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Attn: Shannon Curtis, Fairfax County

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Ref: **Task 3.2 Pohick Creek Restoration Strategies Candidate Project Selection**

Restoration Strategies:
Based on the watershed impact indicators, source indicators, and field reconnaissance, areas of impairment or degraded conditions throughout Pohick Creek watershed was mapped using the subwatershed ranking procedure. Once these areas were mapped, restoration strategies were identified to address and mitigate these areas. Within Pohick Creek, all 10 of the WMAs experienced some level of impairment. Impairments ranged from severe stream bank erosion in the Rabbit Branch WMA to minor raised nutrient loading in Potomac-Lower. While it is not feasible to implement restoration efforts on every location in an older fully built-out urbanized watershed such as Pohick Creek, the restoration strategies focused on meeting and addressing the County goals and objectives identified in the table below. For Pohick Creek watershed the following restoration strategies were identified and presented to the Watershed Advisory Group.

(1) Stream Restoration and improving Habitat Quality
(2) Addressing Flooding Issues
(3) Improve Water Quality
(4) Identify Regional Pond Alternatives

The table below links the Pohick Creek restoration strategies to the County goals and objectives.

County Goals & Objectives	Restoration Strategies: Stream Restoration & Improve Habitat Quality	Flooding	Water Quality	Regional Pond Alternative
Minimize impacts of stormwater runoff on stream hydrology to promote stable stream morphology, protect habitat, and support biota.	●			●
Minimize flooding to protect property, human health, and safety		●		●
Provide for healthy habitat through protecting, restoring, and maintaining riparian buffers, wetlands, and instream habitat	●			
Improve and maintain diversity of native plants and animals in the county	●			
Minimize impacts to stream water quality from pollutants in stormwater runoff			●	●
Minimize impacts to drinking water sources from pathogens, nutrients, and toxics in stormwater runoff			●	
Minimize impacts to drinking water storage capacity from sediment in stormwater runoff			●	
Encourage the public to participate in watershed stewardship	●	●	●	
Coordinate with regional jurisdictions on watershed management and restoration efforts such as Chesapeake Bay initiatives	●	●		
Improve watershed aesthetics in Fairfax County	●	●		

Candidate Site Selection Strategy:
The process for candidate site selection was based on the broad restoration strategies. The candidate site selection strategy began by preparing color coded watershed maps and scoring spreadsheets based on the output from subwatershed ranking. These maps and spreadsheets were color coded using the scoring thresholds developed for the watershed metrics. The colors show lower scored areas in red, and higher scored areas in green. This gave a visual representation of potential problem trends or issues throughout the overall watershed. The scoring worksheets from the Subwatershed Ranking Spreadsheets were reviewed and some basic statistical calculations were performed to identify some of the more prevalent issues affecting the watershed as a whole. A statistical analysis of the indicators for “good” to “very poor” was performed. The table below illustrates the results of the indicators which reflected “very poor”. This process allows the top 10 issues throughout the watershed to be highlighted.

This is the first step in capturing and identifying the major issues/trends throughout the watershed and allows for the initial identification of the universe of potential projects which will address these issues.

Impact Indicators			
Ranking of Issues	Metric	Impact Indicator	% Watershed Categorized as "Very Poor"
1	3.3.4	Channel Morphology	77%
2	3.3.19	Phosphorous	40%
3	3.3.1	Benthic Communities	34%
4	3.3.14	Wetland Habitat	27%
5	3.3.13	Headwater Riparian Habitat	24%
6	3.3.3	Aquatic Habitat	19%
7	3.3.18	Nitrogen	17%
8	3.3.17	Upland Sediment	12%
9	3.3.11	Flood Complaints	10%
10	3.3.12	RPA Riparian Habitat	9%

Source Indicator			
Ranking of Issues	Metric	Source Indicator	% Watershed Categorized as "Very Poor"
1	4.3.1	Channelized/Piped Streams	78%
2	4.3.4	Stormwater Outfalls	57%
3	4.3.11	Total Urban Land Cover	45%
4	4.3.2	Directly Connected Impervious Area	42%
5	4.3.3	Total Impervious Area	41%
6	4.3.12	TP Load	40%
7	4.3.9	Streambank Buffer Deficiency	39%
8	4.3.10	TN Load	17%
9	4.3.5	Parcels Served by Septic Tanks	13%
10	4.3.13	TSS Load	12%

After identifying some basic trends, individual WMAs were selected to be analyzed. Each subwatershed has a composite score for its Source Indicators and Impact Indicators. The individual metrics comprising the watershed's composite score were reviewed for each subwatershed and any potential project areas were identified. The different indicators are as specified in the Tetra Tech ranking document (Fairfax County WMP Subwatershed Ranking Approach). The scoring spreadsheets and GIS maps were used to identify subwatersheds with severe area conditions, moderate area conditions, and good area conditions. The subwatersheds with severe area conditions in both source and impact indicators were addressed first. Below is an example of Pohick –Lower WMA with the individual subwatersheds and the scoring.

			Impact Indicators Metrics and Scores												
SITE_CODE	Scenario	WMA Name	331	332	333	334	335	3312	3313	3314	3315	3316	3317	3318	3319
PC-PC-0001	Existing	Pohick-Lower	8	8	4	2	5	10	2	8	8	5	10	7.5	5
PC-PC-0002	Existing	Pohick-Lower	8	6	6	6	5	4	10	4	10	5	10	7.5	5
PC-PC-0003	Existing	Pohick-Lower	8	8	2	2	5	4	6	4	8	5	10	7.5	5
PC-PC-0004	Existing	Pohick-Lower	8	8	2	2	5	4	10	4	10	5	10	7.5	5
PC-PC-0005	Existing	Pohick-Lower	8	8	2	2	5	8	2	4	4	5	2.5	5	5
PC-PC-0006	Existing	Pohick-Lower	8	8	2	2	5	6	10	4	10	5	10	5	5
PC-PC-0007	Existing	Pohick-Lower	8	8	4	2	5	10	4	4	6	5	10	5	5
PC-PC-0008	Existing	Pohick-Lower	8	8	2	2	5	4	6	4	6	5	10	5	5
PC-PC-0009	Existing	Pohick-Lower	6	8	2	2	5	4	6	4	4	5	7.5	5	5
PC-PC-0010	Existing	Pohick-Lower	6	8	2	2	5	2	4	4	2	5	10	5	2.5
PC-PC-0011	Existing	Pohick-Lower	6	8	6	4	7.5	10	2	4	2	5	10	7.5	5
PC-PC-0012	Existing	Pohick-Lower	6	8	4	2	7.5	6	4	4	4	5	2.5	2.5	2.5
PC-PC-0013	Existing	Pohick-Lower	6	8	4	2	5	8	4	4	4	5	5	5	2.5
PC-PC-0014	Existing	Pohick-Lower	6	8	2	2	5	2	2	2	2	5	10	7.5	5
PC-PC-0015	Existing	Pohick-Lower	6	8	6	2	7.5	2	2	2	4	5	10	7.5	5
PC-PC-0016	Existing	Pohick-Lower	6	8	2	2	5	6	4	2	4	5	10	5	5
PC-PC-0017	Existing	Pohick-Lower	6	8	6	2	7.5	8	2	2	6	5	10	10	10
PC-PC-0019	Existing	Pohick-Lower	6	8	6	2	7.5	4	4	4	4	5	10	5	5

SITE_CODE	WMA Name	Objective Composite Score							Overall Composite Score
		Stormwater Runoff	Flooding Hazards	Habitat Health	Habitat Diversity	Stream Water Quality	Drinking Water Quality	Storage Capacity	
PC-PC-0001	Pohick- Lower	5.40	10.00	4.80	8.00	6.93	6.88	7.50	7.27
PC-PC-0002	Pohick- Lower	6.20	10.00	4.80	7.00	6.64	6.88	7.50	7.20
PC-PC-0003	Pohick- Lower	5.00	10.00	3.20	8.00	6.93	6.88	7.50	7.00
PC-PC-0004	Pohick- Lower	5.00	10.00	4.00	8.00	6.93	6.88	7.50	7.11
PC-PC-0005	Pohick- Lower	5.00	10.00	3.20	8.00	5.50	4.38	3.75	5.98
PC-PC-0006	Pohick- Lower	5.00	10.00	4.40	8.00	6.57	6.25	7.50	7.03
PC-PC-0007	Pohick- Lower	5.40	7.00	4.40	8.00	6.57	6.25	7.50	6.48
PC-PC-0008	Pohick- Lower	5.00	10.00	3.20	8.00	6.57	6.25	7.50	6.87
PC-PC-0009	Pohick- Lower	4.60	10.00	3.20	7.00	5.93	5.63	6.25	6.35
PC-PC-0010	Pohick- Lower	4.60	9.20	2.40	7.00	5.93	5.63	7.50	6.25
PC-PC-0011	Pohick- Lower	6.30	5.10	4.40	7.00	7.00	6.88	8.75	6.40
PC-PC-0012	Pohick- Lower	5.50	10.00	3.60	7.00	4.86	3.13	5.00	5.88
PC-PC-0013	Pohick- Lower	5.00	10.00	4.00	7.00	5.21	4.38	5.00	6.08
PC-PC-0014	Pohick- Lower	4.60	8.40	1.60	7.00	6.64	6.88	7.50	6.24
PC-PC-0015	Pohick- Lower	5.90	10.00	2.40	7.00	7.00	6.88	8.75	7.06
PC-PC-0016	Pohick- Lower	4.60	10.00	2.80	7.00	6.29	6.25	7.50	6.59
PC-PC-0017	Pohick- Lower	5.90	10.00	3.60	7.00	8.07	8.75	8.75	7.61
PC-PC-0019	Pohick- Lower	5.90	10.00	3.60	7.00	6.64	6.25	8.75	7.09

When the potential project areas were identified, the subwatershed was crosschecked against any ProRata projects that may be on the County's project list already.

Universe of Project Selection Strategy:
The final step of the strategy involved looking at GIS orthographic maps, field site visit forms, site photos, and other pertinent information related to the given watershed. The objective was to select projects and sites that fit the overall condition of the watershed. Typically, there were multiple ways to remedy any one issue, but the universe of projects were selected based on meeting the County's goals and objectives as described in the "Fairfax County Watershed Management Plan Development Standards, Version 3.2". The table below identifies the type of structural projects and the associated BMPs used for project section.

