APPENDIX I

PROJECT DECISION MATRIX CRITERIA DEFINITIONS FOR SCORING

PROJECT COMPARISON DECISION MATRIX CRITERIA & SCORING

Criteria Scoring: Scores range from 1 to 5 and values increase from left to right. Higher score indicates greater restoration potential and expected benefit(s).

I. CHANNEL BED & BANK STABILITY

1. Channel Dimension at Bankfull Cross-Section

Channel dimension is the cross sectional shape of the channel, including channel width, depth, and cross sectional area. The bankfull discharge is considered to be the most effective flow for moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphological characteristics of channels (*Dunne and Leopold, 1978*). Research indicates that the hydraulic geometry substantially increases for urban streams in comparison to rural streams (*Doll et al., 2003*). Channel Evolution Model (CEM – *Schumm & Parker, 1973*) is an approach to explain the complexity of a fluvial system. A fluvial system is constantly changing and evolving, which is the systems attempt to reach equilibrium. A system that is considered stable or in equilibrium is well vegetated, frequently interacts with its floodplain and the sediment is suspended. CEM is used to classify the current stage of the system in order to predict how the system will evolve. Knowing the current stage of a system is incredibly beneficial when alterations to a system are being considered, especially when those alterations are aimed to provide restoration.

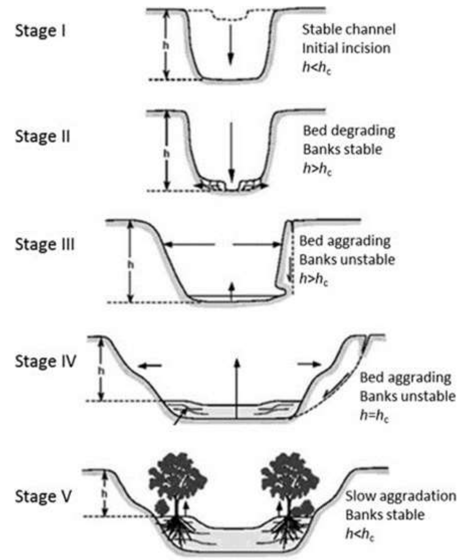

Figure 1. Channel Evolution Model

(1) Good: Stage I or V of Channel Evolution Model	(3) Fair: Stage IV of Channel Evolution Model	(5) Poor: Stage II or III of Channel Evolution Model.

2. Channel Planform Pattern

Channel pattern can be meandering, branching, or straight. The existence of one or another pattern is closely related to the amount and character of the available sediment and to the quantity and variability of the discharge - factors which may be heavily impacted by human alterations to the landscape. The meandering pattern refers to the plan view of a channel executing rounded curves of repetitive and uniform shape. A braided channel is one that is divided into several channels, which successively meet and re-divide. Straight reaches are rare in natural conditions and usually indicate alteration by human activities. Indicators of disequilibrium include tight bends, cutoffs, rapid down-valley meander migration, or straightening.

(1) Good: natural equilibrium meander pattern with sinuosity expected for the watershed	(3) Fair: disequilibrium indicated by tight bends, cutoffs, rapid down-valley meander migration, or straightening for < 50% of the reach	(5) Poor: disequilibrium indicated by tight bends, cutoffs, rapid down-valley meander migration, or straightening for > 50% of the reach

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3. Channel Bed Longitudinal Profile

The longitudinal profile of a channel characterizes average stream slopes and depths of riffles, pools, runs, glides, rapids and step/pools. Essentially it is a measure of how channel depth varies moving downstream. Human alteration of the surrounding landscape can significantly alter the natural pool-riffle-run sequence.

