Phase III Stream Assessment Stream Restoration and Outfall Stabilization Feasibility Study

Prepared for:
Stormwater Management Division
Transportation and Environmental Services

City of Alexandria

February 2019

wood.

Phase III Stream Assessment: Stream Restoration and Outfall Stabilization Feasibility Study

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Chantilly, VA

ACKNOWLEDGEMENTS

The Phase III Stream Assessment: Stream Restoration and Outfall Stabilization Feasibility Study was a team effort between the City of Alexandria's Department of Transportation & Environmental Services, Stormwater Management Division; Department of Project Implementation; Department of Recreation, Parks, and Cultural Activities, Park Operations & Natural Resources Division; and Wood Environment & Infrastructure Solutions, Inc. The staff primarily involved in the project are listed below:

City of Alexandria

Joni Calmbacher, Civil Engineer, Department of Transportation & Environmental Services, Stormwater Management Division
Brian Rahal, Civil Engineer, Department of Transportation & Environmental Services, Stormwater Management Division
Jesse Maines, Division Chief, Department of Transportation & Environmental Services, Stormwater Management Division
Brian Meli, Project Manager, Department of Project Implementation
Robert Williams, Division Chief, Department of Recreation, Parks, and Cultural Activities, Park Operations & Natural Resources Division
James Nichols, Division Chief, Department of Recreation, Parks and Cultural Activities, Operations & Maintenance Division

Wood Environment & Infrastructure Solutions, Inc.

Tucker Clevenger, Project Manager
Troy Biggs, Senior Technical
Michael Hepp, Design Engineer
David Bulova, Senior Planner
John Miller, GIS Analyst
Marius Burdubus, Senior Engineer
Dr. Gregory Jennings (Jennings Environmental), Senior Review

Wood Environment & Infrastructure Solutions, Inc.
4795 Meadow Wood Lane, Ste. 310 East
Chantilly, VA 20151
Tel (703) 488-3700
Fax (703) 488-3701
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Fax (703) 488-3701
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SECTION 1 – INTRODUCTION

1.1 Background

The City of Alexandria, Virginia, is an urban community of 15.75 square miles with a population of approximately 150,000. With its stable residential neighborhoods, its historic districts, and its proximity to Washington, D.C., the City continues to attract new residents, tourists, and businesses.

The City is very supportive of stream and outfall restoration as one of the tools approved through the Chesapeake Stormwater Network that can be implemented towards addressing state and federal mandates for the Chesapeake Bay Total Maximum Daily Load (TMDL) that are enforced through the City's Municipal Separate Storm Sewer System (MS4) General Permit.

This document represents Phase III of the City's Stream Assessment Program. Phase I of the program was completed in 2004 and involved the identification and mapping of perennial and intermittent streams, defining the intermittent/ephemeral stream interface, and approximate limits of ephemeral streams. Phase II of the program was completed in 2008 and involved the assessment of fifty-seven (57) streams within the City's eight (8) local watersheds. Information related to stream conditions was collected relating to habitat, infrastructure inventory and impacts, problem areas, stream characteristics, and geomorphic classification.

The Phase III Stream Assessment: Stream Restoration and Outfall Stabilization Feasibility Study project has required collaboration of staff from the City of Alexandria's Department of Transportation & Environmental Services (T&ES), Stormwater Management Division, Department of Project Implementation (DPI), Department of Recreation, Parks, and Cultural Activities Department (RPCA), and Wood Environment & Infrastructure Solutions, Inc. (Wood).

1.2 Purpose of the Phase III Stream Assessment: Stream Restoration and Outfall Stabilization Feasibility Study

In July of 2017, the City issued a Request for Qualifications (RFQU) for the sole purpose and intent to solicit proposals to provide professional engineering services for the development of a prioritized list of streams and outfall stabilization and/or restoration projects and corresponding conceptual designs. Over the course of the past year, Wood staff have been engaged with the City on 5 streams and 4 outfalls to perform field assessments, determine existing nutrient and sediment loading, provide recommendations, develop a project decision matrix, select projects based on scoring, develop conceptual designs and planning level cost estimates, aid with grant submittal applications, and work alongside stakeholders. The ultimate purpose of the selected stream and outfall projects are to prevent erosion, enhance water quality, and improve stream habitat.

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SECTION 2 – RECOMMENDATIONS

2.1 Introduction

During March and April of 2018, field assessments were performed along reaches of the following streams: Strawberry Run, Taylor Run, Timber Branch, an Unnamed Tributary near Walleston Ct, and Holmes Run. Additionally, field assessments were performed along four stormwater outfalls; 3 along Holmes Run and 1 along Cameron Run. During the field investigation, the streams were visually assessed, photographed, and select samples were taken of bed and bank materials in order to understand the mechanisms causing ongoing fluvial processes.

2.2 Outfalls

2.2.1 - 000109 Holmes Run

Site Description:

A 72-inch RCP outfall is located just south of Glen Hills Park which is located in Fairfax County. Existing RCP pipe is spalling and eroding along flow line with rebar exposed. Flow has eroded a hole in the existing concrete outfall apron and scoured an approximately 2 ft. deep hole under the apron. Pieces of the undermined apron have broken off and remain in the channel. Material from the scour hole has deposited downstream creating a mid-channel bar (maximum particle size approx. 100mm). The mid-channel bar splits flow and directs it towards the banks. Existing concrete channel lining is breaking apart, and there are large bedrock outcroppings which were observed in the mid- and lower portion of the project reach. There is approximately 80 ft. of channel from the pipe outfall to Holmes Run and the reach slope is approximately 10%. Flow from the outfall is directed into Holmes Run in an upstream direction.

Figure 2.1. 72-inch RCP Outfall and receiving channel

Figure 2.2. Looking downstream from outfall towards Holmes Run

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Restoration Recommendations:

- Line/repair RCP pipe
- Repair/replace concrete end section and apron
- Establish plunge pool downstream of end section
- Stabilize eroding banks via re-grading, vegetation, and slope stabilization practices (soils lifts, coir matting)
- Utilize existing bedrock features as natural grade control
- Remove existing pieces of broken concrete and channel debris
- Realign outfall/confluence into Holmes Run at an appropriate angle (30-45^0) and route flow over existing vane arm/rock well revetment
- Remove invasive vegetation, re-vegetate with native species

2.2.2 - 000166 Holmes Run

Site Description:

An existing 36-inch RCP storm drain outfalls from under Raleigh Avenue and is directed towards the stream bank, and the existing wingwall/apron is undermined. The existing sandy stream bank shows little vegetative growth and is beginning to undercut at the toe of slope. The stream channel makes an approximate 90^0 bend with a tight radius of curve immediately downstream of the outfall. Largest observed particle approx. 90mm rounded cobble. There were 3 observed headcuts located downstream of the project extents.