Type	BMP	Water Quantity	Water Quality	Habitat Quality	Stream Morphology
Streams /Buffers	New stream alignment		X	X	X
	Re-alignment of existing channel		X	X	X
	Stream stabilization		X	X	X
	Bank stabilization		X	X	X
	Buffer restoration		X	X	X
Outfalls / Culverts	Culvert Retrofit	X	X		
	Outfall Retrofit	X	X		X
LID	Sand Filters		X		
	Bioretention / Rain Gardens	X	X		
	Infiltration Basins / Trenches	X	X		
	Rain Barrels / Cisterns	X	X		
	Green Roofs	X	X		
	Porous Pavements	X	X		
New Pond / Retrofit	Wet Pond	X	X		
	Extended Dry Pond	X	X		
	Wetland System	X	X	X	
	Micropool ED Pond	X	X		
	Shallow Marsh	X	X		
Area-wide Drainage Improvements	Dumpsites		X	X	
	Obstructions			X	X
	Utility Crossings			X	X

For example project PC92-SO1, a subwatershed with stream buffer deficiency issues and water quality issues, is a potential candidate for a stream restoration project. Stream restoration can help to return a stream to its natural channel, reduce drainage complaints, and reduce erosive velocities and downstream sedimentation. These reductions can result in potential increases in water quality.

Capturing the universe of projects consisted of developing the following table and a watershed map identifying the location of the project:

Project #	Project Type	WMA	Description	Indicator	Benefit	Cost	Map ID #
PC92-SO1	Stream restoration	Upper South Run	Provide localized stability to stream channel	Channel morphology	Water Quality	$100,000	1

Approach to Project Prioritization and Selection

Stormwater system improvement, system repair, prevention, and site specific conditions were all considered during project selection and prioritization. The improvement projects were focused on areas of extreme degradation or severe conditions. In some cases the conditions were moderate and repair projects were proposed. In areas that were in good condition, but had the potential for future degradation, prevention projects were selected. Finally, for specific sites, community input and site photos were used to select specific projects.

The areas needing improvement were areas with extreme conditions. These areas were determined during the first phase of project selection. The scoring worksheets and GIS maps were used to identify areas that scored poorly in multiple indicator and source categories. These areas were analyzed to determine feasible candidate projects. Stream restoration and LID retrofits were two common recommendations. These projects are generally located in areas without treatment or with very little stormwater management BMP facilities.

In areas with moderate scores, projects were targeted to the specific negative indicators. Identified projects included buffer repair, spot stream improvements, pond retrofits, and outfall improvements. These projects were generally selected in areas with some existing treatment. However, the treatment was inadequate to meet the current needs of the site.

In areas with only a single negative indicator, prevention type projects were selected. These projects were selected based on their future benefit to the watershed and their benefit to public outreach. An example of this would be the rain barrel/cistern projects at local schools or public buildings. Neighborhood street sweeping programs, obstruction removal projects, and stream crossing upgrades are projects designed to prevent sedimentation and pollutants from reaching streams and help prevent potential flooding.

Community member recommendations and site visits identified issues at some specific sites. The issues, recommendations and size constraints were analyzed to determine an appropriate project. These projects varied based on the type of problem identified, but fell within the same general strategy of the other projects.

After all of the indicators were examined, potential sites were identified. Based on existing site improvements, topography, on-site utilities, and existing vegetation, an appropriate improvement project was recommended. The selections weighed the existing site use, ownership, and potential costs when selecting project types and locations. Most projects were targeted to open areas on public land.

Candidate Project Sites

The candidate project sites are shown on the attached map. The attached table lists details for each project: project type, description, affected watershed indicators, and project benefits. These details are included in the attributes of the GIS shapefile used to create the map.

Fairfax County

Pohick Creek Watershed

Technical Memorandum 3.4/3.5/3.6

Project Ranking

January 2011

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Introduction

The Fairfax County Watershed Management Plan Standards Version 3.2 (WMP 3.2) requires an initial ranking of the Pohick Creek Watershed improvement candidate projects created for subtask 3.2. This ranking will be used to help determine the 0-10 and 11-25-year project groups. The ranking employed the following methods:

1. Structural projects were scored and ranked using the quantitative analysis detailed in Subtask 5.1-E. This analysis uses five factors to compare and rank the projects. The factors include: (1) impact indicators, (2) source indicators, (3) priority subwatersheds, (4) sequencing, and (5) implementability. Each proposed project was assigned a score for each of the five prioritization factors. Projects that propose the greatest benefit to the watershed were given a preliminary project score of 5, and projects that propose the least benefit were assigned a project score of 1. The proposed structural projects were then ranked according to a weighted average of these five preliminary project scores.

2. Non-structural projects were scored using similar factors, but more emphasis was placed on best professional judgment (BPJ). The analysis for non-structural projects was completed using more of a qualitative comparison than the quantitative comparison that was completed for structural projects. Buffer restoration rain barrel projects were an exception to this rule. These projects were scored using the quantitative prioritization schemes because they are similar to stream restoration and other BMP/LID projects which can be quantified.

This memo provides a brief description of the methods used for the candidate project selections, the field investigations, community involvement, the project cost estimates, and water quality modeling. This information was used for the evaluation of the structural and nonstructural projects as outlined by subtask 3.4 and 3.5 (WMP 3.2). A list of the guidance documents used for this evaluation can be found in the bibliography in Appendix A. Additionally a description of all files used for the prioritization is provided in Appendix B. A shapefile of the proposed projects has been provided as *PC_WMP_Projects.shp*.

Project Ranking Subtasks

Candidate Project Selection

In subtask 3.2, projects were strategically proposed throughout subwatersheds with the lowest composite impact and source indicator scores. Proposed projects were selected by comparing the lowest scoring impact indicators to the types of proposed projects to ensure proposed projects would provide the most benefit within each subwatershed. The candidate projects were then located and saved in the GIS file *PC_Projects*. (See Appendix M for a map of the candidate projects.) The candidate projects were then presented at watershed advisory group (WAG) meetings for community input. This input was used to modify the project selection and was added to the ranking comments for score adjustments (See Appendix C: Pohick Creek Master Project List).

Regional Pond Alternative Projects

Using the WMP Standards 3.2, all unconstructed regional ponds from the County's current Regional Pond Program were evaluated for inclusion into one of the following disposition categories (see Table 1 Category column) developed with the Cub Run and Difficult Run watershed plans:

1. Recommend deletion of the proposed regional pond and implementation of a group of alternative projects.
2. Recommend deletion of the proposed regional pond and no alternative projects are necessary.
3. Recommend deferral of the proposed regional pond and implementation of a group of alternative projects. If the alternative projects cannot be implemented, then a modified scope regional pond may be considered at a future date.
4. Recommend implementation of a reduced-size or modified regional pond. If the pond still cannot be implemented, then pursue implementation of a group of alternative projects.

Table 1: Regional Pond Data (from Pond_on_Grid_UPDATED_020409.shp)

Status *	Project Name*	Stat Jan08*	Storm-net ID*	Con-structed	Category	Alter. Projects Proposed?	PRJ_ID _LEG	PRJ_TYPE
Inactive	Pond P-01	C	0791DP	Y	N/A	Y	PC9001A PC9001B	Stormwater Pond Retrofit Stream Restoration
Inactive	Pond P-02	Non-exist	--	N	2	N	N/A	N/A
Inactive	Pond P-03	Non-exist	0922DP	N	1	Y	PC9003	Stormwater Pond Retrofit
Inactive	Pond P-04	Non-exist	--	N	1	Y	PC9004A PC9004B	Stream Restoration Dumpsite/obstruction removal
Active	Pond P-05	Non-exist	--	N	2	N	N/A	N/A
Inactive	Pond P-06	Non-exist	--	N	2	N	N/A	N/A
Inactive	Pond P-07	Non-exist	--	N	1	Y	PC9007	Stormwater Pond Retrofit
Completed	Pond P-08	C	0525DP	Y	N/A	Y	PC9008	Stormwater Pond Retrofit

In the 1989 Regional Stormwater Management Plan Final Report, a total of eight regional ponds were proposed for the portion of Pohick Creek that drains to Burke Lake. Of these eight recommended regional ponds, two (P-01 and P-08) have a status of “C” (completed), one (P-05) has a status of “A” (active County project, partially funded), and five (P-02, P-03, P-04, P-06 and P-07) have a status of “I” (not an active funded County project).

Alternative regional pond projects were proposed for P-03, P-04 and P-07, which included stormwater pond retrofits to existing stormwater ponds, stream restorations, and dumpsite/obstruction removal projects. Although P-01 and P-08 are completed, alternative regional pond projects were proposed to provide supplemental benefits, which included stormwater pond retrofits to the existing stormwater ponds, and stream restorations. No alternative regional pond projects were proposed for P-02 and P-06, as the proposed areas for these regional ponds were largely undeveloped, natural and densely forested areas and no existing stormwater ponds were available to retrofit. No alternative regional pond projects were proposed for P-01, since this is an active County project.

Field Investigations

In subtask 3.3 field reconnaissance was performed for the candidate project sites. The reconnaissance consisted of completing site visits to document site conditions, check for feasibility and to take photos. This information was compiled into the access database file *PC-LO_Candidate_Project_Investigation.* This database was used to populate some of the metrics for the prioritization scheme. Additionally, the field visit form comments were condensed and added to the ranking comments column in the Pohick Creek Master Project List. These ranking comments were utilized to support project ranking modifications.

Cost Estimates

Cost estimates were performed for the projects during the ranking process based on County cost guidance. Projects costing less than $80,000 were grouped together with other projects based on whether the projects would be constructed simultaneously. These projects were scored under the project type “Suite of Projects”, where the benefits were added together.

Projects excluded from the grouping were rain barrel/cisterns and street sweepings. These projects do not currently have cost information provided by the County, and since these projects are non-structural they are still being further evaluated. Types of projects that were grouped together in project suites included buffer restorations, stream restorations, pipe daylighting and obstruction/dumpsite removals; bioretention areas, bioswales and swale retrofits; and stream restorations and stormwater pond retrofits. The large majority of grouped projects are in the same subwatershed. Most of the BMP/LID groups are located on a single site. Stream restorations were only grouped with stormwater pond retrofits if restoration is directly upstream of the pond and has existing negative impacts on the condition of the pond. In some cases, low-cost projects are not grouped as a result of an isolated site which could not be matched with another higher cost project. According to County guidance these projects were dropped to the bottom of the rankings. Costs for grouped projects are the sum of all projects in the group (before rounding up). The subcomponents of the grouped projects are called subprojects and are denoted by a project ID number and letter (i.e. PC9001A). The subproject ID numbers were used in all of the tables except the final ranking.

Structural Project Prioritization

The following section describes PBS&J's implementation of the Fairfax County WMP 3.2 guidance for the structural project prioritization. The structural project prioritization was completed using a spreadsheet based on the prioritization scheme outlined in subtask 5.1-E. The spreadsheet uses the five factors explained below to provide a basis to compare each project's ability to improve the watershed and rank the most beneficial projects.

1. Impact Indicators

Table 2, which was taken from Attachment #1 in the WMP 3.2, lists the relationship between the different project types and the impact indicators that were evaluated. For each project type, the indicators marked with an X were included in the prioritization, indicators marked with an O had their potential effects considered but not scored, and the remaining indicators were not considered for the prioritization.

