Appendix A
SWM Field Reconnaissance

Appendix A provides a summary of the initial evaluation of the potential Best Management Practices (BMPs) in the Declaration Run and Riverside watersheds. The primary goal of the evaluation was to identify and analyze high-priority projects in both watersheds that could be included in Harford County's Capital Improvement Program.

The URS team reviewed the geographic information system (GIS) data provided by Harford County that included property ownership, 2-foot contours, storm drains, existing stormwater management facilities, land use, and impervious cover. The team also reviewed County-provided design plans for existing stormwater management facilities because the information had not been translated into GIS data.

The URS team conducted a desktop analysis using the County GIS information and stormwater management plans to identify opportunities for BMPs. The team identified 23 locations in the Declaration Run watershed and 11 locations in the Riverside watershed as potential BMP sites.

The 34 sites were assessed during the field reconnaissance for feasibility of new or retrofit BMPs. The BMPs under consideration included Environmental Site Design, Low Impact Development, green infrastructure, and traditional structural techniques. Programmatic management strategies that could be implemented on a watershed level were also considered.

The data that were collected during the field reconnaissance consisted of:

- Location
- Potential BMPLand use in surrounding area
- Percent impervious area
- Recommendations for the site
- Benefits and constraints
- Potential conflicts with existing utilities
- Potential permits/regulatory approvals
- Any observed problems

The stormwater field reconnaissance was focused on determining whether in-field conditions were appropriate for BMPs that could obtain additional water quality treatment for stormwater runoff. Ownership of the potential sites is not a selection factor because most are privately owned.

Table A-1 is a lists all the potential sites assessed as a part of field reconnaissance. A description of existing conditions and the proposed projects is provided in the main report (Section 3) for all the projects where a proposed improvement was recommended. The section below provides a description of all the projects that were not selected for any potential improvement.

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Table A-1: Potential Watershed Improvement Projects in the Study Watersheds

Watershed	Site ID	Location	Drainage Area (acres)	Existing Facility	Proposed Project
Declaration Run	D-ES-2	End of Oreganum Court	11.3	Water quality trap	Wetland
	D-ES-3	Liriope Court and Baneberry Drive	7.8	Water quality trap	N/A
	D-ES-4	West of Arabis Court	7.4	Water quality trap	N/A
	D-ES-5	North end of Foxglove Court	8.9	Extended detention basin	Bioretention
	D-ES-6	Germander Drive	3.4	Water quality trap	Bioretention
	D-ES-7	Germander Drive and Church Creek Road	2.8	Water quality trap	Bioswale and Bioretention
	D-ES-8	Baneberry Drive	7.8	Water quality trap	Wetland and Step Pool Conveyance System
	D-ES-9	Baneberry Drive and Primrose Place	4.5	Water quality trap	N/A
	D-ES-10	Baneberry Drive and Golden Rod Court	7.2	Water quality trap	N/A
	D-ES-11	Lavender Drive	1.4	Water quality trap	N/A
	D-ES-12	End of Marigold Lane	1.8	Water quality trap	Micropool and Wetland
	D-ES-15	Procedure Way	3.3	Dry pond	Bioretention
	D-NS-1	Golden Rod Court	N/A	Directly connected downspouts	Downspout Disconnection
	D-NS-2	Marigold Lane	N/A	Wide driveways	Impervious Area Reduction
	D-NS-3	Liriope Court	0.1	Sloped impervious roofs	Green Roofs
	D-NS-4	Church Creek Road	2.1	Wide sidewalks	Green Street Bump Out
	D-NS-5	Sedum Square, Horner Lane, Downs Square, Baylis Court	N/A	Large open medians	Curb Cuts
	D-NS-6	Magness Court, Hampton Hall Court, Talbots Square	N/A	Large open medians	Curb Cuts
	D-NS-7	Foxglove Court	6.0	Foxglove Court	Step Pool Conveyance System
	D-NS-8	Dalmation Place	4.6	Outfall	Bioretention
	D-NS-9	Golden Rod Court	6.3	Traditional storm drains	Tree Box Filters
	D-NS-10	Philadelphia Road	6.2	Maryland SHA wet pond	N/A
	D-NS-11	Philadelphia Road	3.3	Maryland SHA swale	N/A
	D-NS-12	Church Creek Elementary School	0.9	Traditional storm drains	Bioretention or Tree Box Filter
	D-NS-13	Church Creek Road across Church Creek Elementary School	0.9	Impervious right-of-way	Green Street Bump Out
	D-SWM0110 (ES-1)	Church Creek Elementary School	8.2	Infiltration basin	Upgrade Infiltration Basin
	D-SWM0630	Policy Drive	0.6	Underground sand filters	N/A

Watershed	Site ID	Location	Drainage Area (acres)	Existing Facility	Proposed Project
Riverside	R-ES-1	Halls Chance Road	130.4	Dry Pond	Dry Pond Retrofit
	R-NS-1	Belcamp Park	5.5	Traditional storm drains	Bioretention
	R-NS-2	Halls Chance Lane, Caldwell Court, Caldwell Lane, Griffith Place, Independence Square, Rigbie Hall Court, Bartley Place, Jervis Square, and Courtney Lane	N/A	Large open medians	Curb Cuts
	R-NS-3	Commercial Complex on Bata Boulevard	N/A	Open area next to parking lot	Curb Cuts
	R-NS-4	Bata Boulevard	N/A	Wet Pond	N/A
	R-NS-5	Winners Circle and Carlyle Garth	N/A	Large open areas	Tree Planting
	R-NS-6	Winners Circle	1.3	Open area with yard inlet	Rain Garden
	R-NS-7	Caldwell Court South	64.3	Grass swales	Bioswale and Check Dams
	R-NS-8	Carlyle Garth	1.8	Grass swales	Bioswale and Check Dams
	R-SWM0267	Water Park Drive	N/A	Stormwater management facility	N/A
	R-SWM0491	West end of Millennium Drive	4.9	Dry swales	Filter Strips
	R-SWM0624	Millennium Drive	2.8	Dry swales	N/A
	R-SWM0627	Millennium Drive	4.6	Dry swales	Filter Strips
	R-SWM0638	Water Park Drive	6.6	Sand Filter	N/A
	R-SWM0864	Millennium Drive	0.9	Rain garden, submerged gravel wetland and permeable pavement	N/A
	R-SWM0865	Millennium Drive	6.6	Dry swales	N/A
	R-SWM0866	Route 40	2.5	Grass swales	N/A

A.1 DECLARATION RUN WATERSHED

Project ID: D-ES-3

Project Location: Liriope Court and Baneberry Drive

Existing Conditions: The facility was identified in existing plans as a water quality trap but because it is a large, wooded area with steep slopes, access is a project-limiting condition.

Proposed Project: No improvements are recommended for the facility because access to the site is not available.

Project ID: D-ES-4

Project Location: West of Arabis Court

Existing Conditions: The facility was identified in existing plans as a water quality trap, but because it is in a large, wooded area with steep slopes, access is a project-limiting condition.

Proposed Project: No improvements are recommended for the facility because access to the site is not available.

Project ID: D-ES-9

Project Location: Baneberry Drive and
Primrose Place

Existing Conditions: The facility was identified in existing plans as a water quality trap but because it is in a large, wooded area with steep slopes, access is a project-limiting condition.

Proposed Project: No improvements are recommended for the facility because access to the site is not available.

Project ID: D-ES-10

Project Location: Baneberry Drive and Golden Rod Court

Existing Conditions: The facility was identified in existing plans as a water quality trap but because it is in a large, wooded area with steep slopes, access is a project-limiting condition.

Proposed Project: No improvements are recommended for the facility because access to the site is not available.

Project ID: D-ES-11

Project Location: End of Lavender Drive

Existing Conditions: The facility was identified in existing plans as a water quality trap but because it is in a large, wooded area with steep slopes, access is a project-limiting condition.

Proposed Project: No improvements are recommended for the facility because access to the site is not available.

Project ID: D-NS-10

Project Location: Philadelphia Road

Existing Conditions: The existing facility is a pond owned by the Maryland State Highway (MD SHA) that captures runoff from Riverside Parkway and Philadelphia Road. The facility could not be accessed during the field reconnaissance because it was fenced. Some erosion was observed at the outfall of the facility.

Proposed Project: No recommendations were proposed for this site because the pond is owned by the state and it could not be accessed.

D-NS-10: Erosion observed downstream of the outfall

Project ID: D-NS-11

Project Location: Philadelphia Road

Existing Conditions: The existing site is a channel that captures runoff from Philadelphia Road and Riverside Parkway and conveys to the stormwater management facility south of Philadelphia Road. The facility appeared to be overgrown with some trees and vegetation during the field reconnaissance. The facility is located in the MD SHA right-of-way.

Proposed Project: No recommendations are proposed at this site because it is in the MD SHA right-of-way.

D-NS-11: Existing channel along Philadelphia Road

Project ID: D-SWM0630

Project Location: Policy Drive

Existing Conditions: The existing facilities are underground sand filters that capture and treat runoff from the commercial area north of Policy Drive. The facility was designed in 2007 in accordance with the current Maryland stormwater management regulations.

Proposed Project: No improvement is recommended at this site because the facility was designed recently in accordance with the current Maryland stormwater management regulations. Regular maintenance and inspections should be continued as applicable.

A.2 RIVERSIDE WATERSHED

Project ID: R-NS-4

Project Location: Bata Boulevard and Water Park Drive

Existing Conditions: The wet pond was identified as a potential BMP opportunity based on desktop analyses. However, the County has confirmed that it is not a stormwater management facility and was installed only for aesthetic purposes.

Proposed Project: No recommendations are proposed at this time.

sediment to settle.

R-NS-4: Pond along Bata Boulevard

Project ID: R-SWM0267

Project Location: Water Park Drive

Existing Conditions: The facility was identified as a stormwater management facility based on the County GIS shapefile. However, the facility could not be located during the field reconnaissance. The County has confirmed that the facility was removed during the development along Water Park Drive.

Proposed Project: There are no recommendations for this site at this time.

Project ID: R-SWM0624

Project Location: Millennium Drive

Existing Conditions: Runoff from the parking lot and the office building on Millennium Drive is captured and treated by dry swales with filter strips that were designed in 2005 as a part of the development. No major issues were observed during the field reconnaissance.

Proposed Project: There are no recommendations for this site because the dry swale system was designed recently according to the current Maryland stormwater management regulations and because there were no issues observed at the site during field reconnaissance.

R-SWM0424:Dry swale with filter strips that capture the parking lot runoff on Millennium Drive

Project ID: R-SWM0638

Project Location: Water Park Drive

Existing Conditions: The existing facility is a sand filter that was designed in 2008 to capture runoff from the development on Water Park Drive. No problems were observed at the facility during the field reconnaissance.

Proposed Project: There are no recommendations for this site because the facility was designed recently according to the current Maryland stormwater management regulations.

R-SWM0638:Existing sand filter

Project ID: R-SWM0864

Project Location: Millennium Drive

Existing Conditions: Runoff from rooftop and parking lot if Waters Edge Corporate Campus on Millennium Drive is treated by combination of ESD practices that include a rain garden, submerged gravel wetland and permeable pavement. These practices were implemented in 2013 and appear to be functioning well. The ESD practices capture runoff from approximately 0.9 acre of which 0.6 acre is impervious.

Proposed Project: No recommendations are proposed at this site as the ESD practices were designed recently following the current Maryland stormwater management regulations.

Project ID: R-SWM0865

Project Location: Millennium Drive

Existing Conditions: Runoff from a section of parking lot and four story building is captured by a system of grass swales that drain to the inlets at the east end of the parking lot. The swale system was implemented in 2013 and capture runoff from 6.6 acres of drainage area of which 4.5 acre are impervious.

Proposed Project: No recommendations are proposed at this site as the swale system was implemented recently following the current Maryland stormwater management regulations.

R-SWM0865:Existing swale

Project ID: R-SWM0866

Project Location: Route 40

Existing Conditions: Impervious runoff from a section of Pulaksi Highway is treated by grass channel located along the edge of the roadway. The grass channels convey the treated runoff to the swale to recreational pond located along Millennium Drive via swale system SWM0491. A total of 2.5 acres is treated by the grass channels of which 1.2 acres are impervious.

Proposed Project: No recommendations were proposed for the site as the swale system was designed recently following the current Maryland stormwater management regulations.

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Appendix B
Stream Field Reconnaissance and Restoration Projects

Appendix B contains the methodology, results, and conclusions from the stream field reconnaissance for the Declaration Run and Riverside watersheds. (Sections B.1, B.2, and B.3). Conceptual restoration designs for high priority sites are provided (Section B.4).

B.1 STREAM ASSESSMENT METHODOLOGY

URS conducted stream assessments along approximately four miles of streams listed in Table B-1 within the Declaration Run and Riverside watersheds in September and October 2013. The field reconnaissance included:

- Stream Walks and Restoration Site Assessment
- Maryland Biological Stream Survey (MBSS) Habitat Assessment
- Bank Erosion Hazard Index (BEHI) Assessment
- Measured Cross Sections and Stream Classification

The length of these reaches were walked and visually assessed. Detailed assessments were performed at specified monitoring points and included the MBSS Habitat Assessment, BEHI Assessment and Cross Sections.

Table B-1: Stream Reconnaissance Assessment Locations

Watershed	Stream Name	Reach ID	Monitoring Point ID	Stream Walks	MBSS Habitat	BEHI	Cross Sections
Declaration Run	Declaration Run	Reach 1	DR-1	☒	☒	☒	☒
	Tributary 5 to Declaration Run	Tributary DR5*	T5DR	☒	☒	☒	☒
	Declaration Run	Reach 2	DR-2	☒	☒	☐	☒
	Tributary 9 to Declaration Run	Reach 1	T9DR-1	☒	☒	☒	☒
	Tributary 9 to Declaration Run	Reach 2	T9DR-2	☒	☒	☒	☒
	Tributary 9C to Declaration Run	Tributary DR9C*	T9CDR	☒	☒	☒	☒
	Tributary 9 to Declaration Run	Reach 3	T9DR-3	☒	☒	☒	☒
	Tributary 2 to Bynum Run	Tributary BR2*	T2BR	☒	☒	☒	☒
	Tributary 3 to Bynum Run	Tributary BR3*	T3BR	☒	☒	☒	☒
Riverside	Tributary 2A to Church Creek	Tributary CC2A*	N/A	☒	☐	☐	☐

*Reach discussed refers to entire stream length

Figure B-1 shows the nine locations within the Declaration Run watershed where detailed assessments were conducted, and one reach within the Riverside watershed that was walked but was found unsuitable for detailed assessments (Tributary CC2A).

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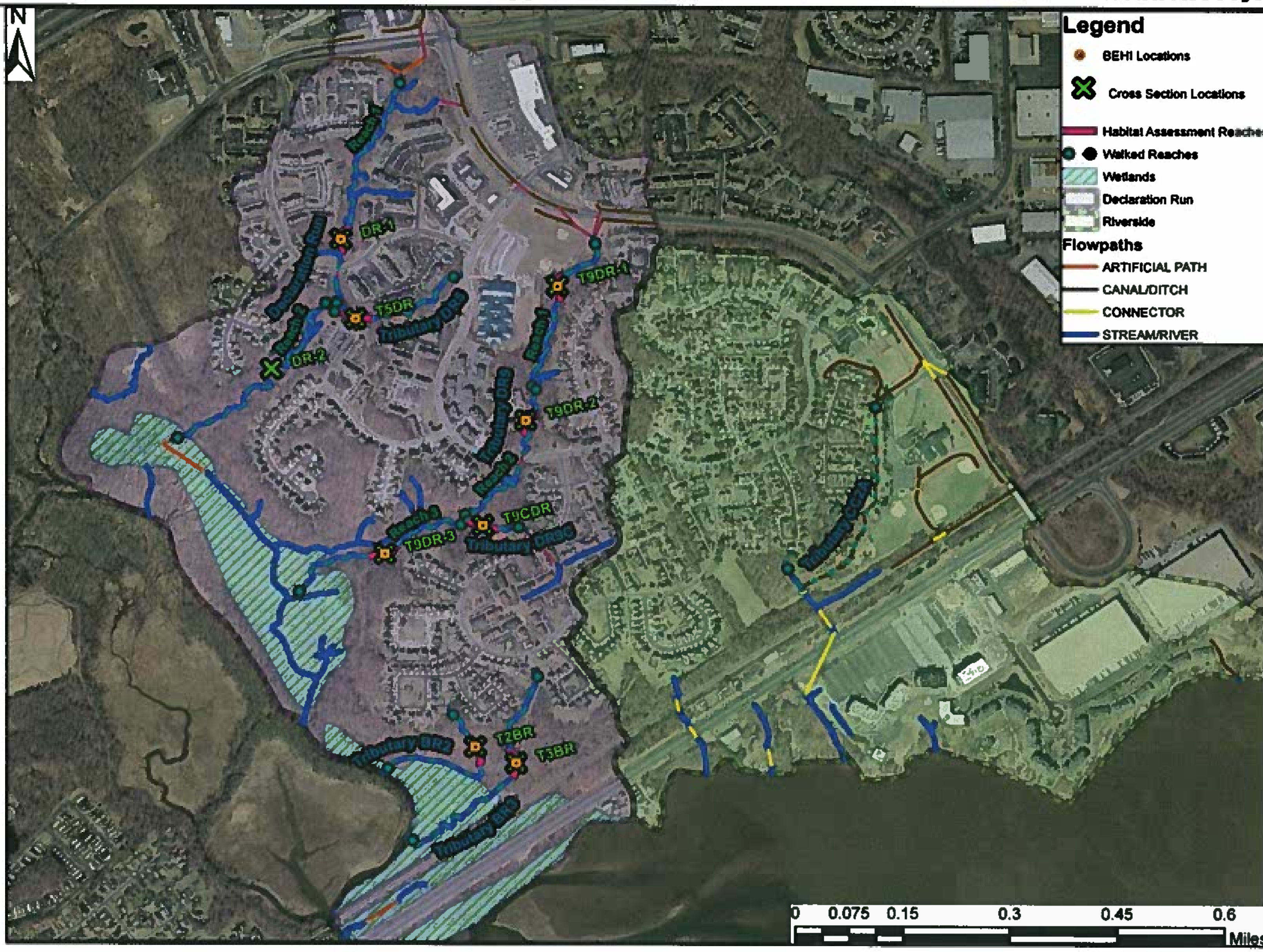

Figure B-1: Stream Assessment Reaches and Monitoring Points

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B.1.1 Stream Walks and Restoration Site Assessment

The study stream miles were reviewed in the field by URS to visually assess stream morphology and conditions; noting areas of bank erosion, streambed degradation, presence of invasive species, and stream buffer concerns such as encroachment or dumping.