Figure 2.3. 36-inch RCP outfall structure directed towards left overbank

Figure 2.4. Severely eroded left overbank area downstream of outfall

Restoration Recommendations:

- Replace and realign pipe outfall (new structure) to not impinge flow against bank
- Stabilize/replace undercut end wall

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- Stabilize outside of bank along toe and up the slope. Utilize toe wood to protect bank and direct flow around the meander; stabilize bank above toe protection with stepped grading, vegetation, and slope stabilization practices.
- Establish plunge pool below pipe outfall, establish point bar depositional area on inside of bend
- Improve radius of curvature such that Rc/W (Radius of pool curvature to the riffle channel width at the upstream cross over) is at least 3
- Remove debris from channel
- A significant amount of the bank erosion is occurring along 50 ft of left overbank; however, need to ensure 100+ linear feet of restoration to qualify for Chesapeake Bay TMDL Credits
- Place rock grade control structures upstream of existing headcuts to prevent future migration and degradation
- Remove invasive vegetation, re-vegetate with native species

2.2.3 - JBFNC Holmes Run

Site Description:

The soil under the existing concrete outfall apron has been eroded by flow cutting under and around the apron. Approximately 8-feet of soil has been removed from under the apron where the channel has cut down to a layer of weathered, friable bedrock. It appears an old section of the 18-inch RCP outfall pipe has broken off and fallen into the channel. This outfall is located on a steep hillslope, immediately downstream of the school parking lot and adjacent to wooden trail/stairs which presents a safety concern. Flow exits the 18-inch RCP and cuts under/around the apron and proceeds straight down a steep slope. Th stream channel bends approximately 90° to the right and the channel flattens at this point where the bank height greatly reduces after the bend, and the channel appears stable from this section onward. The flow travels under a wooden pedestrian bridge before fanning out in the low terrace of Holmes Run and eventually joining the main channel.

Figure 2.5. 18-inch RCP cantilevered outfall structure

Figure 2.6. Stable outfall section

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Restoration Recommendations:

- Protect bank and existing trail/stairs
- Replace end section and apron with proposed manhole drop structure to dissipate energy inside structure; pipe flow down to lower elevation where channel flattens and bank height decreases
- Establish plunge pool/stilling basin at pipe outlet
- Fill material over proposed pipe and stabilize
- Outfall to stable channel section
- Remove invasive vegetation, re-vegetate with native species

2.2.4 - Dual 90in Cameron Run

Site Description:

Two approx. 90-inch corrugated metal pipe arches carry water from Lake Cook to Cameron Run. CMP lining was observed to be eroded and missing in several locations. Flow exists the CMP arches and flows perpendicular into Cameron Run. The area directly beneath one of the pipe outfalls has been stabilized with grouted rock and riprap, while the other has begun to undercut the pipe. Flow discharges upstream from Lake Cook and exits the pipe arches approximately 3.5 feet vertically above the downstream water surface elevation.

Figure 2.7. Outfall location looking downstream towards Cameron Run

Figure 2.8. 90-inch outfall pipe looking upstream towards Lake Cook

Restoration Recommendations:

- Stabilize area below pipe outfalls, establish plunge pool (potential for multi-step plunge pool to reduce step height)
- Re-align outfall to improve angle of entry into Cameron Run to more appropriate angle (30-45°)
- Remove invasive vegetation, re-vegetate with native species

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- Stabilize pipes - re-line/coat pipes
- Utilize area to the West of the outfall for staging and construction access

2.3 Streams

2.3.1 - Strawberry Run

Site Description:

There is approximately 880 linear feet of stream downstream of a 72-inch CMP outfall. The stream channel has downcut with abandoned meanders which are approximately 3 ft. higher than the current stream bed and several tributaries along the reach have headcut. There are significant amounts of broken concrete in the channel, where it approaches and runs approximately parallel to Taft Avenue. Pebble counts were taken along a riffle section and point bar and both areas consisted primarily of gravel. There were no observed sanitary sewer utility crossings and two storm sewer outfalls located along the project length. Downstream of the project reach, there is a recently completed stream restoration project near the vicinity of the pedestrian bridge.

Figure 2.9. 72-inch CMP Outfall at upstream project extents

Figure 2.10. Bamboo and channel debris blockage in channel

Figure 2.11. Abandoned meander 3 ft (+) above ex. channel

Figure 2.12. Severely eroded bank

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Restoration Recommendations:

- Stabilize right banks in upper reaches below existing plunge pool at the end of the CMP outfall
- Potential to reconnect to legacy floodplain/terrace. Establish wetland cells in abandoned meanders (oxbows)
- Using natural channel design principles to re-establish riffle pool sequences
- Repair head cutting along tributaries along reach with boulder grade control structures
- Stabilize outfall channel opposite Trinity Dr.
- Remove existing concrete debris and curb and gutter. Improve radius of curvature and stabilize banks in area of tight bend and bamboo outcroppings
- Connect to existing restoration at downstream extents near pedestrian bridge
- Utilize existing materials (trees, rock, urbanite, etc.) on-site
- Remove invasive vegetation, re-vegetate with native species

2.3.2 - Taylor Run

Site Description:

There is approximately 1,807 linear feet of stream which daylights downstream of TC Williams High School and flows parallel to the existing nature trail. There are two sanitary sewer crossings and five storm sewer outfalls which were observed along the project reach. The stream is downcutting and widening at various locations, and vast amounts of debris/riprap appear to have been placed over the years in an attempt to protect the eroding banks. Pebble counts were taken along a riffle section and point bar and both areas consisted primarily of gravel. There is a 72-inch RCP outfall at the upstream project limits and copious amounts of fallen trees, riprap, and debris in the channel. Skunk cabbage was observed in an emerging wetland along the lower project extents.

