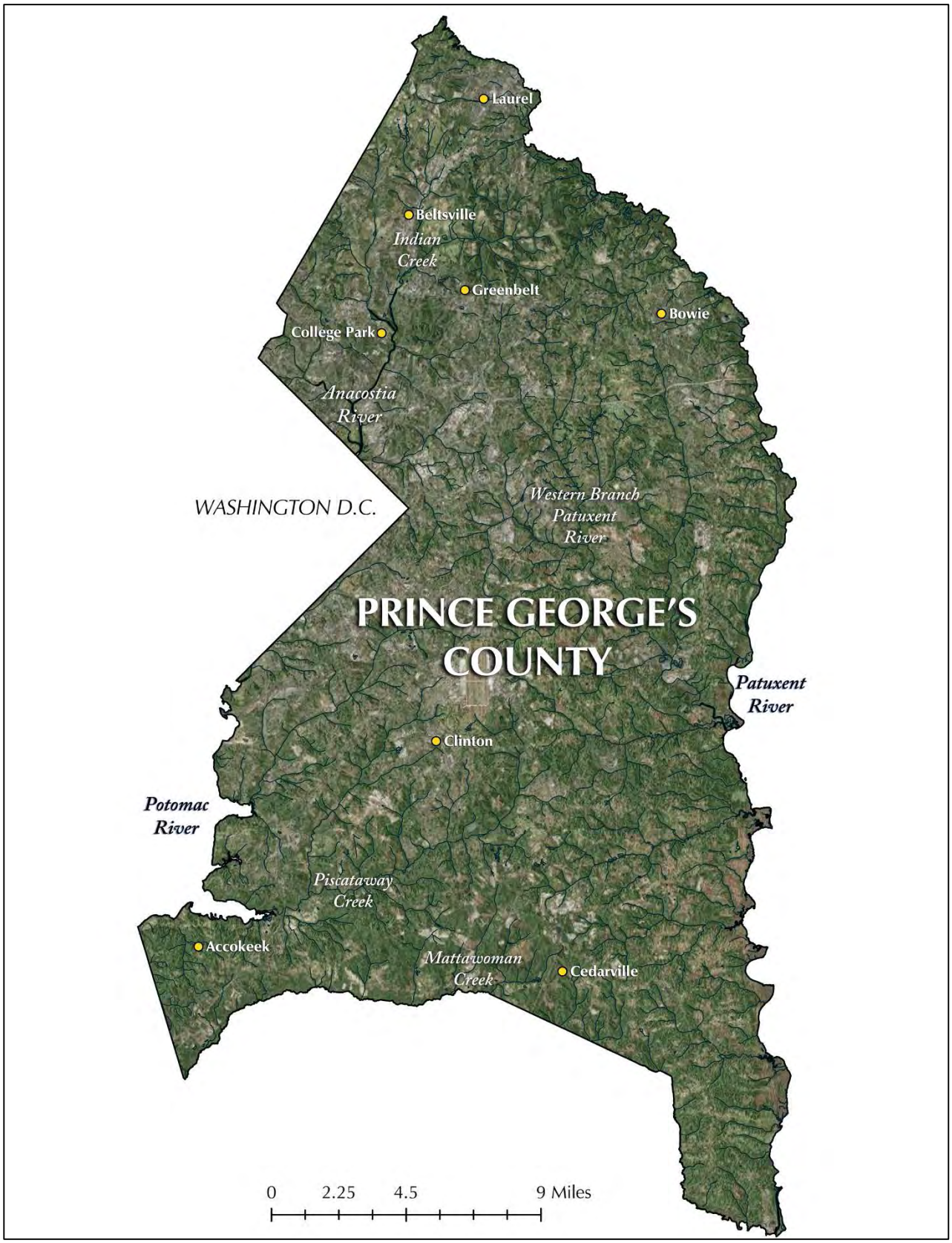

Figure 1. Prince George's County, Maryland.

Site Selection

Sampling reaches were selected to target channel areas that would be exposed to the effects of future restoration or BMP activities in the study area (Figure 2). Eleven (11) sites were chosen in coordination with the USACE, which has a need for establishing baseline data for stream reaches targeted for restoration or to be exposed to the effects of restoration (Table 1). In general, stream reaches selected are various distances downstream from where restoration or BMP activities will likely be implemented. Final locations were approved by the USACE site selection team.

Table 1. Site locations, including identification number, stream name, Strahler order, and latitude/longitude coordinates.

Site ID	Stream Name	Strahler Order	Latitude	Longitude
01	Indian Creek	1	39.05001	-76.90424
03	Northwest Branch	3	38.96176	-76.97173
05	Paint Branch	3	38.98008	-76.91894
07	Paint Branch	2	39.02367	-76.94775
09	Sligo Creek	3	38.95959	-76.97582
10	Chillum Rd Tributary	1	38.95619	-76.97678
11A	Indian Creek	3	38.98356	-76.91869
11B	Indian Creek	3	39.00517	-76.91356
12	Little Paint Branch	2	39.01217	-76.93597
13	Lower Northwest Branch	3	38.97889	-76.96356
15	Northeast Branch	4	38.97275	-76.91803

Methods

Field Sampling

During the index period (March-April) field collections of benthic macroinvertebrate, physical habitat, water quality, and substrate data were made using protocols consistent with those of the MBSS, and outlined in PG DoE (2015).

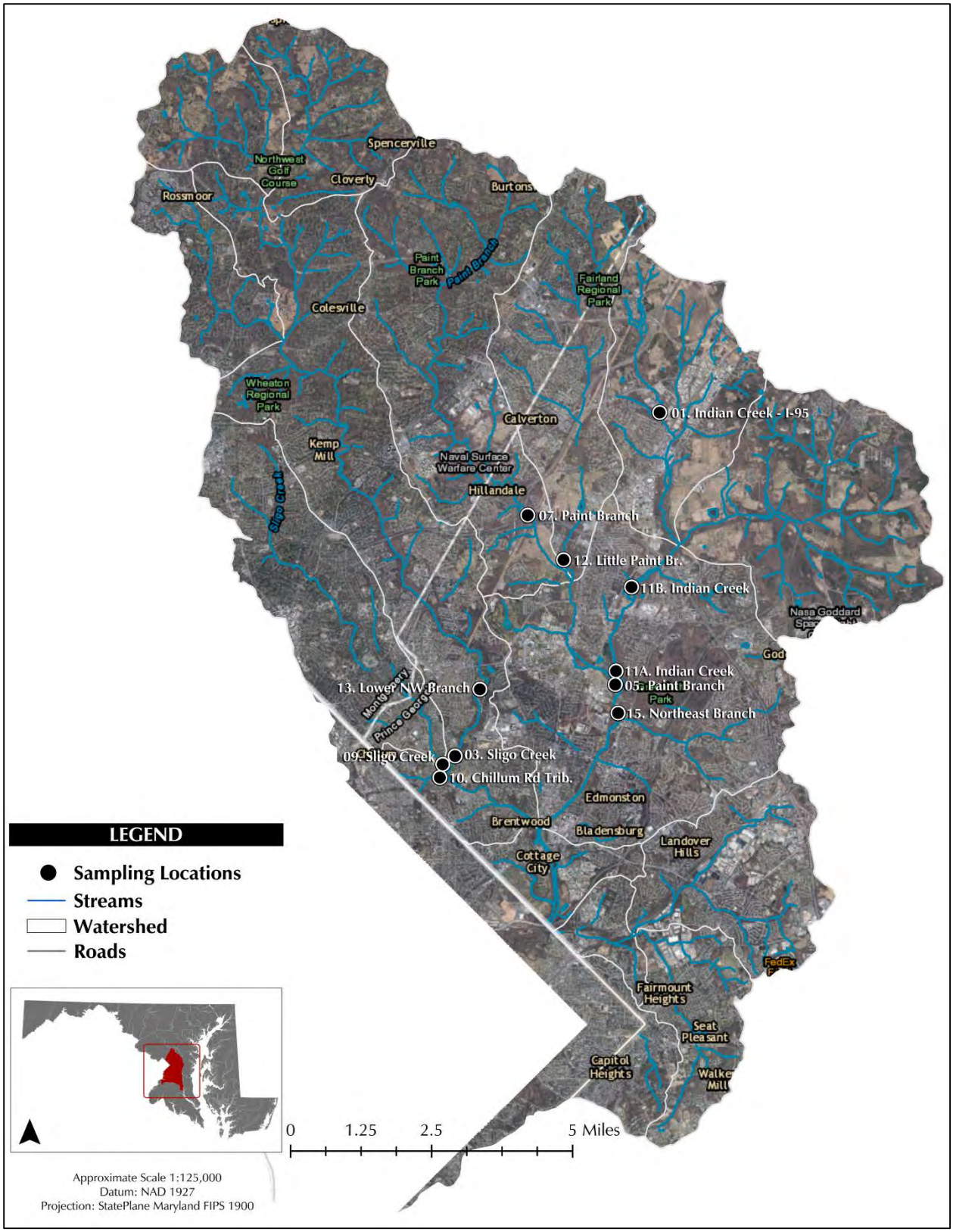

Figure 2. Location of sites within the Anacostia Watershed.

In addition to the spring benthic sampling, sampling of the fish assemblage followed MBSS protocols, with slight modifications, for the summer index period (June-September).

Benthic Macroinvertebrates

Benthic macroinvertebrates were collected from 100m reaches by making 20 one-meter linear sweeps (jabs) with a D-frame net (500-micron mesh) through different habitat types (snag, vegetated bank, bottom, riffle/cobble, sand, leaf packs, root wads), sampled in proportion to their frequency at each site. All sample material was composited in a 500-micron sieve bucket (Figure 3), placed in one or more 1-liter sample containers and preserved with 95% ethanol. Internal and external sample labels were completed for each container.

Figure 3. Processing benthic macroinvertebrate field samples. Sample material (leaf litter, small woody debris, algae, silt) is emptied from the D-frame net to a sieve-bottom bucket for washing of fine silt.

Physical Habitat Quality

Ten parameters describing physical habitat (i.e., instream and planform morphology, riparian zone condition, and stream bank condition) were visually assessed for each of the 75m sample reaches using the Rapid Bioassessment Protocols (RBP)

physical habitat assessment procedure (Barbour et al. 1999, PG DoE 2015). Each parameter is scored on a 20-point scale, along a continuum of conditions categorized from optimal, suboptimal, marginal, or poor (with 20 being the best). Rating scores were summed for all PHAB parameters for a total and ranked based on criteria (Table 2). Detailed RBP, visual-based physical habitat assessment (PHAB) results are presented in Appendix E.

Table 2. Criteria for translating total numeric physical habitat scores (PHAB) to narrative ratings, as condition categories and percentage of reference conditions.

Condition Category Method	
Numeric Score	**Narrative Rating**
151-200	Optimal
101-150	Suboptimal
51-100	Fair
0-50	Poor

Water Quality

Dissolved oxygen (DO), conductivity, temperature, and pH were measured at each site using a YSI Quattro field meter that was calibrated each day (PG DoE 2015). Water quality data were collected during both index periods. Field chemistry results are presented for all sites and measurements in Appendix B.

Substrate Particle Size Distribution

Substrate was sampled using the modified Wolman 100 particle pebble count (PG DoE 2015) at a series of ten transects evenly spaced at 10 meter intervals over the length of the sampling reach. Transects extended from bankfull on each bank and particles were sampled at equal intervals across each transect. When water depth prevented actual pebble grabs, size distribution was estimated based on knowledge of the stream bed in other locations, other nearby streams, and visual estimation. Full pebble count results are presented in Appendix C.

Fish

Fish were sampled within the same 100 meter reach that was sampled for benthic macroinvertebrates. Block nets were set at the downstream (0m) and upstream (100m) ends of the reach and a single-pass electroshocking effort was conducted (Figures 4, 5). Depending on the wetted width of the stream, either two backpack units were employed, or we added an additional pram-based electrofisher. Generally, we allotted one shocking unit per 4m wetted width. Fish were counted and identified to species in the field. Where positive field identification was uncertain, individuals were preserved in formalin in the field and returned to the lab for positive identification. Total biomass of fish catch was measured and recorded at each site. Detailed fish sample data are presented in Appendix G.

Figure 4. Electrofishing on Sligo Creek.

Figure 5. Setting block nets in prearation for electrofishing.

Laboratory processing (benthic macroinvertebrates)

Sorting and Subsampling

The sorting and subsampling process is based on randomly selecting portions of the sample detritus spread over a 30-grid Caton screen, with each grid square of 6cm x 6cm (Caton 1991, Barbour et al. 1999, Flotemersch et al. 2006). Prior to beginning the sorting and subsampling process, the sample is mixed thoroughly and distributed evenly across the sorting tray to reduce the effect of organism clumping that may have occurred in the sample container. The grids are randomly selected, individually removed from the screen, placed in a sorting tray, and all organisms removed with forceps; the process is repeated until the rough count by the sorter exceeds the 100 organism target.

Taxonomic Identification

Benthic macroinvertebrates were identified primarily to genus level, unless otherwise indicated, including worms and midges (Oligochaeta and Chironomidae). Appropriate magnification, procedures, and technical literature necessary for attaining target levels are used, along with the most up to date and accepted nomenclature. Full detailed sample results are presented in Appendix A.

Metric Calculation, Data Analysis, and Site Assessments

Data Management

Benthos, habitat, and water quality data were entered into a customized version of the Ecological Data Application System (EDAS) (Tetra Tech 1999). This relational database system allows for the management of locational and other metadata, taxonomic and count data, raw physical habitat scores, calculation and scoring of metric values, physical habitat and water quality rankings, and index values, and assigning index values to narrative assessment categories. As necessary, data and assessment results are spatially displayed using Geographic Information System (GIS).

Physical Habitat Index (PHI)

In addition to the PHAB assessments, we also calculated the Physical Habitat Index (PHI) (Paul et al. 2003) for each of the sites. Variables included in the PHI include remoteness, shading, epifaunal substrate, instream habitat, instream wood, and bank stability. Categorical narrative assessments, such as good, fair, or poor, are not available for PHI; in general, higher values are indicative of dynamic physical stability. Detailed results of the PHI are given in Appendix F.

Relative Bed Stability (RBS)

We used the pebble count data to calculate the percent of sediment particles in each of several sediment size classes: fine (<0.0625 mm), sand (0.0625 - 2 mm), fine gravel (2-16 mm), coarse gravel (16-64 mm), cobble (64-256 mm), boulder (256-4096 mm), and bedrock (>4096 mm). We calculated reach slope by dividing the differences in height between the upstream and downstream points by the distance between them. Lastly, we

calculated the relative bed stability described earlier. Relative bed stability (RBS) is the ratio of the median stream particle size (D50), calculated from the frequency distribution of sediment data, to the critical particle size moved during bankfull flow (Kaufmann et al. 1999). Critical particle size is calculated using values for shear stress, and channel cross section, slope, and roughness. The expected value is 1, with values <0.2 and >1 indicating unstable conditions (i.e., those for which at least half of the particles are moving during bankfull events). Detailed RBS results are shown in Appendix F.

Table 3. Relative Bed Stability (RBS) narrative interpretations and scoring criteria (log10 transformed) for streams of the Mid-Atlantic Highlands.

Mid Atlantic Highlands [LRBS = log10(RBS)]
Good Condition, >0.2 to 1.0
Impaired, >-1.0 to 0.2 AND >1.0 to 2.0
Highly Impaired, <-1 and >2.0

Index Calculation and Scoring

Benthic Macroinvertebrates

Metrics (Table 4) were calculated directly from sample data, and associated autecological characteristics[1] (Appendix A); resulting metric values were compared to reference criteria and scored on a scale from 5 to 1 (5=nearest to reference, 3 = neutral, 1=greatest deviation from reference) (Table 5). Detailed metric and index results are presented in Appendix D.

Table 4. Benthic macroinvertebrate metrics and descriptions (Southerland et al. 2007).

Metric Name	Description
Number of taxa	Measure of the overall variety of the benthic macroinvertebrate assemblage in the subsample.
Number of EPT taxa	Total number of distinct taxa of mayflies, stoneflies, and caddisflies (Ephemeroptera, Plecoptera, and Trichoptera, respectively).
Number of Ephemeroptera taxa	Number of distinct taxa of mayflies (Ephemeroptera) in the subsample
Percent individuals as intolerant of urban stressors	Percent of individuals in the subsample with urban stressor tolerance value of 0–3

[1] Refers to functional feeding group, locomotory habit, and stressor tolerance values

Metric Name	Description
Percent individuals as Ephemeroptera	Percent of individuals in the subsample that are mayflies
Number of scraper taxa	Number of distinct taxa in the subsample that are of the functional feeding group scrapers
Percent individuals as climbers	Percent of individuals in the subsamples that of the habitat climbers

Table 5. Metric scoring criteria for the benthic IBI (Southerland et al. 2007).

Metric	1	3	5
Number of taxa	<14	14–21	≥22
Number of EPT taxa	<2	2-4	≥5
Number of Ephemeroptera taxa	<1	1	≥2
Percent intolerant to urban	<10	10–27	≥28
Percent Ephemeroptera	<0.8	0.8-10	≥11
Number of scraper taxa	<1	1	≥2
Percent climbers	<0.9	0.9–7.9	≥8

Overall biological index scores were calculated by summing individual metric scores for each site, and dividing the total by the number of metrics (7 benthic, 6 fish). The resulting mean value was then compared to the scoring criteria (Table 6) for translation to the corresponding narrative assessment. Samples fully picked (30 grid squares) and producing <80 organisms were automatically assigned a rating of very poor. Exceptions to this would be if there was information indicating that the stream was naturally underproductive.

Table 6. Benthic and fish IBI score ranges and corresponding narrative ratings.

Scoring Criteria	Narrative Ratings
4.0 – 5.0	Good
3.0 – 3.9	Fair
2.0 – 2.9	Poor
1.0 – 1.9	Very Poor

Fish

Fish metrics were similarly calculated in accordance with Southerland et al. (2007) for all sites, and resulting metric values were compared to reference criteria and scored on a scale from 5 to 1 (5=nearest to reference, 3=neutral, 1=greatest deviation from

reference) (Table 7). The mean value for the F-IBI was then compared to scoring criteria (Table 6) for attaining the condition narrative.

Table 7. Fish IBI metrics and thresholds for Maryland coastal plain streams (Southerland et al. 2007).

Metric	1	3	5
Abundance per square meter	<0.45	0.46-0.71	≥0.72
Number of benthic species adjusted	0	0.1-0.21	≥0.22
Percent tolerants	>97	68-96	≤68
Percent generalists, omnivores, invertivores	100	93-99	≤92
Percent non-tolerant suckers (all suckers except white suckers)	0	1	≥2
Percent abundance of dominant species	>69	41-68	≤40

Results and Discussion

The objective of this project is to characterize existing—or baseline—ecological conditions at 11 stream reaches within the Anacostia watershed that are being considered for restoration/rehabilitation projects. B-IBI ratings were generally poor to fair, with 10.Chillum Road Trib scoring 'Very Poor' and 05. Paint Branch scoring 'Good'; F-IBI scores tended to be higher with narrative ratings from 'Fair' to 'Good' (Table 8). Spatial distribution of the biological condition ratings is shown in Figures 6 and 7). With the different interpretations provided by the two indices, we paid closer examination of the physical habitat as that is likely to provide insight to the differences.

Table 8. Benthic and Fish IBI scores, narrative, and physical habitat (PHAB) scores with mean scores (SD) calculated for the basin.

Site ID	Benthic IBI			Fish IBI			PHAB		
	Score	Narr.	Mean (SD)	Score	Narr.	Mean (SD)	Score	Narr.	Mean (SD)
01.Indian Creek-I95	3.3	F	3.0 (0.72)	3.0	F	3.7 (0.42)	164	O	129.9 (19.14)
03.Northwest Branch	2.7	P		3.7	F		117	S	
05.Paint Branch	2.7	P		3.7	F		123	S	
07.Paint Branch	2.7	P		3.7	F		145	S	
09.Sligo Creek	2.7	P		4.3	G		148	S	
10.Chillum Rd Tributary	1.6	VP		3.3	F		120	S	
11A.Indian Creek	4.1	G		4.0	G		128	S	
11B.Indian Creek	3.9	F		4.0	G		128	S	

12.Little Paint Br.	3.3	F		4.3	G		113	S	
13.Lower NW Branch	3.6	F		3.8	F		146	S	
15.Northeast Branch	2.4	P		3.3	F		97	F	

While ecological integrity is often considered the endpoint for stressor-reduction efforts (e.g., stream channel restoration), watershed management typically addresses mechanisms to enhance the physical habitat available to a diversity of organisms, particularly those that affect water quality.

Assessment of Site Conditions

Site 1. Indian Creek – I-95

This potential restoration reach comprises approximately 7,000 feet (roughly 2,100 meters) between I-95 and Beltsville (Figure 2), and the specific sample site is near an industrial park and cemetery. Access to the site is via the cemetery behind the Beltsville Motor Vehicle Administration on the west side of Rt. 1. The site has an upstream drainage area of approximately 1,250 acres (5.1 km^2). Of the reaches sampled for this project, this site had the best physical habitat, rating as optimal (Table 8) with an RBP physical habitat score of 164. There was some bank instability and sediment deposition, but little evidence of human-induced channel alteration or disturbance of riparian vegetation (Figure 8). There also seemed to be sufficient instream physical complexity.

The physical habitat index (PHI) scored 88.3, resulting from high scores for remoteness, site shading, diverse and complex instream habitat, including woody debris. Substrate particle sizes were primarily made up of medium gravel, with 87% larger than 8mm, and the remainder in the size range of sand and silt/clay; these were associated with a relative bed stability (LRBS) score of -0.938, indicating sediment impairment, and an increased risk of bottom erosion. *In situ* water quality measurements for the Spring sampling were conductivity, 880µS/cm, DO, 8.6mg/l, pH 7.0, and water and air temperature, 14.0 and 9.4°C, respectively; for Fall, measurements recorded were 600 µS/cm, 12.2 mg/l, pH 8.0, and air and water temperature, 22.2 and 22.4, respectively. The B-IBI rated the reach as being in "fair" biological condition (Figure 6), with a score of 3.29. The sample had 103 specimens representing 42 total taxa. Approximately 75% were of the sample was worms (Annelida: Oligochaeta) and midges (Insecta: Chironomidae). The most abundant worms were *Nais* (Naididae; n=20) and *Bothrioneurum* (Tubificidae; n=12).

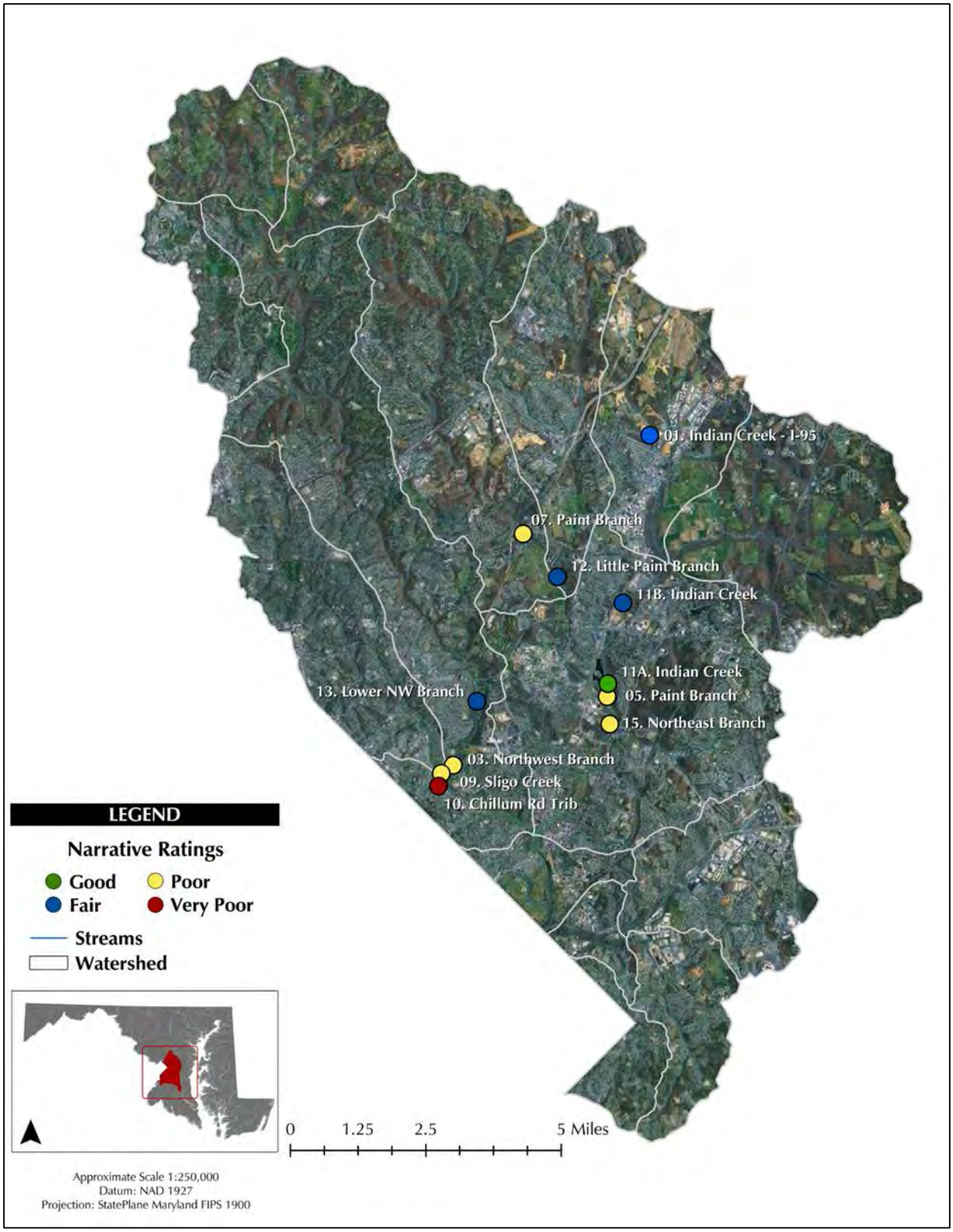

Figure 6. Distribution of B-IBI site condition ratings.

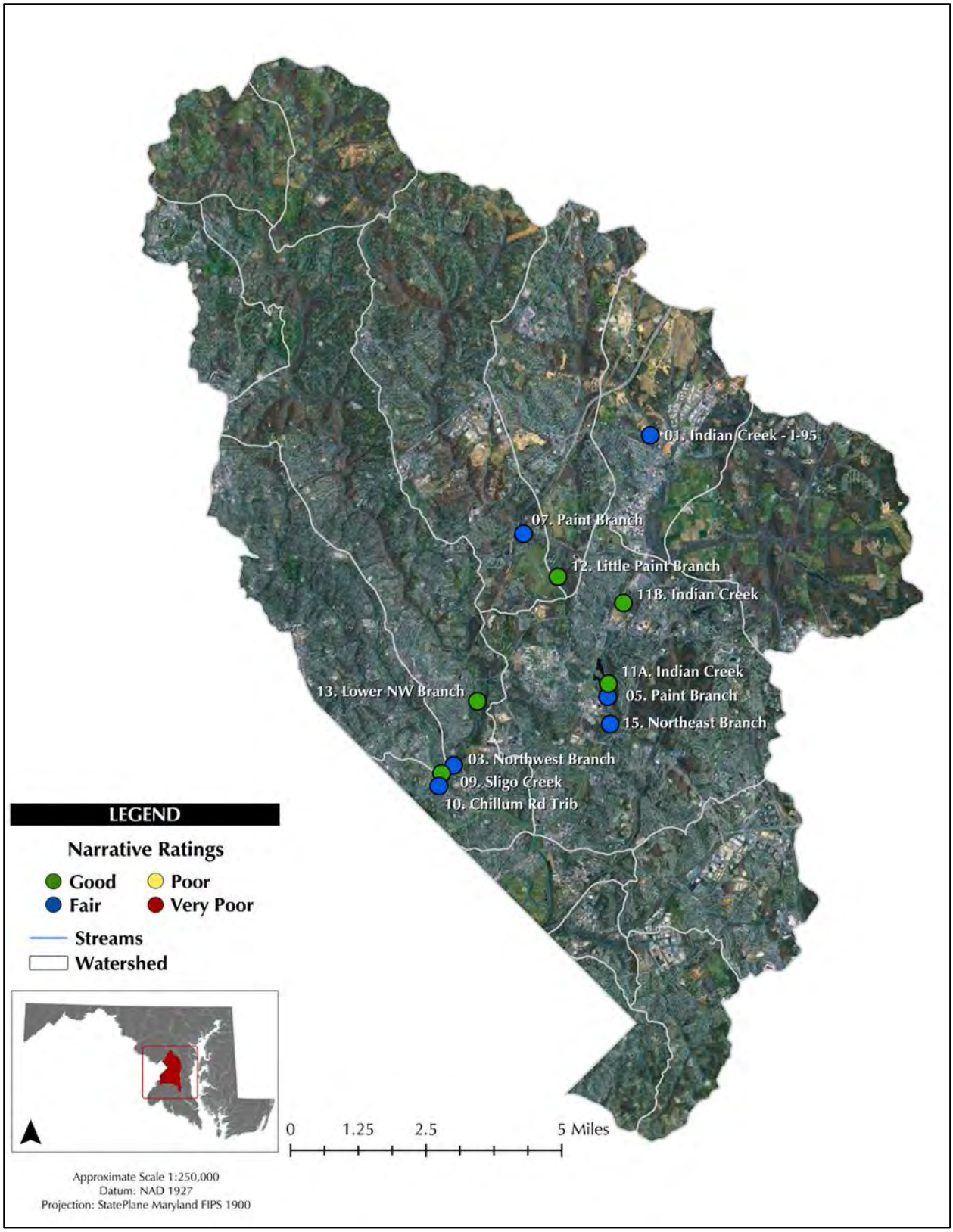

Figure 7. Distribution of F-IBI site condition ratings.

Figure 8. Downstream view of Site 1. Indian Creek-I95.

Midges were mostly in low numbers with 1-3 specimens per genus, with *Orthocladius/Cricotopus* and *Diplocladius* represented by 5 and 6 specimens, respectively. Other taxa represented by only 1-2 specimens included riffle beetles (Elmidae: *Dubiraphia, Macronychus*), biting midges (Ceratopogonidae: *Bezzia/Palpomyia, Dasyhelea, Serromyia, and Culicoides*), caddisflies (Trichoptera: *Hydropsyche, Ironoquia, Polycentropus*), clams (Bivalvia: *Corbicula, Pisidium*), and a freshwater Nemertea (*Prostoma*). The fish IBI rated the site as "fair" (Figure 7) with a score of 3.0. The sample consisted of 141 individuals, and was dominated by Creek chub (n=47; *Semotilus atromaculatus*), Blacknose dace (n=27; *Rhinichthys atratulus*), and American eel (n=27; *Anguilla rostrata*), all considered tolerant species.

Site 3. Northwest Branch

This reach is next to Nicholson Street in Hyattsville (Figure 2), approximately 185 meters downstream of the Ager Road Bridge. The potential restoration area is approximately 7,600 feet long (~2,300 meters). The USACE site selection team noted a

partial fish blockage, which had been previously identified by the Metropolitan Washington Council of Governments (MWCOG). There is a large restoration project directly upstream in design by Prince George's County, as well as multiple small projects already completed in the reach. This site receives drainage from 22,680 acres (~92km^2) and is influenced by tributary inflow from Sligo Creek. The RBP habitat assessment resulted in a narrative of 'suboptimal' (score, 117); this part of Northwest Branch has undergone extensive channelization, including straightening and channel armoring. Some bank instability exists, as well as a lack of riparian vegetation (Figure 9).

The PHI score was determined to be 50.4 for the reach, heavily influenced by low scores for remoteness and complexity of habitat. Pebble count showed channel bottom materials to be slightly dominated by fines, 57% composition of sand and silt/clay, with 29% boulder present, suggesting substantial extreme erosional and depositional forces in play for the reach. The reach is 'highly impaired' for RBS with a log10 score of -2.9, indicating severely unstable bottom substrate. *In situ* water chemistry during the spring sampling (April 27) was 435µS/cm for conductivity, 10.8 mg/l for DO, pH of 8.0 standard units (S.U.), and water and air temperature of 1.31°C and 18.3°C, respectively. For the fall sampling (September 02), those parameters were 440 µS/cm, 6.92 mg/l, 6.37 S.U., 24.3°C, and 26.7°C. The B-IBI rated the sampling reach as 'poor' (score, 2.71) (Figure 6); processing resulted in 101 specimens representing 21 macroinvertebrate taxa, no stressor sensitive taxa, and consisting of around 45% midges, and 51% worms. Coarsely, both of these groups are stressor tolerant, and are often overwhelmingly represented in samples from degraded sites. For this site, tolerance values (TV[2]) for the midges ranged from 4.1-8.6, with an average of 6.5; identical values for the worms showed a range of 6-10, averaging 8. In this sample, there are seven different genera of worms of three families, and are dominated by *Nais* (82%). Of 12 genera of midges (Chironomidae), in this sample the most abundant is *Orthocladius*/*Cricotopus* with 15 specimens, followed by *Polypedilum* with 13, and *Tanytarsus* with 5.

All remaining midge genera are represented by 1-2 specimens. The sample also contained one riffle beetle (Elmidae: *Ancyronyx*), which is relatively stressor tolerant (urban TV=7.6), and one mayfly (Baetidae: *Acentrella*). The fish IBI narrative rating of 'Fair' (score, 3.67) (Figure 7) was based on 450 individuals caught, and high values for the metrics benthic taxa, percent tolerants, and dominant one percent. The most abundant

[2] Tolerance values range from 0-10, with 0 being most stressor sensitive (=least tolerant), and 10 least stressor sensitive (=most tolerant)

Figure 9. View of the left bank and riparian zone of 3.Northwest Branch. Note minimal riparian zone and relatively unstable bank.

species in the sample were the Redbreast sunfish (*Lepomis auritus*, n=108), White sucker (*Catastomus sommersoni,* n=57), Tessellated darter (*Etheostoma olmstedi*, n=52), Swallowtail shiner (*Notropus procne*, n=45), and the American eel. All other species numbered 23 or less.

Site 5. Paint Branch

This restoration reach is near the College Park Airport, and is immediately downstream of the Paint Branch CAP Section 206 project (Figure 2). It has long been identified as a priority project by the Maryland-National Capital Park and Planning Commission (M-NCPPC), MWCOG, and Prince George's County. This project is intended to connect restoration and BMP activities from its confluence with Little Paint

Branch to Indian Creek. This reach receives drainage from 5,878 acres (approximately 23.8 km^2). The RBP physical habitat assessment score is 123, equating to a narrative of 'fair'. The assessment demonstrated high scores for channel flow status, instream habitat, width of vegetated riparian zone, and sediment deposition; and, low scores for bank stability, channel sinuosity, channel alteration, and the quality of pool size variability and substrate (Figure 10); these habitat conditions led to a PHI score of 54.5. Substrate particle sizes are dominated by gravel (68%) with another 20% as sand and silt/clay. RBS was calculated (log10) as -1.62, indicating 'highly impaired' conditions, and a high risk for substantial sediment mobilization/accelerated erosion. Water chemistry measurements *in situ* during April and September were, respectively, for conductivity (μS/cm), 327 and 550; for DO (mg/l), 10.0 and 10.6; for pH (S.U.), 7.7 and 8.42; water temperature (°C), 15.5 and 29.6; and air temperature (°C), 15.5 and 29.4. The B-IBI narrative rating the site received was "poor" (Figure 6) with a score of 2.71. The final sample was 101 organisms, and the most influential metrics for keeping the index as high as it is are total taxa (value=24) and percent climbers (value=28.7). Of the seven remaining metrics, five of them got scores of 1 or 0. Numerically dominant taxa in the sample are midges (*Polypedilum*, 26 specimens; and *Orthocladius*/*Cricotopus*, 14 specimens), worms (*Nais*, 15 specimens), and a genus of empidid fly (*Hemerodromia*, 15 specimens). Other than the midge *Saetheria* (5 specimens), all other taxa are represented by only 1-2 specimens. The fish IBI score was 3.67, with a narrative rating of 'fair' (Figure 7), and seemed to be largely driven by the metrics number of benthic taxa, percent tolerants, and percent dominant. There were a total of 383 fishes collected; most dominant in the sample were the Tessellated darter (n=88), Longnose dace (n=46), Swallowtail shiner (n=43), Blacknose dace (n=37), Spottail shiner (n=35), American eel (n=33), Eastern silvery minnow (n=22), and the Banded killifish and Bluegill, each with 20. All other species were represented by 10 or fewer specimens.

Site 7. Paint Branch

This section of Paint Branch is entirely under highway bridges associated with Interstate 95, and is approximately 5,900 feet long (~1,800 meters). The USACE site selection team included this site as a potential opportunity to decrease erosion and bank instability where bedrock-control is lacking, and notes that there are access issues that will make the work difficult. The reach sampled is in a wooded area near the exit ramp off of I – 95/495 interchange, and surrounded on all sides by multiple, elevated highways (Figures 2, 11). This reach receives drainage from 10,457 acres (~42.3 km^2). The RBP

Figure 10. Downstream view of 5. Paint Branch. Note lack of sinuosity and low diversity of instream habitat. vegetative protection.

physical habitat assessment score is 145 with a narrative of 'suboptimal', and exhibits some problems with bank stability, channel alteration/lacking sinuosity, and limited bank vegetative protection. The PHI score is 73.3, and resulted from lower scores for remoteness, and for instream habitat and low woody debris. Bed materials are coarse,with 80% of the particle sizes ranging from gravel to bedrock, but receives a bed stability rating of highly impaired (log10RBS= -1.03), likely reflecting risk of effects from episodes of severe scour during stormflows. Water chemistry measurements in situ during April and September were, respectively, for conductivity (µS/cm), 359 and 407; for DO (mg/l), 9.4 and 9.35; for pH (S.U.), 7.8, for both dates; water temperature (°C), 17.0 and 25.1; and air temperature (°C), 15.5 and 32.2. The B-IBI resulted in a rating of 'poor' (score, 2.71) (Figure 6), with total taxa, EPT taxa, and percent climbers pushing the score higher. There are 104 organisms in the sample, 69 of which are distributed among 11

genera of midges (Chironomidae). The two dominant midges are *Polypedilum* (n=36), *Saetheria* (n=14), and *Orthocladius/Cricotopus* (n=7). All other taxa are in low numbers of 1-2, with the exception of, *Nais* (n=4), *Hemerodromia* (n=6), *Antocha* (n=5), and *Hydropsyche* (n=4). The site was rated 'fair' by the F-IBI (score, 3.67) (Figure 7), with the metrics benthic taxa, percent tolerant, and percent dominants seemingly most influential. There were a total of 17 species captured in 375 individuals; the sample was largely dominated by seven species: Blacknose dace (n=141), Longnose dace (n=87), American eel (n=27), Yellow bullhead (n=26), Creek chub (n=24), Redbreast sunfish (n=17), and Satinfin shiner (n=14).

Site 9. Sligo Creek

This potential restoration reach on Sligo Creek is 2,329 feet long (approx. 710 meters), and parallels Sligo Creek Parkway east-southeast of Chillum, and north of Queen's Chapel Road (Rt. 208) (Figure 2). The USACE site selection team identified a fish passage issue that presents an opportunity for in-stream restoration. The reach sampled for biological assessment (Figure 12) is just off the trail near a project site of the Washington Suburban Sanitary Commission (WSSC). Access was from Nicholson Street adjacent to the parkland. Physical habitat quality assessment resulted in a narrative of 'suboptimal' (score, 148), and like much of this stream, exhibits some problems with low channel sinuosity and channelization, reduced flow status, and lack of complexity of instream habitat (Figure 12); it received a PHI score of 80.6 calculated from low scores for remoteness, shading, epifaunal substrate, and instream habitat. Stream bottom materials are primarily sand and gravel with some cobble and boulders, and receives an RBS rating of 'highly impaired' (log10RBS, -1.05). Water chemistry measurements in situ during April and September were, respectively, for conductivity (µS/cm), 1,290 and 780; for DO (mg/l), 10.8 and 11.2; for pH (S.U.), 7.3 and 7.9; water temperature (°C), 12.3 and 24.3; and air temperature (°C), 10.0 and 29.4. The benthic macroinvertebrate sample consisted of 107 specimens, and resulted in a B-IBI narrative rating of 'poor' (score, 2.71) (Figure 6) . There were 23 total taxa, 2 scraper taxa, and 24.3 percent climbers; these metrics had the greatest influence on the index being as high as it was. The sample was dominated by worms (Oligochaeta) and midges (Chironomidae), the four most abundant taxa being *Polypedilum* (n=22), *Nais* (n=19), *Orthocladius/Cricotopus* (n=17) and *Saetheria* (n=14). Other than the midges and worms, in very small numbers there were also damselflies (Odonata: Coenagrionidae: *Argia, Enallagma*), and nemerteans (Enopla: Tetrastemmatidae: *Prostoma*). The fish IBI rated the sampling reach as 'good' (score, 4.3) (Figure 7) , with the index largely driven by abundance (individuals/m^2), number of benthic taxa, percent

tolerants, and percent dominance, with somewhat lower values for percent intolerant suckers, percent generalists, omnivores, invertivores, and percent dominance. There were 747 individuals caught that were distributed among 18 species, with those most dominant as White sucker (*Catostomus commersoni*, n=148), Spottail shiner (*Notropis hudsonius*, n=143), Bluntnose minnow (*Pimephales notatus*, n=134), and Redbreast sunfish (*Lepomis auritus*, n=81). Fourteen other species numbered <50 specimens.

Figure 11. Looking upstream at site 7.Paint Branch. Note overpass from I-95/495 interchange.

Site 10. Chillum Road Tributary

The Chillum Road tributary, feeds into the mainstem of Northwest Branch approximately 225 meters downstream of the Sligo Creek confluence from the west side (Figure 2). This tributary was originally identified by MWCOG as one where a restoration/stabilization project would integrate well with comprehensive restoration

Figure 12. Looking upstream at 9. Sligo Creek, and showing instream habitat of low physical complexity.

activity with the Northwest Branch mainstem. In confirming this, the USACE site selection team noted evident channel incision and erosion. The RBP physical habitat assessment resulted in a score of 120, which translates to 'suboptimal' (Table 8). There is substantial degradation shown through stream bank instability, lack of sinuosity, instream structure (including lack of pool variability), and riparian vegetation (Figure 13). The PHI score of 67.3 resulted from very low scores on remoteness, shading, instream habitat, woody debris, and bank stability. Substrate particle sizes are dominated by sand and gravel (87%), with little cobble. The reach is rated for RBS as 'highly impaired' with a score of -1.99 (log10RBS), indicating substantial risk of accelerated sediment movement. Water chemistry measurements in situ during April and September were, respectively, for conductivity (µS/cm), 1,440 and 690; for DO (mg/l), 7.7 and 10.1; for pH (S.U.), 6.9 and 6.5; water temperature (°C), 16.3 and 22.1; and air temperature (°C), 14.4 and 27.8. The stream is rated as 'very poor' by the B-IBI (Figure 6) , with the sample of 105 specimens resulting in a score of 1.57. There were 16 taxa, primarily consisting of worms and midges.

The seven genera of midges were represented by 66 specimens, of which 50 were *Orthocladius/Cricotopus*, and another seven were *Polypedilum*. The 33 worms were distributed among *Nais*, *Paranais*, enchytraeids, and unidentified Tubificinae. The site was rated as 'fair' by the F-IBI (score, 3.33) (Figure 7) , with the metrics receiving the highest scores including number of benthic taxa, percent tolerants, and percent dominants. Fish sampling produced 529 individuals dominated by six species: Swallowtail shiner (n=167), Satinfin shiner (n=74), Blacknose dace (n=72), Banded killifish (n=64), Bluntnose minnow (n=59), and White sucker (n=41). This is the only site where Fallfish (*Semotilus corporalis*) (n=11 specimens) was encountered.

Site 11A. Indian Creek

This site is situated adjacent to Lake Artemesia just downstream from the pedestrian bridge over Indian Creek (Figure 2). The site was accessed via the walking trail at the intersection of Vassar Drive and Sweetbriar Drive in College Park. This stream has been channelized for at least 70 years (evidence of channelization is apparent in 1945 USGS 7.5 minute topo maps). Additionally, WSSC is currently doing infrastructure repair work just upstream from the sample reach and have partially removed a fish blockage. This sampling reach receives drainage from an area of approximately 18,500 acres (~75 km^2). Physical habitat quality was rated as 'suboptimal', with an RBP habitat assessment score of 128 (Table 8). It is experiencing channel instability, lack of bank vegetative protection, channel alteration, low sinuosity, and lack of complexity in pool structure (Figure 14). Substrate particle size composition is primarily gravel (56%) and sand (23%), with some silt/clay, cobble, and boulder. Stream channel and substrate characteristics were measured as 'impaired' by RBS (score, log10RBS -0.77). The site received a PHI score of 58.7, with very low scores for remoteness, shading, and instream woody debris. Water chemistry measurements *in situ* during April and September were, respectively, for conductivity (μS/cm), 435 and 480; for DO (mg/l), 11.1 and 8.0; for pH (S.U.), 7.4 and 6.7; water temperature (°C), 14.1 and 24.4; and air temperature (°C), 21.1 and 23.9. The B-IBI led to a rating of 'good' (Table 8, Figure 6) , with high scores (5) for the metrics total taxa, EPT taxa, number of mayfly taxa, number of scraper taxa, and percent climbers. In 110 specimens, there were 34 taxa among 18 families; the most abundant taxa were midges, of which *Orthocladius/Cricotopus* (n=26), *Polypedilum* (n=11), and *Cladotanytarsus* (n=10) were most common. The riffle beetle, *Stenelmis* (Coleoptera: Elmidae, n=6) was also found. This site was rated as 'good' by the F-IBI with a score of 4.0 (Figure 7). The highest metrics were benthic taxa; percent tolerants; percent generalists, omnivores, and insectivores; and percent dominants. The fish sampling collected 447

specimens and 25 species, dominated by Longnose dace (n=81), Bluegill (n=56), Spottail shiner (n=55), Pumpkinseed (n=52), and Tessellated darter (n=46). All other species were represented by 27 or fewer individuals; four of which only by a single specimen (Black crappie, Common carp, Mummichog, and Sea Lamprey).

Figure 13. Downstream view at 10.Chillum Road Tributary. Note the eroding banks.

Site 11B. Indian Creek

This potential restoration reach is located behind a new housing development that is actively under construction. Field crews noticed evidence of uncontained sediment from the construction zone washing off and down into the stream valley, eventually reaching the creek. However, this area is downstream from the sampling site. The upstream drainage area is 17,204 acres, or, approximately 70 km2. The RBP physical habitat score of 128 ('suboptimal'; Table 8)) results from bank instability and minimal undisturbed riparian vegetation, excessive deposition, and lack of both sinuosity and

complexity of pool structure (Figure 15). The PHI score of 66.4 resulted from low scores for remoteness, instream habitat, and woody debris. Bed materials are primarily made up of gravel and sand (68 and 26 percent, respectively); the reach is rated as 'highly impaired' for bed stability (log10RBS [LRBS] = -1.29).

Figure 14. Site 11a.Indian Creek, looking at the right bank. Note abundance of gravel.

Water chemistry measurements in situ during April and September were, respectively, for conductivity (µS/cm), 395 and 400; for DO (mg/l), 9.6 and 8.6; for pH (S.U.), 7.3 and 7.3; water temperature (°C), 13.5 and 24.3; and air temperature (°C), 12.8 and 31.1. The B-IBI rating of 'fair' (score, 3.86) (Figure 6) was driven by high scores for the metrics total taxa, number of Ephemeroptera taxa, number of scraper taxa, and percent climbers. There are 23 total taxa of invertebrates in the sample; of note in this sample is that worm and midges combined are not the overwhelmingly dominant groups. There were 31 riffle beetles (Elmidae) in the genera *Stenelmis* (n=31) and *Oulimnius* (n=1), while there were 33 midges (primarily, *Polypedilum* and *Cladotanytarsus*). There were also two genera of

relatively stressor-sensitive mayflies, *Maccaffertium* and *Plauditus*. There were 309 fish caught at this site, from which an F-IBI rating of 'good' was attained (Figure 7).

Metrics scoring highest were number of benthic taxa, percent tolerants, percent intolerant suckers, and percent dominant. The most common species in the sample were American eel (n=73), Redbreast sunfish (n=43), Tessellated darter (n=43), Longnose dace (n=41), Spottail shiner (n=17), Swallowtail shiner (n=17), White sucker (n=11), and Satinfin shiner (n=10). Some of the other species showing up in the sample with <7 specimens included Northern hogsucker, Pumpkinseed, Sea Lamprey, Creek chub, Mummichog, Bluntnose minnow, Bluegill, Green sunfish, Largemouth bass, Yellow bullhead, and Least brook lamprey.

Figure 15. Looking downstream at site 11b.Indian Creek. The stream reach was well-forested with an extensive vegetated riparian zone.

Site 12. Little Paint Branch

This potential restoration reach is in College Park (Figure 2), directly upstream of an Inter-County Connector (ICC) mitigation project at Paint Branch/Little Paint Branch confluence. Access to the site was via the foot trail that parallels the stream beginning where Cherry Hill Road crosses the stream. The length of this reach is 4,389 feet (approx.

Figure 16. Looking downstream at 12.Little Paint Branch. Like many other streams, this was historically straightened and therefore scored low due to no sinuosity.

1,338 meters), and the USACE site selection team recognizes the opportunity to increase stream habitat heterogeneity (mix of pools, riffles, runs) where it has been degraded by channelization (Figure 16). The 100 meter sampling reach drains an area of 6,874 acres (approx. 28km^2).Physical habitat quality is rated by the RBP habitat assessment as

'suboptimal' with a score of 113 (Table 8). This channel has been straightened, resulting in a low score for sinuosity, pool substrate and variability, and riparian vegetation. The PHI score of 68.8 reflects very low scores for shading and instream woody debris, but moderate to high scores for epifaunal substrate, instream habitat, and bank stability. Inorganic bottom materials are dominated by gravel and sand, with the pebble count of 62 and 33%, respectively, and there is some cobble present (5%). The reach is rated 'highly impaired' for RBS (Table 8), with a log10 score of -1.50. Water chemistry measurements in situ during April and September were, respectively, for conductivity (µS/cm), 476 and 540; for DO (mg/l), 9.8 and 12.4; for pH (S.U.), 7.6 and 7.0; water temperature (°C), 16.3 and 24.7; and air temperature (°C), 18.3 and 28.9. The site is rated as being in 'fair' biological condition by the B-IBI (Table 8, Figure 6) . The only metrics that scored 5 points (the highest possible) was total taxa and percent climbers, whereas EPT taxa, Ephemeroptera taxa, percent Ephemeroptera, and number of scraper taxa scored the next step down, 3. There are a total of 25 taxa, which are characteristically dominated by midges. Eighty (80) of the 104 total specimens are chironomids, typically considered to be a stressor tolerant group at the family level. The two genera represented by the most individuals are *Polypedilum* (n=26) and *Orthocladius/Cricotopus* (n=25). This reach was rated as 'good' by the fish IBI (Figure 7), with a score of 4.33; there were 875 individuals caught. Metrics which seem to have driven the rating are density of individuals, number of benthic taxa, percent tolerants, and percent dominance. Almost 80% of the total catch (n=692) was made up of six species: Blacknose dace (n=275), Longnose dace (n=116), Swallowtail shiner (n=98), Mummichog (n=73), and the American eel and Banded killifish, each with 65. A few of the remaining species found in this sample that may be of some interest, but are in lower numbers, include Yellow bullhead, Spottail shiner, Bluegill, Bluntnose minnow, Sea lamprey, Cutlips minnow, Eastern mudminnow, Brown bullhead, and Northern hogsucker.

Site 13. Lower Northwest Branch

This sampling reach is located on Lower Northwest Branch off a paved trail adjacent to Gumwood Drive and has an upstream drainage area of 21,745 acres (approximately 88km^2) (Figure 2). Access to the site was via the adjacent residential neighborhood. The reach was rated as 'suboptimal' by the RBP physical habitat assessment procedure (score, 146) (Table 8), and has been exposed to channelization, there is some bank instability, and low scores for riparian vegetation and bank protection (Figure 17).

Low habitat scores for remoteness, shading, instream habitat, and woody debris resulted in a low PHI score, 65; scores for epifaunal substrate and bank stability were moderate. Distribution of substrate particle sizes was gravel (60%), sand (29%), and cobble (11%). Relative bed stability calculations rated the reach as 'highly impaired' (log10RBS = -1.15). Water chemistry measurements *in situ* during April and September were, respectively, for conductivity (µS/cm), 990 and 440; for DO (mg/l), 10.5 and 9.9; for pH (S.U.), 7.3 and 6.9; water temperature (°C), 13.9 and 25.5; and air temperature (°C), 19.4 and 31.1. Analysis of the benthic macroinvertebrate sample resulted in high scores

Figure 17. View of left bank at 13.Lower Northwest Branch. Note incomplete vegetated riparian zone, in addition to unstable steep banks, a likely result of past channelization.

for the metrics total taxa, number of scraper taxa, and percent climbers, combined with lower score in the remaining six metrics resulted in a B-IBI rating of 'fair' (score, 3.57) (Figure 6). There are 109 individuals in 24 taxa, and 93.6% of the sample is comprised of worms and midges. The worms captured in the sample are *Nais* (n=30), *Limnodrilus* (n=11),

unidentified tubificines (n=11), *Bothrioneurum* (n=3), and Enchytraeidae (n=2); whereas, the three most abundant midges are *Polypedilum* (n=15), *Orthocladius/Cricotopus* (n=12), and *Thienemannimyia* (n=4). There are 10 additional midge genera with either 1-2 individuals. Other non-midge or worm taxa represented by a single individual include *Hydropsyche, Corbicula, Physa, Nematoda,* and *Prostoma*. The F-IBI rated the site as 'good' (Figure 7) with an index score of 4.67. There were 1,458 individual fish caught, resulting in high index score for density (individuals/m^2), benthic taxa, percent tolerants, percent intolerant suckers, and percent dominant. The top seven most abundant species account for 77% of the sample (Spottail shiner [n=328], Swallowtail shiner [n=213], Bluntnose minnow [n=193], Redbreast sunfish [n=109], White sucker [n=99], Blacknose dace [n=94], and Northern hogsucker [n=87]). Some of the remaining species with 70 or fewer individuals include Longnose dace, Yellow bullhead, Least brook lamprey, Brown bullhead, Fantail darter, and Smallmouth bass.

Site 15. Northeast Branch

This site is on the mainstem of Northeast Branch, approximately 250 meters west of the intersection of Good Luck Road and Kenilworth Avenue (Hwy. 201) (Figure 2). Access to the site was via WSSC temporary roadway as they were conducting work on a nearby tributary. The upstream drainage area is 39,263 acres (~159km^2). The reach was rated as 'fair' by the RBP physical habitat assessment, with a score of 97. There is severe bank instability, low sinuosity due to straightening, diminished epifaunal substrate and pool quality, riparian vegetation is nearly nonexistent, there is substantial fine sedimentation, and little vegetative protection of the banks (Figure 18). The degraded bank stability, complete lack of instream woody debris, lack of remoteness, and poor epifaunal substrate and instream habitat resulted in a PHI score of 42.9. Wolman pebble count resulted in 81% gravel and sand, with some cobble and boulder, likely reflecting intermittent episodes of high scour during storm flows. The RBS narrative rating for this reach is 'impaired' (log10RBS = -0.858). Water chemistry measurements *in situ* during April and September were, respectively, for conductivity (µS/cm), 446 and 2475; for DO (mg/l), 10.2 and 9.2; for pH (S.U.), 7.7 and 7.2; water temperature (°C), 14.9 and 24.6; and air temperature (°C), 15.6 and 29.4. The B-IBI resulted in rating of 'poor' (Table 8, Figure 6); only one of the metrics received a score of 5, percent climbers, total taxa got a 3, and all other metrics were either 0 or 1. The benthic macroinvertebrate sample was 106 individuals, and overwhelmingly dominated by midges (n=93), with Polypedilum (n=54) and *Cladotanytarsus* (n=16) being most abundant. Other midge genera in the sample, but not commonly observed are *Cryptochironomus, Phaenopsectra, Dicrotendipes, Ablabesmyia,*

and *Rheotanytarsus*. Fish sampling produce 242 individuals, and received an F-IBI rating of 'fair' (Figure 7) with a score of 3.33. Metrics that provided the highest scores (5) were number of benthic taxa and percent dominant, where 'percent generalists, omnivores, and insectivores' scored 3. Two hundred forty two (242) individuals were captured, representing 14 species. The seven most abundant species are Bluegill (n=52), Pumpkinseed (n=44), American eel (n=40), Redbreast sunfish (n=30), Tessellated darter (n=23), White sucker (n=19), and Green sunfish (n=15). Some of the other species captured, though in small numbers include the Eastern silvery minnow, Yellow bullhead, Black crappie, and Channel catfish.

Figure 18. View looking downstream at 15. Northeast Branch.

Conclusions and Recommendations

From a technical perspective, we recommend further "data-mining" into other agency surveys and natural resource inventories to provide a more complete ecological dataset for these stream reaches. The 2015 survey provides a snapshot of conditions, but does not account for any inter-annual variability over the past 10-20 years. For example, both Prince George's County and the MBSS have close to 20 years' of bioassessment data. It is likely that some of the previous assessments are located within the targeted stream reaches, thus they would provide additional useful data for understanding site characteristics. More in-depth statistical analyses to evaluate associations among different stressors and the stream biota, and the sources of those stressors can lead to identification of causal factors, and inform additional restoration decisionmaking.

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Appendix A. Benthic macroinvertebrate sample results

Table A-1. Benthic macroinvertebrate sample data, including counts, tolerance values (TV), functional feeding group (FFG), and urban tolerance values (TV_Urb).

SiteID	Date	Family	Taxon (Final ID)	Count	TV	FFG	Habit	TV_Urb
01.Indian Creek-I95	04/21/15	Caenidae	*Caenis*	2	7	CG	Sprawler	2.1
01.Indian Creek-I95	04/21/15	Calopterygidae	*Calopteryx*	1	6	PR	Climber	8.3
01.Indian Creek-I95	04/21/15	Ceratopogonidae	*Bezzia/Palpomyia*	1	6	PR	Burrower	
01.Indian Creek-I95	04/21/15	Ceratopogonidae	*Culicoides*	1	10	PR	Burrower	5.9
01.Indian Creek-I95	04/21/15	Ceratopogonidae	*Dasyhelea*	1	6	CG	Sprawler	3.6
01.Indian Creek-I95	04/21/15	Ceratopogonidae	*Serromyia*	2	6	PR	Burrower	
01.Indian Creek-I95	04/21/15	Chironomidae	*Brillia*	1	5	SH	Burrower	7.4
01.Indian Creek-I95	04/21/15	Chironomidae	*Chaetocladius*	3	6	CG	Sprawler	7
01.Indian Creek-I95	04/21/15	Chironomidae	*Cryptotendipes*	1	8	CG	Sprawler	6.6
01.Indian Creek-I95	04/21/15	Chironomidae	*Diplocladius*	5	7	CG	Sprawler	5.9
01.Indian Creek-I95	04/21/15	Chironomidae	*Hydrobaenus*	2	8	SC	Sprawler	7.2
01.Indian Creek-I95	04/21/15	Chironomidae	*Limnophyes*	2	8	CG	Sprawler	8.6
01.Indian Creek-I95	04/21/15	Chironomidae	*Nilotanypus*	1	6	PR	Sprawler	6.6
01.Indian Creek-I95	04/21/15	Chironomidae	*Orthocladius/Cricotopus*	7	6	CG	Sprawler	
01.Indian Creek-I95	04/21/15	Chironomidae	*Pseudosmittia*	1	6	CG	Sprawler	6.6
01.Indian Creek-I95	04/21/15	Chironomidae	*Rheocricotopus*	2	6	CG	Sprawler	6.2
01.Indian Creek-I95	04/21/15	Chironomidae	*Stenochironomus*	1	5	SH	Burrower	7.9
01.Indian Creek-I95	04/21/15	Chironomidae	*Tanytarsus*	1	6	CF	Climber	4.9
01.Indian Creek-I95	04/21/15	Chironomidae	*Thienemannimyia*	1	6	PR	Sprawler	6.7
01.Indian Creek-I95	04/21/15	Chironomidae	*Zavrelimyia*	2	8	PR	Sprawler	5.3
01.Indian Creek-I95	04/21/15	Corbiculidae	*Corbicula*	2	6	CF	Burrower	6
01.Indian Creek-I95	04/21/15	Dytiscidae	*Neoporus*	1	5	PR	Swimmer	
01.Indian Creek-I95	04/21/15	Elmidae	*Dubiraphia*	1	6	CG	Clinger	5.7
01.Indian Creek-I95	04/21/15	Elmidae	*Macronychus*	2	4	OM	Clinger	6.8
01.Indian Creek-I95	04/21/15	Enchytraeidae	*Enchytraeidae*	3	10	CG	Burrower	9.1
01.Indian Creek-I95	04/21/15	Hydropsychidae	*Hydropsychidae*	1	4	CF	Clinger	5.7
01.Indian Creek-I95	04/21/15	Limnephilidae	*Ironoquia*	1	3	SH	Sprawler	4.9
01.Indian Creek-I95	04/21/15	Naididae	*Dero*	1	10	CG	Burrower	
01.Indian Creek-I95	04/21/15	Naididae	*Nais*	20	8	CF	Burrower	
01.Indian Creek-I95	04/21/15	Naididae	*Slavina*	1		CG		
01.Indian Creek-I95	04/21/15	Naididae	*Stylaria*	2				
01.Indian Creek-I95	04/21/15	Pisidiidae	*Pisidiidae*	1		CG		
01.Indian Creek-I95	04/21/15	Pisidiidae	*Pisidium*	2	8	CF	Burrower	5.7
01.Indian Creek-I95	04/21/15	Planorbidae	*Helisoma*	1	6	SC	Climber	7.6
01.Indian Creek-I95	04/21/15	Polycentropodidae	*Polycentropus*	1	5	PR	Clinger	1.1
01.Indian Creek-I95	04/21/15	Sciaridae	*Sciaridae*	1				

SiteID	Date	Family	Taxon (Final ID)	Count	TV	FFG	Habit	TV_Urb
01.Indian Creek-I95	04/21/15	Simuliidae	*Simulium*	2	7	CF	Clinger	5.7
01.Indian Creek-I95	04/21/15	Tetrastemmatidae	*Prostoma*	3		PR		7.3
01.Indian Creek-I95	04/21/15	Tipulidae	*Erioptera*	1	7	CG		4.8
01.Indian Creek-I95	04/21/15	Tubificidae	*Aulodrilus*	1	5	CG	Sprawler	
01.Indian Creek-I95	04/21/15	Tubificidae	*Bothrioneurum*	12				
01.Indian Creek-I95	04/21/15	Tubificidae	*Spirosperma*	4	10	CG	Clinger	6.6
01.Indian Creek-I95	04/21/15	Tubificidae	*Tubificinae*	1				
03.Northwest Br.	04/27/15	Baetidae	*Acentrella/Plauditus*	1			Swimmer	
03.Northwest Br.	04/27/15	Chironomidae	*Corynoneura*	1	7	CG	Sprawler	4.1
03.Northwest Br.	04/27/15	Chironomidae	*Eukiefferiella*	1	8	CG	Sprawler	6.1
03.Northwest Br.	04/27/15	Chironomidae	*Hydrobaenus*	2	8	SC	Sprawler	7.2
03.Northwest Br.	04/27/15	Chironomidae	*Limnophyes*	1	8	CG	Sprawler	8.6
03.Northwest Br.	04/27/15	Chironomidae	*Nanocladius*	2	3	CG	Sprawler	7.6
03.Northwest Br.	04/27/15	Chironomidae	*Orthocladiinae*	2	6	CG	Burrower	7.6
03.Northwest Br.	04/27/15	Chironomidae	*Orthocladius/Cricotopus*	15	6	CG	Sprawler	
03.Northwest Br.	04/27/15	Chironomidae	*Parachironomus*	1	10	PR	Sprawler	6.6
03.Northwest Br.	04/27/15	Chironomidae	*Polypedilum*	13	6	SH	Climber	6.3
03.Northwest Br.	04/27/15	Chironomidae	*Rheotanytarsus*	2	6	CF	Clinger	7.2
03.Northwest Br.	04/27/15	Chironomidae	*Tanytarsus*	5	6	CF	Climber	4.9
03.Northwest Br.	04/27/15	Coenagrionidae	*Enallagma*	1	8	PR	Climber	9
03.Northwest Br.	04/27/15	Elmidae	*Ancyronyx*	1	2	OM	Clinger	7.8
03.Northwest Br.	04/27/15	Lumbricidae	*Eiseniella*	1				
03.Northwest Br.	04/27/15	Naididae	*Chaetogaster*	2	6	PR		
03.Northwest Br.	04/27/15	Naididae	*Nais*	42	8	CF	Burrower	
03.Northwest Br.	04/27/15	Naididae	*Paranais*	3				
03.Northwest Br.	04/27/15	Naididae	*Stylaria*	1				
03.Northwest Br.	04/27/15	Tipulidae	*Antocha*	1	5	CG	Clinger	8
03.Northwest Br.	04/27/15	Tipulidae	*Tipulidae*	1	4	SH	Burrower	4.8
03.Northwest Br.	04/27/15	Tubificidae	*Bothrioneurum*	1				
03.Northwest Br.	04/27/15	Tubificidae	*Limnodrilus*	1	10	CG	Clinger	8.6
05.Paint Branch	04/22/15	Chironomidae	*Cladotanytarsus*	2	7	CG	Climber	6.6
05.Paint Branch	04/22/15	Chironomidae	*Cryptochironomus*	2	8	PR	Sprawler	7.6
05.Paint Branch	04/22/15	Chironomidae	*Krenosmittia*	1	1	CG	Sprawler	
05.Paint Branch	04/22/15	Chironomidae	*Nilotanypus*	1	6	PR	Sprawler	6.6
05.Paint Branch	04/22/15	Chironomidae	*Orthocladius/Cricotopus*	14	6	CG	Sprawler	
05.Paint Branch	04/22/15	Chironomidae	*Polypedilum*	26	6	SH	Climber	6.3
05.Paint Branch	04/22/15	Chironomidae	*Rheotanytarsus*	1	6	CF	Clinger	7.2
05.Paint Branch	04/22/15	Chironomidae	*Saetheria*	6	4	CG	Burrower	6.6
05.Paint Branch	04/22/15	Chironomidae	*Tanytarsus*	1	6	CF	Climber	4.9
05.Paint Branch	04/22/15	Chironomidae	*Thienemannimyia*	1	6	PR	Sprawler	6.7

SiteID	Date	Family	Taxon (Final ID)	Count	TV	FFG	Habit	TV_Urb
05.Paint Branch	04/22/15	Chironomidae	*Tribelos*	1	5	CG	Burrower	7
05.Paint Branch	04/22/15	Elmidae	*Ancyronyx*	1	2	OM	Clinger	7.8
05.Paint Branch	04/22/15	Elmidae	*Stenelmis*	1	6	SC	Clinger	7.1
05.Paint Branch	04/22/15	Empididae	*Hemerodromia*	15	6	PR	Sprawler	7.9
05.Paint Branch	04/22/15	Empididae	*Neoplasta*	1			Sprawler	
05.Paint Branch	04/22/15	Hydropsychidae	*Cheumatopsyche*	1	5	CF	Clinger	6.5
05.Paint Branch	04/22/15	Hydropsychidae	*Hydropsyche*	2	6	CF	Clinger	7.5
05.Paint Branch	04/22/15	Lebertiidae	*Lebertia*	1	8	PR		
05.Paint Branch	04/22/15	Naididae	*Nais*	15	8	CF	Burrower	
05.Paint Branch	04/22/15	Philopotamidae	*Chimarra*	1	4	CF	Clinger	4.4
05.Paint Branch	04/22/15	Philopotamidae	*Philopotamidae*	1	3	CF	Clinger	2.6
05.Paint Branch	04/22/15	Pisidiidae	*Pisidiidae*	1		CG		
05.Paint Branch	04/22/15	Sperchonidae	*Sperchon*	1	8	PR		
05.Paint Branch	04/22/15	Tetrastemmatidae	*Prostoma*	1		PR		7.3
05.Paint Branch	04/22/15	Tipulidae	*Antocha*	2	5	CG	Clinger	8
05.Paint Branch	04/22/15		*Veneroida*	1				
07.Paint Branch	04/21/15	Ceratopogonidae	*Bezzia/Palpomyia*	1	6	PR	Burrower	
07.Paint Branch	04/21/15	Chironomidae	*Cardiocladius*	1	6	PR	Burrower	10
07.Paint Branch	04/21/15	Chironomidae	*Cryptochironomus*	1	8	PR	Sprawler	7.6
07.Paint Branch	04/21/15	Chironomidae	*Dicrotendipes*	2	10	CG	Burrower	9
07.Paint Branch	04/21/15	Chironomidae	*Orthocladius/Cricotopus*	9	6	CG	Sprawler	
07.Paint Branch	04/21/15	Chironomidae	*Phaenopsectra*	1	7	SC	Clinger	8.7
07.Paint Branch	04/21/15	Chironomidae	*Polypedilum*	36	6	SH	Climber	6.3
07.Paint Branch	04/21/15	Chironomidae	*Pseudorthocladius*	1	0	CG	Sprawler	6
07.Paint Branch	04/21/15	Chironomidae	*Saetheria*	14	4	CG	Burrower	6.6
07.Paint Branch	04/21/15	Chironomidae	*Stenochironomus*	1	5	SH	Burrower	7.9
07.Paint Branch	04/21/15	Chironomidae	*Synorthocladius*	1	2	CG		6.6
07.Paint Branch	04/21/15	Chironomidae	*Tanytarsus*	2	6	CF	Climber	4.9
07.Paint Branch	04/21/15	Empididae	*Hemerodromia*	6	6	PR	Sprawler	7.9
07.Paint Branch	04/21/15	Enchytraeidae	*Enchytraeidae*	2	10	CG	Burrower	9.1
07.Paint Branch	04/21/15	Hydropsychidae	*Cheumatopsyche*	1	5	CF	Clinger	6.5
07.Paint Branch	04/21/15	Hydropsychidae	*Hydropsyche*	4	6	CF	Clinger	7.5
07.Paint Branch	04/21/15	Hydropsychidae	*Hydropsychidae*	1	4	CF	Clinger	5.7
07.Paint Branch	04/21/15	Hydroptilidae	*Hydroptilidae*	1	4	PI	Climber	4
07.Paint Branch	04/21/15	Lebertiidae	*Lebertia*	1	8	PR		
07.Paint Branch	04/21/15	Lumbricidae	*Lumbricidae*	1	10	CG	Burrower	
07.Paint Branch	04/21/15	Naididae	*Nais*	4	8	CF	Burrower	
07.Paint Branch	04/21/15	Naididae	*Pristina*	2	8	CG		
07.Paint Branch	04/21/15	Philopotamidae	*Chimarra*	1	4	CF	Clinger	4.4
07.Paint Branch	04/21/15	Simuliidae	*Simulium*	1	7	CF	Clinger	5.7

SiteID	Date	Family	Taxon (Final ID)	Count	TV	FFG	Habit	TV_Urb
07.Paint Branch	04/21/15	Tetrastemmatidae	*Prostoma*	1		PR		7.3
07.Paint Branch	04/21/15	Tipulidae	*Antocha*	5	5	CG	Clinger	8
07.Paint Branch	04/21/15	Tipulidae	*Tipulidae*	1	4	SH	Burrower	4.8
07.Paint Branch	04/21/15	Tubificidae	*Bothrioneurum*	1				
07.Paint Branch	04/21/15	Veliidae	*Veliidae*	1	8	PR	Skater	
09.Sligo Creek	04/22/15	Chironomidae	*Ablabesmyia*	3	8	CG	Sprawler	8.1
09.Sligo Creek	04/22/15	Chironomidae	*Brillia*	1	5	SH	Burrower	7.4
09.Sligo Creek	04/22/15	Chironomidae	*Chaetocladius*	1	6	CG	Sprawler	7
09.Sligo Creek	04/22/15	Chironomidae	*Dicrotendipes*	1	10	CG	Burrower	9
09.Sligo Creek	04/22/15	Chironomidae	*Hydrobaenus*	1	8	SC	Sprawler	7.2
09.Sligo Creek	04/22/15	Chironomidae	*Nilotanypus*	1	6	PR	Sprawler	6.6
09.Sligo Creek	04/22/15	Chironomidae	*Orthocladius/Cricotopus*	21	6	CG	Sprawler	
09.Sligo Creek	04/22/15	Chironomidae	*Pentaneura*	2	6	PR	Sprawler	6.6
09.Sligo Creek	04/22/15	Chironomidae	*Phaenopsectra*	1	7	SC	Clinger	8.7
09.Sligo Creek	04/22/15	Chironomidae	*Polypedilum*	24	6	SH	Climber	6.3
09.Sligo Creek	04/22/15	Chironomidae	*Saetheria*	14	4	CG	Burrower	6.6
09.Sligo Creek	04/22/15	Chironomidae	*Tanytarsus*	1	6	CF	Climber	4.9
09.Sligo Creek	04/22/15	Chironomidae	*Thienemannimyia*	1	6	PR	Sprawler	6.7
09.Sligo Creek	04/22/15	Coenagrionidae	*Argia*	1	8	PR	Clinger	9.3
09.Sligo Creek	04/22/15	Coenagrionidae	*Enallagma*	1	8	PR	Climber	9
09.Sligo Creek	04/22/15	Crangonyctidae	*Crangonyx*	1	4	CG	Sprawler	6.7
09.Sligo Creek	04/22/15	Enchytraeidae	*Enchytraeidae*	6	10	CG	Burrower	9.1
09.Sligo Creek	04/22/15	Lumbricidae	*Lumbricidae*	1	10	CG	Burrower	
09.Sligo Creek	04/22/15	Naididae	*Nais*	19	8	CF	Burrower	
09.Sligo Creek	04/22/15	Tetrastemmatidae	*Prostoma*	2		PR		7.3
09.Sligo Creek	04/22/15	Tubificidae	*Bothrioneurum*	1				
09.Sligo Creek	04/22/15	Tubificidae	*Limnodrilus*	1	10	CG	Clinger	8.6
09.Sligo Creek	04/22/15	Tubificidae	*Tubificinae*	2				
10.Chillum Rd Trib	04/21/15	Chironomidae	*Chironomini*	1	6	CG	Burrower	5.9
10.Chillum Rd Trib	04/21/15	Chironomidae	*Dicrotendipes*	2	10	CG	Burrower	9
10.Chillum Rd Trib	04/21/15	Chironomidae	*Glyptotendipes*	2	10	CF	Burrower	6.6
10.Chillum Rd Trib	04/21/15	Chironomidae	*Orthocladius/Cricotopus*	50	6	CG	Sprawler	
10.Chillum Rd Trib	04/21/15	Chironomidae	*Polypedilum*	6	6	SH	Climber	6.3
10.Chillum Rd Trib	04/21/15	Chironomidae	*Pseudosmittia*	1	6	CG	Sprawler	6.6
10.Chillum Rd Trib	04/21/15	Chironomidae	*Thienemannimyia*	4	6	PR	Sprawler	6.7
10.Chillum Rd Trib	04/21/15	Coenagrionidae	*Argia*	2	8	PR	Clinger	9.3
10.Chillum Rd Trib	04/21/15	Empididae	*Hemerodromia*	1	6	PR	Sprawler	7.9
10.Chillum Rd Trib	04/21/15	Enchytraeidae	*Enchytraeidae*	7	10	CG	Burrower	9.1
10.Chillum Rd Trib	04/21/15	Naididae	*Nais*	10	8	CF	Burrower	
10.Chillum Rd Trib	04/21/15	Naididae	*Paranais*	1				

SiteID	Date	Family	Taxon (Final ID)	Count	TV	FFG	Habit	TV_Urb
10.Chillum Rd Trib	04/21/15	Nepidae	*Ranatra*	1	7	PR	Climber	5.6
10.Chillum Rd Trib	04/21/15	Psychodidae	*Psychoda*	1	10	CG	Burrower	4
10.Chillum Rd Trib	04/21/15	Tetrastemmatidae	*Prostoma*	1		PR		7.3
10.Chillum Rd Trib	04/21/15	Tubificidae	*Limnodrilus*	2	10	CG	Clinger	8.6
10.Chillum Rd Trib	04/21/15	Tubificidae	*Tubificinae*	13				
11A.Indian Crk	04/28/15	Ancylidae	*Ferrissia*	1	7	SC	Climber	7
11A.Indian Crk	04/28/15	Baetidae	*Acentrella*	2	4	CG	Swimmer	4.9
11A.Indian Crk	04/28/15	Baetidae	*Baetis*	5	6	CG	Swimmer	3.9
11A.Indian Crk	04/28/15	Baetidae	*Plauditus*	1	5		Swimmer	
11A.Indian Crk	04/28/15	Chironomidae	*Brillia*	2	5	SH	Burrower	7.4
11A.Indian Crk	04/28/15	Chironomidae	*Cladotanytarsus*	10	7	CG	Climber	6.6
11A.Indian Crk	04/28/15	Chironomidae	*Cryptochironomus*	1	8	PR	Sprawler	7.6
11A.Indian Crk	04/28/15	Chironomidae	*Eukiefferiella*	1	8	CG	Sprawler	6.1
11A.Indian Crk	04/28/15	Chironomidae	*Nanocladius*	1	3	CG	Sprawler	7.6
11A.Indian Crk	04/28/15	Chironomidae	*Nilotanypus*	2	6	PR	Sprawler	6.6
11A.Indian Crk	04/28/15	Chironomidae	*Orthocladiinae*	1	6	CG	Burrower	7.6
11A.Indian Crk	04/28/15	Chironomidae	*Orthocladius/Cricotopus*	27	6	CG	Sprawler	
11A.Indian Crk	04/28/15	Chironomidae	*Polypedilum*	12	6	SH	Climber	6.3
11A.Indian Crk	04/28/15	Chironomidae	*Synorthocladius*	2	2	CG		6.6
11A.Indian Crk	04/28/15	Chironomidae	*Tanytarsus*	1	6	CF	Climber	4.9
11A.Indian Crk	04/28/15	Chironomidae	*Thienemannimyia*	2	6	PR	Sprawler	6.7
11A.Indian Crk	04/28/15	Coenagrionidae	*Enallagma*	2	8	PR	Climber	9
11A.Indian Crk	04/28/15	Dorylaimidae	*Nematoda*	5	6	PA		
11A.Indian Crk	04/28/15	Elmidae	*Dubiraphia*	1	6	CG	Clinger	5.7
11A.Indian Crk	04/28/15	Elmidae	*Stenelmis*	6	6	SC	Clinger	7.1
11A.Indian Crk	04/28/15	Empididae	*Empididae*	1	6	PR	Sprawler	7.5
11A.Indian Crk	04/28/15	Enchytraeidae	*Enchytraeidae*	1	10	CG	Burrower	9.1
11A.Indian Crk	04/28/15	Hydrobiidae	*Hydrobiidae*	3	8	SC	Climber	8
11A.Indian Crk	04/28/15	Hydropsychidae	*Cheumatopsyche*	2	5	CF	Clinger	6.5
11A.Indian Crk	04/28/15	Hydropsychidae	*Hydropsyche*	1	6	CF	Clinger	7.5
11A.Indian Crk	04/28/15	Leptoceridae	*Oecetis*	1	8	PR	Clinger	4.7
11A.Indian Crk	04/28/15	Naididae	*Nais*	7	8	CF	Burrower	
11A.Indian Crk	04/28/15	Philopotamidae	*Chimarra*	1	4	CF	Clinger	4.4
11A.Indian Crk	04/28/15	Pisidiidae	*Pisidiidae*	1		CG		
11A.Indian Crk	04/28/15	Planariidae	*Planariidae*	1	1	OM	Sprawler	8.4
11A.Indian Crk	04/28/15	Planorbidae	*Menetus*	1	8	SC	Climber	7.6
11A.Indian Crk	04/28/15	Polycentropodidae	*Polycentropus*	1	5	PR	Clinger	1.1
11A.Indian Crk	04/28/15	Sperchonidae	*Sperchon*	1	8	PR		
11A.Indian Crk	04/28/15	Tipulidae	*Antocha*	1	5	CG	Clinger	8
11A.Indian Crk	04/28/15	Tipulidae	*Tipulidae*	1	4	SH	Burrower	4.8

SiteID	Date	Family	Taxon (Final ID)	Count	TV	FFG	Habit	TV_Urb
11A.Indian Crk	04/28/15	Tubificidae	*Bothrioneurum*	1				
11B.Indian Crk	04/22/15	Baetidae	*Plauditus*	5	5		Swimmer	
11B.Indian Crk	04/22/15	Chironomidae	*Cladotanytarsus*	7	7	CG	Climber	6.6
11B.Indian Crk	04/22/15	Chironomidae	*Cryptochironomus*	4	8	PR	Sprawler	7.6
11B.Indian Crk	04/22/15	Chironomidae	*Orthocladius/Cricotopus*	3	6	CG	Sprawler	
11B.Indian Crk	04/22/15	Chironomidae	*Polypedilum*	15	6	SH	Climber	6.3
11B.Indian Crk	04/22/15	Chironomidae	*Pseudorthocladius*	1	0	CG	Sprawler	6
11B.Indian Crk	04/22/15	Chironomidae	*Saetheria*	3	4	CG	Burrower	6.6
11B.Indian Crk	04/22/15	Elmidae	*Oulimnius*	1	2	SC	Clinger	2.7
11B.Indian Crk	04/22/15	Elmidae	*Stenelmis*	31	6	SC	Clinger	7.1
11B.Indian Crk	04/22/15	Empididae	*Hemerodromia*	9	6	PR	Sprawler	7.9
11B.Indian Crk	04/22/15	Empididae	*Neoplasta*	3			Sprawler	
11B.Indian Crk	04/22/15	Gomphidae	*Hagenius*	1	3	PR	Sprawler	2.2
11B.Indian Crk	04/22/15	Heptageniidae	*Maccaffertium*	1	4	SC	Clinger	4.6
11B.Indian Crk	04/22/15	Hydropsychidae	*Hydropsyche*	2	6	CF	Clinger	7.5
11B.Indian Crk	04/22/15	Hydroptilidae	*Hydroptila*	1	6	SC	Clinger	6
11B.Indian Crk	04/22/15	Lumbricidae	*Lumbricidae*	1	10	CG	Burrower	
11B.Indian Crk	04/22/15	Lumbriculidae	*Lumbriculidae*	1	10	CG	Burrower	6.6
11B.Indian Crk	04/22/15	Naididae	*Nais*	13	8	CF	Burrower	
11B.Indian Crk	04/22/15	Simuliidae	*Simulium*	1	7	CF	Clinger	5.7
11B.Indian Crk	04/22/15	Tetrastemmatidae	*Prostoma*	1		PR		7.3
11B.Indian Crk	04/22/15	Tipulidae	*Antocha*	1	5	CG	Clinger	8
11B.Indian Crk	04/22/15	Tubificidae	*Bothrioneurum*	1				
11B.Indian Crk	04/22/15	Tubificidae	*Limnodrilus*	1	10	CG	Clinger	8.6
12.Little Paint Br.	04/21/15	Baetidae	*Plauditus*	1	5		Swimmer	
12.Little Paint Br.	04/21/15	Chironomidae	*Ablabesmyia*	1	8	CG	Sprawler	8.1
12.Little Paint Br.	04/21/15	Chironomidae	*Cladotanytarsus*	2	7	CG	Climber	6.6
12.Little Paint Br.	04/21/15	Chironomidae	*Cryptochironomus*	2	8	PR	Sprawler	7.6
12.Little Paint Br.	04/21/15	Chironomidae	*Diamesa*	1	5	CG	Sprawler	8.5
12.Little Paint Br.	04/21/15	Chironomidae	*Dicrotendipes*	2	10	CG	Burrower	9
12.Little Paint Br.	04/21/15	Chironomidae	*Eukiefferiella*	2	8	CG	Sprawler	6.1
12.Little Paint Br.	04/21/15	Chironomidae	*Microtendipes*	2	6	CF	Clinger	4.9
12.Little Paint Br.	04/21/15	Chironomidae	*Orthocladius/Cricotopus*	28	6	CG	Sprawler	
12.Little Paint Br.	04/21/15	Chironomidae	*Polypedilum*	27	6	SH	Climber	6.3
12.Little Paint Br.	04/21/15	Chironomidae	*Rheotanytarsus*	5	6	CF	Clinger	7.2
12.Little Paint Br.	04/21/15	Chironomidae	*Saetheria*	6	4	CG	Burrower	6.6
12.Little Paint Br.	04/21/15	Chironomidae	*Tanytarsus*	2	6	CF	Climber	4.9
12.Little Paint Br.	04/21/15	Dorylaimidae	*Nematoda*	1	6	PA		
12.Little Paint Br.	04/21/15	Elmidae	*Stenelmis*	1	6	SC	Clinger	7.1
12.Little Paint Br.	04/21/15	Empididae	*Hemerodromia*	3	6	PR	Sprawler	7.9

SiteID	Date	Family	Taxon (Final ID)	Count	TV	FFG	Habit	TV_Urb
12.Little Paint Br.	04/21/15	Enchytraeidae	*Enchytraeidae*	1	10	CG	Burrower	9.1
12.Little Paint Br.	04/21/15	Hydrophilidae	*Berosus*	1	5	PR	Swimmer	4.1
12.Little Paint Br.	04/21/15	Hydropsychidae	*Cheumatopsyche*	1	5	CF	Clinger	6.5
12.Little Paint Br.	04/21/15	Hydropsychidae	*Hydropsyche*	5	6	CF	Clinger	7.5
12.Little Paint Br.	04/21/15	Hygrobatidae	*Hygrobates*	1		PR		
12.Little Paint Br.	04/21/15	Naididae	*Nais*	6	8	CF	Burrower	
12.Little Paint Br.	04/21/15	Pisidiidae	*Pisidium*	1	8	CF	Burrower	5.7
12.Little Paint Br.	04/21/15	Simuliidae	*Simulium*	1	7	CF	Clinger	5.7
12.Little Paint Br.	04/21/15	Tubificidae	*Limnodrilus*	1	10	CG	Clinger	8.6
13.Lower NW Br.	04/22/15	Baetidae	*Baetidae*	1	4	CG		2.3
13.Lower NW Br.	04/22/15	Chironomidae	*Brillia*	1	5	SH	Burrower	7.4
13.Lower NW Br.	04/22/15	Chironomidae	*Cardiocladius*	1	6	PR	Burrower	10
13.Lower NW Br.	04/22/15	Chironomidae	*Chaetocladius*	1	6	CG	Sprawler	7
13.Lower NW Br.	04/22/15	Chironomidae	*Cladotanytarsus*	2	7	CG	Climber	6.6
13.Lower NW Br.	04/22/15	Chironomidae	*Endochironomus*	1	10	SH	Clinger	6.2
13.Lower NW Br.	04/22/15	Chironomidae	*Orthocladius/Cricotopus*	12	6	CG	Sprawler	
13.Lower NW Br.	04/22/15	Chironomidae	*Phaenopsectra*	2	7	SC	Clinger	8.7
13.Lower NW Br.	04/22/15	Chironomidae	*Polypedilum*	15	6	SH	Climber	6.3
13.Lower NW Br.	04/22/15	Chironomidae	*Stenochironomus*	2	5	SH	Burrower	7.9
13.Lower NW Br.	04/22/15	Chironomidae	*Tanytarsus*	3	6	CF	Climber	4.9
13.Lower NW Br.	04/22/15	Chironomidae	*Thienemannimyia*	4	6	PR	Sprawler	6.7
13.Lower NW Br.	04/22/15	Chironomidae	*Zavrelimyia*	1	8	PR	Sprawler	5.3
13.Lower NW Br.	04/22/15	Corbiculidae	*Corbicula*	1	6	CF	Burrower	6
13.Lower NW Br.	04/22/15	Dorylaimidae	*Nematoda*	1	6	PA		
13.Lower NW Br.	04/22/15	Enchytraeidae	*Enchytraeidae*	2	10	CG	Burrower	9.1
13.Lower NW Br.	04/22/15	Hydropsychidae	*Hydropsyche*	1	6	CF	Clinger	7.5
13.Lower NW Br.	04/22/15	Hydropsychidae	*Hydropsychidae*	1	4	CF	Clinger	5.7
13.Lower NW Br.	04/22/15	Naididae	*Nais*	30	8	CF	Burrower	
13.Lower NW Br.	04/22/15	Physidae	*Physa*	1	8	SC		
13.Lower NW Br.	04/22/15	Tetrastemmatidae	*Prostoma*	1		PR		7.3
13.Lower NW Br.	04/22/15	Tubificidae	*Bothrioneurum*	3				
13.Lower NW Br.	04/22/15	Tubificidae	*Limnodrilus*	11	10	CG	Clinger	8.6
13.Lower NW Br.	04/22/15	Tubificidae	*Tubificinae*	11				
15.Northeast Br.	04/22/15	Chironomidae	*Ablabesmyia*	1	8	CG	Sprawler	8.1
15.Northeast Br.	04/22/15	Chironomidae	*Cladotanytarsus*	16	7	CG	Climber	6.6
15.Northeast Br.	04/22/15	Chironomidae	*Cryptochironomus*	6	8	PR	Sprawler	7.6
15.Northeast Br.	04/22/15	Chironomidae	*Dicrotendipes*	1	10	CG	Burrower	9
15.Northeast Br.	04/22/15	Chironomidae	*Orthocladius/Cricotopus*	5	6	CG	Sprawler	
15.Northeast Br.	04/22/15	Chironomidae	*Phaenopsectra*	4	7	SC	Clinger	8.7
15.Northeast Br.	04/22/15	Chironomidae	*Polypedilum*	54	6	SH	Climber	6.3

SiteID	Date	Family	Taxon (Final ID)	Count	TV	FFG	Habit	TV_Urb
15.Northeast Br.	04/22/15	Chironomidae	*Rheotanytarsus*	1	6	CF	Clinger	7.2
15.Northeast Br.	04/22/15	Chironomidae	*Saetheria*	4	4	CG	Burrower	6.6
15.Northeast Br.	04/22/15	Chironomidae	*Tanytarsus*	1	6	CF	Climber	4.9
15.Northeast Br.	04/22/15	Elmidae	*Stenelmis*	2	6	SC	Clinger	7.1
15.Northeast Br.	04/22/15	Enchytraeidae	*Enchytraeidae*	2	10	CG	Burrower	9.1
15.Northeast Br.	04/22/15	Gammaridae	*Gammarus*	1	6	OM	Sprawler	6.7
15.Northeast Br.	04/22/15	Hydropsychidae	*Hydropsyche*	1	6	CF	Clinger	7.5
15.Northeast Br.	04/22/15	Hygrobatidae	*Hygrobates*	1		PR		
15.Northeast Br.	04/22/15	Pisidiidae	*Pisidium*	2	8	CF	Burrower	5.7
15.Northeast Br.	04/22/15	Tetrastemmatidae	*Prostoma*	1		PR		7.3
15.Northeast Br.	04/22/15	Tipulidae	*Antocha*	1	5	CG	Clinger	8
15.Northeast Br.	04/22/15	Tubificidae	*Limnodrilus*	1	10	CG	Clinger	8.6
15.Northeast Br.	04/22/15		*Gastropoda*	1	7	SC		

Appendix B. Water Quality Results

Table B-1. *In situ* water quality measurements recorded at Anacostia watershed sites, 2015.

Site ID		Season	Temperature (◦C)	Dissolved Oxygen (mg/L)	pH	Conductivity (mS/cm)
01	Indian Creek-I95	Spring	14	9.6	7	0.880
		Summer	22.4	12.21	6.55	0.600
03	Northwest Branch	Spring	13.1	10.8	8	0.435
		Summer	24.3	6.92	6.37	0.440
05	Paint Branch	Spring	15.5	10	7.7	0.327
		Summer	29.6	10.55	8.42	0.550
07	Paint Branch	Spring	17	9.4	7.8	0.359
		Summer	25.1	9.35	7.8	0.407
09	Sligo Creek	Spring	12.3	10.8	7.3	1.290
		Summer	24.3	11.2	7.9	0.780
10	Chillum Rd Tributary	Spring	16.3	7.7	6.9	1.440
		Summer	22.1	10.1	6.5	0.690
11A	Indian Creek	Spring	14.1	11.1	7.4	0.435
		Summer	24.4	7.99	6.68	0.480
11B	Indian Creek	Spring	13.5	9.6	7.3	0.395
		Summer	24.3	8.57	7.26	0.400
12	Little Paint Br	Spring	16.3	9.83	7.59	0.476
		Summer	24.7	12.38	7	0.540
13	Lower NW Branch	Spring	13.9	10.5	7.3	0.990
		Summer	25.5	9.91	6.93	0.440
15	Northeast Branch	Spring	14.9	10.2	7.7	0.446
		Summer	24.6	9.15	7.18	2.475

Appendix C. Pebble Count

Table C-1. Substrate particle size distribution (percent) for all sampling sites (n=11). Estimates made using a modified Wolman 100 particle count.

Site ID	Silt/Clay	Sand	Gravel	Cobble	Boulder	Bedrock
01.Indian Creek-I95	1	12	84	3	0	0
03.Northwest Branch	13	44	11	3	29	0
05.Paint Branch	8	13	68	2	9	0
07.Paint Branch	0	21	31	24	19	5
09.Sligo Creek	3	30	39	11	16	1
10.Chillum Rd Tributary	8	41	46	5	0	0
11A.Indian Creek	11	23	56	7	3	0
11B.Indian Creek	6	26	68	0	0	0
12.Little Paint Br.	0	33	62	5	0	0
13.Lower NW Branch	0	29	60	11	0	0
15.Northeast Branch	0	29	52	10	9	0

Appendix D. Benthic Macroinvertebrate Metric Values and Scores

Table D-1. Benthic Index of Biological Integrity (B-IBI) metric values and converted metric scores for sites sampled within the Anacostia watershed

Site ID	Values							Scores						
	Number of Taxa	Number of EPT Taxa	Number of Ephemeroptera Taxa	Percent Urban Intolerant Taxa	Percent Ephemeroptera Taxa	Number of Scraper Taxa	Percent Climber Taxa	Number of Taxa	Number of EPT Taxa	Number of Ephemeroptera Taxa	Percent Urban Intolerant Taxa	Percent Ephemeroptera Taxa	Number of Scraper Taxa	Percent Climber Taxa
01.Indian Creek-I95	42	4	1	2.9	1.9	2	2.9	5	3	3	1	3	5	3
03.Northwest Branch	21	1	1	0.0	1.0	1	18.8	3	1	3	1	3	3	5
05.Paint Branch	24	3	0	1.0	0.0	1	28.7	5	3	1	1	1	3	5
07.Paint Branch	27	4	0	0.0	0.0	1	37.5	5	3	1	1	1	3	5
09.Sligo Creek	23	0	0	0.0	0.0	2	24.3	5	1	1	1	1	5	5
10.Chillum Rd Tributary	16	0	0	0.0	0.0	0	6.7	3	1	1	1	1	1	3
11A.Indian Creek	34	8	3	0.9	7.3	4	27.3	5	5	5	1	3	5	5
11B.Indian Creek	23	4	2	1.9	5.6	4	20.6	5	3	5	1	3	5	5
12.Little Paint Br.	25	3	1	0.0	1.0	1	29.8	5	3	3	1	3	3	5
13.Lower NW Branch	24	3	1	0.9	0.9	2	18.4	5	3	3	1	3	5	5
15.Northeast Branch	20	1	0	0.0	0.0	3	67.0	3	1	1	1	1	5	5

Appendix E. Visual-based Physical Habitat Quality Scores

Table E-1. Rapid Bioassessment Protocols (RBP) physical habitat assessment scores (PHAB) for Anacostia bioassessment sites, 2015, n=11. *Abbreviations*: O = optimal, S = suboptimal, F = fair, P=poor.

Site ID	Narrative Rating	Total PHAB Score	Bank Stability (Left Bank)	Bank Stability (Right Bank)	Channel Alteration	Channel Flow Status	Channel Sinuosity	Instream Cover/Epifaunal Substrate	Pool Substrate Characterization	Pool Variability	Riparian Vegetative Zone Width (Left Bank)	Riparian Vegetative Zone Width (Right Bank)	Sediment Deposition	Vegetative Protection (Left Bank)	Vegetative Protection (Right Bank)
01.Indian Creek-I95	O	**164**	8	8	19	15	13	17	18	16	10	10	12	9	9
03.NW Branch	S	**117**	7	8	12	19	5	9	13	14	3	4	9	7	7
05.Paint Branch	S	**123**	1	5	11	18	1	16	12	11	10	7	16	8	7
07.Paint Branch	S	**145**	7	9	20	17	6	16	13	11	10	9	13	6	8
09.Sligo Creek	S	**148**	7	8	13	15	7	15	16	16	9	9	14	9	10
10.Chillum Rd Trib	S	**120**	7	4	16	11	9	14	16	10	3	5	13	7	5
11A.Indian Creek	S	**128**	6	7	8	16	5	16	14	7	10	10	14	9	6
11B.Indian Creek	S	**128**	7	8	18	15	5	17	16	12	5	1	12	8	4
12.Little Paint Br.	S	**113**	9	7	14	19	1	16	11	3	2	1	13	9	8
13.Lower NW Branch	S	**146**	8	7	15	15	6	17	16	16	5	8	18	8	7
15.NE Branch	F	**97**	4	2	7	17	2	14	12	13	2	2	12	6	4

Appendix F. Physical Habitat Index (PHI) and Relative Bed Stability (RBS) results

Table F-1. Results from application of the MBSS Physial Habitat Index (PHI) and assessment of bottom substrate using Relative Bed Stability (RBS).

StationID	Physical habitat index (PHI)							Relative bed stability (RBS)						
	REMTE	SHAD	EPI	INSTRHAB	WOOD	BNKSTB	PHI	D50	Slope	Thalwg	Rbf	RBS	LRBS	Rating
01.Indian Creek-I95	53.9	95.8	96.9	96.4	100.0	86.6	88.3	20	0.025	0.337	0.02	0.12	-0.94	Impaired
03.Northwest Branch	32.3	80.2	37.4	28.0	43.7	80.6	50.4	0.375	0.005	0.895	0.04	0.00	-2.94	H. impaired
05.Paint Branch	32.3	64.8	90.4	68.0	12.5	59.2	54.5	20	0.005	0.349	0.02	0.02	-1.62	H. impaired
07.Paint Branch	64.6	96.4	94.7	74.7	19.9	89.5	73.3	56	0.005	0.491	0.02	0.09	-1.03	H. impaired
09.Sligo Creek	70.0	73.5	79.7	73.0	92.2	94.9	80.6	14	0.015	0.614	0.03	0.09	-1.05	H. impaired
10.Chillum Rd Trib	43.1	56.7	85.2	79.8	64.6	74.2	67.3	5	0.01	0.301	0.02	0.01	-1.99	H. impaired
11A.Indian Creek	37.7	60.6	73.6	74.5	22.3	83.7	58.7	20	0.025	0.499	0.02	0.17	-0.77	Impaired
11B.Indian Creek	32.3	100.0	79.8	69.7	35.0	83.7	66.7	20	0.005	0.737	0.04	0.05	-1.30	H. impaired
12.Little Paint Br.	86.2	36.3	100.0	79.0	24.6	86.6	68.8	20	0.0075	0.305	0.02	0.03	-1.50	H. impaired
13.Lower NW Branch	53.9	60.0	78.3	67.3	44.1	86.6	65.0	20	0.01	0.516	0.03	0.07	-1.15	H. impaired
15.Northeast Branch	32.3	56.1	57.0	55.7	2.0	54.8	43.0	28	0.005	1.447	0.07	0.14	-0.86	Impaired

Abbreviations and units: RMTE, remoteness; SHAD, shading; EPI, epifaunal substrate/instream habitat; WOOD, instream wood; BNKSTB, bank stability; PHI, physical habitat index; D50, millimeters; Slope, %; Thalweg, mean meters; Rbf, bankfull radius; RBS, relative bed stability; LRBS, Log10RBS; H. impaired, highly impaired

Appendix G. List of Fish Species Collected and Abundances

Table G-1. Fish species and abundances collected at Anacostia watershed stream sites (n=11)

Common Name	Scientific Name	Tolerance Level	01.Indian Creek-I95	03.Northwest Branch	05.Paint Branch	07.Paint Branch	09.Sligo Creek	10.Chillum Rd Trib	11A.Indian Creek	11B.Indian Creek	12.Little Paint Br.	13.Lower NW Branch	15.Northeast Branch
American eel	*Anguilla rostrata*	Tolerant	27	41	33	27	19	15	21	73	65	26	40
American shad	*Alosa sapidissima*				1								
Banded killifish	*Fundulus diaphanus*	Moderate	3	5	20		7	64			65	22	1
Black crappie	*Pomoxis nigromaculatus*	Moderate							1				1
Blacknose dace	*Rhinichthys atratulus*	Tolerant	27		37	141	48	72	7	7	275	94	
Bluegill	*Lepomis macrochirus*	Tolerant		27	20		12		56	3	8	10	52
Bluntnose minnow	*Pimephales notatus*	Tolerant		10	1	1	134	59	17	4	4	193	
Brown bullhead	*Ameiurus nebulosus*	Tolerant							3		1	2	
Channel catfish	*Ictalurus punctatus*	Moderate											1
Common carp	*Cyrpinus carpio*	Tolerant							1				
Creek chub	*Semotilus atromaculatus*	Tolerant	47			24		3		5	34	1	
Cutlips minnow	*Exoglossum maxillingua*	Moderate		1		4	2				2	25	
Eastern mudminnow	*Umbra pygmaea*	Tolerant									2		
Eastern silvery minnow	*Hybognathus regius*	Moderate		7	22	3	1		6			70	8
Fallfish	*Semotilus corporalis*	Moderate						11				6	
Fantail darter	*Etheostoma flabellare*	Moderate										1	
Fathead minnow	*Pimephales promelas*	Tolerant						1					
Gizzard shad	*Dorosoma cepedianum*	Moderate					1						
Golden redhorse	*Moxostoma erythrurum*	Moderate							2				
Golden shiner	*Notemigonus crysoleucas*	Tolerant							8				
Goldfish	*Carassius auratus*	Tolerant						1					

Common Name	Scientific Name	Tolerance Level	01.Indian Creek-I95	03.Northwest Branch	05.Paint Branch	07.Paint Branch	09.Sligo Creek	10.Chillum Rd Trib	11A.Indian Creek	11B.Indian Creek	12.Little Paint Br.	13.Lower NW Branch	15.Northeast Branch
Green sunfish	*Lepomis cyanellus*	Tolerant		8	1				2	3	16	2	15
Hybrid (Green Sunfish/Bluegill)	*Lepomis*				1								
Hybrid (Sunfish)	*Lepomis*		3										
Lamprey (sp)		Intolerant		13								3	
Largemouth bass	*Micropterus salmoides*	Moderate		1					4	3			2
Least brook lamprey	*Lampetra aepyptera*	Intolerant		3						2		6	
Longnose dace	*Rhinichthys cataractae*	Moderate	6		46	87	27	14	81	41	116	17	
Mummichog	*Fundulus heteroclitus*	Moderate	9						1	5	73	1	
Northern hogsucker	*Hypentelium nigricans*	Intolerant		3	5	3	3		6	7	1	87	
Pumpkinseed	*Lepomis gibbosus*	Moderate		9			5	1	52	6	1		44
Redbreast sunfish	*Lepomis auritus*	Moderate		108	8	17	81	2	15	43	33	109	30
Rosyside dace	*Clinostomus funduloides*	Intolerant	12			4							
Satinfin shiner	*Cyprinella analostana*	Moderate		23	8	14	38	74	27	10	26	59	
Sea Lamprey	*Petromyzon marinus*			3	2				1	6	4	9	
Slimy Sclupin	*Cottus cognatus*	Intolerant				2							
Smallmouth bass	*Micropterus dolomieu*	Moderate		2								1	
Spottail shiner	*Notropis hudsonius*	Moderate		18	35	5	143		55	17	10	328	2
Swallowtail shiner	*Notropis procne*	Moderate		45	43	8	40	167	19	17	98	213	
Tessellated darter	*Etheostoma olmstedi*	Moderate	4	52	88	8	30	4	46	43	26	67	23
White sucker	*Catostomus commersoni*	Tolerant	3	57	2	1	148	41	3	11		99	19
Yellow bullhead	*Ameiurus natalis*	Tolerant		14	10	26	8		11	3	15	7	4
Yellow perch	*Perca flavescens*	Moderate							2				
Species Richness (S)			**10**	**21**	**19**	**17**	**18**	**15**	**25**	**20**	**21**	**26**	**14**
Sum (total fish per site)			**141**	**450**	**383**	**375**	**747**	**529**	**447**	**309**	**875**	**1458**	**242**

A-4: Hazardous, Toxic, and Radioactive Waste Summary

Hazardous, Toxic, and Radioactive Wastes Summary Report

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 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 for the ten study sites considered (these include sites 1, 3, 5, 7, 9, 10, 11, 12, 13, and 15). A summary of the search for these sites is provided below; however, based on selection criteria discussed in the main report, only six sites, sites 3, 9, 13, 5, 11, and 15, are included in the plan recommending sites for detailed engineering design. These sites are denoted below with an asterisk (*).

Follow-up actions, primarily consisting of web searches and mapping, were performed to determine if HTRW concerns actually existed in close enough proximity to the study reaches to pose a concern. Additionally, coordination with agencies, including Maryland Department of the Environment for inquiries regarding potential groundwater wells in the area, and USEPA for information on the University of Maryland (UMD) landfills (described below) was conducted. A summary of the EDR reports is included below. Supporting documentation can be provided upon request.

Evaluation of these reports and appropriate follow-up coordination indicates that the only site with a potential HTRW concern is Paint Branch (site 5) adjacent to UMD in College Park. Attachments to this summary include further information on this site.

Site Summary

Indian Creek, Site 1

There are six sites listed in the Environmental Data Resources (EDR) report that were identified as potentially posing an environmental risk. Upon further review, these sites were determined to have no impact on project activities. Individual sites were either located at too great a distance from the project reach to have an impact, or the environmental cases have been closed.

Paint Branch, Site 7 and Little Paint Branch, Site 12

Five sites were listed in the EDR report in the area of these two project sites. The Beltsville Agricultural Research Center (BARC) and U.S. Army Garrison, Adelphia Laboratory are both included in these sites as producers of hazardous waste. No sites near this reach are expected have an impact on the project, as they are either located too far away from the project reach, or the timeframe for possibly incurring an impact has passed.

Indian Creek College Park, Site 11*

The EDR report found four potential sites in the College Park section of Indian Creek. The environmental cases for two potential sites are closed and were determined to pose no risk. A portion of the BARC facility is just north of the project reach, but it is not likely to impact the project. There are water supply wells located close to the project streams, which will be considered and avoided during construction activities.

Paint Branch, Site 5* and Northeast Branch Calvert Road, Site 15*

The University of Maryland Environmental Services Facility manages hazardous waste and waste oil for the College Park campus. The university is responsible for several landfills, three of which are located near the project reach (Landfill Areas 1B, 1C and 3A). An EPA report for a remediation project at the University of Maryland is attached. The selected remedy for groundwater contamination is natural attenuation and no further remediation has been determined to be necessary. Activities such as excavation, grading and dewatering should be coordinated with the University prior to beginning the project. No residual soil or ground water contaminants present a risk to human or environmental health. See attachments for further information on remedial actions at this site.

Sligo Creek, Site 9*; Northwest Branch Hyattsville, Site 3*; and Chillum Road Tributary, Site 10

These three reaches contain three points of interest. These points include an underground storage tank with no known releases located at the apartment complex close to site 9. Near site 3, a release of heating oil occurred in 2007 that was remediated. Groundwater wells may be located in close proximity to the project reaches, and will be taken into account during project planning and construction.

Northwest Branch Riggs Road, Site 13*

There are several underground storage tanks with known past releases in close proximity to the stream reach. However, these incidents have been remediated per MDE requirements. Wells exist within a one mile radius and should be avoided during project construction.

A-5: Cultural Resources Evaluation

Tentatively Selected Project Sites for Stream Restoration in Prince George's County, MD
Potential Effects to Historic Properties and Recommendations
December 2015

This document contains information gathered for the preliminary cultural evaluation of project sites within the recommended plan. Record reviews, including review of all available existing information from the Maryland Historic Trust (MHT), field visits were performed to conduct this evaluation. Some limited field evaluation will be required as described below. Supporting documentation for this evaluation is available upon request. Coordination with MHT is shown in Appendix C.

3. Northwest Branch, Hyattsville

Proposed Action

In-stream restoration

Known Resources

Several archaeological surveys have been done on portions of the project area, though none completely encompass it. The portion of the study area north of Hwy 410 has already been surveyed in 1994 by USACE. The survey did not identify anything within the project area. Two Phase I archaeological surveys were completed for the construction of the Metrorail E Route (Green/Yellow Line) where it crosses the Northwest Branch, south of the Northwest Branch's junction with Sligo Creek (Taylor 1980, Anderson 1981). A prehistoric site, 18PR212 (Surface Collection C), was recorded during the survey nearby, but is not within the current project area. It is uncertain if this site has been evaluated for National Register eligibility. No historic or prehistoric sites were identified in the portion of the project area that is located within these survey areas. Finally, a 1993 survey was completed by Gibb and Creveling for the Anacostia Tributaries Trail construction. This survey covered the project area from Queens Chapel Rd to approximately Hwy 410. They identified one site, a bridge approach for the Washington, Westminster, and Gettysburg Railroad (18PR432). This 750ft early 20th century feature was for a bridge that was never constructed and is in the northern portion of the project area near Ager Rd. It is uncertain if this resource has been evaluated for National Register eligibility. There is one architectural resource in the project vicinity, WRC Radio Station (PG65-17), but it will not be affected by the proposed action because the proposed work will not be visible from the building. It is uncertain if the building has been evaluated for National Register eligibility.

USACE and Gibb and Creveling found the stream to suffer from extensive erosion, run-off from increased development, utility line construction, and frequent flooding episodes before the flood control projects of the mid-20th century, all of which may have affected cultural resources along its banks.

Potential Effects and Recommendations

The in-stream restoration will be confined to in between the stream banks, and will not result in an adverse effect on cultural resources. Any access roads or staging areas will not include subsurface excavation.

5. Paint Branch

Proposed Action

In-stream restoration

Known Resources
There is one historic architectural resource and one archaeological site adjacent to the project, and two archaeological sites in the project vicinity. The College Park Airport (PG66-4), located adjacent to the stream, is listed on the National Register. The Baltimore Goldfish Co. (18PR262) is also adjacent to the project site (Cheek 1985). There is an early 20th century power plant (18PR261; Cheek 1985) and a Late Woodland village site (18PR237; Potter 1980) near the proposed project area, but none of these resources will be affected by the proposed action because the proposed work will not be visible from the building, and the site will not be disturbed. It is uncertain if any of these resources, other than PG66-4, have been evaluated for National Register eligibility.

Potential Effects and Recommendations
The in-stream restoration will be confined to in between the stream banks, and will not result in an adverse effect on cultural resources. Any access roads or staging areas will not include subsurface excavation.

9. Sligo Creek
Proposed Action
In-stream restoration

Known Resources
Gibb and Creveling (1993) surveyed the eastern bank of the project area for the Anacostia Tributaries Trail construction on Sligo Creek. They did not find any historic properties that could be affected. Evans (1978) did an archeological survey for Sligo Creek Relief Sewer construction, but the only sites it identified are outside of the proposed project area. The project is within the Sligo Creek Parkway historic site (PG65-25), which will need to be considered before the project is implemented. PG65-25 is a National Register eligible resource.

Potential Effects and Recommendations
The in-stream restoration will be confined to in between the stream banks, and will not result in an adverse effect on cultural resources. Any access roads or staging areas will not include subsurface excavation. . Sligo Creek and its surrounding floodplains are two of the components of the National Register listed Sligo Creek Parkway. Restoration of the stream will result in an effect on the Sligo Creek Parkway historic site, but the effect will not be adverse since the stream bank will be protected and preserved.

11. Indian Creek, College Park
Proposed Action
Some floodplain and in-stream restoration including the creation of two ponds and controlled flooding to recreate historic wetlands.

Known Resources
There are no recorded archaeological sites or archaeological surveys in the project area, though there are two architectural resources nearby, the Graves-Keleher House (PG67-23) and the

Kleiner-Dillon House (PG67-17). It is uncertain if either of these resources have been evaluated for National Register eligibility. Neither of these resources whould be affected by the proposed action, because the proposed work will not be visible from the buildings.

Potential Effects and Recommendations
Because the creation of two ponds in the floodplain would require subsurface excavation, a more in-depth look at these areas will be required including fieldwork. The controlled low velocity flooding for wetland creation should not be an adverse effect requiring further investigation as it is already within the stream's floodplain and subject to intermittent submersion. No subsurface excavation will be needed to restore the historic surface wetland flooding. The in-stream restoration will be confined to in between the stream banks, and will not result in an adverse effect on cultural resources. Any access roads or staging areas will not include subsurface excavation.

13. Northwest Branch, Riggs Rd
Proposed Action
In-stream restoration

Known Resources
The USACE 1994 survey covers the entire proposed Project area. The survey found evidence of extensive scouring of the stream bed, erosion of the stream banks, and frequent flood episodes (especially before the flood controls of the 20th century). They found no prehistoric or historic sites located within the project area.

There is one prehistoric site (18PR417) divided by an intermittent stream north of Lyndon St (Simmons and Kassner 1991), a historic artifact scatter (18PR1035) (Proper 2012), and a Late Archaic short-term resource procurement site (18PR76) (Goldsmith 1971) near the project area, but these sites are far enough away to be unaffected by the proposed action. It is uncertain if any of these sites have been evaluated for National Register eligibility.

Potential Effects and Recommendations
The in-stream restoration will be confined to in between the stream banks, and will not result in an adverse effect on cultural resources. Any access roads or staging areas will not include subsurface excavation.

15. Northeast Branch
Proposed Action
Some floodplain and in-stream restoration including some contouring in the floodplain along a small tributary.

Known Resources
There are two historic resources adjacent to the project area, the Maryland-National Capital Park and Planning Commission: Department of Parks & Recreation Regional Headquarters (PG68-101) and College Park Airport (PG66-4). It is uncertain if either of these resources have been evaluated

for National Register eligibility. Both sites are far enough away that they will not be affected by the proposed action.

Cheek (1985) conducted a Phase I archaeological survey for the relocation of Calvert Rd which crossed the Northeast Branch. It identified 18PR256, Walker-Cross Mill, at the confluence of Brier Creek and Paint Branch on the east bank. All that is left of the site is a potential mill race which should be near the proposed project area. There was also a Washington East MHT Quad File Note (3) that, as of 1973, many small finds had been identified in gardens and in the park in the vicinity of the Calvert Rd Bridge. It is uncertain if either of these resources have been evaluated for National Register eligibility.

Potential Effects and Recommendations

The potential floodplain contouring portion of the project along the stream bank could result in an adverse effect to previously unidentified archaeological resources. Fieldwork will be necessary to determine the presence or absence of archaeological sites. The in-stream restoration portion of this project will be confined to in between the stream banks, and will not result in an adverse effect on cultural resources. Any access roads or staging areas will not include subsurface excavation.

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1991 Phase I Archaeological Survey of the Lyndon Street Stormwater Retrofit Project Area, Prince George's County, MD. Greenhorne & O'Mara, Inc.

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Ward, Jeanne A. and Antonia M. Davidson
2005 A Phase I Archaeological Investigation of the Mazza Property, Prince George's County, MD (Preliminary Plan #4-04104). Applied Archaeology and History Associates, Inc.

Washington East Quad File Note 3
1973 Maryland Historical Trust.

Webb, Dennis
1972 Local collector, reported site 18PR87 to Maryland Geological Survey.

Maryland Historical Trust Site Forms:

Baltimore Goldfish Co. (18PR262)
The Beltsville Agricultural Research Center (PG62-14)
College Park Airport (PG66-4)
Graves-Keleher House (PG67-23)
Kleiner-Dillon House (PG67-17)
Maryland-National Capital Park and Planning Commission: Department of Parks & Recreation Regional Headquarters (PG68-101)
Sligo Creek Parkway (PG65-25)
WRC Radio Station (PG65-17)

A-6: Prior Reports (Table)

The table below contains a list of USACE reports related to recommended projects in the Anacostia River watershed.

Date	Document or Annual Report	Subject	Recommendations or Action
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
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 improvement desired
1935	House Doc 22-74/1	Washington Harbor project including Anacostia River channel to 2,100 feet above Anacostia Bridge	Concurred 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 modification
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 for Modify Existing Corps Project

Date	Document or Annual Report	Subject	Recommendations or Action
1993	Section 1135 Report	Habitat Restoration	Requested Authorization for Modify Existing Corps Project
1994	Integrated Feasibility Report and Final EIS Section 206 Report	Anacostia River and Tributaries DC and MD for	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 cost share feasibility study for fish and wildlife habitat restoration
2001	Section 1135 Preliminary Restoration Plan	Marsh Restoration at Heritage Island	Recommended cost share feasibility study for fish and wildlife habitat restoration
2001	Section 206 Preliminary Restoration Plan	Habitat Restoration at Fort Chaplin and Fort DuPont	Recommended cost share feasibility study for fish and wildlife habitat restoration
2002	Section 1135 Preliminary Restoration Plan	Habitat Restoration on Lower Kingman Island	Recommended cost share feasibility study for fish and wildlife habitat restoration
2002	Section 206 Preliminary Restoration Plan	Paint Branch Anadromous Fish Passage and Stream Restoration	Recommended cost share feasibility fish habitat
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	Received funding to construct Heritage Island Marsh
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

A-7: Anacostia Restoration Plan Candidate Restoration Projects

Anacostia Restoration Plan Candidate Restoration Projects

As part of the Anacostia Restoration Plan, a provisional restoration project inventory of potential restoration opportunities was completed for each of the 14 primary subwatersheds and tidal river reach. Restoration opportunities, including stream, wetland and riparian restoration options; fish blockage concerns; stormwater retrofits; and trash reduction opportunities were identified. A provisional restoration project inventory was cataloged based on these restoration strategies. The effort included a systematic evaluation of existing information using GIS and as well as field verification. Over 3,000 potential restoration opportunities were identified (for more information on these projects and plan formulation see http://www.anacostia.net/maps/Data_download.php).

Of the projects identified, 396 potential aquatic ecosystem restoration projects in Prince George's County were considered as potential restoration opportunities that USACE could implement. USACE evaluation 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. Although the projects evaluated in this feasibility study were formulated primarily for aquatic habitat restoration and fish blockage removal, wetland restoration/creation and invasive species removal are considered secondary benefits. Stream restoration will reconnect streams with their floodplain, thereby restoring the functional processes required for the reestablishment of wetlands. In addition, the project will capitalize on opportunities to remove invasive species and restore riparian forests as appropriate. The plan recommended in this feasibility report addresses 14 Anacostia Restoration Plan (ARP) candidate restoration projects (CRP). A brief description of each of these projects is found below.

ARP CRP ID	USACE Project Site	General Description
NW-L-02-SR-2	3	Stream channel morphology restoration, in-stream habitat enhancement
NW-L-04-F-10	3	Fish blockage removal
PB-L-03-W-2	5	Wetland enhancement
PB-L-02-SR-10	5	Stream channel morphology restoration
PB-L-02-SR-6	5	Stream channel morphology restoration
SC-L-04-F-1	9	Fish blockage removal/riffle grade control removal - ~12 inch high sheet pile weir
SC-L-03-W-1	9	Wetland creation
SC-L-03-W-2	9	Wetland creation
IC-L-02-SR-5	11	Soft bottom channel creation, in-stream habitat enhancement
IC-M-05-R-2	11	Invasive species removal
IC-L-03-W-3	11	Vernal pool creation/enhancement
IC-L-02-SR-1	11	Stream channel morphology restoration, in-stream habitat enhancement
IC-L-05-R-5	11	Riparian reforestation
IC-L-05-R-6	11	Riparian reforestation

Appendix B. Plan Formulation and Environmental Benefits Model Appendix

DEPARTMENT OF THE ARMY
MISSISSIPPI VALLEY DIVISION, CORPS OF ENGINEERS
P.O. BOX 80
VICKSBURG, MISSISSIPPI 39181-0080

REPLY TO
ATTENTION OF:

CEMVD-PD-N 22 January, 2015

MEMORANDUM FOR CECW-NAD (Shuman)

SUBJECT: Recommendation for Single Use Approval of the MBSS Physical Habitat Index and MCDEP Rapid Habitat Assessment for the Montgomery County and Prince George's County Anacostia Watershed Ecosystem Restoration Feasibility Studies.

1. References:
   a. Engineering Circular 1105-2-412: Assuring Quality of Planning Models, dated 31 March 2010.

   b. US Army Corps of Engineers. Assuring Quality of Planning Models - Model Certification/Approval Process: Standard Operating Procedures. February 2012

   c. Model Approval Plan, Maryland Biological Stream Survey Habitat Assessment and Physical Habitat Index and Montgomery County Water Quality Monitoring Program Rapid Habitat Assessment, dated 11 April 2014 (Enclosure 1)

   d. Anacostia Watershed Assessment Model Documentation, October 2014 (Enclosure 2).

   e. Physical Habitat Assessment spreadsheet (Enclosure 3)

   f. Model Review Comment Response Record (Enclosure 4).

   g. Maryland Department of Natural Resources. 2003. A Physical Habitat Index for Freshwater Wadeable Streams in Maryland. Final Report. Chesapeake Bay and Watershed Programs. Monitoring and Non-tidal Assessment. CBWP-MANTA-EA-03-4.

   h. Maryland Department of Natural Resources. 2013. Sampling Manual: Field Protocols. Rev. Jan. 2013. Maryland Biological Stream Survey. Chesapeake Bay and Watershed Programs. Monitoring and Non-tidal Assessment. CBWP-MANTA-EA-07-01. 63 pages.

   i. Montgomery County Department of Environmental Protection. 1997. Montgomery County Water Quality Monitoring Program: Stream Monitoring Protocols.

   j. Montgomery County Department of Environmental Protection. Online. Accessed 23 October 2013. *Biological Monitoring Program* Design.

2. The National Ecosystem Restoration Planning Center of Expertise (ECO-PCX) evaluated the Maryland Biological Stream Survey Habitat Assessment and Physical Habitat Index (PHI) and Montgomery County Water Quality Monitoring Program Rapid Habitat Assessment (RHA) in accordance with References 1.a., 1.b., and the Model Approval Plan (Encl. 1). Based on the results of the evaluation, the ECO-PCX recommends single use approval of the PHI and RHA for the Anacostia Watershed Assessment Studies in Montgomery and Prince George's Counties, Maryland. Please log in this recommendation with the Office of Water Project Review for consideration by the Model Certification Team.

3. The Maryland Biological Stream Survey (MBSS) assesses the status and trends in the water chemistry, physical habitat, and biological condition of wadeable, non-tidal streams in Maryland. The MBSS has been collecting a variety of physical habitat measures for streams in the State since 1994. In 1999, the MBSS developed a provisional Physical Habitat Index (PHI) to synthesize those parameters into a single multimetric indicator of physical habitat quality. MBSS revised, updated, and finalized the PHI in 2003 (Reference. 1.g.), the latest field manual was published in 2013 (Reference 1.h.).

   Montgomery County Department of Environmental Protection (MCDEP) employs similar methods to assess local water quality conditions in the Rapid Habitat Assessment (RHA; References 1.i. and 1.j.) at more locations, and is therefore able to contribute finer-scale data to the State, which can be used to protect statewide water resources and the Chesapeake Bay. Within Montgomery County, the combined MBSS and MCDEP dataset is utilized in permitting and planning decisions. The data have been used to characterize the importance of numerous stressors upon aquatic life, and has identified thresholds of urban land use, percent impervious cover, acid pH, conductivity, and other variables applicable to streams in Maryland, including by County.

4. The ECO-PCX reviewed the technical quality, system quality and usability of the PHI for use in Prince George's County and the RHA for use in Montgomery County following procedures described by the Anacostia Watershed Assessment Procedures (Encl. 2 and 3). The review was conducted by Elliott Stefanik (MVP) and Dr. Bruce Pruitt (ERDC), and was managed by Dr. Charles Theiling (MVD). There were 14 comments including 3 critical comments (Enclosure 4). The comments addressed model documentation, scoring, normalization, reference sites, model sensitivity, and inclusion of appropriate parameters.

5. Model review comments were addressed to the satisfaction of the ECO-PCX. Model documentation was integrated into a single, project-specific procedures manual to help clarify methodology (Encl 2). Scores for the separate metrics were calculated using the State of Maryland methods and were then normalized and indexed on a 0 to 1 scale to provide a common scale for comparison. Reference sites and recommendations for using water quality parameters were addressed by more clearly identifying supporting background information. Scoring is sensitive to embeddedness and remoteness parameters. Sensitivity of model

outputs to these parameters should be considered during model application and reviewed during ATR.

6. The models facilitate forecasting of the future with- and without-project conditions due to their focus on physical parameters, and the assumptions used in creating the model are valid and supported in the literature. The underlying theory and relationships in the models reflect fundamental fluvial geomorphological principles which hold true and are valid in piedmont and coastal plains streams. The PHI and RHA provide indicators of habitat quality by measuring those physical factors which are known to affect fish communities. The RHA and PHI have been applied within the county and state, respectively, and were subsequently validated by empirical studies, showing a consistent relationship between model parameters and stream quality in the Anacostia River Watershed. The metric scoring criteria, formulas, and aggregations used to calculate final PHI and RHA scores are scientifically and mathematically valid within the range of conditions expected in the Anacostia River Watershed. Finally, the models comply with USACE policies, guidance, and procedures. The outputs can be readily used within our alternative evaluation, comparison, and selection process, and the model does not calculate non-ecological outputs.

7. The PHI has sufficient technical and system quality and usability. The PHI relies on field data sheets and quantitative formulae derived by Maryland DNR following common bio-assessment protocols. A spreadsheet incorporating best spreadsheet practices was developed by USACE Baltimore District to calculate the PHI score. The formulas used to calculate index scores are biologically accurate, computed in a straightforward manner, and computationally correct within the expected range encountered in the Anacostia River Watershed. Input scores, calculations, and output scores should be documented and ATR teams should be charged with reviewing the inputs, outputs, and checking computational correctness of model application. The remoteness parameter can have particularly strong influence on the model, but is not appreciably affected by project alternatives. Embeddedness also exerts a strong influence on the model and should be considered carefully by PDTs and ATR teams. Scores beyond the expected range can be encountered and should be reported to Maryland DNR as unique conditions.

   The PHI, which can be implemented statewide in Maryland piedmont streams, has acceptable usability in that the scoring of metrics and calculating an overall score is simple, and output interpretation is straightforward. Data required for input is available through field collection surveys. Model output is normalized to a score from 0-100, which is easily understandable. Scoring is rescaled on a 0 to 1 index to provide uniform and useful information in determining habitat quality to support habitat benefit evaluations.

8. The RHA has sufficient technical quality and usability. The RHA relies on field data sheets and hand calculations (i.e., no software currently exists) to produce an index score. However, the method used to calculate index scores is biologically accurate, computed in a straightforward manner, and computationally correct. Input scores, calculations, and output

scores should be documented and ATR teams charged with reviewing the inputs, outputs, and ensuring computational correctness during application of the model.

The RHA, which can be implemented in Montgomery County only, has acceptable usability in that the scoring of metrics and calculating an overall score is simple, and output interpretation is straightforward. Data required for input is available through field collection surveys. Model output is a score from 0-200, which is understandable. Scoring is rescaled on a 0 to 1 score to provide uniform and useful information in determining habitat quality to support habitat benefit evaluations.

9. The PHI and RHA are comparable metrics when transformed to habitat suitability scores fitting a 0 – 1 scale. Changes in habitat suitability due to restoration would be expected to increase habitat suitability index scores and provide higher habitat unit benefits in restoration project areas.

10. MBSS and Montgomery County require training or certification to implement PHI and RHA.

11. In summary, the ECO-PCX finds the Maryland Biological Stream Survey Habitat Assessment and Physical Habitat Index and Montgomery County Water Quality Monitoring Program Rapid Habitat Assessment meet the technical and system quality criteria, meet usability criteria for Anacostia Watershed Assessment following the procedures developed for the project, and complies with USACE policy and guidance. It is the recommendation of the ECO-PCX that the models be approved for single use on the Anacostia Watershed Restoration Studies. ATR teams assigned to projects using the RHA and PHI should be charged with reviewing the application of the model and checking computational correctness of outputs. Please notify the ECO-PCX of the findings of the Model Certification Panel.

Encl (4)

Marshall Plumley
Operating Director, Ecosystem Restoration
Planning Center of Expertise

CF (w/ enclosures):
CECW-PC (Coleman, Matusiak, Trulick, Ware, Bee)
CECW-PB (Carlson)
CECW-CP (Hughes)
CECW-NAD (Hannon, Wimbrough)
CENAD-PD (Vietri, Weichenberg, Henn, Jones)
CENAB-PL (Bierly, Guise, Roach, Spaur, Sowers)
CENAB-PP-C (Nolta, Gross)
CEMVD-PD-N (Wilbanks, Lachney, Young, Plumley)
CEMVP-PD-P (Richards, Theiling)

Anacostia Watershed Assessment Plan Formulation and Environmental Benefits Model Appendix

April 2016

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INTRODUCTION

This appendix provides details specific to the plan formulation of the study to support the information provided in the main report. Information contained in this appendix includes:

1. Details on sites considered and the final sites selected for analysis in the study,
2. The procedures used to quantify environmental benefits,
3. Field data sheets for habitat assessments, and
4. Results of model runs to quantify environmental benefits.

In fall 2013, Baltimore District, U.S. Army Corps of Engineers (USACE) began documenting biological benefit models for approval by USACE Headquarters. The proposed models utilize existing methods of the Maryland Biological Stream Survey (MBSS data) and are applicable within the Anacostia Watershed in Prince George's County. These methods characterize changes in aquatic habitat conditions that could be produced by stream geomorphic restoration projects. MBSS has published habitat and biological condition assessment procedures, and has collected data in the study area since the 1990s using these methods. The methodology and metrics in MBSS are based on USEPA rapid bioassessment methodology (Barbour et al. 1999).

MBSS developed its Physical Habitat Index (PHI) for three geographic regions in Maryland: Piedmont, Coastal Plain, and Highlands. For this study, Piedmont and Coastal Plain models are utilized and are applicable within the Anacostia Watershed (in appropriate geomorphic areas) in Prince George's County. PHI will be utilized in Prince George's County because MBSS protocols and metrics are also utilized by Prince Georges County in their biological monitoring programs. Furthermore, statewide MBSS datasets include Prince George's Counties, but the data network is less dense than county datasets.

SITE SELECTION

Table 1 provides a summary of the reaches considered and identifies those eliminated from further consideration for this study. Table 2 includes field and office notes on general habitat condition and potential restoration opportunities at the study sites selected for further consideration. Section 3 of the main report details the specific site selection criteria used for consideration or elimination of the sites.

Table 1. Summary of Sites Considered and Selection

Map No.	Reach	Subwatershed	Current Status	Length (ft)	Notes
1	Indian Creek – I-95	Indian Creek	Selected	6,958	Multiple opportunities for stream and wetland restorations between I-95 and Beltsville. Restoration potential may be impacted by regional stormwater facility. This entry only includes "selected" portion of reach.
1	Indian Creek Upstream of –I-95	Indian Creek	Eliminated	6,911	Upstream of I-95 eliminated due to disconnection from rest of stream by large culverts; downstream section eliminated due to large concrete channels.
2	Lower Beaverdam Creek – Cabin Branch	Lower Beaverdam Creek	Eliminated	26,689	Upper half of reach is very constrained with real estate and fish movement is constrained by lower half of reach which is compromised by legacy pollutants and land use. Issues identified by field team.
3	Northwest Branch – Hyattsville	Northwest Branch	Selected	7,644	Partial fish blockage identified by MWCOG. Influences confluence of Sligo Creek. Large restoration project directly upstream in design by Prince George's Count. Multiple small projects completed in reach; opportunity to tie projects together. Small AWS project in reach may be incorporated into design.
4	Northwest Branch – Upstream of University Blvd	Northwest Branch	Eliminated	10,114	Habitat/geomorphic conditions are very good in reach and potential restoration actions would likely have little impact.
5	Paint Branch	Paint Branch	Selected	5,879	Immediately downstream of Paint Branch CAP Section 206 project. Long identified as priority by MNCPPC, MWCOG, and Prince George's County. Connects restoration activities from confluence with Little Paint Branch to confluence with Indian Creek.
6	Dueling Creek/Colmar Manor Wetlands	Tidal	Eliminated	N/A	Tidal wetland restoration with small restoration potential.
7	Paint Branch – I-95 Interchange	Paint Branch	Selected	5,935	Eroded stream banks. Opportunity to decrease erosion and instability where not bedrock controlled. Entirely under highway bridges. Difficult access.
8	Cross Creek	Little Paint Branch	Eliminated	8,553	Crosses many private parcels and is through a golf course. Immediately downstream of ICC detention basins.
9	Sligo Creek	Sligo Creek	Selected	2,330	Fish passage issue with in-stream restoration potential.
10	Chillum Road Tributary	Northwest Branch	Selected	2,226	Provides opportunity for comprehensive restoration with Northwest Branch main

Map No.	Reach	Subwatershed	Current Status	Length (ft)	Notes
					stem. Evident channel incision and erosion. MWCOG suggested site.
11	Indian Creek – College Park	Indian Creek	Selected	9,843	Opportunity to increase stream habitat heterogeneity (mix of pools, riffles, runs) where degraded by channelization.
12	Little Paint Branch	Little Paint Branch	Selected	4,389	Directly upstream of ICC mitigation project at Paint Branch/Little Paint Branch confluence. Opportunity to increase stream habitat heterogeneity (mix of pools, riffles, runs) where degraded by channelization. Channel incision and erosion evident. Good access.
13	Northwest Branch: East-West Highway to Fordham Road	Northwest Branch	Selected	2,953	Already partially designed by Prince George's County. Proposed Purple Line may run on road above project site. Cultural resources surveys already performed and clear for this area. Project designed for reach at Fordham Road into Northwest Branch.
14	William Wirt Middle School	Briers Mill Run	Eliminated	2,797	Sewage evident in water. Extremely unstable. Good opportunity for restoration, but unrealistic given needs to address sewage issues. AWS stormwater project at Middle School. This segment is a side tributary to the Northeast Branch.
15	Northeast Branch: Calvert Road Disc Golf Park	Northeast Branch	Selected	5,323 (includes approx. length for side tributary up to UMD property)	On public land. Would provide connectivity with other restoration already targeted in Paint Branch #5 (1.1 mi) and Indian Creek #11 (1.86 mi) segments. The addition of this segment will link up with approximately 5.3 miles of Paint Branch either already designed for or planned under the ARP for targeted stream restoration. This 0.7 miles is a critical junction along the main stem of the Northeast Branch downstream at the confluence of Indian Creek and Paint Branch.
16	Dueling Creek	Tidal	Eliminated	8,641	Highly urbanized, entrenched, incised, and eroded. Upstream reach underground, tidal area is stable. Limited restoration potential given stream crossings/culvert/paving and real estate issues. Abundant trash. Too many issues for restoration success.
17	Quincy Manor	Northeast Branch	Eliminated	3,096	Previously studied and designed by Prince George's County. Issues with real estate/access.
18	Indian Creek: Calvert Road Disc Golf North	Indian Creek	Eliminated	2,335	Habitat/geomorphic conditions are good in reach and potential restoration actions would likely have little impact.