(1) Good: natural equilibrium riffles, pools, steps, glides, and runs with bedform expected for the watershed	(3) Fair: disequilibrium indicated by head cutting, plane bed, aggradation, or riffle migration into pool for < 50% of reach	(5) Poor: disequilibrium indicated by head cutting, plane bed, aggradation, or riffle migration into pool for > 50% of reach

4. Streambank Stability and Protection from Erosion

Streambanks are principal features of a fluvial system that are popularly recognized as the regular, non-flooding, boundaries of a stream channel. Streambanks deliver critical functions for fluvial systems, including the responsibility of energy response and dissipation, through adjustment processes. The adjustment of channel width by mass-wasting and related erosional processes represents an important mechanism of channel response and energy dissipation in incised alluvial channels (*Simon et. al., 1999*). The Bank Assessment for Non-point Source Consequences of Sediment (BANCS) (*Rosgen, 2008*) assessment was used to estimate the expected streambank erosion rates along each of the project reaches. The BANCS assessment utilizes field assessment of the Bank Erosion Hazard Index (BEHI) and Near-Bank Stress (NBS) to derive annual streambank erosion rates. The District of Columbia Bank Erosion Curve (*USFWS, 2005*) was used to determine a Lateral Bank Erosion Rate for each BEHI and NBS combination. For the purposes of this analysis, streams with unit bank erosion rates within plus or minus (±) one half the standard deviation of the average erosion rate were assigned a score of 3. Streams with unit bank erosion rates less than or greater than the above range were assigned scores of 1 and 5 respectively.

(1) Good: Expected unit streambank erosion rate ≤1.41 ft/yr.	(3) Fair: Expected unit streambank erosion rate > 1.41 ft/yr. & < 1.74 ft/yr.	(5) Poor: Expected streambank erosion rate ≥ 1.74 ft/yr.

** The average unit erosion rate was computed for each of the 5 assessed streams. The average of these values was then taken (1.57) and used for the division of scoring "bins".*

5. Presence of Urbanite

Urbanite is defined as large broken pieces of concrete, such as curb and gutter. It is frequently placed in streams in the City as an attempt to prevent erosion and increase stability. While, it may be helpful in a few instances, overall it is detrimental to the stream and provides poor instream and riparian habitat.

(1) Low: Only natural materials observed. No presence of urbanite located throughout the reach	(3) Moderate: moderate presence of urbanite materials found in 1 or 2 locations throughout the channel.	(5) High: extensive presence of urbanite indicated by greater than 3 locations throughout the entire channel length

6. Channel Obstructions

Channel obstructions include manmade restrictions/blockages (bridges, culverts, sewer line crossings, etc.) and debris. Debris could include log jams, sediment, garbage, and any other material that can build up and obstruct flow. Obstructed flow can easily lead to unstable streambanks if flow is directed at them and Near-Bank Stress (NBS) increases.

(1) Low: No channel obstructions	(3) Moderate: Small number of channel obstructions (1-2) found throughout the reach	(5) High: Substantial number (>3) of channel obstructions which inhibit flow and cause contraction and expansion

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II. STREAM HEALTH (RIPARIAN, HABITAT)

7. Riparian Vegetation

Riparian areas are plant communities contiguous to and affected by surface and subsurface hydrologic features. Riparian areas are usually transitional between wetland and upland. They have one or both of the following characteristics: 1) distinctly different vegetative species than adjacent areas, and 2) species similar to adjacent areas but exhibiting more vigorous or robust growth forms. Riparian vegetation is extremely important because of the many functions it serves, such as: bank stabilization, fish & wildlife habitat, food chain support, thermal cover, and flood control. Native plants are particularly advantageous in riparian areas because they are unlikely to be invasive/overly competitive with other native plants, provide food sources for native wildlife, and promote biodiversity. If native plants are absent onsite, stream restoration can provide an excellent opportunity improve riparian habitat.