Figure 2.13. 72-inch RCP outfall at upstream project extents

Figure 2.14. Sanitary sewer crossing located along downstream project extents

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Figure 2.15. Recently constructed sanitary manhole protection which partially blocks the channel (background)

Figure 2.16. Inside channel

Restoration Recommendations:

- Stabilize pipe outfalls into Taylor Run and reconstruct plunge pool downstream of pipe outfall
- Use natural channel design principles to establish riffle/pool sequences
- Establish radius curvature of width values of 3 for meander bends and lateral scour pools
- Re-purpose existing "urbanite" in channel to stabilize riffle bed and banks
- Placement of boulder steps for grade control and log vanes for flow direction
- Realign and stabilize stream over sanitary sewer crossings to reduce stress. Modify channel obstruction in the location of downstream sewer crossing to improve conveyance and energy dissipation
- Stabilize eroding banks at select locations along Chinquapin Park Nature Trail which currently present safety issues

2.3.3 - Timber Branch

Site Description:

There is approximately 1,043 linear feet of restoration between sections of Timber Branch Parkway. The stream channel runs within the Ivy Hill Cemetery, and the upstream project limits begin at existing concrete box culvert and the downstream project limit ends in a stable section of Timber Branch located just upstream of a pedestrian bridge crossing. Downstream of the proposed restoration, an existing bridge crosses Timber Branch with flow passing through four (4) 1 ft PVC pipe culverts (according to maintenance staff this area requires frequent cleaning due to sediment and debris accumulation). Small sections of the stream have been armored with rock/concrete walls and sections of grouted riprap. Remnants of concrete encased sanitary sewer crossing remain in the channel near the upstream project extents; however, GIS information indicates that this section of sanitary sewer is no longer active. Pebble counts were taken along a riffle section and point bar, and the riffle consisted primarily of cobble whereas the point bar deposition consisted mainly of gravel.

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Figure 2.17. 5 ft. by 8 ft. concrete box culvert outfall along upstream project extents

Figure 2.18. Photo from inside channel

Figure 2.19. Stable section located at downstream project extents

Figure 2.20. Bridge crossing located at downstream project extents (four [4]– 1 ft. diameter PVC pipes)

Restoration Recommendations:

- Create multi-stage channel with existing stream banks
- Utilize the stable lower portion of Timber Branch as a reference and "blue-print" upstream through project limits
- Stabilize banks and tributary pipe outfalls
- Boulder drops and point bar creation as seen on recommendation map
- Reconnect floodplain in the downstream portion of the reach
- Potential to improve bridge & culverts transport capacity to reduce sediment accumulation
- Establish riffle/pool patterns along the project reach
- Remove stacked block wall in the vicinity of 647 Oakland Terrace. Restore natural streambanks by re-aligning channel and using vegetation and flow redirection techniques such as vane arms or toe wood

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- The vented ford bridge crossing is located outside the project extents; however, a potential improvement would be to replace with a clear-span bridge or bottomless culvert to improve sediment transport, debris passage, and aquatic organism passage

2.3.4 - Unnamed Tributary near Walleston Ct.

Site Description:

There is approximately 1,213 linear feet of restoration on an Unnamed Tributary to Taylor Run near Walleston Ct. located in Forest Park and running parallel to Chinquapin Trek. The upstream project limits begin at the end of an existing concrete channel and existing pedestrian bridge and flow to the downstream project limits at the vicinity of 1609 Walleston Court. The stream has downcut and widened throughout much of the reach with bank heights ranging from 4 to 10 feet, several downed trees, and tortuous meanders. A pebble count was taken along a riffle section which consisted predominately of gravel. Several informal pedestrian crossings of the stream were observed. Near the downstream extents, homeowners have taken measures, including riprap revetment placement, to stabilize the banks in the rear of their properties.

Figure 2.21. Eroded bank

Figure 2.22. Tight radius causing accelerated bank erosion

Figure 2.23. Riprap revetment placed by homeowner along right overbank

Figure 2.24. Dam/debris blockage at downstream project extents

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Restoration Recommendations:

- Create multi-stage channel
- Stabilize banks through improved stream pattern, slope grading, and vegetative stabilization
- Protect downstream property owner improvements (include riprap revetment along outer right bank)
- Room to establish low terrace/ floodplain
- Incorporate natural channel design principles to reintroduce riffle/pool sequences
- Re-align channel away from sanitary sewer infrastructure
- Create wetland cell in abandoned meanders (oxbow)
- Reuse existing rock and trees to act as re-directive structures and create roughness elements to stabilize banks
- Remove channel blockage downstream to remove backwater pooling effect
- Remove invasive vegetation, re-vegetate with native species

2.3.5 - Holmes Run

Site Description:

There is approximately 2,136 linear feet (approximately ½ the length has downcut to a stable bedrock formation) of identified project length between Chambliss St. and Beauregard St. The channel has downcut and widened, creating new point bar development within the incised channel. Bed material consists of bedrock, large boulders, and cobble. Pebble counts were taken along a riffle section and point bar, and the riffle consisted primarily of cobble whereas the point bar deposition consisted mainly of gravel. Three sanitary sewer crossings were identified in the lower reach of the project. The upper ½ of the channel is experiencing accelerated bank erosion, whereas the lower ½ has cut to bedrock and is more stable. Just upstream of the large arch culverts, which flow under Beauregard St., the right overbank area is severely eroded, causing undermining of the pedestrian walkway. In the lower ½ of the stream, there are severe drops over the sanitary sewer crossings which is causing scour holes below the existing infrastructure.