Where applicable the Stream Restoration Assessment form was used to evaluate eight factors that affect project feasibility including:

- Hydrologic modification
- Channel condition
- In-stream and riparian habitats
- Water quality
- Property constraints and opportunities
- Potential community acceptance
- Types of restoration opportunities.

Each factor contains several questions that can be answered in the field or determined from property ownership information. These categories were used to identify the stream sites in most need of help and with the greatest potential for constructability.

B.1.2 Maryland Biological Stream Survey Habitat Assessment

The URS team conducted a stream habitat assessment at the nine sites in the Declaration Run watershed listed in Table B-1. The site in the Riverside watershed, Tributary CC2A, did not have a defined stream channel where a habitat assessment could be performed. The team evaluated 75 meters (246 feet) of stream channel and completed Maryland Biological Stream Survey (MBSS) Summer Habitat Data Sheets using habitat assessment guidance in *Sampling Manual: Field Protocols* (MDNR 2010).

A physical habitat index (PHI) was calculated for each stream reach in accordance with *A Physical Habitat Index for Freshwater Wadeable Streams in Maryland – Final Report* (MDNR 2003). The following eight parameters were used to calculate the PHI:

- Instream habitat
- Epifaunal substrate
- Bank stability
- Embeddedness
- Percent shading
- Remoteness
- Woody debris/rootwads
- Riffle quality

The results of the MBSS habitat assessments are provided in Section B.2.3.

B.1.3 Bank Erosion Hazard Index

Evaluation of bank erosion of eight tributaries in the Declaration Run watershed listed in Table B-1. Tributary CC2A in the Riverside watershed is a drainage ditch and was not evaluated.

Bank erosion was evaluated using Bank Erosion Hazard Index (BEHI) field data forms, and photographs were taken at each site.

Example of bank erosion

The BEHI is a rating system developed by Wildland Hydrology, Inc., that measures the ability of stream banks to resist. The results of an evaluation using the BEHI are a baseline of the extent and severity of streambank erosion in urbanized streams.

Bank Erosion Hazard Index Ratings

- Very low
- Low
- Moderate
- High
- Very high
- Extreme

The BEHI has five parameters:

- Bank height relative to the bankfull height
- Rooting depth of vegetation on the stream banks
- Weighted density of the roots
- Angle of the bank
- Whether any protection is present at the toe of the bank (i.e., rock or large woody material)

Once these parameters are assessed the stream is assigned one of six descriptive ratings. The BEHI results are provided in Section B.2.4.

B.1.4 Cross Sections and Stream Classification

Cross sections were measured using a level and surveyor's rod at the nine sites in the Declaration Run watershed listed in Table B-1. A cross section was not performed at the Riverside reach (Tributary CC2A) because the reach is a drainage ditch and does not contain natural geomorphic characteristics.

Stations and elevations across the cross sections were entered into the Mecklenburg Reference Reach Spreadsheet model developed by the Ohio Department of Natural Resources. The spreadsheet model is based on Manning's Equation and is widely used in the United States.

Stream reaches were classified using the Rosgen stream classification system (Rosgen [1996]). The system identifies eight stream types. The characteristics used to classify streams are the number of channels (single-thread or multiple), entrenchment ratio (ratio of the width of the floodprone area to bankfull width), bankfull width to depth ratio, and sinuosity. The floodprone area is measured at an elevation of twice the maximum bankfull depth. The stream types are subdivided according to the median particle size (D50) of the streambed material and the slope of the stream channel.

Figure B-1 shows the characteristics used to identify the stream type in the Rosgen classification of natural rivers. Table B-2 provides a description of the stream types in the Rosgen stream classification system.

Table B-2: Rosgen Stream Classification System

Channel	Type	Description
Single	A	Steep, entrenched, cascading step/pool stream with high energy and debris transport. Found in very high relief areas.
	G	Entrenched gully with step/pool features and low width/depth ratios on moderate gradients.
	F	Entrenched meandering riffle/pool channel on low gradient with a high width/depth ratio.
	B	Moderately entrenched, moderate gradient with a slope generally greater than 2%, riffle dominated, and infrequently spaced pools. Found in high relief areas.
	E	Low gradient, meandering riffle/pool stream with a low width/depth ratio and little deposition. Found in broad valleys.
	C	Low gradient, meandering, riffle/pool, alluvial channel with point bars and a well-defined floodplain.
Multiple	D	Very wide, braided, high bedload channel with longitudinal and transverse bars. Found in broad alluvial valleys and steeper fans.
	DA	Narrow and deep multiple-channel stream, with low bedload, well-vegetated floodplains, and very gentle relief.

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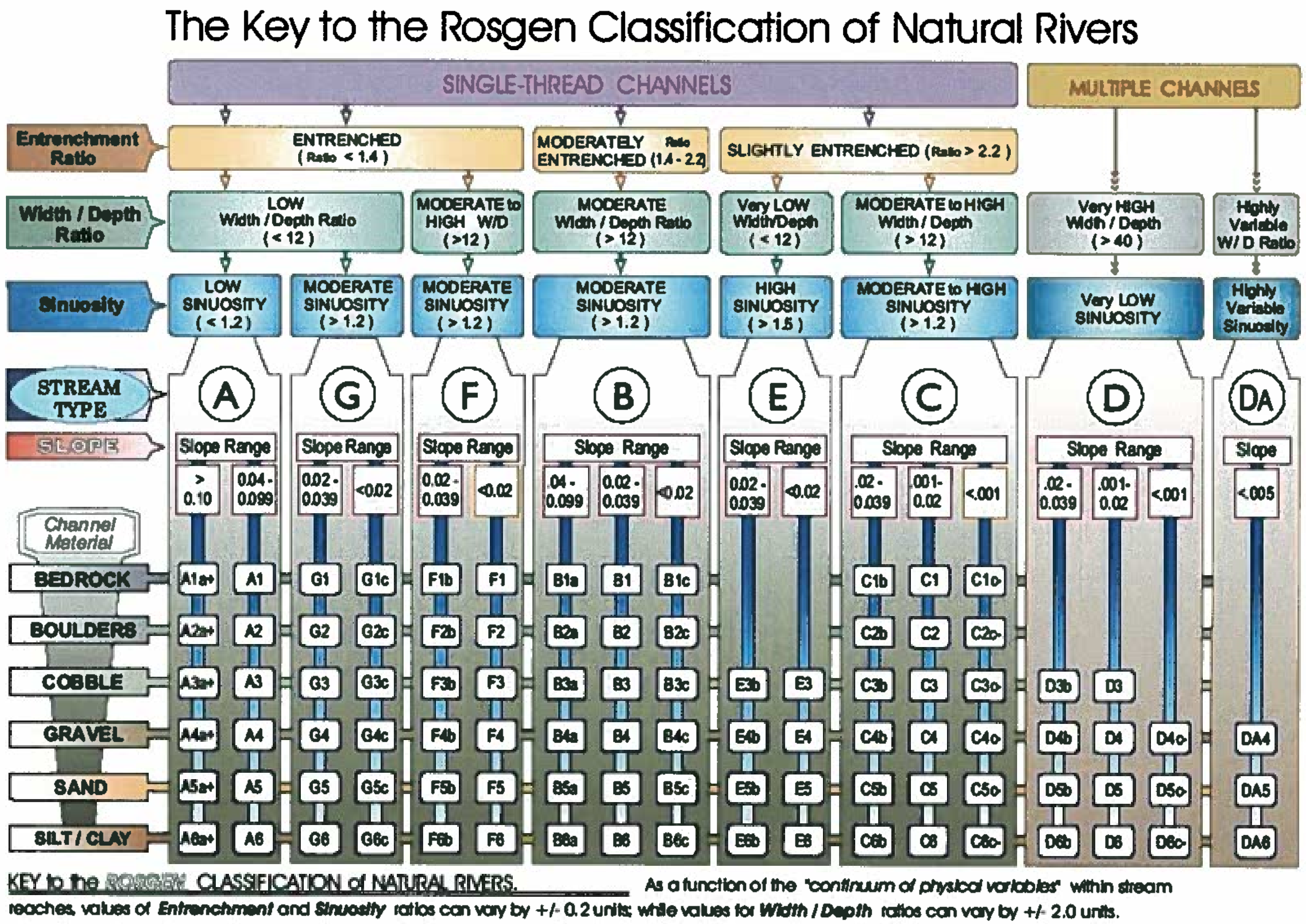

Figure B-1: Rosgen Classification of Natural Rivers

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The cross section and stream classification results are provided in Section B.2.5.

B.1.5 Restoration Site Assessment

A Stream Restoration Assessment form was used to evaluate eight factors that affect project feasibility: hydrologic modification, channel condition, instream and riparian habitats, water quality, property constraints and opportunities, potential community acceptance, and types of restoration opportunities. The questions about each factor can be answered in the field or determined from property ownership information. The factors were used to identify the stream sites in most need of help and with the greatest potential for constructability. The results of the restoration site assessments are provided in Section B.4.

B.2 RESULTS

The results of the general assessments and detailed assessments described in Section B.1 are provided in this section.

B.2.1 Channel Dynamics and Erosion

Stream channel erosion is part of natural channel migration, in which streams meander, widen, and narrow to reach a stable equilibrium. Increases in imperviousness as a result of urbanization accelerate stream channel erosion by increasing the volume of water that channels receive. The extra force of the water adjusts the stream flowpath, channel, and type of material lining the streambed. The process changes a stable stream to an unstable stream in cross section, pattern, and profile. The stream will continue to adjust to the change in watershed hydrology, and over a long period, will eventually stabilize but generally at a lower elevation.

Channel dynamics, or changes in stream channels, are described in terms of:

- **Stability**: Channel is in balance between erosion and deposition
- **Bed aggradation**: Streambed is raised up by deposits of sediment carried from upstream
- **Bed degradation or downcutting**: Streambed erodes and the channel becomes deeper or incised
- **Bank erosion and stream widening**: Stream banks erode and the channel becomes wider
- **Headcutting**: Bed erosion and channel slope flattening migrates upstream to nick points, creating drop-offs or waterfalls within the channel

B.2.2 Stream Walks

The results of the general assessments that were conducted during the stream walks of the stream sites listed in Table B-1 are provided in the following subsections.

Declaration Run Reach 1


Declaration Run Reach 1

Declaration Run Reach 1 is north (upstream) of Baneberry Drive and extends upstream to Riverside Parkway and Maryland Route (MD) 7. The stream is highly degraded, and stream conditions are highly variable. Just upstream of Baneberry Drive, the stream is somewhat incised with 3- to 4-foot-high banks. Farther upstream, the channel becomes deeply incised, extending up to an 8-foot-deep headcut. Above the headcut, the stream is only 1- to 2-feet deep but contains a heavy load of sand and gravel. Farther upstream, toward the headwaters, the stream becomes incised again, with 4-foot-high banks. There is a slope failure at a storm drain outfall opposite Dalmation Place and another headcut farther upstream in the stream channel. Declaration Run Reach 1 is rated a high-priority reach for restoration.

Tributary DR5


Tributary DR5

The Tributary DR5 reach is south of Baneberry Drive and runs east-west between Arabis Court and Germander Drive. The stream is an ephemeral channel and is moderately incised. There are two problem areas that need to be addressed: a slope failure at a storm drain outfall from a detention basin and a 2-foot-deep headcut within the stream channel. This stream reach is rated moderate for restoration potential, but the slope failure at the storm drain outfall should be addressed.

Declaration Run Reach 2


Declaration Run Reach 2

Declaration Run Reach 2 has high, eroding banks downstream of the confluence with the Tributary DR5 stream reach. Streambank erosion is common on outside meander bends. There is a slope failure at a 36-inch storm drain outfall and a second slope failure immediately upstream of the small Tributary DR5 stream. The reach includes a small pond located at this area, and further bank erosion would result in failure of the pond. This reach is rated moderate for restoration potential, but the slope failure at the storm drain outfalls requires immediate attention.

Tributary DR9: Reach 1

Tributary DR9 Reach 1, located south of Riverside Parkway to the southern end of Church Creek Elementary School, receives drainage from Riverside Parkway and the shopping center on the northern side of Riverside Parkway. Downstream of the culvert draining the shopping center and Riverside Parkway there is a flat section of stream with no thalweg where fresh sand and gravel have accumulated over the stream bed. Below this section there is a failed stormwater management feature made of white polyvinyl chloride.

Tributary DR9 Reach 1

The in-stream stormwater retention facility that appears to have been built is not functional because the berm that was constructed across the stream has failed. A severe scour hole exists along the left bank in this area. Below this area, the stream has 3- to 4- foot-high eroding banks. Sand and gravel have accumulated over the stream bed covering over the thalweg. Downstream of this area, the steep stream banks increase in height, up to 8 feet in one area. Approaching the cross section location, the banks decrease in height to approximately 2 feet. There are three headcuts in this area. Two are less than 2 feet deep, and one is approximately 4 feet deep.

Tributary DR9 Reach 2

Tributary DR9 Reach 2 extends from Riverside Parkway and Church Creek Elementary School to Church Creek Road Drive. Nearly vertical banks, up to 10 feet tall, exist throughout this reach. There is a failed storm drain outfall that discharges into a short side channel. Two sections of reinforced concrete pipe have separated from the outfall. Because of the height and steepness of the stream banks restoration options are limited without significant grading and tree clearing. However, the erosion at the failing outfall needs immediate attention.

Tributary DR9 Reach 2

This reach is the most severely eroded stream channel that was observed in the watershed and is assumed to be contributing the most sediment to Declaration Run. It is rated a high-priority restoration site.

Tributary DR9C

Tributary DR9C is an ephemeral channel that drains to Tributary DR9. The channel has high eroding banks and a steep channel gradient. However, there are portions of the stream where the eroding banks have partially healed. Restoration options are limited in this area.

Tributary DR9C

Tributary DR9 Reach 3

Tributary DR9 is a perennial stream through a scrub-shrub wetland dominated by willow, red maple, and ash. The stream is approximately 6 feet wide with low banks and minimal erosion. No restoration is required in this area.

Tributary DR9 Reach 3

Tributary BR2

Tributary BR2 is an ephemeral channel that has a steep gradient and is deeply incised. Headcuts exist in this small tributary. The stream flattens out as it approaches the Bush Declaration wetlands and the stream becomes less incised. No restoration is recommended in this tributary. The benefits of restoration are negligible, and construction access is poor.

Tributary BR2

Tributary BR3

Tributary BR3 is adjacent to a sanitary sewer pumping station. The narrow stream is somewhat incised with 1.5-foot-high banks. As the stream approaches the Bush Declaration wetlands, the slope of the stream flattens out and the stream becomes less incised. There is no restoration potential at this site.

Tributary BR3

Tributary CC2A

Tributary CC2A is a large detention basin in the Riverside subwatershed. The drainage upstream from the basin flows down a grassed swale, with no defined channel. Wetlands exist within the detention basin, dominated by willow, maple, and ash in the overstory and smartweeds, cattail, dogwood, soft rush, and sedges in the shrub and herbaceous layers. There is no stream restoration potential at this site.

Tributary CC2A

B.2.3 MBSS Habitat Assessments

As described in Section B.1.3, the physical habitat of the nine stream assessment sites was evaluated using the MBSS Summer Habitat Data Sheets. Table B-3 shows the PHI scores for the eight stream assessment parameters and the habitat assessment ratings for the nine sites. The ratings were all fair or poor using the Physical Habitat Assessment protocol. None of the streams were rated good or very poor.

PHI Scoring
- Good: 72–100
- Fair: 42–71.9
- Poor: 12–41.9
- Very poor: 0–11.9

Scores for the parameters with the exception of remoteness can be obtained from the MBSS Summer Habitat Data Sheet. Remoteness is a qualitative score based on the stream's proximity to buildings, roads, and other development activities.

