Attachment C: Stormwater Concept Approval Letter

City of Takoma Park

DEPARTMENT OF PUBLIC WORKS
Oswego Avenue 31
Silver Spring, MD 20910
Telephone: 301-891-7633

Nonmember 8, 2024

Ms. Roz Grigsby Community Development Manager
City of Takoma Park
7500 Maple Avenue
Takoma Park, MD
20912

RE: Stormwater Management Concept Approval SWC24-10-18
MET Branch Trail Upgrade

Dear Ms. Grigsby:

The referenced Stormwater Management Concept No. SWC24-10-18 based on 30% plans has been reviewed and approved. This approval and subsequent permit are contingent upon the following items:

1. Approval of the tree protection plan within the LOD by City of Takoma Park Urban Forest Manager prior to finalization of the plans.

2. Approved sediment and erosion control plans from DPS Montgomery County.

3. Satisfactory Geotechnical Investigation and Infiltration rates at the location(s) of the proposed micro bioretention and swale facilities

4. Please describe in subsequent development stages how The Environmental Site Design (ESD) is provided to Maximum Extent Practicable (MEP)

5. In subsequent submittals Provide sufficient rational for requested water quality variances and clarify request for “a debit of O.21 Acres from “WQ Bank”.

Should you have any questions, please contact the undersigned at 301-891-7620 or email at allk@takomaparkmd.gov.

Sincerely yours,

Ali Khalilian, P.E.
City Engineer

cc: Robert Gillespie, P.E. RK&K
700 E. Pratt Street, Suite 500
Baltimore, MD 21202

FILE

700 East Pratt Street, Suite 500 | Baltimore, MD 21202 | P 410.728.2900 | www.rkk.com

Date: October 8, 2024

To: City of Takoma Park
Ms. Rosalind Grigsby, Community Development Manager

From: Jonathan Clunie, PE – RK&K

Cc: Robert Gillespie, PE – RK&K
Emily F. Martin, PE – RK&K

Subject: **Metropolitan Branch Trail Upgrade**
DC Line to South of New York Avenue

RE: Stormwater Management (SWM) Concept Summary

Background

The project limits for the *Metropolitan (Met) Branch Trail* are along the west side of Takoma Avenue / Fenton Street from the Washinton DC Line to approximately 250 feet south of the Fenton Street / New York Avenue intersection; an approximate distance of 0.45 miles. RK&K submitted 30% design plans to the City in May 2023 and made updates in October 2024 to address agency comments received requesting to widen the existing asphalt trail segment that connects from the intersection of Takoma Avenue / Fenton Street to the Met Branch Trail at approximately STA 63+25. The project will improve the existing trail to meet current design guidelines and standards and to provide a continuous trail that is safe for all user types.

Concept Stormwater Management Design Analysis

The site was divided into four (4) Points of Investigation (POIs) for stormwater analysis.

- **POI 1** is located at an existing inlet along northbound Takoma Avenue just after Buffalo Avenue. The POI encompasses all work from the intersection of Takoma Avenue and Baltimore Avenue to the high point at STA 63+14. The work proposed in this POI involves reconstruction and widening of the Met Branch Trail including construction of ADA compliant sidewalk. Runoff from this POI drains to an existing storm drainage system under Takoma Avenue that discharges outside of the project limits.

- **POI 2** is located at an existing inlet along southbound Fenton Street just before the intersection with Takoma Avenue. The POI encompasses all work from the high point at STA 63+14 to the high point at STA 64+67 and includes runoff from the Met Branch Trail. The proposed improvements in this POI involve reconstruction and widening of the trail. Runoff from this POI drains to an existing storm drainage system under Takoma Avenue that discharges outside of the project limits.

- **POI 3** is located at an existing ditch west of Albany Avenue and the Met Branch Trail. The POI encompasses all work from the high point at STA 64+67 to the high point at STA 68+50. The work proposed in this POI involves reconstruction and widening of the Met Branch Trail. Runoff from this POI sheet flows towards the existing WMATA Metro Red Line.

- **POI 4** is located at an existing inlet along northbound Fenton Street north of the parking entrance to Montgomery College. The POI encompasses work from the high point at STA 68+50 to the intersection of Fenton Street and New York Avenue. The work proposed in this POI involves

reconstruction and widening of the Met Branch Trail. Runoff from this POI drains to an existing storm drainage system under Takoma Avenue that discharge outside of the project limits.