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Figure 2.25. Bank erosion and point bar development within channel

Figure 2.26. Upstream project extents looking downstream

Figure 2.27. Pedestrian trail undermined at downstream project extents just upstream of Beauregard Street

Figure 2.28. Sanitary sewer crossing and exposed bedrock

Restoration Recommendations:

- Realign the main channel to reduce stress on outside of meander bends. Establish Rc/W of 3+
- Remove deposition in areas which is causing split flows and high Near Bank Stress; utilize removed material to stabilize banks, re-shape channel, and build flow plain benches
- Provide step pools to reconnect existing downcut tributaries into the mainstem
- Create riffle/pool sequences in the upper half of the project area
- Create floodplains within the existing over widened channel footprint
- In the lower, stable half where the stream has cut down to bedrock, minimize drop heights over the sanitary sewer crossings by adding intermediate grade control structures, such as rock vanes
- Use re-directive techniques to keep flow and sediment moving towards the arch culverts
- CMP culverts under Beauregard St. may require relining but will need to have debris and sediment cleaned from the left cell; potential to raise the elevation of the culvert to create a floodplain culvert

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- Establish multi-stage channel to improve sediment transport capacity through range of flows; establish low terrace
- Multiple existing sanitary sewer crossings acting as grade control throughout the lower reach of the project area; potential to add boulder grade control between sewer crossings to step stream down more gradually (improved fish passage, balances energy dissipation over more drops without causing severe turbulence in the water column and eddies causing bank erosion)
- Step down the existing outfall channel along the right bank just upstream of Beauregard St.
- Protect existing paved trail in downstream extents and stabilize banks
- Remove invasive vegetation, re-vegetate with native species

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SECTION 3 – POLLUTANT REMOVAL

3.1 Introduction

Streambank erosion rates can be predicted using the Bank Assessment for Non-Point Source Consequences of Sediment (BANCS; Rosgen 2006). The BANCS method provides an estimate of the rate of erosion and the amount of bank material being eroded from streambanks and deposited into the river system. It is a visual assessment tool which can provide a reasonable estimate of erosion rates. The BANCS method uses two bank erodibility estimation tools: Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS). The application involves evaluating the bank characteristics and flow distribution along river reaches, mapping the location and extent of each bank feature, and developing risk ratings per bank feature. In each reach of river or stream an overall annual estimate of erosion is determined by multiplying the length and height of each bank type by the lateral recession (erosion) rate as well as the bulk density of the bank material, and then summing the estimates of erosion. This provides an estimate of cubic yards and/or tons of sediment that erode per reach per year.

Bank erosion estimates were determined for the Phase III Assessment which includes 5 stream sites and 1 additional outfall. However, for the remaining 3 outfalls, it is unlikely that they will be able to qualify for nutrient and sediment reduction credits since they would address less than 100 linear feet of stream restoration are primarily focused on preserving and fixing storm sewer infrastructure.

3.2 Methodology

During March and April of 2018, bank erosion assessments were performed on 2,786 linear feet of eroded streambanks along Holmes Run, Strawberry Run, Taylor Run, Timber Branch, Unnamed Tributary near Walleston Ct., and an outfall into Holmes Run (000166). During the field investigation, a range of eroded banks were targeted (BEHI – Low, Moderate, High, Very High, and Extreme) and analyzed in order to determine the sediment and nutrient loading due to bank erosion.

The entire right and left banks along the project reaches were analyzed for erosion, deposition, rock armoring, and bedrock. Eroded banks were divided into segments and inventoried based on the changes of physical bank characteristics and the applied shear stress, e.g., bank height, root depths, root density, bank angle, and amount of surface protection. The locations of bank segments were marked on aerial photographs during the field survey and have been converted into BANCS maps (Appendix F).

The BEHI evaluates the susceptibility to erosion for multiple erosional processes. The BEHI model is a process-integration approach that does not isolate individual processes of erosion (such as surface erosion, fluvial entrainment or mass erosion). The process integrates

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multiple variables that relate to "combined" erosional processes leading to annual erosion rates. Erosion risk is then established for a variety of BEHI variables to obtain an overall BEHI rating. Since the urbanized watershed and make up of the stream system is out of equilibrium, the bankfull or effective discharge becomes extremely difficult to locate in the field. For the study bank-height ratio, the bankfull height was determined by using the rural bankfull regional curves for Coastal Plain and Piedmont based on drainage area (*Bankfull Regional Curves for Streams in the Non-Urban, Non-Tidal Coastal Plain Physiographic Province, Virginia and Maryland / Regional Curves of Bankfull Channel Geometry for Non-Urban Streams in the Piedmont Physiographic Province, Virginia).* The non-urban curve was used because an urban curve would not reflect the equilibrium condition and channel adjustment is due to incision and widening. For bank material adjustment, points were on occasion subtracted from the BEHI score based on the amount of clay present in the bank. A majority of the bank material consisted of cobbles, gravels, and sands with small amounts of silts with clays sometimes found lower in the soil column. The cobble sandy bank material was found to be quite erosive and easily moved as there did not seem to be present large enough amounts of clay to help "cement" the soil and resist erosion.

The individual BEHI variables used for the erosion prediction model include six categories:

1. Study bank height divided by bankfull height (study bank-height ratio)
2. Root depth divided by study bank height (root depth ratio)
3. Weighted root density
4. Bank angle
5. Bank material
6. Stratification of bank material

Figure 3.1. Study bank height (Holmes Run)

Figure 3.2. Rooting depth (Holmes Run)

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Figure 3.3. Bank angle measurement (Strawberry Run)

Figure 3.4. Stratification of bank material (Holmes Run)

Figure 3.5. Example of bank conditions with a BEHI rating of Very High (Unnamed Tributary near Walleston Ct.)

Figure 3.6. Example of bank conditions with a BEHI rating of Extreme (Strawberry Run)

In the BANCS model there are seven methods that can be used to assess energy distribution against streambanks, which is referred to as NBS. Method 1 was used during the field survey to estimate NBS with Method 4 being used as a supplemental resource, at select banks to corroborate NBS. This method is the most rapid due to lack of required measurements but nevertheless can be an accurate, appropriate method. Channel pattern features that create a disproportionate energy distribution in the near-bank region include chute cutoffs and split channels that converge against study banks. Additionally, depositional features including transverse bars and central bars create a disproportionate distribution of energy in the near bank region. Method 4 is completed in the field and involves measuring the slope of pools in the river and the slope of the riffle, then calculating the ratio of pool slope to riffle slope. Although not recorded or used to make the final determination of near bank stress, Method 4 was used intermittently to field verify the ocular estimates from Method 1. Figure 3.7 below shows an extreme NBS rating due to extensive channel deposition, transverse bars, pool slope to riffle slope as well as radius of curvature to bankfull width. Large amounts of old

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concrete materials which has been coined as "urbanite" were present in a majority of the eroded sections of stream. If the dominant NBS was determined to be High/Very High, the overall NBS rating chosen typically was High, unless compelling evidence suggested otherwise (i.e. tight radius, lack of vegetation in overbank areas, riffles in bend, etc.). It should be noted that multiple site locations were evaluated using field calibrated ocular estimate per Rosgen's - River Stability Field Guide, eliminating the need to complete BEHI and NBS worksheets for each site. The ocular estimate involves assigning BEHI and NBS scores along with measured stream bank height and length to predict streambank erosion. For sites evaluated using the ocular estimate and field calibration technique, BEHI and NBS scores are assigned based on banks exhibiting similar characteristics along the stream reach.