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Table B-3: 2013 MBSS Protocol Physical Habitat Index Ratings

Stream Reach ID	Reach ID	Instream Habitat	Epifaunal Substrate	Bank Stability	Embedded-ness	Percent Shading	Remote-ness	No. Woody Debris / Rootwads	Riffle Quality	PHI	
										Score	Rating
Declaration Run	Reach 1	5	2	5	50	90%	10	3	0	42.5	Fair
Tributary DR5		2	1	10	80	100%	10	3	0	40.0	Poor
Declaration Run Reach 2	Reach 2	2	2	15	90	80%	10	8	2	44.1	Fair
Tributary DR9	Reach 1	3	3	10	80	70%	10	9	5	47.5	Fair
Tributary DR9	Reach 2	1	3	5	85	70%	10	2	6	34.7	Poor
Tributary DR9C		5	4	10	80	85%	10	10	5	53.1	Fair
Tributary DR9	Reach 3	6	4	10	90	20%	10	6	5	40.5	Poor
Tributary BR2		2	2	5	50	75%	10	9	6	47.7	Fair
Tributary BR3		5	2	10	90	70%	10	5	4	42.2	Fair
Tributary CC2A		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

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B.2.4 Bank Erosion Hazard Index

Eight monitoring sites in the Declaration Run watershed were evaluated for their ability to resist erosion using the BEHI protocol. Declaration Run Reach 2 did not have a high bank, and therefore a BEHI was not conducted. All evaluated reaches received a high or very high rating. The result of all BEHI ratings in Declaration Run show that:

- All of the streams are incised to some degree
- In general, the weighted rooting densities are low
- Bank angles are steep
- There is little or no rock, roots, or other material to protect the lower banks from erosion

Table B-5 shows the BEHI values for the Declaration Run stream reaches.

Table B-5. BEHI Scores and Descriptive Ratings

Stream	Reach ID	Monitoring Point ID	BEHI	
			Score	Rating
Declaration Run	Reach 1	DR-1	42.42	Very high
Tributary DR5		T5DR	37.49	High
Declaration Run	Reach 2	DR-2	N/A(1)	N/A(1)
Tributary DR9	Reach 1	T9DR-1	30.72	High
Tributary DR9	Reach 2	T9DR-2	39.9	Very high
Tributary DR9C		T9CDR	38.34	High
Tributary DR9	Reach 3	T9DR-3	30.65	High
Tributary BR2		T2BR	41.84	Very high
Tributary BR3		T3BR	37.88	High

(1) Low bank

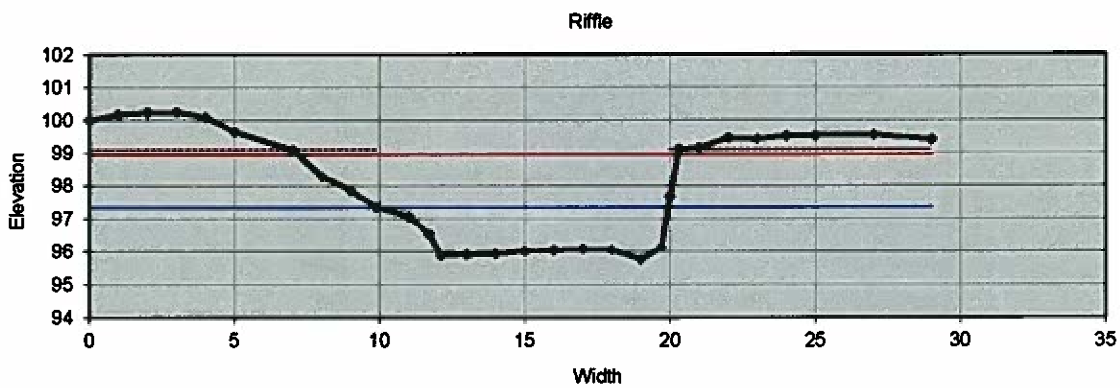
B.2.5 Cross Sections and Stream Classifications

The cross section graphs and stream type for the nine sites were assessed and results are provided in this section. A cross section was not conducted at Tributary CC2A in the Riverside watershed because the drainage from the watershed has not formed a fluvial channel. The drainage swales discharge into a large wetland detention basin.

The cross sections show that five of the nine stream reaches are the unstable G stream type (gully), two reaches classify as the C stream type, and two classify as the E stream type.

Declaration Run Reach 1

The Declaration Run Reach 1 cross section (Figure B-2) at DR-1 classifies as the unstable G4 stream type. The stream has a width-to-depth ratio of less than 12 and an entrenchment ratio of 1.3. The entrenchment ratio is the ratio of the width of the floodprone area (defined as twice the bankfull height and shown as the red line in the graph) to the bankfull height (blue line in the graph). The entrenchment ratio is a measure of the confinement of the stream within its valley. In the cross section, the floodprone area is confined to the stream channel, indicating the stream is now disconnected from its former floodplain. In addition, the stream is deeply incised with a low bank height ratio of 2.1. The low bank height ratio is the ratio of the low bank height (3.4 feet) to the maximum bankfull depth (1.6 feet). Low bank height ratios greater than 1.2 indicate vertical instability.



Bankfull Dimensions	
11.5	x-section area (ft.sq.)
10.0	width (ft)
1.1	mean depth (ft)
1.6	max depth (ft)
11.8	wetted parimeter (ft)
1.0	hyd radi (ft)
8.7	width-depth ratio

Flood Dimensions	
13.1	W flood prone area (ft)
1.3	entrenchment ratio
3.4	low bank height (ft)
2.1	low bank height ratio

Materials	
—	D50 (mm)
—	D84 (mm)
45	threshold grain size (mm):

Bankfull Flow	
5.5	velocity (ft/s)
63.0	discharge rate (cfs)
0.97	Froude number

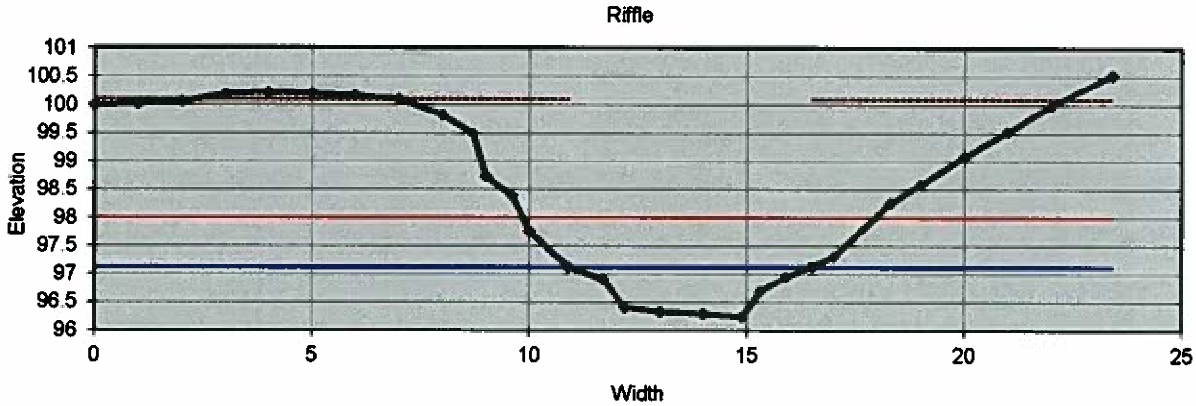
Flow Resistance	
0.033	Manning's roughness
0.13	D'Arcy-Weisbach fric.
—	resistance factor u/u*
—	relative roughness

Forces & Power	
1.5	channel slope (%)
0.92	shear stress (lb/sq.ft.)
0.69	shear velocity (ft/s)
5.9	unit strm power (lb/ft/s)

Figure B-2: Cross Section Data at Monitoring Point DR-1

Tributary DR5

The cross section for Tributary DR5 (Figure B-3) at monitoring point T5DR also classifies as the G4 stream type, with a low width-to-depth ratio and a low entrenchment ratio. The cross section has a very high low bank ratio, indicating vertical instability.



Bankfull Dimensions	
3.0	x-section area (ft.sq.)
5.6	width (ft)
0.5	mean depth (ft)
0.9	max depth (ft)
6.1	wetted parimeter (ft)
0.5	hyd radi (ft)
10.3	width-depth ratio

Flood Dimensions	
8.1	W flood prone area (ft)
1.5	entrenchment ratio
3.9	low bank height (ft)
4.4	low bank height ratio

Materials	
---	D50 (mm)
---	D84 (mm)
23	threshold grain size (mm):

Bankfull Flow	
3.4	velocity (ft/s)
10.3	discharge rate (cfs)
0.87	Froude number

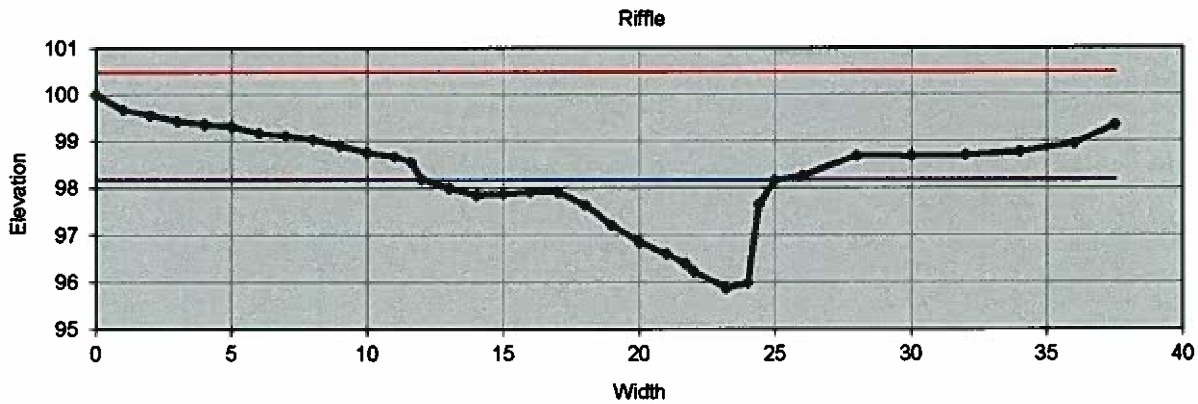
Flow Resistance	
0.033	Manning's roughness
0.16	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power	
1.5	channel slope (%)
0.46	shear stress (lb/sq.ft.)
0.49	shear velocity (ft/s)
1.74	unit strm power (lb/ft/s)

Figure B-3: Cross Section Data at Monitoring Point T5DR

Declaration Run Reach 2

The cross section for Declaration Run Reach 2 (Figure B-4) was taken at monitoring point DR-2; a location where the channel was not deeply incised and the stream was connected with its floodplain. The reach was classified as the stable C4 stream type.



Bankfull Dimensions

11.8	x-section area (ft.sq.)
13.1	width (ft)
0.9	mean depth (ft)
2.3	max depth (ft)
15.0	wetted parimeter (ft)
0.8	hyd radi (ft)
14.5	width-depth ratio

Flood Dimensions

50.0	W flood prone area (ft)
3.8	entrenchment ratio
2.3	low bank height (ft)
1.0	low bank height ratio

Materials

—	D50 (mm)
—	D84 (mm)
36	threshold grain size (mm):

Bankfull Flow

4.7	velocity (ft/s)
55.8	discharge rate (cfs)
0.94	Froude number

Flow Resistance

0.033	Manning's roughness
0.14	D'Arcy-Weisbach fric.
—	resistance factor u/u*
—	relative roughness

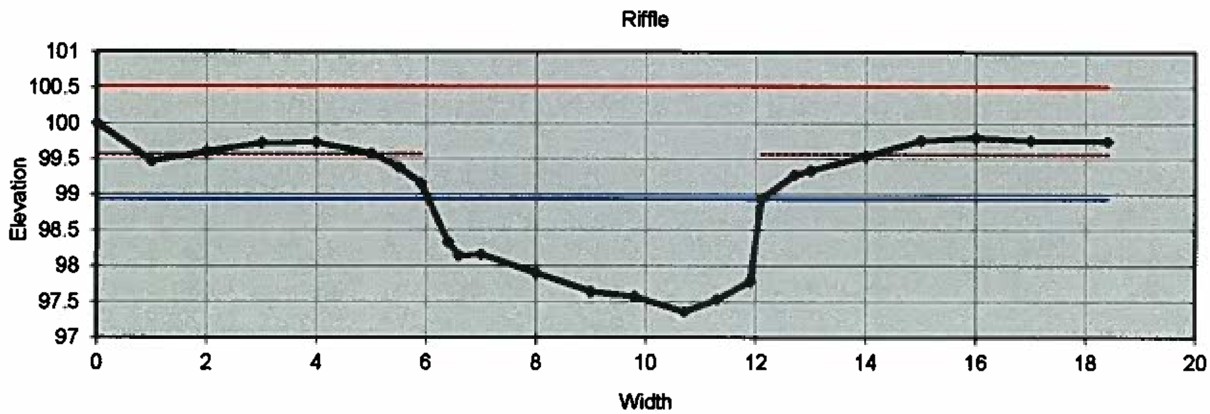
Forces & Power

1.5	channel slope (%)
0.74	shear stress (lb/sq.ft.)
0.62	shear velocity (ft/s)
4	unit strm power (lb/ft/s)

Figure B-4: Cross Section Data at Monitoring Point DR-2

Tributary DR9 Reach 1

The cross section at T9DR-1 (Figure B-5) classifies Tributary DR9 Reach 1 as an incising E4 steam type. The stream has a low width-to-depth ratio similar to a G4 stream, but the stream has a high entrenchment ratio because the floodprone area extends outside the channel. The stream at this location is evolving toward the G4 stream type.



Bankfull Dimensions	
6.8	x-section area (ft.sq.)
6.1	width (ft)
1.1	mean depth (ft)
1.6	max depth (ft)
7.6	wetted parimeter (ft)
0.9	hyd radi (ft)
5.4	width-depth ratio

Flood Dimensions	
50.0	W flood prone area (ft)
8.2	entrenchment ratio
2.2	low bank height (ft)
1.4	low bank height ratio

Materials	
---	D50 (mm)
---	D84 (mm)
27	threshold grain size (mm):

Bankfull Flow	
4.2	velocity (ft/s)
28.3	discharge rate (cfs)
0.77	Froude number

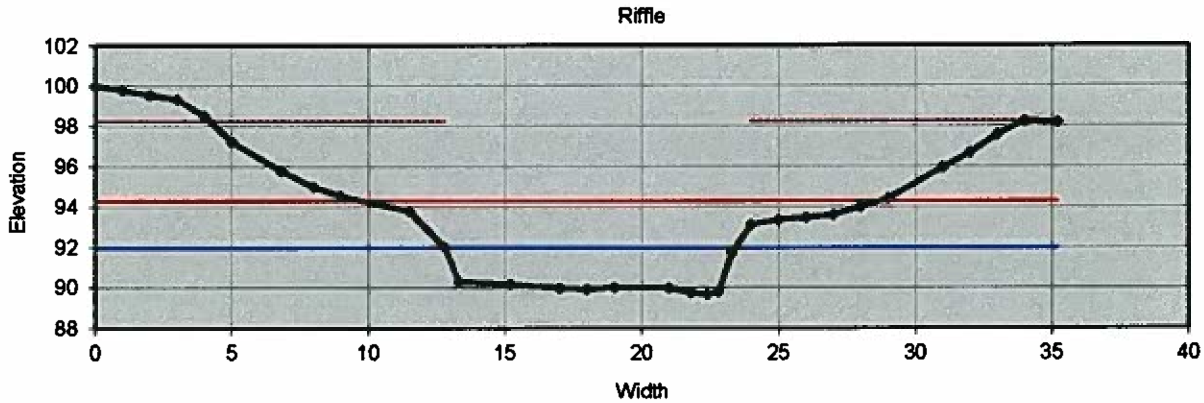
Flow Resistance	
0.033	Manning's roughness
0.13	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power	
0.98	channel slope (%)
0.55	shear stress (lb/sq.ft.)
0.53	shear velocity (ft/s)
2.9	unit strm power (lb/ft/s)

Figure B-5: Cross Section Data at Monitoring Point T9DR-1

Tributary DR9 Reach 2

The cross section at T9DR-2 (Figure B-6) is an incising E4 stream type, evolving to a G4 stream type. The stream has a high low bank ratio, indicating vertical instability.