Table 2. Prince George's County Selected Stream Segments General Habitat Condition Description and Implications for Assessment. All segments are situated in the Coastal Plain unless otherwise noted.

USACE Segment	General Location (up to down)	General Habit Condition Segment Scale [Review of Google Earth Photos, linear measurements in Google Earth (i.e., not following thalweg) plus previous site visit]	Wetlands Along Candidate Segment (NWI Map Review)	Habitat Restoration Opportunities and Needs	Habitat Assessment and Restoration Project Issues/Uncertainties
1	Indian Creek I95 (I95 to Caroline/Quimby Aves)	Lowermost 0.3 mi reach is mature riparian forest. Stream apparently had braided condition previously based on aerial photos and site visits, unclear whether braided condition occurred over historical or geologic time. Small ponds near Caroline Avenue neighborhood on W side of stream with levee system. Middle reach downstream of Ammendale Rd by 0.1 to 0.3 mi passes through FRM/SWM basin and outfall structures. Some downcutting downstream of outfall. Substantial physical alteration. Channelized downstream of FRM feature, very altered within feature. Uppermost 0.6 mi (Rt 95 – Ammendale Rd) entirely wooded. In photos appears to also have multiple braided/anastomosing stream segments present historically or over geologic time (similar to lowermost reach). Stream ditched /straightened on E side of wetland. No erosion observed in wetland, ideal stream floodplain interaction.	Uppermost segment above Ammendale Rd is mapped as PFO/PSS wetland parcel up to about ½ way to 95. On site visit, observed large wetland area with water level controlled by beaver pond just upstream of Ammendale Rd. PEM wetland mapped along stream midway between Ammendale and Quimby	In uppermost reach above Ammendale Rd could increase sinuosity of stream in wetland to restore instream habitat and increase stream/wetland interaction, but would need to maintain water supply to wetland from creek Below FRM/SWM feature, increase habitat complexity in ditched stream down to point where stream meandering again occurs.	(Did not visit uppermost reach immediately below route 95, however presumably woods as per lower end of segment above Ammendale Rd) Eliminate consideration of portion within uppermost FRM/SWM feature because of mission limits? Would be worried about environmental trade-offs of stream restoration project in lowermost reach (mature forest impacts). Uppermost reach would have wetlands impacts, however could be net positive for wetland. Possible private property concerns in uppermost reach.
3	Northwest Branch Hyattsville (Ager	Majority of segment channelized historically.	No wetlands mapped (11/14/14)	Increase stream habitat heterogeneity (mix of riffles,	

USACE Segment	General Location (up to down)	General Habit Condition Segment Scale [Review of Google Earth Photos, linear measurements in Google Earth (i.e., not following thalweg) plus previous site visit]	Wetlands Along Candidate Segment (NWI Map Review)	Habitat Restoration Opportunities and Needs	Habitat Assessment and Restoration Project Issues/Uncertainties
	Rd to Queens Chapel Rd (Rt 500))	Uppermost reach above 410 channelized but no stabilization. Remains in earthen channel. Fill placed along channel though did include concrete rubble which now has mature trees growing out of it. Habitat simplified in channelized reach, but naturally developing multistage channel in bottom. However, large dewatered channel area (bars) lacking vegetation presumably because of frequent scour. Also, presumably pools would be deeper if channel narrower. Below this but still above 410, stream not channelized (or if it was, they left meanders in). Severe erosion on cut banks there with occasional deep pools at woody debris jams but also braided sections at sediment jams. Then stabilized in vicinity of 410. Then below 410, not channelized (or if it was, they kept meanders) nor stabilized. As with reach above 410 not channelized, severe erosion on cut banks, with large woody debris jams and braided sections. Based on field observations, stream is then downstream stabilized with boulders but not channelized, forming deep pools. Locally severe erosion where not stabilized. Downstream		runs, pools, velocities, and depths). Habitat degraded (homogenized) by channelization. Decrease locally severe erosion/instability	

USACE Segment	General Location (up to down)	General Habit Condition Segment Scale [Review of Google Earth Photos, linear measurements in Google Earth (i.e., not following thalweg) plus previous site visit]	Wetlands Along Candidate Segment (NWI Map Review)	Habitat Restoration Opportunities and Needs	Habitat Assessment and Restoration Project Issues/Uncertainties
		channelized with mix of gabion baskets and boulders, again forming deep pools, but not eroding. Downstream, stream channelized and stabilized but stabilization partially buried by channel parallel deposits.			
5	Paint Branch (Rt 1 to Indian Creek confluence)	Historically channelized. Spoil placed parallel to channel along much of stream based on presence of channel-parallel levees. Stream remains primarily in earthen channel with minimal stabilization. Boulder stabilization occurs in vicinity of sewer infrastructure and bridges. Latter include Route 1, two pedestrian trails, and dual railroad tracks. Riffle grade control boulder stabilization features occur immediately downstream of lower pedestrian bridge. Bank heights vary along channel, presumably as function of natural topography and extent of overbank spoil placement. Stream habitat simplified by historic channelization. Long reaches with homogeneous conditions occur where earthen channel occurs. Drastically different conditions occur in vicinity of woody debris jams where heterogeneous but unstable conditions occur. In vicinity of boulder stabilization works, stream is typically wider and has greater depth.	Majority of stream riparian corridor mapped as PFO wetlands. Large PFO parcel to N of stream S of RR tracks. PFO on both sides of stream in large parcel between Route 1 and RR tracks.	Increase stream habitat heterogeneity (riffles, runs, pools mix, velocities, depths), habitat degraded (homogenized) by channelization. Possibly rewater wetlands drained by channelization by raising stream water surface elevation to raise groundwater level and increase frequency of overbank flooding. Eradicate bamboo patch if can be done in conjunction with upstream bamboo eradication. Consider possibly restoring stream to historic channel which is still present along much of S bank downstream of Route 1.	Need to determine where wetland vs upland mature trees occur to determine whether wetland rewatering acceptable. (Not acceptable if impacting substantial number of upland mature trees).

USACE Segment	General Location (up to down)	General Habit Condition Segment Scale [Review of Google Earth Photos, linear measurements in Google Earth (i.e., not following thalweg) plus previous site visit]	Wetlands Along Candidate Segment (NWI Map Review)	Habitat Restoration Opportunities and Needs	Habitat Assessment and Restoration Project Issues/Uncertainties
		Invasive bamboo patch at upper end, south bank.			
7	Paint Branch I95 Interchange (Powder Mill Rd to I95)	Lowermost 0.4 miles historically channelized. Substantial portion of segment (channelized and unchannelized) is underneath 95/495 Interchange. The stream is bedrock-controlled Piedmont for awhile immediately south of Powder Mill Road, then becomes alluvial Piedmont, then intermittently again becomes bedrock-controlled Piedmont locally under Route 95 to just above the power lines. From the power lines downstream, the stream is then again alluvial Piedmont but becomes increasingly coastal plain in character.	PFO wetland mapped in large parcel on both sides of stream segment between Powder Mill Rd and 95. No wetlands mapped occurring S of 95 along stream segment	Decrease erosion/instability in Piedmont section where not bedrock controlled. Possibly rewater wetlands drained by stream incision in Piedmont sections by raising stream grade to raise groundwater level and increase overbank flooding frequency.	Need to determine where wetland vs upland trees are to determine whether can raise stream water surface elevation.
9	Sligo Creek (Vicinity of Balfour Dr Ray Rd intersection to NW Branch confluence)	Historically channelized with ponded sections	No wetlands mapped along segment (11/14/14)	Increase stream habitat heterogeneity (mix of riffles, runs, pools), habitat degraded (homogenized) by channelization. Notch various grade-control structures to induce thalweg formation.	Numerous cross-stream structures. Bank stabilization works in many cases buried in sediment and not visible. Unclear whether boulder field appropriate for coastal plain stream (is exotic habitat type)
10	Chillum Rd Tributary (Chillum Rd to Nicholson St)	Upper portion from Chillum Rd downstream 0.13 miles (to vicinity of Longford Dr) probably historically channelized (straight). Channel includes boulder and gabion basket stabilization (not sure what total stabilized length is).	No wetlands mapped along segment (11/14/14)	Decrease locally severe erosion/instability. Manage invasive riparian vegetation. Excavate out broader channel/floodplain area along north bank of stream in Chillum Park. No recreation	

USACE Segment	General Location (up to down)	General Habit Condition Segment Scale [Review of Google Earth Photos, linear measurements in Google Earth (i.e., not following thalweg) plus previous site visit]	Wetlands Along Candidate Segment (NWI Map Review)	Habitat Restoration Opportunities and Needs	Habitat Assessment and Restoration Project Issues/Uncertainties
		Downstream of this 0.13 miles, channel not stabilized but severe entrenchment/bank erosion with lots of meandering.		negative impacts (narrow mowed lawn).	
11	Indian Creek – College Park	Based on map/aerial photo review, stream in 0.2 miles downstream of I95 channelized; Map review indicates probable channelization and massive effects of historic quarrying etc., between Greenbelt Metro Drive and Greenbelt Rd. Reach immediately upstream of Greenbelt Rd uniform width and ponded but meandering. Probably channelized/dredged with spoil deposited on east bank (high west bank topography)? Channelized from Greenbelt Rd downstream to end of segment; Generally minimal channel or bank erosion up to above Greenbelt Rd to reed grass patch. From that point downstream, habitat degraded/simplified by historic channelization/dredging and modern ponding such that homogeneous habitat conditions occur. Majority is pool/glide. Minimal runs or riffles, except where artificially formed. Minimal stream shading. Notable stand of invasive bush honeysuckle on west bank upstream of Greenbelt Rd.	Majority of segment S of Greenbelt Rd is mapped as being within PFO wetland. Majority of wetland parcels lie on W bank of stream. Between just S of Greenbelt Metro Dr. and N end of industrial complex just N of Greenbelt Rd., segment is mapped as within PFO and PEM wetland. Within braided stream section south of beltway, stream is mapped as PFO wetland.	Increase stream habitat heterogeneity (mix of riffles, runs, pools, velocities, depths) homogenized by channelization. Within channelized portions, possibly rewater drained wetlands by raising stream elevation to raise groundwater elevation and increase frequency of overbank flooding. Excavate to create multistage channel, probably on E bank (W bank mature trees). Just south and west of braided stream portion, restore Phragmites wetlands to forested wetlands. East bank north of Greenbelt Rd has substantial poured concrete, degrading riparian habitat. Could modify this to increase capability of plants to grow on east bank. Could remove this entirely to establish floodplain and riparian buffer.	Braided vs single channel stream, wetland vs stream trade-off concerns in reach above Green Belt Rd and below Greenbelt Metro Drive. Wetland impact concerns. Structure/property flooding concerns could preclude raising stream water surface elevation. Property ownership and liability for historic impacts (gravel quarrying, industrial/commercial activity disturbances).

USACE Segment	General Location (up to down)	General Habit Condition Segment Scale [Review of Google Earth Photos, linear measurements in Google Earth (i.e., not following thalweg) plus previous site visit]	Wetlands Along Candidate Segment (NWI Map Review)	Habitat Restoration Opportunities and Needs	Habitat Assessment and Restoration Project Issues/Uncertainties
12	Little Paint Branch	From I95 to Cherry Hill Rd., stream historically channelized. From Cherry Hill Rd ¼ mi downstream, no obvious historic channelization. Stream floodplain often low, frequent flooding into floodplain. From ¼ mi below Cherry Hill Rd, stream channel historically channelized 0.3 mi further downstream to where trail crosses stream	Segment from 495 through S end is mapped as lying within PFO wetland. Stream lies within middle of PFO parcel except at S end of segment where W bank of segment not mapped as PFO.	Increase stream habitat heterogeneity (mix of riffles, runs, pools, velocities, depths) where habitat degraded (homogenized) by channelization. Raise stream water surface elevation to raise groundwater level and increase stream/floodplain interactions in channelized sections to rewater wetlands.	Flooding concerns to structures/properties. Wetland impact concerns.
13	Lower Northwest Branch	Segment originates just below Piedmont contact. Historically channelized in uppermost reach, then severe channel and bank instability to above archery range. Then historically channelized with unstable channel and banks in archer range. Below University Boulevard, stream channelized through majority of Lane Recreational Center. Portion of stream is systematically stabilized with boulders in Lane Recreation Center.	Large part of segment above University Boulevard mapped as flowing adjacent to or within PFO1A wetland.	Increase stream habitat heterogeneity (mix of riffles, runs, pools, velocities, depths) where habitat degraded (homogenized) by channelization. Reduce severe channel and bank instability and increase overbank flooding and or raise stream grade within mapped wetland area.	Need to determine where wetland vs upland trees are to determine whether can raise stream water surface elevation.
15	Northeast Branch	Stream is entirely channelized and stabilized with boulders. Stream has minimal shade. Stream has occasional large point bar deposits downstream of Paint Branch Parkway,	S-flowing tributary on W bank opposite MNCPPC flows through mapped PFO1A parcel. NE Branch	Increase stream habitat heterogeneity (mix of riffles, runs, pools, velocities, depths) where habitat degraded (homogenized) by channelization.	Uncertain what stream-parallel infrastructure present. Uncertain whether boulder works could be modified.

USACE Segment	General Location (up to down)	General Habit Condition Segment Scale [Review of Google Earth Photos, linear measurements in Google Earth (i.e., not following thalweg) plus previous site visit]	Wetlands Along Candidate Segment (NWI Map Review)	Habitat Restoration Opportunities and Needs	Habitat Assessment and Restoration Project Issues/Uncertainties
		in these areas boulder stabilization works are buried by sediment.	at Brier Ditch flows through mapped PF01A. Mapped PF01A parcels inland from NE Branch on both banks S of Paint Branch Parkway.	Alter grade control structures to influence/reduce ponding conditions	

PROCEDURES

In Fall 2013, NAB prepared a model approval plan providing documentation to the USACE Ecosystem Planning Center of Expertise (EcoPCX) on proposed utilization of existing methods and data of Montgomery County Department of Environmental Protection (MCDEP) and Maryland Biological Stream Survey (MBSS data) for the Anacostia Watershed. These methods could characterize changes in finfish biological condition that could be expected with stream geomorphic restoration projects. In December 2013, Baltimore District further explored correlations between finfish indices of biological condition (including finfish index of biotic integrity) and individual metrics of the habitat condition scores that could be improved by USACE in restoration projects. Weak positive relationships between individual habitat parameters and fish score were evident. The strongest correlations between any individual habitat parameter and fish score was for instream cover at 0.1887, followed by riparian buffer at 0.1499. The correlation between instream cover plus riparian buffer versus fish score was 0.2688, as high as considering all habitat metrics combined versus fish score. Theoretically, this indicates that just improving instream cover and increasing riparian buffer width would produce as great benefits to fish score as would comprehensively improving the full suite of habitat metrics. However, increasing cover in a sustainable manner in these rapidly eroding systems requires that erosion of the channel also be dealt with, or longevity of instream cover restoration efforts (such as via structures) would likely be reduced. Thus, comprehensive geomorphic restoration work is appropriate if sustainable habitat improvement benefits are to be realized. Overall though, finfish biological response to instream habitat improvement is likely to be weak, instead improvement in biological condition would be reliant upon comprehensive watershed restoration measures. In accordance with this finding, the EcoPCX advised Baltimore District in 2014 that it would be appropriate to measure habitat improvements by a habitat metric rather than by forecast change in biotic integrity.

Physical Habitat Index

The Physical Habitat Index (PHI) was used in the quantification of the environmental benefits of potential stream restoration alternatives in Prince George's County, Maryland, for the Anacostia Watershed Restoration, Prince George's County, Study. MBSS (2003) procedures were chosen to assess habitat conditions because they have been utilized by the Prince George's County Department of the Environment (PGDOE) since the 1990s and thus allowed for ready comparison of previous to current conditions. PGDOE has used the protocols to assess existing conditions recently through contracts with Tetra Tech. MBSS has also sampled extensively throughout Prince George's County during several rounds of stream surveys. Use of these procedures was coordinated with USACE Ecological Center of Expertise. Table 3 shows the sequence of steps used for the assessment of stream habitat.

Table 3. Steps in the assessment of the Physical Habitat Index.

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

1. Segment Subdivision Into Reaches

The stream reaches selected for the study were subdivided into segments for analysis of habitat quality. Streams often have the presence/absence of several natural and built environment features and conditions that have major controlling effect on habitat conditions within segments. Because of the screening criteria utilized in the study, the candidate segments generally possess wooded riparian corridors with pervasive conditions of erosion. Instream habitat conditions within any segment vary longitudinally. Instream habitat conditions can vary along a gradual gradient in response to changes in relative importance of watershed versus local hydrologic influences accompanying increase in drainage area proceeding downstream, or show pronounced changes at major points of substrate change. Additionally, there are often localized erosional and depositional areas that extend for only short lengths of stream. These often occur in the vicinity of woody debris jams, coarse sediment deposits (particularly cobble and gravel), bedrock outcrops, and built environment features such as stormwater outfall pipes, concrete structures, and boulder stabilization works.

Segments can contain reaches with any combination of these features and conditions. Segments which possess a range of varying habitat conditions along their length can be divided into reaches at break points based on presence/absence of these features/conditions. Reaches were sampled rather than the entire segment because this is cost and time efficient. PHI was calculated for each reach. Tables 4 and 5 provide a summary of affecting/controlling habitat conditions used to divide segments into reaches. Table 1-1 and maps provided in Attachment 1 show the habitat segments for each site.

Table 1-2 (Attachment 1) provides a summary of various data for the selected stream reaches and Table 1-3 (Attachment 1) summarizes stream reach metrics such as reach length, width, and area. Tables 1-4 to 1-15 (Attachment 1) provide field observations and information used to determine reach endpoints.

Table 4: Channel physical materials affecting habitat conditions.

Stream Substrate
Piped or in culvert
Concrete channel
Natural meander (not channelized)
Channelized (earthen)
Stabilized discontinuously but systematically
Stabilized continuously
Earth (alluvium, colluvium, in-place soil)
Bedrock channel/banks

Table 5: Flows affecting habitat.

Flow
Intermittent flow (such as via loss into substrate)
Frequent backwater from downstream
Ponded (lentic rather than lotic)
Receiving flow from joining stream and stormwater outfalls

2. Reach Habitat Condition Assessment

Within each reach, a representative 75 m length measured along the channel thalweg capturing the range of conditions in that reach was field-identified and habitat sampled as per MBSS procedures (MDDNR 2013). Only parameters pertinent to PHI analysis were collected. The stream reach was assessed per MBSS field protocols and the data recorded onto MBSS data sheets. Not all habitat metrics collected on the data sheet were used to calculate PHI but all habitat metrics were collected for consistency with past and future monitoring efforts. The distance from the stream to the nearest road was recorded in meters, utilizing GIS and aerial photography. This distance was used to determine the remoteness score. Information on the metrics used to calculate PHI are reproduced in Tables 6 and 7.

Table 6. Habitat assessment parameters utilized for PHI (from MDDNR 2013).

Metric	Units	Value Range*	Notes
Watershed Area	Acres	19.95-93,325.4 acres (Coastal Plain) 28.84-38,904.5 acres (Piedmont)	
Remoteness	Meters	0-700 m	Based on measured distance (in meters) from stream to nearest road. If road were

			greater than 700 m from stream, a remoteness score of 20 is assigned (see section 3).
Percent Shading	Percentage	5.2-99 (Coastal Plain) 4-100 (Piedmont)	Rated based on estimates of the degree and duration of shading at a site during summer, including any effects of shading caused by landforms.
Embeddedness	Percentage	0-100	Not used in Coastal Plain PHI. Rated as a percentage based on the fraction of surface area of larger particles* that is surrounded by fine sediments on the stream bottom. In low gradient streams with substantial natural deposition, the correlation between embeddedness and fishability or ecological health may be weak or non-existent, but this metric is rated in all streams to provide similar information from all sites statewide. (*> 0.5")
Epibenthic Substrate	Unitless	0-20	Rated based on the amount and variety of hard, stable substrates usable by benthic macroinvertebrates. Because they inhibit colonization, floculent materials or fine sediments surrounding otherwise good substrates are assigned low scores. Scores are also reduced when substrates are less stable.
Instream Habitat	Unitless	0-20	Rated based on perceived value of habitat to the fish community. Within each category, higher scores should be assigned to sites with a variety of habitat types and particle sizes. In addition, higher scores should be assigned to sites with a high degree of hypsographic complexity (uneven bottom). In streams where ferric hydroxide is present, instream habitat scores are not lowered unless the precipitate has changed the gross physical nature of the substrate. In streams where substrate types are favorable but flows are so low that fish are essentially precluded from using the habitat, low scores are assigned. If none of the habitat within a segment is useable by fish, a score of zero is assigned.

Total number instream woody debris and rootwads	Enumerated	0-32	
Erosion Extent	Meters	0-75**	Based on procedures in MDDNR 2013.
Severity	Unitless	0 = none; 1=min; 2=mod; 3=severe	
Riffle Quality	Unitless	0-20	Not used in Coastal Plain PHI Rated based on the depth, complexity, and functional importance of riffle/run habitat in the segment, with highest scores assigned to segments dominated by deeper riffle/run areas, stable substrates, and a variety of current velocities.

*Value Range: Watershed Area, Percent Shading, and Total Number of Instream Woody Debris and Rootwads based on data reported in MDDNR 2003. These values informed the development of the PHI.
**Bank erosion may exceed 75m in braided streams.

Table 7. Selected Metrics from MBSS Stream Habitat Assessment Guidance Sheet MDDNR 2013)

Habitat Parameter	Optimal 16-20	Sub-Optimal 11-15	Marginal 6-10	Poor 0-5
Instream Habitat	Greater than 50% of a variety of cobble, boulder, submerged logs, undercut banks, snags, root wads, aquatic plants, or other stable habitat	30-50% of stable habitat. Adequate habitat	10-30% mix of stable habitat. Habitat availability less than desirable	Less than 10% stable habitat. Lack of habitat is obvious
Epifaunal Substrate	Preferred substrate abundant, stable, and at full colonization potential (riffles well developed and dominated by cobble; and/or woody debris prevalent, not new, and not transient)	Abundance of cobble with gravel &/or boulders common; or woody debris, aquatic veg., undercut banks, or other productive surfaces common but not prevalent /suited for full colonization	Large boulders and/or bedrock prevalent; cobble, woody debris, or other preferred surfaces uncommon	Stable substrate lacking; or particles are over 75% surrounded by fine sediment or flocculent material
Riffle/Run Quality	Riffle/run depth generally >10 cm, with maximum depth greater than 50 cm (maximum score); substrate stable (e.g. cobble, boulder) & variety of current velocities	Riffle/run depth generally 5-10 cm, variety of current velocities	Riffle/run depth generally 1-5 cm; primarily a single current velocity	Riffle/run depth < 1 cm; or riffle/run substrates concreted
Embeddedness[a]	Percentage that gravel, cobble, and boulder particles are surrounded by fine sediment or flocculent material. Based on approximated observation and compared to MBSS representative conditions.			
Shading[b]	Percentage of segment that is shaded by overhanging vegetation or other structures (duration is considered in scoring). 0% = fully exposed to sunlight all day in summer; 100% = fully and densely shaded all day in summer. Percentage is approximated based on a visual assessment.			

a) Embeddedness- Rated as a percentage based on the fraction of surface area of larger particles that is surrounded by fine sediments on the stream bottom. Based on riffle substrates – area with the fastest flow within riffle or run habitats. Several substrates should be examined within the riffle to determine the approximate average condition within the fast part of the riffle. In low gradient streams with substantial natural deposition, the correlation between embeddedness and fishability or ecological health may be weak or non-existent, but this metric is rated in all streams to provide similar information from all sites statewide. See MDDNR 2013 page 26 for more information on methodology.

b) Shading- Rated based on estimates of the degree and duration of shading at a site during summer, including any effects of shading caused by landforms (MDDNR 2013, page 26).

3. Compute PHI

The metrics collected in the field are entered into a spreadsheet (PhysicalHabitatIndexModel.xlsx) which calculates PHI utilizing the equations listed below. Separate worksheets for Coastal Plain or Piedmont stream reaches were used as appropriate.

PHI was developed by MBSS for Maryland streams, thus its calculations are based on data collected in Maryland streams and it is not valid for use outside of Maryland.

a. Metrics are first transformed:

<u>Coastal Plain</u>

REMOTE = Remoteness Score
Remoteness Score = 0.615 + (0.733*(√distance in meters from road))
TSHADING = arcsine(square root(percent shading/100))
RESEPISUB = epibenthic substrate score - (3.5233+2.5821(Log(Watershed Area in acres))
RESINSTRHAB = instream habitat score - (0.5505 + 4.2475(Log(Watershed Area in acres))
RESWOOD = total # of instream woody debris and rootwads - (-12.24+8.8120(Log(Watershed Area in acres))
TBANKSTAB = square root of the final value calculated
BANKSTAB = if bank stability on 0-20 score = 0-20 score
BANKSTAB = if erosion extent is used = [((erosion extent)/-15) x severity] for each bank + 20
Note: severity is altered so that original severity 0 = 0, 1 = 1, 2 = 1.5, and 3 = 2.0

<u>Piedmont</u>

EMBEDDED = percent embeddedness
REMOTE = Remoteness Score
Remoteness Score = 0.615 + (0.733*(√distance in meters from road))
RESTSHADING = arcsine(square root(percent shading/100)) - (1.7528 - 0.1990(Log(Watershed Area in acres))
EPISUB = epibenthic substrate score
RESINSTRHAB = instream habitat score - (9.9876 + 1.5476(Log(Watershed Area in acres))
WOOD = total number of instream woody debris and rootwads
TBANKSTAB = square root of the final value calculated
BANKSTAB = if bank stability on 0-20 score = 0-20 score
BANKSTAB = if erosion extent is used = [((erosion extent)/-15) x severity] for each bank + 20
Note: severity is altered so that original severity 0 = 0, 1 = 1, 2 = 1.5, and 3 = 2.0
RESRIFFQUAL = riffle quality score - (5.8467 + 2.4075(Log(Watershed Area in acres))

b. The transformed metrics are then scaled:

<u>Coastal Plain</u>

REMOTE = (value)/(18.570)
TSHADING = (value - 0.226)/(1.120)
RESEPISUB = (value + 13.199)/(17.213)
RESINSTRHAB = (value + 15.094)/(18.023)
RESWOOD = (value + 28.903)/(33.803)
TBANKSTAB = (value)/(4.472)

<u>Piedmont</u>

EMBEDDED = (100 - value)/(90)
REMOTE = (value)/(16)
RESTSHADING = (value + 1.142)/(1.405)
EPISUB = (value - 1)/(17)

RESINSTRHAB = (value + 12.805)/(15.745)
WOOD = (value)/(12)
TBANKSTAB = (value - 1)/(3.243)
RESRIFFQUAL = (value + 16.252)/(19.637)

c. Final scores are calculated:

Coastal Plain

Coastal Plain PHI = (sum of metric scores)/6

Piedmont

Piedmont PHI = (sum of metric scores)/8

The resulting PHI score is multiplied by 100. The score corresponds to one of four narrative classes: minimally degraded; partially degraded; degraded; severely degraded (Table 8).

Table 8. Description of PHI Scoring Classes (MDDNR, 2011)

Narrative Class	Score
Minimally Degraded	81-100
Partially Degraded	66-80
Degraded	51-65
Severely Degraded	0-50

MD DNR. 2011. Results from Round 3 of the Maryland Biological Stream Survey (2007-2009). Prepared by: Versar, Inc. 77 pages. http://www.dnr.maryland.gov/streams/R3ReportIntro.asp

Normalization

The range of possible values for individual metrics can result in final PHI scores that are over or under the acceptable 0 to 100 range. While it is highly unlikely that streams with such scores will be encountered, scores were normalized so that all possible scores are within 0–100, and then rescaled from 0–1. Coastal Plain streams have a possible PHI range from -9.82 to 135.88 while Piedmont streams have a possible range from -3.44 to 134.77. No final PHI scores were outside of the acceptable range of 0–100. Tables 2-1 and 2-2 (Attachment 2) provide all metric scores and resulting PHI FWOP scores for Piedmont and Coastal Plain stream reaches.

4. Quantify Existing Stream Habitat

Quantifying stream habitat for use in the calculation of benefits requires consideration of habitat quantity and quality.

Habitat Quantity

Physical habitat quantity is determined using stream length and stream order. Generally, for the calculation of stream quantity for use in the calculation of habitat benefits, stream width is used. In this case, the use of stream width was problematic, so stream order was used as a surrogate. Many of the study streams have been over-widened through channelization, so restoration would

result in a decrease in the channel width. This would falsely result in a decrease in project benefits (stream habitat units) for the post-restoration condition (future with project). Stream order was used as a surrogate for width because order shows a close correlation to stream width, depth, wetted perimeter, and volume, and is simpler to determine/measure. This is supported by empirical relationships between dimensions of bankfull channel geometry and discharge or drainage area established for coastal plain streams in Maryland (USFWS, 2003). Using this empirically established relationship between drainage area and width, stream widths were calculated for each site (Table 9). Based on this, similar to stream order relationships, a fourth order stream is about four times wider than a first order stream; therefore, the use of order as a surrogate for width is supported (Table 9).

Table 9: Evaluation of use of stream width as a surrogate for stream order using established relationships for streams in the Maryland Coastal Plain.

Stream Site	Stream Order	DA (mi2)	Width (ft)	Width Scaled
Site 10	1	2.02	13.5	1
Site 1	1	2.52	14.6	1
Site 12	2	10.5	25.2	2
Site 9	2	11.2	25.8	2
Site 7	2	16.4	29.8	2
Site 11	4	27.4	36.2	3
Site 5	3	31.1	38.0	3
Site 13	3	34.1	39.4	3
Site 3	3	35.6	40.0	3
Site 15	4	69.2	51.5	4

W=10.3(DA)^0.38
Widths were calculated for each given drainage area (DA) based on the equation above. Widths were then scaled based on the smallest width to compare to known stream order.
Reference: USFWS. 2003. Bankful Discharge and Channel Characteristics in the Coastal Plain Hydrologic Region. CBFO-S03-02, July 2003.

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 dewatered concrete channel, that reach is considered as having zero habitat quantity under existing conditions.

Total Habitat Availability

Habitat available within a stream reach is a function of habitat quantity and habitat quality. The total habitat available within a reach is represented by the simple equation:

Habitat Quantity x PHI = Stream Habitat Units (SHU)

For a segment, total habitat availability is the simple sum of SHUs for all the reaches within the segment. The benefits derived from restoration of the stream study reach are referred to as "Project Specific Benefits" as opposed to the "Aggregate Benefits" discussed later in this document.

5. Forecast future stream habitat with and without project

Without Project

Stream water quality is expected to improve over the 50-year evaluation period. In 2011 Prince George's County initiated development of its local strategies to fulfill Phase II Watershed Implementation Plan (WIP) requirements to meet Chesapeake Bay Watershed TMDLs. By 2025 non-federal (not originating from federally owned lands) nutrient loads delivered to the Chesapeake Bay from Prince George's County will be reduced from 2009 loads by 9.32 percent for total nitrogen and 3.61 percent for total phosphorus. These reductions will be accomplished through implementation of stormwater BMPs and retrofits, impervious surface reduction and disconnection, agriculture BMPs, and other methods and account for projected population growth in the county. Prince George's County will retrofit water quality treatment for 7,109 acres of untreated impervious area throughout the county by 2017, which does not include treatment of state or federal area.

Maryland Department of the Environment (MDE) requires that urban stormwater runoff be managed through "… a unified approach for sizing stormwater BMPs in the State of Maryland to meet pollutant removal goals, maintain groundwater recharge, reduce channel erosion, prevent overbank flooding, and pass extreme floods." Design features required by MDE for MS4 stormwater permits include the use of pre-treatment vegetation, wetland pockets and pools, flow reduction techniques, native plants, meadows, trees, permeable soils, and the creation of sinuous flow paths.

Current stormwater management policy required in COMAR for redevelopment basically specifies a 50% reduction in impervious surface area below existing conditions. Since this may be impractical due to site constraints, environmental site design (ESD) practices are to be used to the maximum extent practicable (MEP) to meet the equivalent in water quality control of a 50% decrease in impervious surface area. Various alternative BMPs that do not necessarily meet the performance criteria established in this manual may be implemented for redevelopment projects provided that it is demonstrated that impervious area reduction and ESD have been implemented to the maximum extent practicable (MEP).

While stormwater retrofits and upgrades will help address stormwater quantity, it is expected that stormwater runoff quantity control will remain inadequate for decades. While stream geomorphic conditions would be expected to eventually achieve a condition of dynamic equilibrium with stormwater runoff, based on the pattern evidenced in urban streams of the study area and elsewhere in Maryland, the streams reaching an equilibrium condition would likely take many decades to centuries and only after substantial quantities of sediment were eroded and trees lost to bank erosion. Accordingly, absent a geomorphic restoration project, future habitat conditions without project in the streams are assumed to be equivalent to current conditions.

With Restoration Project

With a geomorphic restoration project, future stream conditions would differ from without project conditions. Forecasting the change in condition from existing to future provides benefits for input into the cost-effectiveness analyses.

i Reach Habitat Quantity

Possible change in stream length could occur via either increasing or decreasing stream sinuosity.

Changes in other physical metric changes of width, depth, wetted perimeter, and volume could change. However, accurately determining these over a segment length is challenging. Because stream order is used as a proxy to represent these stream attributes these changes are not determined.

ii Reach Habitat Quality Change

Based on findings of habitat assessments of other previously restored reaches in the Anacostia Watershed (MCDEP, 2013), it is expected that instream habitat quality of existing erosion surface streams could be improved up to minimally degraded or partially degraded. Many streams in the Anacostia Watershed 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. However, trees will be planted where opportunities exist. Change in individual parameters could theoretically be as great as 20. Tables 2-3 through 2-6 (Attachment 2) provide all metric scores and resulting PHI FWP scores for Piedmont and Coastal Plain stream reaches as projected for design alternative 1 (Tables 2-3 and 2-4) and design alternative 2 (Tables 2-5 and 2-6).

Sensitivity

Most PHI metrics may be influenced by a stream geomorphic restoration project. However, watershed area and remoteness score will not be affected by a project. Similarly, percent shading is unlikely to be affected appreciably by a project. Theoretically, sites with all scores at the extremes of the metric value range can produce final PHI scores that are greater than 100 and less than 0. This occurs because the PHI computations are based on observed streams in Maryland and those extreme conditions have not been sampled and thus are not reflected in the PHI equations. If a final PHI score is outside of the acceptable range of 0-100 the scoring for the stream must be reviewed and if the scores are representative of stream conditions, Maryland DNR should be contacted for further consultation as these would constitute novel conditions. The best attainable condition (BAC) for restored streams would not exceed the conditions of the most natural streams in the watershed (Stoddard et al. 2006). BAC represents the highest value stream condition that can be reached given current conditions and limits of restoration techniques. If we assume that a geomorphic restoration project can improve stream conditions from one level to the next best level at the same relative condition, PHI can improve to 58, “degraded”. If we assume that conditions can further be improved, with more instream woody debris, less erosion, and relatively modest improvements in other scores, we can reach a score of at least 66, “moderately degraded”. Other streams with different combinations of

metric scores demonstrate similar results and sensitivity to metric changes. However, in all cases BAC is achievable. Tables 2-7 and 2-8 (Attachment 2) provide all metric scores and resulting BAC PHI scores for Piedmont and Coastal Plain stream reaches.

iii Segment Total Habitat Availability Change

As with existing conditions, total habitat availability under forecasted future conditions would be the sum of all the reach habitat quantities for a given segment.

iv. 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). 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.

Fish Blockages

Opportunities for remediation of fish blockages within the Anacostia Watershed of Prince George's County were evaluated by the study team. The Anacostia Restoration Plan (ARP) identified fish blockages within the watershed and regional fisheries experts (from MWCOG) were consulted on these and other potential blockages. The inventory in the ARP includes consideration of the severity and likely longevity of the blockage. Fish blockages were considered for remediation only when within the study segments identified to be candidates for geomorphic restoration work. Conceptual design drawings and cost estimates for restoration of the study segments, include both stream restoration and fish blockage remediation. Although fish passage could also potentially be provided by independent projects within those segments without comprehensive geomorphic restoration, this was not the formulation strategy undertaken in this study. Projects to provide fish passage if undertaken independently would be small-scale projects because the structures forming blockages in study stream segments are low in height.

When fish passage needs are evaluated, natural blockages (waterfalls, beaver dams) are often viewed to be inherently good, and seldom targeted for remediation. Conversely, anthropogenic blockages are generally considered to be inherently harmful to aquatic ecosystems. In the study area, the natural limit of the historical range of anadromous fish is the Fall Line, which is the boundary between the Coastal Plain and Piedmont physiographic provinces. Presence of natural blockages within the extent of their range was assumed to represent stream habitat that would remain inaccessible to resident and or anadromous fish, depending on the severity of the blockage. Accordingly, this study considered only anthropogenic fish blockages for remediation. Fish blockages can affect either up and or downstream movements of aquatic life. Downstream blockages can occur when downstream flow first passes through turbines or other structures that kill aquatic life. There are no downstream blockages of this type in the study area. Field work was conducted to assess stream habitat and geomorphic conditions and to identify fish blockages.

Fish blockages present in the study area differ in which fish are affected, based on the movement capabilities of a given fish. For example, American eel are highly mobile and even able to crawl over moist land for short distances. Blockages for eels may have vertical surfaces or would require long crawls over land to bypass. No eel blockages were identified within Anacostia study stream segments in Prince George's County.

Resident fish blockages would include eel blockages (if there had been any) plus vertical blockages and long reaches of continuously high currents or de-watered reaches that are not periodically made passable by flooding or downstream backwater. For the purposes of this study, dewatered reaches were assumed to occur at least in large part because of boom/bust flow conditions caused by stormwater runoff as well as excess erosion/sedimentation causing loss of water into the stream bed. (Dewatered reaches occur in many pipes and concrete channels as well. However, intermittent streams do naturally occur in the study area). Piped streams and streams in concrete channels typically possess flows that are periodically scouring such that aquatic life cannot traverse upstream. Anthropogenic vertical structures or flow conditions can be verified as fish blockages by comparing upstream and downstream fish data. Blockages can also be verified by lack of physical evidence indicating overtopping of structures in channels and floodplains.

Anadromous fish blockages include all eel and resident fish blockages plus vertical drops of 1 foot or greater during spring flow when anadromous fish migrate upstream. Many complete and partial anadromous fish blockages occur in the study area. Anadromous fish passage benefits for blockage remediation were only counted where no downstream blockages exist. Benefits of providing fish passage were determined by length and order of stream upstream of the blockage to which access for fish from downstream would be provided. Stream lengths opened by blockage removal were measured in GIS. Fish passage benefits were assumed to proceed upstream to the next manmade or natural blockage. For Northwest Branch, the natural blockage was generally the limits of the natural range of anadromous fish at the Fall Line. Table 10 shows the fish blockages on the study stream reaches for which fish passage benefits are counted within the Aggregate Benefits metric.

Connectivity

The project stream reaches are located in highly urbanized areas of Prince George's County, where impervious cover is high and pervasive habitat degradation occurs in streams. Any remaining higher quality habitat areas are likely physically separated (fragmented) from other stream areas with comparable higher quality conditions. Connectivity, or the connection of habitat patches, has long been recognized as a fundamental factor in determining the distribution of species; therefore, benefits were considered for the connection of study streams to previously restored stream segments.

An inventory was made of all previous stream restoration projects adjacent to the study's stream reaches. Based on best professional judgment, small gaps between restoration projects (less than approximately 800 feet) were considered a reasonable distance across which to count sites for connectivity benefits. If restored projects were located longer distances away from a project site, connected benefits were not counted. Therefore, large gaps were used to identify

the extent of the connectivity benefits to a study stream reach. Attachment 3 includes previous restoration projects associated with each project site.

Table 10: Fish blockages present in the study stream segments (* indicates blockages that would be removed under the recommended plan).

Site No.	ARP Identifier	Description	Passage Opened by Removal (ft)
1	Several identified in ARP (see MWCOG, 2009)	Several blockages for anadromous and resident fish (and potentially eel) located in close proximity upstream and downstream of Ammendale Road. These blockages are associated with culverts and storm water management features. Benefits claimed for one resident fish blockage upstream of Ammendale Road. Removal of this blockage would not benefit anadromous fish due to presence of blockages (storm water management feature) immediately downstream.	3,257
***3**	NW-L-04-F-10	Anadromous fish blockage on Northwest Branch at downstream end of Ager Road consists of a 1 ft concrete sill. Not a blockage for resident fish as backwater effects could would likely ameliorate conditions for resident fish passage. ARP also notes debris and log jams with 1 ft drop height blocks 95% of flow. ARP ranks blockage as Tier I Project (Tier I are project providing greatest benefits), with priority 13/806 projects for Northwest Branch.	18,984
7	PB-M-04-F-7 PB-M-04-F-6	Two anadromous fish blockages (partial) in close proximity that that result from box culverts at I-495 underpasses. Fish ladders are present but inaccessible. Drop height of 1 foot. Debris and log jams also present.	5,876
***9**	SC-L-04-F-1	Anadromous fish blockage consisting of steel weir with 1 foot drop on Sligo Creek upstream of Northwest Branch confluence. Passable for resident fish. ARP notes this as a complete fish blockage due to a 1 ft high sheet pile weir. One of top five fish blockage removal priorities for MWCOG.	3,084

Calculation of Aggregate Benefits

Aggregate benefits are calculated similarly to the "Project Specific In-Stream Benefits" (derived from restoration at a given study reach) discussed earlier, specifically: habitat quantity x PHI. Habitat quantity for aggregate benefits was defined as 1) the length of the stream that would be accessible for fish following removal of a fish passage 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 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." In some cases, where data were not available for a given stream reach, data were extrapolated from the closest monitoring data. Some stream reaches were connected to more than one project. The total aggregate benefits (SHUs incorporating total quantity restored or opened for fish passage) for each stream reach were used as a metric in the cost effectiveness/incremental cost analysis (CE/ICA). However, when reaches were combined to develop the alternatives used for input into the CE/ICAs, steps were taken to not double count projects. Some stream reaches, e.g. site 13, have no connected projects or fish blockages and therefore were determined to provide no aggregate benefits. Table 3-1 (Attachment 3) provides the complete summary of PHI (including the source of the data) and project-specific SHUs for each linked prior stream restoration project or length opened via blockage removal on a study stream site.

Figure 1 shows the aggregate benefits for each site, incorporating the study stream site itself, connected restoration projects, and fish passage opened by removal of a blockage. For example, aggregate benefits for site 3 include the site itself (shown in orange), connected downstream restoration projects (shown in yellow), and upstream fish passage opened from removal of a blockage (shown by the purple dashed line).

6. Quantify total future habitat quantity change

For each segment, the difference between with-project total habitat quantity and existing conditions total habitat quantity is determined by simple subtraction. That difference constitutes the in-stream project habitat quantity.

Aggregate Benefits Determination

Two CE/ICAs were run, one for the Northwest Branch alternatives and one for the Northeast Branch alternatives. Average annual environmental benefits input into each of the two CE/ICAs include benefits for the two metrics: Project Specific In-Stream Benefits and Aggregate Benefits (Section 3.5.2 of main report). Project Specific In-Stream Habitat Benefits and Aggregate Benefits were combined to develop one average annual benefit variable that represents a more complete quantified value of the benefits attributed to each plan than the Project Specific In-Stream benefit metric alone for Northwest Branch and Northeast Branch, respectively. 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 denominator is the maximum SHUs for each subwatershed (i.e. SHUs for the highest level alternative). The numerator is the sum of benefits for a given alternative.

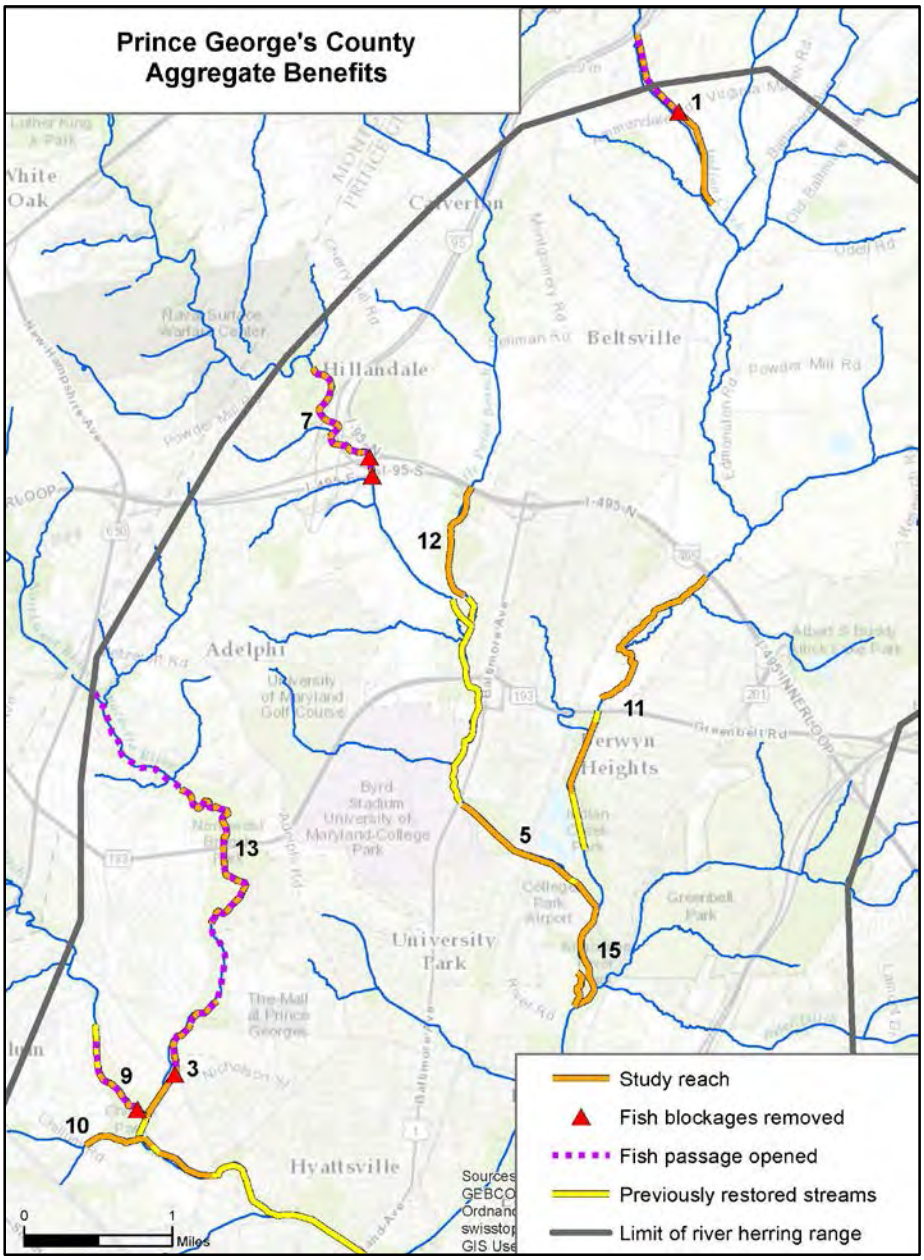

Figure 1. Aggregate Benefits for each Project Site.

The CE/ICAs were then performed using the combined benefits ("Combined Index") and the average annual cost for each alternative plan to determine the most cost-effective and efficient (best-buy) alternatives. Based on the outcomes of team discussions at USACE review meetings, two CE/ICAs were run to evaluate a solution for each of the Northwest Branch and Northeast Branch subwatersheds,. A summary of the project specific and aggregate benefits (SHUs) for the alternatives considered in the two CE/ICAs is shown in Table 11.

Table 11. Summary of Total Habitat Benefits (SHUs) for the Alternatives Considered in the CE/ICAs (* indicates alternatives in the recommended plan).

Northwest Branch Alternatives	Project Specific SHUs	Aggregate SHUs
3	2068	53679
3, 9	2738	58330
3, 9, 10	2860	59640
3, 13	5162	53679
*3, 9, 13	5832	58330
3, 9, 10, 13	5953	59640
Northeast Branch Alternatives		
11, 15	7975	22703
*11, 15, 5	10626	63131
11, 15, 5, 7	12035	69507
11, 15, 5, 12	11666	67846
11, 15, 1	8832	25083
11, 15, 5, 1	11483	65511
11, 15, 5, 12, 1	12523	70226
11, 15, 5, 12, 7	13075	74222
11, 15, 5, 12, 1, 7	13932	76602

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Attachment 1: Stream Reach Data and Maps

Table 1-1: Habitat Segment Codes for PHI Scoring
Table 1-2: Stream Reach/PHI Station Summary Information (RHA Data Summary)
Table 1-3: Stream Reach Metrics
Table 1-4: Stream Segment Access Information
Table 1-5: Embeddedness Evaluations
Table 1-6: Reach Coordinates and Condition – Segment 1
Table 1-7: Reach Coordinates and Condition – Segment 3
Table 1-8: Reach Coordinates and Condition – Segment 5
Table 1-9: Reach Coordinates and Condition – Segment 7
Table 1-10: Reach Coordinates and Condition – Segment 9
Table 1-11: Reach Coordinates and Condition – Segment 10
Table 1-12: Reach Coordinates and Condition – Segment 11
Table 1-13: Reach Coordinates and Condition – Segment 12
Table 1-14: Reach Coordinates and Condition – Segment 13
Table 1-15: Reach Coordinates and Condition – Segment 15

Attachment 1: Habitat Segment Maps and Codes

Each study stream segment was subdivided into representative reaches based on habitat conditions. The habitat segment maps for each stream reach show these subdivisions. The codes located in the map legends are defined below in Table 1-1.

Table 1-1: Habitat Segment Codes for PHI Scoring

Predominant Attribute	Code	Notes
Channel Conditions		
Piped or in culvert	No code	Applicable in/near bridges. No code - assumed no change in habitat conditions with-project because of need to protect bridge
Concrete channel	No code	Applicable in/near bridges. No code - assumed no change in habitat conditions with-project because of need to protect bridge
	c	Channelized - straightened with few or no meanders, whether by excavation or fill
	m	Meander, not channelized such that it is affecting instream habitat
Substrate and Bank Conditions		
	s	Stabilized continuously (few or no gaps) typically with boulders, but may include gabions, concrete, etc.
	g	Stabilized systematically, but discontinuously (with gaps); typically with bounders, but may include gabions, concrete, etc.
	e	Notable sediment bars in stream channel
	b	Bedrock channel banks
	n	Fined-grained substrate (sand, silt, clay)
	o	Coarse grained substrate (cobble, gravel)
	h	High bank height (based on relative differences within segment; higher banks typically have greater erosion/instability)
	l	Low bank height (based on relative differences within segment)
	w	Woody debris jams
Flow Conditions		
	i	Intermittent flow (includes loss into substrate)
	d	Frequent backwater from downstream
	p	Ponded - lentic rather than lotic
	f	Receiving flow from joining stream and stormwater outfalls

	r	Riffle/runs dominant
	t	Pools/glides dominant (deeper than homogeneous shallow depth category below)
	u	Homogeneous shallow depths, slow velocities
Other		
Palustrine, forested wetland	PFO	Stream reach intimately linked with a wetland classified as PFO, Palustrine scrub-shrub (PSS), or Palustrine emergent (PEM) by the National Wetlands Inventory.
Tributary	T	Segment is a tributary to the numbered site. Tributary conditions often differ from mainstem conditions.
Physiographic Province	C	Segment located in Coastal Plain physiographic province
Physiographic Province	P	Segment located in Piedmont physiographic province

Considerations:

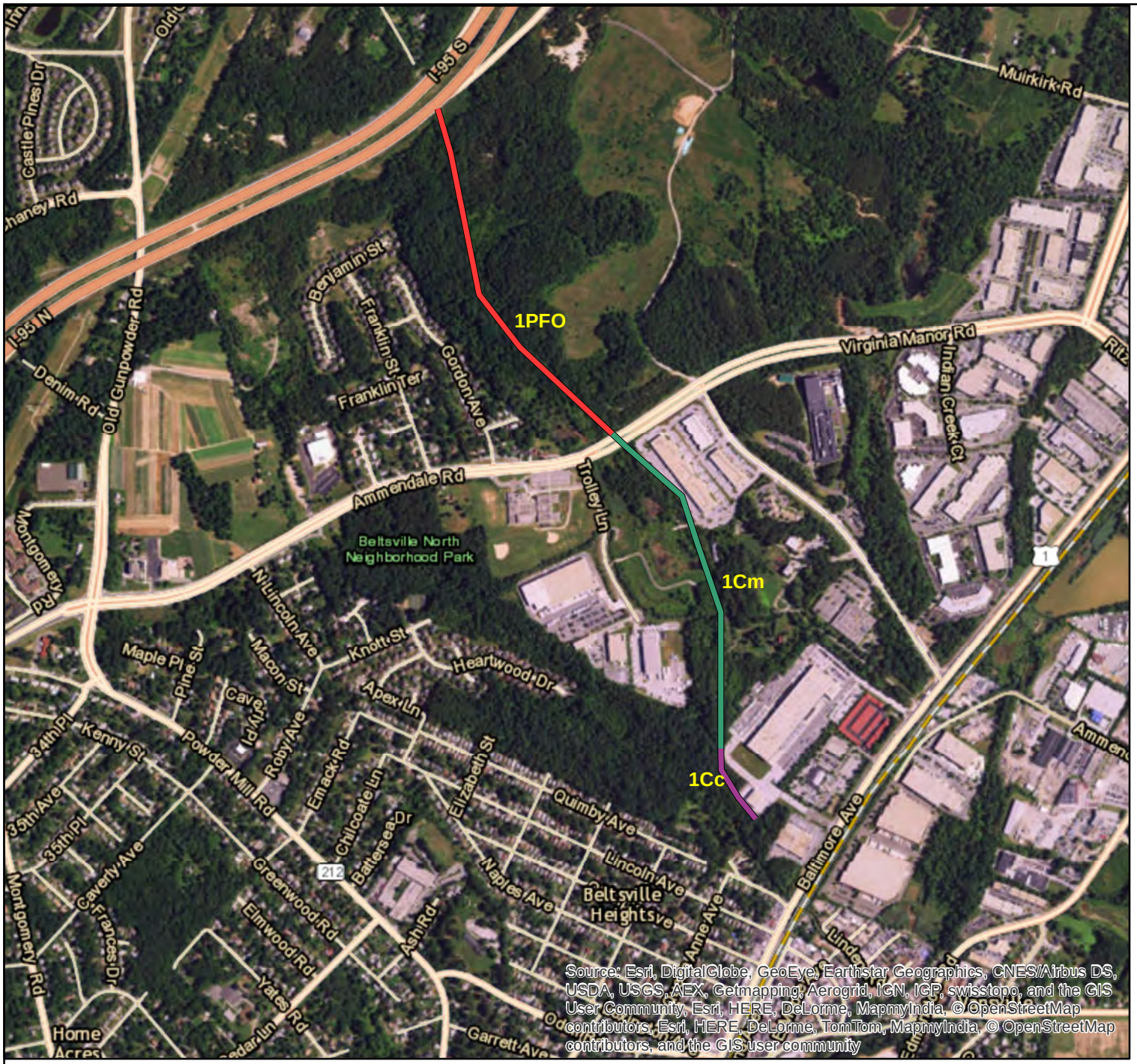
- PHI data from a representative reach may be used to represent multiple reaches within a given segment assuming habitat conditions are similar.
- Attributes are identified that correlate with and allow ready discrimination between habitat conditions.
- Reach habitat conditions may correlate with any combination or number of natural and/or built-feature attributes.
- Portions of segments under/in vicinity of bridges often have concrete channels, continuous stabilization, and or culverts.

Anacostia Watershed Restoration
Prince George's County

Subwatershed: Indian Creek
Site: Indian Creek
Project Segment #: 1

Reach	Habitat Type Code[1]	Legend	Length (ft)
1A	1Cc		695
1B	1Cm		2994
1C	1PFO		3268

1 Type Code Definition see attached table



N
W E
S

0 700 1,400 2,800 4,200 5,600 Feet

Anacostia Watershed Restoration
Prince George's County

Subwatershed: Northwest Branch
Site: Hyattsville
Project Segment #: 3

Reach	Habitat Type Code	Legend	Length (ft)
3A	3Cce		817
3B	3Cm		470
3C	3Ccp		377
3D	3Ccp		208
3E	3Cce		86
3F	3Ccp		51
3G	3Ccst		218
3H	None		235
3I	3Ccp		1375
3J	3Ccst		456
3K	9Cs		156
3L	3Ccst		339
3M	9Cs		203
3N	3Ccst		171
3O	3Ccu		95
3P	3Ccu		761
3Q	3Ccpg		1268

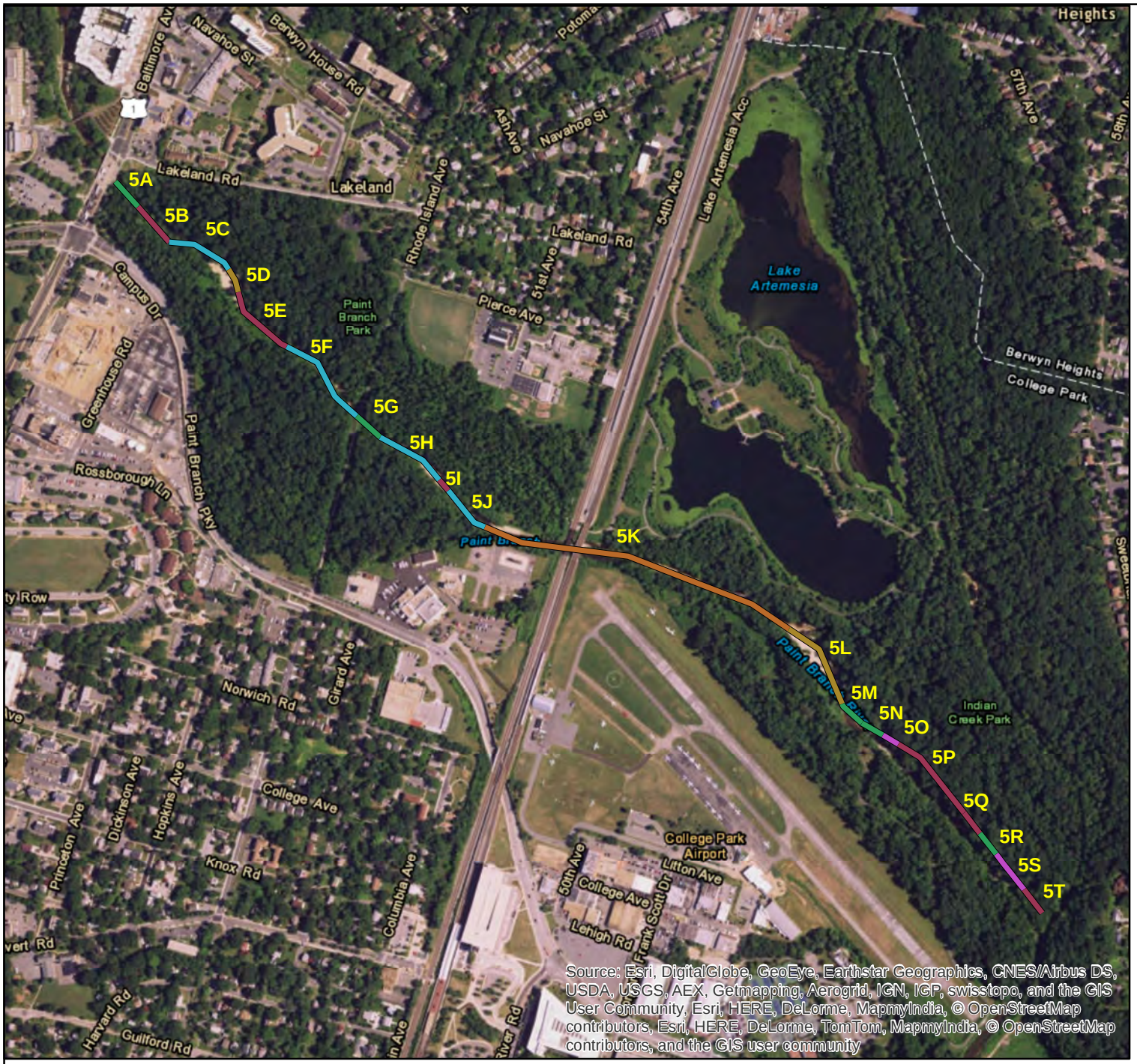
1 Type Code Definition see attached table

N
W E
S

0 600 1,200 2,400 3,600 4,800
Feet

Anacostia Watershed Restoration
Prince George's County

Subwatershed: Paint Branch
Site: Paint Branch
Project Segment #: 5



Reach	Habitat Type Code	Legend	Length (ft)
5A	5Ccst		176
5B	5Ccgu		244
5C	5Ccehu		359
5D	5Cw		128
5E	5Ccgu		396
5F	5Ccehu		534
5G	5Ccst		164
5H	5Ccehu		386
5I	5Ccgu		72
5J	5Ccehu		273
5K	5Ccle		1694
5L	5Cw		497
5M	5Ccst		146
5N	5Ccst		126
5O	9Cs		94
5P	5Ccgu		502
5Q	5Ccgu		135
5R	5Ccst		137
5S	9Cs		235
5T	5Ccgu		155

1 Type Code Definition see attached table

N
W E
S

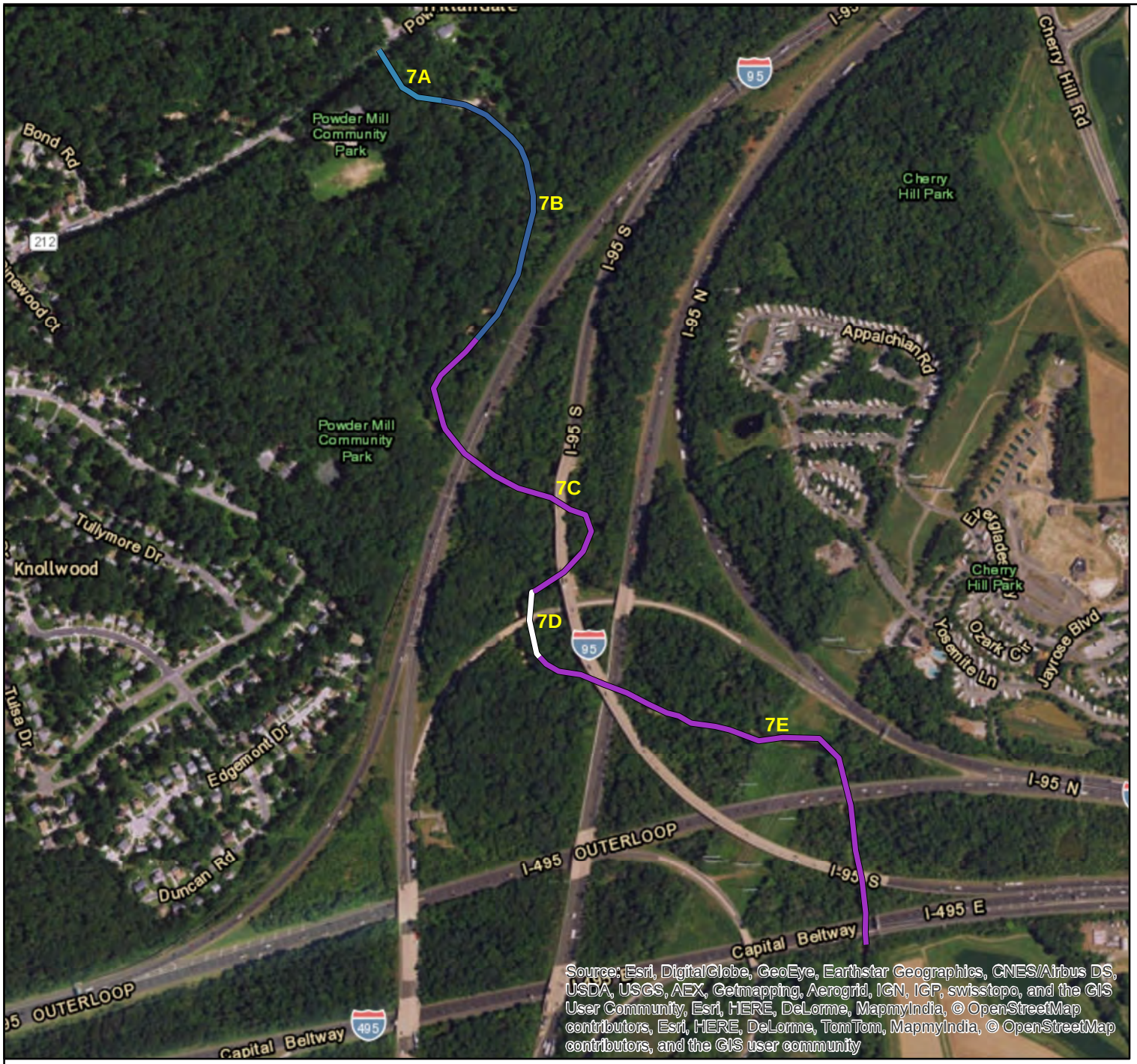
0 450 900 1,800 2,700 3,600
Feet

Anacostia Watershed Restoration
Prince George's County

Subwatershed: Paint Branch
Site: Paint Branch I-95
Project Segment #: 7

Reach	Habitat Type Code[1]	Legend	Length (ft)
7A	7Pb		376
7B	7Pe		1314
7C	7Cc		1653
7D	None		295
7E	7Cc		2239

1 Type Code Definition see attached table



N
W E
S

0 375 750 1,500 2,250 3,000 Feet

Anacostia Watershed Restoration
Prince George's County

Subwatershed: Sligo Creek
Site: Sligo Creek
Project Segment #: 9

Reach	Habitat Type Code[1]	Legend	Length (ft)
9A	9Cg		568
9B	9Cs		243
9C	9Cg		1430

1 Type Code Definition see attached table

N
W E
S

0 200 400 800 1,200 1,600
Feet

Anacostia Watershed Restoration
Prince George's County

Subwatershed: Northwest Branch
Site: Chillum Road
Project Segment #: 10

Reach	Habitat Type Code[1]	Legend	Length (ft)
10A	10Cs		370
10B	10Cg		441
10C	10Ce		798
10D	10Cg		486

1 Type Code Definition see attached table

N
W E
S

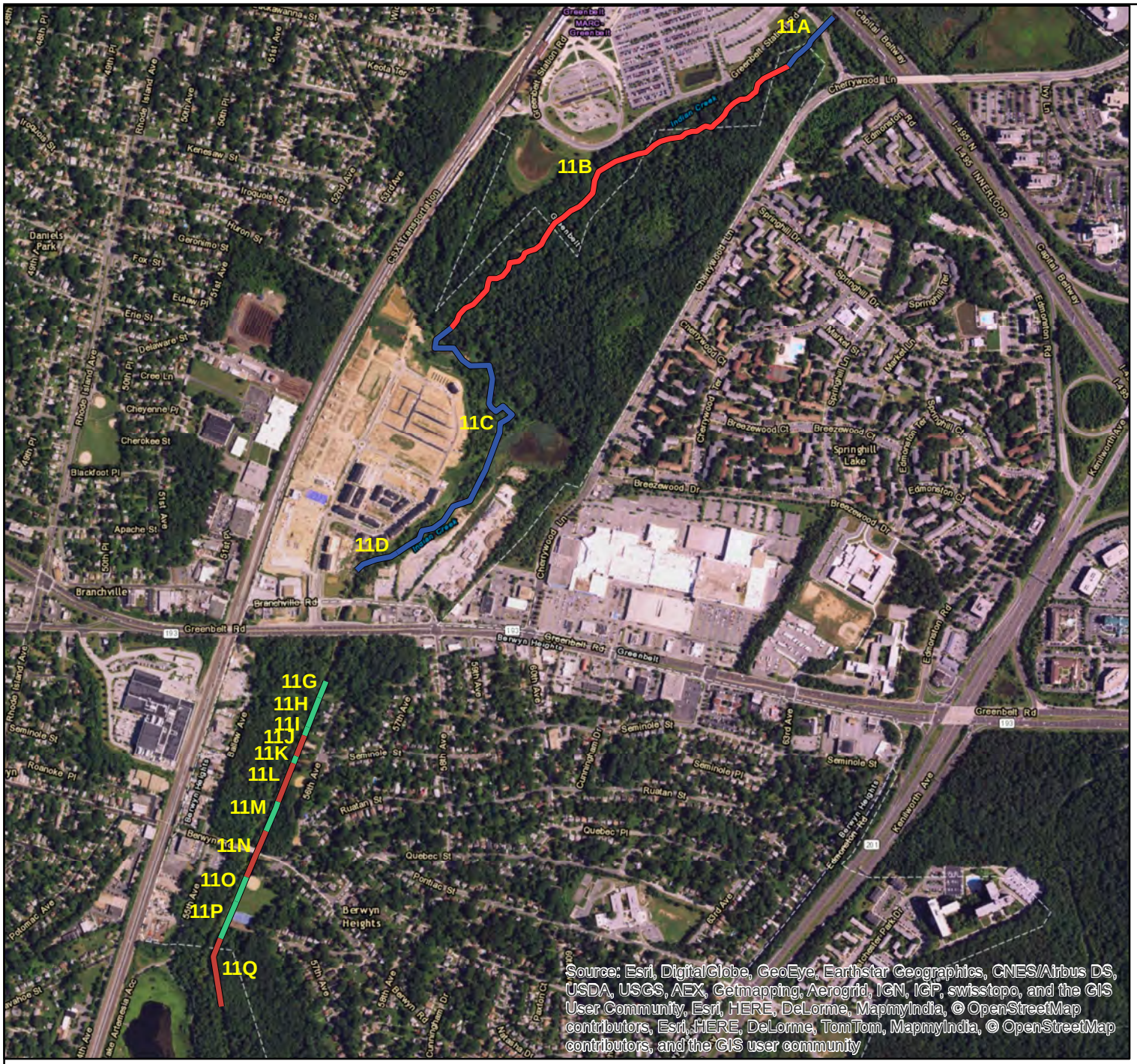
0 200 400 800 1,200 1,600
Feet

Anacostia Watershed Restoration
Prince George's County

Subwatershed: Indian Creek
Site: Indian Creek - College Park
Project Segment #: 11

Reach	Habitat Type Code[1]	Legend	Length (ft)
11A	11Ccp		524
11B	11PFO		3571
11C	11Ccp		2762
11D	11Ccp		352
11E	None		324
11F	None		112
11G	11Ccg		139
11H	11Ccg		247
11I	11Ccg		70
11J	11Cc		176
11K	11Ccg		58
11L	11Cc		325
11M	11Ccg		245
11N	11Cc		394
11O	11Ccg		204
11P	11Ccg		316
11Q	11Cc		549

1 Type Code Definition see attached table



N
W E
S

0 650 1,300 2,600 3,900 5,200 Feet

Anacostia Watershed Restoration
Prince George's County

Subwatershed: Little Paint Branch
Site: Little Paint Branch
Project Segment #: 12

Reach	Habitat Type Code[1]	Legend	Length (ft)
12A	12Cc		896
12B	12Cm		1974
12C	12Cc		1660

1 Type Code Definition see attached table

N
W E
S

0 375 750 1,500 2,250 3,000 Feet

Anacostia Watershed Restoration
Prince George's County

Subwatershed: Northwest Branch
Site: Riggs Road
Project Segment #: 13

Reach	Habitat Type Code[1]	Legend	Length (ft)
13A	13Cmhe		2258
13B	13Cml		1506
13C	13Cct		792
13D	13Ccsr		844
13E	13Cc		1296
13F	13Ccsr		489
13G	13Ccsr		505

1 Type Code Definition see attached table

N
W E
S

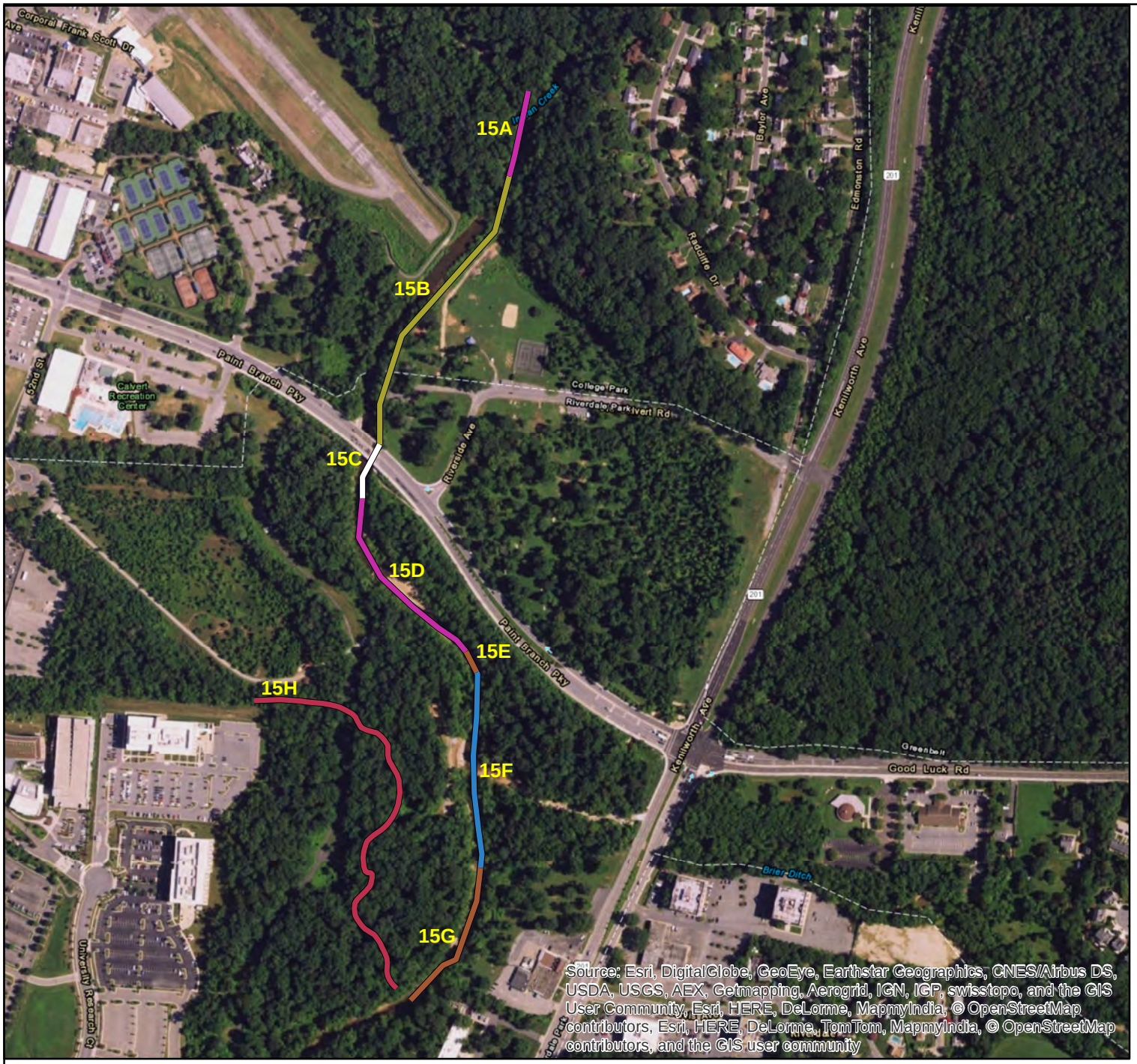
0 500 1,000 2,000 3,000 4,000 Feet

Anacostia Watershed Restoration
Prince George's County

Subwatershed: Northeast Branch
Site: Northeast Branch
Project Segment #: 15

Reach	Habitat Type Code[1]	Legend	Length (ft)
15A	15Ccor		328
15B	15Ccgt		1163
15C	None		220
15D	15Ccor		754
15E	15Cce		86
15F	15Ccp		741
15G	15Cce		593
15H	15TCm		1635

1 Type Code Definition see attached table



N
W E
S

0 325 650 1,300 1,950 2,600
Feet

Table 1-2: PHA Data Summary															
			RHA STATION				Station Endpoints								
							Upstream			Downstream					
Habitat Station Code	**USACE SEGMENT NO.**	**SEGMENT NAME**	**LOCATION NOTES**	**HABITAT DESCRIPTION**	**HABITAT CODE**	**DATES ASSESSED**	**Latitude**	**Longitude**	**Accuracy (ft)**	**Latitude**	**Longitude**	**Accuracy (ft)**	**Endpoint Comments**	**Endpoint GPS Gadget**	**Watershed Area (acres)**
1AD	1	Indian Creek - I95	E of Caroline Ave	Mature forest	**1Cm**	6/27/2014	39.04934	76.90416	22	39.04854	76.90438	65	NR	CS	1235
1BU	1	Indian Creek - I95	SE of Trolley Ln Cul de Sac	Channelized, not stabilized. Substantial floodplain fill W bank	**1Cc**	4/14/2015	39.052009	76.90425	131?					SK	1210
2AD	3	Northwest Branch - Hyattsville	Off Nicholson Street. Kudzu eradication site	Channelized, all pool	**3Ccp**	7/1/2014	NR	NR		38.96074	76.97206	19	Down end sapling box eldar	CS	22720
2BU	3	Northwest Branch - Hyattsville	Upstream of 500	Channelized, deep pool, no bars, no riffle/run, boulders one bank	**3Ccpg**	10/28/2014	38.95258	76.96752	45	NR	NR	NR	Up silver maple, down river birch	CS	31616
2CD	3	Northwest Branch - Hyattsville	Upstream of W Hyattsville metro bridge	Lower channelized, shallow	**3Ccu**	10/28/2014	38.95437	76.97131	16	38.95402	76.97068	13	Up river birch S bank, down box eldar S bank	CS	31488
2DD	3	Northwest Branch - Hyattsville	Upstream of 410	Earth, channelized, extensive bars	**3Cce**	10/31/2014	38.96904	76.96646	45	38.96850	76.96680	45	Up box eldar SE bank, down bitternut hickory SE bank	CS	22272
2ED	3	Northwest Branch - Hyattsville		Gabion pool, channelized	**3Ccst**	11/5/2014	38.95579	76.97399	26	38.95542	76.97336	16	Up river birch E bank, down sycamore E bank	CS	31296
2FD	3	Northwest Branch - Hyattsville	Downstream of 410	Unstabil, not channelized	**3Cm**	10/31/2014	38.96696	76.96914	13	38.96640	76.96966	16	Up sycamore W bank, down spice bush	CS	22592
3A	5	Paint Branch	Below Route 1	Generic continuous boulder stabilization on banks, continuous pool. Riffles absent	**5Ccst**	11/7/2014	NA	NA		NA	NA		NA	CS	19584
3BD	5	Paint Branch	Downstream of Rte 1, Upstream of pedestrian bridge	Channelized, unstabilized, eroding tall earth bank one side, homogeneous shallow habitat, large continuous channel parallel bar	**5Ccehu**	6/26/2014	NR	NR		38.98673	76.93022	32	NR	CS	19648
3CD	5	Paint Branch		Gravel bars, woody debris jam, braided flow	**5Cw**	11/7/2014	38.98265	76.92159	26	38.98192	76.92116	26	Up tulip tree NE bank, down silver maple E bank	CS	19904
3DD	5	Paint Branch	Lowermost reach	Channelized, some boulder stabilization, shallow but w/some pool area, no continuous channel parallel bar	**5Ccgu**	11/7/2014	38.98051	76.91925	32	38.98002	76.91870	16	Down sycamore NE bank, Up opposite shrub NE bank	CS	19904

Table 1-2: PHA Data Summary															
			RHA STATION				Station Endpoints								
							Upstream			Downstream					
Habitat Station Code	**USACE SEGMENT NO.**	**SEGMENT NAME**	**LOCATION NOTES**	**HABITAT DESCRIPTION**	**HABITAT CODE**	**DATES ASSESSED**	**Latitude**	**Longitude**	**Accuracy (ft)**	**Latitude**	**Longitude**	**Accuracy (ft)**	**Endpoint Comments**	**Endpoint GPS Gadget**	**Watershed Area (acres)**
3ED	5	Paint Branch	Downstream of RR bridge	Channelized, minimal stabilization, low-bank, minimal erosion, braided flow	**5Ccle**	11/5/2014	38.98358	76.92382	13	38.98351	76.92368	22	Up sycamore within channel bar, down sycamore E bank	CS	19840
4A	7	Paint Branch - I95 Interchange	Power Line	Channelized, woody vegetation cleared	**7Cc**	7/23/2014	39.02349	-76.94705	ND	39.02329	-76.9461	ND	Determined in office by SK via aerial photo interpretation	CS	10432
4BD	7	Paint Branch - I95 Interchange	Upstream of 95	Alluvium, point bars, some woody debris jams	**7Pe**	7/31/2014	39.02843	76.95130	42	39.02817	76.95141	65	Up muscle wood, Down muscle wood	CS	10048
4CD	7	Paint Branch - I95 Interchange	Downstream of Rte 212	Pdmt Bedrock, Stabilized Locally	**7Pb**	7/31/2014	39.03144	76.95234	26	39.03137	76.95201	42	Up musclewood W bank, Down rusty vertical axle E bank	CS	9856
5AD	9	Sligo Creek	Just upstream NW Branch Confluence	Shallow pools w/occasional riffles. Ponded by structures.	**9Cg**	7/1/2014	38.95909	76.97469	22	38.95911	76.97439	45	Up multitrunk silver maple, down box eldar root N bank	CS	7168
5BD	9	Sligo Creek		Ecodisney boulder works	**9Cs**	10/21/2014	38.96164	76.97813	13	38.96134	76.97739	26	Up mulberry, down mulberry	CS	7040
6AD	10	Chillum Road Tributary	Upstream-most, below Chillum Rd	Continuously stabilized and channelized	**10Cs**	10/17/2014	38.95600	76.98075	26	38.95630	76.98036	22	Up elm S bank, down elm N bank	CS	1242
6BD	10	Chillum Road Tributary	Downstream of pedestrian bridge	Systematic discontinuous stabilization, channelized	**10Cg**	10/17/2014	38.95675	76.97964	16	38.95688	76.97890	19	Down S bank mulberry, uup S bank box eldar	CS	1254
6CD	10	Chillum Road Tributary	Lower	Unstabilized, earth channel, unstable	**10Ce**	10/21/2014	38.95597	76.97642	13	38.95589	76.97632	13	Up large elm, down large downed silver maple	CS	1286
7AD	11	Indian Creek - College Park	Downstream of Berwyn Rd	Channelized, systematically stabilized. Pond/glide.	**11Ccg**	11/10/2014	38.99287	76.91993	42	38.99264	76.92026	22	Up sycamore, Down basket oak	CS	18176
7BU	11	Indian Creek - College Park	Downstream of Berwyn Heights Park	Channelized, not systematically stabilized. Long, homogeneous ponded reaches.	**11Cc**	11/10/2014	38.99154	76.92059	13	NR	NR	NR	Synthetic, only one endpoint recorded.	CS	18176
7E	11	Indian Creek - College Park	Upstream of Greenbelt Rd	Channelized, deep pool, no bars, no riffle/run, minimal woody debris. Riparian habitat disturbed on one bank from historic activity	**11Ccp**	11/10/2014	NA	NA	NA	NA	NA	NA	Synthetic, no specific endpoint	NA	17536

Table 1-2: PHA Data Summary															
			RHA STATION				Station Endpoints								
							Upstream			Downstream					
Habitat Station Code	**USACE SEGMENT NO.**	**SEGMENT NAME**	**LOCATION NOTES**	**HABITAT DESCRIPTION**	**HABITAT CODE**	**DATES ASSESSED**	**Latitude**	**Longitude**	**Accuracy (ft)**	**Latitude**	**Longitude**	**Accuracy (ft)**	**Endpoint Comments**	**Endpoint GPS Gadget**	**Watershed Area (acres)**
7CD	12	Little Paint Branch	Downstream of unchannelized reach downstream of Cherry Hill Rd	Channelized, earth	**12Cc**	7/23/2014	39.01289	76.93584	19	39.01198	76.93601	16	Up multitrunk ash, down river birch	CS	6720
7DD	12	Little Paint Branch	Downstream of Cherry Hill Rd	Unchannelized, earth	**12Cm**	6/16/2014	39.01432	76.9356	26	39.01381	76.93587	16	Up tulip tree sapling E bank, Down sycamore sapling	CS	6720
8AD	13	NW Branch Anacostia Mainstem	Below pedestrian bridge, upstream of University Boulevard	Earth channel, Unstabilized, Unchannelized, Severe bank/channel erosion, large sand bars, timber jams	**13Cmhe**	4/2/2015	38.98937	76.96636	32	38.98927	76.96587	16	Up box elder & woody debris; down slumping elm	CS	21312
8BD	13	NW Branch Anacostia Mainstem	Archery range, upstream of University Boulevard	Meander, erosion, not stab, bars	**13Cml**	4/14/2015	38.985647	76.963973	52	38.985342	76.96395	52	Up box elder sapling, down box elder sapling and large sycamore	SK	21504
8CD	13	NW Branch Anacostia Mainstem	Below University Blvd, in Lane Manor Recreation Center	Channelized earth, not stabilized	**13Cct**	4/14/2015	38.983977	76.964622	46	38.974702	76.9528733	46	Box eldars, W bank	SK	53
8DD	13	NW Branch Anacostia Mainstem	Below University Blvd, in Lane Manor Recreation Center	Channelized, systematically stabilized w/boulders. Run/riffle	**13Ccsr**	4/9/2015	38.98202	76.96381	22	38.98176	76.96293	42	Up elm W bank; down ash	CS	21760
8ED	13	NW Branch Anacostia Mainstem	Near downstream end of segment	Channelized, not stabilized. Moderate erosion	**13Cc**	4/9/2015	38.97941	76.96307	16	38.97892	76.96361	16	Up & down, box eldars W bank	CS	21760
9AD	15	NE Branch Anacostia Mainstem	Upstream of Paint Branch Parkway	Channelized, systematic boulder stabilized, no bar deposits, minimal erosion	**15Ccgt**	3/30/2015	38.9766	76.908	45	38.97612	76.91942	42	Upstream end just downstream of airport.	CS	115
9BD	15	NE Branch Anacostia Mainstem	Downstream of Paint Branch Parkway	Channelized, systematic boulder stabilized, large bar deposits, riffles	**15Ccor**	4/2/2015	38.97477	76.91965	26	38.97419	76.91971	32	River birch E bank both up and down	CS	192

Table 1-2: PHA Data Summary															
			RHA STATION				Station Endpoints								
							Upstream			Downstream					
Habitat Station Code	**USACE SEGMENT NO.**	**SEGMENT NAME**	**LOCATION NOTES**	**HABITAT DESCRIPTION**	**HABITAT CODE**	**DATES ASSESSED**	**Latitude**	**Longitude**	**Accuracy (ft)**	**Latitude**	**Longitude**	**Accuracy (ft)**	**Endpoint Comments**	**Endpoint GPS Gadget**	**Watershed Area (acres)**
9CD	15	NE Branch Anacostia Mainstem	Downstream of Paint Branch Parkway	Channelized, systematic boulder stabilized, sediment point bar deposits against boulders on W bank, between grade-control structures. Erosion behind boulders E bank	**15Ccp**	3/31/2015	38.97298	76.91832	32	38.9722	76.91806	45	Downstream end upstream of active sanitary sewer crossing work and temporary bridge.	CS	685
9DD	15	NE Branch Anacostia Mainstem	Opposite MNCPPC building	Channelized, systematic boulder stabilized, sediment point bar deposits against boulders on W bank, no bank erosion behind boulders E bank	**15Cce**	3/31/2015	38.97005	96.91873	16	38.96967	76.91922	13	Sycamore sapling W bank, upstream end	CS	44288
10DD	15	NE Branch Anacostia Tributary	Downstream of Paint Branch Parkway	Unchannelized, unstabilized, earthen channel w/locally severe bank erosion	**15TCm**	3/31/2015	38.97056	76.91974	26	38.97042	76.91975	26	Downstream at NE Branch confluence. Upstream end Anacostia paved trail.	CS	486
habitat code relates to data sheet having watershed area and nearest road data															
NA	Not applicable. See reach notes														
NR	Not recorded														
Endpoint GPS Gadget															
CS	CS Blackberry														
SK	SK Blackberry														

Table 1-3: Stream Reach Metrics											
Reach	Habitat Code	Reach Number	Physiographic Province*	Reach Length (ft)	Reach Length (m)	Reach Width (ft)	Reach Width (m)	Road Distance (ft)	Road Distance (m)	Area (ft^2)	Area (acres)
1A	1Cc	1	C	695.0	211.8	60	18.3	414.4	126.3	41698.4	1.0
1B	1Cm	1	C	6262.6	1908.8	60	18.3	0.0	0.0	375756.4	8.6
3A	3Cce	3	C	817.0	249.0	81	24.7	31.8	9.7	66179.5	1.5
3B	3Cm	3	C	470.3	143.3	81	24.7	408.7	124.6	38094.0	0.9
3C	*3Ccp*	3	C	376.6	114.8	81	24.7	267.2	81.4	30504.0	0.7
3D	*3Ccp*	3	C	207.6	63.3	81	24.7	189.3	57.7	16812.6	0.4
3E	*3Cce*	3	C	85.6	26.1	81	24.7	144.3	44.0	6933.0	0.2
3F	*3Ccp*	3	C	50.8	15.5	81	24.7	121.2	36.9	4111.9	0.1
3G	*3Ccst*	3	C	217.8	66.4	81	24.7	40.6	12.4	17645.8	0.4
3H	None	3	C	234.6	71.5	81	24.7	51.5	15.7	18998.9	0.4
3I	3Ccp	3	C	1374.6	419.0	81	24.7	125.3	38.2	111341.3	2.6
3J	3Ccst	3	C	456.1	139.0	81	24.7	243.3	74.1	36945.6	0.8
3K	9Cs	3	C	156.4	47.7	81	24.7	298.9	91.1	12666.0	0.3
3L	3Ccst	3	C	339.3	103.4	81	24.7	405.5	123.6	27485.8	0.6
3M	9Cs	3	C	203.0	61.9	81	24.7	586.9	178.9	16442.6	0.4
3N	3Ccst	3	C	171.1	52.1	81	24.7	546.9	166.7	13856.9	0.3
3O	*3Ccu*	3	C	95.2	29.0	81	24.7	527.1	160.7	7710.3	0.2
3P	3Ccu	3	C	761.3	232.0	81	24.7	402.5	122.7	61662.1	1.4
3Q	3Ccpg	3	C	1267.7	386.4	81	24.7	25.9	7.9	102683.3	2.4
5A	5Ccst	5	C	176.1	53.7	98	29.9	58.5	17.8	17253.3	0.4
5B	5Ccgu	5	C	244.4	74.5	98	29.9	83.0	25.3	23949.7	0.5
5C	5Ccehu	5	C	358.6	109.3	98	29.9	166.9	50.9	35145.5	0.8
5D	5Cw	5	C	128.4	39.1	98	29.9	162.5	49.5	12581.9	0.3
5E	5Ccgu	5	C	396.2	120.8	98	29.9	189.3	57.7	38823.8	0.9
5F	5Ccehu	5	C	533.6	162.6	98	29.9	194.9	59.4	52288.8	1.2
5G	5Ccst	5	C	163.8	49.9	98	29.9	322.3	98.2	16050.1	0.4
5H	5Ccehu	5	C	386.3	117.7	98	29.9	346.7	105.7	37858.1	0.9
5I	5Ccgu	5	C	72.2	22.0	98	29.9	441.4	134.5	7078.6	0.2
5J	5Ccehu	5	C	272.7	83.1	98	29.9	415.6	126.7	26720.4	0.6
5K	5Ccle	5	C	1694.2	516.4	98	29.9	87.1	26.6	166030.1	3.8
5L	5Cw	5	C	497.2	151.5	98	29.9	114.5	34.9	48725.4	1.1
5M	5Ccst	5	C	145.7	44.4	98	29.9	86.7	26.4	14279.2	0.3
5N	5Ccst	5	C	125.9	38.4	98	29.9	24.7	7.5	12337.5	0.3
5O	9Cs	5	C	93.7	28.5	98	29.9	43.7	13.3	9178.8	0.2
5P	5Ccgu	5	C	501.7	152.9	98	29.9	131.0	39.9	49166.7	1.1
5Q	5Ccgu	5	C	135.2	41.2	98	29.9	241.9	73.7	13246.9	0.3
5R	5Ccst	5	C	137.1	41.8	98	29.9	265.3	80.9	13435.9	0.3
5S	9Cs	5	C	235.3	71.7	98	29.9	328.3	100.1	23061.3	0.5
5T	5Ccgu	5	C	155.0	47.3	98	29.9	459.9	140.2	15192.8	0.3
7A	7Pb	7	P	375.5	114.5	80	24.4	21.2	6.5	30040.1	0.7
7B	7Pe	7	P	1313.9	400.5	80	24.4	113.2	34.5	105115.6	2.4
7C	7Cc	7	C	1653.4	504.0	80	24.4	0.0	0.0	132274.0	3.0
7D	None	7	C	294.8	89.9	80	24.4	28.7	8.7	23583.1	0.5
7E	7Cc	7	C	2238.7	682.3	80	24.4	0.0	0.0	179094.0	4.1
9A	9Cg	9	C	568.1	173.2	138	42.1	181.5	55.3	78402.2	1.8
9B	9Cs	9	C	243.4	74.2	138	42.1	251.4	76.6	33582.7	0.8
9C	9Cg	9	C	1429.6	435.8	138	42.1	248.8	75.8	197289.1	4.5
10A	10Cs	10	C	369.7	112.7	138	42.1	38.9	11.9	51018.4	1.2
10B	10Cg	10	C	441.4	134.5	138	42.1	60.5	18.4	60916.9	1.4
10C	10Ce	10	C	798.4	243.4	138	42.1	42.5	13.0	110182.2	2.5
10D	10Cg	10	C	486.1	148.2	138	42.1	318.7	97.1	67082.4	1.5
11A	11Ccp	11	C	5971.9	1820.2	54	16.5	31.9	9.7	322482.5	7.4
11B	11Ccp	11	C	885.5	269.9	54	16.5	196.6	59.9	47816.2	1.1
11C	11Ccp	11	C	351.5	107.1	54	16.5	99.8	30.4	18978.4	0.4

Table 1-3: Stream Reach Metrics											
Reach	Habitat Code	Reach Number	Physiographic Province*	Reach Length (ft)	Reach Length (m)	Reach Width (ft)	Reach Width (m)	Road Distance (ft)	Road Distance (m)	Area (ft^2)	Area (acres)
11D	11Ccp	0	C	98.3	30.0	54	16.5	122.4	37.3	5308.2	0.1
11E	None	0	C	324.5	98.9	54	16.5	32.4	9.9	17521.4	0.4
11F	None	0	C	111.5	34.0	54	16.5	0.0	0.0	6022.6	0.1
11G	11Ccg	11	C	139.2	42.4	54	16.5	17.3	5.3	7514.1	0.2
11H	11Ccg	11	C	246.5	75.1	54	16.5	4.7	1.4	13311.0	0.3
11I	11Ccg	11	C	70.4	21.5	54	16.5	6.4	2.0	3800.9	0.1
11J	11Cc	11	C	175.7	53.6	54	16.5	6.6	2.0	9490.5	0.2
11K	11Ccg	11	C	57.6	17.5	54	16.5	10.2	3.1	3108.7	0.1
11L	11Cc	11	C	325.1	99.1	54	16.5	1.6	0.5	17558.0	0.4
11M	11Ccg	11	C	245.1	74.7	54	16.5	0.0	0.0	13233.1	0.3
11N	11Cc	11	C	393.8	120.0	54	16.5	0.0	0.0	21263.8	0.5
11O	11Ccg	11	C	204.2	62.3	54	16.5	0.0	0.0	11029.1	0.3
11P	11Ccg	11	C	316.2	96.4	54	16.5	0.0	0.0	17072.4	0.4
11Q	11Cc	11	C	549.3	167.4	54	16.5	0.0	0.0	29660.9	0.7
12A	12Cc	12	C	896.3	273.2	112	34.1	48.1	14.7	100385.5	2.3
12B	12Cm	12	C	1973.8	601.6	112	34.1	22.6	6.9	221062.6	5.1
12C	12Cc	12	C	1660.0	506.0	112	34.1	3.5	1.1	185915.7	4.3
13A	13Cmhe	13	C	2258.4	688.4	161	49.1	333.7	101.7	363601.7	8.3
13B	13Cml	13	C	1505.9	459.0	161	49.1	43.8	13.4	242447.2	5.6
13C	13Cct	13	C	791.7	241.3	161	49.1	42.0	12.8	127455.9	2.9
13D	13Ccsr	13	C	843.6	257.1	161	49.1	45.9	14.0	135824.9	3.1
13E	13Cc	13	C	1296.5	395.2	161	49.1	251.1	76.5	208734.5	4.8
13F	13Ccsr	13	C	489.4	149.2	161	49.1	240.6	73.3	78792.9	1.8
13G	13Ccsr	13	C	504.9	153.9	161	49.1	197.2	60.1	81296.5	1.9
15A	15Ccor	15	C	328.1	100.0	137	41.8	422.8	128.9	44948.7	1.0
15B	15Ccgt	15	C	1162.6	354.4	137	41.8	7.1	2.2	159281.6	3.7
15C	None	15	C	219.6	66.9	137	41.8	0.0	0.0	30079.5	0.7
15D	15Ccor	15	C	753.9	229.8	137	41.8	116.6	35.5	103282.4	2.4
15E	15Cce	15	C	86.5	26.4	137	41.8	164.4	50.1	11843.7	0.3
15F	15Ccp	15	C	740.7	225.8	137	41.8	185.3	56.5	101477.7	2.3
15G	15Cce	15	C	593.2	180.8	137	41.8	432.0	131.7	81264.8	1.9
15H	15TCm	15	C	1634.5	498.2	30	9.1	104.1	31.7	49036.0	1.1

*C = Coastal Plan, P = Piedmont

Table 1-4: Stream Segment Access Information - Anacostia Prince George's County		
Segment No.	**Segment Name**	**Parking and Stream Access**
1	Indian Creek - I95	To access downstream end of segment, park on Caroline Ave north of Quimby Ave. From Route 1, drive west on various small roads to access Caroline Ave, then turn north on Caroline Ave. Walk north into woods along informal trails to access stream. To access middle of segment, park in vicinity of Trolley Lane cul de sac. Can also park at MLK School. Walk east to stream then up/down. (No trail)
3	Northwest Branch	For southern end of segment: park on Nicholson Street off Ager Road, then walk down trail and cut across woods to west or south to stream. For northern end of segment: park on West Park Drive, access via Amherst Rd, walk east through woods to stream, then along stream (no trail)
5	Paint Branch	From Route 1, drive east on Lakeland Rd, then make right on Rhode Island Ave, then left on Pierce Avenue. Park behind community center, then walk along paved trails. Can access stream from pedestrian bridge or by walking south through woods from trails.
7	Paint Branch - I95 Interchange	Access problematic for all but upper end. To access uppermost segment, park in Powder Mill Community Park on Powder Mill Rd. Walk SE from parking lot through woods to stream on informal trails. After reaching stream, no further trails. Walk downstream along stream to access remainder of stream. To access segment from downstream, get permission to enter agricultural research lands off Cherry Hill Rd. Drive west/north on gravel and dirt roads to park about where stream goes under beltway. Then walk upstream along stream. No trails.
9	Sligo	For northern end of segment, park on Sligo Parkway near Powhatan Road intersection. Walk west across ballfields to access stream. Walk in stream to access downstream points. For southern end of segment, can park on Nicholson Street and take paved trails of Anacostia trail system across the river then up Sligo Creek.
10	Chillum	Park on 16th Avenue off Chillum Road, access stream at pedestrian bridge. No trail for points downstream of bridge, walk in stream valley to access. Points upstream of bridge can be accessed via walking on lawn parallel to stream or walking in stream.
11	Indian Creek - College Park	Park in Indian Creek Park in Berwyn Heights on Berwyn Road and use Anacostia trail system (paved) to access portion of segment downstream of Greenbelt Rd. Walk through informal trails through woods to access west bank or portion of stream immediately downstream of Greenbelt Rd. To access stream upstream of Greenbelt Rd., can park on Branchville Rd and walk upstream on west bank on paved road/trail then behind multifamily housing. East bank is not readily accessible there.
12	Little Paint Branch	Park in "Little Paint Branch Stream Valley Park" on Cherry Hill Road. For upstream, follow paved trail upstream. To go downstream, walk west along and cross Cherry Hill Road, then head south on trail. RHA segment is across from park bench labelled "PPVA Donation"
13New	Lower Northwest Branch	Lower boundary about Fordham St (downstream of Univ Blvd); upper boundary about Rosette Ln just downstream of Riggs Rd. Access from Adelphi Manor archery range on N side of E bank off University Boulevard, or through Lane Manor Recreation Center on S side of W bank off W Park Dr. Also, can access via Anacostia trail access point below power line off Cool Spring Rd
15	Northeast Branch	Upper point is confluence of Paint and Indian Creek; lower point is just downstream of Brier Ditch confluence. Access off Paint Branch Parkway, park on SW side of NE Branch to utilize Anacostia trail and parking lot, or park on NE side in Riverside Ave parking lot in park.
Between 3&13	Northwest Branch - East-West Highway	Parked on West Park Drive, then walked E through park to access stream.

Table 1-5: Embeddedness - Individual Data Points and Average											
	USACE Segment No. and Date										
Embeddedness Sample	**1**	**3**	**3**	**3**	**5**	**5**	**5**	**5**	**7**	**7**	**7**
Date	**6/27/2014**	**10/28/2014**	**10/31/2014**	**10/31/2014**	**6/26/2014**	**11/7/2014**	**11/7/2014**	**11/5/2014**	**7/23/2014**	**7/31/2014**	**7/31/2014**
Habitat Type Code	**1Cm**	**3Ccu**	**3Cce**	**3Cm**	**5Ccehu**	**5Ccgu**	**5Cw**	**5Ccle**	**7Cc**	**7Pe**	**7Pb**
1	40	40	40	20	30	40	20	60	65	65	50
2	20	50	40	40	60	50	15	40	50	25	60
3	50	20	35	40	50	35	25	40	80	50	70
4	20	30	55	50	40	40	30	40	60	70	40
5	60	60	35	55	20	50	10	50	75	80	50
6	50	70	45	35	20	60	15	70	95	10	40
7	50	85	35	40	20	25	15	65	100	60	40
8	10	80	30	40	40	35	25	60	25	15	80
9	10	75	20	20	10	75	15	60	75	10	75
10	5	85	30	30	30	60	10	55	95	10	80
Mean	32	60	37	37	32	47	18	54	72	40	59

Table 1-5: Embeddedness - Individual Data Points and Average												
Embeddedness Sample	**9**	**9**	**10**	**10**	**12**	**12**	**13**	**13**	**13**	**15**	**15**	**15**
Date	**7/1/2014**	**10/21/2014**	**10/21/2014**	**10/17/2014**	**7/23/2014**	**6/16/2014**	**4/9/2015**	**4/2/2015**	**4/14/2015**	**3/31/2015**	**4/2/2015**	**3/31/2015**
Habitat Type Code	**9Cg**	**9Cs**	**10Ce**	**10Cs**	**12Cc**	**12Cm**	**13Cc**	**13Cmhe**	**13Cml**	**15TCm**	**15Ccor**	**15Ccp**
1	50	40	20	50	40	40	40	10	35	45	50	25
2	40	30	30	30	10	10	50	45	40	50	30	50
3	50	20	20	60	50	25	5	10	5	50	70	0
4	10	30	60	30	60	25	30	50	5	25	50	10
5	50	30	30	40	80	15	10	20	10	35	20	20
6	40	10	40	85	50	60	60	10	25	40	30	30
7	30	25	20	70	40	5	50	60	30	35	30	40
8	40	30	30	90	50	30	40	45	15	35	15	25
9	60	10	20	10	50	40	50	20	10	35	50	0
10	60	20	30	20	60	75	60	40	5	40	35	30
Mean	43	25	30	49	49	33	40	31	18	39	38	23

Table 1-6: Reach Coordinates and Condition - Segment 1

Stream Segment 1 Reaches and Reach Data: **Indian Creek - I95** Strahler Stream Order Determined by Andrew Roach4/22/2015: 1

Reach Subdivision Assessment D June 26, 2014; July 31, 2014; March 30, 2015

NFR: Not field recorded. Determined using GIS. Upstream reach coordinates recorded using SK phone.

Reach Data by Mainstem or Tributary in Rows Below. Top upstream, bottom downstream.
One Reach per Row Below

					Predominant Conditions						Endpoint Upstream			Endpoint Downstream			Coordinate Notes
Tally No.	**Code Letter for CEICA**	**Segment Mainstem or Tributary**	**Overall Flow Direction**	**Physiographic Province**	**Channel and Bank Material**	**Channelized?**	**Continuously Stabilized?**	**Systematic Discontinuously Stabilized?**	**Notes**	**Representative RHA Station Habitat Type Code (for CEICA)**	**Latitude**	**Longitude**	**Accuracy (ft)**	**Latitude**	**Longitude**	**Accuracy (ft)**	
	1A	M	SE	CP	Earth banks, bed gravel	Yes	No	No	Patch stabilization	1Cc	NFR	NFR	NFR	39.05049	76.90377		Upstream end is downstream of SWM/FRM feature
	1B	M	SE	CP	Earth banks, bed gravel	No	No	No	Mature pine forest with native understory	1Cm	39.05049	76.90377		NFR	NFR	NFR	Coordinate recorded 4/14/2015. Identify downstream end as edge of woods/upstream end of concrete channel on aerial image.
	1C	M	SE	CP	Earth banks, bed gravel	No	No	No	PFO	1PFO	NFR	NFR	NFR	39.05049	76.90377		

Additional habitat type reaches
- Within SWM/FRM feature
- Upstream of Ammendale Rd in beaver pond

Table 1-7: Reach Coordinates and Condition - Segment 3

Stream Segment 3 Reaches and Reach Data: **Northwest Branch - Hyattsville** Strahler Stream Order Determined by Andrew Roach4/22/2015: 3

Reach Subdivision Assessment Dat June 11, 2014; Oct 24, 2014; Oct 28, 2014; Oct 31, 2014

NFR: Not field recorded. Determined using GIS.

Reach Data by Mainstem or Tributary in Rows Below. Top upstream, bottom downstream.
One Reach per Row Below

					Predominant Conditions					Representative RHA Station		Endpoint Upstream			Endpoint Downstream			
Tally No.	Code Letter for CEICA	Segment Mainstem or Tributary	Overall Flow Direction	Physiographic Province	Channel and Bank Material	Channelized?	Continuously Stabilized?	Systematically Stabilized?	Notes	Habitat Type Code (for CEICA)	Notes	Latitude	Longitude	Accuracy (ft)	Latitude	Longitude	Accuracy (ft)	Notes
1	3A	M		CP		No?	No	No	Stream banks/channel not stabilized. Recent tree plantings. Ponded all pool. S bank erosion 2 to 3 m.	3Cce	Unstabilized like 3Cm, but all pool. Assigned 3Cce because of proximity.	38.96853	76.96849	16	38.96641	76.96925	16	Upstream end is 410 Bridge grade control structure
2	3B	M		CP		No	No	No	Not stabilized nor channelized. Gravel bar/braided, Woody debris jam in reach	3Cm		38.96641	76.96925	16	38.96588	76.97062	39	
3	3C	M		CP		No?	No	Yes	Primarly ponded/pool. Some riffle on boulders/concrete	*3Ccp*	*Upper segment probably warranting additional pool/boulder habitat type*	38.96588	76.97062	39	38.96496	76.97092	16	Upstream end just upstream of pedestrian bridge
4	3D			CP		Yes?	No	No	Patch bank stabilization, run/riffle from exotic materials. Minimal/no bars. Minimal bank erosion.	*3Ccp*	*Probably warranting additional run/riffle habitat type*	38.96496	76.97092	16	38.96443	76.97101	19	
5	3E	M		CP		Yes	No	No	Erosion minor to moderate. Run/riffle. No bank stabilization, bank heights 2 m, erosion minor to locally moderate	*3Cce*	*Probably warranting additional run/riffle habitat type*	38.96443	76.97101	19	38.96417	76.971	19	
6	3F	M		CP		Yes		No	Patch bank stabilization, ponded	*3Ccp*	*Upper segment probably warranting additional pool/boulder habitat type*	38.96417	76.971	19	38.96406	76.97102	16	
7	3G	M		CP		Yes		Yes	Systematic boulder/concrete stabilization. Ponded	*3Ccst*	*Upper segment probably warranting additional pool/boulder habitat type*	38.96406	76.97102	16	38.96347	76.97075	13	Downstream end is concrete grade-control structure upstream of Ager Rd which forms riffle
8	3H	M		CP		Yes			Riffle then under bridge habitat, then sill	None	Under bridge	38.96347	76.97075	13	38.96281	76.97093	13	Ager Rd bridge
9	3I	M		CP	Concrete rubble and boulder stabilization.	Yes		Yes	Predominantly pond/glide. Entire channel wetted, no bars except minor bar formation from anthropogenic placement (?). Minor to moderate bank erosion.	3Ccp		38.96281	76.97093	13	38.9597	76.97318	32	
10	3J	M		CP	Sands, muds, cobble.	Yes	Yes		Point bars in channel. Mostly ponded. Various bank stabilization works (boulders, gabion baskets)	3Ccst		38.9597	76.97318	32	38.95645	76.97441	32	Downstream end is concrete blanket sill just below Chillum confluence
11	3K	M		CP		Yes	Yes		Artificial boulder riffle	(Use Sligo Creek Ecodisneyland: 9Cs)		38.95645	76.97441	32	38.95594	76.9744	16	

					Predominant Conditions					Representative RHA Station		Endpoint Upstream			Endpoint Downstream			
Tally No.	Code Letter for CEICA	Segment Mainstem or Tributary	Overall Flow Direction	Physiographic Province	Channel and Bank Material	Channelized?	Continuously Stabilized?	Systematically Stabilized?	Notes	Habitat Type Code (for CEICA)	Notes	Latitude	Longitude	Accuracy (ft)	Latitude	Longitude	Accuracy (ft)	Notes
12	3L	M		CP		Yes	Yes		Ponded. Stabilized with variety of gabions, boulders. Local minor to moderate erosion E bank.	3Ccst		38.95594	76.9744	16	38.9553	76.97353	26	Downstream end is boulder riffle grade control
13	3M	M		CP		Yes	Yes		Artificial boulder riffle	(Use Sligo Creek Ecodisneyland: 9Cs)		38.9553	76.97353	26	38.95534	76.97345	26	
14	3N	M		CP		Yes	Yes		Ponded. Stabilized with variety of gabions, boulders. Local minor to moderate erosion E bank.	3Ccst		38.95534	76.97345	26	38.95492	76.97235	45	Downstream end is naturally formed riffle
15	3O	M		CP		Yes	Yes		Naturally formed riffle. Boulder, cobble, gravel	*3Ccu*	*Probably warranting additional run/riffle habitat type*	38.95492	76.97235	45	38.95481	76.97202	55	
16	3P	M		CP	Banks boulder stabilized, but boulders often buried in sediment.	Yes	Yes	No	Wide, shallow. Pool/glide w/infrequent riffle	3Ccu		38.95481	76.97202	55	38.95362	76.96979	85	
17	3Q	M		CP	Banks boulder stabilized, but boulders often buried in sediment.	Yes	Yes	No	Uniform pool/glide deeper than above but w/few pronounced deep areas. Some large channel parallel bars just downstream of MARC bridge, E bank	3Ccpg		38.95362	76.96979	85	38.9526	76.9665	26	Upstream end just downstream of MARC station pedestrian bridge. Downstream end is upstream end of artificial riffle immediately upstream of Route 500.

Coordinates of Notable Points in Stream Segment

Large patch Japanese knotweed			38.96608	76.97018	19				Heurich Park
Artificial riffle below Ager Rd - concrete rubble			38.96281	76.97093	13				
Flap valves releasing water into boulders			38.96588	76.97062	39				
Concrete blanket sill just below Chillum confluence			38.95645	76.97441	32				
Concrete grade-control structure			38.96347	76.97075	13				
Concrete sill with 1 ft drop, likely blockage for anadromous but not resident fish. Riffle on downstream side of sill made of concrete rubble			38.96281	76.97093	13				Just downstream of Agar Rd bridge
Kudzu notable			NFR	NFR	NFR				Downstream of Agar Rd
Bars w/cobbles & boulder (anthropogenic placement?) Massive kudzu area			38.96047	76.97259	26				
Severe erosion 2-3 m, E bank, immediately downstream of pedestrian bridge			38.95889	76.97352	13				

3 Multiple stations to characterize because of confounding effects of combinations of with/without stabilization and channelization. Also, exclude artificial boulder grade control riffles.

Table 1-8: Reach Coordinates and Condition - Segment 5

Stream Segment 5 Reaches and Reach D Paint Strahler Stream Order Determined by Andrew Roach4/22/2015: 3
Reach Subdivision Assess June 26, 2014; Nov 5, 2014; Nov 7, 2014;
NFR: Not field recorded. Determined using GIS.

Reach Data by Mainstem or Tributary in Rows Below. Top upstream, bottom downstream.
One Reach per Row Below

					Predominant Conditions							Endpoint Upstream			Endpoint Downstream			
Tally No.	**Code Letter for CEICA**	**Segment Mainstem or Tributary**	**Overall Flow Direction**	**Physiographic Province**	**Channel and Bank Material**	**Channelized?**	**Continuously Stabilized?**	**Systematic Discontinuously Stabilized?**	**Notes**	**Representative RHA Station Habitat Type Code (for CEICA)**	**RHA Best Fit Notes**	**Latitude**	**Longitude**	**Accuracy (ft)**	**Latitude**	**Longitude**	**Accuracy (ft)**	**Notes**
1	5A	M	SE	CP	Banks stablized w/boulders, rubble, concrete; Channel natural gravel, etc.	Yes	Yes	No	Water fills entire channel	5Ccst		NFR	NFR	NFR	38.9891	76.93398	13	Upstreammost point is Route 1
2	5B	M	SE	CP					Full wetted bottom, minimal bars, homogeneous instream shallow	5Ccgu	Not sure boulders present, but otherwise 5Ccgu appears best fit	38.9891	76.93398	13	38.988879	76.93342	13	
3	5C	M	SE	CP					Homogeneous instream habitat, but not full wetted bottom. Channel-parallel gravel bars on channel margin	5Ccehu		38.988879	76.93342	13	38.98826	76.93223	16	
4	5D	M	SE	CP					Woody debris jam, gravel bars	5Cw	Boulder stabilization present, but mostly fronted by gravel bar. Boulders don't affect stream much (?)	38.98826	76.93223	16	38.98785	76.93221	22	
5	5E	M	SE	CP	Boulders SW bank	Yes			Deep along boulders, Water fills channel, Opposite non stabilized bank 2 m high, shallow water	5Ccgu	In between 5Ccgu and 5Ccst	38.98785	76.93221	22	38.98697	76.93135	26	
6	5F	M	SE	CP		Yes	No		Stream occupies only small part of channel, has gravel bars.	5Ccehu		38.98697	76.93135	26	38.98622	76.92992	26	
7	5G	M	SE	CP	Boulders both banks bridge vicinity	Yes	Yes		Boulders failing both banks.	5Ccst		38.98622	76.92992	26	NFR	NFR	NFR	Downstream end is downstream end of pedestrian bridge boulders

					Predominant Conditions							Endpoint Upstream			Endpoint Downstream			
Tally No.	Code Letter for CEICA	Segment Mainstem or Tributary	Overall Flow Direction	Physiographic Province	Channel and Bank Material	Channelized?	Continuously Stabilized?	Systematic Discontinuously Stabilized?	Notes	Representative RHA Station Habitat Type Code (for CEICA)	RHA Best Fit Notes	Latitude	Longitude	Accuracy (ft)	Latitude	Longitude	Accuracy (ft)	Notes
8	5H	M	SE	CP		Yes	No		Gravel bars. Sewer line in W bank, stabilizes bank/channel locally downstream of pedest bridge	5Ccehu		NFR	NFR	NFR	38.98536	76.92824	22	Upstream end is downstream end of pedestrian bridge boulders.
9	5I	M	SE	CP					Short reach w/failing concrete rubble stablization, pool along stabilized bank	5Ccgu		38.98536	76.92824	22	38.98502	76.92834	13	
10	5J	M	SE	CP		Yes	No		Gravel bars, stream fills only portion of channel. Tall erosional banks as per all above down to this point	5Ccehu		38.98502	76.92834	13	38.9845	76.92767	13	Downstream point is just upstream of Metro RR bridge
11	5K	M	SE	CP					Bank height drops to ~1 m, vegetated bank slopes, stream fills more of channel but still has gravel bars. Could separate out bridge as separate habitat type.	5Ccle		38.9845	76.92767	13	38.9803	76.92232	16	Upstream point is just upstream of Metro RR bridge
12	5L	M	SE	CP					Gravel deposit/woody debris jam, bank height increase	5Cw		38.9803	76.92232	16	38.98188	76.92124	22	Downstream end just upstream of pedestrian bridge
13	5M	M	SE	CP					Single thread stream, deep channel, high 3 m banks	5Ccst	Not sure boulders present, but otherwise boulders appear best fit	38.98188	76.92124	22	38.98183	76.92088	32	Downstream end is bridge boulder stabilization works
14	5N	M	SE	CP			Boulder stabilization works, bridge		Pool/glide	5Ccst		38.98183	76.92088	32	38.98126	76.92052	32	Downstream end is boulder grade-control stablization works upstream end
15	5O	M	SE	CP					Boulder grade control structure		Use data from Sligo or elsewhere	38.98126	76.92052	32	38.98111	76.9203	26	
16	5P	M	SE	CP				Patchwork boulder stabilization R bank	Stream covers majority of channel w/some gravel bars, some severe erosion	5Ccgu		38.98111	76.9203	26	38.98019	76.91903	22	
17	5Q	M	SE	CP					Stream uniformly wide glide w/severe to moderate erosion where not stabilized. Banks 2-3 m high	5Ccgu		38.98019	76.91903	22	38.98011	76.91874	42	

					Predominant Conditions							Endpoint Upstream			Endpoint Downstream			
Tally No.	Code Letter for CEICA	Segment Mainstem or Tributary	Overall Flow Direction	Physiographic Province	Channel and Bank Material	Channelized?	Continuously Stabilized?	Systematic Discontinuously Stabilized?	Notes	Representative RHA Station Habitat Type Code (for CEICA)	RHA Best Fit Notes	Latitude	Longitude	Accuracy (ft)	Latitude	Longitude	Accuracy (ft)	Notes
18	5R	M	SE	CP			Boulders both banks		Stream deeper narrowed by boulders	5Ccst		38.98011	76.91874	42	38.97964	76.91847	55	End at steel weir
19	5S	M	SE	CP					Boulder grade control structure		Use data from Sligo or elsewhere	38.97964	76.91847	55	38.9795	76.91831	22	
20	5T	M	SE	CP				Systematically stabilized, one or both banks w/boulders.	Shallow depth, homogeneous velocity run/glide, presumably because of backwater effects	5Ccgu		38.97907	76.91795	22	38.97897	76.91748	55	Ends at NE Branch Confluence

Additional Segment 5 Notable Points and Subreach Notes										
	Bamboo patch			38.9888	76.93362	26	38.98844	76.93319	26	Double-check downstream coordinate in field book
	Sewer line in bank			38.98578	76.9295	16				
	Concrete rubble E bank			38.98536	76.92824	22	38.98502	76.92834	13	
	Downstream end RR bridge boulders			38.984	76.92567	55				
	Metal pedestrian bridge boulder stabilization						38.98183	76.92088	32	
	Steel weir			38.97964	76.91847	55				

5 1) Earth channel high bank not stabilized, 2) Earth channel low bank not stabilized, 3) Earth (gravel) channel woody debris jam, 4) Boulder stabilized channel

Note: Paint Branch general observations. Pools absent from homogeneous shallow channelized reaches except where timber jams occur, then locally pools form.
If Paint Branch channelized and stabilized, then water fills bottom and stream has deep pools.
If Paint Branch channelized but not stabilized large gravel bars and no deep pools
Any spots w/large woody debris have highly variable local conditions, including deep pools

Channelized, eroding tall earth banks, homogeneous shallow habitat, channel-parallel gravel bars on channel outer edge
Gravel bars, woody debris jam, braided flow
Channelized, shallow, homogeneous, some boulder stabilization
Generic continuous boulder stabilization on banks, continuous pool
Channelized, unstabilized, low-bank, minimal erosion, braided flow

Trees on N bank topped for airport

Table 1-9: Reach Coordinates and Condition - Segment 7

Stream Segment 7 Reaches and Reach Data: **Paint Branch - I95 Interchange** Strahler Stream Order Determined by Andrew Roach4/22/2015: 2

Reach Subdivision and Sampling Station Assessment Dates: 7/23/2014; 7/31/2014 Note: other than concrete trapezoidal channel, bridges not divided out as habitat type

NFR: Not field recorded. Determined using GIS.

Note: CP reaches below highways inadequately sampled/subdivided in that boulder reaches with deep pools and some shade occurred that are more similar to Piedmont because of boulders. However, uncertain how to deal with complex infrastructure effects or whether can even do work there because of access challenges, etc.

Reach Data by Mainstem or Tributary in Rows Below. Top upstream, bottom downstream.

One Reach per Row Below

					Predominant Conditions					Endpoint Upstream			Endpoint Downstream				Representative RHA Station	
Tally No.	**Code Letter for CEICA**	**Segment Mainstem or Tributary**	**Overall Flow Direction**	**Physiographic Province**	**Channel and Bank Material**	**Channelized?**	**Continuously Stabilized?**	**Systematic Discontinuous Stabilization?**	**Notes**	**Latitude**	**Longitude**	**Accuracy (ft)**	**Latitude**	**Longitude**	**Accuracy (ft)**	**Coordinate Notes**	**Habitat Type Code (for CEICA)**	**Notes**
1	7A	M	SE	P	Bedrock	No (except channelized at uppermost end immediately downstream of Route 212)	No	No	Notable bedrock outcrops, plus bars. Some deep pools and cliffs. Channel/bank erosion. Stabilization immediately downstream of Route 212	NFR	NFR	NFR	39.031	76.95208	19	Upstream end of segment is Route 212	7Pb	
2	7B	M	S (meanders)	P	Alluvium, soil	No (possible historic?)	No	No	Long reach. Minimal/no bedrock outcrops. Moderate to severe bank erosion, point bars. Occasional failing patch stabilization works.	39.031	76.95208	19	39.0274	76.95255	19		7Pe	
3	7C	M	SE	CP	Alluvium, soil, boulder stabilization	Yes	No	No?	Highway construction channelization, etc. Patch stabilization, locally severe bank erosion.	39.0274	76.95255	19	39.02503	76.95098	55	Downstream end is concrete channel	7Cc	Some shading versus 0% below power line
4	7D	M	SE		Concrete sloped banks	Yes	Yes		Trapezoidal channel	39.02503	76.95098	55	39.02423	76.95071	42		None	Assume no or minimal work
5	7E	M	SE, S	CP	Alluvium, soil, boulder stabilization	Yes	No	No?	Highway construction channelization, etc. Patch stabilization, locally severe bank erosion.	39.02423	76.95071	42	NFR	NFR	NFR	Downstream end of segment is beltway	7Cc	Some shading versus 0% below power line

Coordinates of Notable Points in Stream Segment

Locally severe bank erosion	39.02623	76.95023	NR				Below highway bridge
Downstreammost bedrock outcroppings in stream	39.02367	76.94778	22				
Concrete structure with fish passage works?							Below beltway?

B Blackberry phone

NR not recorded

Table 1-10: Reach Coordinates and Condition - Segment 9

Stream Segment 9 Reaches and Reach Data: **Sligo Creek** Strahler Stream Order Determined by Andrew Roach4/22/2015: 2

Reach Subdivision Assessment Dates: June 11, 2014; Oct 21, 2014

NFR: Not field recorded. Determined using GIS.

Reach Data by Mainstem or Tributary in Rows Below. Top upstream, bottom downstream.
One Reach per Row Below

					Predominant Conditions							Endpoint Coordinates Upstream			Endpoint Coordinates Downstream			
Tally No.	**Code Letter for CEICA**	**Segment Mainstem or Tributary**	**Overall Flow Direction**	**Physiographic Province**	**Channel and Bank Material**	**Channelized?**	**Continuously Stabilized?***	**Systematic Discontinuous Stabilization?***	**Ponded from Downstream Structure?**	**Notes**	**Representative RHA Station Habitat Type Code (for CEICA)***	**Latitude**	**Longitude**	**Accuracy (ft)**	**Latitude**	**Longitude**	**Accuracy (ft)**	**Coordinate Notes**
1	9A	M	S	CP	Boulder stabilization, gabion stabilization, earth	Yes	No	Yes	Substantially	Shallow pools from ponding caused by downstream structures, but w/occasional shallow riffles. Not fully impounded. Reach contains other cross-stream structures, but these don't affect overall habitat type.	9Cg	38.96224	76.97906	26	38.96164	76.97813	13	Upstream end is downstream end of another grade-control ecodisneyland boulder field
2	9B	M	SE	CP	Boulder works	Yes	Yes	No	No	Ecodisneyland boulder field	9Cs	38.96164	76.97813	13	38.96132	76.97716	32	
3	9C	M	SE	CP	Boulder stabilization, earth	Yes	No	Yes	Substantially	Shallow pools formed by ponding upstream of structures, but w/occasional shallow riffles. Not fully impounded. Reach contains other cross-stream structures, but these don't affect overall habitat type.	9Cg	38.96132	76.97716	32	38.95851	76.97404	13	Downstream end is confluence w/NW Branch; upstream end is downstream end of boulder field.

*Stabilization works affecting stream channel. Reach w/substantial stabilization works buried in excess sediment in bank included in discontinuous category because can't easily evaluate whether present and may not be felt by stream.

Additional Segment 9 Notable Points and Subreach Notes				
	Steel weir w/boulders upstream	38.96158	76.97831	16
	Steel weir	38.95929	76.97556	16
	Concrete sill	38.9594	76.97544	55

Table 1-11: Reach Coordinates and Condition - Segment 10

Stream Segment 10 Reaches and Reach Data: **Chillum Road Tributary** Strahler Stream Order Determined by Andrew Roach4/22/2015: 1

Reach Subdivision Assessment Dates: 7/1/2014; Oct 17, 2014; Oct 21, 2014

NFR: Not field recorded. Determined using GIS.

Reach Data by Mainstem or Tributary in Rows Below. Top upstream, bottom downstream.
One Reach per Row Below

					Predominant Conditions				Representative RHA Station Habitat Type Code (for CEICA)	Endpoint Coordinates Upstream (Decimal degrees [B])			Endpoint Coordinates Downstream (Decimal Degrees [B])			Coordinate Notes
Tally No.	Code Letter for CEICA	Segment Mainstem or Tributary	Overall Flow Direction	Physiographic Province	Channel and Bank Material	Channelized?	Continuously Stabilized?	Discontinuously Systematically Stabilized?		Latitude	Longitude	Accuracy (ft)	Latitude	Longitude	Accuracy (ft)	
1	10A	M	E	CP	Boulder, gabion, concrete	Y	Y	N	10Cs	38.95603	76.98101	26	38.9563	76.98036	22	Assigned lower end of RHA sampling reach as lower end of this reach
2	10B	M	E	CP	Boulder, earth	Y	N	Y	10Cg	38.9563	76.98036	22	38.95666	76.97848	22	
3	10C	M	E	CP	Earth	N?	N	N	10Ce	38.95666	76.97848	22	38.95608	76.97593	19	
4	10D	M	E	CP	Boulder, earth	Y	N	Y	10Cg	38.95608	76.97593	19	38.95641	76.97491	39	Confluence with NW Branch downstream end pt

Additional Segment 10 Notable Points and Subreach Notes								
	Pipe crossing w/boulders	38.95666	76.97944	19				

Table 1-12: Reach Coordinates and Condition - Segment 11

Stream Segment 11 Reaches and Reach Data: **Indian Creek - College Park** Strahler Stream Order Determined by Andrew Roach 4/22/2015: 4

Reach Subdivision Assessment Dates: June 12, 2014; June 26, 2014; Nov 10, 2014; **Segment highly problematic to habitat type upstream of Greenbelt Rd**

NFR: Not field recorded. Determined using GIS. Probable water quality problems upstream of Greenbelt Rd

Reach Data by Mainstem or Tributary in Rows Below. Top upstream, bottom downstream.
One Reach per Row Below

					Predominant Conditions					Endpoint Upstream			Endpoint Downstream				Representative RHA	
Inverse Tally No.	**Code Letter for CEICA**	**Segment Mainstem or Tributary**	**Overall Flow Direction**	**Physiographic Province**	**Channel and Bank Material**	**Channelized?**	**Continuously Stabilized?**	**Systematic Discontinuous Stabilization?**	**Notes**	**Latitude**	**Longitude**	**Accuracy (ft)**	**Latitude**	**Longitude**	**Accuracy (ft)**	**Coordinate Notes**	**Habitat Type Code (for CEICA)**	**Notes**
17	11A					Yes			Channelized, deep pool, no bars, no riffle/run, minimal woody debris	) Dr, plus Greenbelt Rd up to reed grass in braided reach							11Ccp	Synthetic habitat type
16	11B					No	No	No	Braided intermittent stream network								11PFO	
15	11C	M	SW	CP		Yes	SE bank, yes	No	Concrete debris and poured concrete SE bank; NW bank unstabilized, vertical 0.8 m. Bottom 95% embedded, some woody debris (couldn't count - poor visiility, poor access)	39.0011	76.91392	45	38.99909	76.91686	13	Upstream coordinate is as far as I walked on Nov 10, 2014	11Ccp	Synthetic habitat type
14	11D	M	S	CP		Yes	?	Yes	Boulder stabilized W bank. E bank earthen (?) (fill?). Ponded. Pond >3 ft. Concrete boulder debris in channel	38.99909	76.91686	26	38.99914	76.91696	19		11Ccp	Synthetic habitat type
13	11E	M	SW	CP		Yes	Yes	No	Concrete trapezoidal channel, ponded. Pond > 3ft. Concrete boulder debris in channel	38.99914	76.91696	19	Greenbelt Rd			Greenbelt Rd downstream end, upstream end upstream of Branchville Rd	None	Assume can't modify concrete
12	11F	M		CP		Yes	NR	NR	Greenbelt Rd bridge	NR	NR	NR	NR	NR	NR		None	
11	11G	M	SW	CP		Yes	Yes		Boulder stabilized. Pool.	38.99699	76.91773	22	38.9967	76.9179	19	Upstream end is riffle grade control structure below Greenbelt Rd	11Ccg	
10	11H	M	SW	CP		Yes			SE bank moderate erosion, NW bank w/historic severe erosion, but now stable material at slope toe. Depth and embeddedness similar to stabilized reaches, except pool depth <2 ft	38.9967	76.9179	19	38.99608	76.9183	26		11Ccg	
9	11I	M	SW	CP		Yes		Yes	Stormwater outfall with boulder stabilization for part of reach	38.99608	76.9183	26	39.99614	76.91844	19		11Ccg	
8	11J	M	SW	CP		Yes			Back to pool/glide minor to moderate bank erosion condition as per below	39.99614	76.91844	19	38.99544	76.91859	26		11Cc	
7	11K	M	SW	CP		Yes			Severe/moderate erosion NW bank. Riffle w/gravel and transported boulders.	38.99544	76.91859	26	38.99544	76.91859	26	Readings as recorded. (Short reach presumably)	11Ccg	

					Predominant Conditions					Endpoint Upstream			Endpoint Downstream				Representative RHA	
Inverse Tally No.	Code Letter for CEICA	Segment Mainstem or Tributary	Overall Flow Direction	Physiographic Province	Channel and Bank Material	Channelized?	Continuously Stabilized?	Systematic Discontinuous Stabilization?	Notes	Latitude	Longitude	Accuracy (ft)	Latitude	Longitude	Accuracy (ft)	Coordinate Notes	Habitat Type Code (for CEICA)	Notes
6	11L	M	SW	CP		Yes			Pool/glide, 2 ft maximum depth. Cobble and gravel bottom w/substantial embeddedness. Minor to moderate bank erosion, ~50 cm height.	38.99544	76.91859	26	38.99451	76.91922	26		11Cc	
5	11M	M	SW	CP		Yes			Ponded. SE bank more notable erosion, 1 to 2 m	38.99451	76.91922	26	38.99389	76.91956	32		11Ccg	
4	11N	M	SW	CP		Yes	No	No	Ponded. Generally minor bank erosion	38.99389	76.91956	32	38.993	76.91993	13		11Cc	
3	11O	M	SW	CP		Yes	No	Yes, stone toe SE bank	Ponded, but greater depth than ponding below.	38.993	76.91993	13	38.99234	76.92022	22	Upstream end is riffle grade control structure below Berwyn Rd	11Ccg	
2	11P	M	SW	CP		Yes	No	No (Patch)	Ponded. W bank heights ~2 m, moderate erosion. E bank <0.5 m, minor erosion. Caused by stormwater outfall. Some boulders in stream bank and bed.	38.99234	76.92022	22	38.99209	76.92065	22	Upstream end is stormwater outfall	11Ccg	
1	11Q	M	SW/SE	CP		Yes	No	No	Stream shallow ponded upstream of gabion baskets. Low banks, minimal erosion	38.99209	76.92065	22	38.99063	76.92102	22	Gabion baskets at downstream end	11Cc	

Additional Segment 15 Notable Points and Subreach Notes							
	Valley w forested wetlands and lots of recent sand deposits.						W of Cherrywood Lane
	Reed grass ponds						
	Invasive exotic woody understory vegetation, NW bank	38.99983	76.91569	13	39.00073	76.91436	22	Upstream of Branchville Rd
	Riffle grade control structure	38.99699	76.91773	22				Below Greenbelt Rd
	Riffle grade control structure	38.993	76.91993	13				Below Berwyn Rd
	Stormwater outfall structure	38.99234	76.92022	22				
	Gabion baskets (3) filled w/cobbles. Grade-control structures? Artificial riffle at gabion baskets. Some erosion up/down of baskets	38.99063	76.92102	22				

1: channelized not stabilized;
1: channelized and stabilized;
1: braided streams through former gravel mining area?

Table 1-13: Reach Coordinates and Condition - Segment 12

Stream Segment 12 Reaches and Reach Data: **Little Paint Branch** Strahler Stream Order Determined by Andrew Roach4/22/2015: 2

Reach Subdivision Assessment Dates: June 12, 2014; June 27, 2014; July 23, 2014;

NFR: Not field recorded. Determined using GIS.