Figure 3.7. Panoramic photo illustrating Extreme NBS (Strawberry Run)

The BEHI and NBS numbers for each of the bank segments analyzed (shown in Appendix E) for the project sites were converted to bank erosion rates using graphs of curves for Hickey Run, District of Columbia (USFWS 2005, Figure 3.10). It was concluded that, based on soil cohesion, vegetation type, climate, etc., this curve would be the most representative of which are available and be most representative of the stream systems being analyzed in Alexandria, VA. Hickey run is a Tributary of the Anacostia River in Washington, D.C. and is highly urbanized, with 36 percent impervious surface, similar to the watersheds in Alexandria, VA. According to the Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects (Appendix G – Clarifications and Edits Resulting from the "Test Drive Period"), in the absence of region-specific curves, localities should use the Hickey Run curve.

In order to determine the sediment loading and associated credits for pollutant removal, there are two methods which can be followed; linear footage of restoration and computing the amount of sediment delivered from the banks into the stream system. The pollutant removal computations provided are based on the guidance in the Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects (prepared

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by Chesapeake Stormwater Network and Center for Watershed Protection), test drive revisions approved by the WQGIT on September 8, 2014.

For the purposes of the field assessment, the Urban Stream Restoration Protocol 1: Credit for Prevented Sediment During Stormflow was used to compute the potential associated credits. This protocol provides an annual mass nutrient and sediment reduction credit for qualifying stream restoration practices that prevent channel or bank erosion that would otherwise be delivered downstream from an actively enlarging or incising urban stream.

The process is as follows:

1. Estimate stream sediment erosion rates (from BANCS assessment)
2. Convert erosion rates to phosphorous loadings
3. Estimate reduction efficiency attributed to restoration

Using the results from the BEHI and NBS risk ratings, the Hickey Run curve can be used to determine the lateral recession expected from erosion. The corresponding erosion rate is then multiplied by the bank height and length in order to determine the volume of sediment eroded from the bank. However, in order to convert the volume into a tonnage of soil being lost, the bulk density of the soil must be determined. Using a soil probe, bank soil samples were collected at multiple bank locations to collect a known volume of soil and determine the weight after drying. The length of sediment collected was documented in order to be able to compute the in-situ soil volume. The samples were placed in bags until they were later weighed in order to determine the moist density. The samples were sent to the laboratory for testing to determine the soil moisture content and dry weight, so the in-situ bulk density could be determined. For six different project samples, the bulk density ranged from 100 to 120 lb/ft^3 (summary table included in Appendix D). The examples provided by the expert panel assume a bulk density of 125 lb/ft^3; however, the documentation also states that bulk density measurements, although fairly simple, can be highly variable and each project site should have samples collected to develop site-specific bulk density estimates.

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Figure 3.8. Soil probe sample of bank material

Figure 3.9. Bulk density determination

Based on the expert panel report, the nutrient levels in stream sediments are variable, however, the Panel elected to use a value of 1.05 pounds of TP per ton of sediment and 2.28 pounds of TN per ton of sediment. Using the Panel's conservative approach, the restoration efficiency is assumed to be 50% effective in reducing sediment and nutrients from entering the stream reach. The Sediment Delivery Ratio (SDR) for non-coastal plain streams is 0.181 and 0.061 for coastal plain streams.

An additional analysis of sediment and nutrient loading was prepared using the edge of stream revised default rates. Credits are assigned per linear foot of qualifying stream restoration (lb./ft/yr.) as follows: TN = 0.075, TP = 0.068, TSS = 44.88 (non-coastal plain) and 15.13 (coastal plain). A summary of the pollutant removals is provided in Appendix G.

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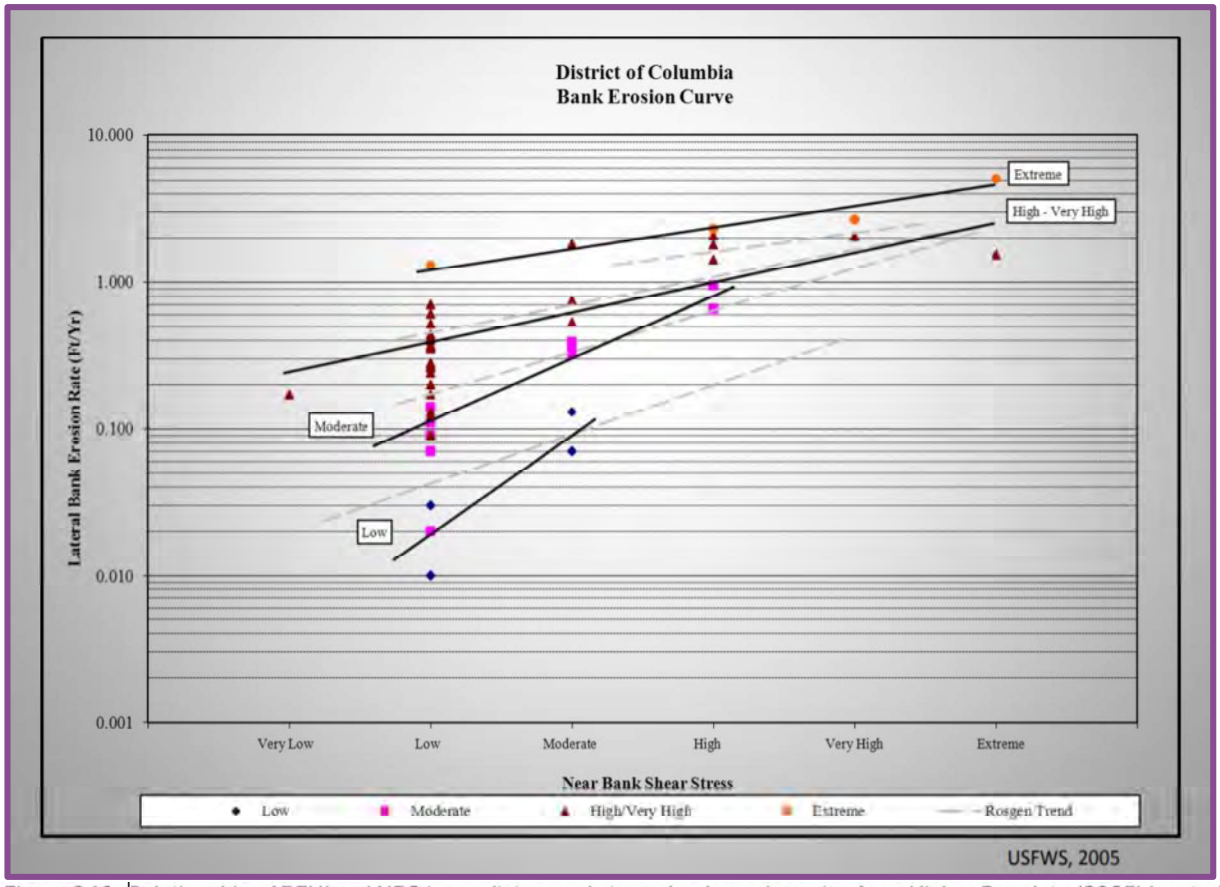