Stormwater Management design for this project is in accordance with the *Maryland Stormwater Design Manual (Revised May 2009).* Per the guidelines in this manual, for "redevelopment" areas the goal is 50% removal of existing impervious. Therefore, 50% of existing pavement within the LOD that is not removed is required to be treated at a PE of 1.0 inch for water quality purposes. New impervious area is to be treated at the appropriate composite PE, based on soil type. For this project, all new and redeveloped impervious occurs in Type B and D soil. The stormwater management requirements are summarized in *Table 1*.

Table 1: Stormwater Management Requirements

POI	Total IART Required (AC)	Total ESDv Required for POI (CF)	Total ESDv Required for Project (CF)
1	0.23	807	1,290
2	0.04	90	193
3	0.05	69	207
4	0.07	138	310
TOTAL	0.39	1,104	2,000

Table 1

Due to site constraints, the only suitable space for SWM facilities is the open space adjacent to the intersection of Takoma Avenue and Fenton Street. As such, no SWM facilities are proposed for POIs 3 and 4 and a variance for water quality will be required. A 40' long 2' bottom width swale is proposed in POI 2 to provide approximately 475 CF of ESDv, meeting the POI requirements. A microbioretention is proposed in POI 1 to provide approximately 1,200 CF of ESDv. This does not meet the full POI SWM requirements and a variance for water quality will be required for POI 1 as well. Additionally, a debit of approximately 0.21 acres will be required from the WQ Bank for this project.

All four POIs experience an increase in impervious area in proposed conditions. The bioretention in POI 1 is anticipated to provide quantity management for the POI. POIs 2, 3 and 4 experience minor net increases in impervious area and therefore it is anticipated that a variance will be requested for quantity management due to the limited space in POIs 2, 3 & 4.

Drainage upgrades within the project corridor are limited to those structures which are impacted by the proposed improvements, as well as additional drainage to convey flow to and from the proposed microbioretention safely into the existing system. There are no known flooding concerns in this area.

Attachment C: Stormwater Concept Approval Letter

MDE Sediment & Stormwater Plan Review for State & Federal Projects

SWM Calculator Condensed Format

Project Description: MET Branch Trail Upgrades

Washington Metropolitan Watershed

County: Montgomery County

MDE Tracking Number:

Job #: 20166.008

Contract #: MWCOG 21-093

Date: 10/7/2024

Designed by: JAC

Reviewed by: JAC

Clear Input Cells

Determine Development Classification for the Reconstruction Activities:

STEP 1 – Site / Drainage Area Data

Report to ESD Summary Sheet »»»

Report to WQSS»»

POI	SWM Study Area	Existing Impervious Surface Area	Percent Existing Impervious-ness	Development Classification for Re-construction	Existing Condition Drainage Area	Proposed Condition Drainage Area	Existing Imp. Area within LOD	Proposed Imp. Area within LOD	Area for which WQ is Not Req'd (i.e. 3.3.A Waiver)	Loss of Existing Water Quality (Area)	Loss of Existing ESD_v/ WQ_v (Volume)	Loss of Existing Recharge (Volume)	Re-constructed Imp. Area Already Treated (Area)	Ex. Imp. Area outside of LOD Shifted in/out of POI	Will POI qualify for a Cp_v Waiver under Section 3.3.B of the Guide-
			Col. D				Col. B	Col. C	Col. E	Col. F			Col. G		
	A_s	A_{EXI}	%I		A_E	A_P	A_{Ei}	A_{Pi}	A_{Mi}	A_{Li}	$ESD_{V\,Loss}$	$Re_{v\,Loss}$	A_{RECi}	A_{SHIFT}	Cp_{VW}
	acres	acres	%I = A_{EXI}/A_s		acres	acres	acres	acres	acres	acres	cubic feet	cubic feet	acres	acres	
1	0.36	0.27	75.0%	Re-dev'l	1.00	1.00	0.27	0.36	0.00	0.00	0.0	0.0	0.00	0.00	NO
2	0.04	0.03	75.0%	Re-dev'l	1.00	1.00	0.05	0.06	0.00	0.00	0.0	0.0	0.00	0.00	NO
3	0.09	0.08	88.9%	Re-dev'l	1.00	1.00	0.08	0.09	0.00	0.00	0.0	0.0	0.00	0.00	NO
4	0.12	0.10	83.3%	Re-dev'l	1.00	1.00	0.10	0.12	0.00	0.00	0.0	0.0	0.00	0.00	NO