Bankfull Dimensions	
19.7	x-section area (ft.sq.)
10.6	width (ft)
1.9	mean depth (ft)
2.3	max depth (ft)
13.6	wetted parimeter (ft)
1.4	hyd radi (ft)
5.7	width-depth ratio

Flood Dimensions	
18.9	W flood prone area (ft)
1.8	entrenchment ratio
8.6	low bank height (ft)
3.7	low bank height ratio

Materials	
---	D50 (mm)
---	D84 (mm)
43	threshold grain size (mm):

Bankfull Flow	
5.7	velocity (ft/s)
112.6	discharge rate (cfs)
0.84	Froude number

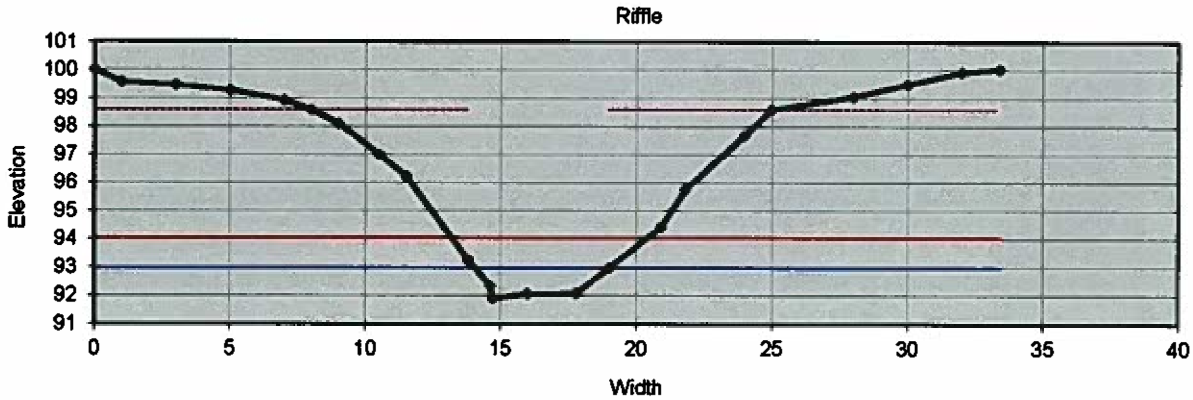
Flow Resistance	
0.033	Manning's roughness
0.11	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power	
0.98	channel slope (%)
0.89	shear stress (lb/sq.ft.)
0.68	shear velocity (ft/s)
6.5	unit strm power (lb/ft/s)

Figure B-6: Cross Section Data at Monitoring Point T9DR-2

Tributary DR9C

The stream at monitoring point T9CDR on Tributary DR9C is an ephemeral channel with a low width-to-depth ratio and a low entrenchment ratio. It classifies as the unstable G4 stream type. The stream has an extremely high low bank height ratio indicating vertical instability. See Figure B-7.



Bankfull Dimensions

3.7	x-section area (ft.sq.)
5.0	width (ft)
0.7	mean depth (ft)
1.1	max depth (ft)
5.9	wetted parimeter (ft)
0.6	hyd radi (ft)
6.6	width-depth ratio

Flood Dimensions

7.2	W flood prone area (ft)
1.5	entrenchment ratio
6.7	low bank height (ft)
6.2	low bank height ratio

Materials

---	D50 (mm)
---	D84 (mm)
29	threshold grain size (mm):

Bankfull Flow

4.1	velocity (ft/s)
15.0	discharge rate (cfs)
0.90	Froude number

Flow Resistance

0.033	Manning's roughness
0.15	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

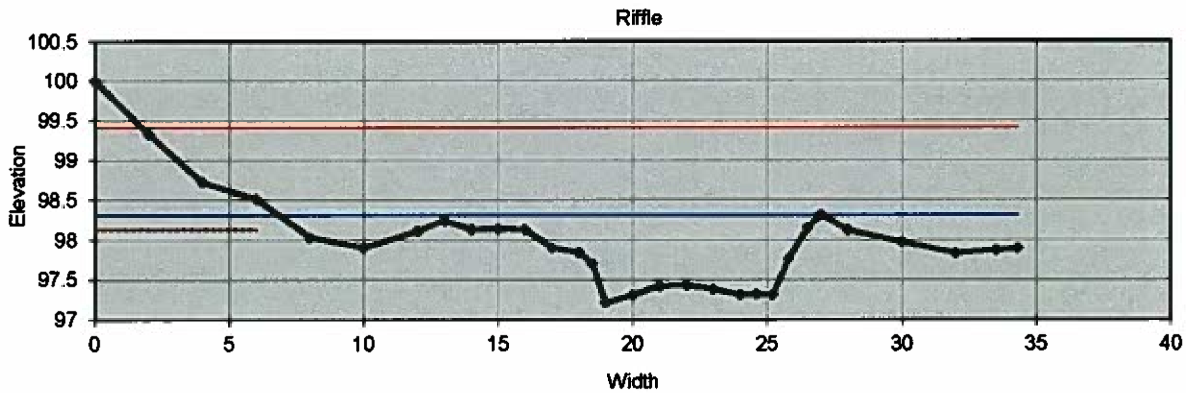
Forces & Power

1.5	channel slope (%)
0.59	shear stress (lb/sq.ft.)
0.55	shear velocity (ft/s)
2.8	unit strm power (lb/ft/s)

Figure B-7: Cross Section Data at Monitoring Point T9CDR

Tributary DR9 Reach 3

The cross section at T9DR-3 (Figure B-8) has a very high width-to-depth ratio, indicating that Tributary DR9 Reach 3 is aggrading with sediment and losing its capacity to convey the flow and sediment from its watershed. The stream classifies as the C4 stream type.



Bankfull Dimensions

12.7	x-section area (ft.sq.)
27.5	width (ft)
0.5	mean depth (ft)
1.1	max depth (ft)
28.1	wetted parimeter (ft)
0.5	hyd radi (ft)
59.5	width-depth ratio

Flood Dimensions

50.0	W flood prone area (ft)
1.8	entrenchment ratio
0.9	low bank height (ft)
0.8	low bank height ratio

Materials

---	D50 (mm)
---	D84 (mm)
17	threshold grain size (mm):

Bankfull Flow

2.9	velocity (ft/s)
37.4	discharge rate (cfs)
0.77	Froude number

Flow Resistance

0.033	Manning's roughness
0.16	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

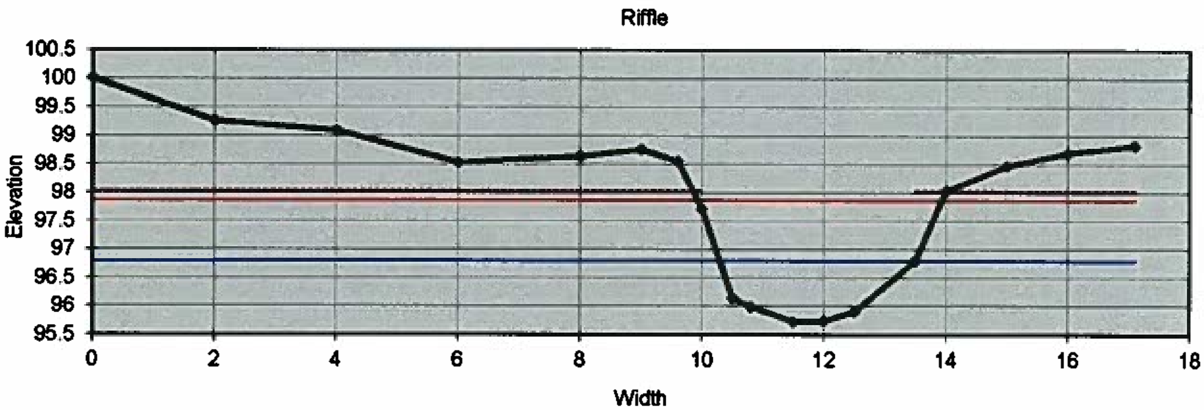
Forces & Power

1.23	channel slope (%)
0.35	shear stress (lb/sq.ft.)
0.42	shear velocity (ft/s)
1.04	unit strm power (lb/ft/s)

Figure B-8: Cross Section Data at Monitoring Point T9DR-3

Tributary BR2

The cross section at T2BR (Figure B-9) is the G4 stream type. It has a very low width-to-depth ratio, a low entrenchment ratio, and a high low bank height ratio, indicating vertical instability.



Bankfull Dimensions

2.4	x-section area (ft.sq.)
3.2	width (ft)
0.8	mean depth (ft)
1.1	max depth (ft)
4.1	wetted parimeter (ft)
0.6	hyd radi (ft)
4.3	width-depth ratio

Flood Dimensions

4.0	W flood prone area (ft)
1.2	entrenchment ratio
2.3	low bank height (ft)
2.1	low bank height ratio

Materials

---	D50 (mm)
---	D84 (mm)
152	threshold grain size (mm):

Bankfull Flow

9.2	velocity (ft/s)
22.3	discharge rate (cfs)
2.12	Froude number

Flow Resistance

0.033	Manning's roughness
0.15	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

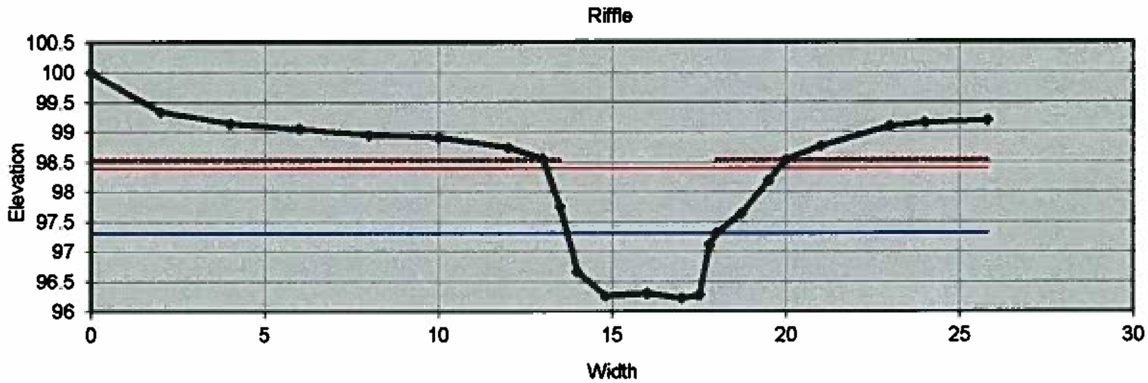
Forces & Power

8.5	channel slope (%)
3.10	shear stress (lb/sq.ft.)
1.26	shear velocity (ft/s)
37	unit strm power (lb/ft/s)

Figure B-9: Cross Section Data at Monitoring Point T2BR

Tributary BR3

The cross section at T3BR (Figure B-10) is the G4 stream type. It has a very low width-to-depth ratio, a low entrenchment ratio, and a high low bank height ratio, indicating vertical instability.



Bankfull Dimensions	
3.8	x-section area (ft.sq.)
4.3	width (ft)
0.9	mean depth (ft)
1.1	max depth (ft)
5.5	wetted parimeter (ft)
0.7	hyd radi (ft)
4.9	width-depth ratio

Flood Dimensions	
6.7	W flood prone area (ft)
1.6	entrenchment ratio
2.3	low bank height (ft)
2.1	low bank height ratio

Materials	
---	D50 (mm)
---	D84 (mm)
23	threshold grain size (mm):

Bankfull Flow	
3.7	velocity (ft/s)
14.0	discharge rate (cfs)
0.78	Froude number

Flow Resistance	
0.033	Manning's roughness
0.14	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power	
1.09	channel slope (%)
0.47	shear stress (lb/sq.ft.)
0.49	shear velocity (ft/s)
2.2	unit strm power (lb/ft/s)

Figure B-10: Cross Section Data at Monitoring Point T3BR

B.3 CONCLUSIONS

The MBSS PHI measured cross sections, BEHI ratings, and visual observations all indicate fair-to-poor aquatic habitat and channel stability conditions in the Declaration Run watershed. Extensive areas of bank erosion and sediment deposition were observed during the evaluations. This degradation is typical of urban streams where the hydrology of the watershed has been altered as a result of the significant increase in impervious surfaces.

The Riverside watershed consists of channelized and underground stream systems, with one remaining tributary identified as Tributary CC2A. This tributary is a drainage ditch and does not contain natural geomorphic characteristics and the habitat and physical assessments could not be applied.

Table B-6 is an overarching summary for the stream assessment results.

Table B-6: Stream Assessment Summary

Watershed	Stream	Reach ID	PHI	BEHI Erosion Potential	Stream Classification
Declaration Run	Declaration Run	Reach 1	Fair	Very high	Unstable G4
	Tributary DR5		Poor	High	Unstable G4
	Declaration Run	Reach 2	Fair	N/A	Stable C4
	Tributary DR9	Reach 1	Fair	High	Incising E4
	Tributary DR9	Reach 2	Poor	Very high	Incising E4
	Tributary DR9C		Fair	High	Unstable G4
	Tributary DR9	Reach 3	Poor	High	Stable C4
	Tributary BR2		Fair	Very high	Unstable G4
	Tributary BR3		Fair	High	Unstable G4
Riverside	Tributary CC2A		N/A	N/A	N/A

B.4 STREAM RESTORATION CONCEPTUAL DESIGNS

The stream assessment provided a window of understanding into stream physical and ecological conditions. Areas that were damaged that could benefit from restoration were assessed and prioritized for restoration potential. Concept designs (10% design) were developed for the 4 high priority sites. Discussion of the restoration potential of each site and in-depth discussion of the high priority sites are provided in this section.

B.4.1 Declaration Run Reach 1 Restoration

Recommended stream restoration at Declaration Run1 includes remediating two headcuts —one approximately 4 feet deep and the other one approximately 8 feet deep. Measures to remediate headcuts include installing riffle grade control structures or step pools. The stream channel at Declaration Run Reach 1 is narrow, making it more conducive to rock riffles than step pools. Constructed riffles typically have slopes ranging from 15:1 (6.7 percent) to 20:1 (5 percent). Assuming a 5 percent slope on the riffle and a 1-foot drop per riffle, each riffle would be 20-feet long.

Riffles are typically spaced 5 to 7 bankfull widths apart. At a stream width of 6 feet and riffle spacing at 5 bankfull widths apart (30 feet), each foot of headcut drop would require a stream length of 30 feet (20 feet of riffle plus 10 additional feet to make up the 30-foot spacing). Therefore, the 4-foot-deep headcut at this stream would require four riffle grade control structures and 120 feet of stream restoration, and the 8-foot-deep headcut would require eight riffle grade control structures and 240 feet of stream restoration. The rock used in the grade control structures would extend up to the top of the bank, thereby stabilizing the stream banks.

Double rock toe protection is proposed for the 10 feet between the riffles. Minor grading of the banks would be required for installation of the riffles and the toe protection.

The other recommended restoration action in this stream reach is to correct the slope failure at a storm drain outfall, which would involve regrading the slope and placing additional rock against the slope.

Project Cost Estimate for Declaration Run Reach 1

The estimated cost for this project is $285,654 including design and construction. The cost includes topographic surveys, preparation of construction documents (plans, specifications, cost estimates, and bid tabs), stream geomorphic surveys, hydrologic and hydraulic analyses, and permitting. Costs for optional tasks not included in the estimate are $25,000 for construction monitoring and $50,000 for 5 years of post-construction monitoring.

Opportunities and Constraints

The benefits of the Declaration Run Reach 1 restoration concept are stabilization of the stream bed and banks for a total of 360 feet of stream, remediation of two headcuts, and restoration of a slope failure at a storm drain outfall. Stabilization of the stream bed and banks would potentially reduce the amount of sediment, nitrogen, and phosphorus entering the stream and help meet the requirements of the County's National Pollutant Discharge Elimination System (NPDES) permit and Chesapeake Bay Total Maximum Daily Load (TMDL) allocation.

Construction access to the site would be difficult. Construction equipment could access the stream from either Riverside Parkway or Baneberry Drive. Both access paths would require constructing a temporary access road within the forested stream valley and removing trees. Trees would be replaced after the stream restoration work has been completed. Tree replacement is included in the estimated cost of the project.

B.4.2 Tributary DR5 Restoration

Tributary DR5 is an ephemeral channel with little aquatic habitat potential. Recommended restoration is limited to correcting a minor headcut with grade control structures and remediating a slope failure at a storm drain outfall.

Remediating the headcut would require approximately 120 feet of stream restoration with four riffle grade control structures. The rock used in the grade control structures would extend up to the top of the bank, thereby stabilizing the stream banks. Double rock toe protection is proposed for the 10 feet between the riffles. Minor grading of the banks would be required for the installation of the riffles and toe protection.

Project Cost Estimate for Tributary DR5

The estimated cost for this project is $173,161 including design and construction. The cost includes topographic surveys, preparation of construction documents (plans, specifications, cost estimates, and bid tabs), stream geomorphic surveys, hydrologic and hydraulic analyses, and permitting. Costs for optional tasks not included in the estimate are $25,000 for construction monitoring and $50,000 for 5 years of post-construction monitoring.

Opportunities and Constraints

The benefits of this concept are stabilization of the stream bed and banks for a total of 120 feet of stream, remediation of one headcut, and restoration of a slope failure at a storm drain outfall. Stabilization of the stream bed and banks would potentially reduce the amount sediment, nitrogen, and phosphorus entering the stream and help meet the requirements of the County's NPDES permit and Chesapeake Bay TMDL allocation.

Construction access to the site would be difficult. Construction equipment could access the stream from either Baneberry Drive or Church Creek Road. However, access from Baneberry Drive would require traversing down a steep slope on the southern side of the road. Both access paths would require constructing a temporary access road within the forested stream valley and removing trees. The trees would be replaced after the stream restoration work has been completed. Tree replacement is included in the estimated cost of the project.

B.4.3 Declaration Run Reach 2 Restoration

Declaration Run Reach 2 has high, eroding banks below the confluence with Tributary DR5. However, stabilization of these banks would require significant grading and tree clearing. Therefore, stream restoration is not recommended at this time for this stream reach. Prior attempts at placing rock against the eroding banks have been largely unsuccessful, probably because bed grade control was not provided and as the stream continued to incise, the rocks slid off the banks. In addition, it appears that the rock used in the slope protection was undersized for this second-order perennial stream. The recommended restoration is limited to correcting the slope failures at 36-inch culverts both upstream and downstream of the confluence with Tributary DR5.