Figure 3.10. Relationship of BEHI and NBS to predict annual streambank erosion rates from Hickey Run data (2005) located in the District of Columbia

While Bank Erosion Prediction Curves are one means to determine the amount of sediment loading into the stream system, another option is to determine sediment export and bank retreat from aerial imagery. This method involves obtaining aerial imagery for several time intervals and tracing the top of bank for each year and determining the difference. For the project locations, the forested buffer makes it difficult to see and try to determine any type of changes or recession along the bank line. However, the bank recession was estimated, using Google Earth, along a representative section of Holmes Run where the stream size and lack of forested buffer allowed a multi-year comparison. As can be seen below in Figures 3.11 and 3.12, the left overbank along Holmes Run retreated approximately 60 ft from April 2002 until December 2016 (14.7 years), an erosion rate of 4.1 ft/yr. This location lies in the approximate location of BEHI #3 and #4, from the BANCS assessment of Holmes run, where the bank erosion rate was calculated to be 2.4 ft/yr. and 3.2 ft./yr., respectively. Therefore, when erosion and deposition is considered along the section, the BANCS methodology and usage of the Hickey Run curve produce comparable results and provide some sense of quasi-calibration.

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Figure 3.11. Holmes Run Bankline (River Left) as of 12/2016 (Google Maps, 2018)

Figure 3.12. Holmes Run Left Overbank Recession from 04/2002 to 12/2016 (Google Maps, 2018)

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Figure 3.13. BEHI #3 Location – Extreme BEHI, High NBS (Holmes Run)

3.3 Results

The 67 bank segments inventoried ranged from 16 to 290 feet in length. The curves shown in Figure 3.10 were used to estimate yearly bank recession rates based on BEHI and NBS values generated from the field survey. The total bank erosion predicted from the 5,055 linear feet of streambank analyzed using the BANCS method was estimated to be approximately 3,165 tons/year using the Hickey Run USFWS Curve (Figure 3.10). The rates are based on several conditions, including soil cohesion and vegetation, which vary along and within the stream reaches. Stable alluvial streams generally demonstrate very low erosion rates of 0.001 to 0.005 feet/year. Analyzed project locations have erosion rates ranging up to 4.5 feet/year which exhibit a state of accelerated bank erosion. When combined with measurements of stream height and bank length, the rates of erosion can be converted into a weight of sediment reaching the river. The average sediment loading rate for the project sites is approximately 0.63 tons/yr./ft. A summary of annual streambank erosion estimates along with pollutant removal credits for the various study reaches is provided in Appendix G. It should be noted that the pollutant removal credits provided do not consider the required baseline reductions involving the regulated, unregulated and forested lands. Per conversations with VA DEQ, the City will be able to take credit for the regulated MS4 area regardless of whether the regulated area is in the City of Alexandria or another MS4.

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SECTION 4 – PROJECT DECISION MATRIX

4.1 Introduction

Wood worked alongside T&ES Stormwater staff to develop a project decision matrix to prioritize the potential projects. The matrix provided a simple and straightforward method for comparing, contrasting, and evaluating the different potential projects. The matrix allowed for a direct comparison of the potential projects, ensuring equal consideration and implementing a logical selection process.

The project decision matrix included a set of criteria for which each project was scored. In addition, weights were given to each criterion based on their determined importance. The process and decisions for selecting and weighting the criteria drew on past project experience from multiple individuals, including both Wood and City staff. This process enabled relevant information to be documented, understood, and ultimately used to determine which projects should be selected.

Since the five-stream restoration potential projects had distinct differences in scope from the four-outfall stabilization potential projects, two separate prioritized lists were developed.

4.2 Methodology

The project weighted decision matrix was created in MS Excel using the following simplified process:

1. Develop a list of criteria for the potential projects to be scored;
2. Develop scoring methodology for each criterion;
3. List potential projects as rows and criteria to consider as columns;
4. Score each project/criterion combination based on the developed methodology and document reason for the score;
5. Weight this score by the relative importance of the criterion;
6. Add scores up to give an overall weighted score for each project; and
7. Rank the potential projects based on their overall weighted scores.

Wood coordinated closely with the City to develop a list of 23 criteria as presented in Figure 1. The criteria were then grouped into five distinct categories as follows:

1. Channel Bed & Bank Stability
2. Stream Health (Riparian, Habitat)
3. Feasibility
4. Other Benefits
5. Cost/Benefit

A scoring system was determined for each criterion and corresponding conditions which were required for each score were outlined in the Project Comparison Decision Matrix Criteria & Scoring document (Appendix I). This document provided a transparent basis for others to understand the criteria and scoring procedures and can be used in the future to support the decisions made in this study. The scoring system of 1, 3, or 5 was chosen to provide a wider

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spread of the overall score, as opposed to using a tighter scoring band (i.e. 1,2,3). Higher scores indicated a higher restoration/stabilization potential and expected benefit(s).