(1) Good: healthy native plants growing in more than 90% of 50-ft buffer on both sides	(3) Fair: healthy native plants growing in half to 90% of 50-ft buffer on both sides	(5) Poor: healthy native plants growing in less than half of 50-ft buffer on both sides

8. Presence of desirable fish and wildlife

Human land-disturbing activities can seriously degrade nearby waterways. Sediment from runoff and in-stream erosion are the primary sources of non-point source pollution. These alterations, and resulting non-point source pollution, can result in a loss habitat for fish and wildlife. Stream restoration can help recreate this habitat and allow adjacent communities to repopulate the affected reach. Notes were taken during field surveys to determine the presence of fish, birds, and other wildlife.

(1) Good: healthy communities including fish, birds, or wildlife (All 3 present)	(3) Fair: missing some expected species of fish, birds, or wildlife (1-2 present)	(5) Poor: lacking expected communities and the presence of fish, birds, or wildlife (none)

9. Environmentally Sensitive Areas(ESAs)

Environmentally Sensitive Areas (ESAs) are generally, but not limited to, wetlands and floodplains (EPA Region 3). United States Fish & Wildlife (FWS) field offices generate data and information on the presence of critical habitat for threatened and endangered species. Threatened and Endangered species, migratory birds, and critical habitat were evaluated using the Information for Planning and Consulting (IPaC) provided by FWS using their Environmental Conservation Online System (ECOS). FWS also maintains an inventory of the nation's wetlands in the National Wetlands Inventory (NWI). These sources were used to determine potential impacts of a stream restoration project, as well as important considerations for timing and habitat disturbance.

(1) Present: Presence of critical habitat, threatened & endangered species, and wetlands	(3) Potentially Present: Potential presence of critical habitat, threatened & endangered species, or wetland areas	(5) Not Present: Lacks critical habitat, threatened & endangered species, and wetland features

"Endangered" means a species is in danger of extinction throughout all or a significant portion of its range.
"Threatened" means a species is likely to become endangered within the foreseeable future.

10. Impacts to Trees

Stream restoration often involves removing established trees along the streambank to reconfigure the channel/floodplain and allow for access by heavy equipment. However stream erosion frequently undermines these trees and they often fall into the stream. Therefore even though stream restoration may involve initially removing trees, ultimately the long-term health of the stream valley forest is improved as further undercutting is avoided. It is still best practice to minimize the removal of existing mature trees during the project.

(1) High: Multiple, large established trees and overstory community (>75% reach)	(3) Moderate: Small number of larger established trees (50-75% reach)	(5) Low: presence of established stand of larger trees (< 50% reach)

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III. FEASIBILITY

11. Construction Access

Site access and constraints are important considerations for any stream restoration project. Potential issues with access include lack of necessary easements, steep slopes, high-traffic, and width of project site. Any of these issues can affect the project timeline, schedules, and ultimately budget.

(1) Difficult: Multiple issues with access including width, slope, entry, etc.	(3) Moderate: Moderately difficult access	(5) Easy: None or only small issues with construction access, multiple access points

12. Property Ownership

The number of adjacent property owners is another important consideration for stream restoration projects. Construction and earth grading require adequate space and also generate a good deal of noise that can be disruptive. In general, it is easier to manage projects that impact fewer property owners.

(1) Many: > 4 property owners affected	(3) Multiple: 3-4 property owners affected	(5) Few: 1-2 property owners affected

13. Utility Conflicts

Most urban environments include numerous buried utility lines such as sanitary sewers, water and gas distribution systems, electrical and communication lines, steam distribution systems, oil storage and piping, and fiber optics. These facilities are often below grade and not obvious visually. If there are too many or ones that cannot be relocated, they can prevent a project from taking place or introduce prohibitive costs. These utilities were identified in GIS and later field verified.

(1) Multiple: > 3 conflicts with utilities based on preliminary analysis	(3) Few: 1-3 utility conflicts	(5) None: no utility conflicts

14. Stakeholders

In addition to the III.12, the type of stakeholders involved in project should be considered for feasibility. Public stakeholders typically offer reduced liability issues, fewer points of contact/easier coordination, and greater stakeholder subject matter awareness. This makes it preferable for projects to be done with public vs. private stakeholders. A 200-foot project buffer was used to identify adjacent property owners and estimate the number and type of stakeholders.