Project Cost Estimate for Declaration Run Reach 2

The estimated cost for this project is $89,875 including design and construction. The cost includes topographic surveys, preparation of construction documents (plans, specifications, cost estimates, and bid tabs), hydrologic and hydraulic analyses, and permitting. Costs for an optional task not included in the estimate are $15,000 for construction monitoring.

B.4.4 Tributary DR9 Reaches 1 and 2 Restoration

The stream reach containing Tributaries DR 9A1 and DR9A2 has the highest potential for restoration. The reach is between Riverside Parkway and Church Creek Road. Starting at the upstream end, the elements of the restoration would be:

- Stabilize the stream bed and banks for approximately 300 feet at the upstream limit of the stream down to the point where the banks become very high and steep
- Remove a failed in-stream stormwater management feature and stabilize approximately 50 feet of stream left bank immediately downstream of the failed structure
- Grade the high steep banks back for a distance of approximately 100 feet and install grade control structures
- Remediate three headcuts in the vicinity of Church Creek Elementary School by installing step pools varying in depth from 2 to 4 feet.
- Grade and stabilize the high stream banks and stream bed from the southern end of the school to Church Creek Road for a stream length of approximately 1,300 feet.
- Remediate a failed storm drain outfall that discharges stormwater from Cranesbill Court.

Project Cost Estimate for Tributary DR9 Reaches 1 and 2 Restoration

The estimated cost for this project is $830,568 including design and construction. The cost includes topographic surveys, preparation of construction documents (plans, specifications, cost estimates, and bid tabs), stream geomorphic surveys, hydrologic and hydraulic analyses, and permitting. Costs for optional tasks not included in the estimate are $50,000 for construction monitoring and $100,000 for 5 years of post-construction monitoring.

Opportunities and Constraints

The benefits of this concept are stabilization of the stream bed and banks for approximately 1,900 feet of stream, remediation of three headcuts, and restoration of a slope failure at a storm drain outfall. Stabilization of the stream bed and banks would potentially reduce the amount sediment, nitrogen, and phosphorus entering the stream and help meet the requirements of the County's NPDES permit and Chesapeake Bay TMDL allocation.

Construction access to the site would be difficult. Construction equipment could access the stream from either Riverside Parkway or Church Creek Road. Both access paths would require constructing a temporary access road within the forested stream valley and removing trees. The trees would be replaced after the stream restoration work has been completed. Tree replacement is included in the estimated cost of the project.

B.4.5 Tributary DR9C

Tributary DR9C is an ephemeral channel that drains to Tributary DR9. The stream has high, eroding banks and a steep channel gradient. However, eroding banks have partially healed in some portions of the stream. Restoration options are limited in this area, and this reach is not considered a high-priority stream restoration site.

B.4.6 Tributary DR9 Reach 3

This reach is a perennial stream through a scrub-shrub wetland dominated by willow, red maple, and ash. The stream is approximately 6 feet wide with low banks and minimal erosion. No restoration is required in this area.

B.4.7 Tributary BR2

Tributary BR2 is an ephemeral channel that has a steep gradient and is deeply incised. Headcuts exist in this small tributary. As the stream flattens out as it approaches the Bush Declaration wetlands, the stream becomes less incised. No restoration is recommended in this tributary. The benefits of restoration are negligible, and construction access would be poor.

B.4.8 Tributary BR3

Tributary BR3 is adjacent to a sanitary sewer pumping station. The narrow stream is somewhat incised with 1.5-foot-high banks. As the stream approaches the Bush Declaration wetlands, the slope of the stream flattens out and the stream becomes less incised. There is no restoration potential at this site.

B.4.9 Tributary CC2A

Tributary CC2A is a large detention basin in the Riverside watershed. The drainage upstream from the basin flows down a grassed swale, with no defined channel. Wetlands exist within the detention basin, dominated by willow, maple, and ash in the overstory and smartweeds, cattail, dogwood, soft rush, and sedges in the shrub and herbaceous layers. There is no stream restoration potential at this site.

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Appendix C
Watershed Treatment Model

As a part of the Small Watershed Action Plan for the Declaration Run and Riverside Watersheds, the URS team developed a baseline water quality model for the two watersheds based on Harford County (County) geographic information system (GIS) data and additional information on County operations. The team used the data as input into the Watershed Treatment Model (WTM), a spreadsheet-based model developed by the Center for Watershed Protection (CWP 2013).

The WTM calculates annual pollutant loading rates based on various primary and secondary sources of pollution. The model accounts for different sources of pollutants and factors in Best Management Practices (BMPs) to estimate pollutant load reductions. It can be used to estimate the following pollutants:

- Total nitrogen
- Total phosphorus
- Total suspended solids
- Fecal coliform (bacteria)

The WTM was used to estimate current pollutant loads in the two watersheds and projected pollutant load reductions from future Best Management Practices.

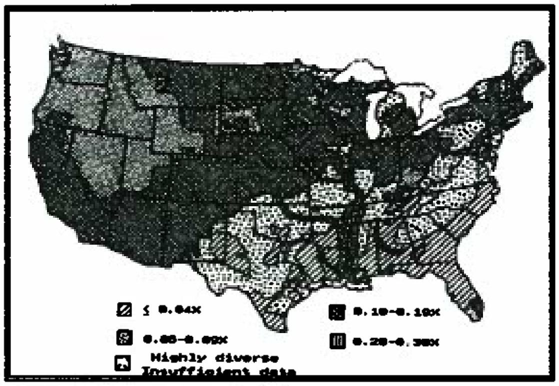
C.1 EXISTING CONDITIONS ANALYSIS

An existing conditions model was developed to estimate the pollutant loads from primary sources such as existing land use and secondary sources such as illicit discharges, onsite sanitary disposal systems, and sanitary sewer overflows and the current pollutant reductions from existing BMPs.

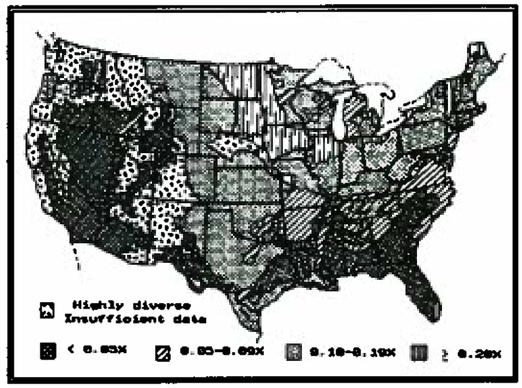
The data that were used in the model to estimate the current pollutant loads were based on the following:

- **Primary sources:** The primary sources are existing land use and impervious cover. GIS data for existing land use were obtained by modifying County land cover data by verifying the data against aerial imagery. The impervious cover was obtained from County GIS data. The default impervious cover percentage per land use type was adjusted in the model to reflect existing watershed conditions by intersecting the land use and impervious cover GIS data. Table C-1 provides the primary source data that were used as input.
- **Secondary sources:** The input information for secondary sources was obtained from County GIS data, operations information, and research. The secondary sources are as follows:
  - **Nutrient concentration in stream channel:** Because the County does not have any sampling/monitoring data on the current nutrient concentration in the stream channels, the phosphorus and nitrogen concentrations for Maryland provided in Figures 4.1 and 4.2 of Watershed Treatment Model (CWP 2013) documentation were used. Based on

the figures, phosphorus concentration of 0.020 percent and nitrogen concentration of 0.05 percent were assumed in the stream channel.



Distribution of phosphorus (P2O5) in the top 12 inch of soil
(Source: Figure 4.1, CWP 2013)



Distribution of nitrogen in the top 12 inch of soil
(Source: Figure 4.2, CWP 2013)

Table C-1: Primary Source Data for Declaration Run and Riverside Watersheds

Land Use Category	Declaration Run Area (acres)	Declaration Run Impervious Cover (%)	Riverside Area (acres)	Riverside Impervious Cover (%)
Low-density residential	1.9	12%	—	—
Medium-density residential	51.6	21%	45.6	29%
High-density residential	82.6	33%	51.0	36%
Open space	8.9	44%	48.7	5%
Commercial	22.8	12%	7.1	52%
Office	0.6	72%	22.1	70%
Institutional	15.4	72%	5.6	45%
Unimproved land	—	—	8.4	2%
Other mixed land uses	—	80%	7.2	21%
Roadway	60.0	80%	49.6	56%
Industrial	—		24.6	77%
Forest	129.1	—	32.6	—
Wetland	52.7	—	—	—
Open water	1.3	—	0.25	—

- **Onsite sewage disposal system (OSDS):** Based on County information, the Riverside watershed does not include any OSDSs. Two OSDSs in the Declaration Run watershed were included in the model and were assumed to be conventional OSDSs.
- **Sanitary sewer overflows:** Based on County GIS data, the Declaration Run watershed has approximately 8.5 miles of sanitary sewer lines, and the Riverside watershed has approximately 6.8 miles of sanitary sewer lines.

- **Combined sewer overflows:** Neither watershed has any combined sewer outfalls.
- **Illicit connections:** The WTM default assumptions were used to estimate the pollutant loads from illicit connections (1 in 1,000 homes and 10 percent of businesses are assumed to be illicitly connected).
- **Urban channel erosion:** Estimates of urban channel erosion in both the watersheds were based on typical estimates of channel erosion rates. Moderate sediment loads were used for both the watersheds based on indications of degradation and areas of severe channel erosion that were observed in both watersheds during the field reconnaissance.
- **Livestock and marinas:** Neither watershed has livestock or marinas.
- **Road sanding:** Based on County information, road sanding is not performed in either watershed.
- **Non-stormwater point sources:** Neither watershed has facilities with individual National Pollutant Discharge Elimination System (NPDES) permits for wastewater discharges.
- **Existing management practices:** Input data for existing management practices were developed based on field observations, County GIS data, and other management practices data related to County operations.
- **Turf condition and management practices:** Input data for existing turf condition and management practices were based on field observations. During field investigation, it was observed that approximately 5 percent of the lawns in the watersheds appeared to be bare or compacted and 10 percent appeared to be highly managed as a result of excess fertilization.
- **Erosion and sediment control:** Based on County information, the County's existing erosion and sediment control program was assumed to be 70 percent efficient. All building permits were assumed to be regulated with frequent site inspections.
- **Street sweeping:** According to the County, all County roads are swept using mechanical sweepers. The Declaration Run watershed has approximately 2.1 acres of County roads, and the Riverside watershed has approximately 10.5 acres of County roads.
- **Structural stormwater management (SWM) practices:** Information on existing structural SWM practices was obtained from County stormwater management GIS data. Drainage areas for most of the SWM facilities in the watersheds were available. Drainage areas for SWM facilities implemented in the last few years were not available and were delineated based on the County's SWM plans for the facilities. See Table C-2.

Table C-2: Existing Stormwater Management Practices in the Declaration Run and Riverside Watersheds and Drainage and Impervious Areas

	Declaration Run		Riverside	
SWM Practice	Drainage Area (acres)	Impervious Area (acres)	Drainage Area (acres)	Impervious Area (acres)
Wet pond	4.8	1.2	—	—
Filters – sand filter	0.6	0.5	6.6	3.9
Dry swale (bio swale, water quality swale)	8.8	5.0	23.45	15.9
Infiltration practice	8.19	4.4	—	—
ESD practice	—	—	0.9	0.6

The default pollutant removal efficiencies in the model were modified to match the *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (MDE 2011). Table C-3 provides the efficiencies of stormwater management practices used in the model.

Table C-3: Pollutant Removal Efficiencies of Stormwater Management Practices

	Pollutant Removal Efficiency (Percent)		
SWM Practice	Total Suspended Solids	Total Phosphorus	Total Nitrogen
Constructed between 1985-2002	40	30	17
Construction between 2002 and 2010	80	40	30
Environmental Site Design Practices	90	60	50

- **Riparian Buffers:** The input data for riparian buffers was calculated based on County GIS data and aerials. The default pollutant removal efficiencies in the model were modified to match the MDE approved pollutant removal efficiencies.
- **Catch basin cleanouts:** Based on County information, catch basins in the County are cleaned every 3 years.
- **Baseline pollutant loads:** The pollutant loads from primary and secondary sources and subsequent load reductions from existing management practices are provided in Table C-4 and C-5.

Table C-4: Existing Pollutant Loads in Declaration Run and Riverside Watersheds

Watershed Source	Receiving Waterbody	Total Nitrogen (lbs/yr)	Total Phosphorus (lbs/yr)	Total Suspended Solids (lbs/yr)	Fecal Coliform Bacteria (billion/yr)
Declaration Run	Surface water	3,005	501	180,126	157,734
	Groundwater	16,129	817	N/A	31
Riverside	Surface water	3,456	628	148,405	176,594

Watershed Source	Receiving Waterbody	Total Nitrogen (lbs/yr)	Total Phosphorus (lbs/yr)	Total Suspended Solids (lbs/yr)	Fecal Coliform Bacteria (billion/yr)
	Groundwater	30,204	1,451	N/A	37

Table C-5: Pollutant Load Reductions from Existing Management Practices

Stormwater Management Practice	Total Nitrogen (lbs/yr)		Total Phosphorus (lbs/yr)		Total Suspended Solids (lbs/yr)		Fecal Coliform Bacteria (billion/yr)	
	DR	R	DR	R	DR	R	DR	R
Structural stormwater management practices	88	362	16	69	2,663	10,519	3,645	8,644
Riparian Buffers	559	57	93	10	16,296	1,272	19,768	1,669
Street Sweeping	0.4	2	0.05	0.2	24	108	—	—
Catch basin cleanouts	104	25	11	3	9,819	2,409	—	—

DR = Declaration Run
R = Riverside

C.2 FUTURE CONDITIONS ANALYSIS

The proposed watershed improvements described in Section 3 of the Small Watershed Action Plan for the Declaration Run and Riverside Watersheds are stormwater structural projects, stormwater nonstructural projects, stream restoration projects, and improvements from education and outreach.

- **Structural SWM practices:** Structural SWM projects include green infrastructure, urban retrofits, environmental site design, low impact development, and stream restoration. Pollutant removal efficiencies for proposed projects were obtained from the MDE's *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (MDE 2011) document. Table C-6 lists the pollutant removal efficiencies used for the proposed projects.

Table C-6: Pollutant Removal Efficiencies of Proposed Structural Stormwater Management Practices

SWM Practice	Pollutant Removal Efficiency (Percent)		
	Total Suspended Solids	Total Phosphorus	Total Nitrogen
Urban BMP Retrofit	65	35	25
Environmental Site Design Practices	90	60	50
	Pollutant Removal Efficiency (lb/ft)		
SWM Practice	Total Suspended Solids	Total Phosphorus	Total Nitrogen
Stream Restoration	2.5	0.0035	0.02

- **Residential lawn care education and pet waste education:** An outreach program developed by the County to educate homeowners on lawn care and pet waste is proposed. It is assumed that the County will use brochures to educate homeowners.
- **Impervious cover disconnection program:** An outreach program to educate homeowners on the benefits of disconnecting impervious areas such as rooftops and driveways is proposed for implementation by the County. It is assumed that the County will use brochures to educate homeowners.
- **Septic system upgrade:** The two onsite OSDS located in Declaration were assumed to be upgraded to improve their efficiency
- **Other practices:** It was assumed that the County would continue the existing BMPs.

Table C-7 shows the pollutant load reductions that will be achieved by implementing the proposed watershed improvements.

Table C-7: Estimated Pollutant Load Reductions from Proposed Stormwater Management Practices in the Declaration Run and Riverside Watersheds

Stormwater Management Practice	Total Nitrogen (lbs/yr)		Total Phosphorus (lbs/yr)		Total Suspended Solids (lbs/yr)		Fecal Coliform Bacteria (billion/yr)	
	DR	R	DR	R	DR	R	DR	R
Structural improvements	259	891	43	191	8,151	29,893	9,256	32,970
Lawn care	27	47	6	11	—	—	—	—
Pet waste education	14	18	2	2	—	—	121	159
Septic system – surface	7	—	1	—	50	—	731	—
Stream restoration	55	—	10	—	6,962	—	—	—

DR = Declaration Run
R = Riverside

Appendix D
Prioritization of Stormwater Management Projects

D.1 INTRODUCTION

The stormwater management measures that were identified as potential projects in the Declaration Run and Riverside watersheds were prioritized based on the nine criteria listed in Table D-1. The prioritization was used to determine whether a project would be included in Harford County's Capital Improvement Projects and evaluated further as part of the Small Watershed Action Plan (SWAP) for the Declaration Run and Riverside Watersheds.

The maximum score for each criterion was 10 points, and the total maximum score was 90 points. A high score represents a good stormwater management opportunity or Best Management Practice (BMP), while a low score represents a less favorable opportunity. Additional information about each criterion is provided after Table D-1.