Reach Data by Mainstem or Tributary in Rows Below. Top upstream, bottom downstream.
One Reach per Row Below

					Predominant Conditions							Endpoint Coordinate Upstream			Endpoint Coordinate Downstream				
Tally No.	**Code Letter for CEICA**	**Segment Mainstem or Tributary**	**Overall Flow Direction**	**Physiographic Province**	**Channel and Bank Material**	**Channelized?**	**Continuously Stabilized?**	**Discontinuous Systematic Stabilization?**	**Notes**	**Representative RHA Station Habitat Type Code (for CEICA)**	**Reach Location Notes**	**Latitude**	**Longitude**	**Accuracy**	**Latitude**	**Longitude**	**Accuracy**	**Coordinate Notes**	**Location Notes**
1	12A	M	S	CP	Earth	Yes	No	No	Only observed from Cherry Hill Rd - didn't walk up. Aerial photos and USGS maps show straight channel so confident though.	12Cc	Immediately upstream of Cherry Hill Rd	NR	NR	NR	NR	NR	NR	Interpreted from aerial photos. NFR.	
2	12B	M	S	CP	Earth	No	No	No		12Cm	Immediately downstream of Cherry Hill Rd	NR	NR	NR	NR	NR	NR	Interpreted from aerial photos. NFR.	Enter stream across from park bench "PPVA Donation"
3	12C	M	S	CP	Earth	Yes	No	No		12Cc	Further downstream than unchannelized portion	NR	NR	NR	NR	NR	NR	Interpreted from aerial photos. NFR.	

Additional Segment 12 Notable Points and Subreach Notes: None recorded

Table 1-14: Reach Coordinates and Condition - Segment 13

Stream Segment 13 Reaches and Reach Data: Lower Northwest Branch **Note: Lower end extends in Segment 13 "old" (previous rejected version)**

Reach Subdivision Assessment Dates: 4/2/2015, 4/9/2015, 4/14/2015, (also see Seg 13 old for lowermost end of new Seg 13)

NFR: Not field recorded. Would need to be determined using GIS. All coordinates determined using Chris's Blackberry USACE phone Strahler Stream Order Determined by Andrew Roach4/22/2015: 3

Reach Data by Mainstem or Tributary in Rows Below. Top upstream, bottom downstream.
One Reach per Row Below

					Predominant Conditions					Endpoint Upstream			Endpoint Downstream				Representative RHA Station	
Tally No.	Code Letter for CEICA	Segment Mainstem or Tributary	Overall Flow Direction	Physiographic Province	Channel and Bank Material	Channelized?	Continuously Stabilized?	Systematic Discontinuous Stabilization?	Notes	Latitude	Longitude	Accuracy (ft)	Latitude	Longitude	Accuracy (ft)	Coordinate Notes	Habitat Type Code (for CEICA)	Notes
1	13A	M	SE	CP	Alluvium	No	No	No	Highly unstable, severe erosional reach. Eroding banks >2 m, large bars	38.99059	76.96953	22	38.98782	76.96406	26	Upstream end of highly unstable severe erosional reach is segment upstream end	13Cmhe	
2	13B	M	S	CP	Alluvium	No? (Possible historic?)	No	No	Eroding banks 1.5 m. Some patchwork stabilization, not systematic (see inventory below)	38.98845	76.9636	13	38.98511	76.96416	16	Downstream end is concrete rubble upstream of Route 193	13Cml	
3	13C	M	S	CP	Alluvium	Yes	No	No	Minor/moderate erosion	NFR	NFR	NFR	38.98248	76.96399	16	Reach upstream end is Route 193, downstream end is upstream end of systematic boulder works	13Cct	
4	13D	M	SE	CP	Boulders	Yes	Yes	NA	Ecodisneyland: boulder channel and banks riffle and run	38.98248	76.96399	16	38.98073	76.9619	19	Two bridges cross within reach	13Ccsr	
5	13E	M	S	CP	Alluvium, some in-place soil/strata on eroding E banks	Yes	No	No	Patchwork stabilization	38.98073	76.9619	19	38.97819	76.96392	26	Downstream reach end is upstream end of boulder stabilization works, E bank	13Cc	
6	13F	M	W	CP	Boulders (E bank)	Yes	Yes (E bank)		All pool within boulder stabilized reach	38.97819	76.96392	26	38.97836	76.96395	16			Use data from other stream segment, no Seg 13 field data recorded
7	13G	M	SW	CP	Boulders	Yes?	Yes		Ecodisneyland: Boulder riffle grade control	38.97841	76.96443	16	38.97838	76.96484	26			Use data from other stream segment, no Seg 13 field data recorded

Additional Segment 13 Notable Points and Subreach Notes							
	Bamboo patch, NE side of paved trail	38.98936	76.96745	26	38.98959	76.96766	22	
	Paved trail threatened by erosion, NE bank	38.98956	76.96783	19				Below power lines
	Pedestrian bridge boulders, SW bank				38.9888	76.96707	16	
	Stone toe stabilization, E bank	38.98845	76.9636	13	38.98846	76.9635	13	
	Stone toe stabilization, W bank	38.98778	76.9643	22	38.98706	76.96399	16	
	Concrete grade control structure	NFR	NFR	NFR				Just upstream of archery range parking lot, upstream of 193
	Patch stabilization, W bank	38.98073	76.9619	19				Extends down to notable severe bank erosion area below
	Notable severe bank erosion, SE bank	38.98002	76.96204	32	38.97958	76.96262	22	
	Patch stabilization, NW bank	38.9796	76.96286	19				
	Concrete supports for former pedestrian trail bridge (bridge removed, paved trail	38.97894	76.96327	42				

Table 1-15: Reach Coordinates and Condition - Segment 14

Stream Segment 15 Reaches and Reach Data: **Northeast Branch** Strahler Stream Order Determined by Andrew Roach 4/22/2015: 4

Reach Subdivision Assessment Dates: March 30, 2015; March 31, 2015; April 1, 2015

NFR: Not field recorded. Determined using GIS.

Reach Data by Mainstem or Tributary in Rows Below. Top upstream, bottom downstream.
One Reach per Row Below

					Predominant Conditions					Endpoint Upstream			Endpoint Downstream				Representative RHA Station	
Tally No.	Code Letter for CEICA	Segment Mainstem or Tributary	Overall Flow Direction	Physiographic Province	Channel and Bank Material	Channelized?	Continuously Stabilized?	Systematic Discontinuous Stabilization?	Notes	Latitude	Longitude	Accuracy (ft)	Latitude	Longitude	Accuracy (ft)	Coordinate Notes	Habitat Type Code (for CEICA)	Notes
1	15A	M	S	CP	Cobble, boulder	Yes? (Historic?)	No	Boulders, E bank	Gravel bar, riffles	38.97871	76.91744	26	38.97809	76.91779	32	Upstream end of segment	15Ccor	
2	15B	M	SW	CP		Yes	No	Yes, either or both banks stone toe	Predominantly pool	38.97809	76.91779	32	38.97559	76.91942	26	Includes airport. Downstream end is grade-control structure	15Ccgt	
3	15C			CP	Boulder	Yes	Yes		Not assigned a habitat type.	NFR	NFR	NFR	NFR	NFR	NFR	Under Paint Branch Parkway.		
4	15D	M	S	CP	Boulder bank	Yes	Yes, boulders in banks		Large point bars	38.97494	76.91958	42	38.97309	76.91833	16	Upstream end is downstream end of Paint Branch Pkwy bridge boulder stabilization works.	15Ccor	
5	15E	M	S	CP		Yes	Yes, boulders in banks		No point bars. I think all glide/run (but that not recorded in notes)	38.97309	76.91833	16	38.97305	76.91825	26		15Cce	Intergradational habitat type. Assigned closest fit of samples
6	15F	M	S	CP		Yes	Yes, boulders in banks		Water fills entire channel either as run or pool upstream of grade-control structures	38.97305	76.91825	26	38.97093	76.91808	32		15Ccp	
7	15G	M	SE	CP		Yes	Yes, boulders in banks		Broad channel, moderate bars, pool along cut bank	38.97093	76.91808	32	38.9695	76.9194	32	Upstream end is Brier's Ditch. Downstream end is downstream end walked to, assumed downstream end of segment.	15Cce	
	15H	T	S, SE		Earth	No	No		Some stabilization at upper end, boulder stabilization at lower end	38.97247	76.92008	26	38.96962	76.91968	22	Upstream end is paved Anacostia trail. Downstream end is upstream end of NE Branch boulder stabilization works. Left gap from this point to actual NE Branch (because boulder-controlled conditions rather than earth channel/bank conditions)	15TCm	

Additional Segment 15 Notable Points and Subreach Notes																	
		M						Small bamboo patch	38.97828	76.91763	45						
		M						Gabion baskets	38.97749	76.91798	16	38.97691	76.91858	13	Airport		
		M						Gabion/concrete grade control structure. Causes upstream ponding	38.97567	76.9195	26	38.97559	76.91942	26	Upstream of Paint Branch Pkwy		
		M						Bridge				38.97494	76.91958	42	Downstream end bridge boulder stabilization works		
		M						Concrete gabion grade control structure	38.97396	76.91957	16						
		M						Concrete gabion grade control structure	38.97309	76.91833	16						
		M						Grade control structure over large diameter pipe	38.97139	76.91819	32						
		M						Bamboo patch	38.97018	76.91858	45	38.96995	76.91898	16	Recorded as NE bank, but I think actually NW bank		
		M						Grade control concrete/gabion basket	38.97305	76.91825	26						
		T						Boulder grade control structure	38.97244	76.91981	22						
		T						Concrete trapezoidal channel	38.9724	76.91966	36						
		T						Boulder grade control structure, sewer crossing	38.9716	76.91952	36						
		T						Boulder bank stabilization works along NE Branch	38.96962	76.91968	22	38.96953	76.91957	16			

Note: could probably have lumped mainstem reaches together and had fewer sampling stations. Downstreammost station is intergradational between station just below Paint Branch Parkway and station between grade-control structures.

Table 2-1: Piedmont Physiographic Province FWOP PHI Metrics and Scores

Stream		Metric Values Input												Transform Bank Severity		Prepare Metric Values								Scale Metric Values								Final Score	Normalize Final Score	Rescaled Final Score
									Left Bank Stability		Right Bank Stability																							
Reach No.	Habitat Code	Watershed Area (acres)	% Embeddedness	Remoteness (meters)	%Shading	Epibenthic Substrate Score	Instream Habitat Score	Total No. Instream Woody Debris and Rootwads	Erosion Extent (meters)	Severity	Erosion Extent (meters)	Severity	Riffle Quality Score	Left	Right	EMBEDDED	REMOTE	RESTSHADING	EPISUB	RESINSTRHAB	WOOD	TBANKSTANB	RESRIFFQUAL	EMBEDDED	REMOTE	RESTSHADING	EPISUB	RESINSTRHAB	WOOD	TBANKSTANB	RESRIFFQUAL	Piedmont PHI	Normalized Piedmont PHI	Rescaled Piedmont PHI
7A	7Pb	9856	59	114.5	50	8	16	5	52	2	16	2	13	1.5	1.5	59	8.46	-0.1727	8	-0.17	5	3.63	-2.46	0.46	0.53	0.69	0.41	0.8	0.42	0.81	0.7	**60.241**	**46.075**	**0.461**
7B	7Pe	10048	40	400.5	30	13	13	17	75	2	67	2	13	1.5	1.5	40	15.3	-0.3767	13	-3.18	17	2.41	-2.48	0.67	0.96	0.54	0.71	0.61	1.42	0.43	0.7	**75.448**	**57.078**	**0.571**

Attachment 2: PHI Scores

Table 2-1: Piedmont Physiographic Province Future Without Project PHI Metrics and Scores
Table 2-2: Coastal Plain Physiographic Province Future Without Project PHI Metrics and Scores
Table 2-3: Piedmont Physiographic Province Future With Project PHI Metrics and Scores for Design Alternative 1
Table 2-4: Coastal Plain Physiographic Province Future With Project PHI Metrics and Scores for Design Alternative 1
Table 2-5: Piedmont Physiographic Province Future With Project PHI Metrics and Scores for Design Alternative 2
Table 2-6: Coastal Plain Physiographic Province Future With Project PHI Metrics and Scores for Design Alternative 2
Table 2-7: Piedmont Physiographic Province best attainable condition PHI Metrics and Scores
Table 2-8: Coastal Plain Physiographic Province best attainable condition C PHI Metrics and Scores

Table 2-2: Coastal Plain Physiographic Province FWOP PHI Metrics and Scores

Stream		Metric Values Input										Transform Bank Severity		Prepare Metric Values						Scale Metric Values						Final Score	Normalize Final Score	Rescaled Final Score
								Left Bank Stability		Right Bank Stability																		
Reach Code	Habiat Code	Watershed Area (acres)	Remoteness (meters)	%Shading	Epibenthic Substrate Score	Instream Habitat Score	Total No. Instream Woody Debris and Rootwads	Erosion Extent (meters)	Severity	Erosion Extent (meters)	Severity	Left	Right	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	Coastal Plain PHI	Normalized Coastal Plain PHI	Rescaled Coastla Plain PHI
1A	1Cc	1209.6	211.8	15.00	7	7	3	75	2	75	2	1.5	1.5	11.28	0.398	-4.483	-6.64	-11.9	2.236	0.608	0.153	0.506	0.469	0.502	0.5	**45.640**	**38.066**	**0.381**
1B	1Cm	1235.2	1908.8	80.00	13	13	5	75	2	75	3	1.5	2	32.64	1.107	1.494	-0.68	-10	1.581	1.758	0.787	0.854	0.8	0.559	0.354	**85.171**	**65.196**	**0.652**
3A	3Cce	22272	249.0	35.00	12	11	28	58	2	47	2	1.5	1.5	12.18	0.633	-2.750	-8.02	1.928	3.082	0.656	0.363	0.607	0.393	0.912	0.689	**60.341**	**48.155**	**0.482**
3B	3Cm	22592	143.3	5.00	10	10	32	71	3	46	1	2	1	9.391	0.226	-4.766	-9.04	5.873	2.733	0.506	0	0.49	0.336	1.029	0.611	**49.512**	**40.723**	**0.407**
3C	*3Ccp*	22720	114.8	15.00	10	15	5	75	2	75	2	1.5	1.5	8.468	0.398	-4.772	-4.05	-21.1	2.236	0.456	0.153	0.49	0.613	0.229	0.5	**40.681**	**34.662**	**0.347**
3D	*3Ccp*	22720	63.3	15.00	10	15	5	75	2	75	2	1.5	1.5	6.445	0.398	-4.772	-4.05	-21.1	2.236	0.347	0.153	0.49	0.613	0.229	0.5	**38.865**	**33.416**	**0.334**
3E	*3Cce*	22272	26.1	35.00	12	11	28	58	2	47	2	1.5	1.5	4.359	0.633	-2.750	-8.02	1.928	3.082	0.235	0.363	0.607	0.393	0.912	0.689	**53.319**	**43.336**	**0.433**
3F	*3Ccp*	22720	15.5	15.00	10	15	5	75	2	75	2	1.5	1.5	3.498	0.398	-4.772	-4.05	-21.1	2.236	0.188	0.153	0.49	0.613	0.229	0.5	**36.220**	**31.601**	**0.316**
3G	*3Ccst*	31296	66.4	5.00	3	3	5	21	1	0	0	1	0	6.588	0.226	-12.131	-16.6	-22.4	4.313	0.355	0	0.062	-0.09	0.193	0.964	**24.797**	**23.761**	**0.238**
3H	None		71.5																									
3I	3Ccp	22720	419.0	15.00	10	15	5	75	2	75	2	1.5	1.5	15.62	0.398	-4.772	-4.05	-21.1	2.236	0.841	0.153	0.49	0.613	0.229	0.5	**47.098**	**39.067**	**0.391**
3J	3Ccst	31296	139.0	5.00	3	3	5	21	1	0	0	1	0	9.258	0.226	-12.131	-16.6	-22.4	4.313	0.499	0	0.062	-0.09	0.193	0.964	**27.194**	**25.406**	**0.254**
3K	9Cs	7040	47.7	5.00	15	20	2	3	1	0	0	1	0	5.675	0.226	1.542	3.107	-19.7	4.45	0.306	0	0.856	1.01	0.273	0.995	**57.329**	**46.088**	**0.461**
3L	3Ccst	31296	103.4	5.00	3	3	5	21	1	0	0	1	0	8.07	0.226	-12.131	-16.6	-22.4	4.313	0.435	0	0.062	-0.09	0.193	0.964	**26.127**	**24.674**	**0.247**
3M	9Cs	7040	61.9	5.00	15	20	2	3	1	0	0	1	0	6.381	0.226	1.542	3.107	-19.7	4.45	0.344	0	0.856	1.01	0.273	0.995	**57.962**	**46.523**	**0.465**
3N	3Ccst	31296	52.1	5.00	3	3	5	21	1	0	0	1	0	5.908	0.226	-12.131	-16.6	-22.4	4.313	0.318	0	0.062	-0.09	0.193	0.964	**24.187**	**23.343**	**0.233**
3O	*3Ccu*	31488	29.0	15.00	3	8	3	50	1	12	1	1	1	4.563	0.398	-12.138	-11.7	-24.4	3.983	0.246	0.153	0.062	0.191	0.133	0.891	**27.924**	**25.907**	**0.259**
3P	3Ccu	31488	232.0	15.00	3	8	3	50	1	12	1	1	1	11.78	0.398	-12.138	-11.7	-24.4	3.983	0.634	0.153	0.062	0.191	0.133	0.891	**34.401**	**30.353**	**0.304**
3Q	3Ccpg	31616	386.4	25.00	6	8	14	75	2	75	1	1.5	1	15.02	0.524	-9.143	-11.7	-13.4	2.739	0.809	0.266	0.236	0.19	0.458	0.612	**42.856**	**36.155**	**0.362**
5A	5Ccst	19584	53.7	5.00	6	6	0	35	2	0	0	1.5	0	5.985	0.226	-8.605	-12.8	-25.6	4.062	0.322	0	0.267	0.128	0.098	0.908	**28.728**	**26.459**	**0.265**
5B	5Ccgu	19904	74.5	5.00	8	6	7	75	3	33	2	2	1.5	6.941	0.226	-6.624	-12.8	-18.6	2.588	0.374	0	0.382	0.127	0.304	0.579	**29.407**	**26.925**	**0.269**
5C	5Ccehu	19648	109.3	10.00	14	8	5	75	3	5	1	2	1	8.279	0.322	-0.609	-10.8	-20.6	3.109	0.446	0.085	0.731	0.239	0.246	0.695	**40.714**	**34.685**	**0.347**
5D	5Cw	19904	39.1	10.00	12	12	29	75	2	75	1	1.5	1	5.2	0.322	-2.624	-6.81	3.358	2.739	0.28	0.085	0.614	0.46	0.954	0.612	**50.105**	**41.130**	**0.411**
5E	5Ccgu	19904	120.8	5.00	8	6	7	75	3	33	2	2	1.5	8.67	0.226	-6.624	-12.8	-18.6	2.588	0.467	0	0.382	0.127	0.304	0.579	**30.958**	**27.990**	**0.280**
5F	5Ccehu	19648	162.6	10.00	14	8	5	75	3	5	1	2	1	9.963	0.322	-0.609	-10.8	-20.6	3.109	0.536	0.085	0.731	0.239	0.246	0.695	**42.225**	**35.722**	**0.357**
5G	5Ccst	19584	49.9	5.00	6	6	0	35	2	0	0	1.5	0	5.794	0.226	-8.605	-12.8	-25.6	4.062	0.312	0	0.267	0.128	0.098	0.908	**28.557**	**26.342**	**0.263**
5H	5Ccehu	19648	117.7	10.00	14	8	5	75	3	5	1	2	1	8.569	0.322	-0.609	-10.8	-20.6	3.109	0.461	0.085	0.731	0.239	0.246	0.695	**40.974**	**34.864**	**0.349**
5I	5Ccgu	19904	22.0	5.00	8	6	7	75	3	33	2	2	1.5	4.054	0.226	-6.624	-12.8	-18.6	2.588	0.218	0	0.382	0.127	0.304	0.579	**26.816**	**25.147**	**0.251**
5J	5Ccehu	19648	83.1	10.00	14	8	5	75	3	5	1	2	1	7.297	0.322	-0.609	-10.8	-20.6	3.109	0.393	0.085	0.731	0.239	0.246	0.695	**39.833**	**34.080**	**0.341**
5K	5Ccle	19840	516.4	15.00	6	3	18	75	1	75	2	1	1.5	17.27	0.398	-8.620	-15.8	-7.63	2.739	0.93	0.153	0.266	-0.04	0.629	0.612	**42.529**	**35.931**	**0.359**
5L	5Cw	19904	151.5	10.00	12	12	29	75	2	75	1	1.5	1	9.639	0.322	-2.624	-6.81	3.358	2.739	0.519	0.085	0.614	0.46	0.954	0.612	**54.088**	**43.864**	**0.439**

Table 2-2: Coastal Plain Physiographic Province FWOP PHI Metrics and Scores																												
Stream		Metric Values Input										Transform Bank Severity		Prepare Metric Values						Scale Metric Values						Final Score	Normalize Final Score	Rescaled Final Score
								Left Bank Stability		Right Bank Stability																		
Reach Code	Habiat Code	Watershed Area (acres)	Remoteness (meters)	%Shading	Epibenthic Substrate Score	Instream Habitat Score	Total No. Instream Woody Debris and Rootwads	Erosion Extent (meters)	Severity	Erosion Extent (meters)	Severity	Left	Right	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	Coastal Plain PHI	Normalized Coastal Plain PHI	Rescaled Coastla Plain PHI
5M	5Ccst	19584	44.4	5.00	6	6	0	35	2	0	0	1.5	0	5.5	0.226	-8.605	-12.8	-25.6	4.062	0.296	0	0.267	0.128	0.098	0.908	**28.293**	**26.161**	**0.262**
5N	5Ccst	19584	38.4	5.00	6	6	0	35	2	0	0	1.5	0	5.156	0.226	-8.605	-12.8	-25.6	4.062	0.278	0	0.267	0.128	0.098	0.908	**27.984**	**25.949**	**0.259**
5O	9Cs	7040	28.5	5.00	15	20	2	3	1	0	0	1	0	4.531	0.226	1.542	3.107	-19.7	4.45	0.244	0	0.856	1.01	0.273	0.995	**56.303**	**45.384**	**0.454**
5P	5Ccgu	19904	152.9	5.00	8	6	7	75	3	33	2	2	1.5	9.679	0.226	-6.624	-12.8	-18.6	2.588	0.521	0	0.382	0.127	0.304	0.579	**31.864**	**28.612**	**0.286**
5Q	5Ccgu	19904	41.2	5.00	8	6	7	75	3	33	2	2	1.5	5.32	0.226	-6.624	-12.8	-18.6	2.588	0.286	0	0.382	0.127	0.304	0.579	**27.952**	**25.926**	**0.259**
5R	5Ccst	19584	41.8	5.00	6	6	0	35	2	0	0	1.5	0	5.353	0.226	-8.605	-12.8	-25.6	4.062	0.288	0	0.267	0.128	0.098	0.908	**28.162**	**26.070**	**0.261**
5S	9Cs	7040	71.7	5.00	15	20	2	3	1	0	0	1	0	6.823	0.226	1.542	3.107	-19.7	4.45	0.367	0	0.856	1.01	0.273	0.995	**58.359**	**46.795**	**0.468**
5T	5Ccgu	19904	47.3	5.00	8	6	7	75	3	33	2	2	1.5	5.654	0.226	-6.624	-12.8	-18.6	2.588	0.304	0	0.382	0.127	0.304	0.579	**28.251**	**26.132**	**0.261**
7C	7Cc	10432	504.0	0.00	8	8	4	20	2	45	2	1.5	1.5	17.07	0	-5.899	-9.62	-19.2	3.674	0.919	0	0.424	0.304	0.288	0.822	**42.582**	**35.967**	**0.360**
7D	None		89.9																									
7E	7Cc	10432	682.3	0.00	8	8	4	20	2	45	2	1.5	1.5	19.76	0	-5.899	-9.62	-19.2	3.674	1.064	0	0.424	0.304	0.288	0.822	**44.998**	**37.625**	**0.376**
9A	9Cg	7168	173.2	15.00	6	8	6	55	2	75	2	1.5	1.5	10.26	0.398	-7.478	-8.93	-15.7	2.646	0.553	0.153	0.332	0.342	0.39	0.592	**39.360**	**33.756**	**0.338**
9B	9Cs	7040	74.2	5.00	15	20	2	3	1	0	0	1	0	6.928	0.226	1.542	3.107	-19.7	4.45	0.373	0	0.856	1.01	0.273	0.995	**58.453**	**46.860**	**0.469**
9C	9Cg	7168	435.8	15.00	6	8	6	55	2	75	2	1.5	1.5	15.92	0.398	-7.478	-8.93	-15.7	2.646	0.857	0.153	0.332	0.342	0.39	0.592	**44.436**	**37.240**	**0.372**
10A	10Cs	1241.6	112.7	35.00	8	10	2	16	1	5	1	1	1	8.396	0.633	-3.512	-3.69	-13	4.313	0.452	0.363	0.563	0.633	0.47	0.964	**57.418**	**46.149**	**0.461**
10B	10Cg	1254.4	134.5	15.00	10	12	15	36	2	13	1	1.5	1	9.117	0.398	-1.524	-1.71	-0.06	3.941	0.491	0.153	0.678	0.743	0.853	0.881	**63.326**	**50.204**	**0.502**
10C	10Ce	1286.4	243.4	5.00	8	8	10	12	1	36	2	1	1.5	12.05	0.226	-3.552	-5.76	-5.16	3.95	0.649	0	0.56	0.518	0.702	0.883	**55.209**	**44.633**	**0.446**
10D	10Cg	1254.4	148.2	15.00	10	12	15	36	2	13	1	1.5	1	9.537	0.398	-1.524	-1.71	-0.06	3.941	0.514	0.153	0.678	0.743	0.853	0.881	**63.703**	**50.463**	**0.505**
11A	11Ccp	17536	1820.2	10.00	5	5	2	35	1	75	1	1	1	31.89	0.322	-9.482	-13.6	-23.2	3.559	1.717	0.085	0.216	0.084	0.17	0.796	**51.144**	**41.843**	**0.418**
11B	11Ccp	17536	269.9	10.00	5	5	2	35	1	75	1	1	1	12.66	0.322	-9.482	-13.6	-23.2	3.559	0.682	0.085	0.216	0.084	0.17	0.796	**33.884**	**29.998**	**0.300**
11C	11Ccp	17536	107.1	10.00	5	5	2	35	1	75	1	1	1	8.202	0.322	-9.482	-13.6	-23.2	3.559	0.442	0.085	0.216	0.084	0.17	0.796	**29.885**	**27.253**	**0.273**
11D	11Ccp	17536	30.0	10.00	5	5	2	35	1	75	1	1	1	4.627	0.322	-9.482	-13.6	-23.2	3.559	0.249	0.085	0.216	0.084	0.17	0.796	**26.677**	**25.052**	**0.251**
11E	None	#N/A	98.9																									
11F	None	#N/A	34.0																									
11G	11Ccg	18176	42.4	5.00	4	6	10	0	0	75	2	0	1.5	5.389	0.226	-10.522	-12.6	-15.3	3.536	0.29	0	0.156	0.136	0.403	0.791	**29.574**	**27.040**	**0.270**
11H	11Ccg	18176	75.1	5.00	4	6	10	0	0	75	2	0	1.5	6.969	0.226	-10.522	-12.6	-15.3	3.536	0.375	0	0.156	0.136	0.403	0.791	**30.992**	**28.013**	**0.280**
11I	11Ccg	18176	21.5	5.00	4	6	10	0	0	75	2	0	1.5	4.01	0.226	-10.522	-12.6	-15.3	3.536	0.216	0	0.156	0.136	0.403	0.791	**28.337**	**26.191**	**0.262**
11J	11Cc	18176	53.6	5.00	7	5	6	75	1	75	1	1	1	5.98	0.226	-7.522	-13.6	-19.3	3.162	0.322	0	0.33	0.081	0.284	0.707	**28.722**	**26.455**	**0.265**
11K	11Ccg	18176	17.5	5.00	4	6	10	0	0	75	2	0	1.5	3.685	0.226	-10.522	-12.6	-15.3	3.536	0.198	0	0.156	0.136	0.403	0.791	**28.046**	**25.991**	**0.260**
11L	11Cc	18176	99.1	5.00	7	5	6	75	1	75	1	1	1	7.912	0.226	-7.522	-13.6	-19.3	3.162	0.426	0	0.33	0.081	0.284	0.707	**30.456**	**27.645**	**0.276**
11M	11Ccg	18176	74.7	5.00	4	6	10	0	0	75	2	0	1.5	6.95	0.226	-10.522	-12.6	-15.3	3.536	0.374	0	0.156	0.136	0.403	0.791	**30.976**	**28.002**	**0.280**

Table 2-2: Coastal Plain Physiographic Province FWOP PHI Metrics and Scores																													
Stream		Metric Values Input										Transform Bank Severity		Prepare Metric Values						Scale Metric Values						Final Score	Normalize Final Score	Rescaled Final Score
								Left Bank Stability		Right Bank Stability																		
Reach Code	Habiat Code	Watershed Area (acres)	Remoteness (meters)	%Shading	Epibenthic Substrate Score	Instream Habitat Score	Total No. Instream Woody Debris and Rootwads	Erosion Extent (meters)	Severity	Erosion Extent (meters)	Severity	Left	Right	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	Coastal Plain PHI	Normalized Coastal Plain PHI	Rescaled Coastla Plain PHI
11N	11Cc	18176	120.0	5.00	7	5	6	75	1	75	1	1	1	8.645	0.226	-7.522	-13.6	-19.3	3.162	0.466	0	0.33	0.081	0.284	0.707	**31.114**	**28.097**	**0.281**
11O	11Ccg	18176	62.3	5.00	4	6	10	0	0	75	2	0	1.5	6.398	0.226	-10.522	-12.6	-15.3	3.536	0.345	0	0.156	0.136	0.403	0.791	**30.481**	**27.662**	**0.277**
11P	11Ccg	18176	96.4	5.00	4	6	10	0	0	75	2	0	1.5	7.811	0.226	-10.522	-12.6	-15.3	3.536	0.421	0	0.156	0.136	0.403	0.791	**31.748**	**28.532**	**0.285**
11Q	11Cc	18176	167.4	5.00	7	5	6	75	1	75	1	1	1	10.1	0.226	-7.522	-13.6	-19.3	3.162	0.544	0	0.33	0.081	0.284	0.707	**32.419**	**28.992**	**0.290**
12A	12Cc	6720	273.2	5.00	7	5	2	4	1	43	1	1	1	12.73	0.226	-6.406	-11.8	-19.5	4.107	0.686	0	0.395	0.182	0.279	0.918	**40.984**	**34.870**	**0.349**
12B	12Cm	6720	601.6	5.00	13	7	8	65	2	15	1	1.5	1	18.59	0.226	-0.406	-9.81	-13.5	3.536	1.001	0	0.743	0.293	0.456	0.791	**54.734**	**44.307**	**0.443**
12C	12Cc	6720	506.0	5.00	7	5	2	4	1	43	1	1	1	17.1	0.226	-6.406	-11.8	-19.5	4.107	0.921	0	0.395	0.182	0.279	0.918	**44.908**	**37.564**	**0.376**
13A	13Cmhe	21312	688.4	10.00	5	8	14	75	3	75	1	2	1	19.85	0.322	-9.700	-10.9	-11.9	2.236	1.069	0.085	0.203	0.231	0.503	0.5	**43.185**	**36.381**	**0.364**
13B	13Cml	21504	459.0	10.00	10	8	31	75	3	75	3	2	2	16.32	0.322	-4.710	-11	5.062	0	0.879	0.085	0.493	0.23	1.005	0	**44.866**	**37.535**	**0.375**
13C	13Cct	52.736	241.3	75.00	8	8	17	75	2	75	2	1.5	1.5	12	1.047	0.030	0.135	14.06	2.236	0.646	0.733	0.769	0.845	1.271	0.5	**79.402**	**61.237**	**0.612**
13D	13Ccsr	21760	257.1	5.00	17	14	8	75	1	75	1	1	1	12.37	0.226	2.276	-4.97	-18	3.162	0.666	0	0.899	0.561	0.323	0.707	**52.605**	**42.846**	**0.428**
13E	13Cc	21760	395.2	10.00	10	7	17	75	2	75	2	1.5	1.5	15.19	0.322	-4.724	-12	-8.98	2.236	0.818	0.085	0.492	0.173	0.589	0.5	**44.301**	**37.147**	**0.371**
13F	13Ccsr	21760	149.2	5.00	17	14	8	75	1	75	1	1	1	9.567	0.226	2.276	-4.97	-18	3.162	0.515	0	0.899	0.561	0.323	0.707	**50.091**	**41.121**	**0.411**
13G	13Ccsr	21760	153.9	5.00	17	14	8	75	1	75	1	1	1	9.709	0.226	2.276	-4.97	-18	3.162	0.523	0	0.899	0.561	0.323	0.707	**50.218**	**41.208**	**0.412**
15A	15Ccor	192	100.0	10.00	12	12	19	75	1	75	1	1	1	7.945	0.322	2.581	1.751	11.12	3.162	0.428	0.085	0.917	0.935	1.184	0.707	**70.931**	**55.423**	**0.554**
15B	15Ccgt	115.2	354.4	25.00	7	6	2	75	1	75	1	1	1	14.41	0.524	-1.846	-3.31	-3.93	3.162	0.776	0.266	0.66	0.654	0.739	0.707	**63.358**	**50.226**	**0.502**
15C	None		66.9																									
15D	15Ccor	192	229.8	10.00	12	12	19	75	1	75	1	1	1	11.73	0.322	2.581	1.751	11.12	3.162	0.631	0.085	0.917	0.935	1.184	0.707	**74.325**	**57.752**	**0.578**
15E	15Cce	44288	26.4	15.00	8	8	5	75	1	75	1	1	1	4.378	0.398	-7.520	-12.3	-23.7	3.162	0.236	0.153	0.33	0.156	0.154	0.707	**28.929**	**26.597**	**0.266**
15F	15Ccp	684.8	225.8	10.00	10	10	18	43	1	28	3	1	2	11.63	0.322	-0.845	-2.59	5.253	3.661	0.626	0.085	0.718	0.694	1.01	0.819	**65.866**	**51.947**	**0.519**
15G	15Cce	44288	180.8	15.00	8	8	5	75	1	75	1	1	1	10.47	0.398	-7.520	-12.3	-23.7	3.162	0.564	0.153	0.33	0.156	0.154	0.707	**34.398**	**30.350**	**0.304**
15H	15TCm	486.4	498.2	35.00	10	12	9	75	2	54	2	1.5	1.5	16.98	0.633	-0.461	0.036	-2.44	2.665	0.914	0.363	0.74	0.84	0.783	0.596	**70.598**	**55.195**	**0.552**

Table 2-3: Piedmont Physiographic Province FWP PHI Metrics and Scores for design alternative 1

Stream		Metric Values Input												Transform Bank Severity		Prepare Metric Values								Scale Metric Values								Final Score	Normalize Final Score	Rescaled Final Score
									Left Bank Stability		Right Bank Stability																							
Reach No.	Habitat Code	Watershed Area (acres)	% Embeddedness	Remoteness (meters)	%Shading	Epibenthic Substrate Score	Instream Habitat Score	Total No. Instream Woody Debris and Rootwads	Erosion Extent (meters)	Severity	Erosion Extent (meters)	Severity	Riffle Quality Score	Left	Right	EMBEDDED	REMOTE	RESTSHADING	EPISUB	RESINSTRHAB	WOOD	TBANKSTANB	RESRIFFQUAL	EMBEDDED	REMOTE	RESTSHADING	EPISUB	RESINSTRHAB	WOOD	TBANKSTANB	RESRIFFQUAL	Piedmont PHI	Normalized Piedmont PHI	Rescaled Piedmont PHI
7A	7Pb	9856	20	114.5	50	14	16	11	10	1	10	1	15	1	1	20	8.457	-0.17	14	-0.17	11	4.32	-0.46	0.889	0.529	0.69	0.765	0.803	0.917	1.024	0.804	**80.242**	**60.546**	**0.605**
7B	7Pe	10048	20	400.5	30	14	15	17	10	1	10	1	15	1	1	20	15.28	-0.38	14	-1.18	17	4.32	-0.48	0.889	0.955	0.545	0.765	0.738	1.417	1.024	0.803	**89.193**	**67.022**	**0.670**

Table 2-4: Coastal Plain Physiographic Province FWP PHI Metrics and Scores for design alternative 1

Stream		Metric Values Input										Transform Bank Severity		Prepare Metric Values						Scale Metric Values						Final Score	Normalize Final Score	Rescaled Final Score
								Left Bank Stability		Right Bank Stability																		
Reach Code	Habiat Code	Watershed Area (acres)	Remoteness (meters)	%Shading	Epibenthic Substrate Score	Instream Habitat Score	Total No. Instream Woody Debris and Rootwads	Erosion Extent (meters)	Severity	Erosion Extent (meters)	Severity	Left	Right	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	Coastal Plain PHI	Normalized Coastal Plain PHI	Rescaled Coastla Plain PHI
1A	1Cc	1210	211.8	15.00	15	15	11	10	1	10	1	1	1	11.28	0.398	3.517	1.356	-3.92	4.32	0.608	0.153	0.971	0.913	0.739	0.966	**72.497**	**56.498**	**0.565**
1B	1Cm	1235	1908.8	80.00	15	15	11	10	1	10	1	1	1	32.64	1.107	3.494	1.317	-4	4.32	1.758	0.787	0.97	0.911	0.737	0.966	**102.124**	**76.831**	**0.768**
3A	3Cce	22272	249.0	35.00	15	15	28	10	1	10	1	1	1	12.18	0.633	0.25	-4.02	1.928	4.32	0.656	0.363	0.781	0.615	0.912	0.966	**71.559**	**55.854**	**0.559**
3B	3Cm	22592	143.3	5.00	15	15	44	10	1	10	1	1	1	9.391	0.226	0.234	-4.04	17.87	4.32	0.506	-0	0.78	0.613	1.384	0.966	**70.812**	**55.341**	**0.553**
3C	*3Ccp*	22720	114.8	15.00	15	15	11	10	1	10	1	1	1	8.468	0.398	0.228	-4.05	-15.1	4.32	0.456	0.153	0.78	0.613	0.407	0.966	**56.249**	**45.347**	**0.453**
3D	*3Ccp*	22720	63.3	15.00	15	15	11	10	1	10	1	1	1	6.445	0.398	0.228	-4.05	-15.1	4.32	0.347	0.153	0.78	0.613	0.407	0.966	**54.433**	**44.101**	**0.441**
3E	*3Cce*	22272	26.1	35.00	15	15	28	10	1	10	1	1	1	4.359	0.633	0.25	-4.02	1.928	4.32	0.235	0.363	0.781	0.615	0.912	0.966	**64.538**	**51.036**	**0.510**
3F	*3Ccp*	22720	15.5	15.00	15	15	11	10	1	10	1	1	1	3.498	0.398	0.228	-4.05	-15.1	4.32	0.188	0.153	0.78	0.613	0.407	0.966	**51.788**	**42.285**	**0.423**
3G	*3Ccst*	31296	66.4	5.00	15	15	11	10	1	0	0	1	0	6.588	0.226	-0.13	-4.65	-16.4	4.397	0.355	-0	0.759	0.58	0.371	0.983	**50.786**	**41.597**	**0.416**
3H	None																											
3I	3Ccp	22720	419.0	15.00	15	15	11	10	1	10	1	1	1	15.62	0.398	0.228	-4.05	-15.1	4.32	0.841	0.153	0.78	0.613	0.407	0.966	**62.666**	**49.751**	**0.498**
3J	3Ccst	31296	139.0	5.00	15	15	11	10	1	0	0	1	0	9.258	0.226	-0.13	-4.65	-16.4	4.397	0.499	-0	0.759	0.58	0.371	0.983	**53.182**	**43.242**	**0.432**
3K	9Cs	7040	47.7	5.00	15	20	11	3	1	0	0	1	0	5.675	0.226	1.542	3.107	-10.7	4.45	0.306	-0	0.856	1.01	0.54	0.995	**61.767**	**49.134**	**0.491**
3L	3Ccst	31296	103.4	5.00	15	15	11	10	1	0	0	1	0	8.07	0.226	-0.13	-4.65	-16.4	4.397	0.435	-0	0.759	0.58	0.371	0.983	**52.115**	**42.510**	**0.425**
3M	9Cs	7040	61.9	5.00	15	20	11	3	1	0	0	1	0	6.381	0.226	1.542	3.107	-10.7	4.45	0.344	-0	0.856	1.01	0.54	0.995	**62.400**	**49.568**	**0.496**
3N	3Ccst	31296	52.1	5.00	15	15	11	10	1	0	0	1	0	5.908	0.226	-0.13	-4.65	-16.4	4.397	0.318	-0	0.759	0.58	0.371	0.983	**50.175**	**41.178**	**0.412**
3O	*3Ccu*	31488	29.0	15.00	15	15	11	10	1	10	1	1	1	4.563	0.398	-0.14	-4.66	-16.4	4.32	0.246	0.153	0.759	0.579	0.37	0.966	**51.217**	**41.893**	**0.419**
3P	3Ccu	31488	232.0	15.00	15	15	11	10	1	10	1	1	1	11.78	0.398	-0.14	-4.66	-16.4	4.32	0.634	0.153	0.759	0.579	0.37	0.966	**57.695**	**46.339**	**0.463**
3Q	3Ccpg	31616	386.4	25.00	15	15	14	10	1	10	1	1	1	15.02	0.524	-0.14	-4.66	-13.4	4.32	0.809	0.266	0.759	0.579	0.458	0.966	**63.939**	**50.624**	**0.506**
5A	5Ccst	19584	53.7	5.00	15	15	11	10	1	0	0	1	0	5.985	0.226	0.395	-3.78	-14.6	4.397	0.322	-0	0.79	0.628	0.424	0.983	**52.437**	**42.731**	**0.427**
5B	5Ccgu	19904	74.5	5.00	15	15	11	10	1	10	1	1	1	6.941	0.226	0.376	-3.81	-14.6	4.32	0.374	-0	0.789	0.626	0.422	0.966	**52.935**	**43.072**	**0.431**
5C	5Ccehu	19648	109.3	10.00	15	15	11	10	1	5	1	1	1	8.279	0.322	0.391	-3.79	-14.6	4.359	0.446	0.085	0.79	0.627	0.423	0.975	**55.771**	**45.019**	**0.450**
5D	5Cw	19904	39.1	10.00	15	15	29	10	1	10	1	1	1	5.2	0.322	0.376	-3.81	3.358	4.32	0.28	0.085	0.789	0.626	0.954	0.966	**61.680**	**49.074**	**0.491**
5E	5Ccgu	19904	120.8	5.00	15	15	11	10	1	10	1	1	1	8.67	0.226	0.376	-3.81	-14.6	4.32	0.467	-0	0.789	0.626	0.422	0.966	**54.486**	**44.137**	**0.441**
5F	5Ccehu	19648	162.6	10.00	15	15	11	10	1	5	1	1	1	9.963	0.322	0.391	-3.79	-14.6	4.359	0.536	0.085	0.79	0.627	0.423	0.975	**57.283**	**46.056**	**0.461**
5G	5Ccst	19584	49.9	5.00	15	15	11	10	1	0	0	1	0	5.794	0.226	0.395	-3.78	-14.6	4.397	0.312	-0	0.79	0.628	0.424	0.983	**52.266**	**42.613**	**0.426**
5H	5Ccehu	19648	117.7	10.00	15	15	11	10	1	5	1	1	1	8.569	0.322	0.391	-3.79	-14.6	4.359	0.461	0.085	0.79	0.627	0.423	0.975	**56.032**	**45.198**	**0.452**
5I	5Ccgu	19904	22.0	5.00	15	15	11	10	1	10	1	1	1	4.054	0.226	0.376	-3.81	-14.6	4.32	0.218	-0	0.789	0.626	0.422	0.966	**50.344**	**41.294**	**0.413**
5J	5Ccehu	19648	83.1	10.00	15	15	11	10	1	5	1	1	1	7.297	0.322	0.391	-3.79	-14.6	4.359	0.393	0.085	0.79	0.627	0.423	0.975	**54.890**	**44.414**	**0.444**
5K	5Ccle	19840	516.4	15.00	15	15	18	10	1	10	1	1	1	17.27	0.398	0.38	-3.8	-7.63	4.32	0.93	0.153	0.789	0.626	0.629	0.966	**68.235**	**53.573**	**0.536**
5L	5Cw	19904	151.5	10.00	15	15	29	10	1	10	1	1	1	9.639	0.322	0.376	-3.81	3.358	4.32	0.519	0.085	0.789	0.626	0.954	0.966	**65.663**	**51.808**	**0.518**
5M	5Ccst	19584	44.4	5.00	15	15	11	10	1	0	0	1	0	5.5	0.226	0.395	-3.78	-14.6	4.397	0.296	-0	0.79	0.628	0.424	0.983	**52.002**	**42.432**	**0.424**
5N	5Ccst	19584	38.4	5.00	15	15	11	10	1	0	0	1	0	5.156	0.226	0.395	-3.78	-14.6	4.397	0.278	-0	0.79	0.628	0.424	0.983	**51.693**	**42.220**	**0.422**
5O	9Cs	7040	28.5	5.00	15	20	11	3	1	0	0	1	0	4.531	0.226	1.542	3.107	-10.7	4.45	0.244	-0	0.856	1.01	0.54	0.995	**60.740**	**48.429**	**0.484**
5P	5Ccgu	19904	152.9	5.00	15	15	11	10	1	10	1	1	1	9.679	0.226	0.376	-3.81	-14.6	4.32	0.521	-0	0.789	0.626	0.422	0.966	**55.392**	**44.759**	**0.448**
5Q	5Ccgu	19904	41.2	5.00	15	15	11	10	1	10	1	1	1	5.32	0.226	0.376	-3.81	-14.6	4.32	0.286	-0	0.789	0.626	0.422	0.966	**51.480**	**42.074**	**0.421**
5R	5Ccst	19584	41.8	5.00	15	15	11	10	1	0	0	1	0	5.353	0.226	0.395	-3.78	-14.6	4.397	0.288	-0	0.79	0.628	0.424	0.983	**51.871**	**42.342**	**0.423**
5S	9Cs	7040	71.7	5.00	15	20	11	3	1	0	0	1	0	6.823	0.226	1.542	3.107	-10.7	4.45	0.367	-0	0.856	1.01	0.54	0.995	**62.797**	**49.840**	**0.498**

Table 2-4: Coastal Plain Physiographic Province FWP PHI Metrics and Scores for design alternative 1

Stream		Metric Values Input										Transform Bank Severity		Prepare Metric Values						Scale Metric Values						Final Score	Normalize Final Score	Rescaled Final Score
								Left Bank Stability		Right Bank Stability																		
Reach Code	Habiat Code	Watershed Area (acres)	Remoteness (meters)	%Shading	Epibenthic Substrate Score	Instream Habitat Score	Total No. Instream Woody Debris and Rootwads	Erosion Extent (meters)	Severity	Erosion Extent (meters)	Severity	Left	Right	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	Coastal Plain PHI	Normalized Coastal Plain PHI	Rescaled Coastla Plain PHI
5T	5Ccgu	19904	47.3	5.00	15	15	11	10	1	10	1	1	1	5.654	0.226	0.376	-3.81	-14.6	4.32	0.304	-0	0.789	0.626	0.422	0.966	**51.779**	**42.279**	**0.423**
7C	7Cc	10432	504.0	0.00	14	14	11	10	1	10	1	1	1	17.07	0	0.101	-3.62	-12.2	4.32	0.919	-0.2	0.773	0.637	0.495	0.966	**59.800**	**47.784**	**0.478**
7D	None																											
7E	7Cc	10432	682.3	0.00	14	14	11	10	1	10	1	1	1	19.76	0	0.101	-3.62	-12.2	4.32	1.064	-0.2	0.773	0.637	0.495	0.966	**62.216**	**49.442**	**0.494**
9A	9Cg	7168	173.2	15.00	14	14	11	10	1	10	1	1	1	10.26	0.398	0.522	-2.93	-10.7	4.32	0.553	0.153	0.797	0.675	0.538	0.966	**61.362**	**48.856**	**0.489**
9B	9Cs	7040	74.2	5.00	15	20	11	3	1	0	0	1	0	6.928	0.226	1.542	3.107	-10.7	4.45	0.373	-0	0.856	1.01	0.54	0.995	**62.891**	**49.905**	**0.499**
9C	9Cg	7168	435.8	15.00	14	14	11	10	1	10	1	1	1	15.92	0.398	0.522	-2.93	-10.7	4.32	0.857	0.153	0.797	0.675	0.538	0.966	**66.437**	**52.339**	**0.523**
10A	10Cs	1242	112.7	35.00	15	15	11	10	1	5	1	1	1	8.396	0.633	3.488	1.308	-4.02	4.359	0.452	0.363	0.969	0.91	0.736	0.975	**73.429**	**57.138**	**0.571**
10B	10Cg	1254	134.5	15.00	15	15	15	10	1	10	1	1	1	9.117	0.398	3.476	1.289	-0.06	4.32	0.491	0.153	0.969	0.909	0.853	0.966	**72.355**	**56.401**	**0.564**
10C	10Ce	1286	243.4	5.00	15	15	11	10	1	10	1	1	1	12.05	0.226	3.448	1.242	-4.16	4.32	0.649	-0	0.967	0.906	0.732	0.966	**70.335**	**55.014**	**0.550**
10D	10Cg	1254	148.2	15.00	15	15	15	10	1	10	1	1	1	9.537	0.398	3.476	1.289	-0.06	4.32	0.514	0.153	0.969	0.909	0.853	0.966	**72.732**	**56.659**	**0.567**
11A	11Ccp	17536	1820.2	10.00	15	15	11	10	1	10	1	1	1	31.89	0.322	0.518	-3.58	-14.2	4.32	1.717	0.085	0.797	0.639	0.436	0.966	**77.349**	**59.828**	**0.598**
11B	11Ccp	17536	269.9	10.00	15	15	11	10	1	10	1	1	1	12.66	0.322	0.518	-3.58	-14.2	4.32	0.682	0.085	0.797	0.639	0.436	0.966	**60.090**	**47.983**	**0.480**
11C	11Ccp	17536	107.1	10.00	15	15	11	10	1	10	1	1	1	8.202	0.322	0.518	-3.58	-14.2	4.32	0.442	0.085	0.797	0.639	0.436	0.966	**56.091**	**45.238**	**0.452**
11D	11Ccp	17536	30.0	10.00	15	15	11	10	1	10	1	1	1	4.627	0.322	0.518	-3.58	-14.2	4.32	0.249	0.085	0.797	0.639	0.436	0.966	**52.883**	**43.037**	**0.430**
11E	None																											
11F	None																											
11G	11Ccg	18176	42.4	5.00	15	15	11	0	0	10	1	0	1	5.389	0.226	0.478	-3.64	-14.3	4.397	0.29	-0	0.795	0.635	0.432	0.983	**52.251**	**42.603**	**0.426**
11H	11Ccg	18176	75.1	5.00	15	15	11	0	0	10	1	0	1	6.969	0.226	0.478	-3.64	-14.3	4.397	0.375	-0	0.795	0.635	0.432	0.983	**53.669**	**43.576**	**0.436**
11I	11Ccg	18176	21.5	5.00	15	15	11	0	0	10	1	0	1	4.01	0.226	0.478	-3.64	-14.3	4.397	0.216	-0	0.795	0.635	0.432	0.983	**51.014**	**41.754**	**0.418**
11J	11Cc	18176	53.6	5.00	15	15	11	10	1	10	1	1	1	5.98	0.226	0.478	-3.64	-14.3	4.32	0.322	-0	0.795	0.635	0.432	0.966	**52.497**	**42.772**	**0.428**
11K	11Ccg	18176	17.5	5.00	15	15	11	0	0	10	1	0	1	3.685	0.226	0.478	-3.64	-14.3	4.397	0.198	-0	0.795	0.635	0.432	0.983	**50.723**	**41.554**	**0.416**
11L	11Cc	18176	99.1	5.00	15	15	11	10	1	10	1	1	1	7.912	0.226	0.478	-3.64	-14.3	4.32	0.426	-0	0.795	0.635	0.432	0.966	**54.231**	**43.962**	**0.440**
11M	11Ccg	18176	74.7	5.00	15	15	11	0	0	10	1	0	1	6.95	0.226	0.478	-3.64	-14.3	4.397	0.374	-0	0.795	0.635	0.432	0.983	**53.653**	**43.565**	**0.436**
11N	11Cc	18176	120.0	5.00	15	15	11	10	1	10	1	1	1	8.645	0.226	0.478	-3.64	-14.3	4.32	0.466	-0	0.795	0.635	0.432	0.966	**54.889**	**44.414**	**0.444**
11O	11Ccg	18176	62.3	5.00	15	15	11	0	0	10	1	0	1	6.398	0.226	0.478	-3.64	-14.3	4.397	0.345	-0	0.795	0.635	0.432	0.983	**53.158**	**43.225**	**0.432**
11P	11Ccg	18176	96.4	5.00	15	15	11	0	0	10	1	0	1	7.811	0.226	0.478	-3.64	-14.3	4.397	0.421	-0	0.795	0.635	0.432	0.983	**54.425**	**44.095**	**0.441**
11Q	11Cc	18176	167.4	5.00	15	15	11	10	1	10	1	1	1	10.1	0.226	0.478	-3.64	-14.3	4.32	0.544	-0	0.795	0.635	0.432	0.966	**56.194**	**45.309**	**0.453**
12A	12Cc	6720	273.2	5.00	14	14	11	4	1	10	1	1	1	12.73	0.226	0.594	-2.81	-10.5	4.367	0.686	-0	0.801	0.682	0.545	0.976	**61.490**	**48.943**	**0.489**
12B	12Cm	6720	601.6	5.00	14	14	11	10	1	10	1	1	1	18.59	0.226	0.594	-2.81	-10.5	4.32	1.001	-0	0.801	0.682	0.545	0.966	**66.580**	**52.437**	**0.524**
12C	12Cc	6720	506.0	5.00	14	14	11	4	1	10	1	1	1	17.1	0.226	0.594	-2.81	-10.5	4.367	0.921	-0	0.801	0.682	0.545	0.976	**65.414**	**51.637**	**0.516**
13A	13Cmhe	21312	688.4	10.00	15	15	14	10	1	10	1	1	1	19.85	0.322	0.3	-3.94	-11.9	4.32	1.069	0.085	0.784	0.619	0.503	0.966	**67.109**	**52.800**	**0.528**
13B	13Cml	21504	459.0	10.00	15	15	31	10	1	10	1	1	1	16.32	0.322	0.29	-3.95	5.062	4.32	0.879	0.085	0.784	0.618	1.005	0.966	**72.283**	**56.351**	**0.564**
13C	13Cct	52.74	241.3	75.00	15	15	17	10	1	10	1	1	1	12	1.047	7.03	7.135	14.06	4.32	0.646	0.733	1.175	1.233	1.271	0.966	**100.422**	**75.663**	**0.757**
13D	13Ccsr	21760	257.1	5.00	17	15	11	10	1	10	1	1	1	12.37	0.226	2.276	-3.97	-15	4.32	0.666	-0	0.899	0.617	0.412	0.966	**59.326**	**47.459**	**0.475**
13E	13Cc	21760	395.2	10.00	15	15	17	10	1	10	1	1	1	15.19	0.322	0.276	-3.97	-8.98	4.32	0.818	0.085	0.783	0.617	0.589	0.966	**64.308**	**50.878**	**0.509**
13F	13Ccsr	21760	149.2	5.00	17	15	11	10	1	10	1	1	1	9.567	0.226	2.276	-3.97	-15	4.32	0.515	-0	0.899	0.617	0.412	0.966	**56.811**	**45.733**	**0.457**

Table 2-4: Coastal Plain Physiographic Province FWP PHI Metrics and Scores for design alternative 1

Stream		Metric Values Input										Transform Bank Severity		Prepare Metric Values						Scale Metric Values						Final Score	Normalize Final Score	Rescaled Final Score
								Left Bank Stability		Right Bank Stability																		
Reach Code	Habiat Code	Watershed Area (acres)	Remoteness (meters)	%Shading	Epibenthic Substrate Score	Instream Habitat Score	Total No. Instream Woody Debris and Rootwads	Erosion Extent (meters)	Severity	Erosion Extent (meters)	Severity	Left	Right	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	Coastal Plain PHI	Normalized Coastal Plain PHI	Rescaled Coastla Plain PHI
13G	13Ccsr	21760	153.9	5.00	17	15	11	10	1	10	1	1	1	9.709	0.226	2.276	-3.97	-15	4.32	0.523	-0	0.899	0.617	0.412	0.966	**56.938**	**45.820**	**0.458**
15A	15Ccor	192	100.0	10.00	14	14	19	10	1	10	1	1	1	7.945	0.322	4.581	3.751	11.12	4.32	0.428	0.085	1.033	1.046	1.184	0.966	**79.034**	**60.984**	**0.610**
15B	15Ccgt	115.2	354.4	25.00	14	14	11	10	1	10	1	1	1	14.41	0.524	5.154	4.693	5.074	4.32	0.776	0.266	1.066	1.098	1.005	0.966	**86.288**	**65.963**	**0.660**
15C	None																											
15D	15Ccor	192	229.8	10.00	14	14	19	10	1	10	1	1	1	11.73	0.322	4.581	3.751	11.12	4.32	0.631	0.085	1.033	1.046	1.184	0.966	**82.427**	**63.313**	**0.633**
15E	15Cce	44288	26.4	15.00	14	14	11	10	1	10	1	1	1	4.378	0.398	-1.52	-6.29	-17.7	4.32	0.236	0.153	0.678	0.489	0.331	0.966	**47.562**	**39.385**	**0.394**
15F	15Ccp	684.8	225.8	10.00	14	14	18	10	1	10	1	1	1	11.63	0.322	3.155	1.405	5.253	4.32	0.626	0.085	0.95	0.915	1.01	0.966	**75.897**	**58.831**	**0.588**
15G	15Cce	44288	180.8	15.00	14	14	11	10	1	10	1	1	1	10.47	0.398	-1.52	-6.29	-17.7	4.32	0.564	0.153	0.678	0.489	0.331	0.966	**53.030**	**43.138**	**0.431**
15H	15TCm	486.4	498.2	35.00	15	15	11	10	1	10	1	1	1	16.98	0.633	4.539	3.036	-0.44	4.32	0.914	0.363	1.03	1.006	0.842	0.966	**85.371**	**65.333**	**0.653**

Table 2-5: Piedmont Physiographic Province FWP PHI Metrics and Scores for design alternative 2

		Metric Values Input												Transform Bank Severity		Prepare Metric Values								Scale Metric Values								Final Score	Normalize Final Score	Rescaled Final Score
									Left Bank Stability		Right Bank Stability																							
Reach No.	Habitat Code	Watershed Area (acres)	% Embeddedness	Remoteness (meters)	%Shading	Epibenthic Substrate Score	Instream Habitat Score	Total No. Instream Woody Debris and Rootwads	Erosion Extent (meters)	Severity	Erosion Extent (meters)	Severity	Riffle Quality Score	Left	Right	EMBEDDED	REMOTE	RESTSHADING	EPISUB	RESINSTRHAB	WOOD	TBANKSTANB	RESRIFFQUAL	EMBEDDED	REMOTE	RESTSHADING	EPISUB	RESINSTRHAB	WOOD	TBANKSTANB	RESRIFFQUAL	Piedmont PHI	Normalized Piedmont PHI	Rescaled Piedmont PHI
7A	7Pb	9856	20	114.5	50	15	16	11	10	1	10	1	15	1	1	20	8.46	-0.17	15	-0.17	11	4.32	-0.46	0.89	0.53	0.69	0.82	0.8	0.92	1.02	0.8	**80.977**	**61.078**	**0.611**
7B	7Pe	10048	20	400.5	30	15	15	17	10	1	10	1	15	1	1	20	15.3	-0.38	15	-1.18	17	4.32	-0.48	0.89	0.96	0.54	0.82	0.74	1.42	1.02	0.8	**89.928**	**67.554**	**0.676**

Table 2-6: Coastal Plain Physiographic Province FWP PHI Metrics and Scores for design alternative 2

		Metric Values Input										Transform Bank Severity		Prepare Metric Values						Scale Metric Values						Final Score	Normalize Final Score	Rescaled Final Score
								Left Bank Stability		Right Bank Stability																		
Reach Code	Habiat Code	Watershed Area (acres)	Remoteness (meters)	%Shading	Epibenthic Substrate Score	Instream Habitat Score	Total No. Instream Woody Debris and Rootwads	Erosion Extent (meters)	Severity	Erosion Extent (meters)	Severity	Left	Right	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	Coastal Plain PHI	Normalized Coastal Plain PHI	Rescaled Coastla Plain PHI
1A	1Cc	1210	211.8	15.00	15	15	11	10	1	10	1	1	1	11.28	0.398	3.517	1.356	-3.92	4.32	0.608	0.153	0.971	0.913	0.739	0.966	**72.497**	**56.498**	**0.565**
1B	1Cm	1235	1908.8	80.00	15	15	11	10	1	10	1	1	1	32.64	1.107	3.494	1.317	-4	4.32	1.758	0.787	0.97	0.911	0.737	0.966	**102.124**	**76.831**	**0.768**
3A	3Cce	22272	249.0	35.00	15	15	28	10	1	10	1	1	1	12.18	0.633	0.25	-4.02	1.928	4.32	0.656	0.363	0.781	0.615	0.912	0.966	**71.559**	**55.854**	**0.559**
3B	3Cm	22592	143.3	5.00	15	15	44	10	1	10	1	1	1	9.391	0.226	0.234	-4.04	17.87	4.32	0.506	-0	0.78	0.613	1.384	0.966	**70.812**	**55.341**	**0.553**
3C	3Ccp	22720	114.8	15.00	15	15	11	10	1	10	1	1	1	8.468	0.398	0.228	-4.05	-15.1	4.32	0.456	0.153	0.78	0.613	0.407	0.966	**56.249**	**45.347**	**0.453**
3D	3Ccp	22720	63.3	15.00	15	15	11	10	1	10	1	1	1	6.445	0.398	0.228	-4.05	-15.1	4.32	0.347	0.153	0.78	0.613	0.407	0.966	**54.433**	**44.101**	**0.441**
3E	3Cce	22272	26.1	35.00	15	15	28	10	1	10	1	1	1	4.359	0.633	0.25	-4.02	1.928	4.32	0.235	0.363	0.781	0.615	0.912	0.966	**64.538**	**51.036**	**0.510**
3F	3Ccp	22720	15.5	15.00	15	15	11	10	1	10	1	1	1	3.498	0.398	0.228	-4.05	-15.1	4.32	0.188	0.153	0.78	0.613	0.407	0.966	**51.788**	**42.285**	**0.423**
3G	3Ccst	31296	66.4	5.00	15	15	11	10	1	0	0	1	0	6.588	0.226	-0.13	-4.65	-16.4	4.397	0.355	-0	0.759	0.58	0.371	0.983	**50.786**	**41.597**	**0.416**
3H	None	#N/A	71.5	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6.813	#N/A	#N/A	#N/A	#N/A	#N/A	0.367	#N/A	#N/A	#N/A	#N/A	#N/A	**#N/A**	**#N/A**	**#N/A**
3I	3Ccp	22720	419.0	15.00	15	15	11	10	1	10	1	1	1	15.62	0.398	0.228	-4.05	-15.1	4.32	0.841	0.153	0.78	0.613	0.407	0.966	**62.666**	**49.751**	**0.498**
3J	3Ccst	31296	139.0	5.00	15	15	11	10	1	0	0	1	0	9.258	0.226	-0.13	-4.65	-16.4	4.397	0.499	-0	0.759	0.58	0.371	0.983	**53.182**	**43.242**	**0.432**
3K	9Cs	7040	47.7	5.00	15	20	11	3	1	0	0	1	0	5.675	0.226	1.542	3.107	-10.7	4.45	0.306	-0	0.856	1.01	0.54	0.995	**61.767**	**49.134**	**0.491**
3L	3Ccst	31296	103.4	5.00	15	15	11	10	1	0	0	1	0	8.07	0.226	-0.13	-4.65	-16.4	4.397	0.435	-0	0.759	0.58	0.371	0.983	**52.115**	**42.510**	**0.425**
3M	9Cs	7040	61.9	5.00	15	20	11	3	1	0	0	1	0	6.381	0.226	1.542	3.107	-10.7	4.45	0.344	-0	0.856	1.01	0.54	0.995	**62.400**	**49.568**	**0.496**
3N	3Ccst	31296	52.1	5.00	15	15	11	10	1	0	0	1	0	5.908	0.226	-0.13	-4.65	-16.4	4.397	0.318	-0	0.759	0.58	0.371	0.983	**50.175**	**41.178**	**0.412**
3O	3Ccu	31488	29.0	15.00	15	15	11	10	1	10	1	1	1	4.563	0.398	-0.14	-4.66	-16.4	4.32	0.246	0.153	0.759	0.579	0.37	0.966	**51.217**	**41.893**	**0.419**
3P	3Ccu	31488	232.0	15.00	15	15	11	10	1	10	1	1	1	11.78	0.398	-0.14	-4.66	-16.4	4.32	0.634	0.153	0.759	0.579	0.37	0.966	**57.695**	**46.339**	**0.463**
3Q	3Ccpg	31616	386.4	25.00	15	15	14	10	1	10	1	1	1	15.02	0.524	-0.14	-4.66	-13.4	4.32	0.809	0.266	0.759	0.579	0.458	0.966	**63.939**	**50.624**	**0.506**
5A	5Ccst	19584	53.7	5.00	15	15	11	10	1	0	0	1	0	5.985	0.226	0.395	-3.78	-14.6	4.397	0.322	-0	0.79	0.628	0.424	0.983	**52.437**	**42.731**	**0.427**
5B	5Ccgu	19904	74.5	5.00	15	15	11	10	1	10	1	1	1	6.941	0.226	0.376	-3.81	-14.6	4.32	0.374	-0	0.789	0.626	0.422	0.966	**52.935**	**43.072**	**0.431**
5C	5Ccehu	19648	109.3	10.00	15	15	11	10	1	5	1	1	1	8.279	0.322	0.391	-3.79	-14.6	4.359	0.446	0.085	0.79	0.627	0.423	0.975	**55.771**	**45.019**	**0.450**
5D	5Cw	19904	39.1	10.00	15	15	29	10	1	10	1	1	1	5.2	0.322	0.376	-3.81	3.358	4.32	0.28	0.085	0.789	0.626	0.954	0.966	**61.680**	**49.074**	**0.491**
5E	5Ccgu	19904	120.8	5.00	15	15	11	10	1	10	1	1	1	8.67	0.226	0.376	-3.81	-14.6	4.32	0.467	-0	0.789	0.626	0.422	0.966	**54.486**	**44.137**	**0.441**
5F	5Ccehu	19648	162.6	10.00	15	15	11	10	1	5	1	1	1	9.963	0.322	0.391	-3.79	-14.6	4.359	0.536	0.085	0.79	0.627	0.423	0.975	**57.283**	**46.056**	**0.461**
5G	5Ccst	19584	49.9	5.00	15	15	11	10	1	0	0	1	0	5.794	0.226	0.395	-3.78	-14.6	4.397	0.312	-0	0.79	0.628	0.424	0.983	**52.266**	**42.613**	**0.426**
5H	5Ccehu	19648	117.7	10.00	15	15	11	10	1	5	1	1	1	8.569	0.322	0.391	-3.79	-14.6	4.359	0.461	0.085	0.79	0.627	0.423	0.975	**56.032**	**45.198**	**0.452**
5I	5Ccgu	19904	22.0	5.00	15	15	11	10	1	10	1	1	1	4.054	0.226	0.376	-3.81	-14.6	4.32	0.218	-0	0.789	0.626	0.422	0.966	**50.344**	**41.294**	**0.413**
5J	5Ccehu	19648	83.1	10.00	15	15	11	10	1	5	1	1	1	7.297	0.322	0.391	-3.79	-14.6	4.359	0.393	0.085	0.79	0.627	0.423	0.975	**54.890**	**44.414**	**0.444**
5K	5Ccle	19840	516.4	15.00	15	15	18	10	1	10	1	1	1	17.27	0.398	0.38	-3.8	-7.63	4.32	0.93	0.153	0.789	0.626	0.629	0.966	**68.235**	**53.573**	**0.536**
5L	5Cw	19904	151.5	10.00	15	15	29	10	1	10	1	1	1	9.639	0.322	0.376	-3.81	3.358	4.32	0.519	0.085	0.789	0.626	0.954	0.966	**65.663**	**51.808**	**0.518**
5M	5Ccst	19584	44.4	5.00	15	15	11	10	1	0	0	1	0	5.5	0.226	0.395	-3.78	-14.6	4.397	0.296	-0	0.79	0.628	0.424	0.983	**52.002**	**42.432**	**0.424**
5N	5Ccst	19584	38.4	5.00	15	15	11	10	1	0	0	1	0	5.156	0.226	0.395	-3.78	-14.6	4.397	0.278	-0	0.79	0.628	0.424	0.983	**51.693**	**42.220**	**0.422**
5O	9Cs	7040	28.5	5.00	15	20	11	3	1	0	0	1	0	4.531	0.226	1.542	3.107	-10.7	4.45	0.244	-0	0.856	1.01	0.54	0.995	**60.740**	**48.429**	**0.484**
5P	5Ccgu	19904	152.9	5.00	15	15	11	10	1	10	1	1	1	9.679	0.226	0.376	-3.81	-14.6	4.32	0.521	-0	0.789	0.626	0.422	0.966	**55.392**	**44.759**	**0.448**
5Q	5Ccgu	19904	41.2	5.00	15	15	11	10	1	10	1	1	1	5.32	0.226	0.376	-3.81	-14.6	4.32	0.286	-0	0.789	0.626	0.422	0.966	**51.480**	**42.074**	**0.421**
5R	5Ccst	19584	41.8	5.00	15	15	11	10	1	0	0	1	0	5.353	0.226	0.395	-3.78	-14.6	4.397	0.288	-0	0.79	0.628	0.424	0.983	**51.871**	**42.342**	**0.423**
5S	9Cs	7040	71.7	5.00	15	20	11	3	1	0	0	1	0	6.823	0.226	1.542	3.107	-10.7	4.45	0.367	-0	0.856	1.01	0.54	0.995	**62.797**	**49.840**	**0.498**

Table 2-6: Coastal Plain Physiographic Province FWP PHI Metrics and Scores for design alternative 2																												
		Metric Values Input										Transform Bank Severity		Prepare Metric Values						Scale Metric Values						Final Score	Normalize Final Score	Rescaled Final Score
								Left Bank Stability		Right Bank Stability																		
Reach Code	Habiat Code	Watershed Area (acres)	Remoteness (meters)	%Shading	Epibenthic Substrate Score	Instream Habitat Score	Total No. Instream Woody Debris and Rootwads	Erosion Extent (meters)	Severity	Erosion Extent (meters)	Severity	Left	Right	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	Coastal Plain PHI	Normalized Coastal Plain PHI	Rescaled Coastla Plain PHI
5T	5Ccgu	19904	47.3	5.00	15	15	11	10	1	10	1	1	1	5.654	0.226	0.376	-3.81	-14.6	4.32	0.304	-0	0.789	0.626	0.422	0.966	**51.779**	**42.279**	**0.423**
7C	7Cc	10432	504.0	0.00	15	15	11	10	1	10	1	1	1	17.07	0	1.101	-2.62	-12.2	4.32	0.919	-0.2	0.831	0.692	0.495	0.966	**61.693**	**49.083**	**0.491**
7D	None	#N/A	89.9	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	7.563	#N/A	#N/A	#N/A	#N/A	#N/A	0.407	#N/A	#N/A	#N/A	#N/A	#N/A	**#N/A**	**#N/A**	**#N/A**
7E	7Cc	10432	682.3	0.00	15	15	11	10	1	10	1	1	1	19.76	0	1.101	-2.62	-12.2	4.32	1.064	-0.2	0.831	0.692	0.495	0.966	**64.109**	**50.741**	**0.507**
9A	9Cg	7168	173.2	15.00	15	15	11	10	1	10	1	1	1	10.26	0.398	1.522	-1.93	-10.7	4.32	0.553	0.153	0.855	0.731	0.538	0.966	**63.255**	**50.155**	**0.502**
9B	9Cs	7040	74.2	5.00	15	20	11	3	1	0	0	1	0	6.928	0.226	1.542	3.107	-10.7	4.45	0.373	-0	0.856	1.01	0.54	0.995	**62.891**	**49.905**	**0.499**
9C	9Cg	7168	435.8	15.00	15	15	11	10	1	10	1	1	1	15.92	0.398	1.522	-1.93	-10.7	4.32	0.857	0.153	0.855	0.731	0.538	0.966	**68.330**	**53.638**	**0.536**
10A	10Cs	1242	112.7	35.00	13	13	9	10	1	5	1	1	1	8.396	0.633	1.488	-0.69	-6.02	4.359	0.452	0.363	0.853	0.799	0.677	0.975	**68.657**	**53.862**	**0.539**
10B	10Cg	1254	134.5	15.00	13	13	15	10	1	10	1	1	1	9.117	0.398	1.476	-0.71	-0.06	4.32	0.491	0.153	0.853	0.798	0.853	0.966	**68.569**	**53.802**	**0.538**
10C	10Ce	1286	243.4	5.00	13	13	10	10	1	10	1	1	1	12.05	0.226	1.448	-0.76	-5.16	4.32	0.649	-0	0.851	0.795	0.702	0.966	**66.056**	**52.077**	**0.521**
10D	10Cg	1254	148.2	15.00	13	13	15	10	1	10	1	1	1	9.537	0.398	1.476	-0.71	-0.06	4.32	0.514	0.153	0.853	0.798	0.853	0.966	**68.946**	**54.061**	**0.541**
11A	11Ccp	17536	1820.2	10.00	13	13	11	10	1	10	1	1	1	31.89	0.322	-1.48	-5.58	-14.2	4.32	1.717	0.085	0.681	0.528	0.436	0.966	**73.563**	**57.230**	**0.572**
11B	11Ccp	17536	269.9	10.00	13	13	11	10	1	10	1	1	1	12.66	0.322	-1.48	-5.58	-14.2	4.32	0.682	0.085	0.681	0.528	0.436	0.966	**56.304**	**45.384**	**0.454**
11C	11Ccp	17536	107.1	10.00	13	13	11	10	1	10	1	1	1	8.202	0.322	-1.48	-5.58	-14.2	4.32	0.442	0.085	0.681	0.528	0.436	0.966	**52.305**	**42.640**	**0.426**
11D	11Ccp	17536	30.0	10.00	13	13	11	10	1	10	1	1	1	4.627	0.322	-1.48	-5.58	-14.2	4.32	0.249	0.085	0.681	0.528	0.436	0.966	**49.097**	**40.438**	**0.404**
11E	None	#N/A	98.9	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	7.905	#N/A	#N/A	#N/A	#N/A	#N/A	0.426	#N/A	#N/A	#N/A	#N/A	#N/A	**#N/A**	**#N/A**	**#N/A**
11F	None	#N/A	34.0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	4.889	#N/A	#N/A	#N/A	#N/A	#N/A	0.263	#N/A	#N/A	#N/A	#N/A	#N/A	**#N/A**	**#N/A**	**#N/A**
11G	11Ccg	18176	42.4	5.00	14	14	11	0	0	10	1	0	1	5.389	0.226	-0.52	-4.64	-14.3	4.397	0.29	-0	0.736	0.58	0.432	0.983	**50.358**	**41.304**	**0.413**
11H	11Ccg	18176	75.1	5.00	14	14	11	0	0	10	1	0	1	6.969	0.226	-0.52	-4.64	-14.3	4.397	0.375	-0	0.736	0.58	0.432	0.983	**51.776**	**42.277**	**0.423**
11I	11Ccg	18176	21.5	5.00	14	14	11	0	0	10	1	0	1	4.01	0.226	-0.52	-4.64	-14.3	4.397	0.216	-0	0.736	0.58	0.432	0.983	**49.121**	**40.455**	**0.405**
11J	11Cc	18176	53.6	5.00	14	14	11	10	1	10	1	1	1	5.98	0.226	-0.52	-4.64	-14.3	4.32	0.322	-0	0.736	0.58	0.432	0.966	**50.604**	**41.473**	**0.415**
11K	11Ccg	18176	17.5	5.00	14	14	11	0	0	10	1	0	1	3.685	0.226	-0.52	-4.64	-14.3	4.397	0.198	-0	0.736	0.58	0.432	0.983	**48.830**	**40.255**	**0.403**
11L	11Cc	18176	99.1	5.00	14	14	11	10	1	10	1	1	1	7.912	0.226	-0.52	-4.64	-14.3	4.32	0.426	-0	0.736	0.58	0.432	0.966	**52.338**	**42.663**	**0.427**
11M	11Ccg	18176	74.7	5.00	14	14	11	0	0	10	1	0	1	6.95	0.226	-0.52	-4.64	-14.3	4.397	0.374	-0	0.736	0.58	0.432	0.983	**51.760**	**42.266**	**0.423**
11N	11Cc	18176	120.0	5.00	14	14	11	10	1	10	1	1	1	8.645	0.226	-0.52	-4.64	-14.3	4.32	0.466	-0	0.736	0.58	0.432	0.966	**52.996**	**43.115**	**0.431**
11O	11Ccg	18176	62.3	5.00	14	14	11	0	0	10	1	0	1	6.398	0.226	-0.52	-4.64	-14.3	4.397	0.345	-0	0.736	0.58	0.432	0.983	**51.265**	**41.926**	**0.419**
11P	11Ccg	18176	96.4	5.00	14	14	11	0	0	10	1	0	1	7.811	0.226	-0.52	-4.64	-14.3	4.397	0.421	-0	0.736	0.58	0.432	0.983	**52.532**	**42.796**	**0.428**
11Q	11Cc	18176	167.4	5.00	14	14	11	10	1	10	1	1	1	10.1	0.226	-0.52	-4.64	-14.3	4.32	0.544	-0	0.736	0.58	0.432	0.966	**54.301**	**44.010**	**0.440**
12A	12Cc	6720	273.2	5.00	15	15	11	4	1	10	1	1	1	12.73	0.226	1.594	-1.81	-10.5	4.367	0.686	-0	0.859	0.737	0.545	0.976	**63.383**	**50.243**	**0.502**
12B	12Cm	6720	601.6	5.00	15	15	11	10	1	10	1	1	1	18.59	0.226	1.594	-1.81	-10.5	4.32	1.001	-0	0.859	0.737	0.545	0.966	**68.473**	**53.736**	**0.537**
12C	12Cc	6720	506.0	5.00	15	15	11	4	1	10	1	1	1	17.1	0.226	1.594	-1.81	-10.5	4.367	0.921	-0	0.859	0.737	0.545	0.976	**67.307**	**52.936**	**0.529**
13A	13Cmhe	21312	688.4	10.00	14	14	14	10	1	10	1	1	1	19.85	0.322	-0.7	-4.94	-11.9	4.32	1.069	0.085	0.726	0.564	0.503	0.966	**65.216**	**51.501**	**0.515**
13B	13Cml	21504	459.0	10.00	14	14	31	10	1	10	1	1	1	16.32	0.322	-0.71	-4.95	5.062	4.32	0.879	0.085	0.726	0.563	1.005	0.966	**70.390**	**55.052**	**0.551**
13C	13Cct	52.74	241.3	75.00	14	14	17	10	1	10	1	1	1	12	1.047	6.03	6.135	14.06	4.32	0.646	0.733	1.117	1.178	1.271	0.966	**98.529**	**74.364**	**0.744**
13D	13Ccsr	21760	257.1	5.00	17	14	11	10	1	10	1	1	1	12.37	0.226	2.276	-4.97	-15	4.32	0.666	-0	0.899	0.561	0.412	0.966	**58.401**	**46.824**	**0.468**
13E	13Cc	21760	395.2	10.00	14	14	17	10	1	10	1	1	1	15.19	0.322	-0.72	-4.97	-8.98	4.32	0.818	0.085	0.725	0.561	0.589	0.966	**62.415**	**49.579**	**0.496**
13F	13Ccsr	21760	149.2	5.00	17	14	11	10	1	10	1	1	1	9.567	0.226	2.276	-4.97	-15	4.32	0.515	-0	0.899	0.561	0.412	0.966	**55.887**	**45.098**	**0.451**
13G	13Ccsr	21760	153.9	5.00	17	14	11	10	1	10	1	1	1	9.709	0.226	2.276	-4.97	-15	4.32	0.523	-0	0.899	0.561	0.412	0.966	**56.013**	**45.185**	**0.452**

Table 2-6: Coastal Plain Physiographic Province FWP PHI Metrics and Scores for design alternative 2

		Metric Values Input										Transform Bank Severity		Prepare Metric Values						Scale Metric Values						Final Score	Normalize Final Score	Rescaled Final Score
								Left Bank Stability		Right Bank Stability																		
Reach Code	Habiat Code	Watershed Area (acres)	Remoteness (meters)	%Shading	Epibenthic Substrate Score	Instream Habitat Score	Total No. Instream Woody Debris and Rootwads	Erosion Extent (meters)	Severity	Erosion Extent (meters)	Severity	Left	Right	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	Coastal Plain PHI	Normalized Coastal Plain PHI	Rescaled Coastla Plain PHI
15A	15Ccor	192	100.0	10.00	15	15	19	10	1	10	1	1	1	7.945	0.322	5.581	4.751	11.12	4.32	0.428	0.085	1.091	1.101	1.184	0.966	**80.927**	**62.283**	**0.623**
15B	15Ccgt	115.2	354.4	25.00	15	15	11	10	1	10	1	1	1	14.41	0.524	6.154	5.693	5.074	4.32	0.776	0.266	1.124	1.153	1.005	0.966	**88.181**	**67.262**	**0.673**
15C	None	#N/A	66.9	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6.611	#N/A	#N/A	#N/A	#N/A	#N/A	0.356	#N/A	#N/A	#N/A	#N/A	#N/A	**#N/A**	**#N/A**	**#N/A**
15D	15Ccor	192	229.8	10.00	15	15	19	10	1	10	1	1	1	11.73	0.322	5.581	4.751	11.12	4.32	0.631	0.085	1.091	1.101	1.184	0.966	**84.320**	**64.612**	**0.646**
15E	15Cce	44288	26.4	15.00	15	15	11	10	1	10	1	1	1	4.378	0.398	-0.52	-5.29	-17.7	4.32	0.236	0.153	0.737	0.544	0.331	0.966	**49.455**	**40.684**	**0.407**
15F	15Ccp	684.8	225.8	10.00	15	15	18	10	1	10	1	1	1	11.63	0.322	4.155	2.405	5.253	4.32	0.626	0.085	1.008	0.971	1.01	0.966	**77.790**	**60.131**	**0.601**
15G	15Cce	44288	180.8	15.00	15	15	11	10	1	10	1	1	1	10.47	0.398	-0.52	-5.29	-17.7	4.32	0.564	0.153	0.737	0.544	0.331	0.966	**54.923**	**44.437**	**0.444**
15H	15TCm	486.4	498.2	35.00	15	15	11	10	1	10	1	1	1	16.98	0.633	4.539	3.036	-0.44	4.32	0.914	0.363	1.03	1.006	0.842	0.966	**85.371**	**65.333**	**0.653**

Table 2-7: Piedmont Physiographic Province BAC PHI Metrics and Scores

Stream		Metric Values Input												Transform Bank Severity		Prepare Metric Values								Scale Metric Values								Final Score	Normalize Final Score	Rescaled Final Score
									Left Bank Stability		Right Bank Stability																							
Reach No.	Habitat Code	Watershed Area (acres)	% Embeddedness	Remoteness (meters)	%Shading	Epibenthic Substrate Score	Instream Habitat Score	Total No. Instream Woody Debris and Rootwads	Erosion Extent (meters)	Severity	Erosion Extent (meters)	Severity	Riffle Quality Score	Left	Right	EMBEDDED	REMOTE	RESTSHADING	EPISUB	RESINSTRHAB	WOOD	TBANKSTANB	RESRIFFQUAL	EMBEDDED	REMOTE	RESTSHADING	EPISUB	RESINSTRHAB	WOOD	TBANKSTANB	RESRIFFQUAL	Piedmont PHI	Normalized Piedmont PHI	Rescaled Piedmont PHI
7A	7Pb	9856	20	114.5	50	20	20	32	0	0	0	0	20	0	0	20	8.46	-0.17	20	3.83	32	4.47	4.54	0.89	0.53	0.69	1.12	1.06	2.67	1.07	1.06	**113.471**	**84.589**	**0.846**
7B	7Pe	10048	20	400.5	30	20	20	32	0	0	0	0	20	0	0	20	15.3	-0.38	20	3.82	32	4.47	4.52	0.89	0.96	0.54	1.12	1.06	2.67	1.07	1.06	**116.966**	**87.117**	**0.871**

Table 2-8: Coastal Plain Physiographic Province BAC PHI Metrics and Scores

Stream		Metric Values Input										Transform Bank Severity		Prepare Metric Values						Scale Metric Values						Final Score	Normalize Final Score	Rescaled Final Score
								Left Bank Stability		Right Bank Stability																		
Reach Code	Habiat Code	Watershed Area (acres)	Remoteness (meters)	%Shading	Epibenthic Substrate Score	Instream Habitat Score	Total No. Instream Woody Debris and Rootwads	Erosion Extent (meters)	Severity	Erosion Extent (meters)	Severity	Left	Right	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	Coastal Plain PHI	Normalized Coastal Plain PHI	Rescaled Coastla Plain PHI
1A	1Cc	1209.6	211.8	15.00	20	20	32	0	0	0	0	0	0	11.28	0.398	8.517	6.356	17.08	4.472	0.608	0.153	1.262	1.19	1.36	1	**92.882**	**70.488**	**0.705**
1B	1Cm	1235.2	1908.8	80.00	20	20	32	0	0	0	0	0	0	32.64	1.107	8.494	6.317	17	4.472	1.758	0.787	1.26	1.188	1.358	1	**122.509**	**90.821**	**0.908**
3A	3Cce	22272	249.0	35.00	20	20	32	0	0	0	0	0	0	12.18	0.633	5.25	0.982	5.928	4.472	0.656	0.363	1.072	0.892	1.03	1	**83.562**	**64.092**	**0.641**
3B	3Cm	22592	143.3	5.00	20	20	32	0	0	0	0	0	0	9.391	0.226	5.234	0.956	5.873	4.472	0.506	-0	1.071	0.891	1.029	1	**74.925**	**58.164**	**0.582**
3C	3Ccp	22720	114.8	15.00	20	20	32	0	0	0	0	0	0	8.468	0.398	5.228	0.946	5.851	4.472	0.456	0.153	1.071	0.89	1.028	1	**76.633**	**59.336**	**0.593**
3D	3Ccp	22720	63.3	15.00	20	20	32	0	0	0	0	0	0	6.445	0.398	5.228	0.946	5.851	4.472	0.347	0.153	1.071	0.89	1.028	1	**74.817**	**58.090**	**0.581**
3E	3Cce	22272	26.1	35.00	20	20	32	0	0	0	0	0	0	4.359	0.633	5.25	0.982	5.928	4.472	0.235	0.363	1.072	0.892	1.03	1	**76.540**	**59.273**	**0.593**
3F	3Ccp	22720	15.5	15.00	20	20	32	0	0	0	0	0	0	3.498	0.398	5.228	0.946	5.851	4.472	0.188	0.153	1.071	0.89	1.028	1	**72.172**	**56.275**	**0.563**
3G	3Ccst	31296	66.4	5.00	20	20	32	0	0	0	0	0	0	6.588	0.226	4.869	0.355	4.626	4.472	0.355	-0	1.05	0.857	0.992	1	**70.885**	**55.391**	**0.554**
3H	None	#N/A	71.5	#N/A	20	20	32	0	0	0	0	0	0	6.813	#N/A	#N/A	#N/A	#N/A	4.472	0.367	#N/A	#N/A	#N/A	#N/A	1	**#N/A**	**#N/A**	**#N/A**
3I	3Ccp	22720	419.0	15.00	20	20	32	0	0	0	0	0	0	15.62	0.398	5.228	0.946	5.851	4.472	0.841	0.153	1.071	0.89	1.028	1	**83.051**	**63.741**	**0.637**
3J	3Ccst	31296	139.0	5.00	20	20	32	0	0	0	0	0	0	9.258	0.226	4.869	0.355	4.626	4.472	0.499	-0	1.05	0.857	0.992	1	**73.281**	**57.036**	**0.570**
3K	9Cs	7040	47.7	5.00	20	20	32	0	0	0	0	0	0	5.675	0.226	6.542	3.107	10.34	4.472	0.306	-0	1.147	1.01	1.161	1	**77.046**	**59.620**	**0.596**
3L	3Ccst	31296	103.4	5.00	20	20	32	0	0	0	0	0	0	8.07	0.226	4.869	0.355	4.626	4.472	0.435	-0	1.05	0.857	0.992	1	**72.215**	**56.304**	**0.563**
3M	9Cs	7040	61.9	5.00	20	20	32	0	0	0	0	0	0	6.381	0.226	6.542	3.107	10.34	4.472	0.344	-0	1.147	1.01	1.161	1	**77.679**	**60.054**	**0.601**
3N	3Ccst	31296	52.1	5.00	20	20	32	0	0	0	0	0	0	5.908	0.226	4.869	0.355	4.626	4.472	0.318	-0	1.05	0.857	0.992	1	**70.275**	**54.973**	**0.550**
3O	3Ccu	31488	29.0	15.00	20	20	32	0	0	0	0	0	0	4.563	0.398	4.862	0.344	4.602	4.472	0.246	0.153	1.049	0.857	0.991	1	**71.601**	**55.883**	**0.559**
3P	3Ccu	31488	232.0	15.00	20	20	32	0	0	0	0	0	0	11.78	0.398	4.862	0.344	4.602	4.472	0.634	0.153	1.049	0.857	0.991	1	**78.079**	**60.329**	**0.603**
3Q	3Ccpg	31616	386.4	25.00	20	20	32	0	0	0	0	0	0	15.02	0.524	4.857	0.336	4.587	4.472	0.809	0.266	1.049	0.856	0.991	1	**82.844**	**63.599**	**0.636**
5A	5Ccst	19584	53.7	5.00	20	20	32	0	0	0	0	0	0	5.985	0.226	5.395	1.22	6.42	4.472	0.322	-0	1.08	0.905	1.045	1	**72.536**	**56.525**	**0.565**
5B	5Ccgu	19904	74.5	5.00	20	20	32	0	0	0	0	0	0	6.941	0.226	5.376	1.19	6.358	4.472	0.374	-0	1.079	0.903	1.043	1	**73.319**	**57.062**	**0.571**
5C	5Ccehu	19648	109.3	10.00	20	20	32	0	0	0	0	0	0	8.279	0.322	5.391	1.214	6.407	4.472	0.446	0.085	1.08	0.905	1.045	1	**76.012**	**58.910**	**0.589**
5D	5Cw	19904	39.1	10.00	20	20	32	0	0	0	0	0	0	5.2	0.322	5.376	1.19	6.358	4.472	0.28	0.085	1.079	0.903	1.043	1	**73.189**	**56.973**	**0.570**
5E	5Ccgu	19904	120.8	5.00	20	20	32	0	0	0	0	0	0	8.67	0.226	5.376	1.19	6.358	4.472	0.467	-0	1.079	0.903	1.043	1	**74.871**	**58.127**	**0.581**
5F	5Ccehu	19648	162.6	10.00	20	20	32	0	0	0	0	0	0	9.963	0.322	5.391	1.214	6.407	4.472	0.536	0.085	1.08	0.905	1.045	1	**77.524**	**59.948**	**0.599**
5G	5Ccst	19584	49.9	5.00	20	20	32	0	0	0	0	0	0	5.794	0.226	5.395	1.22	6.42	4.472	0.312	-0	1.08	0.905	1.045	1	**72.365**	**56.408**	**0.564**
5H	5Ccehu	19648	117.7	10.00	20	20	32	0	0	0	0	0	0	8.569	0.322	5.391	1.214	6.407	4.472	0.461	0.085	1.08	0.905	1.045	1	**76.273**	**59.089**	**0.591**
5I	5Ccgu	19904	22.0	5.00	20	20	32	0	0	0	0	0	0	4.054	0.226	5.376	1.19	6.358	4.472	0.218	-0	1.079	0.903	1.043	1	**70.728**	**55.284**	**0.553**
5J	5Ccehu	19648	83.1	10.00	20	20	32	0	0	0	0	0	0	7.297	0.322	5.391	1.214	6.407	4.472	0.393	0.085	1.08	0.905	1.045	1	**75.131**	**58.306**	**0.583**
5K	5Ccle	19840	516.4	15.00	20	20	32	0	0	0	0	0	0	17.27	0.398	5.38	1.196	6.37	4.472	0.93	0.153	1.079	0.904	1.043	1	**85.168**	**65.194**	**0.652**
5L	5Cw	19904	151.5	10.00	20	20	32	0	0	0	0	0	0	9.639	0.322	5.376	1.19	6.358	4.472	0.519	0.085	1.079	0.903	1.043	1	**77.172**	**59.707**	**0.597**
5M	5Ccst	19584	44.4	5.00	20	20	32	0	0	0	0	0	0	5.5	0.226	5.395	1.22	6.42	4.472	0.296	-0	1.08	0.905	1.045	1	**72.101**	**56.226**	**0.562**
5N	5Ccst	19584	38.4	5.00	20	20	32	0	0	0	0	0	0	5.156	0.226	5.395	1.22	6.42	4.472	0.278	-0	1.08	0.905	1.045	1	**71.792**	**56.014**	**0.560**
5O	9Cs	7040	28.5	5.00	20	20	32	0	0	0	0	0	0	4.531	0.226	6.542	3.107	10.34	4.472	0.244	-0	1.147	1.01	1.161	1	**76.019**	**58.915**	**0.589**
5P	5Ccgu	19904	152.9	5.00	20	20	32	0	0	0	0	0	0	9.679	0.226	5.376	1.19	6.358	4.472	0.521	-0	1.079	0.903	1.043	1	**75.777**	**58.749**	**0.587**
5Q	5Ccgu	19904	41.2	5.00	20	20	32	0	0	0	0	0	0	5.32	0.226	5.376	1.19	6.358	4.472	0.286	-0	1.079	0.903	1.043	1	**71.864**	**56.064**	**0.561**
5R	5Ccst	19584	41.8	5.00	20	20	32	0	0	0	0	0	0	5.353	0.226	5.395	1.22	6.42	4.472	0.288	-0	1.08	0.905	1.045	1	**71.970**	**56.136**	**0.561**
5S	9Cs	7040	71.7	5.00	20	20	32	0	0	0	0	0	0	6.823	0.226	6.542	3.107	10.34	4.472	0.367	-0	1.147	1.01	1.161	1	**78.075**	**60.326**	**0.603**
5T	5Ccgu	19904	47.3	5.00	20	20	32	0	0	0	0	0	0	5.654	0.226	5.376	1.19	6.358	4.472	0.304	-0	1.079	0.903	1.043	1	**72.164**	**56.269**	**0.563**
7C	7Cc	10432	504.0	0.00	20	20	32	0	0	0	0	0	0	17.07	0	6.101	2.381	8.83	4.472	0.919	-0.2	1.121	0.97	1.116	1	**82.077**	**63.073**	**0.631**
7D	None	#N/A	89.9	#N/A	20	20	32	0	0	0	0	0	0	7.563	#N/A	#N/A	#N/A	#N/A	4.472	0.407	#N/A	#N/A	#N/A	#N/A	1	**#N/A**	**#N/A**	**#N/A**

Table 2-8: Coastal Plain Physiographic Province BAC PHI Metrics and Scores																												
Stream		Metric Values Input										Transform Bank Severity		Prepare Metric Values						Scale Metric Values						Final Score	Normalize Final Score	Rescaled Final Score
								Left Bank Stability		Right Bank Stability																		
Reach Code	Habiat Code	Watershed Area (acres)	Remoteness (meters)	%Shading	Epibenthic Substrate Score	Instream Habitat Score	Total No. Instream Woody Debris and Rootwads	Erosion Extent (meters)	Severity	Erosion Extent (meters)	Severity	Left	Right	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	Coastal Plain PHI	Normalized Coastal Plain PHI	Rescaled Coastla Plain PHI
7E	7Cc	10432	682.3	0.00	20	20	32	0	0	0	0	0	0	19.76	0	6.101	2.381	8.83	4.472	1.064	-0.2	1.121	0.97	1.116	1	**84.493**	**64.731**	**0.647**
9A	9Cg	7168	173.2	15.00	20	20	32	0	0	0	0	0	0	10.26	0.398	6.522	3.074	10.27	4.472	0.553	0.153	1.146	1.008	1.159	1	**83.639**	**64.145**	**0.641**
9B	9Cs	7040	74.2	5.00	20	20	32	0	0	0	0	0	0	6.928	0.226	6.542	3.107	10.34	4.472	0.373	-0	1.147	1.01	1.161	1	**78.170**	**60.391**	**0.604**
9C	9Cg	7168	435.8	15.00	20	20	32	0	0	0	0	0	0	15.92	0.398	6.522	3.074	10.27	4.472	0.857	0.153	1.146	1.008	1.159	1	**88.715**	**67.628**	**0.676**
10A	10Cs	1241.6	112.7	35.00	20	20	32	0	0	0	0	0	0	8.396	0.633	8.488	6.308	16.98	4.472	0.452	0.363	1.26	1.187	1.357	1	**93.670**	**71.029**	**0.710**
10B	10Cg	1254.4	134.5	15.00	20	20	32	0	0	0	0	0	0	9.117	0.398	8.476	6.289	16.94	4.472	0.491	0.153	1.259	1.186	1.356	1	**90.767**	**69.037**	**0.690**
10C	10Ce	1286.4	243.4	5.00	20	20	32	0	0	0	0	0	0	12.05	0.226	8.448	6.242	16.84	4.472	0.649	-0	1.258	1.184	1.353	1	**90.719**	**69.004**	**0.690**
10D	10Cg	1254.4	148.2	15.00	20	20	32	0	0	0	0	0	0	9.537	0.398	8.476	6.289	16.94	4.472	0.514	0.153	1.259	1.186	1.356	1	**91.144**	**69.296**	**0.693**
11A	11Ccp	17536	1820.2	10.00	20	20	32	0	0	0	0	0	0	31.89	0.322	5.518	1.423	6.842	4.472	1.717	0.085	1.087	0.916	1.057	1	**97.734**	**73.818**	**0.738**
11B	11Ccp	17536	269.9	10.00	20	20	32	0	0	0	0	0	0	12.66	0.322	5.518	1.423	6.842	4.472	0.682	0.085	1.087	0.916	1.057	1	**80.474**	**61.973**	**0.620**
11C	11Ccp	17536	107.1	10.00	20	20	32	0	0	0	0	0	0	8.202	0.322	5.518	1.423	6.842	4.472	0.442	0.085	1.087	0.916	1.057	1	**76.475**	**59.228**	**0.592**
11D	11Ccp	17536	30.0	10.00	20	20	32	0	0	0	0	0	0	4.627	0.322	5.518	1.423	6.842	4.472	0.249	0.085	1.087	0.916	1.057	1	**73.267**	**57.026**	**0.570**
11E	None	#N/A	98.9	#N/A	20	20	32	0	0	0	0	0	0	7.905	#N/A	#N/A	#N/A	#N/A	4.472	0.426	#N/A	#N/A	#N/A	#N/A	1	**#N/A**	**#N/A**	**#N/A**
11F	None	#N/A	34.0	#N/A	20	20	32	0	0	0	0	0	0	4.889	#N/A	#N/A	#N/A	#N/A	4.472	0.263	#N/A	#N/A	#N/A	#N/A	1	**#N/A**	**#N/A**	**#N/A**
11G	11Ccg	18176	42.4	5.00	20	20	32	0	0	0	0	0	0	5.389	0.226	5.478	1.357	6.705	4.472	0.29	-0	1.085	0.913	1.053	1	**72.351**	**56.398**	**0.564**
11H	11Ccg	18176	75.1	5.00	20	20	32	0	0	0	0	0	0	6.969	0.226	5.478	1.357	6.705	4.472	0.375	-0	1.085	0.913	1.053	1	**73.769**	**57.371**	**0.574**
11I	11Ccg	18176	21.5	5.00	20	20	32	0	0	0	0	0	0	4.01	0.226	5.478	1.357	6.705	4.472	0.216	-0	1.085	0.913	1.053	1	**71.113**	**55.548**	**0.555**
11J	11Cc	18176	53.6	5.00	20	20	32	0	0	0	0	0	0	5.98	0.226	5.478	1.357	6.705	4.472	0.322	-0	1.085	0.913	1.053	1	**72.881**	**56.762**	**0.568**
11K	11Ccg	18176	17.5	5.00	20	20	32	0	0	0	0	0	0	3.685	0.226	5.478	1.357	6.705	4.472	0.198	-0	1.085	0.913	1.053	1	**70.822**	**55.348**	**0.553**
11L	11Cc	18176	99.1	5.00	20	20	32	0	0	0	0	0	0	7.912	0.226	5.478	1.357	6.705	4.472	0.426	-0	1.085	0.913	1.053	1	**74.616**	**57.952**	**0.580**
11M	11Ccg	18176	74.7	5.00	20	20	32	0	0	0	0	0	0	6.95	0.226	5.478	1.357	6.705	4.472	0.374	-0	1.085	0.913	1.053	1	**73.752**	**57.359**	**0.574**
11N	11Cc	18176	120.0	5.00	20	20	32	0	0	0	0	0	0	8.645	0.226	5.478	1.357	6.705	4.472	0.466	-0	1.085	0.913	1.053	1	**75.274**	**58.404**	**0.584**
11O	11Ccg	18176	62.3	5.00	20	20	32	0	0	0	0	0	0	6.398	0.226	5.478	1.357	6.705	4.472	0.345	-0	1.085	0.913	1.053	1	**73.257**	**57.019**	**0.570**
11P	11Ccg	18176	96.4	5.00	20	20	32	0	0	0	0	0	0	7.811	0.226	5.478	1.357	6.705	4.472	0.421	-0	1.085	0.913	1.053	1	**74.524**	**57.889**	**0.579**
11Q	11Cc	18176	167.4	5.00	20	20	32	0	0	0	0	0	0	10.1	0.226	5.478	1.357	6.705	4.472	0.544	-0	1.085	0.913	1.053	1	**76.579**	**59.299**	**0.593**
12A	12Cc	6720	273.2	5.00	20	20	32	0	0	0	0	0	0	12.73	0.226	6.594	3.193	10.51	4.472	0.686	-0	1.15	1.015	1.166	1	**83.595**	**64.115**	**0.641**
12B	12Cm	6720	601.6	5.00	20	20	32	0	0	0	0	0	0	18.59	0.226	6.594	3.193	10.51	4.472	1.001	-0	1.15	1.015	1.166	1	**88.858**	**67.726**	**0.677**
12C	12Cc	6720	506.0	5.00	20	20	32	0	0	0	0	0	0	17.1	0.226	6.594	3.193	10.51	4.472	0.921	-0	1.15	1.015	1.166	1	**87.519**	**66.808**	**0.668**
13A	13Cmhe	21312	688.4	10.00	20	20	32	0	0	0	0	0	0	19.85	0.322	5.3	1.064	6.096	4.472	1.069	0.085	1.075	0.897	1.035	1	**86.014**	**65.775**	**0.658**
13B	13Cml	21504	459.0	10.00	20	20	32	0	0	0	0	0	0	16.32	0.322	5.29	1.047	6.062	4.472	0.879	0.085	1.074	0.896	1.034	1	**82.806**	**63.573**	**0.636**
13C	13Cct	52.736	241.3	75.00	20	20	32	0	0	0	0	0	0	12	1.047	12.03	12.13	29.06	4.472	0.646	0.733	1.466	1.511	1.715	1	**117.848**	**87.622**	**0.876**
13D	13Ccsr	21760	257.1	5.00	20	20	32	0	0	0	0	0	0	12.37	0.226	5.276	1.025	6.017	4.472	0.666	-0	1.073	0.894	1.033	1	**77.774**	**60.119**	**0.601**
13E	13Cc	21760	395.2	10.00	20	20	32	0	0	0	0	0	0	15.19	0.322	5.276	1.025	6.017	4.472	0.818	0.085	1.073	0.894	1.033	1	**81.734**	**62.837**	**0.628**
13F	13Ccsr	21760	149.2	5.00	20	20	32	0	0	0	0	0	0	9.567	0.226	5.276	1.025	6.017	4.472	0.515	-0	1.073	0.894	1.033	1	**75.259**	**58.394**	**0.584**
13G	13Ccsr	21760	153.9	5.00	20	20	32	0	0	0	0	0	0	9.709	0.226	5.276	1.025	6.017	4.472	0.523	-0	1.073	0.894	1.033	1	**75.386**	**58.481**	**0.585**
15A	15Ccor	192	100.0	10.00	20	20	32	0	0	0	0	0	0	7.945	0.322	10.58	9.751	24.12	4.472	0.428	0.085	1.382	1.379	1.569	1	**97.366**	**73.566**	**0.736**
15B	15Ccgt	115.2	354.4	25.00	20	20	32	0	0	0	0	0	0	14.41	0.524	11.15	10.69	26.07	4.472	0.776	0.266	1.415	1.431	1.626	1	**108.565**	**81.252**	**0.813**
15C	None	#N/A	66.9	#N/A	20	20	32	0	0	0	0	0	0	6.611	#N/A	#N/A	#N/A	#N/A	4.472	0.356	#N/A	#N/A	#N/A	#N/A	1	**#N/A**	**#N/A**	**#N/A**
15D	15Ccor	192	229.8	10.00	20	20	32	0	0	0	0	0	0	11.73	0.322	10.58	9.751	24.12	4.472	0.631	0.085	1.382	1.379	1.569	1	**100.760**	**75.895**	**0.759**
15E	15Cce	44288	26.4	15.00	20	20	32	0	0	0	0	0	0	4.378	0.398	4.48	-0.29	3.297	4.472	0.236	0.153	1.027	0.822	0.953	1	**69.839**	**54.674**	**0.547**
15F	15Ccp	684.8	225.8	10.00	20	20	32	0	0	0	0	0	0	11.63	0.322	9.155	7.405	19.25	4.472	0.626	0.085	1.299	1.248	1.425	1	**94.723**	**71.752**	**0.718**

Table 2-8: Coastal Plain Physiographic Province BAC PHI Metrics and Scores

Stream		Metric Values Input										Transform Bank Severity		Prepare Metric Values						Scale Metric Values						Final Score	Normalize Final Score	Rescaled Final Score
								Left Bank Stability		Right Bank Stability																		
Reach Code	Habiat Code	Watershed Area (acres)	Remoteness (meters)	%Shading	Epibenthic Substrate Score	Instream Habitat Score	Total No. Instream Woody Debris and Rootwads	Erosion Extent (meters)	Severity	Erosion Extent (meters)	Severity	Left	Right	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	REMOTE	TSHADING	RESEPISUB	RESINSTRHAB	RESWOOD	TBANKSTAN	Coastal Plain PHI	Normalized Coastal Plain PHI	Rescaled Coastla Plain PHI
15G	15Cce	44288	180.8	15.00	20	20	32	0	0	0	0	0	0	10.47	0.398	4.48	-0.29	3.297	4.472	0.564	0.153	1.027	0.822	0.953	1	**75.308**	**58.427**	**0.584**
15H	15TCm	486.4	498.2	35.00	20	20	32	0	0	0	0	0	0	16.98	0.633	9.539	8.036	20.56	4.472	0.914	0.363	1.321	1.283	1.463	1	**105.755**	**79.323**	**0.793**

Attachment 3: Aggregate Benefits Tables

Table 3-1: Aggregate Benefits for Northwest Branch and Tributaries
Table 3-2: Aggregate Benefits for Northeast Branch and Tributaries

ATTACHMENT 3: AGGREGATE BENEFITS

Table 3-1. Aggregate Benefits for Northwest Branch and Tributaries

Site	Length (ft)	Order	Project	Owner	Project Type	Completed	PHI	SHUs	PHI used	Data Source
3	626	3	NW6&7 - Woodrow Wilson bridge mitigation	SHA	Riffle/grade	2005	69.60	1306	PHI=Ave 2004 data for 09-005 (Tetra Tech; surrogate for PHI)	Tetra Tech monitoring data
3	221	3	NW8 - Woodrow Wilson Bridge mitigation	SHA	Riffle/grade	2004	74.50	495	PHI =2005 PHI for NW-8B and 8A average	Post Construction Monitoring Report, 2006
3	4291	3	Site 3 - Non-FRM impacted reach	USACE	Stream restoration	Design	54.06	6959	PHI=FWP Site 3	FWP
3	5597	3	Fish passage benefits upstream of site 13	N/A	N/A	N/A	72.62	12194	Feet in excess (not overlapping) site 3 length and connectivity = 16283, minus site 13 (7690) = 8593; PHI = average of 2010 data for 09-009 (Tetra Tech; surrogate for PHI); not selected by team due to high quality habitat	Tetra Tech monitoring data
3	2996	3	Fish passage benefits between sites 3 and 13	N/A	N/A	N/A	56.30	5060	PHI=average FWP for sites 3 and 13; not selected by team due to good quality habit	FWP Site 3 and 13
3	7690	3	Fish passage benefits for length of site 13*	USACE	Stream restoration	Design	40.57	9359	FWOP PHI for Site 13	FWOP for site 13 (so benefits not dependent on construction of site 13)
3	903	3	NW3-Woodrow Wilson Bridge mitigation	SHA	Riffle/grade	2004	67.00	1814	PHI = 2005 PHI for NW-3A and 3B average	Post Construction Monitoring Report, 2006
3	874	3	NW2-Woodrow Wilson Bridge mitigation	SHA	Riffle/grade	2003	60.50	1586	PHI = 2005 PHI for NW-2A and 2B average	Post Construction Monitoring Report, 2006
3	497	3	NWB1 - Woodrow Wilson Bridge mitigation	SHA	Riffle/grade	2003	58.50	871	PHI =2005 PHI for NW-1A and 1B average	Post Construction Monitoring Report, 2006
3	389	3	NW4, NW5 - Woodrow Wilson Bridge mitigation	SHA	Riffle/grade	2005	67.00	783	PHI=2005 PHI for NW-4B	Post Construction Monitoring Report, 2006
3	3523	3	USACE 1135 - Connects to downstream end of NWB1	USACE	Stream restoration, fish passage, riffle grade	1999	66.00	6976	PHI=2005 PHI for NW-0A	Post Construction Monitoring Report, 2006
3	2994	3	Site 3 - FRM Impacted Reach	USACE	Stream restoration	Design	55.00	4940	PHI=FWP	FWP
3	680	3	Gap Between NWB1 and NW2	N/A	N/A	N/A	40.08	818	PHI=ANAC-302-X-2000 (MDNR MBSS)	Maryland Biological Stream Survey
3	430	3	Gap Between NW2 and NW3	N/A	N/A	N/A	40.08	517	PHI=ANAC-302-X-2000 (MDNR MBSS)	Maryland Biological Stream Survey
9	319	2	Sligo Creek - SC - Woodrow Wilson Br mitigation	SHA	Fish passage	2004	58.33	372	PHI=average of 2010 data for 14-001 (Tetra Tech; surrogate for PHI); PHI is same as 2006 WW Br Mitigation data	Tetra Tech monitoring data; WW Br Mitigation Post Construction Monitoring Report, 2006
9	324	2	SC2 - Woodrow Wilson Br mitigation	SHA	Fish passage	2004	58.33	378	PHI=average of 2010 data for 14-001 (Tetra Tech; surrogate for PHI); PHI is same as 2006 WW Br Mitigation data	Tetra Tech monitoring data; WW Br Mitigation Post Construction Monitoring Report, 2006
9	107	2	SC3 - Woodrow Wilson Br mitigation	SHA	Fish passage	2004	58.33	125	PHI=average of 2010 data for 14-001 (Tetra Tech; surrogate for PHI); PHI is same as 2006 WW Br Mitigation data	Tetra Tech monitoring data; WW Br Mitigation Post Construction Monitoring Report, 2006
9	209	2	SC4 - Woodrow Wilson Br mitigation	SHA	Fish passage	2004	58.33	243	PHI=average of 2010 data for 14-001 (Tetra Tech; surrogate for PHI); PHI is same as 2006 WW Br Mitigation data	Tetra Tech monitoring data; WW Br Mitigation Post Construction Monitoring Report, 2006
9	2241	2	Site 9	USACE	Stream restoration	Design	60.40	2707	Site 9 fish passage benefits overlap with site 9 and connectivity, so include benefits for fish passage	FWP
9	515	2	GAP Between SC and SC2	N/A	N/A	N/A	48.21	497	PHI=Oct 1999 data for 14-001 (Tetra Tech; surrogate for PHI)	Tetra Tech monitoring data
9	240	2	GAP Between SC2 and SC3	N/A	N/A	N/A	48.21	231	PHI=Oct 1999 data for 14-001 (Tetra Tech; surrogate for PHI)	Tetra Tech monitoring data

Site	Length (ft)	Order	Project	Owner	Project Type	Completed	PHI	SHUs	PHI used	Data Source
9	100	2	GAP Between SC3 and SC4	N/A	N/A	N/A	48.21	96	PHI=Oct 1999 data for 14-001 (Tetra Tech; surrogate for PHI)	Tetra Tech monitoring data
10	2096	1	Site 10	USACE	Stream restoration	Design	62.51	1310	PHI = FWP Site 10	

Table 3-2. Aggregate Benefits for Northeast Branch and Tributaries

Site	Length (ft)	Order	Project	Owner	Project Type	Completed	PHI	SHUs	PHI used	Data Source
1	3257	1	Site 1 fish passage benefits upstream of Ammendale Rd	USACE	Stream restoration	Design	73.08	2380	Overlaps with upper portion of site 1	FWP
5	5040	3	USACE Paint Branch 206	USACE	Stream restoration	2015	55.36	8370	PHI = same as average for site 5.	Site 5 FWP
5	6453	3	Site 5	USACE	Stream restoration	Design	55.36	10717	Site 5 benefits	FWP
5	808	3	GAP between Paint CAP and Paint ICC	N/A	N/A	N/A	35.42	859	PHI = FWOP average Site 12 and Site 5	FWOP Sites 12 and 5
5	3488	2	Paint Branch/Little Paint Branch ICC	SHA	Stream restoration	2012/2013	66.67	4650	PHI = 08/30/2010 data for 05-208 (Tetra Tech; surrogate for PHI)	Tetra Tech monitoring data
5	215	3	Paint Branch WSSC Sewer Line Riffle	WSSC	Fish passage	2005	55.36	357	Restored section in the middle of site 5; PHI = FWP site 5	Average FWP Sites 5 and 15
7	5876	2	Site 7 counted for Fish passage benefits	USACE	Stream restoration	Design	54.25	6376	Site 7 along entire length for fish passage; PHI-FWP Site 7	FWP Site 7
11	1944	4	Indian Creek WSSC	WSSC	Fish passage, riffle/grade	2011	36.50	2838	PHI = ave FWOP and FWP Site 11 (improved habitat, but not to point of FWP since riffle grade by WSSC)	Extrapolated
11	419	4	Indian Creek 2002 - Woodrow Wilson Br mitigation	SHA	Stream restoration	2002	56.50	946	PHI= average of 2005 PHI for IC-1B and IC-1A	Post Construction Monitoring Report, 2006
11	400	4	GAP between IC2002 and Site 11	N/A	N/A	N/A	24.34	389	PHI=FWOP Site 11	FWOP Site 11
11	2723	4	Site 11 (lower portion - FRM)	USACE	Stream restoration	Design	46.24	5036	PHI = FWP Site 11 lower portion	FWP Site 11
11	7443	4	Site 11 (upper portion - non-FRM)	USACE	Stream restoration	Design	45.32	13493	PHI = FWP Site 11 upper portion	FWP Site 11
12	3488	2	Paint Branch/Little Paint Branch ICC	SHA	Stream restoration	2012/2013	66.67	4650	PHI = 08/30/2010 data for 05-208 (Tetra Tech; surrogate for PHI)	Tetra Tech monitoring data
12	4530	2	Site 12	USACE	Stream restoration	Design	52.04	4715	PHI = FWP Site 12	FWP Site 12
12	808	3	GAP between Paint CAP and Paint ICC	N/A	N/A	N/A	35.42	859	PHI = FWOP average Site 12 and Site 5	FWOP Sites 12 and 5
12	5040	3	USACE Paint Branch 206	USACE	Stream restoration	2015	55.36	8370	PHI = same as average for site 5.	FWP Site 5
15	1069	4	Site 15 (upper portion - FRM)	USACE	Stream restoration	Design	78.32	3349	PHI = FWP Site 15 upper portion	FWP Site 15
15	4450	4	Site 15 (lower portion - non-FRM)	USACE	Stream restoration	Design	68.12	12125	PHI = FWP Site 15 lower portion	FWP Site 15

Attachment 4: Physical Habitat Index Model Documentation

A. Physical Habitat Assessment, Sampling Manual: Field Protocols, Revision January 2013

Maryland Department of Natural Resources
Maryland Biological Stream Survey

Selected Document Sections:
Section 3.5.9 Physical Habitat (in part)

B. A Physical Habitat Index For Freshwater Wadeable Streams in Maryland, May 2003

Maryland Department of Natural Resources

Selected Document Sections:
Methods: Sections 2.1 and 2.3
Results and Discussion: Sections 3.1, 3-1 to 3-20
Appendix B: 7-1 to 7-3

C. Physical Habitat Index- Maryland Biological Stream Survey

Data Sheets and Assessment Guidance

Attachment 4: Physical Habitat Index Model Documentation

A. Physical Habitat Assessment, Sampling Manual: Field Protocols, Revision January 2013

Maryland Department of Natural Resources
Maryland Biological Stream Survey

Selected Document Sections:
Section 3.5.9 Physical Habitat (in part)

B. A Physical Habitat Index For Freshwater Wadeable Streams in Maryland, May 2003

Maryland Department of Natural Resources

Selected Document Sections:
Methods: Sections 2.1 and 2.3
Results and Discussion: Sections 3.1, 3-1 to 3-20
Appendix B: 7-1 to 7-3

C. Physical Habitat Index- Maryland Biological Stream Survey

Data Sheets and Assessment Guidance

A. Physical Habitat Assessment, Sampling Manual: Field Protocols, Revision January 2013
Maryland Department of Natural Resources Maryland Biological Stream Survey
Selected Document Sections: Section 3.5.9 Physical Habitat (in part)

3.5.9 Physical Habitat

Physical habitat assessments conducted by MBSS are intended to represent the habitat conditions available to the organisms living in the streams and to report on the extent to which certain anthropogenic factors may be affecting Maryland's streams. MBSS Habitat assessment protocols are based on a combination of metrics modified and adapted from USEPA's Rapid Bioassessment Protocols (RBP) and Ohio EPA's Qualitative Habitat Evaluation Index (QHEI). Although EPA's RBP habitat assessment protocols differentiate between riffle-run and pool-glide stream types, all metrics selected for the MBSS are scored at all MBSS sample sites to allow direct comparisons across physiographic regions and summaries of conditions on a statewide basis.

Certain MBSS physical habitat variables are recorded based on counts, measurements, or estimates made in the field. These variables include distance from nearest road to site, width of riparian buffer, stream gradient, width, depth, velocity, culvert width and length, extent and height of eroded bank, numbers of woody debris and root wads, extent of channelization, percent embeddedness, and percent shading. The quality of five habitat assessment metric variables along with the severity of bank erosion, buffer breaks, and bar formation are rated using standardized MBSS rating methods. The collection of data on certain other habitat variables are based on the observation (or not) of certain conditions such as buffer breaks, land use types, and evidence of channelization. Based on observations at sites, the absence, presence or extensive presence of stream character and bar substrate is recorded. The type and relative size of riparian vegetation and the type of land cover adjacent to the buffer are reported using standard MBSS codes. The method used for collecting data in the field for each variable differs based on the expected use of each variable as well as optimizing the time required to collect useable information.

Data sheet entries for all physical habitat variables are based on observations within or from the 75 m site only, unless otherwise stated below.

In all cases where it is necessary to differentiate the left bank of the stream from the right bank, the left and right are determined while facing upstream.

Only persons who have attended MBSS training and have demonstrated proficiency with performing MBSS physical habitat assessments should conduct MBSS physical habitat assessments.

Most MBSS physical habitat assessment information is collected during the Summer Index Period.

Attachment 4-A

Physical Habitat Assessment
Sampling Manual: Field Protocols
Revision January 2013

Maryland Department of Natural Resources
Maryland Biological Stream Survey

Selected Document Sections

A. Section 3.5.9 Physical Habitat (in part)

3.5.9.2 Summer Index Period Physical Habitat Assessment

The physical habitat assessment variables recorded during the Summer Index Period can be found on the MBSS Summer Habitat Data Sheet and should be recorded on this sheet. The methods used to determine exactly what should be recorded for each variable are described, by variable, below. Data sheet entries for all Summer Index Period physical habitat variables are based on observations within or from the 75 m site only, unless otherwise specified.

In all cases where it is necessary to differentiate the left bank of the stream from the right bank, the left and right are determined while facing upstream.

Many of the summer physical habitat assessment measures require sufficiently clear water to observe the stream bottom throughout the majority of the 75 m site. If conditions do not allow sufficient visibility to see all of the features that must be observed, or if conditions are unsafe for wading, the site should be considered unsampleable for physical habitat. In many cases, the stream may be sampleable during a return visit when the water level is lower. However, if the stream cannot be sampled for summer physical habitat assessment, this should be noted on the Summer Index Period Data Sheet. Codes designating reasons that a stream could not be sampled are provided on page 43.

1. **Habitat Assessment Metrics.** Five metrics: instream habitat, epifaunal substrate, pool quality, riffle quality, and velocity depth diversity are rated on a scale of 0-20 using criteria provided on the Habitat Assessment Guidance Sheet (pages 44 and 45). The scores for each of these metrics are meant to characterize a distinct aspect of stream habitat. The instream habitat metric primarily addresses habitat for fishes and epifaunal substrate is meant to rate the suitability of habitat for benthic macroinvertebrates. The general quality of riffle and pool habitats are rated based primarily on the prevalence of sufficient depth and extent of these habitats. Velocity/depth/diversity provides a measure of the how well fast, slow, deep, and shallow areas are represented in the stream.

2. **Embeddedness.** The percent of riffle substrates surrounded by fine substrates, such as sand and silt, is recorded based on visual observation. Riffle substrates that are examined should include the area with the fastest flow within riffle or run habitats. If no riffle is present within the 75 m site, embeddedness can be rated based on the closest available riffle located in the same reach as the site (but should not be more than 75 m away from the upstream or downstream end of the site). Several substrates should be examined within the riffle to determine the approximate average condition within the fast part of the riffle. Substrates should be examined for embeddedness prior to disturbances (such as walking or netting) that are likely to dislodge fine materials from around larger substrate.

3. **Shading.** The percent of the wetted area of the 75 m site that is shaded by overhanging vegetation or other structures is approximated based on a visual assessment. If clearing of vegetation was conducted to facilitate electrofishing, or for any other reason, shading should be rated based on the condition prior to clearing.

4. **Woody Debris.** For the MBSS, large woody debris are defined as any natural woody structures (e.g. logs, snags, dead tree trunks), with the exception of live trees that are at least 10 cm in diameter and more than 1.5 m long. The number of large woody debris, located in the wetted portion of the 75 m stream site (instream woody debris), is counted. The number of large woody debris in the stream channel or immediate riparian area, but not in the wetted portion of the stream (dewatered woody debris) are counted separately from instream woody

debris. Only those dewatered woody debris from the immediate riparian area that (in the opinion of the evaluator) are likely to become wetted during high flows, or fall into the stream channel should be counted.

5. **Root Wads.** For the MBSS, root wads that are on live trees with a chest high trunk diameter (DBH) of at least 15 cm should be counted. These should be counted along both banks of the stream within the 75 m site. Those root wads that are in the water (instream) are counted separately from those not in the stream (dewatered). However, only those dewatered root wads that provide stability to the stream bank or that are likely to become wetted during high flows should be counted.

6. **Stream Character.** The Stream Character portion of the MBSS Summer Habitat Data Sheet lists 15 stream features. For each feature, an A, P, or E should be recorded in the box next to the feature indicating whether the feature is absent, present, or extensive respectively in the 75 m stream site.

7. **Maximum Depth.** The maximum depth of the MBSS site is considered the deepest area found anywhere within the 75 m. Maximum depth is recorded to the nearest cm.

8. **Wetted Width, Thalweg Depth, and Thalweg Velocity.** The wetted width, thalweg depth and thalweg velocity are measured at four transects within the 75 m MBSS site. The four transects are located at the 0 m, 25 m, 50 m, and 75 m portions of the MBSS site (beginning with 0m at the downstream-most end of the site). Wetted width is measured from bank to bank (perpendicular to the direction of the stream flow) to the nearest 0.1 m and includes only the wetted portion of the stream. Islands or other large features in the stream that would not be covered by water during higher base-flow should not be included in the measurement of wetted width. Features that would be covered by water (during higher base-flow should be included in the wetted width measurement. Thalweg depth is the depth (in cm) of the deepest part of the stream at each transect. Thalweg velocity is the stream current velocity (in m/sec) in the deepest part of the stream at each transect.

9. **Flow.** Measurements that can be used to calculate flow (often referred to as discharge) are recorded on the MBSS Summer Habitat Data Sheet. A transect that is suitable for taking these measurements should be located. A suitable transect approximates a "U" shaped channel to the extent possible. The most useful measurements are acquired by avoiding transects with boulders or other irregularities that create backflows and cross flows. The stream channel can be modified to more closely approximate a "U" shaped channel and provide laminar flow with adequate depth for taking velocity measurements. Unless the stream is very small (less than 0.5 m wide), a minimum of 10 measurements should be taken. As many as 25 measurements can be recorded on the MBSS Summer Habitat Data Sheet. In general, more measurements are required in larger streams. The measurements consist of depth (to the nearest 0.5 cm) and velocity (to the nearest 0.001 m/sec) and should be recorded at regular intervals. Velocity measurements should be taken at 0.6 of the distance from the water surface to the bottom (measured from the surface), making sure to orient the sensor to face upstream and taking care to stand well downstream to avoid deflection of flows. Depth and velocity measurements should be taken at the exact same locations. The Lat Loc on the MBSS Summer Habitat Data Sheet refers to the distance from one stream bank (either left or right) where each depth and velocity measurement is taken.

10. **Alternative Flow**. If flows are so low that they can not be measured with a flow meter,

the stream should be constricted as much as possible in a 1 meter section of uniform width and depth. The speed of a floated object should be recorded three times as a substitute for velocity measured with the flow meter. Record on the data sheet the depth, width, and time (3 trials) for the floated object.

11. **Bank Erosion.** The length and average height of erosion on both banks of the stream, within the 75 m site should be recorded along with the severity of erosion, on the MBSS Summer Habitat Data Sheet. In braided streams it is possible to have the total extent of eroded bank add up to more than 75 m. Since the objective of this measure is to determine the total area of erosion present at the site, this is acceptable.

12. **Bar Formation and Substrate**. Boxes in this portion of the MBSS Summer Habitat Data Sheet should be filled in completely to indicate if the bar formation is absent (fill in the box next to "None"), minor, moderate, or extensive; and the dominant substrate type(s) that make up the bars in the site. More than one substrate can be selected. However substrates comprising only a minor part of the substrate should not be selected.

Attachment 4-B

A Physical Habitat Index For Freshwater Wadeable Streams in Maryland

Maryland Department of Natural Resources

May 2003
Selected Document Sections

A. Methods: Sections 2.1 and 2.3
B. Results and Discussion: Sections 3.1, 3-1 to 3-20
C. Appendix B: 7-1 to 7-3

2 METHODS

2.1 Physical Habitat Index Revision

Revising the PHI consisted of classifying streams in the state, developing a new set of reference criteria that did not include any biological variables, analyzing the physical habitat metrics statistically for normality and transforming as necessary, selecting discriminatory habitat metrics that were free of watershed area effects, assembling the metrics into a new multimetric physical habitat index, testing the new index for discrimination efficiency and association with biological indices, and comparing it to the provisional PHI. Physical habitat data were collected by the MBSS from 1994-2000 and methods for the collection of these data have been extensively described elsewhere (Roth et al. 1999). A list of the physical habitat data collected for each site by sampling periods is shown in Table 1. Habitat variables are shown along with the nature of the data (character or numeric) and what aspect of habitat is reflected by each variable.

We used general level III ecoregions as the main classification of streams, consistent with the MBSS program (Omernik 1987, Roth et al. 1999). We used the Piedmont and Coastal Plain regions and combined all other ecoregions in the state into a Highlands class.

After streams were classified, we developed new reference criteria for establishing reference habitat characteristics. We relied on land use/land cover values to develop reference and degraded stream criteria for selecting reference streams. Land use/land cover analysis and data are described in Roth et al. (1999).

Table 1 – Habitat variables collected during the three MBSS study periods. The types of data as well as the habitat feature represented by each measure are also indicated. (LCLU = land cover/land use, Data Types: Char = character, Num = numeric)

Variable	Feature	1994	1995-1997	2000	Data Type
1	Site Info	SITE	SITE	SITEYR	Char
2	Site Info	LAT	LAT	LAT_DD	Num
3	Site Info	LONG	LONG	LONG_DD	Num
4	Site Info	NORTHING	NORTHING	NORTHING	Num
5	Site Info	EASTING	EASTING	EASTING	Num
6	Catchment Size	ACREAGE	ACREAGE	ACRES	Num
7	LCLU-Catchment	URBAN	URBAN	URBAN	Num
8	LCLU-Catchment	AGRI	AGRI	AGRI	Num
9	LCLU-Catchment	FOREST	FOREST	FOREST	Num
10	LCLU-Catchment		WETLANDS	WETLANDS	Num
11	LCLU-Catchment		BARREN	BARREN	Num
12	LCLU-Catchment		WATER	WATER	Num
13	LCLU-Catchment		HIGHURB		Num
14	LCLU-Catchment		LOWURB	LOW_URB	Num
15	LCLU-Catchment		PASTUR	HAYPAST	Num
16	LCLU-Catchment		PROBCROP		Num
17	LCLU-Catchment		ROWCROP	ROWCROP	Num
18	LCLU-Catchment		CONIFER	CONIFOR	Num
19	LCLU-Catchment		DECIDFOR	DECIDFOR	Num
20	LCLU-Catchment		MIXEDFOR	MIXEDFOR	Num
21	LCLU-Catchment		EMERGWET	EMERWET	Num
22	LCLU-Catchment		WOODYWET	WOODWET	Num
23	LCLU-Catchment		COALMINE		Num
24	LCLU-Catchment		TRANS	TRANS	Num
25	LCLU-Catchment			OTHGRASS	Num
26	LCLU-Catchment			HIGH_RES	Num
27	LCLU-Catchment			HIGH_COM	Num
28	LCLU-Catchment			BAREROCK	Num
29	LCLU-Catchment			QUARRY	Num
30	LCLU-Reach	OLD_FLD	OLD_FLD	OLD_FLD	Char
31	LCLU-Reach	DEC_FOR	DEC_FOR	DEC_FOR	Char
32	LCLU-Reach	CONI_FOR	CONI_FOR	CONI_FOR	Char
33	LCLU-Reach	WETLAND	WETLAND	WETLAND	Char
34	LCLU-Reach	SURFMINE	SURFMINE	SURFMINE	Char
35	LCLU-Reach	LANDFILL	LANDFILL	LANDFILL	Char
36	LCLU-Reach	RESIDENT	RESIDENT	RESIDENT	Char
37	LCLU-Reach	COMM_IND	COMM_IND	COMM_IND	Char
38	LCLU-Reach	CROPLAND	CROPLAND	CROPLAND	Char
39	LCLU-Reach	PASTURE	PASTURE	PASTURE	Char
40	LCLU-Reach	ORCH_VIN	ORCH_VIN	ORCH_VIN	Char
41	LCLU-Reach			GOLF	Char
42	Hydrology		THAVEL0	THALVE0	Num

Table 1 (continued).

Variable	Feature	1994	1995-1997	2000	Data Type
43	Hydrology		THAVEL25	THALVE25	Num
44	Hydrology		THAVEL50	THALVE50	Num
45	Hydrology		THAVEL75	THALVE75	Num
46	Hydrology		DISCHARG	DISC_CFS	Num
47	Geomorphology			GRAD	Num
48	Geomorphology	SEG_LEN		SEG_LEN	Num
49	Geomorphology	MAXDEPTH	MAXDEPTH	MAXDEPTH	Num
50	Geomorphology			STWID_0	Num
51	Geomorphology			STWID_75	Num
52	Geomorphology	WETWID0	WETWID0	WETWID0	Num
53	Geomorphology	WETWID25	WETWID25	WETWID25	Num
54	Geomorphology	WETWID50	WETWID50	WETWID50	Num
55	Geomorphology	WETWID75	WETWID75	WETWID75	Num
56	Geomorphology	THADEP0	THADEP0	THALDE0	Num
57	Geomorphology	THADEP25	THADEP25	THALDE25	Num
58	Geomorphology	THADEP50	THADEP50	THALDE50	Num
59	Geomorphology	THADEP75	THADEP75	THALDE75	Num
60	Geomorphology	FLOODHT			Num
61	Geomorphology			TURB_FLD	Num
62	Geomorphology	VEL_DPTH	VEL_DPTH	VEL_DEPT	Num
63	Geomorphology	POOLQUAL	POOLQUAL		Num
64	Geomorphology			POOLGLID	Num
65	Geomorphology			EXPOOL	Num
66	Geomorphology	RIFFQUAL	RIFFQUAL		Num
67	Geomorphology			RIFFLRUN	Num
68	Geomorphology			EXRIFRUN	Num
69	Geomorphology	EMBEDDED	EMBEDDED	EMBED	Num
70	Geomorphology			CONCR_L	Num
71	Geomorphology			CONCR_B	Num
72	Geomorphology			CONCR_R	Num
73	Geomorphology			GABIO_L	Num
74	Geomorphology			GABIO_B	Num
75	Geomorphology			GABIO_R	Num
76	Geomorphology			RIPRP_L	Num
77	Geomorphology			RIPRP_B	Num
78	Geomorphology			RIPRP_R	Num
79	Geomorphology			BERM_L	Num
80	Geomorphology			BERM_B	Num
81	Geomorphology			BERM_R	Num
82	Geomorphology			DREG_L	Num
83	Geomorphology			DREG_B	Num
84	Geomorphology			DREG_R	Num
85	Geomorphology			PIPE_L	Num
86	Geomorphology			PIPE_B	Num

Table 1 (continued).