Table 2: Matrix showing links between Project Types and Impact Indicator Scores

Individual Impact Indicators	Stream Restoration	Outfall Improvement	BMP/LID	Stormwater Pond Retrofit	Buffer Restoration
Benthic Communities	O	O			O
Fish Communities	O	O			O
Aquatic Habitat	O	O			O
Channel Morphology (CEM)	X	O		O	X
Instream Sediment	X	X		O	X
Hydrology	X	X	X	X	X
Number of Road Hazards					
Magnitude of Road Hazards					
Residential Building Hazards					
Non-residential Building Hazards					
Flood Complaints		O	O		
RPA Riparian Habitat	X		O		X
Headwater Riparian Habitat	X		O		X
Wetland Habitat	X		O		X
Terrestrial Forested Habitat			O		X
E. Coli	O	O	O	O	
TSS (Upland Sediment)	X	X	X	X	X
TN (Nitrogen Load)		X	X	X	X
TP (Phosphorus)	X	X	X	X	X
Total X's	8	5	4	4	10
Total O's	4	6	6	3	3

***Note**: Flood protection / mitigation and culvert retrofit projects were omitted, since flood protection / mitigation or culvert retrofit projects are not proposed in the Pohick Creek Watershed.*

As shown by Table 1, a different number of indicators were scored depending on the project type. For example, stream restorations have 8 indicators that were scored, whereas stormwater pond retrofits only have 4 indicators that were scored. For this reason, a composite indicator project score was determined for each project by averaging only the indicators that were affected by the corresponding project type (indicators marked with an X in Table 1). These composite impact indicator scores were reviewed to verify that, comparing different project types by impact indicator ranking was reasonable.

The existing and future without (FWO) impact indicator metric values and scores were determined using the Subwatershed Ranking (SWR) Approach, section 3.4, which was completed under a previous task. The scoring of the candidate projects and description of each impact indicator is provided below. (See Appendix D: Summary of Impact Indicator Scoring.)

Channel Morphology ICEM Metric Score

Only stream restoration and buffer restoration projects were scored based on the ICEM impact indicator. The channel morphology ICEM score was based on geomorphic stability. Table 3 was taken from Table 3-4 of the SWR guidance and shows the ICEM subwatershed scoring thresholds for channel morphology ICEM stage values. The preliminary project scores were based on existing conditions. The candidate projects have SWR scores of either 2 or 6, where higher scores indicate higher geomorphology stability.

Table 3: SPS/SPA ICEM Class Scoring Thresholds

Average SPA/SPS ICEM Stage Value	Description1	Score
1 to 1.5	Well developed baseflow and bankfull stages; consistent floodplain features easily identified and covered by diverse vegetation; one terrace apparent above active floodplain; streambank slopes less than or equal to 45 degrees.	10
4.5 to 5	Well developed baseflow and bankfull stages; consistent floodplain features easily identified and covered by diverse vegetation; two terraces apparent above active floodplain; streambank slopes less than or equal to 45 degrees.	8
1.5 to 2.5	Headcuts and exposed cultural features (i.e., property, infrastructure) apparent; absent or sparse sediment deposits; exposed bedrock; streambank slopes greater than 45 degrees.	6
3.5 to 4.5	Streambank aggrading while sloughed material not eroding; vegetative colonization of sloughed material; development of baseflow, bankfull, and floodplain channel features; predictable sinuous flow patterns developing streambank slopes less than 45 degrees.	4
2.5 to 3.5	Streambank sloughing with sloughed material actively eroding; streambanks are ~60 degrees and vertical or concave.	2

[1] Descriptions modified from Fairfax County SPS Baseline Study (Fairfax County, 2001)

Notice that the table gives a higher stability score to the ICEM stage value range 1.5 to 2.5 than the 2.5 to 3.5 range, which correspond to scores of 6 and 2, respectively. The ICEM Stage value range of 1.5 to 2.5 (channel incision) is more stable than the 2.5 to 3.5 ICEM stage value range (channel widening).

Projects proposed in subwatersheds with channel morphology ICEM scores of 2 were given preliminary project scores of 4 since they have the most room for improvement, where projects proposed in subwatersheds with channel morphology ICEM scores of 6 were given preliminary project scores of 2 since they have less room for improvement.

Instream Sediment Metric Score

Stream restoration, outfall improvement, and buffer restoration projects were scored for this impact indicator. The instream sediment metric is not a predictive indicator, therefore the future conditions scores were not available and the preliminary project scores were based solely on existing conditions. Projects addressing this indicator were only proposed in subwatersheds with existing conditions instream sediment scores of 2.5, 5, and 7.5.

Subwatersheds with an existing conditions instream sediment metric score of 2.5 had streambanks that were unstable with signs of mass erosion and slumping. Projects proposed in these subwatersheds were given a preliminary project score of 5 because they provide the most benefit. Projects proposed in subwatersheds with an existing conditions instream sediment metric scores of 5.0 and 7.5 were given preliminary project scores of 4 and 3, respectively, since they provide the next two levels of improvement compared to the other projects.

Hydrology Metric Score

Stream restoration, outfall improvement, BMP/LID, stormwater pond retrofit and buffer restoration projects were evaluated and scored for this impact indicator. The hydrology metric is area-weighted based on the flow rate in cubic feet per second per square mile (cfs/mi^2). The metric values from the subwatershed ranking spreadsheet were used to assign the project scores for this indicator (direct-metric value method).

Rather than scoring projects based on how much the hydrology metric changes in cfs, which would require extensive modeling at this preliminary stage, the existing conditions metric was compared to the FWO conditions metric and the percent change was calculated. As per the County's quintile scoring method, the range of percent change was divided into five preliminary project scores ranging from 1 to 5. See Table 4. Projects that provided the largest percent change, corresponding to the largest improvement, were assigned a preliminary project score of 5, where projects that proposed the least improvement were assigned a preliminary project score of 1.

Table 4: Hydrology Metric Quintile Scoring Method.

Percentile	% Change: Future w/o to Future w/ Project	Preliminary Score
80%	3.94%	5
60%	2.35%	4
40%	0.84%	3
20%	0.03%	2
0%	-6.18%	1

RPA Riparian Habitat Metric Score

Stream restoration and buffer restoration projects were scored for this impact indicator. The RPA riparian habitat score is the percentage of riparian habitat in the regulated Chesapeake Bay Resource Protection Areas. The preliminary project scores were based on FWO conditions. The SWR scores for this indicator range from 2 to 10, which indicate the lowest and highest percentages of riparian habitat, respectively.

Projects proposed in subwatersheds with RPA riparian habitat scores of 2 were given preliminary project scores of 5 since they provide the greatest benefit. Projects proposed in subwatersheds with RPA riparian habitat scores of 4, 6, 8, and 10 were given preliminary project scores of 4, 3, 2, and 1, respectively, since they provide the next four levels of improvement compared to the other projects.

Headwater RPA Riparian Habitat Metric Score

Stream restoration and buffer restoration projects were scored for this impact indicator. The headwater RPA riparian habitat score is the percent of riparian habitat in the RPA riparian areas that are located at the stream headwaters. The preliminary project scores were based on FWO conditions. The SWR scores for this indicator range from 2 to 10, which indicate the lowest and highest percentages of riparian habitat located at stream headwaters, respectively.

Projects proposed in subwatersheds with headwater RPA Riparian habitat scores of 2 were given preliminary project scores of 5 since they provide the greatest benefit. Projects proposed in subwatersheds with headwater RPA riparian habitat scores of 4, 6, 8, and 10 were given preliminary project scores of 4, 3, 2, and 1, respectively, since they provide the next four levels of improvement compared to the other projects.

Wetland Habitat Metric Score

Stream restoration and buffer restoration projects should were scored for this impact indicator. The Wetland Habitat score is the percentage of wetland habitat in the subwatershed. The preliminary project scores were based on FWO conditions. The SWR scores for this indicator range from 2 to 10, which indicate the lowest and highest percentages of wetland habitat, respectively.

Projects proposed in subwatersheds with wetland habitat scores of 2 were given preliminary project scores of 5 since they provide the greatest benefit. Projects proposed in subwatersheds with wetland habitat scores of 4 and 6 were given preliminary project scores of 4 and 3, respectively, since they provide the next two levels of improvement compared to the other projects.

The percent change between the existing conditions metric to the FWO conditions metric was calculated for informational purposes only and was not directly used in the calculations. Per County Guidance, this metric did not employ the quintile method since this metric was not directly modeled.

Terrestrial Forested Habitat Metric Score

Buffer restoration projects were scored for this impact indicator. The Terrestrial Forested Habitat score is based on the percentage that the VDOF forested cover classification area covers in the subwatershed. The preliminary project scores were based on FWO conditions. The SWR scores for this indicator range from 2 to 10, which indicate the lowest and highest percentages of terrestrial forested habitat, respectively.

All of the proposed buffer restoration projects were located in subwatersheds with a terrestrial forested habitat score of 4, and these projects were given preliminary project scores of 4 since they provide roughly equal benefit.

The percent change between the existing conditions metric and the FWO conditions metric was calculated for informational purposes only and was not directly used in the calculations. Per County Guidance, this metric did not employ the quintile method since this metric was not directly modeled.

Pollutant Load Indicator Scores (TSS, TN, & TP)

The County provided Spreadsheet Tool for Estimating Pollutant Loads (STEPL) was used to calculate upland sediment (TSS), total nitrogen (TN), and total phosphorous (TP). GIS processing was used to determine the directly connected impervious area, land use types, BMP types, and drainage areas to determine the amount of pollutants for all subwatersheds. The FWO project conditions used future land use information to determine pollutant loads. The future with project conditions (FW) were determined by estimating the amount of pollutant that a project would remove if it was the only project implemented. This pollutant removal was then subtracted from a subwatershed's entire pollutant load.

To allow the comparison of results across different watersheds, the subwatershed's pollutant loads were divided by their areas to get units of mass/acre/year. STEPL was not capable of estimating the FW project conditions for the non-structural projects, outfall improvement projects, and stream restoration projects. The non-structural projects were judged on their existing conditions.

The percentage of change from the FW project to the FWO conditions was determined for all of the projects except for the buffer restorations, outfall improvements and non-structural projects, since the FW project loads was not calculated. The amount of improvement that the projects provided (AKA percentage of change from the FW project to the FWO conditions) was broken into quintiles per the County's Guidance, and the highest project scores were given to the projects that caused the most improvement. The metric values from the subwatershed ranking spreadsheet were used to assign the project scores for this indicator (direct-metric value method). See the percentages of change and quintile thresholds in Appendix E.

Stream restorations were not modeled in STEPL, but metric values were calculated for TSS, TP, and TN, by considering all streambank erosion pollutants that had previously been created along the length of the stream restoration were eliminated once the stream restoration was complete. This method was also extrapolated to stream restorations that involved daylighting a storm pipe. For these projects that involved daylighting some distance (D) of existing stormwater pipe, it was assumed that the pollutant removal of the project was equal to the pollutants caused by that same distance (D) in the downstream eroding reach. A stream restoration project's pollutant removal was then subtracted from the FWO conditions total subwatershed pollutant load and divided by the subwatershed area. This allowed stream restorations to be quantitatively compared to the projects modeled by STEPL.