Table D-1: Stormwater Management Prioritization Criteria

Criterion	Maximum Score
A. Property Ownership	10 points
B. Access to Project Site	10 points
C. Drainage Area	10 points
D. Contributing Impervious Area	10 points
E. Cost	10 points
F. Utility Impacts	10 points
G. Environmental Impacts	10 points
H. Stormwater Management Era	10 points
I. Estimated Pollutant Load Reduction	10 points
Total	**90 points**

A. Property Ownership

The property ownership criterion is the impact of property ownership on a proposed project. Projects on public sites owned by Harford County would be easier to implement than projects on privately owned sites because property or easements would not need to be acquired on public sites but could be required on privately owned sites. In addition, the cost of acquiring property or easements could make a project infeasible or not cost-effective.

Whether land use would need to be changed to implement a project would also affect the project. Projects would be easier to implement on sites with land that is already dedicated to stormwater management (i.e., no change in land use would be required) than sites that would require a change in land use.

Table D-2 shows the points assigned for private and public ownership and whether land use would need to be changed.

Table D-2: Property Ownership

Ownership	Required Change in Land Use?	Points
Private	Yes	3
Private	No	5
Public	Yes	7
Public	No	10

B. Access to Project Site

Site access for construction was rated as good, fair, or poor. Fair access was defined as good access but limited space for staging without compromising existing land use (e.g., parking). Poor access was defined as access that would require demolition of structures, road construction, and acquisition of easements on private property, or clearing and grubbing of trees. Table D-3 shows the points assigned for access to the project site.

Table D-3: Site Access

Access	Points
Poor	3
Fair	7
Good	10

C. Contributing Drainage Area

The drainage area criterion is the size of the contributing drainage area for the project. Larger drainage areas have more potential to provide water quality benefits than smaller areas. Drainage areas were delineated based on County-provided data that included 2-foot contours and storm drain information and information in stormwater management plans for existing facilities. Drainage areas that were less than 25th percentile of the total range were assigned lower scores, and drainage areas that were higher than the 75th percentile value were assigned higher scores. Table D-4 shows the points assigned for drainage area in the two study watersheds.

Table D-4: Drainage Area

	Declaration Run Watershed		Riverside Watershed	
Percentile of Total Drainage Range	Drainage Area (Acres)	Points	Drainage Area (Acres)	Points
25th percentile	2.0	3	3.0	3
50th percentile	3.0	5	5.0	5
75th percentile	7.0	7	35.0	7
>75th percentile	>7.0	10	>35.0	10

D. Contributing Impervious Area

The contributing impervious area criterion is based on the number of impervious acres that would drain to a proposed stormwater facility. The larger the impervious area, the greater the potential for stormwater management. The impervious area was calculated using County GIS data. Impervious areas that were lower than the 25th percentile value were assigned lower scores and impervious areas that were higher than the 75th percentile value were assigned higher scores. Table D-5 shows the points assigned for the contributing impervious area in the two study watersheds.

Table D-5: Contributing Impervious Area

Percentile of Contributing Impervious Area	Declaration Run Watershed		Riverside Watershed	
	Impervious Area (Acres)	Points	Impervious Area (Acres)	Points
25th percentile	1.0	3	1.0	3
50th percentile	2.0	5	3.0	5
75th percentile	3.0	7	12.0	7
>75th percentile	>3.1	10	>12.0	10

E. Cost

The scores for cost were based on a comparison of costs for a new or retrofit project for each type of proposed stormwater management facility. Relative capital costs were adapted from the Maryland Department of the Environment's *Costs of Stormwater Management Practices in Maryland Counties* (MDE 2011). Table D-6 shows the points assigned for cost in the two study watersheds.

Table D-6: Cost

Cost Percentile	Declaration Run Watershed		Riverside Watershed	
	Cost	Points	Cost	Points
>75th percentile	>$201,100	3	>$321,200	3
50th percentile	$140,000	7	$85,700	7
75th percentile	$201,100	5	$321,200	5
25th percentile	$79,600	10	$55,900	10

F. Utility Impacts

An estimate of the impact of utilities on project implementation was based on data collected during the field reconnaissance. The points are based on the typical impacts existing utilities can have on a project during construction. An example of a major impact is having to relocate a utility, and an example of a minor impact is having to raise manhole rims. Table D-7 shows the points assigned for utility impacts.

Table D-7: Utility Impacts

Type of Impact	Explanation	Points
Major	Utilities would be affected directly during project implementation and may have to be relocated.	3
Minor	Utilities are near the project area.	5
Unknown	There are potential impacts, but data are insufficient to determine the extent of the impact.	5
None	No utilities were observed in the project vicinity.	10

G. Environmental Impacts

Potential environmental impacts were assigned the points listed in Table D-8. A lower score was assigned to projects that would affect wetlands or floodplains because obtaining regulatory approval for wetland and floodplain impacts can be time-consuming and expensive.

Table D-8: Environmental Impacts

Type of Impact	Points
Impacts to wetlands, large number of mature trees, and floodplains	3
Minor impacts to potential wetlands, some mature trees, streams, dam safety	5
Impacts to small trees or saplings (<6 inches in diameter)	7
No potential impacts	10

H. Stormwater Management Era

As the new National Pollutant Discharge Elimination System municipal separate storm sewer system permit is expected to focus on restoration of pre-1985 impervious area that has little or no stormwater management, a higher priority is given to all the sites that drain pre-1985 impervious cover. For areas draining to existing stormwater management facilities, the age of impervious cover draining to the facility was assumed to be the as-built date of the stormwater management facility. For drainage areas where a new stormwater management facility is proposed, the age of impervious cover was estimated using the year of construction date provided in the property ownership layer. A higher priority was given to proposed projects treating impervious area developed prior to 1985 and a lower priority was given to impervious area developed after 2002 as they are provided with adequate stormwater control based on the current Maryland stormwater management regulations. Table D-9 shows the points assigned for the date of construction of the impervious cover.

Table D-9: Stormwater Management Era

Impervious Cover Construction Date	Points
After 2010	1
2002–2010	3
1985–2002	7
Pre-1985	10

I. Estimated Pollutant Load Reduction

The estimated pollutant load reduction criterion evaluates the water quality benefits of a project by evaluating the reduction of the pollutant loadings that would be achieved by the proposed project. The pollutant reduction estimates are based on the performance-based removal efficiencies for total nitrogen, total phosphorus, and total suspended solids.

The proposed projects were modeled using the Center for Watershed Protection's Watershed Treatment Model (WTM), and the pollutant load reductions from each potential project were estimated. The pollutant removal rates provided in Table 4 of the Maryland Department of the Environment's *Draft Accounting for Stormwater Waste Load Allocations and Impervious Acres Treated* (MDE 2011) were used in the WTM model. Priority was given to the sites that would remove higher amounts of pollutants.

Tables D-10, D-11, and D-12 show the points assigned for the estimated pollutant load reduction for total nitrogen, total phosphorus, and total suspended solids, respectively.

Table D-10: Estimated Pollutant Load Reduction for Total Nitrogen

	Declaration Run		Riverside	
Total Nitrogen	Reduction (lbs/year)	Points	Reduction (lbs/year)	Points
25th percentile	12.0	1	30	1
50th percentile	25.0	1.5	42	1.5
75th percentile	43.0	2.5	142	2.5
>75th percentile	>43.0	3.3	>142	3.3

Table D-11: Estimated Pollutant Load Reduction for Total Phosphorus

	Declaration Run		Riverside	
Total Phosphorus	Reduction (lbs/year)	Points	Reduction (lbs/year)	Points
25th percentile	2.0	1	5	1
50th percentile	4.0	1.5	8	1.5
75th percentile	7.0	2.5	33	2.5
>75th percentile	>7.0	3.3	>33	3.3

Table D-12: Estimated Pollutant Load Reduction for Total Suspended Solids

	Declaration Run		Riverside	
Total Suspended Solids	Reduction (lbs/year)	Points	Reduction (lbs/year)	Points
25th percentile	404.0	1	1,024	1
50th percentile	754.0	1.5	1,549	1.5
75th percentile	1,281.0	2.5	6,521	2.5
>75th percentile	>1,281.0	3.3	>6,521	3.3

D.2 PRIORITY RANKING OF PROPOSED PROJECTS

The priority rankings of the stormwater management projects in the Declaration Run and Riverside watersheds are provided in Tables D-13 and D-14, respectively.

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Table D-13: Priority Ranking of Proposed Projects in the Declaration Run Watershed

Project ID	Project Location	Project Type	Score (Maximum of 10 Points)									Total Score	County Priority	Rank
			Property Ownership	Access to Project Site	Drainage Area	Impervious Area	Cost	Utility Impacts	Environmental Impacts	SWM Era	Estimated Pollutant Load Reduction			
D-SWM0110 (ES-1)	Church Creek Elementary School	Retrofit – infiltration basin	10	10	10	10	3	10	10	7	10	80	High	1
D-NS-9	Golden Rod Court	Tree box filters	3	10	7	10	5	5	10	7	8	65	Low	2
D-NS-12	Church Creek Elementary School	Bioretention	7	10	3	3	10	10	10	7	3	63	High	3
D-ES-8	Baneberry Drive	Retrofit – step pool conveyance system	5	3	10	10	5	10	3	7	10	63	High	3
D-ES-5	North end of Foxglove Court	Retrofit – bioretention	5	3	10	7	5	10	3	7	10	60	Low	5
D-NS-3	Liriope Court	Green roofs	3	10	3	3	10	10	10	7	3	59	Low	6
D-ES-15	Procedure Way	Retrofit – bioretention	5	10	5	7	7	5	5	7	8	59	High	6
D-ES-7	Germander Drive and Church Creek Road	Bioretention and water quality swale	3	10	5	5	10	10	5	7	3	58	High	8
D-ES-2	End of Oreganum Court	Retrofit – wetland	5	3	10	10	3	10	3	7	7	58	High	8
D-NS-8	Dalmation Place	Bioretention	3	7	7	7	7	5	7	7	8	58	High	8
D-ES- 6	Germander Drive	Bioretention	5	7	7	5	7	5	7	7	6	56	Medium	11
D-NS-7	Foxglove Court	Step pool conveyance	3	3	7	7	3	10	3	7	9	52	Low	12
D-ES- 12	End of Marigold Lane	Retrofit – micropool	5	3	3	3	10	10	5	7	5	51	Medium	13
D-NS-13	Church Creek Road across from Church Creek Elementary School	Green street	7	10	3	3	5	2	10	7	3	50	High	14
D-NS-4	Church Creek Road	Green street	7	10	5	5	3	2	3	7	5	47	Medium	15

Table D-14: Priority Ranking of Proposed Projects in the Riverside Watershed

Project ID	Project Location	Project Type	Score (Maximum of 10 Points)									Total Score	County Priority	Rank
			Property Ownership	Access to Project Site	Drainage Area	Impervious Area	Cost	Utility Impacts	Environmental Impacts	SWM Era	Estimated Pollutant Load Reduction			
R-ES-11	Halls Chance Road	Retrofit – wetland	5	10	10	10	3	10	3	10	10	71	High	1
R-NS-7	Caldwell Court South	Retrofit – swale	5	10	10	10	3	5	7	10	10	70	High	2
R-SWM0491[1]	West end of Millennium Drive	Retrofit – swale	5	10	7	7	7	10	10	3	8	67	Low	3
R-SWM0627[1]	Millennium Drive	Retrofit – swale	5	10	5	7	5	10	10	3	5	60	Low	4
R-NS-1	Belcamp Park	Bioretention	3	10	7	5	5	10	3	7	8	58	High	5
R-NS-6	Winners Circle	Rain garden	3	7	3	3	10	10	10	7	3	56	Low	6
R-NS-8	Carlyle Garth	Retrofit – swale	5	3	3	3	10	10	7	7	3	51	High	7

(1) Low-priority project because it was designed according to current Maryland stormwater management regulations

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Appendix E
Water Quality Volume and Channel Protection Volume Computations

E.1 DECLARATION RUN WATERSHED

Project: D-ES-2

Table E-1: Water Quality Volume Calculation for D-ES-2

Design Parameters	Site Value
Drainage Area (A, Acres)	11.3
Impervious Area (I, Acres)	4.9
Percent Impervious (%)	44
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.44
Soil Specific Recharge Factor (S)	0.24
Water Quality Volume (WQ_v, acre-feet)	**0.42**
Recharge Volume (Re_v, acre-feet)	**0.10**

Table E-2: Channel Protection Volume Calculation for D-ES-2

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.36
Time of Concentration (Tc, hrs)	0.24
Curve Number (CN)	86
Initial Abstraction (Ia, in)	0.32
Ia/P	0.12
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	728
1-Year post-development peak discharge (qi, cfs)	17.4
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.02
Peak outflow discharge (qo, cfs)	0.38
Ratio of storage to runoff volume (Vs/Vr)	0.65
Channel Protection Volume, Cp_v (acre-feet)	**0.83**

Project: D-ES-5

Table E-3: Water Quality Volume Calculation for D-ES-5

Design Parameters	Site Value
Drainage Area (A, Acres)	8.9
Impervious Area (I, Acres)	2.8
Percent Impervious (%)	32
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.33
Soil Specific Recharge Factor (S)	0.25
Water Quality Volume (WQ_v, acre-feet)	**0.25**
Recharge Volume (Re_v, acre-feet)	**0.06**

Table E-4: Channel Protection Volume Calculation D-ES-5

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	0.82
Time of Concentration (Tc, hrs)	0.27
Curve Number (CN)	77
Initial Abstraction (Ia, in)	0.59
Ia/P	0.23
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	623
1-Year post-development peak discharge (qi, cfs)	7.1
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.03
Peak outflow discharge (qo, cfs)	0.21
Ratio of storage to runoff volume (Vs/Vr)	0.64
Channel Protection Volume, Cp_v (acre-feet)	**0.39**

Project: D-ES-6

Table E-5: Water Quality Volume Calculation for D-ES-6

Design Parameters	Site Value
Drainage Area (A, Acres)	3.4
Impervious Area (I, Acres)	1.6
Percent Impervious (%)	47
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.47
Soil Specific Recharge Factor (S)	0.19
Water Quality Volume (WQ_v, acre-feet)	**0.13**
Recharge Volume (Re_v, acre-feet)	**0.03**

Table E-6: Channel Protection Volume Calculation for D-ES-6

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.46
Time of Concentration (Tc, hrs)	0.28
Curve Number (CN)	88
Initial Abstraction (Ia, in)	0.28
Ia/P	0.11
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	685
1-Year post-development peak discharge (qi, cfs)	5.29
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.03
Peak outflow discharge (qo, cfs)	0.13
Ratio of storage to runoff volume (Vs/Vr)	0.65
Channel Protection Volume, Cp_v (acre-feet)	**0.27**

Project: D-ES-7

Table E-7: Water Quality Volume Calculation for D-ES-7

Design Parameters	Site Value
Drainage Area (A, Acres)	2.8
Impervious Area (I, Acres)	1.6
Percent Impervious (%)	56
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.56
Soil Specific Recharge Factor (S)	0.19
Water Quality Volume (WQ_v, acre-feet)	**0.13**
Recharge Volume (Re_v, acre-feet)	**0.02**

Table E-8: Channel Protection Volume Calculation for D-ES-7

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.74
Time of Concentration (Tc, hrs)	0.35
Curve Number (CN)	91
Initial Abstraction (Ia, in)	0.19
Ia/P	0.07
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	656
1-Year post-development peak discharge (qi, cfs)	4.98
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.03
Peak outflow discharge (qo, cfs)	0.12
Ratio of storage to runoff volume (Vs/Vr)	0.65
Channel Protection Volume, Cp_v (acre-feet)	**0.26**

Project: D-ES-8

Table E-9: Water Quality Volume Calculation for D-ES-8

Design Parameters	Site Value
Drainage Area (A, Acres)	7.8
Impervious Area (I, Acres)	3.3
Percent Impervious (%)	42
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.43
Soil Specific Recharge Factor (S)	0.26
Water Quality Volume (WQ_v, acre-feet)	**0.28**
Recharge Volume (Re_v, acre-feet)	**0.07**

Table E-10: Channel Protection Volume Calculation for D-ES-8

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.60
1-Year post-development runoff depth (Qa, in)	1.16
Time of Concentration (Tc, hrs)	0.15
Curve Number (CN)	83
Initial Abstraction (Ia, in)	0.40
Ia/P	0.15
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	854
1-Year post-development peak discharge (qi, cfs)	12.09
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.02
Peak outflow discharge (qo, cfs)	0.24
Ratio of storage to runoff volume (Vs/Vr)	0.66
Channel Protection Volume, Cp_v (acre-feet)	**0.49**

Project: D-ES-12

Table E-11: Water Quality Volume Calculation for D-ES-12

Design Parameters	Site Value
Drainage Area (A, Acres)	1.8
Impervious Area (I, Acres)	1.0
Percent Impervious (%)	54
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.54
Soil Specific Recharge Factor (S)	0.22
Water Quality Volume (WQ_v, acre-feet)	**0.08**
Recharge Volume (Re_v, acre-feet)	**0.02**

Table E-12: Channel Protection Volume Calculation for D-ES-12

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.60
1-Year post-development runoff depth (Qa, in)	1.24
Time of Concentration (Tc, hrs)	0.03
Curve Number (CN)	85
Initial Abstraction (Ia, in)	0.36
Ia/P	0.14
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	1000
1-Year post-development peak discharge (qi, cfs)	3.4
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.02
Peak outflow discharge (qo, cfs)	0.07
Ratio of storage to runoff volume (Vs/Vr)	0.66
Channel Protection Volume, Cp_v (acre-feet)	**0.12**