Variable	Feature	1994	1995-1997	2000	Data Type
87	Geomorphology			PIPE_R	Num
88	Geomorphology			CULVPRES	Num
89	Geomorphology			CULVSAMP	Num
90	Geomorphology			CULVWID	Num
91	Geomorphology	CHAN_ALT	CHAN_ALT		Num
92	Geomorphology	CH_FLOW	CH_FLOW		Num
93	Geomorphology	BANKSTAB	BANKSTAB		Num
94	Geomorphology		BANKHTFH		Num
95	Geomorphology		BANKANGL		Num
96	Geomorphology		BANKROOT		Num
97	Geomorphology		BANKSOIL		Num
98	Geomorphology		PARTSIZE		Num
99	Geomorphology		ERODIND5		Num
100	Geomorphology		ERODIND3		Num
101	Geomorphology			ERODEXLT	Num
102	Geomorphology			ERODEXRT	Num
103	Geomorphology			ERODSVLT	Num
104	Geomorphology			ERODSVRT	Num
105	Geomorphology			ERODARLT	Num
106	Geomorphology			ERODARRT	Num
107	Geomorphology			BAR_NONE	Num
108	Geomorphology			BAR_MIN	Num
109	Geomorphology			BAR_MOD	Num
110	Geomorphology			BAR_EXT	Num
111	Geomorphology			COB_BAR	Num
112	Geomorphology			GRAV_BAR	Num
113	Geomorphology			SAND_BAR	Num
114	Geomorphology			SC_BAR	Num
115	Wood	WOOD_DEB	WOOD_DEB	WOODINST	Num
116	Wood			WOODDEWA	Num
117	Wood		NUMROOT	ROOTINST	Num
118	Wood			ROOTDEWA	Num
119	Visual Habitat	INSTRHAB	INSTRHAB	INSTRHAB	Num
120	Visual Habitat	EPI_SUB	EPI_SUB	EPI_SUB	Num
121	Stream Character	MEANDER	MEANDER		Char
122	Stream Character	BRAIDED	BRAIDED	BRAIDED	Char
123	Stream Character	CHANNEL	CHANNEL	CHAN_YN	Char
124	Stream Character	STRAIGHT	STRAIGHT		Char
125	Stream Character	RIFFLE	RIFFLE	RIFFLE	Char
126	Stream Character	RUN_GLID	RUN_GLID	RUNGLIDE	Char
127	Stream Character	DEEPPOOL	DEEPPOOL	DEEPOOL	Char
128	Stream Character	SHALPOOL	SHALPOOL	SHALPOOL	Char
129	Stream Character	BOULDGT2	BOULDGT2	LRGBOULD	Char
130	Stream Character	BOULDLT2	BOULDLT2	SMLBOULD	Char

Table 1 (continued).

Variable	Feature	1994	1995-1997	2000	Data Type
131	Stream Character	COBBLE	COBBLE	COBBLE	Char
132	Stream Character	BEDROCK	BEDROCK	BEDROCK	Char
133	Stream Character	GRAVEL	GRAVEL	GRAVEL	Char
134	Stream Character	SAND	SAND	SAND	Char
135	Stream Character	SILTCLAY	SILTCLAY	SILTCLAY	Char
136	Stream Character	CONCRETE	CONCRETE		Char
137	Stream Character	ROOTWAD	ROOTWAD		Char
138	Stream Character	UNDCTBNK	UNDCTBNK	UNDERCUT	Char
139	Stream Character	OH_COVER	OH_COVER	OH_COVER	Char
140	Stream Character	H_REFUSE	H_REFUSE		Char
141	Stream Character	EMER_VEG	EMER_VEG	EMRPLANT	Char
142	Stream Character	SUBM_VEG	SUBM_VEG		Char
143	Stream Character	FLOATVEG	FLOATVEG	FLTPLANT	Char
144	Stream Character	STORMDRN	STORMDRN		Char
145	Stream Character	EFF_DIS	EFF_DIS		Char
146	Stream Character	BEAVPOND	BEAVPOND	BEAVPND	Char
147	Stream Blockage	ST_BLKHT	ST_BLKHT	ST_BLKHT	Num
148	Stream Blockage	ST_BLKTP	ST_BLKTP	ST_BLKTP	Char
149	Riparian Condition	SHADING	SHADING	SHADING	Num
150	Riparian Condition	RIP_WID	RIP_WID	RV_WID_L	Num
151	Riparian Condition			RV_WID_R	Num
152	Riparian Condition	BUFF_TYP	BUFF_TYP		Char
153	Riparian Condition	ADJ_COVR	ADJ_COVR	ADJ_CV_L	Char
154	Riparian Condition			ADJ_CV_R	Char
155	Riparian Condition			RV_BU_BL	Char
156	Riparian Condition			RV_BU_BR	Char
157	Riparian Condition			VEG_T_1L	Char
158	Riparian Condition			VEG_T_2L	Char
159	Riparian Condition			VEG_T_3L	Char
160	Riparian Condition			VEG_T_4L	Char
161	Riparian Condition			VEG_T_1R	Char
162	Riparian Condition			VEG_T_2R	Char
163	Riparian Condition			VEG_T_3R	Char
164	Riparian Condition			VEG_T_4R	Char
165	Riparian Condition			BRKTYPE	Char
166	Riparian Condition			BRK_SIDE	Char
167	Riparian Condition			BRK_SEV	Char
168	Riparian Condition			MULTFLOR	Char
169	Riparian Condition			MILEMIN	Char
170	Riparian Condition			JHONEY	Char
171	Riparian Condition			RCANGRAS	Char
172	Riparian Condition			THISTLE	Char
173	Riparian Condition			EXO_OTHE	Char
174	Remoteness	REMOTE	REMOTE		Num

Table 1 (continued).

Variable	Feature	1994	1995-1997	2000	Data Type
175	Remoteness			DIST_RD	Num
176	Aesthetics	AESTHET	AESTHET	AESTHET	Num

Once streams were classified and new reference criteria developed, we examined and transformed the physical habitat metrics for use in the multimetric habitat index. The databases from the three sampling periods (1994, 1995-1997, and 2000) were merged and numerically and visually examined for statistical distributions (central tendency and variance) and adherence to assumptions of normality and equal error variance. Several metrics required transformations to meet those assumptions (Table 2). In addition, there were some differences in the way habitat metrics were measured among the 3 collection periods. We calibrated two metrics (erosion index and remoteness) to make them comparable among sampling periods. Lastly, some riparian land use, habitat, and substrate data consisted of discrete presence/absence values. These were difficult to model using a parametric statistical approach and were combined into a percentage of the different land use, habitat, and substrate types present at a site to approximate more continuous variable behavior (Table 2).

We looked at the spatial dependence of metrics using standard pearson correlation analysis of each metric with watershed area. Watershed areas had been calculated by the MBSS (e.g. Roth et al. 1999) and areas were plotted against each metric for reference sites. For metrics exhibiting spatial dependence, a regression model was built to predict the metric value for each site based on watershed area. The residuals from this prediction were then used as the value for that metric. Conceptually, degraded sites would have larger or smaller residuals than reference sites, whose mean residuals should be equal to

zero. Table 2 lists metrics requiring spatial modeling. Metrics not showing spatial dependence were not modeled this way.

Once reference sites for each stream class were identified, the data prepared, transformed, and corrected for spatial dependence, individual metrics were rescaled from 0 to 100 (Barbour et al. 1999). For metrics decreasing with degradation, we calculated the scaled metric value using the formula:

$$\text{Metric}_{\text{scale}} = \frac{(\text{value}) - (\text{min})}{(95^{\text{th}}\ \text{Percentile}) - (\text{min})} \times 100$$

where min = minimum value for that metric and the 95th percentile is the 95th percentile of the metric values. For metrics that increased in value with degradation, we used the formula:

$$\text{Metric}_{\text{scaled}} = \frac{(\text{max}) - (\text{value})}{(\text{max}) - (5^{\text{th}}\ \text{percentile})} \times 100$$

where max = maximum value for that metric and 5th percentile is the 5th percentile of metric values.

Once the metrics were properly scored, we evaluated their ability to discriminate between reference and degraded sites in each stream class. We used box and whisker plots to analyze the distributions of scores in reference and degraded streams and calculated discrimination efficiencies for each metric (discrimination efficiency = percent of degraded site scores below the 25th percentile of reference site scores)(Barbour et al. 1999).

Table 2 - Variables used for building metrics. The variables listed are the ones that could be normalized. Transformations used for transformed variables are shown, along with the formulae for calculating new variables and variables transformed for comparability among years.

Variable	Description (Transformation)
TACRE	Watershed area (common log)
FORLU	Adjacent forested land use
SINUOUS	Sinuosity
MAXDEPTH	Maximum depth
WETWID	Wetted width
THADEP	Thalweg depth
WIDDEP	Wetted width/Thalweg depth
VELDEP	Velocity/depth quality
POOLQUAL	Pool quality
RIFFQUAL	Riffle quality
EMBEDDED	Embeddedness
TBANKSTAB	Transformed bank stability (square root)
WOOD	Instream Wood
INSTRHAB	Instream Habitat
EPISUB	Epibenthic substrate
SUBSTR	Substrate
HAB	Habitat
TSHAD	Transformed percent shading (arc-sine square-root)
RIPWID	Riparian width
REMOTE	Remoteness
AESTHET	Aesthetics

FORLU = percent of adjacent forest types present (old field, deciduous forest, coniferous forest, wetland).
SINUOUS = Straight line distance of upstream to downstream ÷ 75m.
BANKSTAB = MBSS 2000 erosion extent was converted to 0-20 score bank stability using the formula:

$$= \left[\frac{(\text{Erosion Extent})}{-15} \times (\text{Severity}) \right]_{\text{left bank}} + \left[\frac{(\text{Erosion Extent})}{-15} \times (\text{Severity}) \right]_{\text{right bank}} + 20$$

SUBSTR = Percent of substrate types present in Coastal Plain (cobble, gravel, sand, and silt/clay), Piedmont (small boulder, cobble, gravel, sand, silt/clay), and Highland (bedrock, large boulders, small boulders, cobble, gravel, sand, and silt/clay) streams.
HAB = percent of habitat types present (riffle, run/glide, deep pools, shallow pools, undercut banks, overhanging cover).
REMOTE = MBSS 2000 distance to road was converted to a 0-20 remoteness score using the equation:

$$= 0.615 + 0.733\sqrt{\text{meters from road}}$$

Of the most discriminating metrics, we selected the set that was least redundant (avoiding an abundance of highly correlated metrics) and reflected the largest diversity of habitat characteristics. The scores for these metrics were averaged to calculate a final physical habitat index (PHI) score for each site within each stream class.

Once the final PHI was calculated for each site, we looked for watershed area effects in final scores among the reference sites by measuring correlation between watershed area and the final PHI scores. Variables exhibiting watershed area effects were corrected using regression analysis. After investigating for area effects, we looked at the discrimination efficiency of the overall PHI scores by looking at both box and whisker distribution plots of scores in reference and degraded sites and calculating the percent discrimination efficiency as the percentage of degraded sites scoring below the 25th percentile of the reference scores.

We investigated the relationship between the new PHI developed here and the provisional PHI (Hall et al. 2000) using regression analysis. We developed and equation for converting between the different PHI values as well and we measured the root mean square error of the regression to estimate the error involved in predicting the provisional PHI value from the revised value. We also compared correlations between each of the habitat indices and the fish and benthic indices to compare the indices.

We looked at the relationship between the PHI and the fish index of biological integrity (FIBI, Roth et al. 1997, 1998, 2000) and the benthic index of biological integrity (BIBI, Stribling et al. 1998) using correlation analysis. We looked at these relationships statewide, within each stream class, and then by major river basin. Finally, we constructed multiple regression models to predict FIBI and BIBI scores using a variety of

chemical measures (pH, acid neutralizing capacity, nitrate and sulfate concentration, conductivity, dissolved oxygen, and mean temperature) and the PHI. Chemistry data were collected by MBSS (Roth et al. 1999). We used the forward-stepwise selection method, and limited the models to 4 final variables.

2.3 Statistical Analysis

Statistical analyses were made using standard visual and numeric analysis techniques along with correlation analysis, simple linear regression, and multiple linear regression with Statistica 5.0 software (Statsoft 1995, Zar 1999).

3 RESULTS AND DISCUSSION

3.1 Physical Habitat Index Revision

We investigated a number of different stream classifications for the state. We originally split study sites into Coastal Plain and Non-Coastal Plain sites, consistent with the original PHI approach. Non-Coastal Plain sites consisted of the Piedmont, Blue Ridge, Valley and Ridge, and Appalachian Plateau (Figure 1). Seeing as the Piedmont represents nearly a third of the state and has markedly different soils and land use history, we added the Piedmont region as a third class of streams and combined the remaining non-Coastal Plain sites into a Highlands class in our final classification. An additional reason for distinguishing the Piedmont class was that original reference criteria for the non-Coastal Plain sites led to a predominance of Highland streams serving as reference sites for the whole non-Coastal Plain class. Because Piedmont streams were so underrepresented, we were concerned that the two class approach would be biased against Piedmont streams.

Figure 1 – Map of Maryland indicating ecoregions of the state. The Highland stream class was formed by joining the Blue Ridge, Valley and Ridge, and Appalachian Plateau ecoregions.

Once we had classified the streams of the state, we proceeded to define reference criteria. Our objective while selecting reference and degraded criteria was to refrain from using biological or chemical variables. We wanted to avoid the circularity affecting the original PHI reference criteria, which included FIBI scores. In addition, we wanted to avoid using chemical variables because one function of the PHI is to be used to diagnose biological stream degradation separately from chemical degradation. By keeping the criteria separate, we hoped to isolate their effects. For this reason, we selected land use/land cover values as our reference criteria, with the implicit assumption that greater landscape disturbance alters channel morphology, the template upon which physical habitat is based. Relationships between agricultural and urban transformations of the landscape and stream condition are well established (see Wiley et al. 1990, Roth et al. 1996, Wang et al. 1997, Paul and Meyer 2002). We excluded any channelized streams from consideration as reference sites.

We used different criteria for each of the three stream classes. We sought criteria that maximized the contrast in land cover between reference and degraded conditions (reflecting the least disturbed reference and most degraded land use conditions possible), while at the same time providing enough sites for statistical comparison (Table 3). For Coastal Plain areas, reference criteria were greater than 70% forest and less than 3% urban land cover, while degraded sites were less than 15% forest and/or greater than 85% agriculture and/or greater than 50% urban. This resulted in 40 reference sites and 49 degraded sites in the Coastal Plain class (7 and 9 % of the sites in the class respectively). For the Piedmont class, reference criteria were set lower to provide enough sites for adequate comparison. We set reference criteria at greater than 55% forest and less than

2% urban. Due to the amount of disturbed landscape, however, we were able to set stricter criteria for degraded sites: less than 10% forest, and/or greater than 85% agriculture and/or 70% urban. These criteria resulted in 30 reference sites and 66 degraded sites (5 and 12% of Piedmont sites respectively). The Highlands class contained the most forested watersheds. For this reason, criteria could be set much higher. Reference criteria were set at greater than 95% forest and less than 0.5% urban. Degraded criteria were set at less than 25% forest and/or greater than 75% agriculture and/or greater than 30% urban. This gave 36 reference sites and 28 degraded sites (11 and 8% of Highland sites respectively).

Table 3 – Reference and degraded stream criteria for each of the three stream classes used for constructing physical habitat indices for Maryland. Below this is shown the number of sites in each stream class and the distribution of those sites in reference, degraded, and non-categorized groups. (F=forest, A=agriculture, U=urban).

Stream Class	*Reference Criteria*	*Degraded Criteria*
Coastal Plain	F>70% and U<3%	F<15% and/or A>85% and/or U>50%
Piedmont	F>55% and U<2%	F<10% and/or A>85% and/or U>70%
Highlands	F>95% and U<0.5%	F<25% and/or A>75% and/or U>30%

	Reference	*Non-categorized*	*Degraded*
Coastal Plain (544)	40 (7%)	455 (84%)	49 (9%)
Piedmont (561)	30 (5%)	465 (83%)	66 (12%)
Highlands (343)	36 (10%)	279 (82%)	28 (8%)

There was equal representation of reference sites across the state and no east to west bias (Figure 2). This was a result, in part, of relaxing the reference criteria for Piedmont streams as compared to other areas so we could identify ample reference sites within the Piedmont. This needs to be considered when comparing results from

Piedmont sites with the two other regions as the Piedmont criteria set a lower reference standard, resulting in greater habitat degradation in reference sites. As a result, there are lower expectations for the reference condition within this class and the calculation of impairment thresholds for physical habitat in the Piedmont may have to be different from the other two stream classes. For example, the 25th percentile of reference PHI could be used for Coastal Plain and Highland streams, while the 75th percentile of reference PHI is used for Piedmont streams.

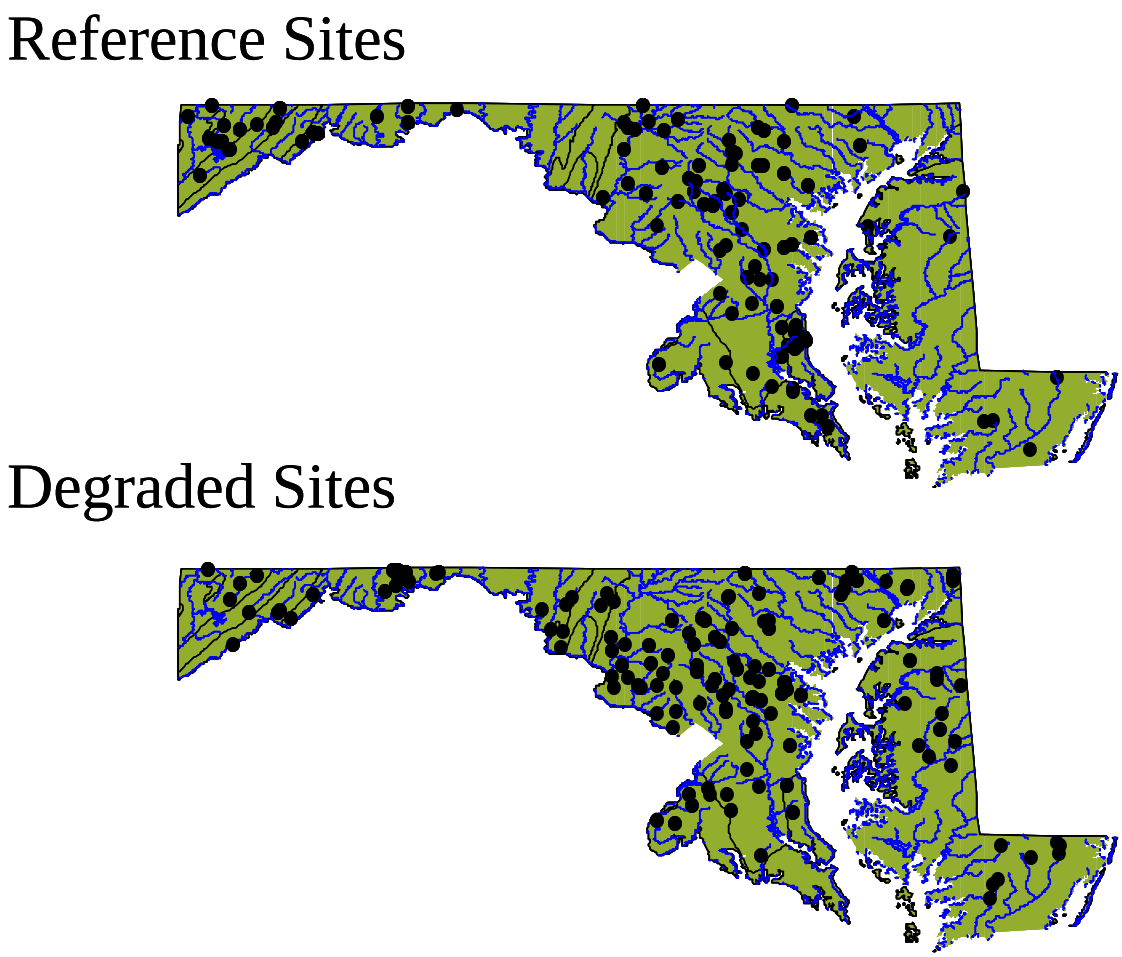


Figure 2 – Map of the location of physical habitat reference and degraded sites across the state.

Reference streams did tend to be smaller than degraded streams in the Coastal Plain and Highland stream classes, but were actually larger, on average, than degraded streams in the Piedmont region (Figure 3). It is generally difficult to find large sized reference streams, because the patchy nature of land use disturbance tends to disrupt large contiguous patches of forested land. While this situation may affect this analysis, the box-and-whisker plots clearly indicate overlap in stream sizes among the reference and degraded conditions in each stream class. In addition, we corrected for area effects to isolate the effects of area on several potential metrics (see below).

Once we established stream classes and reference and degraded criteria, we began to analyze potential metrics. Metrics were transformed as necessary (Table 2). We also had to modify a few variables. Adjacent forested land use was constructed from the percent of four land use types (old field, deciduous forest, coniferous forest, and wetland) observed adjacent to the study reach. The substrate variables were constructed from the percent of sediment types present at a site, with the assumption that a variety of sediment types is preferable to more homogeneous substrate conditions. We determined which sediment classes to consider by considering only those present in at least 50% of the reference sites (Table 4). For Coastal Plain streams, we calculated the percent in cobble, gravel, sand, and silt/clay; for Piedmont streams, the percent of small boulder, cobble, gravel, sand, and silt/clay; and, lastly, for Highland streams, the percent bedrock, large and small boulders, cobble, gravel, sand, and silt/clay.

We modified the habitat metric in a similar way. We calculated the percent of habitat types present at each site, again assuming that a variety of habitat types was preferable to only a few types. In this case, all three classes used the same set of habitat

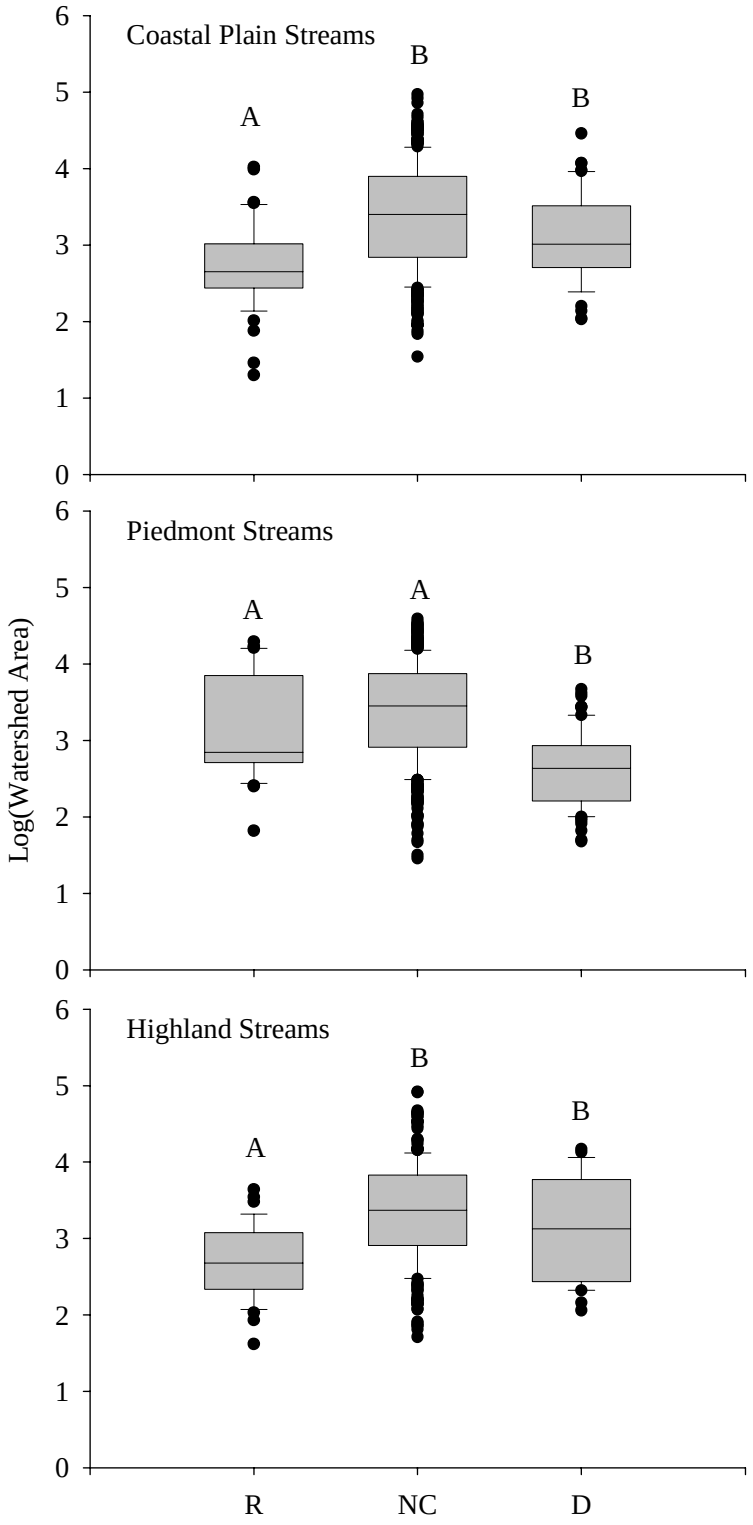


Figure 3 – Box and whisker plots of watershed area by reference category (R=reference, NC=non-categorized, D=degraded) and by stream class. Boxes indicate the median, 10th, 25th, 75th, and 90th percentiles. Within a stream class, categories with different letters above the boxes are significantly different ($p<0.05$, one-way ANOVA, Tukey's HSD multiple comparisons test).

types, which were present in at least 50% of the reference sites in each class. These habitat types were riffle, run/glide, deep pools, shallow pools, undercut banks, and overhanging cover. Emergent and floating vegetation were excluded, as they were only present in, at most, 30% of the reference sites.

Table 4 – The percent of reference sites having each substrate types in each of the three stream classes. Substrate types in bold were used in calculating the SUBSTR metric for each stream class (>50% reference sites).

	Stream Class		
Substrate Type	*Coastal Plain*	*Piedmont*	*Highlands*
Large Boulder	7.1	40.0	**54.5**
Small Boulder	28.6	**93.1**	**93.9**
Cobble	**51.5**	**97.2**	**94.3**
Bedrock	3.6	28.6	**56.5**
Gravel	**78.9**	**97.3**	**97.1**
Sand	**91.5**	**100.0**	**100.0**
Silt/clay	**97.9**	**100.0**	**96.8**

Two other new variables were considered. The width:depth ratio was calculated as the ratio of wetted width to average stream thalweg depth calculated for each site. Bankfull or channel widths would have been more comparable than wetted widths, which are subject to flow conditions, but these data were not available for the MBSS sites. Sinuosity was also estimated as the ratio of the straight line distance between the upstream and downstream segment endpoints and 75 m, the stream reach length assessed and measured along the thalweg.

Two other variables were collected in each period, but using different approaches. For each, we derived equations to make the measurements comparable among years. Bank stability was measured on a 0-20 scale from 1994-1997. During the 2000 sampling, the MBSS estimated bank stability as the linear extent of erosion along both banks

(maximum of 75 m each bank) and also noted the severity of the erosion (from 0=minimal to 3=severe). We converted the year 2000 data to a 0-20 scale using the following formula:

$$=\left[\frac{(\text{Erosion Extent})}{-15}\times(\text{Severity})\right]_{\text{left bank}}+\left[\frac{(\text{Erosion Extent})}{-15}\times(\text{Severity})\right]_{\text{right bank}}+20$$

and we used severity values of 0,1,1.5, and 2. Thus, if all 75 m of stream were eroded severely on each bank, each bank would score –10, for a sum total of –20. Adding 20 to this score would result in a score of 0 for bank stability. Likewise, if there was no erosion, a site would get a score of 20.

The second variable we converted was remoteness, which had been scored on a scale of 0-20 from 1994-1997, wheras, during the 2000 sampling, instead of using this scale, the actual distance to a road was estimated. Because of this discrepancy, we converted the 1994-1997 values to make the measures comparable. The original method stated distance criteria for each scoring range: 0-5 scores had roads adjacent to the stream, 6-10 were where roads were within 0.25 miles of the stream but accessible by trail, scores of 11-15 for streams within 0.25 miles but not accessible by trail, and scores of 16-20 for sites more than 0.25 miles. We converted the miles to meters and created a gradient of distances corresponding to each metric score. We then regressed the 0-20 based scores for each site against the distance in meters to calculate new remoteness scores for the 2000 data. The formula for this conversion was

$$=0.615+0.733\sqrt{\text{meters from road}}\ .$$

These values can be found in Appendix A where all the physical habitat data are shown for each site.

We found relationships between watershed area and several variables in reference sites in each of the three regions (Coastal Plain: pool quality, instream wood, instream habitat quality, and epibenthic substrate quality; Piedmont: velocity-depth quality, pool quality, riffle quality, instream habitat quality, and percent shading; Highlands: velocity-depth quality and percent of habitat present)(Table 5). The likely reason is the description of the different habitat metrics and their dependence on depth criteria for scoring. Since stream depth, like most channel dimensions, increases with stream size, it is not surprising that we found these relationships (e.g. Figure 4). We corrected these variables by regressing reference site values against the $\log_{10}$ of their watershed area. We used the regression formula, based on reference sites, to predict the metric value for any given site based on its watershed area. We took the residual of this value and used it as our metric score. We assumed increasing negative residuals were correlated with physical disturbance, which is demonstrated by the mean residual riffle quality in degraded Piedmont streams (Figure 5).

Once we finished the area corrections, we analyzed all the metrics for their ability to discriminate between reference and degraded sites. We calculated discrimination efficiencies for each metric and examined correlation coefficients among the metrics (Table 6). In general, we sought to combine metrics that exhibited some discrimination (>0.25) and we attempted to avoid having too many highly correlated variables together. Ultimately, it was the performance of the final multimetric that was our focus, rather than any one metric alone. Based on our analyses, we selected a set of discriminatory metrics for each of the three stream classes and these were combined into a final multimetric PHI (Table 7). In the Coastal Plain region, we found that bank stability, wood, instream

Table 5 – Regression equations used to correct spatial dependence for different variables in each of the three stream classes. The equations were derived from reference site catchment area versus metric value regressions. Watershed area values (acres) were then entered for each site and the residuals from the predicted values used as the response variable. (Abbreviations are explained in Table 2).

Stream Classes		
Coastal Plain	*Piedmont*	*Highlands*
POOLQUAL = -1.170+4.3125 (TACRE)	VELDEP = 1.2083+3.3096 (TACRE)	VELDEP = 1.4974+2.4473 (TACRE)
WOOD = -12.24+8.8120 (TACRE)	POOLQUAL = -1.751+4.4219 (TACRE)	HAB = -0.1591+0.28704 (TACRE)
INSTRHAB = 0.5505+4.2475 (TACRE)	RIFFQUAL = 5.8467+2.4075 (TACRE)	
EPISUB = 3.5233+2.5821 (TACRE)	INSTRHAB = 9.9876+1.5476 (TACRE)	
	TSHAD = 1.7528-0.1990 (TACRE)	

habitat, epibenthic substrate, shading, and remoteness were the best combination of metrics for discriminating degraded sites from reference. In Piedmont streams, riffle quality, bank stability, wood, instream habitat, epibenthic substrate, shading, remoteness, and embeddedness were the best metrics. Finally, in the Highlands streams, bank stability, epibenthic substrate, shading, riparian width, and remoteness were used. All the multimetrics originally had aesthetics included as a metric. This was a very discriminating metric but it was felt to reflect stressors that may be independent of instream habitat, so it was left out of the multimetric indicator. Detailed equations and procedures for calculating the final multimetric PHI in each region are given in Appendix B.

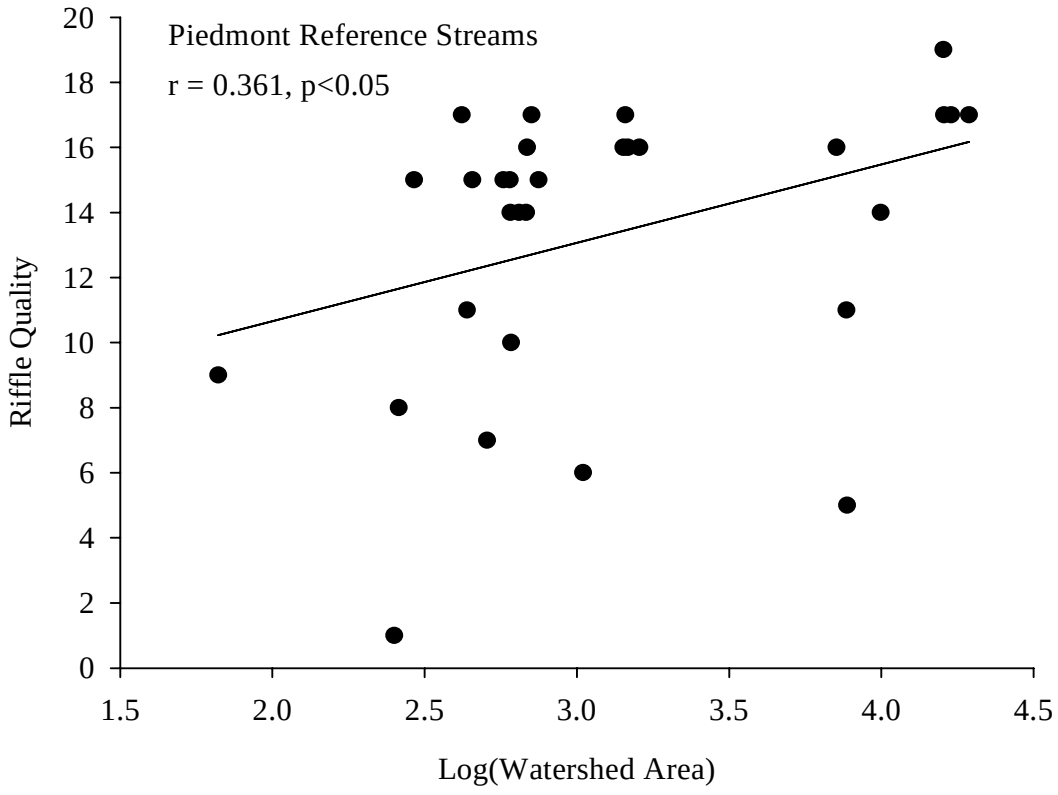


Figure 4 – Plot of watershed area against riffle quality scores in Piedmont reference streams. The pearson correlation coefficient is shown. Similar analyses were run for all metrics to check for watershed area effects.

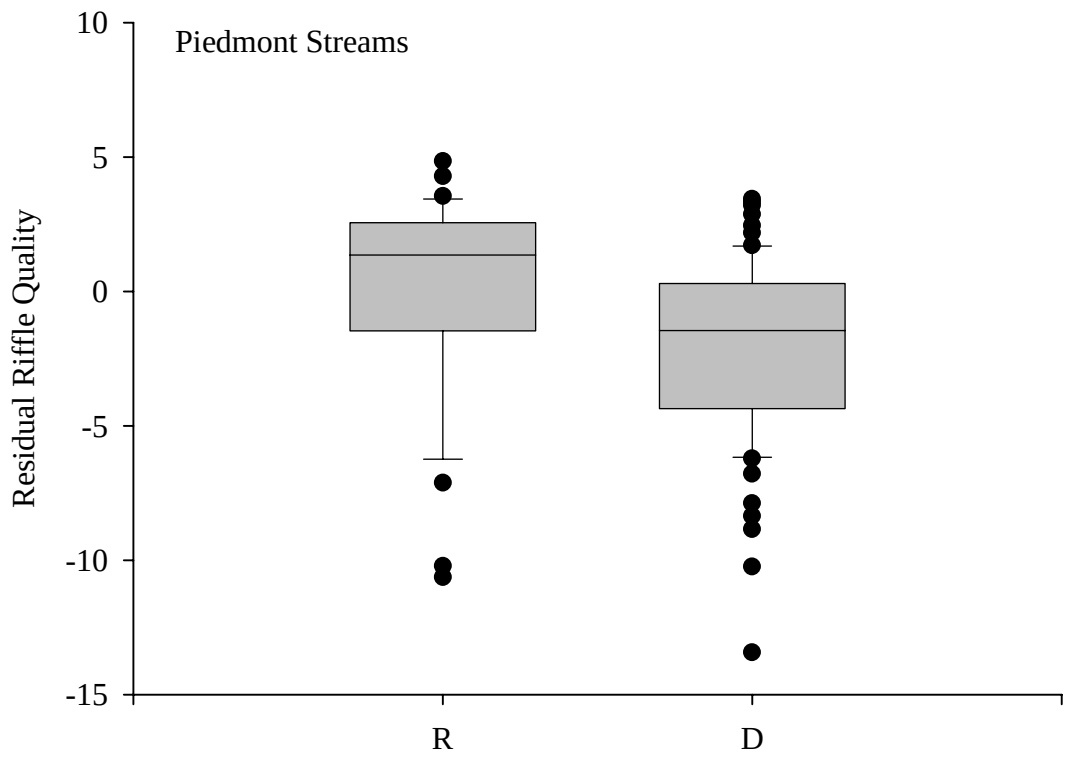


Figure 5 – Box and whisker plot of residual riffle quality in reference (R) and degraded (D) sites in Piedmont streams. Residual riffle quality was calculated by subtracting the riffle quality of a test site predicted based on the area of that watershed (estimated from the regression of area versus riffle quality in reference sites) from the observed riffle quality. Negative residuals indicate sites having worse riffle quality than that predicted for reference sites of similar watershed area. Boxes indicate the median, 10th, 25th, 75th, and 90th percentiles.

The final metrics selected reflected a mix of different habitat characteristics (e.g. reach land cover, geomorphology, wood, visual habitat, riparian condition, etc.), but we do not consider these to be the only metrics of importance in stream habitat assessment. Land use changes will continue to affect stream habitat and it may be that other metrics currently collected will need to be used in the future to better assess and diagnose habitat problems. While the current PHI can be used to assess habitat and calculate the number of habitat impaired streams across the state, variables not used likely will be important in

diagnosing specific habitat problems at sites indicated as generally degraded by the PHI. In addition, it may be that future insights and modifications to the habitat assessment will result in revisions to the PHI. The program will be most flexible in terms of meeting any future changes by keeping the full suite of variables.

Table 6 – Discrimination efficiencies of each metric in each of the three stream classes in Maryland. Values in bold represent metrics selected for the PHI of each class. (Abbreviations are explained in Table 2).

Variable	**Discrimination Efficiency**		
	Coastal Plain	*Piedmont*	*Highlands*
FORLU	0.27	0.23	0.18
SINUOUS	0.08	0.23	0.21
MAXDEPTH	0.16	0.30	0.07
WETWID	0.10	0.59	0.18
THADEP	0.16	0.36	0.04
WIDDEP	0.16	0.52	0.46
VEL_DPTH	0.10	0.26	0.29
POOLQUAL	0.37	0.29	0.07
RIFFQUAL	0.18	**0.50**	0.14
EMBEDDED	0.22	**0.29**	0.00
TBANKSTAB	**0.53**	**0.32**	**0.57**
WOOD	**0.82**	**0.36**	0.25
INSTRHAB	**0.45**	**0.64**	0.25
EPI_SUB	**0.53**	**0.35**	**0.43**
SUBSTR	0.12	0.14	0.32
HABITAT	0.16	0.20	0.29
TSHADING	**0.51**	**0.70**	**0.46**
RIPWID	0.86	0.41	**0.75**
REMOTE	**0.71**	**0.36**	**0.64**
AESTHET	0.80	0.36	0.89

After assembling the multimetrics, we checked to see if there were any watershed area effects in the final multimetric by plotting watershed area versus the PHI for each region. There was no significant relationship between area and PHI score (Figure 6). This means there was no apparent dependence on area. This is not surprising, given the

careful attention to controlling for stream size in the construction of the individual metrics. The lack of bias against small streams also means that habitat quality can be equally compared in streams of any size.

Table 7 – Metrics used in the PHI for each stream class, the direction of change with degradation, and the habitat feature reflected by each metric. Metrics denoted with an asterisk were watershed area corrected. (Abbreviations are explained in Table 2)

Region	Direction of Change	Feature
Coastal Plain		
TBANKSTAB	Decreases	Geomorphology
WOOD*	Decreases	Wood
INSTRHAB*	Decreases	Visual Habitat
EPISUB*	Decreases	Visual Habitat
TSHAD	Decreases	Riparian Condition
REMOTE	Decreases	Remoteness
Piedmont		
RIFFQUAL *	Decreases	Geomorphology
TBANKSTAB	Decreases	Geomorphology
WOOD	Decreases	Wood
INSTRHAB*	Decreases	Visual Habitat
EPISUB	Decreases	Visual Habitat
TSHAD*	Decreases	Riparian Condition
REMOTE	Decreases	Remoteness
EMBEDDED	Increases	Geomorphology
Highlands		
TBANKSTAB	Decreases	Geomorphology
EPISUB	Decreases	Visual Habitat
TSHAD	Decreases	Riparian Condition
RIPWID	Decreases	Riparian Condition
REMOTE	Decreases	Remoteness

After checking for watershed size dependence, we examined the ability of the overall multimetric indices to discriminate between reference and degraded streams in each stream class. Discrimination efficiency for the final PHI was highest for Highland streams (89%) and this was similar to the discrimination efficiency observed in the Coastal Plain region (84%). The discrimination in the Piedmont region was much lower

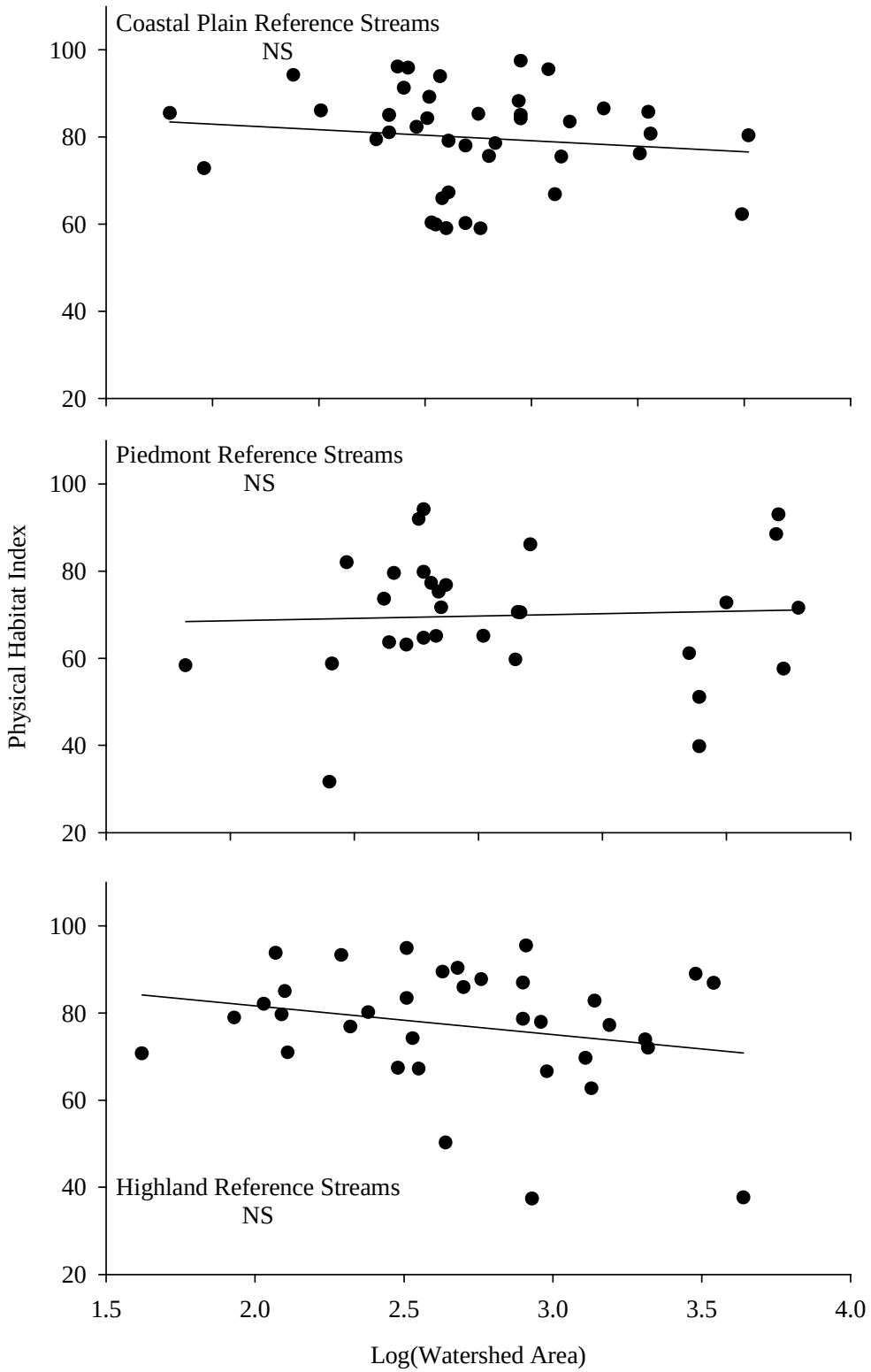


Figure 6 – Plots of watershed area versus the final PHI for reference streams in each stream class. None of the classes showed a significant correlation between area and PHI, indicating no watershed area effects. (NS = not significant).

(55%). This is likely a result of the lowered reference criteria used in the Piedmont region. We used streams with more land use disturbance in our reference set for this region to get a sufficient number of reference sites for identifying and scoring metrics. Scores are scaled to the reference distribution, which resulted in higher values for degraded sites in this region and the decreased observed discrimination efficiency. As mentioned above, any conclusions about the habitat quality in Piedmont streams must be tempered by these facts. Any threshold value should be based on the confidence with which the reference set reflects truly minimally disturbed conditions. For the Piedmont region, we are less confident reference sites reflect as minimally impacted a condition as in the other two regions and the impairment thresholds should reflect that uncertainty. In setting thresholds for establishing habitat impairment criteria, it may be necessary to use more conservative values (e.g., the 75th percentile of reference scores) for this region as opposed to others (which might use, for example, the 25th percentile of reference).

Having compiled new PHI scores, we related them to the FIBI and BIBI multimetric scores calculated for the same sites from the same study periods. We calculated correlation coefficients between the PHI and IBIs for each individual region (Table 8). We ran separate correlations between the PHI and IBIs for sites where the low pH (<5) and DO (<2 mg/L) sites had been removed in order to remove the potential interference of acid precipitation and low oxygen stressed sites (Table 8). These correlations are generally higher, largely because sites with these obvious chemical disturbances have been removed. Even without the low DO and low pH sites, the correlation coefficients are still quite low, but they are comparable to correlations observed with the provisional PHI (0.15 for the B-IBI and 0.46 with the FIBI)(Hall et al.

1999). The previous PHI was more strongly correlated with the FIBI, but FIBI scores were used for defining the reference condition, so that result is not surprising.

Table 8 – Results of correlation analyses among PHI and IBI values for each stream class. Values are Pearson product-moment correlation coefficients and significant coefficients ($p<0.05$) are indicated with an asterisk.

Stream Class	**All Sites**			**Low pH and DO Sites Removed**		
Coastal Plain	N	BIBI	FIBI	N	BIBI	FIBI
PHI versus	349	+0.300*	+0.070	331	+0.330*	+0.100
Piedmont						
PHI versus	415	+0.290*	+0.380*	414	+0.280*	+0.360*
Highlands						
PHI versus	263	+0.250*	+0.120*	254	+0.280*	+0.150*
Overall						
PHI versus	1027	+0.250*	+0.200*	999	+0.260*	+0.220*

Some studies have observed stronger relationships between physical habitat scores and multimetric biotic scores, while others show similar correlations to the ones we observed (Rankin 1995, Gerritsen et al. 1996, Dyer et al. 1998, Rankin et al. 1999, Rockdale County 2001). Habitat clearly constrains the biological integrity of streams. The degree to which it is statistically associated with biotic integrity will depend on the extent and nature of different stressors. Areas with numerous effluents would be expected to show stronger relationships between IBI scores and stream chemistry, those with extensive channelization and hydrologic modification may show stronger relationships with habitat, those with a mixture of stresses (e.g. urban land use) would likely show relationships with both chemistry and habitat.

Due to spatial differences in land use and therefore potential spatial differences in the types of habitat impacts, we expected to find various degrees of correlation between habitat and biological integrity in Maryland streams across the state. When we examined these relationships by river basin, we observed clear differences (Table 9). The BIBI was significantly correlated with the PHI in 12 of the 17 basins studied, most highly correlated with the habitat index in the North Branch Potomac, Chester, and Patapsco basins, but not correlated with the PHI in the Bush, Elk, Lower Potomac, Susquehanna, and Youghiogheny basins. The FIBI was significantly correlated with the PHI in fewer basins, 10 of 17, most highly correlated with the PHI in the Pocomoke, Nanticoke-Wicomico, and Middle Potomac basins, but not related to the PHI in the Choptank, Chester, Lower Potomac, Patuxent, Susquehanna, Upper Potomac, and West Chesapeake basins.

To examine the relative contribution of chemical and habitat variables in predicting biological integrity, we constructed very simple forward stepwise multiple linear regression models using a mixture of water chemistry variables (pH, acid neutralizing capacity, nitrate and sulfate concentration, conductivity, dissolved oxygen, and mean temperature) and the PHI. There were differences in the variables chosen in each region and between the BIBI and FIBI (Table 10). The PHI is a significant predictor in 5 of the 6 models, and is the first or second variable selected in 3 of those 5. The most common chemical predictors were conductivity and dissolved oxygen. These preliminary models predicted from 10 to 26 percent of the variance in IBI scores. The remaining variance may be due to other stressors, interactions among chemical and physical stressors, non-linear responses in biological responses to these stressors, and/or

natural variability and sampling error. Because the PHI appears so frequently in the regression models, clearly the physical habitat index presents an important and significant predictor of biological integrity in Maryland streams.

Table 9 – Basin specific correlations between PHI and IBI values. For this analysis, all sites with pH<5 and dissolved oxygen < 2mg/L have been removed. Values are Pearson product-moment correlation coefficients and significant coefficients (p<0.05) are indicated with an asterisk.

	PHI versus		
Basin	**BIBI**	**FIBI**	**N**
Bush	-0.170	+0.380*	24
Choptank	+0.360*	-0.140	44
Chester	+0.510*	+0.150	41
Elk	+0.190	+0.440*	19
Gunpowder	+0.280*	+0.270*	48
Lower Potomac	-0.050	-0.010	65
Middle Potomac	+0.190*	+0.430*	125
North Branch Potomac	+0.500*	+0.310*	59
Nanticoke-Wicomico	+0.500*	+0.500*	22
Pocomoke	+0.400*	+0.590*	27
Patapsco	+0.420*	+0.330*	152
Potomac-Washington Metro	+0.230*	+0.250*	65
Patuxent	+0.230*	+0.060	92
Susquehanna	-0.150	+0.030	33
Upper Potomac	+0.260*	-0.140	74
West Chesapeake	+0.390*	-0.240	24
Youghiogheny	+0.130	+0.250*	85
Number Significant	**12 of 17**	**10 of 17**	

We compared our revised PHI to the provisional PHI (Hall et al. 1999)(Figure 7). The two were significantly correlated (r^2=0.23) and the regression equation between them is represented by the equation:

$$\text{Revised PHI} = 0.2368(\text{Provisional PHI}) + 53.331.$$

Using this score, previous values can be converted and compared with new PHI values, however, this will introduce error associated with the regression equation. The root mean square error of this regression was 12.9, which represents 20% of the mean revised PHI score, which is a fairly inaccurate estimate of the revised PHI. A much better approach is to calculate the revised PHI directly from the data. Appendix A contains revised PHI values calculated for each site using the habitat data directly, along with the provisional PHI values from the 1999 analysis.

Table 10 – Multiple linear regression model results. Models were built to predict BIBI and FIBI from a suite of chemical variables (pH, acid neutralizing capacity, nitrate and sulfate concentration, conductivity, dissolved oxygen, and mean temperature) and the PHI. Variables are shown in the order with which they entered the forward stepwise models. The signs in front of each variable represent the response of each IBI to that particular predictor. (DO=dissolved oxygen, Temp=temperature, NO_3=nitrate, ANC=acid neutralizing capacity).

	Response Variables			
Site Class	**BIBI**	**R^2**	**FIBI**	**R^2**
Coastal Plain	-Conductivity, +DO, +PHI, +Temp	0.20	+DO, -ANC, +Temp, +PHI	0.09
Piedmont	-Conductivity, +PHI, -NO_3, -Temp	0.19	+PHI, -Conductivity, +Temp, +DO	0.26
Highlands	+PHI, +pH, -Conductivity, -NO_3	0.16	+pH, -Conductivity, +DO, +PHI	0.12
Overall	-Conductivity, +DO, +PHI, +pH	0.15	+PHI, +DO, +Temp, -Conductivity	0.10

This revised PHI was not validated with an independent set of data. We recommend validation with data collected since 2000. The variables collected since 2000 can be entered into the models and PHI scores calculated. The reference and degraded criteria can be applied based on land use and the number of sites scoring in the correct category can be evaluated. Ideally, high percent classification rates are sought.

Attachment 4-C

Physical Habitat Index

Maryland Biological Stream Survey

Data Sheets and Assessment Guidance

v. 2012

MBSS SUMMER HABITAT DATA SHEET

Page ☐ Of ☐

SITE — Watershed Code ☐☐☐☐ Segment ☐☐☐ Type ☐ Year ☐☐☐☐

Reviewer: First ____ / Second ____

BANK EROSION

	Left Bank	Right Bank
Extent (m)	☐☐	☐☐
Severity 0=none 1=min 2=mod 3=severe	☐	☐
Average Height (m)	☐☐.☐	☐☐.☐

BAR FORMATION & SUBSTRATE

Severity ___
0=none
1=min
2=mod
3=extensive

☐ Cobble
☐ Gravel
☐ Sand
☐ Silt/Clay

HABITAT ASSESSMENT

1. Instream Habitat (0-20) ☐☐
2. Epifaunal Substrate (0-20) ☐☐
3. Velocity/Depth Diversity (0-20) ☐☐
4. Pool/Glide/Eddy Quality (0-20) ☐☐
   Extent (m) ☐☐
5. Riffle/Run Quality (0-20) ☐☐
   Extent (m) ☐☐
6. Embeddedness (%) ☐☐☐
7. Shading (%) ☐☐☐

FLOW

Lat Loc (m)	Depth (cm)	Velocity (m/s)
0 0 . 0 0	0 0 . 0	0 . 0 0

STREAM CHARACTER

☐ Braided	☐ Gravel	☐ Boulder >2m
☐ Riffle	☐ Sand	☐ Boulder <2m
☐ Run/Glide	☐ Silt/Clay	☐ Beaver Pond
☐ Deep Pool(>= .5m)	☐ Cobble	☐ Overhead Cover
☐ Shallow Pool(< .5m)	☐ Bedrock	☐ Undercut Bank

A = Absent P = Present E = Extensive

☐☐ No. of Instream Woody Debris
☐☐ No. of Dewatered Woody Debris
☐☐ No. of Instream Rootwads
☐☐ No. of Dewatered Rootwads

Maximum Depth (cm) ☐☐☐

	Wetted Width (m)	Thalweg Depth (cm)	Thalweg Velocity (m/s)
0 m	☐☐.☐	☐☐☐	☐.☐☐
25 m	☐☐.☐	☐☐☐	☐.☐☐
50 m	☐☐.☐	☐☐☐	☐.☐☐
75 m	☐☐.☐	☐☐☐	☐.☐☐

Alternative Flow Measurements

Distance (cm) ☐☐☐
Depth (cm) ☐
Width (cm) ☐☐
Time (sec) 1. ☐☐☐ 2. ☐☐☐ 3. ☐☐☐

COMMENTS ____________________

MBSS Stream Habitat Assessment Guidance Sheet

Habitat Parameter	Optimal 16-20	Sub-Optimal 11-15	Marginal 6-10	Poor 0-5
1. Instream Habitat[a]	Greater than 50% of a variety of cobble, boulder, submerged logs, undercut banks, snags, root wads, aquatic plants, or other stable habitat	30-50% of stable habitat. Adequate habitat	10-30% mix of stable habitat. Habitat availability less than desirable	Less than 10% stable habitat. Lack of habitat is obvious
2. Epifaunal Substrate[b]	Preferred substrate abundant, stable, and at full colonization potential (riffles well developed and dominated by cobble; and/or woody debris prevalent, not new, and not transient)	Abund. of cobble with gravel &/or boulders common; or woody debris, aquatic veg., undercut banks, or other productive surfaces common but not prevalent /suited for full colonization	Large boulders and/or bedrock prevalent; cobble, woody debris, or other preferred surfaces uncommon	Stable substrate lacking; or particles are over 75% surrounded by fine sediment or flocculent material
3. Velocity/Depth Diversity[c]	Slow (<0.3 m/s), deep (>0.5 m); slow, shallow (<0.5 m); fast (>0.3 m/s), deep; fast, shallow habitats all present	Only 3 of the 4 habitat categories present	Only 2 of the 4 habitat categories present	Dominated by 1 velocity/depth category (usually pools)
4. Pool/Glide/Eddy Quality[d]	Complex cover/&/or depth > 1.5 m; both deep (> .5 m)/shallows (< .2 m) present	Deep (>0.5 m) areas present; but only moderate cover	Shallows (<0.2 m) prevalent in pool/glide/eddy habitat; little cover	Max depth <0.2 m in pool/glide/eddy habitat; or absent completely
5. Riffle/Run Quality[e]	Riffle/run depth generally >10 cm, with maximum depth greater than 50 cm (maximum score); substrate stable (e.g. cobble, boulder) & variety of current velocities	Riffle/run depth generally 5-10 cm, variety of current velocities	Riffle/run depth generally 1-5 cm; primarily a single current velocity	Riffle/run depth < 1 cm; or riffle/run substrates concreted
6. Embeddedness[f]	Percentage that gravel, cobble, and boulder particles are surrounded by line sediment or flocculent material.			
7. Shading[g]	Percentage of segment that is shaded (duration is considered in scoring). 0% = fully exposed to sunlight all day in summer; 100% = fully and densely shaded all day in summer			
8. Trash Rating[h]	Little or no human refuse visible from stream channel or riparian zone	Refuse present in minor amounts	Refuse present in moderate amounts	Refuse abundant and unsightly

a) Instream Habitat Rated based on perceived value of habitat to the fish community. Within each category, higher scores should be assigned to sites with a variety of habitat types and particle sizes. In addition, higher scores should be assigned to sites with a high degree of hypsographic complexity (uneven bottom). In streams where ferric hydroxide is present, instream habitat scores are not lowered unless the precipitate has changed the gross physical nature of the substrate. In streams where substrate types are favorable but flows are so low that fish are essentially precluded from using the habitat, low scores are assigned. If none of the habitat within a segment is useable by fish, a score of zero is assigned.

b) Epifaunal Substrate Rated based on the amount and variety of hard, stable substrates usable by benthic macroinvertebrates. Because they inhibit colonization, floculent materials or fine sediments surrounding otherwise good substrates are assigned low scores. Scores are also reduced when substrates are less stable.

c) Velocity/Depth Diversity Rated based on the variety of velocity/depth regimes present at a site (slow-shallow, slow-deep, fast-shallow, and fast-deep). As with embeddedness, this metric may result in lower scores in low-gradient streams but will provide a statewide information on the physical habitat found in Maryland streams.

d) Pool/Glide/Eddy Quality Rated based on the variety and spatial complexity of slow- or still-water habitat within the sample segment. It should be noted that even in high-gradient segments, functionally important slow-water habitat may exist in the form of larger eddies. Within a category, higher scores are assigned to segments which have undercut banks, woody debris or other types of cover for fish.

e) Riffle/Run Quality Rated based on the depth, complexity, and functional importance of riffle/run habitat in the segment, with

highest scores assigned to segments dominated by deeper riffle/run areas, stable substrates, and a variety of current velocities.

f) Embeddedness Rated as a percentage based on the fraction of surface area of larger particles that is surrounded by fine sediments on the stream bottom. In low gradient streams with substantial natural deposition, the correlation between embeddedness and fishability or ecological health may be weak or non-existent, but this metric is rated in all streams to provide similar information from all sites statewide.

g) Shading Rated based on estimates of the degree and duration of shading at a site during summer, including any effects of shading caused by landforms.

h) Trash Rating The scoring of this metric is based on the amount of human refuse in the stream and along the banks of the sample segment.

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 Activities

C-5: Clean Air Act General Air Quality Conformity Analysis

C-6: Agency Coordination

C-1: U.S. Fish and Wildlife Service Coordination Act Report

Fish and Wildlife Coordination Act Report

on

Anacostia Watershed Restoration Studies in Montgomery County and Prince Georges County, Maryland
DRAFT FINAL REPORT

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INTRODUCTION

This constitutes the report of the U.S. Fish and Wildlife Service (Service) on Anacostia Watershed Restoration Studies being conducted by the U.S. Army Corps of Engineers (USACE) in Montgomery County and Prince Georges County, Maryland. It is submitted in accordance with Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat 401, as amended; 16 U.S.C. et seq.) and Section 7 of the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1513 et seq.). The present report summarizes information on biological resources and project impacts, and provides the Service's official position on the USACE feasibility studies.

PROJECT DESCRIPTION

The primary goal of the project is to conduct feasibility studies of aquatic ecosystem restoration needs and opportunities within the Anacostia Watershed (Figure 1) in Montgomery County (USACE 2015a; Figure 2) and Prince Georges County (USACE 2015b; Figure 3). These studies build on the USACE (2010) Anacostia Restoration Plan. Report synopses for investigation of aquatic ecosystem restoration opportunities within the Corps mission were developed for the Anacostia Watershed of each county (USACE 2015a, b). For Montgomery County, the proposed project area includes seven candidate stream reaches in four sub-watersheds: Paint Branch, Little Paint Branch, Sligo Creek, and Northwest Branch (Figure 2). For Prince Georges County, the proposed project area includes ten candidate stream reaches within six subwatersheds: Indian Creek, Little Paint Branch, Paint Branch, Northwest Branch, Northeast Branch, and Sligo Creek (Figure 3). The Report Synopses identify problems and opportunities, planning goals and objectives, with a focus on stream restoration in candidate reaches. Selection of the reaches for restoration is scheduled to occur in late 2015 or early 2016 (USACE 2015a, b).

The Service's Planning Aid Report (PAR; Pinkney and Davis 2015) describes the results of an on-site geomorphic investigation of a subset of those stream reaches: Montgomery County—Sligo Creek (Montgomery Site #12; 0.7 miles), Prince Georges County—Paint Branch (PG Site #5, 1.2 miles), and Little Paint Branch (PG Site #12; 0.8 miles). In addition, the PAR summarizes available information on fish passage; recreational use of the candidate reaches

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including the potential for recreational fishing; and provides a listing of game fish species and bird species within the watershed.

FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT

The Anacostia Watershed (Figure 1) has a drainage area of about 176 square miles. It consists of 14 primary subwatersheds and the tidal river. The tributaries flow through Montgomery and Prince Georges County. The main tributaries, the Northwest and Northeast Branch, meet in Bladensburg, Maryland to form the tidal river which flows about 8.4 miles to the mouth at the Potomac River.

Ecological problems within the watershed are summarized in USACE (2010). These include "lack of stormwater management; loss and degradation of forest, wetland, stream, and riparian habitat; pollution from nutrients, chemical contaminants, sediment, and trash; and loss of species diversity."

Biological resources within the watershed are summarized in USACE (2010) and by Metropolitan Washington Council of Governments (MWCOG 2008). According to USACE (2010), 93 fish species have been tabulated. MWCOG (2008) has produced watershed maps that indicate the biological conditions for fish and macroinvertebrates within the subwatersheds. In general, poor and fair conditions are common. According to the Report Synopses (USACE 2015a, b), MDE (2012) stated that approximately 95% of stream miles in the watershed have poor to very poor ratings for fish and/or benthic macroinvertebrates. Causes include poor water quality, altered hydrology, and degraded in-stream habitat. Beginning in 1991, some fish blockages within the watershed have been removed. Anadromous fish runs, however, are limited by about 120-130 remaining fish blockages (USACE 2010). Fish species in the two counties are discussed in the PAR (Pinkney and Davis 2015).

The Anacostia Watershed provides wildlife habitat for migratory birds, mammals, reptiles, and amphibians. Bird species strongly affiliated with stream and riparian habitats include the Kentucky warbler (*Geothlypis formosa*), Acadian flycatcher (*Empidonax virescens*), willow

flycatcher (*Empidonax traillii*), woodcock (*Scolopax minor*), prothonotary warbler (*Protonotaria citrea*), great blue heron (*Ardea herodias*), green heron (*Butorides virescens*), wood duck (*Aix sponsa*), marsh wren (*Cistothorus palustris*), mallard (*Anas platyrhnchos*), and red-shouldered hawk (*Buteo lineatus*). Additional bird species affiliated with mature forests include wood thrush (*Hylocichla mustelina*), red-eyed vireo (*Vireo olivaceus*), northern parula (*Setophaga americana*), yellow warbler (*Setophaga petechia*), Cooper's hawk (*Accipiter cooperii*), and barred owl (*Strix varia*). The eBird data base was searched (7/8/2015) to identify birding hotspots within the Anacostia Watershed. These are areas visited by experienced birders who keep species lists. For example, Bladensburg Waterfront Park located in Prince Georges County near the upper boundary of the tidal Anacostia includes a listing of 134 bird species. In addition to most of the above-listed species, the formerly-endangered bald eagle (*Haliaeetus leucocephalus*) was observed.

The Anacostia Watershed Society maintains lists of birds, amphibians, and reptiles within the watershed (http://www.anacostiaws.org/news/blog/wildlife-watershed). Currently, there are 233 bird species, 61 amphibian and reptile species, and 35 species of mammals. These lists (Appendix A) include the conservation status of the species as defined by Maryland Department of Natural Resources and the District Department of Energy and Environment. Information on federally listed species is provided in the next section.

THREATENED AND ENDANGERED SPECIES

There is one federally listed threatened species in the Anacostia Watershed, the Northern long-eared bat (*Myotis septentrionalis*) based on a search of the Service's Information for Planning and Conservation (IPaC) data base (USFWS 2015). 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 U.S. where the species has declined by up to 99 percent from pre-white-nose syndrome levels at many hibernation sites. CBFO Supervisor LaRouche prepared

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a "*Not Likely to Adversely Affect"* letter (Appendix B) that describes USFWS concerns about the proposed project:

> "This project is within the range of the northern long-eared bat, a federally listed threatened species. The northern long-eared bat is a temperate, insectivorous migratory bat that hibernates in mines and caves in the winter and summers in wooded areas. Since the forest clearing for this proposed project is minimal, and there are no current records of northern long-eared bats in the project vicinity, this 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."

A field survey yielded the existence of Kenk's amphipod (*Stygobromus kenki*) within the Anacostia watershed at one location on Northwest Branch in Montgomery County. This location is not within or near the candidate stream reaches (A. Moser, personal communication, 2015).

FUTURE CONDITIONS WITHOUT PROJECT

Without the project and additional work addressing water quality in the watershed, conditions in these stream sections are unlikely to improve. Many problems in the Anacostia Watershed contribute to the poor ratings of streams for fish and benthic macroinvertebrates. Stream restoration projects can help stabilize hydrology, reduce erosion, decrease the loadings of sediments and nutrients, and increase in-stream habitat heterogeneity (Stranko et al. 2011). Improvements in small reaches of urban streams alone, however, are unlikely to lead to marked improvements in biological conditions (Bernhardt and Palmer 2011; Stranko et al. 2011). A more comprehensive watershed-wide approach is needed that includes measures to reduce the volume of stormwater flow off impervious surfaces and the loadings of contaminants contained therein (Frazer 2005). Such efforts are ongoing. Thus, these project feasibility studies should be viewed as contributing to the multi-jurisdictional efforts to improve habitat and water quality and reduce sediment and nutrient loadings within the watershed. Ultimately these efforts are likely to improve the biological resources within the stream corridors.

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BIOLOGICAL EFFECTS OF THE PROJECT

Stream restoration projects may have temporary negative impacts on riparian habitat. However, once completed, these projects will result in improved riparian and in-stream habitat. Based on results of the Function-based Rapid Stream Assessment, for Montgomery County Sligo Creek tributary (Montgomery County Site #12) has the potential for the most functional lift, and therefore has the highest priority, followed by the mainstem portion of that site. Within Prince Georges County, the site with the greatest potential for functional lift and the highest priority is Paint Branch (PG Site #5) with a lesser potential and priority for Little Paint Branch (PG Site #12). Crucially, however, until the stressors in the watershed are addressed, water quality and biological lift in all of the stream segments is severely limited. If the streams are reconnected to their floodplains, lateral instability is reduced, and bedform diversity is improved, the subsequent reduction in sediment and nutrients will result in at least partial water quality and biological lift in areas where tolerant species already exist. These tolerant species will be able to inhabit the stream reaches, even if more intolerant species cannot.

ENVIRONMENTAL EDUCATION

All of the candidate stream reaches have the potential to serve as living classrooms for educating students of all ages. Signage and kiosks can explain to the public the reason for the project and whether it has been successful through before and after photographs of habitat or presentation of monitoring data. Local watershed groups such as the Anacostia Watershed Society provide opportunities for citizens to conduct activities such as water quality monitoring, trail maintenance, and invasive plant removal. The Anacostia Watershed is frequented by birders who document their observations in the eBird data base, and several of the stream reach sites may be suitable locations for birding.

CONCLUSION

The Service supports the proposed project in accordance with Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat 401, as amended; 16 U.S.C. et seq.) and Section 7 of the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1513 et seq.). .

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FIGURES

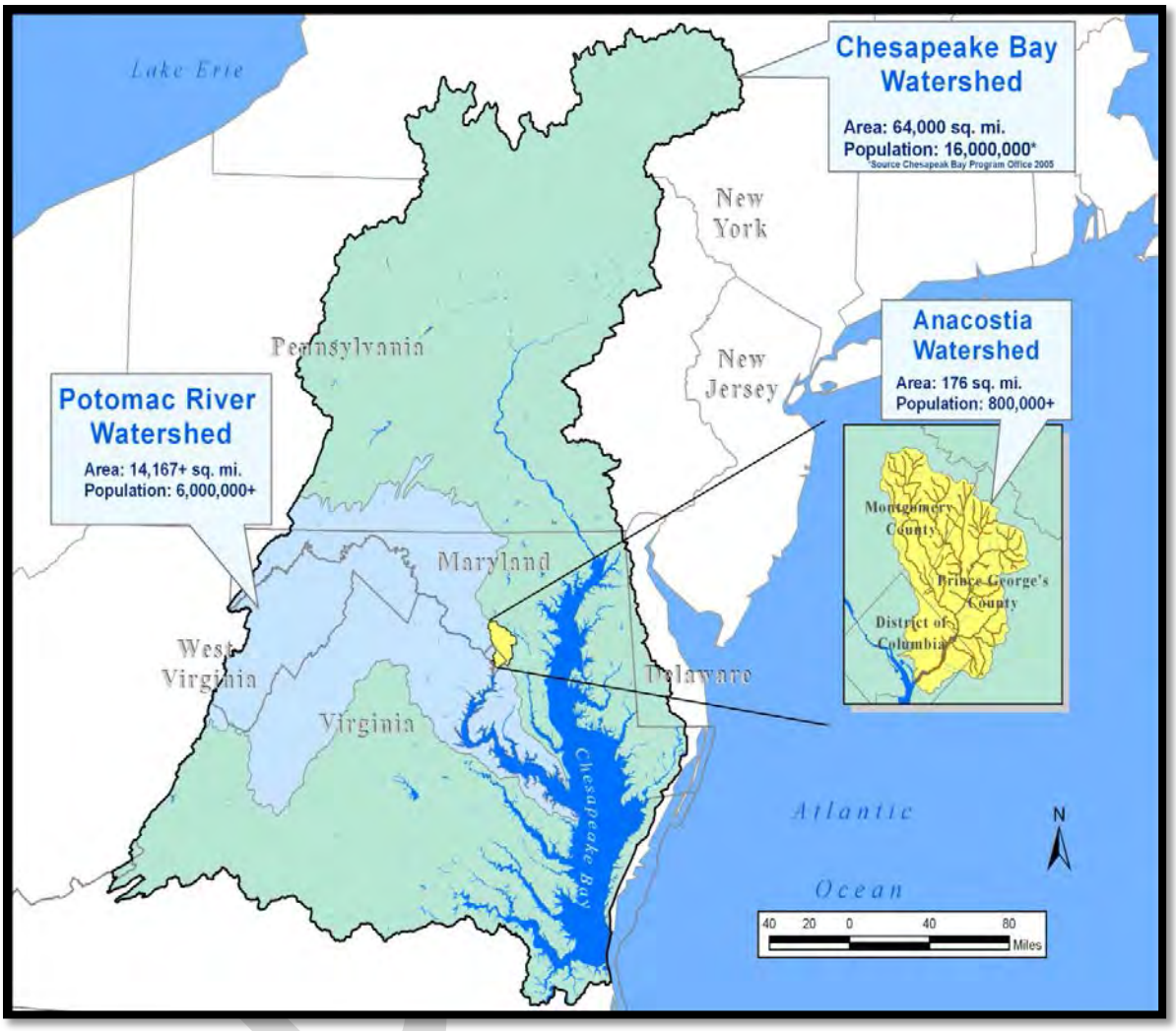

Figure 1. Anacostia watershed in relation to the Potomac and Chesapeake Bay watersheds (from ACOE 2015b).

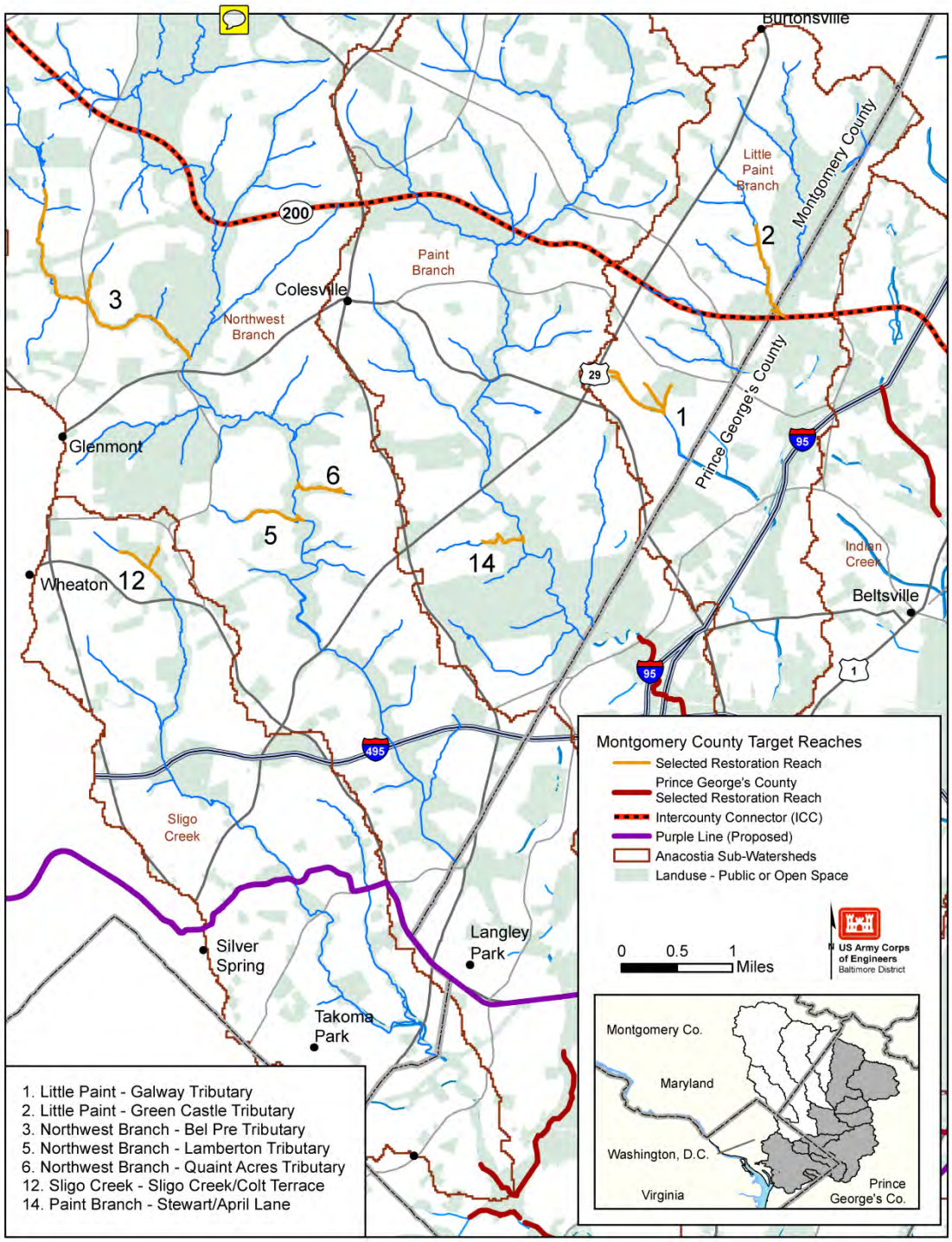

Figure 2. Montgomery County stream reaches under evaluation for stream restoration (from ACOE 2015a). Function-based Rapid Stream Assessment was conducted on Sligo Creek (Site #12).

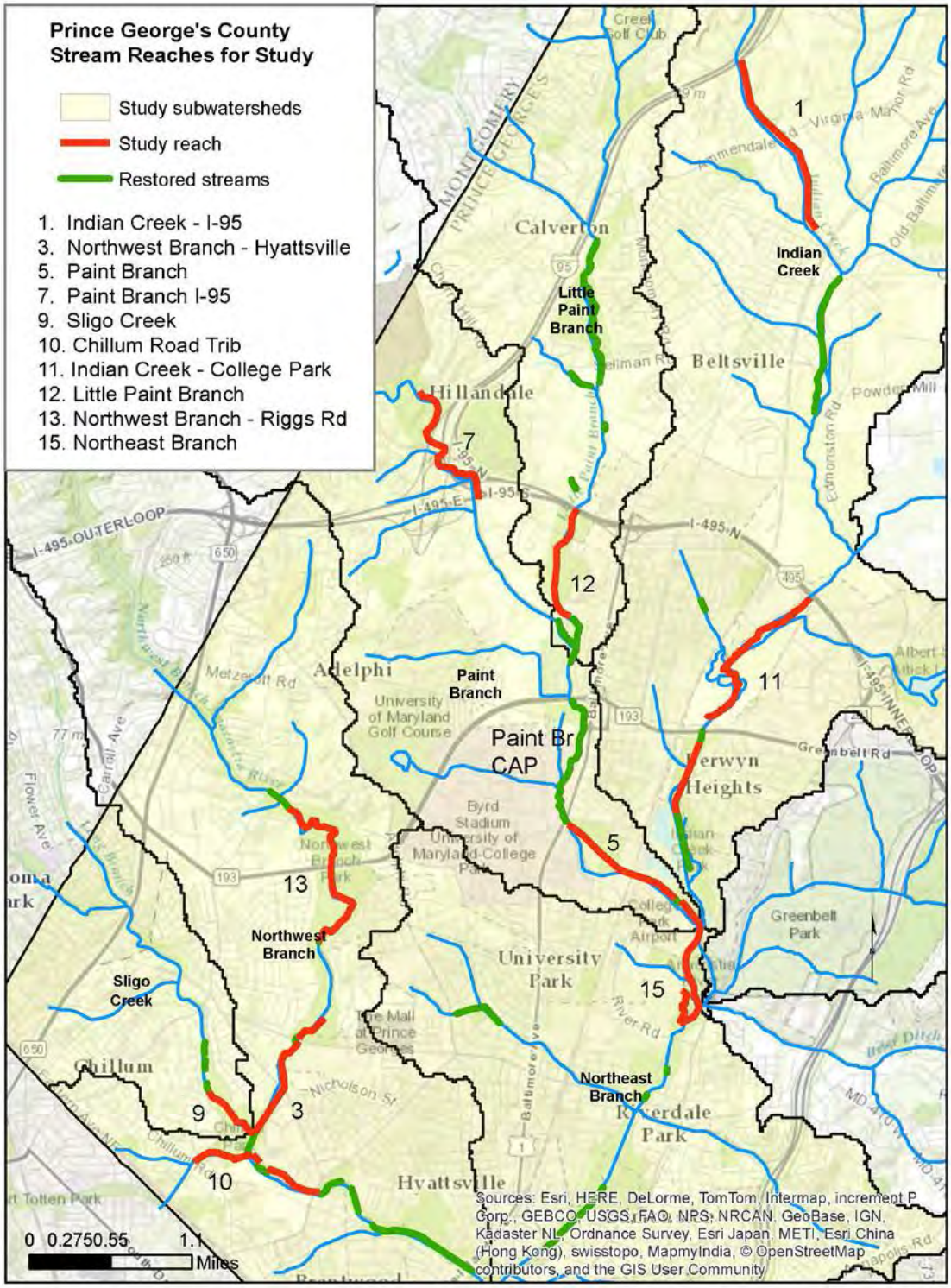

Figure 3. Prince Georges County stream reaches under evaluation for stream restoration (from ACOE 2015b). Function-based Rapid Stream Assessment was conducted on Paint Branch (Site #5), and Little Paint Branch (Site #12).

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Appendix A

Species lists compiled by Anacostia Watershed Society

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				Conservation status								
Mammals	**Conservation Status**	**Native**	**Nonnative**	**S1**	**S2**	**S3**	**S4**	**S5**	**SH**	**SX**	**SNR**	**SNA**
n=35	MD	33	2	0	1	1	3	29	0	0	0	2
	DC	33	2	0	2	5	10	12	1	0	3	2
Birds	**Conservation Status**	**Native**	**Nonnative**	**S1**	**S2**	**S3**	**S4**	**S5**	**SH**	**SX**	**SNR**	
n=233	MD	217	6	21	31	43	80	76	1	1	0	
	DC	217	6	45	62	81	56	31	6	1	8	
Herps	**Conservation Status**			**S1**	**S2**	**S3**	**S4**	**S5**	**SH**		**SNR**	**SNA**
n=61	MD			1	1	2	9	50	0		0	0
	DC			4	2	6	16	10	15		2	8

Abbreviations:

S1: Critically Imperiled
S2: Imperiled
S3: Vulnerable
S4: Apparentley Secure
S5: Secure
SNR: Status Not Ranked/Under Review
SNA: Status Not Assessed/Not applicable
SX: Presumed Extirpated
SH: Possibly Extirpated

Table A-1. Summary of species conservation status, prepared by Anacostia Watershed Society.

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Checklist of the mammals of the Anacostia River Watershed

Compilled by Jason Donaldson, AWS Stewardship Intern and Jorge Bogantes Montern, AWS Conservation Biologist

July, 2011

	Common Name	Scientific Name	Family	Non-native	Native	Conservation Status	Reference	Comments
1	American Beaver	*Castor canadensis*	Beavers (Castoridae)		X	MD: S5/ DC S3	2, 3	The only native species of beaver in North America
2	Big Brown Bat	*Eptesicus fuscus*	Bats (Vespertilionidae)		X	MD: S5/ DC S4	2, 3	Is larger than many other bats
3	Common Raccoon	*Procyon lotor*	Raccoons (Procyonidae)		X	MD: S5/ DC S5	2, 3	Can adapt to different habitats
4	Eastern Chipmunk	*Tamias striatus*	Squirrels (Sciuridae)		X	MD: S5/ DC S5	1, 2	
5	Eastern Cottontail	*Sylvilagus floridanus*	Rabbits and Hares (Leporidae)		X	MD: S5/ DC S5	1, 2	
6	Eastern Gray Squirrel	*Sciurus carolinensis*	Squirrels (Sciuridae)		X	MD: S5/ DC S5	2, 3	
7	Eastern Mole	*Scalopus aquaticus*	Moles (Talpidae)		X	MD: S5/ DC S5	2, 3	
8	Eastern Pipistrelle	*Pipistrellus subflavus*	Bats (Vespertilionidae)		X	MD: S5/ DC S4	2, 3	
9	Eastern Red Bat	*Lasiurus borealis*	Bats (Vespertilionidae)		X	MD: S5/ DC S4	1, 2	May migrate south
10	Evening Bat	*Nycticeius humeralis*	Bats (Vespertilionidae)		X	MD: S5/ DC S2	2, 3	
11	Gray Fox	*Urocyon cinereoargenteus*	Dogs (Canidae)		X	MD: S5/ DC S3	1, 2	Mostly in Southern America
12	Hairy-tailed Mole	*Parascalops breweri*	Moles (Talpidae)		X	MD: S4/ DC SNR	2, 3	
13	Hoary Bat	*Lasiurus cinereus*	Bats (Vespertilionidae)		X	MD: S5/ DC S2	2, 3	

14	House Mouse	*Mus musculus*	Rats and mice (Muridae)	X		MD: SNA/ DC SNA	2, 3	Has been domesticated as a pet
15	Little Brown Bat	*Myotis lucifugus*	Bats (Vespertilionidae)		X	MD: S5/ DC S4	2, 3	
16	Long-tailed Weasel	*Mustela frenata*	Weasels (Mustelidae)		X	MD: S5/ DC S3	2, 3	
17	Masked Shrew	*Sorex cinereus*	Shrews (Soricidae)		X	MD: S5/ DC SNR	2, 3	
18	Meadow Jumping Mouse	*Zapus hudsonius*	Jumping mice (Dipodidae)		X	MD: S5/ DC S3	2, 3	
19	Meadow Vole	*Microtus pennsylvanicus*	Rodents (Cricetidae)		X	MD: S5/ DC S5	2, 3	
20	Muskrat	*Ondatra zibethicus*	Rodents (Cricetidae)		X	MD: S5/ DC S4	2, 3	Found mainly in wetlands but can adapt
21	North American Least Shrew	*Cryptotis parva*	Shrews (Soricidae)		X	MD: S5/ DC S4	2, 3	One of the smallest mammals
22	Northern Long-eared bat	*Myotis septentrionalis*	Bats (Vespertilionidae)		X	MD: S4/ DC S4	2, 3	
23	Northern Short-tailed S*hrew*	*Blarina brevicauda*	Shrews (Soricidae)		X	MD: S5/ DC S5	2, 3	
24	Norway Rat	*Rattus norvegicus*	Rats and mice (Muridae)	X		MD: SNA/ DC SNA	2, 3	
25	Red Fox	*Vulpes vulpes*	Dogs (Canidae)		X	MD: S5/ DC S4	2, 3	Very invasive in other countries
26	Smokey Shrew	*Sorex fumeus*	Shrews (Soricidae)		X	MD: S2/S3/ DC SNR	2, 3	
27	Southern Flying Squirrel	*Glaucomys volans*	Squirrels (Sciuridae)		X	MD: S5/ DC S5	2, 3	Can return to their nests if moved one mile away
28	Star-nosed mole	*Condylura cristata*	Moles (Talpidae)		X	MD: S4/ DC S3	2, 3	

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	Striped Skunk	*Mephitis mephitis*	Skunks (Mephitidae)	X	MD: S5/ DC S4	2, 3	Pry on honeybees by scratching the nest and waiting for them to come out
29							
30	Virginia Opossum	*Didelphis Virginiana*	Opossums (Didelphidae)	X	MD: S5/ DC S5	1, 2	
31	White-footed Deermouse	*Peromyscus leucopus*	Rodents (Cricetidae)	X	MD: S5/ DC S5	2, 3	One of the most common found in the United States
32	White-tailed deer	*Odocoileus virginianus*	Deer (Cervidae)	X	MD: S5/ DC S5	2, 3	
33	Woodchuck	*Marmota monax*	Squirrels (Sciuridae)	X	MD: S5/ DC S5	2, 3	Also refered to as the groundhog or the land baever
34	Woodland Vole	*Microtus pinetorum*	Rodents (Cricetidae)	X	MD: S5/ DC S4	2, 3	They live in burrows exclusive to the family groups

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2. Nature Serve
3. DNR

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Reptiles and Amphibians of the Anacostia River Watershed

Compiled by Emily Stransky, AWS Stewardship Intern and Jorge Bogantes Montero, AWS Conservation Biologist

Contributions from Rachel Gauza, head of the MARA (Maryland Amphibian and Reptile Atlas) Program, and Lindsay Rohrbaugh, Wildlife Biologist with DDOE

November, 2011

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Salamanders

Common name	Scientific name	Family	Non-Native	Native	Reference	Conservation status	Comments
Jefferson Salamander	*Ambystoma jeffersonianum*	Ambystomatidae		x	1,2	MD:S3/DC:NA	They are found in well shaded, deciduous forests, and breed in the early spring in seasonal pools
Marbled Salamander	*Ambystoma opacum*	Ambystomatidae		x (SGCN)	1,2	MD:S5/DC:S3	Adults are entirely terrestrial, but breed in seasonal pools and the females stay with the egg clutch

Spotted Salamander	*Ambystoma maculatum*	Ambystomatidae	x (SGCN)	1,2	MD:S5/DC:S4	Adults are most active during rain, at night, and during breeding periods, some individuals lack spots
Northern Dusky Salamander	*Desmognathus fuscus*	Plethodontidae	x (SGCN)	1,2	MD:S5/DC:S5	They are usually found near running or trickling water
Long-tailed Salamander	*Eurycea longicauda*	Plethodontidae	x	1,2	MD:S5/DC:SNR	Their colors vary from yellow to orange to red with black dumbbell shaped markings
Northern Two-lined Salamander	*Eurycea bislineata*	Plethodontidae	x (SGCN)	1,2	MD:S5/DC:S5	Females stay with the eggs during the approximately 30 day incubation period, and these are most common in stream habitat

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Mud Salamander	*Pseudotriton montanus*	Plethodontidae	x	1,2	MD:S2/DC:NA	They feed on arthropods and earthworms, and are typically found in muddy floodplains
Red Salamander	*Pseudotriton ruber*	Plethodontidae	x (SGCN)	1,2	MD:S5/DC:S3	The larval stage can last up to 5 years Females lay their eggs in moss next to a pool, which larvae can drop into after hatching, and they are distinguishable by the white belly and black spots, 4 toes on hind feet and squarish snout
Four-Toed Salamander	*Hemidactylium scutatum*	Plethodontidae	x	1,2	MD:S5/DC:SH	

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Eastern Red-backed Salamander	*Plethodon cinereus*	Plethodontidae	x (SGCN)	1,2	MD:S5/DC:S5	Their home range is usually less than a few meters across, and they are the most common woodland salamander
Northern Slimy Salamander	*Plethodon glutinosus*	Plethodontidae	x	1,2	MD:S5/DC:SH	Females stay with their eggs until they develop into larvae, and they have glue-like skin secretions when handled roughly
Red-Spotted Newt (Eastern Newt)	*Notophthalmus viridescens*	Salamandridae	x (SGCN)	1,2	MD:S5/DC:S3	They produce highly toxic skin secretions

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Toads and Frogs

Common name	Scientific name	Family	Non-Native	Native	Reference	Conservation status	Comments
American Toad	*Anaxyrus americanus*	Bufonidae		x (SGCN)	1,2	MD:S5/DC:S5	Their mating call lasts up to 30 seconds, it's a long, musical trill, they can mate with Fowler's toads, and have one or two warts per dark dorsal spot
Fowler's Toad	*Anaxyrus fowleri*	Bufonidae		x (SGCN)	1,2	MD:S5/DC:S5	Hognose snakes are immune to the toad's toxic skin excretions, they have three warts per dark dorsal spot, and typically have a

						white chest with central spot
American Bullfrog	*Lithobates catesbeianus*	Ranidae	x (SGCN)	1,2	MD:S5/DC:S4	Maryland's largest frog
Northern Green Frog	*Lithobates clamitans melanota*	Ranidae	x	1,2	MD:S5/DC:S5	Adult males' eardrums are larger than their eye, females and juveniles are about the same size
Pickerel Frog	*Lithobates palustris*	Ranidae	x (SGCN)	1,2	MD:S5/DC:S5	Their mating call is a 1-2 second long low snore

Southern Leopard Frog	*Lithobates sphenocephalus*	Ranidae	x	1,2	MD:S5,S4/DC:S3,S2	Usually have dark spots on the back with a yellow ridge extending down each side
Wood Frog	*Lithobates sylvaticus*	Ranidae	x (SGCN)	1,2	MD:S5/DC:S2	They have a dark "mask" across eyes, mating call is 1-8 loud clacks
Gray Treefrog	*Hyla versicolor*	Hylidae	x (SGCN)	1,2	MD:S5/DC:S4	Their mating call is loud slow trill, and they are identical to Cope's Gray Treefrog except for their call
Cope's Gray Treefrog	*Hyla chrysoscelis*	Hylidae	x	1,2	MD:S5/DC:S4	Their skin secretions can irritate human eyes and other membranes

Green Treefrog	*Hyla cinerea*	Hylidae	x	1,2	MD:S5/DC:SH	Their upper surface and part of the throat is usually green, but can range from yellow to gray, a breeding male has a gray or pinkish throat, and they often gather in large groups
Northern Spring Peeper	*Pseudacris crucifer*	Hylidae	x (SGCN)	1,2	MD:S5/DC:S4	These often have a dark "X" on their back
Upland Chorus Frog	*Pseudacris feriarum*	Hylidae	x	1,2	MD:S5/DC:SH	Mainly an upland frog in the North, but a lowland frog in the South, and have a dark triangle between the eyes

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Eastern Cricket Frog	*Acris crepitans*	Hylidae		x	1,2	MD:S4/DC:NA	This frog is very small, about 4 cm in length, with a dark triangle between the eyes on the back of the head and short hind legs
Eastern Spadefoot	*Scaphiopus holbrookii*	Scaphiopodidae		x	1,2	MD:S5/DC:NA	Their eye is elliptical in bright light, and there are sickle shaped spades on the inner underside of the hind feet

Turtles

Common name	Scientific name	Family	Non-Native	Native	Reference	Conservation status	Comments

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Spotted Turtle	*Clemmys guttata*	Emydidae		x (SGCN)	1,2	MD:S5/DC:S1	This is a small black turtle with yellow spots, although some individuals may lack spots on the carapace
Wood Turtle	*Glyptemys insculpta*	Emydidae		x (SGCN)	1,2	MD:S4/DC:SH	These lack a hinged plastron, their plastron is yellow with dark, irregular blotch on each scute
Eastern Box Turtle	*Terrapene carolina*	Emydidae		x (SGCN)	1,2	MD:S5/DC:S3	Their name comes from a hinged shell that allows the shell to become tightly closed
Red-eared Slider	*Trachemys scripta*	Emydidae	x		1,2	MD:S5/DC:SNR	These are aquatic, with a very small home range, and they have a prominent red or yellow patch on the head

Painted Turtle	*Chrysemys picta*	Emydidae		x (SGCN)	1,2	MD:S5/DC:S5	These have bright yellow lines on their head and limbs
Northern Red-bellied Cooter	*Pseudemys rubriventris*	Emydidae		x (SGCN)	1,2	MD:S5/DC:S4	They like large deep bodies of water, sometimes brackish
Chinese spiny softshell turtle	*Pelodiscus sinensis*	Trionychidae	x				
Stinkpot Turtle	*Stenothernus odoratus*	Kinosternidae		x (SGCN)	1,2	MD:S5/DC:S4	There are two light stripes on the head and neck, with barbells coming off chin and throat, and their plastron does not cover appendages

Eastern Mud Turtle	*Kinosternon subrubrum*	Kinosternidae		x (SGCN)	1,2	MD:S5/DC:SH	These have triangular pectoral scutes and a double hinged shell
Eastern Snapping Turtle	*Chelydra serpentina*	Chelydridae		x	1,2	MD:S5/DC:S5	These are large, up to 50 lbs, with powerful jaws, a plastron that does not cover appendages and they are mostly aquatic

Snakes

Common name	Scientific name	Family	Non-Native	Native	Reference	Conservation status	Comments

Copperhead	*Agkistrodon contortrix*	Viperidae	x (SGCN)	1,2	MD:S5/DC:S1	These are distinguishable as venomous snake by the slitted irises and pits located by eyes, they also have hour-glass like pattern down the body
Northern Water Snake	*Nerodia sipedon*	Colubridae	x	1,2	MD:S5/DC:S4	These are often mistaken for venomous Water Moccasin snakes, but are not venomous themselves, and they are very common in aquatic habitats
Queen Snake	*Regina septemvittata*	Colubridae	x (SGCN)	1,2	MD:S5/DC:S1	These occur only where there are crayfish, which are a main diet staple

Eastern Smooth Earthsnake	*Virginia valeriae*	Colubridae	x (SGCN)	1,2	MD:S4,S5/DC:SH	They do not come out into the open often, but are usually found under boards or logs
Northern Brownsnake	*Storeria dekayi*	Colubridae	x (SGCN)	1,2	MD:S5/DC:S4	This snake has two parallel lines of dark spots running down its back, it feeds on worms and soft-bodied insects and gives live birth
Red-bellied Snake	*Storeria occipitomaculata*	Colubridae	x	1,2	MD:S5/DC:SH	These are characterized by a red, unmarked belly, and will have three spots at the nape of the neck
Eastern Gartersnake	*Thamnophis sirtalis*	Colubridae	x (SGCN)	1,2	MD:S5/DC:S4	This snake has a checkerboard pattern on its back with a distinct yellow or white stripe down the center of its back

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Common Ribbon Snake	*Thamnophis sauritus*	Colubridae	x (SGCN)	1,2	MD:S5/DC:S4	They are found in wet areas, such as marshes, bogs, ponds and shallow streams, and they have three bold cream stripes down the back
Eastern Wormsnake	*Carphophis amoenus*	Colubridae	x (SGCN)	1,2	MD:S5/DC:S4	These are small in size, about 7-11 inches, and look similar to an earthworm
Rough Greensnake	*Opheodrys aestivus*	Colubridae	x (SGCN)	1,2	MD:S5/DC:S4	These are bright green snakes with a white or cream colored belly
Eastern Hog-nosed Snake	*Heterodon platirhinos*	Colubridae	x (SGCN)	1,2	MD:S5/DC:SH	These will fan out their neck, like a cobra, when approached and then play dead

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Rainbow Snake	*Farancia erytrogramma*	Colubridae		x	1,2	MD:S1/DC:NA	These are considered endangered in Maryland and are rarely found, they are a highly aquatic species with red, yellow and black stripes going vertically down their body
Northern Black Racer	*Coluber constrictor*	Colubridae		x (SGCN)	1,2	MD:S5/DC:S4	They are normally black or dark gray in color, with a white chin and conspicuous eye
Red Cornsnake	*Pantherophis guttatus*	Colubridae		x (SGCN)	1,2	MD:S4/DC:SH	An orange or orange-red snake, which eats most rodents

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Eastern Ratsnake	*Pantherophis alleghaniensis*	Colubridae	x	1,2	MD:S5/DC:S3,S5	Maryland's largest snake, and has an all black, shiny back
Mole Kingsnake	*Lampropeltis calligaster*	Colubridae	x	1,2	MD:S4/DC:SH	These are a subterranean, nocturnal species, with a yellow or greenish hued color
Eastern Kingsnake	*Lampropeltis getula*	Colubridae	x	1,2	MD:S5/DC:SH	These eat many other reptiles, and are shiny black, with white or light colored rings around its body
Eastern Milksnake	*Lampropeltis triangulum*	Colubridae	x	1,2	MD:S5/DC:SH	These are red with black bordered blotches down the back, and a blotch on the head that may resemble an A, Y, U, or V

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Coastal Plain Milksnake	*Lampropeltis triangulum elapsoides X triangulum*	Colubridae	x	1,2	N/A	This is a mix between the Eastern Milksnake and the Scarlet Kingsnake
Northern Scarletsnake	*Cemophora coccinea*	Colubridae	x	1,2	MD:S3/DC:NA	These are similar to the venomous Coral Snake, but are non-venomous and have black separating red and yellow (or white) sections, with an upper jaw that protrudes beyond the lower jaw
Ring-Necked Snake	*Diadophis punctatus*	Colubridae	x (SGCN)	1,2	MD:S5/DC:S4	These have a dark body with a cream/yellow ring around it's neck
Lizards and Skinks						

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Common name	Scientific name	Family	Non-Native	Native	References	Conservation status	Comments
Broad-headed Skink	*Plestiodon laticeps*	Scinidae		x	1,2	MD:S4/DC:S1	Maryland's largest skink, with juveniles and females resembling the five-lined skink
Common Five-lined Skink	*Plestiodon fasciatus*	Scinidae		x (SGCN)	1,2	MD:S5/DC:S4	These have 5 yellow or white stripes on their head, which extend down the back, and juveniles have a blue tail
Little Brown Skink	*Scincella lateralis*	Scinidae		x	1,2	MD:S5/DC:NA	They have a golden or dark brown back with a darker stripe running along either side

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Eastern Six-lined Racerunner	*Aspidoscelis sexlineatus*	Teiidae	x	1,2	MD:S4/DC:SH	These have 6 colored lines extending from the head to the tail
Eastern Fence Lizard	*Sceloporous undulatus*	Phrynosomatidae	x (SGCN)	1,2	MD:S5/DC:SH	These have pointed scales on the back, males have a bright blue patch on the belly and underside of the throat, while females have crossbands along the back

References and Acronyms

References	URL
1. Nature Serve	http://www.natureserve.org/explorer/
2. Maryland Department of Natural Resources	http://www.dnr.state.md.us/wildlife/Plants_Wildlife/herps/

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Birds of the Anacostia River Watershed

Compiled by Mallory Shramek, AWS Stewardship Intern and Jorge Bogantes Montero, AWS Conservation Biologist

July, 2011 UPDATED AUGUST 28, 2012 Michael Schramm

	Common Name	Scientific Name	Family	Non-native	Native	DC Conservation Status	MD Conservation Status	References	Comments
1	Acadian Flycatcher	*Empidonax virescens*	Flycatchers (Tyrannidae)		X	SNR	S5B	1, 2, 4	Passage migrant through the District of Columbia; primarily breeds in moist, upland deciduous forests with a moderate understory, generally near a stream.
2	Alder Flycatcher	*Empidonax alnorum*	Flycatchers (Tyrannidae)		X	S1N	S2B	1,3,6	
3	American Avocet	*Recurvirostra americana*	Avocets and Stilts (Recurvirostridae)		X	SNR	SNA	1, 2	
4	American Bittern	*Botaurus lentiginosus*	Bitterns, Egrets, and Herons (Ardeidae)		X	S1B	S1B	1, 2	Breed in freshwater marshes; local migrant within the District of Columbia.

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5	American Black Duck	*Anas rubripes*	Geese, Swans, and Ducks (Anatidae)	X	S3 S4N	S4B S5N	1, 2	Hybridization between the American Black Ducks and Mallards is a major concern.
6	American Coot	*Fulica americana*	Rails (Rallidae)	X	S2N	S3N	1, 2	
7	American Crow	*Corvus brachyrhynchos*	Crows and Jays (Corvidae)	X	S5B S5N	S5	1, 4	
8	American Goldfinch	*Spinus tristis*	Finches and Grosbeaks (Fringillidae)	X	S4N S5B	S5	1, 4	
9	American Kestrel	*Falco sparverius*	Falcons (Falconidae)	X	S2B S3N	S4N S5B	1, 3, 4	North American's smallest falcon.
10	American Pipit	*Anthus rubescens*	Pipits and Wagtails (Motacillidae)	X	S4N	S3N	1, 2	
11	American Redstart	*Setophaga ruticilla*	Warblers (Parulidae)	X	S1B S4N	S4B	1, 3, 4	Flashes its orange and black wings and tail to flush insect prey from foliage.
12	American Robin	*Turdus migratorius*	Thrushes (Turdidae)	X	S5B S5N	S5B S5N	1, 4	
13	American Tree Sparrow	*Spizella arborea*	Sparrows and Towhees (Emberizidae)	X	S4N	S3N	1,3,6	
14	American Wigeon	*Anas americana*	Geese, Swans, and Ducks (Anatidae)	X	S3N	S4N	1,3,6	

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15	American Woodcock	*Scolopax minor*	Sandpiper (Scolopacidae)	X	S3N	S4B S4N	1, 2	The most serious threat is habitat loss and alteration, through urbanization, reforestation, drainage of wetlands, and agricultural development.
16	Bald Eagle	*Haliaeetus leucocephalus*	Eagles and Hawks (Accipitridae)	X	S2N SXB	S2 S3B	1, 2	Migrant and breeder within the District of Columbia.
17	Baltimore Oriole	*Icterus galbula*	Blackbirds and Orioles (Icteridae)	X	S1B S3N	S5B	1	
18	Bank Swallow	*Riparia riparia*	Swallows and Martins (Hirundinidae)	X	S3N	S3 S4B	1,3,6	
19	Barn Owl	*Tyto alba*	Barn Owls (Tytonidae)	X	S1	S3	1, 4	
20	Barn Swallow	*Hirundo rustica*	Swallows and Martins (Hirundinidae)	X	S5B S5N	S5B	1, 4	
21	Barred Owl	*Strix varia*	True Owls (Strigidae)	X	S2	S5	1	

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22	Bay-breasted Warbler	*Dendroica castanea*	Warblers (Parulidae)	X	S3N	SNA	1, 3, 5	Benefits from spruce budworm outbreaks when the caterpillars provide abundant food - spraying to control the destructive outbreaks may have reduced populations of this warbler.
23	Belted Kingfisher	*Megacerycle alcyon*	Kingfishers (Alcedindae)	X	S2N S2 S3B	S5B S4N	1, 4	
24	Black Vulture	*Coragyps atratus*	New World Vultures (Cathartidae)	X	S1	S4B S4N	1, 2	
25	Black-and-white Warbler	*Mniotilta varia*	Warblers (Parulidae)	X	S4N	S4B	1, 4	
26	Blackburnian Warbler	*Dendroica fusca*	Warblers (Parulidae)	X	S3N	S1 S2B	1, 5	
27	Black-billed Cuckoo	*Coccyzus erythropthalmus*	Cuckoos (Cuculidae)	X	S1 S2N	S4B	1,3,6	
28	Black-capped Chickadee	*Poecile atricapillus*	Chickadees and Titmice (Paridae)	X	S1	S4	1,3,6	
29	Black-crowned Night-Heron	*Nycticorax nycticorax*	Bitterns, Egrets, and Herons (Ardeidae)	X	S3B	S3B S2N	1, 2, 4	Local migrant and breeder within the District of Columbia.

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30	Blackpoll Warbler	*Dendroica striata*	Warblers (Parulidae)	X	S4 S4N	SNA	1, 4	
31	Black-throated Blue Warbler	*Dendroica caerulescens*	Warblers (Parulidae)	X	S4N	S3 S4B	1, 4	
32	Black-throated Green Warbler	*Dendroica virens*	Warblers (Parulidae)	X	S4N	S4B	1, 4	
33	Blue Grosbeak	*Passerina caerulea*	Cardinals and Buntings (Cardinalidae)	X	S2B S2N	S5B	1, 4	
34	Blue Jay	*Cyanocitta cristata*	Crows and Jays (Corvidae)	X	S4N S5B	S5B S5N	1, 4	
35	Blue-gray Gnatcatcher	*Polioptila caerulea*	Gnatcatchers (Sylviidae)	X	S3B S3N	S5B	1, 3, 4	Flicks its white-edged tail from side to side to scare hiding insects.
36	Blue-headed Vireo	*Vireo solitarius*	Vireos (Vireonidae)	X	S2N	S3 S4B	1, 2	
37	Blue-winged Teal	*Anas discors*	Geese, Swans, and Ducks (Anatidae)	X	S2N	S2B S3 S4N	1,3,6	
38	Blue-winged Warbler	*Vermivora pinus*	Warblers (Parulidae)	X	S3N	S4B	1, 5	
39	Bobolink	*Dolichonyx oryzivorus*	Blackbirds and Orioles (Icteridae)	X	S3 S4N	S3 S4B	1, 2	Passage migrant through the District of Columbia.
40	Bonaparte's Gull	*Chroicocephalus philadelphia*	Gulls and Terns (Laridae)	X	S3N	S2N	1,3,6	
41	Broad-winged Hawk	*Buteo platypterus*	Eagles and Hawks (Accipitridae)	X	S1B S4N	S4B	1, 2	Passage migrant and breeder in the District of Columbia.

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42	Brown Creeper	*Certhis americana*	Creepers (Certhiidae)		X	S3N	S4	1, 2	Resident, local migrant, and breeder within the District of Columbia.
43	Brown Thrasher	*Toxostoma rufum*	Mimids and Thrashers (Mimidae)		X	S3B S3N	S5B S2N	1, 2	Resident, local migrant, and breeder in the District of Columbia.
44	Brown-headed Cowbird	*Molothrus ater*	Blackbirds and Orioles (Icteridae)		X	S4	S5	1, 4	
45	Bufflehead	*Bucephala albeola*	Geese, Swans, and Ducks (Anatidae)		X	S1 S2N	S5N	1, 2	
46	Canada Goose	*Branta canadensis*	Geese, Swans, and Ducks (Anatidae)	X	X	S5	S4B S5N	1, 4	
47	Canada Warbler	*Wilsonia canadensis*	Warblers (Parulidae)		X	S4N	S3B	1	
48	Cape May Warbler	*Dendroica tigrina*	Warblers (Parulidae)		X	S2 S3N	SNA	1, 5	
49	Carolina Chickadee	*Poecile carolinensis*	Chickadees and Titmice (Paridae)		X	S5	S5	1, 2	
50	Carolina Wren	*Thryothorus ludovicianus*	Wrens (Troglodytidae)		X	S5	S5	1, 4	
51	Caspian Tern	*Hydroprogne caspia*	Gulls and Terns (Laridae)		X	S1 S2N	SNA	1, 2	
52	Cattle Egret	*Bubulcus ibis*	Bitterns, Egrets, and Herons (Ardeidae)	X		SNA	S3 S4B	1,3,6	
53	Common Tern	*Sterna hirundo*	Gulls and Terns (Laridae)		X				

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54	Cedar Waxwing	*Bombycilla cedrorum*	Waxwings (Bombycillidae)	X	S1 S2B S4N	S5B S5N	1, 4	
55	Cerulean Warbler	*Dendroica cerulea*	Warblers (Parulidae)	X	S2N	S3 S4B	1, 2	Breeding populations in small forest tracts throughout the range are declining rapidly to extirpation.
56	Chestnut-sided Warbler	*Dendroica pensylvanica*	Warblers (Parulidae)	X	S4N	S4B	1, 5	
57	Chimney Swift	*Chaetura pelagica*	Swift (Apodidae)	X	S4N S5B	S5B	1, 2, 4	Passage migrant and breeder in the District of Columbia.
58	Chipping Sparrow	*Spizella passerina*	Sparrows and Towhees (Emberizidae)	X	S3B S4N	S5B S1N	1, 2	
59	Cliff Swallow	*Petrochelidon pyrrhonota*	Swallows and Martins (Hirundinidae)	X	S2N SHB	S3 S4B	1,3,6	
60	Common Grackle	*Quiscalus quiscula*	Blackbirds and Orioles (Icteridae)	X	S4 S5N S5B	S5	1, 4	
61	Common Loon	*Gavia immer*	Loons (Gaviidae)	X	SNA	S4N	1,3,6	

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62	Common Merganser	*Mergus merganser*	Geese, Swans, and Ducks (Anatidae)	X	S3N	S3N	1, 2	
63	Common Nighthawk	*Chordeiles minor*	Nightjars (Caprimulgidae)	X	S4N	S3 S4B	1	
64	Common Raven	*Corvus corax*	Crows and Jays (Corvidae)	X	SNA	S2	1,3,6	
65	Common Yellowthroat	*Geothlypis trichas*	Warblers (Parulidae)	X	S3B S4N	S5B	1, 4	
66	Cooper's Hawk	*Accipiter cooperii*	Eagles and Hawks (Accipitridae)	X	S3B S4N	S4B S4N	1	
67	Dark-eyed Junco	*Junco hyemalis*	Sparrows and Towhees (Emberizidae)	X	S5N	S2B	1, 2, 3	Easy to recognize by their crisp (though extremely variable) markings and the bright white tail feathers they habitually flash in flight.
68	Double-crested Cormorant	*Phalacrocorax auritus*	Cormorants (Phalacrocoracidae)	X	S4N	S1B S3 S4N	1, 2	
69	Downy Woodpecker	*Picoides pubescens*	Woodpeckers (Picidae)	X	S5	S5	1, 4	
70	Eastern Bluebird	*Sialia Sialis*	Thrushes (Turdidae)	X	S4N	S5B S4N	1, 4	
71	Eastern Kingbird	*Tyrannus tyrannus*	Flycatchers (Tyrannidae)	X	S4B	S5B	1, 4	

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72	Eastern Meadowlark	*Sturnella magna*	Blackbirds and Orioles (Icteridae)		X	S1B S4N	S5B S3N	1, 2, 3	Local habitat: Rock Creek National Park, Kenilworth Park, Anacostia Park, and Oxon Cove Park.
73	Eastern Phoebe	*Sayornis phoebe*	Flycatchers (Tyrannidae)		X	S3B	S5B	1, 4	
74	Eastern Screech-Owl	*Megascops asio*	True Owls (Strigidae)		X	S1	S5	1	
75	Eastern Towhee	*Pipilo erythrophthalmus*	Sparrows and Towhees (Emberizidae)		X	S4B S4 S5N	S5B S4N	1, 2	Local habitat: Rock Creek National Park, Kenilworth Park, Anacostia Park, Oxon Run Parkway, Oxon Cove Park, and the Fort Circle Parks area.
76	Eastern Wood-Pewee	*Contopus virens*	Flycatchers (Tyrannidae)		X	SNR	S5B	1, 4	
77	European Starling	*Sturnus vulgaris*	Starlings (Sturnidae)	X		SNA	SNA	1, 4	
78	Field Sparrow	*Spizella pusilla*	Sparrows and Towhees (Emberizidae)		X	S2B S4N	S5	1, 2, 4	Current intensive agricultural practices and spreading urbanization continue to restrict, or eliminate nesting habitat of old weedy fields with shrubs or small trees.

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79	Fish Crow	*Corvus ossifragus*	Crows and Jays (Corvidae)	X	S1 S2N S3B	S5	1, 4
80	Forster's Tern	*Sterna forsteri*	Gulls and Terns (Laridae)	X	S2 S3N	S4B	1,3,6
81	Fox Sparrow	*Passerella iliaca*	Sparrows and Towhees (Emberizidae)	X	S3N	S2N	1, 2
82	Gadwall	*Anas strepera*	Geese, Swans, and Ducks (Anatidae)	X	SNA	S2B S4N	1,3,6
83	Glossy Ibis	*Plegadis falcinellus*	Ibises and Spoonbills (Threskiornithidae)	X	SNA	S4B	1,3,6
84	Golden-crowned Kinglet	*Regulus satrapa*	Kinglets (Regulidae)	X	S3 S4N	S2B	1, 2
85	Grasshopper Sparrow	*Ammodramus savannarum*	Sparrows and Towhees (Emberizidae)	X	S3N	S4B	1, 2

Populations declines have resulted in part from loss of habitat, especially the conversion of grassland to row-crop agriculture, urban sprawl, and reforestation, compounded by losses incurred as a result of mowing of habitat and subsequent increased predation.

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86	Gray Catbird	*Dumetella carolinensis*	Mimids and Thrashers (Mimidae)		X	S4N S5B	S5B S1N	1, 4
87	Gray Cheeked Thrush	*Catharus minimus*	Thrushes (Turdidae)		X	S3N	SNA	1, 5
88	Great Black-backed Gull	*Larus marinus*	Gulls and Terns (Laridae)		X	S5N	S4B	1, 4
89	Great Blue Heron	*Ardea herodias*	Bitterns, Egrets, and Herons (Ardeidae)		X	S4N	S4B S3 S4N	1, 4
90	Great Crested Flycatcher	*Myiarchus crinitus*	Flycatchers (Tyrannidae)		X	S3B	S5B	1, 4
91	Great Egret	*Ardea alba*	Bitterns, Egrets, and Herons (Ardeidae)		X	S4N	S4B	1
92	Great Horned Owl	*Bubo virginianus*	True Owls (Strigidae)		X	S2	S5	1, 2	Local habitat: Rock Creek National Park, Kenilworth Park, Oxon Cove Park, and the Fort Circle Parks area.
93	Greater Scaup	*Aythya marila*	Geese, Swans, and Ducks (Anatidae)		X	S1N	S4N	1,3,6
94	Greater Yellowlegs	*Tringa melanoleuca*	Sandpiper (Scolopacidae)		X	S3N	S1N	1, 2
95	Green Heron	*Butorides virescens*	Bitterns, Egrets, and Herons (Ardeidae)		X	S3 S4B S3 S4N	S5B	1

96	Green-winged Teal	*Anas crecca*	Geese, Swans, and Ducks (Anatidae)		X	S2N	S4N	1,3,6	
97	Hairy Woodpecker	*Picoides villosus*	Woodpeckers (Picidae)		X	S3	S5	1, 4	
98	Hermit Thrush	*Catharus guttatus*	Thrushes (Turdidae)		X	S3N	S3 S4B S4N	1, 4	
99	Herring Gull	*Larus argentatus*	Gulls and Terns (Laridae)		X	S4N	S5B S5N	1, 4	
100	Hooded Merganser	*Lophodytes cucullatus*	Geese, Swans, and Ducks (Anatidae)		X	S3N	S1B	1	
101	Hooded Warbler	*Wilsonia citrina*	Warblers (Parulidae)		X	S3 S4N	S4 S5B	1, 2, 4	Passage migrant within the District of Columbia.
102	Horned Grebe	*Podiceps auritus*	Grebes (Podicipedidae)		X	SNA	S4N	1,3,6	
103	Horned Lark	*Eremophila alpestris*	Larks (Alauidae)		X	S2N	S4B S4N	1,3,6	
104	House Finch	*Carpodacus mexicanus*	Finches and Grosbeaks (Fringillidae)	X		SNA	SNA	1, 4	
105	House Sparrow	*Passer domesticus*	Old World Sparrows (Passeridae)	X		SNA	SNA	1, 4	
106	House Wren	*Troglodytes aedon*	Wrens (Troglodytidae)		X	S4N S5B	S5B	1, 4	
107	Indigo Bunting	*Passerina cyanea*	Cardinals and Buntings (Cardinalidae)		X	S4 S5N S5B	S5B	1, 4	

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108	Kentucky Warbler	*Oporornis formosus*	Warblers (Parulidae)	X	S3 S4N	S4B	1, 2, 4	Breeds in humid deciduous forest, dense second growth, swamps.
109	Killdeer	*Charadrius vociferus*	Plovers and Lapwings (Charadriidae)	X	S2B S4N	S5B S4N	1, 4	
110	Laughing Gull	*Leucophaeus atricilla*	Gulls and Terns (Laridae)	X	S3N	S1B S4N	1, 4	
111	Least Bittern	*Lxobrychus exilis*	Bitterns, Egrets, and Herons (Ardeidae)	X	S1B S2N	S2 S3B	1, 2	Breeds in tall emergent vegetation in marshes, primarily freshwater, less commonly in coastal brackish marshes and mangrove swamps.
112	Least Flycatcher	*Empidonax minimus*	Flycatchers (Tyrannidae)	X	S2 S3N	S3 S4B	1,3,6	
113	Least Sandpiper	*Calidris minutilla*	Sandpiper (Scolopacidae)	X	S3N	SNA	1,3,6	
114	Least Tern	*Sternula antillarum*	Gulls and Terns (Laridae)	X	SNR	S2B	1	
115	Lesser Black-Backed Gull	*Larus fuscus*	Gulls and Terns (Laridae)	X	SNR	SNA	1, 3	
116	Lesser Scaup	*Aythya affinis*	Geese, Swans, and Ducks (Anatidae)	X	S2S3N	S4N	1, 2	
117	Lesser Yellowlegs	*Tringa flavipes*	Sandpiper (Scolopacidae)	X	S3N	S1N	1, 2	

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118	Lincoln's Sparrow	*Melospiza lincolnii*	Sparrows and Towhees (Emberizidae)	X	SNA	SNA	1,3,6	
119	Little Blue Heron	*Egretta caerulea*	Bitterns, Egrets, and Herons (Ardeidae)	X	S3N	S3B	1, 2	
120	Louisiana Waterthrush	*Seiurus motacilla*	Warblers (Parulidae)	X	S3 S4N	S5B	1, 2, 4	Breeds in moist forest, woodland, and ravines along streams, mature deciduous and mixed floodplain and swamp forests.
121	Magnolia Warbler	*Dendroica magnolia*	Warblers (Parulidae)	X	S4N	S3 S4B	1, 4	
122	Mallard	*Anas platyrhynchos*	Geese, Swans, and Ducks (Anatidae)	X	S4N S5B	SNA	1, 4	
123	Marsh Wren	*Cistothorus palustris*	Wrens (Troglodytidae)	X	S1B S3N	S4B S2N	1, 2	Local habitat: Kenilworth Park and Anacostia Park.
124	Merlin	*Falco columbarius*	Falcons (Falconidae)	X	S1N	S1N	1,3,6	
125	Mourning Dove	*Zenaida macroura*	Doves (Columbidae)	X	S4N S5B	S5	1, 4	
126	Mourning Warbler	*Oporornis philadelphia*	Warblers (Parulidae)	X	S2N	S1B	1, 5	
127	Nashville Warbler	*Vermivora ruficapilla*	Warblers (Parulidae)	X	S2N	S1 S2B	1, 5	

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128	Northern Bobwhite	*Colinus virginianus*	Quails (Odontophoridae)	X	S1	S5	1, 2	Principal threat appears to be habitat loss and fragmentation associated with changing land use, particularly clean farming techniques, single crop production, plantation forestry, fire suppression, replacement of native grass pasture with Tall Fescue, and over-grazing by cattle.
129	Northern Cardinal	*Cardinalis cardinalis*	Cardinals and Buntings (Cardinalidae)	X	S5	S5	1, 4	
130	Northern Flicker	*Colaptes auratus*	Woodpeckers (Picidae)	X	S2 S3N S5B	S5B S5N	1, 4	
131	Northern Goshawk	*Accipiter gentilis*	Eagles and Hawks (Accipitridae)	X	SNA	S1B	1,3,6	
132	Northern Harrier	*Circus cyaneus*	Eagles and Hawks (Accipitridae)	X	S2N	S2B	1, 2	
133	Northern Mockingbird	*Mimus polyglottos*	Mimids and Thrashers (Mimidae)	X	S5	S5	1, 4	
134	Northern Parula	*Parula americana*	Warblers (Parulidae)	X	S3B S3N	S4 S5B	1, 4	
135	Northern Pintail	*Anas acuta*	Geese, Swans, and Ducks (Anatidae)	X	S2N	S4N	1,3,6	

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136	Northern Rough-winged Swallow	*Stegidopteryx serripennis*	Swallows and Martins (Hirundinidae)	X	S2N S3B	S4B	1, 4	
137	Northern Shoveler	*Anas clypeata*	Geese, Swans, and Ducks (Anatidae)	X	S1N	S2N	1,3,6	
138	Northern Waterthrush	*Seiurus noveboracensis*	Warblers (Parulidae)	X	S3N	S2S3B	1, 4	
139	Orange-crowned Warbler	*Oreothlypis celata*	Warblers (Parulidae)	X	S1N	SNA	1,3,6	
140	Orchard Oriole	*Icterus spurius*	Blackbirds and Orioles (Icteridae)	X	S1B S3S4N	S5B	1, 4	
141	Osprey	*Pandion haliaetus*	Eagles and Hawks (Accipitridae)	X	S2 S3N	S4B	1, 4	
142	Ovenbird	*Seiurus aurocapilla*	Warblers (Parulidae)	X	S2B S3N	S5B	1, 2, 4	Typically nests in mid-late successional, closed-canopied deciduous or deciduous-coniferous forests that have deep leaf litter and limited understory.
143	Palm Warbler	*Dendroica palmarum*	Warblers (Parulidae)	X	S3N	S2N	1, 2	
144	Pectoral Sandpiper	*Calidris melanotos*	Sandpiper (Scolopacidae)	X	S2N	SNA	1,3,6	
145	Peregrine Falcon	*Falco peregrinus*	Falcons (Falconidae)	X	S1B S1N	S2B S3N	1, 2	

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146	Philadelphia Vireo	*Vireo philadelphicus*	Vireos (Vireonidae)	X	S1N	SNA	1, 5	
147	Pied-billed Grebe	*Podilymbus podiceps*	Grebes (Podicipedidae)	X	S4 S5N	S2B	1, 2	
148	Pileated Woodpecker	*Dryocopul pileatus*	Woodpeckers (Picidae)	X	S3	S5	1, 4	
149	Pine Siskin	*Spinus pinus*	Finches and Grosbeaks (Fringillidae)	X	S1N	S1 S2N	1,3,6	
150	Pine Warbler	*Dendroica pinus*	Warblers (Parulidae)	X	S1B S1 S3N	S4B S2N	1, 4	
151	Prairie Warbler	*Dendroica discolor*	Warblers (Parulidae)	X	S1B S2N	S4B	1, 2	
152	Prothonotary Warbler	*Protonotaria citrea*	Warblers (Parulidae)	X	S1B	S4B	1, 2	Breeds in mature deciduous floodplain, river, and swamp forests; wet lowland forest.
153	Purple Finch	*Carpodacus purpureus*	Warblers (Parulidae)	X	S3N	S3B S3N	1, 5	
154	Purple Martin	*Progne subis*	Swallows and Martins (Hirundinidae)	X	S1B S5N	S5B	1,3,6	
155	Red-bellied Woodpecker	*Melanerpes carolinus*	Woodpeckers (Picidae)	X	S5	S5	1, 4	
156	Red-breasted Merganser	*Mergus serrator*	Geese, Swans, and Ducks (Anatidae)	X	S2N	S3N	1,3,6	
157	Red-breasted Nuthatch	*Sitta canadensis*	Nuthatches (Sittidae)	X	S1 S2N	S1B	1,3,6	
158	Red-eyed Vireo	*Vireo olivaceus*	Vireos (Vireonidae)	X	S5B S5N	S5B	1, 4	

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159	Red-headed Woodpecker	*Melanerpes erythrocephalus*	Woodpeckers (Picidae)		X	S1N SHB	S4	1,3,6	
160	Red-shouldered Hawk	*Buteo lineatus*	Eagles and Hawks (Accipitridae)		X	S2B S3N	S4 S5B S4N	1, 2, 4	Breeds in bottomland hardwoods and riparian areas to upland deciduous or mixed deciduous-conifer forest.
161	Red-tailed Hawk	*Buteo jamaicensis*	Eagles and Hawks (Accipitridae)		X	S3N	S5B S5N	1	
162	Red-winged Blackbird	*Agelaius phoeniceus*	Blackbirds and Orioles (Icteridae)		X	S4 S5N	S5	1, 4	
163	Ring-billed Gull	*Larus delawarensis*	Gulls and Terns (Laridae)		X	S2 S4N	S5N	1, 4	
164	Ring-necked Duck	*Aythya collaris*	Geese, Swans, and Ducks (Anatidae)		X	S3N	S2N	1,3,6	
165	Rock Pigeon	*Columba livia*	Doves (Columbidae)	X		SNA	SNA	3, 4	
166	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Cardinals and Buntings (Cardinalidae)		X	S3N	S3 S4B	1, 4	
167	Royal Tern	*Thalasseus maximus*	Gulls and Terns (Laridae)		X	SNR	S1B	1	
168	Ruby-crowned Kinglet	*Regulus calendula*	Kinglets (Regulidae)		X	S4N	S3N	1, 2	
169	Ruby-throated Hummingbird	*Archilochus colubris*	Hummingbirds (Trochilidae)		X	S3B S3N	S5B	1	
170	Ruddy Duck	*Oxyura jamaicensis*	Geese, Swans, and Ducks (Anatidae)		X	S3 S4N	S3N	1, 2	

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171	Rusty Blackbird	*Euphagus carolinus*	Blackbirds and Orioles (Icteridae)	X	S3N	S2 S3N	1,3,6	
172	Savannah Sparrow	*Passerculus sandwichensis*	Sparrows and Towhees (Emberizidae)	X	S1 S3N	S3 S4B S4N	1,3,6	
173	Scarlet Tanager	*Piranga olivacea*	Cardinals and Buntings (Cardinalidae)	X	S2B S4N	S5B	1, 2, 4	Local habitat: Rock Creek National Park, Kenilworth Park, Anacostia Park, Capitol Hill Parks, Oxon Run Parkway, Oxon Cove Park, and the Fort Circle Parks area.
174	Sedge Wren	*Cistothorus platensis*	Wrens (Troglodytidae)	X	SHB	S1B	1,3,6	
175	Semipalmated Plover	*Charadrius semipalmatus*	Plovers and Lapwings (Charadriidae)	X	S2N	SNA	1,3,6	
176	Semipalmated Sandpiper	*Calidris pusilla*	Sandpiper (Scolopacidae)	X	S2N	SNA	1,3,6	
177	Sharp-shinned Hawk	*Accipiter striatus*	Eagles and Hawks (Accipitridae)	X	S3N SHB	S1 S2B	1, 2	
178	Snow Bunting	*Plectrophenax nivalis*	Longspurs and Buntings (Calcariidae)	X	S1N	S1N	1,3,6	
179	Snowy Egret	*Egretta thula*	Bitterns, Egrets, and Herons (Ardeidae)	X	S2N	S3 S4B	1,3,6	
180	Solitary Sandpiper	*Tringa solitaria*	Sandpiper (Scolopacidae)	X	S3N	SNA	1, 2	

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181	Song Sparrow	*Melospiza melodia*	Sparrows and Towhees (Emberizidae)	X	S5B S5N	S5	1, 4	
182	Sora	*Porzana carolina*	Rails (Rallidae)	X	S2N	S1B	1, 2, 3	Nesting habitat includes freshwater swamps, bogs, and swamps with dense stands of cattails, reeds, bulrushes, or sedges.
183	Spotted Sandpiper	*Actitis macularius*	Sandpiper (Scolopacidae)	X	S4N	S3 S4B	1, 3, 4	
184	Summer Tanager	*Piranga rubra*	Cardinals and Buntings (Cardinalidae)	X	S1 S2B S1 S2N	S4B	1,3,6	
185	Swainson's Thrush	*Catharus ustulatus*	Thrushes (Turdidae)	X	S4N	SXB	1, 4	
186	Swamp Sparrow	*Melospiza gerorgiana*	Sparrows and Towhees (Emberizidae)	X	S2 S3N	S4B S5N	1, 2	
187	Tennessee Warbler	*Vermivora peregrina*	Warblers (Parulidae)	X	S2 S3N	SNA	1, 5	
188	Tree Swallow	*Tachycineta bicolor*	Swallows and Martins (Hirundinidae)	X	S1B	S4B	1, 4	
189	Tricolored Heron	*Egretta tricolor*	Bitterns, Egrets, and Herons (Ardeidae)	X	S1N	S3B	1,3,6	
190	Tufted Titmouse	*Baeolophus bicolor*	Chickadees and Titmice (Paridae)	X	S5	S5	1, 4	

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191	Tundra Swan	*Cygnus columbianus*	Geese, Swans, and Ducks (Anatidae)	X	S2N	S4N	1,3,6	
192	Turkey Vulture	*Cathartes aura*	New World Vultures (Cathartidae)	X	S3N	S5B S5N	1, 2	
193	Upland Sandpiper	*Bartramia longicauda*	Sandpiper (Scolopacidae)	X	S1N	S1B	1, 2	
194	Veery	*Catharus fuscescens*	Thrushes (Turdidae)	X	S2B S3N	S4B	1, 4	
195	Vesper Sparrow	*Pooecetes gramineus*	Sparrows and Towhees (Emberizidae)	X	S3N	S3 S4B S2N	1,3,6	
196	Virginia Rail	*Rallus limicola*	Rails (Rallidae)	X	S1N SHB	S4B S4N	1, 2	Inhabits shallow, freshwater, emergent wetlands of every size and type, from roadside ditches and borders of lakes and streams to large cattail marshes.
197	Warbling Vireo	*Vireo gilvus*	Vireos (Vireonidae)	X	S1B S1S2N	S4B	1, 4	
198	Western Sandpiper	*Calidris mauri*	Sandpiper (Scolopacidae)	X	S1 S2N	SNA	1,3,6	
199	Whip-poor-will	*Caprimulgus vociferus*	Nightjars (Caprimulgidae)	X	S3N	S3 S4B	1	
200	White-breasted Nuthatch	*Sitta carolinensis*	Nuthatches (Sittidae)	X	S3B S3N	S5	1	

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201	White-crowned Sparrow	*Zonotrichia leucophrys*	Sparrows and Towhees (Emberizidae)	X	S3N	S3 S4N	1,3,6	
202	White-eyed Vireo	*Vireo griseus*	Vireos (Vireonidae)	X	S1B S2 S4N	S5B	1, 2, 4	During breeding season, inhabits early-late successional, shrubby habitats such as deciduous scrub, old fields, abandoned pastures, regenerating clearcuts or other heavily logged areas, drainage and streamside thickets, forest edges, reclaimed strip mines, and mangrove swamps.
203	White-rumped Sandpiper	*Calidris fuscicollis*	Sandpiper (Scolopacidae)	X	S1N	SNA	1	
204	White-throated Sparrow	*Zonotrichia albicollis*	Sparrows and Towhees (Emberizidae)	X	S5N	S5N	1, 4	

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205	Wild Turkey	*Meleagris gallopavo*	Turkeys and pheasants (Phasianidae)	X	SNR	S4	1, 2	
206	Willet	*Tringa semipalmata*	Sandpiper (Scolopacidae)	X	S2N	S3 S4B	1,3,6	
207	Willow Flycatcher	*Empidonax traillii*	Flycatchers (Tyrannidae)	X	SNR	S4B	1	
208	Wilson's Snipe	*Gallinago delicata*	Sandpiper (Scolopacidae)	X	S2 S3N	S2N	3	
209	Wilson's Warbler	*Wilsonia pusilla*	Warblers (Parulidae)	X	S2 S3N	SNA	1, 2	
210	Winter Wren	*Troglodytes troglodytes*	Wrens (Troglodytidae)	X	S2 S3N	S2B	1, 2	
211	Wood Duck	*Aix sponsa*	Geese, Swans, and Ducks (Anatidae)	X	S3N S4B	S5B S3N	1, 2, 4	Inhabits quiet inland waters near woodland, such as wooded swamps, flooded forest, greentree reservoirs, ponds, marshes, and along streams. Local habitat: Rock Creek National Park, Anacostia Park, Kenilworth Park, Oxon Run Parkway, Oxon Cove Park, and the Fort Circle Parks area.
212	Wood Thrush	*Hylocichla mustelina*	Thrushes (Turdidae)	X	S3B S4N	S5B	1, 2, 4	

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213	Worm-eating Warbler	*Helmitheros vermivorum*	Warblers (Parulidae)	X	S2N	S4B	1, 2	Breeds in well-drained upland deciduous forests with understory patches of mountain laurel or other shrubs, drier portions of stream swamps with an understory of mountain laurel, deciduous woods near streams
214	Yellow Warbler	*Dendroica petechia*	Warblers (Parulidae)	X	S2N	S5B	1, 4	
215	Yellow-bellied sapsucker	*Sphyrapicus varius*	Woodpeckers (Picidae)	X	S2N	SHB S3N	1, 2	
216	Yellow-bellied Flycatcher	*Empidonax flaviventris*	Flycatchers (Tyrannidae)	X	S1 S2N	SNA	1,3,6	
217	Yellow-billed Cuckoo	*Coccyzus americanus*	Cuckoos (Cuculidae)	X	S2B S3N	S5B	1, 4	
218	Yellow-breasted Chat	*Icteria virens*	Warblers (Parulidae)	X	S3 S4N	S5B	1, 4	
219	Yellow-crowned Night Heron	*Nyctanassa violacea*	Bitterns, Egrets, and Herons (Ardeidae)	X	SHB	S2B	1	
220	Yellow-rumped Warbler	*Dendroica coronata*	Warblers (Parulidae)	X	S5N	S4N	1, 4	

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221	Yellow-throated Vireo	*Vireo flavifrons*	Vireos (Vireonidae)	X	S2 S3B S2 S3N	S4 S5B	1, 2	Breeds primarily in open deciduous forest and woodland, mixed forest near clearings or water, moist upland forest riparian woodland, tall floodplain forest, lowland swamp forest;
222	Yellow-throated Warbler	*Dendroica dominica*	Warblers (Parulidae)	X	S1N	S4B	1	

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APPENDIX B

Endangered Species Letter from Genevieve LaRouche to Fred Pinkney 11/2/2015

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United States Department of the Interior

FISH AND WILDLIFE SERVICE

Chesapeake Bay Field Office
177 Admiral Cochrane Drive
Annapolis, Maryland 21401
http://www.fws.gov/chesapeakebay

November 2, 2015

Fred Pinkney, Ph.D.
Senior Biologist
Environmental Contaminants Program
U.S. Fish and Wildlife Service
Chesapeake Bay Field Office
177 Admiral Cochrane Drive
Annapolis, MD 21401

RE: "Not Likely to Adversely Affect" northern long-eared bat determination; Anacostia IPaC Database Results for Anacostia Watershed Restoration Studies in Montgomery and Prince George's Counties in Maryland

Dear Dr. Pinkney:

The U.S. Fish and Wildlife Service (Service) has reviewed your project information from the Service's Information for Planning and Conservation (IPaC) online system dated July 7, 2015. The Service has evaluated the potential effects of this project to the threatened northern long-eared bat (*Myotis septentrionalis*). The comments provided below are in accordance with Section 7 of the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*).