Streams	(1) Challenging: Entirely private and/or > 25 stakeholders within 200 feet.	(3) Moderate: Mix of public and/or private or 20-25 stakeholders within 200 feet	(5) Favorable: Partially public and/or < 20 stakeholders within 200 feet.
Outfalls	(1) Challenging: Entirely private and/or > 10 stakeholders within 200 feet.	(3) Moderate: Mix of public and/or private or 3-10 stakeholders within 200 feet	(5) Favorable: Entirely public and/or < 3 stakeholders within 200 feet.

15. Historically Sensitive Areas

The City of Alexandria established an Archaeological Protection Code in recognition of the rich archaeological resources present within its jurisdiction. The Code requires the evaluation of all development projects for which site plans must be filed, to determine the potential for impacting archaeological resources and whether there is a need for preservation action prior to site development. The City has also invested in GIS to predict topographical locations of Native American occupation and to identify the locations of historic sites on the contemporary maps. The map "Alexandria Archaeological Resource Areas" was used determine the likelihood of archaeological sites being affected.

(1) No: Land not included in Archaeological Resources Areas	(3) Maybe: Land where only specific properties may have the potential to contain significant archaeological materials.	(5) Yes: Land that may have the potential to contain significant archaeological materials

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IV. OTHER BENEFITS

16. Public Education and Outreach

The Phase II Regulations require an MS4 permittee to develop a program to educate the public about the impact of stormwater discharges on local waterways and the steps that citizens, businesses, and other organizations can take to reduce the contamination of stormwater, thus preventing/reducing pollutants from discharging into our surface waters - rivers, streams, lakes, ponds and wetlands. Highly visible projects can help to garner support from the community for additional investment in stormwater infrastructure and green practices. Stream restoration projects present excellent opportunities to educate the public. In particular, paths or park open space that is parallel to stream restorations can draw attention to the work being undertaken and encourage community support. Citizens can be educated about specific problems in their watershed (i.e. sediment, nutrients, trash, etc. Homeowner's Associations (HOAs) can be approached about tree plantings and open space preservation. Moreover, volunteer monitoring programs can be established to monitor streams following restoration.

(1) No: no access or visibility along stream corridor	(3) Maybe: moderate visibility and foot traffic along a portion of stream corridor	(5) Yes: large amount of traffic (trails) and visibility along entire stream corridor

17. Recreation Potential

Stream restoration projects can also add significant recreational value to the local community. Anecdotal evidence suggests that aesthetic and recreation enhancements such as instream riffles and falls, walking paths, stream access, debris removal, signage, and desirable streamside vegetation may have public appeal. Studies using contingent valuation to elicit the willingness-to-pay (WTP) of the public for these benefits have quantified these benefits as being worth $560-1,100 per foot (*Kenney et. al., 2012*). These values are of the same order of magnitude as the cost of stream restoration itself, and may even be in excess of water quality benefits. Therefore, projects that can incorporate these features should be strongly favored.

(1) Low: none or very limited opportunities for fishing and/or hiking	(3) Moderate: decent access and potential of hiking and/or fishing along a portion of reach	(5) High: access for fishing and or hiking along entire stream corridor once reach is restored

18. Infrastructure at Risk

Urban stream projects are often undertaken to stabilize streambanks to protect sewer lines, stormwater outfalls, bridges, roads, and property boundaries. Even when other objectives are stated, the immediate need to protect infrastructure frequently determines the location and design of stream projects. Projects that protect infrastructure in imminent danger of failure should be prioritized.