For outfall improvement projects, streambank erosion was assumed to be eliminated for a distance of 135 ft downstream of the projects. This distance is based on VDOT design standards which call for a minimum of 135 ft of protection downstream of an outfall. This method provides a planning-level estimate of TSS, TN and TP reduction for outfall improvement projects.

Final Project Score based on Impact Indicators

Each project type's average score was based on a different number of indicators per Table 1. The initial impact indicator score was determined by adding the project scores assigned for each impact indicator and dividing this sum by the number of indicators evaluated to obtain a score between 1 and 5. These project scores were then ranked with the highest project scores receiving the highest priority rank.

Per County Guidance BPJ was used to account for the fact that different project types provide a different number of benefits. An additional score was added to account for this difference. Project types that addressed the most impact indicators were given higher scores, whereas project types that addressed the least impact indicators were given the lowest scores. Table 5 summarizes this scoring. The final project score was determined by including this additional value in the average score.

Table 5: BPJ Score Adjustment for Number Impact Indicator Evaluated

	Suite of Projects	Stream Restor.	Suite of Projects	Outfall Improve.	BMP/LID	SW Pond Retrofit	Buffer Restor.
# of Impact Indicators Addressed	9	8	6	5	4	4	9
Score Assigned	5	4	3	2	1	1	5

2. Source Indicators

Table 6 lists the relationship between the different project types and the source indicators that were included when evaluating a project. For each project type, the indicators marked with an X were included in the prioritization, indicators marked with an O only had their potential effects considered but not scored, and the remaining indicators were not considered for the prioritization.

Table 6: Matrix showing links between Project Types and Source Indicator Scores

Individual Source Indicators Scores	Stream Restoration	Outfall Improvement	BMP/LID	Stormwater Pond Retrofit	Buffer Restoration
Channelized/ Piped Streams	X	X			
DCIA			X	X	
Impervious Surface			O		
Stormwater Outfalls	X	X	X	X	
Sanitary Sewer Crossings	X				
Streambank Buffer Deficiency	X				X
TSS (Upland Sediment)	O	X	X	X	O
TN (Nitrogen Load)	O	X	X	X	O
TP (Phosphorus)	O	X	X	X	O
Total X's	4	5	5	5	1
Total O's	3	0	1	0	3

Note: *Flood protection / mitigation and culvert retrofit projects were omitted, since no flood protection / mitigation or culvert retrofit projects are proposed in Pohick Creek*

As was the case with impact indicators, different project types were scored based on a different number of source indicators. For example, stream restorations have 4 indicators that were evaluated and scored, where buffer restorations only have 1 indicator that was evaluated and scored. For this reason, a composite indicator project score was determined for each project by averaging only the indicators that were affected by the corresponding project type (indicators marked with an X in attachment #2). These composite impact indicator scores were reviewed to verify that, although each project type is scored based on a different number of impact indicators, comparing different project types by impact indicator ranking was reasonable.

Existing and FWO impact indicator metric values and scores were determined using the Subwatershed Ranking (SWR) Approach section 3.4 (See Appendix B) under a previously completed task. Note that FWO conditions were determined only for predicative indicators.

Channelized/ Piped Streams Metric Score

Stream restoration and outfall improvement projects were scored for this impact indicator. The channelized/ piped streams score is the percentage of channelized or piped streams in a subwatershed. The channelized/ piped streams metric is not a predictive indicator, therefore the future conditions scores were not available and the preliminary project scores were based solely on existing conditions. The SWR scores for this indicator range from 2.5 to 10, which indicate the highest and lowest percentages of channelized/ piped streams, respectively.

Projects proposed in subwatersheds with channelized/ piped streams scores of 2.5 were given preliminary project scores of 5 since these areas had the most room for improvement. Projects proposed in subwatersheds with channelized/ piped streams scores of 5, 7.5 and 10 were given preliminary project scores of 4, 3, and 2, respectively, since they provide the next three levels of improvement compared to the other projects.

DCIA Metric Score

Stormwater pond retrofits and BMP/LID projects were scored for this impact indicator. The directly connected impervious area metric score is based on the percentage of impervious area that flows directly to a stormwater system. The directly connected impervious area indicator scores were taken from the FWO SWR spreadsheets. The SWR scores for this indicator range from 2.5 to 10, where 2.5 indicate the largest percentage of DCIA and 10 indicates the smallest percentage of DCIA.

Projects proposed in subwatersheds with DCIA scores of 2.5 were given preliminary project scores of 5 since they provide the greatest benefit. Projects proposed in subwatersheds with stormwater outfalls scores of 5, 7.5, and 10 were given preliminary project scores of 4, 3, and 2, respectively, since they provide the next three levels of improvement compared to the other projects.

Stormwater Outfalls Metric Score

Stream restoration, outfall improvement, BMP/LID, and stormwater pond retrofit projects were scored for this impact indicator. The stormwater outfalls score is based on the number of outfalls per mile of stream. The stormwater outfalls metric is not a predictive indicator, therefore the future conditions scores were not available and the preliminary project scores were based solely on existing conditions. The SWR scores for this indicator range from 2.5 to 10, where 2.5 indicates the largest number of outfalls per mile of stream and 10 indicates the fewest number of outfalls per mile of stream.

Projects proposed in subwatersheds with stormwater outfalls scores of 2.5 were given preliminary project scores of 5 since they provide the greatest benefit. Projects proposed in subwatersheds with stormwater outfalls scores of 5, 7.5, and 10 were given preliminary project scores of 4, 3, and 2, respectively, since they provide the next three levels of improvement compared to the other projects.

Sanitary Sewer Crossings Metric Score

Stream restoration projects were scored for this impact indicator. The sanitary sewer crossings score is based on the number of sanitary sewer crossings per mile of stream. The sanitary sewer crossings metric is not a predictive indicator, therefore the future conditions scores were not available and the preliminary project scores were based solely on existing conditions. The SWR scores for this indicator range from 2.5 to 10, where 2.5 indicates the largest number of sanitary sewer crossings per mile of stream and 10 indicates the fewest number of sanitary sewer crossings per mile of stream.

Projects proposed in subwatersheds with sanitary sewer crossings scores of 2.5 were given preliminary project scores of 5 since they provide the greatest benefit. Projects proposed in subwatersheds with sanitary sewer crossings scores of 5, 7.5, and 10 were given preliminary project scores of 4, 3, and 2, respectively, since they provide the next three levels of improvement compared to the other projects.

Stream Bank Deficiency Metric Score

Stream restoration and buffer restoration projects were scored for this impact indicator. The stream bank deficiency score is based on the percentage of forest area in the buffer areas of the streams. The stream bank deficiency metric is not a predictive indicator, therefore the future conditions scores were not available and the preliminary project scores were based solely on existing conditions. The SWR scores for this indicator range from 2.5 to 10, which indicate the highest and lowest percentages of stream bank deficiency, respectively.

Projects proposed in subwatersheds with stream bank deficiency scores of 2.5 were given preliminary project scores of 5 since they provide the greatest benefit. Projects proposed in subwatersheds with stream bank deficiency scores of 5, 7.5, and 10 were given preliminary project scores of 4, 3, and 2, respectively, since they provide the next three levels of improvement compared to the other projects.

TSS (Upland Sediment) Metric Score

Outfall improvement, BMP/LID, and stormwater pond retrofit projects were evaluated and scored for this source indicator. The TSS source indicator preliminary scoring process is the same as that of the TSS impact indicator scoring process. Therefore, the preliminary project scores for this indicator were pulled from the TSS impact indicator table. See the TSS impact indicator scoring description from section 1 of the prioritization spreadsheet methods for a detailed description of the scoring process for this indicator.

Total Nitrogen (TN) Metric Score

Outfall improvement, BMP/LID, and stormwater pond retrofit projects were scored for this source indicator. The TN source indicator preliminary scoring process is the same as that of the TN impact indicator scoring process. Therefore, the preliminary project scores for this indicator were pulled from the TN impact indicator table. See the TN impact indicator scoring description from section 1 of the prioritization spreadsheet methods for a detailed description of the scoring process for this indicator.

Total Phosphorous (TP) Metric Score

Outfall improvement, BMP/LID, and stormwater pond retrofit projects were scored for this source indicator. The TP source indicator preliminary scoring process is the same as that of the TP impact indicator scoring process. Therefore, the preliminary project scores for this indicator were pulled from the TP impact indicator table. See the TP impact indicator scoring description from section 1 of the prioritization spreadsheet methods for a detailed description of the scoring process for this indicator.

Final Project Score based on Source Indicators

Each project type's average score was based on a different number of indicators per Table 2. The initial source indicator score was determined by adding the project scores assigned for each source indicator and dividing this sum by the number of indicators evaluated to obtain a score between 1 and 5. Per County Guidance BPJ was used to account for the fact that different project types address a different number of indicators. An additional score was added to account for this difference. Project types that addressed the most source indicators were given higher scores, whereas project types that addressed the least source indicators were given the lowest scores. Table 7 below summarizes this scoring. The final source indicator project scores were determined by averaging in this new score. See Appendix F: Summary of Source Indicator Scoring for more information.

Table 7: BPJ Score Adjustment for Number Impact Indicator Evaluated

	Suite of Projects	Stream Restoration	Outfall Improvement	BMP/LID	Stormwater Pond Retrofit	Buffer Restoration
# of Source Indicators Addressed	6	4	5	5	5	1
Score Assigned	5	3	4	4	4	1

3. Priority Subwatersheds

The third factor in the prioritization process was the priority subwatershed selection, which was based on a subwatershed's overall impact composite score. The subwatershed overall impact composite scores were pulled from the "Overall and Objective Composite Scores Pohick" spreadsheet for existing conditions.

The County's quintile scoring method was used to break the range of subwatershed overall composite scores into five preliminary project scores ranging from 1 to 5. Subwatersheds with the lowest overall impact composite scores, which represent the worst overall watershed conditions, were assigned a preliminary project score of 5. Subwatersheds with the highest overall impact composite scores, which represent the best overall watershed conditions, were assigned a preliminary project score of 1.

Each proposed project was then assigned the preliminary project score based on score of subwatershed where it is proposed. See Appendix G: Priority Subwatershed Scoring for more information.

4. Sequencing

Project Score based on Subwatershed Order

Projects in headwater subwatersheds were considered the highest priority and given the highest project scores, per WMP Standards 3.2. The order of the subwatersheds was determined per Figure 1, Hypothetical Subwatershed Ordering Example, from the WMP Standards 3.2 and the following criteria:

A. All subwatersheds where a stream originates were classified as a headwater subwatershed and given an order of 1.

B. Subwatershed order increased going downstream, specifically at the confluence of tributaries.

C. BPJ was used to determine whether a subwatershed should be given an order of 1 (headwater subwatershed) based on whether the majority of the drainage came from the subwatershed itself.