The purpose of this proposed project is to conduct feasibility studies of aquatic ecosystem restoration needs and opportunities within the Anacostia Watershed in Montgomery and Prince George's Counties in Maryland.

This project is within the range of the northern long-eared bat, a federally listed threatened species. The northern long-eared bat is a temperate, insectivorous migratory bat that hibernates in mines and caves in the winter and summers in wooded areas. Since the forest clearing for this proposed project is minimal, and there are no current records of northern long-eared bats in the project vicinity, this 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.

Except for occasional transient individuals, no other Federal proposed or listed endangered or threatened species under our jurisdiction are known to exist within the project impact area. Should project plans change, or if additional information on the distribution of listed or proposed species becomes available, this determination may be reconsidered.

TAKE PRIDE IN AMERICA

We appreciate the opportunity to provide information relevant to threatened and endangered fish and wildlife resources. This Endangered Species Act determination does not exempt this project from obtaining all permits and approvals that may be required by other State or Federal agencies.
If you have any questions or concerns regarding this letter, please contact Trevor Clark of my Endangered Species staff at (410) 573-4527 or by email at Trevor_Clark@fws.gov.

Sincerely,

G. La Rouche

Genevieve LaRouche
Supervisor

DRAFT

C-2: U.S. Fish and Wildlife Service Planning Aid Report

Evaluation of Stream Restoration Sites in Anacostia River Tributaries in Montgomery County and Prince Georges County, Maryland: Planning Aid Report

FINAL REPORT

CBFO-C15-01

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December 2015

ABSTRACT

The Baltimore District, U.S. Army Corps of Engineers (USACE) is conducting feasibility studies of aquatic ecosystem restoration needs and opportunities within the Anacostia Watershed in Montgomery County and Prince Georges County, Maryland. These studies build on the USACE Anacostia Restoration Plan completed in 2010. Report synopses for investigation of aquatic ecosystem restoration opportunities within the Corps mission were developed for the Anacostia Watershed of each county. For Montgomery County, the proposed project area includes seven candidate stream reaches in four sub-watersheds: Paint Branch, Little Paint Branch, Sligo Creek, and Northwest Branch. For Prince Georges County, the proposed project area includes ten candidate stream reaches within six subwatersheds: Indian Creek, Little Paint Branch, Paint Branch, Northwest Branch, Northeast Branch, and Sligo Creek. The Report Synopses identify problems and opportunities, planning goals and objectives, with a focus on stream restoration in candidate reaches. Selection of the reaches for restoration is scheduled to occur in late 2015 or early 2016. The U.S. Fish and Wildlife Service Chesapeake Bay Field Office (CBFO) is working with USACE on evaluating the environmental benefits to fish and wildlife resources from the proposed projects. Here we present a Planning Aid Report (PAR) consisting of: 1) an analysis of available information on fishing, potential for anadromous fish migration, and educational use of all candidate stream reaches of interest in both counties; 2) a Function-based Rapid Stream Assessment of the following stream reaches assigned to USFWS by USACE: Montgomery County—Sligo Creek (Site #12; 0.7 miles), Prince Georges County—Paint Branch (Site #5, 1.2 miles), and Little Paint Branch (0.8 miles). The Sligo Creek stream reach in Montgomery County (Site #12) includes portions of an unnamed tributary and the mainstem Sligo Creek. The unnamed tributary and mainstem were assessed separately for this site.

Based on a map provided by Jorge Montero of the Anacostia Watershed Society, three of the candidate reaches (all in Prince Georges County) have documented recreational fishing: Paint Branch (PG#5), Northeast Branch (PG Site #15), and Northeast Branch-Riggs Road (PG Site #13) Survey data from Montgomery County Department of the Environment showed that the following game species were collected from four of the seven candidate reaches: American eel, sunfish sp., redbreasted sunfish, green sunfish, bluegill, pumpkinseed, brown bullhead, smallmouth and largemouth bass. Survey data from Prince Georges County were obtained from a search of the Maryland Department of Natural Resources Maryland Biological Stream Survey data base. The following game species were collected from four of the ten candidate reaches: green and redbreasted sunfish, bluegill, largemouth and smallmouth bass, striped bass, fallfish, white sucker, American eel, yellow bullhead. The other candidate reaches in each county were not sampled.

The historical range of anadromous fish migration generally follows the line between Montgomery and Prince Georges County. It is important to recognize these historical limits of anadromous fish migration in evaluating the benefits of removing stream blockages. Therefore, removal of stream blockages in or near the candidate Montgomery County stream reaches would not benefit anadromous fish which would not migrate that

far in any case. Removal of any blockages in or near all of the candidate stream reaches in Prince Georges County would be within the area of historic anadromous fish migration and would potentially benefit those species if there was an increase in blockage-free stream miles.

All of the candidate stream reaches have the potential to serve as living classrooms for educating students of all ages. Signage and kiosks can explain to the public the reason for the project and whether it has been successful through before and after photographs of habitat or monitoring data. Local watershed groups such as the Anacostia Watershed Society (AWS) provide opportunities for citizens to conduct activities such as water quality monitoring, trail maintenance, and invasive plant removal. The Anacostia Watershed is frequented by birders who document their observations in the eBird data base, and several of the stream reach sites may be suitable locations for birding. AWS maintains lists of reported amphibian, reptile, bird, and mammal species within the watershed.

Based on results of the Function-based Rapid Stream Assessment of the three assigned reaches, in Montgomery County Sligo Creek tributary has the potential for the most functional lift, and therefore has the highest priority, followed by Sligo Creek mainstem. In Prince Georges County, Paint Branch has the highest priority, followed by Little Paint Branch. Overall for both counties Sligo Creek tributary has the highest priority, followed by Sligo Creek mainstem, Paint Branch, and Little Paint Branch, Paint Branch, and Little Paint Branch. Until the stressors in the watershed are addressed, water quality and biological lift in all of the stream segments is severely limited. However, if the streams are reconnected to their floodplains, lateral instability is reduced, and bedform diversity is improved, the subsequent reduction in sediment and nutrients will result in at least partial water quality and biological lift in areas where tolerant species already exist. These tolerant species will be able to inhabit the stream reaches, even if more intolerant species cannot.

ACKNOWLEDGMENTS

We thank Ray Li for assistance in the field. This project was funded by the Baltimore District, U.S. Army Corps of Engineers. We appreciate the help of Chris Spaur and Andrew Roach of the Baltimore District.

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INTRODUCTION

Federal agencies have been working with state and local agencies for decades on the restoration of the Anacostia Watershed. The US Environmental Protection Agency designated the Anacostia River as one of three Regions of Concern for toxic contamination in the Chesapeake Bay. The U.S. Fish and Wildlife Service (Service) Chesapeake Bay Field Office (CBFO) has conducted studies aimed at documenting the magnitude and effects of toxic chemical impacts in the tidal river. These included studies of the concentrations of toxic chemicals in fish tissues, the prevalence of tumors in brown bullhead catfish, the bioaccumulation of contaminants in deployed clams, and toxicity of ambient waters to larval fish. In coordination with state and local agencies, the National Oceanic and Atmospheric Administration and the U.S. Environmental Protection Agency have worked to reduce the flow of pollutants into the watershed.

Biological resources within the watershed are summarized in USACE (2010) and by Metropolitan Washington Council of Governments (Galli et al. 2010). According to Galli et al.2010), 50 fish species have been documented within the watershed since 2008 (Table 1). Galli et al. produced watershed maps that indicate the biological conditions for fish and macroinvertebrates within the subwatersheds. In general, poor and fair conditions are common. MDE (2012) stated that approximately 95% of stream miles in the watershed have poor to very poor ratings for fish and/or benthic macroinvertebrates. Causes include poor water quality, altered hydrology, and degraded in-stream habitat. Beginning in 1991, some fish blockages within the watershed have been removed. Anadromous fish runs, however, may be limited by about 120-130 remaining fish blockages (USACE 2010).

CBFO biologists have also provided support on numerous restoration projects through multiple partnerships. This includes reviewing the U.S. Army Corps of Engineers (USACE 2010) Anacostia Restoration Plan, commenting on monitoring protocols proposed by the Metropolitan Washington Council of Governments, and serving on the Anacostia Watershed Toxics Alliance, and the Leadership Council for a Cleaner Anacostia. CBFO also conducted stream restoration projects within the watershed, including the 1.8 mile Watt's Branch project (completed in 2011), which reduced bank erosion by an estimated 1500 tons per year.

Many Federal Agencies have promoted efforts to increase recreation within the watershed. The National Park Service helped obtain funding for a riverside trail along the Anacostia. Fourteen federal agencies have collaborated with local and private partners in the Urban Waters Federal Partnership Anacostia Pilot to improve water quality, aid underprivileged communities, and encourage urban residents to enjoy the natural resources of the Anacostia River.

The Baltimore District, U.S. Army Corps of Engineers (USACE) is conducting feasibility studies of aquatic ecosystem restoration needs and opportunities within the Anacostia Watershed in Montgomery County and Prince Georges County, Maryland. These studies build on the USACE (2010) Anacostia Restoration Plan. Report synopses for

investigation of aquatic ecosystem restoration opportunities within the Corps mission were developed for the Anacostia Watershed of each county (USACE 2015a, b). For Montgomery County, the proposed project area includes seven candidate stream reaches in four sub-watersheds: Paint Branch, Little Paint Branch, Sligo Creek, and Northwest Branch (Figure 1). For Prince Georges County, the proposed project area includes ten candidate stream reaches within six subwatersheds: Indian Creek, Little Paint Branch, Paint Branch, Northwest Branch, Northeast Branch, and Sligo Creek (Figure 2). The Report Synopses identify problems and opportunities, planning goals and objectives, with a focus on stream restoration in candidate reaches. Selection of the reaches for restoration is scheduled to occur in late 2015 or early 2016 (USACE 2015a, b).

CBFO is working with USACE on evaluating the environmental benefits to fish and wildlife resources from the proposed projects. Here we present a Planning Aid Report (PAR) consisting of: 1) an analysis of available information on fishing, potential for anadromous fish migration, and educational use of all candidate stream reaches of interest in both counties; 2) a Function-based Rapid Stream Assessment of the following stream reaches: Montgomery County—Sligo Creek (Site Mont #12; 0.7 miles), Prince Georges County—Paint Branch (Site PG #5, 1.2 miles) and Little Paint Branch (Site PG#12, 0.8 miles). These particular reaches were assigned to USFWS by USACE.

METHODS

Study Area

The study area for the project consists of seven stream reaches in Montgomery County (Figure 1) and ten reaches in Prince Georges County (Figure 2) being evaluated for stream restoration. These stream reaches were evaluated for their use as recreational fishing areas, the potential for anadromous fish migration, and the overall potential for environmental educational activities. As noted above, a subset of these reaches: Montgomery County—Sligo Creek (Site Mont #12; 0.7 miles), Prince Georges County—Paint Branch (Site PG#5, 1.2 miles), and Little Paint Branch (Site PG#12; 0.8 miles) were evaluated using the Function-based Rapid Stream Assessment.

Data and document analysis

<u>Fishing, Anadromous Fish Migration, and Education</u>

Documents and data were obtained through contacts with the Counties, Maryland Department of Natural Resources, Metropolitan Washington Council of Governments, the Interstate Commission for the Potomac River basin, and the Anacostia Watershed Society.

Function-based Rapid Stream Assessment methodology

Assessment of the stream segments consisted of four steps:

1. Reach-scale function-based rapid stream assessment

2. Restoration potential
3. Potential lift
4. Restoration priority

The function-based rapid stream assessment methodology was developed based on the Stream Functions Pyramid Framework (SFPF) (Harman et. al. 2012), which focuses on the hierarchical relationship of stream functions to determine the overall functional condition of a stream reach. The function-based rapid stream assessment methodology evaluates aspects of the stream functions identified in the SFPF. Hydrologic (level 1), hydraulic (level 2), geomorphic (level 3), physicochemical (level 4), and biologic (level 5) functions are evaluated, however, in order to remain a rapid methodology, only parameters that are critical to understanding stream processes are evaluated (Starr et.al. 2015). For the purpose of this study, the methodology included two parts: watershed assessment and rapid stream assessment. The watershed assessment identifies potential constraints and stressors that may influence the stream segment (and potential restoration), and was completed based on information provided by USACE (2015a,b). For the purposes of this study the rapid function-based assessment methodology was used to rapidly determine existing function-based stream conditions and the potential function-based uplift due to restoration for each stream segment identified by USACE. The stream segments are split into stream reaches according to existing conditions, and reaches were numbered starting at the upstream limit of the stream segment. The methodology uses a rating system of Functioning (F), Functioning-At-Risk (FAR) and Not Functioning (NF). Detailed information about the methodology can be found in the document: FINAL DRAFT – Function-Based Rapid Stream Assessment Methodology (Starr et. al. 2015).

Restoration potential determines the highest level of restoration that can be achieved, given the watershed conditions, function-based assessment results, and known stressors and constraints. It identifies the highest pyramid level that a stream segment can achieve after restoration.

Potential lift determines how much lift a reach can achieve after restoration. It is based on the existing function-based stream conditions of each assessment parameter, as determined by the rapid methodology. Each stream reach was ranked using a rating system of maximum, moderate, and low. Flood plain connectivity is particularly important when determining potential lift because it is an easy to measure, lower level function (level 2 - hydraulics) which influences many of the other levels. For example, if a stream is not connected to its flood plain, there can be reduced groundwater recharge from stream flow and subsequent decreases in riparian condition, increase in erosion and sedimentation due to changes in stream energy, and lower in-stream species diversity (Harman et. al. 2012). Therefore, if flood plain connectivity is not functioning, many other parameters cannot be functioning. If the flood plain connectivity is NF, the potential lift is maximum. If the flood plain connectivity is FAR, and any other parameter is NF, the potential lift is moderate. Low potential lift is when all categories are F or FAR, or a combination thereof.

Lastly, stream segments were prioritized numerically, with the stream segments with the most potential lift ranked as the highest priority. It is an expression of the amount of change in functional lift from existing conditions that can occur in a stream segment, if the segment is restored to its maximum restoration potential. Therefore, stream segments can have the same restoration potential, but still be prioritized differently due to differences in their existing conditions and in the amount of potential lift that can occur. The priority is based on the stream segment with the most potential uplift and is based only on results from the function-based rapid stream assessment. Restoration feasibility, based on constraints such as access, infrastructure, and cost, was not evaluated as part of this study due to lack of information, but should be considered by USACE in the final prioritization of stream segments.

RESULTS AND INTERPRETATION

Recreational fishing in the candidate stream reaches

According to Galli et al. (2010) there are 50 currently reported fish species in the Anacostia watershed (Table 1). Game fish are defined as fish pursued by recreational fishermen. Within the Anacostia watershed, the list of game fish includes several sunfish species (e.g. bluegill, pumpkinseed), largemouth bass, carp, American and hickory shad, blueback herring, alewife, white perch, yellow perch, channel catfish, brown bullhead, and snakehead. The natural resources specialist from the Anacostia Watershed Society, Jorge A. Bogantes Montero, was contacted to identify recreational fishing locations in Prince Georges and Montgomery counties, MD. As an expert in recreational fishing hotspots in the Anacostia watershed, Montero pinpointed 10 locations in the two counties where recreational fishing currently occurs (Figure 3). From the map, it is apparent that fishing may be occurring in three candidate reaches in Prince Georges County: Paint Branch (PG#5), Northeast Branch (PG Site #15), and Northeast Branch-Riggs Road (PG Site #13) (Figure 2).

Survey data from Montgomery County Department of the Environment showed that the following game species were collected from four of the seven candidate reaches: American eel, sunfish sp., redbreasted sunfish, green sunfish, bluegill, pumpkinseed, brown bullhead, smallmouth and largemouth bass (Table 2).Survey data from Prince Georges County was obtained from a search of the Maryland Department of Natural Resources Maryland Biological Stream Survey data base. The following game species were collected from four candidate reaches: green and redbreasted sunfish, bluegill, largemouth and smallmouth bass, striped bass, fallfish, white sucker, American eel, yellow bullhead (Table 3).

Potential for anadromous fish migration

From a fisheries perspective, the watershed has historically provided important spawning and nursery habitat for the catadromous American eel, and anadromous alewife, American shad, Atlantic sturgeon, striped bass, and blueback herring. All of these are fish species of conservation concern in the Service's Northeast Region. White perch, not a

species of conservation concern, have also spawned in the watershed. The Service supports efforts to remove stream blockages within the watershed, opening up greater habitat for anadromous and catadromous fish. Other stream restoration work, such as bank stabilization and addition of in-stream habitat, benefit fish and wildlife resources by enhancing habitat for benthic invertebrates—the base of the riparian food chain.

The Anacostia watershed spans two physiographic regions—the coastal plain and the piedmont. The division between these regions is the fall line. USACE (2010) includes a map titled the "Historical Range of Anadromous Fish" (Figure 4). The map shows a "fall zone" which approximates the Montgomery County-Prince Georges County line as the upper limits of historical range of anadromous fish. The potential spawning ranges of river herring and white perch (a smaller area) are indicated in the map. The information contained in this map was confirmed by Jim Cummins, Interstate Commission for the Potomac River Basin, in a personal communication.

It is important to recognize these historical limits of anadromous fish migration in evaluating the benefits of removing stream blockages. Therefore, removal of stream blockages in or near the candidate Montgomery County stream reaches would not benefit anadromous fish which would not migrate that far in any case. Removal of any blockages in or near all of the candidate stream reaches in Prince Georges County would be within the area of historic anadromous fish migration and would potentially benefit those species if there was an increase in blockage-free stream miles.

Environmental education

All of the stream reaches have the potential to serve as living classrooms for educating students of all ages. Signage and kiosks can explain to the public the reason for the project and whether it has been successful through before and after photographs of habitat or monitoring data. Local watershed groups such as the Anacostia Watershed Society provide opportunities for citizens to conduct activities such as water quality monitoring, trail maintenance, and invasive plant removal.

The streams and trails within the watershed provide many opportunities for the public to view and photograph wildlife. According to USACE (2015b), "Bird species strongly affiliated with stream and riparian habitats include the Kentucky warbler (*Geothlypis formosa*), Acadian flycatcher (*Empidonax virescens*), willow flycatcher (*Empidonax traillii*), woodcock (*Scolopax minor*), prothonotary warbler (*Protonotaria citrea*), great blue heron (*Ardea herodias*), green heron (*Butorides virescens*), wood duck (*Aix sponsa*), marsh wren (*Cistothorus palustris*), mallard (*Anas platyrhnchos*), and red-shouldered hawk (*Buteo lineatus*). Additional bird species affiliated with mature forests include wood thrush (*Hylocichla mustelina*), red-eyed vireo (*Vireo olivaceus*), northern parula (*Setophaga americana*), yellow warbler (*Setophaga petechia*), Cooper's hawk (*Accipiter cooperii*), and barred owl (*Strix varia*)."

The eBird data base was searched (7/8/2015) to identify birding hotspots within the Anacostia Watershed. These are areas visited by experienced birders who keep species

lists. For example, Bladensburg Waterfront Park located in Prince Georges County near the upper boundary of the tidal Anacostia includes a listing of 134 bird species. In addition to most of the above-listed species, the formerly-endangered bald eagle (*Haliaeetus leucocephalus*) was observed.

The Anacostia Watershed Society maintains lists of birds, amphibians, and reptiles within the watershed (http://www.anacostiaws.org/news/blog/wildlife-watershed). Currently, there are 233 bird species, 61 amphibian and reptile species, and 35 species of mammals. These lists (Appendix A) include the conservation status of the species as defined by Maryland Department of Natural Resources and the District Department of Energy and Environment. Information on threatened and endangered species is provided in the Fish and Wildlife Coordination Act Report (Pinkney et al. 2015) and a "*Not Likely to Adversely Affect"* letter from USFWS Field Supervisor LaRoucheis reproduced here as Appendix B.

Function-based Rapid Stream Assessment results

Approximately 2.7 miles of the three stream reaches assigned by USACE were assessed using the Function-based Rapid Stream Assessment methodology. Each stream segment was divided into reaches based on existing conditions, with a total of 33 reaches. Seventeen function-based parameters were assessed for each reach. Channel evolution trend, overall function-based condition, restoration potential and potential lift were determined for each reach (Table 4). Each stream segment was then prioritized for restoration. All raw data sheets are provided in Appendix C. Further discussion on the stream segment prioritization is found in the conclusions and recommendations portion of this report.

In order to fully predict restoration potential, both watershed and site-level conditions, stressors, and constraints of a stream segment must be assessed. Site-level conditions are determined in the field using the Function-based Rapid Stream Assessment methodology, and are the primary driver when determining restoration potential. However, watershed information, particularly regarding water quality, is crucial in making a complete prediction of potential. Therefore, because limited water quality and watershed characteristic data were provided, particularly for Paint Branch and Little Paint Branch in Prince George's County, the restoration potential could not be fully determined for any of the stream segments. Visual observations of water quality and nutrients (level 4 – physicochemical) were determined using the methodology, however, without additional information CBFO can only confidently predict that the highest fully functioning level achieved by restoration for the stream segments is level 3 – geomorphology. If water quality is an issue in these watersheds, and it can be improved, the stream segments should be fully functioning to level 5 – biology. However, that cannot be determined at this time due to lack of available data.

Sligo Creek mainstem (Montgomery)

A total of ten stream reaches were assessed in the Sligo Creek mainstem. The majority (93 percent) of the stream segment's overall function-based condition is

currently FAR, and 7 percent is NF. Therefore the overall function-based condition for the stream segment is FAR, with restoration potential to fully functional up to level 3 – geomorphology (Table 4). Moderate lift can be achieved in approximately 40 percent, while 31 percent of the stream segment has low potential lift and 29 percent has maximum potential lift (Table 4). Floodplain connectivity and bedform diversity are both influencing the ratings for this stream, and the channel evolution trend for the majority of the reach indicates that the segment is trending towards NF. Therefore, without intervention the stream will continue to degrade.

Sligo Creek tributary (Montgomery)

A total of seven stream reaches were assessed in the Sligo Creek tributary. The overall function-based condition for the stream is FAR. Fifty-four percent of the stream was FAR, while 46 percent was NF. The channel evolution trend for the majority of the reach indicates that the segment is trending towards NF. Therefore, without intervention the stream will continue to degrade. However, maximum lift can be achieved in 54 percent of the stream, with the remainder achieving moderate lift (Table 4).

Floodplain connectivity is a major contributing factor to the ratings of this stream. The segment begins at a culvert, and the subsequent high velocities from that, as well as numerous areas of concentrated flow entering the stream throughout the floodplain are lowering the level of the bed and causing the stream to become incised. The floodplain flows are also causing numerous headcuts at the upstream portion of the reach. If the headcuts are not addressed, they will further contribute to the vertical and lateral instability, and therefore increase sediment and nutrient inputs to the stream.

Paint Branch (Prince Georges)

A total of 9 nine stream reaches were assessed in Paint Branch. The overall function-based condition for the stream is FAR. Eighty-four percent of the stream was FAR, while 16 percent was NF. Maximum lift can be achieved in 16 percent of the stream, while moderate lift can be achieved in 40 percent. The remaining 44 percent has low potential lift. In many places, the stream is attempting to rebuild its floodplain, and reduce its width/depth ratio through bar development and other deposition. This is reflected in the channel evolutionary trend of FAR (trend toward F) for most of the stream segment (Table 4).

Little Paint Branch (Prince Georges)

A total of 7 stream reaches were assessed in Little Paint Branch. All reaches in the stream segment have an overall function-based rating of FAR, therefore the overall function-based condition for the stream is FAR. The majority of the stream can achieve moderate lift (74 percent). Maximum lift can be achieved in 5

percent of the stream, while low lift can be achieved in 21 percent. As with Paint Branch, the channel evolutionary trend of the majority of Little Paint Branch is a trend toward F. The stream is attempting to regain a stable pattern and profile through the deposition of gravel and though point bar formation. However, the stream is still in adjustment, and bedform diversity is poor throughout most of the reaches (Table 4).

CONCLUSIONS AND PRIORITIZATION

Recreational Fishing, Stream Blockage Analysis, and Environmental Education

Montgomery County

Based on the maps provided by Jorge Montero of the Anacostia Watershed Society, there is no evidence that recreational fishing is occurring within the candidate reaches (Figure 3). Survey data from Montgomery County Department of the Environment showed that the following game species were collected from four of the seven candidate reaches: American eel, sunfish sp., redbreasted sunfish, green sunfish, bluegill, pumpkinseed, brown bullhead, smallmouth and largemouth bass. The historical range of anadromous fish migration generally follows the line between Montgomery and Prince Georges County. It is important to recognize these historical limits of anadromous fish migration in evaluating the benefits of removing stream blockages. Therefore, removal of stream blockages in or near the candidate Montgomery County stream reaches would not benefit anadromous fish which would not migrate that far in any case.

Prince Georges County

Based on the maps provided by Jorge Montero of the Anacostia Watershed Society recreational fishing may be occurring in three of the candidate reaches in Prince Georges County: Paint Branch (PG#5), Northeast Branch (PG Site #15), and Northeast Branch-Riggs Road (PG Site #13). Survey data from Prince Georges County was obtained from a search of the Maryland Department of Natural Resources Maryland Biological Stream Survey data base. The following game species were collected from four candidate reaches: green and redbreasted sunfish, bluegill, largemouth and smallmouth bass, striped bass, fallfish, white sucker, American eel, and yellow bullhead.

The historical range of anadromous fish migration generally follows the line between Montgomery and Prince Georges County. It is important to recognize these historical limits of anadromous fish migration in evaluating the benefits of removing stream blockages. Therefore, removal of stream blockages in or near the candidate Montgomery County stream reaches would not benefit anadromous fish which would not migrate that far in any case. Removal of any blockages in or near all of the candidate stream reaches in Prince Georges County would be within the area of historic anadromous fish migration and would potentially benefit those species if there was an increase in blockage-free stream miles.

Both Counties

All of the candidate stream reaches have the potential to serve as living classrooms for educating students of all ages. Signage and kiosks can explain to the public the reason for the project and whether it has been successful through before and after photographs of habitat or monitoring data. Local watershed groups such as the Anacostia Watershed Society provide opportunities for citizens to conduct activities such as water quality monitoring, trail maintenance, and invasive plant removal. The Anacostia Watershed is frequented by birders who document their observations in the eBird data base, and several of the stream reach sites may be suitable locations for birding.

Function-Based Rapid Stream Assessment

Although all stream segments assessed currently have a restoration potential up to level 3 – geomorphology, based on results of the Function-based Rapid Stream Assessment, in Montgomery County Sligo Creek tributary has the potential for the most functional lift, and therefore has the highest priority, followed by Sligo Creek mainstem. In Prince Georges County, Paint Branch has the highest priority, followed by Little Paint Branch. Overall for both counties Sligo Creek tributary has the highest priority, followed by Sligo Creek mainstem, Paint Branch, and Little Paint Branch (Table 4).

Floodplain connectivity (level 2- hydraulics) and bedform diversity (level 3 – geomorphology) are the main contributors to impairment in all of the stream segments. Floodplain connectivity represents the vertical stability of the stream. All of the stream segments are incised to some degree, likely as a result of urbanization, which increases runoff and therefore contributes to channel enlargement. Increases in the stream power can cause headcuts as well, as was observed especially in Sligo Creek tributary and mainstem. In addition, floodplain connectivity plays a key role in sediment transport and nutrient reduction. Also, diverse bedform, particularly in the form of pools (both pool-to-pool spacing and pool depth variability), plays a significant role in both dissipating energy and creating habitat diversity. Although the stream segments have these constraints, all of the streams have the restoration potential to achieve fully functioning levels up to level 3 – geomorphology with proper stream restoration techniques.

As stated in the "Methodology" section of this report, because of limited water quality and watershed information CBFO can currently only determine study stream segments' maximum restoration potential to be level 3 – geomorphology. For the stream segments to become fully functioning up to level 5 - biology, more detailed analysis into which parameters are limiting lift will have to be conducted. Tolerant aquatic species were observed in all of the stream segments during the rapid assessment (Appendix A and Table 3). Therefore, assessment results indicate that at the minimum, tolerant species have the *potential* to exist in all of the study streams. However, increase in the density of existing tolerant species, or future colonization by intolerant species, will depend on whether the limiting factor for aquatic species is water quality (level 4- physicochemical) or bedform diversity (from level 3 –geomorphology). Assessment results indicate a system wide need for habitat improvements in all stream segments (Table 3). As

indicated above, bedform diversity improvements can create habitat to potentially support aquatic species. However, due to lack of background watershed and water quality information, and due to the rapid, visual-based format of the assessment, the results of this study cannot determine if water quality is also limiting biological lift and species presence in the stream segments.

However, if USACE determines, through additional water quality information or analysis, that the water quality in the stream segments is either not a contributing factor, or is impaired and can be improved, all of the segments should be able to achieve lift in level 4 – physicochemical and level 5 – biology to F, and therefore have restoration potential to level 5.

Ultimately, until the stressors in the watershed are addressed, water quality and biological lift in all of the stream segments is severely limited. However, if the streams are reconnected to their floodplains, lateral instability is reduced, and bedform diversity is improved, the subsequent reduction in sediment and nutrients will result in at least partial water quality and biological lift in areas where tolerant species already exist. These tolerant species will be able to inhabit the stream reaches, even if more intolerant species cannot.

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TABLES

Species	Origin	Status	Collected or expected (1898-2000)
1. Alewife	N	M	H,●
2. American eel	N	M/R	H,●
3. American shad	N	M	H,●
4. Atlantic needlefish	N	M	P,●
5. Atlantic silverside	N	R	
6. Atlantic sturgeon	N	M	P
7. Banded killifish	N	R	H,●
8. Bay anchovy	N	R	P,●
9. Black crappie	N	R	H,●
10. Blueback herring	N	M	H,●
11. Bluegill sunfish	IP	R	H,●
12. Bluntnose minnow	N	R	H,●
13. Bridle shiner	N	R	P,●
14. Brown bullhead	N	R	H,●
15. Chain pickerel	N	R	P
16. Channel catfish	IP	R	H,●
17. Common carp	I	R	H,●
18. Common shiner	N	R	H,●
19. Creek chubsucker	N	R	P,●
20. Eastern mosquitofish	N	R	P,●
21. Eastern mudminnow	N	R	P,●
22. Eastern silvery minnow	N	R	H,●
23. Gizzard shad	N	R	P,●
24. Golden redhorse	N	R	P,●
25. Golden shiner	N	R	P,●
26. Goldfish	I	R	H,●
27. Green sunfish	N	R	H,●
28. Hickory shad	N	M	H,●
29. Inland silverside	N	R	P,●
30. Largemouth bass	I	R	H,●
31. Longear sunfish	N	R	H,●
32. Longnose gar	N	R	H,●
33. Menhaden	N	M	H,●
34. Mummichog	N	R	H,●
35. Pumpkinseed sunfish	N	R	H,●
36. Quillback sucker	N	R	P,●
37. Redbreast sunfish	N	R	H,●
38. River chub	N	R	P
39. Sea lamprey	N	M	P,●
40. Shorthead redhorse	N	R	P,●
41. Shortnose sturgeon	N	M	P
42. Smallmouth bass	I	R	P,●
43. Snakehead	I	R	P,●
44. Spotfin shiner	N	R	H,●
45. Spottail shiner	N	R	H,●
46. Striped bass	N	R	H,●
47. Summer Flounder	N	R	P,•
48. Swallowtail shiner	N	R	H,●
49. Tessellated darter	N	R	P,●
50. Walleye	IP	R	P,●
51. White crappie	N	R	P,●
52. White perch	N	R	H,●
53. White sucker	N	R	P,•
54. Yellow bullhead	N	R	P,●
55. Yellow perch	N	R	H,●

Table 1. Provisional list of Anacostia River fish species (reproduced from Galli et al. 2010). N = native; I = introduced; IP = probably introduced; R = resident; M = migratory; M/R = migratory/resident;H= historical presence documented; P = probable historical presence; ●= collected since 1988

Station	Date	Species	Total	Stream Reach #
LPLP101	7/7/2004	American eel	7	Mont #1
LPLP101	8/13/2009	American eel	6	Mont #1
LPLP101	7/7/2004	Bluegill	1	Mont #1
LPLP101	7/7/2004	Redbreast sunfish	1	Mont #1
LPLP101	8/13/2009	Sunfish sp.	1	Mont #1
LPLP204	7/1/1996	American Eel	8	Mont #2
LPLP204	7/21/2004	American eel	9	Mont #2
LPLP205	7/1/1996	American Eel	5	Mont #2
LPLP205	9/26/2003	American eel	13	Mont #2
LPLP205	7/21/2004	American eel	10	Mont #2
LPLP205	8/11/2009	American eel	16	Mont #2
LPLP209	8/10/2011	American eel	15	Mont #2
LPLP205	9/26/2003	Bluegill	14	Mont #2
LPLP205	7/21/2004	Bluegill	4	Mont #2
LPLP205	8/11/2009	Bluegill	1	Mont #2
LPLP205	9/26/2003	Brown bullhead	12	Mont #2
LPLP205	7/21/2004	Brown bullhead	2	Mont #2
LPLP205	8/10/2011	Brown bullhead	1	Mont #2
LPLP205	8/10/2011	Green Sunfish	1	Mont #2
LPLP205	7/1/1996	Pumpkinseed	1	Mont #2
LPLP205	7/21/2004	Redbreast sunfish	1	Mont #2
LPLP205	8/11/2009	Redbreast sunfish	2	Mont #2
LPLP205	7/21/2004	Smallmouth bass	1	Mont #2
NWBP203	6/5/1995	Bluegill	5	Mont #3
NWBP203	6/5/1995	Brown Bullhead	1	Mont #3
NWBP203	6/5/1995	Redbreast Sunfish	7	Mont #3
NWBP203	7/10/2001	Redbreast Sunfish	10	Mont #3
NWBP205	7/23/2004	Bluegill	1	Mont #3
NWBP205	8/24/2009	Bluegill	3	Mont #3

Table 2. Game fish collected by Montgomery County Department of the Environment sampling stations within the Montgomery County candidate stream reaches. See Figure 1 for stream reach locations.

Station	Date	Species	Total	Stream Reach #
NWBP205	10/3/2011	Green Sunfish	1	Mont #3
NWBP205	8/24/2009	Largemouth bass	11	Mont #3
NWBP205	8/24/2009	Pumpkinseed	4	Mont #3
NWBP205	6/6/1995	Redbreast Sunfish	7	Mont #3
NWBP205	6/29/2001	Redbreast Sunfish	2	Mont #3
NWBP205	6/6/2002	Redbreast sunfish	2	Mont #3
NWBP205	7/23/2004	Redbreast sunfish	10	Mont #3
NWBP205	8/24/2009	Redbreast sunfish	32	Mont #3
NWBP205	10/3/2011	Redbreast sunfish	3	Mont #3
NWLT101	6/20/2002	Bluegill	1	Mont #3
NWNW407A	8/4/1999	American Eel	2	Mont #3
NWNW407A	8/29/2001	American Eel	2	Mont #3
NWNW407A	10/9/2003	American eel	2	Mont #3
NWNW407A	8/4/1999	Bluegill	15	Mont #3
NWNW407A	8/29/2001	Bluegill	4	Mont #3
NWNW407A	6/26/2002	Bluegill	9	Mont #3
NWNW407A	10/9/2003	Bluegill	6	Mont #3
NWNW407A	10/9/2003	Brown bullhead	1	Mont #3
NWNW407A	8/29/2001	Green Sunfish	1	Mont #3
NWNW407A	6/26/2002	Largemouth bass	2	Mont #3
NWNW407A	6/22/2007	Largemouth bass	2	Mont #3
NWNW407A	8/29/2001	Pumpkinseed	1	Mont #3
NWNW407A	6/26/2002	Pumpkinseed	4	Mont #3
NWNW407A	10/9/2003	Pumpkinseed	1	Mont #3
NWNW407A	8/4/1999	Redbreast Sunfish	25	Mont #3
NWNW407A	8/29/2001	Redbreast Sunfish	16	Mont #3
NWNW407A	6/26/2002	Redbreast sunfish	11	Mont #3
NWNW407A	10/9/2003	Redbreast sunfish	6	Mont #3
NWNW407A	6/22/2007	Redbreast sunfish	2	Mont #3

Table 2 (continued). Game fish collected by Montgomery County Department of the Environment sampling stations within the Montgomery County candidate stream reaches. See Figure 1 for stream reach locations.

Station	Year	Species	Total	Stream Reach #
ANAC-117-R	2004	American eel	6	PG#1
ANAC-302-X	2000	Pumpkinseed	5	PG#3
ANAC-302-X	2000	Common carp	1	PG#3
ANAC-302-X	2000	White sucker	100	PG#3
ANAC-302-X	2000	Yellow bullhead	20	PG#3
ANAC-302-X	2000	Smallmouth bass	1	PG#3
ANAC-302-X	2000	Striped bass	4	PG#3
ANAC-302-X	2000	Bluegill	2	PG#3
ANAC-302-X	2000	American eel	42	PG#3
ANAC-302-X	2000	Redbreast sunfish	132	PG#3
ANAC-302-X	2000	Green sunfish	1	PG#3
ANAC-302-X	2000	Largemouth bass	1s	PG#3
ANAC-208-R	2004	American eel	18	PG#7
ANAC-208-R	2004	Fallfish	49	PG#7
ANAC-208-R	2004	Largemouth bass	6	PG#7
ANAC-208-R	2004	Green sunfish	2	PG#7
ANAC-208-R	2004	Bluegill	1	PG#7
ANAC-304-R	2004	White sucker	27	PG#13
ANAC-304-R	2004	Green sunfish	7	PG#13
ANAC-304-R	2004	American eel	61	PG#13
ANAC-304-R	2004	Bluegill	6	PG#13
ANAC-304-R	2004	Yellow bullhead	1	PG#13

Table 3. Game fish survey data collected by Maryland Biological Stream Survey from stations within the Prince Georges County candidate stream reaches. See Figure 2 for stream reach locations.

Anacostia Watershed Study														
			Level 1 - Hydrology	Level 2 - Hydraulics	Level 3 - Geomorphology			Level 4 - Physicochemical	Level 5 - Biology	Channel Evolution Trend	Overall Function-Based Condition	Restoration Potential	Potential Lift	Stream Segment Priority
			Assessment Parameter	Assessment Parameter	Assessment Parameters			Assessment Parameter	Assessment Parameter					
			Runoff	Floodplain Connectivity (Vertical Stability)	Riparian Vegetation	Lateral Stability	Bedform Diversity	Water Quality and Nutrients	Biology					
Stream Segment ID	**Reach**	**Length, approximate (ft)**												
Sligo Creek	**1**	**108**	NF	FAR	FAR	F	FAR	FAR	FAR	FAR (TREND TOWARD F)	FAR	3	Low	2
	2	**268**	NF	FAR	FAR	FAR	NF	FAR	FAR	FAR (TREND TOWARD NF)	FAR	3	Moderate	
	3	**120**	NF	FAR	FAR	FAR	FAR	FAR	FAR	FAR (TREND TOWARD NF)	FAR	3	Moderate	
	4	**370**	NF	NF	FAR	FAR	FAR	FAR	FAR	NF	FAR	3	Maximum	
	5	**298**	NF	FAR	FAR	F	FAR	NF	FAR	FAR (TREND TOWARD F)	FAR	3	Moderate	
	6	**376**	NF	FAR	FAR	FAR	FAR	FAR	FAR	FAR (TREND TOWARD NF)	FAR	3	Low	
	7	**208**	NF	FAR	FAR	FAR	NF	FAR	FAR	FAR (TREND TOWARD NF)	FAR	3	Moderate	
	8	**160**	NF	NF	FAR	FAR	NF	FAR	NF	FAR (TREND TOWARD NF)	NF	3	Maximum	
	9	**132**	NF	NF	FAR	NF	FAR	FAR	FAR	FAR (TREND TOWARD NF)	FAR	3	Maximum	
	10	**230**	NF	FAR	FAR	FAR	FAR	FAR	FAR	FAR (TREND TOWARD NF)	FAR	3	Low	
Sligo Creek Tributary	**1**	**50**	NF	NF	FAR	FAR	NF	FAR	FAR	FAR (TREND TOWARD NF)	NF	3	Maximum	1
	2	**166**	NF	NF	FAR	NF	NF	FAR	FAR	FAR (TREND TOWARD NF)	NF	3	Maximum	
	3	**126**	NF	FAR	FAR	FAR	NF	FAR	FAR	FAR (TREND TOWARD NF)	FAR	3	Moderate	
	4	**30**	NF	FAR	FAR	FAR	NF	FAR	FAR	FAR (TREND TOWARD F)	FAR	3	Moderate	
	5	**220**	NF	NF	FAR	FAR	NF	FAR	FAR	FAR (TREND TOWARD F)	NF	3	Maximum	
	6	**160**	NF	F	FAR	F	NF	FAR	FAR	F	FAR	3	Moderate	
	7	**50**	NF	FAR	FAR	F	NF	FAR	NF	F	FAR	3	Moderate	
Paint Branch	**1**	**600**	NF	NF	FAR	FAR	NF	FAR	F	F	NF	3	Maximum	3
	2	**264**	NF	FAR	FAR	NF	NF	FAR	F	FAR (TREND TOWARD NF)	FAR	3	Moderate	
	3	**410**	NF	NF	FAR	FAR	NF	FAR	FAR	F	NF	3	Maximum	
	4	**1250**	NF	FAR	FAR	FAR	FAR	FAR	FAR	FAR (TREND TOWARD F)	FAR	3	Low	
	5	**1850**	NF	FAR	NF	FAR	FAR	FAR	FAR	FAR (TREND TOWARD F)	FAR	3	Moderate	
	6	**726**	NF	FAR	FAR	FAR	FAR	FAR	FAR	FAR (TREND TOWARD F)	FAR	3	Low	
	7	**275**	NF	FAR	FAR	F	FAR	FAR	F	F	FAR	3	Low	
	8	**610**	NF	FAR	FAR	FAR	FAR	FAR	FAR	FAR (TREND TOWARD F)	FAR	3	Low	
	9	**440**	NF	FAR	F	FAR	NF	FAR	FAR	FAR (TREND TOWARD F)	FAR	3	Moderate	
Little Paint Branch	**1**	**900**	NF	FAR	FAR	FAR	NF	FAR	FAR	FAR (TREND TOWARD F)	FAR	3	Moderate	4
	2	**995**	NF	FAR	FAR	FAR	NF	FAR	FAR	FAR (TREND TOWARD F)	FAR	3	Moderate	
	3	**1083**	NF	FAR	FAR	FAR	NF	FAR	FAR	FAR (TREND TOWARD NF)	FAR	3	Moderate	
	4	**110**	NF	FAR	FAR	FAR	NF	FAR	FAR	FAR (TREND TOWARD F)	FAR	3	Moderate	
	5	**188**	NF	NF	FAR	FAR	FAR	FAR	FAR	NF	FAR	3	Maximum	
	6	**440**	NF	FAR	FAR	F	FAR	FAR	FAR	FAR (TREND TOWARD F)	FAR	3	Low	
	7	**443**	NF	FAR	FAR	FAR	FAR	FAR	FAR	FAR (TREND TOWRD F)	FAR	3	Low	

Table 4. Function-based Rapid Stream Assessment results.

FIGURES

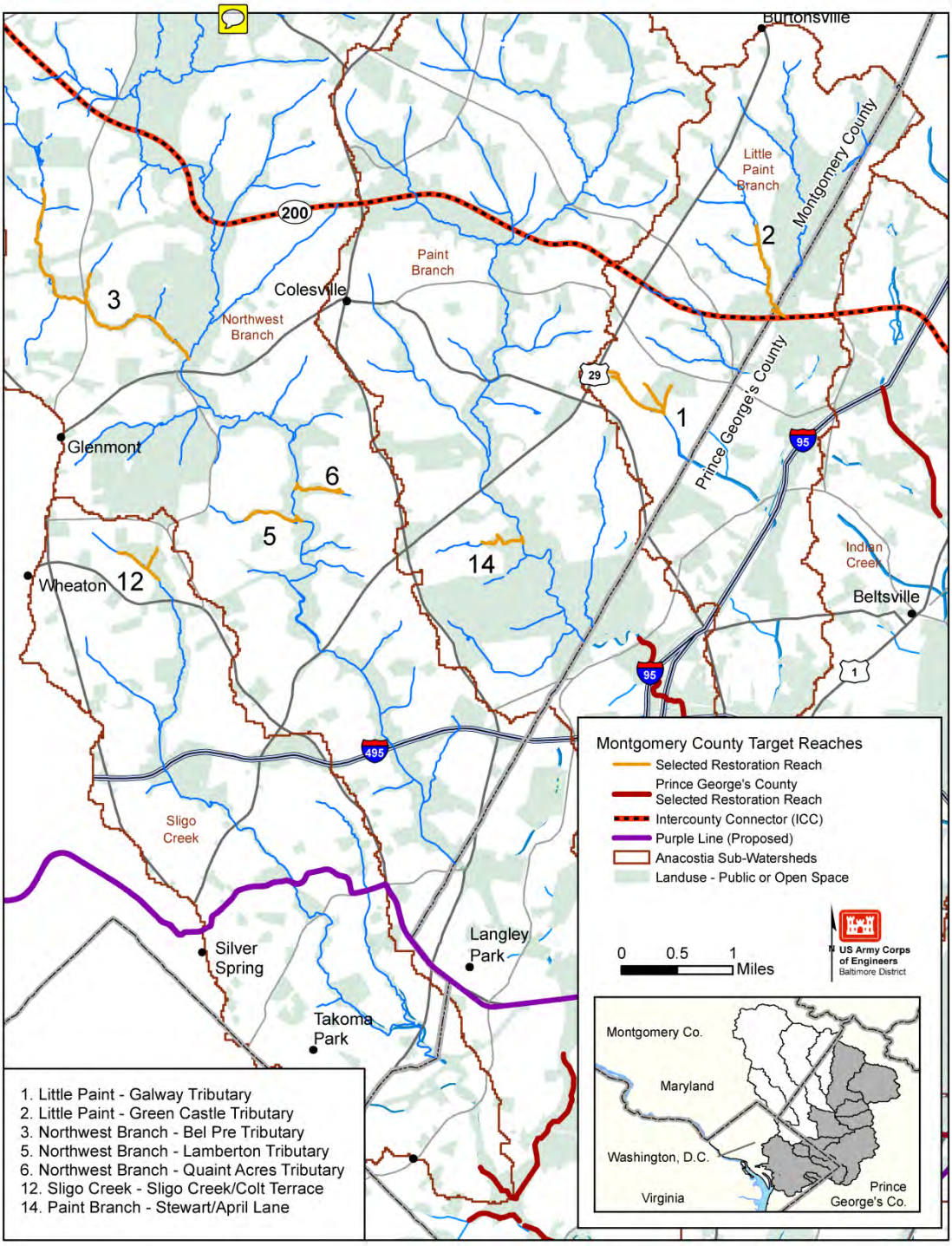

Figure 1. Montgomery County stream reaches under evaluation for stream restoration. Function-based Rapid Stream Assessment was conducted on Sligo Creek (Site #12).

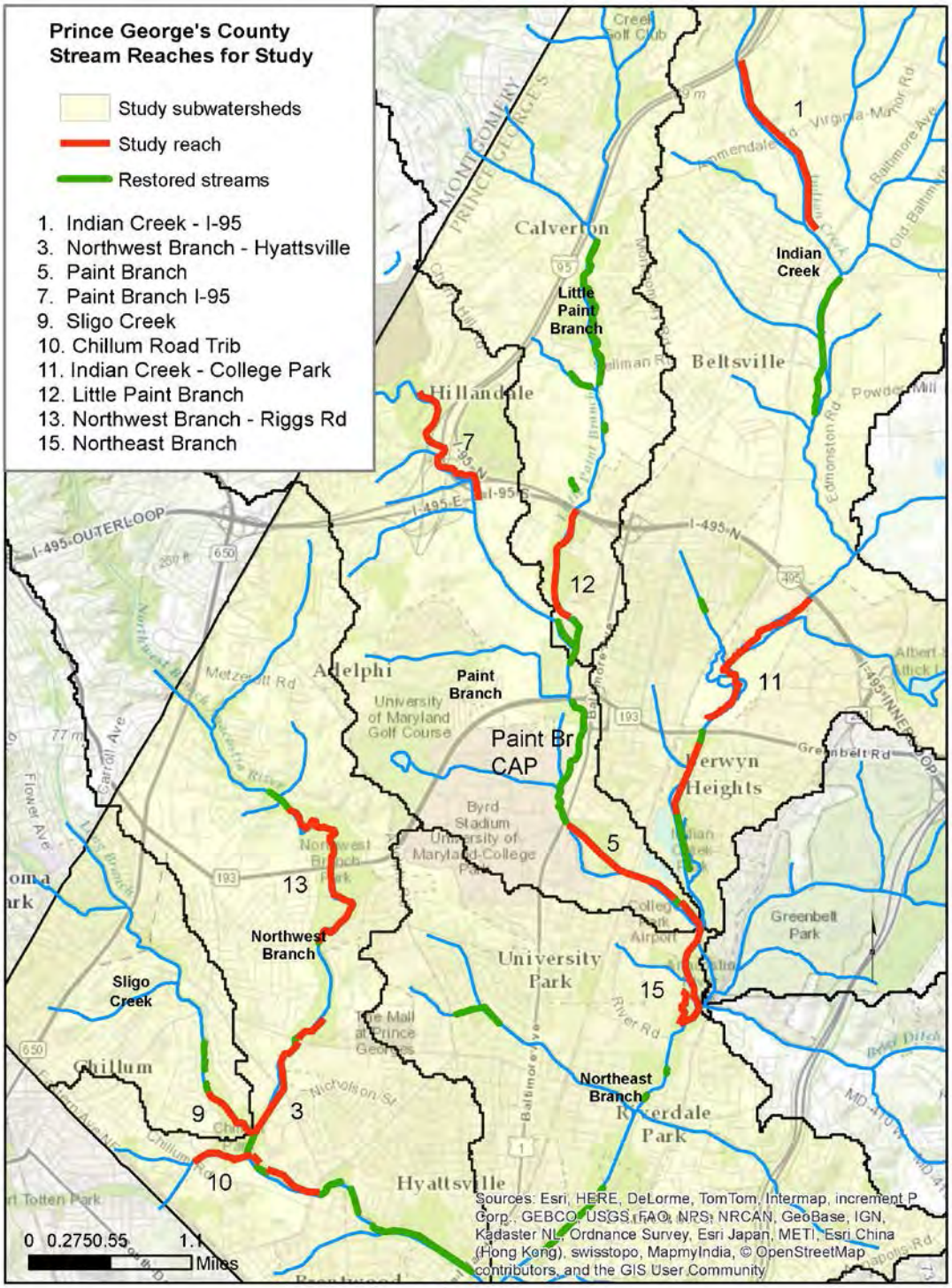

Figure 2. Prince Georges County stream reaches under evaluation for stream restoration. Function-based Rapid Stream Assessment was conducted on Paint Branch (Site #5), and Little Paint Branch (Site #12).

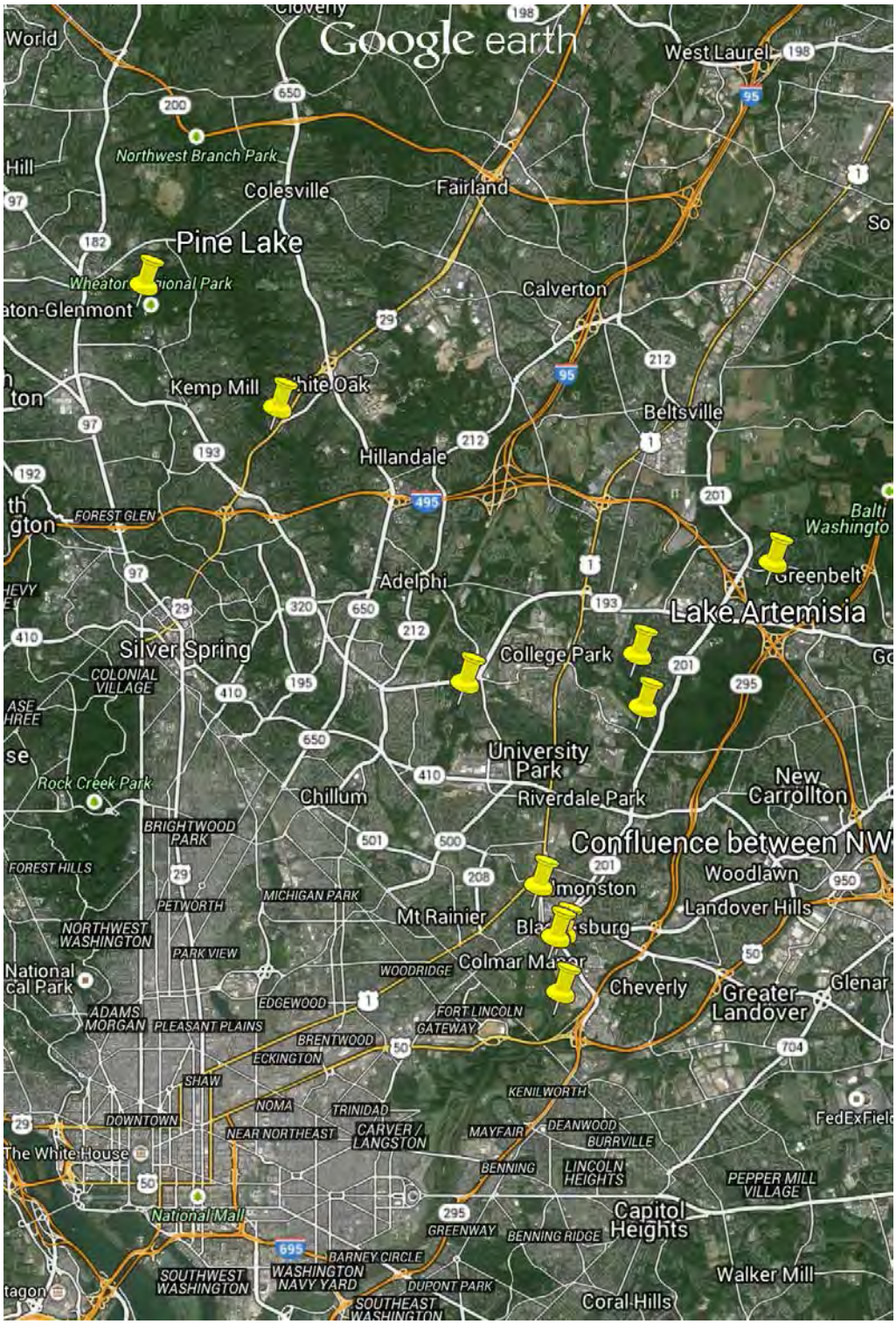

Figure 3. Map of recreational fishing locations in Montgomery and Prince Georges Counties (Jorge Montero, Anacostia Watershed Society, personal communication).

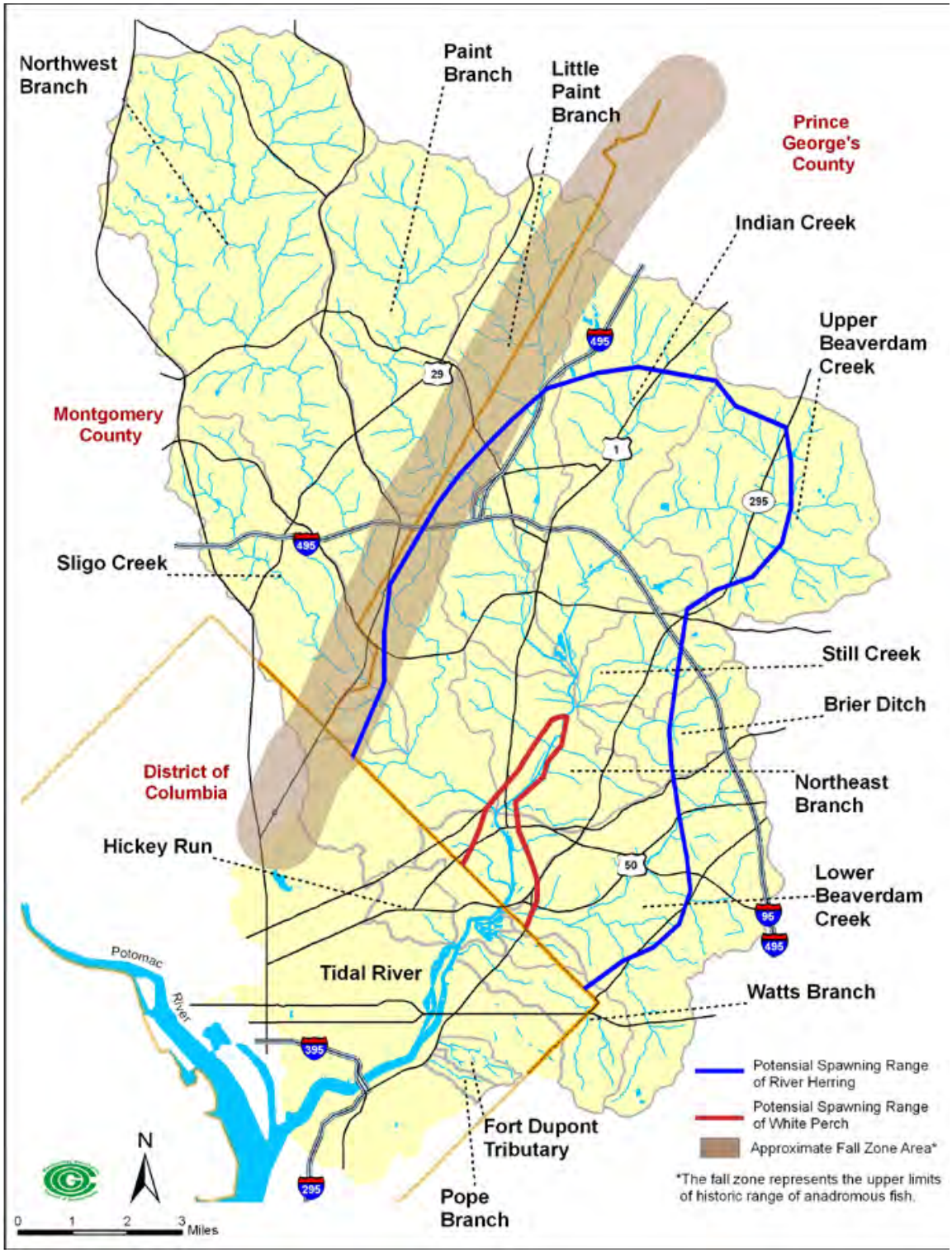

Figure 4. Historical range of anadromous fish (from USACE 2010).

Appendix A

Lists of amphibian, reptile, bird, and mammal species in the Anacostia watershed compiled by the Anacostia Watershed Society

				Conservation status								
Mammals	**Conservation Status**	**Native**	**Nonnative**	**S1**	**S2**	**S3**	**S4**	**S5**	**SH**	**SX**	**SNR**	**SNA**
n=35	MD	33	2	0	1	1	3	29	0	0	0	2
	DC	33	2	0	2	5	10	12	1	0	3	2
Birds	**Conservation Status**	**Native**	**Nonnative**	**S1**	**S2**	**S3**	**S4**	**S5**	**SH**	**SX**	**SNR**	
n=233	MD	217	6	21	31	43	80	76	1	1	0	
	DC	217	6	45	62	81	56	31	6	1	8	
Herps	**Conservation Status**			**S1**	**S2**	**S3**	**S4**	**S5**	**SH**		**SNR**	**SNA**
n=61	MD			1	1	2	9	50	0		0	0
	DC			4	2	6	16	10	15		2	8

Abbreviations:
S1: Critically Imperiled
S2: Imperiled
S3: Vulnerable
S4: Apparentley Secure
S5: Secure
SNR: Status Not Ranked/Under Review
SNA: Status Not Assessed/Not applicable
SX: Presumed Extirpated
SH: Possibly Extirpated

Table A-1. Summary of species conservation status, prepared by Anacostia Watershed Society.

Checklist of the mammals of the Anacostia River Watershed

Compilled by Jason Donaldson, AWS Stewardship Intern and Jorge Bogantes Montern, AWS Conservation Biologist

July, 2011

	Common Name	Scientific Name	Family	Non-native	Native	Conservation Status	Reference	Comments
1	American Beaver	*Castor canadensis*	Beavers (Castoridae)		X	MD: S5/ DC S3	2, 3	The only native species of beaver in North America
2	Big Brown Bat	*Eptesicus fuscus*	Bats (Vespertilionidae)		X	MD: S5/ DC S4	2, 3	Is larger than many other bats
3	Common Raccoon	*Procyon lotor*	Raccoons (Procyonidae)		X	MD: S5/ DC S5	2, 3	Can adapt to different habitats
4	Eastern Chipmunk	*Tamias striatus*	Squirrels (Sciuridae)		X	MD: S5/ DC S5	1, 2	
5	Eastern Cottontail	*Sylvilagus floridanus*	Rabbits and Hares (Leporidae)		X	MD: S5/ DC S5	1, 2	
6	Eastern Gray Squirrel	*Sciurus carolinensis*	Squirrels (Sciuridae)		X	MD: S5/ DC S5	2, 3	
7	Eastern Mole	*Scalopus aquaticus*	Moles (Talpidae)		X	MD: S5/ DC S5	2, 3	
8	Eastern Pipistrelle	*Pipistrellus subflavus*	Bats (Vespertilionidae)		X	MD: S5/ DC S4	2, 3	
9	Eastern Red Bat	*Lasiurus borealis*	Bats (Vespertilionidae)		X	MD: S5/ DC S4	1, 2	May migrate south
10	Evening Bat	*Nycticeius humeralis*	Bats (Vespertilionidae)		X	MD: S5/ DC S2	2, 3	
11	Gray Fox	*Urocyon cinereoargenteus*	Dogs (Canidae)		X	MD: S5/ DC S3	1, 2	Mostly in Southern America
12	Hairy-tailed Mole	*Parascalops breweri*	Moles (Talpidae)		X	MD: S4/ DC SNR	2, 3	

13	Hoary Bat	*Lasiurus cinereus*	Bats (Vespertilionidae)		X	MD: S5/ DC S2	2, 3	
14	House Mouse	*Mus musculus*	Rats and mice (Muridae)	X		MD: SNA/ DC SNA	2, 3	Has been domesticated as a pet
15	Little Brown Bat	*Myotis lucifugus*	Bats (Vespertilionidae)		X	MD: S5/ DC S4	2, 3	
16	Long-tailed Weasel	*Mustela frenata*	Weasels (Mustelidae)		X	MD: S5/ DC S3	2, 3	
17	Masked Shrew	*Sorex cinereus*	Shrews (Soricidae)		X	MD: S5/ DC SNR	2, 3	
18	Meadow Jumping Mouse	*Zapus hudsonius*	Jumping mice (Dipodidae)		X	MD: S5/ DC S3	2, 3	
19	Meadow Vole	*Microtus pennsylvanicus*	Rodents (Cricetidae)		X	MD: S5/ DC S5	2, 3	
20	Muskrat	*Ondatra zibethicus*	Rodents (Cricetidae)		X	MD: S5/ DC S4	2, 3	Found mainly in wetlands but can adapt
21	North American Least Shrew	*Cryptotis parva*	Shrews (Soricidae)		X	MD: S5/ DC S4	2, 3	One of the smallest mammals
22	Northern Long-eared bat	*Myotis septentrionalis*	Bats (Vespertilionidae)		X	MD: S4/ DC S4	2, 3	
23	Northern Short-tailed S*hrew*	*Blarina brevicauda*	Shrews (Soricidae)		X	MD: S5/ DC S5	2, 3	
24	Norway Rat	*Rattus norvegicus*	Rats and mice (Muridae)	X		MD: SNA/ DC SNA	2, 3	
25	Red Fox	*Vulpes vulpes*	Dogs (Canidae)		X	MD: S5/ DC S4	2, 3	Very invasive in other countries
26	Smokey Shrew	*Sorex fumeus*	Shrews (Soricidae)		X	MD: S2/S3/ DC SNR	2, 3	
27	Southern Flying Squirrel	*Glaucomys volans*	Squirrels (Sciuridae)		X	MD: S5/ DC S5	2, 3	Can return to their nests if moved one mile away
28	Star-nosed mole	*Condylura cristata*	Moles (Talpidae)		X	MD: S4/ DC S3	2, 3	

	Striped Skunk	*Mephitis mephitis*	Skunks (Mephitidae)	X	MD: S5/ DC S4	2, 3	Pry on honeybees by scratching the nest and waiting for them to come out
29							
30	Virginia Opossum	*Didelphis Virginiana*	Opossums (Didelphidae)	X	MD: S5/ DC S5	1, 2	
31	White-footed Deermouse	*Peromyscus leucopus*	Rodents (Cricetidae)	X	MD: S5/ DC S5	2, 3	One of the most common found in the United States
32	White-tailed deer	*Odocoileus virginianus*	Deer (Cervidae)	X	MD: S5/ DC S5	2, 3	
33	Woodchuck	*Marmota monax*	Squirrels (Sciuridae)	X	MD: S5/ DC S5	2, 3	Also refered to as the groundhog or the land baever
34	Woodland Vole	*Microtus pinetorum*	Rodents (Cricetidae)	X	MD: S5/ DC S4	2, 3	They live in burrows exclusive to the family groups

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Reptiles and Amphibians of the Anacostia River Watershed

Compiled by Emily Stransky, AWS Stewardship Intern and Jorge Bogantes Montero, AWS Conservation Biologist

Contributions from Rachel Gauza, head of the MARA (Maryland Amphibian and Reptile Atlas) Program, and Lindsay Rohrbaugh, Wildlife Biologist with DDOE

November, 2011

Salamanders

Common name	Scientific name	Family	Non-Native	Native	Reference	Conservation status	Comments
Jefferson Salamander	*Ambystoma jeffersonianum*	Ambystomatidae		x	1,2	MD:S3/DC:NA	They are found in well shaded, deciduous forests, and breed in the early spring in seasonal pools
Marbled Salamander	*Ambystoma opacum*	Ambystomatidae		x (SGCN)	1,2	MD:S5/DC:S3	Adults are entirely terrestrial, but breed in seasonal pools and the females stay with the egg clutch

Spotted Salamander	*Ambystoma maculatum*	Ambystomatidae	x (SGCN)	1,2	MD:S5/DC:S4	Adults are most active during rain, at night, and during breeding periods, some individuals lack spots
Northern Dusky Salamander	*Desmognathus fuscus*	Plethodontidae	x (SGCN)	1,2	MD:S5/DC:S5	They are usually found near running or trickling water Their colors vary from yellow to orange to red with black dumbbell shaped markings
Long-tailed Salamander	*Eurycea longicauda*	Plethodontidae	x	1,2	MD:S5/DC:SNR	
Northern Two-lined Salamander	*Eurycea bislineata*	Plethodontidae	x (SGCN)	1,2	MD:S5/DC:S5	Females stay with the eggs during the approximately 30 day incubation period, and

						these are most common in stream habitat
Mud Salamander	*Pseudotriton montanus*	Plethodontidae	x	1,2	MD:S2/DC:NA	They feed on arthropods and earthworms, and are typically found in muddy floodplains
Red Salamander	*Pseudotriton ruber*	Plethodontidae	x (SGCN)	1,2	MD:S5/DC:S3	The larval stage can last up to 5 years Females lay their eggs in moss next to a pool, which larvae can drop into after hatching, and they are distinguishable
Four-Toed Salamander	*Hemidactylium scutatum*	Plethodontidae	x	1,2	MD:S5/DC:SH	

						by the white belly and black spots, 4 toes on hind feet and squarish snout
Eastern Red-backed Salamander	*Plethodon cinereus*	Plethodontidae	x (SGCN)	1,2	MD:S5/DC:S5	Their home range is usually less than a few meters across, and they are the most common woodland salamander Females stay with their eggs until they develop into larvae, and they have glue-like skin secretions when handled roughly
Northern Slimy Salamander	*Plethodon glutinosus*	Plethodontidae	x	1,2	MD:S5/DC:SH	

Red-Spotted Newt (Eastern Newt)	*Notophthalmus viridescens*	Salamandridae		x (SGCN)	1,2	MD:S5/DC:S3	They produce highly toxic skin secretions

Toads and Frogs							
	Scientific name						
Common name		**Family**	**Non-Native**	**Native**	**Reference**	**Conservation status**	**Comments**

American Toad	*Anaxyrus americanus*	Bufonidae	x (SGCN)	1,2	MD:S5/DC:S5	Their mating call lasts up to 30 seconds, it's a long, musical trill, they can mate with Fowler's toads, and have one or two warts per dark dorsal spot
Fowler's Toad	*Anaxyrus fowleri*	Bufonidae	x (SGCN)	1,2	MD:S5/DC:S5	Hognose snakes are immune to the toad's toxic skin excretions, they have three warts per dark dorsal spot, and typically have a white chest with central spot
American Bullfrog	*Lithobates catesbeianus*	Ranidae	x (SGCN)	1,2	MD:S5/DC:S4	Maryland's largest frog

Northern Green Frog	*Lithobates clamitans melanota*	Ranidae	x	1,2	MD:S5/DC:S5	Adult males' eardrums are larger than their eye, females and juveniles are about the same size
Pickerel Frog	*Lithobates palustris*	Ranidae	x (SGCN)	1,2	MD:S5/DC:S5	Their mating call is a 1-2 second long low snore
Southern Leopard Frog	*Lithobates sphenocephalus*	Ranidae	x	1,2	MD:S5,S4/DC:S3,S2	Usually have dark spots on the back with a yellow ridge extending down each side
Wood Frog	*Lithobates sylvaticus*	Ranidae	x (SGCN)	1,2	MD:S5/DC:S2	They have a dark "mask" across eyes, mating call is 1-8 loud clacks

Gray Treefrog	*Hyla versicolor*	Hylidae	x (SGCN)	1,2	MD:S5/DC:S4	Their mating call is loud slow trill, and they are identical to Cope's Gray Treefrog except for their call
Cope's Gray Treefrog	*Hyla chrysoscelis*	Hylidae	x	1,2	MD:S5/DC:S4	Their skin secretions can irritate human eyes and other membranes
Green Treefrog	*Hyla cinerea*	Hylidae	x	1,2	MD:S5/DC:SH	Their upper surface and part of the throat is usually green, but can range from yellow to gray, a breeding male has a gray or pinkish throat, and they often gather in large groups

Northern Spring Peeper	*Pseudacris crucifer*	Hylidae	x (SGCN)	1,2	MD:S5/DC:S4	These often have a dark "X" on their back
Upland Chorus Frog	*Pseudacris feriarum*	Hylidae	x	1,2	MD:S5/DC:SH	Mainly an upland frog in the North, but a lowland frog in the South, and have a dark triangle between the eyes
Eastern Cricket Frog	*Acris crepitans*	Hylidae	x	1,2	MD:S4/DC:NA	This frog is very small, about 4 cm in length, with a dark triangle between the eyes on the back of the head and short hind legs

Eastern Spadefoot	*Scaphiopus holbrookii*	Scaphiopodidae		x	1,2	MD:S5/DC:NA	Their eye is elliptical in bright light, and there are sickle shaped spades on the inner underside of the hind feet

Turtles

Common name	Scientific name	Family	Non-Native	Native	Reference	Conservation status	Comments
Spotted Turtle	*Clemmys guttata*	Emydidae		x (SGCN)	1,2	MD:S5/DC:S1	This is a small black turtle with yellow spots, although some individuals may lack spots on the carapace

Wood Turtle	*Glyptemys insculpta*	Emydidae			x (SGCN)	1,2	MD:S4/DC:SH	These lack a hinged plastron, their plastron is yellow with dark, irregular blotch on each scute
Eastern Box Turtle	*Terrapene carolina*	Emydidae			x (SGCN)	1,2	MD:S5/DC:S3	Their name comes from a hinged shell that allows the shell to become tightly closed
Red-eared Slider	*Trachemys scripta*	Emydidae		x		1,2	MD:S5/DC:SNR	These are aquatic, with a very small home range, and they have a prominent red or yellow patch on the head
Painted Turtle	*Chrysemys picta*	Emydidae			x (SGCN)	1,2	MD:S5/DC:S5	These have bright yellow lines on their head and limbs

Northern Red-bellied Cooter	*Pseudemys rubriventris*	Emydidae		x (SGCN)	1,2	MD:S5/DC:S4	They like large deep bodies of water, sometimes brackish
Chinese spiny softshell turtle	*Pelodiscus sinensis*	Trionychidae	x				
Stinkpot Turtle	*Stenothernus odoratus*	Kinosternidae		x (SGCN)	1,2	MD:S5/DC:S4	There are two light stripes on the head and neck, with barbells coming off chin and throat, and their plastron does not cover appendages

Eastern Mud Turtle	*Kinosternon subrubrum*	Kinosternidae		x (SGCN)	1,2	MD:S5/DC:SH	These have triangular pectoral scutes and a double hinged shell
Eastern Snapping Turtle	*Chelydra serpentina*	Chelydridae		x	1,2	MD:S5/DC:S5	These are large, up to 50 lbs, with powerful jaws, a plastron that does not cover appendages and they are mostly aquatic

Snakes

Common name	Scientific name	Family	Non-Native	Native	Reference	Conservation status	Comments

Copperhead	*Agkistrodon contortrix*	Viperidae	x (SGCN)	1,2	MD:S5/DC:S1	These are distinguishable as venomous snake by the slitted irises and pits located by eyes, they also have hour-glass like pattern down the body
Northern Water Snake	*Nerodia sipedon*	Colubridae	x	1,2	MD:S5/DC:S4	These are often mistaken for venomous Water Moccasin snakes, but are not venomous themselves, and they are very common in aquatic habitats
Queen Snake	*Regina septemvittata*	Colubridae	x (SGCN)	1,2	MD:S5/DC:S1	These occur only where there are crayfish, which are a main diet staple

Eastern Smooth Earthsnake	*Virginia valeriae*	Colubridae	x (SGCN)	1,2	MD:S4,S5/DC:SH	They do not come out into the open often, but are usually found under boards or logs
Northern Brownsnake	*Storeria dekayi*	Colubridae	x (SGCN)	1,2	MD:S5/DC:S4	This snake has two parallel lines of dark spots running down its back, it feeds on worms and soft-bodied insects and gives live birth
Red-bellied Snake	*Storeria occipitomaculata*	Colubridae	x	1,2	MD:S5/DC:SH	These are characterized by a red, unmarked belly, and will have three spots at the nape of the neck

Eastern Gartersnake	*Thamnophis sirtalis*	Colubridae	x (SGCN)	1,2	MD:S5/DC:S4	This snake has a checkerboard pattern on its back with a distinct yellow or white stripe down the center of its back
Common Ribbon Snake	*Thamnophis sauritus*	Colubridae	x (SGCN)	1,2	MD:S5/DC:S4	They are found in wet areas, such as marshes, bogs, ponds and shallow streams, and they have three bold cream stripes down the back
Eastern Wormsnake	*Carphophis amoenus*	Colubridae	x (SGCN)	1,2	MD:S5/DC:S4	These are small in size, about 7-11 inches, and look similar to an earthworm

Rough Greensnake	*Opheodrys aestivus*	Colubridae	x (SGCN)	1,2	MD:S5/DC:S4	These are bright green snakes with a white or cream colored belly
Eastern Hog-nosed Snake	*Heterodon platirhinos*	Colubridae	x (SGCN)	1,2	MD:S5/DC:SH	These will fan out their neck, like a cobra, when approached and then play dead
Rainbow Snake	*Farancia erytrogramma*	Colubridae	x	1,2	MD:S1/DC:NA	These are considered endangered in Maryland and are rarely found, they are a highly aquatic species with red, yellow and black stripes going vertically down their body

Northern Black Racer	*Coluber constrictor*	Colubridae	x (SGCN)	1,2	MD:S5/DC:S4	They are normally black or dark gray in color, with a white chin and conspicuous eye
Red Cornsnake	*Pantherophis guttatus*	Colubridae	x (SGCN)	1,2	MD:S4/DC:SH	An orange or orange-red snake, which eats most rodents
Eastern Ratsnake	*Pantherophis alleghaniensis*	Colubridae	x	1,2	MD:S5/DC:S3,S5	Maryland's largest snake, and has an all black, shiny back
Mole Kingsnake	*Lampropeltis calligaster*	Colubridae	x	1,2	MD:S4/DC:SH	These are a subterranean, nocturnal species, with a yellow or greenish hued color

Eastern Kingsnake	*Lampropeltis getula*	Colubridae	x	1,2	MD:S5/DC:SH	These eat many other reptiles, and are shiny black, with white or light colored rings around its body
Eastern Milksnake	*Lampropeltis triangulum*	Colubridae	x	1,2	MD:S5/DC:SH	These are red with black bordered blotches down the back, and a blotch on the head that may resemble an A, Y, U, or V
Coastal Plain Milksnake	*Lampropeltis triangulum elapsoides X triangulum*	Colubridae	x	1,2	N/A	This is a mix between the Eastern Milksnake and the Scarlet Kingsnake

Northern Scarletsnake	*Cemophora coccinea*	Colubridae		x	1,2	MD:S3/DC:NA	These are similar to the venomous Coral Snake, but are non-venomous and have black separating red and yellow (or white) sections, with an upper jaw that protrudes beyond the lower jaw
Ring-Necked Snake	*Diadophis punctatus*	Colubridae		x (SGCN)	1,2	MD:S5/DC:S4	These have a dark body with a cream/yellow ring around it's neck

Lizards and Skinks

Common name	Scientific name	Family	Non-Native	Native	References	Conservation status	Comments

Broad-headed Skink	*Plestiodon laticeps*	Scinidae	x	1,2	MD:S4/DC:S1	Maryland's largest skink, with juveniles and females resembling the five-lined skink
Common Five-lined Skink	*Plestiodon fasciatus*	Scinidae	x (SGCN)	1,2	MD:S5/DC:S4	These have 5 yellow or white stripes on their head, which extend down the back, and juveniles have a blue tail
Little Brown Skink	*Scincella lateralis*	Scinidae	x	1,2	MD:S5/DC:NA	They have a golden or dark brown back with a darker stripe running along either side
Eastern Six-lined Racerunner	*Aspidoscelis sexlineatus*	Teiidae	x	1,2	MD:S4/DC:SH	These have 6 colored lines extending from the head to the tail

Eastern Fence Lizard	*Sceloporous undulatus*	Phrynosomatidae	x (SGCN)	1,2	MD:S5/DC:SH	These have pointed scales on the back, males have a bright blue patch on the belly and underside of the throat, while females have crossbands along the back

References and Acronyms

References	URL
1. Nature Serve	http://www.natureserve.org/explorer/
2. Maryland Department of Natural Resources	http://www.dnr.state.md.us/wildlife/Plants_Wildlife/herps/

Birds of the Anacostia River Watershed

Compiled by Mallory Shramek, AWS Stewardship Intern and Jorge Bogantes Montero, AWS Conservation Biologist

July, 2011 UPDATED AUGUST 28, 2012 Michael Schramm

	Common Name	Scientific Name	Family	Non-native	Native	DC Conservation Status	MD Conservation Status	References	Comments
1	Acadian Flycatcher	*Empidonax virescens*	Flycatchers (Tyrannidae)		X	SNR	S5B	1, 2, 4	Passage migrant through the District of Columbia; primarily breeds in moist, upland deciduous forests with a moderate understory, generally near a stream.
2	Alder Flycatcher	*Empidonax alnorum*	Flycatchers (Tyrannidae)		X	S1N	S2B	1,3,6	
3	American Avocet	*Recurvirostra americana*	Avocets and Stilts (Recurvirostridae)		X	SNR	SNA	1, 2	
4	American Bittern	*Botaurus lentiginosus*	Bitterns, Egrets, and Herons (Ardeidae)		X	S1B	S1B	1, 2	Breed in freshwater marshes; local migrant within the District of Columbia.

5	American Black Duck	*Anas rubripes*	Geese, Swans, and Ducks (Anatidae)	X	S3 S4N	S4B S5N	1, 2	Hybridization between the American Black Ducks and Mallards is a major concern.
6	American Coot	*Fulica americana*	Rails (Rallidae)	X	S2N	S3N	1, 2	
7	American Crow	*Corvus brachyrhynchos*	Crows and Jays (Corvidae)	X	S5B S5N	S5	1, 4	
8	American Goldfinch	*Spinus tristis*	Finches and Grosbeaks (Fringillidae)	X	S4N S5B	S5	1, 4	
9	American Kestrel	*Falco sparverius*	Falcons (Falconidae)	X	S2B S3N	S4N S5B	1, 3, 4	North American's smallest falcon.
10	American Pipit	*Anthus rubescens*	Pipits and Wagtails (Motacillidae)	X	S4N	S3N	1, 2	
11	American Redstart	*Setophaga ruticilla*	Warblers (Parulidae)	X	S1B S4N	S4B	1, 3, 4	Flashes its orange and black wings and tail to flush insect prey from foliage.
12	American Robin	*Turdus migratorius*	Thrushes (Turdidae)	X	S5B S5N	S5B S5N	1, 4	
13	American Tree Sparrow	*Spizella arborea*	Sparrows and Towhees (Emberizidae)	X	S4N	S3N	1,3,6	
14	American Wigeon	*Anas americana*	Geese, Swans, and Ducks (Anatidae)	X	S3N	S4N	1,3,6	

15	American Woodcock	*Scolopax minor*	Sandpiper (Scolopacidae)	X	S3N	S4B S4N	1, 2	The most serious threat is habitat loss and alteration, through urbanization, reforestation, drainage of wetlands, and agricultural development.
16	Bald Eagle	*Haliaeetus leucocephalus*	Eagles and Hawks (Accipitridae)	X	S2N SXB	S2 S3B	1, 2	Migrant and breeder within the District of Columbia.
17	Baltimore Oriole	*Icterus galbula*	Blackbirds and Orioles (Icteridae)	X	S1B S3N	S5B	1	
18	Bank Swallow	*Riparia riparia*	Swallows and Martins (Hirundinidae)	X	S3N	S3 S4B	1,3,6	
19	Barn Owl	*Tyto alba*	Barn Owls (Tytonidae)	X	S1	S3	1, 4	
20	Barn Swallow	*Hirundo rustica*	Swallows and Martins (Hirundinidae)	X	S5B S5N	S5B	1, 4	
21	Barred Owl	*Strix varia*	True Owls (Strigidae)	X	S2	S5	1	

22	Bay-breasted Warbler	*Dendroica castanea*	Warblers (Parulidae)	X	S3N	SNA	1, 3, 5	Benefits from spruce budworm outbreaks when the caterpillars provide abundant food - spraying to control the destructive outbreaks may have reduced populations of this warbler.
23	Belted Kingfisher	*Megacerycle alcyon*	Kingfishers (Alcedindae)	X	S2N S2 S3B	S5B S4N	1, 4	
24	Black Vulture	*Coragyps atratus*	New World Vultures (Cathartidae)	X	S1	S4B S4N	1, 2	
25	Black-and-white Warbler	*Mniotilta varia*	Warblers (Parulidae)	X	S4N	S4B	1, 4	
26	Blackburnian Warbler	*Dendroica fusca*	Warblers (Parulidae)	X	S3N	S1 S2B	1, 5	
27	Black-billed Cuckoo	*Coccyzus erythropthalmus*	Cuckoos (Cuculidae)	X	S1 S2N	S4B	1,3,6	
28	Black-capped Chickadee	*Poecile atricapillus*	Chickadees and Titmice (Paridae)	X	S1	S4	1,3,6	
29	Black-crowned Night-Heron	*Nycticorax nycticorax*	Bitterns, Egrets, and Herons (Ardeidae)	X	S3B	S3B S2N	1, 2, 4	Local migrant and breeder within the District of Columbia.

30	Blackpoll Warbler	*Dendroica striata*	Warblers (Parulidae)	X	S4 S4N	SNA	1, 4	
31	Black-throated Blue Warbler	*Dendroica caerulescens*	Warblers (Parulidae)	X	S4N	S3 S4B	1, 4	
32	Black-throated Green Warbler	*Dendroica virens*	Warblers (Parulidae)	X	S4N	S4B	1, 4	
33	Blue Grosbeak	*Passerina caerulea*	Cardinals and Buntings (Cardinalidae)	X	S2B S2N	S5B	1, 4	
34	Blue Jay	*Cyanocitta cristata*	Crows and Jays (Corvidae)	X	S4N S5B	S5B S5N	1, 4	
35	Blue-gray Gnatcatcher	*Polioptila caerulea*	Gnatcatchers (Sylviidae)	X	S3B S3N	S5B	1, 3, 4	Flicks its white-edged tail from side to side to scare hiding insects.
36	Blue-headed Vireo	*Vireo solitarius*	Vireos (Vireonidae)	X	S2N	S3 S4B	1, 2	
37	Blue-winged Teal	*Anas discors*	Geese, Swans, and Ducks (Anatidae)	X	S2N	S2B S3 S4N	1,3,6	
38	Blue-winged Warbler	*Vermivora pinus*	Warblers (Parulidae)	X	S3N	S4B	1, 5	
39	Bobolink	*Dolichonyx oryzivorus*	Blackbirds and Orioles (Icteridae)	X	S3 S4N	S3 S4B	1, 2	Passage migrant through the District of Columbia.
40	Bonaparte's Gull	*Chroicocephalus philadelphia*	Gulls and Terns (Laridae)	X	S3N	S2N	1,3,6	
41	Broad-winged Hawk	*Buteo platypterus*	Eagles and Hawks (Accipitridae)	X	S1B S4N	S4B	1, 2	Passage migrant and breeder in the District of Columbia.

42	Brown Creeper	*Certhis americana*	Creepers (Certhiidae)		X	S3N	S4	1, 2	Resident, local migrant, and breeder within the District of Columbia.
43	Brown Thrasher	*Toxostoma rufum*	Mimids and Thrashers (Mimidae)		X	S3B S3N	S5B S2N	1, 2	Resident, local migrant, and breeder in the District of Columbia.
44	Brown-headed Cowbird	*Molothrus ater*	Blackbirds and Orioles (Icteridae)		X	S4	S5	1, 4	
45	Bufflehead	*Bucephala albeola*	Geese, Swans, and Ducks (Anatidae)		X	S1 S2N	S5N	1, 2	
46	Canada Goose	*Branta canadensis*	Geese, Swans, and Ducks (Anatidae)	X	X	S5	S4B S5N	1, 4	
47	Canada Warbler	*Wilsonia canadensis*	Warblers (Parulidae)		X	S4N	S3B	1	
48	Cape May Warbler	*Dendroica tigrina*	Warblers (Parulidae)		X	S2 S3N	SNA	1, 5	
49	Carolina Chickadee	*Poecile carolinensis*	Chickadees and Titmice (Paridae)		X	S5	S5	1, 2	
50	Carolina Wren	*Thryothorus ludovicianus*	Wrens (Troglodytidae)		X	S5	S5	1, 4	
51	Caspian Tern	*Hydroprogne caspia*	Gulls and Terns (Laridae)		X	S1 S2N	SNA	1, 2	
52	Cattle Egret	*Bubulcus ibis*	Bitterns, Egrets, and Herons (Ardeidae)	X		SNA	S3 S4B	1,3,6	
53	Common Tern	*Sterna hirundo*	Gulls and Terns (Laridae)		X				

54	Cedar Waxwing	*Bombycilla cedrorum*	Waxwings (Bombycillidae)	X	S1 S2B S4N	S5B S5N	1, 4	
55	Cerulean Warbler	*Dendroica cerulea*	Warblers (Parulidae)	X	S2N	S3 S4B	1, 2	Breeding populations in small forest tracts throughout the range are declining rapidly to extirpation.
56	Chestnut-sided Warbler	*Dendroica pensylvanica*	Warblers (Parulidae)	X	S4N	S4B	1, 5	
57	Chimney Swift	*Chaetura pelagica*	Swift (Apodidae)	X	S4N S5B	S5B	1, 2, 4	Passage migrant and breeder in the District of Columbia.
58	Chipping Sparrow	*Spizella passerina*	Sparrows and Towhees (Emberizidae)	X	S3B S4N	S5B S1N	1, 2	
59	Cliff Swallow	*Petrochelidon pyrrhonota*	Swallows and Martins (Hirundinidae)	X	S2N SHB	S3 S4B	1,3,6	
60	Common Grackle	*Quiscalus quiscula*	Blackbirds and Orioles (Icteridae)	X	S4 S5N S5B	S5	1, 4	
61	Common Loon	*Gavia immer*	Loons (Gaviidae)	X	SNA	S4N	1,3,6	

62	Common Merganser	*Mergus merganser*	Geese, Swans, and Ducks (Anatidae)	X	S3N	S3N	1, 2	
63	Common Nighthawk	*Chordeiles minor*	Nightjars (Caprimulgidae)	X	S4N	S3 S4B	1	
64	Common Raven	*Corvus corax*	Crows and Jays (Corvidae)	X	SNA	S2	1,3,6	
65	Common Yellowthroat	*Geothlypis trichas*	Warblers (Parulidae)	X	S3B S4N	S5B	1, 4	
66	Cooper's Hawk	*Accipiter cooperii*	Eagles and Hawks (Accipitridae)	X	S3B S4N	S4B S4N	1	
67	Dark-eyed Junco	*Junco hyemalis*	Sparrows and Towhees (Emberizidae)	X	S5N	S2B	1, 2, 3	Easy to recognize by their crisp (though extremely variable) markings and the bright white tail feathers they habitually flash in flight.
68	Double-crested Cormorant	*Phalacrocorax auritus*	Cormorants (Phalacrocoracidae)	X	S4N	S1B S3 S4N	1, 2	
69	Downy Woodpecker	*Picoides pubescens*	Woodpeckers (Picidae)	X	S5	S5	1, 4	
70	Eastern Bluebird	*Sialia Sialis*	Thrushes (Turdidae)	X	S4N	S5B S4N	1, 4	
71	Eastern Kingbird	*Tyrannus tyrannus*	Flycatchers (Tyrannidae)	X	S4B	S5B	1, 4	

72	Eastern Meadowlark	*Sturnella magna*	Blackbirds and Orioles (Icteridae)		X	S1B S4N	S5B S3N	1, 2, 3	Local habitat: Rock Creek National Park, Kenilworth Park, Anacostia Park, and Oxon Cove Park.
73	Eastern Phoebe	*Sayornis phoebe*	Flycatchers (Tyrannidae)		X	S3B	S5B	1, 4	
74	Eastern Screech-Owl	*Megascops asio*	True Owls (Strigidae)		X	S1	S5	1	
75	Eastern Towhee	*Pipilo erythrophthalmus*	Sparrows and Towhees (Emberizidae)		X	S4B S4 S5N	S5B S4N	1, 2	Local habitat: Rock Creek National Park, Kenilworth Park, Anacostia Park, Oxon Run Parkway, Oxon Cove Park, and the Fort Circle Parks area.
76	Eastern Wood-Pewee	*Contopus virens*	Flycatchers (Tyrannidae)		X	SNR	S5B	1, 4	
77	European Starling	*Sturnus vulgaris*	Starlings (Sturnidae)	X		SNA	SNA	1, 4	
78	Field Sparrow	*Spizella pusilla*	Sparrows and Towhees (Emberizidae)		X	S2B S4N	S5	1, 2, 4	Current intensive agricultural practices and spreading urbanization continue to restrict, or eliminate nesting habitat of old weedy fields with shrubs or small trees.

79	Fish Crow	*Corvus ossifragus*	Crows and Jays (Corvidae)	X	S1 S2N S3B	S5	1, 4	
80	Forster's Tern	*Sterna forsteri*	Gulls and Terns (Laridae)	X	S2 S3N	S4B	1,3,6	
81	Fox Sparrow	*Passerella iliaca*	Sparrows and Towhees (Emberizidae)	X	S3N	S2N	1, 2	
82	Gadwall	*Anas strepera*	Geese, Swans, and Ducks (Anatidae)	X	SNA	S2B S4N	1,3,6	
83	Glossy Ibis	*Plegadis falcinellus*	Ibises and Spoonbills (Threskiornithidae)	X	SNA	S4B	1,3,6	
84	Golden-crowned Kinglet	*Regulus satrapa*	Kinglets (Regulidae)	X	S3 S4N	S2B	1, 2	
85	Grasshopper Sparrow	*Ammodramus savannarum*	Sparrows and Towhees (Emberizidae)	X	S3N	S4B	1, 2	Populations declines have resulted in part from loss of habitat, especially the conversion of grassland to row-crop agriculture, urban sprawl, and reforestation, compounded by losses incurred as a result of mowing of habitat and subsequent increased predation.

86	Gray Catbird	*Dumetella carolinensis*	Mimids and Thrashers (Mimidae)	X	S4N S5B	S5B S1N	1, 4	
87	Gray Cheeked Thrush	*Catharus minimus*	Thrushes (Turdidae)	X	S3N	SNA	1, 5	
88	Great Black-backed Gull	*Larus marinus*	Gulls and Terns (Laridae)	X	S5N	S4B	1, 4	
89	Great Blue Heron	*Ardea herodias*	Bitterns, Egrets, and Herons (Ardeidae)	X	S4N	S4B S3 S4N	1, 4	
90	Great Crested Flycatcher	*Myiarchus crinitus*	Flycatchers (Tyrannidae)	X	S3B	S5B	1, 4	
91	Great Egret	*Ardea alba*	Bitterns, Egrets, and Herons (Ardeidae)	X	S4N	S4B	1	
92	Great Horned Owl	*Bubo virginianus*	True Owls (Strigidae)	X	S2	S5	1, 2	Local habitat: Rock Creek National Park, Kenilworth Park, Oxon Cove Park, and the Fort Circle Parks area.
93	Greater Scaup	*Aythya marila*	Geese, Swans, and Ducks (Anatidae)	X	S1N	S4N	1,3,6	
94	Greater Yellowlegs	*Tringa melanoleuca*	Sandpiper (Scolopacidae)	X	S3N	S1N	1, 2	
95	Green Heron	*Butorides virescens*	Bitterns, Egrets, and Herons (Ardeidae)	X	S3 S4B S3 S4N	S5B	1	

96	Green-winged Teal	*Anas crecca*	Geese, Swans, and Ducks (Anatidae)		X	S2N	S4N	1,3,6	
97	Hairy Woodpecker	*Picoides villosus*	Woodpeckers (Picidae)		X	S3	S5	1, 4	
98	Hermit Thrush	*Catharus guttatus*	Thrushes (Turdidae)		X	S3N	S3 S4B S4N	1, 4	
99	Herring Gull	*Larus argentatus*	Gulls and Terns (Laridae)		X	S4N	S5B S5N	1, 4	
100	Hooded Merganser	*Lophodytes cucullatus*	Geese, Swans, and Ducks (Anatidae)		X	S3N	S1B	1	
101	Hooded Warbler	*Wilsonia citrina*	Warblers (Parulidae)		X	S3 S4N	S4 S5B	1, 2, 4	Passage migrant within the District of Columbia.
102	Horned Grebe	*Podiceps auritus*	Grebes (Podicipedidae)		X	SNA	S4N	1,3,6	
103	Horned Lark	*Eremophila alpestris*	Larks (Alauidae)		X	S2N	S4B S4N	1,3,6	
104	House Finch	*Carpodacus mexicanus*	Finches and Grosbeaks (Fringillidae)	X		SNA	SNA	1, 4	
105	House Sparrow	*Passer domesticus*	Old World Sparrows (Passeridae)	X		SNA	SNA	1, 4	
106	House Wren	*Troglodytes aedon*	Wrens (Troglodytidae)		X	S4N S5B	S5B	1, 4	
107	Indigo Bunting	*Passerina cyanea*	Cardinals and Buntings (Cardinalidae)		X	S4 S5N S5B	S5B	1, 4	

108	Kentucky Warbler	*Oporornis formosus*	Warblers (Parulidae)	X	S3 S4N	S4B	1, 2, 4	Breeds in humid deciduous forest, dense second growth, swamps.
109	Killdeer	*Charadrius vociferus*	Plovers and Lapwings (Charadriidae)	X	S2B S4N	S5B S4N	1, 4	
110	Laughing Gull	*Leucophaeus atricilla*	Gulls and Terns (Laridae)	X	S3N	S1B S4N	1, 4	
111	Least Bittern	*Lxobrychus exilis*	Bitterns, Egrets, and Herons (Ardeidae)	X	S1B S2N	S2 S3B	1, 2	Breeds in tall emergent vegetation in marshes, primarily freshwater, less commonly in coastal brackish marshes and mangrove swamps.
112	Least Flycatcher	*Empidonax minimus*	Flycatchers (Tyrannidae)	X	S2 S3N	S3 S4B	1,3,6	
113	Least Sandpiper	*Calidris minutilla*	Sandpiper (Scolopacidae)	X	S3N	SNA	1,3,6	
114	Least Tern	*Sternula antillarum*	Gulls and Terns (Laridae)	X	SNR	S2B	1	
115	Lesser Black-Backed Gull	*Larus fuscus*	Gulls and Terns (Laridae)	X	SNR	SNA	1, 3	
116	Lesser Scaup	*Aythya affinis*	Geese, Swans, and Ducks (Anatidae)	X	S2S3N	S4N	1, 2	
117	Lesser Yellowlegs	*Tringa flavipes*	Sandpiper (Scolopacidae)	X	S3N	S1N	1, 2	

118	Lincoln's Sparrow	*Melospiza lincolnii*	Sparrows and Towhees (Emberizidae)	X	SNA	SNA	1,3,6	
119	Little Blue Heron	*Egretta caerulea*	Bitterns, Egrets, and Herons (Ardeidae)	X	S3N	S3B	1, 2	
120	Louisiana Waterthrush	*Seiurus motacilla*	Warblers (Parulidae)	X	S3 S4N	S5B	1, 2, 4	Breeds in moist forest, woodland, and ravines along streams, mature deciduous and mixed floodplain and swamp forests.
121	Magnolia Warbler	*Dendroica magnolia*	Warblers (Parulidae)	X	S4N	S3 S4B	1, 4	
122	Mallard	*Anas platyrhynchos*	Geese, Swans, and Ducks (Anatidae)	X	S4N S5B	SNA	1, 4	
123	Marsh Wren	*Cistothorus palustris*	Wrens (Troglodytidae)	X	S1B S3N	S4B S2N	1, 2	Local habitat: Kenilworth Park and Anacostia Park.
124	Merlin	*Falco columbarius*	Falcons (Falconidae)	X	S1N	S1N	1,3,6	
125	Mourning Dove	*Zenaida macroura*	Doves (Columbidae)	X	S4N S5B	S5	1, 4	
126	Mourning Warbler	*Oporornis philadelphia*	Warblers (Parulidae)	X	S2N	S1B	1, 5	
127	Nashville Warbler	*Vermivora ruficapilla*	Warblers (Parulidae)	X	S2N	S1 S2B	1, 5	

128	Northern Bobwhite	*Colinus virginianus*	Quails (Odontophoridae)	X	S1	S5	1, 2	Principal threat appears to be habitat loss and fragmentation associated with changing land use, particularly clean farming techniques, single crop production, plantation forestry, fire suppression, replacement of native grass pasture with Tall Fescue, and over-grazing by cattle.
129	Northern Cardinal	*Cardinalis cardinalis*	Cardinals and Buntings (Cardinalidae)	X	S5	S5	1, 4	
130	Northern Flicker	*Colaptes auratus*	Woodpeckers (Picidae)	X	S2 S3N S5B	S5B S5N	1, 4	
131	Northern Goshawk	*Accipiter gentilis*	Eagles and Hawks (Accipitridae)	X	SNA	S1B	1,3,6	
132	Northern Harrier	*Circus cyaneus*	Eagles and Hawks (Accipitridae)	X	S2N	S2B	1, 2	
133	Northern Mockingbird	*Mimus polyglottos*	Mimids and Thrashers (Mimidae)	X	S5	S5	1, 4	
134	Northern Parula	*Parula americana*	Warblers (Parulidae)	X	S3B S3N	S4 S5B	1, 4	
135	Northern Pintail	*Anas acuta*	Geese, Swans, and Ducks (Anatidae)	X	S2N	S4N	1,3,6	

136	Northern Rough-winged Swallow	*Stegidopteryx serripennis*	Swallows and Martins (Hirundinidae)	X	S2N S3B	S4B	1, 4	
137	Northern Shoveler	*Anas clypeata*	Geese, Swans, and Ducks (Anatidae)	X	S1N	S2N	1,3,6	
138	Northern Waterthrush	*Seiurus noveboracensis*	Warblers (Parulidae)	X	S3N	S2S3B	1, 4	
139	Orange-crowned Warbler	*Oreothlypis celata*	Warblers (Parulidae)	X	S1N	SNA	1,3,6	
140	Orchard Oriole	*Icterus spurius*	Blackbirds and Orioles (Icteridae)	X	S1B S3S4N	S5B	1, 4	
141	Osprey	*Pandion haliaetus*	Eagles and Hawks (Accipitridae)	X	S2 S3N	S4B	1, 4	
142	Ovenbird	*Seiurus aurocapilla*	Warblers (Parulidae)	X	S2B S3N	S5B	1, 2, 4	Typically nests in mid-late successional, closed-canopied deciduous or deciduous-coniferous forests that have deep leaf litter and limited understory.
143	Palm Warbler	*Dendroica palmarum*	Warblers (Parulidae)	X	S3N	S2N	1, 2	
144	Pectoral Sandpiper	*Calidris melanotos*	Sandpiper (Scolopacidae)	X	S2N	SNA	1,3,6	
145	Peregrine Falcon	*Falco peregrinus*	Falcons (Falconidae)	X	S1B S1N	S2B S3N	1, 2	

146	Philadelphia Vireo	*Vireo philadelphicus*	Vireos (Vireonidae)	X	S1N	SNA	1, 5	
147	Pied-billed Grebe	*Podilymbus podiceps*	Grebes (Podicipedidae)	X	S4 S5N	S2B	1, 2	
148	Pileated Woodpecker	*Dryocopul pileatus*	Woodpeckers (Picidae)	X	S3	S5	1, 4	
149	Pine Siskin	*Spinus pinus*	Finches and Grosbeaks (Fringillidae)	X	S1N	S1 S2N	1,3,6	
150	Pine Warbler	*Dendroica pinus*	Warblers (Parulidae)	X	S1B S1 S3N	S4B S2N	1, 4	
151	Prairie Warbler	*Dendroica discolor*	Warblers (Parulidae)	X	S1B S2N	S4B	1, 2	
152	Prothonotary Warbler	*Protonotaria citrea*	Warblers (Parulidae)	X	S1B	S4B	1, 2	Breeds in mature deciduous floodplain, river, and swamp forests; wet lowland forest.
153	Purple Finch	*Carpodacus purpureus*	Warblers (Parulidae)	X	S3N	S3B S3N	1, 5	
154	Purple Martin	*Progne subis*	Swallows and Martins (Hirundinidae)	X	S1B S5N	S5B	1,3,6	
155	Red-bellied Woodpecker	*Melanerpes carolinus*	Woodpeckers (Picidae)	X	S5	S5	1, 4	
156	Red-breasted Merganser	*Mergus serrator*	Geese, Swans, and Ducks (Anatidae)	X	S2N	S3N	1,3,6	
157	Red-breasted Nuthatch	*Sitta canadensis*	Nuthatches (Sittidae)	X	S1 S2N	S1B	1,3,6	
158	Red-eyed Vireo	*Vireo olivaceus*	Vireos (Vireonidae)	X	S5B S5N	S5B	1, 4	

159	Red-headed Woodpecker	*Melanerpes erythrocephalus*	Woodpeckers (Picidae)		X	S1N SHB	S4	1,3,6	
160	Red-shouldered Hawk	*Buteo lineatus*	Eagles and Hawks (Accipitridae)		X	S2B S3N	S4 S5B S4N	1, 2, 4	Breeds in bottomland hardwoods and riparian areas to upland deciduous or mixed deciduous-conifer forest.
161	Red-tailed Hawk	*Buteo jamaicensis*	Eagles and Hawks (Accipitridae)		X	S3N	S5B S5N	1	
162	Red-winged Blackbird	*Agelaius phoeniceus*	Blackbirds and Orioles (Icteridae)		X	S4 S5N	S5	1, 4	
163	Ring-billed Gull	*Larus delawarensis*	Gulls and Terns (Laridae)		X	S2 S4N	S5N	1, 4	
164	Ring-necked Duck	*Aythya collaris*	Geese, Swans, and Ducks (Anatidae)		X	S3N	S2N	1,3,6	
165	Rock Pigeon	*Columba livia*	Doves (Columbidae)	X		SNA	SNA	3, 4	
166	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Cardinals and Buntings (Cardinalidae)		X	S3N	S3 S4B	1, 4	
167	Royal Tern	*Thalasseus maximus*	Gulls and Terns (Laridae)		X	SNR	S1B	1	
168	Ruby-crowned Kinglet	*Regulus calendula*	Kinglets (Regulidae)		X	S4N	S3N	1, 2	
169	Ruby-throated Hummingbird	*Archilochus colubris*	Hummingbirds (Trochilidae)		X	S3B S3N	S5B	1	
170	Ruddy Duck	*Oxyura jamaicensis*	Geese, Swans, and Ducks (Anatidae)		X	S3 S4N	S3N	1, 2	

171	Rusty Blackbird	*Euphagus carolinus*	Blackbirds and Orioles (Icteridae)	X	S3N	S2 S3N	1,3,6	
172	Savannah Sparrow	*Passerculus sandwichensis*	Sparrows and Towhees (Emberizidae)	X	S1 S3N	S3 S4B S4N	1,3,6	
173	Scarlet Tanager	*Piranga olivacea*	Cardinals and Buntings (Cardinalidae)	X	S2B S4N	S5B	1, 2, 4	Local habitat: Rock Creek National Park, Kenilworth Park, Anacostia Park, Capitol Hill Parks, Oxon Run Parkway, Oxon Cove Park, and the Fort Circle Parks area.
174	Sedge Wren	*Cistothorus platensis*	Wrens (Troglodytidae)	X	SHB	S1B	1,3,6	
175	Semipalmated Plover	*Charadrius semipalmatus*	Plovers and Lapwings (Charadriidae)	X	S2N	SNA	1,3,6	
176	Semipalmated Sandpiper	*Calidris pusilla*	Sandpiper (Scolopacidae)	X	S2N	SNA	1,3,6	
177	Sharp-shinned Hawk	*Accipiter striatus*	Eagles and Hawks (Accipitridae)	X	S3N SHB	S1 S2B	1, 2	
178	Snow Bunting	*Plectrophenax nivalis*	Longspurs and Buntings (Calcariidae)	X	S1N	S1N	1,3,6	
179	Snowy Egret	*Egretta thula*	Bitterns, Egrets, and Herons (Ardeidae)	X	S2N	S3 S4B	1,3,6	
180	Solitary Sandpiper	*Tringa solitaria*	Sandpiper (Scolopacidae)	X	S3N	SNA	1, 2	

181	Song Sparrow	*Melospiza melodia*	Sparrows and Towhees (Emberizidae)	X	S5B S5N	S5	1, 4	
182	Sora	*Porzana carolina*	Rails (Rallidae)	X	S2N	S1B	1, 2, 3	Nesting habitat includes freshwater swamps, bogs, and swamps with dense stands of cattails, reeds, bulrushes, or sedges.
183	Spotted Sandpiper	*Actitis macularius*	Sandpiper (Scolopacidae)	X	S4N	S3 S4B	1, 3, 4	
184	Summer Tanager	*Piranga rubra*	Cardinals and Buntings (Cardinalidae)	X	S1 S2B S1 S2N	S4B	1,3,6	
185	Swainson's Thrush	*Catharus ustulatus*	Thrushes (Turdidae)	X	S4N	SXB	1, 4	
186	Swamp Sparrow	*Melospiza gerorgiana*	Sparrows and Towhees (Emberizidae)	X	S2 S3N	S4B S5N	1, 2	
187	Tennessee Warbler	*Vermivora peregrina*	Warblers (Parulidae)	X	S2 S3N	SNA	1, 5	
188	Tree Swallow	*Tachycineta bicolor*	Swallows and Martins (Hirundinidae)	X	S1B	S4B	1, 4	
189	Tricolored Heron	*Egretta tricolor*	Bitterns, Egrets, and Herons (Ardeidae)	X	S1N	S3B	1,3,6	
190	Tufted Titmouse	*Baeolophus bicolor*	Chickadees and Titmice (Paridae)	X	S5	S5	1, 4	

191	Tundra Swan	*Cygnus columbianus*	Geese, Swans, and Ducks (Anatidae)	X	S2N	S4N	1,3,6	
192	Turkey Vulture	*Cathartes aura*	New World Vultures (Cathartidae)	X	S3N	S5B S5N	1, 2	
193	Upland Sandpiper	*Bartramia longicauda*	Sandpiper (Scolopacidae)	X	S1N	S1B	1, 2	
194	Veery	*Catharus fuscescens*	Thrushes (Turdidae)	X	S2B S3N	S4B	1, 4	
195	Vesper Sparrow	*Pooecetes gramineus*	Sparrows and Towhees (Emberizidae)	X	S3N	S3 S4B S2N	1,3,6	
196	Virginia Rail	*Rallus limicola*	Rails (Rallidae)	X	S1N SHB	S4B S4N	1, 2	Inhabits shallow, freshwater, emergent wetlands of every size and type, from roadside ditches and borders of lakes and streams to large cattail marshes.
197	Warbling Vireo	*Vireo gilvus*	Vireos (Vireonidae)	X	S1B S1S2N	S4B	1, 4	
198	Western Sandpiper	*Calidris mauri*	Sandpiper (Scolopacidae)	X	S1 S2N	SNA	1,3,6	
199	Whip-poor-will	*Caprimulgus vociferus*	Nightjars (Caprimulgidae)	X	S3N	S3 S4B	1	
200	White-breasted Nuthatch	*Sitta carolinensis*	Nuthatches (Sittidae)	X	S3B S3N	S5	1	

201	White-crowned Sparrow	*Zonotrichia leucophrys*	Sparrows and Towhees (Emberizidae)	X	S3N	S3 S4N	1,3,6	
202	White-eyed Vireo	*Vireo griseus*	Vireos (Vireonidae)	X	S1B S2 S4N	S5B	1, 2, 4	During breeding season, inhabits early-late successional, shrubby habitats such as deciduous scrub, old fields, abandoned pastures, regenerating clearcuts or other heavily logged areas, drainage and streamside thickets, forest edges, reclaimed strip mines, and mangrove swamps.
203	White-rumped Sandpiper	*Calidris fuscicollis*	Sandpiper (Scolopacidae)	X	S1N	SNA	1	
204	White-throated Sparrow	*Zonotrichia albicollis*	Sparrows and Towhees (Emberizidae)	X	S5N	S5N	1, 4	

205	Wild Turkey	*Meleagris gallopavo*	Turkeys and pheasants (Phasianidae)	X	SNR	S4	1, 2	
206	Willet	*Tringa semipalmata*	Sandpiper (Scolopacidae)	X	S2N	S3 S4B	1,3,6	
207	Willow Flycatcher	*Empidonax traillii*	Flycatchers (Tyrannidae)	X	SNR	S4B	1	
208	Wilson's Snipe	*Gallinago delicata*	Sandpiper (Scolopacidae)	X	S2 S3N	S2N	3	
209	Wilson's Warbler	*Wilsonia pusilla*	Warblers (Parulidae)	X	S2 S3N	SNA	1, 2	
210	Winter Wren	*Troglodytes troglodytes*	Wrens (Troglodytidae)	X	S2 S3N	S2B	1, 2	
211	Wood Duck	*Aix sponsa*	Geese, Swans, and Ducks (Anatidae)	X	S3N S4B	S5B S3N	1, 2, 4	Inhabits quiet inland waters near woodland, such as wooded swamps, flooded forest, greentree reservoirs, ponds, marshes, and along streams. Local habitat: Rock Creek National Park, Anacostia Park, Kenilworth Park, Oxon Run Parkway, Oxon Cove Park, and the Fort Circle Parks area.
212	Wood Thrush	*Hylocichla mustelina*	Thrushes (Turdidae)	X	S3B S4N	S5B	1, 2, 4	

213	Worm-eating Warbler	*Helmitheros vermivorum*	Warblers (Parulidae)	X	S2N	S4B	1, 2	Breeds in well-drained upland deciduous forests with understory patches of mountain laurel or other shrubs, drier portions of stream swamps with an understory of mountain laurel, deciduous woods near streams
214	Yellow Warbler	*Dendroica petechia*	Warblers (Parulidae)	X	S2N	S5B	1, 4	
215	Yellow-bellied sapsucker	*Sphyrapicus varius*	Woodpeckers (Picidae)	X	S2N	SHB S3N	1, 2	
216	Yellow-bellied Flycatcher	*Empidonax flaviventris*	Flycatchers (Tyrannidae)	X	S1 S2N	SNA	1,3,6	
217	Yellow-billed Cuckoo	*Coccyzus americanus*	Cuckoos (Cuculidae)	X	S2B S3N	S5B	1, 4	
218	Yellow-breasted Chat	*Icteria virens*	Warblers (Parulidae)	X	S3 S4N	S5B	1, 4	
219	Yellow-crowned Night Heron	*Nyctanassa violacea*	Bitterns, Egrets, and Herons (Ardeidae)	X	SHB	S2B	1	
220	Yellow-rumped Warbler	*Dendroica coronata*	Warblers (Parulidae)	X	S5N	S4N	1, 4	

221	Yellow-throated Vireo	*Vireo flavifrons*	Vireos (Vireonidae)	X	S2 S3B S2 S3N	S4 S5B	1, 2	Breeds primarily in open deciduous forest and woodland, mixed forest near clearings or water, moist upland forest riparian woodland, tall floodplain forest, lowland swamp forest;
222	Yellow-throated Warbler	*Dendroica dominica*	Warblers (Parulidae)	X	S1N	S4B	1	

APPENDIX B

Endangered Species Letter from Genevieve LaRouche to Fred Pinkney
11/2/2015

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Chesapeake Bay Field Office
177 Admiral Cochrane Drive
Annapolis, Maryland 21401
http://www.fws.gov/chesapeakebay

November 2, 2015

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Environmental Contaminants Program
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Annapolis, MD 21401

RE: "Not Likely to Adversely Affect" northern long-eared bat determination; Anacostia IPaC Database Results for Anacostia Watershed Restoration Studies in Montgomery and Prince George's Counties in Maryland

Dear Dr. Pinkney:

The U.S. Fish and Wildlife Service (Service) has reviewed your project information from the Service's Information for Planning and Conservation (IPaC) online system dated July 7, 2015. The Service has evaluated the potential effects of this project to the threatened northern long-eared bat (*Myotis septentrionalis*). The comments provided below are in accordance with Section 7 of the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*).

The purpose of this proposed project is to conduct feasibility studies of aquatic ecosystem restoration needs and opportunities within the Anacostia Watershed in Montgomery and Prince George's Counties in Maryland.

This project is within the range of the northern long-eared bat, a federally listed threatened species. The northern long-eared bat is a temperate, insectivorous migratory bat that hibernates in mines and caves in the winter and summers in wooded areas. Since the forest clearing for this proposed project is minimal, and there are no current records of northern long-eared bats in the project vicinity, this 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.

Except for occasional transient individuals, no other Federal proposed or listed endangered or threatened species under our jurisdiction are known to exist within the project impact area. Should project plans change, or if additional information on the distribution of listed or proposed species becomes available, this determination may be reconsidered.

TAKE PRIDE IN AMERICA

We appreciate the opportunity to provide information relevant to threatened and endangered fish and wildlife resources. This Endangered Species Act determination does not exempt this project from obtaining all permits and approvals that may be required by other State or Federal agencies.
If you have any questions or concerns regarding this letter, please contact Trevor Clark of my Endangered Species staff at (410) 573-4527 or by email at Trevor_Clark@fws.gov.

Sincerely,

G. La Rouche

Genevieve LaRouche
Supervisor

APPENDIX C

Function-Based Rapid Field Stream Assessment data sheets
Sligo Creek Mainstem/Sligo Creek Tributary
Paint Branch
Little Paint Branch

RAPID WATERSHED ASSESSMENT DATA SHEETS
Sligo Creek Mainstem/Sligo Creek Tributary
Paint Branch
Little Paint Branch

RAPID WATERSHED ASSESSMENT DATA SHEET

Watershed: Sligo / Sligo Tr. 6

Rater(s): 6/4/15

Stream:

Date: RL, SD

Photo(s):

Overall Watershed Condition Good Fair Poor

WATERSHED ASSESSMENT

	Category / Parameter / Measurement Method	Description of Watershed Condition			Rating (G/F/P)
		Good	Fair	Poor	
1	Hydrology / Runoff / Watershed Impoundments	No impoundment upstream of project area	No impoundment within 1 mile upstream of project area OR impoundment does not adversely affect hydrology or fish passage	Impoundment(s) located within 1 mile upstream of project area and/or has an adverse effect on hydrology and/or fish passage	G or F?
2	Hydrology / Runoff / Concentrated Flow	No potential for concentrated flow/impairments from adjacent land use	Some potential for concentrated flow/impairments to reach restoration site, however, measures are in place to protect resources	Potential for concentrated flow/impairments to reach restoration site and no treatments are in place	P
3	Hydrology / Runoff / Land Use Change	Rural communities/slow growth or primarily forested (>70%)	Single family homes/suburban development occurring or active agricultural practices occurring, or commercial and/or industrial development starting, forested area 20 - 70%	Rapidly urbanizing/urban or primarily active agricultural practices (> 70%), forested area <20%	P
4	Hydrology / Runoff / Distance to Roads	No roads in or adjacent to site. No proposed major roads in or adjacent to site in 10 year DOT plans	No roads in or adjacent to site. No more than one major road proposed in 10 year DOT plans	Roads located in or adjacent to site boundary and/or major roads proposed in 10 year DOT plans	P
5	Hydrology / Runoff / Flashiness	Non-flashy flow regime as a result of rainfall patterns, geology, and soils, impervious cover less than 6%	Semi-flashy flow regime as a result of rainfall patterns, geology, and soils, impervious cover 7%- 15%	Flashy flow regime as a result of rainfall patterns, geology, and soils, impervious cover greater than 15%	P
6	Geomorphology / Riparian Vegetation	>80% of contributing stream length has >25 ft corridor width	50 - 80% of contributing stream length has >25 ft corridor width	<50% of contributing stream length has >25 ft corridor width	F
7	Geomorphology / Sediment Supply	Low sediment supply. Upstream bank erosion and bed load supply is minimal. There are few bars present in the channel	Moderate sediment supply from upstream bank erosion and bed load supply. There are some point bars and small lateral bars	High sediment supply from upstream bank erosion and bed load supply. There are numerous alternating point bars, transverse bars and/or mid-channel bars	F
8	Physicochemical / Water Quality / 303(d) List	Very clear, or clear but tea-colored; objects visible at depth 3 to 6 ft (less if slightly colored); no oil sheen on surface; no noticeable film on submerged objects or rocks. Clear water along entire reach; diverse aquatic plant community includes low quantities of many species of macrophytes; little algal growth present. Not on 303d list	Considerable cloudiness most of the time; objects visible to depth 0.5 to 1.5 ft; slow sections may appear pea-green; bottom rocks or submerged objects covered with green or olive-green film; or moderate odor of ammonia or rotten eggs. Greenish water along entire reach; overabundance of lush green macrophytes; abundant algal growth, especially during warmer months. On or downstream of 303d list and TMDL/WS Mgmt plan addressing deficiencies	Very turbid or muddy appearance most of the time; objects visible at depth< 0.5 ft; slow moving water maybe bright green; other obvious water pollutants; floating algal mats, surface scum, sheen or heavy coat of foam on surface; or strong odor of chemicals, oil, sewage, or other pollutants. Pea-green, gray, or brown water along entire reach; dense stands of macrophytes clogging stream; severe algal blooms creating thick algal mats in stream. On or downstream of 303d list and no TMDL/WS mgmt plan to address deficiencies	F?
9	Biology / Landscape Connectivity	Channel upstream and downstream of project area has native bed and bank materials and is not impaired	Channel upstream and downstream of project area has native bed and bank materials but is impaired	Channel upstream and downstream of project area is concrete piped, or hardened	P

RAPID WATERSHED ASSESSMENT DATA SHEET

Watershed: _____ Rater(s): RL

Stream: Paint Branch Date: 6/8/15

Photo(s): _____

Overall Watershed Condition Good Fair Poor

WATERSHED ASSESSMENT

	Category / Parameter / Measurement Method	Description of Watershed Condition			Rating (G/F/P)
		Good	Fair	Poor	
1	Hydrology / Runoff / Watershed Impoundments	No impoundment upstream of project area	No impoundment within 1 mile upstream of project area OR impoundment does not adversely affect hydrology or fish passage	Impoundment(s) located within 1 mile upstream of project area and/or has an adverse effect on hydrology and/or fish passage	G or F?
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3	Hydrology / Runoff / Land Use Change	Rural communities/slow growth or primarily forested (>70%)	Single family homes/suburban development occurring or active agricultural practices occurring, or commercial and/or industrial development starting, forested area 20 - 70%	Rapidly urbanizing/urban or primarily active agricultural practices (> 70%), forested area <20%	P
4	Hydrology / Runoff / Distance to Roads	No roads in or adjacent to site. No proposed major roads in or adjacent to site in 10 year DOT plans	No roads in or adjacent to site. No more than one major road proposed in 10 year DOT plans	Roads located in or adjacent to site boundary and/or major roads proposed in 10 year DOT plans	P
5	Hydrology / Runoff / Flashiness	Non-flashy flow regime as a result of rainfall patterns, geology, and soils, impervious cover less than 6%	Semi-flashy flow regime as a result of rainfall patterns, geology, and soils, impervious cover 7%- 15%	Flashy flow regime as a result of rainfall patterns, geology, and soils, impervious cover greater than 15%	P
6	Geomorphology / Riparian Vegetation	>80% of contributing stream length has >25 ft corridor width	50 - 80% of contributing stream length has >25 ft corridor width	<50% of contributing stream length has >25 ft corridor width	F
7	Geomorphology / Sediment Supply	Low sediment supply. Upstream bank erosion and bed load supply is minimal. There are few bars present in the channel	Moderate sediment supply from upstream bank erosion and bed load supply. There are some point bars and small lateral bars	High sediment supply from upstream bank erosion and bed load supply. There are numerous alternating point bars, transverse bars and/or mid-channel bars	F or P
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9	Biology / Landscape Connectivity	Channel upstream and downstream of project area has native bed and bank materials and is not impaired	Channel upstream and downstream of project area has native bed and bank materials but is impaired	Channel upstream and downstream of project area is concrete piped, or hardened	F

RAPID WATERSHED ASSESSMENT DATA SHEET

Watershed: _____ Rater(s): SD, RL

Stream: Little Paint Branch Date: 6/8/15

Photo(s): _____

Overall Watershed Condition Good Fair Poor

WATERSHED ASSESSMENT

	Category / Parameter / Measurement Method	Description of Watershed Condition			Rating (G/F/P)
		Good	Fair	Poor	
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5	Hydrology / Runoff / Flashiness	Non-flashy flow regime as a result of rainfall patterns, geology, and soils, impervious cover less than 6%	Semi-flashy flow regime as a result of rainfall patterns, geology, and soils, impervious cover 7%- 15%	Flashy flow regime as a result of rainfall patterns, geology, and soils, impervious cover greater than 15%	P
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9	Biology / Landscape Connectivity	Channel upstream and downstream of project area has native bed and bank materials and is not impaired	Channel upstream and downstream of project area has native bed and bank materials but is impaired	Channel upstream and downstream of project area is concrete piped, or hardened	F

APPENDIX D

Comments and responses on the draft report submitted to USACE in July 2015

Comments and responses on the draft report submitted to USACE in June 2015.

NUMBERED COMMENTS				
		USACE Comment	Author	**USFWS Response**
1		Please provide clarity as to why the stream reaches selected were chosen. Are they representative of those that were not studied? That is, can the results be extrapolated to other sites? If so, please discuss this in the PAR**.**	Sowers	There are two parts to the PAR: 1) The assessment of recreational fishing, fish sampling data, potential for anadromous fish migration, and environmental education was conducted on all candidate reaches summarized in USACE (2015a,b). 2) The Function-based Rapid Stream Assessment was conducted on the following candidate stream reaches which were assigned to USFWS by USACE: Sligo Creek (Montgomery County) which included a mainstem and tributary subsection; Paint Branch (Prince Georges County), and Little Paint Branch (Prince Georges County). The assessment was based on field measurements and analysis of data provided by USACE. The results are specific to the reaches assessed and cannot be extrapolated to areas where no field work was conducted.
2		It appears much of the text was pulled from the Report Synopsis that USACE drafted. Please revise text to reduce the redundancy.	Gomez	The Introduction has been revised. The text that discusses bird species (in the Environmental Education section of "Results and Interpretation") is now given in quotes.
3		Please replace 'USACE' with 'USACE'	Gomez	Accepted

4		Please provide separate recommendations and prioritizations for Montgomery County and Prince George's County. The current draft has just one set of recommendations for the Anacostia.	Sowers	The Conclusions and Prioritization section is now divided into subsections for each county.
5		Please develop the recommendations/conclusions section further to include advice or conservation recommendations for both Montgomery and Prince George's County. See specific comments in the report.	Sowers/Gomez	Determination of the proper restoration techniques to be used on the stream segments is part of the design/development process and can vary significantly based on site conditions. This level of effort was beyond the scope of this study, but can be included in the next phase, or any joint future work.
6		It is identified that we would get tolerant species only and they are already there. Do you have any recommendations to address this?	Gomez	Text has been revised to further explain the potential biologic lift (p. 9 and 10 of report.)
7		Can you expand the discussion of what species would likely benefit from these projects?	Sowers	The biology parameter in the rapid assessment is a visual observation of tolerant vs. intolerant species only, and as such, individual species were not identified past their family in fish and order for benthic macroinvertebrates. A more detailed inventory of the baseline biological community present in the streams would have to occur for further discussion to take place.
8		Not all of the functions covered in the pyramid are stream functions. For example, 'provide clean water' is really a watershed function. Streams have some limited ability to address WQ, but this is usually overwhelmed by watershed factors. Is it appropriate in the Anacostia to credit the streams with water quality improvements? Does this lead to any problems in using the pyramid in this setting**?**	Spaur	Concur. Water quality cannot be addressed at the reach level without additional information about the watershed conditions. Based on that, please note that the restoration potential identified by CBFO as part of this study is only up to level 3 – geomorphology, not level 4 – physicochemical. However, any restoration on the stream segments will affect sediment supplies, and therefore nutrients. This would be the one water quality parameter that can be achieved at the reach rather than watershed level (through lateral stability improvements). USACE can determine whether crediting sediment/nutrient reductions at a site is acceptable, but it is something that can be quantified.

9		How do we address the issue that the pyramid structure implies that undertaking work at any level can provide functional lift that can be measured? Whereas, in reality, measurable improvement in some of the functions of the pyramid may produce no meaningful ecological improvement.	Spaur	Concur, that is why it is critical to select functions that: 1. Stakeholders believe they can change 2. Are measureable As in the reply to comment 5 above, this determination is something that occurs during the design process, but CBFO can assist in the process of identifying which functions to select.
COMMENTS IN TEXT				
abstract		For both Montgomery and Prince George's County? From Figure 3, it looks like a couple of the segments in Prince George's County are pinpointed.	JS1	Revised; "Based on a map provided by Jorge Montero of the Anacostia Watershed Society, three of the candidate reaches (all in Prince Georges County) have documented recreational fishing: Paint Branch (PG#5), Northeast Branch (PG Site #15), and Northeast Branch-Riggs Road (PG Site #13)."
abstract		In Montgomery County? Please provide a similar listing of species for Prince George's County.	JS2	Revised. The text and Table 3 provide the list of game fish species identified in the four Prince Georges candidate reaches that were surveyed by MBSS.
p.2		Please provide the corresponding stream reach number for Little Paint Branch	E3	Provided. As noted above, a subset of these reaches: Montgomery County—Sligo Creek (Site Mont #12; 0.7 miles), Prince Georges County—Paint Branch (Site PG#5, 1.2 miles), and Little Paint Branch (Site PG#12; 0.8 miles) were evaluated using the Function-based Rapid Stream Assessment.
p. 3		Where is this? (Refers to statement on page 3, "The watershed assessment identifies potential constraints and stressors that may influence the stream segment (and potential restoration) and was completed based on information provided by USACE."	E4	Text has been clarified by referencing the USACE (2015a,b) synopses
p.3		Why? Is this just an example or does flood plain connectivity drive the lift potential?	E5	Text has been added explaining the use of floodplain connectivity when determining potential lift.

p.4		Based on Table 3(now Table 4), all segments have a 'restoration potential' = 3, but the ranking ranges from low to maximum. Please explain how they can all have the same restoration potential but vary from low to maximum.	E6	Text has been added (p. 4) explaining the difference between restoration potential and the potential lift.
p. 4		This seems to be inconsistent with what is shown on Figure 3, which pinpoints a couple of study segments, including at least on Sites 15 and 13.	JS7	Text has been revised; Based on the maps provided by Jorge Montero of the Anacostia Watershed Society, fishing may be occurring in three of the candidate reaches in Prince Georges County: Paint Branch (PG#5), Northeast Branch (PG Site #15), and Northeast Branch-Riggs Road (PG Site #13).
p. 4		Why is this relevant?	E8	Sentence deleted.
p.4		Please provide similar table for Prince George's County.	JS9	Provided as Table 3
p.4		Please include the listing of these fish.	JS10	The section has been revised to include Galli et al. (2010) list of reported species within the watershed and the game species collected from the candidate reaches that were surveyed by the counties or MBSS.
p. 4		Communication with MBSS indicated the presence (1997) of two federally listed species within the Anacostia watershed including bluespotted sunfish and American brook lamprey. Do you have any further information on these species or where these watershed these observations may have occurred? Are our projects likely to affect these species?	JS11	No information on the presence of either of these two species was identified in a search of the MBSS data base and neither were listed by Galli et al. (2010)
p. 5		Can you provide any discussion about which birds have special value and which may potentially benefit improved stream network.	E12	Information of the conservation status of bird, amphibian, reptile, and mammal species in the watershed has been added as Appendix A.
p. 6		Why were the surveyed reaches chosen? Why only 2.7 mi? Are these reaches representative of any others? That is, can the results here be transferred to other reaches not surveyed? See emails on why sites were chosen.	E13	See response to Comment 1.

p. 6		Is this the case for stream segments not chosen? If this information is available for other reaches, why not chose those reaches instead?	E14	See response to Comment 1. We assessed all candidate reaches assigned to USFWS by USACE and used all USACE-provided data in the assessment.
p. 7		It would be beneficial to have some input provided on what specifically should be addressed/ actions taken to achieve level 3. Is it the floodplain connectivity and bedform diversity identified below?	E15	See response to Comment 5.
p. 7		What is the channel evolutionary trend?	E16	Text was added (p. 7), "The channel evolution trend for the majority of the reach indicates that the segment is trending towards NF."
p. 9		Such as? (refers to sentence in Conclusions and Recommendations section, "Although the stream segments have these constraints, all of the streams have a potential to achieve fully functioning levels up to level 3 – geomorphology with proper stream restoration techniques."	E17	See response to Comment 5.
p. 10		Can you provide any discussion on which species will benefit from these improvements.	E18	See response to Comments 6 and 7.
p. 14		Please provide similar list for Prince George's County.	JS19	Revised. The text and Table 3 provide the list of game fish species identified in the four Prince Georges candidate reaches that were surveyed by MBSS.

C-3: Endangered Species Act Determination

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Chesapeake Bay Field Office
177 Admiral Cochrane Drive
Annapolis, Maryland 21401
http://www.fws.gov/chesapeakebay

November 2, 2015

Fred Pinkney, Ph.D.
Senior Biologist
Environmental Contaminants Program
U.S. Fish and Wildlife Service
Chesapeake Bay Field Office
177 Admiral Cochrane Drive
Annapolis, MD 21401

RE: "Not Likely to Adversely Affect" northern long-eared bat determination; Anacostia IPaC Database Results for Anacostia Watershed Restoration Studies in Montgomery and Prince George's Counties in Maryland

Dear Dr. Pinkney:

The U.S. Fish and Wildlife Service (Service) has reviewed your project information from the Service's Information for Planning and Conservation (IPaC) online system dated July 7, 2015. The Service has evaluated the potential effects of this project to the threatened northern long-eared bat (*Myotis septentrionalis*). The comments provided below are in accordance with Section 7 of the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*).

The purpose of this proposed project is to conduct feasibility studies of aquatic ecosystem restoration needs and opportunities within the Anacostia Watershed in Montgomery and Prince George's Counties in Maryland.

This project is within the range of the northern long-eared bat, a federally listed threatened species. The northern long-eared bat is a temperate, insectivorous migratory bat that hibernates in mines and caves in the winter and summers in wooded areas. Since the forest clearing for this proposed project is minimal, and there are no current records of northern long-eared bats in the project vicinity, this 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.

Except for occasional transient individuals, no other Federal proposed or listed endangered or threatened species under our jurisdiction are known to exist within the project impact area. Should project plans change, or if additional information on the distribution of listed or proposed species becomes available, this determination may be reconsidered.

TAKE PRIDE® IN AMERICA

We appreciate the opportunity to provide information relevant to threatened and endangered fish and wildlife resources. This Endangered Species Act determination does not exempt this project from obtaining all permits and approvals that may be required by other State or Federal agencies.

If you have any questions or concerns regarding this letter, please contact Trevor Clark of my Endangered Species staff at (410) 573-4527 or by email at Trevor_Clark@fws.gov.

Sincerely,

G. La Rouche

Genevieve LaRouche
Supervisor

C-4: Nationwide Permit #27 Aquatic Habitat Restoration, Establishment, and Enhancement Activities

Nationwide Permit (NWP) #27, *AQUATIC HABITAT RESTORATION, ESTABLISHMENT, and ENHANCEMENT ACTIVITIES*, with specific conditions.