Project:D-ES-15

Table E-13: Water Quality Volume Calculation for D-ES-15

Design Parameters	Site Value
Drainage Area (A, Acres)	3.3
Impervious Area (I, Acres)	2.2
Percent Impervious (%)	68
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.66
Soil Specific Recharge Factor (S)	0.22
Water Quality Volume (WQ_v, acre-feet)	**0.18**
Recharge Volume (Re_v, acre-feet)	**0.04**

Table E-14: Channel Protection Volume Calculation for D-ES-15

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.89
Time of Concentration (Tc, hrs)	0.18
Curve Number (CN)	93
Initial Abstraction (Ia, in)	0.15
Ia/P	0.06
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	829
1-Year post-development peak discharge (qi, cfs)	8.00
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.03
Peak outflow discharge (qo, cfs)	0.20
Ratio of storage to runoff volume (Vs/Vr)	0.65
Channel Protection Volume, Cp_v (acre-feet)	**0.33**

Project: D-NS-3

Table E-15: Water Quality Volume Calculation for D-NS-3

Design Parameters	Site Value
Drainage Area (A, Acres)	0.1
Impervious Area (I, Acres)	0.1
Percent Impervious (%)	99
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.95
Soil Specific Recharge Factor (S)	0.07
Water Quality Volume (WQ_v, acre-feet)	**0.01**
Recharge Volume (Re_v, acre-feet)	**0.0004**

Table E.16: Channel Protection Volume Calculation for D-NS-3

Channel Protection Volume, Cp_v (acre-feet)	**Not Required**

Project: D-NS-4

Table E-17: Water Quality Volume Calculation for D-NS-4

Design Parameters	Site Value
Drainage Area (A, Acres)	2.1
Impervious Area (I, Acres)	1.6
Percent Impervious (%)	79
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.76
Soil Specific Recharge Factor (S)	0.19
Water Quality Volume (WQ_v, acre-feet)	**0.13**
Recharge Volume (Re_v, acre-feet)	**0.025**

Table E-18: Channel Protection Volume Calculation for D-NS-4

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	2.4
Time of Concentration (Tc, hrs)	0.1
Curve Number (CN)	98
Initial Abstraction (Ia, in)	0.04
Ia/P	0.016
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	1000
1-Year post-development peak discharge (qi, cfs)	7.9
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.02
Peak outflow discharge (qo, cfs)	0.2
Ratio of storage to runoff volume (Vs/Vr)	0.66
Channel Protection Volume, Cp_v (acre-feet)	**0.27**

Project: D-NS-7

Table E-19: Water Quality Volume Calculation for D-NS-7

Design Parameters	Site Value
Drainage Area (A, Acres)	6.0
Impervious Area (I, Acres)	2.1
Percent Impervious (%)	34
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.36
Soil Specific Recharge Factor (S)	0.24
Water Quality Volume (WQ_v, acre-feet)	**0.18**
Recharge Volume (Re_v, acre-feet)	**0.04**

Table E-20: Channel Protection Volume Calculation for D-NS-7

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	0.75
Time of Concentration (Tc, hrs)	0.27
Curve Number (CN)	76
Initial Abstraction (Ia, in)	0.64
Ia/P	0.25
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	614
1-Year post-development peak discharge (qi, cfs)	4.31
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.04
Peak outflow discharge (qo, cfs)	0.15
Ratio of storage to runoff volume (Vs/Vr)	0.63
Channel Protection Volume, Cp_v (acre-feet)	**0.24**

Project: D-NS-8

Table E-21: Water Quality Volume Calculation for D-NS-8

Design Parameters	Site Value
Drainage Area (A, Acres)	4.6
Impervious Area (I, Acres)	2.5
Percent Impervious (%)	55
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.55
Soil Specific Recharge Factor (S)	0.22
Water Quality Volume (WQ_v, acre-feet)	**0.21**
Recharge Volume (Re_v, acre-feet)	**0.05**

Table E-22: Channel Protection Volume Calculation for D-NS-8

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.34
Time of Concentration (Tc, hrs)	0.13
Curve Number (CN)	86
Initial Abstraction (Ia, in)	0.32
Ia/P	0.12
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	936
1-Year post-development peak discharge (qi, cfs)	8.9
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.02
Peak outflow discharge (qo, cfs)	0.18
Ratio of storage to runoff volume (Vs/Vr)	0.65
Channel Protection Volume, Cp_v (acre-feet)	**0.33**

Project: D-NS-9

Table E-23: Water Quality Volume Calculation for D-NS-9

Design Parameters	Site Value
Drainage Area (A, Acres)	6.3
Impervious Area (I, Acres)	3.6
Percent Impervious (%)	57
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.57
Soil Specific Recharge Factor (S)	0.23
Water Quality Volume (WQ_v, acre-feet)	**0.30**
Recharge Volume (Re_v, acre-feet)	**0.07**

Table E-24: Channel Protection Volume Calculation for D-NS-9

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.34
Time of Concentration (Tc, hrs)	0.19
Curve Number (CN)	86
Initial Abstraction (Ia, in)	0.32
Ia/P	0.12
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	780
1-Year post-development peak discharge (qi, cfs)	10.3
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.03
Peak outflow discharge (qo, cfs)	0.31
Ratio of storage to runoff volume (Vs/Vr)	0.64
Channel Protection Volume, Cp_v (acre-feet)	**0.45**

Project: D-NS-12

Table E-25: Water Quality Volume Calculation for D-NS-12

Design Parameters	Site Value
Drainage Area (A, Acres)	0.9
Impervious Area (I, Acres)	0.9
Percent Impervious (%)	96
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.91
Soil Specific Recharge Factor (S)	0.13
Water Quality Volume (WQ_v, acre-feet)	**0.07**
Recharge Volume (Re_v, acre-feet)	**0.01**

Table E-26: Channel Protection Volume Calculation for D-NS-12

Design Parameters	Site Value
Channel Protection Volume, Cp_v (acre-feet)	**Not Required**

Project: D-NS-13

Table E-27: Water Quality Volume Calculation for D-NS-13

Design Parameters	Site Value
Drainage Area (A, Acres)	0.9
Impervious Area (I, Acres)	0.8
Percent Impervious (%)	84
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.81
Soil Specific Recharge Factor (S)	0.19
Water Quality Volume (WQ_v, acre-feet)	**0.06**
Recharge Volume (Re_v, acre-feet)	**0.01**

Table E-28: Channel Protection Volume Calculation for D-NS-13

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.60
1-Year post-development runoff depth (Qa, in)	2.36
Time of Concentration (Tc, hrs)	0.04
Curve Number (CN)	98
Initial Abstraction (Ia, in)	0.04
Ia/P	0.02
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	1000
1-Year post-development peak discharge (qi, cfs)	3.35
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.02
Peak outflow discharge (qo, cfs)	0.05
Ratio of storage to runoff volume (Vs/Vr)	0.66
Channel Protection Volume, Cp_v (acre-feet)	**0.12**

Project: D-SWM0110(ES-1)

Table E-29: Water Quality Volume Calculation for D-SWM0110 (ES-1)

Design Parameters	Site Value
Drainage Area (A, Acres)	8.2
Impervious Area (I, Acres)	4.4
Percent Impervious (%)	54
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.54
Soil Specific Recharge Factor (S)	0.19
Water Quality Volume (WQ_v, acre-feet)	**0.37**
Recharge Volume (Re_v, acre-feet)	**0.07**

Table E-30: Channel Protection Volume Calculation for D-SWM0110 (ES-1)

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.60
1-Year post-development runoff depth (Qa, in)	1.15
Time of Concentration (Tc, hrs)	0.36
Curve Number (CN)	83
Initial Abstraction (Ia, in)	0.41
Ia/P	0.16
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	600
1-Year post-development peak discharge (qi, cfs)	8.81
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.03
Peak outflow discharge (qo, cfs)	0.26
Ratio of storage to runoff volume (Vs/Vr)	0.64
Channel Protection Volume, Cp_v (acre-feet)	**0.50**

E.2 RIVERSIDE WATERSHED

Project: R-ES-1

Table E-31: Water Quality Volume Calculation for R-ES-1

Design Parameters	Site Value
Drainage Area (A, Acres)	130.4
Impervious Area (I, Acres)	40.30
Percent Impervious (%)	31
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.33
Soil Specific Recharge Factor (S)	0.20
Water Quality Volume (WQ_v, Acre-feet)	**3.57**
Recharge Volume (Re_v, acre-feet)	**0.71**

Table E-32: Channel Protection Volume Calculation for R-ES-1

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.08
Time of Concentration (Tc, hrs)	0.43
Curve Number (CN)	82
Initial Abstraction (Ia, in)	0.44
Ia/P	0.17
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	542
1-Year post-development peak discharge (qi, cfs)	118.8
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.04
Peak outflow discharge (qo, cfs)	4.75
Ratio of storage to runoff volume (Vs/Vr)	0.63
Channel Protection Volume, Cp_v (acre-feet)	**7.35**

Project: R-NS-1

Table E-33: Water Quality Volume Calculation for R-NS-1

Design Parameters	Site Value
Drainage Area (A, Acres)	5.5
Impervious Area (I, Acres)	1.7
Percent Impervious (%)	31
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.33
Soil Specific Recharge Factor (S)	0.15
Water Quality Volume (WQ_v, acre-feet)	**0.15**
Recharge Volume (Re_v, acre-feet)	**0.02**

Table E-34: Channel Protection Volume Calculation for R-NS-1

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.30
Time of Concentration (Tc, hrs)	0.30
Curve Number (CN)	86
Initial Abstraction (Ia, in)	0.34
Ia/P	0.13
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	662
1-Year post-development peak discharge (qi, cfs)	7.4
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.03
Peak outflow discharge (qo, cfs)	0.18
Ratio of storage to runoff volume (Vs/Vr)	0.65
Channel Protection Volume, Cp_v (acre-feet)	**0.38**

Project: R-NS-6

Table E-35: Water Quality Volume Calculation for R-NS-6

Design Parameters	Site Value
Drainage Area (A, Acres)	1.3
Impervious Area (I, Acres)	0.2
Percent Impervious (%)	17
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.20
Soil Specific Recharge Factor (S)	0.14
Water Quality Volume (WQ_v, acre-feet)	**0.02**
Recharge Volume (Re_v, acre-feet)	**0.003**

Table E-36: Channel Protection Volume Calculation for R-NS-6

Design Parameters	Site Value
Channel Protection Volume, Cp_v (acre-feet)	**Not Required**

Project: R-NS-7

Table E-37: Water Quality Volume Calculation for R-NS-7

Design Parameters	Site Value
Drainage Area (A, Acres)	64.3
Impervious Area (I, Acres)	21.4
Percent Impervious (%)	33
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.35
Soil Specific Recharge Factor (S)	0.19
Water Quality Volume (WQ_v, acre-feet)	**1.9**
Recharge Volume (Re_v, acre-feet)	**0.36**

Table E-38: Channel Protection Volume Calculation for R-NS-7

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.25
Time of Concentration (Tc, hrs)	0.42
Curve Number (CN)	85
Initial Abstraction (Ia, in)	0.36
Ia/P	0.14
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	561
1-Year post-development peak discharge (qi, cfs)	70.2
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.04
Peak outflow discharge (qo, cfs)	2.46
Ratio of storage to runoff volume (Vs/Vr)	0.64
Channel Protection Volume, Cp_v (acre-feet)	**4.24**

Project: R-NS-8

Table E-39: Water Quality Volume Calculation for R-NS-8

Design Parameters	Site Value
Drainage Area (A, Acres)	1.8
Impervious Area (I, Acres)	0.7
Percent Impervious (%)	38
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.39
Soil Specific Recharge Factor (S)	0.21
Water Quality Volume (WQ_v, acre-feet)	**0.06**
Recharge Volume (Re_v, acre-feet)	**0.01**

Table E-40: Channel Protection Volume Calculation for R-NS-8

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.06
Time of Concentration (Tc, hrs)	0.21
Curve Number (CN)	82
Initial Abstraction (Ia, in)	0.45
Ia/P	0.17
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	764
1-Year post-development peak discharge (qi, cfs)	2.34
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.03
Peak outflow discharge (qo, cfs)	0.06
Ratio of storage to runoff volume (Vs/Vr)	0.65
Channel Protection Volume, Cp_v (acre-feet)	**0.11**

Project: R-SWM0491

Table E-41: Water Quality Volume Calculation for R-SWM0491

Design Parameters	Site Value
Drainage Area (A, Acres)	4.9
Impervious Area (I, Acres)	3.1
Percent Impervious (%)	64
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.62
Soil Specific Recharge Factor (S)	0.14
Water Quality Volume (WQ_v, acre-feet)	**0.25**
Recharge Volume (Re_v, acre-feet)	**0.034**

Table E-42: Channel Protection Volume Calculation for R-SWM0491

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.87
Time of Concentration (Tc, hrs)	0.12
Curve Number (CN)	93
Initial Abstraction (Ia, in)	0.15
Ia/P	0.06
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	970
1-Year post-development peak discharge (qi, cfs)	13.8
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.02
Peak outflow discharge (qo, cfs)	0.28
Ratio of storage to runoff volume (Vs/Vr)	0.66
Channel Protection Volume, Cp_v (acre-feet)	**0.50**

Project: R-SWM0627

Table E-43: Water Quality Volume Calculation for R-SWM0627

Design Parameters	Site Value
Drainage Area (A, Acres)	4.6
Impervious Area (I, Acres)	3.3
Percent Impervious (%)	73
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.71
Soil Specific Recharge Factor (S)	0.12
Water Quality Volume (WQ_v, acre-feet)	**0.27**
Recharge Volume (Re_v, acre-feet)	**0.032**

Table E-44: Channel Protection Volume Calculation for R-SWM0627

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.99
Time of Concentration (Tc, hrs)	0.06
Curve Number (CN)	94
Initial Abstraction (Ia, in)	0.12
Ia/P	0.05
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	1000
1-Year post-development peak discharge (qi, cfs)	14.2
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.02
Peak outflow discharge (qo, cfs)	0.28
Ratio of storage to runoff volume (Vs/Vr)	0.66
Channel Protection Volume, Cp_v (acre-feet)	**0.49**

Appendix E
Water Quality Volume and Channel Protection Volume Computations

E.1 DECLARATION RUN WATERSHED

Project: D-ES-2

Table E-1: Water Quality Volume Calculation for D-ES-2

Design Parameters	Site Value
Drainage Area (A, Acres)	11.3
Impervious Area (I, Acres)	4.9
Percent Impervious (%)	44
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.44
Soil Specific Recharge Factor (S)	0.24
Water Quality Volume (WQ_v, acre-feet)	**0.42**
Recharge Volume (Re_v, acre-feet)	**0.10**

Table E-2: Channel Protection Volume Calculation for D-ES-2

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.36
Time of Concentration (Tc, hrs)	0.24
Curve Number (CN)	86
Initial Abstraction (Ia, in)	0.32
Ia/P	0.12
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	728
1-Year post-development peak discharge (qi, cfs)	17.4
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.02
Peak outflow discharge (qo, cfs)	0.38
Ratio of storage to runoff volume (Vs/Vr)	0.65
Channel Protection Volume, Cp_v (acre-feet)	**0.83**

Project: D-ES-5

Table E-3: Water Quality Volume Calculation for D-ES-5

Design Parameters	Site Value
Drainage Area (A, Acres)	8.9
Impervious Area (I, Acres)	2.8
Percent Impervious (%)	32
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.33
Soil Specific Recharge Factor (S)	0.25
Water Quality Volume (WQ_v, acre-feet)	**0.25**
Recharge Volume (Re_v, acre-feet)	**0.06**

Table E-4: Channel Protection Volume Calculation D-ES-5

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	0.82
Time of Concentration (Tc, hrs)	0.27
Curve Number (CN)	77
Initial Abstraction (Ia, in)	0.59
Ia/P	0.23
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	623
1-Year post-development peak discharge (qi, cfs)	7.1
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.03
Peak outflow discharge (qo, cfs)	0.21
Ratio of storage to runoff volume (Vs/Vr)	0.64
Channel Protection Volume, Cp_v (acre-feet)	**0.39**

Project: D-ES-6

Table E-5: Water Quality Volume Calculation for D-ES-6

Design Parameters	Site Value
Drainage Area (A, Acres)	3.4
Impervious Area (I, Acres)	1.6
Percent Impervious (%)	47
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.47
Soil Specific Recharge Factor (S)	0.19
Water Quality Volume (WQ_v, acre-feet)	**0.13**
Recharge Volume (Re_v, acre-feet)	**0.03**

Table E-6: Channel Protection Volume Calculation for D-ES-6

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.46
Time of Concentration (Tc, hrs)	0.28
Curve Number (CN)	88
Initial Abstraction (Ia, in)	0.28
Ia/P	0.11
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	685
1-Year post-development peak discharge (qi, cfs)	5.29
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.03
Peak outflow discharge (qo, cfs)	0.13
Ratio of storage to runoff volume (Vs/Vr)	0.65
Channel Protection Volume, Cp_v (acre-feet)	**0.27**