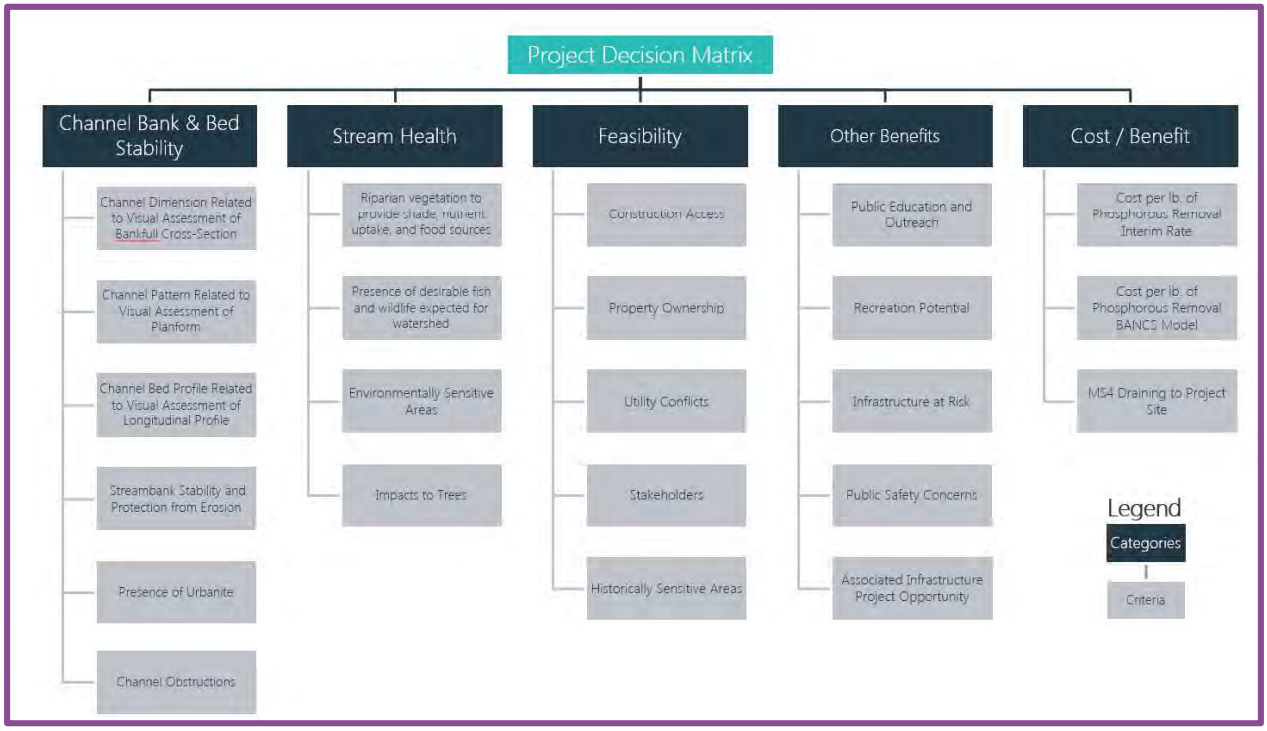

Figure 1. Weighted Project Decision Matrix Architecture

In order to keep the size of the decision matrix manageable, matrices were created for each of the five categories along with a summary weighted project decision matrix. In the category matrix, each project/criterion was scored based on the documented scoring methodology and the reasoning for each score was documented to support and validate the score selection. It should be noted that not all criteria were evaluated for each project as there were several criteria that were only applicable for the stream restoration projects and not the outfall stabilization projects.

The scores for each project/criterion in the category matrices were then fed into the overall weighted project decision matrix (Appendix J) where the criteria scores were weighted, and overall total weighted project scores were tabulated.

After the final scoring had been tabulated, the ranking of the stream restoration projects and the outfall stabilization projects were as follows:

<u>Stream Restoration Projects</u>

1) Strawberry Run near Chinquapin Park
2) Taylor Run near Taft Avenue
3) Holmes Run, north of N. Beauregard St.
4) Timber Branch near Ivy Hill Cemetery

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5) Unnamed Tributary near Walleston Court

<u>Outfalls Stabilization/Restoration Projects</u>

1) Jerome Buddie Ford Nature Center Outfall into Holmes Run
2) Raleigh Avenue Outfall into Holmes Run
3) N. Chambliss St. Outfall into Holmes Run
4) Dual 90" Outfall into Cameron Run

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SECTION 5 – CONCEPT DESIGNS

5.1 Background

Based on the final rankings, the top two stream and top two outfall projects were further developed into preliminary conceptual designs with associated planning level cost estimates.

Top Ranking Stream Restoration Projects

1) Strawberry Run near Chinquapin Park
2) Taylor Run near Taft Avenue

Top Ranking Outfall Stabilization/Restoration Projects

1) Jerome Buddie Ford Nature Center Outfall into Holmes Run
2) Raleigh Avenue Outfall into Holmes Run

Based on this study, Stormwater Local Assistance Fund (SLAF) grants administered by the Virginia Department of Environmental Quality were submitted for Strawberry Run and Taylor Run.

5.2 Conceptual Designs and Planning Level Cost Estimates

The preliminary conceptual designs for each of the four project sites are provided in Appendices K-N. The concept layouts are preliminary and based on field reconnaissance and the City of Alexandria's GIS topographic data. As such, the number of structures and planimetric layout is subject to change and will be refined upon completion of a field survey. Additionally, rock toe areas may be converted into toe wood features depending on the abundance and availability of wood materials on-site and further investigation into drought-prone behavior of the stream. Dimensions for typical pool and riffle sections are preliminary and based on best professional judgement and previous experience. As the preliminary concepts move into the design phase after field survey has been collected, the typical sections will be refined and developed from hydrologic and hydraulic analyses and further field investigation of depositional areas in stable sections of stream located either upstream, downstream, or nearby the project areas.

Along with the concept design, planning level cost estimates were developed for each of the four project sites. The planning level cost estimates are based conceptual designs and should be used for general budgeting purposes and grant application purposes only. They are planning level Rough Order of Magnitude (ROM) estimates and are not engineering estimates which are typically based on final design drawings. In order to determine a base cost, the planning level costs were broken into several general categories as applicable: mobilization, clearing and grubbing, earthwork (cut and haul), constructed riffles (place substrate armoring mix, part of pool and glide), structure rock (rock vanes), rock toe, log vanes, access road (temporary timber matting), and utility relocation (storm, sanitary). The

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material quantities used to compute the base costs were based on the planning level designs which consisted of a plan view providing a general location of the proposed alignment and stream structures.