STEP 2 – Impervious Area Requiring Treatment (IART); STEP 3 – Required ESD Volume for Treating Redevelopment ($ESD_{V\,RE\text{-}DEV'L}$); STEP 4 – ESD Volume Reduction from Decreasing Impervious Area ($ESD_{V\,reducedAi}$) (for Redevelopment Classification when ΔAi<0)

POI	IART from Redevelopment: For Re-dev'l Classification, $IART_{RE\text{-}DEV'L}$ = 50% of ($A_{Ei} - A_{Mi} - A_{RECi}$) For New Dev'l Classification, $IART_{RE\text{-}DEV'L}$ = 0	IART from New Development: For Re-dev'l Classification, $IART_{NEW}$ = ΔAi = $A_{Pi} - A_{Ei}$ For New Dev'l Classification, $IART_{NEW} = A_{Pi} - A_{Mi}$ -	Total IART: IART = $IART_{RE\text{-}DEV'L}$ + $IART_{NEW}$ + A_{Li}	STEP 3 P_E	STEP 3 R_V	$ESD_{V\,RE\text{-}DEV'L}$	Applied to Project P_E	Applied to Project R_V	$ESD_{V\,reducedAi}$	Applied to POI P_E	Applied to POI R_V	$ESD_{V\,reducedAi}$
	Col. 1	Col. 2				Col. 3			Col. 4a			Col. 4b
	should match Col. I	should match Col. J	should match Col. K									
	$IART_{RE\text{-}DEV'L}$	$IART_{NEW}$	IART									
	acres	acres	acres	in.		cubic feet	in.		cubic	in.		cubic
1	0.14	0.09	0.23	1.00	0.95	483	N/A	N/A	0	N/A	N/A	0
2	0.03	0.01	0.04	1.00	0.95	103	N/A	N/A	0	N/A	N/A	0
3	0.04	0.01	0.05	1.00	0.95	138	N/A	N/A	0	N/A	N/A	0
4	0.05	0.02	0.07	1.00	0.95	172	N/A	N/A	0	N/A	N/A	0

STEP 5 – Required ESD Volume for treating New Development ($ESD_{V\,NEW}$) for POI

POI	$ESD_{V\,NEW}$ for 3.3.B Waiver P_E	R_V	$ESD_{V\,NEW}$	$ESD_{V\,NEW}$ for No Waiver or No Impervious Reduction (i.e. ΔAi >=0) Soil Group A (P_E 2.6)	B (P_E 2.6)	C (P_E 2.2)	D (P_E 2.0)	Weighted P_E	R_V	$ESD_{V\,NEW}$
			Col. 5a							Col. 5b
	in.		cubic feet	ac.	ac.	ac.	ac.	in.		cubic feet
1	N/A	N/A	0		0.09			2.60	0.95	807
2	N/A	N/A	0		0.01			2.60	0.95	90
3	N/A	N/A	0				0.01	2.00	0.95	69
4	N/A	N/A	0				0.02	2.00	0.95	138

STEP 6 – ESD Volume for the Shifted Impervious Area ($ESD_{V\,SHIFT}$) in/out of POI; STEP 7 – Req'd ESDv from Loss of Existing SWM ($ESD_{V\,Loss}$); STEP 8 – Required ESD Volume for the POI ($ESD_{V\,POI}$); STEP 9 – Required Recharge Volume (Re_V)

POI	STEP 6 P_E	STEP 6 R_V	$ESD_{V\,SHIFT}$	ESDV Loss	$ESD_{V\,POI}$	1-Year Management Requirement	Soil Specific Recharge Factor (S) Soil Group A (###)	B (###)	C (###)	D (###)	Weighted S	Recharge Volume ($Re_{V\,NEW}$) for New Development	Loss of Existing Recharge Volume (Rev Loss)	Total Required Recharge Volume (Rev)
			Col. 6	Col. 7	Col. 8									Col. 10
												$Re_{v\,NEW}$	$Re_{v\,Loss}$	Re_v
	in.		cubic feet	cubic feet	cubic feet		ac.	ac.	ac.	ac.	in.	cubic feet	cubic feet	cubic feet
1	2.60	0.95	0	0	807	NO	0.00	0.09	0.00	0.00	0.26	81	0	81
2	2.60	0.95	0	0	90	NO	0.00	0.01	0.00	0.00	0.26	9	0	9
3	2.60	0.95	0	0	69	NO	0.00	0.00	0.00	0.01	0.07	2	0	2
4	2.60	0.95	0	0	138	NO	0.00	0.00	0.00	0.02	0.07	5	0	5