Activities in waters of the United States associated with the restoration, enhancement, and establishment of tidal and non-tidal wetlands and riparian areas, the restoration and enhancement of non-tidal streams and other non-tidal open waters, and the rehabilitation or enhancement of tidal streams, tidal wetlands, and tidal open waters, provided those activities result in net increases in aquatic resource functions and services.

To the extent that a Corps permit is required, activities authorized by this NWP include, but are not limited to: the removal of accumulated sediments; the installation, removal, and maintenance of small water control structures, dikes, and berms, as well as discharges of dredged or fill material to restore appropriate stream channel configurations after small water control structures, dikes, and berms, are removed; the installation of current deflectors; the enhancement, restoration, or establishment of riffle and pool stream structure; the placement of in-stream habitat structures; modifications of the stream bed and/or banks to restore or establish stream meanders; the backfilling of artificial channels; the removal of existing drainage structures, such as drain tiles, and the filling, blocking, or reshaping of drainage ditches to restore wetland hydrology; the installation of structures or fills necessary to establish or re-establish wetland or stream hydrology; the construction of small nesting islands; the construction of open water areas; the construction of oyster habitat over unvegetated bottom in tidal waters; shellfish seeding; activities needed to reestablish vegetation, including plowing or discing for seed bed preparation and the planting of appropriate wetland species; re-establishment of submerged aquatic vegetation in areas where those plant communities previously existed; re-establishment of tidal wetlands in tidal waters where those wetlands previously existed; mechanized land clearing to remove non-native invasive, exotic, or nuisance vegetation; and other related activities. Only native plant species should be planted at the site.

This NWP authorizes the relocation of non-tidal waters, including non-tidal wetlands and streams, on the project site provided there are net increases in aquatic resource functions and services.

Except for the relocation of non-tidal waters on the project site, this NWP does not authorize the conversion of a stream or natural wetlands to another aquatic habitat type (e.g., stream to wetland or vice versa) or uplands. Changes in wetland plant communities that occur when wetland hydrology is more fully restored during wetland rehabilitation activities are not considered a conversion to another aquatic habitat type. This NWP does not authorize stream channelization. This NWP does not authorize the relocation of tidal waters or the conversion of tidal waters, including tidal wetlands, to other aquatic uses, such as the conversion of tidal wetlands into open water impoundments.

Compensatory mitigation is not required for activities authorized by this NWP since these activities must result in net increases in aquatic resource functions and services.

Reversion. For enhancement, restoration, and establishment activities conducted: (1) In accordance with the terms and conditions of a binding stream or wetland enhancement or restoration agreement, or a wetland establishment agreement, between the landowner and the U.S. Fish and Wildlife Service (FWS), the Natural Resources Conservation Service (NRCS), the Farm Service Agency (FSA), the National Marine Fisheries Service (NMFS), the National Ocean Service (NOS), U.S. Forest Service (USFS), or their designated state cooperating agencies; (2) as voluntary wetland restoration, enhancement, and establishment actions documented by the NRCS or USDA Technical Service Provider pursuant to NRCS Field Office Technical Guide standards; or (3) on reclaimed surface coal mine lands, in accordance with a Surface Mining Control and Reclamation Act permit issued by the Office of Surface Mining Reclamation and Enforcement (OSMRE) or the applicable state agency, this NWP also authorizes any future discharge of dredged or fill material associated with the reversion of the area to its documented prior condition and use (i.e., prior to the restoration, enhancement, or establishment activities). The reversion must occur within five years after expiration of a limited term wetland restoration or establishment agreement or permit, and is authorized in these circumstances even if the discharge occurs after this NWP expires. The five-year reversion limit does not apply to agreements without time limits reached between the landowner and the FWS, NRCS, FSA, NMFS, NOS, USFS, or an appropriate state cooperating agency. This NWP also authorizes discharges of dredged or fill material in waters of the United States for the reversion of wetlands that were restored, enhanced, or established on prior-converted cropland or on uplands, in accordance with a binding agreement between the landowner and NRCS, FSA, FWS, or their designated state cooperating agencies (even though the restoration, enhancement, or establishment activity did not require a section 404 permit). The prior condition will be documented in the original agreement or permit, and the determination of return to prior conditions will be made by the Federal agency or appropriate state agency executing the agreement or permit. Before conducting any reversion activity the permittee or the appropriate Federal or state agency must notify the district engineer and include the documentation of the prior condition. Once an area has reverted to its prior physical condition, it will be subject to whatever the Corps Regulatory requirements are applicable to that type of land at the time. The requirement that the activity results in a net increase in aquatic resource functions and services does not apply to reversion activities meeting the above conditions. Except for the activities described above, this NWP does not authorize any future discharge of dredged or fill material associated with the reversion of the area to its prior condition. In such cases a separate permit would be required for any reversion.

Reporting. For those activities that do not require pre-construction notification, the permittee must submit to the district engineer a copy of: (1) The binding stream enhancement or restoration agreement or wetland enhancement, restoration, or establishment agreement, or a project description, including project plans and location map; (2) the NRCS or USDA Technical Service Provider documentation for the voluntary stream enhancement or restoration action or wetland restoration, enhancement, or establishment action; or (3) the SMCRA permit issued by OSMRE or the applicable state agency. The report must also include information on baseline ecological conditions on the project site, such as a delineation of wetlands, streams, and/or other aquatic habitats.

These documents must be submitted to the district engineer at least 30 days prior to commencing activities in waters of the United States authorized by this NWP.

Notification: The permittee must submit a pre-construction notification to the district engineer prior to commencing any activity (see general condition 31), except for the following activities:

(1) Activities conducted on non-Federal public lands and private lands, in accordance with the terms and conditions of a binding stream enhancement or restoration agreement or wetland enhancement, restoration, or establishment agreement between the landowner and the
U.S. FWS, NRCS, FSA, NMFS, NOS, USFS or their designated state cooperating agencies;

(2) Voluntary stream or wetland restoration or enhancement action, or wetland establishment action, documented by the NRCS or USDA Technical Service Provider pursuant to NRCS Field Office Technical Guide standards; or

(3) The reclamation of surface coal mine lands, in accordance with an SMCRA permit issued by the OSMRE or the applicable state agency. However, the permittee must submit a copy of the appropriate documentation to the district engineer to fulfill the reporting requirement. (Sections 10 and 404)

Note: This NWP can be used to authorize compensatory mitigation projects, including mitigation banks and in-lieu fee projects. However, this NWP does not authorize the reversion of an area used for a compensatory mitigation project to its prior condition, since compensatory mitigation is generally intended to be permanent.

Nationwide Permit General Conditions

Note: To qualify for NWP authorization, the prospective permittee must comply with the following general conditions, as applicable, in addition to any regional or case-specific conditions imposed by the division engineer or district engineer. Prospective permittees should contact the appropriate Corps district office to determine if regional conditions have been imposed on an NWP. Prospective permittees should also contact the appropriate Corps district office to determine the status of Clean Water Act Section 401 water quality certification and/or Coastal Zone Management Act consistency for an NWP. Every person who may wish to obtain permit authorization under one or more NWPs, or who is currently relying on an existing or prior permit authorization under one or more NWPs, has been and is on notice that all of the provisions of 33 CFR §§ 330.1 through 330.6 apply to every NWP authorization. Note especially 33 CFR § 330.5 relating to the modification, suspension, or revocation of any NWP authorization.

1. Navigation. (a) No activity may cause more than a minimal adverse effect on navigation.
(b) Any safety lights and signals prescribed by the U.S. Coast Guard, through regulations or otherwise, must be installed and maintained at the permittee's expense on authorized facilities in navigable waters of the United States. (c) The permittee understands and agrees that, if future operations by the United States require the removal, relocation, or other alteration, of the structure or work herein authorized, or if, in the opinion of the Secretary of the Army or his authorized representative, said structure or work shall cause unreasonable obstruction to the free navigation of the navigable waters, the permittee will be required, upon due notice from the Corps of Engineers, to remove, relocate, or alter the structural work or obstructions caused thereby, without expense to the United States. No claim shall be made against the United States on account of any such removal or alteration.

2. Aquatic Life Movements. No activity may substantially disrupt the necessary life cycle movements of those species of aquatic life indigenous to the waterbody, including those species that normally migrate through the area, unless the activity's primary purpose is to impound water. All permanent and temporary crossings of waterbodies shall be suitably culverted, bridged, or otherwise designed and constructed to maintain low flows to sustain the movement of those aquatic species.

3. Spawning Areas. Activities in spawning areas during spawning seasons must be avoided to the maximum extent practicable. Activities that result in the physical destruction (e.g., through excavation, fill, or downstream smothering by substantial turbidity) of an important spawning area are not authorized.

4. Migratory Bird Breeding Areas. Activities in waters of the United States that serve as breeding areas for migratory birds must be avoided to the maximum extent practicable.

5. Shellfish Beds. No activity may occur in areas of concentrated shellfish populations, unless the activity is directly related to a shellfish harvesting activity authorized by NWPs 4 and 48, or is a shellfish seeding or habitat restoration activity authorized by NWP 27.

6. Suitable Material. No activity may use unsuitable material (e.g., trash, debris, car bodies, asphalt, etc.). Material used for construction or discharged must be free from toxic pollutants in toxic amounts (see Section 307 of the Clean Water Act).

7. Water Supply Intakes. No activity may occur in the proximity of a public water supply intake, except where the activity is for the repair or improvement of public water supply intake structures or adjacent bank stabilization.

8. Adverse Effects From Impoundments. If the activity creates an impoundment of water, adverse effects to the aquatic system due to accelerating the passage of water, and/or restricting its flow must be minimized to the maximum extent practicable.

9. Management of Water Flows. To the maximum extent practicable, the pre-construction course, condition, capacity, and location of open waters must be maintained for each activity, including stream channelization and storm water management activities, except as provided below. The activity must be constructed to withstand expected high flows. The activity must not restrict or impede the passage of normal or high flows, unless the primary purpose of the activity is to impound water or manage high flows. The activity may alter the pre-construction course, condition, capacity, and location of open waters if it benefits the aquatic environment (e.g., stream restoration or relocation activities).

10. Fills Within 100-Year Floodplains. The activity must comply with applicable FEMA-approved state or local floodplain management requirements.

11. Equipment. Heavy equipment working in wetlands or mudflats must be placed on mats, or other measures must be taken to minimize soil disturbance.

12. Soil Erosion and Sediment Controls. Appropriate soil erosion and sediment controls must be used and maintained in

effective operating condition during construction, and all exposed soil and other fills, as well as any work below the ordinary high water mark or high tide line, must be permanently stabilized at the earliest practicable date. Permittees are encouraged to perform work within waters of the United States during periods of low-flow or no-flow.

13. Removal of Temporary Fills. Temporary fills must be removed in their entirety and the affected areas returned to pre-construction elevations. The affected areas must be revegetated, as appropriate.

14. Proper Maintenance. Any authorized structure or fill shall be properly maintained, including maintenance to ensure public safety and compliance with applicable NWP general conditions, as well as any activity-specific conditions added by the district engineer to an NWP authorization.

15. Single and Complete Project. The activity must be a single and complete project. The same NWP cannot be used more than once for the same single and complete project.

16. Wild and Scenic Rivers. No activity may occur in a component of the National Wild and Scenic River System, or in a river officially designated by Congress as a "study river" for possible inclusion in the system while the river is in an official study status, unless the appropriate Federal agency with direct management responsibility for such river, has determined in writing that the proposed activity will not adversely affect the Wild and Scenic River designation or study status. Information on Wild and Scenic Rivers may be obtained from the appropriate Federal land management agency responsible for the designated Wild and Scenic River or study river (e.g., National Park Service, U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service).

17. Tribal Rights. No activity or its operation may impair reserved tribal rights, including, but not limited to, reserved water rights and treaty fishing and hunting rights.

18. Endangered Species. (a) No activity is authorized under any NWP which is likely to directly or indirectly jeopardize the continued existence of a threatened or endangered species or a species proposed for such designation, as identified under the Federal Endangered Species Act (ESA), or which will directly or indirectly destroy or adversely modify the critical habitat of such species. No activity is authorized under any NWP which "may affect" a listed species or critical habitat, unless Section 7 consultation addressing the effects of the proposed activity has been completed.
(b) Federal agencies should follow their own procedures for complying with the requirements of the ESA. Federal permittees must provide the district engineer with the appropriate documentation to demonstrate compliance with those requirements. The district engineer will review the documentation and determine whether it is sufficient to address ESA compliance for the NWP activity, or whether additional ESA consultation is necessary.
(c) Non-federal permittees must submit a pre-construction notification to the district engineer if any listed species or designated critical habitat might be affected or is in the vicinity of the project, or if the project is located in designated critical habitat, and shall not begin work on the activity until notified by the district engineer that the requirements of the ESA have been satisfied and that the activity is authorized. For activities that might affect Federally-listed endangered or threatened species or designated critical habitat, the pre-construction notification must include the name(s) of the endangered or threatened species that might be affected by the proposed work or that utilize the designated critical habitat that might be affected by the proposed work. The district engineer will determine whether the proposed activity "may affect" or will have "no effect" to listed species and designated critical habitat and will notify the non-Federal applicant of the Corps' determination within 45 days of receipt of a complete pre-construction notification. In cases where the non-Federal applicant has identified listed species or critical habitat that might be affected or is in the vicinity of the project, and has so notified the Corps, the applicant shall not begin work until the Corps has provided notification the proposed activities will have "no effect" on listed species or critical habitat, or until Section 7 consultation has been completed. If the non-Federal applicant has not heard back from the Corps within 45 days, the applicant must still wait for notification from the Corps.
(d) As a result of formal or informal consultation with the FWS or NMFS the district engineer may add species-specific regional endangered species conditions to the NWPs.
(e) Authorization of an activity by a NWP does not authorize the "take" of a threatened or endangered species as defined under the ESA. In the absence of separate authorization (e.g., an ESA Section 10 Permit, a Biological Opinion with "incidental take" provisions, etc.) from the U.S. FWS or the NMFS, The Endangered Species Act prohibits any person subject to the jurisdiction of the United States to take a listed species, where "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. The word "harm" in the definition of "take" means an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering.
(f) Information on the location of threatened and endangered species and their critical habitat can be obtained directly from the offices of the U.S. FWS and NMFS or their world wide web pages at http://www.fws.gov/ or http://www.fws.gov/ipac and http://www.noaa.gov/fisheries.html respectively.

19. Migratory Birds and Bald and Golden Eagles. The permittee is responsible for obtaining any "take" permits required under

the U.S. Fish and Wildlife Service's regulations governing compliance with the Migratory Bird Treaty Act or the Bald and Golden Eagle Protection Act. The permittee should contact the appropriate local office of the U.S. Fish and Wildlife Service to determine if such "take" permits are required for a particular activity.

20. Historic Properties. (a) In cases where the district engineer determines that the activity may affect properties listed, or eligible for listing, in the National Register of Historic Places, the activity is not authorized, until the requirements of Section 106 of the National Historic Preservation Act (NHPA) have been satisfied.
(b) Federal permittees should follow their own procedures for complying with the requirements of Section 106 of the National Historic Preservation Act. Federal permittees must provide the district engineer with the appropriate documentation to demonstrate compliance with those requirements. The district engineer will review the documentation and determine whether it is sufficient to address section 106 compliance for the NWP activity, or whether additional section 106 consultation is necessary.
(c) Non-federal permittees must submit a pre-construction notification to the district engineer if the authorized activity may have the potential to cause effects to any historic properties listed on, determined to be eligible for listing on, or potentially eligible for listing on the National Register of Historic Places, including previously unidentified properties. For such activities, the pre-construction notification must state which historic properties may be affected by the proposed work or include a vicinity map indicating the location of the historic properties or the potential for the presence of historic properties. Assistance regarding information on the location of or potential for the presence of historic resources can be sought from the State Historic Preservation Officer or Tribal Historic Preservation Officer, as appropriate, and the National Register of Historic Places (see 33 CFR 330.4(g)). When reviewing pre-construction notifications, district engineers will comply with the current procedures for addressing the requirements of Section 106 of the National Historic Preservation Act. The district engineer shall make a reasonable and good faith effort to carry out appropriate identification efforts, which may include background research, consultation, oral history interviews, sample field investigation, and field survey. Based on the information submitted and these efforts, the district engineer shall determine whether the proposed activity has the potential to cause an effect on the historic properties. Where the non-Federal applicant has identified historic properties on which the activity may have the potential to cause effects and so notified the Corps, the non-Federal applicant shall not begin the activity until notified by the district engineer either that the activity has no potential to cause effects or that consultation under Section 106 of the NHPA has been completed.
(d) The district engineer will notify the prospective permittee within 45 days of receipt of a complete pre-construction notification whether NHPA Section 106 consultation is required. Section 106 consultation is not required when the Corps determines that the activity does not have the potential to cause effects on historic properties (see 36 CFR §800.3(a)). If NHPA section 106 consultation is required and will occur, the district engineer will notify the non-Federal applicant that he or she cannot begin work until Section 106 consultation is completed. If the non-Federal applicant has not heard back from the Corps within 45 days, the applicant must still wait for notification from the Corps.
(e) Prospective permittees should be aware that section 110k of the NHPA (16 U.S.C. 470h-2(k)) prevents the Corps from granting a permit or other assistance to an applicant who, with intent to avoid the requirements of Section 106 of the NHPA, has intentionally significantly adversely affected a historic property to which the permit would relate, or having legal power to prevent it, allowed such significant adverse effect to occur, unless the Corps, after consultation with the Advisory Council on Historic Preservation (ACHP), determines that circumstances justify granting such assistance despite the adverse effect created or permitted by the applicant. If circumstances justify granting the assistance, the Corps is required to notify the ACHP and provide documentation specifying the circumstances, the degree of damage to the integrity of any historic properties affected, and proposed mitigation. This documentation must include any views obtained from the applicant, SHPO/THPO, appropriate Indian tribes if the undertaking occurs on or affects historic properties on tribal lands or affects properties of interest to those tribes, and other parties known to have a legitimate interest in the impacts to the permitted activity on historic properties.

21. Discovery of Previously Unknown Remains and Artifacts. If you discover any previously unknown historic, cultural or archeological remains and artifacts while accomplishing the activity authorized by this permit, you must immediately notify the district engineer of what you have found, and to the maximum extent practicable, avoid construction activities that may affect the remains and artifacts until the required coordination has been completed. The district engineer will initiate the Federal, Tribal and state coordination required to determine if the items or remains warrant a recovery effort or if the site is eligible for listing in the National Register of Historic Places.

22. Designated Critical Resource Waters. Critical resource waters include NOAA-managed marine sanctuaries and marine monuments, and National Estuarine Research Reserves. The district engineer may designate, after notice and opportunity for public comment, additional waters officially designated by a state as having particular environmental or ecological significance, such as outstanding national resource waters or state natural heritage sites. The district engineer may also designate additional critical resource waters after notice and opportunity for public comment.
(a) Discharges of dredged or fill material into waters of the United States are not authorized by NWPs 7, 12, 14, 16, 17, 21, 29, 31, 35, 39, 40, 42, 43, 44, 49, 50, 51, and 52 for any activity within, or directly affecting, critical resource waters, including wetlands adjacent to such waters.
(b) For NWPs 3, 8, 10, 13, 15, 18, 19, 22, 23, 25, 27, 28, 30, 33, 34, 36, 37, and 38, notification is required in accordance with general condition 31, for any activity proposed in the designated critical resource waters including wetlands adjacent to those waters. The district engineer may authorize activities under these NWPs only after it is determined that the impacts to the critical

resource waters will be no more than minimal.

23. <u>Mitigation</u>. The district engineer will consider the following factors when determining appropriate and practicable mitigation necessary to ensure that adverse effects on the aquatic environment are minimal:
(a) The activity must be designed and constructed to avoid and minimize adverse effects, both temporary and permanent, to waters of the United States to the maximum extent practicable at the project site (i.e., on site).
(b) Mitigation in all its forms (avoiding, minimizing, rectifying, reducing, or compensating for resource losses) will be required to the extent necessary to ensure that the adverse effects to the aquatic environment are minimal.
(c) Compensatory mitigation at a minimum one-for-one ratio will be required for all wetland losses that exceed 1/10-acre and require pre-construction notification, unless the district engineer determines in writing that either some other form of mitigation would be more environmentally appropriate or the adverse effects of the proposed activity are minimal, and provides a project-specific waiver of this requirement. For wetland losses of 1/10-acre or less that require pre-construction notification, the district engineer may determine on a case-by-case basis that compensatory mitigation is required to ensure that the activity results in minimal adverse effects on the aquatic environment. Compensatory mitigation projects provided to offset losses of aquatic resources must comply with the applicable provisions of 33 CFR part 332.
(1) The prospective permittee is responsible for proposing an appropriate compensatory mitigation option if compensatory mitigation is necessary to ensure that the activity results in minimal adverse effects on the aquatic environment.
(2) Since the likelihood of success is greater and the impacts to potentially valuable uplands are reduced, wetland restoration should be the first compensatory mitigation option considered.
(3) If permittee-responsible mitigation is the proposed option, the prospective permittee is responsible for submitting a mitigation plan. A conceptual or detailed mitigation plan may be used by the district engineer to make the decision on the NWP verification request, but a final mitigation plan that addresses the applicable requirements of 33 CFR 332.4(c)(2) – (14) must be approved by the district engineer before the permittee begins work in waters of the United States, unless the district engineer determines that prior approval of the final mitigation plan is not practicable or not necessary to ensure timely completion of the required compensatory mitigation (see 33 CFR 332.3(k)(3)).
(4) If mitigation bank or in-lieu fee program credits are the proposed option, the mitigation plan only needs to address the baseline conditions at the impact site and the number of credits to be provided.
(5) Compensatory mitigation requirements (e.g., resource type and amount to be provided as compensatory mitigation, site protection, ecological performance standards, monitoring requirements) may be addressed through conditions added to the NWP authorization, instead of components of a compensatory mitigation plan.
(d) For losses of streams or other open waters that require pre-construction notification, the district engineer may require compensatory mitigation, such as stream rehabilitation, enhancement, or preservation, to ensure that the activity results in minimal adverse effects on the aquatic environment.
(e) Compensatory mitigation will not be used to increase the acreage losses allowed by the acreage limits of the NWPs. For example, if an NWP has an acreage limit of 1/2-acre, it cannot be used to authorize any project resulting in the loss of greater than 1/2-acre of waters of the United States, even if compensatory mitigation is provided that replaces or restores some of the lost waters. However, compensatory mitigation can and should be used, as necessary, to ensure that a project already meeting the established acreage limits also satisfies the minimal impact requirement associated with the NWPs.
(f) Compensatory mitigation plans for projects in or near streams or other open waters will normally include a requirement for the restoration or establishment, maintenance, and legal protection (e.g., conservation easements) of riparian areas next to open waters. In some cases, riparian areas may be the only compensatory mitigation required. Riparian areas should consist of native species. The width of the required riparian area will address documented water quality or aquatic habitat loss concerns. Normally, the riparian area will be 25 to 50 feet wide on each side of the stream, but the district engineer may require slightly wider riparian areas to address documented water quality or habitat loss concerns. If it is not possible to establish a riparian area on both sides of a stream, or if the waterbody is a lake or coastal waters, then restoring or establishing a riparian area along a single bank or shoreline may be sufficient. Where both wetlands and open waters exist on the project site, the district engineer will determine the appropriate compensatory mitigation (e.g., riparian areas and/or wetlands compensation) based on what is best for the aquatic environment on a watershed basis. In cases where riparian areas are determined to be the most appropriate form of compensatory mitigation, the district engineer may waive or reduce the requirement to provide wetland compensatory mitigation for wetland losses.
(g) Permittees may propose the use of mitigation banks, in-lieu fee programs, or separate permittee-responsible mitigation. For activities resulting in the loss of marine or estuarine resources, permittee-responsible compensatory mitigation may be environmentally preferable if there are no mitigation banks or in-lieu fee programs in the area that have marine or estuarine credits available for sale or transfer to the permittee. For permittee-responsible mitigation, the special conditions of the NWP verification must clearly indicate the party or parties responsible for the implementation and performance of the compensatory mitigation project, and, if required, its long-term management.
(h) Where certain functions and services of waters of the United States are permanently adversely affected, such as the conversion of a forested or scrub-shrub wetland to a herbaceous wetland in a permanently maintained utility line right-of-way, mitigation may be required to reduce the adverse effects of the project to the minimal level.

<u>24. Safety of Impoundment Structures</u>. To ensure that all impoundment structures are safely designed, the district engineer may

require non-Federal applicants to demonstrate that the structures comply with established state dam safety criteria or have been designed by qualified persons. The district engineer may also require documentation that the design has been independently reviewed by similarly qualified persons, and appropriate modifications made to ensure safety.

25. Water Quality. Where States and authorized Tribes, or EPA where applicable, have not previously certified compliance of an NWP with CWA Section 401, individual 401 Water Quality Certification must be obtained or waived (see 33 CFR 330.4(c)). The district engineer or State or Tribe may require additional water quality management measures to ensure that the authorized activity does not result in more than minimal degradation of water quality.

26. Coastal Zone Management. In coastal states where an NWP has not previously received a state coastal zone management consistency concurrence, an individual state coastal zone management consistency concurrence must be obtained, or a presumption of concurrence must occur (see 33 CFR 330.4(d)). The district engineer or a State may require additional measures to ensure that the authorized activity is consistent with state coastal zone management requirements.

27. Regional and Case-By-Case Conditions. The activity must comply with any regional conditions that may have been added by the Division Engineer (see 33 CFR 330.4(e)) and with any case specific conditions added by the Corps or by the state, Indian Tribe, or U.S. EPA in its section 401 Water Quality Certification, or by the state in its Coastal Zone Management Act consistency determination.

28. Use of Multiple Nationwide Permits. The use of more than one NWP for a single and complete project is prohibited, except when the acreage loss of waters of the United States authorized by the NWPs does not exceed the acreage limit of the NWP with the highest specified acreage limit. For example, if a road crossing over tidal waters is constructed under NWP 14, with associated bank stabilization authorized by NWP 13, the maximum acreage loss of waters of the United States for the total project cannot exceed 1/3-acre.

29. Transfer of Nationwide Permit Verifications. If the permittee sells the property associated with a nationwide permit verification, the permittee may transfer the nationwide permit verification to the new owner by submitting a letter to the appropriate Corps district office to validate the transfer. A copy of the nationwide permit verification must be attached to the letter, and the letter must contain the following statement and signature: "When the structures or work authorized by this nationwide permit are still in existence at the time the property is transferred, the terms and conditions of this nationwide permit, including any special conditions, will continue to be binding on the new owner(s) of the property. To validate the transfer of this nationwide permit and the associated liabilities associated with compliance with its terms and conditions, have the transferee sign and date below."
(Transferee)

(Date)

30. Compliance Certification. Each permittee who receives an NWP verification letter from the Corps must provide a signed certification documenting completion of the authorized activity and any required compensatory mitigation. The success of any required permittee-responsible mitigation, including the achievement of ecological performance standards, will be addressed separately by the district engineer. The Corps will provide the permittee the certification document with the NWP verification letter. The certification document will include:
(a) A statement that the authorized work was done in accordance with the NWP authorization, including any general, regional, or activity-specific conditions;
(b) A statement that the implementation of any required compensatory mitigation was completed in accordance with the permit conditions. If credits from a mitigation bank or in-lieu fee program are used to satisfy the compensatory mitigation requirements, the certification must include the documentation required by 33 CFR 332.3(l) (3) to confirm that the permittee secured the appropriate number and resource type of credits; and
(c) The signature of the permittee certifying the completion of the work and mitigation.

31. Pre-Construction Notification. (a) Timing. Where required by the terms of the NWP, the prospective permittee must notify the district engineer by submitting a pre-construction notification (PCN) as early as possible. The district engineer must determine if the PCN is complete within 30 calendar days of the date of receipt and, if the PCN is determined to be incomplete, notify the prospective permittee within that 30 day period to request the additional information necessary to make the PCN complete. The request must specify the information needed to make the PCN complete. As a general rule, district engineers will request additional information necessary to make the PCN complete only once. However, if the prospective permittee does not provide all of the requested information, then the district engineer will notify the prospective permittee that the PCN is still incomplete and the PCN review process will not commence until all of the requested information has been received by the district engineer. The prospective permittee shall not begin the activity until either:
(1) He or she is notified in writing by the district engineer that the activity may proceed under the NWP with any special conditions imposed by the district or division engineer; or

(2) 45 calendar days have passed from the district engineer's receipt of the complete PCN and the prospective permittee has not received written notice from the district or division engineer. However, if the permittee was required to notify the Corps pursuant to general condition 18 that listed species or critical habitat might be affected or in the vicinity of the project, or to notify the Corps pursuant to general condition 20 that the activity may have the potential to cause effects to historic properties, the permittee cannot begin the activity until receiving written notification from the Corps that there is "no effect" on listed species or "no potential to cause effects" on historic properties, or that any consultation required under Section 7 of the Endangered Species Act (see 33 CFR 330.4(f)) and/or Section 106 of the National Historic Preservation (see 33 CFR 330.4(g)) has been completed. Also, work cannot begin under NWPs 21, 49, or 50 until the permittee has received written approval from the Corps. If the proposed activity requires a written waiver to exceed specified limits of an NWP, the permittee may not begin the activity until the district engineer issues the waiver. If the district or division engineer notifies the permittee in writing that an individual permit is required within 45 calendar days of receipt of a complete PCN, the permittee cannot begin the activity until an individual permit has been obtained. Subsequently, the permittee's right to proceed under the NWP may be modified, suspended, or revoked only in accordance with the procedure set forth in 33 CFR 330.5(d)(2).

(b) Contents of Pre-Construction Notification: The PCN must be in writing and include the following information:

(1) Name, address and telephone numbers of the prospective permittee;

(2) Location of the proposed project;

(3) A description of the proposed project; the project's purpose; direct and indirect adverse environmental effects the project would cause, including the anticipated amount of loss of water of the United States expected to result from the NWP activity, in acres, linear feet, or other appropriate unit of measure; any other NWP(s), regional general permit(s), or individual permit(s) used or intended to be used to authorize any part of the proposed project or any related activity. The description should be sufficiently detailed to allow the district engineer to determine that the adverse effects of the project will be minimal and to determine the need for compensatory mitigation. Sketches should be provided when necessary to show that the activity complies with the terms of the NWP. (Sketches usually clarify the project and when provided results in a quicker decision. Sketches should contain sufficient detail to provide an illustrative description of the proposed activity (e.g., a conceptual plan), but do not need to be detailed engineering plans);

(4) The PCN must include a delineation of wetlands, other special aquatic sites, and other waters, such as lakes and ponds, and perennial, intermittent, and ephemeral streams, on the project site. Wetland delineations must be prepared in accordance with the current method required by the Corps. The permittee may ask the Corps to delineate the special aquatic sites and other waters on the project site, but there may be a delay if the Corps does the delineation, especially if the project site is large or contains many waters of the United States. Furthermore, the 45 day period will not start until the delineation has been submitted to or completed by the Corps, as appropriate;

(5) If the proposed activity will result in the loss of greater than 1/10-acre of wetlands and a PCN is required, the prospective permittee must submit a statement describing how the mitigation requirement will be satisfied, or explaining why the adverse effects are minimal and why compensatory mitigation should not be required. As an alternative, the prospective permittee may submit a conceptual or detailed mitigation plan.

(6) If any listed species or designated critical habitat might be affected or is in the vicinity of the project, or if the project is located in designated critical habitat, for non-Federal applicants the PCN must include the name(s) of those endangered or threatened species that might be affected by the proposed work or utilize the designated critical habitat that may be affected by the proposed work. Federal applicants must provide documentation demonstrating compliance with the Endangered Species Act; and

(7) For an activity that may affect a historic property listed on, determined to be eligible for listing on, or potentially eligible for listing on, the National Register of Historic Places, for non-Federal applicants the PCN must state which historic property may be affected by the proposed work or include a vicinity map indicating the location of the historic property. Federal applicants must provide documentation demonstrating compliance with Section 106 of the National Historic Preservation Act.

(c) Form of Pre-Construction Notification: The standard individual permit application form (Form ENG 4345) may be used, but the completed application form must clearly indicate that it is a PCN and must include all of the information required in paragraphs (b) (1) through (7) of this general condition. A letter containing the required information may also be used.

(d) Agency Coordination: (1) The district engineer will consider any comments from Federal and state agencies concerning the proposed activity's compliance with the terms and conditions of the NWPs and the need for mitigation to reduce the project's adverse environmental effects to a minimal level.

(2) For all NWP activities that require pre-construction notification and result in the loss of greater than 1/2-acre of waters of the United States, for NWP 21, 29, 39, 40, 42, 43, 44, 50, 51, and 52 activities that require pre-construction notification and will result in the loss of greater than 300 linear feet of intermittent and ephemeral stream bed, and for all NWP 48 activities that require pre-construction notification, the district engineer will immediately provide (e.g., via e-mail, facsimile transmission, overnight mail, or other expeditious manner) a copy of the complete PCN to the appropriate Federal or state offices (U.S. FWS, state natural resource or water quality agency, EPA, State Historic Preservation Officer (SHPO) or Tribal Historic Preservation Office (THPO), and, if appropriate, the NMFS). With the exception of NWP 37, these agencies will have 10 calendar days from the date the material is transmitted to telephone or fax the district engineer notice that they intend to provide substantive, site-specific comments. The comments must explain why the agency believes the adverse effects will be more than minimal. If so contacted by an agency, the district engineer will wait an additional 15 calendar days before making a decision on the pre-construction notification. The district engineer will fully consider agency comments received within the specified time frame concerning the proposed activity's compliance with the terms and conditions of the NWPs, including the need for mitigation to ensure the net adverse environmental

effects to the aquatic environment of the proposed activity are minimal. The district engineer will provide no response to the resource agency, except as provided below. The district engineer will indicate in the administrative record associated with each pre-construction notification that the resource agencies' concerns were considered. For NWP 37, the emergency watershed protection and rehabilitation activity may proceed immediately in cases where there is an unacceptable hazard to life or a significant loss of property or economic hardship will occur. The district engineer will consider any comments received to decide whether the NWP 37 authorization should be modified, suspended, or revoked in accordance with the procedures at 33 CFR 330.5.
(3) In cases of where the prospective permittee is not a Federal agency, the district engineer will provide a response to NMFS within 30 calendar days of receipt of any Essential Fish Habitat conservation recommendations, as required by Section 305(b)(4)(B) of the Magnuson-Stevens Fishery Conservation and Management Act.
(4) Applicants are encouraged to provide the Corps with either electronic files or multiple copies of pre-construction notifications to expedite agency coordination.

D. District Engineer's Decision

1. In reviewing the PCN for the proposed activity, the district engineer will determine whether the activity authorized by the NWP will result in more than minimal individual or cumulative adverse environmental effects or may be contrary to the public interest. For a linear project, this determination will include an evaluation of the individual crossings to determine whether they individually satisfy the terms and conditions of the NWP(s), as well as the cumulative effects caused by all of the crossings authorized by NWP. If an applicant requests a waiver of the 300 linear foot limit on impacts to intermittent or ephemeral streams or of an otherwise applicable limit, as provided for in NWPs 13, 21, 29, 36, 39, 40, 42, 43, 44, 50, 51 or 52, the district engineer will only grant the waiver upon a written determination that the NWP activity will result in minimal adverse effects. When making minimal effects determinations the district engineer will consider the direct and indirect effects caused by the NWP activity. The district engineer will also consider site specific factors, such as the environmental setting in the vicinity of the NWP activity, the type of resource that will be affected by the NWP activity, the functions provided by the aquatic resources that will be affected by the NWP activity, the degree or magnitude to which the aquatic resources perform those functions, the extent that aquatic resource functions will be lost as a result of the NWP activity (e.g., partial or complete loss), the duration of the adverse effects (temporary or permanent), the importance of the aquatic resource functions to the region (e.g., watershed or ecoregion), and mitigation required by the district engineer. If an appropriate functional assessment method is available and practicable to use, that assessment method may be used by the district engineer to assist in the minimal adverse effects determination. The district engineer may add case-specific special conditions to the NWP authorization to address site-specific environmental concerns.
2. If the proposed activity requires a PCN and will result in a loss of greater than 1/10acre of wetlands, the prospective permittee should submit a mitigation proposal with the PCN. Applicants may also propose compensatory mitigation for projects with smaller impacts. The district engineer will consider any proposed compensatory mitigation the applicant has included in the proposal in determining whether the net adverse environmental effects to the aquatic environment of the proposed activity are minimal. The compensatory mitigation proposal may be either conceptual or detailed. If the district engineer determines that the activity complies with the terms and conditions of the NWP and that the adverse effects on the aquatic environment are minimal, after considering mitigation, the district engineer will notify the permittee and include any activity-specific conditions in the NWP verification the district engineer deems necessary. Conditions for compensatory mitigation requirements must comply with the appropriate provisions at 33 CFR 332.3(k). The district engineer must approve the final mitigation plan before the permittee commences work in waters of the United States, unless the district engineer determines that prior approval of the final mitigation plan is not practicable or not necessary to ensure timely completion of the required compensatory mitigation. If the prospective permittee elects to submit a compensatory mitigation plan with the PCN, the district engineer will expeditiously review the proposed compensatory mitigation plan. The district engineer must review the proposed compensatory mitigation plan within 45 calendar days of receiving a complete PCN and determine whether the proposed mitigation would ensure no more than minimal adverse effects on the aquatic environment. If the net adverse effects of the project on the aquatic environment (after consideration of the compensatory mitigation proposal) are determined by the district engineer to be minimal, the district engineer will provide a timely written response to the applicant. The response will state that the project can proceed under the terms and conditions of the NWP, including any activity-specific conditions added to the NWP authorization by the district engineer.
3. If the district engineer determines that the adverse effects of the proposed work are more than minimal, then the district engineer will notify the applicant either: (a) That the project does not qualify for authorization under the NWP and instruct the applicant on the procedures to seek authorization under an individual permit; (b) that the project is authorized under the NWP subject to the applicant's submission of a mitigation plan that would reduce the adverse effects on the aquatic environment to the minimal level; or (c) that the project is authorized under the NWP with specific modifications or conditions. Where the district engineer determines that mitigation is required to ensure no more than minimal adverse effects occur to the aquatic environment, the activity will be authorized within the 45-day PCN period, with activity-specific conditions that state the mitigation requirements. The authorization will include the necessary conceptual or detailed mitigation or a requirement that the applicant submit a mitigation plan that would reduce the adverse effects on the aquatic environment to the minimal level. When mitigation is required, no work in waters of the United States may occur until the district engineer has approved a specific mitigation plan or has determined that prior approval of a final mitigation plan is not practicable or not necessary to ensure timely completion of the required compensatory mitigation.

<u>Nationwide Permit #27 *Aquatic Habitat Restoration, Establishment, and Enhancement Activities*</u>

Permit Specific Regional Condition –

1. Any activity involving shellfish seeding, such as the placement of shell material or any other habitat development or enhancement, is restricted to shellfish species that are native to that waterbody.

2. Prior to doing the work, the permittee shall submit a pre-construction notification to the District Engineer, in accordance with the current Corps of Engineers permit application procedures (See general condition 31 and regional condition 31a). The Corps' review period shall commence with the receipt of a complete permit application at the Corps District Office.

3. **Essential Fish Habitat Regional Condition (Applicable to the Delaware River in Pennsylvania)**:

    a. For any activity on the Delaware River, a complete copy of any PCN submitted to the Corps of Engineers shall also be forwarded directly to the National Marine Fisheries Service Habitat Conservation Division, 74 Magruder Road, Sandy Hook, Highlands, New Jersey 07732. The applicant must provide evidence that this has been accomplished. The Corps of Engineers will coordinate review of the PCN with the National Marine Fisheries Service pursuant to the requirements of the Magnuson Stevens Fishery Conservation and Management Act.

4. **Essential Fish Habitat Regional Conditions (Applicable to the District of Columbia, Maryland, activities affecting the Potomac River watershed within military installations of Northern Virginia in the regulatory geographic boundaries of the Baltimore District):**

    a. For activities in all tidal and nontidal coastal plain streams within the areas referenced above, or nontidal Piedmont streams in Harford and Cecil Counties, Maryland, the Corps of Engineers will coordinate review of the PCN with the National Marine Fisheries Service pursuant to the requirements of the Magnuson Stevens Fishery Conservation and Management Act.

    b. For activities involving the restoration and/or establishment of tidal marsh in mesohaline waters (i.e., salinity of 5-18 ppt) of the mid and upper Chesapeake Bay, the PCN should include information concerning the distribution of horned pondweed (*Zannichellia palustris)* within the project site. Distribution information of horned pondweed may require recent ground-truth survey of the area by the applicant (i.e., employing a survey crew with relevant experience) during the period of May 1 through June 15, of any year.

C-5: Clean Air Act General Air Quality Conformity Analysis

General Conformity Analysis

Introduction

The alternative selected for the proposed ecosystem restoration projects in Prince George's County, Maryland, was evaluated for air quality emissions associated with project construction. Direct emissions were evaluated as discussed below and shown in Attachment 1. Upon consultation with the Maryland Department of the Environment (MDE) it was agreed that the project would not result in any sources of indirect emissions (MDE, personal communication 3/17/2015); therefore, indirect emissions were not calculated. The analysis demonstrates that the proposed projects comply with Clean Air Act General Conformity Rule.

Regulatory Background

The 1990 Federal Clean Air Act Amendments directed the Environmental Protection Agency (EPA) to develop two separate federal conformity rules. Those rules (promulgated as 40 CFR Parts 51 and 93) are designed to ensure that federal actions do not cause or contribute to air quality violations in areas that do not meet the national ambient air quality standards. The two rules include transportation conformity, which applies to transportation plans, programs, and projects; and general conformity, which applies to all other non transportation-related projects, including the projects proposed in this feasibility study.

The general conformity regulation requires that federal agencies sponsoring non transportation-related activities show that the emissions associated with those activities conform to state implementation plans (SIPs) if emissions meet specific criteria. First, the emissions must occur in areas designated as non-attainment areas for one or more of the federal ambient air quality standards. Second, those emissions must exceed certain *de minimus* threshold levels.

Ozone

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, nitrogen dioxide, ozone, lead, particulates, and sulfur dioxide. For Prince George's County, 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.

Ozone is a gas that forms in the presence of sunlight in the atmosphere when three atoms of oxygen are combined (O_3). Ozone is not emitted directly into the air by any aspect of the project, but is created at ground level by a chemical reaction between oxides of nitrogen (NOx), and volatile organic compounds (VOC). For ozone, the *de minimus* thresholds are 100 tons/year (TPY) for NOx and 50 TPY VOC for Prince George's County.

Motor vehicle exhaust and industrial emissions, gasoline vapors, and chemical solvents are some of the major sources of NOx and VOC, also known as ozone precursors. Strong sunlight and hot

weather cause ground-level ozone to form in harmful concentrations in the air. Many urban areas tend to have high levels of ozone, but other areas are also subject to high ozone levels as winds carry NOx emissions hundreds of miles away from their original sources.

$PM_{2.5}$ (Particulate Matter)

On October 6, 2014 EPA published a Final Rule in the Federal Register approving the State of Maryland's request to redesignate 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. 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. Maintenance areas must continue to meet the requirements of General Conformity regulations.

De minimis levels for $PM_{2.5}$ is 100 TPY for each of the precursors that form it (SO_2, NO_x, VOC, and ammonia). Under the current EPA policy for addressing $PM_{2.5}$ precursors, only SO_2 and NO_x must be evaluated in all regions. Evaluation of VOCs or ammonia are not required unless the State or EPA make a technical demonstration that those particular emissions from sources within the given State significantly contribute to $PM_{2.5}$ concentrations. This has not been done for the state of Maryland, so VOC and ammonia are not considered further for the purposes of calculating $PM_{2.5}$ emissions. $PM_{2.5}$ emissions for this project include particulate emissions from construction vehicles and fugitive dust.

Carbon monoxide (CO)

Prince George's County has been in maintenance for carbon monoxide (CO) since 1996. Later this year, it is expected that Prince George's County will be in full attainment for CO (i.e. will come out of maintenance status). Since construction of this project is not scheduled until several years from now, upon consultation with MDE (MDE, personal communication 3/17/2015), it was determined that evaluation of CO emissions is not required for this conformity evaluation.

Conformity Evaluation

The Clean Air Act General Conformity Rule (58 FR 63214, November 30, 1993, Final Rule, Determining Conformity of General Federal Actions to State or Federal Implementation Plans) dictates that a conformity review be performed when a Federal action generates air pollutants in a region that has been designated a non-attainment or maintenance area for one or more NAAQS. The general conformity rule was designed to ensure that Federal actions do not impede local efforts to control air pollution. It is called a conformity rule because Federal agencies are required to demonstrate that their actions "conform with" (i.e. do not undermine) the approved State Implementation Plan for their geographic area. The purpose of conformity is to (1) ensure Federal activities do not interfere with the air quality budgets in the SIPs; (2) ensure actions do not cause or contribute to new violations, and (3) ensure attainment and maintenance of the NAAQS. Federal agencies make this demonstration by performing a conformity review. The stream restoration activities in Prince George's County are subject to detailed conformity determinations

unless these actions are clearly considered *de minimus* emissions; use of these thresholds assures that the conformity rule covers only major federal actions. Thresholds for de minimus are shown in Table 1 for the pollutants relevant for this analysis.

Table 1: *De minimus* thresholds for relevant pollutants.

Pollutant	*De minimus* (TPY)
NO_x	100
VOC	50
SO_2	100
$PM_{2.5}$	100

Methodology

A conformity review requires consideration of both direct and indirect air emissions associated with the proposed action. Direct emissions are those that occur as a direct result of the action, and occur at the same time and place as the action. Sources that would contribute to direct emissions from this project would include demolition or construction activities associated with the proposed action and equipment used to facilitate the action (e.g. construction vehicles). Indirect emissions are those that occur at a later time or distance from the place where the action takes place, but may be reasonably anticipated because of the proposed action. Upon consultation with MDE, it was agreed that this project would result in no sources of indirect emissions (MDE, personal communication 3/17/2015). Both stationary and mobile sources must be included when calculating the total of emissions, but this project involves only mobile sources.

Air pollutant emissions generated by the proposed action were calculated to determine whether the total of direct emissions for NOx, VOCs, SO_2, and $PM_{2.5}$, would be below the conformity *de minimus* limits. The selected alternative, with the most equipment operating over the longest duration was assessed in detail in order to ensure a conservative evaluation. Table 2 shows a list of equipment that is expected to be used to construct the project and was developed based on engineering estimates. Each of the pieces of equipment to be used for the project was assumed to operate all day (8 hours) for a seven-month construction period (154 days), for a total of 1232 hours per year, except where noted. While assuming all of the equipment operating the entire project duration is unrealistic, this represents a bounding, albeit conservative approach to quantifying the direct emissions.

Given the hours of operation assumed, emissions were estimated based on equipment-specific emission factors recommended by the EPA for fuel-burning equipment (USEPA, 1998 and USEPA, 2000) that could be used. The following discussion summarizes the calculations for the exhaust and fugitive dust emissions.

Table 2. Potential Equipment List

Equipment Description	Specifications	PO - Power output (hp)	Fuel Type	Operating weight (tons)
Crane	Hyd, 33T	230	Diesel	
Loader, Crawler	F/E, 2.6 CY	160	Diesel	19.84
Loader, Crawler	F/E, 3.75 CY	210	Diesel	27.8
Loader/Backhoe	0.80 CY	60	Diesel	5.68
Loader/Backhoe	1.25 CY	84	Diesel	7.88
Roller	Vib, DD, 6.0 T	111	Diesel	
Roller	Vib,DD,12T	100	Diesel	
Roller	Static,14 T	80	Diesel	
Dozer, Crawler		240	Diesel	28.82
Dozer, Crawler		405	Diesel	50.98
Truck, Hwy	50K GVW, 6X4	330		20
Truck, Hwy	25K GVW	210	Diesel	20
Truck, Hwy	45K GVW	330		20
Scraper	ELEV, 11 CY	175	Diesel	
Grader	motor	135	Diesel	14.42
Asphalt Paver	10.0' W, SP	155	Diesel	16
Brush Chipper	12" Dia Log	135	Diesel	
Chainsaw	24"-42"Long Bar	5.7	Diesel	21.04

Annual Emissions

To calculate annual emissions in tons per year for VOC, NO_x, $PM_{2.5}$, the following equation was used:

AE = ((EF)(LF)(PO)(t))/907185

Where:

- *AE = annual emissions (tons/year)*
- *EF = emission factor (grams/horsepower-hour; from NR-009d[1] Tables 4, 5, 6 for Tier 3 except for NR-010f[2] Table 3 Phase 2 for chainsaw; PM_{10} emissions factors are conservatively used for $PM_{2.5}$)*
- *LF = load factor (typical fraction of available power available for each type of engine per vehicle specification)*
- *PO = power output (horsepower of vehicle engine per vehicle specifications);*
- *t = time of operation (1232 hours/year)*
- *907185 is the number of grams per ton*

[1] U.S. Environmental Protection Agency. July 2010. EPA-420-R-10-018. Exhaust and Crankcase Emissions Factors for Nonroad Engine Modeling – Compression-Ignition. NR-009d.

[2] U.S. Environmental Protection Agency. July 2010. EPA-420-R-10-019. Exhaust Emission Factors for Nonroad Engine Modeling – Spark-Ignition. NR-010f.

Emissions factors for SO_2 are rarely measured; instead they are typically calculated based on brake-specific fuel consumption (BSFC). The following equation was used to calculate SO_2 emissions factors (Equation 7 from EPA NR009d):

SO_2 = (BSFC 453.6 (1 – soxcnv) – HC)(0.01)(soxdsl)(2)

Where:

- *SO_2 is the emission factor in g/hp-hr*
- *BSFC is the in-use adjusted fuel consumption in lb/hp-hr (NR-009d, Table C1 and NR-010f, Table 3 Phase 2 for chainsaw)*
- *453.6 is the conversion factor from pounds to grams*
- *soxcnv is the fraction of fuel sulfur converted to direct PM (NR-009d p.22 default value of 0.02247 used for diesel)*
- *HC is the in-use adjusted hydrocarbon emissions in g/hp-hr (NR-009d, Table 4 and NR-010f, Table 3 Phase 2 for chainsaw)*
- *0.01 is the conversion factor from weight percent to weight fraction*
- *soxdsl is the episodic weight percent of sulfur in nonroad diesel fuel (default of 0.33 wt % used per NR-009d p.C1)*
- *2 is the grams of SO_2 formed from one gram of sulfur*

Fugitive Dust Emissions ($PM_{2.5}$)

The analysis of the construction emissions included identification of the type of equipment needed for the activity, the duration it is needed, and when during the construction phase it would be used. The construction process was broken down into component operations where each component involved traffic and material movements. The emission factors from other AP-42 sections were used to generate estimates for particulate emissions from construction activities. Table 13.2.3-1 was used to identify dust sources involved with construction activities and recommended particulate emission factors to use. Table 3 indicates those recommended emission factors (from Table 13.2.3-1) for itemized activities associated with stream restoration construction and their approximate duration for this project. Durations and vehicles used for each phase were based on discussions with USACE-EN Civil (Ben Soleimani). The actual equations used are shown below the table for each component and associated duration listed in Table 3.

Table 3. Sources of emissions factor equations for different phases of construction.

Phases of Construction	Duration	Source of Emission Factor (from EPA AP-42)
Demolition and Debris Removal Phase		
General land clearing	5 days	Dozer equation (overburden) in Tables 11.9-1 and 11.9-2
Delivery, Removal, & Truck Transport of Materials		
Vehicular traffic on unpaved access road	Continuous throughout construction period (97 km/day for 154 days)	Unpaved road emission factor equation in Section 13.2.2

Vehicular traffic on paved urban road	Continuous throughout construction period (97 km/day for 154 days)	Paved road emission factor in Section 13.2.1
Unloading and loading of construction materials (dirt, sand, gravel, rock)	77 days	Material handling emission factor equation in Tables 13.2.4
Site Preparation & Earth Moving Phase		
Creating access roads (compacting)	5 days	Dozer equation (overburden) in Tables 11.9-1 and 11.9-2
Excavation and grading of stream bed material	77 days	Grading equation in Table 11.9-1 and 11.9-2

<u>Paved road equation (for three highway trucks):</u>
Source: EPA AP-42, 13.2.1, Paved Roads

$$\mathbf{E = k\,(sL)^{0.91}\,(W)^{1.02}}$$

- *E = particulate emission factor (same units as k)*
- *k = particle size multiplier for $PM_{2.5}$ (from table 13.2.1-1; k=0.15 g/vehicle km traveled)*
- *sL=road surface silt loading (g/m^2; 0.2 per Table 13.2.1-2)*
- *W=average weight of vehicle fleet (20 tons)*

So, E = 0.73 g/km

Then, Annual Emissions = E (distance x time)
AE =(0.73 g/km)(97 km/day x 154 days) = 10904.74 g = 0.012 tons per truck

<u>Unpaved road equation (for trucks only transport of debris & construction materials):</u>
Source: EPA AP-42, 13.2.2, Unpaved Roads

$PM_{2.5}$ emissions from unpaved roads are a function of the vehicle miles traveled (VMT) on the roads, silt content of the roadway material, and the moisture content of this material. Equation (1a) was used to estimate the quantity in pounds of site-specific particulate emissions from an unpaved road at industrial sites (e.g., construction sites), per vehicle mile traveled (VMT):

$$\mathbf{E = k\,(s/12)^{a}(W/3)^{b}}$$

- *E = size-specific emission factor (same units as k) for each construction site (e.g. pounds of $PM_{2.5}$ emissions from an unpaved road per vehicle mile traveled (lb/VMT))*
- *k = particle size multiplier for PM2.5 (from table 13.2.2-2; k=0.15 lb/VMT)*
- *a = 0.9 (empirical constant provided in Table 13.2.2-2)*
- *b = 0.45 (empirical constant provided in Table 13.2.2-2)*
- *s = surface material silt content in percent (default mean silt content for construction sites from Table 13.2.2-1; s = 8.5 %; Silt refers to particles that have a diameter equal to or*

less than 75 microns. The silt content is determined by measuring the portion of dry aggregate material that passes through a 200 mesh screen, using ASTM-C-136 method. Since measured data were not available, the default of 8.5 percent was used. However, the use of the default introduces error. The silt content of the parent soils in the construction areas as identified through mapping on: http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx provides a conservative approximation of silt content, which ranges from 34-55% for all sites. These values are much higher than the default. Further clarification in Section13.2.2 noted that silt content will vary with geographic location and that road silt content is normally lower than in the surrounding parent soil due to the removal of fines by vehicle traffic. In a telephone conversation on Oct 14, 2015, Jim Myers, District Conservationist of Montgomery County NRCS, indicated that actual silt percentage values from the soil survey are likely higher than actual values based on prior disturbances, and that without site specific tests, there is no good way to estimate silt content. Brian Hug (MDE indicated that use of the appropriate default values from Table 13.2.2-1 are permitted when site-specific values have not been obtained (MDE, personal communication 27 Oct 2015).

- *W = mean vehicle weight (21 tons; averaged operating weight of each type of equipment identified for use on unpaved roads using online specifications for similar equipment. Sources: http://www.ritchiespecs.com/; http://www.specguideonline.com/)*

So, $E = 0.15(8.5/12)^{0.9}(21/3)^{0.45} = 0.263$ lb/VMT (unmitigated value, defined below)

The metric conversion from lb/VMT to grams per vehicle kilometer traveled (VKT) is:
1 lb/VMT = 281.9 g/VKT

So, conversion of 0.263 lb/VMT = 74.14 g/VKT (unmitigated value)

The construction trucks will be traveling the total length of the project (i.e. stream and access areas) an estimated three dozen times a day for the construction period (154 days). Based on mapping of access points and likely travel routes, the linear distance that trucks will travel for each of the project sites was estimated (Site 9 = 2,241 ft; Site 3 = 7,285 ft; Site 15 = 6,453 ft; Site 5 = 6,453 ft; Site 13 = 7,690 ft; and Site 11 = 10,466 ft). The total travel distance for the three combined project areas is 39,654 ft.

Travel distance for 36 one-way trips = 39,654 x 36 = 1,427,544 ft or 435 km/day

Then Annual Emissions = E (distance x time):
AE = (74.14 g/km)(435 km/day x 154 days) = 4,966,638.6 g = 5.48 tons (short) per truck (unmitigated)

As discussed in Section 13.2.2, all roads are subject to some natural mitigation because of rainfall and other precipitation. Below is the calculation using natural mitigation due to rainfall and other precipitation (Equation 2 from EPA AP-42, 13.2.2). Equation 2 provides an estimate that accounts for precipitation on an annual average basis for the purpose of inventorying emissions.

$$\mathbf{E_{ext} = E\ [(365-P)/365]}$$

- *E_{ext} = annual size-specific emission factor extrapolated for natural mitigation (g/VKT)*
- *E = emission factor from Equation 1a (g/VKT)*
- *P = number of days in a year with at least 0.254 mm (0.01 in) of precipitation (from Figure 13.2.2-1, the mean annual number of "wet" days for Prince George's County, MD = 120 days)*

E_{ext} = 74.14 g/VKT[(365-120)/365] = 49.76 g/VKT (natural mitigated value)

AE = (49.76 g/km)(435 km/day x 154 days) = 3,333,422 g = 3.68 tons (short) per truck (natural mitigated value)

General Land Clearing (roller, dozer, scraper, grader, brush chipper, chainsaw)
Source: EPA AP-42, 13.2.3 Heavy Construction Operations (Table 13.2.3-1, Recommended Emission Factors for Construction Operations) & 11.9 Western Surface Coal Mining

Table 13.2.3-1 recommends the use of the dozer equation (overburden) in Tables 11.9-1 and 11.9-2 for estimating the emission factor for general land clearing associated with construction operations. Table 11.9-1 was used since it identifies English units of lb/hr for the overburden emissions. It was assumed that most on-site materials (fill, trees, rock, boulders) would be used on-site and not transported off-site.

Dozer emission factor equations (overburden) from Table 11.9-1 are below. The equation is for total suspended particulates (TSP). Particulate matter less than or equal to 30 µm in aerodynamic diameter is sometimes termed "suspended particulate" and is often used as a surrogate for TSP. For smaller particle sizes (≤2.5µm), the TSP predictive equation is multiplied by a scaling factor of 0.105 to determine the emissions. For TSP ≤30µm:

$$\mathbf{E = 5.7(s)^{1.2}/(M)^{1.3}}$$

- *E = Emissions (lb/hr)*
- *s = percent silt content of material (site-specific value not obtained, therefore used geometric mean value from Table 11.9-3; bulldozer overburden geometric mean = 6.9%)*
- *M = percent moisture content of material (site-specific value not obtained, therefore used geometric mean value from Table 11.9-3; bulldozer overburden geometric mean = 7.9%)*

$E= 5.7(6.9)^{1.2}/(7.9)^{1.3}$ = 3.93 lb/hr

Using ≤2.5µm/TSP scaling factor (*Bulldozing - overburden scaling factor for ≤2.5 µm/TSP = 0.105, from Table 11.9-1)*:

E = 3.93 lb/hr x 0.105 = 0.413 lb/hr

Assuming 5 days duration for general land clearing with 8 hour days:
0.413 lb/hr x 40 total hrs = 16.52 lbs = 0.00826 tons per truck

Creating Access Roads - Compacting (roller, scraper, grader, asphalt paver)
Source: EPA AP-42, 13.2.3 Heavy Construction Operations (Table 13.2.3-1, Recommended Emission Factors for Construction Operations) & 11.9 Western Surface Coal Mining

Table 13.2.3-1 recommends the use of the dozer equation (overburden) in Tables 11.9-1 (English units) for estimating the emission factor for dust-generating compacting activities associated with creating access road construction operations. The emission factor is downgraded because of differences in operating equipment from those used in western surface coal mining (section 11.9). Again, the TSP scaling factor of 0.105 is applied. For TSP ≤30µm:

$$\mathbf{E = 5.7(s)^{1.2}/(M)^{1.3}}$$

- *E = Emissions (lb/hr)*
- *s = percent silt content of material (site-specific value not obtained, therefore used geometric mean value from Table 11.9-3; bulldozer overburden geometric mean = 6.9%)*
- *M = percent moisture content of material (site-specific value not obtained, therefore used geometric mean value from Table 11.9-3; bulldozer overburden geometric mean = 7.9%)*

$E= 5.7(6.9)^{1.2}/(7.9)^{1.3} = 3.93$ lb/hr

Using ≤2.5µm/TSP scaling factor (*Bulldozing - overburden scaling factor for ≤2.5 µm/TSP = 0.105, from Table 11.9-1)*:

E = 3.93 lb/hr x 0.105 = 0.413 lb/hr

Assuming 5 days duration for general land clearing with 8 hour days:
0.413 lb/hr x 40 total hrs = 16.52 lbs = 0.00826 tons per truck

Excavation & Grading of Stream Bed Materials (loader-backhoe, loader-crawler, dozer-crawler, scraper, grader)
Source: EPA AP-42, 13.2.3 Heavy Construction Operations (Table 13.2.3-1, Recommended Emission Factors for Construction Operations) & 11.9 Western Surface Coal Mining

The motor grading emission factor equation from Table 11.9-1 (English units) was used to estimate the emissions of the excavation and land moving activities associated with the stream bed and bank reconfiguration and/or stream structure installation. The grading emission factor equation is below. The TSP predictive equation is multiplied by a scaling factor of 0.031 to determine emissions. For TSP ≤30µm:

$$\mathbf{E = 0.040(S)^{2.5}}$$

- *E = Emissions (lb/VMT)*

- *S = mean vehicle speed (mph; 10 mph based on average vehicle speed from equipment specifications – see above for website references)*

$E = 0.040(10)^{2.5} = 12.26$ lb/VMT

Using ≤2.5µm/TSP scaling factor of 0.031 (*Bulldozing - overburden scaling factor for ≤2.5 µm/TSP = 0.105, from Table 11.9-1)*:

E = 12.26 lb/VMT x 0.031 = 0.380 lb/VMT = 107.12 g/VKT

The estimated distance that equipment will travel for land grading per day (total project and access length = 39,654 ft) is 7.51 miles. The total distance traveled for grading equipment for the entire project (assuming a total of 4 passes along the stream for the entire project) is 30.04 miles (48.35 km) per vehicle.

Annual Emissions = E(distance x time)
AE = (107.12 g/VKT)(48.35 km) = 5,179.25 g = 0.006 tons per truck

<u>Loading and unloading of debris and construction materials into trucks (dirt, sand, gravel, rock)</u>
Source: EPA AP-42, 13.2.3 Heavy Construction Operations (Table 13.2.3-1, Recommended Emission Factors for Construction Operations) & 13.2.4 Aggregate Handling and Storage Piles

<u>Loading debris and materials into Trucks:</u> Table 13.2.3-1 recommends the use of the material handling emission factor equation in Tables 13.2.4 for estimating the emission factor for loading of debris and materials into trucks. Loading material from a stockpile to a truck with a front end loader is an example of a batch drop operation. The quantity of particulate emissions generated by a drop operation, per ton of material transferred, is estimated using the following equation:

$$\mathbf{E = k(0.0032)\ [(U/5)^{1.3}/(M/2)^{1.4}]}$$

- *Where E = emission factor (lb/ton, i.e. lbs emitted per ton of material transferred)*
- *k = particle size multiplier (dimensionless; from Section 13.2.4 Aggregate Handling and Storage Piles = 0.053 for <2.5µm)*
- *U = mean wind speed (miles per hour; from http://www.erh.noaa.gov/er/gyx/climo/avgwind.html, the annual average wind speed in Baltimore, MD is 9.1 mph)*
- *M = material moisture content in percent (From Table 13.2.4-1, mean moisture content for exposed ground = 3.4%)*

$E = 0.053(0.0032)\ [(U/5)^{1.3}/(3.4/2)^{1.4}] = 0.0002$ lb/ton

The approximate total of material transferred is estimated to be 8 tons (based on personal communication with Ben Soleimani, NAB-EN), so annual emissions are:

AE = 0.0002 lb/ton x 8 tons = 0.0016lbs per truck = 0.0000008 ton/truck

Unloading debris and materials from Trucks: Table 13.2.3-1 recommends the use of the material handling emission factor equation in Tables 13.2.4 for estimating the emission factor for unloading of debris and materials into trucks. The quantity of particulate emissions generated by a drop operation, per ton of material transferred, is estimated using the following equation.

$$\mathbf{E = k(0.0032)\ [(U/5)^{1.3}/(M/2)^{1.4}]}$$

- *E = emission factor (lb/ton)*
- *k = particle size multiplier (dimensionless; from Section 13.2.4 Aggregate Handling and Storage Piles = 0.053 for <2.5µm)*
- *U = mean wind speed (miles per hour; from http://www.erh.noaa.gov/er/gyx/climo/avgwind.html, the annual average wind speed in Baltimore, MD is 9.1 mph)*
- *M = material moisture content in percent (From Table 13.2.4-1, mean moisture content for exposed ground = 3.4%)*

$$E = 0.053(0.0032)\ [\ (U/5)^{1.3}/(3.4/2)^{1.4}] = 0.0002 \text{ lb/ton}$$

The approximate total of material transferred is estimated to be 8 tons (based on personal communication with Ben Soleimani, NAB-EN), so annual emissions are:

AE = 0.0002 lb/ton x 8 tons = 0.002 lbs per truck = 0.000001 ton/truck

On-site Truck transport of debris and construction materials (soil, sand, gravel, rock): Included in unpaved road equation and emissions as shown above.

Summary of Emissions

As shown in Table 4, both annual emissions from exhausts and fugitive dust are below de minimus thresholds, therefore complying with the Clean Air Act General Conformity Rule.

Table 4: Summary of emissions for stream restoration in Prince Georges County, MD.

SUMMARY - Direct emissions for preferred alternative			
Pollutant	**Emissions per Stream Site (TPY)**	**Emissions Project Total (TPY)**	**Annual Limit (de minimus) (TPY)**
NOx	5.77	34.6	100
VOCs	0.56	3.4	50
SO2	1.95	11.7	100
PM2.5 (exhaust)	0.44	2.6	see PM 2.5 total
PM2.5 (fugitive dust)	N/A	11.2	see PM 2.5 total
PM2.5 Total (exhaust and dust)	N/A	13.9	100

Notes:

Paved road - trucks
Unpaved road – trucks, loader crawler, loader backhoe, paver
Dozer – roller, dozer crawler, scraper, grader
Compacting – roller, scraper, grader, asphalt paver
Excavation and grading - loader-backhoe, loader-crawler, dozer-crawler, scraper, grader
Loading and unloading of debris and excavated materials into trucks (dirt, sand, gravel, rock) - trucks

Assumptions:

- Total construction period estimated to be 154 days
- 5 days for general land clearing, access road compacting – dozer, scraper, grader, paver, chipping – 40 hours/day
- 50% all other equip – 616 hours = 0.86 mo
- 77 days for in-stream excavation and grading and loading and unloading of materials (10-26-15 email from USACE-EN, Ben Soleimani)
- The total length, including access points, of the three combined project areas = 20,851 lf. (stream reach lengths provided by Andrew Roach from GIS mapping of project area)
- Based on discussions with USACE-EN Civil (Ben Soleimani), the construction trucks will be traveling the total length of the project (i.e., stream and access areas) a couple of dozen times a day for the construction period (154 days).
- Approximate total of material transferred was estimated to be 8 tons (based on personal communication with Ben Soleimani, NAB-EN).

Stream Restoration, Prince Georges County Maryland

Table 1: Conformity Assessment: Preferred Alternative

DIRECT IMPACTS

EQUIPMENT

ANNUAL EXHAUST EMISSIONS

Equipment Description	Crane	Loader, Crawler	Loader, Crawler	Loader/Back hoe	Loader/Back hoe	Roller	Roller	Roller	Dozer, Crawler	Dozer, Crawler	Truck, Hwy	Truck, Hwy	Truck, Hwy	Scraper	Grader	Asphalt Paver	Brush Chipper	Chainsaw
Specifications	Hyd, 33T	F/E, 2.6 CY	F/E, 3.75 CY	0.80 CY	1.25 CY	Vib, DD, 6.0 T	Vib,DD,12T	Static,14 T			50K GVW, 6X4	25K GVW	45K GVW	ELEV, 11 CY	motor	10.0' W, SP	12" Dia Log	4"-42"Long Bar
PO - Power output (hp)	230	160	210	60	84	111	100	80	240	405	330	210	330	175	135	155	135	5.7
Fuel Type	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel		Diesel		Diesel	Diesel	diesel	diesel	Diesel
BSFC	0.367	0.367	0.367	0.408	0.408	0.367	0.408	0.408	0.367	0.367	0.367	0.367	0.367	0.367	0.367	0.367	0.367	0.608
Operating weight (tons)		19.84	27.8	5.68	7.88				28.82	50.98	20	20	20		14.42	16		21.0381818
EF - Emission Factors (grams/hp-hr)*																		
NOx	2.5	2.5	2.5	3	3	2.5	3	3	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	0.9
HC	0.1836	0.1836	0.1836	0.1836	0.1836	0.1836	0.1836	0.1836	0.1836	0.1669	0.1669	0.1836	0.1669	0.1836	0.1836	0.1836	0.1836	47.98
SO2	0.85	0.85	0.85	0.95	0.95	0.85	0.95	0.95	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	1.09
PM2.5 (using PM10 factors)	0.15	0.22	0.15	0.3	0.3	0.22	0.3	0.3	0.15	0.15	0.15	0.15	0.15	0.22	0.22	0.22	0.22	7.7
LF - Load Factor (fraction of power)	0.43	0.80	0.21	0.21	0.21	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.43	0.59	0.59	0.43	0.43
t - Time of operation (hr/yr)	1232	1232	1232	1232	1232	1232	1232	1232	1232	1232	1232	1232	1232	1232	1232	1232	1232	1232
AE - Annual Emissions (tons/year)* = (EF X LF X PO X t)/907185																		
NOx	0.3358	0.4346	0.1497	0.0513	0.0719	0.2223	0.2404	0.1923	0.4807	0.8113	0.6610	0.4207	0.6610	0.2555	0.2704	0.3105	0.1971	0.0030
VOCs	0.0247	0.0319	0.0110	0.0031	0.0044	0.0163	0.0147	0.0118	0.0353	0.0542	0.0441	0.0309	0.0441	0.0188	0.0199	0.0228	0.0145	0.1597
SO2	0.1142	0.1479	0.0509	0.0162	0.0227	0.0757	0.0758	0.0606	0.1636	0.2761	0.2249	0.1431	0.2249	0.0869	0.0920	0.1056	0.0671	0.0036
PM2.5 (exhaust)	0.0201	0.0382	0.0090	0.0051	0.0072	0.0196	0.0240	0.0192	0.0288	0.0487	0.0397	0.0252	0.0397	0.0225	0.0238	0.0273	0.0173	0.0256

ANNUAL FUGITIVE DUST EMISSIONS

Equipment Description	Crane	Loader, Crawler	Loader, Crawler	Loader/Back hoe	Loader/Back hoe	Roller	Roller	Roller	Dozer, Crawler	Dozer, Crawler	Truck, Hwy	Truck, Hwy	Truck, Hwy	Scraper	Grader	Asphalt Paver	Brush Chipper	Chainsaw	Total
Paved Roads - tons (Equations from EPA AP-42, equation 13.2.1)																			
											0.012	0.012	0.012						0.036
Unpaved roads - tons, natural mitigated value (Equations from EPA AP-42, 13.2.2)																			
											3.68	3.68	3.68						11.04
General Land Clearing - tons (Equations from EPA AP-42 13.2.3)																			
						0.008	0.008	0.008	0.008	0.008				0.008	0.008		0.008	0.008	0.072
Creating access roads (compacting) - tons (Equations from EPA AP-42 13.2.3)																			
						0.008	0.008	0.008						0.008	0.008	0.008			0.048
Excavation & grading of stream bed materials -tons (Equations from EPA AP-42 13.2.3)																			
		0.006	0.006	0.006	0.006				0.006	0.006				0.006	0.006				0.024
Loading of debris & construction materials -tons (Equations from EPA AP-42 13.2.3)																			
											0.000001	0.000001	0.000001						0.000003
Unloading of debris & construction materials -tons (Equations from EPA AP-42 13.2.3)																			
											0.000001	0.000001	0.000001						0.000003

Total Direct Emission Amounts (tons/yr)			Direct
NOx			5.77
VOCs			0.56
SO2			1.95
PM2.5 Total			0.4412

Total On-Site Fugitive Dust Emissions (tons/yr)	
PM2.5 Total (Fugitive Dust)	11.220006

SUMMARY - Direct emissions for preferred alternative

Pollutant	Emissions per Stream Site (TPY)	Emissions Project Total (TPY)	Annual Limit (de minimus) (TPY)
NOx	5.77	34.6	100
VOCs	0.56	3.4	50
SO2	1.95	11.7	100
PM2.5 (exhaust)	0.44	2.6	see PM 2.5 total (exhaust and dust)
PM2.5 (fugitive dust)	N/A	11.2	see PM 2.5 total (exhaust and dust)
PM2.5 Total (exhaust and dust)	N/A	13.9	100

C-6: Agency Coordination

Rushern L. Baker, III
County Executive

THE PRINCE GEORGE'S COUNTY GOVERNMENT
Department of Permitting, Inspections and Enforcement
Office of the Director

DPIE
DEPARTMENT OF PERMITTING, INSPECTIONS AND ENFORCEMENT

MEMORANDUM

August 7, 2015

TO: Dawn Hawkins-Nixon, Acting Associate Director
Department of the Environment

FROM: Haitham A. Hijazi, Director
Department of Permitting, Inspections and Enforcement

RE: Anacostia River Watershed Multiple Stream & Wetland Restoration Projects
Clearinghouse Referral Number: MD20150605-0487

This memorandum is in response to your June 26, 2015, memorandum regarding the U.S. Army Corps of Engineers Anacostia River Watershed Multiple Stream & Wetland Restoration Projects.

The Department of Permitting, Inspections and Enforcement (DPIE) has reviewed this request and offers the following comments:

1. Stormwater Management Concept approval and site development fine grading permits are required for all of these project sites.

2. 100-year floodplain approval from DPIE is required.

If you have any questions or need additional information, please feel free to contact Mr. Steve Snyder, District Engineer for the area, at 301.636.2060.

HAH:SS:dar

cc: Gary E. Cunningham, Deputy Director, DPIE
Dawit Abraham, P.E., Associate Director, DO, DPIE
Mary C. Giles, P.E. Associate Director, S/RPRD, DPIE
Rey de Guzman, P.E., Chief, Site/Road Section, S/RPRD, DPIE
Steve Snyder, P.E., District Engineer, S/RPRD, DPIE
M.J. Labban, Engineer, S/RPRD, DPIE

Maryland Department of Planning

Larry Hogan, Governor
Boyd Rutherford, Lt. Governor

David R. Craig, Secretary
Wendi W. Peters, Deputy Secretary

July 13, 2015

Mr. Christopher Spaur
CENAB-PL-P (Spaur)
U.S. Army Corps of Engineers, Baltimore District
P.O. Box 1715
Baltimore, MD 21203-1715

STATE CLEARINGHOUSE RECOMMENDATION

State Application Identifier: MD20150605-0487
Applicant: U.S. Army Corps of Engineers, Baltimore District
Project Description: Scoping to Prepare an Environmental Assessment (EA) for Multiple Stream and Wetland Restoration Projects being Proposed in Anacostia River Watershed, Prince George's County, MD
Project Location: Prince George's County
Approving Authority: U.S. Department of Defense DOD/ARMY
Recommendation: Consistent with Qualifying Comment(s) and Contingent Upon Certain Action(s)

Dear Mr. Spaur:

In accordance with Presidential Executive Order 12372 and Code of Maryland Regulation 34.02.01.04-.06, the State Clearinghouse has coordinated the intergovernmental review of the referenced project. This letter constitutes the State process review and recommendation. This recommendation is valid for a period of three years from the date of this letter.

Review comments were requested from the Maryland Department(s) of Natural Resources (DNR), Transportation (MDOT), the Environment (MDE) and the Maryland Department of Planning (MDP), including the Maryland Historical Trust; and Prince George's County.

The Maryland Department(s) of Transportation and the Maryland Department of Planning; and Prince George's County found this project to be consistent with their plans, programs and objectives.

The Department of Transportation stated that "as far as can be determined at this time, the subject has no unacceptable impacts on plans or programs."

Prince George's County stated that all 10 sites are located within the Anacostia River watershed (maps listing the 10 sites will be sent to MDP electronically). In addition, there are three maps for each site which include the effective FEMA map, the preliminary DFIRM (Digital Flood Insurance Rate Map) and the Storm Water Management Technical Group (SWMTG) Anacostia River watershed study each with the 1-percent annual chance (100-year) floodplain shown. The Department of Permitting, Inspections, and Enforcement (DPIE) is the regulatory agency that determines which study governs at each site (the highest 100-year floodplain elevation) and therefore should review all sites.

The Maryland Department(s) of Natural Resources and Environment found this project to be generally consistent with their plans, programs and objectives, but included certain qualifying comments summarized below.

The Maryland Department of Natural Resources (DNR) generally supports these restoration projects. DNR stated, please ensure that the historic and cultural resources are identified and protected.

The Maryland Department of Environment comments are as follows:

1. Any solid waste including construction, demolition and land clearing debris, generated from the subject project, must be properly disposed of at a permitted solid waste acceptance facility, or recycled if possible. Contact the Solid Waste Program at (410) 537-3315 for additional information regarding solid waste activities and contact the Waste Diversion and Utilization Program at (410) 537-3314 for additional information regarding recycling activities.

2. The Waste Diversion and Utilization Program should be contacted directly at (410) 537-3314 by those facilities which generate or propose to generate or handle hazardous wastes to ensure these activities are being conducted in compliance with applicable State and federal laws and regulations. The Program should also 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 Maryland Historical Trust (MHT) stated that their finding of consistency is contingent upon the applicant's completion of the review process required under Section 106 of the National Historic Preservation Act.

In response to a request from the U.S. Army Corps of Engineers, the Maryland Historical Trust (MHT) is reviewing this project to assess potential effects on historic properties in accordance with Section 106 of the National Historic Preservation Act. Following our careful review of the ten stream segments/reaches, it is our opinion that the proposed restoration work is unlikely to have an adverse effect on cultural resources within six of the ten reaches, including:

- Indian Creek – I-95
- Paint Branch – I-95 Interchange
- Indian Creek – College Park
- Paint Branch
- Northeast Branch
- Chillum Road Tributary

No cultural resources survey work will be recommended for these six reaches for Section 106 purposes.

While much of the area surrounding the remaining four stream reaches has never been systematically surveyed for archeological deposits, MHT files indicate that several archeological sites, both prehistoric and historic, have already been identified in the vicinity these four study areas:

- Little Paint Branch
- Lower Northwest Branch
- Northwest Branch Hyattsville
- Sligo Creek

Given the presence of these archeological resources, we believe that these four stream reaches have moderate to high potential for containing additional archeological resources that have not yet been identified. For these reasons, archeological investigations may be needed prior to any stream or wetland restoration work, depending upon the location and extent of the proposed impact areas. We have therefore requested that we be provided with more detailed site plans (as they become available) illustrating the location and boundaries of all proposed ground-disturbing activities (bank grading, removal of fish blockages, sediment removal, plantings, fencing, staging areas, etc.) that would be involved in the restoration work within the four stream reaches listed above. The plans should clearly indicate where all activities will be taking place and to what depth the ground disturbance will extend. Upon our review of these plans, we will be able to provide informed recommendations regarding what, if any, archeological investigations will be necessary prior to construction. All recommended survey work will need to be carried out by a qualified professional archeologist and performed in accordance with the Standards and Guidelines for Archeological Investigations in Maryland (Shaffer and Cole 1994).

Any statement of consideration given to the comments(s) should be submitted to the approving authority, with a copy to the State Clearinghouse. The State Application Identifier Number must be placed on any correspondence pertaining to this project. The State Clearinghouse must be kept informed if the approving authority cannot accommodate the recommendation.

Please remember, you must comply with all applicable state and local laws and regulations. If you need assistance or have questions, contact the State Clearinghouse staff person noted above at 410-767-4490 or through e-mail at nasrin.rahman@maryland.gov. **Also please complete the attached form and return it to the State Clearinghouse as soon as the status of the project is known.** ***Any substitutions of this form must include the State Application Identifier Number.*** **This will ensure that our files are complete.**

Thank you for your cooperation with the MIRC process.

Sincerely,

Linda C. Janey

Linda C. Janey, J.D., Assistant Secretary

LCJ:NR
cc:

Tina Quinichette - MDOT
Amanda Degen - MDE
Greg Golden - DNR
Kathleen Herbert - PGEO
John Leocha/LaVerne Gray - MDPLR&WC
Beth Cole - MHT

15-0487_CRR.CLS.doc

PROJECT STATUS FORM

Please complete this form and return it to the State Clearinghouse upon receipt of notification that the project has been approved or not approved by the approving authority.

TO: **Maryland State Clearinghouse**
Maryland Department of Planning
301 West Preston Street
Room 1104
Baltimore, MD 21201-2305

DATE: _____
(Please fill in the date form completed)

FROM: _____
(Name of person completing this form.)

PHONE: ____-____-_____
(Area Code & Phone number)

RE: **State Application Identifier:** **MD20150605-0487**
Project Description: Scoping to Prepare an Environmental Assessment (EA) for Multiple Stream and Wetland Restoration Projects being Proposed in Anacostia River Watershed, Prince George's County, MD

PROJECT APPROVAL

This project/plan was: ☐ **Approved** ☐ **Approved with Modification** ☐ **Disapproved**

Name of Approving Authority: _____ **Date Approved:** _____

FUNDING APPROVAL

The funding (if applicable) has been approved for the period of:

_____, 201____ to _____, 201____ as follows:

Federal $:	Local $:	State $:	Other $:

OTHER

☐ *Further comment or explanation is attached*

Maryland Department of Planning
Maryland Historical Trust

Larry Hogan, Governor
Boyd Rutherford, Lt. Governor

David R. Craig, Secretary
Wendi W. Peters, Deputy Secretary

June 15, 2015

Mr. Christopher Spaur
Planning Division
Baltimore District
U.S. Army Corps of Engineers
P.O. Box 1715
Baltimore, MD 21203-1715

Re: MHT Review of Anacostia River Watershed Restoration Project – Prince George's County, Maryland

Dear Mr. Spaur:

In response to a request from the U.S. Army Corps of Engineers, the Maryland Historical Trust (MHT) is reviewing the above-referenced project to assess potential effects on historic properties in accordance with Section 106 of the National Historic Preservation Act. It is our understanding that the Corps, in partnership with Prince George's County, is preparing an environmental assessment (EA) for multiple stream and wetland restoration projects that are being proposed within ten stream segments in the Anacostia River watershed. As a federal ecosystem restoration project, the proposed undertaking is subject to federal historic preservation law. We are therefore reviewing the proposed restoration study to assess potential effects on historic properties.

Following our careful review of the ten stream segments/reaches, it is our opinion that the proposed restoration work is unlikely to have an ***adverse*** effect on cultural resources within six of the ten reaches, including:

- Indian Creek – I-95
- Paint Branch – I-95 Interchange
- Indian Creek – College Park
- Paint Branch
- Northeast Branch
- Chillum Road Tributary

No archeological survey work will be recommended for these six reaches for *Section 106* purposes.

While much of the area surrounding the remaining four stream reaches has never been *systematically* surveyed for archeological deposits, MHT files indicate that several archeological sites, both prehistoric and historic, have already been identified in the vicinity these four study areas:

- Little Paint Branch
- Lower Northwest Branch
- Northwest Branch Hyattsville
- Sligo Creek

Given the presence of these archeological resources, we believe that these four stream reaches have moderate to high potential for containing additional archeological resources that have not yet been identified. For these reasons, archeological investigations *may* be needed prior to any stream or wetland restoration work, depending upon the location and extent of the proposed impact areas. We are therefore requesting that we be provided with more detailed site plans (as they become available) illustrating the location and boundaries of all proposed ground-disturbing activities (bank grading, removal of fish blockages, sediment removal, plantings, fencing, staging areas, etc.) that would be involved in the restoration work within the four stream reaches listed above. The plans should clearly indicate where all activities will be taking place and to what depth the ground disturbance will extend. Upon our review of these plans, we will be able to provide informed recommendations regarding what, if any, archeological investigations will be necessary prior to construction. All recommended survey work will need to be carried out by a qualified professional archeologist and performed in accordance with the *Standards and Guidelines for Archeological Investigations in Maryland* (Shaffer and Cole 1994).

We look forward to receiving the information requested above and to further coordination as project planning proceeds. If you have any questions or we may be of assistance, please do not hesitate to contact me at dixie.henry@maryland.gov or 410-514-7638. Thank you for providing us with this opportunity to comment.

Sincerely,

Dixie Henry

Dixie L. Henry, Ph.D.
Preservation Officer
Maryland Historical Trust

DLH/201502225

MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

Larry Hogan, *Governor*
Boyd K. Rutherford, *Lt. Governor*
Mark J. Belton, *Secretary*
Mark L. Hoffman, *Acting Deputy Secretary*

July 29, 2015

U.S. Army Corps of Engineers
Baltimore District
ATTN: CENAB-PL-P (Spaur)
P.O. Box 1715
Baltimore, MD 21203-1715

RE: Environmental Review for Anacostia River Watershed Restoration Project, 10 Streams, Prince George's County, Maryland.

Dear Mr. Spaur:

With the one exception as described below, the Wildlife and Heritage Service determined that there are no State or Federal records for rare, threatened or endangered species within the boundaries of the stream segments as shown on your map. As a result, we have no specific comments or requirements pertaining to protection measures at this time. This statement should not be interpreted however as meaning that rare, threatened or endangered species are not in fact present. If appropriate habitat is available, certain species could be present without documentation because adequate surveys have not been conducted.

The stream segment located in Indian Creek in the Greenbelt area is known to support a population of state-listed endangered Trailing Stitchwort (*Stellaria alsine*). This occurrence could potentially be impacted by any proposed work associated with stream restoration. Further coordination with the WHS is recommended if the work proposed for the Indian Creek site is pursued.

Thank you for allowing us the opportunity to review this project. If you should have any further questions regarding this information, please contact me at (410) 260-8573.

Sincerely,

Lori A. Byrne

Lori A. Byrne,
Environmental Review Coordinator
Wildlife and Heritage Service
MD Dept. of Natural Resources

ER# 2015.0801.pg
Cc: K. McCarthy, DNR

MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

Larry Hogan, *Governor*
Boyd K. Rutherford, *Lt. Governor*
Mark J. Belton, *Secretary*
Mark L. Hoffman, *Acting Deputy Secretary*

July 2, 2015

Daniel M. Bierly, Chief
Civil Project Development Branch
U.S. Army Corps of Engineers, Baltimore District
P.O. Box 1715
Baltimore, MD 21203-1715

ATTN: Christopher Spaur

RE: CENAB-PL-P (Ancostia Watershed Restoration Project), Prince George's County, Maryland

Dear Mr. Bierly:

The Department has reviewed the above referenced area associated with your request. The U.S. Army Corps of Engineers, Baltimore District (USACE), is preparing an Environmental Assessment (EA) for multiple stream and wetland restoration projects proposed in the Anacostia River watershed, Prince George's County, Maryland. If implemented, the projects would directly support USACE's commitment to the Chesapeake Bay goals included in Executive Order 13508, *Chesapeake Bay Protection and Restoration.*

The Department has a long history of interagency coordination in support of restoration opportunities in the Anacostia watershed. The Department has also partnered with local agencies including the Metropolitan Council of Governments (MWCOG), Maryland-National Capital Park and Planning Commission (M-NCPPC), and the Anacostia Watershed Restoration Partnership (AWRP) to improve water quality, restore streams, and protect and improve aquatic and riparian habitat in the Anacostia watershed. The Department strongly advocates continued coordination with local groups to integrate federal, state, and local efforts and encourage citizen participation in Anacostia watershed restoration efforts.

The Department offers the following recommendations for consideration during the development of a draft EA which will be integrated within a USACE feasibility report for the Anacostia River Watershed Project:

- The Department supports Anacostia watershed restoration projects, particularly those projects that provide functional uplift in terms of increased biodiversity and the protection and restoration of aquatic and riparian habitat.
- Fish passage improvements are extremely important in the Anacostia watershed. Anadromous fish migrations and sustainable local fish populations are important factors in proposed stream restoration projects in this watershed. The removal of fish barriers is essential to ensure that aquatic species can complete those activities necessary for their particular life cycles in order to sustain healthy populations. Anadromous fish restoration

activities are ongoing in the Anacostia watershed. The ultimate goal of anadromous fish restoration efforts is to achieve fish passage to the middle reaches of the watershed.

- These streams may support many resident fish species documented by our Maryland Biological Stream Survey (MBSS). MBSS stations are located near several of the proposed stream and wetland sites. Information about the MBSS, including a link to an interactive stream health map, can be accessed via the following link: http://streamhealth.maryland.gov/
- Stream projects should be designed to minimize thermal impacts to coldwater fish species in Paint Branch stream reaches above the Capital Beltway.
- It is the overarching policy of the Department to protect riparian forests and tree cover and to minimize tree clearing associated with stream restoration or other proposed stream projects.
- Existing riparian vegetation should be preserved to the greatest extent possible to maintain aquatic and riparian habitat, provide shading to the stream, sustain allochthonous input into the stream, and protect water quality.
- Proposed stream projects should have clear goals and objectives provided in the project documentation. The proposal should include a description of the restoration potential of the reach and the explicit performance standards that will be used to evaluate the project.
- Monitoring protocols for stream projects should include the most appropriate measures to determine the degree to which the project objectives and performance standards have been achieved.
- Restoration and retrofit projects proposed to address water quality issues should incorporate a watershed approach. Essential items in this approach include identifying the specific pollutants of concern and their sources within the watershed, assessing the ability of various BMPs (structural and non-structural) to reduce pollutant loads, and prioritizing the implementation of pollution reduction strategies based on the ability of the proposed activities to achieve increased water quality in a cost-effective manner.
- Proposed SWM BMPs, when incorporated into a watershed restoration strategy, should meet state-of-the-art design criteria and minimize the need for ongoing maintenance activities.
- The preparation of an EA investigating proposed restoration efforts in the Anacostia River watershed represents an outstanding opportunity to increase citizens' awareness of and access to the extraordinary natural resources in their own backyard. The Anacostia River flows through some of the most economically disadvantaged, low-income areas in the country. Past environmental damage and pollution continue to negatively impact the citizens living in the watershed. The Anacostia River represents the most significant natural area and the sole connection to natural resources for many of the citizens living in the highly urbanized watershed. Community outreach opportunities, educational efforts, and increased citizen access to the Anacostia River would be valuable additions to the EA.
- The Anacostia River is a state-designated Scenic River. It is the policy of the State of Maryland to preserve and protect the natural values of these rivers, enhance their water quality, and wisely use the resources within their surrounding environment. Further review related to this designation will be conducted for any of the proposed stream projects selected to move forward to design.
- In addition to the general comments above regarding the potential stream and wetland restoration projects, the Department would like to offer the following comments concerning specific stream reaches:

- Paint Branch, a tributary to the Anacostia River, is a designated Use III stream (Nontidal Cold Water) and supports wild (naturally reproducing) brown trout above the Capital Beltway. Individual brown trout can potentially be found at times a short distance downstream of the Capital Beltway. Brown trout are highly sensitive to changes in habitat including sedimentation and changes in water temperature. No instream work should be conducted during the Use III restriction period of October 1 through April 30 of any year in these Use III stream reaches.
- Paint Branch has limited sustainable habitat for brown trout in reaches between US 29 and the Capital Beltway. Stream restoration in these reaches would potentially serve to support the long term protection of this population which is centered in headwater tributaries further upstream.
- Northwest Branch Anacostia River above East West Highway is a designated Use IV stream (Recreational Trout Waters). The Department's Fisheries Service and the MWCOG have conducted a joint effort to establish a limited, local fishery for smallmouth bass and sunfish in the middle reaches of Northwest Branch main stem.
- Anadromous fish species documented in the area include River Herring (*Alosa* spp.) and Sea Lamprey (*Petromyzon marinus*). No instream work should be conducted during the Use I restriction period of March 1 through June 15 of any year in Use I stream reaches.
- The Department's Wildlife and Heritage Service (WHS) is reviewing the Public Notice for potential impacts to sensitive species. More specific comments on the occurrence and protection of these sensitive species will be forwarded by Ms. Lori Byrne from WHS as soon as they are available.

Thank you for the opportunity to provide comments to assist in the development of the EA for the Anacostia River Watershed Restoration Project. The Department is extremely interested in continued partnership and interagency coordination regarding Anacostia watershed restoration initiatives. In addition, we are available to discuss stream restoration methodologies and review criteria in order to avoid and/or minimize adverse impacts to natural resources to the greatest degree possible. The Department would appreciate being notified if and when specific stream and wetland restoration projects are selected to move forward to the design phase. If you have any questions or concerns regarding these comments, you may contact Susan Makhlouf, DNR Project Review Division (PRD), at 410.260.8750.

Sincerely,

Gregory J Golden

Greg Golden, Manager
Project Review Division, Integrated Policy and Review Unit
Maryland Department of Natural Resources

cc: Christopher Spaur, USACE
Lori Byrne, DNR WHS
Susan Makhlouf, DNR PRD

THE MARYLAND-NATIONAL CAPITAL PARK AND PLANNING COMMISSION
Department of Parks and Recreation
6600 Kenilworth Avenue Riverdale, Maryland 20737

VOICE 301-699-2516
TTY 301-699-2544
FAX 301-277-9041

June 23, 2015

Daniel M. Bierly, Chief
Civil Project Development Branch
US Army Corps of Engineers, Baltimore District
Attn: CENAB-PL-P
P.O. Box 1715
Baltimore, Maryland 21203-1715

RE: Anacostia River Watershed Restoration Project
Prince George's County, Maryland

Dear Mr. Bierly:

This letter responds to the public notice recently sent to The Maryland-National Capital Park and Planning Commission (M-NCPPC) regarding the environmental assessment for multiple stream and wetland restoration projects proposed by the U.S. Army Corps of Engineers in the Anacostia River Watershed. The M-NCPPC owns and manages several properties that abut the streams and tributaries of the Anacostia River. These include the following stream valley parks:

- Anacostia River
- Northwest Branch
- Sligo Creek
- Paint Branch
- Little Paint Branch
- Indian Creek

Each of these parks is improved with facilities and amenities that are heavily used by the public. As such, we are very supportive of your proposed environmental assessment as the first step in developing restoration projects for the Anacostia River Watershed to implement the goals of protecting and restoring the Chesapeake Bay. In addition, the Corps' future project will assist the M-NCPPC in determining ways to enhance the experience of our park users. For your information and use, we have enclosed a set of maps that delineate parcels owned by M-NCPPC in the Anacostia River Watershed.

Should you have any questions, please contact me at 301-699-2525. Thank you for providing notice of your pending environmental assessment study.

Very truly yours,

Lawrence E. Quarrick, Division Chief
Park Planning and Development Division

Enclosures

C: Patricia Colihan Barney
Darin Conforti
Alvin McNeal
Robert Clark
Laura Connelly
Eileen Nivera

GIS

M59 - Powder Mill Park

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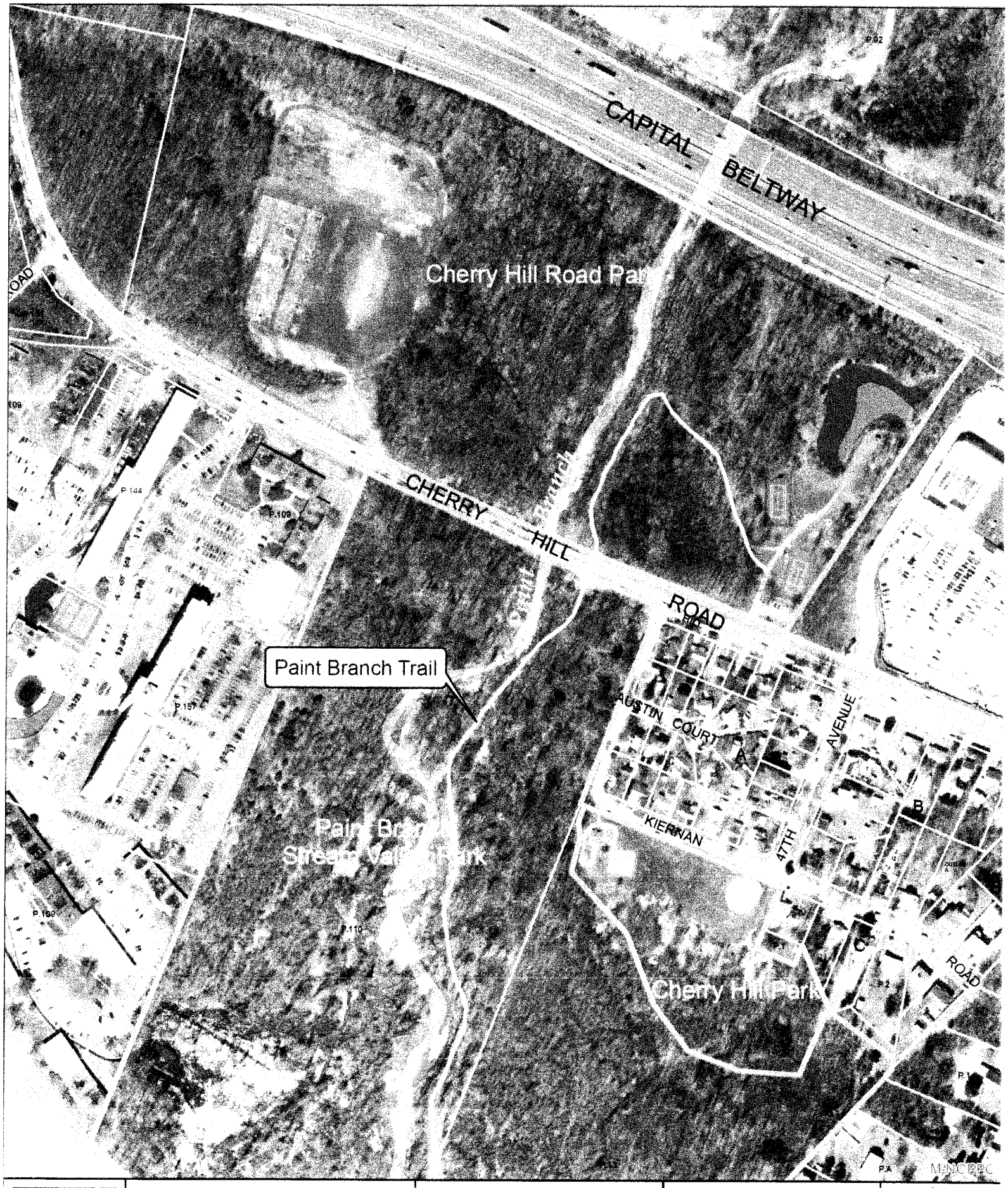
DATE: 06/19/2015

SCALE: 200 Feet

N



GIS

S59 - Cherry Hill Road Park and N32 - Cherry Hill Park

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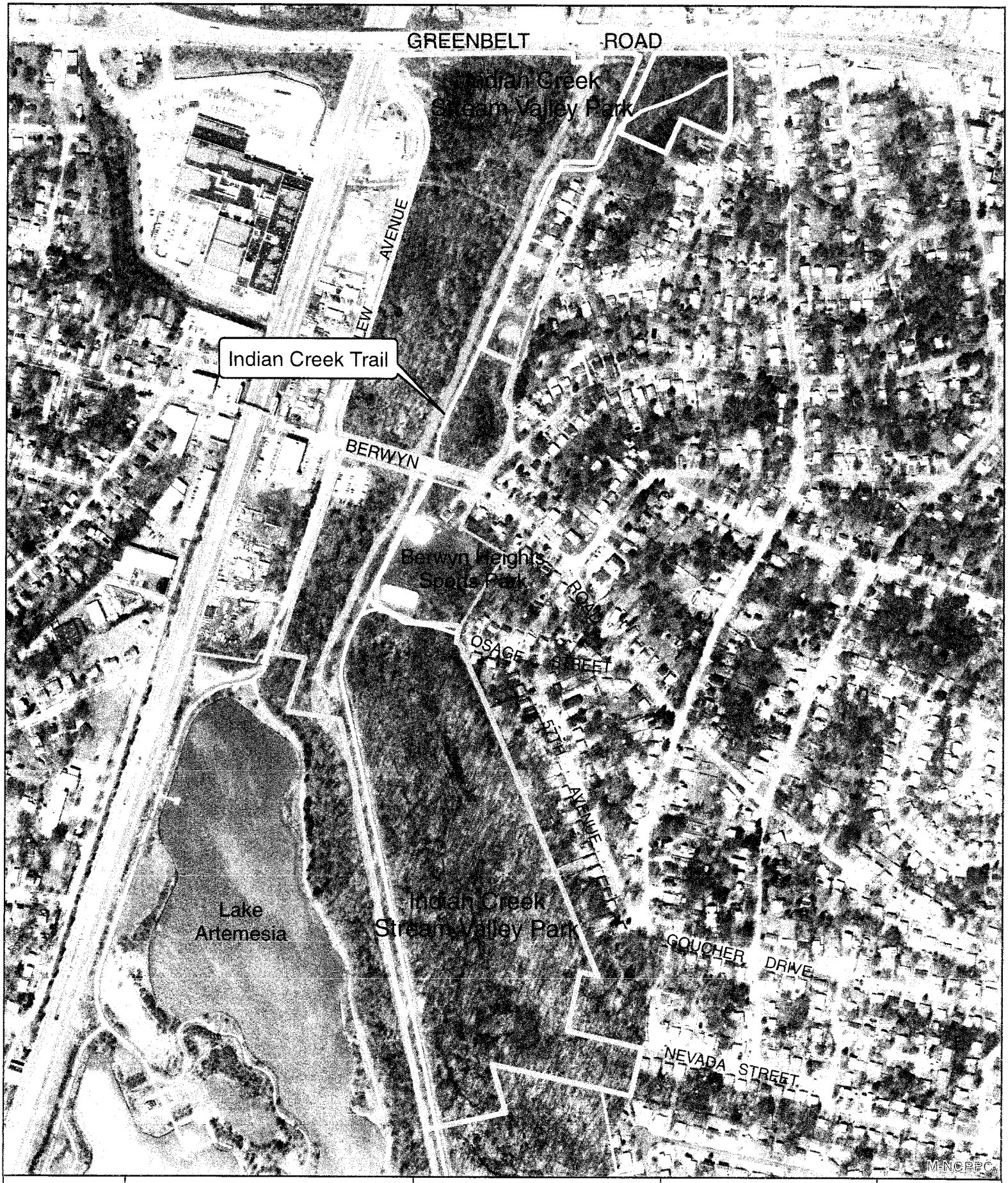
DATE: 06/19/2015

SCALE: 300 Feet

N



GIS

N79 - Indian Creek Stream Valley Park and Park Trail

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DATE: 06/19/2015

SCALE: 500 Feet

N

GIS

N64 - Paint Branch Parkway Park

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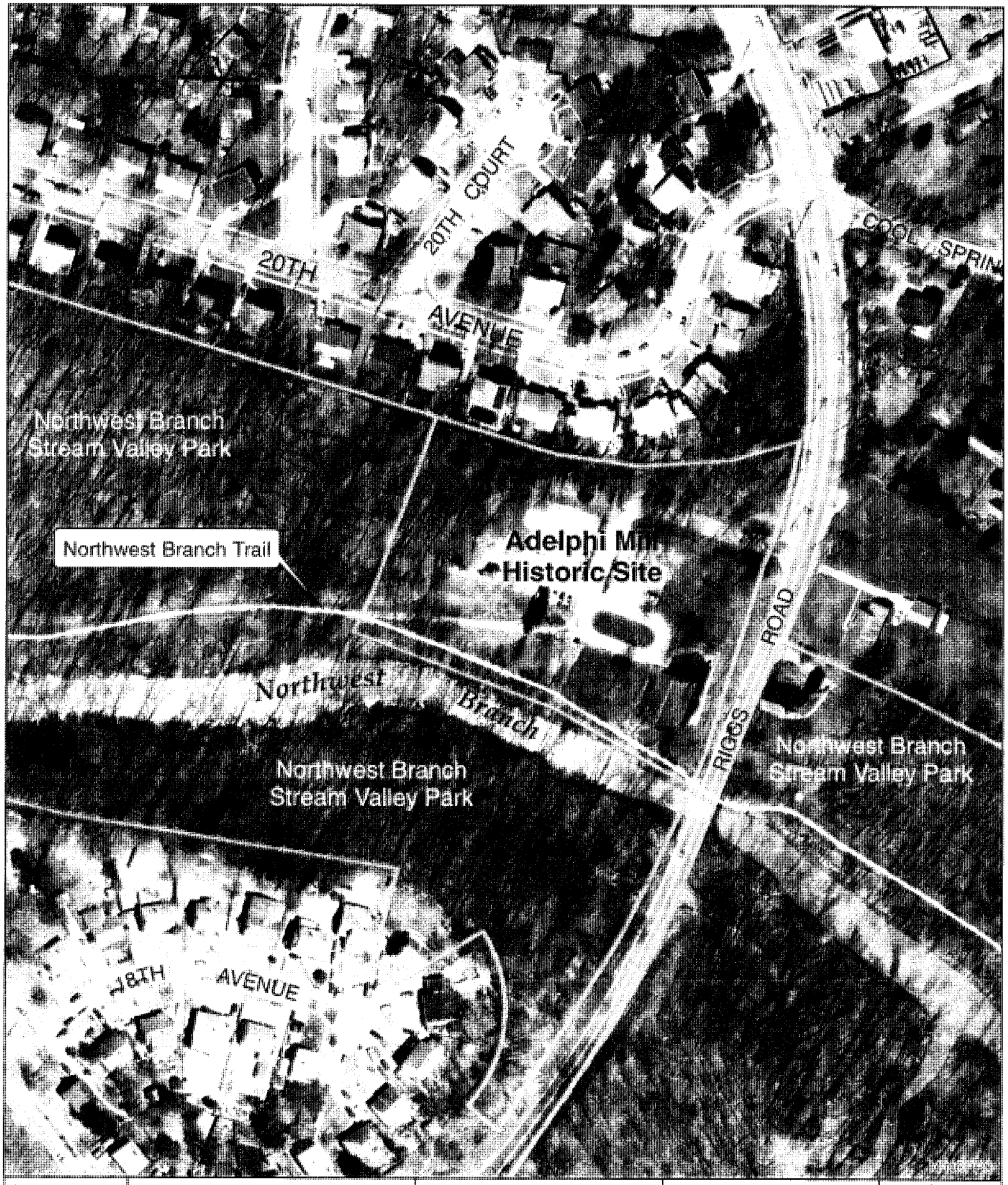
DATE: 06/19/2015

SCALE: 250 Feet

N



GIS

N86 - Adelphi Mill Historic Site

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DATE: 06/19/2015

SCALE: 150 Feet

N

GIS

N63 - Adelphi Manor Park Building and N71 - Lane Manor Park Building

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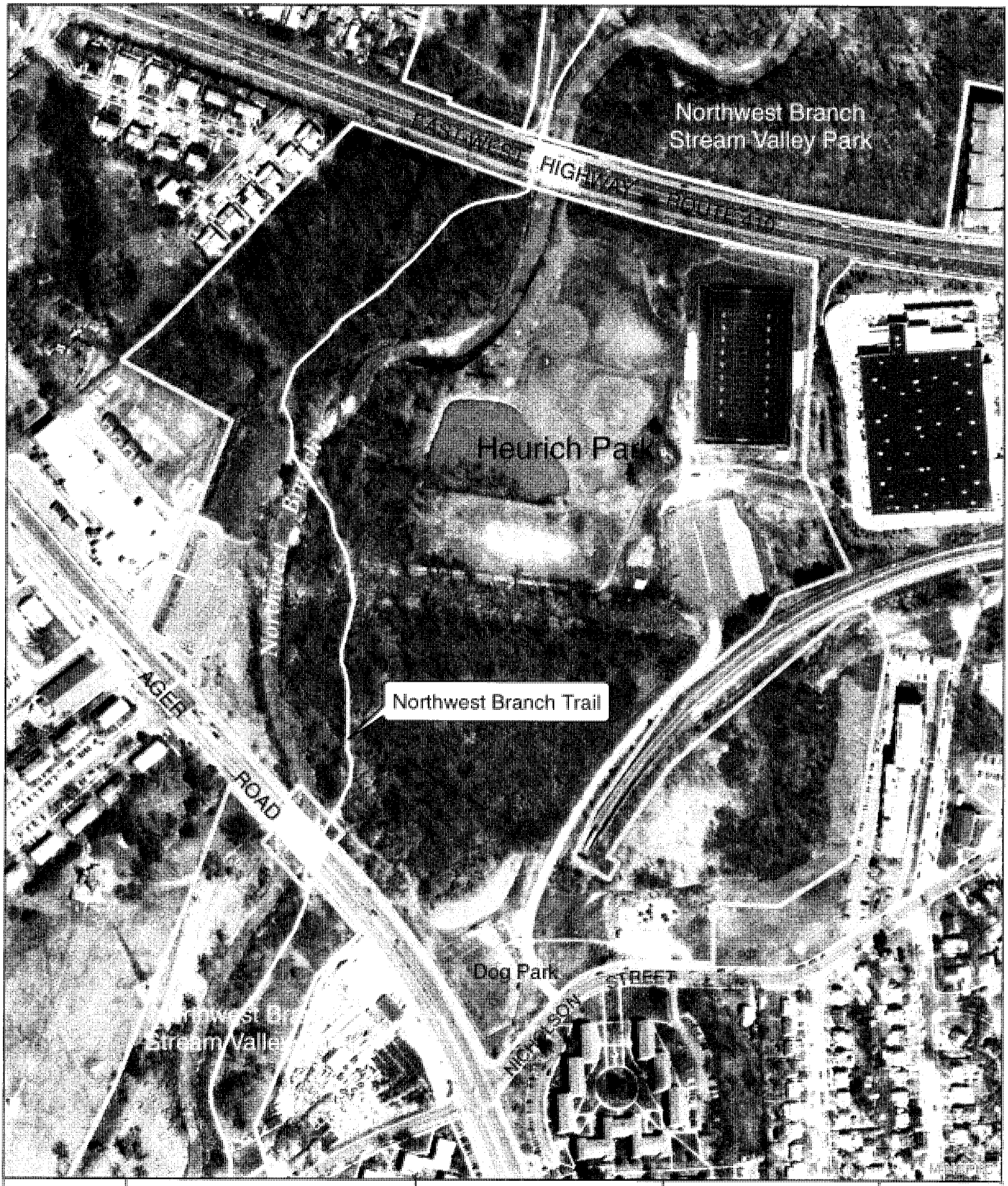
DATE: 06/19/2015

SCALE: 400 Feet

N



GIS

N69 - Heurich Park

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DATE: 06/19/2015

SCALE: 300 Feet

N

GIS

N68 - Green Meadows Park Building

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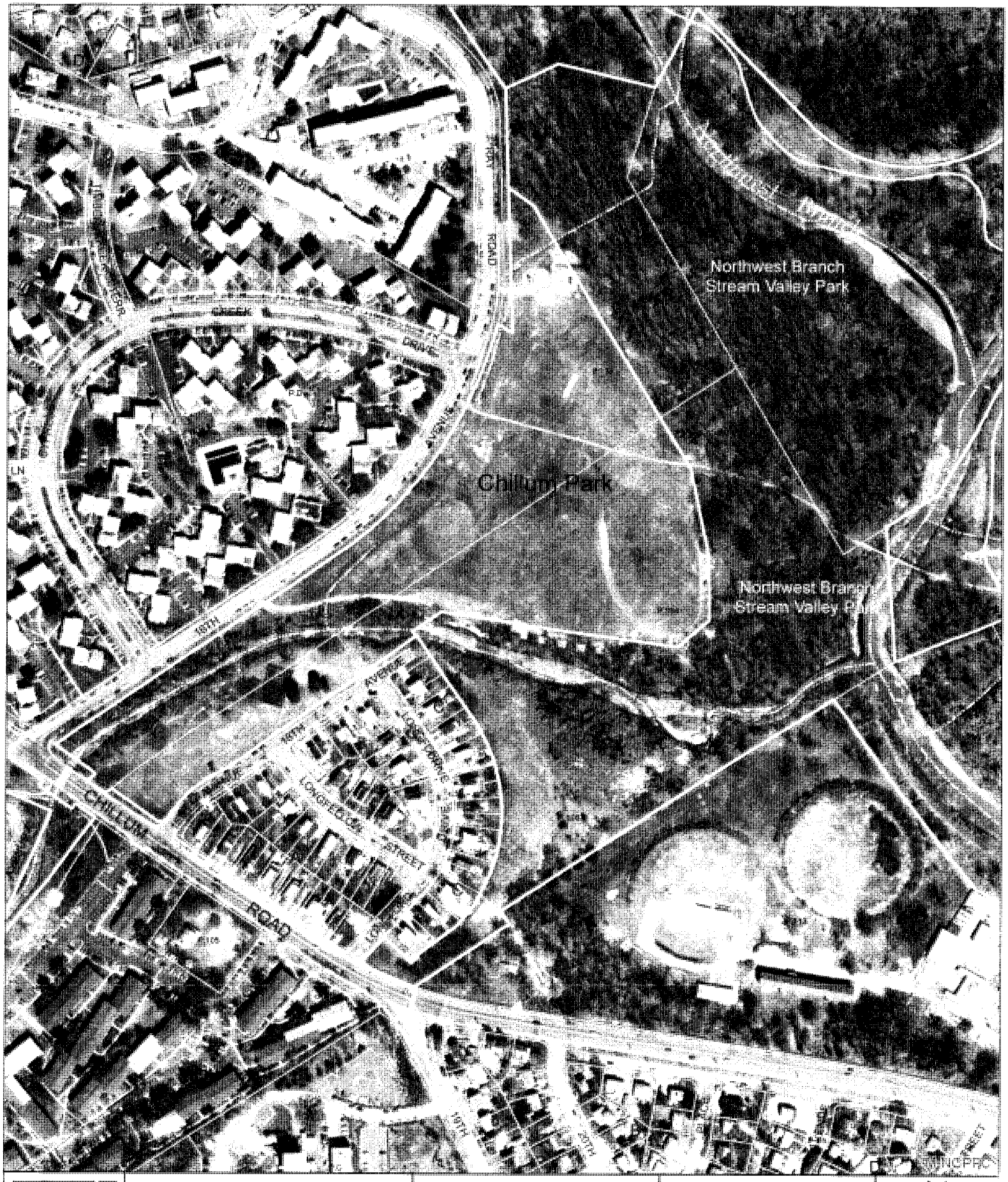
DATE: 06/19/2015

SCALE: 300 Feet

N



GIS

N65 - Chillum Park

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DATE: 06/19/2015

SCALE: 300 Feet

N

From:	Brian Hug -MDE-
To:	Seiple, Jacqueline A NAB
Subject:	[EXTERNAL] Fwd: Emissions factors - General Conformity (UNCLASSIFIED)
Date:	Friday, March 20, 2015 12:28:46 PM
Attachments:	420r10018.pdf

---------- Forwarded message ----------
From: Walter Simms -MDE- <walter.simms@maryland.gov>
Date: Fri, Mar 20, 2015 at 12:12 PM
Subject: Re: Emissions factors - General Conformity (UNCLASSIFIED)
To: Brian Hug -MDE- <brian.hug@maryland.gov>

Hi Roger:

I checked the formulas and methodologies being used by Ms. Seiple and they appear to be acceptable, I would however inform her that she should make sure she uses the most up to date guidance. There is a NR-009d and most of the table and values match the NR-009b , but I have not checked all. I'm sure that there are changes in the guidance somewhere. I have attached the NR-009d document.

Walter

On Fri, Mar 20, 2015 at 7:53 AM, Brian Hug -MDE- <brian.hug@maryland.gov> wrote:

Walter...please review this for the corp of engineers and email me your comments today. Thanks.

---------- Forwarded message ----------
From: Seiple, Jacqueline A NAB <Jacqueline.A.Seiple@usace.army.mil>
Date: Friday, March 20, 2015
Subject: Emissions factors - General Conformity (UNCLASSIFIED)
To: Brian Hug -MDE- <brian.hug@maryland.gov>

Classification: UNCLASSIFIED
Caveats: NONE

Brian,

Thanks for meeting with me on Monday regarding General Conformity analyses for the stream restoration projects we are planning in Montgomery County. I do have a few more questions, mainly regarding where to find emissions factors for construction equipment. I just want to verify that my thoughts below are correct, before moving on.

For NOx, VOC (HC), and PM2.5, I will use emissions factors from Tables 4, 2, and 5, respectively, from EPA NR-009B (see attached).

For SO2, I could not find a similar table, so was going to use Equation 7 on pg. 19 of EPA NR-009B. For the variables, I would use:

>BSFC from Appendix C Table C1
>HC from Table 2
>soxcnv = 0.02247 for diesel (from p. 17)
>soxdsl = 500 ppm = 0.05 weight percent (max S content of fuel for nonroad vehicles June 2007)

Can you tell me if I am on the right track with regards to vehicle emissions??

I also have a chainsaw on the list of equipment - I was looking at using information in EPA NR010f (attached), p. 4-6 and Table 3 for Class V (spark Ignitions, handheld, <25 hp, 2 stroke, >50cc). I was not entirely clear on Phase I and Phase II difference, but seems like the date of manufacture. Assuming the chainsaw likely in use would be manufactured in the last 10 years, could I use Phase II?

Can I then use Equation 7 above using HC and BSCF from Table 3 (EPA NR010f), and same soxcnv and soxdsl as above??

Thanks, your help is much appreciated!

Jacqui

Jacqueline Seiple
Geographer, P.G.
Planning Division
U.S. Army Corps of Engineers, Baltimore
(410) 962-4398 <tel:%28410%29%20962-4398>

Classification: UNCLASSIFIED
Caveats: NONE

--

Brian J. Hug
Deputy Program Manager
Air Quality Planning Program
Maryland Department of the Environment
1800 Washington Boulevard
Baltimore, Maryland 21230
410 537 4125 <tel:410%20537%204125>

--

Brian J. Hug
Deputy Program Manager
Air Quality Planning Program
Maryland Department of the Environment
1800 Washington Boulevard
Baltimore, Maryland 21230
410 537 4125

From: Brian Hug -MDE-
To: Seiple, Jacqueline A NAB
Subject: [EXTERNAL] Re: Emissions factors - General Conformity (UNCLASSIFIED)
Date: Friday, May 15, 2015 9:40:44 AM

Seems ok

On Friday, May 15, 2015, Seiple, Jacqueline A NAB <Jacqueline.A.Seiple@usace.army.mil> wrote:

Classification: UNCLASSIFIED
Caveats: NONE

Hi Brian,

It has been a while, but if you recall, I am trying to complete a general air quality conformity analysis for our stream restoration projects in Montgomery County. I calculated the chemical emissions and we are below the de minimus. I now am looking at particulate (PM2.5) emissions. I've been trying to figure out how to perform this analysis.

It seems that there is an option to use a default value (Section 3. Construction in http://www.epa.gov/airquality/genconform/training/files/General_Conformity_Training_Manual.pdf) for the emissions factor (E=1.2 tons/acre/month). To calculate dust emissions at the site, can I just use this value multiplied by the site area and time?

I saw that it is necessary to also calculate offsite emissions. For these projects, there will be some delivery of materials (sand, gravel, rock) and some removal of materials. However, it is hoped that any materials excavated from the stream bed will be reused on site, including woody debris, and vegetation would be mulched. So, I think it would mainly be delivery of material on paved roads, using the paved roads equation AP-42 Section 13.2.1.3 equation 1. Roads within the site limits would be unpaved, but I think this would be included in the calculation using the default value and site acres.

Can you let me know if this is correct? Any help would be appreciated.
Thanks!

Jacqui

Jacqueline Seiple
Geographer, P.G.
Planning Division
U.S. Army Corps of Engineers, Baltimore
(410) 962-4398

-----Original Message-----
From: Brian Hug -MDE- [mailto:brian.hug@maryland.gov <javascript:;>]
Sent: Friday, March 20, 2015 12:20 PM
To: Seiple, Jacqueline A NAB
Subject: [EXTERNAL] Fwd: Emissions factors - General Conformity (UNCLASSIFIED)

---------- Forwarded message ----------
From: Walter Simms -MDE- <walter.simms@maryland.gov <javascript:;> >
Date: Fri, Mar 20, 2015 at 12:12 PM
Subject: Re: Emissions factors - General Conformity (UNCLASSIFIED)
To: Brian Hug -MDE- <brian.hug@maryland.gov <javascript:;> >

Hi Roger:

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Date: Friday, March 20, 2015
Subject: Emissions factors - General Conformity (UNCLASSIFIED)
To: Brian Hug -MDE- <brian.hug@maryland.gov <javascript:;> >

Classification: UNCLASSIFIED
Caveats: NONE

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Can I then use Equation 7 above using HC and BSCF from Table 3 (EPA NR010f), and same soxcnv and soxdsl as above??

From: Brian Hug -MDE-
To: Bachur, Beth NAB
Cc: Seiple, Jacqueline A NAB; Roger Thunell -MDE-
Subject: [EXTERNAL] Re: Unpaved road equation for PM2.5 emissions (UNCLASSIFIED)
Date: Tuesday, October 27, 2015 10:43:19 AM

Beth,

Responses below - keep in mind MDE is not an approving entity for general conformity assessments - we can try to guide and answer questions but always refer to the feds for the final say. We only have a few on staff engineers so we can try to help but cant guarantee fast responses.

Brian

1. In reviewing EPA AP-42, Section13.2.2 Unpaved roads, would the PM2.5 fugitive dust emissions apply for construction access roads that have wood much chips laid over silt fabric? If wood mulching is required on construction access roads within the wooded areas along streams, then do we still need to calculate the unpaved road emissions PM2.5 factor?

Response:

Unpaved road dust emissions vary directly with the amount of silt in the roads surface material. Other variables such as weight of the vehicle and moisture content factor into emissions as well. From your description it appears that any emissions from the original road surface material would be contained by the silt fabric with the wood mulch overlay.

In this case, the main factor for any unpaved road dust emissions come from the wood mulch chips. EPA AP-42, Section 13.2.2 Unpaved roads, does not specify a silt factor for wood mulch. Table 13.2.2-1 cites a silt content range of 4.8-12 with a mean of 8.4 for lumber sawmills with a log yard surface material.

Another factor in unpaved road dust emissions is precipitation. The emission factor is adjusted based on the number of days in a year with at least 0.01 inches of precipitation using the following equation:

Eext = E [365-P)/365]

Eext = annual size-specific emission factor extrapolated for natural mitigation, lb/VMT

E = emission factor

P = number of days in a year with at least 0.254 mm (0.01 in) of precipitation

If the wood mulch chips are kept wet, then the emission factor goes to zero and no fugitive unpaved road dust emissions are generated.

A third factor in calculating unpaved road dust emissions is vehicle miles travelled. The units of the size specific emission factors are in pounds per vehicle mile travelled. Without knowing the specifics of the project, one would assume that the VMT would be quite low, making the overall tonnage (poundage) quite low.

2. We did not do field investigations for the measured silt content at the sites. It appears that Section 13.2.2-6 of EPA AP-42 will allow for the use of these default mean values when on-site investigations have not been obtained. We would like to use the default mean values from Table 13.2.2-1 and wanted to be sure that this was a reasonable approach for these stream restoration projects?

Response:

This is an acceptable calculation and Table 13.2.2-1 default values are permitted.

3. We had separated out the construction emissions into component operations. One component is for the excavation of stream bed materials. Do you have any suggestions for which component operations from Table 13.2.3-1 would be the best to use?

Response:

The type of equipment used in the excavation would determine what dust-generating activity is appropriate. Activities listed in Table 13.2.3-1 include bulldozers, scrapers, loaders and trucks. The fugitive dust emissions from these activities are for general construction activities and do not include dust control programs like watering. If the excavation of the stream bed materials is conducted wet, control factors can be applied.

On Tue, Oct 20, 2015 at 3:44 PM, Bachur, Beth NAB <BETH.BACHUR@usace.army.mil <mailto:BETH.BACHUR@usace.army.mil> > wrote:

CLASSIFICATION: UNCLASSIFIED

Hello Brian,

My name is Beth Bachur and I work for the Corps of Engineers, Baltimore District Planning Division. We are working on the calculations for the PM2.5 emissions from unpaved roads for the Montgomery County Anacostia stream restoration projects and I have a couple of questions that I would like to get your feedback on to provide some direction on how to proceed with our air conformity for the PM2.5 fugitive dust emissions:

1. In reviewing EPA AP-42, Section13.2.2 Unpaved roads, would the PM2.5 fugitive dust emissions apply for

construction access roads that have wood much chips laid over silt fabric? If wood mulching is required on construction access roads within the wooded areas along streams, then do we still need to calculate the unpaved road emissions PM2.5 factor?

2. We did not do field investigations for the measured silt content at the sites. It appears that Section 13.2.2-6 of EPA AP-42 will allow for the use of these default mean values when on-site investigations have not been obtained. We would like to use the default mean values from Table 13.2.2-1 and wanted to be sure that this was a reasonable approach for these stream restoration projects?

3. We had separated out the construction emissions into component operations. One component is for the excavation of stream bed materials. Do you have any suggestions for which component operations from Table 13.2.3-1 would be the best to use?

Thanks again for your time and support.

Beth Bachur
USACE-Baltimore
Regulatory Branch
P.O. Box 1715
Baltimore, MD 21203
(o) 410-962-4336

CLASSIFICATION: UNCLASSIFIED

--

Brian J. Hug
Acting Program Manager
Air Quality Planning Program
Maryland Department of the Environment
1800 Washington Boulevard
Baltimore, Maryland 21230
410 537 4125

From: Lori Byrne -DNR-
To: Sowers, Angela NAB
Subject: [EXTERNAL] Re: Anacostia River Watershed Restoration Project, Prince George"s County - RTE coordination
Date: Monday, January 04, 2016 4:09:33 PM

Dear Ms. Sowers,

Could you provide us with the latest plans for the Indian Creek site, so that we can evaluate the details and make a determination regarding our level of concern? That seems like the best way to proceed. Thanks.

Lori Byrne

On Mon, Jan 4, 2016 at 3:15 PM, Sowers, Angela NAB <Angela.Sowers@usace.army.mil <mailto:Angela.Sowers@usace.army.mil> > wrote:

Hi Lori,

Prior coordination for our Anacostia River Watershed Restoration Project in Prince George's County identified that we should reach back to you if the Indian Creek site in the Greenbelt area is included in the recommended plan. Please see the attached letter. We are projecting that it will be included. Can you please let me know what the next steps are that we should take to coordinate this project with the Wildlife and Heritage Service?

Thank you,
Angie Sowers

--

Lori A. Byrne
Environmental Review Coordinator

MD DNR
Wildlife and Heritage Service
Tawes State Office Building
410-260-8573

From: Katharine McCarthy -DNR-
To: Sowers, Angela NAB
Cc: Lori Byrne -DNR-; Greg Golden -DNR-; Tim Larney -DNR-
Subject: [EXTERNAL] Re: Additional information on Site 11 for Anacostia- PG County
Date: Thursday, January 14, 2016 1:47:05 PM

Angela,
Lori Byrne forwarded to me your info on the Indian Creek project. It appears from the mapping you provided that quite a bit of the proposed work north of Rte 193 has potential direct impacts on a population of Trailing stitchwort, a State Endangered plant in the Pink family that grows on the gravel bars and banks of the small, braided streams in this forest.
The wetlands creation due east of Stream Bank Lane would not impact this species, nor would the pond creation proposed at the northern jct of Stream Bank Lane and Greenbelt Station Parkway.
However, the work proposed north of these projects would have the potential to directly destroy plants of Trailing stitchwort, perhaps the entire population known at this site. I'd like to get a better understanding of the proposed work and how it would affect existing stream hydrology and flooding in the forest of this area.
How would the hydrology of the small, braided stream channels that support this rare annual be affected by the proposed work?
Some of the large polygons representing wetland creation occur where, based upon our GPS records of the rare plant locations, there are braided stream channels. Would these channels be inundated for extended periods by the wetland creation?
How would the instream structures in the main channel affect the hydrology of the small, braided channels?
The forest in this area to the north of Stream Bank Lane and east of the Greenbelt Metro parking area has a number of invasive plants in the herbaceous layer, but the shrub and tree canopy are of native species.The forest provides habitat for several reptile and amphibian species we noted while we conducted a site survey in 2009: snapping turtle, green frog, southern leopard frog, northern watersnake. It also offers habitat for forest interior breeding birds. How would the proposed work affect the forest of this area?
Attached is a photo of the Trailing stitchwort from this site.
Thank you for continuing to coordinate with us on this review.
Kathy McCarthy

On Thu, Jan 7, 2016 at 5:26 PM, Lori Byrne -DNR- <lori.byrne@maryland.gov <mailto:lori.byrne@maryland.gov> > wrote:

Hi Kathy, passing this on to you...

Lori

---------- Forwarded message ----------
From: Sowers, Angela NAB <Angela.Sowers@usace.army.mil <mailto:Angela.Sowers@usace.army.mil> >
Date: Thu, Jan 7, 2016 at 4:06 PM
Subject: Additional information on Site 11 for Anacostia- PG County
To: "lori.byrne@maryland.gov <mailto:lori.byrne@maryland.gov> " <lori.byrne@maryland.gov <mailto:lori.byrne@maryland.gov> >

Hi Lori,
Please see the attached write-up. I should have sent this originally with the figures. This provides some discussion of the plans for Site 11 in Indian Creek.

Thanks,
Angie

Sowers, Angela NAB

From: Katharine McCarthy -DNR- <katharine.mccarthy@maryland.gov>
Sent: Tuesday, February 02, 2016 1:23 PM
To: Sowers, Angela NAB
Cc: Lori Byrne -DNR-; Greg Golden -DNR-; Tim Larney -DNR-
Subject: Re: [EXTERNAL] Re: Additional information on Site 11 for Anacostia- PG County

Thank you, Angie, for arranging for the conference call today. A summary of our discussion follows.

Stream restoration and wetland creation work are two potentially independent options at the Indian Creek site. The purpose of the stream restoration work is to improve instream habitat. The wetland creation work would involve excavation in the floodplain to improve the connection with the stream channel, though the intent is not to remove trees.
The trailing stitchwort (state endangered) grows in shallow, braided streams within several of the areas identified for wetland creation work, and that work would likely alter the hydrology of the trailing stitchwort's habitat. Due to this potential for habitat alteration, we should not pursue this option further.
The proposed pond and wetland creation at the south end of the project site adjacent to Stream Bank Lane would NOT disturb habitat of the trailing stitchwort, and this work may be pursued further.
Regarding instream work, the next step is to discuss with the project engineer the potential hydrologic impacts from that work on the shallow braided stream system that supports trailing stitchwort.
Further survey work to delineate the population of trailing stitchwort on site is not necessary to proceed with this review, but I am available to meet on site at the end of June or first week of July to confirm locations if needed.
Let me know if you'd like to add any other points to the summary.
Kathy

On Thu, Jan 14, 2016 at 2:14 PM, Katharine McCarthy -DNR- <katharine.mccarthy@maryland.gov <mailto:katharine.mccarthy@maryland.gov> > wrote:

Angie,
I also meant to mention that we have been reviewing proposals for major projects at the Greenbelt Metro Station...FBI headquarters, plus hotel and shops. Greg Golden of DNR's Environmental Review Unit has been coordinating that review for us. If that work moves forward, it appears that there will be better stormwater management for the area. Just wanted to bring this up in case you were not aware.
Kathy

On Thu, Jan 14, 2016 at 1:59 PM, Sowers, Angela NAB <Angela.Sowers@usace.army.mil <mailto:Angela.Sowers@usace.army.mil> > wrote:

Thank you for the input Katharine. We will discuss within the team and get back to you to set up a time to discuss.
Angie

-----Original Message-----
From: Katharine McCarthy -DNR- [mailto:katharine.mccarthy@maryland.gov <mailto:katharine.mccarthy@maryland.gov>]
Sent: Thursday, January 14, 2016 1:44 PM
To: Sowers, Angela NAB <Angela.Sowers@usace.army.mil <mailto:Angela.Sowers@usace.army.mil> >

Cc: Lori Byrne -DNR- <lori.byrne@maryland.gov <mailto:lori.byrne@maryland.gov> >; Greg Golden -DNR- <greg.golden@maryland.gov <mailto:greg.golden@maryland.gov> >; Tim Larney -DNR- <tim.larney@maryland.gov <mailto:tim.larney@maryland.gov> >

Subject: [EXTERNAL] Re: Additional information on Site 11 for Anacostia- PG County

Angela,

Lori Byrne forwarded to me your info on the Indian Creek project. It appears from the mapping you provided that quite a bit of the proposed work north of Rte 193 has potential direct impacts on a population of Trailing stitchwort, a State Endangered plant in the Pink family that grows on the gravel bars and banks of the small, braided streams in this forest.

The wetlands creation due east of Stream Bank Lane would not impact this species, nor would the pond creation proposed at the northern jct of Stream Bank Lane and Greenbelt Station Parkway.

However, the work proposed north of these projects would have the potential to directly destroy plants of Trailing stitchwort, perhaps the entire population known at this site. I'd like to get a better understanding of the proposed work and how it would affect existing stream hydrology and flooding in the forest of this area.

How would the hydrology of the small, braided stream channels that support this rare annual be affected by the proposed work?

Some of the large polygons representing wetland creation occur where, based upon our GPS records of the rare plant locations, there are braided stream channels. Would these channels be inundated for extended periods by the wetland creation?

How would the instream structures in the main channel affect the hydrology of the small, braided channels?

The forest in this area to the north of Stream Bank Lane and east of the Greenbelt Metro parking area has a number of invasive plants in the herbaceous layer, but the shrub and tree canopy are of native species.The forest provides habitat for several reptile and amphibian species we noted while we conducted a site survey in 2009: snapping turtle, green frog, southern leopard frog, northern watersnake. It also offers habitat for forest interior breeding birds. How would the proposed work affect the forest of this area?

Attached is a photo of the Trailing stitchwort from this site.

Thank you for continuing to coordinate with us on this review.

Kathy McCarthy

On Thu, Jan 7, 2016 at 5:26 PM, Lori Byrne -DNR- <lori.byrne@maryland.gov <mailto:lori.byrne@maryland.gov> <mailto:lori.byrne@maryland.gov <mailto:lori.byrne@maryland.gov> > > wrote:

Hi Kathy, passing this on to you...

Lori

---------- Forwarded message ----------

From: Sowers, Angela NAB <Angela.Sowers@usace.army.mil <mailto:Angela.Sowers@usace.army.mil> <mailto:Angela.Sowers@usace.army.mil <mailto:Angela.Sowers@usace.army.mil> > >

Date: Thu, Jan 7, 2016 at 4:06 PM

Subject: Additional information on Site 11 for Anacostia- PG County

To: "lori.byrne@maryland.gov <mailto:lori.byrne@maryland.gov> <mailto:lori.byrne@maryland.gov <mailto:lori.byrne@maryland.gov> > " <lori.byrne@maryland.gov <mailto:lori.byrne@maryland.gov> <mailto:lori.byrne@maryland.gov <mailto:lori.byrne@maryland.gov> > >

Hi Lori,

Please see the attached write-up. I should have sent this originally with the figures. This provides some discussion of the plans for Site 11 in Indian Creek.