Project: D-ES-7

Table E-7: Water Quality Volume Calculation for D-ES-7

Design Parameters	Site Value
Drainage Area (A, Acres)	2.8
Impervious Area (I, Acres)	1.6
Percent Impervious (%)	56
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.56
Soil Specific Recharge Factor (S)	0.19
Water Quality Volume (WQ_v, acre-feet)	**0.13**
Recharge Volume (Re_v, acre-feet)	**0.02**

Table E-8: Channel Protection Volume Calculation for D-ES-7

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.74
Time of Concentration (Tc, hrs)	0.35
Curve Number (CN)	91
Initial Abstraction (Ia, in)	0.19
Ia/P	0.07
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	656
1-Year post-development peak discharge (qi, cfs)	4.98
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.03
Peak outflow discharge (qo, cfs)	0.12
Ratio of storage to runoff volume (Vs/Vr)	0.65
Channel Protection Volume, Cp_v (acre-feet)	**0.26**

Project: D-ES-8

Table E-9: Water Quality Volume Calculation for D-ES-8

Design Parameters	Site Value
Drainage Area (A, Acres)	7.8
Impervious Area (I, Acres)	3.3
Percent Impervious (%)	42
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.43
Soil Specific Recharge Factor (S)	0.26
Water Quality Volume (WQ_v, acre-feet)	**0.28**
Recharge Volume (Re_v, acre-feet)	**0.07**

Table E-10: Channel Protection Volume Calculation for D-ES-8

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.60
1-Year post-development runoff depth (Qa, in)	1.16
Time of Concentration (Tc, hrs)	0.15
Curve Number (CN)	83
Initial Abstraction (Ia, in)	0.40
Ia/P	0.15
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	854
1-Year post-development peak discharge (qi, cfs)	12.09
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.02
Peak outflow discharge (qo, cfs)	0.24
Ratio of storage to runoff volume (Vs/Vr)	0.66
Channel Protection Volume, Cp_v (acre-feet)	**0.49**

Project: D-ES-12

Table E-11: Water Quality Volume Calculation for D-ES-12

Design Parameters	Site Value
Drainage Area (A, Acres)	1.8
Impervious Area (I, Acres)	1.0
Percent Impervious (%)	54
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.54
Soil Specific Recharge Factor (S)	0.22
Water Quality Volume (WQ_v, acre-feet)	**0.08**
Recharge Volume (Re_v, acre-feet)	**0.02**

Table E-12: Channel Protection Volume Calculation for D-ES-12

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.60
1-Year post-development runoff depth (Qa, in)	1.24
Time of Concentration (Tc, hrs)	0.03
Curve Number (CN)	85
Initial Abstraction (Ia, in)	0.36
Ia/P	0.14
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	1000
1-Year post-development peak discharge (qi, cfs)	3.4
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.02
Peak outflow discharge (qo, cfs)	0.07
Ratio of storage to runoff volume (Vs/Vr)	0.66
Channel Protection Volume, Cp_v (acre-feet)	**0.12**

Project:D-ES-15

Table E-13: Water Quality Volume Calculation for D-ES-15

Design Parameters	Site Value
Drainage Area (A, Acres)	3.3
Impervious Area (I, Acres)	2.2
Percent Impervious (%)	68
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.66
Soil Specific Recharge Factor (S)	0.22
Water Quality Volume (WQ_v, acre-feet)	**0.18**
Recharge Volume (Re_v, acre-feet)	**0.04**

Table E-14: Channel Protection Volume Calculation for D-ES-15

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.89
Time of Concentration (Tc, hrs)	0.18
Curve Number (CN)	93
Initial Abstraction (Ia, in)	0.15
Ia/P	0.06
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	829
1-Year post-development peak discharge (qi, cfs)	8.00
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.03
Peak outflow discharge (qo, cfs)	0.20
Ratio of storage to runoff volume (Vs/Vr)	0.65
Channel Protection Volume, Cp_v (acre-feet)	**0.33**

Project: D-NS-3

Table E-15: Water Quality Volume Calculation for D-NS-3

Design Parameters	**Site Value**
Drainage Area (A, Acres)	0.1
Impervious Area (I, Acres)	0.1
Percent Impervious (%)	99
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.95
Soil Specific Recharge Factor (S)	0.07
Water Quality Volume (WQ_v, acre-feet)	**0.01**
Recharge Volume (Re_v, acre-feet)	**0.0004**

Table E.16: Channel Protection Volume Calculation for D-NS-3

Channel Protection Volume, Cp_v (acre-feet)	**Not Required**

Project: D-NS-4

Table E-17: Water Quality Volume Calculation for D-NS-4

Design Parameters	Site Value
Drainage Area (A, Acres)	2.1
Impervious Area (I, Acres)	1.6
Percent Impervious (%)	79
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.76
Soil Specific Recharge Factor (S)	0.19
Water Quality Volume (WQ_v, acre-feet)	**0.13**
Recharge Volume (Re_v, acre-feet)	**0.025**

Table E-18: Channel Protection Volume Calculation for D-NS-4

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	2.4
Time of Concentration (Tc, hrs)	0.1
Curve Number (CN)	98
Initial Abstraction (Ia, in)	0.04
Ia/P	0.016
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	1000
1-Year post-development peak discharge (qi, cfs)	7.9
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.02
Peak outflow discharge (qo, cfs)	0.2
Ratio of storage to runoff volume (Vs/Vr)	0.66
Channel Protection Volume, Cp_v (acre-feet)	**0.27**

Project: D-NS-7

Table E-19: Water Quality Volume Calculation for D-NS-7

Design Parameters	Site Value
Drainage Area (A, Acres)	6.0
Impervious Area (I, Acres)	2.1
Percent Impervious (%)	34
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.36
Soil Specific Recharge Factor (S)	0.24
Water Quality Volume (WQ_v, acre-feet)	**0.18**
Recharge Volume (Re_v, acre-feet)	**0.04**

Table E-20: Channel Protection Volume Calculation for D-NS-7

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	0.75
Time of Concentration (Tc, hrs)	0.27
Curve Number (CN)	76
Initial Abstraction (Ia, in)	0.64
Ia/P	0.25
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	614
1-Year post-development peak discharge (qi, cfs)	4.31
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.04
Peak outflow discharge (qo, cfs)	0.15
Ratio of storage to runoff volume (Vs/Vr)	0.63
Channel Protection Volume, Cp_v (acre-feet)	**0.24**

Project: D-NS-8

Table E-21: Water Quality Volume Calculation for D-NS-8

Design Parameters	Site Value
Drainage Area (A, Acres)	4.6
Impervious Area (I, Acres)	2.5
Percent Impervious (%)	55
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.55
Soil Specific Recharge Factor (S)	0.22
Water Quality Volume (WQ_v, acre-feet)	**0.21**
Recharge Volume (Re_v, acre-feet)	**0.05**

Table E-22: Channel Protection Volume Calculation for D-NS-8

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.34
Time of Concentration (Tc, hrs)	0.13
Curve Number (CN)	86
Initial Abstraction (Ia, in)	0.32
Ia/P	0.12
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	936
1-Year post-development peak discharge (qi, cfs)	8.9
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.02
Peak outflow discharge (qo, cfs)	0.18
Ratio of storage to runoff volume (Vs/Vr)	0.65
Channel Protection Volume, Cp_v (acre-feet)	**0.33**

Project: D-NS-9

Table E-23: Water Quality Volume Calculation for D-NS-9

Design Parameters	Site Value
Drainage Area (A, Acres)	6.3
Impervious Area (I, Acres)	3.6
Percent Impervious (%)	57
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.57
Soil Specific Recharge Factor (S)	0.23
Water Quality Volume (WQ_v, acre-feet)	**0.30**
Recharge Volume (Re_v, acre-feet)	**0.07**

Table E-24: Channel Protection Volume Calculation for D-NS-9

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.34
Time of Concentration (Tc, hrs)	0.19
Curve Number (CN)	86
Initial Abstraction (Ia, in)	0.32
Ia/P	0.12
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	780
1-Year post-development peak discharge (qi, cfs)	10.3
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.03
Peak outflow discharge (qo, cfs)	0.31
Ratio of storage to runoff volume (Vs/Vr)	0.64
Channel Protection Volume, Cp_v (acre-feet)	**0.45**

Project: D-NS-12

Table E-25: Water Quality Volume Calculation for D-NS-12

Design Parameters	Site Value
Drainage Area (A, Acres)	0.9
Impervious Area (I, Acres)	0.9
Percent Impervious (%)	96
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.91
Soil Specific Recharge Factor (S)	0.13
Water Quality Volume (WQ_v, acre-feet)	**0.07**
Recharge Volume (Re_v, acre-feet)	**0.01**

Table E-26: Channel Protection Volume Calculation for D-NS-12

Design Parameters	Site Value
Channel Protection Volume, Cp_v (acre-feet)	**Not Required**

Project: D-NS-13

Table E-27: Water Quality Volume Calculation for D-NS-13

Design Parameters	Site Value
Drainage Area (A, Acres)	0.9
Impervious Area (I, Acres)	0.8
Percent Impervious (%)	84
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.81
Soil Specific Recharge Factor (S)	0.19
Water Quality Volume (WQ_v, acre-feet)	**0.06**
Recharge Volume (Re_v, acre-feet)	**0.01**

Table E-28: Channel Protection Volume Calculation for D-NS-13

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.60
1-Year post-development runoff depth (Qa, in)	2.36
Time of Concentration (Tc, hrs)	0.04
Curve Number (CN)	98
Initial Abstraction (Ia, in)	0.04
Ia/P	0.02
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	1000
1-Year post-development peak discharge (qi, cfs)	3.35
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.02
Peak outflow discharge (qo, cfs)	0.05
Ratio of storage to runoff volume (Vs/Vr)	0.66
Channel Protection Volume, Cp_v (acre-feet)	**0.12**

Project: D-SWM0110(ES-1)

Table E-29: Water Quality Volume Calculation for D-SWM0110 (ES-1)

Design Parameters	Site Value
Drainage Area (A, Acres)	8.2
Impervious Area (I, Acres)	4.4
Percent Impervious (%)	54
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.54
Soil Specific Recharge Factor (S)	0.19
Water Quality Volume (WQ_v, acre-feet)	**0.37**
Recharge Volume (Re_v, acre-feet)	**0.07**

Table E-30: Channel Protection Volume Calculation for D-SWM0110 (ES-1)

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.60
1-Year post-development runoff depth (Qa, in)	1.15
Time of Concentration (Tc, hrs)	0.36
Curve Number (CN)	83
Initial Abstraction (Ia, in)	0.41
Ia/P	0.16
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	600
1-Year post-development peak discharge (qi, cfs)	8.81
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.03
Peak outflow discharge (qo, cfs)	0.26
Ratio of storage to runoff volume (Vs/Vr)	0.64
Channel Protection Volume, Cp_v (acre-feet)	**0.50**

E.2 RIVERSIDE WATERSHED

Project: R-ES-1

Table E-31: Water Quality Volume Calculation for R-ES-1

Design Parameters	Site Value
Drainage Area (A, Acres)	130.4
Impervious Area (I, Acres)	40.30
Percent Impervious (%)	31
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.33
Soil Specific Recharge Factor (S)	0.20
Water Quality Volume (WQ_v, Acre-feet)	**3.57**
Recharge Volume (Re_v, acre-feet)	**0.71**

Table E-32: Channel Protection Volume Calculation for R-ES-1

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.08
Time of Concentration (Tc, hrs)	0.43
Curve Number (CN)	82
Initial Abstraction (Ia, in)	0.44
Ia/P	0.17
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	542
1-Year post-development peak discharge (qi, cfs)	118.8
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.04
Peak outflow discharge (qo, cfs)	4.75
Ratio of storage to runoff volume (Vs/Vr)	0.63
Channel Protection Volume, Cp_v (acre-feet)	**7.35**

Project: R-NS-1

Table E-33: Water Quality Volume Calculation for R-NS-1

Design Parameters	Site Value
Drainage Area (A, Acres)	5.5
Impervious Area (I, Acres)	1.7
Percent Impervious (%)	31
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.33
Soil Specific Recharge Factor (S)	0.15
Water Quality Volume (WQ_v, acre-feet)	**0.15**
Recharge Volume (Re_v, acre-feet)	**0.02**

Table E-34: Channel Protection Volume Calculation for R-NS-1

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.30
Time of Concentration (Tc, hrs)	0.30
Curve Number (CN)	86
Initial Abstraction (Ia, in)	0.34
Ia/P	0.13
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	662
1-Year post-development peak discharge (qi, cfs)	7.4
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.03
Peak outflow discharge (qo, cfs)	0.18
Ratio of storage to runoff volume (Vs/Vr)	0.65
Channel Protection Volume, Cp_v (acre-feet)	**0.38**

Project: R-NS-6

Table E-35: Water Quality Volume Calculation for R-NS-6

Design Parameters	Site Value
Drainage Area (A, Acres)	1.3
Impervious Area (I, Acres)	0.2
Percent Impervious (%)	17
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.20
Soil Specific Recharge Factor (S)	0.14
Water Quality Volume (WQ_v, acre-feet)	**0.02**
Recharge Volume (Re_v, acre-feet)	**0.003**

Table E-36: Channel Protection Volume Calculation for R-NS-6

Design Parameters	Site Value
Channel Protection Volume, Cp_v (acre-feet)	**Not Required**

Project: R-NS-7

Table E-37: Water Quality Volume Calculation for R-NS-7

Design Parameters	Site Value
Drainage Area (A, Acres)	64.3
Impervious Area (I, Acres)	21.4
Percent Impervious (%)	33
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.35
Soil Specific Recharge Factor (S)	0.19
Water Quality Volume (WQ_v, acre-feet)	**1.9**
Recharge Volume (Re_v, acre-feet)	**0.36**

Table E-38: Channel Protection Volume Calculation for R-NS-7

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.25
Time of Concentration (Tc, hrs)	0.42
Curve Number (CN)	85
Initial Abstraction (Ia, in)	0.36
Ia/P	0.14
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	561
1-Year post-development peak discharge (qi, cfs)	70.2
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.04
Peak outflow discharge (qo, cfs)	2.46
Ratio of storage to runoff volume (Vs/Vr)	0.64
Channel Protection Volume, Cp_v (acre-feet)	**4.24**

Project: R-NS-8

Table E-39: Water Quality Volume Calculation for R-NS-8

Design Parameters	Site Value
Drainage Area (A, Acres)	1.8
Impervious Area (I, Acres)	0.7
Percent Impervious (%)	38
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.39
Soil Specific Recharge Factor (S)	0.21
Water Quality Volume (WQ_v, acre-feet)	**0.06**
Recharge Volume (Re_v, acre-feet)	**0.01**

Table E-40: Channel Protection Volume Calculation for R-NS-8

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.06
Time of Concentration (Tc, hrs)	0.21
Curve Number (CN)	82
Initial Abstraction (Ia, in)	0.45
Ia/P	0.17
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	764
1-Year post-development peak discharge (qi, cfs)	2.34
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.03
Peak outflow discharge (qo, cfs)	0.06
Ratio of storage to runoff volume (Vs/Vr)	0.65
Channel Protection Volume, Cp_v (acre-feet)	**0.11**

Project: R-SWM0491

Table E-41: Water Quality Volume Calculation for R-SWM0491

Design Parameters	Site Value
Drainage Area (A, Acres)	4.9
Impervious Area (I, Acres)	3.1
Percent Impervious (%)	64
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.62
Soil Specific Recharge Factor (S)	0.14
Water Quality Volume (WQ_v, acre-feet)	**0.25**
Recharge Volume (Re_v, acre-feet)	**0.034**

Table E-42: Channel Protection Volume Calculation for R-SWM0491

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.87
Time of Concentration (Tc, hrs)	0.12
Curve Number (CN)	93
Initial Abstraction (Ia, in)	0.15
Ia/P	0.06
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	970
1-Year post-development peak discharge (qi, cfs)	13.8
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.02
Peak outflow discharge (qo, cfs)	0.28
Ratio of storage to runoff volume (Vs/Vr)	0.66
Channel Protection Volume, Cp_v (acre-feet)	**0.50**

Project: R-SWM0627

Table E-43: Water Quality Volume Calculation for R-SWM0627

Design Parameters	Site Value
Drainage Area (A, Acres)	4.6
Impervious Area (I, Acres)	3.3
Percent Impervious (%)	73
Rainfall Depth (P, inches)	1.0
Volumetric Runoff Coefficient (R_v)	0.71
Soil Specific Recharge Factor (S)	0.12
Water Quality Volume (WQ_v, acre-feet)	**0.27**
Recharge Volume (Re_v, acre-feet)	**0.032**

Table E-44: Channel Protection Volume Calculation for R-SWM0627

Design Parameters	Site Value
1-Year Precipitation for Harford County (P, in)	2.6
1-Year post-development runoff depth (Qa, in)	1.99
Time of Concentration (Tc, hrs)	0.06
Curve Number (CN)	94
Initial Abstraction (Ia, in)	0.12
Ia/P	0.05
qu (csm/in), (taken from Figure D.11.1, in MDE Manual)	1000
1-Year post-development peak discharge (qi, cfs)	14.2
Outflow to inflow ratio (qo/qi), Use Type I, 24 hours	0.02
Peak outflow discharge (qo, cfs)	0.28
Ratio of storage to runoff volume (Vs/Vr)	0.66
Channel Protection Volume, Cp_v (acre-feet)	**0.49**