Attachment C: Stormwater Concept Approval Letter

Project:	Takoma Park MBT Upgrades	Designed By:	JAC
		Checked By:	JAC
County/Cr:	Montgomery	Approved By:	
Watershed:	Washington Metropolitan	Date:	10/4/2024
MWCOG Contract Number:	21-093		
RKK Project Number:	20166.008	**POI:**	**1**
Design Phase:	Concept	**Facility No:**	**MBR-1**
		Location:	

M-6: Micro-bioretention Design Calculations

Step 1: Determine Contributing Area Data:

Input Cell

ESD_v Target (P_E) =	2.6	in.	= Target Pe (1.0 to 2.6 inches) ---> will be iterative based on site constraints	
Contributing Area (A) =	14171	sf.	---------->	0.33 ac.
Contributing Impervious Area (A_i) =	5547	sf.	---------->	0.13 ac.
Percent Impervious Area ($\%_{IMP}$) =	39.1	% → use	40%	
Volumetric Runoff Coefficient (R_v) =	0.402		= 0.05 + 0.009 * ($\%_{IMP}$) (pg 5-18 of the MDE manual)	
$ESDv$ Required (ESD_v) =	1235	cf.	= (P_E * A * R_v) / 12 (pg 5-18 of the MDE manual)	

Step 2: Assume Micro-bioretention Dimensions:

Side Slope =	0.25	ft/ft	= 4:1 or flatter	A_f / A =
Filter Bed Area (A_f) =	1050	sf.	= Surface Area must be ≥ 2% of the contributing Area ---->	7%

The facility footprint is adequately sized.

Step 2: Determine Storage Requirements:

Percent Impervious Area ($\%_{IMP}$) =	40.0%		= impervious area divided by total contributing drainage area (A_i/A)
A_f/A_i =	18.9%		= filter bed area divided by impervious area (A_f/A_i)
$ESDv$ Required (ESD_v) =	1235	cf.	= (P_E * A * R_v) / 12
Percent Storage Required Above Surface ($V_{\%-R}$) =	41.6%	of ESD_v	= Surface Storage tables based on P_E, $\%_{IMP}$, and A_f/A_i
Min. Surface Storage Required (V_S)=	514	cf.	= $V_{\%-R}$ * ESD_v

Tables to be used with State Highway Administration (SHA) Bioretention Soil Mix (BSM)

Storage Volume (% of ESDv) required above surface for Pe = 2 - 2.6 inches

%Imp	Af/Ai										
	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	46%	43%	39%	36%	32%	28%	26%	23%	21%	19%	18%
10%	50%	46%	41%	36%	32%	29%	27%	25%	23%	21%	20%
15%	53%	49%	43%	39%	35%	32%	30%	28%	26%	25%	24%
20%	55%	51%	45%	41%	38%	35%	33%	31%	29%	28%	26%
25%	55%	51%	46%	42%	39%	36%	34%	32%	30%	28%	27%
30%	56%	52%	46%	42%	39%	37%	35%	32%	31%	29%	28%
35%	56%	52%	47%	43%	40%	38%	35%	33%	31%	30%	28%
40%	57%	53%	48%	44%	41%	38%	36%	34%	32%	31%	29%
45%	58%	54%	48%	45%	42%	39%	37%	35%	33%	31%	30%
50%	58%	54%	49%	45%	42%	40%	38%	36%	34%	32%	30%
55%	59%	55%	50%	46%	43%	41%	38%	36%	34%	33%	31%
60%	59%	55%	50%	46%	44%	41%	39%	37%	35%	33%	31%
65%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
70%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
75%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
80%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
85%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
90%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
95%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
100%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%

Project:	Takoma Park MBT Upgrades	Designed By:	JAC
		Checked By:	JAC
County/Cr:	Montgomery	Approved By:	
Watershed:	Washington Metropolitan	Date:	10/4/2024
MWCOG Contract Number:	21-093		
RKK Project Number:	20166.008	**POI:**	**1**
Design Phase:	Concept	**Facility No:**	**MBR-1**
		Location:	