Thanks,
Angie

Angie Sowers, Ph.D.
U.S. Army Corps of Engineers
Baltimore District- Planning Division
Civil Project Development Branch
Integrated Water Resources Management Specialist
10 S. Howard St.
Rm 11700-E
Baltimore, MD 21201
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(410)962-7440 <tel:%28410%29962-7440> <tel:%28410%29962-7440>

--

Lori A. Byrne
Environmental Review Coordinator

MD DNR
Wildlife and Heritage Service
Tawes State Office Building
410-260-8573 <tel:410-260-8573> <tel:410-260-8573 <tel:410-260-8573> >

--

Katharine A. McCarthy
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phone: 410/260-8569 <tel:410%2F260-8569>
fax: 410/260-8596 <tel:410%2F260-8596>
Katharine.McCarthy@maryland.gov <mailto:Katharine.McCarthy@maryland.gov> <mailto:Katharine.McCarthy@maryland.gov <mailto:Katharine.McCarthy@maryland.gov> >

Sowers, Angela NAB

From: Katharine McCarthy -DNR- <katharine.mccarthy@maryland.gov>
Sent: Friday, February 12, 2016 1:37 PM
To: Sowers, Angela NAB
Cc: Seiple, Jacqueline A NAB
Subject: Re: [EXTERNAL] Re: Anacostia - Indian Creek - Site 11

Jacqui and Angie,
Apologies for being late on the call! I got sucked into something this morning and got totally distracted from my planned schedule.
I've checked all of our data for this species. Last week of June-first week of July looks like the best time to do a survey for Stellaria alsine. In addition to checking our database, I've looked online for info on habitat from other state programs. There's just very little to go on, and the habitat at this site seems typical of where it's found...on exposed gravel bars in small streams, sometimes on the stream bank if it's not densely vegetated. It's also reported to grow in springs and seeps. We noted that the stream it was growing in at Indian Creek was 2-4 ft wide, and the gravel had very little vegetation on it...80% bare. We found 7 separate locations, 215-315m west of Cherrywood Lane, at it's closest point about 115 m from the sewer alignment.
Let's be in touch in mid-May to come up with a survey time. By then I should have a sense of whether plants are blooming at typical times (whether it's an early spring, late spring or normal timing).
Kathy

On Tue, Feb 9, 2016 at 11:09 AM, Katharine McCarthy -DNR- <katharine.mccarthy@maryland.gov <mailto:katharine.mccarthy@maryland.gov> > wrote:

Ok. Look forward to talking with Jacqui and others on Friday morning. -Kathy

On Mon, Feb 8, 2016 at 9:11 PM, Sowers, Angela NAB <Angela.Sowers@usace.army.mil <mailto:Angela.Sowers@usace.army.mil> > wrote:

Great. Below is the call-in information. Jacqui will be leading the call.

Thanks!

AUDIO CONFERENCE ACCESS INFORMATION:
USA Toll-Free: 877-336-1828 <tel:877-336-1828>
USA Caller Paid/International Toll: 404-443-6396 <tel:404-443-6396>
ACCESS CODE: 4495502
Security Code: 4321

-----Original Message-----
From: Katharine McCarthy -DNR- [mailto:katharine.mccarthy@maryland.gov <mailto:katharine.mccarthy@maryland.gov>]
Sent: Monday, February 08, 2016 5:33 PM
To: Sowers, Angela NAB <Angela.Sowers@usace.army.mil <mailto:Angela.Sowers@usace.army.mil> >
Subject: Re: [EXTERNAL] Re: Anacostia - Indian Creek - Site 11

Yes, Friday 11am works for me.-Kathy

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 1715
BALTIMORE, MARYLAND 21203-1715

CENAB-PL-P

Ms. Elizabeth Hughes
State Historic Preservation Officer
Maryland Historical Trust
100 Community Place
Crownsville, Maryland 21032-2023

APR 25 2016

Dear Ms. Hughes:

The purpose of this letter is to initiate consultation with your office under Section 106 of the National Historic Preservation Act regarding the Anacostia Watershed Restoration, Prince George's County, Maryland feasibility study and environmental assessment. The study is developing and evaluating potential ecosystem restoration solutions to address degraded aquatic ecosystems in the Anacostia River watershed. The study's goal is to provide a solution to restore ecological function, structure, and health in selected stream reaches and riparian zones in the Anacostia River watershed in Prince George's County. The study is being conducted under the authority of a September 8, 1988 resolution of the House Committee on Public Works and Transportation and is being performed by the U.S. Army Corps of Engineers, Baltimore District (USACE).

The feasibility study and environmental assessment will evaluate aquatic ecosystem restoration to restore in-stream habitat and fish passage. The proposed project area includes ten stream reaches within six sub-watersheds of the Anacostia River watershed, including the Northwest Branch, Sligo Creek, the Northeast Branch, Indian Creek, Paint Branch, and Little Paint Branch (Enclosure 1). The stream reaches are primarily on land owned by Maryland-National Capital Parks and Planning Commission.

The area of potential effect for the project is the area of direct construction impacts and the areas within which the undertaking may directly or indirectly cause alterations in the character or use of historic properties, including visual effects. This area of potential effect would likely include work performed in and around the streams, staging areas, newly constructed access roads, and any other areas of potential ground disturbance. The viewsheds of any nearby historic properties would also be included in the area of potential effect.

USACE completed a preliminary examination of areas of potential project impact in 2014 and 2015. Maryland state databases were searched for known archeological and historic resources in the project vicinity. Based on these searches, as well as field visits and information received from the Maryland Historical Trust, some historic properties are likely located in and around the project areas.

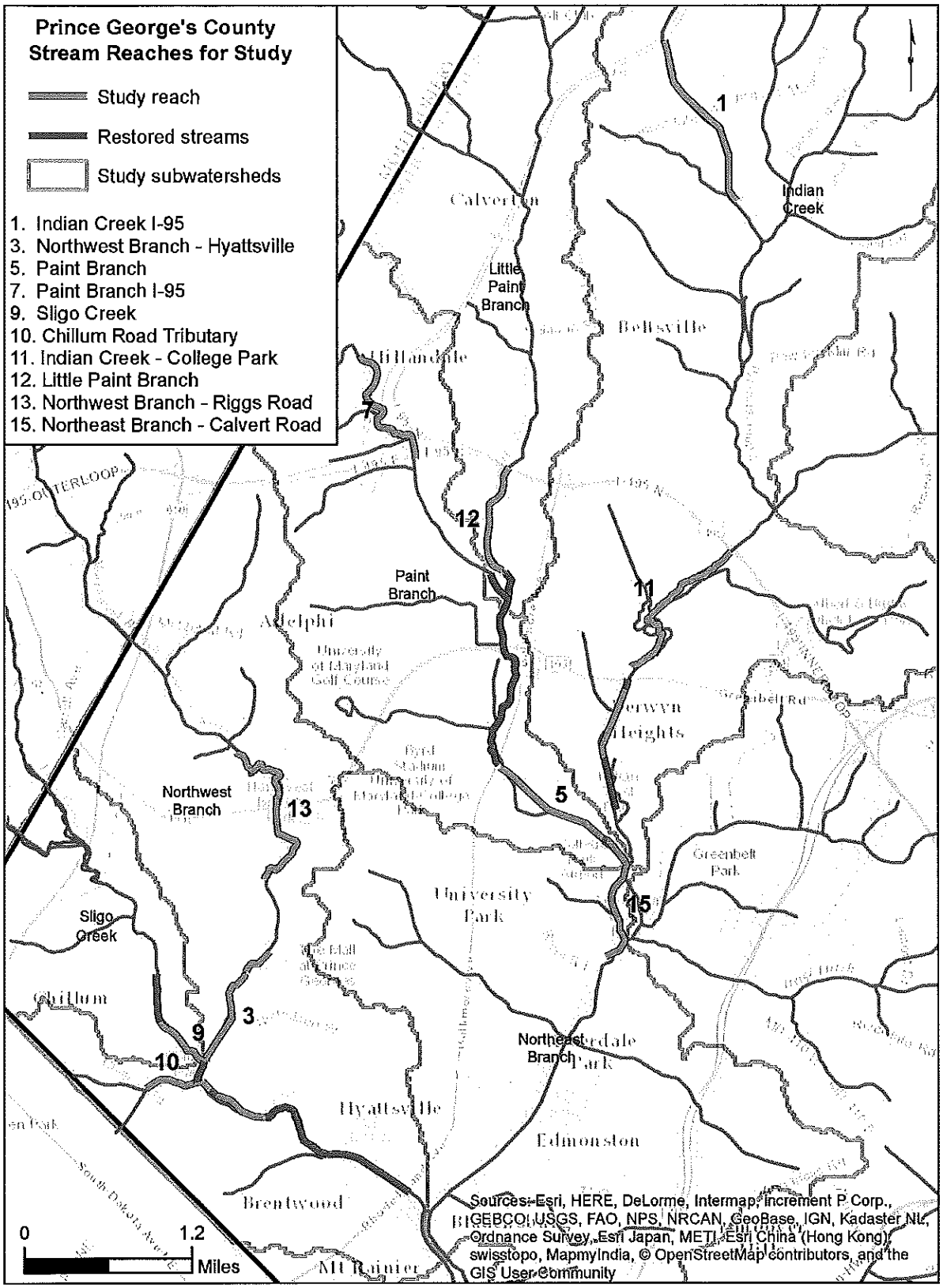
We look forward to consulting with your office regarding the nature and scope of additional investigations to identify historic properties in the project areas, and to assess potential effects to those properties should they exist. In the interim, we would appreciate your concurrence with the project's area of potential effect as defined in the third paragraph of this letter.

Thank you for your assistance with the Anacostia River Watershed Restoration, Prince George's County, Project. Questions regarding this matter should be directed to Jacqueline Seiple at (410) 962-4398 or email at Jacqueline.A.Seiple@usace.army.mil.

Sincerely,

Daniel Bierly
Chief, Civil Projects Development Branch
Planning Division

Enclosure



Enclosure: Project area and study stream reaches (orange) in Prince George's County, Maryland.

From: Sowers, Angela NAB
To: "pgscd@verizon.net"
Subject: USACE Feasibility Study - Anacostia River Watershed Restoration in Prince George"s County
Date: Tuesday, May 17, 2016 4:50:00 PM
Attachments: NW-C+NE-A_for_PI.pdf
Anacostia_PG_Farmland_Classification.pdf

Hello Mr. Darcey,

I work in the Planning Division of the U.S. Army Corps of Engineers, Baltimore District (USACE). USACE, in partnership with the Prince George's County Department of the Environment, serving as the non-federal sponsor, is undertaking an investigation of watershed restoration opportunities in the Anacostia River Watershed, specifically stream restoration and removal of fish blockages. This email is in reference to evaluating the presence of prime and unique farmlands (CEQ Memorandum, 11 August 1980) within the study area.

In February 2010, USACE, in cooperation with local resource agencies, completed the Anacostia Restoration Plan (ARP) which identified numerous environmental restoration opportunities in the Anacostia watershed. The current Anacostia River watershed restoration study includes more detailed consideration of some of the restoration projects previously identified in the ARP that USACE can implement in Prince George's County. The investigation has also considered additional stream and wetland restoration projects that were not included in the ARP.

Ten stream segments totaling approximately 10 miles in length, were initially selected for investigation. The primary project objectives for the selected stream segments are to: (1) restore in-stream habitat; (2) remove fish barriers; and (3) increase stream-floodplain connection. To achieve these objectives, stream restoration methods involving placement of in-stream structures, fish blockages removal/modification, excavating floodplain sediments, placing fill and soil in the floodplain, or planting native vegetation in the floodplain are being investigated. The recommended plan includes restoration efforts at six sites and has been formulated to optimize environmental benefits, avoid increasing flood risk, and minimize detrimental impacts to structures, properties, and human use of the streams and floodplain. The six sites, summing to 6.9 miles of restoration on the Northwest Branch and Northeast Branch and tributaries is provided in a map attached to this email. I have reviewed the soils survey for the stream reaches where we are proposing work and concluded that the recommended plan does not impact prime and unique farmland soils.

In addition to the map of our proposed project, I have attached the soil survey maps for the study area. We are requesting your concurrence that the proposed project is in compliance with the Prime and Unique Farmlands Executive Order and would provide no further impacts to the prime and unique soils located at the site. If you have any questions, please feel free to contact me at (443) 676-4679 or via email. If possible, please confirm receipt of this email.

Thank you,
Angie

Angie Sowers, Ph.D.
U.S. Army Corps of Engineers
Baltimore District- Planning Division
Civil Project Development Branch
Integrated Water Resources Management Specialist
10 S. Howard St.
Rm 11700-E
Baltimore, MD 21201
angela.sowers@usace.army.mil
(410)962-7440

Appendix D. Public Involvement

This Appendix contains the June 2015 Study Notice and mailing list. Following the public comment period for the draft Feasibility Report and Integrated Environmental Assessment, this section will be updated with public comments and responses.

US Army Corps of Engineers
Baltimore District

Public Notice

Anacostia River Watershed Restoration Project
Prince George's County, Maryland

All Interested Parties: In compliance with the National Environmental Policy Act (NEPA), the U.S. Army Corps of Engineers, Baltimore District (USACE), is preparing an environmental assessment (EA) for multiple stream and wetland restoration projects being proposed in the Anacostia River watershed, Prince George's County, Maryland. The study is being conducted in partnership with the Prince George's County Department of the Environment to determine if there are restoration projects to be implemented by the Corps. If implemented, the projects would directly support USACE's commitment to the Chesapeake Bay goals included in Executive Order 13508, *Chesapeake Bay Protection and Restoration.*

In February 2010, USACE, in cooperation with local resource agencies, completed the Anacostia Restoration Plan (ARP) which identified numerous environmental restoration opportunities in the Anacostia watershed. The current Anacostia River watershed restoration study includes more detailed consideration of some of the restoration projects previously identified in the ARP that USACE can implement in Prince George's County. The EA under preparation also contains additional stream and wetland restoration projects that were not included in the ARP.

Ten stream segments totaling approximately 10 miles in length, have been selected for investigation (see attached map). The primary project objectives for the selected stream segments are to: (1) restore in-stream habitat; (2) remove fish barriers; and (3) restore floodplain wetlands and increase stream-floodplain connection. To achieve these objectives, stream and wetland restoration methods involving placement of in-stream structures, fish blockages removal/modification, excavating floodplain sediments, placing fill and soil in the floodplain, or planting native vegetation in the floodplain are being investigated. Projects would be formulated to optimize environmental benefits, avoid increasing flood risk, and minimize detrimental impacts to structures, properties, and human use of the streams and floodplain.

Alternatives that achieve project objectives are being planned and benefits and costs will be evaluated. This planning information will be presented in a draft EA integrated within a USACE feasibility report anticipated to be released for public review in late 2015. A notice of availability will be released to inform the public that the EA describing proposed actions is available for review and comment.

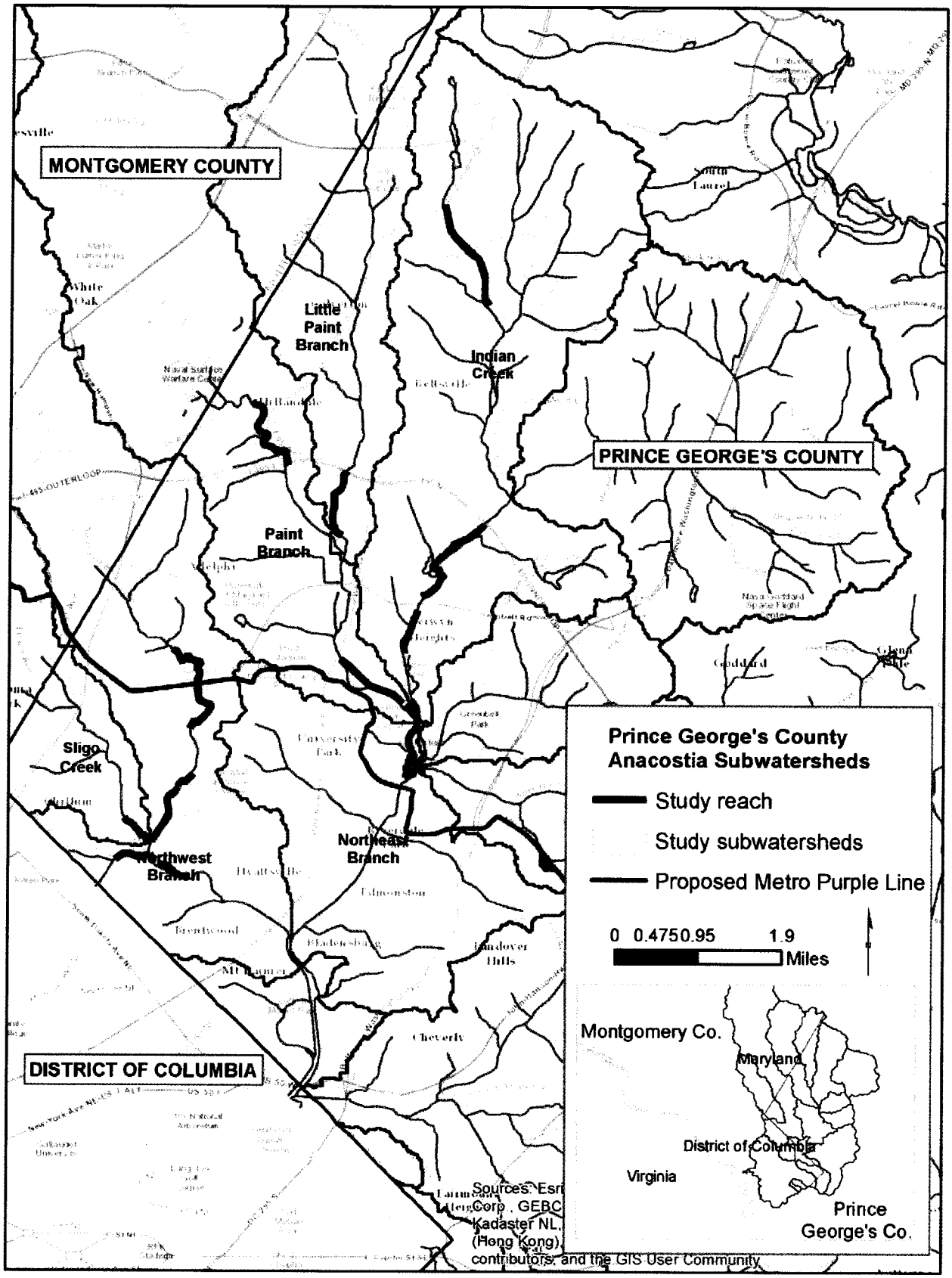
To assist in the development of the EA, we are requesting that you provide information concerning your interests or your organization's area of responsibility or expertise within 30 days from the date of this notice to the address below. A timely review of this information and a written response will be greatly appreciated. Substantive public comments received via the NEPA process will be fully considered by USACE.

If you have any questions, please contact Christopher Spaur by email at christopher.c.spaur@usace.army.mil, by telephone at (410) 962-6134, or by mail at U.S. Army

Corps of Engineers, Baltimore District, ATTN: CENAB-PL-P (Spaur), P.O. Box 1715, Baltimore, Maryland 21203-1715.

Daniel M. Bierly
Chief, Civil Project Development Branch

Enclosure: Site Map



Attachment - Map of the stream reaches in Prince George's County

rom: Chesapeake Bay Program [baybrief=chesapeakebay.net@mail6.atl31.mcdlv.net] on behalf of Chesapeake Bay Program [baybrief@chesapeakebay.net] Sent: Thu 6/11/2015 2:05 PM
o: Gross, Sarah D NAB
c:
ubject: [EXTERNAL] Bay Brief June 5-11, 2015

New! From the Bay Program

Going green at the Gunston School

Join the Discussion on Management Strategies

As part of the new Chesapeake Bay Watershed Agreement, Bay Program partners are developing management strategies that will outline how we will accomplish the goals and outcomes that will lead to a restored watershed.

Bay Program partners are now crafting the management strategies for meeting the goals of the Chesapeake Bay Watershed Agreement signed last June. Each week, we offer a listing (below) of upcoming open discussions and meetings for your information.

NOVEMBER

Tues 10 - Toxic Contaminants Policy and Prevention Management Strategy

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What We're Reading

Our Path Forward: The Comprehensive Conservation & Management Plan for Maryland's Coastal Bays
Our Path Forward represents a revision to the 1999 Comprehensive Conservation & Management Plan for the Coastal Bays of Maryland. The work is the culmination of three years (2012–2014) of technical investigation and community involvement to protect the future of the Coastal Bays.
For more: http://ow.ly/ObzNK

Greater Baltimore Wilderness Coalition To Expand Green Network in Central Maryland
Baltimore Mayor Stephanie Rawlings-Blake and U.S. Representative John Sarbanes, met with representatives from local, state and federal agencies, non-governmental organizations, and professional associations at Ridgely's Cove to officially launch the Greater Baltimore Wilderness Coalition.
For more: http://ow.ly/ObKbE

Anacostia River Watershed Restoration Project
The Anacostia watershed is one of the most urbanized watersheds within the Chesapeake Bay Basin and has suffered from years of environmental neglect. The U.S. Army Corps of Engineers is currently working on an environmental assessment and are seeking any relevant information from members of the public and organizations until July 1. If implemented, the projects would directly support interagency commitment to the Chesapeake Bay goals included in Executive Order 13508, Chesapeake Bay Protection and Restoration.
For more: http://www.nab.usace.army.mil/Missions/Environmental/anacostiawatershedrestoration.aspx

Baltimore District, U.S. Army Corps of Engineers

Published by Cynthia Mitchell [?] · June 9 at 4:00pm ·

NEW STUDY! The Anacostia watershed is one of the most urbanized watersheds within the #ChesapeakeBay Basin and has suffered from years of environmental neglect. The Baltimore District is preparing an environmental assessment for potential stream and wetland restoration projects in the Anacostia River watershed in Prince George's County, Maryland. In partnership with the Prince George's County Department of the Environment, 10 miles of stream have been selected for investigation. The district is requesting information on the study from the public and interested organizations by July 1.

For more info: http://1.usa.gov/1B41QW7

Anacostia Watershed Restoration

The official public website of the Baltimore District, U.S. Army Corps of Engineers

NAB.USACE.ARMY.MIL | BY BALTIMORE DISTRICT

183 people reached

Boost Post

Like · Comment · Share

Kathleen Guevremont, Dredging Today and Andrea M Takash like this.

Write a comment...

DPIE
June 9 at 3:37pm

PLEASE SHARE - U.S. Army Corps of Engineers, Baltimore District:
We are working on a study, in coordination with Prince George's County Department of Environmental Restoration, identifying several stream restoration and fish passage projects in the Anacostia River watershed in Prince George's County, Maryland. The Anacostia watershed is one of the most urbanized watersheds within the Chesapeake Bay Basin and has suffered from years of environmental neglect. We are currently working on an environmental assessment and are seeking any relevant information from members of the public and organizations until July 1. We can all work together to help restore the Bay! More info and study area maps can be found at: http://www.nab.usace.army.mil/ .../anacostiawatershedrestorati....

Anacostia Watershed Restoration

The official public website of the Baltimore District, U.S. Army Corps of Engineers

NAB.USACE.ARMY.MIL | BY BALTIMORE DISTRICT

Like · Comment · Share

Prince George's County Office of Community Relations

June 9 at 3:36pm

We can all work together to help restore the Bay! Learn More about the Anacostia Watershed Restoration.

Anacostia Watershed Restoration

The official public website of the Baltimore District, U.S. Army Corps of Engineers

NAB.USACE.ARMY.MIL | BY BALTIMORE DISTRICT

Like · Comment · Share

DPIE likes this.

Write a comment...

PGC Department of the Environment

20 hrs ·

Can you help us?

Your input, suggestions and recommendations are needed by July 1, 2015!

The U.S. Army Corps of Engineers, Baltimore District and the Prince George's County Department of the Environment are working to identify several stream restoration and fish passage projects in the Anacostia River watershed. We are seeking any information from the public that may assist us in making final project decisions.

Remember...the deadline is JULY 1, 2015. Contact Christopher Spaur at (410) 962-6134 or christopher.c.spaur@usace.army.mil to share your thoughts.

We can all work together to help restore the Anacostia River watershed!

More information and a map of potential project locations is available here: http://www.nab.usace.army.mil/.../anacostiawatershedrestorati...

Anacostia Watershed Restoration

The official public website of the Baltimore District, U.S. Army Corps of Engineers

NAB.USACE.ARMY.MIL | BY BALTIMORE DISTRICT

Like · Comment · Share

Baltimore District, U.S. Army Corps of Engineers likes this.

Write a comment...

Dana Minerva
Anacostia Watershed Restoration Partnership
777 North Capitol Street, NE, Suite 300
Washington, D.C. 20002

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Montgomery County, Maryland
Department of Environmental Protection
255 Rockville Pike, Suite 120
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District of Columbia
District Department of the Environment
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Charles Wilson
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Samuel Moki
Associate Director
Prince George's County, Maryland
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Ken Yetman
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Annapolis, Maryland 21401-2397

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U.S. Environmental Protection Agency, Region III
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1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

Diana Esher
U.S. Environmental Protection Agency, Region III
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Patricia Montanio
National Oceanic and Atmospheric
1401 Constitution Avenue NW Room 6217
Washington, District of Columbia 20230

Tom Brosnan
National Oceanic and Atmospheric
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Washington Dc, District of Columbia 20230

Mike Smith
Anacostia Watershed Citizens Advisory Committee
777 North Capitol Street, NE, Suite 300
Washington, D.C. 20002-4201

Mary Barber
Anacostia Watershed Citizens Advisory Committee
2839 Chesterfield Place
Washington, D.C. 20008

Verna Harrison
The Campbell Foundation
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Annapolis, Maryland 21403

Linda Howard
The Summit Fund of Washington
2100 Pennsylvania Avenue N.W. Suite 525
Washington, District of Columbia 20037

Andrew Fellows
4500 Knox Road
College Park, MD 20740

Jim Foster
The George Washington House
4302 Baltimore Avenue
Bladensburg, MD 20710

John Akridge III
The John Akridge Companies
601 13th Street NW, Suite 300N
Washington, DC 20005-3870

David Tuchman
The John Akridge Companies
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Eric Siegel
The Cohen Companies
2701 Tower Oaks Boulevard, Suite 200
Rockville, Maryland 20852

Michael Stevens

Eleanor Norton
The Honorable Eleanor Holmes Norton
United States House of Representatives
Rayburn House Office Building
National Press Building, Suite 900
529 14th Street, NW
Washington, D.C. 20045

Barbara Mikulski
1629 Thames Street, Suite 400
Baltimore, Maryland 21231

The Honorable Donna Edwards
United States House of Representatives
Attn.: Ms. Adrienne Christain
Rayburn House Office Building
9200 Basil Court, Suite 221
Largo, Maryland 20774

Steny Hoyer
The Honorable Steny H. Hoyer
US District Courthouse
6500 Cherrywood Lane, Suite 310
Greenbelt, MD 20770

Ben Cardin
The Honorable Benjamin L. Cardin
Baltimore Office
100 South Charles Street
Tower 1, Suite 1710
Baltimore, MD 21201

Donna Edwards
Price George's County Office
5001 Silver Hill Road
Suite 106
Suitland, MD 20746

The Honorable Chris Van Hollen
United States House of Representatives
1707 Longworth House Office Building
Washington, D.C. 20515

Sheila Besse
District of Columbia
District Department of the Environment
51 N Street, NE, 6th Floor
Washington, D.C. 20002

Catherine King
U.S. Environmental Protection Agency, Region III
3WP10
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

David Prevar
Beltsville Agricultural Research Center
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Building 003 BARC-WEST
Beltsville, Maryland 20705

Susan Barnett
Beaverdam Creek Watershed Watch Group
P.O. Box 1244
Greenbelt, MD 20768

Zelda Bell
Citizens to Conserve and Restore Indian Creek
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Berwyn Heights, Maryland 20740

Dennis Chestnut
Groundwork Anacostia DC
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Washington, DC 20019

Bill Duncan
Friends of Still Creek
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Greenbelt, Maryland 20770

Anne Ambler
Neighbors of the Northwest Branch of the Anacostia River
P.O. Box 4314
Silver Spring, MD 20914

Michael Wilpers
President, Friends of Sligo Creek
7209 Spruce Avenue
Takoma Park, Maryland 20912

David Dunmire
Eyes of Paint Branch
1258 Cavendish Drive
Silver Spring, Maryland 20904

John Galli
Metropolitan Washington Council of Governments
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Washington, DC 20002

Phong Trieu
Metropolitan Washington Council of Governments
Department of Environmental Programs
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Aubin Maynard
Metropolitan Washington Council of Governments
Department of Environmental Programs
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Ted Graham
Metropolitan Washington Council of Governments
Department of Environmental Programs
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Stuart Freudburg
Metropolitan Washington Council of Governments
Department of Environmental Programs
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Peter Hill
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James George
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Adam Ortiz
Director
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Jerry Maldonado
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Largo, Maryland 20774

Laura Connelly
Maryland-National Capital Park and Planning Commission
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Riverdale, Maryland 20737

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Appendix E. Engineering Appendix

E-1: Civil Engineering Summary

E-2: Hydrology and Hydraulics Appendix with Concept Design Descriptions

Attachment 1: Field Data (sediment gradation curves and cross sections)
Attachment 2: Conceptual Design Drawings

E-1: Civil Engineering Summary

Engineering Appendix – Civil Engineering
Anacostia Watershed Restoration Plan: Prince George's County, MD

May 2016

Concept-Level Designs

Introduction

The study encompasses roughly 60,000 linear feet of stream distributed between 10 project sites within the Anacostia Watershed in Prince George's County, Maryland. Sites are primarily comprised of the Paint Branch, Little Paint Branch, Sligo Creek, Indian Creek, Northeast Branch and Northwest Branch tributaries of the Anacostia River.

Mapping:

GIS shapefiles of sewer lines and manholes were provided by Washington Suburban Sanitary Commission (WSSC) in 2015. Other GIS shapefiles, including two-foot contours, water lines, and streets were provided by Prince George's County in 2014 and 2015. The team determined that the provided topographic data paired with field data gathered by the Hydraulics and Hydrology Section was adequate for concept-level designs. Therefore, no additional survey data was collected for this phase of the study.

Horizontal control: Maryland State Plane, NAD83.

Vertical control: NAVD88

The original mapping data is filed under:
\\nab-netapp1\CADD_DATA\Civil\Anacostia 2013_PGCo\Data\Mapping\GIS

Aerial Imagery

High resolution aerial imagery used is Esri's World Imagery base map. Sources for this mapping are Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

Concept Design Drawings

The prepared drawings, provided as an attachment to the Hydrology & Hydraulics Appendix show the proposed stream centerlines, in-stream structures, and the primary riparian restoration features for each alternative. Only a few, key proposed contour alterations were shown on the concept design drawings, other changes will be necessary and these will be shown in the feasibility level drawings. As the site designs for the alternatives within the tentatively selected plan are progressed, additional wetlands and vernal pools will be incorporated along the stream banks to the furthest extent practical, in order to maximize habitat benefit. Benches will be integrated wherever possible to reconnect the streams with their floodplains. The number and type of in-stream features may change as selected plans move forward and modeling is performed. Proposed structure dimensions are approximate and will be refined for the feasibility level drawings.

Utility Impacts

GIS shapefiles of existing and water lines and sanitary sewer lines and manholes were provided by Prince George's County and WSSC, respectively, in late 2014 and early 2015. Other utilities may be present. Utility impacts, however, are not expected. Sewer manholes may need to be raised and/or protected with stone structures.

Cost Estimate:

Due to the conceptual nature of the design at this point, individual construction quantities were not estimated. For the purpose of developing costs for the cost-benefit analyses, the cost of recent nearby stream restoration projects were utilized. Linear foot costs were developed and adjusted based on comparisons between stream widths, access, and other impacts. The next phase of the feasibility report will provide individual construction quantities for each site alternative within tentative selected plan.

Regulatory/Compliance Considerations:

Construction will affect existing wetlands, streams, and trees.

Required permits/approvals may include: erosion and sediment control, NPDES, and authorization to work in streams and wetlands.

Impacts to Existing Flood Risk Management Project

Improvements to Northwest Branch, Paint Branch and Indian Creek were included in the "Anacostia River Local Flood Protection Project", authorized in 1950, and constructed between 1973 and 1974.

Northwest Branch was widened to 70-feet upstream of Queens Chapel Road, and 80-feet downstream. The improved channel capacity was 5000 cfs and 8000 cfs.

Paint Branch was widened and deepened, and a portion of the floodway was cleared. The channel was widened to 50-feet, transitioning to 135-feet in the vicinity of the railroad bridge. A two-foot drop structure was constructed 400-feet upstream of the confluence with Indian Creek to maintain acceptable grade. The improved channel capacity was 2500 cfs from Route 1 to the railroad bridge, and 3000 cfs downstream of the railroad bridge.

Indian Creek was widened to 30-feet, and straightened to provide a capacity of 1000 cfs. A two-foot drop structure was constructed 400-feet upstream of the confluence with Paint Branch to maintain acceptable grade.

Section 7.5 of the O&M manual states that the improved channels and floodways are to be kept clear of wild growth, encroachments, and shoals (33 CFR Part 208 – Flood Control Regulations).

The channels have not been maintained for many years, and therefore the channel capacity has likely been reduced, but this has not been confirmed through modeling yet.

The proposed stream restoration does not involve re-establishing the original design channel dimensions, nor does it involve re-clearing the floodway. Therefore the water surface profile for the stream restoration will likely be higher than the profile for the original flood protection design. As a result, the proposed stream restoration will be considered a modification to the project.

In order to document the extent of the modification, the water surface profile will be modelled for 3 scenarios: original design, existing condition, and proposed condition. This will occur in the next design phase.

Remaining Effort:
Several civil engineering-related tasks are deferred to the next phase:

1. Channel cross-sections and thalweg profile for feasibility-level design, quantities, and construction drawings
2. Feasibility-level designs and construction drawings
3. Feasibility-level site access/staging plans
4. List of permits
5. Feasibility-level cost estimate
6. Water surface profile modeling for 3 scenarios

E-2: Hydrology and Hydraulics Appendix with Concept Designs

Attachment 1: Field Data (sediment gradation curves and stream cross sections)

Attachment 2: Conceptual Design Drawings

Anacostia Watershed Study/Prince George's County
USACE Stream Restoration Projects

Hydrology and Hydraulics Appendix with Conceptual Design Descriptions

May 2016

DRAFT

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Attachment 1	Field Data (sediment gradation curves & cross sections)
Attachment 2	Proposed 10% concept designs

INTRODUCTION

Located in Prince George's County, Maryland, most of the streams in this study start in Montgomery County except Indian Creek and the Chillum Road tributary. These streams are generally third order stream or larger, except the Chillum Road tributary is a 2nd order stream. Almost all systems cross the Capital Beltway (I-495) or other major state and county roads through different types of stream crossings. The watershed is urbanized and there is high resident and commercial concentration throughout the entire stream system. The stream network draining into Northwest and Northeast Branch of the Anacostia River watershed are shown in Figure 1. Each of the tributaries has experienced significant urbanization and suburban growth, resulting in degraded biological health. The storm flow characteristics and concentrations have been altered due to stressors in the watersheds such as increased impervious surface areas and storm drain construction. Other manmade impacts such as stream crossings, channelization, floodplain impacts, channel/bank armoring, utility crossings has caused sediment loading, lateral erosion tree uprooting, fish blockage and other environmental impacts.

Almost all the projects are nested in high-density residential/commercial neighborhoods. Most of the watershed is part of the suburban network surrounding Washington, D.C., and demand for housing is very high. Large areas of the stream valleys have been dedicated to or purchased by Maryland-National Capital Park and Planning Commission (M-NCPPC) for preservation of natural resources or for use as green or open space. Although County zoning regulations restrict development from floodplain areas, some stream system floodplains have encroached into residential areas and neighborhoods. Table 1, below, shows the flows, drainage area, and percent forest cover of each stream system that is part of our study in Prince George's County.

Table 1. Data compiled from GISHYDRO-2000

Stream	2-Yr Q (cfs)	10-Yr Q (cfs)	50-Yr Q (cfs)	100-Yr Q (cfs)	DA (mi^2)	% Forest
Indian Creek #1	165	420	820	1060	2.6	29
Northwest Branch #3	2143	5245	9514	11879	48.8	17.8
Paint Branch #5	1451	3618	5230	8445	31.3	20.4
Paint Branch #7	988	2513	3645	5868	16.4	21.2
Sligo Creek #9	900	2207	3155	4994	10.7	8.7
Chillum #10	188	407	685	841	1.2	5.6
Indian Creek #11	856	2330	4740	6230	29.3	40.4
Little Paint Branch #12	596	1497	2805	3580	10.6	21.3
Northwest Branch #13	1652	4116	5905	9385	34.6	21.5
Northeast Branch #15	2091	5414	10407	13400	70.0	29.8

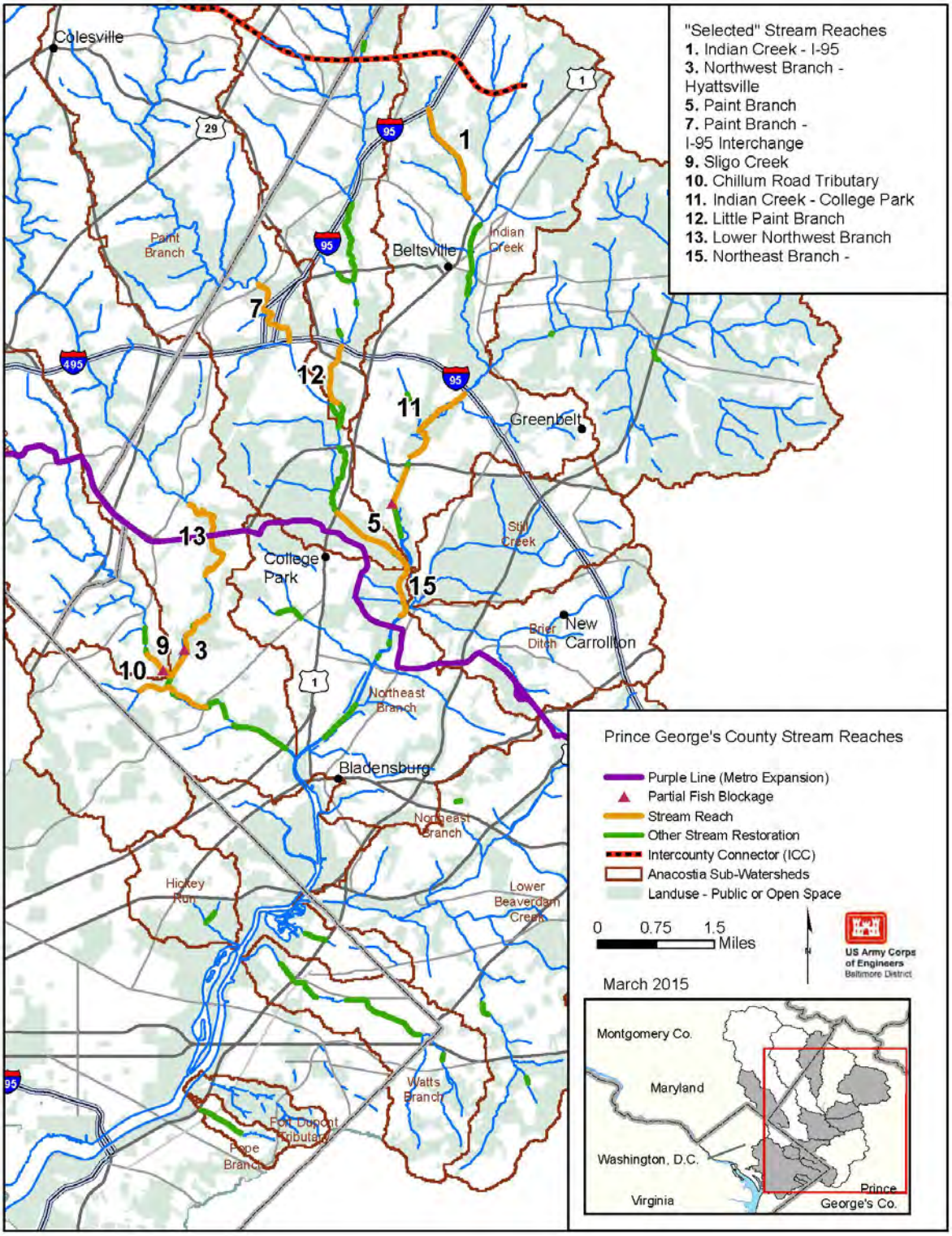

Figure 1: Location of tributaries in Anacostia River watershed in Prince George's County.

EXISTING CONDITIONS

Indian Creek (Site 1)

At the northern (upstream) end of the selected reach, Indian Creek crosses I-95 through two 11 ft by 8 ft box culverts and daylights in a wooded area. The stream is experiencing bank and bed (entrenched) 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. Additionally, erosion was present that resulted in a gully 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 was channelized through the 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 1960's 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 1960's.

Northwest Branch (Site 3)

Improvements to Northwest Branch were included in the "Anacostia River Local Flood Protection Project", authorized in 1950, and constructed between 1973 and 1974. Northwest Branch was widened to 70-feet upstream of Queens Chapel Road, and 80-feet downstream. The improved channel capacity was 5000 cfs upstream and 8000 cfs downstream of Queens Chapel Road. Section 7.5 of the O&M manual states that the improved channels and floodways are to be kept clear of wild growth, encroachments, and shoals (33 CFR Part 208 – Flood Control Regulations). The channel has not been maintained for many years, and therefore the channel capacity may have been reduced, but this has not been confirmed through modeling yet.

Northwest Branch is an entrenched system in an urbanized area that experiences frequent flashy flows. Most of the bridges have tight angles (i.e., are skewed) that create back eddies and bed and bank erosion. Some of the high sinuosity upstream of the bridges is directly related to the hydraulic opening—backwater caused by constriction during high flow—that stresses the stream. There is spotty bank armoring present and a number of riffle grade controls were previously constructed to improve fish passage potential. The utility crossings (sewer, gas, and water lines) are currently acting as grade control, and without them, the stream would have become more entrenched and less stable. There are some long, deep pools that are loaded with soft sediment, with little potential for healthy fish habitat. Additionally, a thick layer of sand has been deposited on both side of the floodplain that indicates out of bank activity from larger storms.

Paint Branch (Site 5)

Improvements to Paint Branch were included in the "Anacostia River Local Flood Protection Project", authorized in 1950, and constructed between 1973 and 1974. Paint Branch was widened

and deepened, and a portion of the floodway was cleared. The channel was widened to 50-feet, transitioning to 135-feet in the vicinity of the railroad bridge. A two-foot drop structure was constructed 400-feet upstream of the confluence with Indian Creek to maintain acceptable grade. The improved channel capacity was 2500 cfs from Route 1 to the railroad bridge, and 3000 cfs downstream of the railroad bridge. Section 7.5 of the O&M manual states that the improved channels and floodways are to be kept clear of wild growth, encroachments, and shoals (33 CFR Part 208 – Flood Control Regulations). The channel has not been maintained for many years, and therefore the channel capacity has likely been reduced, but this has not been confirmed through modeling yet.

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 which 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.

Paint Branch, I-95 Interchange (Site 7)

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 ft 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 1990's. 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.

Sligo Creek (Site 9)

Sligo Creek is in the backwater of Northwest Branch. The stream has made a lateral shift to the left due to deposition on the right side, 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 (i.e., velocity vector) to the toe of the embankment. Figure 2, below, shows the toe erosion and destabilization of some of the trees at the top of the bank. A point bar is growing at the left side that this will further increase the erosion potential at the right toe of the embankment. This is an urban environment with turbulent flow.

Figure 2. Flow direction at riffle grade structure, Sligo Creek.

Northwest Branch, Chillum Rd Tributary (Site 10)

No aquatic life was observed in this system. 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 trash to this reach. A metal sanitary sewer line is suspended in the air with some attached bedrock.

Indian Creek, College Park (Site 11)

Upper Portion

This area is wide and flat along the upper reach and turns into a narrow and constricted area at MD 193. Historically, this area had a huge body of water and high quality network of wetlands. Over the last half century, however, the body of water was converted to an upland housing community on one side and a metal scrap yard on the other side. A concrete plant on one side 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. Habitat is not of good quality and vegetation is primarily invasive. There are two storm 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 (under MD Route 193) acts to pond water and create pooled conditions.

Lower Portion

Improvements to Indian Creek were included in the "Anacostia River Local Flood Protection Project", authorized in 1950, and constructed between 1973 and 1974. Indian Creek was widened to 30-feet, and straightened to provide a capacity of 1000 cfs. A two-foot drop structure was constructed 400-feet upstream of the confluence with Paint Branch to maintain acceptable grade. Section 7.5 of the O&M manual states that the improved channels and floodways are to be kept clear of wild growth, encroachments, and shoals (33 CFR Part 208 – Flood Control Regulations).

The channel has not been maintained for many years, and therefore the channel capacity has likely been reduced, but this has not been confirmed through modeling yet.

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. There are some mature trees with a lot of Sumac 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 over a fish blockage. 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 abutment scour.

Little Paint Branch (Site 12)

Little Paint Branch is loaded with sediment (gravel/cobble). The section 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 full of 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 hiker-biker path.

Northwest Branch, Riggs Rd (Site 13)

The reach starts at Riggs Road and ends 500 ft downstream of Drexel Street. This system is severely incised and experiencing major lateral erosion. There has been some spot fixes to protect existing utilities; however, this system is extremely unstable. The high sinuosity in this system is not natural, and is caused by the stress in the system. This site is located at the transition between the Piedmont and the Coastal Plain provinces. There is an undersized concrete arch and the sewer/water line maintains the grade until it reaches the high power electric area. This area has highly erodible soils and many trees are being uprooted.

Northeast Branch, Calvert Rd Disc Golf Park (Site 15)

There are several sanitary sewer crossings that pose stability and fish passage issues. The more challenging crossing is under the River Road Bridge where sheet-pile has been used to provide grade control. This system is powerful during high flow. Much of the stream bank length is already armored with large rip-rap.

ENGINEERING OBJECTIVES

The planning objectives for the study include:

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

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.

The goal of the engineering design team is to restore aquatic and riparian habitat within the two major subwatersheds (Northwest Branch and Northeast Branch) by creating dynamically stable streams using natural stream channel (fluvial geomorphic) design techniques. Specifically, the engineering objectives developed by the design team are:

a. To maximize aquatic and riparian habitat;
b. To increase stability of the stream system;
c. To remove or ameliorate fish blockages;
d. To 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. To recommend culvert replacement and proper sizing for geomorphic stability where necessary (HEC-RAS modeling performed to design the restoration will allow identification of areas where conveyance through structures can be improved);
f. To provide self-sustaining geomorphic conditions (naturally dynamic) to reduce or eliminate the need for channel maintenance;
g. To improve aesthetic value; and
h. To allow public access to the stream and recreational opportunities per landowner agreement.

FLUVIAL GEOMORPHOLOGY

The fluvial geomorphology of a stream or river is influenced by seven major variables (Leopold et al., 1964):

1) channel slope,
2) width,
3) depth,
4) discharge,
5) velocity,
6) roughness of channel materials, and
7) sediment size.

A change in any one of these variables causes a series of channel adjustments, which leads to a change in the others, resulting in channel pattern alterations (Rosgen, 1996).

Stream Classification

Rosgen (1996) developed a stream classification system based on the seven variables presented above. The classification system organizes the morphological variables of a stream into characteristics commonly observed, creating several stream types. The different stream types, or geomorphic characterizations, are classified as A, B, C, D, DA, E, F, or G. Figure 4 provides a summary of the geomorphology of each functional stream type within its valley type. Descriptions of each of the morphological variables contained in the classification system are addressed below.

One must inspect the floodplain valley of a stream to determine the stream type and dimension, pattern and profile for a properly functioning system, as specific stream types are only found in certain valley types (Table 2). For example, in Valley Type I ("V" notched canyons) A and G stream types will be found, while in Valley Type X (very broad and gentle slopes), C and D type streams are predominantly found. For more information, Rosgen's *Applied River Morphology* (1996) contains a complete description of valley types.

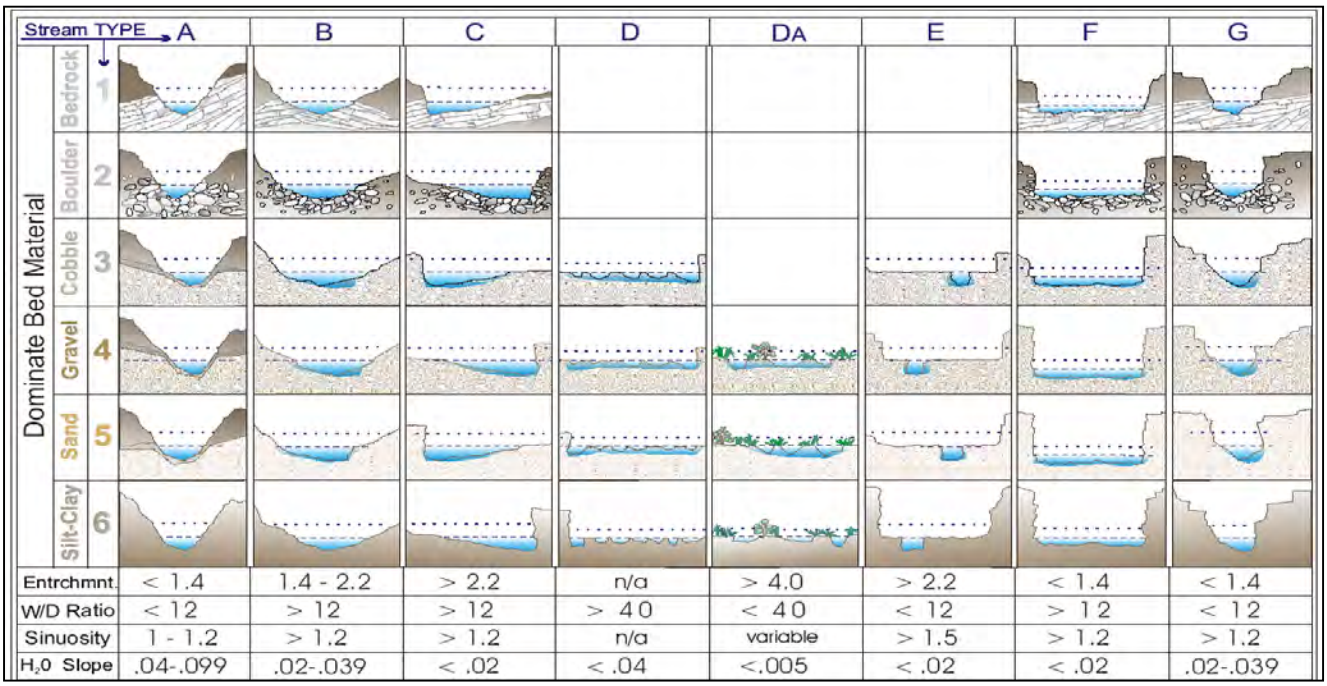

Figure 3. Stream classification system (from Rosgen, 1996).

Table 2. Valley types (Rosgen and Silvey, 1998).

Valley Type	Description	Stream Types
I	"V" notched canyons, rejuvenated side slopes	A and G
II	Moderately steep, gentle sloping side slopes often in colluvial valleys	B
III	Alluvial fans and debris cones	A, G, D and B
IV	Gentle gradient canyons, gorges and confined alluvial valleys	F and C
V	Moderately steep valley slopes, "U" shaped glacial trough valleys	D, C and Bc
VI	Moderately steep, fault controlled valleys	B, G and C
VII	Steep, highly dissected fluvial slopes	A and G
VIII	Wide, gentle valley slope with a well-developed floodplain adjacent to river terraces	C, E and Bc

IX	Broad, moderate to gentle slopes, associated with glacial outwash and/or aeolian sand dunes	Predominantly D and some C
X	Very broad and gentle slopes, associated with extensive floodplains – Great Plains, semi-desert and desert provinces; coastal plains and tundra; lacustrine valleys	C and D

Bankfull Discharge

The bankfull discharge is the "channel forming flow." It is typically associated with an instantaneous peak discharge that occurs a few days a year and is often related to the 1.5-year recurrence interval but may vary depending on the level of urbanization in the watershed. It is perhaps the most important variable in the classification system, as many of the other variables are dependent on it. Determination of the bankfull discharge is critical for proper application of the classification system. Discussions of bankfull discharge indicators and their significance are presented by Leopold et al. (1964), Dunne and Leopold (1978), Andrews (1980), Rosgen (1996), and Leopold (1994).

Width/Depth Ratio

The width/depth ratio is defined as the ratio of the bankfull channel width to the bankfull mean depth. The width and depth measurements used for the calculation are associated with the bankfull discharge.

Entrenchment Ratio

The entrenchment ratio describes the vertical containment of the stream or river and the degree to which it is incised in the valley floor (Kellerhals et al., 1972). The entrenchment ratio is defined as the ratio of the width of the flood-prone area to the bankfull width of the channel. The flood-prone area is defined as the width of the channel at an elevation of twice the maximum bankfull depth (Rosgen, 1996).

Sinuosity

Sinuosity is a parameter describing the meander pattern of a stream or river. It is defined as the ratio of channel length to valley length. It can also be described as the ratio of the valley slope to the channel slope (Rosgen, 1996).

A stream's meander length and the radius of curvature are closely related to sinuosity. The meander length is the straight-line length for one complete meander cycle, and the radius of curvature is a measure of the radius of the stream bend.

Langbein and Leopold (1966) developed the following relationship:

$$R_c = \frac{L_m K^{1.5}}{13 (K - 1)^{0.5}}$$

where, R_c = Radius of bend curvature (feet)
K = Channel sinuosity
L_m = Meander length (feet)

Meander Width Ratio

The meander width ratio is defined as the ratio of the belt width to the bankfull width of the channel and is related to stream type according to Rosgen's classification system. Thus, if the stream type (i.e. classification) is known, the most probable proper channel pattern may be determined and used in stream restoration efforts.

Channel Materials

Channel materials influence the ultimate shape of the channel, as different materials provide varying resistance to flow and consequently, require different energy levels for transport to occur. Field determination of the channel materials is accomplished using the "pebble count" method presented by Wolman (1954). The dominant bed material particle size, or d_{50}, is an important parameter for further classifying stream channels. Mathematically, d_{50} represents the particle size diameter for which 50% of the sampled population is equal to or finer. As shown in Figure 4, the d_{50} is broken into size classes, which are given a numeric value. For example, bedrock systems are given a value of 1 while streams containing mostly silt and clay are given a value of 6.

Slope

The slope of a stream channel is the final parameter used in the stream classification system presented by Rosgen. Channel slope affects the energy of a stream system and is an important factor in sediment (or bedload) transfer. The slope is typically measured over at least 20 channel widths or 2 meander wavelengths.

Along with stream type, the parameters discussed above are used to further organize and classify stream systems. A reference summary of the stream classification parameters is provided in Figure 4.

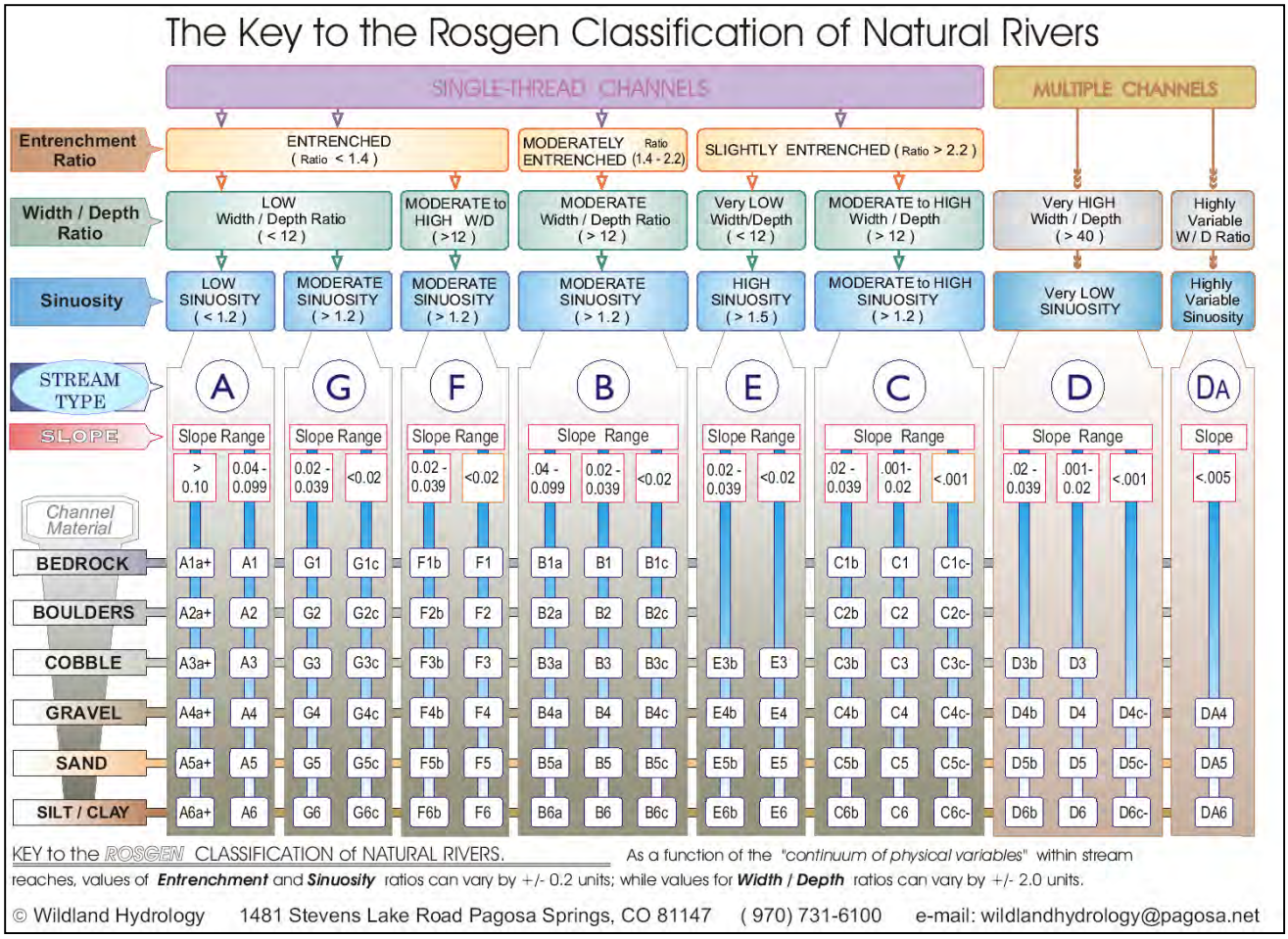

Figure 4: **Stream classification table (from Rosgen, 1996).**

FIELD DATA

The proposed stream reaches were assessed using Rosgen's methodology for Levels I through III analyses (Rosgen, 1996). Relative topographic surveys were conducted using a laser level and rod to obtain cross section and longitudinal profile data. Grab samples and pebble counts were used to assess the nature and distribution of channel materials.

Cross section data was collected at pool and riffle features of the proposed reaches and where the team determined useful design information could be obtained. A hypothetical base elevation of 100.00 feet was identified for the left bank station (0.00 feet) of each cross section.

Longitudinal profile data was collected along the proposed reaches of a representative segment the length of at least 20 bankfull widths or greater. An elevation of 1,000.00 feet was used as a baseline for the upstream limit of the profile.

Grab samples, indicative of the sub-pavement or bedload that is transported in the stream system, were taken from representative bar features in the proposed stream reaches. The grab samples were collected according to the procedures described in *Applied River Morphology* for determining bedload size distribution (Rosgen, 1996). A 5-gallon open bottom bucket was placed to a depth of twice the largest particle size diameter observed at the sampling location, and all of the sediment was removed and placed in a bag. A sieve analysis of these materials was then conducted at the Corps' Geotechnical Laboratory at Fort McHenry.

Pebble counts, which are used to classify and characterize the bed surface material or pavement of the stream channel, were conducted using a modified Wolman method (Rosgen, 1993). The pavement (surface) material collected in the count was used to determine the composition of the bed and banks for stream classification purposes.

The data collected in the field for each of the proposed reaches is found in Attachment A of this report.

ROSGEN ANALYSIS

Rosgen analyses (Levels I&II) were performed on all the proposed stream reaches.

Level I: Geomorphic Characterization

The Rosgen Level I analysis enables integration of basin characteristics, valley types, and landforms with stream system morphology, aiding the development of sound restoration solutions. The valley type is a general description of the valley in which the stream system is located. The general stream type uses variables including dominant slope range, cross-section view, plan view, entrenchment ratio, width/depth ratio, sinuosity, slope, landform/soils/features to broadly classify the stream as Type Aa+, A, B, C, D, DA, E, F, or G. The following broad-level descriptions were determined for the proposed stream reaches (Table 3).

Table 3. Rosgen Level I analysis results for the existing conditions of the proposed stream reaches.

PROPOSED STREAM REACH	VALLEY TYPE	EXISTING GENERAL STREAM TYPE
Indian Creek (site-1)	IV	E/C
Northwest Branch (site-3)	VIII	E/C
Paint Branch (site-5)	VIII	C
Paint Branch (site-7)	VIII	C
Sligo Creek (site-9)	V	B
Chillum (site-10)	IV	F
Indian Creek (site-11)	IV	D/G
Northwest Branch (site-13)	VIII	C
Northeast Branch (site-15)	VIII	Bc/C

Level II: Morphological Description

Morphological descriptions (Level II) of the proposed stream reaches include the parameters listed in Table 4. This information in combination with the sediment component (dominant bed materials) was used to determine the present stream type of each proposed reach.

Table 4. Rosgen Level II assessment parameters.

PARAMETER	DESCRIPTION
Bankfull Width (W_{bkf}) in feet	Width of the stream channel, at bankfull stage/elevation, in a riffle section
Mean Depth (d_{bkf}) in feet	Mean depth of the stream channel cross section, at bankfull stage/elevation, in a riffle section ($d_{bkf} = A/W_{bkf}$)
Bankfull Cross Section Area (A_{bkf}) in square feet	Area of the stream cross section, at bankfull stage/elevation, in a riffle section
Width/Depth Ratio (W_{bkf}/d_{bkf})	Bankfull width divided by bankfull mean depth, in a riffle section
Maximum Depth (d_{mrif}) in feet	Maximum bankfull depth of the bankfull channel cross section; or elevation between the bankfull stage and thalweg in a riffle section
Flood-Prone Area Width (W_{fpa}) in feet	Flood-prone area width is determined (in a riffle section) at the stage/elevation which is twice the maximum bankfull depth or ($2 \times d_{mrif}$)
Entrenchment ratio (ER)	The ratio of flood-prone area width divided by bankfull channel width (W_{fpa}/W_{bkf}) in a riffle section
Channel materials (d_{50} and d_{84}) in mm	The 50th and 84th percentiles or less than, from the pebble count frequency distribution of channel particles. The d_{50} is the median or dominant particle size.
Water surface slope (S) in feet/feet	Average water surface slope as measured between the same position of bed features in the profile over two meander wave lengths
Channel sinuosity (k)	An index of channel pattern determined from stream length/valley length (SL/VL); or estimated from a ratio of valley slope divided by channel slope (VS/S).

The values of the Table 4 parameters for each of the proposed stream restoration sites are found in Attachment A of this report.

Manning n equation was used to calculate bankfull discharge. We were planning to compare the result against GISHydro2000 to get a better validation of the calculated bankfull discharge, but due to software and security issues we were unable to use this program. We are looking to resolve this issue in time for the next submission.

SUMMARY OF FIELD WORK AND ANALYSIS

Table 5. Bankfull discharge based on Manning equation

Anacostia Restoration Project Sites - Prince George's County								
Project Site	**Area (ft^2)**	**BFW (ft)**	**Depth (ft)**	**WP (ft)**	**R***	**Slope**	**n**	**Q** (cfs)**
indian Creek #1	21	10.1	2	14	1.50	0.0039	0.055	47
Northwest Branch#3	417	72.1	1.5	80.4	5.19	0.0039	0.05	2325
Paint Branch#5	210	62	3.4	78	2.69	0.01	0.045	1346
Paint Branch#7	140	28	5	38	3.68	0.005	0.045	782
Sligo#9	151.9	48	3.16	105	1.45	0.0056	0.04	542
Chillum#10								
Indian Creek#11	51.9	20	2.59	25.2	2.06	0.0059	0.045	214
Little Paint Branch#12	103.8	45	2.28	50	1.66	0.009	0.045	457
Northwest Branch#13								
Northeast Branch#15	290	70	4.1	90	3.22	0.021	0.04	3415

*	**R** = (Area/ WP)
**	**Q** = (1.49/n)(A)($R^{2/3}$))($S^{1/2}$)

Table 6. Length of stream reaches initially proposed for restoration.

STUDY REACH	STREAM LENGTH (MI)
Indian Creek (site-1)	1.3
Northwest Branch (site-3)	1.4
Paint Branch (site-5)	1.1
Paint Branch (site-7)	1.1
Sligo Creek(site-9)	.45
Chillum (site-10)	.4
Indian Creek (site-11)	1.8
Northwest Branch (site-13)	1.2
Northeast Branch (site-15)	.7
Total	**9.45**

PROPOSED CONDITIONS

Two concept-level designs were developed for the stream miles proposed for restoration. The proposed concept designs are found in Attachment 2 of this report; the sub-sections below discuss the proposed concept-level designs. The general difference is one alternative uses less structure or onsite trees (uprooting or falling trees) to construct the structures. Other types of in-stream structures (e.g. riffle grade controls or structures for slope protection) may be used to remediate the problem.

The main objective is to create stable and functional system that does not have any adverse impacts on flooding, trees, safety, and improves aesthetics for local resident/community. In-stream structures will be used to provide bed and bank grade control in combination with planting. Different designs will be used to best match the floodplain for long-term stability and ecosystem improvements. For example, where a wider and flatter valley is present, a more sinuous stream will be created; whereas, where a narrow and steeper valley is present, a more structured system is proposed (step-pool-system).

As the designs progress for all sites, additional wetlands and vernal pools will be incorporated along the stream banks to the furthest extent practical, in order to maximize habitat benefit. Benches will be integrated wherever possible to reconnect the streams with their floodplains. The number and type of in-stream features may change as selected plans move forward and modeling is performed.

Indian Creek (Site 1)

<u>Alternative Design 1</u>

In the upper portion of reach (I-95 Box Culvert) a step-pool system will be proposed to reduce the erosive forces of flood waters (clear water scour) and convey the flow through the stream system with proper dimension , pattern and profile. A series of cross vanes and J-hooks will be proposed to provide grade control and move the flood flows from the banks to center of channel. Ten structures will be used to maintain stability from I-95 to Ammendale road. Four structures will be used downstream of the regional pond for stability (monastery area). No work should be performed below monastery since this area is stable and any construction traffic will be more damaging to the ecosystem.

<u>Alternative Design 2</u>

At the upstream reach, about half way between I-95 and Ammendale Road, there is an existing culvert that could be used (pending inspection of pipe condition near Flash Drive) for low-flow passage and a low berm over the pipe would be constructed to block the high flood flows for detention. This area could be transformed into a wetland. Five structures are proposed downstream of the berm to provide stability. The area upstream of Ammendale Road could be excavated to improve aquatic habitat and dissipate flood flows. Five structures are proposed for construction by the old monastery for stability. The three ponds at the end of the project would be combined into one and deepened to improve potential aquatic life and slow down the flood flows into the existing concrete channel. The stream will be reconnected to the floodplain and habitat will be improved. Woody debris and roots will be added to provide habitat diversity.

Northwest Branch (Site 3)

Alternative Design 1

A more functional and stable system will be created to reduce maintenance at the stream crossings and enhance habitat. By minimally relocating the stream and providing better approach angles, conveyance will be improved to reduce the risk of flooding. Maintenance will be decreased by placing armor stone to protect and guide the flood flows away from eroded areas. A total of 31 in-stream structures are proposed to maintain grade and provide better connection with the floodplain. Some of the structures will be placed higher than the existing bed elevation to create diversity and to improve flow. With this concept, one of the pedestrian bridges will be relocated to improve conveyance and safety. A nested cross vane (placing additional boulders to act as riffle grade control) will be used to provide fish passage at Ager Road.

Alternative Design 2

Minimum stream relocation will be used with this alternative. A total of 22 in-stream structures are proposed, including one is a W-weir (below its confluence with Sligo).

Impacts to Existing Flood Risk Management Project

Improvements to Northwest Branch were included in the "Anacostia River Local Flood Protection Project", authorized in 1950, and constructed between 1973 and 1974. The proposed stream restoration does not involve re-establishing the original design channel dimensions, nor does it involve re-clearing the floodway. Therefore, the water surface profile for the stream restoration may be higher than the profile for the original flood protection design. As a result, the proposed stream restoration will be considered a modification to the project. In order to document the extent of the modification, the water surface profile should be modelled for 3 scenarios: original design, existing condition, and proposed condition. This should occur in the next design phase.

Paint Branch (Site 5)

Alternative Design 1

Sinuosity in the upper portion of paint Branch. We are also proposing to set the first in-stream structure in a manner to increase right floodplain flooding to activate the historic path of the flow. We will be placing a head gate to control the amount of flow getting on the right floodplain. A total of 27 in-stream structures are proposed that two of the will be W-weir. The W-weir is necessary by the railroad crossing to eliminate sediment loading and will provide more stable and functional system.

Alternative Design 2

For this concept, the stream will be fixed within its existing envelope. Twenty-five in-stream structures will be used to reconnect the stream with its floodplain. A W-weir will be used on the upstream side of the railroad crossing, and a cross vane placed on the downstream side to provide grade control, fish passage, and to eliminate potential for debris jams.

Impacts to Existing Flood Risk Management Project

Improvements to Paint Branch were included in the "Anacostia River Local Flood Protection Project", authorized in 1950, and constructed between 1973 and 1974. The proposed stream restoration does not involve re-establishing the original design channel dimensions, nor does it involve re-clearing the floodway. Therefore, the water surface profile for the stream restoration may be higher than the profile for the original flood protection design. As a result, the proposed stream restoration will be considered a modification to the project. In order to document the extent of the modification, the water surface profile should be modelled for 3 scenarios: original design, existing condition, and proposed condition. This should occur in the next design phase.

Paint Branch, I-95 Interchange (Site 7)

Alternative Design 1
Twenty-eight in-stream structures will be placed to restore this site. Three of these structures will be W-weir at the box culverts to conform to existing sediment deposition and provide fish passage. There will be some minor stream relocations to improve stability and function.

Alternative Design 2
Twenty-nine structures will be placed along existing flow paths to provide bed control, improve conveyance, and reduce debris jams. These improvements will provide fish passage throughout and upstream of the reach.

Sligo Creek (Site 9)

Alternative Design 1
The stream requires 9 in-stream structures to provide fish passage and improve stability. There will be a lateral shifting of the stream to the left adjacent to the baseball field to create a floodplain bench at the toe of an eroded embankment.

Alternative Design 2
Sligo Creek is a tributary to Northwest Branch. Northwest Branch is very entrenched (U-shape channel) and larger system that carries most of the flood flows in the active channel. Therefore, Because of that during the flooding events Northwest brand acts as a hydraulic dam forcing Sligo to create back eddies at its confluence and become much wider and shallower system. Thirteen in-stream structures are proposed to provide fish passage and improve geomorphic stability and potential fish habitat. The last structure is proposed to be a J-hook that leads to a deep pool before Sligo joins the Northwest Branch.

Northwest Branch, Chillum Rd Tributary (Site 10)

Alternative Design 1
It will be necessary to cut into the left or right bank to create a floodplain for this system. Eight in-stream structures are required to provide stability and function. As part of improvements, the stream will be widened and deepened to provide shelter for fish.

Alternative Design 2
Three cross vanes will be emplaced to achieve stability and improve habitat.

Indian Creek, College Park (Site 11)

Upper Segment

Alternative Design 1
A total of 15 in-stream structures (log/stone) are proposed to provide a functional and stable system. The valley will be graded and planted to create a stable braided system with native vegetation. The area closer to MD 193 needs to be more structured to convey flood flows effectively and yet maintain stability. The concrete channel will be removed and will be replaced with in-stream structures to provide better conveyance and functional ecological system. The two large ponds will be deepened to improve habitat diversity.

Alternative Design 2
The existing channel will be stabilized using 23 in-stream structures to maintain grade control. A riffle grade control is recommended to offset the skewed angle upstream of MD193 box culvert.

Note: The County is considering plans for a multi-use development at the property currently used by the Washington D.C. metro adjacent to Indian Creek, so the design for Indian Creek will be coordinated with the County.

Lower Segment

Alternative Design 1
A more sinuous system will be achieved by using nine structures upstream of Berwyn Road and two structures downstream of Berwyn Road to provide fish passage. The stream will be raised to provide connectivity with its right floodplain and add to aesthetic value to the community.

Alternative Design 2
The system will be stabilized using 9 in-stream structures. These structures will ensure fish passage at Berwyn Road.

Impacts to Existing Flood Risk Management Project
Improvements to Indian Creek were included in the "Anacostia River Local Flood Protection Project", authorized in 1950, and constructed between 1973 and 1974. The proposed stream restoration does not involve re-establishing the original design channel dimensions, nor does it involve re-clearing the floodway. Therefore, the water surface profile for the stream restoration may be higher than the profile for the original flood protection design. As a result, the proposed stream restoration will be considered a modification to the project. In order to document the extent of the modification, the water surface profile should be modelled for 3 scenarios: original design, existing condition, and proposed condition. This should occur in the next design phase.

Little Paint Branch (Site 12)

Alternative Design 1

Twenty-two structures will be used to stabilize the system at its present location. There will be some lateral shifting of the stream as sewer lines run parallel to the stream.

Alternative Design 2
A more sinuous system with a network of interconnected wetlands will be created on the right floodplain. A pedestrian bridge need to be realigned. Thirty-two structures are required to provide stability. A riffle grade control is proposed under the pedestrian bridge for stability.

Northwest Branch, Riggs Rd (Site 13)

Alternative Design 1
In order to slow down the high-energy flows from Piedmont into the flatter Coastal Plain province a geomorphic plan is most essential to maintain stability and function (considering we need to work around the manmade structures such as, concrete arch bridge, failing hiker biker path and couple of pedestrian bridges). Forty-eight structures are required to create a stable system. Stream relocation will be required in a few places to provide proper channel dimension and profile. Most of work will be increasing the channel cross sectional area while raising the bed to improve conveyance, reduce stress and improve diversity. The sinuosity will be reduced to increase stability. Restoration of this site will have positive result (reducing sediment load) on the projects downstream.

Alternative Design 2
This design requires stream relocation and pedestrian bridge relocation. Forty-one structures will be used to maintain grade and reconnect the stream with its floodplain.

Northeast Branch, Calvert Rd Disc Golf Park (Site 15)

Alternative Design 1
Sixteen structures will be used to provide stability and provide continuous fish passage for all flows (low and high). The tributary across from Maryland National Capital Park and Planning will be widening to provide a shelter for fish habitat with wetland buffers.

Alternative Design 2
This reach was straightened and widened in the 1970s and much of the stream banks were armored with large rip-rap. Most of the suspended and some of bed load that efficiently move through lower portion of Indian Creek (site 11) ends in this reach causing alternating bars (sediment loading) and a shallow wide channel with no habitat features. There are five sanitary/water crossings that pose stability and fish passage issues. Seventeen structures will be used to provide stability and continuous fish passage at all flows (low and high). The tributary will be widened to provide a shelter for fish with wetland buffers. Structures will be placed at bridges to include woody material to improve potential fish habitat.

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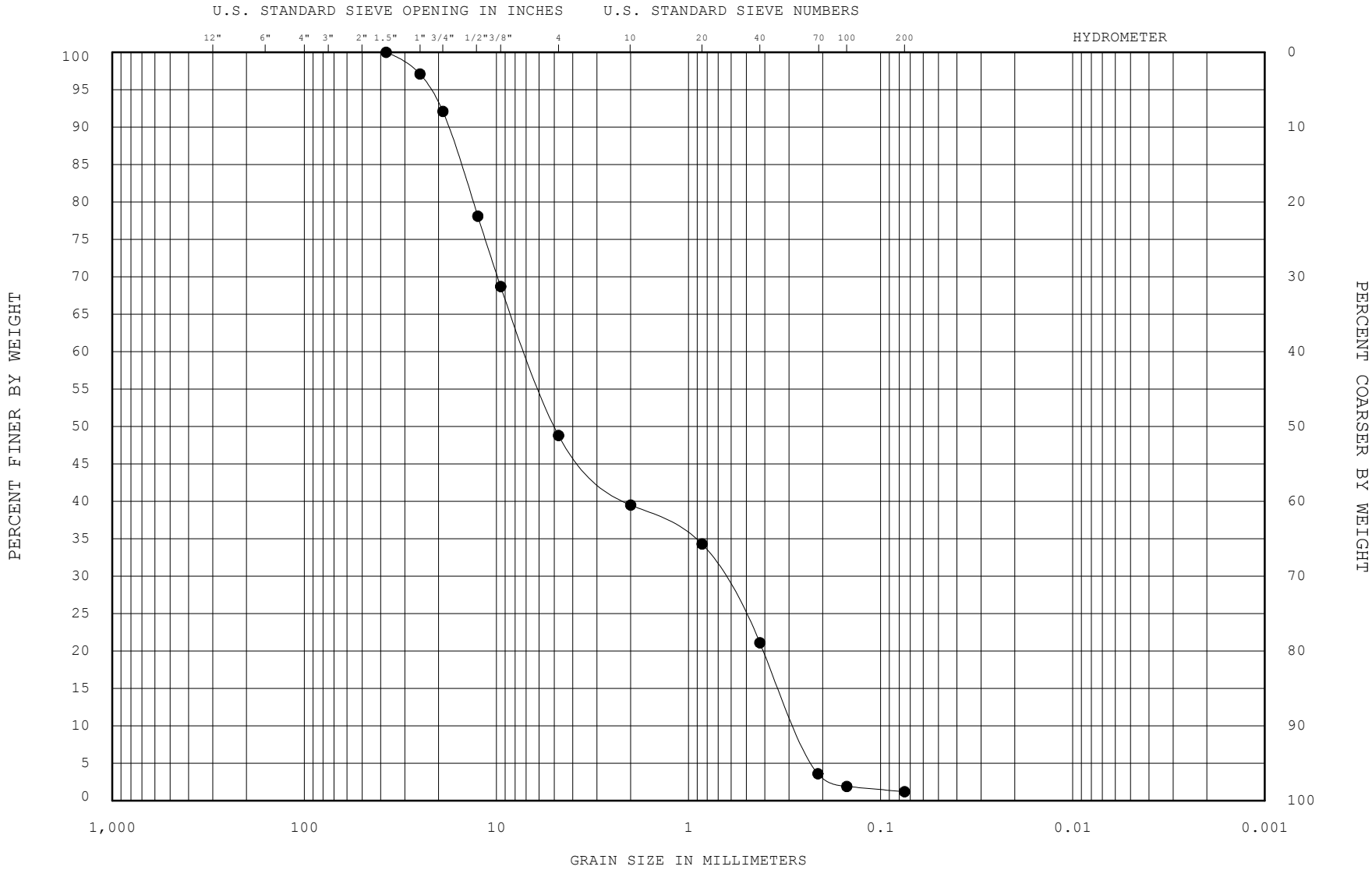
ATTACHMENT 1



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	SB-1	0.0	POORLY GRADED GRAVEL with SAND	GP				
—⊠—								
—▲—								
—★—								

REMARKS : **D84 = 16 mm** **D50 = 5 mm**

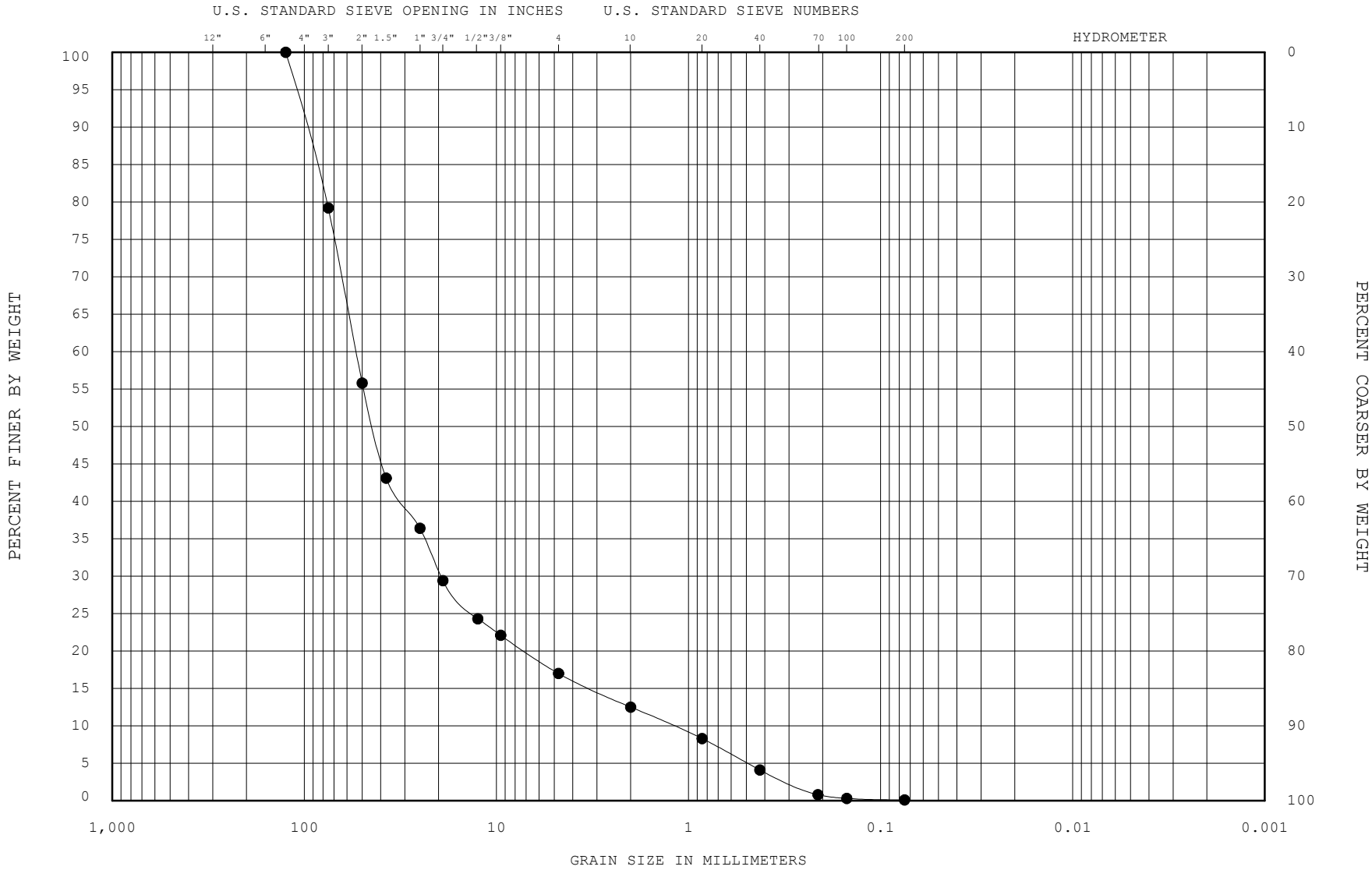
ENG FORM ENG2087 NO ATTS & DASHANACOSTIA WATERSHED PROJECT DEC 2014 **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Anacostia Watershed Project*

AREA: *Prince Georges County, MD*

Sampling Location: *Indian Creek #11*

DATE: *Dec 2014*



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	SB-1	0.0	POORLY GRADED GRAVEL with SAND	GP				
—⊠—								
—▲—								
—★—								

REMARKS : **D84 = 82 mm** **D50 = 44 mm**

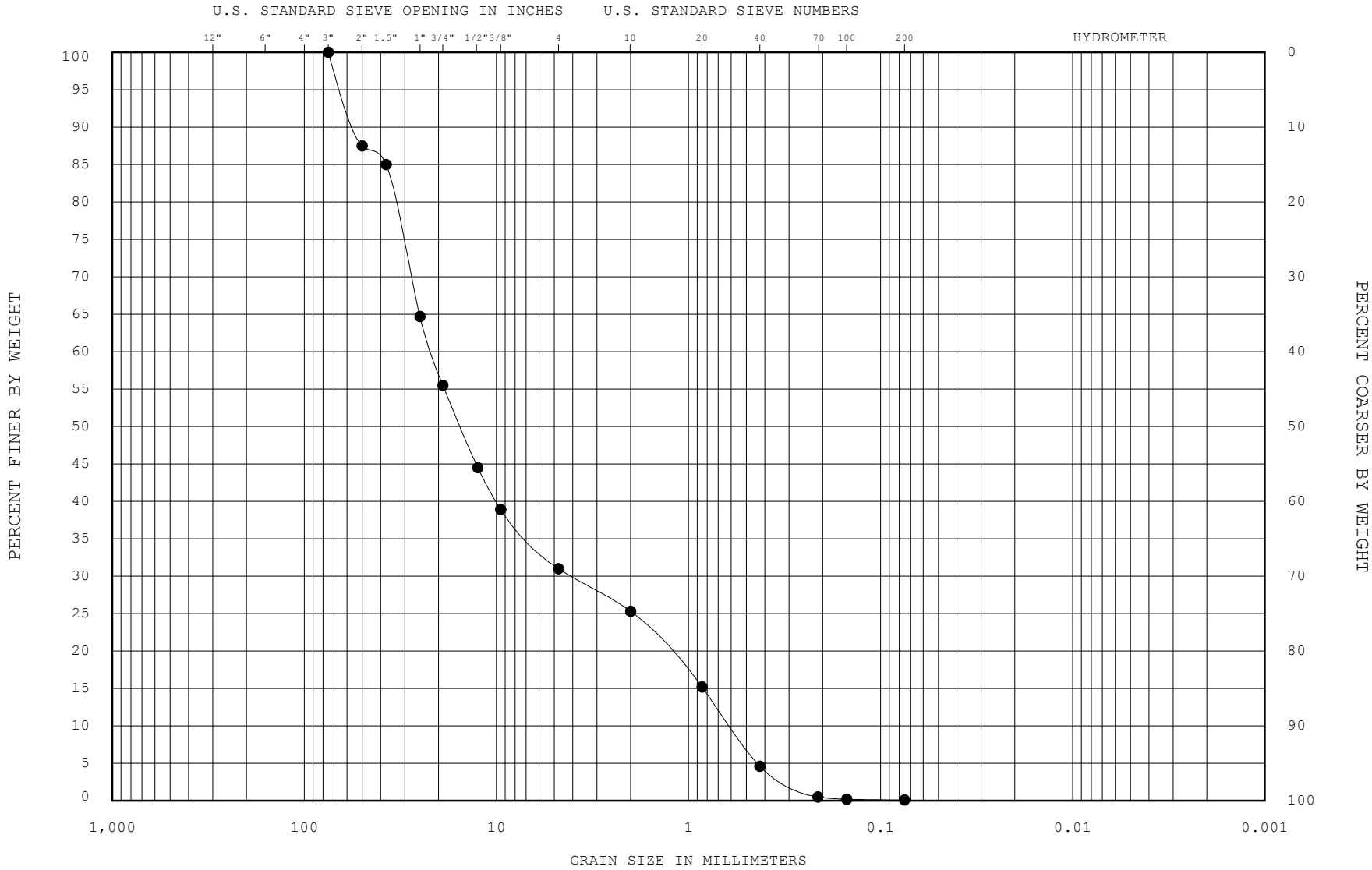
ENG FORM ENG2087 NO ATTS & DASHANACOSTIA WATERSHED PROJECT DEC 2014 **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Anacostia Watershed Project*

AREA: *Prince Georges County, MD*

Sampling Location: *Little PB*

DATE: *Dec 2014*



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	SB-1	0.0	WELL-GRADED GRAVEL with SAND	GW				
—⊠—								
—▲—								
—★—								

REMARKS : **D84 = 36 mm** **D50 = 18 mm**

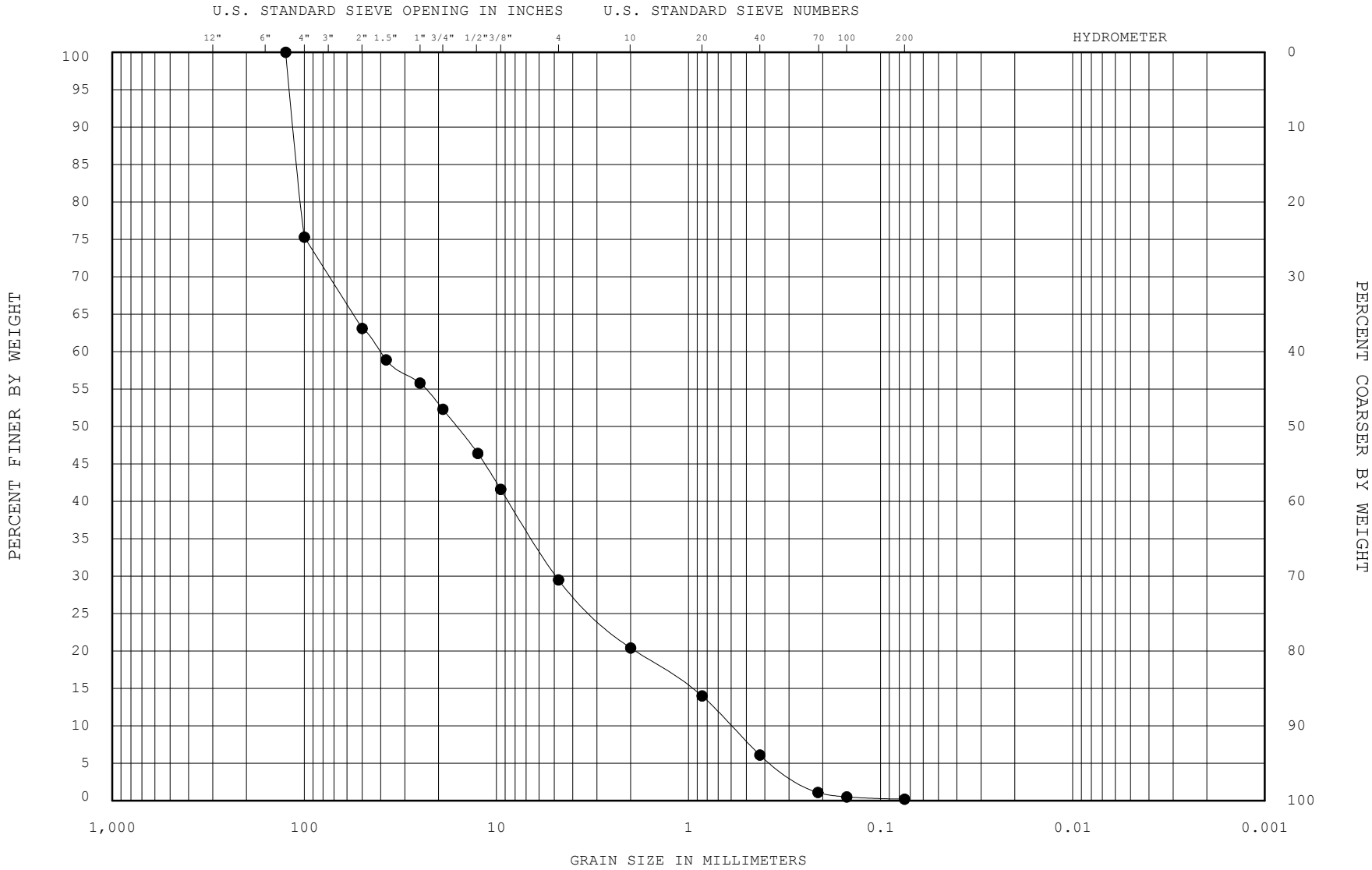
ENG FORM ENG2087 NO ATTS & DASHANACOSTIA WATERSHED PROJECT DEC 2014 **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Anacostia Watershed Project*

AREA: *Prince Georges County, MD*

Sampling Location: *NE Branch*

DATE: *Dec 2014*



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	SB-1	0.0	POORLY GRADED GRAVEL with SAND	GP				
—⊠—								
—▲—								
—★—								

REMARKS : **D84 = 120 mm** **D50 = 17 mm**

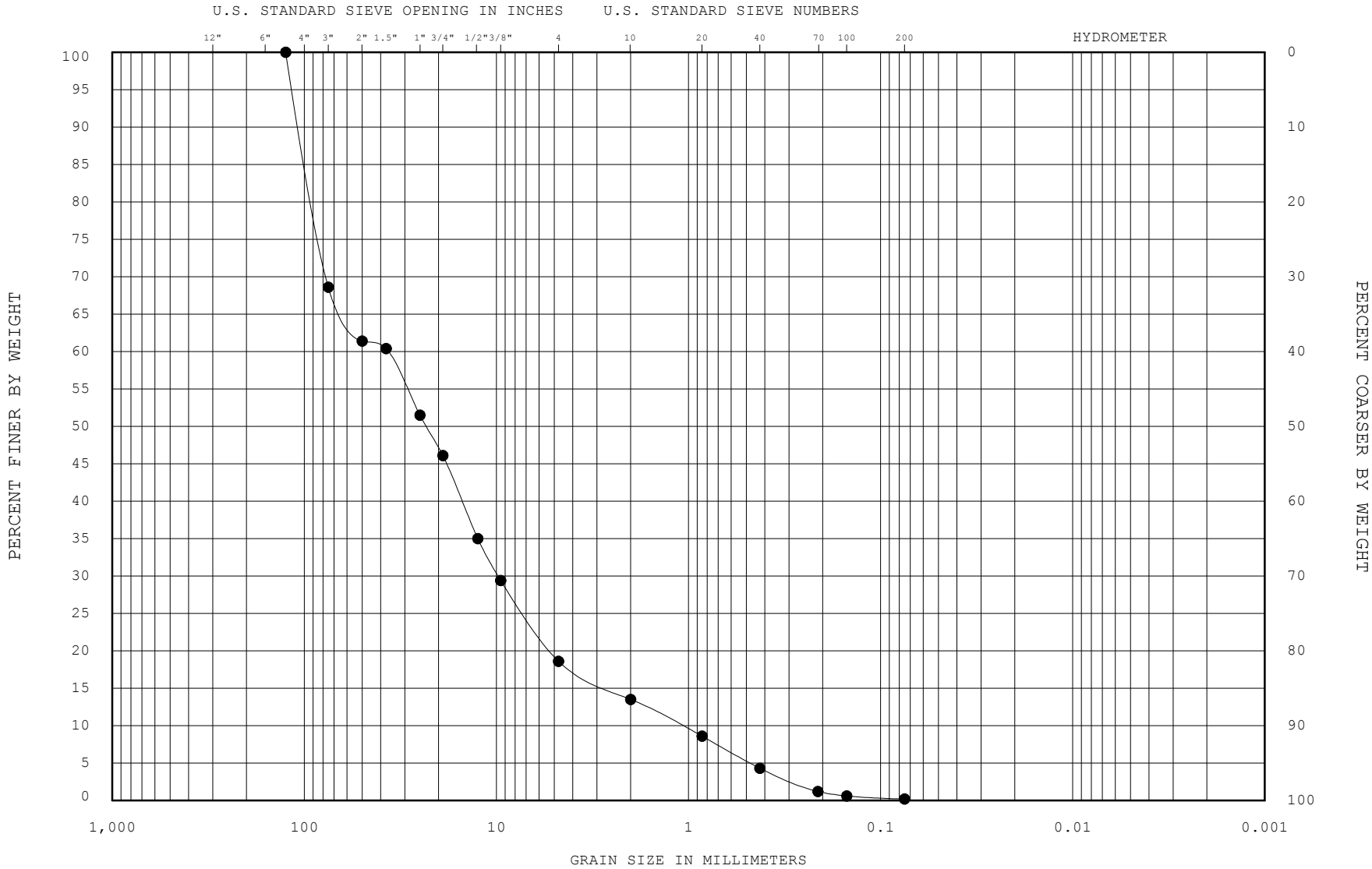
ENG FORM ENG2087 NO ATTS & DASHANACOSTIA WATERSHED PROJECT DEC 2014 **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Anacostia Watershed Project*

AREA: *Prince Georges County, MD*

Sampling Location: *NW Branch*

DATE: *Dec 2014*



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	SB-1	0.0	WELL-GRADED GRAVEL with SAND	GW				
—⊠—								
—▲—								
—★—								

REMARKS : **D84 = 100 mm** **D50 = 24 mm**

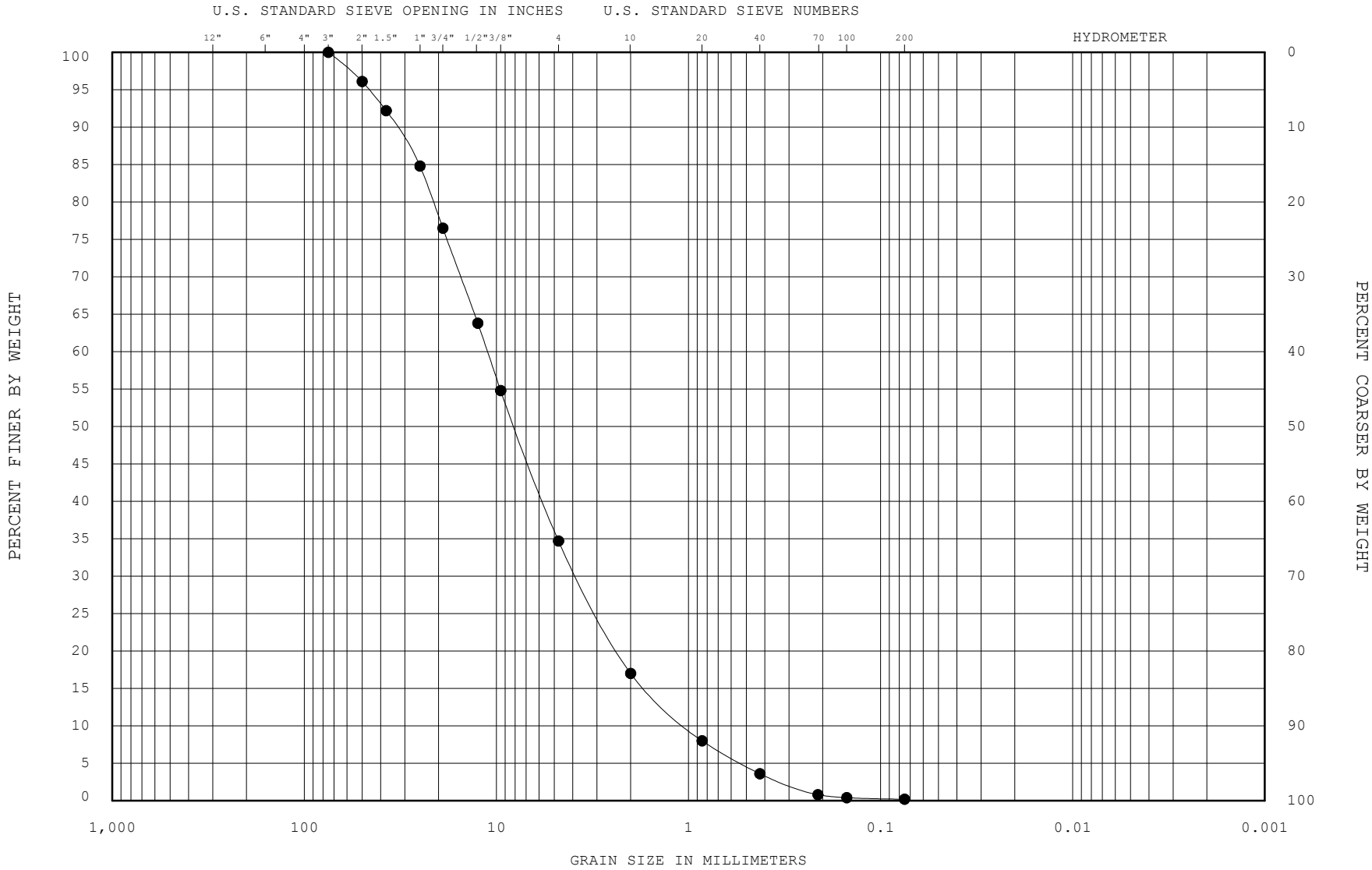
ENG FORM ENG2087 NO ATTS & DASHANACOSTIA WATERSHED PROJECT DEC 2014 **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Anacostia Watershed Project*

AREA: *Prince Georges County, MD*

Sampling Location: *PB Site #5*

DATE: *Dec 2014*



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	SB-1	0.0	WELL-GRADED GRAVEL with SAND	GW				
—⊠—								
—▲—								
—★—								

REMARKS : **D84 = 25 mm** **D50 = 8 mm**

ENG FORM ENG2087 NO ATTS & DASHANACOSTIA WATERSHED PROJECT DEC 2014 **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Anacostia Watershed Project*

AREA: *Prince Georges County, MD*

Sampling Location: *Sligo*

DATE: *Dec 2014*

Project: #3, Northwest Branch - Cross Section

Location: Prince George's County, MD

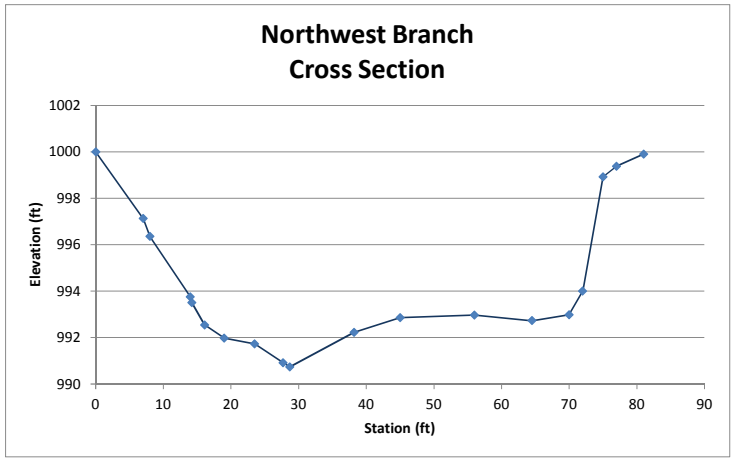
Date: 1 July, 2014

Party: BS, IB, CS

Opening along RB, shallow area at end of bend, near red and white tower

STATION (ft)	BS (ft)	HI (ft)	FS (ft)	Elevation (ft)	NOTES	
		1005.58				
0			5.58	1000		
7			8.44	997.14		
8			9.22	996.36		
14			11.82	993.76		
14.2			12.07	993.51	EOW	
16.1			13.03	992.55		
19			13.6	991.98		
23.5			13.85	991.73		
27.7			14.66	990.92		
28.7			14.84	990.74		
38.2			13.35	992.23		
45			12.72	992.86		
56			12.61	992.97		
64.5			12.85	992.73		
70			12.59	992.99		
72			11.57	994.01		
75			6.66	998.92		
77			6.2	999.38	BF	
81			5.68	999.9		

Note: Lots of sediment & fines deposited everywhere, leaves along bank coated

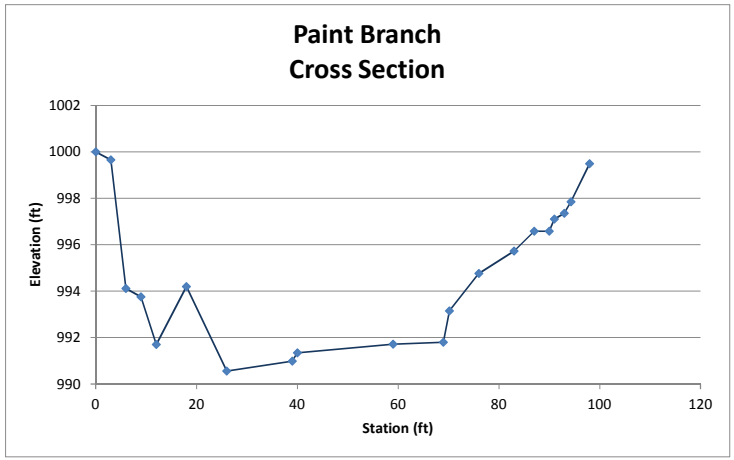


Project: #5, Paint Branch - Cross Section

Location: Prince George's County, MD
Date: 26 June, 2014
Party: BS, IB, CH, CS

Paint Branch Park off of Cherry Hill Road, several hundred feet upstream of the channelized portion

STATION (ft)	BS (ft)	HI (ft)	FS (ft)	Elevation (ft)	NOTES	
		1005.6				
0			5.6	1000		
3			5.94	999.66		
6			11.49	994.11		
9			11.84	993.76		
12			13.89	991.71	EOW	
18			11.4	994.2		
26			15.04	990.56		
39			14.61	990.99		
40			14.25	991.35		
59			13.88	991.72	EOW	
69			13.8	991.8		
70.2			12.45	993.15		
76			10.84	994.76	*	
83			9.87	995.73		
87			9.02	996.58		
90			9.02	996.58		
91			8.49	997.11		
93			8.25	997.35		
94.3			7.75	997.85		
98			6.11	999.49		
--			10.64	994.96	BF (near STA 6 but off of cross section)	



Project: #9, Sligo Creek - Cross Section

Location: Prince George's County, MD

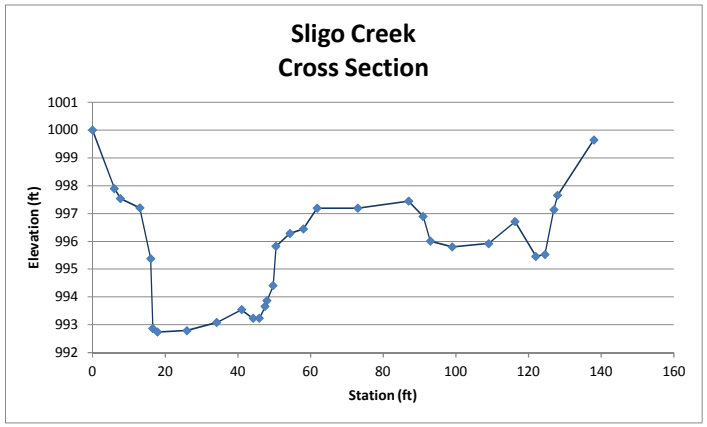
Date: 1 July, 2014

Party: BS, IB, CS

Several hundred feet US of riffle grade control/confluence

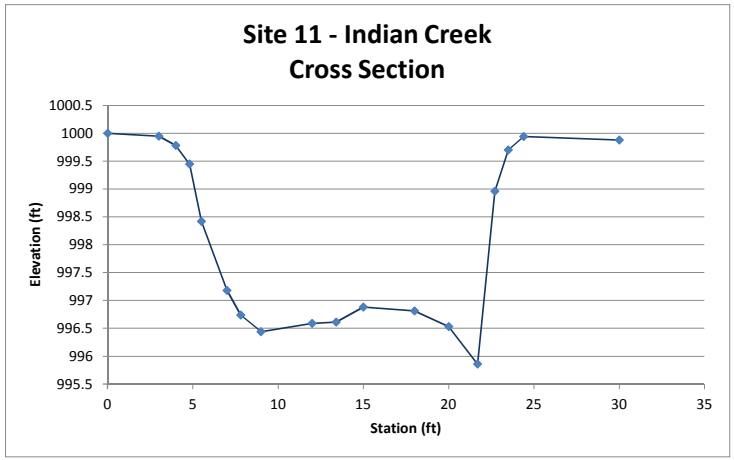
STATION (ft)	BS (ft)	HI (ft)	FS (ft)	Elevation (ft)	NOTES	
		1003.52				
0			3.52	1000		
6			5.62	997.9		
7.7			5.98	997.54		
13			6.32	997.2	BF	
16			8.14	995.38		
16.6			10.65	992.87		
17.9			10.78	992.74	TW	
26			10.73	992.79		
34.2			10.44	993.08		
41			9.98	993.54		
44.2			10.29	993.23		
45.9			10.29	993.23		
47.5			9.86	993.66		
48			9.65	993.87	EOW	
49.7			9.11	994.41		
50.5			7.7	995.82		
54.3			7.24	996.28		
58			7.08	996.44		
61.8			6.33	997.19	BF	
73			6.33	997.19		
87			6.07	997.45		
91			6.63	996.89		
93			7.51	996.01		
99			7.72	995.8		
109			7.6	995.92		
116.3			6.81	996.71		
122			8.06	995.46		
124.5			8	995.52		
127			6.38	997.14		
128			5.87	997.65	Bench, goes up from here 10h, 2v	
138			3.87	999.65	(estimated from previous notation)	

Note: Lots of sandy/silty deposition
Lots of negotiation



Project: #11, Indian Creek - APG - Cross Section
Location: Prince George's County, MD
Date: 27 June, 2014
Party: BS, IB, CH, CS

STATION (ft)	BS (ft)	HI (ft)	FS (ft)	Elevation (ft)	NOTES	
		1005.83				
0			5.83	1000		
3			5.88	999.95		
4			6.05	999.78	BF	
4.8			6.38	999.45		
5.5			7.41	998.42		
7			8.65	997.18		
7.8			9.09	996.74	EOW	
9			9.39	996.44		
12			9.24	996.59		
13.4			9.22	996.61	gravel start	
15			8.95	996.88		
18			9.02	996.81	gravel end	
20			9.3	996.53		
21.7			9.97	995.86		
22.7			6.87	998.96		
23.5			6.13	999.7		
24.4			5.89	999.94	BF	
30			5.95	999.88		



Project: #12, Little Paint Branch - Cross Section

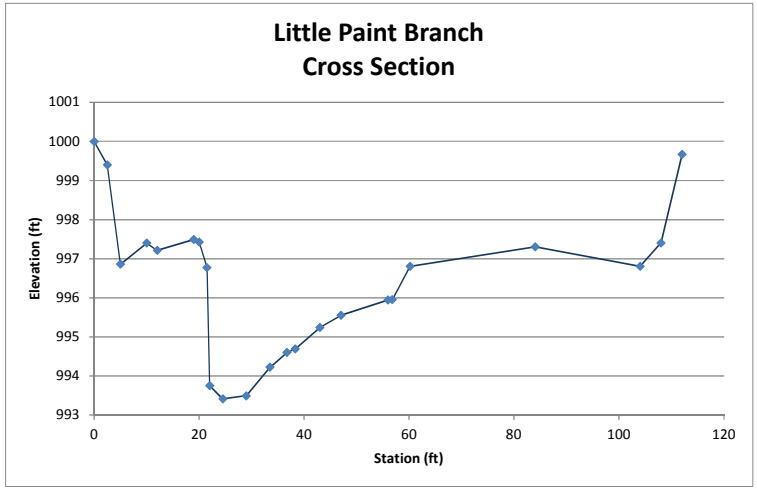
Location: Prince George's County, MD

Date: 16 June, 2014

Party: BS, IB, CS

Paint Branch Park off of Cherry Hill Road, several hundred feet upstream of the channelized portion

STATION (ft)	BS (ft)	HI (ft)	FS (ft)	Elevation (ft)	NOTES	
		1005.65				
0			5.65	1000		
2.5			6.25	999.4		
5			8.79	996.86		
10			8.25	997.4	Bankfull	
12			8.44	997.21		
19			8.16	997.49		
20			8.22	997.43		
21.5			8.88	996.77	Top of bank	Range from cobble and large gravel to smaller gravel as go across the stream
22			11.9	993.75		
24.5			12.24	993.41	Thalweg	
29			12.16	993.49		
33.5			11.43	994.22		
36.7			11.05	994.6		
38.3			10.96	994.69	Edge of water	
43			10.41	995.24	End of gravel/cobble, begin sand	
47			10.1	995.55		
56			9.71	995.94		
56.8			9.7	995.95	Edge of vegetation, begin bank	
60.2			8.85	996.8		
84			8.35	997.3		Estimated
104			8.85	996.8	Toe of slope	
108			8.25	997.4	Bankfull	
112			5.98	999.67	Top of Slope	



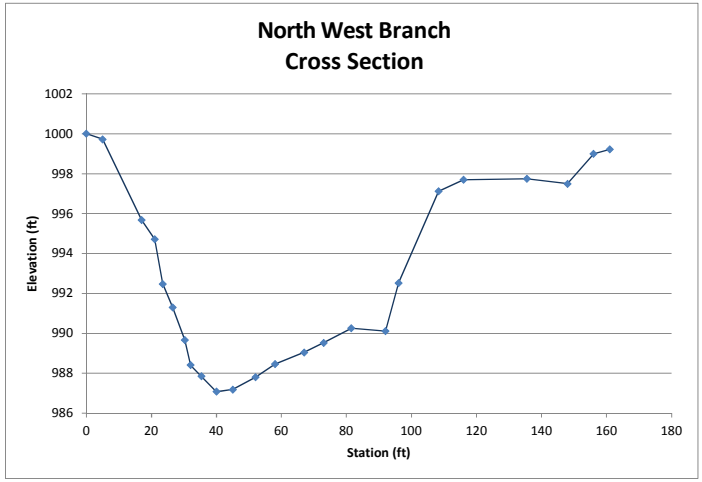
Project: #18, North West Branch - Cross Section

Location: Prince George's County, MD
Date: 13 Nov 2014
Party: BS, IB

Behind MNCPP office

STATION (ft)	BS (ft)	HI (ft)	FS (ft)	Elevation (ft)		
		1005.64				
0			5.64	1000		
5			5.92	999.72	begin riprap	
17			9.97	995.67	very defined bench, bankfull	
21			10.93	994.71		
23.5			13.17	992.47		
26.5			14.35	991.29		
30.3			15.98	989.66	WSE, still on riprap	
32			17.23	988.41		
35.4			17.79	987.85		
40			18.57	987.07	end of riprap	
45			18.46	987.18	sand and gravel	
52			17.84	987.8		
58			17.18	988.46		
67			16.6	989.04		
73			16.12	989.52	edge of water	pea gravel and mostly course sand
81.5			15.39	990.25		
92			15.53	990.11	toe of slope	
96			13.12	992.52	some trees, but bank mostly soft sand from here to top of bank	
108.3			8.53	997.11	top of bank	
116			7.95	997.69		
135.5			7.9	997.74		
148			8.15	997.49		
156			6.65	998.99		
161			6.43	999.21		

Note: Tape was sagging roughly 5' at the center for stations 17 through 108.3. Difference at 108.3' was noted to be roughly 1', corrections were not made.



SURVEY DATA → CROSS - SECTION 1

SITE: #3 NW Branch Date: 7/14

Location: over RB, shallow area @ end of [illegible]

Party / Notes: BS CS - B HUC:

Item	Distance, Point, or STATION Ft.	Back-Sight BS Ft.	Height of Instrument HI Ft.	Fore-Sight FS Ft.	Elevation Ft.	NOTES / COMMENT / REMARKS
1	6			5.58		
2	7			7.44		
3	8			9.22		
4	11			11.52		
5	14.2			12.07		EOW
6	16.1			13.03		
7	19			13.60		
8	23.5			13.25		
9	27.7			14.46		
10	35.7			14.81		
11	38.2			13.35		
12	45			12.72		
13	56			12.61		
14	64.5			12.85		
15	70			12.59		
16	72			12.57		
17	75			6.66		
18	77			6.20		OF
19	81			5.60		Lots of sed after [illegible] Curve 3 Control
20						
21						
22						
23						
24						
25						
26						
27						
28						

Reach 5

SURVEY DATA → CROSS - SECTION 2

SITE: Date:

Item	STATION Ft.	BS Ft.	HI Ft.	FS Ft.	Elevation Ft.	NOTES / COMMENT / REMARKS
29						
30						
31						
32						
33			Profile from Pop			
34						
35						
36						
37						
38						
39						
40						
41						
42						
43						
44						
45						
46						
47						
48						
49						
50						
51						
52						
53						
54						
55						
56						
57						
58						

Reach 5

SURVEY DATA → LONGITUDINAL PROFILE 1

SITE: # 5 CROSS SECTION Date: 06/26/14

Location: PAINT BRANCH

Party / Notes: HUC:

Item	Distance, Point, or STATION Ft.	Back-Sight BS Ft.	Height of Instrument HI Ft.	Fore-Sight FS Ft.	Elevation Ft.	NOTES / COMMENT / REMARKS
1	0				5.60	
2	3				5.94	
3	6				11.49	
4	7				10.64	BF Elevation
5	9				11.84	
6	12				13.89	EOW
7	18				11.40	
8	26				15.04	
9	39				14.61	
10	40				14.25	
11	59				13.88	EOW
12	69				13.80	
13	70.2				12.45	
14	76				10.84*	
15	83				9.87	
16	87				9.02	
17	90				9.02	
18	91				8.49	
19	93				8.25	
20	94.3				7.75	
21	98				6.11	
22						
23						
24						
25						
26						
27						
28						

Reach 5

SURVEY DATA → LONGITUDINAL PROFILE 2

SITE: Date:

Item	STATION Ft.	BS Ft.	HI Ft.	FS Ft.	Elevation Ft.	NOTES / COMMENT / REMARKS
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						
40						
41						
42						
43						
44						
45						
46						
47						
48						
49						
50						
51						
52						
53						
54						
55						
56						
57						
58						

Reach 5

SURVEY DATA → ~~LONGITUDINAL PROFILE 1~~

SITE: # 9 Sligo Creek Date: 7/1/14

Location: [illegible]

Party / Notes: BS CS JS HUC:

Item	Distance, Point, or STATION Ft.	Back-Sight BS Ft.	Height of Instrument HI Ft.	Fore-Sight FS Ft.	Elevation Ft.	NOTES / COMMENT / REMARKS
1	0			3.52		
2	6			5.62		
3	7.7			5.98		
4	13			6.32		BF
5	16			8.14		
6	16.6			10.45		
7	17.9			10.78		TW
8	26			10.73		
9	34.2			10.41		
10	41			9.98		
11	41.2			10.29		
12	45.9			10.29		
13	47.5			9.86		
14	48			9.85		EGW
15	49.7			9.11		
16	50.5			7.7		
17	54.3			7.04		
18	58			7.58		
19	61.8			6.33		BF
20	73			6.33		
21	87			6.07		
22	91			6.63		Lots of [illegible]
23	93			7.51		deep [illegible]
24	99			7.10		Lots of negotiation
25	109			7.60		
26	116.3			6.81		
27	122			8.86		
28	124.5			6.90		

Reach 5

SURVEY DATA → ~~LONGITUDINAL PROFILE~~

SITE: Date:

Item	STATION Ft.	BS Ft.	HI Ft.	FS Ft.	Elevation Ft.	NOTES / COMMENT / REMARKS
29	127			6.38		
30	126.6			5.67		Bench
31						goes up from here
32						& 6h 2v
33						
34						
35	322.5			8.11		Fish blockage
36	measured				50 ft	(Sustainable grade)
37	& ⊥ to blockage					(gravel)
38	not clear if there is hinge					
39						
40						
41						
42						
43		Profile from top				
44						
45						
46						
47						
48						
49						
50						
51						
52						
53						
54						
55						
56						
57						
58						

Reach 5

CROSS SECTION #1

SURVEY DATA → ~~LONGITUDINAL PROFILE 1~~

SITE: #11 Date: 06/27/14

Location: INDIAN CREEK - ADG

Party / Notes: HUC:

Item	Distance, Point, or STATION Ft.	Back-Sight BS Ft.	Height of Instrument HI Ft.	Fore-Sight FS Ft.	Elevation Ft.	NOTES / COMMENT / REMARKS
1	0				5.83	
2	3				5.88	
3	4				6.05	BF_elevation
4	4.8				6.38	
5	5.5				7.41	
6	7				8.65	
7	7.8				9.09	COW
8	9				9.39	
9	12				9.24	
10	13.4				9.22	Gravel start
11	15				8.95	
12	18				9.02	Gravel end
13	20				9.30	
14	21.7				9.97	
15	22.7				6.87	
16	23.5				6.13	
17	24.4				5.89	Bankfull_elev
18	30				5.95	
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						

Reach 5

SURVEY DATA → ~~LONGITUDINAL PROFILE 2~~

SITE: #11 PROFILE Date: 06/27/14

Item	STATION Ft.	BS Ft.	HI Ft.	FS Ft.	Elevation Ft.	NOTES / COMMENT / REMARKS
29	84				8.7	Top of riffle
30	72				9.56	
31	54				10.21	Pool
32	34				9.91	Beg glide
33	24				9.39	@Cross Section Top of
34						
35						
36						
37						
38						
39						
40						
41						
42						
43						
44						
45						
46						
47						
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49						
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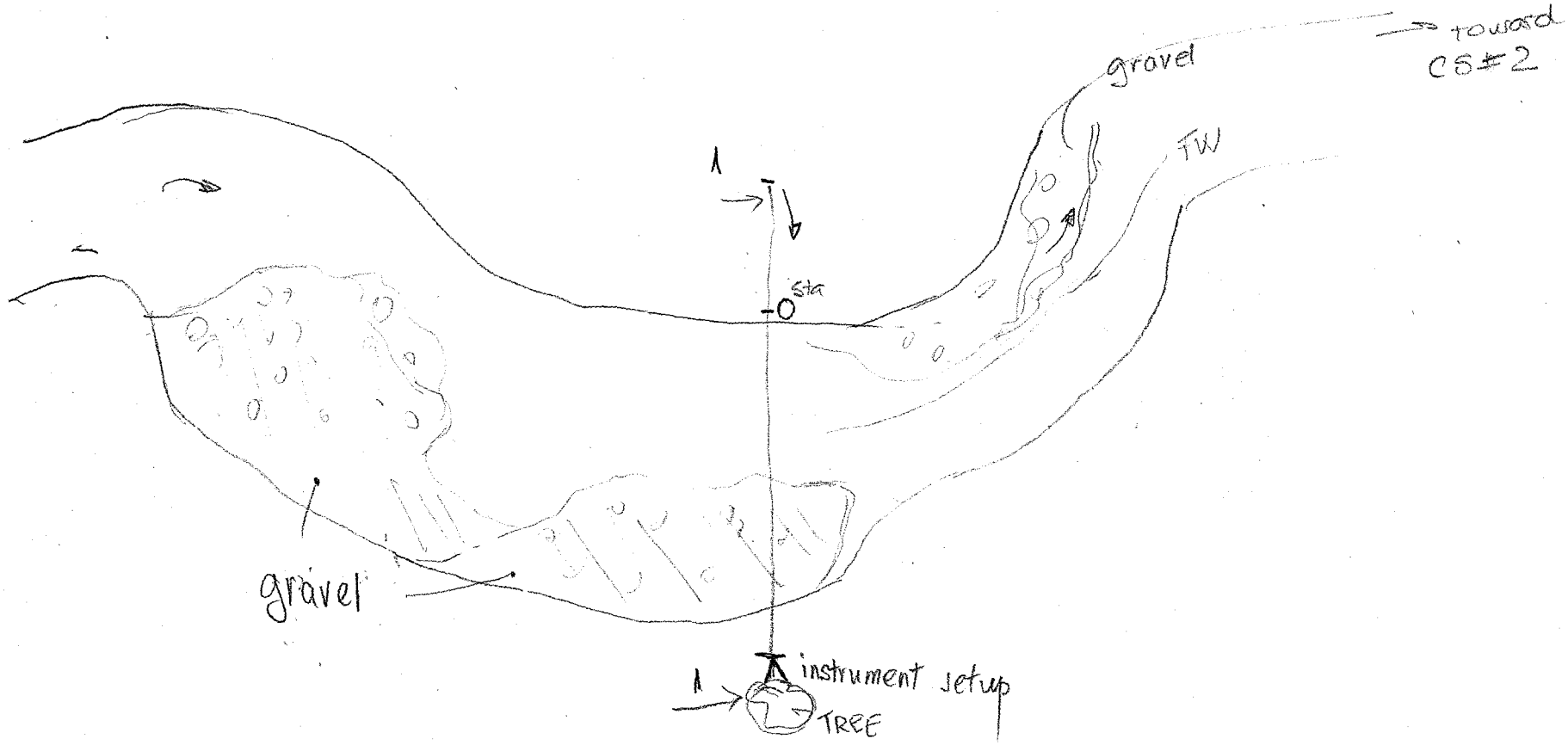
53						
54						
55						
56						
57						
58						

Reach 5


toward
CS#2
gravel
TW
sta
gravel
instrument setup
TREE

CROSS SECTION #2

SURVEY DATA ⟶ ~~LONGITUDINAL PROFILE 1~~

SITE: #11 Date: 06/27/14

Location: INDIAN CREEK - APG

Party / Notes: HUC:

Item	Distance, Point, or STATION Ft.	Back-Sight BS Ft.	Height of Instrument HI Ft.	Fore-Sight FS Ft.	Elevation Ft.	NOTES / COMMENT / REMARKS
1	54				5.65	
2	53.0				6.02	BF
3	52				6.76	
4	51.4				8.44	
5	50.5				8.88	
6	47.7				9.20	
7	47.5				9.25	EOW
8	45.8				9.42	
9	45				9.49	
10	44.4				9.46	
11	44				7.65	
12	42.2				6.45	BF
13	38				6.44	
14	22				6.69	
15	5				6.05	
16	0				5.85	
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						

Reach 5

Note

SURVEY DATA ⟶ LONGITUDINAL PROFILE 2

SITE: Date:

Item	STATION Ft.	BS Ft.	HI Ft.	FS Ft.	Elevation Ft.	NOTES / COMMENT / REMARKS
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						
40						
41						
42						
43						
44						
45						
46						
47						
48						
49						
50						
51						
52						
53						
54						
55						
56						
57						
58						

0 on tape = Station 30

Reach 5

SURVEY DATA → CROSS - SECTION 1

SITE: NW Branch, Site 18 Date: 11/13/14

Location: Behind MNCPP office

Party / Notes: BS, IB HUC:

Item	STATION (Distance, Point, or) Ft.	BS (Back-Sight) Ft.	HI (Height of Instrument) Ft.	FS (Fore-Sight) Ft.	Elevation Ft.	NOTES / COMMENT / REMARKS
1	0			5.64		
2	5			5.92		begin riprap
3	17			9.97		very defined bench, possible
4	21			10.93		
5	23.5			13.17		
6	26.5			14.35		
7	30.3			15.98		WSE, still on riprap
8	32			17.23		
9	35.4			17.79		~~end of riprap~~
10	40			18.57		end of riprap
11	45			18.46		sand & gravel
12	52			17.84		
13	58			17.18		
14	67			16.60		
15	73			16.12		EOW, start
16	81.5			15.39		pea gravel & mostly coarse sand
17	92			15.55		toe of slope
18	96			13.12		shrub at trees, but bank
19	108.3			8.53		mostly soft sand
20						bankpoint
21	116			7.95		
22	135.5			7.90		
23	148			8.15		
24	156			6.65		
25	161			6.43		
26						
27						
28						

w/ SGS

(Bankfull Not Found)

Reach 5

SURVEY DATA → CROSS - SECTION 2

SITE: Date:

Item	STATION Ft.	BS Ft.	HI Ft.	FS Ft.	Elevation Ft.	NOTES / COMMENT / REMARKS
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						
40						
41						
42						
43						
44						
45						
46						
47						
48						
49						
50						
51						
52						
53						
54						
55						
56						
57						
58						

Reach 5

ATTACHMENT 2

GIS shapefiles of existing and water and sanitary sewer lines and manholes were provided by Prince George's County in 2014 and 2015. Other utilities may be present.

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Baltimore District

ANACOSTIA WATERSHED RESTORATION
PRINCE GEORGE'S COUNTY, MD

Concept Level Design

Indian Creek (Site 1)

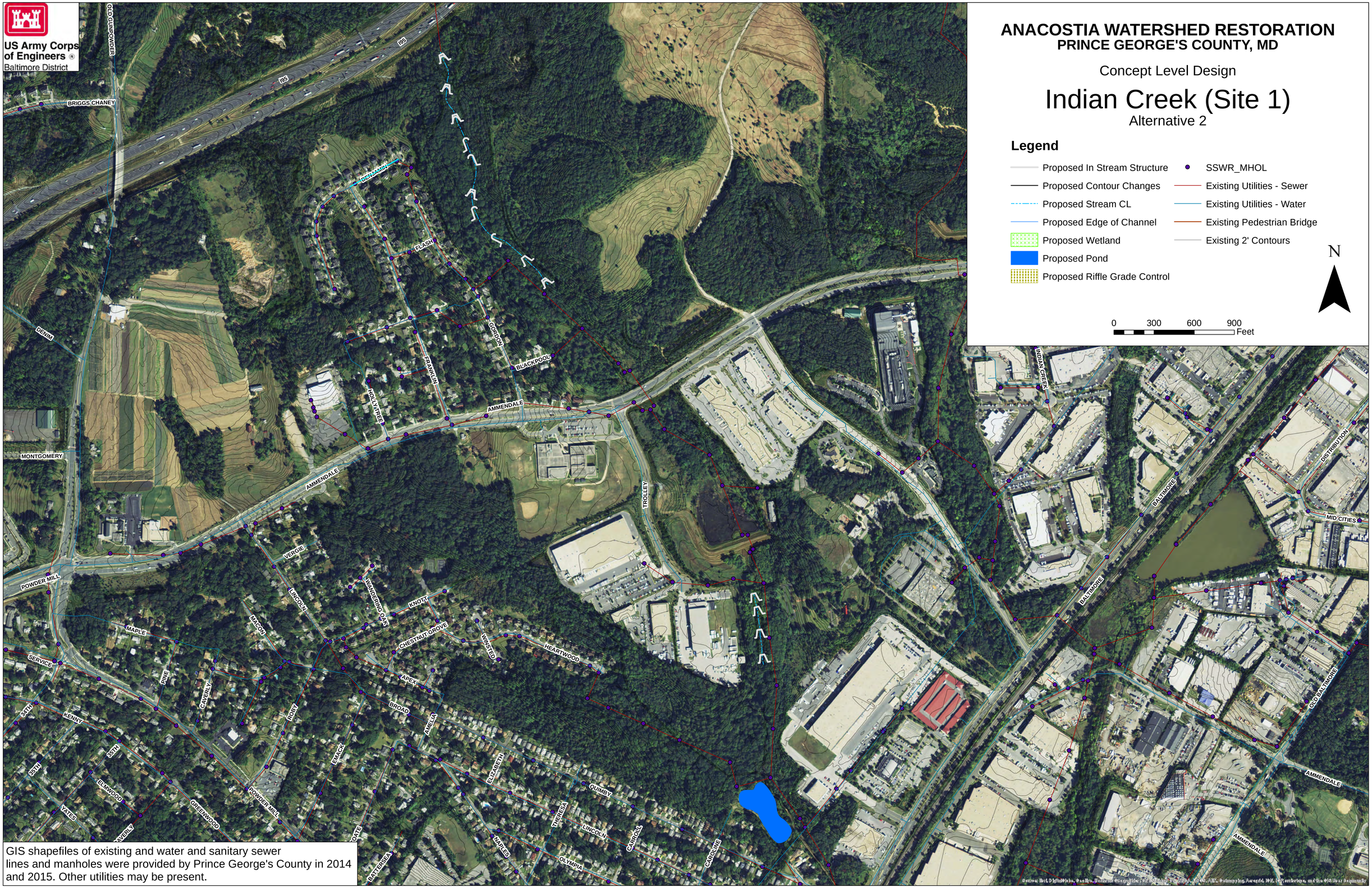
Alternative 2

Legend

- Proposed In Stream Structure
- Proposed Contour Changes
- Proposed Stream CL
- Proposed Edge of Channel
- Proposed Wetland
- Proposed Pond
- Proposed Riffle Grade Control
- SSWR_MHOL
- Existing Utilities - Sewer
- Existing Utilities - Water
- Existing Pedestrian Bridge
- Existing 2' Contours

N

0 300 600 900 Feet



GIS shapefiles of existing and water and sanitary sewer lines and manholes were provided by Prince George's County in 2014 and 2015. Other utilities may be present.