The following items were then assumed as a percentage of the base cost:

1) Erosion and Sediment Control (10% of Base Cost)
2) Plantings/Geotextile/Wooden Stakes (10%)
3) Miscellaneous Other Items (i.e. Pump Around Maintenance of Stream Flow, Construction Stakeout, Project As-Built Survey, Traffic Control (5%)
4) Other (Contingency) (25%)

The unit prices are based on a combination of previous construction jobs in the local areas adjusted for inflation, best professional judgement, and conversations with contractors and other local municipal entities engaged in stream restoration and storm sewer outfall stabilization work. As previously stated, the planning level opinion of cost was based on limited vertical data (GIS topo), and the costs do not include land acquisitions, required easements, or archaeological cultural resources (assessment or permitting). A summary of the planning level (ROM) cost information is provided in Appendix O. Below in Table 5.1 is an overall planning level cost summary for each of the four project sites which also distributes the cost between design and construction.

Table 5.1. Project Cost Summary

Project	Est. A/E Design Fees	Construction Oversight Fees	Est. Construction Cost	Overall Cost
Strawberry Run	$220K	$116K	$800k	$1.14M
Taylor Run	$475K	$266K	$2.4M	$3.14M
Jerome Buddie Ford Nature Center into Holmes Run	$30K	$4.5K	$91k	$136K
Raleigh Avenue Outfall into Holmes Run	$35K	$15K	$103K	$150K

5.3 Construction Entrance Analysis

For the Strawberry Run and Taylor Run Stream Restoration project sites a field meeting was held on November 20, 2018, between T&ES, DPI, RPCA, and Wood to better understand potential impacts to trees and other resources which could be affected by staging and construction access. Before the field meeting, Wood prepared preliminary potential construction access options and staging areas which were discussed and walked during the field visit. The preliminary construction access maps were compiled with GIS data to show property boundaries and owners, staging areas, construction entrances, and access roads through the site. Prior to the field meeting, T&ES researched easements on the properties to be impacted by the two projects. Wood was provided with a copy of the plat showing easements on the property of the First Baptist Church parcel after the field meeting. Before the meeting, RPCA staff had developed a map for Strawberry Run providing the Fort Williams Park Canopy and Plant Community Inventory including GPS locations (Appendix P).

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During the meeting, the preliminary construction access options were walked and discussed, and at the conclusion of the meeting, the feasible locations with the least impact to trees and natural resources had been identified. Shortly thereafter, Wood updated the construction entrance exhibits and provided concept layout for construction access including slopes and details for tree protection and matting for both sites. The construction access concepts are included as part of Appendix Q.

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SECTION 6 – STAKEHOLDER ENGAGEMENT

6.1 Project Team

The project team for the Phase III Assessment consisted of three City departments and the consultant, Wood Environment & Infrastructure Solutions (Wood). The project was led by the City of Alexandria's Department of Transportation and Environmental Services, Stormwater Management Division (T&ES) with support and input from the Department of Project Implementation (DPI) and Department of Recreation, Parks, and Cultural Activities (RPCA). Biweekly calls were held between Wood and T&ES throughout the duration of the project. Several internal City meetings were also held to discuss the status and different aspects of the project, and T&ES Stormwater presented at the Parks and Recreation Commission September meeting. Additionally, Wood, T&ES, DPI, and RPCA took part in site visits to the Strawberry Run and Taylor Run project sites on November 20, 2018, to determine potential construction access points.

6.2 Stakeholder Meeting Summary

On December 5, 2018, T&ES and DPI, with support from RPCA, hosted a community meeting on the Phase III Assessment process at Douglas MacArthur Elementary School, 1101 Janneys Lane. The location was chosen for its close proximity to the Strawberry Run and Taylor Run project sites. T&ES mailed invitations to potentially affected property owners and notified local civic organizations. Individuals from the entire project team were in attendance. After project team introductions, T&ES and Wood provided an overview of the assessment process using PowerPoint (Appendix R). The presentation highlighted why the City is considering stream restoration, the characteristics of a healthy stream, the three phases of the City's assessment process, the criteria used in the selection of the Strawberry Run and Taylor Run restoration projects, examples of finished stream restoration projects, and next steps.

After the presentation, community members were invited to provide feedback to help inform the upcoming design phase. In general, the feedback was positive.

Below is a summary of significant points brought up by community members:

1) The City should consider the acquisition of easements in the upper headwaters of Strawberry Run to protect existing forested woodlands.
2) The City should consider a way for community members to provide input into favored approaches to stream restoration. One mechanism could be an online survey.
3) When walking along Taylor Run the stream "looks very sad." When the stream looks neglected, it is often taken as a sign that the City does not care. As a result, individuals are less likely to keep the park clean, which in turn results in further decline.

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SECTION 7 – REFERENCES and RESOURCES

Chang, 2002, *Fluvial Processes in River Engineering*

CH2MHill, 2008, *City of Alexandria Stream Assessment Phase 2*

City of Alexandria, VA, 2017, *Request for Qualifications Phase III Stream Assessment; Stream Restoration and Outfall Stabilization Feasibility Study*

Doll B., Greg J. and et al., 2003, *Stream Restoration: A Natural Channel Design Handbook*

Fischenich 2001b, *Stability Thresholds for Stream Restoration Materials*

Leopold, L.B., 1994, *A View of the River*

Leopold et al., 1964, *Fluvial Processes in Geomorphology*

Leopold L.B., and Thomas D. 1978, *Water in Environmental Planning*

NRCS, 2007, *Part 654 Stream Restoration Design National Engineering Handbook, Chapter 11 Rosgen Geomorphic Channel Design*

Reid L., and Thomas D, 1996, *Rapid Evaluation of Sediment Budgets*

Rosgen, D.L. 1996, *Applied River Morphology*

Rosgen, D.L. 2007, *Watershed Assessment of River Stability and Sediment Supply (WARSSS) 2nd Edition*

Rosgen, D.L. 2008, *River Stability Field Guide*

Schueler T, and Bill S., 2014, *Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects*

Schumm S., Harvey D and Watson C., 1984, *Incised Channels; Morphology, Dynamics and Control.* Littleton, Colorado: Water Resources Publications.

Thorne C., Richard H. and Malcolm N., 2005, *Applied Fluvial Geomorphology for River Engineering and Management*

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