Step 3: Determine Surface Storage Provided by Micro-bioretention:

Stage Storage Table

Elevation [ft.]	Area [ft²]	Area [acre]	Change in Elevation [ft]	Average Area [acre]	Incremental Volume [acre·ft]	Cumulative Volume [acre·ft]	Cumulative Volume [ft³]
316.00	1050.00	0.0241				0.0000	0.00
317.00	1,660.00	0.0381	1.0	0.0311	0.0311	0.0311	1,355.00

Step 4: Determine Treatment Provided by the Micro-bioretention:

Min. Surface Storage Required =	514.0	*cf.*	*= Surface Storage tables based on P_E, $\%_{IMP}$, and A_f/A_i*
Surface Storage Provided =	1355.0	*cf.*	*= total volume from stage storage table*
Percent Surface Storage Provided=	110%		*= percent surface storage provided based on a Pe of 2.6 inches*

Because the proposed facility is providing more than enough surface storage, iterations will need to be done to determine the larger Pe treated.

			Percent Storage		*Actual > Required*
From	P_E	ESD_v	Required	Actual	
	in.	cf.	%	%	Y/N
Table	2.60	1235	41.64%	109.70%	Yes
Iteration	2.60	1235	41.64%	109.70%	Yes
Table	0.00	0	0.00%	#DIV/0!	#DIV/0!

The PE treated is based on providing a surface storage volume that is a certain percent of the ESDv, but the ESDv changes depending on the Pe. Therefore, determing the Pe treated is an iterative process. The table shown demonstrates this process. The user should input the highest P_e value possible that still meets the required percent surface storage.

Because the proposed facility is providing a Pe greater than 2.6 in., the Pe credited is 2.6 in. and the ESDv credited is 1235.

Step 5: Determine the Impervious Area Treated by the Micro-bioretention:

Contributing Impervious Area	P_E treated	Impervious Acre Credit*
ac.	in.	ac.
0.13	2.60	0.13

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Watershed:	Washington Metropolitan	Approved By:	
SHA Project Number:	21-093	Date:	10/4/2024
RKK Project Number:	20166.008	**POI:**	**2**
Design Phase:	Concept	**Facility No:**	**BSW-1**
		Location:	

M-8: Bio-swale Design Calculations

Step 1: Determine Contributing Area Data:

Input Cell

ESD_v Target (P_E) =	2.6	in.	= Target P_E (1.0 to 2.6 inches) ---> will be iterative based on site constraints	
Contributing Area (A) =	6092	sf.	---------->	0.14 ac.
Contributing Impervious Area (A_i) =	2235	sf.	---------->	0.05 ac.
Percent Impervious Area ($\%_{IMP}$) =	36.7	% → use	40%	
Volumetric Runoff Coefficient (R_v) =	0.380		= 0.05 + 0.009 * ($\%_{IMP}$) (pg 5-18 of the MDE manual)	
$ESDv$ Required (ESD_v) =	502	cf.	= (P_E * A * R_v) / 12 (pg 5-18 of the MDE manual)	

Step 2: Assume Bio-swale Dimensions:

Bioswale Length (L) =	80	ft.		
Bioswale Bottom Width (W) =	2	ft.		A_f/A =
Bioswale Surface Area (A_f) =	160	sf.	= Surface Area must be ≥ 2% of the contributing Area ---->	7%
Left Side Slope (S_{S1}) =	0.25	ft/ft	= 4:1 or flatter	
Right Side Slope (S_{S2}) =	0.25	ft/ft	= 4:1 or flatter	
Bioswale Slope (S_L) =	0.01	ft/ft	= 4% maximum longitudinal slope	

Step 3: Determine Storage Requirements:

Percent Impervious Area ($\%_{IMP}$) =	40.0%		= impervious area divided by total contributing drainage area (A_i/A)
A_f/A_i =	7.2%		= filter bed area divided by impervious area (A_f/A_i)
ESD_v Required (ESD_v) =	502	cf.	= (P_E * A * R_v) / 12
Percent Storage Required Above Surface ($V_{\%-S}$) =	50.8%	of ESD_v	= Surface Storage tables based on P_E, $\%_{IMP}$, and A_f/A_i
Min. Surface Storage Required (V_S) =	255	cf.	= $V_{\%-R}$ * ESD_v

Tables to be used with State Highway Administration (SHA) Bioretention Soil Mix (BSM)