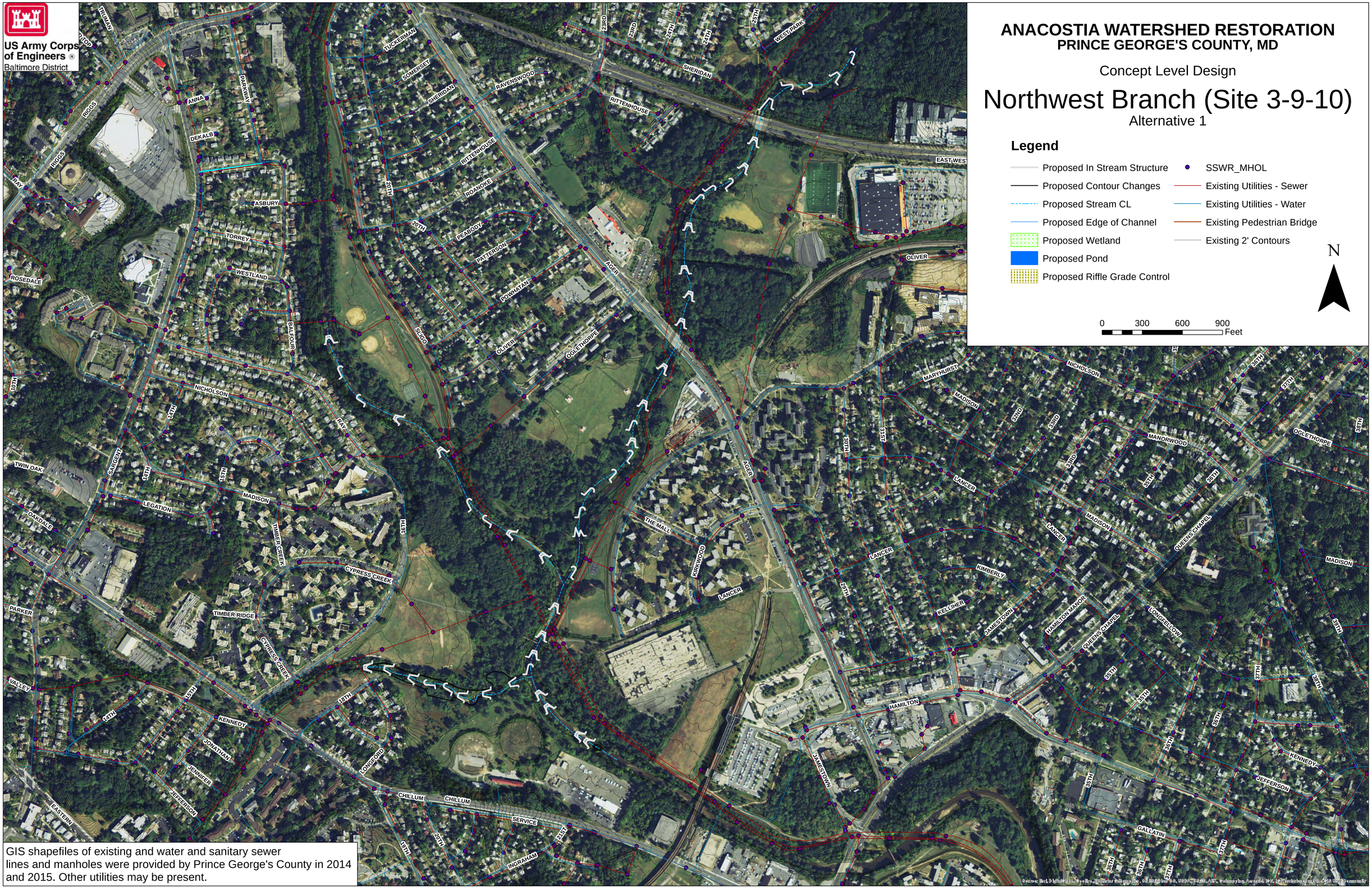
US Army Corps of Engineers ®
Baltimore District

ANACOSTIA WATERSHED RESTORATION
PRINCE GEORGE'S COUNTY, MD

Concept Level Design

Northwest Branch (Site 3-9-10)

Alternative 1



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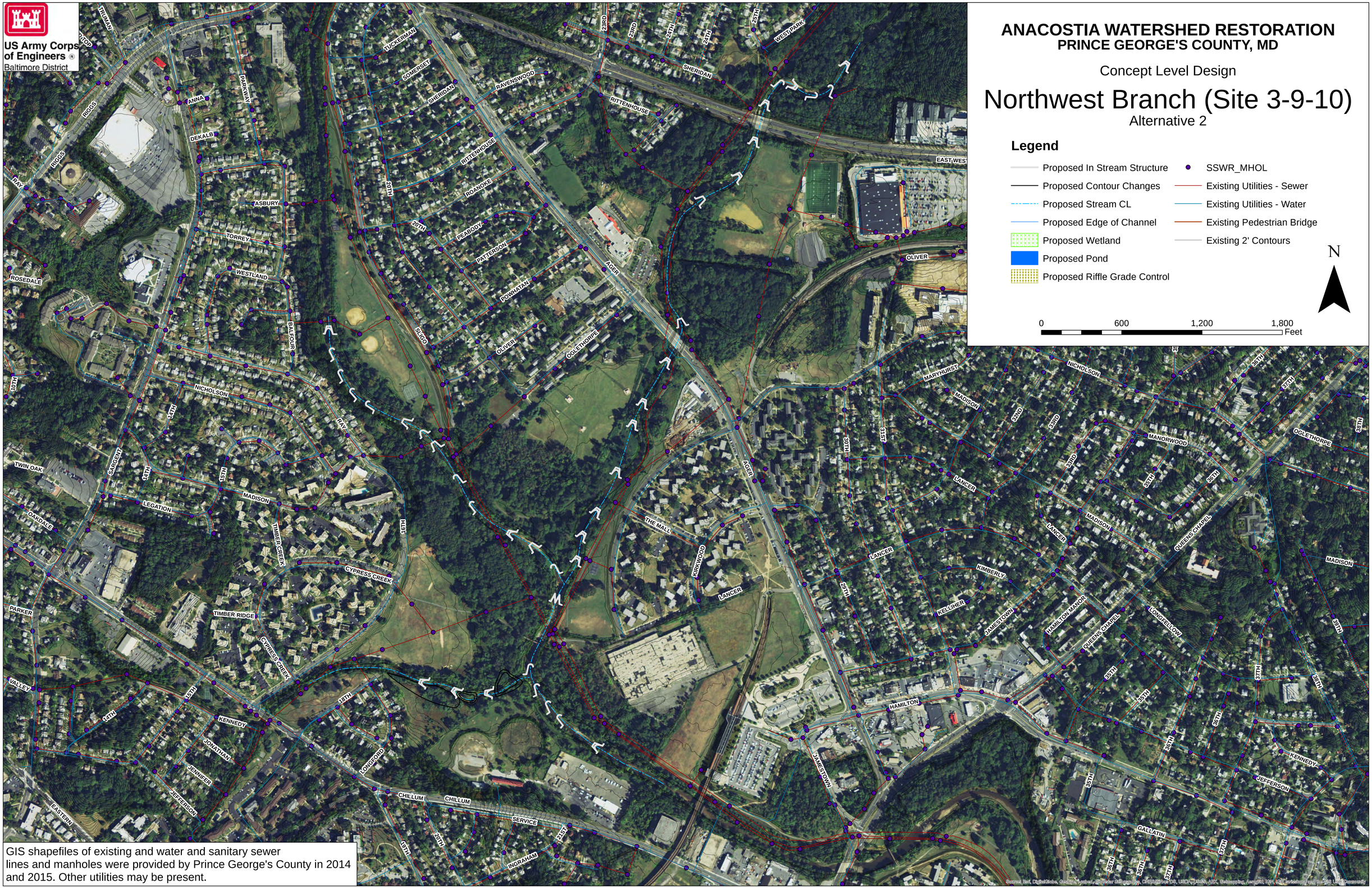
Baltimore District

ANACOSTIA WATERSHED RESTORATION
PRINCE GEORGE'S COUNTY, MD

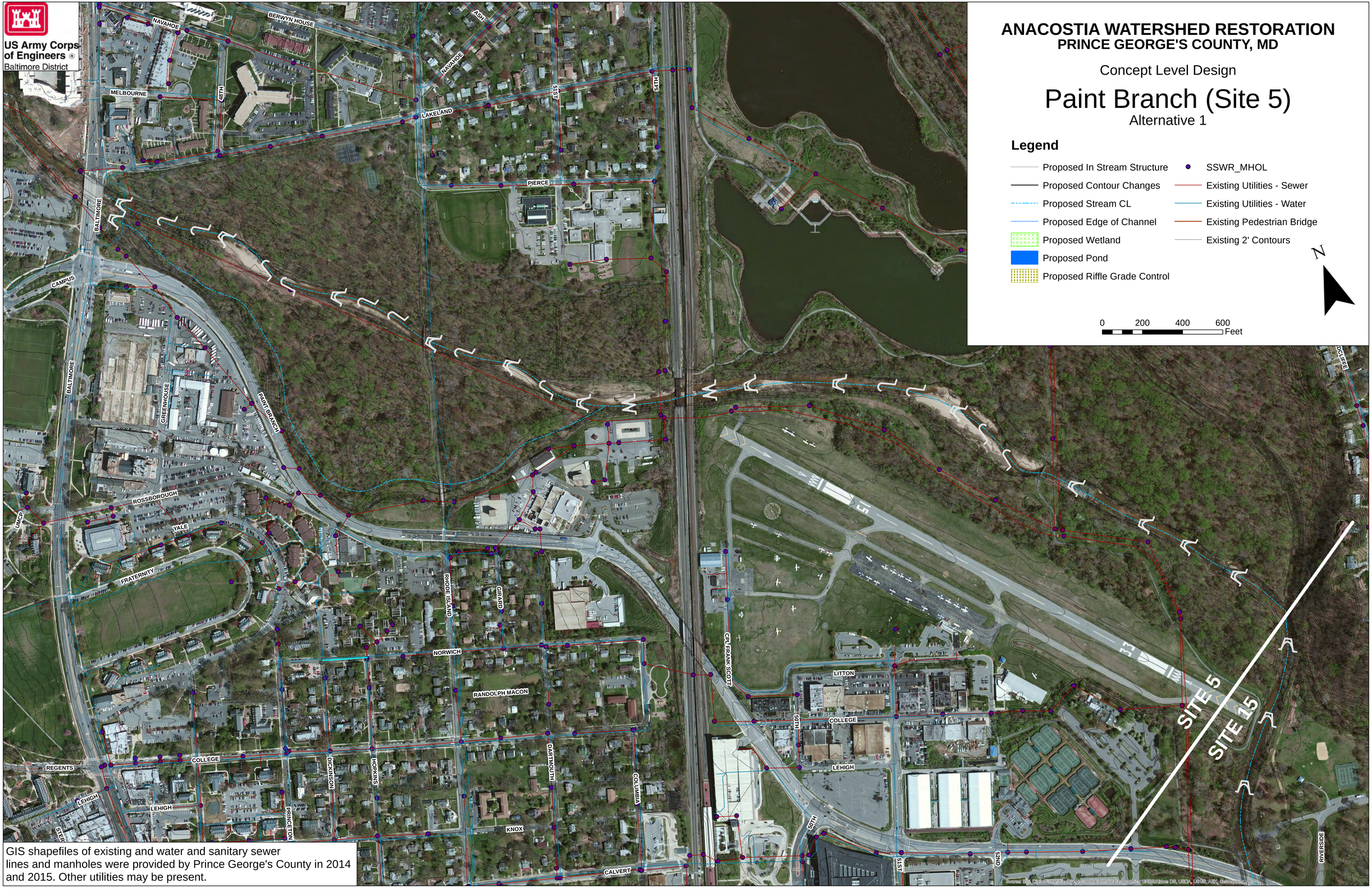
Concept Level Design

Northwest Branch (Site 3-9-10)

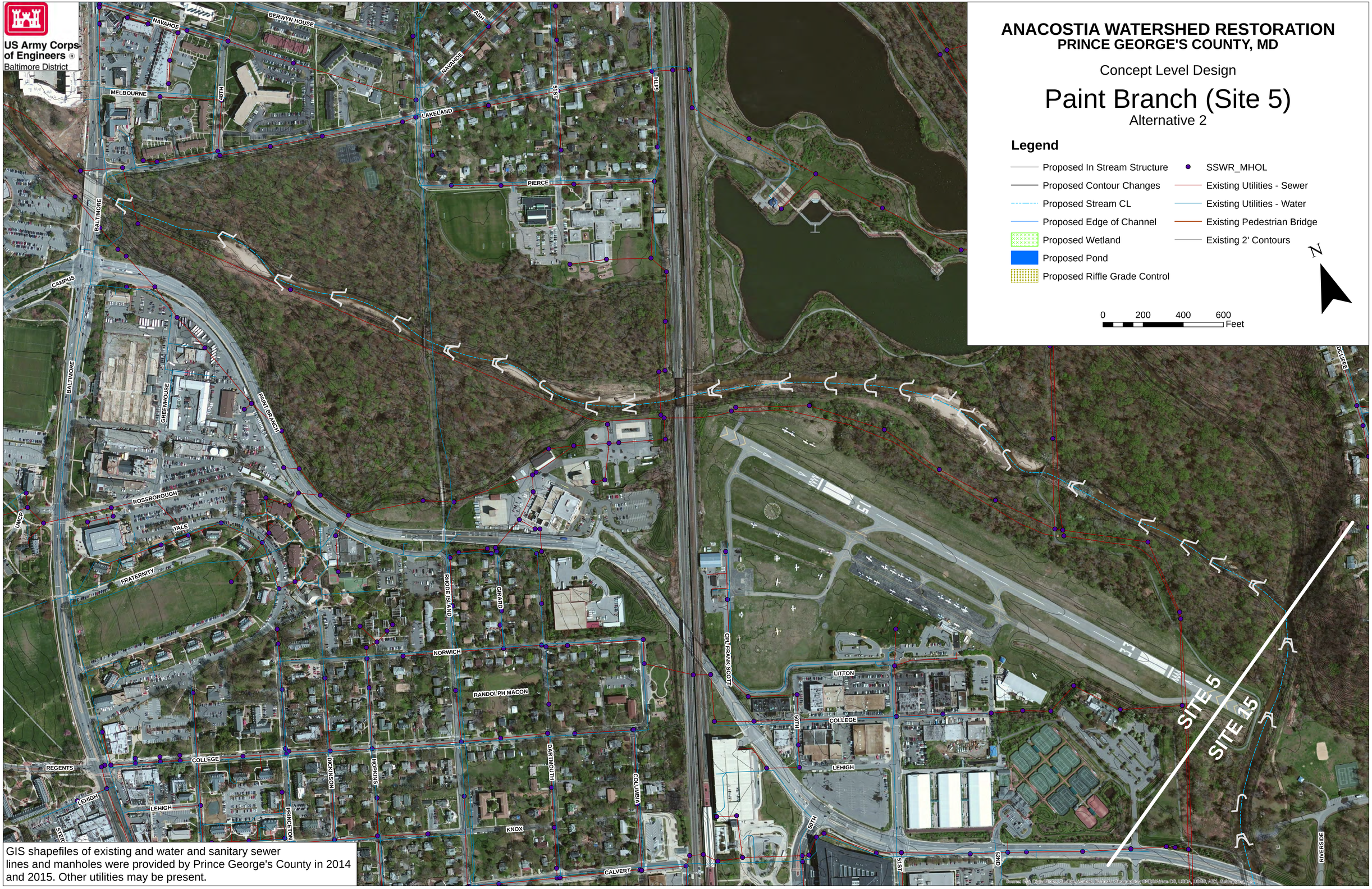
Alternative 2



GIS shapefiles of existing and water and sanitary sewer lines and manholes were provided by Prince George's County in 2014 and 2015. Other utilities may be present.



GIS shapefiles of existing and water and sanitary sewer lines and manholes were provided by Prince George's County in 2014 and 2015. Other utilities may be present.


US Army Corps of Engineers
Baltimore District
ANACOSTIA WATERSHED RESTORATION
PRINCE GEORGE'S COUNTY, MD
Concept Level Design
Paint Branch (Site 5)
Alternative 2
Legend
Proposed In Stream Structure
Proposed Contour Changes
Proposed Stream CL
Proposed Edge of Channel
Proposed Wetland
Proposed Pond
Proposed Riffle Grade Control
SSWR_MHOL
Existing Utilities - Sewer
Existing Utilities - Water
Existing Pedestrian Bridge
Existing 2' Contours
N
0 200 400 600
Feet
NAVAHOE
BERWYN HOUSE
MELBOURNE
LAKELAND
PIERCE
BALTIMORE
CAMPUS
GREENHOUSE
PAINT BRANCH
ROSSBOROUGH
YALE
FRATERNITY
NORWICH
RANDOLPH MACON
COLLEGE
REGENTS
LEHIGH
KNOX
CALVERT
RHODE ISLAND
GRADY
DICKINSON
HOPKINS
PRINCETON
DARTMOUTH
COLUMBIA
GPL FRANK SCOTT
LITTON
RIVERSIDE
SITE 5
SITE 15
GIS shapefiles of existing and water and sanitary sewer lines and manholes were provided by Prince George's County in 2014 and 2015. Other utilities may be present.

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Baltimore District

ANACOSTIA WATERSHED RESTORATION
PRINCE GEORGE'S COUNTY, MD

Concept Level Design

Paint Branch (Site 7)

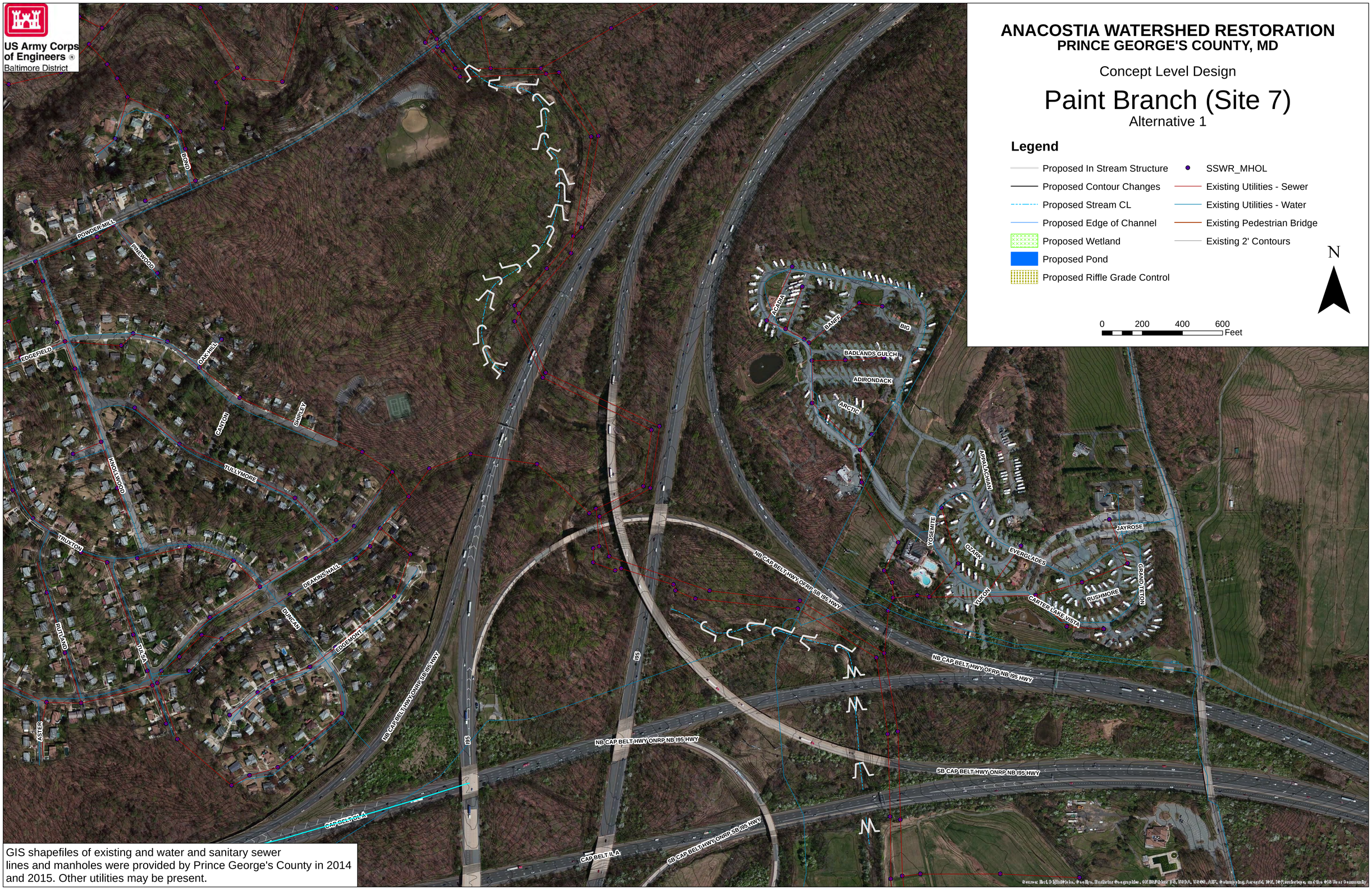
Alternative 1

Legend

- Proposed In Stream Structure
- Proposed Contour Changes
- Proposed Stream CL
- Proposed Edge of Channel
- Proposed Wetland
- Proposed Pond
- Proposed Riffle Grade Control
- SSWR_MHOL
- Existing Utilities - Sewer
- Existing Utilities - Water
- Existing Pedestrian Bridge
- Existing 2' Contours

N

0 200 400 600 Feet



GIS shapefiles of existing and water and sanitary sewer lines and manholes were provided by Prince George's County in 2014 and 2015. Other utilities may be present.

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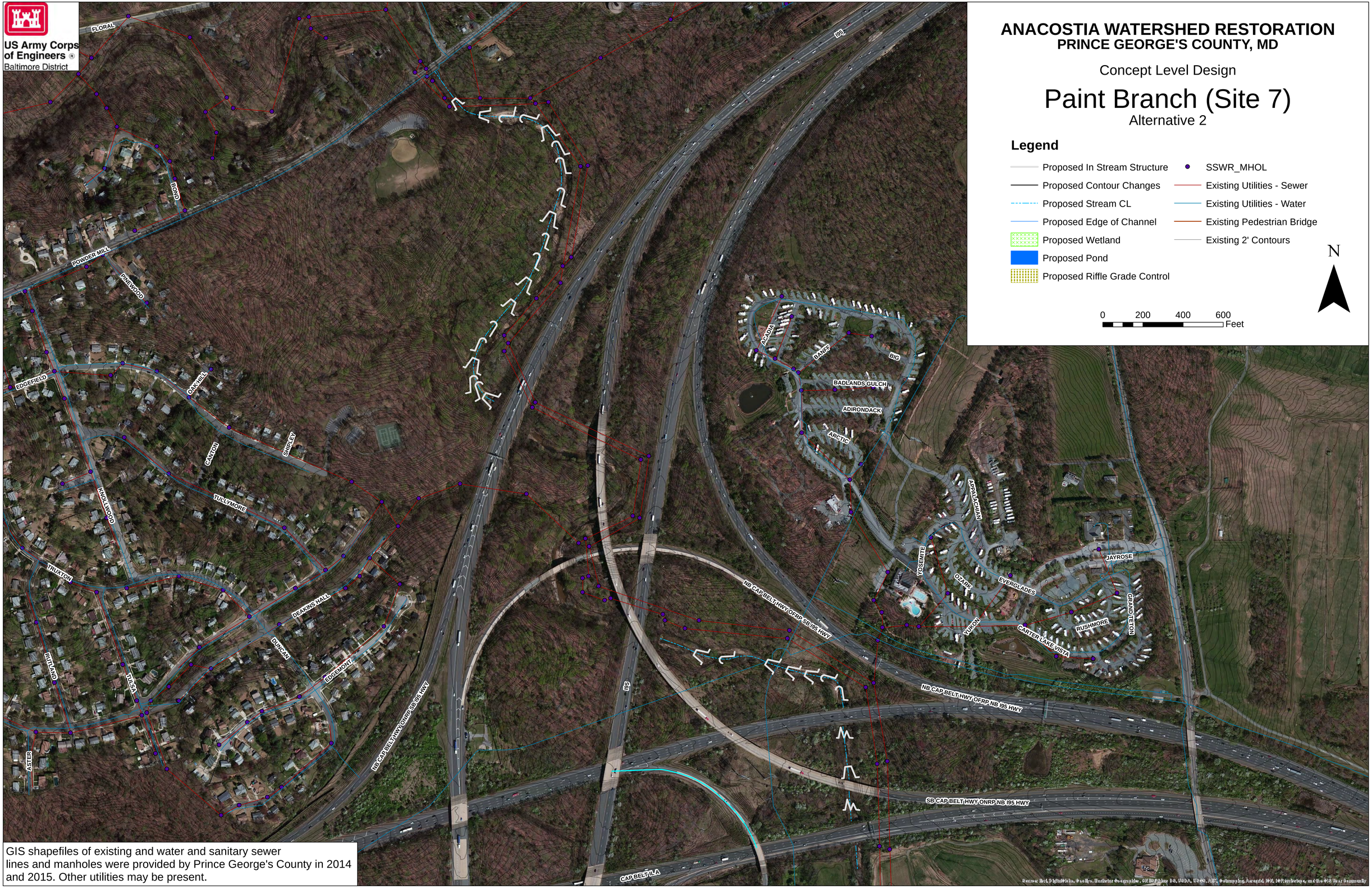
Baltimore District

ANACOSTIA WATERSHED RESTORATION
PRINCE GEORGE'S COUNTY, MD

Concept Level Design

Paint Branch (Site 7)

Alternative 2



Legend

- Proposed In Stream Structure
- Proposed Contour Changes
- Proposed Stream CL
- Proposed Edge of Channel
- Proposed Wetland
- Proposed Pond
- Proposed Riffle Grade Control
- SSWR_MHOL
- Existing Utilities - Sewer
- Existing Utilities - Water
- Existing Pedestrian Bridge
- Existing 2' Contours

GIS shapefiles of existing and water and sanitary sewer lines and manholes were provided by Prince George's County in 2014 and 2015. Other utilities may be present.

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Baltimore District

ANACOSTIA WATERSHED RESTORATION
PRINCE GEORGE'S COUNTY, MD

Concept Level Design

Indian Creek (Site 11 DS)

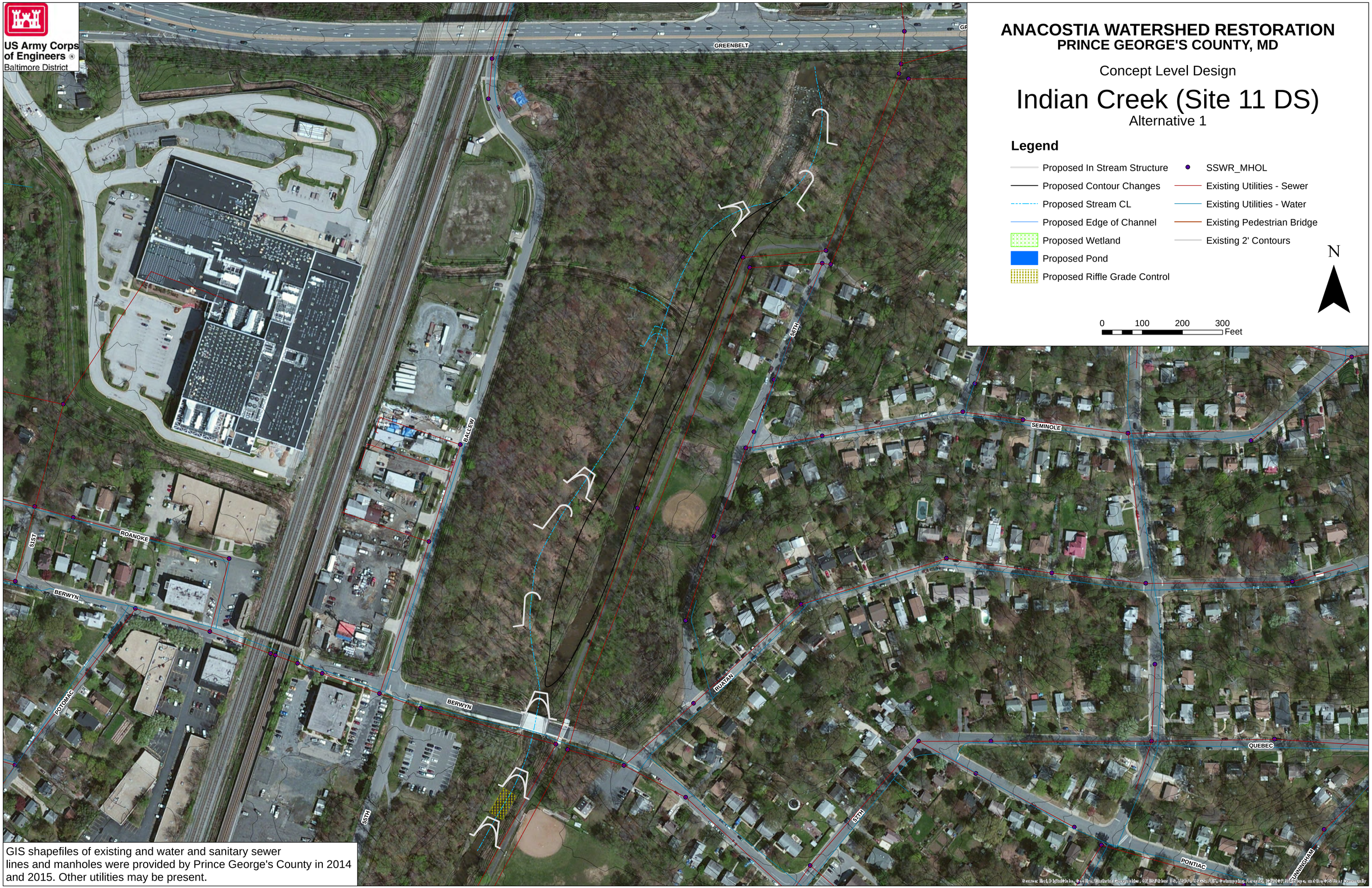
Alternative 1

Legend

- Proposed In Stream Structure
- Proposed Contour Changes
- Proposed Stream CL
- Proposed Edge of Channel
- Proposed Wetland
- Proposed Pond
- Proposed Riffle Grade Control
- SSWR_MHOL
- Existing Utilities - Sewer
- Existing Utilities - Water
- Existing Pedestrian Bridge
- Existing 2' Contours

N

0 100 200 300 Feet



GIS shapefiles of existing and water and sanitary sewer lines and manholes were provided by Prince George's County in 2014 and 2015. Other utilities may be present.

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Baltimore District

ANACOSTIA WATERSHED RESTORATION
PRINCE GEORGE'S COUNTY, MD

Concept Level Design

Indian Creek (Site 11 DS)

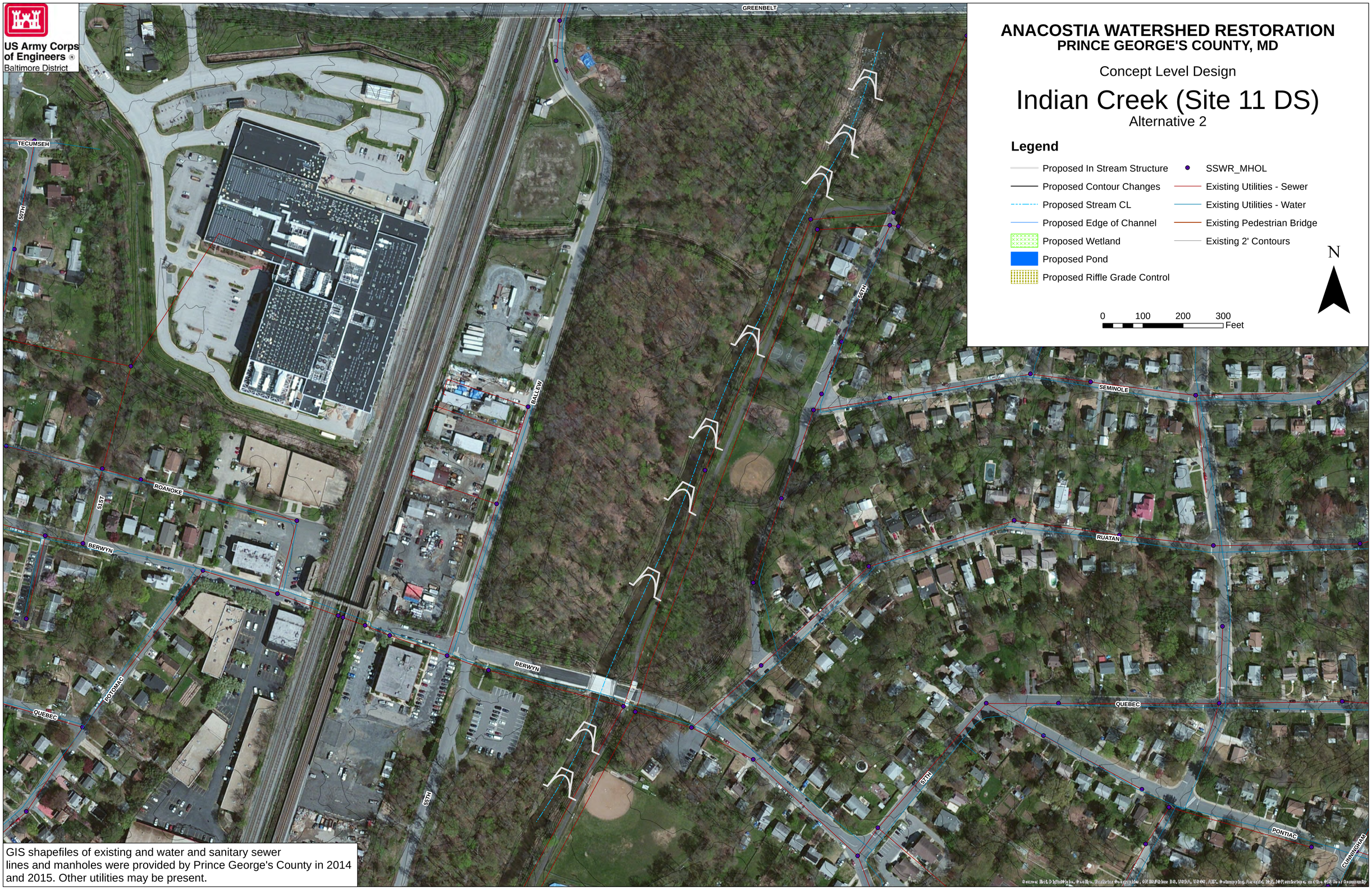
Alternative 2

Legend

- Proposed In Stream Structure
- Proposed Contour Changes
- Proposed Stream CL
- Proposed Edge of Channel
- Proposed Wetland
- Proposed Pond
- Proposed Riffle Grade Control
- SSWR_MHOL
- Existing Utilities - Sewer
- Existing Utilities - Water
- Existing Pedestrian Bridge
- Existing 2' Contours

N

0 100 200 300 Feet



GIS shapefiles of existing and water and sanitary sewer lines and manholes were provided by Prince George's County in 2014 and 2015. Other utilities may be present.

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ANACOSTIA WATERSHED RESTORATION
PRINCE GEORGE'S COUNTY, MD

Concept Level Design

Indian Creek (Site 11)

Alternative 1

GIS shapefiles of existing and water and sanitary sewer lines and manholes were provided by Prince George's County in 2014 and 2015. Other utilities may be present.

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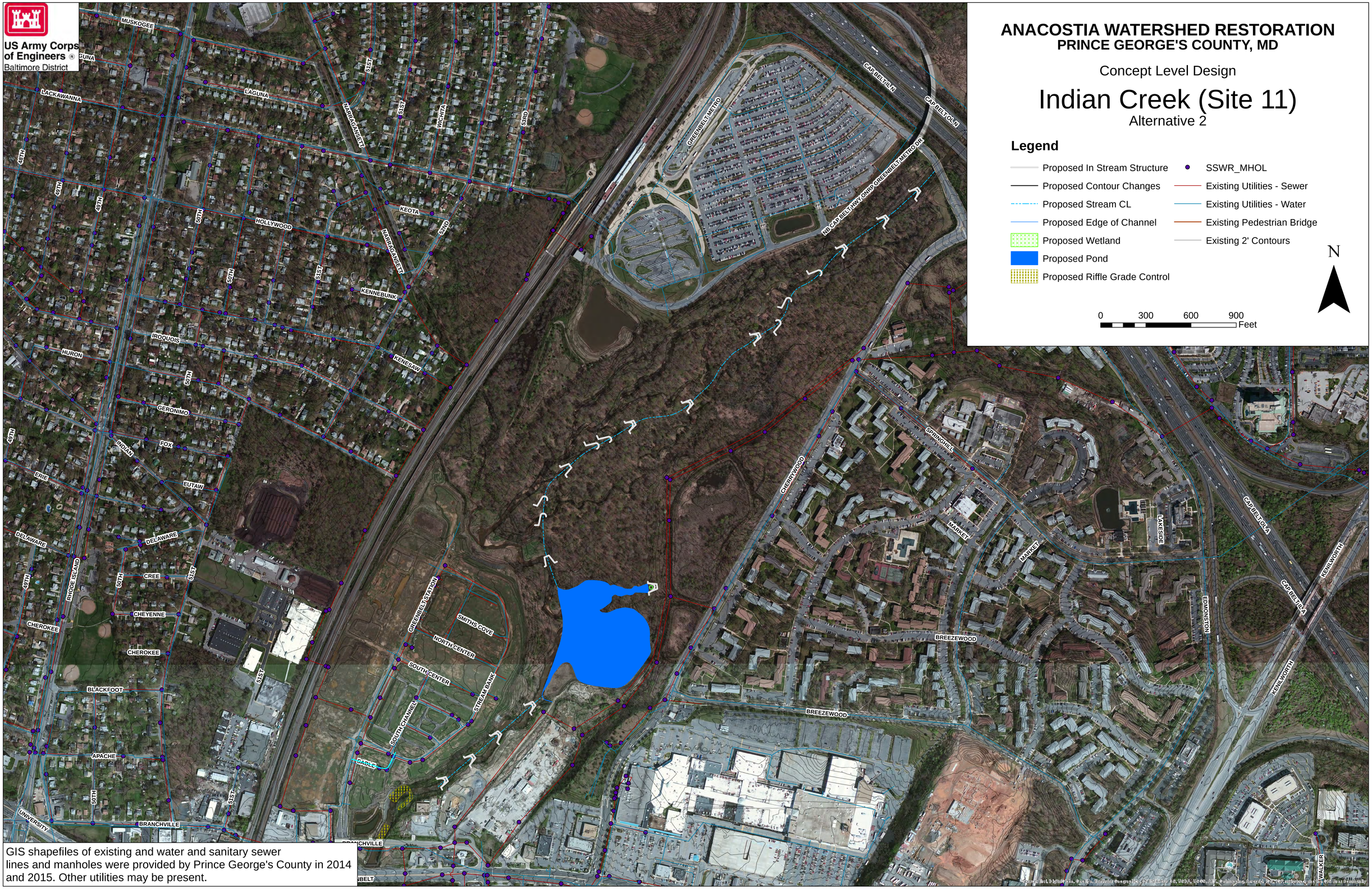
ANACOSTIA WATERSHED RESTORATION
PRINCE GEORGE'S COUNTY, MD

Concept Level Design

Indian Creek (Site 11)

Alternative 2



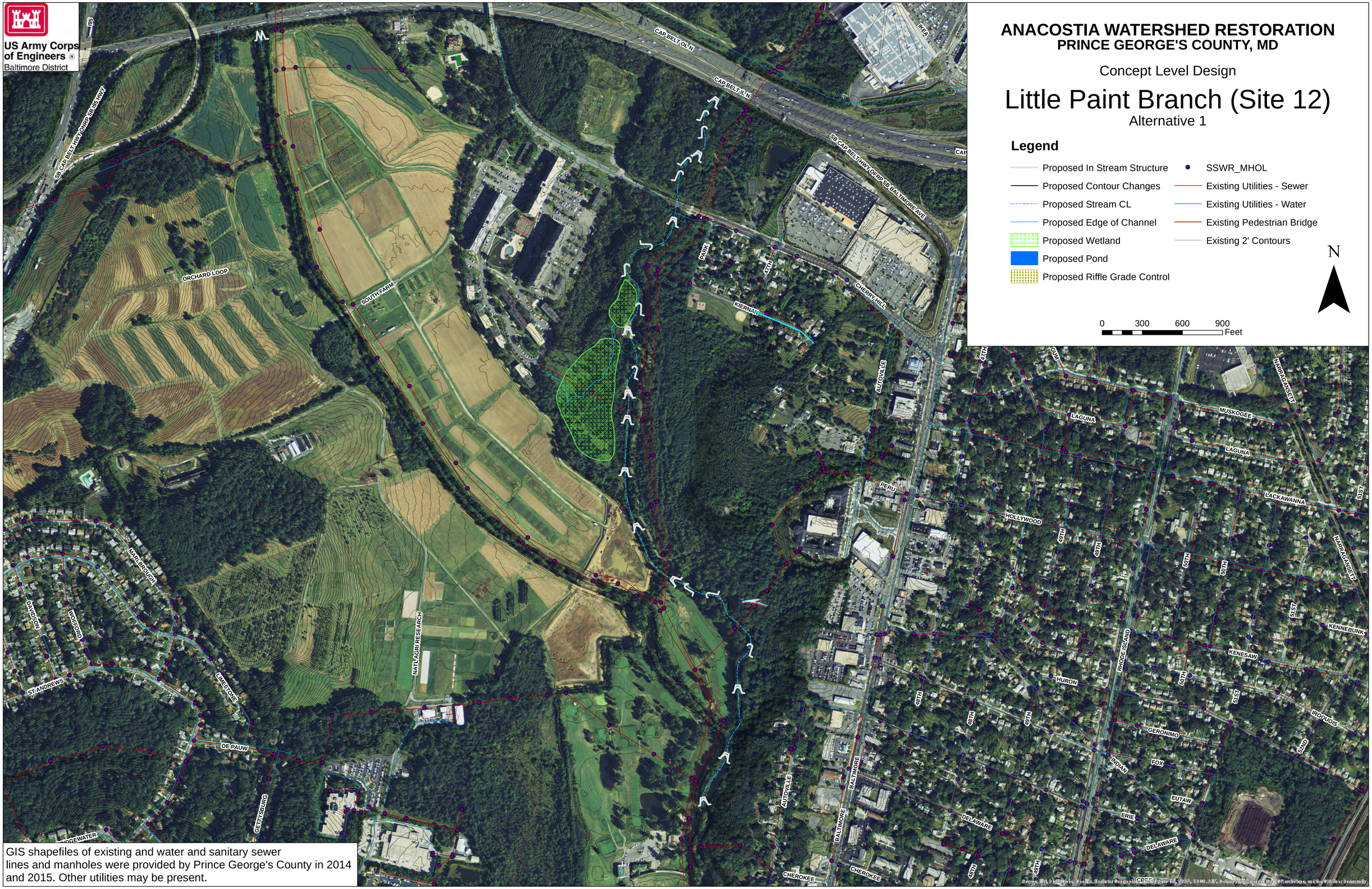
GIS shapefiles of existing and water and sanitary sewer lines and manholes were provided by Prince George's County in 2014 and 2015. Other utilities may be present.

ANACOSTIA WATERSHED RESTORATION
PRINCE GEORGE'S COUNTY, MD

Concept Level Design

Little Paint Branch (Site 12)

Alternative 1



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Baltimore District

ANACOSTIA WATERSHED RESTORATION
PRINCE GEORGE'S COUNTY, MD

Concept Level Design

Little Paint Branch (Site 12)

Alternative 2

Legend

- Proposed In Stream Structure
- Proposed Contour Changes
- Proposed Stream CL
- Proposed Edge of Channel
- Proposed Wetland
- Proposed Pond
- Proposed Riffle Grade Control
- SSWR_MHOL
- Existing Utilities - Sewer
- Existing Utilities - Water
- Existing Pedestrian Bridge
- Existing 2' Contours

N

0 300 600 900 Feet

GIS shapefiles of existing and water and sanitary sewer lines and manholes were provided by Prince George's County in 2014 and 2015. Other utilities may be present.

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Baltimore District

ANACOSTIA WATERSHED RESTORATION
PRINCE GEORGE'S COUNTY, MD

Concept Level Design

Northwest Branch (Site 13)

Alternative 1

Legend

- Proposed In Stream Structure
- Proposed Contour Changes
- Proposed Stream CL
- Proposed Edge of Channel
- Proposed Wetland
- Proposed Pond
- Proposed Riffle Grade Control
- SSWR_MHOL
- Existing Utilities - Sewer
- Existing Utilities - Water
- Existing Pedestrian Bridge
- Existing 2' Contours

N

0 300 600 900 Feet

GIS shapefiles of existing and water and sanitary sewer lines and manholes were provided by Prince George's County in 2014 and 2015. Other utilities may be present.

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Baltimore District

ANACOSTIA WATERSHED RESTORATION
PRINCE GEORGE'S COUNTY, MD

Concept Level Design

Little Paint Branch (Site 13)

Alternative 2

Legend

- Proposed In Stream Structure
- Proposed Contour Changes
- Proposed Stream CL
- Proposed Edge of Channel
- Proposed Wetland
- Proposed Pond
- Proposed Riffle Grade Control
- SSWR_MHOL
- Existing Utilities - Sewer
- Existing Utilities - Water
- Existing Pedestrian Bridge
- Existing 2' Contours

N

0 300 600 900 Feet

GIS shapefiles of existing and water and sanitary sewer lines and manholes were provided by Prince George's County in 2014 and 2015. Other utilities may be present.

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Baltimore District

ANACOSTIA WATERSHED RESTORATION
PRINCE GEORGE'S COUNTY, MD

Concept Level Design

Northeast Branch (Site 15)

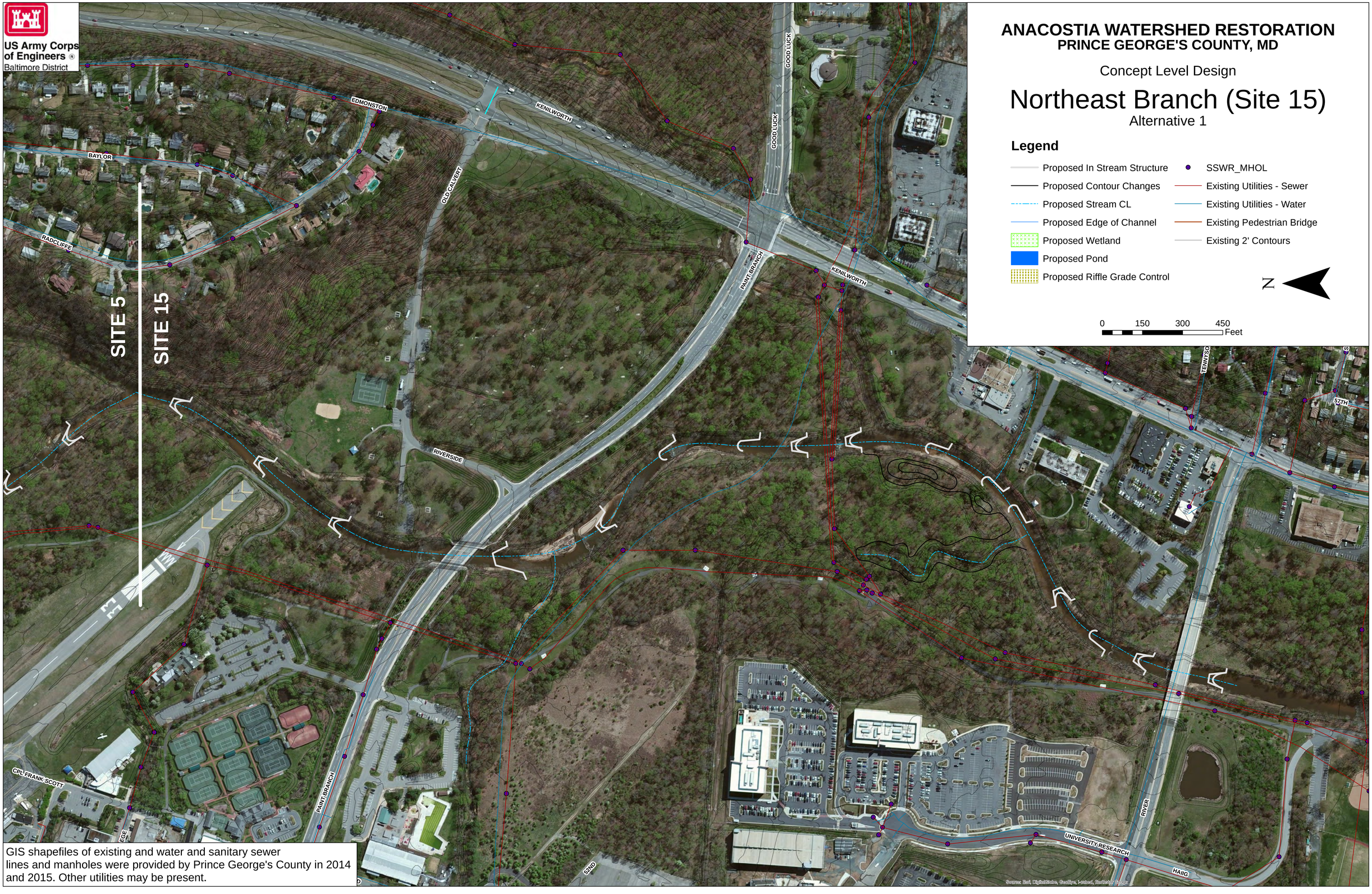
Alternative 1

Legend

- Proposed In Stream Structure
- Proposed Contour Changes
- Proposed Stream CL
- Proposed Edge of Channel
- Proposed Wetland
- Proposed Pond
- Proposed Riffle Grade Control
- SSWR_MHOL
- Existing Utilities - Sewer
- Existing Utilities - Water
- Existing Pedestrian Bridge
- Existing 2' Contours

N

0 150 300 450 Feet



GIS shapefiles of existing and water and sanitary sewer lines and manholes were provided by Prince George's County in 2014 and 2015. Other utilities may be present.

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Baltimore District

ANACOSTIA WATERSHED RESTORATION
PRINCE GEORGE'S COUNTY, MD

Concept Level Design

Northeast Branch (Site 15)

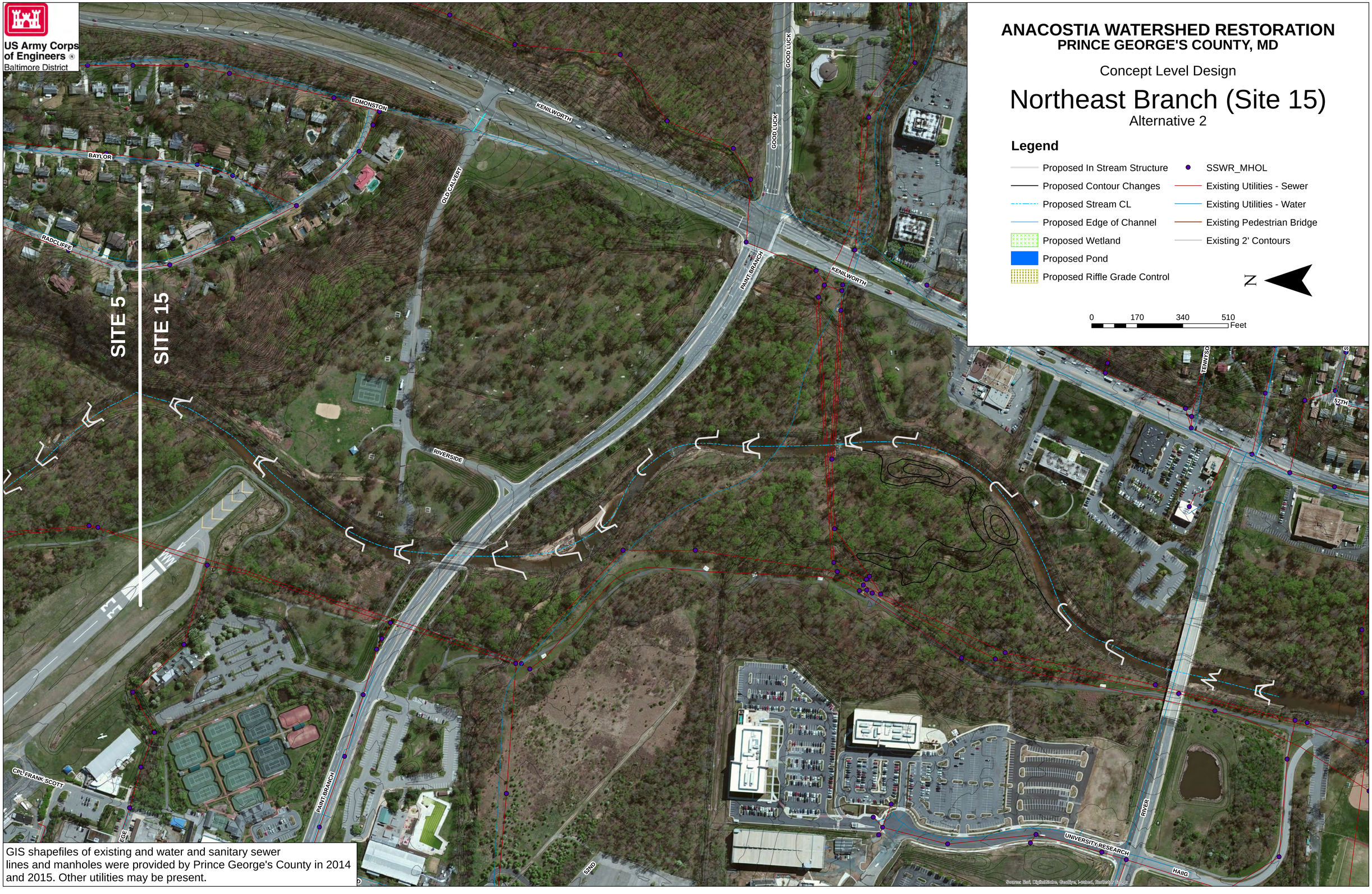
Alternative 2

Legend

- Proposed In Stream Structure
- Proposed Contour Changes
- Proposed Stream CL
- Proposed Edge of Channel
- Proposed Wetland
- Proposed Pond
- Proposed Riffle Grade Control
- SSWR_MHOL
- Existing Utilities - Sewer
- Existing Utilities - Water
- Existing Pedestrian Bridge
- Existing 2' Contours

N

0 170 340 510 Feet



GIS shapefiles of existing and water and sanitary sewer lines and manholes were provided by Prince George's County in 2014 and 2015. Other utilities may be present.

Appendix F. Economics Analysis

ECONOMIC ANALYSIS

APPENDIX

ECONOMICS APPENDIX

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DESCRIPTION OF COSTS	2
DESCRIPTION OF ENVIRONMENTAL BENEFITS	6
COST EFFECTIVE AND INCREMENTAL COST ANALYSIS	8
SENSITIVITY ANALYSIS	13

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2	INVESTMENT COSTS OF ALTERNATIVES	3
3	AVERAGE ANNUAL COSTS OF ALTERNATIVES	5
4	AVERAGE ANNUAL ENVIRONMENATAL BENEFITS	7
5	RESULTS OF COST EFFECTIVE ANALYSES	8
6	RESULTS OF INCREMENTAL COST ANALYSIS NORTHWEST BRANCH	11
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ECONOMICS APPENDIX

In order to make more informed decisions with regard to the development and eventual selection of the NER Plan, a cost effectiveness analysis and incremental cost analysis was conducted on the alternatives that were carried forward for evaluation and comparison. This included nine alternatives, in addition to the no action plan, in the northeast branch of the study area, and six alternatives, in addition to the no action plan, in the northwest branch of the study area. As required by USACE Planning Guidance (ER 1105-2-100, Appendix E, E-36), these analyses were conducted utilizing annualized costs, annualized benefits, and the IWR-Planning Suite Software (version 2.0).

Cost effectiveness analysis identifies the plan, or plans, that produce(s) a level of environmental output that cannot be produced at a lower cost, or a greater level of output cannot be produced at the same or less cost. The environmental outputs, however measured, in turn reflect the environmental benefits, such as biological diversity, fish and wildlife habitat, and nutrient cycling, provided by the plan or plans. Incremental cost analysis examines the changes in costs and the changes in environmental outputs for each additional increment of environmental output. The Best Buy Plans represent those plans that produce the greatest increases in environmental outputs for the least increases in cost.

DESCRIPTION OF ALTERNATIVES

The alternatives included in this analysis were divided into the Northwest Branch and the Northeast Branch. The Northwest Branch included various combinations of sites along the Northwest Branch and Sligo Creek subwatersheds. The Northeast Branch included various combinations of sites along the Northeast Branch, Paint Branch, Little Paint Branch, and Indian Creek subwatersheds. These alternatives were formulated based on ecological dependencies of sites identified by the project team. A single conceptual design was chosen for each site based on site constraints and previous evaluation of designs. The following alternatives, and the associated naming codes used in IWR Planning Suite, were carried forward for the cost effective and incremental cost analysis:

TABLE 1. ALTERNATIVES CARRIED FORWARD FOR CE/ICA

Code	Northwest Branch Alternatives (1)
NWB	3 (alt 2)
NWS	3 (alt 2), 9 (alt 2)
WSC	3 (alt 2), 9 (alt 2), 10 (alt 2)
NWR	3 (alt 2), 13 (alt 1)
NSR	3 (alt 2), 9 (alt 2), 13 (alt 2)
WTR	3 (alt 2), 9 (alt 2), 10 (alt 2), 13 (alt 1)
Code	**Northeast Branch Alternatives (2)**
NEI	11 (alt 2), 15 (alt 2)
NIP	11 (alt 2), 15 (alt 2), 5 (alt 2)
PPI	11 (alt 2), 15 (alt 2), 5 (alt 2), 7 (alt 2)
IPL	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1)
ICE	11 (alt 2), 15 (alt 2), 1 (alt 2)
EPI	11 (alt 2), 15 (alt 2), 5 (alt 2), 1 (alt 2)
ELI	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2)
PLI	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 7 (alt 2)
NET	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2), 7 (alt 2)

(1) Northwest Branch Alternatives include sites in the Northwest Branch and Sligo Creek subwatersheds.
(2) Northeast Branch Alternatives include sites in the Northeast Branch, Paint Branch, Little Paint Branch, and Indian Creek subwatersheds.

DESCRIPTION OF COSTS

The costs for constructing the different alternatives, as discussed in the main report, were developed for the 10-percent level concept designs. Parametric costs were estimated by linear foot based on concept cost estimates contained in 2012 bid data for Northwest Branch Package 2 and for the Paint Branch CAP project. The 2012 estimate, as seen in Appendix G, was escalated to October 2015 costs using the Civil Works Construction Cost Index System. All costs used in this comparison between alternatives are in October 2015 (Fiscal Year 2016) price levels, with a 3-1/8-percent discount rate used in present value and annualized over a 50-year period of analysis with a base year of 2014.

The costs for each alternative plan include the following: preconstruction, engineering and design (PED); real estate; construction; construction management; contingency; and annual monitoring.

After the total costs were determined, the cost of interest during project construction was calculated based on a nine month period of construction for each of the alternatives and a 3-1/8-percent discount rate. The total costs plus the costs of the interest during construction yield the investment cost, as seen in the following table.

TABLE 2. INVESTMENT COST OF ALTERNATIVES
(FY-16 PRICE LEVEL, 3.125 PERCENT DISCOUNT RATE)

Code	Northwest Branch Alternatives (1)	Total First Cost ($)	Interest During Construction ($)	Total Investment Cost ($)
NWB	3 (alt 2)	5,586,200	72,200	$5,658,400
NWS	3 (alt 2), 9 (alt 2)	7,090,100	91,600	$7,181,800
WSC	3 (alt 2), 9 (alt 2), 10 (alt 2)	8,554,600	110,600	$8,665,200
NWR	3 (alt 2), 13 (alt 1)	12,140,300	156,900	$12,297,200
NSR	3 (alt 2), 9 (alt 2), 13 (alt 2)	13,644,200	176,400	$13,820,500
WTR	3 (alt 2), 9 (alt 2), 10 (alt 2), 13 (alt 1)	15,108,600	195,300	$15,303,900
Code	**Northeast Branch Alternatives (2)**	**Total First Cost**	**Interest During Construction**	**Total Investment Cost**
NEI	11 (alt 2), 15 (alt 2)	15,245,300	197,100	$15,442,400
NIP	11 (alt 2), 15 (alt 2), 5 (alt 2)	23,617,700	305,300	$23,923,000
PPI	11 (alt 2), 15 (alt 2), 5 (alt 2), 7 (alt 2)	32,307,600	417,600	$32,725,200
IPL	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1)	29,716,700	384,100	$30,100,800
ICE	11 (alt 2), 15 (alt 2), 1 (alt 2)	19,455,900	251,500	$19,707,400
EPI	11 (alt 2), 15 (alt 2), 5 (alt 2), 1 (alt 2)	27,828,300	359,700	$28,188,000
ELI	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2)	33,927,300	438,600	$34,365,800
PLI	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 7 (alt 2)	38,406,600	496,500	$38,903,000
NET	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2), 7 (alt 2)	42,617,200	550,900	$43,168,100

(1) Northwest Branch Alternatives include sites in the Northwest Branch and Sligo Creek subwatersheds.
(2) Northeast Branch Alternatives include sites in the Northeast Branch, Paint Branch, Little Paint Branch, and Indian Creek subwatersheds.

Monitoring Costs

Annual monitoring will be conducted for each of the alternatives to ensure that project objectives are being fulfilled. The cost associated with monitoring is estimated to be one percent of project construction costs annually for the first 5 years after completion of construction of the project.

Average Annual Costs

Using the total investment costs and annual monitoring, the average annual equivalent costs were derived for each alternative plan, based on a 50-year period of analysis, a 3-1/8-percent discount rate, and October 2015 (FY 2016) price levels. The interest and amortization, average annual monitoring costs, and total average annual costs for the alternatives carried forward for evaluation can be found in the following table.

Table 3. AVERAGE ANNUAL COST OF ALTERNATIVES
(FY-16 PRICE LEVELS, 3.125 PERCENT DISCOUNT RATE

Code	Northwest Branch Alternatives	Average Annual Construction Cost ($)	Annual Interest and Amortization ($)	Annual Monitoring ($)	Total Average Annual Cost ($)
NWB	3 (alt 2)	222,300	2,900	2,000	227,200
NWS	3 (alt 2), 9 (alt 2)	282,200	3,600	2,600	288,400
WSC	3 (alt 2), 9 (alt 2), 10 (alt 2)	340,400	4,400	3,100	347,900
NWR	3 (alt 2), 13 (alt 1)	483,100	6,200	4,400	493,800
NSR	3 (alt 2), 9 (alt 2), 13 (alt 2)	543,000	7,000	5,000	554,900
WTR	3 (alt 2), 9 (alt 2), 10 (alt 2), 13 (alt 1)	601,200	7,800	5,500	614,500
Code	**Northeast Branch Alternatives**	**Average Annual Construction Cost ($)**	**Annual Interest and Amortization ($)**	**Annual Monitoring ($)**	**Total Average Annual Cost ($)**
NEI	11 (alt 2), 15 (alt 2)	606,700	7,800	5,500	620,000
NIP	11 (alt 2), 15 (alt 2), 5 (alt 2)	939,800	12,200	8,600	960,500
PPI	11 (alt 2), 15 (alt 2), 5 (alt 2), 7 (alt 2)	1,285,600	16,600	11,700	1,314,000
IPL	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1)	1,182,500	15,300	10,800	1,208,600
ICE	11 (alt 2), 15 (alt 2), 1 (alt 2)	774,200	10,000	7,100	791,300
EPI	11 (alt 2), 15 (alt 2), 5 (alt 2), 1 (alt 2)	1,107,400	14,300	10,100	1,131,800
ELI	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2)	1,350,100	17,500	12,300	1,379,800
PLI	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 7 (alt 2)	1,528,300	19,800	14,000	1,562,000
NET	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2), 7 (alt 2)	1,695,900	21,900	15,500	1,733,300

(1) Northwest Branch Alternatives include sites in the Northwest Branch and Sligo Creek subwatersheds.
(2) Northeast Branch Alternatives include sites in the Northeast Branch, Paint Branch, Little Paint Branch, and Indian Creek subwatersheds.

DESCRIPTION OF ENVIRONMENTAL BENEFITS

Two environmental benefit metrics were estimated for each of the alternatives in on order to capture the most complete value of benefit from the project, Project Specific In-Stream Benefits and Aggregate Benefits. The In-Stream Benefit metric, measured in stream habitat units (SHUs), estimates the quantity and quality of stream habitat within the stream restoration area. The Aggregate Benefit, measured in SHUs, incorporates the quantity and quality of both fish passage and connectivity of the project restored stream area to previously restored stream areas. It is assumed it will take nine months to construct each alternative, and the environmental benefits will reach the full amount estimated within the first year of the project, remaining constant after that time. Since benefits are fully achieved within the first year of analysis, the amount of SHUs is assumed to be the same each year over the fifty year period of analysis, resulting in an equivalent average annual benefit.

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. Normalization allows benefit categories with different units of measurement, in this case units of measurement with potentially different values, to be evaluated together in one analysis. Within the Planning Suite software, using the two metrics for each separate branch, each metric was normalized using the maximum amount of SHUs for the appropriate branch and added together with equal weighting to obtain a raw weighted score in a range of 0 to 1 for each alternative. The maximum amounts for each branch are the highest amount of estimated SHUs, one for the in-stream benefit and one for the aggregate benefit, which can be achieved by this particular project. The combined benefit index was calculated as follows for each alternative within each branch, with the maximum amounts shown as the denominators of the following formulas:

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

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

The average annual benefits for the in-stream metric, aggregate metric, and resulting combined benefit score can be seen in the following table for each alternative. As explained previously, the combined benefit index was calculated based on the previous formulas for each of the alternatives being evaluated.

Table 4. AVERAGE ANNUAL ENVIRONMENTAL BENEFITS

Code	Northwest Branch Alternatives (1)	Project Specific In-Stream (SHU)	Aggregate (SHU)	Combined Northwest Branch Index (0-1)
NWB	3 (alt 2)	2068	53679	0.62
NWS	3 (alt 2), 9 (alt 2)	2738	58330	0.72
WSC	3 (alt 2), 9 (alt 2), 10 (alt 2)	2860	59640	0.74
NWR	3 (alt 2), 13 (alt 1)	5162	53679	0.88
NSR	3 (alt 2), 9 (alt 2), 13 (alt 2)	5832	58330	0.98
WTR	3 (alt 2), 9 (alt 2), 10 (alt 2), 13 (alt 1)	5953	59640	1.00
Code	**Northeast Branch Alternatives (2)**	**Project Specific In-Stream (SHU)**	**Aggregate (SHU)**	**Combined Northeast Branch Index (0-1)**
NEI	11 (alt 2), 15 (alt 2)	7975	22703	0.43
NIP	11 (alt 2), 15 (alt 2), 5 (alt 2)	10626	63131	0.79
PPI	11 (alt 2), 15 (alt 2), 5 (alt 2), 7 (alt 2)	12035	69507	0.89
IPL	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1)	11666	67846	0.86
ICE	11 (alt 2), 15 (alt 2), 1 (alt 2)	8832	25083	0.48
EPI	11 (alt 2), 15 (alt 2), 5 (alt 2), 1 (alt 2)	11483	65511	0.84
ELI	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2)	12523	70226	0.91
PLI	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 7 (alt 2)	13075	74222	0.95
NET	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2), 7 (alt 2)	13932	76602	1.00

(1) Northwest Branch Alternatives include sites in the Northwest Branch and Sligo Creek subwatersheds.

(2) Northeast Branch Alternatives include sites in the Northeast Branch, Paint Branch, Little Paint Branch, and Indian Creek subwatersheds.

COST EFFECTIVE AND INCREMENTAL COST ANALYIS

The average annual costs and average annual benefits (combined benefit score) identified previously were used to conduct cost effectiveness and incremental cost analyses, using IWR Planning Suite version 2.0. The results of the cost effectiveness analysis indicated nine of the considered plans to be cost effective for the northeast branch, and six for the northwest branch. The cost-effective plans can be found in the following table. Each of these plans is the least-costly means of providing the associated level of output or benefit. The following figures illustrate the cost-effective analysis results, showing average annual environmental benefits (horizontal axis) and average annual costs (vertical axis) of the alternatives, as well as the No Action Plan, which is carried forward for comparison purposes only.

Table 5. RESULTS OF COST-EFFECTIVENESS ANALYSES

Code	Northwest Branch Alternatives (1)	Combined Northwest Branch Index (0-1)	Average Annual Cost ($)
NWB	3 (alt 2)	0.62	227,200
NWS	3 (alt 2), 9 (alt 2)	0.72	288,400
WSC	3 (alt 2), 9 (alt 2), 10 (alt 2)	0.74	347,900
NWR	3 (alt 2), 13 (alt 1)	0.88	493,800
NSR*	3 (alt 2), 9 (alt 2), 13 (alt 2)	0.98	554,900
WTR	3 (alt 2), 9 (alt 2), 10 (alt 2), 13 (alt 1)	1.00	614,500
Code	**Northeast Branch Alternatives (2)**	**Combined Northeast Branch Index (0-1)**	**Average Annual Cost ($)**
NEI	11 (alt 2), 15 (alt 2)	0.43	620,000
NIP*	11 (alt 2), 15 (alt 2), 5 (alt 2)	0.79	960,500
PPI	11 (alt 2), 15 (alt 2), 5 (alt 2), 7 (alt 2)	0.89	1,314,000
IPL	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1)	0.86	1,208,600
ICE	11 (alt 2), 15 (alt 2), 1 (alt 2)	0.48	791,300
EPI	11 (alt 2), 15 (alt 2), 5 (alt 2), 1 (alt 2)	0.84	1,131,800
ELI	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2)	0.91	1,379,800
PLI	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 7 (alt 2)	0.95	1,562,000
NET	11 (alt 2), 15 (alt 2), 5 (alt 2), 12 (alt 1), 1 (alt 2), 7 (alt 2)	1.00	1,733,300

(1) Northwest Branch Alternatives include sites in the Northwest Branch and Sligo Creek subwatersheds.
(2) Northeast Branch Alternatives include sites in the Northeast Branch, Paint Branch, Little Paint Branch, and Indian Creek subwatersheds.
*Tentatively Selected Plan

Figure 1. COST-EFFECTIVE PLANS NORTHWEST BRANCH

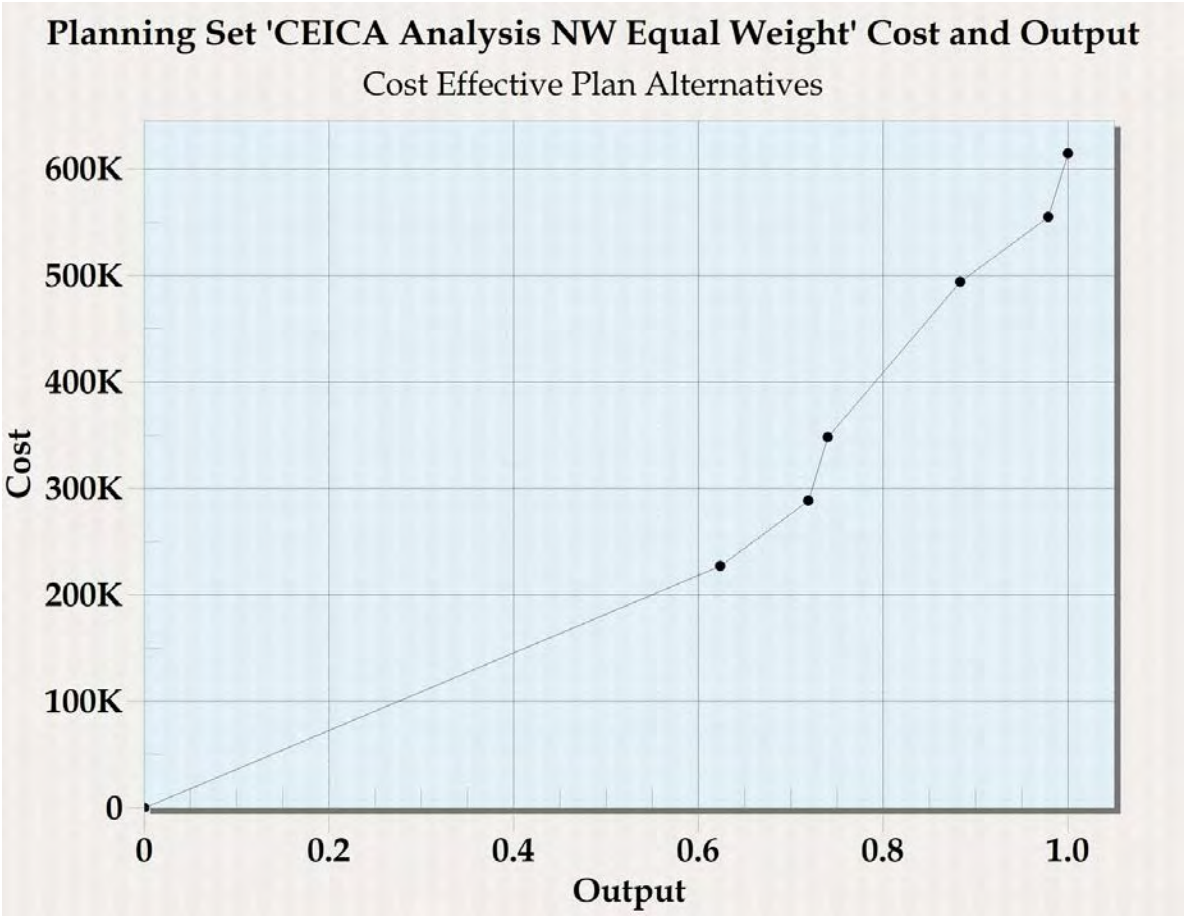
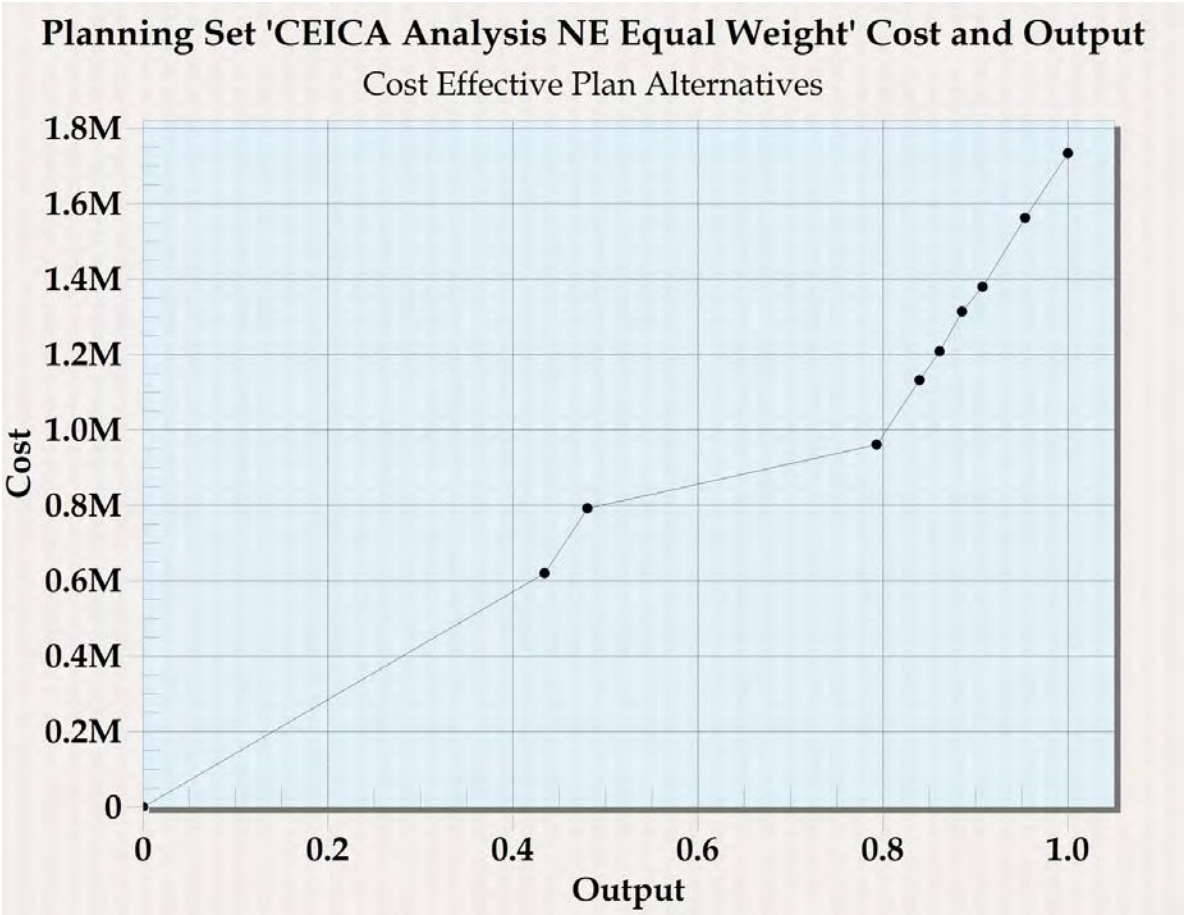


Figure 2. COST-EFFECTIVE PLANS NORTHEAST BRANCH



After conducting the cost effectiveness analysis, incremental cost analysis examines the changes in costs and changes in environmental benefits for each additional increment of output. For each best buy plan there are no other plans that will give the same level of output at a lower incremental cost. The plan with the lowest overall average cost per unit of output, advancing from the No Action Plan, is the first Best Buy Plan. After the first Best Buy Plan is identified, subsequent incremental analyses are done to calculate the change in costs and change in outputs of advancing from the first Best Buy Plan to all of the remaining (and larger) cost-effective plans. The results of the incremental cost analysis indicated four of the considered plans, in addition to the no action plan, to be best buy plans for the northeast branch, and four for the northwest branch. The following tables summarize the information from the incremental cost analysis of the alternatives, and the figures display the information graphically.

Table 6. RESULTS OF INCREMENTAL COST ANALYSIS (BEST BUY PLANS) NORTHWEST BRANCH

Plan	Sites Included	Total Restoration Length (ft)	Average Annual Costs ($)	Combined Index (0-1)	Project Specific SHUs	Aggregate SHUs	Incremental Cost/Output (K)
No Action	-	0	$0	-	0	0	-
NWB (A)	3	7,285	$227,200	0.62	2,068	53,679	$364
NWS (B)	3, 9	9,526	$288,400	0.72	2,738	58,330	$642
NSR (C)*	3, 9, 13	17,216	$554,900	0.98	5,832	58,330	$1,026
WTR (D)	3, 9, 13, 10	19,312	$614,500	1.00	5,953	59,640	$2,819

*Tentatively Selected Plan

Figure 3. BEST BUY PLANS NORTHWEST BRANCH

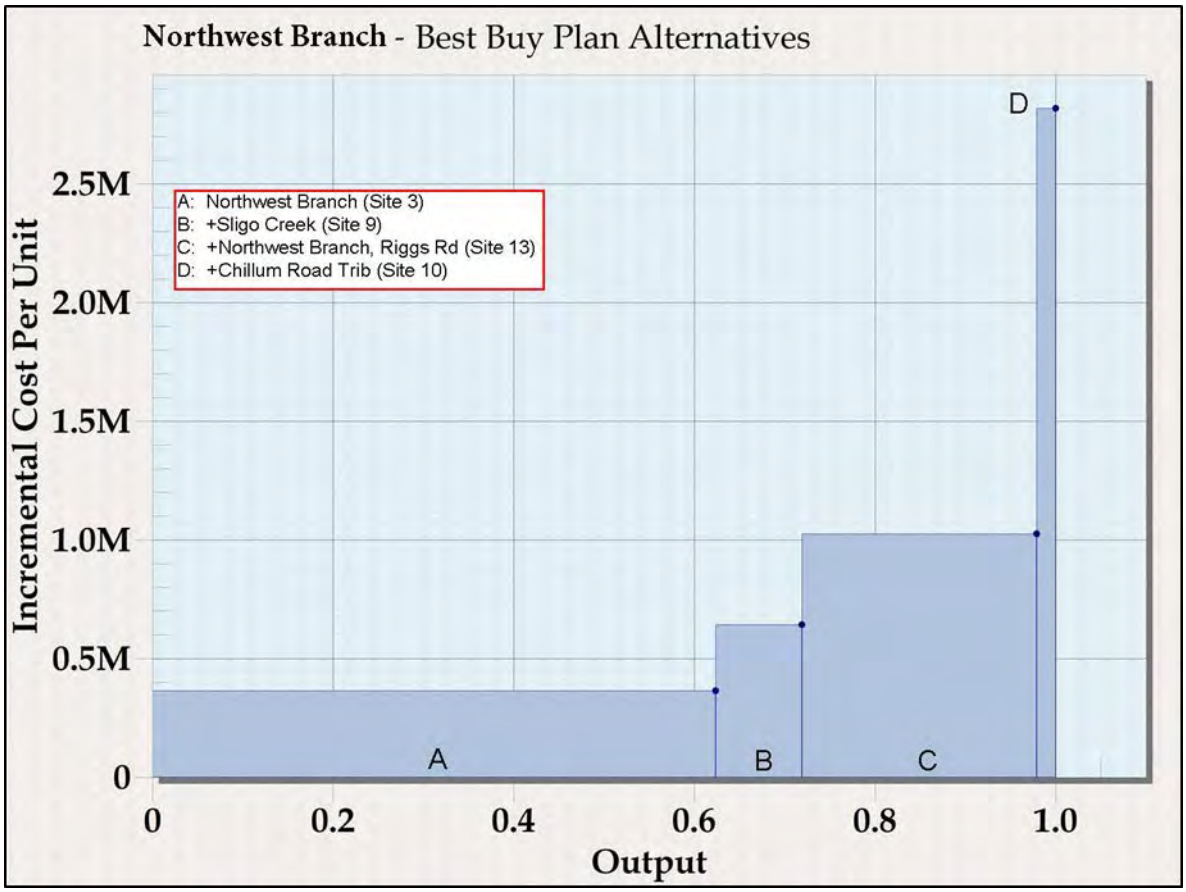
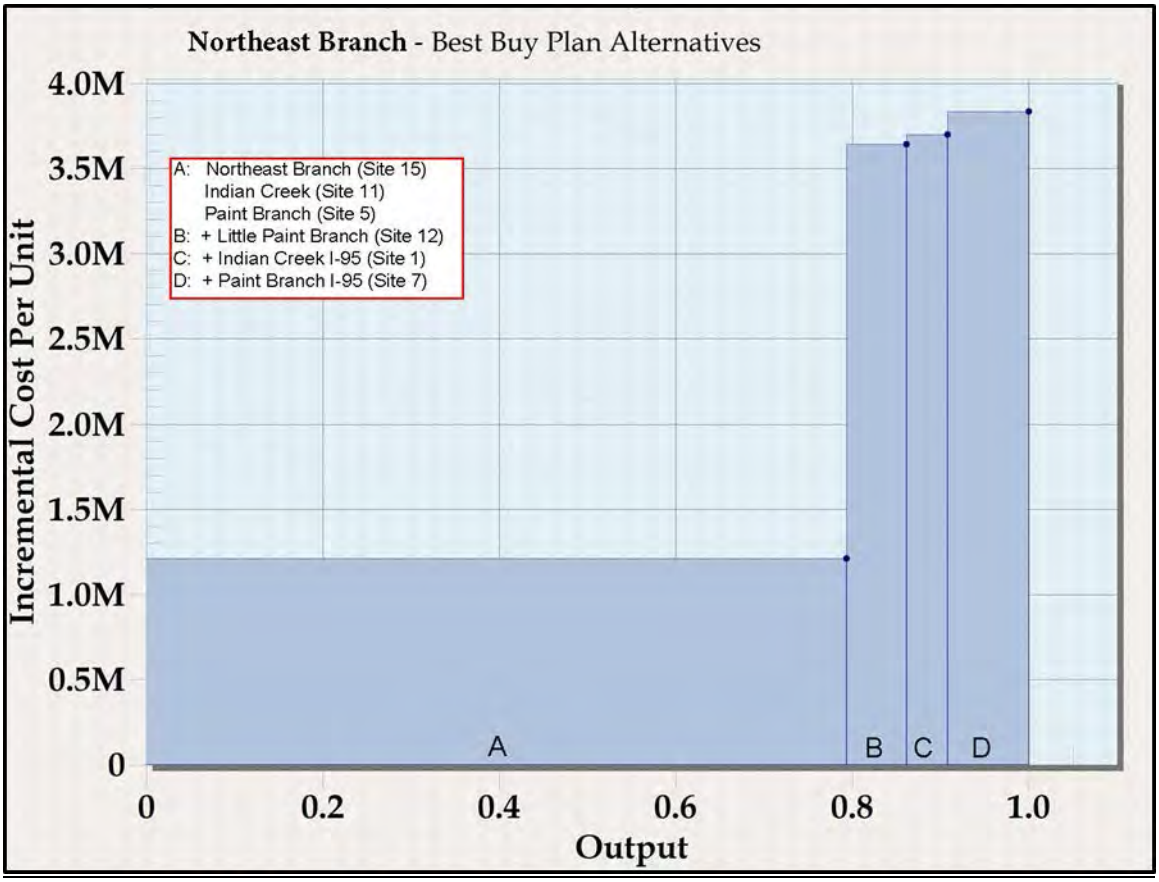


Table 7. RESULTS OF INCREMENTAL COST ANALYSIS (BEST BUY PLANS) NORTHEAST BRANCH

Plan	Sites Included	Total Restoration Length (ft)	Average Annual Costs ($)	Combined Index (0-1)	Project Specific SHUs	Aggregate SHUs	Incremental Cost/Output (K)
No Action	-	0	$0	-	0	0	-
NIP (A)*	15, 11, 5	18,946	$960,500	0.79	10626	63131	$1,211
IPL (B)	15, 11, 5, 12	23,476	$1,208,600	0.86	11666	67846	$3,643
ELI (C)	15, 11, 5, 12, 1	30,434	$1,379,800	0.91	12523	70226	$3,698
NET (D)	15, 5, 11, 12, 1, 7	36,310	$1,733,300	1.00	13932	76602	$3,835

*Tentatively Selected Plan

Figure 4. BEST BUY PLANS NORTHEAST BRANCH



SENSITIVITY ANALYSIS

The original cost/benefits analysis was completed using equal weighting on the two metrics. In order to assess the effect on the outcome of the CE/ICA if greater importance was given to either of the benefit parameters, a sensitivity analysis was performed to evaluate the effect of various weights on the results of the analysis. The analysis was rerun 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). Overall, the results of the sensitivity analysis support the tentatively selected plan for both the Northwest and the Northeast branches. While there are other best buy plans that are identified by the incremental sensitivity analysis, the recommended plan is consistently identified as a best buy plan by each of the analyses. A summary of the results of the sensitivity analysis can be seen in the following table.

Table 8. RESULTS OF SENSITIVITY ANALYSIS (Best Buy Plans)

Code	Equal Weight on metrics	75% weight In-Stream/ 25% weight Aggregate	100 percent weight In-Stream metric (SHUs)
NWB	X	X	
NWS	X	X	
WSC			
NWR			
NSR*	X	X	X
WTR	X	X	X
Code	**Equal Weight on metrics (index)**	**75% weight In-Stream/ 25% weight Aggregate (index)**	**100 percent weight In-Stream metric (SHUs)**
NEI		X	X
NIP*	X	X	X
PPI			
IPL	X		
ICE			
EPI		X	X
ELI	X		X
PLI		X	
NET	X	X	X

*Tentatively Selected Plan

Appendix G. Cost Engineering

Conceptual Cost Estimates

Prince George's County Stream Restoration

Conceptual cost estimates for the stream restoration in the Anacostia River watershed in Prince George's County were based on similar past USACE projects, including Northwest Branch Contract 2 and Paint Branch Contract 1 and 2. These past projects were chosen for the Prince George's county project sites because they have similar in-stream structures and similar project dimensions. Costs for these two projects were then brought up to current pricing level using the latest escalation from the Civil Works Construction Cost Index System (CWCCIS) prepared by the Cost Center of Expertise (CX), Walla Walla District, and the unit costs in $/linear foot (LF) from those two projects were obtained.

The costs were defined based on $/LF from the cost (bid) for Northwest Branch Contract 2 (referred to as "historical cost" below) for the following study projects sites:

- Site 1 - Indian Creek at I-95
- Site 3 – Northwest Branch Downstream (historical cost with additional 30% adjustment)
- Site 9 - Sligo Creek (historical cost with additional 30% adjustment)
- Site 10 - Chillum Road Tributary (historical cost with additional 20% adjustment)
- Site 11 – Indian Creek Downstream (historical cost with additional 30% adjustment
- Site 13 - Northwest Branch Upstream (historical cost with additional 30% adjustment)

The following project sites were used with $/LF from the cost (bid) for Paint Branch Contracts 1 and 2:

- Site 5 - Paint Branch
- Site 7 - Paint Branch Interchange (historical cost with additional 10% adjustment)
- Site 12 - Little Paint Branch (90% of historical cost)
- Site 15 - Calvert Road Disc Golf Park (historical cost with additional 20% adjustment)

The adjustment factors were based on best professional judgment applied to accommodate the stream size, number of structures, difficulty levels, and site accessibility.

Since designs are at a very preliminary level (10% design level), it is probable that projected costs have relatively high risk. A relatively conservative contingency of 25% was applied to the $/LF. There was no formal risk analysis performed at the time of development of the cost estimate. The contingency is based on the best judgments and consensus of the PDT and was used as a placeholder at the time. However, a formal Abbreviated Risk Analysis will be performed by the PDT and checked by Cost CX Walla Walla during Agency Technical Review to ensure proper contingency was adequately applied.

For account 30, Planning Engineering Design (PED) and account 31, Construction Management (CM), conservative percentages (23% and 14.5% respectively) of construction costs were used to arrive at PED and CM costs. Those percentages of the construction costs are default percentages suggested in the Total Project Cost Summary sheet and the civil escalation chart CWCCIS prepared by the Cost CX Walla Walla District. Full percentages (23% and 14.5%) for accounts 30 and 31 are rarely used because they are conservative. However, because this conservative approach was used, team consensus was to use a less conservative contingency (10%) for those two accounts.

Preliminary Real Estate costs are presented in Appendix H. For estimating purposes, it is assumed that Real Estate issues will be resolved in order to access the sites and build the project.

Site #	Name	Subwtshd	Length_ft		$/LF at FY15 Q1 price level	Note	account 16 Bank Stabilization (CCE without Contingency)	Contingency	account 16 Bank Stabilization (with Contingency) or **CCE**	account 30, Planning Engineering Design (PED)	Contingency for PED	account 30, Planning Engineering Design (PED) with Contingency	account 31, Construction Management	Contingency for CM	account 31, Construction Management with Contingency	**Total Project Cost**	**Rounded Total Project Cost**
								25%		23%	10%		14.50%	10.00%			
1	Indian Creek	Indian Creek	6958	Alt 1	$ 382.32	NWB 2 (Woodlawn Site $/LF)	$ 2,660,040.78	$ 665,010.19	3325050.973	$ 611,809.38	$ 61,180.94	672990.3169	$ 385,705.91	$ 38,570.59	424276.5041	$ 4,422,317.79	**$ 4,422,000.00**
			6958	Alt 2	$ 344.09		$ 2,394,036.70	$ 598,509.18	$ 2,992,545.88	$ 550,628.44	$ 55,062.84	$ 605,691.29	$ 347,135.32	$ 34,713.53	$ 381,848.85	$ 3,980,086.01	**$ 3,980,000.00**
3	Northwest Branch Upstream FRM	Northwest Branch	7285	Alt 1	$ 497.02	NWB 2 (Woodlawn Site $/LF) + 30% adjustment	$ 3,620,717.43	$ 905,179.36	$ 4,625,896.78	$ 832,765.01	$ 83,276.50	$ 916,041.51	$ 525,004.03	$ 52,500.40	$ 577,504.43	$ 6,119,442.72	**$ 6,119,000.00**
			7285	Alt 2	$ 447.32		$ 3,258,645.68	$ 814,661.42	$ 4,073,307.11	$ 749,488.51	$ 74,948.85	$ 824,437.36	$ 472,503.62	$ 47,250.36	$ 519,753.99	$ 5,417,498.45	**$ 5,417,000.00**
5	Paint Branch	Paint Branch	6853	Alt 1	$ 882.42	Paint Branch Total Site $/LF incl. change order	$ 6,047,341.54	$ 1,511,835.39	$ 7,559,176.93	$ 1,390,888.55	$ 139,088.86	$ 1,529,977.41	$ 876,864.52	$ 87,686.45	$ 964,550.98	$ 10,053,705.31	**$ 10,054,000.00**
			6453	Alt 2	$ 794.18		$ 5,124,935.13	$ 1,281,233.78	$ 6,406,168.92	$ 1,178,735.08	$ 117,873.51	$ 1,296,608.59	$ 743,115.59	$ 74,311.56	$ 817,427.15	$ 8,520,204.66	**$ 8,520,000.00**
7	Paint Branch Interchange	Paint Branch	5876	Alt 1	$ 970.67	Paint Branch Total Site $/LF incl. change order + 10% adjustment	$ 5,703,954.66	$ 1,425,988.66	$ 7,129,943.32	$ 1,311,909.57	$ 131,190.96	$ 1,443,100.53	$ 827,073.43	$ 82,707.34	$ 909,780.77	$ 9,482,824.62	**$ 9,483,000.00**
			5876	Alt 2	$ 873.60		$ 5,133,559.19	$ 1,283,389.80	$ 6,416,948.99	$ 1,180,718.61	$ 118,071.86	$ 1,298,790.48	$ 744,366.08	$ 74,436.61	$ 818,802.69	$ 8,534,542.15	**$ 8,535,000.00**
9	Sligo Creek	Sligo Creek	2241	Alt 1	$ 497.02	NWB 2 (Woodlawn Site $/LF) + 30% adjustment	$ 1,113,878.22	$ 278,469.56	$ 1,392,347.78	$ 256,191.99	$ 25,619.20	$ 281,811.19	$ 161,512.34	$ 16,151.23	$ 177,663.58	$ 1,851,822.54	**$ 1,852,000.00**
			2241	Alt 2	$ 447.32		$ 1,002,490.40	$ 250,622.60	$ 1,253,113.00	$ 230,572.79	$ 23,057.28	$ 253,630.07	$ 145,361.11	$ 14,536.11	$ 159,897.22	$ 1,666,640.29	**$ 1,667,000.00**
10	Chillum Road Tributary	Northwest Branch	2096	Alt 1	$ 458.79	NWB 2 (Woodlawn Site $/LF) + 20% adjustment	$ 961,458.55	$ 240,364.64	$ 1,201,823.19	$ 221,135.47	$ 22,113.55	$ 243,249.01	$ 139,411.49	$ 13,941.15	$ 153,352.64	$ 1,598,424.84	**$ 1,598,000.00**
			2096	Alt 2	$ 412.91		$ 865,312.70	$ 216,328.17	$ 1,081,640.87	$ 199,021.92	$ 19,902.19	$ 218,924.11	$ 125,470.34	$ 12,547.03	$ 138,017.38	$ 1,438,582.36	**$ 1,439,000.00**
11	Indian Creek	Indian Creek	10466	Alt 1	$ 497.02	NWB 2 (Woodlawn Site $/LF) + 30% adjustment	$ 5,201,877.95	$ 1,300,469.49	$ 6,502,347.43	$ 1,196,431.93	$ 119,643.19	$ 1,316,075.12	$ 754,272.30	$ 75,427.23	$ 829,699.53	$ 8,648,122.08	**$ 8,648,000.00**
			10466	Alt 2	$ 447.32		$ 4,681,690.15	$ 1,170,422.54	$ 5,852,112.69	$ 1,076,788.73	$ 107,678.87	$ 1,184,467.61	$ 678,845.07	$ 67,884.51	$ 746,729.58	$ 7,783,309.88	**$ 7,783,000.00**
12	Little Paint Branch	Little Paint Branch	4530	Alt 1	$ 794.18	90% of Paint Branch Total Site $/LF incl. change order	$ 3,597,664.98	$ 899,416.24	$ 4,497,081.22	$ 827,462.94	$ 82,746.29	$ 910,209.24	$ 521,661.42	$ 52,166.14	$ 573,827.56	$ 5,981,118.02	**$ 5,981,000.00**
			4730	Alt 2	$ 714.76		$ 3,380,850.99	$ 845,212.75	$ 4,326,063.74	$ 777,595.73	$ 77,759.57	$ 855,355.30	$ 490,223.39	$ 49,022.34	$ 539,245.73	$ 5,720,664.78	**$ 5,721,000.00**
13	Northwest Branch Eastwest Highway	Northwest Branch	7,690	Alt 1	$ 497.02	NWB 2 (Woodlawn Site $/LF) + 30% adjustment	$ 3,822,080.12	$ 955,520.03	$ 4,777,600.15	$ 879,078.43	$ 87,907.84	$ 966,986.27	$ 554,201.62	$ 55,420.16	$ 609,621.78	$ 6,354,208.20	**$ 6,354,000.00**
			7,690	Alt 2	$ 447.32		$ 3,439,872.11	$ 859,968.03	$ 4,399,840.14	$ 791,170.59	$ 79,117.06	$ 870,287.64	$ 498,781.46	$ 49,878.15	$ 548,659.60	$ 5,818,787.38	**$ 5,819,000.00**
15	Calvert Road Disc Golf Park	Northeast Branch	3,823	Alt 1	$ 1,058.91	Paint Branch Total Site $/LF incl. change order + 20% adjustment	$ 4,048,436.17	$ 1,012,109.04	$ 5,060,545.22	$ 931,140.32	$ 93,114.03	$ 1,024,254.35	$ 587,023.25	$ 58,702.32	$ 645,725.57	$ 6,730,525.14	**$ 6,731,000.00**
			3,823	Alt 2	$ 953.02		$ 3,643,592.56	$ 910,898.14	$ 4,554,490.70	$ 838,026.29	$ 83,802.63	$ 921,828.92	$ 528,320.92	$ 52,832.09	$ 581,153.01	$ 6,057,472.63	**$ 6,057,000.00**
15	Calvert Road Disc Golf Park Trib	Northeast Branch	1,696	Alt 1	$ 382.32	NWB 2 (Woodlawn Site $/LF)	$ 648,419.31	$ 162,104.83	810524.1431	$ 149,136.44	$ 14,913.64	164050.0866	$ 94,020.80	$ 9,402.08	103422.8807	$ 1,077,997.11	**$ 1,078,000.00**
			1,696	Alt 2	$ 344.09		$ 583,577.38	$ 145,894.35	$ 729,471.73	$ 134,222.80	$ 13,422.28	$ 147,645.08	$ 84,618.72	$ 8,461.87	$ 93,080.59	$ 970,197.40	**$ 970,000.00**

Note: Budgetary 100k is added to account 16 for Site 3 Alt 1 and Site 12 Alt 2, and Site 13 Alt 2 for a pedestrian bridge relocation. Adjustment factor is based on stream size, number of structures, difficulty levels, and accessibility. Alternative 2 is assumed to cost less than Alternative 1 by 10% (or Alt 2 = 90% of Alt 1) because it is assumed to include not as much stone as Alternative 1. All costs are based on the 2012 historical bid data for North West Branch Package 2 and Paint Branch Part 1, 2, and Change Order. Escalation to Q1 FY15 price level from historical price level using CWCCIS dated Sep 2014 was

Appendix H. Real Estate Plan (Draft)

The Real Estate Plan will be finalized for the final Feasibility Report, based on refined engineering designs and identification of real estate impacts.

PRELIMINARY REAL ESTATE PLAN
ANACOSTIA WATERSHED RESTORATION PROJECT
PRINCE GEORGES COUNTY, MARYLAND

1. GENERAL

2. REAL ESTATE REQUIREMENTS

   a. Description of Land, Easements, Rights of Way and Relocations (LERR) Requirements for Project
   b. Standard Estates
   c. Non-Standard Estates
   d. Current Ownership
   e. Real Estate Mapping

3. EXISTING FEDERAL PROJECTS

4. EXISTING FEDERALLY OWNED LANDS

5. LANDS OWNED BY THE NON-FEDERAL PARTNER

6. NAVIGATIONAL SERVITUDE

7. INCREASED FLOODING

8. BASELINE COST ESTIMATE FOR REAL ESTATE

9. PUBLIC LAW 91-646 RELOCATIONS

10. MINERAL ACTIVITY

11. TIMBER RIGHTS

12. ASSESSMENT OF NON-FEDERAL SPONSOR'S ACQUISITION CAPABILITY

13. ZONING

14. ACQUISITION SCHEDULE

15. UTILITY AND FACILITY RELOCATIONS

16. ENVIRONMENTAL CONCERNS

17. ATTITUDES OF THE LANDOWNERS

18. NOTIFICATION TO NON-FEDERAL SPONSOR

19. RISK ANALYSIS

1. GENERAL

This preliminary Real Estate Plan (REP) is in support of the Anacostia Watershed Restoration (AWR) Project, Prince George's County, Maryland, Feasibility Study. The project purpose is to develop and evaluate potential ecosystem restoration opportunities to address degraded aquatic ecosystems in the Anacostia River Watershed. The AWR Study is being conducted under the authority of a September 8, 1988 resolution of the House Committee on Public Works and Transportation. This cost-shared Study is being conducted in partnership with Prince George's County, Maryland, which is the non-Federal Sponsor (NFS) for this project. This preliminary REP is based on the Tentatively Selected Plan (TSP), which is currently at a concept-level of design (approximately 10% design).

The objectives of the Anacostia Watershed Restoration (AWR) study include:

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

2. Enhance aquatic ecosystem resilience by restoring fish passage for migratory and non-migratory fish and connecting existing higher quality habitat in the mainstem

2. REAL ESTATE REQUIREMENTS

a. Description of Land, Easements, Rights-of-Way and Relocations (LERR) Requirements for the Project

In-stream structures, in combination with plantings, will be used to provide streambed and streambank grade control. Varying site-specific designs will be constructed in the floodplain to provide long term environmental stability and ecosystem improvements at each of the 10 locations. Project construction, operation and maintenance will be within the existing streambed/streambank and floodplain. Staging areas and site access which may be required during project construction will be identified as project design is further developed.

b. Standard Estates

Project construction, operation and maintenance in the streambed and adjacent floodplain will require a standard perpetual Channel Improvement Easement, as well as standard Temporary Work Area Easements for staging and access, as needed. Acquisition Tract numbers, Project Approval Date, and Term of TWAE will be determined in the future should this Project be approved.

CHANNEL IMPROVEMENT EASEMENT (Standard Estate No. 8)

A perpetual and assignable right and easement to construct, operate, and maintain channel improvement works on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____) for the purposes as authorized by the Act of Congress approved_____, including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, buildings, improvements and/or other obstructions therefrom; to excavate: dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; and for such other purposes as may be required in

connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements far public roads and highways, public utilities, railroads and pipelines.

TEMPORARY WORK AREA EASEMENT (Standard Estate No.15)
A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tract Nos. ____), for a period not to exceed _____ (__) years, beginning with the date possession of the land is granted to Prince Georges County, Maryland, for use by Prince Georges County, Maryland, its representatives, agents, and contractors as a work area, including the right to move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the Anacostia Watershed Resources Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however to existing easements for public roads and highways, public utilities, railroads and pipelines.

c. Non-Standard Estates

The NFS is a controlling partner in the Maryland National Capital Park and Planning Commission (MNCPPC). In prior cost-shared projects, such as Anacostia Northwest Branch, Paint Branch, and Western Branch-Patuxent River, a permit has been used for access and construction on MNCPPC land (existing park lands).

d. Current Ownership

Current ownership for each of the 10 /reaches sites is shown in Exhibit B.

e. Real Estate Mapping

A map of the locations of the 10 study sites is attached as Exhibit A. For study purposes, it is assumed that the project will be 60 feet wide (30 feet off the centerline of the stream on both sides). As more site-specific design is completed, detailed real estate mapping will be developed for each of the final reaches/locations.

3. EXISTING FEDERAL PROJECTS

There is an existing Anacostia River cost-shared flood protection and navigation project in the proposed project area. This consists of mainly stream channelization in the proposed project reaches. The extent of the proposed project's overlap with the existing project has not been determined at this stage. The NFS will not receive credit for LERR for any lands/interests previously provided for the existing project.

4. EXISTING FEDERALLY OWNED LANDS

There is an existing federally-owned parcel within this project area in Reach 12 Alt 1 and Alt 2. This parcel is owned/managed by GSA. This will be researched further as necessary should project design include Reach 12, which is not currently in the TSP.

5. LANDS OWNED BY THE NON-FEDERAL SPONSOR

The NFS, Prince Georges County, owns 1 property in fee simple in Site/Reach 1 (not in the TSP). As stated, the NFS is a controlling partner in the MNCPPC, which owns parcels in the study area. MNCPPC has participated in other similar cost-shared projects, such as Anacostia Northwest Branch, Paint Branch, and Western Branch-Patuxent River.

The NFS is responsible for providing all real property interests required to construct, operate, and maintain the project, which may require acquisitions. When the NFS owns or controls all real estate required for project construction, operation and maintenance, the NFS executes a standard Authorization for Entry for Construction instrument. This authorizes "… the Department of the Army, its agents, employees and contractors, to enter upon…" the project site(s) as per the executed Project Partnership Agreement (PPA), should the Project proceed to this Approval stage.

These parcels owned/controlled by the NFS are highlighted in Exhibit B.

6. NAVIGATIONAL SERVITUDE

Navigational servitude is not applicable to this project.

7. INCREASED FLOODING

No increased flooding due to the project is anticipated.

8. BASELINE COST ESTIMATE FOR REAL ESTATE

Project information and design for a Real Estate Cost Estimate in MCACES format is not available during this preliminary phase. The value of lands, easements, rights-of-way and relocations (LERR), as well as administrative acquisition expenses, will be developed upon determining the final selected plan design. Real Estate costs are considered to be minimal due to the project areas being within the existing streambed/streambank and floodplain, and therefore undevelopable. At this preliminary stage, a nominal, representative value of $10,000 per acre is used for the required perpetual Channel Improvement Easement, which will be located within the floodplain. This is a representative amount to be used for planning purposes in order to compare potential project sites. A Gross Appraisal will be completed once site designs are at a higher level. For planning purposes, representative real estate costs for each site, including administrative acquisition costs, are shown in Exhibit C.

9. PUBLIC LAW 91-646 RELOCATIONS

No relocations are anticipated for this study project area.

10. MINERAL ACTIVITY

There is no present or anticipated mining and drilling activity in the vicinity of the project that may affect the operation thereof.

11. TIMBER RIGHTS

There is no present or anticipated timber harvesting activity in the vicinity of the project that may affect the operation thereof.

12. ASSESSMENT OF NON-FEDERAL SPONSOR'S ACQUISITION CAPABILITY

Prince Georges County is the NFS. The NFS will be responsible for acquisition of the required real estate interests. The NFS has the necessary experience and resources to acquire the real estate interests required for the project in accordance with PL 91-646 (the 'Uniform Act'). The assessment of the NFS's real estate acquisition capability is included as Exhibit D.

13. ZONING

The enactment of zoning ordinances is not proposed to facilitate acquisition.

14. ACQUISITION SCHEDULE

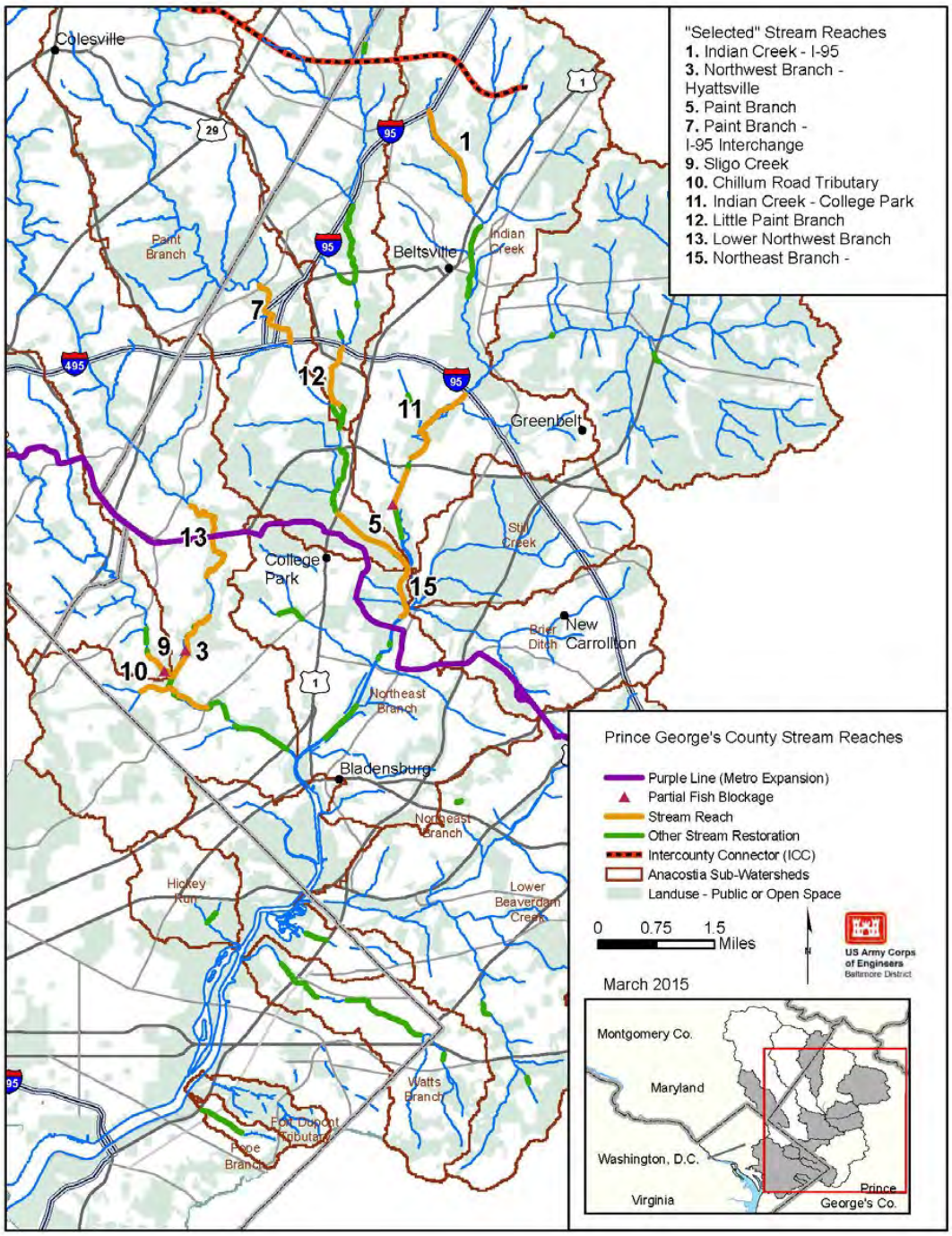
At this preliminary stage, a general acquisition time-requirement for the NFS is estimated to be approximately 12 to 18 months. A detailed schedule will be developed with the NFS as project design and real estate requirements are established.

18. NOTIFICATION TO NON-FEDERAL SPONSOR

The NFS is generally aware of their responsibilities for real estate acquisition under PL 91-646 and the requirements to receive credit for real estate acquisitions. By letter dated February 3, 2016, the NFS has been notified in writing of the risks associated with acquisition of real estate in advance of Project Partnership Agreement (PPA) execution.

19. RISK ANALYSIS

Real estate acquisitions required in conjunction with this project appear to be fairly low risk since the project will be located within the existing streambed/streambank and floodplain where development is prohibited.



Anacostia Watershed Restoration Study-Project Sites, 10 Locations
Prince Georges County, Maryland. Reaches 3, 5, 9, 11, 13, and 15 are included in the Tentatively Selected Plan (TSP).

EXHIBIT A

Properties within Stream Reach One

ACCOUNT	OWNER_NAME	MAIL_STREE	MAIL_CITY	MAIL_	MAIL_ZIP5
0066845	STATE OF MARYLAND	STATE TREASURER OFFICE	ANNAPOLIS	MD	21404
0014357	1325 G STREET ASSOCIATES LLLP	14401 SWEITZER LN	LAUREL	MD	20707
0029132	CHRISTIAN BROS CMTY SUP CHAR TR	444 A ROUTE 35 SOUTH	EATONTOWN	NJ	07724
9999999	UNKNOWN				
3319522	AMMENDALE NORMAL INSITUTE PG CNTY	444 A ROUTE 35 SOUTH	EATONTOWN	NJ	07724
3319514	CHRISTIAN HOPE MINISTRIES INC	6251 AMMENDALE RD	BOWIE	MD	20720
3197704	PROLOGIS TARGETED U S	4545 AIRPORT WAY	DENVER	CO	80239
3646775	MOR AMMENDALE LLC	8601 ROBERT FULTON DR	COLUMBIA	MD	21046
0014365	1325 G STREET ASSOCIATES LLLP	14401 SWITZER LN	LAUREL	MD	20707
3319548	AMMENDALE BUS CMPS S CONDO ASSN	444 A ROUTE 35 SOUTH	EATONTOWN	NJ	07724
3197696	PROLOGIS TARGETED U S	4545 AIRPORT WAY	DENVER	CO	80239
3251477	ROLLING FRITO-LAY SALES LP	PO BOX 565048	DALLAS	TX	75356
3319530	HOLY APOSTLES ORTHODOX CH INC	10760 BALTIMORE AVE	BELTSVILLE	MD	20705
0071944	PRINCE GEORGES COUNTY	8400 DARCY RD	FORESTVILLE	MD	20747
3197720	PROLOGIS TARGETED U S	4545 AIRPORT WAY	DENVER	CO	80239

Highlighted Tract is owned by the Non-Federal Sponsor.

EXHIBIT B

Properties within Stream Reach Three

ACCOUNT	OWNER_NAME	MAIL_STREE	MAIL_CITY	MAIL_	MAIL_ZIP5
1914779	MARYLAND NATL CAPT PARK&PLAN COM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914514	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914688	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914480	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1812379	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1924745	WASHINGTON METRO AREA TRANS AUTH	600 5TH ST NW	WASHINGTON	DC	20001
1859412	MARYLAND NATL CAPT PARK&PLANN COM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
3670320	MARYLAND NATL CAPT PK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914746	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914324	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914753	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914860	MARYLAND NATL CAPT PK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1806298	KAD AGER HOLDINGS LLC	5950 AGER RD	HYATTSVILLE	MD	20782
1826510	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914332	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914472	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914886	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914761	MARYLAND NATL CAPT PARK& PLAN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737

Highlighted Tracts are owned by the Non-Federal Sponsor (Includes MNCPPC)

This Reach is in the Tentatively Selected Plan (TSP).

EXHIBIT B

Properties within Stream Reach Five

ACCOUNT	OWNER_NAME	MAIL_STREE	MAIL_CITY	MAIL_	MAIL_ZIP5
2411213	UNIVERSITY OF MARYLAND	UNIVERSITY OF MARYLAND	COLLEGE PARK	MD	20742
2411213	UNIVERSITY OF MARYLAND	UNIVERSITY OF MARYLAND	COLLEGE PARK	MD	20742
2363463	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2292977	BOARD OF EDUCATION	14201 SCHOOL LN	UPPER MARLBORO	MD	20772
2420487	WASHINGTON SUB SANITARY COMM	14501 SWEITZER LN	LAUREL	MD	20707
2288025	CSX TRANSPORTATION INC	500 WATER ST	JACKSONVILLE	FL	32202
2411213	UNIVERSITY OF MARYLAND	UNIVERSITY OF MARYLAND	COLLEGE PARK	MD	20742
2420487	WASHINGTON SUB SANITARY COMM	14501 SWEITZER LN	LAUREL	MD	20707
2411205	UNIVERSITY OF MARYLAND	UNIVERSITY OF MARYLAND	COLLEGE PARK	MD	20742
2420487	WASHINGTON SUB SANITARY COMM	14501 SWEITZER LN	LAUREL	MD	20707
2420487	WASHINGTON SUB SANITARY COMM	14501 SWEITZER LN	LAUREL	MD	20707
2420479	WASHINGTON SUB SANITARY COMM	14501 SWEITZER LN	LAUREL	MD	20707
2420487	WASHINGTON SUB SANITARY COMM	14501 SWEITZER LN	LAUREL	MD	20707
2411213	UNIVERSITY OF MARYLAND	UNIVERSITY OF MARYLAND	COLLEGE PARK	MD	20742
2411205	UNIVERSITY OF MARYLAND	UNIVERSITY OF MARYLAND	COLLEGE PARK	MD	20742
2292969	BOARD OF EDUCATION	14201 SCHOOL LN	UPPER MARLBORO	MD	20772
2420487	WASHINGTON SUB SANITARY COMM	14501 SWEITZER LN	LAUREL	MD	20707
2400182	STATE OF MARYLAND	ROWE BLVD	ANNAPOLIS	MD	21404
2420487	WASHINGTON SUB SANITARY COMM	14501 SWEITZER LN	LAUREL	MD	20707
2411213	UNIVERSITY OF MARYLAND	UNIVERSITY OF MARYLAND	COLLEGE PARK	MD	20742
2362838	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362804	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2292969	BOARD OF EDUCATION	14201 SCHOOL LN	UPPER MARLBORO	MD	20772
2362820	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2420487	WASHINGTON SUB SANITARY COMM	14501 SWEITZER LN	LAUREL	MD	20707
2362820	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2420487	WASHINGTON SUB SANITARY COMM	14501 SWEITZER LN	LAUREL	MD	20707
2362804	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2400182	STATE OF MARYLAND	ROWE BLVD	ANNAPOLIS	MD	21404

This Reach is in the Tentatively Selected Plan (TSP).

EXHIBIT B

ACCOUNT	OWNER_NAME	MAIL_STREE	MAIL_CITY	MAIL_	MAIL_ZIP5
2362796	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2420487	WASHINGTON SUB SANITARY COMM	14501 SWEITZER LN	LAUREL	MD	20707
2420487	WASHINGTON SUB SANITARY COMM	14501 SWEITZER LN	LAUREL	MD	20707
2839579	WASHINGTON METRO AREA TRANSIT AUT	600 FIFTH ST NW	WASHINGTON	DC	20001

Highlighted Tracts are owned by the Non-Federal Sponsor
(Includes MNCPPC)

This Reach is in the Tentatively Selected Plan (TSP).

EXHIBIT B

Properties within Stream Reach Seven

ACCOUNT	OWNER_NAME	MAIL_STREE	MAIL_CITY	MAIL_	MAIL_ZIP5
2410835	UNITED STATES OF AMERICA	18TH & F STS NW	WASHINGTON	DC	20405
2363232	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
0042200	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2363208	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2363224	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2363216	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
0040790	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2395747	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2363208	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737

Highlighted Tracts are owned by the Non-Federal Sponsor
(Includes MNCPPC)

EXHIBIT B

Properties within Stream Reach Nine

ACCOUNT	OWNER_NAME	MAIL_STREE	MAIL_CITY	MAIL_	MAIL_ZIP5
1914704	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914902	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914506	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914886	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914498	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737

Highlighted Tracts are owned by the Non-Federal Sponsor
(Includes MNCPPC)

This Reach is in the Tentatively Selected Plan (TSP).

EXHIBIT B

Properties within Stream Reach Ten

ACCOUNT	OWNER_NAME	MAIL_STREE	MAIL_CITY	MAIL_	MAIL_ZIP5
1914514	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914530	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914902	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
9999999	UNKNOWN				
1914472	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737

Highlighted Tracts are owned by the Non-Federal Sponsor
(Includes MNCPPC)

EXHIBIT B

Properties within Stream Reach 11

ACCOUNT	OWNER_NAME	MAIL_STREE	MAIL_CITY	MAIL_	MAIL_ZIP5
2284552	REILY BRIAN & ELLEN J	3719 ELBERTA LN	HUNTINGTOWN	MD	20639
2286185	ARCHIBALD KENNETH S & GLORIA A	8906 56TH AVE	COLLEGE PARK	MD	20740
2353571	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2353571	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2353571	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2361632	REILY BRIAN M & ELLEN J	3719 ELBERTA LN	HUNTINGTOWN	MD	20639
2363646	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2363646	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2397420	WASHINGTON METRO AREA TRANS AUTH	600 5TH ST NW	WASHINGTON	DC	20001
2397420	WASHINGTON METRO AREA TRANS AUTH	600 5TH ST NW	WASHINGTON	DC	20001
2397461	WASHINGTON METRO AREA TRANS AUTH	600 5TH ST NW	WASHINGTON	DC	20001
2397479	WASHINGTON METRO AREA TRANS AUTH	600 5TH ST NW	WASHINGTON	DC	20001
2397727	NVR MS CAVALIER GREENBELT LLC	11700 PLAZA AMERICA DR	RESTON	VA	20190
2424273	MARYLAND NATL CAPT PK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2424273	MARYLAND NATL CAPT PK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
3361813	STATE OF MARYLAND	300 W PRESTON ST	BALTIMORE	MD	21201
3820172	NVR MS CAVALIER GREENBELT LLC	11700 PLAZA AMERICA DRIVE	RESTON	VA	20190
3822632	NVR MS CAVALIER GREENBELT LLC	11700 PLAZA AMERICA DRIVE	RESTON	VA	20190
3822673	NVR MS CAVALIER GREENBELT LLC	11700 PLAZA AMERICA DRIVE	RESTON	VA	20190

Highlighted Tracts are owned by the Non-Federal Sponsor (Includes MNCPPC)

This Reach is in the Tentatively Selected Plan (TSP).

EXHIBIT B

Properties within Stream Reach Twelve

ACCOUNT	OWNER_NAME	MAIL_STREE	MAIL_CITY	MAIL_	MAIL_ZIP5
2410835	UNITED STATES OF AMERICA	18TH & F STS NW	WASHINGTON	DC	20405
3949260	MARYLAND NATL CAPT PK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362259	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
0070243	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362945	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737

Highlighted Tracts are owned by the Non-Federal Sponsor
(Includes MNCPPC)

EXHIBIT B

Properties within Stream Reach Thirteen

ACCOUNT	OWNER_NAME	MAIL_STREE	MAIL_CITY	MAIL_	MAIL_ZIP5
1915008	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1932896	POTOMAC ELECTRIC POWER CO	701 NINTH ST NW	WASHINGTON	DC	20068
1902154	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1965557	REDEEMER BAPTIST CHURCH INC	1237 QUINCY ST NE	WASHINGTON	DC	20017
1914415	MARYLAND NATL CAPT PK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914399	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
3670320	MARYLAND NATL CAPT PK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
3670304	MARYLAND NATL CAPT PK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914621	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
3670312	MARYLAND NATL CAPT PK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1981562	BUTLER REX M & EMIKO S	7918 WOODBURY DR	SILVER SPRING	MD	20910
1914605	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1915503	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914860	MARYLAND NATL CAPT PK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914407	MARYLAND NATL CAPT PK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1915016	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1953256	ROCKEROSE NICHOLE	2405 COOL SPRING RD	HYATTSVILLE	MD	20783
1858737	COLONIAL PIPELINE CO	PO BOX 18855	ATLANTA	GA	31126
1914571	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1914555	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
1924596	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737

Highlighted Tracts are owned by the Non-Federal Sponsor
(Includes MNCPPC)

This Reach is in the Tentatively Selected Plan (TSP).

EXHIBIT B

Properties in Stream Reach 15

ACCOUNT	OWNER_NAME	MAIL_STREE	MAIL_CITY	MAIL_	MAIL_ZIP5
2148575	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362531	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362531	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362531	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362531	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362572	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362572	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362598	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362630	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362630	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362630	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362630	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362648	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362648	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362648	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362648	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362648	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362648	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362648	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362648	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362648	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362655	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2362796	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2363000	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2363000	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2363000	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2363000	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2363000	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2363000	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2363000	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2363067	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737
2408607	MARYLAND NATL CAPT PARK & PLANN COMM	6600 KENILWORTH AVE	RIVERDALE	MD	20737

Highlighted Tracts are owned by the Non-Federal Sponsor (Includes MNCPPC)

EXHIBIT B

This Reach is in the Tentatively Selected Plan (TSP).

Anacostia Watershed Restoration
Estimate for Required Real Estate
as of 24 May 2016
Based on Approximately 10% level of Design

Reach ID		Linear Ft	Square Feet	Acres	$10,000 per Acre	Total parcels	NFS & MNCPPC Parcels	Non-NFS & MNCPPC Parcels	NFS Admin Acq Cost	Land & Admin	25% Cont	Real Estate Total	Notes	Reach ID	In TSP
1	Alt 1	6,958	417,480	9.6	95,840	15	1	14	70,000	165,840	41,460	**207,300**	1 unknown owner	1	
	Alt 2	6,958	417,480	9.6	95,840	15	1	14	70,000	165,840	41,460	**207,300**	1 unknown owner	1	
3	Alt 1	7,285	437,100	10.0	100,344	18	16	2	10,000	110,344	27,586	**137,930**		3	
	Alt 2	7,285	437,100	10.0	100,344	18	16	2	10,000	110,344	27,586	**137,930**		3	TSP
5	Alt 1	6,853	411,180	9.4	94,394	33	7	26	130,000	224,394	56,098	**280,492**	1 CSX Railroad	5	
	Alt 2	6,453	387,180	8.9	88,884	33	7	26	130,000	218,884	54,721	**273,605**	1 CSX Railroad	5	TSP
7	Alt 1	5,876	352,560	8.1	80,937	9	8	1	5,000	85,937	21,484	**107,421**	1 USA	7	
	Alt 2	5,876	352,560	8.1	80,937	9	8	1	5,000	85,937	21,484	**107,421**	1 USA	7	
9	Alt 1	2,441	146,460	3.4	33,623	5	5	0	-	33,623	8,406	**42,028**		9	
	Alt 2	2,441	146,460	3.4	33,623	5	5	0	-	33,623	8,406	**42,028**		9	TSP
10	Alt 1	2,096	125,760	2.9	28,871	5	4	1	5,000	33,871	8,468	**42,338**	1 unknown owner	10	
	Alt 2	2,096	125,760	2.9	28,871	5	1	4	20,000	48,871	12,218	**61,088**	1 unknown owner	10	
11	Alt 1	10,466	627,960	14.4	144,160	19	7	12	60,000	204,160	51,040	**255,200**		11	
	Alt 2	10,466	627,960	14.4	144,160	19	7	12	60,000	204,160	51,040	**255,200**		11	TSP
12	Alt 1	4,530	271,800	6.2	62,397	5	4	1	5,000	67,397	16,849	**84,246**	1 USA	12	
	Alt 2	4,730	283,800	6.5	65,152	5	4	1	5,000	70,152	17,538	**87,689**	1 USA	12	
13	Alt 1	7,690	461,400	10.6	105,923	21	16	5	25,000	130,923	32,731	**163,654**	1 Potomac Electric, 1 Colonial pipeline	13	TSP
	Alt 2	7,690	461,400	10.6	105,923	21	16	5	25,000	130,923	32,731	**163,654**	1 Potomac Electric, 1 Colonial pipeline	13	
15	Alt 1	5,519	331,140	7.6	76,019	34	34	0	-	76,019	19,005	**95,024**		15	
	Alt 2	5,519	331,140	7.6	76,019	34	34	0	-	76,019	19,005	**95,024**		15	TSP
					-										

Reaches 3 alt 2,5 alt 2, 9 alt 2, 11 alt 2, 13 alt 1, and 15 alt 2 are in the Tentatively Selected Plan (TSP).

Assumptions
-Based on Approximately 10% level of Design.
-Project is 60' wide.
-Recommended Estate is perpetual Channel Improvement Easement (requirements for Temporary Work Area Easements have not been identified)
-Project will be in existing streambeds/Buffer zones/wetlands where development is prohibited..
-Value is based on $10,000 per acre nominal Value for Perp Chanel Improvement
-Admin cost for acquisition is based on $5000 per parcel not owned by NFS or MNCPPC.
-Contingency is 25%
-This cost estimate assumes there will be no req'd utility/facility relocations.
-This cost estimate assumes there will be no req'd PL91-646 residential or comm'l relocations.
-Maryland National Capital Parks & Planning Commission (MNCPPC) will enter into an MOU w/NFS to provide req'd real estate.

Notes:
Reach 13 includes 2 parcels owned by Utilities, Potomac Electric & Colonial Pipeline.
Reach 5 includes 1 parcel owned by a Railroad, CSX.

-MNCPPC=Maryland National Capital Parks & Planning Commission
-NFS=Non-Federal Sponsor, Prince Georges County

Exhibit C

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

Anacostia Watershed Restoration Project
Located in Prince Georges County, Maryland
Non-Federal Sponsor (NFS): Prince Georges County, Maryland

1. Legal Authority

a. Does the NFS have legal authority to acquire and hold title to real property for project purposes?

Yes. The NFS has acquisition authority in the project area.

b. Does the NFS have the power of eminent domain for this project?

Yes. The NFS has the power of eminent domain for this project, however, it is not likely to be used for an environmental restoration project such as this.

c. Does the NFS have "quick-take" authority for this project?

No.

d. Are there any lands/interests in land required for the project located outside the NFS's political boundary?

No.

e. Are any of the lands/interests in land required for the project owned by an entity whose property the NFS cannot condemn?

The final Project area has not yet been identified, however current concept-level design (approximately 10% level of design) shows 2 ownerships which the NFS cannot condemn, owned by the State of Maryland and USA.

2. Human Resource Requirements:

a. Will the NFS's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended?
No. The NFS is familiar with the requirements of P.L. 91-646.

EXHIBIT D

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

N/A

c. Does the NFS's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project?

Yes.

d. Is the NFS's projected in-house staffing level sufficient considering its other workload, if any, and the project schedule?

Yes.

e. Can the NFS obtain contractor support, if required, in a timely fashion?

Contractor support is not anticipated to be necessary.

f. Will the NFS likely request USACE assistance in acquiring real estate?

No.

3. Other Project Variables:

a. Will the NFS's staff be located within reasonable proximity to the project site?

Yes.

b. Has the NFP approved the project/real estate schedule/milestones?

No, final real estate requirements have not yet been determined. The NFP will be included in establishing an acquisition schedule once the requirements are determined.

4. Overall Assessment:

a. Has the NFS performed satisfactorily on other USACE projects?

Yes, Prince Georges County was also the NFS for the Anacostia Northwest Branch, Paint Branch, and Western Branch-Patuxent River, cost-shared Projects.

EXHIBIT D

b. With regard to this project, the NFS is anticipated to be: highly capable/fully capable/moderately capable/marginally capable/insufficiently capable?

Fully capable.

5. Coordination

a. Has this assessment been coordinated with the NFS?

No, this is a preliminary assessment.

b. Does the NFS concur with this assessment?

N/A.

EXHIBIT D

Appendix I. Preliminary Adaptive Management & Monitoring Plan

Anacostia Watershed, Prince George's County
Preliminary Monitoring and Adaptive Management Plan

Stream restoration is an evolving field and the urban stream environment presents the possibility for rapid, unpredicted changes in conditions that would affect the success of the project. To verify that project objectives are met, it will be necessary to monitor the restored stream following a multiple faceted cost-shared, post-construction monitoring plan. 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.

At this time, conceptual designs have been prepared, but detailed designs including locations of structures have not yet been prepared. Accordingly, this plan is general in nature and will be refined following the production of detailed feasibility level designs. A more complete plan will be provided with the final feasibility report. Additionally, the adaptive management plan will be further expanded upon once the Operations and Maintenance Manual is drafted.

U.S. Army Corps of Engineers (USACE) monitoring and adaptive management policy is required by the Water Resources Development Act of 2007 and presented in planning guidance (Engineering Regulation (ER) 1105-2-100 with further explanation in Engineering Circular (EC) 1105-2-409). 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 will be needed to attain project benefits. Adaptive management addresses the uncertainties about a project's actual 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. At the heart of adaptive management is an appropriate monitoring program to determine if the outputs/results are satisfactory, and to determine if any adjustments are needed.

I. Objectives

The objectives of Anacostia stream restoration projects are to:

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

II. Metrics and Methods to Evaluate Progress Towards Objectives and Desired Outcomes

Pre-project physical and biological data has been collected in each segment, as described below. Data collected includes the evaluation in-stream physical habitat and sampling of fish assemblages. Following construction, physical habitat and biological condition will be assessed periodically. Differences between pre- and post-project physical and biological data will be evaluated to monitor changes. These changes will be compared to water quality and other data being collected concurrently and independently of this study by Prince George's County to characterize project effects versus ambient effects.

A. Stream Habitat and Resident Aquatic Life

Metrics to determine habitat and resident aquatic life changes produced by the stream restoration projects are appropriately relevant metrics used in plan formulation and the project Cost Effective Incremental Cost Analysis (CEICA), as well as additional metrics to assess condition of aquatic life (Table 1).

Table 1: Stream habitat restoration metrics.

Resource	Metrics
Physical Habitat	PHI, plus individual habitat metric component scores (MDDNR, 2003)
Benthic Macroinvertebrates	Benthic Index of Biotic Integrity (BIBI)
Finfish	Fish Index of Biotic Integrity (FIBI), plus consideration of individual species and guilds

Desired outcomes are an improvement in physical habitat index score resulting from increased habitat heterogeneity and or stability, and improved biological condition resulting from increased species richness and or increase in proportion of specialist/less tolerant species. BIBI and FIBI of streams would show an improvement to the degree that physical habitat conditions control biological condition (MDDNR, 2003; MDDNR, 2005b). Other stressors, particularly degraded water quality, may prevent or limit biological improvement even with habitat restoration projects in place (MDDNR, 2005a).

Monitoring of physical habitat and resident aquatic life would be accomplished using established methods of Maryland Biological Stream Survey (MBSS) that were used in study plan formulation and stream assessment (MDDNR, 2013). The MBSS physical habitat assessment methods were approved for use by the USACE Ecosystem Restoration Planning Center of Expertise (EcoPCX). The physical and biological monitoring methods are based on U.S. Environmental Protection Agency (USEPA) methods and have undergone extensive review, and have been used for two decades in Maryland.

B. Fish Passage

To determine whether fish blockage removal efforts have been successful, it will be necessary to determine whether migratory fish have successfully passed through the former blockage during the spawning season. This will be done by evaluating monitoring data up and downstream of the

former blockage. If migratory fish pass the blockage, it can be assumed that they could then successfully swim upstream to the next blockage.

Desired outcome is ability of fish to pass the former blockage in substantial numbers as compared to fish that make it upstream to the downstream side of the blockage. Other factors, particularly regional population trends of the migratory species, may limit the numbers of fish migrating upstream.

Metrics used to determine whether the restoration projects provided fish passage to migratory fish requires monitoring up/down stream of the fish blockages during the herring migratory season. Monitoring of fish passage will likely occur in the same manner as was done on Paint Branch (Section 206) previously by USACE and in a manner similar to herring monitoring currently conducted by the Metropolitan Washington Council of Governments (MWCOG). The fish survey will be conducted both upstream and downstream of the former fish blockages during the herring spawning season. Depending on the season's characteristics and initial results, 1-3 fish surveys will be conducted during each spawning season. The species counts and proportions of anadromous fish to total fish would be compared between the upstream and downstream sites, as well as over the total monitoring period of the project to determine if the fish blockages have been remediated and if spawning fish have re-established themselves in the stream. Backpack electrofishing and hoop nets or seines may be used, depending on the particular characteristics of the stream. The guidelines in pertinent MBSS protocols would be followed. MWCOG monitoring would supplement USACE post-project monitoring.

C. Other Stressors

Prince George's County maintains a Biological Assessment and Monitoring Program, which assesses the health of County streams. Findings of these efforts would be compiled and compared to results of monitoring conducted specifically in the restored segments. Findings from regional studies of herring conducted by the National Marine Fisheries Service (NMFS) and others would be utilized to characterize importance of non-project factors likely affecting herring numbers.

III. Schedule and Cost

Monitoring and adaptive management costs for each site are estimated to be up to the following amount for the first five years of the project:

Site	Approximate Total Cost
3 and 9*	$ 58,700
13	$ 63,500
15 and 5*	$ 150,800
11	$ 77, 800
*These sites are located in close enough proximity that adaptive management and monitoring costs are combined.	

These costs are cost-shared with the non-federal sponsor and are included in the project's total project costs shown in Table 4-2 of the main report, and are included within the construction costs shown in Table 4-3. The adaptive management portion of these costs is assumed to be minimal, because once access to the streams has been closed and areas revegetated it will be difficult to re-enter to the sites with heavy equipment. Adaptive management actions will necessitate the use of small equipment or hand tools. Monitoring costs at the recently completed stream restoration project at Paint Branch were approximately $40,000 over 5 years.

Sampling would follow the protocols of MBSS, and would include sampling in spring and summer.

IV. Mechanism for Corrective Action

If the results of the monitoring program support the need for adaptive management, the costs for any specified adjustment are estimated as above, but will not exceed three percent of the total project cost, excluding the monitoring costs. Adaptive management and monitoring costs will be cost-shared with the non-Federal sponsor.

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. If a constructed structure prevents fish movements, corrective action will be needed. The structure may need to be reset, stones or logs moved, a notch added, or other actions taken. 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.

To prevent establishment of invasive plant species in disturbed and restored areas in the stream corridor, an invasive species monitoring plan (ISMP) will be developed during the D&I phase and implemented.

V. References

Maryland Department of Natural Resources, (MDDNR). 2003. A Physical Habitat Index for Freshwater Wadeable Streams in Maryland. Final Report. Chesapeake Bay and Watershed Programs. Monitoring and Non-tidal Assessment. CBWP-MANTA-EA-03-4. Pagination by chapter. Accessed July 2013 from: http://www.dnr.state.md.us/streams/MBSS.asp

MDDNR. 2005a. Maryland Biological Stream Survey 2000-2004, Volume XIV: Stressors Affecting Maryland Streams. http://www.dnr.state.md.us/streams/mbss/current_act.html

MDDNR. 2005b. New Biological Indicators to Better Assess the Conditions of Maryland Streams. Chesapeake Bay and Watershed Programs. Monitoring and Non-tidal Assessment. CBWP-MANTA-EA-05-13. Pagination by chapter. Accessed October 2013 from: http://www.dnr.state.md.us/streams/pdfs/ea-05-13_new_ibi.pdf

MDDNR. 2013. Sampling Manual: Field Protocols. Rev. Jan. 2013. Maryland Biological Stream Survey. Chesapeake Bay and Watershed Programs. Monitoring and Non-tidal Assessment. CBWP-MANTA-EA-07-01. 63 pages. Accessed July 2013 from: http://www.dnr.state.md.us/streams/MBSS.asp