Using the above criteria and a GIS Pohick Creek Watershed map review (See Appendix L) the subwatersheds were assigned an order between 1 and 13. Projects in subwatersheds with lower orders were farther upstream and would benefit Pohick Creek the most, and therefore were given the highest scores. The subwatershed orders did not have an even distribution, and therefore the typical quintile ranges could not be used to obtain scores between 1 and 5. The project scores were assigned per table 8. See Appendix H: Sequencing Scoring for more information.

Table 8: Subwatershed Order Percentile scoring

Percentile	Subwatershed Order	Preliminary Score
90%	11.00	1
80%	4.00	2
75%	3.00	3
60%	2.00	4
0%	1.00	5

5. Implementability

Project Scores Based on Implementability

The very specific WMP Standards 3.2 project implementability scoring methods were utilized to assign scores. Information from the field investigation database was compiled to help assign the implementability scores. The decision steps for assigning implementability scores for each project are described below. See Appendix I: Implementability Scoring for tabularized results.

A high implementability score of 5 was given to projects with any of the following criteria;

1. Buffer restoration projects.
2. Stormwater Pond retrofits that are County maintained facilities and require no additional land rights. This was determined by researching the parcel owner on the property appraiser's website. The determination of whether additional land rights were required was determined by seeing if easements were provided and if the retrofits would fit into the existing easements. This information was taken from the candidate investigation database.
3. Stream Restorations that do not require upstream runoff quantity reductions, and are proposed on sites with significant land owner support.
    - At this time hydraulic modeling has not been done to determine whether upstream runoff quantity reductions are required. Since channel erosion is related to runoff quantity a surrogate determination was made by reviewing the subwatershed ICEM value. The Subwatershed Ranking Approach states that "Stage Values between 1.5 to 2.5 may still have the potential to be improved or restored." Therefore projects with ICEM STAGE Values between 1.5 to 2.5 will be scored as the most implementable and the other stream restorations will be given a lower score.
    - Land Owner Support is based on WAG comments.
4. BMP and LIDs retrofits located at a school or another county owned facility.

A moderate implementability score of 3 was given to projects with any of the following criteria:

1. Other pond and LID retrofits and other stream restorations that do not require upstream runoff quantity reductions.
    - A direct determination of whether upstream runoff quantity reduction was not determined at this time, because of the lack of hydraulic modeling. Instead the ponds and LID projects that were not maintained by the county were sorted out and reviewed on a case by case basis. Most pond retrofits that were not located on a school site were deemed as requiring upstream runoff reduction. This was due to the fact that the ponds would lose some attenuation ability from the addition of the stormwater quality improvements. The only pond retrofits that were deemed

as not needing upstream runoff reduction were the projects that had available head or room for expansion.
  - The LID projects were reviewed to see whether the type and location of the project would require runoff reduction.

A low implementability score of 1 was given to all other projects that did not fit into the above categories and are likely to be less feasible than the majority of recommended projects.

Initial Structural Project Ranking

The final composite scores were based on the 5 factors and their corresponding weights. . The factors were weighted as follows: impact indicators (30%), source indicators (30%), priority subwatersheds (10%), sequencing (20%), and implementability (10%). This score was used to obtain an initial ranking. The higher the overall composite scores the lower the preliminary rank. Once the initial rankings were completed using the prioritization scheme's quantitative method, the projects were qualitatively reviewed. This review involved going through every project starting at the highest ranked projects and reviewing the project descriptions, GIS information, field observations, WAG comments, and the ability for a project to achieve the County's objectives. From this review BPJ was used to adjust the scores to ensure the projects were ranked correctly. The BPJ Score Adjustments in the structural ranking (See Appendix J), were explained or justified in the Project Ranking Comments Column of the *PC_Master_Project_List* spreadsheet (See Appendix C).

The projects with the lowest ranks will be implemented first. See Appendix J for a Summary of the Individual Project Scores and Initial Ranking. The top ranked 90 projects will be proposed for inclusion into the 10 year watershed management plan as part of the initial ranking. All other projects are considered as part of the 25 year plan. Future tasks will involve further evaluating these rankings on factors such as hydrologic and hydraulic modeling results and estimated costs vs. projected benefits and adjusted as part of the final project sequencing.

Based on revised County Guidance as of March 3rd 2010, only structural projects will be used in the 0-25 year plan. For these reasons the buffer restorations and rain barrel projects were removed from the original prioritization scheme. Additionally any project with a project cost less than $80K that could not be grouped with another project was lowered to the bottom of the ranking. These projects will be eliminated from the WMP.

Cost-Benefit Analysis

The cost benefit analysis (CBA) of the projects was completed on the 10-year projects after the initial ranking. The cost of each project was determined using cost estimates per County Guidance. The benefit of a project, which was quantified by their project score, was compared to its costs. Projects that had too high of a cost with too small of a benefit were moved from the 10-year plan into the next highest ranking 25-year plan projects.

The CBA created a ranking of the projects in which the projects the best benefit per cost were ranked highest. The majority of the top 10 projects were the same as the initial ranking; however a significant portion of the CBA ranking differed from the initial ranking. To complete the final ranking in which the CBA ranking was considered, a final BPJ adjustment was added to some of the project scores. Projects that provided a high benefit with lower costs had their scores increased by 0.25. These high benefit low cost projects consisted of small stormwater pond retrofits, stream daylights, outfall improvements and BMP/LID projects. Projects that had great costs with too small of benefit had their scores adjusted downward by 0.25. All of these projects consisted of very long stream restoration projects. These CBA adjustments moved 11 projects with an average composite score of 3.56 and cost of $115K upward in the final ranking and moved 16 projects with an average composite score of 3.98 and cost of $17,880K downward in the final ranking.

Additional Hydrologic and Hydraulic Modeling

Introduction

During the watershed characterization phase of the Watershed Management Plan, SWMM and HEC-RAS models were developed for the Pohick Creek watershed. These models were developed for existing conditions, as well as future conditions based on land use changes projected from the County's Comprehensive Plan.

SWMM Model Setup

The SWMM model for the Pohick Watershed was developed by TetraTech, Inc., as part of a modeling effort that included several watersheds in the county. These models were provided to PBS&J, along with documentation of the model calibration effort as an addendum to TM3 (Section 4.11). These models included the 2-, 10- and 100-year design storm events.

Watershed sub-areas were determined by TetraTech. Parcels were classified based on development year and drainage to a StormNet facility. These subareas were classified as A (quantity control), B1 (quantity/quality control - wet detention), B2 (quantity/quality control – extended dry detention), C (quality control) and D (no treatment). This is documented in an addendum to TM 3 (Section 5.2).

Model Update Tools

Custom tools were provided by TetraTech to perform the GIS processing for the SWMM and STEPL models. These are documented with the tools provided by TetraTech.

HEC-RAS Models

The HEC-RAS models were developed by PBS&J, using terrain data provided by the County and field survey data. Structures were modeled using field survey data. Manning's 'n' values were chosen based on aerial photographs and site photos from the structure survey. Peak flows from the existing and future conditions SWMM models were entered into the RAS model to create both existing and future water surface elevation profiles.

Hydrology

For the 10-year plan, projects which might have a measurable impact on the watershed hydrology were selected for additional modeling. For the Pohick Creek projects, only stormwater pond retrofits were assumed to have a measurable effect on the hydrology.

A total of 33 projects in the Pohick Creek Watershed were simulated using the SWMM5 (build 11) modeling software. These projects are listed in Table 9.

Table 9: Candidate Stormwater Pond Retrofits (10-year Plan)

Project ID	WMA	Sub-Basin	Description
PC9003	Pohick- Upper South Run	PC-SR-0022	Pond Retrofit (Wetland)
PC9007	Pohick- Upper South Run	PC-SR-0020	Pond Retrofit (Wetland)
PC9008	Pohick- Upper South Run	PC-SR-0026	Pond Retrofit (Wetland)
PC9100	Pohick- Lower	PC-PC-0007	Pond Retrofit (Dry Pond)
PC9101	Pohick- Lower	PC-PC-0012	Pond Retrofit (Dry Pond)
PC9102	Pohick- Lower	PC-PC-0009	Pond Retrofit (Dry Pond)
PC9103	Pohick- Lower	PC-PC-0009	Pond Retrofit (Dry Pond)
PC9104	Pohick- Lower	PC-PC-0009	Pond Retrofit (Dry Pond)
PC9105	Pohick- Lower	PC-PC-0019	Pond Retrofit (Dry Pond)
PC9106	Pohick- Lower South Run	PC-SL-0002	Pond Retrofit (Wetland)
PC9107	Pohick- Middle	PC-PC-0021	Pond Retrofit (Dry Pond)
PC9109	Pohick- Middle Run	PC-MR-0002	Pond Retrofit (Dry Pond)
PC9110	Pohick- Middle South Run	PC-SR-0013	Pond Retrofit (Wetland)
PC9114	Pohick- Middle Run	PC-PR-0001	Pond Retrofit (Wetland)
PC9118	Pohick- Middle Run	PC-SB-0001	Pond Retrofit (Dry Pond)
PC9120	Pohick- Middle Run	PC-PR-0002	Pond Retrofit (Dry Pond)
PC9121	Pohick- Upper South Run	PC-SR-0020	Pond Retrofit (Dry Pond)
PC9122	Pohick- Middle	PC-PC-0034	Pond Retrofit (Dry Pond)
PC9124	Pohick- Upper South Run	PC-OS-0001	Pond Retrofit (Dry Pond)
PC9126	Pohick- Upper	PC-PC-0044	Pond Retrofit (Dry Pond)
PC9127	Pohick- Sideburn Branch	PC-SI-0004	Pond Retrofit (Dry Pond)
PC9128	Pohick- Sideburn Branch	PC-SI-0006	Pond Retrofit (Dry Pond)
PC9129	Pohick- Sideburn Branch	PC-SI-0008	Pond Retrofit (Dry Pond)
PC9130	Pohick- Sideburn Branch	PC-SI-0001	Pond Retrofit (Dry Pond)
PC9131	Pohick- Sideburn Branch	PC-SI-0001	Pond Retrofit (Dry Pond)
PC9132	Pohick- Upper	PC-PC-0055	Pond Retrofit (Dry Pond)
PC9133	Pohick- Upper	PC-PC-0046	Pond Retrofit (Dry Pond)
PC9135	Pohick- Rabbit Branch	PC-RA-0005	Pond Retrofit (Dry Pond)
PC9136	Pohick- Upper	PC-PC-0054	Pond Retrofit (Dry Pond)
PC9138	Pohick- Rabbit Branch	PC-RA-0010	Pond Retrofit (Dry Pond)
PC9139	Pohick- Sideburn Branch	PC-SI-0016	Pond Retrofit (Dry Pond)
PC9140	Pohick- Rabbit Branch	PC-RA-0011	Pond Retrofit (Wetland)
PC9142	Pohick- Rabbit Branch	PC-RA-0012	New Stormwater Pond (Wetland)

Three of the proposed projects (PC9008, PC9127, and PC9135) recommend improvements to the outfall structures of regional ponds that capture 100 percent of the flow from a sub-basin. The regional ponds include RP_ID P-8, RP_ID Burke Center SEC 11B, and RP_ID: Kings Park

West SEC 18, respectively. The remaining 29 proposed pond retrofit projects will capture and treat a limited portion of the runoff from a specific sub-basin.