Storage Volume (% of ESDv) required above surface for Pe = 2 - 2.6 inches

%Imp	Af/Ai										
	2%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
5%	46%	43%	39%	36%	32%	28%	26%	23%	21%	19%	18%
10%	50%	46%	41%	36%	32%	29%	27%	25%	23%	21%	20%
15%	53%	49%	43%	39%	35%	32%	30%	28%	26%	25%	24%
20%	55%	51%	45%	41%	38%	35%	33%	31%	29%	28%	26%
25%	55%	51%	46%	42%	39%	36%	34%	32%	30%	28%	27%
30%	56%	52%	46%	42%	39%	37%	35%	32%	31%	29%	28%
35%	56%	52%	47%	43%	40%	38%	35%	33%	31%	30%	28%
40%	57%	53%	48%	44%	41%	38%	36%	34%	32%	31%	29%
45%	58%	54%	48%	45%	42%	39%	37%	35%	33%	31%	30%
50%	58%	54%	49%	45%	42%	40%	38%	36%	34%	32%	30%
55%	59%	55%	50%	46%	43%	41%	38%	36%	34%	33%	31%
60%	59%	55%	50%	46%	44%	41%	39%	37%	35%	33%	31%
65%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
70%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
75%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
80%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
85%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
90%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
95%	59%	55%	50%	46%	43%	41%	39%	37%	35%	33%	31%
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		Location:	

Step 4: Determine Surface Storage Provided by Bio-swale:

Check Dam Top Width (CD_W) =	1.00	ft.	
Check Dam Slope (S_{CD}) =	0.17	ft/ft	= max. slope 6:1 in clear zone and 3:1 outside the clear zone
Check Dam Height (CD_H) =	1.00	ft.	= max. 12"
Maximal Length of Storage (L_{max}) =	100.00	ft.	= CD_H / S_L, If less than 50 ft. a minimum of 50 ft is used.
Length of Storage (L_S) =	50.00	ft.	= Length must be ≥ 50 ft and < L_{max}
Check Dam Length (CD_L) =	13.00	ft.	= $2 * CD_H / S_{CD} + CD_W$
Check Dam Spacing (CD_S) =	63.00	ft.	= $L_S + CD_L$
Number of cells (C) =	1.00		= L / CD_S
Minimal Storage Depth (d_{min}) =	0.50	ft.	= $S_L * (L_{max} - L_S)$

Surface Storage Per Cell (V_C) = $CD_H^3 / (6 * S_L * S_{S1}) + CD_H^3 / (6 * S_L * S_{S2}) + CD_H^2 * W / (2 * S_L)$
$- d_{min}^3 / (6 * S_L * S_{S1}) - d_{min}^3 / (6 * S_L * S_{S2}) - d_{min}^2 * W / (2 * S_L)$

= 191.67 cf.

Total Surface Storage Provided (V_T) = 243.40 cf. = $V_C * C + ((L - CD_S * C) * V_C / CD_S)$

Step 5: Determine Treatment Provided by the Bio-swale:

Min. Surface Storage Required (V_{S-R}) =	255	cf.	= Surface Storage tables based on P_E, $\%_{IMP}$, and A_f/A_i
Surface Storage Provided (V_{S-P}) =	243.4	cf.	= total volume from step 3
Percent Surface Storage Provided ($V_{\%-S}$) =	48%		= percent surface storage provided based on a Pe of 2.6 inches

Because the proposed facility does not provide enough surface storage to treat the target Pe, iterations will need to be done to determine the reduced

			Percent Storage		Actual >
From	P_E	ESD_v	Required	Actual	Required
	in.	cf.	%	%	Y/N
Table	2.40	463	50.84%	52.54%	Yes
Iteration	2.47	477	50.84%	51.03%	Yes
Table	2.50	483	50.84%	50.44%	No

The Pe credited is 2.47 in. and the ESDv credited is 477 cf.

The PE treated is based on providing a surface storage volume that is a certain percent of the ESDv, but the ESDv changes depending on the Pe. Therefore, determing the Pe treated is an iterative process. The table shown demonstrates this process. The user should input the highest P_e value possible that still meets the required percent surface storage.

Step 6: Determine the Impervious Area Treated by the Bio-swale:

Contributing Impervious Area	P_E treated	Impervious Acre Credit*
ac.	in.	ac.
0.05	2.47	0.05