(1) No: Failure not expected in current condition	(3) Maybe: Potential failure to infrastructure (> 1 yr.) if no action is taken	(5) Yes: Current or imminent failure and undermining (< 1 yr.) if no action is taken

19. Public Safety Concerns

The term "urban stream syndrome" (USS) describes the consistently observed ecological degradation of streams draining urban land (*Walsh et. al., 2005*). Symptoms of USS include a flashier hydrograph and altered channel morphology in the form of incision and eroding banks. Both of these symptoms present safety concerns to the public. Flashier streams can worsen downstream flooding, which increases the risk of drowning and driving emergencies on flooded streets. Restored streams with access to a floodplain can dissipate energy and help control flooding. Additionally, severely incised streams with eroding banks present a falling risk to the public, especially when located near trails, highly trafficked parks, or at stream crossings.

(1) Low: Minimal or no concerns for health and safety	(3) Moderate: Potential concerns to public safety including flooding on trails	(5) High: Multiple concerns to public safety, including large drop offs along trails and street flooding downstream

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20. Associated Infrastructure Project Opportunity

Many localities are striving to address both maintenance backlogs and mitigation of environmental impacts as their infrastructure ages. When much of this infrastructure was built, fluvial processes and stream ecology were not well understood. Therefore, in many cases, existing riverine infrastructure is in conflict with the stream environment or at risk from it. High maintenance costs are often required to keep such infrastructure viable and stream restoration projects are often an excellent opportunity to address this aging, degraded infrastructure. Existing infrastructure to be repaired can be made to be more compatible with the stream environment by incorporating design elements that accommodate physical and ecological processes.

(1) No: No infrastructure project associated with the rehabilitation of the stream	(3) Maybe: 1 potential infrastructure project with restoration of the stream	(5) Likely: > 1 potential infrastructure project with restoration of the stream

V. COST / BENEFIT

21. Cost per lb. of Phosphorous Removed (Interim Rate)

Bank and bed erosion is a significant source of particulate phosphorus loading to streams. In recognition of this, the Virginia Department of Environmental Quality (DEQ) has approved five methodologies for permittees to calculate reductions from urban stream restoration. The interim approved removal rates are one of these methodologies and was developed by the Bay Program. This method assumes a removal of 0.068 lbs. of TP/linear foot of stream restored. However, for ranking purposes the existing stream channel project length was used as a surrogate for the restored stream length.

(1) High: > $15K per lb.	(3) Medium: $13-15K per lb.	(5) Low: < $13K per lb.

22. Cost per lb. of Phosphorous Removed (BANCS)

The Bank Assessment for Non-point source Consequences of Sediment (BANCS) Model uses the Bank Erosion Hazard Index (BEHI) and the Near-Bank Stress (NBS) ratings to derive annual streambank erosion rates. These annual loadings are then converted to erosion rates for phosphorous loadings. This method is recognized by DEQ under Protocol 1 (Credit for Prevented Sediment during Storm Flow). For ranking purposes, the existing stream channel project length was used as a surrogate for the restored stream length.

(1) High: > $5K per lb.	(3) Medium: $3-5K per lb.	(5) Low: < $3K per lb.

23. MS4 Draining to Project Site

The size and extent of the City's Municipal Separate Storm Sewer System (MS4) service area was determined in compliance with Section II B.3.a.(3) of the General Permit. Phase II permittees attempting to meet their TMDL reduction requirements, in accordance with the GP, may receive credit for stream restoration on unregulated lands provided any necessary baseline reduction is accounted for (Section I.C.2.b.(1)). For stream restoration projects that receive drainage from both regulated and unregulated lands, permittees may take full credit for the loads draining from regulated lands and an adjusted credit for loads draining off unregulated lands that accounts for baseline reductions (Section I.C.2.b.(2)). Therefore it is important to characterize the regulated acres draining to the proposed project and projects with a higher proportion of regulated drainage should be prioritized.

(1) Low: < 50% of project site drainage area is MS4	(3) Moderate: 50-75% of project site drainage area is MS4	(5) High: >75% of project site drainage area is MS4

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