Methodology

For this project, PBS&J utilized the tools and methodologies specified by TetraTech and Fairfax County. These documents are listed in Appendix A, references 11-13.

For the 29 projects that capture and treat a limited portion of the runoff from a specific sub-basin, the tools were fully applied. This is shown in Figure 3-1 where Classification Area C was converted to Classification Area A due to the proposed pond retrofit. The sketch on the left shows the model configuration in the Future without project scenario. The sketch on the right shows the model configuration for Sub-basin PC-SR-0022 in the Future with project scenario.

In sub-basins where two (2) or more projects are recommended, the tools were used to combine the projects into common classification areas. As an example, in sub-basin PC-PC-0009, three pond retrofits are recommended. Each of these retrofits calls for implementation of a dry pond. In the combined SWMM model, these three projects were merged and simulated as a single dry pond that treats the combined drainage area of the proposed projects.

For the three regional ponds that capture 100 percent of the flow from the sub-basin, it was assumed for SWMM modeling purposes that the distribution of classification codes upstream of the pond would not change. Therefore, only the outlet structure from the pond was modified using the TetraTech guidance on orifice size. Figure 3-2 shows the configuration of the regional pond located in sub-basin PC-SR-0026 in the Future without project scenario (left) and the Future with project scenario (right).

Figure 2: Comparison of Model Configuration – Sub-basin PC-SR-0022

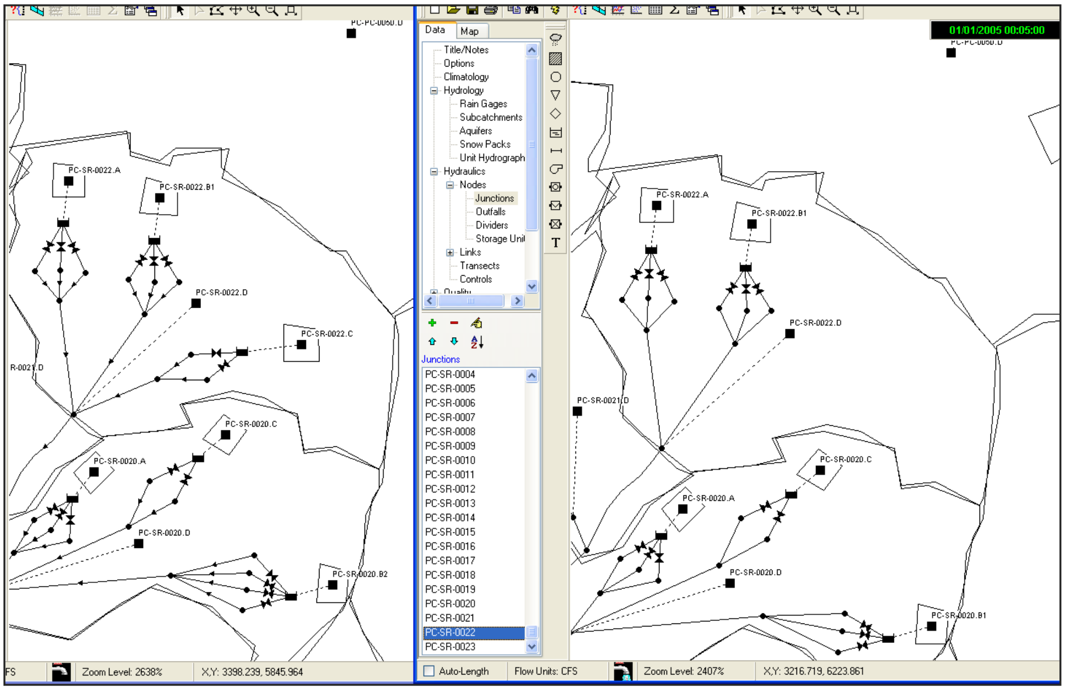
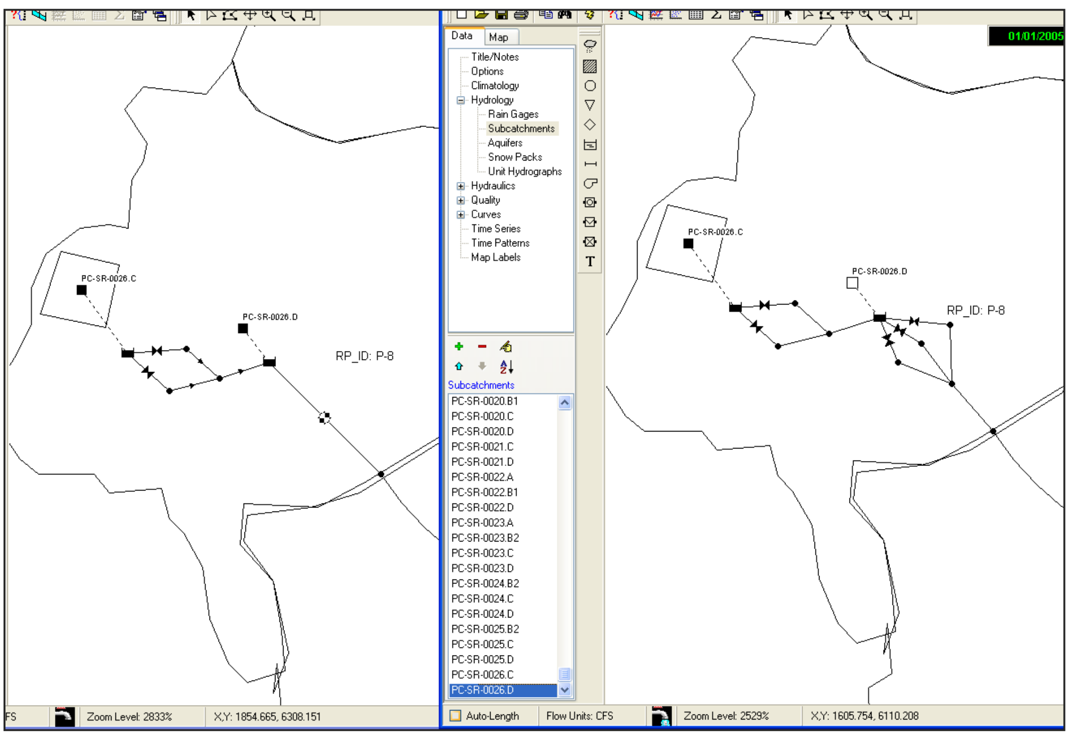


Figure 3: Comparison of Model Configuration – Sub-basin PC-SR-0026



Results

SWMM models were created for each individual project, as well as a combined model. The results of the individual modeling are contained in Appendices N and O. The results of the combined 2- and 10-year SWMM model simulations are presented in Appendices P and Q. The rows highlighted in yellow are those basins where recommended pond retrofits were added to the model.

Discussion

The results show that, for the majority of the proposed projects, the predicted flows from the sub-basin are less than or equal to the predicted peak flow in the Future without projects scenario. This is expected. Most of the proposed ponds are capturing and treating runoff from areas that previously were not treated. Other ponds convert the treatment from a dry pond to a wet pond, or vice-versa.

During the 2-year storm event, two of the basins in the Future with project condition model show a predicted increase in peak flow over the Future without project condition. The two basins are discussed below.

- Sub-Basin PC-RA-005: Project PC9135 is located in this sub-basin and changes the outfall structure for the regional pond named Kings Park West in sub-basin PC-RA-0005. The Future without project model includes a notation for the outlet that states, "The stage-storage-discharge relationship for Regional Pond Kings Park West SEC 18 is assumed. Actual data from field survey need to be used as the regional pond data input". Therefore, it is likely that the predicted discharge from the pond in the without-project model is underestimated.

- Sub-basin PC-SI-0004: Project PC9127 is located in this sub-basin and changes the outfall structure for the regional pond named Burke Center in sub-basin PC-SI-0004. The Future without project model includes a notation for the outlet that states, "The stage-storage-discharge relationship for Regional Pond Burke Center SEC 11B is assumed. Actual data from field survey need to be used as the regional pond data input". Therefore, it is likely that the predicted discharge from the pond in the without-project model is underestimated.

During the 10-year storm event, four of the basins in the Future with project condition model show a predicted increase in peak flow over the Future without project condition. Two of the basins are the same as for the 2-year storm event. The remaining two projects are discussed below.

- Sub-basin PC-PC-0054: Project PC9136 is located in this sub-basin and converts 6.8 acres of the basin from Classification Area A to Classification Area B2. The difference is predicted flow is approximately 0.5 cfs and is likely due to the change of treatment methodology from a wet pond (no treatment) to a dry pond.

- Sub-basin PC-SR-0026: Project PC9008 is the third of the regional ponds recommended for retrofit. This pond captures 100 percent of the flow from the sub-basin. In this project, the outlet structure from the pond (P-8) changes from a single conduit where discharge from the basin is defined by a rating curve named 0525_outlet to a three conduits appropriate for a wet pond. These conduits were defined using the orifice sizing methodology specified by TetraTech. It is possible that the rating curve defined for the basin is appropriate for the 2-year storm, but under-predicts the 10-year storm.

Hydraulics

Once the SWMM modeling was completed, the flows from the 100-, 10-, and 2-year combined models were applied to the HEC-RAS model to model these events. The same cross section flow change locations from the existing and future models were used for the future with projects model.   The flows were taken from the same SWMM nodes as had been used for existing and future. The set water surface elevations were similarly adjusted; lakes were set to the SWMM storage node elevations, and rating curves were used to set water surface elevations for selected structures.

Overall, the 100-year FWP floodplain is very similar to the existing and future floodplains. As compared to the future floodplain, the maximum increase was less than 0.4 foot; the maximum decrease was less than 0.3 ft. The increase occurred in the area downstream of the new pond PC 9142 near Rabbit Branch; there was a small increase between Braddock and Roberts Road for the 100-year event only.

There were more significant differences in the 10-yr floodplain. In general, floodplain increases occurred downstream of the two regional ponds discussed in the SWMM modeling sections, due to differences in how the pond was modeled in baseline and proposed conditions.

Table 10 quantifies the reaches where the 10-yr WSEL increased more than 0.1 ft as compared to the future without projects conditions.

Table 10. 10-Yr Floodplain Increases from Future Conditions to Future with Project Conditions

Stream	Location Description	Range of 10-Yr WSEL Increase
South Run	600 ft upstream of Woods Fair Road to Barsky Court	0.1 - 0.4 ft
Sideburn Branch Trib 1	Burke Center Regional Pond to confluence with Sideburn Branch	0.1 - 1.4 ft
Rabbit Branch Trib 1	Kings Park West Regional Pond to confluence with Rabbit Branch	0.0 - 1.3 ft
Rabbit Branch	2000 ft downstream of Commonwealth Blvd to confluence of Trib 1	0.2 - 0.3 ft
Pohick Creek	3000 ft downstream of Old Keene Mill Rd to 7000 ft downstream of Fairfax County Parkway	0.1 - 0.4 ft

It should be noted that the increases for Sideburn Branch Trib 1 and Rabbit Branch Trib 2 are due to the inconsistencies in the way the existing and proposed pond retrofits are modeled in SWMM. If these two locations are excluded, the 10-yr WSEL differences are all 0.4 ft or less.

These changes in computed WSEL resulted in very minimal changes to the mapped floodplain. The changes are difficult to discern at any reasonable map scale. The measured difference in area shows a 4.3 acre increase from existing to future without projects, and a 0.9 acre increase from future without projects to future with projects.

The following graphs (Figures 5-8) are an analysis of the number of buildings (residential and other types) located within the 100- and 10-yr floodplains, as well as located in or within a 15 foot buffer of the 100- and 10-yr floodplains.

Figure 5. Buildings located in the 100-year floodplain

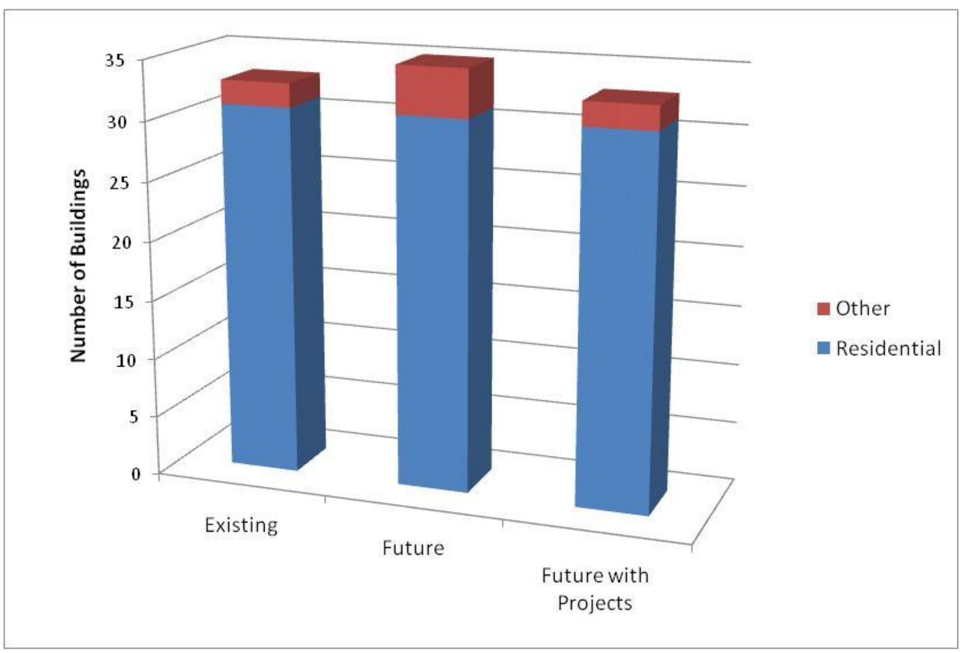


Figure 6. Buildings located within 15 feet of the 100-year floodplain

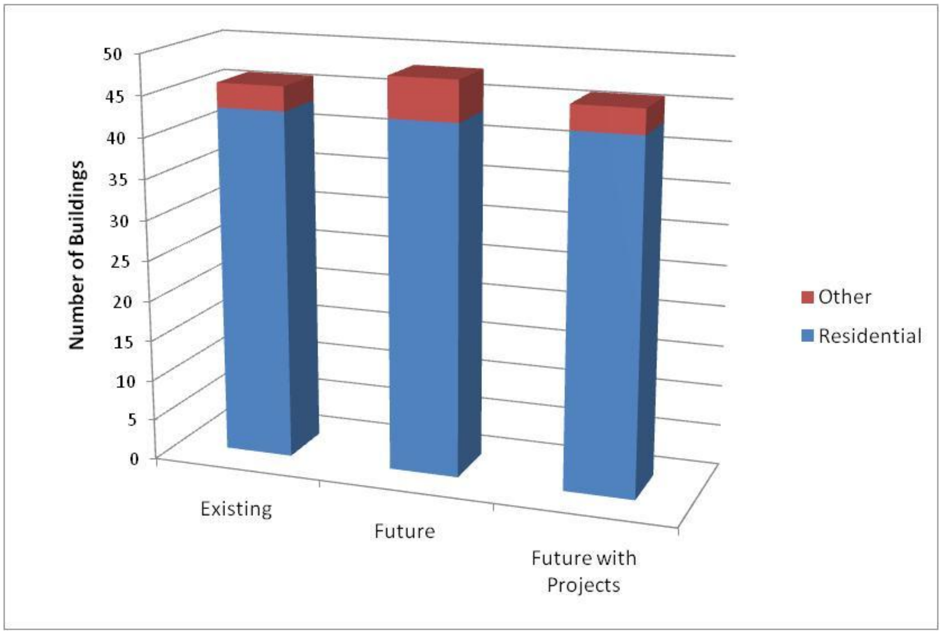


Figure 7. Buildings located within the 10-year floodplain

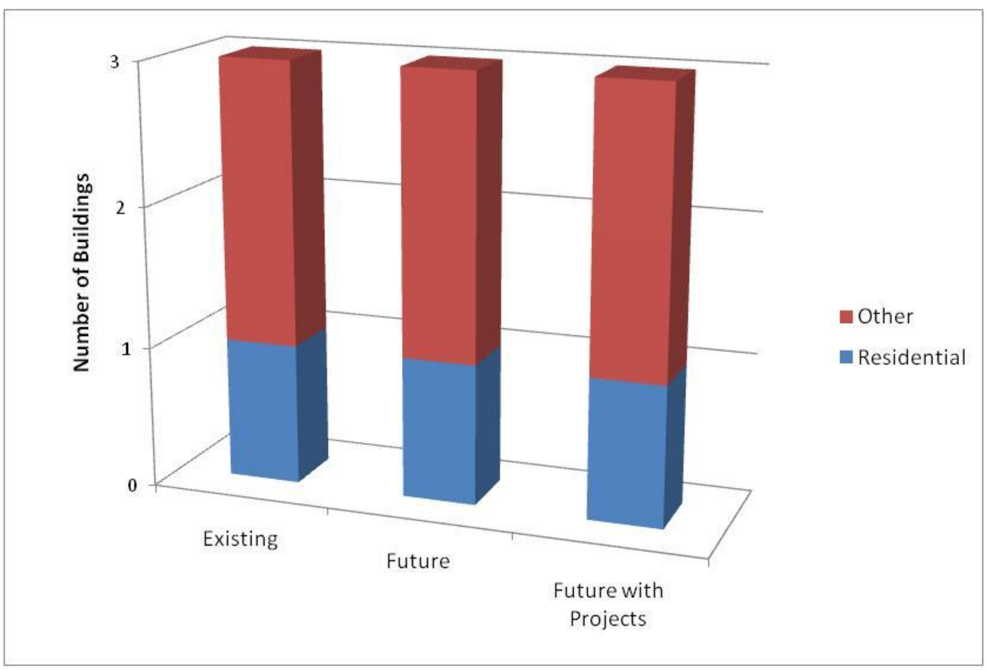
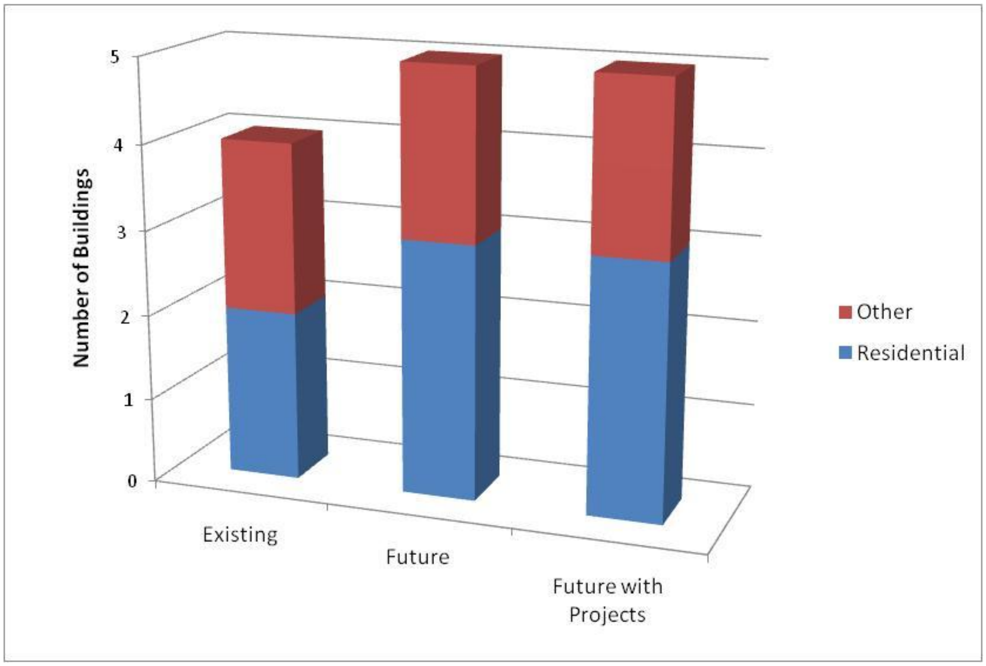


Figure 8. Buildings located within 15 feet of the 10-year floodplain



Between the future and the future with projects model, the roads status as overtopping/not overtopping during the 100- and 10-yr events did not change. There were no increases in flow depth over the road of more than 0.1 foot. The flow depth over Reservation Road (across Sangster Branch) decreased by 0.1 feet. There were no other significant decreases.

Results

The results of the hydrologic and hydraulic modeling did not impact candidate project selection. The changes to the 0-10 and 11-25 year project groupings were due to the cost-benefit analysis and public and County input. The modeling was updated to include all projects in the 0-10 year grouping, but the model results did not impact the project groupings, as the modeling showed the projects to have either positive or insignificant negative impacts to the watershed hydrology and floodplains.

Evaluation of Non-structural Practices

Non-structural Project Selection

Candidate non-structural practices identified under Subtask 3.2 were evaluated by their overall benefit and feasibility in meeting the watershed goals and objectives. The candidate non-structural practices include:

1. Buffer Restoration programs
2. Dumpsite / Obstruction removal projects
3. Street Sweeping Programs
4. Rain Barrels

These non-structural projects were proposed in addition to the structural projects because they have lower initial costs than structural projects and there are little or no design/ construction costs. For these reasons some non-structural projects are easier to implement, and should be ranked separately. Non-structural projects that were grouped with structural projects are not included in this qualitative analysis since these projects will be implemented at the same time and therefore already has a rank.

Non-Structural Project types

Buffer Restorations

Many different factors and indicators were used to decide where buffer restoration projects would be most beneficial throughout the Pohick Creek watershed, with the primary indicator being the Streambank Buffer Deficiency source indicator score from the subwatershed ranking. Sub basins with scores that corresponded to “poor” or “very poor” conditions for this indicator met the initial criteria for buffer restoration placement. Buffer restoration projects, which consist of practices such as the re-planting of upland buffer areas and providing reforestation, would help re-establish Resource Protection Areas (RPAs) by providing additional stream buffer for filtration of pollutants, while reducing runoff by intercepting the water and increasing surface storage and infiltration.

The buffer restoration programs were scored and ranked with the same prioritization scheme as stream restorations, which are structural projects. The only difference was that these projects received either an implementability score of 5 or 3 based on whether the project is located on County owned land.

Dumpsite/ Obstruction Removals

The flood complaints indicator and the results from Task 3.3, Investigation of Candidate Projects were the primary factors used to determine where dumpsite/obstruction projects should be proposed. The removal of the obstructions will help restore the stream channel to its natural conditions and improve the function of the streams. An example of a proposed project includes the cleanup of trash in or near the stream channel to help reduce the amount of pollutants from entering adjacent streams and storm systems.

Dumpsite / obstruction removal projects accomplish many of the County’s watershed management planning goals and objectives. Table 9 explains how the County Watershed Management Planning Objectives are met.

Table 9: County Objectives Met Dumpsite / Obstruction Removals

County Obj.	County Objectives Met by Dumpsite / Obstruction Removal Projects
1A	Minimizes stormwater runoff by creating stable stream morphology and protecting habitat.
1B	Minimizes flooding by restoring conveyance capacity of impacted streams.
2A	Helps restores instream habitat.
3A	Helps reduce pollutants caused by objects placed at the dumpsite.
4A	Removes possible toxins at dumpsites.
5A	Provides opportunity for public to get involved in organized stream cleanups.
5C	Improves watershed aesthetics by removing trash and other foreign objects.

Street Sweeping Programs

In areas where there were no existing stormwater quality treatment, and structural projects were not recommended or practical, street sweeping programs were recommended. Street sweeping helps reduce the amount of potential pollutants entering nearby streams and storm systems. In addition they add the aesthetic benefits of having clean streets, the safety benefits of removing debris that can block storm systems and stormwater facilities. Areas where these projects were proposed are primarily comprised of dense residential development, many of which have their streets piped directly into the nearby streams.

Street sweeping programs accomplish many of the County's watershed management planning goals and objectives. Table 10 explains how the County Watershed Management Planning Objectives are met.

Table 10: County Objectives Met by Street Sweeping Programs.

County Obj.	County Objectives Met by Street Sweeping Programs
1A	Reduces stormwater runoff impacts by reducing road sediment, which can change stream morphology and hurt biota by increasing turbidity and reducing dissolved oxygen.
1B	Reduces inlet and BMP clogging by reducing fines that wash off paved surfaces.
2A	Reduces fines from pavements which are sources of TSS, TN, and TP.
3A	Reduces fines from pavements which are sources of TSS, TN, TP, and heavy metals.
4A	Reduces fines from pavements.
4B	Provides opportunity for public to get involved in organized stream cleanups.
5A	Encourages public to participate in watershed stewardship by being an example of action that the County is taking for water quality.
5B	Mimics other jurisdictions that have implemented street sweeping programs to improve water quality for the Chesapeake Bay.
5C	Reduces trash, leaves, and sediment, which improves the aesthetics of the watershed.

Rain Barrel/ Cistern Programs

Rain Barrels are proposed at Fairfax County Schools that have visible roof drains. These low cost LID's meet many of the county goals and objectives. (See Table 11) The rain barrel programs were chosen to be installed at school sites for two reasons. First they will provide an excellent teaching opportunity about stormwater management. Second, they are highly implementable, since schools are owned by the County. Third, some older schools do not have existing stormwater quality systems and these rain barrels are easy to install on existing buildings that have roof drains on the exterior of the buildings. Rain barrels were only at these sites. Sites with no visible roof drains will require underground cisterns that are sized to handle the full runoff volume from a school building's large roof.

Table 11: County Objectives Met by Rain Barrel Programs.

County Obj.	County Objectives Met by Rain Barrel Programs
1A	Reduces stormwater runoff impacts by reducing runoff volume, which can change stream morphology and hurt biota by increasing turbidity and reducing dissolved oxygen.
3A	Catches fines from roofs which are sources of TSS, TN, TP, and heavy metals.
4B	Rain barrels help retain sediment and heavy metals that wash off roofs from the first flush caused by storm events.
5A	Encourages public to participate in watershed stewardship by being an example of action that the County is taking for water quality, and educating future generations about water stewardship
5B	Similar to other Chesapeake Bay initiatives, such as the free 55-gallon rain barrel program sponsored by the Alliance for the Chesapeake Bay and the Baltimore Coca-Cola Bottling Company.

Non-Structural Project Ranking

The Non-structural projects were ranked using either a quantitative analysis or a qualitative analysis depending on the project type. Rain barrels, cisterns, and buffer restorations were scored per the subtask 5.1E quantitative scheme that was explained in detail above. See Appendix K: Non-Structural Projects Quantitative Analysis. Street Sweeping and reforestation projects had their project ranks determined by comparing the existing conditions TSS, TP, and TN ranking indicator scores and assigning a score of 1 through 5 based on their potential for improvement (See Appendix K: Non-Structural Projects Qualitative Analysis). The average of these scores were used to obtain an initial ranking. Finally a BPJ score modification was used to account for any project specific issues. The score modification also considers the number of flood complaints. Due to the high implementability and immediate results of the non-structural projects, these projects should be evaluated separately from the 0-25 year plan.

Appendix A: Bibliography

1. “Watershed Management Plan Development Standards - V.3.2, March 2009” (WMP Standards 3.2)
2. “Subwatershed Ranking Approach) June 2008 (SWR approach)
3. “Clarification to 3.4 & 3.6 language from March 2009 WMP Standards Version 3.2.doc “
4. “Project_Prioritization_TP_Scores_Example sep2009 v5 - calcs fixed.xls “
5. “Clarification Subwatershed Ranking Approach, June 2008”
6. “Supplemental Guidance on Subwatershed Ranking” - January 19, 20009
7. Previous Homework assignment (HW assignment)
8. The web site http://ffxwmp.tetratech-ffx.com/forum
9. “Guidance for Representing Streambank Erosion and Regional Pond Efficiencies” –October 22, 2009
10. “Task 3.4 Technical Memo Checklist includes Example Tables 012210”
11. “GIS Processing for updating SWMM and STEPL Models”, Tetra Tech
12. “Tutorial for using the SWMM Updating Tool”, Tetra Tech
13. “Subarea Orifice Sizing in SWMM”, Tetra Tech

Appendix B: Description of Files Used for the Prioritization

1. *Subwatershed ranking spreadsheets* – The existing conditions and future without projects were previously submitted. The spreadsheets include impact indicator metric scores and overall and objective composite scores. These files are in GKY's format. The impact indicator spreadsheets include an extra summary tab showing how the STEPL and Streambank Erosion Tabs affected the Subwatershed Scores.
2. *Loads_Pohick_FutureLU_Updated* – This spreadsheet provides the revised future without project STEPL results.
3. *STEPL Runs* – This folder includes the future with project STEPL runs that were used to determine the individual projects results
4. *PC_Streambank_Erosion* – This spreadsheet calculate the amount of erosion and pollutants produced by eroding streams and is added to the STEPL pollutant calculations.
5. *PC_Master_Project_List* – This spreadsheet was used to bring together the work of the WAG meeting, site visit, and other comments for the projects.
6. *PC_Project_Cost_Estimates* – This spreadsheet calculates the Cost Estimates per County Guidance.
7. *Pohick Ordering Map* - , This 11x17 map shows the Pohick Creek subwatershed and the main branches of Pohick Creek. From this figure the subwatershed order was determined.
8. *DCIA with projects* – Spreadsheet used to compile the DCIA metric value.

Appendix C: Pohick Creek Master Project List

Appendix D: Summary of Impact Indicators

Appendix E: STEPL Pollutant Loads

Appendix F: Summary of Source Indicator Scoring

Appendix G: Priority Subwatershed Scoring

Appendix H: Sequencing Scoring

Appendix I: Implementability Scoring

Appendix J: Summary of the Individual Project Scores and Initial Ranking

Appendix K: Non-Structural Quantitative and Qualitative Analyses

Appendix L: Pohick Creek Watershed Subwatersheds by Stream Orders Map

Appendix M: Pohick Creek Watershed All Candidate Projects Map

Appendix N: Storm Event Peak Flow Comparisons for Combined Projects Model, 2-yr Event

Appendix O: Storm Event Peak Flow Comparisons for Combined Projects Model, 10-yr Event

MEMORANDUM

To: Shannon Curtis, Fairfax County
From: Laura Chap, PBS&J
Cc:
Date: October 14, 2010
Re: Streambank erosion shapefile

PBS&J has followed the county guidance to estimate streambank erosion in the Pohick Creek watershed. PBS&J used the following guidance:

1) Guidance for Representing Streambank Erosion and Regional Pond Efficiencies.doc, posted on the forum on 2/5/2009, and
2) The discussion on the forum under the topic STEPL template/Streambank Erosion, dated 1/7/2009 to 2/11/2009.

The following explanation describes PBS&J's methods in computing the streambank erosion loads for the subwatersheds:

Eroding reaches:
PBS&J identified the eroding reaches in the Pohick Creek watershed by considering all the ICEM Type II and Type III reaches as eroding. (This data was available as shapefiles from the subwatershed ranking process.) Reaches identified as channelized, piped, or other alterations were removed, as these reaches are not expected to be significant sources of sediment. The length of each eroding reach was computed using GIS.

Height of eroding reaches:
The SPA data was used to determine the bank height. Left and right bank heights were averaged.

Lateral Recession Rate:
Each reach was assigned a relative severity, and the table provided in county guidance was used to equate the severity with a recession rate. ICEM Type II and III reaches were assigned "moderate" erosion; "severe" erosion reaches were identified by the instream sediment metric shapefile.

Soil Dry Weight and Nutrient Correction Factor
The USDA soils map was used to identify the predominant soil map unit underlying the eroding reach. Based on map unit descriptions, a soil type was assigned to each reach. The dry weight and nutrient correction factor were assigned based on the soil type.

Nutrient Concentration

The nutrient concentrations in the soils were taken from the STEPL model. These concentrations are 0.08% for nitrogen, 0.031% for phosphorus, and 0.16% for BOD.

Results

The following table compares the streambank erosion loads to the land-based loads.

Pohick Watershed	Land-based Sediment Load (tons/yr)	Streambank Erosion Sediment Load (tons/yr)	% of total attributed to Streambank Erosion
Pohick Creek	2970	5279	64%
South Run	632	588	48%
Rabbit Branch	307	756	71%
Sideburn Branch	342	963	74%
Middle Run	350	98	22%